(B) Agricultural drainage

There is currently no meaningful proposal to address salt issues in either the Sacramento or San Joaquin Valleys. In fact, the program, by reallocating existing agricultural water supplies that are necessary for leaching, will exacerbate any salt problems.

3. Water Use Efficiency

Although AB 3616 will be used as the basis of the agricultural water efficiency program, there is a continuing desire to undermine agricultural water rights and to place more stringent regulations on water use by agencies and farmers and ranchers. The water resulting from more efficient water uses in non-agricultural uses will continue to be available by those sectors, but any water that is made available by agricultural water efficiency (if any) will also be made available to other, non-agricultural uses. This is further evidence of the reallocation of water from agriculture to other uses.

4. System Integrity (Appendix D)

As discussed before under ecosystem targets, it appears that prime agricultural lands will be taken out of production by setback levees and by conversion to a bypass system.

5. Conjunctive Use

The conjunctive use program has not been fully developed, but targets in all three alternatives range from 0 to 500,000 af in the Sacramento Valley and 0 to 500,000 af in the San Joaquin Valley. It appears that "conjunctive use" under the program means transferring groundwater, either directly or indirectly, for non-agricultural uses as part of the program. This is another reallocation of important groundwater resources.

6. Water Transfers

Although the discussion is just beginning with water transfers, it is presumed that water transfers will occur from the agricultural to urban and environmental uses. In many cases, this means that additional agricultural water supplies (and possibly land) will be reallocated to other uses.

CONVEYANCE AND STORAGE ALTERNATIVES

It is still too early to evaluate the conveyance and storage options for the program, although it is probably safe to say that from an agricultural perspective, certain parts of the state will be significantly impacted (i.e., delta, area of origin areas) and other parts may benefit from this component of the program. Any benefit will be dependent upon the affordability of the solution, assurances that there will be additional water supply reliability, and assurances that the program will be operated properly. It appears that new storage in the program will not increase the yield of the system, but instead will merely reallocate the timing of flows away from agricultural uses.

FINANCE

Although a benefits approach was initially discussed as part of the program, there now appears to be a desire for punitive measures that require all water users to pay for any Cal-Fed solution, regardless of whether they receive any benefit. This appears to mean that those who receive no benefit from the Cal-Fed solution, such as the large majority of agricultural water users, will nonetheless be required to pay for it. It also appears that agricultural water users will be asked to contribute to the program so that their land and water can then be acquired.

ENVIRONMENTAL REVIEW

Agriculture in California is an environmental resource of global significance. Both agricultural land and water are an important part of the productive environment that must be considered under both NEPA and CEQA. As the previous discussion shows, the program as currently proposed will have significant impacts on agricultural land, water and the agrarian way of life. Yet, despite federal and state laws and the potentially significant impacts to agriculture and the attendant environment, it appears that Cal-Fed will not consider these impacts in its Programmatic EIR/EIS. The cumulative impacts of this program, in conjunction with the implementation of Central Valley Project Improvement Act (CVPIA), the Bay/Delta water rights process, the Department of Water Resources Supplemental Water Purchase Program and numerous other actions that affect the delta, will be particularly significant. Additionally, there does not appear to be any discussion of alternatives that will have less impact on agricultural land and water as required by NEPA and CEQA.

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September 22, 1999

HAND DELIVERED

Mr. Rick Breitenbach
CALFED Bay-Delta Program
1416 Ninth Street, Suite 1155
Sacramento, CA 95814

Dear Mr. Breitenbach:

The South Delta Water Agency submits the following comments to the DEIS/EIR of the CALFED Bay-Delta Program.

Introduction

Although the Program has lofty goals, its broad scope precludes it from reaching those goals. CALFED's generally nonspecific attempt to improve all aspects of water quality, water supply, and ecosystem restoration falls apart each time specifics are developed. California's water problems cannot be solved by State and Federal agencies saying they will "evaluate ways to reduce" constituents that adversely affect water quality. All that means is that the tough decisions on how to deal with a problem will be deferred (once again) to a later date. CR1

The principle example of this is the USBR's inability to meet its permit conditions to maintain the salinity at Vernalis set forth in the 1995 Water Quality Control Plan. The DEIS/EIR does not even mention this obligation or the fact that the Bureau's current operations are estimated (by it) to result in violations of this standard in over 50 percent of the years. CALFED makes no specific attempt to correct this problem and yet seeks to adopt a Preferred Alternative which will increase the amount of water the Bureau (and DWR) will export from the Delta. CALFED was not be constituted to allow a party to increase the benefits it receives from the system while at the same time ignoring that party's adverse effects on the system. IA-5.3-G-4

CALFED also fails to recognize the necessary long-term results from its program. It assumes urban and environmental needs will require an ever greater increasing portion of the IA-5.4.1-4 WO-7.0-1 CR12

available water supply at the expense of agriculture. California's production of food must increase so that there is an adequate food supply for our grandchildren when we have twenty million more Californians to feed. In twenty-five years, the good supply available on the world market will be greatly reduced, due to world population growth and the lack of adequate water in many countries. We will sacrifice our children's future if we follow CALFED's plans to take land and water away from the production of food while the need for food is growing; and if we follow CALFED's plan to not just continue but to increase the unsustainable overdrafting and salinizing of Central Valley groundwaters; and if we accept CALFED's refusal to build the valley drain without which we will gradually destroy the fertile south Central Valley farm lands that are essential to our food supply.

CALFED must vigorously develop and pursue a plan to mitigate the impact of the state and federal projects on the watershed of the San Joaquin and Tulare basins. It must get started on the flow process of raising Friant Dam, increasing storage in the Kings River watershed and elsewhere, and building a drain to convey to the ocean the salt that is imported into the 7South Central Valley by the CVP and SWP. Until the drain is built, CALFED's plan must reduce the high salinity in the San Joaquin River that results from this importation of salt. This can be done in part by installing three tidal barriers in the South Delta to stop the recapture and re-export of the concentrated salt that drains into the river from the CVP service area. IA-1.0.0-25 IA-5.1-197 PH2:4.1-15

Part of the problem is that some of the program's goals or objectives are either misstated or unattainable. One of the objectives is to "reduce the mismatch" between supplies and uses. This assumes that somewhere there is an unused supply of water that can be shifted to an area of need. Although that situation may exist in some places, it ignores the legal restraints on transfers necessary to achieve that goal. The Delta Protection Act requires that the State and Federal projects prevent salinity intrusion and coordinate their operations and flows so as to provide adequate water for in-Delta uses including fisheries and agriculture. Only surplus water to those needs can be exported. In light of this, the starting point for the program should have been a determination of what in-Delta needs are and how to provide them. Thereafter, surplus flows need then be identified, and finally how and when those surplus flows can be exported. IA-1.0.0-25 PH2:3.6.1-25

By not starting from this statutorily required premise, CALFED violates existing laws and ends up then trying to promote a "share the burden" attitude. Strangely enough, those entities that wish to share the burden are the ones that have caused the water quality problem, water supply shortages, and adverse effects on the ecosystem.

1. South Delta Barriers.

A. The DEIS/EIR opts for a two tidal barrier/dredging program for the South Delta in combination with the Head of Old River fish barrier. In order for this to be the Preferred Alternative, there must first be an evaluation of the impacts of the program and that evaluation IP-2.8-1 CR1

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must be subject to public review before the adoption of the Preferred Alternative. This has not yet occurred. As per the ongoing SDIT process, CALFED has not evaluated its Preferred Alternative. Currently, there is an ongoing process to model the effects of a two tidal barrier/dredging program. However, since the amount and location of the dredging has not yet been determined, the analysis cannot yet be completed. Only after that analysis has been done and there is public review can CALFED make a decision. Choosing the Preferred Alternative before this process is complete violates CEQA and NEPA law.

B. CALFED has not yet stated what the goal of the South Delta Improvement Plan is. As originally conceived, the Interim South Delta Program (which CALFED has taken over) was to implement an agreed to settlement of a 1982 lawsuit wherein SDWA sued DWR and USBR over the adverse changes to flows, water levels, water quality, and circulation caused by operation of the CVP and SWP. This agreed to settlement was unilaterally changed by CALFED without SDWA input. SDWA's initial analysis of the two barrier/dredging program is that it, in conjunction with other specified CALFED programs, will result in the South Delta diverters being in a worse condition. IP-2.8-1

The goal or objective of the program is therefore of extreme importance. If the goal is to obtain some level of improvement, then CALFED can choose an alternative with marginal improvement that does not cure the harm the projects have caused the South Delta. If the goal is to maximize water quality and quantity for the South Delta, then the currently designated Preferred Alternative does not meet this goal. If the goal is a settlement of the 1982 lawsuit, then the Preferred Alternative can only be something to which SDWA agrees, which has not yet happened. The drafters must specify what the goal is.

This program is the litmus test for all CALFED actions. If CALFED can implement measures in the South Delta without the approval of the SDWA, then all of CALFED's principles of reducing conflicts, no transferred effects, and public acceptance become meaningless.

C. The analysis of the alternatives is currently incomplete. Initial results attempt to compare a three barrier program, a two barrier program with dredging, and changed SWP operations with a base case of no export operations. This appears to be an attempt to limit the benefit SDWA diverters will receive under the program to something at or near the "no export" scenario. However, that base case must but does not yet include the original levels of San Joaquin River flow and water quality which have been significantly diminished by CVP operations. IP-2.8-1

D. SDWA has numerous comments, input, and corrections to the current modeling/analysis for the barrier program. Since the DEIS/EIR does not yet contain CALFED's

analysis, SDWA's comments will be submitted after an environmental document with that analysis has been released for public review.

2. The document references the need to screen in-Delta diversions. SDWA is aware of no test programs or analyses which indicate unscreened agricultural diversions have any significant effect on fisheries. Enclosed herewith are two DWR studies which evidence the minimal effect such local diversions have on fisheries. Logically, the effect that a 24-inch diversion has on a South Delta channel is infinitesimal when compared with the CVP and SWP operations which pull the entire flow of channels into their pumps. ERPII 4.8-2 ERPII 4.12-6

3. The document notes that salt water intrusion from the Bay/ocean is the major cause of high salinities in the Delta. More correctly, elevated salinity levels in the South Delta are a result of high salinity surface and subsurface agricultural return flows originating from the CVP's west side San Joaquin Valley service areas. These return flows sometimes exceed the Vernalis salinity standard by a factor of 10, and are the cause of decreased crop productivity in the South Delta. Only rarely has salt water intrusion caused any significant decrease in South Delta crops. It is important to note that once salinities reach a certain level, any increase causes harm to crops. For most Delta crops, that threshold level is lower than the standards (see attached testimony and studies). IA-5.3.3.1-2 IA-5.3.3.1-3

4. The document references the installation of tidal barriers or their "functional equivalent." The drafters need to define what they mean by functional equivalent as it is not clear that anything except a barrier can trap incoming tidal flows. IA-2.1-19

5. Under the goals of the Ecosystem Restoration Project, the document describes the restoration of instream and channel forming flows. This goal is in direct conflict with over 100 years of government and locally initiated efforts to provide flood control protection to the people of the State of California. Many of the ERP's proposals seek to implement actions which will frustrate flood control needs. The CALFED process must contain a mechanism by which it insures that efforts to restore habitat or flows do not frustrate necessary flood control efforts. ERPI 4.1-1 CR1

6. CALFED seeks to restore habitat and fisheries to some unspecified level. Absent from this analysis is an investigation into whether or not that is possible. For example, CALFED has adopted both State and Federal goals of doubling anadromous fish populations. Given that there is a fixed amount of biomass in the system, on what basis can CALFED conclude that one species will be able to double in size? In order to supply the appropriate nutrients for that doubling, some other species would be deprived of that amount of nutrients. How will this be accomplished? This issue ties in closely with the ERP's discussion of controlling evasive species. Whether or not that is a desirable goal, the document contains no specifics or analysis of how introduced species may be controlled. ERPI 4.8-1

7. The document does not explain how water use efficiency or water transfers will result in new yield. The document describes how those actions may result in a reallocation of the existing supplies but then confuses that reallocation with the idea that there is now more water available for use. Enclosed herewith are various documents and testimony SDWA put forth in the ongoing SWRCB Bay-Delta Water Right Hearings. These documents show that especially on the San Joaquin system, in most years, there is no excess water. What this means is that all of the water of the system is put to some beneficial use each year. Whether it is consumed by upstream diverters, or downstream diverters, used for instream water quality, used for fish flows, used for the prevention of salt water intrusion, or used to provide Delta outflow, all of it is put to beneficial use. In light of that, increased "water use efficiency" or water transfers necessarily decrease the amount available for some beneficial use. WT-1.2-4 WUE 00-3 WT-1.2-4

For example, if an upstream agricultural diverter applies less water or intercepts the water that would normally escape his control, he may be freeing up water for another use or a transfer to a current use, but he is also decreasing the amount of water used by downstream diverters, fish, salinity intrusion, or Delta outflow. In that event, others must provide a substitute for this decreased flow, and the system has no net gain. A recent example is the sale of water to provide increased fishery flows in April-May which this year resulted in the need for the USBR to release additional water in summer months to maintain water quality (SJRA program).

8. Following on the above comment, CALFED's goal of seeking to reduce the mismatch between supplies and users is the incorrect starting point. Although there are certainly opportunities to save water or transfer water with no adverse third party effects, what is actually needed is an increase in supply, or yield, so that increasing uses will have a sufficient supply. Water use efficiency in upstream areas has no effect on yield because downstream users have relied on the water that escaped the upstream users' districts. PI-2.2.1-6

9. The DEIR/EIS' analysis of potential increased supplies due to conservation appears to be vastly overstated. Conservation by "end users" whose excess or return flows go directly to the ocean will increase the available supply for them. However, before embarking upon a multi-billion dollar plan, the DEIR/EIS should first identify the amount of water projected to be needed by the State of California, next identify the current firm yield of the system supplying that water, then determine how much is available through conservation. After those numbers have been developed, an estimate of the amount of new yield needed can be made. With that new number, CALFED should then determine how to develop that increased yield. Although there is strong opposition to new reservoirs, at this time the only method of adding substantial new yield is by trapping flood flows which would have escaped the system. Off stream storage projects such as those considered by CALFED are most likely impractical. Not only can they not capture any significant portion of that excess flood flow (due to the inability to quickly transfer those high flows), but they also have high costs associated with delivering the PI-2.3.6.1-9 PI-2.5.3-1

water to the off stream storage and delivering the water from the storage. In light of these, it is doubtful any organization would embark on such a project.

10. The DEIR/EIS states that CALFED will contain "mechanisms to provide third party protections" for water transfers. To date, no CALFED agency has recognized any such third party effects resulting from any water transfer. SDWA has alleged such third party transfers in numerous projects including the Bureau's IWAP and the SJRA, but in each case all Federal agencies have decided that no third party effects exist. Before CALFED embarks on a program to encourage transfers, it must recognize the existence of third party effects before promising to mitigate for them. WT-2-1

11. As stated before, CALFED's initial goal should be the adequate protection of water quality, quantity, and circulation in the Delta. Thereafter, the identification of surplus flows could be exported. However, CALFED's initial interest is to improve the transport of Sacramento River water across the Delta to the State and Federal pumps for export out of the region. As per the various comments of Alex Hildebrand submitted herewith, CALFED staff has not attempted to maximize the ability to use through-Delta improvements for that transfer of water. This intentional lack of effort to maximize in-Delta transfer has resulted in the program only temporarily deferring its implementation of an isolated facility. Although the DEIS/EIR repeatedly states that its current Preferred Alternative is the through-Delta transfer of water, the document also repeatedly confirms that CALFED will begin the process of evaluating and designing the isolated facility. If CALFED were truly interested in maximizing the through-Delta transfers, it would focus its efforts in that direction rather than towards the isolated facility. Even if the through-Delta does not work as well as desired, efforts to improve it should precede efforts to supplant it. IA-2.1.2-17 IA-1.0.0-13 IA-1.0.0-25 IA-1.0.0-26 IA-6.1-BT-30

12. The Delta Protection Act (Water Code §§ 12200 et seq.) provides that the State and Federal governments must provide salinity control in the Delta and,

> an adequate water supply for the users of water in the Sacramento-San Joaquin Delta. *If it is determined to be in the public interest to provide a substitute water supply to the users in said Delta in lieu of that which would be provided as a result of salinity control no added financial burden shall be placed upon said Delta water users. . .* (Section 12202)
>
> It is hereby declared to be the policy of the State that no person, corporation, or public or private agency or the State or the United States should divert water from the channels of the Sacramento-San Joaquin Delta to which the users within said Delta are entitled. Section 12203.

> In determining the availability of water for export from the Sacramento-San Joaquin Delta, no water shall be exported which is necessary to meet the requirements of Section 12202 and 12203 of this chapter. Section 12204.
>
> It is the policy of the State that the operation and management o releases from storage in the Sacramento-San Joaquin Delta of water for use outside the area in which such water originates shall be integrated to the maximum extent possible in order to permit the fulfillment of the objectives of this part. Section 12205.

It is clear that an isolated facility as proposed by CALFED and which CALFED is currently working on directly conflicts with the plain language of the Delta Protection Act. Therefore, contemplating, developing, and proceeding with an isolated facility violates CALFED's solution principle that any action must be implementable and have "broad public acceptance and legal feasibility." In addition, there are other restrictions contained in area of origin, watershed protection, and the San Joaquin River Act which also limit the ability to export water from the Delta. By not addressing these restrictions, CALFED continues its preference for exporters at the expense of other beneficial users.

13. The document contemplates that the Preferred Alternative will include a 15,000 CFS intake at Clifton Court Forebay operated independent of the tidal cycle. Current SWP operations are coordinated with the tidal cycle. The South Delta Barrier Program was designed to address South Delta water level, circulation, and quality problems caused by State and Federal project operations and was based upon SWP operations being coordinated with the tidal cycle. Changing the SWP operations from their current practice to one that is independent of tidal cycles can and will have a significant effect on the efficiency of the South Delta tidal barriers. Since the ongoing SDIT has indicated that CALFED staff has only just started modeling the effects of this new SWP operation on tidal barriers, there is no basis on which CALFED can choose this new alternative. Once again, CALFED has put the cart before the horse and chosen a Preferred Alternative before it conducted any analysis of the effects of the choice on other CALFED actions and other interests. Even if the analysis of the changed operations and the tidal barriers is being deferred to a subsequent environmental document, the current DEIS/EIR would be insufficient for selecting a specific action before analysis has been done. IA-5.1-62

14. The document also endorses unlimited joint point of diversion "taking into account fishery, water quality, and storage needs." Absent from CALFED's consideration is the effect JPOD will have on South Delta diverters and/or the South Delta tidal barriers. JPOD anticipates changing pumping operations between SWP and CVP. Depending on when the change occurs, and which pumping operation is increased, potentially significant adverse effects IA-5.2.8-4

result to South Delta water levels. It is inconceivable that an agency committed to reducing conflicts among users would endorse JPOD without even recognizing its potential adverse impact to South Delta riparians as well as to its own South Delta barrier program. Enclosed herewith is a copy of an agreement between USBR and SDWA indicating the issues involved.

15. On what does CALFED base its statement that under the no action alternative fisheries and water quality will deteriorate? Currently, the SWRCB is implementing a new Water Quality Control Plan to protect fisheries and water quality. The Central Valley Regional Water Quality Control Board is developing and will implement water quality standards and TMDL limits on the San Joaquin River. CVPIA requires the Bureau to provide water to improve fisheries. It appears that numerous diverse actions are ongoing which will improve water quality and fisheries even in the absence of CALFED's new bureaucracy. IA-6.1.6-2

16. The DEIR/EIS notes that there are potential significant adverse effects resulting from the conversion of prime agricultural land. On what basis does CALFED decide to address declining fisheries by converting Delta ag land to habitat while at the same time increasing exports from the Delta when the major contributing factor to the declining fisheries is the export of water from the Delta? Since there is no way to mitigate a decrease in prime agricultural land located in the Delta, CALFED should focus its efforts to improve fisheries by addressing the actions its member agencies have undertaken which have diminished the species. ERPII 4.4-1

17. The document references the various models used to analyze the effects of the alternatives. It is SDWA's position that the models generally understate the amount of return flows in the system and thus do not adequately examine downstream effects resulting from transfers and increased water use efficiency. Attached hereto is a memo from a consultant to an upstream water district evidencing that any transfer of water by that upstream entity results in a decrease in river flow in an amount equal to one-third of the transferred water. Does the modeling predict or acknowledge this effect? IA-5.1-63

18. The DEIS/EIR notes increased water stages and water quality in the South Delta resulting from the Preferred Alternative. It should clarify that those improvements are a result of the tidal barrier program, not any other CALFED actions. In a public meeting held two years ago at the Roberts-Union Farm Center, CALFED staff informed the public that its efforts to improve the transfer of water through or around the Delta all resulted in decreased water quality in the South Delta. The document should contain a comparison of how much the through-Delta transfer affects water quality and how that changes the effectiveness of the South Delta Barrier Program. IA 5.3.3.1-3

19. The document fails to adequately describe the existing conditions. Enclosed herewith are numerous documents evidencing the fact that the CVP decreases San Joaquin River flows in excess of 500,000 acre-feet per year, results in the addition of large amounts of salts to IA-Att. A-3-29 IA-5.1-180 WQ-7.4.1-1

the San Joaquin River, and in coordination with the SWP radically alters the normal flow patterns of the Delta which decreases water levels, decreases water quality, and creates null zones. In response to this, the SWRCB through D-1422 imposed upon the USBR the obligation to maintain the water quality objective at Vernalis through releases of fresh water from New Melones. The Bureau has adopted a plan of operations for New Melones which does not meet the Vernalis objective in more than 50 percent of the years. CALFED's stated purpose to improve water quality in the Delta is inadequate unless and until it addresses this problem.

20. The DEIS/EIR states that in the Delta Region, "potentially significant adverse cumulative impacts could occur in all resource categories." It does not seem that CALFED's lofty goals of improving Delta water quality and supply while not transferring impacts to other parties will be met. It appears that the document recognizes that in order to provide additional exports of water, there will be significant adverse impacts in all resources categories in the Delta. IA-3.5-6

21. The document notes potential large increases of exports from the Delta but does not identify whether or not this water is surplus to in-Delta needs as required by the Delta Protection Act. IA-5.1-30

22. The DEIS/EIR notes that new storage facilities would increase the amount of water available for agricultural production. As referenced above, new storage is independent of new yield. The document needs to clarify what new storage may be and whether or not it increases the total amount of water available for beneficial use. CR4

23. The document perpetuates the false notion that efforts should be made to reduce salinity (and other constituent) loading. The problem with salinity is not one of loading, it is one of concentration as confirmed by the salinity standard at Vernalis being one of concentration. It does not matter what the load is if there is sufficient dilution to lower the concentration to an acceptable level. Efforts to reduce loading simply result in the accumulation of the salts in one area, especially the CVP west side service area. That accumulation will eventually drive agriculture in the area out of business. CALFED should take advantage of the recirculation proposal as well as other methods of coordinating the discharge of salt loads out of the system during times of high flows. Attached hereto are analyses done by south Delta and numerous CALFED agencies evidencing how the recirculation proposal may add to this solution. WQ-7.5.2-1

24. The DEIS/EIR notes that no potentially significant adverse impacts to Bay-Delta hydrodynamics and riverine hydrolics have been identified. Since the evaluation of the different impacts resulting from a two tidal barrier program and a three tidal barrier program have not been completed, the document should recognize potential adverse impacts may result since South Delta's analysis suggests the two barrier program will cause harm. IA-5.2-11

25. The ERP anticipates affecting up to approximately 166,000 acres of Delta lands. Since the document does not state or quantify the beneficial effects resulting from ERP efforts on State and Federal lands in the Delta, there is no basis on which to estimate the need to convert additional Delta lands. The Preferred Alternative should seek to maximize the benefits on those publically owned lands and then consider conversion of additional lands if habitat needs require it. ERPII 10.1-3

26. The document repeatedly refers to the concept of "willing sellers" in relation to the conversion of agricultural land and the transfers of water. The fact that a seller is willing in no way addresses the question of whether or not such an action has an adverse effect on third parties or is contrary to public policies. For example, most farmers will sell once a certain price is reached, but that still may be contrary to State and local legislation which attempts to preserve prime agricultural land. IA-7.1.7.1-1

27. It is not clear what "stakeholder" involvement means. It is clear that CALFED believes allowing parties to comment on its decisions constitutes stakeholder involvement. However, if the public comments have no effect on the decisions, the involvement is meaningless. The perfect example of this is CALFED's unilateral change from a three barrier program to a two barrier/dredging program. SDWA was originally told that its comments would have no effect on the decision, and it was denied the ability to present its position to the CALFED Policy Group. This practice is directly in conflict with CALFED's objectives and solution principles. IP 2.8-1

28. Although the document recognizes that the conversion of farm land to wetlands/habitat results in an increase in the consumption of water, it provides no analysis of the amount of that increase or the source of water to supply that increase. The document's analysis gives bookend numbers for increased export from the Delta, and it is not clear whether those numbers affect the projected exports. Of particular importance is the effect of increased water consumption in the Delta during drought years. There is no analysis of how wetlands needs may affect riparian needs in those times of shortage. IA-5.1-31

29. The DEIS/EIR lists the modeling assumptions used in the analysis. Those assumptions include operation of CVP and SWP facilities to meet the SWRCB 1995 Water Quality Control Plan. Since current and projected operations will not meet the Vernalis water quality objective which is part of the plan, it is unclear what the modeling assumed. If it assumed water quality was being met, the analysis is by definition faulty. If it assumed it was not being met, on what basis does the CALFED Program proceed if it chooses to meet some standards and not others. IA-Att. A-3-25

30. The document notes that during dry and critical years, annual Delta exports could increase by as much as 130 TAF. It also notes that over the long term annual Delta outflow IA-5.2-12 IA-ATT.A-3-25

could decrease by as much as 390 TAF. It is not apparent that any portion of the DEIS/EIR analyzes the effects of these two possibilities. During drought times, Delta exports drop to minimal levels in order to provide salinity control, outflow, and in-Delta needs. Absent an increase in yield, there would be no surplus water which would allow increased exports during those times. ERPII 4.8-1

31. The ERP seeks to consolidate agricultural diversions and discharges in the Delta, yet the document states that Delta water rights would not be altered. In order to consolidate diversions, permits to divert would have to be granted by the SWRCB. This would often times result in a riparian being forced to divert under an appropriative right. ERPII 4.2-1

32. The document states that under the ERP, the release of acquired water would flow through the Delta and increase Delta outflow. The only way outflow can be increased is if some upstream use consumes less water. A lower application rate, a greater efficiency, or any other action except decreased consumption will have no effect on net Delta outflow. ERPII4.2-2 CR20

33. The ERP also anticipates very large additional Delta flows and significant upstream purchases on the San Joaquin River and its tributaries. Until the issue of third party impacts resulting from transfers is resolved, the only way to plan on having those increased numbers is to ignore South Delta complaints of third party impacts. This is contrary to CALFED's solution principles. There is still strong disagreement regarding the effects of these upstream transfers.

34. In discussing the various alternatives for the tidal barriers, the document references a flow control structure along Old River near Paradise Cut. This is in error. The Old River barrier is much farther west than Paradise Cut; it is actually close to the CVP diversion point. As stated above, the analysis of the alternatives is not yet complete. Specifically, the two barrier program contains unspecified dredging. SDWA's analysis indicates that the dredging (instead of the Grantline barrier) will allow the trapped tidal flows to escape and thus frustrate the purpose of the barriers. In addition, the points above the dredged areas will have their water levels lowered more quickly and thus either exacerbate old or cause new water level problems. IP-2.8-1 IP-2.8-5

35. The document references the potential for increased TDS in portions of the Delta. If that statement is based upon an analysis of the two barrier program, the result is unacceptable to local interests. If that statement is based upon the fact that the tidal barriers redirect the high saline waters of the San Joaquin River into the Central Delta, it should be noted that DWR's analysis indicates that any TDS increases in the San Joaquin are quickly diluted to a point where they are below the water quality objectives and are expected to cause no significant adverse effects. IA-5.3.8.1-3

36. It is not clear whether or not the DEIS/EIR seeks to include in-Delta agricultural discharges in its efforts to reduce contaminates to the waterways. South Delta agriculture adds no significant salts to the waters. The salts that are in its drainage originated from the same Delta waters and are merely slightly concentrated as they would be from any consumptive use of water. The San Joaquin River/south Delta salinity problem is a function of the addition of salts during low flow times. As the document states, multi-hundreds of thousands of tons are imported by the CVP to the San Joaquin Valley and end up in the River. It is unfair and illogical to equate riparian use of stream water with discharges by entities who receive imported salts. IA-5.3.8.1-4

37. The document should describe how the export projects have radically altered the flows of the Delta. Much of the channels have reverse flows due to the pull of the export projects which overcome the natural hydrology of the San Joaquin River. These flow changes also adversely affect fisheries. IA-5.2-13

38. With regard to resolving the potential third party effects resulting from transfers, the document seeks not only a standardized set of policies but an expedited process. This sounds more like a wish list than a program to be undertaken. Until those parties who feel the effects from transfers are in agreement with those parties who want to do the transfers, there will be no standardized set of policies and there should not be an expedited process. Again, the same CALFED agencies who advocate those policies are the ones who have as of yet never found a significant third party effect resulting from a purchase. WT-4-3

39. SDWA encourages CALFED to act quickly on its proposal to investigate the possibility of a recirculation of DMC water. IA-5.2-14

SDWA's general concerns deal with those effects resulting from the CALFED proposal that have not been addressed. Mr. Alex Hildebrand as a member of the BDAC had repeatedly set forth those issues and as of yet has not received any satisfactory answers. The most important of those unexamined issues is the decision to alter the three tidal barrier program to one of two tidal barriers and dredging. Such a significant change in an ongoing project should not take place until the appropriate analysis has been done. CALFED acknowledges through its SDET Program that such analysis has not been done.

Finally, the DESI/EIR although meant to be a programmatic document contains a fatal lack of specificity. It is one thing to say CALFED seeks to decrease constituts loading, increase water quality, increase water supply, protect third parties, improve environmental conditions, and restore fisheries, it is quite another thing to figure out how to do this. If the follow-on environmental documents will specify and evaluate how to accomplish these goals, then this document is nothing more than a statement of goals. SDWA encourages CALFED to not IA-Preface-3

proceed on any project until the local interest have been brought into the decision making process and are in agreement with the proceeding.

SDWA joins in the comments submitted by Central Delta Water Agency.

Very truly yours,

JOHN HERRICK

JH/dd
Enclosures

635

1352

CALFED BAY-DELTA PROGRAM

AUG 25 1999

Public Comment

Date 8/25/99

The CALFED Bay-Delta Program welcomes your participation. Please use the space below for your written comments (attach additional sheets if necessary).

Comments:

- Recommend making funding available for research on the effects of water salinity on different plant types IPF 5.4.8-6
- Support source control as an efficient method of improving water quality. It is very expensive to remove salt from water WQ-7.5.0-3 WQ-1.2-2
- Recommend considering the local cost of developing water is cost-benefit analyses for developing water recycling projects IPF 5.4.1-4

Name: Mike Nelson

Organization: Pebble Beach CSD

Address: Forest Lake and Lopez Roads
Pebble Beach, CA 93953

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Would you like to be added to our mailing list? Y Check Here

Please return this form to:

CALFED BAY-DELTA PROGRAM
1416 Ninth St., #1155
Sacramento, CA 95814

For more information,
(916) 657-2666
(800) 700-5752
http://calfed.ca.gov

C-114979

C-114979

23443 S. Hays Road
Manteca, CA 95337
September 21, 1999

Mike Madigan
110 W. C Street, Suite 2200
San Diego, CA 92101

Sunne McPeak
Bay Area Council
200 PIne Street, Suite 300
San Francisco, CA 94104

Lester Snow
CALFED Bay-Delta Program
1416 9th Street, Suite 1155
Sacramento, CA 95814

Dear Mike, Sunne, and Lester:

The success of the "preferred alternative" will depend in large part on the extent to which it can compatibly (a) protect fish, (b) provide satisfactory in-channel water quality and availability for agriculture and other in-Delta uses, and (c) deliver an adequate supply of treatable water for urban use. I propose that the agenda for the next BDAC meeting should include an in-depth presentation and discussion of the through-Delta conveyance design and other measures affecting Delta and export water quality. The following items are examples of topics to be discussed.

- What is the current through Delta conveyance plan in respect to channel flows, in-channel water quality, channel alterations, water management within the Delta, structures, etc.?

- How was this plan chosen and what biological, hydraulic, and water quality analyses were made?

- What role did in-Delta interests and expertise play in developing the plan?

- If the plan does not now include control of flows through Georgianna Slough, why not? Dick Daniel has stated that the Slough carries "unnaturally high volumes of Sacramento River water into the interior Delta" and this "exposes young fish of Sacramento River origin to high levels of predation and entrainment". Why is it important to control flow through the cross-channel and not through the Slough?

- What features of the plan serve to minimize the entrainment of bromide in the cross-flow?

- What features of the plan serve to minimize the seismic risk to conveyed water quality in consideration of evidence that seismic risk is greater in the western than eastern Delta?

- What potential is there for sonic fish barriers and for flow control on a tidal basis?

- Roughly 400,000 tons of imported salt drains into the San Joaquin River. If this salt were discharged directly to the ocean, what would be the water quality benefit in the San Joaquin River, in the South Delta, and in the DMC and State Aqueduct?

- If all of the millions of tons of salt that is imported into the South Central Valley were removed from the valley and river systems, what opportunities would this create for water trades to improve urban source water quality without exacerbating the accumulation of salt in the valley?

This list is merely illustrative of the coverage that I believe is needed for BDAC to evaluate the conveyance and water quality plan.

Sincerely,

Alex Hildebrand

SOUTH DELTA WATER AGENCY

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Alex Hildebrand, Secretary
Robert K. Ferguson
Natalino Bacchetti

Counsel:
John Herrick
Engineer:
Gerald T. Orlob

Comments on CalFed's Revised Phase II Report
August 18, 1999 Workshop

My name is John Herrick and I am the attorney for the South Delta Water Agency. My comments are offered in conjunction with Mr. Alex Hildebrand's, on behalf of the South Delta Water Agency.

We would like to endorse Assemblyman Machado's comments, before CalFed moves forward on any project, it must include a three tidal barrier program operated as needed, a bundle of actions to restore the San Joaquin River, and a program to address the D.O. problem near Stockton. We also join with the comments of the County, the City of Stockton, Stockton East Water District, and the Central Delta Water Agency. We believe we are united in our positions regarding CalFed.

CalFed's fundamental problem is that it seeks to improve water quality and quantity for all beneficial uses, and ignores the priorities of California water law. It also excuses those responsible for degrading the environment and water quality. The result is the balance of competing demands, which makes innocent superior right holders share the burden with guilty junior right holders. The first step for CalFed is to make the projects mitigate their adverse impacts on the San Joaquin River and Delta.

The current state of affairs is that superior right holders in the Delta do not get the amount or quality of water to which they are entitled, yet CalFed seeks to increase those activities that currently cause the harm to the Delta.

The clear emphasis is on improving export supply and quantity. If this is not done, the isolated facility will be "re - examined". There is no corresponding commitment to improve Delta quality and quantity for agriculture and other local uses.

The Program gives lip service to "continuing" application of the Delta Protection Act, but those statutes are universally ignored by the State and Federal agencies. That Act requires the State and Federal projects to provide sufficient water to satisfy the beneficial needs of the Delta and to only export water surplus to those needs.

The Program seeks to change the way agriculture uses water, based on the false assumption that runoff from a field is "wasted water". In most years, all of the San Joaquin system's yield is put to beneficial use. Upstream "savings" therefore deprive downstream users, including fish, wildlife, and other public trust needs.

The Program seeks to encourage and expedite transfers which will effectively destroy agriculture, which can never compete with urban interests in a bidding war for water.

This year again, CalFed decided that in order to protect exports and fisheries, one of the tidal barriers could not be operated. The local riparians suffered so exports could rise.

It is hard to reconcile CalFed's recent interest in addressing San Joaquin river quality with its actions. This year, CalFed endorsed a program that plans on violating the Vernalis Salinity Standard in 50% of years. Then, it turned around and endorsed an expansion of exports that will further lower South Delta water levels and perhaps make the barriers ineffective

We recommend that there be fundamental changes to this multi-billion dollar Project, before it permanently harms our Delta, and California agriculture.

Three Minute Presentation by Alex Hildebrand for the South Delta Water Agency at the CALFED Hearing in Stockton on August 18

I am Alex Hildebrand, a farmer, an engineer, and a director of the South Delta Water Agency.

We support the statements submitted by Assemblyman Machado and County Supervisor Cabral. We also agree with the Farm Bureau and others that CALFED's plan would seriously impact most of California'a agriculture and the future production of food. CALFED's South Delta water management plan would be a disaster for agriculture in the South Delta and would impact almost all water related interests in San Joaquin County.

The plan would substantially increase the frequency with which export pumping would draw water out of South Delta channels so that crops can not be irrigated. To prevent this we must have all three of the previously planned tidal barriers. These barriers can capture and hold high tide water for use during the low tide. CALFED's plan would limit the months that any tidal barrier would be allowed to operate and would not permit a barrier in Grantline Canal. High tide water captured by the other two barriers would just run out through Grantline Canal

Unless all three tidal barriers are operated there is a reverse flow in the San Joaquin River south of Stockton which is a major cause of the inadequate dissolved oxygen needed for fish.

The Central Valley Project imports up to a million tons of salt each year into the San Joaquin watershed. Several hundred thousand tons of this salt drains into the San Joaquin River. Unless we have all three of the tidal barriers this salt in the river is drawn to the CVP pumps and reexported. This reexported salt increases the salinity of water exported by the CVP including the water delivered to Tracy. It also results in more salt draining to the river. New Melones Reservoir is then required to dilute that salt by releasing water that is needed for other uses in San Joaquin County. With CALFED's new operations plan much of this river salt will also be drawn to the State Aqueduct. CALFED's plan has other unacceptable features.

There is no rigorous scientific data to support the notion that the barriers are bad for fish. Furthermore, this misguided plan was adopted without any technical analysis of these concerns. Delta interests were told that their suggestions and objections would have no effect on the plan that was to be adopted. Our technical expertise was arrogantly ignored. The plan violates CALFED's promise that improvement for one interest would not be made by impacting another interest.

We must have all three tidal barriers, and they must be operated whenever they are needed for the reasons just discussed. CALFED's South Delta plan must and can be cancelled and replaced with a plan that protects all interests.

8/8/99 Draft

Critique of CALFED by Alex Hildebrand
(Member of Bay Delta Advisory Council, Farmer, Engineer,
Director of South Delta Water Agency)

CALFEd has an enormously difficult task. It is the "only game in town" that can potentially and effectively seek to improve the management of California's water resources in order to take better care of the environment while also meeting society's other water needs. In pursuing this objective it has many able, likeable people on its staff. However, its future depends on whether it can resolve different perceptions of priorities and differences in the level and scope of technical understanding. CALFED must insist and must be perceived to insist on the unbiased application of "good science" and must adhere to its commitment that all needs will "get better together". Unfortunately, CALFED appears to be squandering its potential for overall acceptance and for success in achieving the above objective in spite of significant areas of well accepted accomplishment.

CALFED's program development appears to be dominated by adopting almost any perceived benefit for fish that is consistent with "no net loss" to exports. There is no comparable attempt to protect agriculture and to protect water supplies for non-export water users, or to solve problems for other interrelated interests. CALFED purports to seek a thirty year plan, but does little to address the consequences of anticipated population growth in combination with the ongoing depletion of natural resources.

California supports its current population in part by depleting natural resources. We get through droughts by producing food with an enormous overdraft of groundwater. This overdraft is unsustainable. We are slowly destroying the fertile soils and groundwaters in the south central valley by refusing to remove tens of millions of tons of salt that has been imported into the valley. This salt is Bay salt that is contained in imported water. Furthermore, CALFED proposes to take large amounts of land and water from agriculture for environmental and urban use instead of meeting new needs with adequate new water development. CALFED does not even mention in its PEIS the consequences of these unsustainable resource depletions on the State's future food supply and on the future of agriculture's contribution to the State's overall economy.

CALFED was intended to "fix the Delta". In developing its plans for alterations to Delta channels and to water management in the Delta, and to conveyance through the Delta, CALFED has largely ignored the expertise and needs of Delta interests such as the Delta's agriculture community, the three Delta Water Agencies, the Delta Protection Commission, and Delta counties. Where is the analysis of the compatibility of CALFED's through Delta plan with needed improvement of flood flow conveyance from the Sacramento, Mokelumne, and San

Joaquin River Systems to the Bay? Where is the analysis of the practical feasibility and the effect on Delta agriculture of CALFED proposals to consolidate and treat or relocate drainage water? Where is the analysis that shows that CALFED's through Delta plan optimizes export water quality while fully protecting water quality needed for Delta agriculture?

CALFED's arrogance and selective use or disregard of "good science" was perhaps at its worst when it recently adopted a new water management plan for the South Delta. The plan overrides the 1991 settlement agreement among the Department of Water Resources, the Bureau of Reclamation, and the South Delta Water Agency (SDWA). That agreement provided that three operable tidal flow control barriers would be provided in the South Delta to capture high tide water and hold it in the channels for use by agriculture during low tides. South Delta's agriculture has about 150 small diversion pumps to take water from 75 miles of channels. Most of these channels are shallow, and, without the barriers, operations of the CVP export pumps periodically reduces water depths during low tides so that farmers can not irrigate their crops. The barriers also mitigate other impacts of export pumping by avoiding stagnant channel reaches and by maintaining downstream flow in the San Joaquin River upstream of Stockton. Furthermore, several hundred thousand tons of the previously mention salt load that is imported into the valley by the CVP drains annually into the San Joaquin River. Operation of the three tidal barriers shunts this salt toward the Bay where it originated. In the absence of the three barriers the salt is drawn to the CVP pumps and reexported. This reexport of salt further increases the salt drained to the river, and increases the need for dilution water from the overcommitted New Melones Reservoir. This in turn reduces the New Melones water supply available for fish flows and for delivery to the eastern part of San Joaquin County.

When CALFED decided to make a new South Delta water management plan it insisted on excluding SDWA and other Delta interests from participation in developing the plan. At a public meeting the Delta interests were told explicitly that nothing we said or suggested or requested would have any influence on the CALFED plan that was to be adopted.

The plan includes taking water into the State Water Project's forebay during low tides, which it does not now do. This change will very substantially increase the depletion of the in-channel water depth needed for operation of irrigation pumps. The plan also provides that only the two smaller tidal barriers shall be allowed, and that they can only be operated part of the time. The high tide water captured by these two barriers will therefore run out through Grantline Canal which will have no barrier. The plan proposes dredging which will further facilitate that outflow. The plan will result in shifting the reexport of the salt in the San Joaquin River in substantial part from CVP exports to SWP exports where it will impact the quality of urban water supplies. The plan will also increase rather than prevent the

reverse flow in the San Joaquin River that is a major cause of the problem of inadequate dissolved oxygen (DO) for fish in that reach. No rigorous scientific data have been presented to defend the notion that the Grantline barrier would be bad for fish. In short, the plan will devastate South Delta agriculture by damage to its inchannel water supply. It will exacerbate the DO problem in the San Joaquin River. It will increase the salt load in the State Aqueduct, and it will not provide the reduced burden on New Melones that would result if there were three tidal barriers that were operated most of the time. The plan refers to possible reconsideration of a Grantline barrier, but only if fishery agencies decide after years of trial that alleged fishery benefits are not sufficient in their judgement to justify the impact on agriculture. The need to mitigate the impact of export pumping is not considered a priority. All of San Joaquin County will be damaged by the plan.

Another component of CALFED's South Delta "early implementation plan" was the adoption of a plan for providing spring fish flows into the South Delta with tributary water. Here again there was no discussion with Delta interests of the impact of that plan on the South Delta. CALFED adopted the plan without first evaluating an alternative that would provide most of the fish flow with recirculated water from the Delta Mendota Canal, and would thereby preserve the high quality tributary water for uses that would benefit Steelhead trout and summer water quality and flow into the South Delta, and would increase water availability for eastern San Joaquin County, and would improve water quality for exports and in the San Joaquin River upstream of Vernalis.

CALFED adopted this South Delta water management plan without first evaluating the concerns we have expressed and the alternatives we have proposed. Furthermore, there are no such evaluations in the Draft PEIS. CALFED has apparently also made no analysis of whether the plan is legally defensible. Does it comply with the Delta Protection Statutes, with water rights law, and with the obligation to mitigate adverse impacts of the export projects on third parties that have superior water rights?

The CALFED plan presented in the current draft PEIS must unfortunately be opposed. It would diminish agriculture as a whole while the state's need for agriculture increases as the population grows. In many areas it is far too vague to depict what will actually take place. In other areas it adopts specific implementation plans that are not supported by adequate, unbiased impact analyses, or even analyses to determine whether the proposals are technically sound, and whether they are compatible among interests, and legally defensible. It overrides county planning, and would impact the economy of San Joaquin County among others.

In order for CALFED to succeed, the overall plans and the early implementation plan <u>must</u> be revised with full local participation to make them technically sound, compatible among interests, and legally defensible.

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Counsel:
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Engineer:
Gerald T. Orlob

August 13, 1999

Attached Mailing List

Gentlemen:

Everyone in California will be affected by CALFED's extensive proposals for management of land and water. All citizens are, therefore, urged to attend one of the public hearings on the Environmental Impact Statement for those proposals. The hearing in Stockton will be on Wednesday, August 18, from 6:00 p.m. to 9:00 p.m. at the San Joaquin County Fairgrounds, Building 5, Airport Way and Charter Way, Stockton.

The South Delta Water Agency offers the attached analysis of the substantial impacts of CALFED's plan on this County and the State. Everyone should attend and express his view on this far reaching plan.

Very truly yours,

Alexander Hildebrand

Alexander Hildebrand
Secretary, South Delta Water Agency

Enclosure

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Fresno, CA 93706-2098

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Modesto Bee
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Modesto, CA 95354-2427

Mr. Jim Nickels
The Record
530 East Market Street
Stockton, CA 95202-3009

Mr. Bob Brown
Tracy Press
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Tracy, CA 95376-3903

Los Angeles Times
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Los Angeles, CA 90012-3601

San Jose Mercury News
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San Jose, CA 95190-0001

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San Francisco Examiner
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San Francisco, CA 94103-2905

The Oakland Tribune
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California Farm Bureau Federation
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Sacramento, CA 95833-3239

Critique of CALFED by Alex Hildebrand
(Member of Bay Delta Advisory Council, Farmer, Engineer,
Director of South Delta Water Agency)

CALFED is the "only game in town" that can potentially and effectively seek to improve the management of California's water resources in order to take better care of the environment while also meeting society's other water needs. In pursuing this objective it has many able people on its staff. However, CALFED must insist on the unbiased application of "good science" and must adhere to its commitment that all needs will "get better together".

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In developing its plans for alterations to Delta channels and to water management in the Delta, and to conveyance through the Delta, CALFED has largely ignored the expertise and needs of Delta interests such as the Delta's agriculture community, the three Delta Water Agencies, the Delta Protection Commission, and Delta counties.

CALFED's arrogance and selective use or disregard of "good science" was perhaps at its worst when it recently adopted a new water management plan for the South Delta. The plan overrides the 1991 settlement agreement among the Department of Water Resources, the Bureau of Reclamation, and the South Delta Water Agency (SDWA). That agreement provided that three operable tidal flow control barriers would be provided in the South Delta to capture high tide water and hold it in the channels for use by agriculture during low tides. South Delta's agriculture has about 150 small diversion pumps to take water from 75 miles of channels. Most of these channels are shallow, and, without the barriers, operation of the CVP export pumps periodically reduces water depths during low tides so that farmers can not irrigate their crops. The barriers also mitigate other impacts of export pumping such as by maintaining downstream flow in the San Joaquin River upstream of Stockton. Furthermore, several hundred thousand tons of the

previously mentioned salt load that is imported into the valley by the CVP drains annually into the San Joaquin River. Operation of the three tidal barriers shunts this salt toward the Bay where it originated. In the absence of the three barriers the salt is drawn to the CVP pumps and re-exported. This re-export of salt further increases the drainage of imported salt to the river, and increases the need for dilution water from the overcommitted New Melones Reservoir. This in turn reduces the New Melones water supply available for fish flows and for delivery to the eastern part of San Joaquin County.

At a public meeting the Delta interests were told explicitly that nothing we said or suggested or requested would have any influence on the CALFED plan that was to be adopted.

The plan includes taking water into the State Water Project's forebay during low tides, which it does not now do. This change will very substantially increase the depletion of the in-channel water depth needed for operation of irrigation pumps. The plan also provides that only the two smaller tidal barriers shall be allowed, and that they can only be operated part of the time. The high tide water captured by these two barriers will therefore run out through Grantline Canal which will have no barrier. The plan will shift the re-export of the salt in the San Joaquin River in substantial part from CVP exports to SWP exports where it will impact the quality of urban water supplies. The plan will also increase rather than prevent the reverse flow in the San Joaquin River that is a major cause of the problem of inadequate dissolved oxygen (DO) for fish in that reach. No rigorous scientific data have been presented to defend the notion that the Grantline barrier would be bad for fish. In short, the plan will devastate South Delta agriculture by damage to its inchannel water supply. It will exacerbate the DO problem in the San Joaquin River. It will increase the salt load in the State Aqueduct, and it will not provide the reduced burden on New Melones that would result if there were three tidal barriers that were operated most of the time. The plan refers to possible reconsideration of a Grantline barrier, but only if fishery agencies decide after years of trial that alleged fishery benefits are not sufficient in their judgement to justify the impact on agriculture. The need to mitigate the impact of export pumping is not considered a priority. All of San Joaquin County will be damaged by the plan.

Another component of CALFED's South Delta "early implementation plan" was the adoption of a plan for providing spring fish flows into the South Delta with tributary water. CALFED adopted the plan without first evaluating an alternative that would provide most of the fish flow with recirculated water from the Delta Mendota Canal, and would thereby preserve the high quality tributary water for uses that would benefit Steelhead trout and summer water quality and flow into the South Delta, and would increase water availability for eastern San Joaquin County,

and would improve water quality for exports and in the San Joaquin River upstream of Vernalis.

Furthermore, there are no such evaluations in the Draft PEIS. CALFED has apparently also made no analysis of whether the plan is legally defensible. Does it comply with the Delta Protection Statutes, with water rights law, and with the obligation to mitigate adverse impacts of the export projects on third parties that have superior water rights?

The CALFED plan presented in the current draft PEIS must unfortunately be opposed. It would diminish agriculture as a whole while the state's need for agriculture increases as the population grows. In many areas it is far too vague to depict what will actually take place. In other areas it adopts specific implementation plans that are not supported by adequate, unbiased impact analyses, or even analyses to determine whether the proposals are technically sound, and whether they are compatible among interests, and legally defensible. It overrides county planning, and would impact the economy of San Joaquin County among others.

The overall plans and the early implementation plan must be revised with full local participation to make them technically sound, compatible among interests, and legally defensible.

Currently, various San Joaquin County water interests are developing a joint position regarding CALFED's plan, but it is not anticipated to differ substantially from the above.

C-114992

C-114992

23443 S. Hays Road
Manteca, CA 95337
July 31, 1999

Lester Snow, Executive Director
CALFED Bay-Delta Program
1416 9th Street, Suite 1155
Sacramento, CA 95814

Dear Lester:

Thank you for your July 23 response to our June 3 letter in which we raised what we believe to be very serious concerns about CALFED's water management plan for the South Delta. The concerns addressed both process and substance. We won't reiterate those concerns in this letter. However, we apparently have not previously made it clear why we give little credence to assertions that a decision on the Grant Line Canal barrier is merely being postponed, with the implication that this postponement should not be a serious threat to the South Delta's in-channel water supply.

We refer you to your May 15 documentation of the May 13 Policy Group decision on this issue. Item 17 states that reconsideration of a Grantline barrier would only occur after the system was operated and evaluated without the barrier. It further indicates that a decision to reconsider would have to be made by USFWS, NMFS, DFG, DWR, and USBR. The decision is also stated to be based on whether the detriment to the South Delta was appropriately balanced with alleged benefits to fishery while continuing full export deliveries. That is, it would not be based on whether South Delta agriculture is protected from impacts of that export pumping. Even if a decision to provide a Grantline barrier were made, it is stipulated that there would, at that time, have to be a new EIS/EIR with all the pitfalls and delays that implies. The draft Implementation Schedule suggests that a Grantline barrier might not even be considered before 2012. We believe that any significant interim period could devastate South Delta's agriculture.

There is no justice in an attitude that fishery must be protected with no risk to exports, but that the need to assure mitigation of the impacts of those exports on the South Delta's water supply can be postponed or disregarded.

Your statement that USBR did not sign the 1991 agreement is incorrect. USBR did sign it. That agreement stipulated an intent to sign a previously drafted contract as soon as each signator obtained the necessary authority. This necessary authority included a very successful authorizing election by SDWA's electorate, and state clearance for DWR's signature. It was at least six years before USBR even suggested to their washington office that it might be appropriate to sign. They

then never signed the contract and have left any interim compliance to be provided by DWR instead of a 50-50 responsibility as the agreement stipulated.

Sincerely,

Alex Hildebrand

C-114994

23443 S. Hays Road
Manteca, CA 95337
July 31, 1999

Lester Snow, Executive Director
CALFED Bay-Delta Program
1416 9th Street, Suite 1155
Sacramento, CA 95814

Dear Lester:

Thank you for responding to my recent request for assistance in identifying pages in the draft EIR/EIS which analyze the effects of the preferred alternative as they relate to the South Delta's inchannel water supply. Unfortunately as you acknowledge the draft does not address the project level effects and considerations cited in my letter. We have not seen the analyses of these issues that you will need in preparing a project specific EIR/EIS. Adoption of a South Delta water management plan prior to those analyses appears to prejudge those analyses.

Sincerely,

Alex Hildebrand

P.S. Some typos are inevitable in a document of this size. The Vernalis water depths shown on table 5.2-2 appear to be in error.

23443 S. Hays Road
Manteca, CA 95337
June 29, 1999

Lester Snow, Executive Director
CALFED Bay-delta Program
1416 9th St., Suite 1155
Sacramento, CA 95814

Dear Lester:

The programmatic EIS is an enormous document. Please assist me by identifying the pages in the document that analyze the effects of the preferred alternative as they relate to the South Delta's in-channel water supply.

1) Where is the analysis of the effect on water levels throughout South Delta channels that will result from taking water into Clifton Court during low tides?

2) What will be the distribution of this impact on water levels in dredged channels versus undredged channels?

3) How will this impact compare to the levels that would exist if the Grantline barrier were included in the plan, or if there were no export operations?

4) How will the proposed plan affect the entrainment of San Joaquin River salt load in the SWP exports?

5) How will continuation of reverse flow of the San Joaquin River between Old River and Stockton affect the difficulty of correcting the DO problem in that reach?

6) How will the elimination of the Grantline barrier affect the salt load in the DMC, the long term salt load drained from the CVP service area to the river, and the consequent burden on New Melones for dilution water to meet the Vernalis salinity standard.

7) In determining that the SJRA plan should become part of the CALFED plan what analyses were made of the effect of that and the incorporated Bureau operation plan on summer flow and quality?

We would appreciate help in identifying these analyses if they were made. If they were not made, why were they not made?

Sincerely,

Alex Hildebrand

Sent to AH 7.30
DA

CALFED BAY-DELTA PROGRAM — DEIR

1416 Ninth Street, Suite 1155
Sacramento, California 95814
(916) 657-2666
FAX (916) 654-9780

July 23, 1999

Alex Hildebrand
South Delta Water Agency
P.O. Box 70392
Stockton, CA 95267

Dear Alex:

This is in response to your request for guidance in identifying the pages in the draft PEIR/EIS, which analyze the effects of the preferred alternative as they relate to the south Delta's in-channel water supply.

The relevant analyses are discussed in Sections 5.2 and 5.3 of the draft PEIR/EIS. The document is programmatic in nature, and does not describe in detail the project level effects and considerations you cited in your letter. A great deal of information has been developed on the topics you mentioned in your letter, through hydrodynamic modeling, water quality modeling, field data collection, operational experience, and various technical studies. Although not included in the programmatic document, the information has been made available for public review through various agency planning studies over the past decade, and has been considered by CALFED during the alternative formulation process. As you are aware, CALFED agencies are currently working to advance these analyses to provide the detailed technical information needed to complete project specific environmental documentation for proposed actions in the south Delta region.

CALFED agencies will be pleased to work closely with you and other stakeholders as these technical evaluations are advanced. If you have further comments or questions, please write or call me at (916) 657-2666 or call Stein Buer, Assistant Director, at (916) 653-6628.

Sincerely,

Lester A. Snow
Executive Director

cc: (see attached list)

CALFED Agencies

California
The Resources Agency
Department of Fish and Game
Department of Water Resources
California Environmental Protection Agency
State Water Resources Control Board
Department of Food and Agriculture

Federal
Environmental Protection Agency
Department of the Interior
Fish and Wildlife Service
Bureau of Reclamation
U.S. Geological Survey
Bureau of Land Management
U.S. Army Corps of Engineers
Department of Agriculture
Natural Resources Conservation Service
U.S. Forest Service
Department of Commerce
National Marine Fisheries Service
Western Area Power Administration

8-18-99

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OUTLINE OF PRELIMINARY CAL/FED RELATED CONCERNS AND COMMENTS

The CAL/FED documents continue to reflect a clear bias towards exports of water from the Delta and construction of a peripheral canal. The staffing structure of CAL/FED and strong influence of the export water contractors appear to have effectively precluded an earnest change in direction.

Preliminary concerns and comments are as follows:

1. Oppose the peripheral canal or any other isolated Delta transfer facility including the construction of segments thereof.

2. Willing to work with improvements to existing channels to facilitate through Delta conveyance provided that maintenance of the common pool concept is not jeopardized.

3. Exports of water from the Delta must be limited to water which is truly surplus to the needs within the Delta and the other areas of origin. There must be a clear and unequivocal commitment to provide SWP and CVP water on a first priority basis for Delta salinity control, an adequate in-channel water supply in the Delta and to meet the present and future needs within the Delta and other areas of origin. The proposed assurances are totally inadequate.

4. Conversion or destruction of agricultural lands in the Delta must be minimized. In addition to the numerous private and public habitat-related uses already in place, there are a number of new projects now underway such as those on Prospect Island, Lower Liberty Island, Little Holland Tract and McCormick Williamson Tract. The combination of these

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proje00cts with the already flooded areas on Little Franks Tract, Franks Tract, Mildred Island, Little Mandeville Island and Rhode Island and the channel islands provide ample opportunity for ecosystem restoration. Mitigation of impacts to surrounding lands, including damage from seepage and flood related impacts such as wind wave generation must be assured prior to inundating lands previously protected by levees.

5. Oppose the use of Delta Islands as reservoirs. Adequate mitigation of seepage and flood-related damages is impossible to assure and the related additional direct and potential indirect loss of agricultural land is unacceptable.

6. The acquisition of conservation easements from willing sellers and other incentive-type programs to secure wildlife friendly agricultural practices should be preferred over acquisition of fee interests. There should be no acquisition of any lands or easements by federal agencies which do not pay state and local taxes or assessments.

7. Levee setbacks in limited areas can be considered provided that the direct and indirect impacts on agricultural lands are minimized.

8. No projects should be undertaken without the prior approval of all the affected local agencies. Affected local agencies including The Delta Protection Commission and the North, South and Central Delta Water Agencies should be included in the early stages of planning for all projects in the Delta.

9. All flood-related improvements must provide for passage of flood waters through the Delta and into the bays without adverse impacts. The flood-related benefits should not be reduced by increased development into the flood plains. The flood plain of the Mokelumne and Cosumnes Rivers is of particular concern.

10. Good scientific analysis must be the basis for decisions on operations and fishery

benefits. Accurate data on delta hydraulics and biology must be obtained. Basic channel profiles and cross-sections need to be updated.

11. Export pumping rates and quantities should not be increased unless it is demonstrated (1) that there will not be any adverse impacts on water levels, and (2) that the needs (including the environmental needs) in the Delta and other areas of origin are fully met.

12. Support expedited construction of the Middle River, Grantline Canal, Tracy Old River and Head of Old River barriers. Operation of the barriers must be on an as needed basis to (i) maintain adequate water levels, circulation and quality in the South Delta channels, (ii) address the dissolved oxygen problem on the main stem of the San Joaquin River near the City of Stockton, and (iii) assist in out-migration of salmon smolts and other fish species. Operational decisions must be made with the agreement of all affected parties including the South and Central Delta Water Agencies and the City of Stockton provided that disagreements will be determined by an independent arbitrator.

    The Vernalis Salinity Standards must be met. The source of water to meet such standards must be clearly identified and committed.

    There must be a comprehensive plan to resolve San Joaquin River water quality problems with the highest priority directed towards salinity and dissolved oxygen.

    Attached hereto are position points reflecting further detail which we support.

13. Water transfers should be limited to transfers of water which would have been consumptively used or irretrievably lost to beneficial use. Flood flows which would otherwise reach the bays or ocean and water percolating into unuseable groundwater aquifers are examples of waters irretrievably lost to beneficial use. Water transfers which increase exports from the Delta should not be allowed until it is clearly demonstrated that

the already existing adverse impacts of export pumping have been fully corrected and that there will be no additional adverse impacts.

14. Support water development projects which capture flood flows that would otherwise reach the bays or ocean provided that such projects are committed to meeting the needs including environmental needs in the Delta and other areas of origin on a first priority with only water which is truly surplus available for export.

15. Greater emphasis should be placed on the development of additional water supply in water importing areas by increased investment in: 1) water conservation; 2) water reclamation, including desalting brackish and if necessary sea water; 3) higher levels of treatment of sewage effluent to allow for safe use of effluent for irrigation of golf courses and landscaping, industrial use, and in suitable cases human consumption; 4) installation of dual water systems particularly in new developments; 5) installation of brine lines; and 6) improvements to water treatment facilities so that water from less desirable sources can be beneficially used. Change of use of wastewater to avoid increased levels of treatment should not be allowed.

16. The plan overlooks the likelihood that increased Delta outflows will be required to restore the fisheries. The restoration of favorable salinity conditions in Suisun Bay coupled with the modification of the water control facilities which prevent fish from utilizing the vast natural tidal marshes comprising the Suisun Marsh should be given further consideration. Destroying farmland to create tidal marsh to replace the existing natural marsh which cannot be utilized because of excessive exportation of water is clearly a redirected impact.

MEMORANDUM

MONTGOMERY WATSON

To:	Rick Barzan Oakdale Irrigation District	**Date:**	April 13, 1995
From:	Jeff Kishel	**Client:**	OID
Subject:	Hydrologic Impact Analysis of Potential Water Transfers	**File:**	3436.0020/3.1

INTRODUCTION

This memorandum describes our analysis of hydrologic impacts likely to be associated with potential water transfers from Oakdale Irrigation District (OID). The San Joaquin County Integrated Groundwater Surface Water Model (IGSM) was used to simulate three levels of water transfers from the portion of OID north of the Stanislaus River; 10,000 af/yr, 20,000 af/yr, and 30,000 af/yr. In each case, transfers were simulated by reducing surface water supplies to OID and increasing groundwater pumping in OID by a like amount. No artificial groundwater recharge was considered. and transfers were assumed to occur in every year. Simulations were run for a 70 year simulation period, corresponding to hydrologic conditions in the years 1921 through 1990, and water demand and surface water supply availability were as projected by the American River Water Resources Investigation for the year 2030. Results for the area north of the Stanislaus were applied to the area south of the river as well, based on the hydrological similarities between the two areas. These assumptions are intended to generate conservative (high) estimates of potential impacts. The impacts resulting from an actual transfer program would likely be less.

SIMULATION RESULTS

Key results of the IGSM simulations are tabulated below.

OID NORTH OF STANISLAUS

	Change Associated with Transfer		
	increase - (decrease)		
	10,000 af/yr	20,000 af/yr	30,000 af/yr
Surface Water Supply to OID	(10,000 af/yr)	(20,000 af/yr)	(30,000 af/yr)
Groundwater Pumping in OID	10,000 af/yr	20,000 af/yr	30,000 af/yr
Ending Groundwater Storage (after 70 years of transfers)			
- in Oakdale ID	(8,400 af)	(17,000 af)	(24,500 af)
- in Central San Joaquin Water Conservation District	(9,000 af)	(16,600 af)	(24,000 af)
- in Stockton East Water District	(2,000 af)	(6,000 af)	(10,000 af)
Depletion of Storage in OID	120 af/yr	243 af/yr	350 af/yr
Subsurface Outflow from OID to the North	(6,855 af/yr)	(13,653 af/yr)	(20,385 af/yr)
Canal Losses in OID	(489 af/yr)	(979 af/yr)	(1,469 af/yr)
Losses from River to Model Area	3,519 af/yr	7,087 af/yr	10,739 af/yr
Average Difference in Groundwater Elevation (after 70 years)			
- OID North of River	(2.0 ft)	(4.0 ft)	(5.8 ft)
- Central San Joaquin Water Conservation District	(1.3 ft)	(2.4 ft)	(3.5 ft)
- Stockton East Water District	(0.3 ft)	(0.9 ft)	(1.6 ft)

As shown, transferring a portion of OID's surface water supply and replacing it with groundwater pumping results in a lowering of groundwater levels in OID of up to nearly six feet after 70 years of 30,000 af/yr transfers as compared with no-transfer conditions. Lesser declines would occur in Central San Joaquin Water Conservation District (CSJWCD), Stockton East Water District (SEWD), and throughout the model area. This would decrease subsurface flows from OID to the northwest while increasing losses from the Stanislaus River to the model area.

The groundwater elevation impacts shown above are average values over large areas after 70 years of operation. Impacts at specific locations could be somewhat greater or somewhat less. Also, interim impacts would be roughly proportional to the duration of transfer operations, so that 35 years of operation would result in impacts half as great as those shown.

As indicated in the table, about one third of the transfer volume is reflected in increased river losses, and about two thirds of the transfer volume is reflected in decreased subsurface outflow. Assuming that the transferred volume is conveyed through the Stanislaus River to the Delta or beyond, river flows are increased by about two thirds of the transfer volume, representing a benefit to Stanislaus fisheries and instream values. If the transfer is not conveyed by the Stanislaus, but is diverted upstream, e.g. Goodwin Dam, Stanislaus River flows would be reduced by about one-third of the transfer volume.

About one percent of the transfer volume is reflected in additional storage depletion. There could also be some impact on the water quality degradation situation in the Stockton area, depending on whether corrective measures are implemented.

To place the indicated impacts on groundwater elevations in context, after 70 years of 30,000 af/yr transfers, the cost of pumping an acre foot of water would be increased, in terms of 1995 dollars, by about $0.40 in OID, $0.25 in CSJWCD, and $0.11 in SEWD. Current pumping costs in the model area range from about $15 to $60 per af. If SEWD impacts represent the model area average, total model area pumping costs would be increased by about $80,000 per year after 70 years (1995 dollars), for a total increase of $2.8 million over the 70 year period, or $1.33 per af of water transferred.[1]

As indicated in the prior memorandum on water budgets, hydrologic conditions in OID south of the Stanislaus River are a virtually identical mirror image of conditions north of the river. Therefore, it appears reasonable to conclude that hydrologic impacts from transfers south of the river would be about the same as for transfers north of the river. Specifically, subsurface outflow from OID to the south would be reduced and groundwater levels would be lowered somewhat. If transfers are conveyed in the Stanislaus River, instream flows would be increased by about two-thirds of the transferred volume. If transfers are not conveyed in the river, instream flows would be reduced by about one-third of the transferred volume, possibly requiring mitigation.

Whether transfers take place from north or south of the Stanislaus, or both, it may be possible to mitigate some of the projected adverse groundwater level impacts by implementing a seasonal or year-to-year groundwater recharge program involving artificial direct or in-lieu recharge. However, it does not appear that impacts on groundwater levels within and near OID, and impacts on instream flows would be effectively mitigated by groundwater recharge programs. This is because the groundwater system is hydraulically connected to the river, limiting the effectiveness of recharge, and because of the prevailing hydraulic gradient away from OID. In other words, artificial recharge in OID will, in large part, reduce the volume of water that would otherwise be gained from the river, and will quickly flow away from OID.

CONCLUSIONS AND RECOMMENDATIONS

Simulations of three levels of water transfers from OID north of the Stanislaus, assuming replacement of the transferred water with groundwater, indicate that the resulting groundwater level impacts would be small relative to current pumping lifts and costs. The economic value of these impacts would be small with respect to the value of the transfer itself.

If the transfer is conveyed through the Stanislaus River, instream flows would be increased by about two-thirds of the volume transferred. If the transferred volume is not conveyed through the Stanislaus River, river flows would be decreased by about one-third of the volume transferred.

Similar impacts south of the Stanislaus River can be expected if transfers and increased groundwater pumping were to take place south of the river.

It may be possible to mitigate some of the anticipated adverse impacts through implementation of a groundwater recharge program.

[1] Based on a marginal pumping cost of $0.10 per af per foot lift 800,000 af/yr affected pumped volume, and one foot average decline after 70 years.

Staff Report of the

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

AGRICULTURAL DRAINAGE CONTRIBUTION TO WATER QUALITY IN THE GRASSLAND WATERSHED OF WESTERN MERCED COUNTY, CALIFORNIA: OCTOBER 1995 - SEPTEMBER 1997

(WATER YEARS 1996 AND 1997)

DRAFT

AUGUST 1998

REPORT PREPARED BY:
Jeanne Chilcott, Associate Land and Water Use Analyst
Les Grober, Associate Engineering Geologist
Jan Eppinger, Student Intern
Armando Ramirez, Student Intern

Many thanks to the staff and students of the Agricultural Unit without whose efforts during field sampling, quality control, and data processing, this report would not have been possible.

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EXECUTIVE SUMMARY

Since May 1985, the Central Valley Regional Water Quality Control Board has conducted a water quality monitoring program in the San Joaquin Valley of California to assess the impacts of agricultural subsurface drainage on wetland water supply channels in the Grassland Watershed. The Grassland Watershed is a 370,000-acre area, west of the San Joaquin River covering portions of Merced and Fresno counties between the Tulare Lake Basin and the Orestimba Creek alluvial fan. The watershed contains both farmed land, including a 90,000 acre area known as the Drainage Project Area (DPA), and approximately 100,000 acres of wetland habitat, including State and Federal wildlife refuges and private gun clubs. The watershed is tributary to the San Joaquin River, with Mud Slough (north) and Salt Slough serving as the main drainage arteries. During the period covered by this report, 1 October 1995 through 30 September 1997 (Water Years 1996 and 1997[1]), a major change occurred in the agricultural drainage water management in the Grassland Watershed: the advent of the Grassland Bypass Project (GBP). The project began operation on 23 September 1996 and consolidated subsurface agricultural drainage, which historically flowed through wetland water supply channels, into a single channel, allowing the drainage to bypass approximately 90 miles of wetland water supply channels and Salt Slough. The drainage was redirected into the final 28 miles of the San Luis Drain for discharge into the lower six miles of Mud Slough (north) and eventually into the San Joaquin River. Data presented in this report represents the water quality in selected water bodies within the Grassland Watershed one year prior to and one year after the advent of the Bypass project.

During Water Year 1996, water quality sampling was conducted at 17 sites within the Grassland Watershed and represented drainage from the DPA, internal wetland supply canals and overall discharge from the watershed. During Water Year 1997, the program was altered to reflect the changes in drainage water management resulting from the use of the Grassland Bypass. The remaining nine monitoring sites focused the program on providing data which could be used to evaluate the impact of the bypass. The primary constituents evaluated included electrical conductivity, boron and selenium, with more limited analyses of molybdenum, copper, chromium, lead, nickel, zinc, chloride and sulfate. Grab samples were collected on a weekly, monthly or quarterly schedule depending on the location and automated, composite samples were collected at selected sites to provide information on fluctuating concentrations and to provide a more complete data set for load calculations for salt, boron, and selenium.

The San Joaquin River Index is used to classify water year type in the river basin based on total runoff (SWRCB, 1995). Both Water Year 1996 and 1997 were classified as wet water years with periods of localized flooding occurring during February and March of 1996 and during the end of January and early February 1997. During the flooding in 1997, the Grassland Bypass could not handle the volume of drainage from the DPA and a portion of subsurface agricultural drainage was diverted through the wetland water supply channels and into Salt Slough between 27 January and 5 February.

During Water Year 1996, constituent concentrations followed trends observed during the previous years of study. The highest concentrations occurred in drains from the DPA, with elevated concentrations also apparent in Salt Slough. Internal channels had varying concentrations, depending on the routing of the subsurface agricultural drainage. Concentrations peaked in April 1996, as flood water receded and pre-irrigation began.

During Water Year 1997, all subsurface agricultural drainage from the DPA was removed from the internal wetland supply canals and Salt Slough and rerouted to the final six miles of Mud Slough (north) through the San Luis Drain. Electrical conductivity, boron and selenium concentrations in the internal canals and Salt Slough dropped significantly over previous water years with the lowest mean monthly and annual concentrations recorded since 1985. A corresponding increase in constituent concentrations was noted in Mud Slough (north), reflecting discharge from the San Luis Drain which reached concentrations of 5460 µmhos/cm, 8.4 mg/L, and 107 µg/L for electrical conductivity, boron, and selenium, respectively.

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[1] A Water Year covers the time period from 1 October through 30 September of the following year.

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In October 1988, Central Valley Regional Board adopted water quality objectives for boron, molybdenum and selenium for Mud Slough (north) and Salt Slough and a selenium objective for water used to maintain wetland habitat (Resolution #88-195). The mean monthly boron objective (2.0 mg/L) depends on season and only applies from 15 March through 15 September, while the maximum objective applies year round.. In May 1996, the Regional Board adopted revised selenium water quality objectives for the two sloughs and for wetland water supply channels, as well as a compliance time schedule for Mud Slough (north). The selenium compliance time schedule does not require full compliance with the selenium objective until 1 October 2010. No water quality objectives have been adopted for the San Luis Drain.

During Water Year 1996, based on composite sampling data, the boron objective (2.0 mg/L) was not exceeded in Mud Slough (north), but was exceeded almost continuously from March through July in Salt Slough, with concentrations just below 2.0 mg/L in April. During Water Year 1997, the objective was exceeded in Mud Slough (north) both upstream and downstream of the San Luis Drain discharge. Upstream of the discharge, the exceedances were limited to March and April and may be due to a number of factors including localized elevated levels in groundwater seepage, releases from wetlands, and other surface drainage. Downstream of the discharge, the objective was exceeded continuously from March through September. No boron objective exceedances were observed in Salt Slough, during Water Year 1997. The improved water quality is most likely the result of the diversion of DPA subsurface agricultural drainage out of that water body.

During Water Year 1996, the applicable selenium water quality objective was only exceeded in Salt Slough, with monthly mean concentrations remaining above 10 µg/L from December through September. The selenium objectives changed during Water Year 1997, to a 2 µg/L monthly mean objective for Salt Slough and wetland water supply channels and a 5 µg/L 4-day average objective for Mud Slough (north) that is subject to a compliance time schedule. The revised objectives were not exceeded in Salt Slough, during Water Year 1997, but were exceeded sporadically in the wetland water supply channels. Exceedances in the supply channels may be due to a number of factors including elevated selenium levels in supply water, releases from the DPA (both in response to flood events and seepage from gates and canals), inflows from other agricultural subsurface drainage sources, and local sources such as groundwater seepage and surface return flows. Selenium concentrations in Mud Slough (north) above the drainage discharge remained below 5 µg/L, while monthly mean concentrations in the slough downstream of the drainage discharge remained above 5 µg/L, however, the slough is subject to a compliance time schedule.

Molybdenum concentrations remained consistent between the two water years for all sites except Mud Slough (north) downstream of the San Luis Drain discharge. Prior to Water Year 1997, the 19 µg/L monthly mean molybdenum objective was not exceeded in either Mud Slough (north) or Salt Slough. During Water Year 1997, the molybdenum objective was exceeded downstream of the drainage discharge five times; in February, April, June, August and September. Molybdenum concentrations in the drainage discharge ranged from 22 µg/L to 35 µg/L.

Salt, boron, and selenium loads for the DPA and the Grassland Watershed were calculated using the flow weighted monthly average of the available water quality data. In Water Year 1997, loads that previously had to be summed for individual sites in the DPA were consolidated into the San Luis Drain as part of the GBP. Discharge and loads from the DPA for Water Year 1997 are therefore based on discharge and loads from the GBP. Monthly discharge and monthly flow weighted average concentrations and loads for 1996 and 1997 for the Grassland Watershed are based on the combined discharge and loads for Mud Slough (north) and Salt Slough.

Annual discharge from the DPA dropped 30 percent between Water Years 1996 and 1997, from approximately 53,000 acre-feet to approximately 37,500 acre-feet. Annual salt load for the DPA also dropped 30 percent from just under 200,000 tons in 1996 to 140,000 tons in 1997. Boron loads were practically identical for both years at just over 700,000 pounds. Selenium loads from the DPA dropped 30 percent from approximately 10,000 pounds to under 7,000 pounds between 1996 and 1997.

20TAF

20. TKR

Annual discharge from the Grassland Watershed to the San Joaquin River was similar in both years, increasing slightly from approximately 270,000 acre-feet in 1996 to approximately 290,000 acre-feet in 1997. Annual salt load for the watershed was similar for both years, dropping from just over 475,000 tons to just under 450,000 tons, while boron loads increased from approximately 1.3 million pounds to 1.4 million pounds. Selenium loads dropped almost 20 percent, from 9,500 pounds in 1996 to 7,700 pounds in 1997.

Although the DPA contributes large quantities of salt and boron, it is not the only source of these constituents in the basin. The DPA is, however, the primary source of selenium in the Grassland Watershed. In 1996, a higher selenium load was actually calculated in the DPA than in the watershed, which may be due to losses in the system or errors in the estimates used for calculating the loads. In 1997, the DPA accounted for 90 percent of the selenium load from the Grassland Watershed.

Monthly loading of constituents depended on the season and on the weather pattern. In the DPA, constituent loads tended to increase in January and stay at elevated levels throughout the irrigation season, dropping off by September. The Grassland Watershed followed a similar pattern, but was greatly influenced by storm events during both Water Years 1996 and 1997. During 1996, the highest monthly loads of all constituents leaving the watershed were recorded during February and March. During 1997, the highest loading leaving the watershed occurred during January, February and March and corresponded to major storms and flooding.

When compared to annual records since Water Year 1986, loads during wet Water Years 1996 and 1997 were comparable to loads for another wet water year (1986) but lower than loads during wet Water Year 1995. Water Year 1995 followed several years of dry and critically dry years. High loads of all constituents in 1995 likely resulted from the leaching of salts that had accumulated in the basin during previous years. Generally lower loads of all constituents in 1996 and 1997 was likely due to lower residual salt loads in the Grassland Watershed following a series of wet years.

Water quality monitoring in the Grassland Watershed will continue to allow evaluation of management practices on instream water quality and on constituent loads.

C-115012

INTRODUCTION

The Agricultural Unit of the Central Valley Regional Water Quality Control Board (Regional Board) initiated a water quality monitoring program in May 1985 to evaluate the effects of subsurface agricultural drainage on the water quality of canals, drains, and sloughs in the Grassland Watershed in western Merced County. The Grassland Watershed is located west of the San Joaquin River between the Tulare Lake Basin and the Orestimba Creek alluvial fan. The purpose of this monitoring program was to compile an on-going database of selected inorganic constituents found in agricultural drains that discharge to and flow through wildlife areas before entering the San Joaquin River. This database has been and continues to be used to develop and evaluate agricultural drainage reduction programs in the San Joaquin River Basin.

This report contains laboratory results and a summary of water quality analyses for all constituents measured as part of the program during Water Years 1996 and 1997 (October 1995 through September 1997).[2] These two years represent conditions one year prior to and one year after a major change in the agricultural drainage water management in the Grassland Watershed: the advent of the Grassland Bypass Project. The Grassland Bypass began operation on 23 September 1996. The project consolidated subsurface agricultural drainage, which historically flowed through wetland water supply channels, into a single channel, allowing the drainage to bypass approximately 90 miles of wetland water supply channels. This report presents the data collected during both years, and compares salinity (measured as electrical conductivity), boron and selenium water quality at selected sites with respect to hydrology, change in water management, and applicable water quality objectives.

Water quality data collected during the previous years of study can be found in both a summary report presenting salinity, boron, and selenium information from May 1985 through September 1996 (Steensen et al., 1998) and in a series of annual reports presenting all water quality information collected (James et al., 1988; Chilcott et al., 1989; Westcot et al., 1990, 1991, and 1992; Karkoski and Tucker, 1993; Vargas et al., 1995; Chilcott et al., 1995; and Steensen et al., 1996).

STUDY AREA

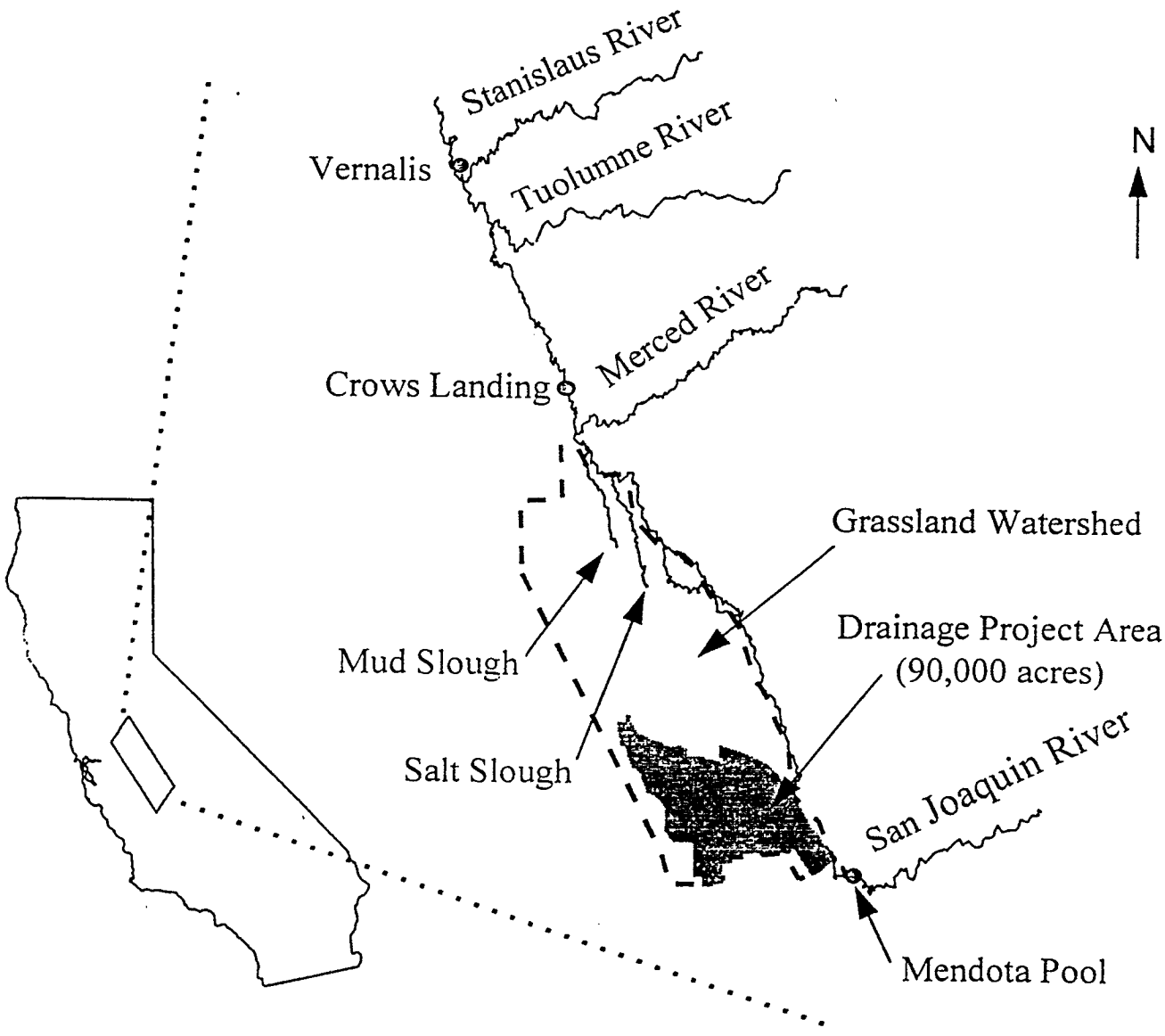
The study area consists of the Grassland Watershed located west of the San Joaquin River between the towns of Newman and Mendota, in the San Joaquin River Basin in California. The watershed encompasses approximately 370,000 acres and includes the northern and southern divisions of Grassland Water District (GWD), and farmlands adjacent to the district. The watershed also contains a 90,000 acre area known as the Drainage Project Area (DPA), and approximately 100,000 acres of wetland habitat, including State and Federal wildlife refuges and private gun clubs (Figure 1).

Prior to October 1996, agricultural lands east, west, and south of the GWD discharged subsurface agricultural drainage water (tile drainage) and surface runoff (irrigation tailwater) through the GWD. Subsurface drainage from this area often contains high concentrations of salt, selenium and other trace elements. This regional drainage flowed north through the GWD, carried by a network of canals that could divert water in several possible ways before discharging into Mud Slough (north) or Salt Slough. These two sloughs are tributary to the San Joaquin River and serve as the primary drainage outlets for the Grassland Watershed.

After October 1996, all subsurface agricultural drainage from the DPA was rerouted into the Grassland Bypass which discharges into the final 28 miles of the San Luis Drain. The consolidated subsurface drainage is then released into the final six miles of Mud Slough (north) for eventual discharge into the San Joaquin River. Consolidating the subsurface drainage removes the primary source of selenium in approximately 90 miles of canals which can supply water to wetland habitat. Reducing selenium in these water bodies is a primary goal of the project, since elevated concentrations of selenium have been documented to be hazardous to waterfowl (Skorupa, 1998).

[2] A water year lasts from October 1st of one year through September 30th of the next year.

Figure 1. The Grassland Watershed Within the Lower San Joaquin River Basin.



SAMPLING PROGRAM

During Water Year 1996, water quality sampling was conducted at 17 sites within the Grassland Watershed: nine inflow sites to and four internal flow sites within the GWD and four outflow sites from the Grassland Watershed (Table 1). Inflow monitoring stations were located on drains that discharge into the GWD and are mainly situated at the southern end of the study area. Internal sites were located on canals within the GWD that carry or could carry subsurface tile drainage as it passes through, before discharging to the San Joaquin River. Outflow monitoring stations were located on water bodies which flow out of the Grassland Watershed.

Mud Slough (north) and Salt Slough are the primary tributaries to the San Joaquin River that drain the Grassland Watershed and are described in detail in previous reports (Pierson et al., 1989a and 1989b). Mud Slough (north) at the San Luis Drain (MER542) and Salt Slough at Lander Avenue (MER531) are located near flow monitoring stations operated by the U.S. Geologic Survey and are two principal stations in this monitoring program. These two sites best represent the water quality of the drainage leaving the Grassland Watershed. Los Banos Creek at Highway 140 (MER554) drains into Mud Slough (north) upstream of the San Joaquin River but downstream of the site near the San Luis Drain. Mud Slough (north) at Newman Gun Club (MER551) represents the combined quality of Mud Slough (north) and Los Banos Creek.

During Water Year 1997, the water quality monitoring program was altered to reflect the changes in drainage water management resulting from the use of the Grassland Bypass. With the consolidation of agricultural subsurface drainage, a majority of the inflow sites which historically contained the drainage, were eliminated from the sampling program. The remaining sites focused the monitoring program on providing data which could be used to evaluate the impact of the new bypass. Key sites which were maintained and provide comparison to pre-bypass conditions include: Camp 13 Slough and Agatha Canal (inflow); Santa Fe and San Luis Canals at Henry Miller Road (internal); and Mud Slough (north) at the San Luis Drain terminus and Salt Slough (outflow). In addition, three new sites were added to evaluate the discharge from the bypass itself: Mud Slough (north) upstream of the bypass discharge (MER536), discharge from the San Luis Drain (MER535), and inflow from the Grassland Bypass to the San Luis Drain at Check 17 (MER562). In total, water samples were collected at nine sites during Water Year 1997 (Table 2).

SAMPLE COLLECTION METHODS

Two distinct types of water samples were collected for this program: grab samples and automated composite samples. Although Regional Board staff collected all the water samples during Water Year 1996, staff from the Panoche Water District collected grab samples from five of the sites during Water Year 1997: Camp 13, Agatha Canal, Santa Fe Canal, San Luis Canal, and the Grassland Bypass inflow to the San Luis Drain. Field measurements for water temperature, electrical conductivity (EC), and pH were conducted at all sites monitored by Regional Board staff. Follow up EC measurements were made on all samples at the Regional Board office laboratory: within 24 hours for samples collected by Regional Board staff and within 24 hours of receipt of samples from Panoche Water District staff. The types of samples, methods for collection and quality control and assurance are discussed below.

Grab Samples

During both water years 1996 and 1997, grab samples were collected on either a weekly, monthly or quarterly basis depending on site and the constituent to be analyzed (Tables 3 and 4). Analyses for EC, total boron, and total selenium were conducted on all samples. Selected sites were also monitored for molybdenum, copper, chromium, nickel, lead, and zinc on a monthly or quarterly basis. During Water Year 1997, samples were also analyzed for dissolved selenium and total suspended solids at both the inflow to and outflow from the San Luis Drain.

Grab samples were collected in polyethylene bottles, usually within six feet of the bank. All sample bottles were rinsed with deionized water before use. All bottles were also rinsed three times with the water to be sampled prior to sample collection. All samples were kept on ice after collection and until

Table 1. Water Quality Monitoring Sites in the Grassland Watershed for Water Year 1996

Map Index*	RWQCB Site I.D.	Site Name	Site Type
I-1	MER556	Main (Firebaugh) Drain @ Russell Ave.	Inflow
I-2	MER501	Panoche Drain	Inflow
I-4	MER506	Agatha Canal @ Mallard Road	Inflow
I-6	MER504	Hamburg Drain	Inflow
I-7	MER505	Camp 13 Slough	Inflow
I-8	MER502	Charleston Drain	Inflow
I-9	MER555	Almond Drive Drain	Inflow
I-10	MER509	Rice Drain	Inflow
I-12	MER528	Salt Slough Ditch @ Hereford Road	Inflow
T-1	MER510	CCID Main @ Russell Avenue	Internal Flow
T-5	MER519	Sante Fe Canal @ Henry Miller Road	Internal Flow
T-7A	MER532	San Luis Canal @ Henry Miller Road	Internal Flow
T-13	MER548	Porter-Blake Bypass	Internal Flow
O-1	MER551	Mud Slough (N) @ Newman Gun Club	Outflow
O-2	MER542	Mud Slough (N) downstream of the San Luis Drain	Outflow
O-3	MER554	Los Banos Creek @ Highway 140	Outflow
O-4	MER531	Salt Slough @ Lander Avenue	Outflow

* Location Map in Appendix A

Table 2. Water Quality Monitoring Sites in the Grassland Watershed for Water Year 1997

Map Index*	RWQCB Site I.D.	Site Name	Site Type
I-4	MER506	Agatha Canal @ Mallard Road	Inflow
I-7	MER505	Camp 13 Slough	Inflow
T-5	MER519	Sante Fe Canal @ Henry Miller Road	Internal Flow
T-7A	MER532	San Luis Canal @ Henry Miller Road	Internal Flow
O-2	MER542	Mud Slough (N) downstream of the San Luis Drain	Outflow
O-4	MER531	Salt Slough @ Lander Avenue	Outflow
SLD-1	MER562	Inflow to San Luis Drain @ Check 17	Internal Flow
SLD-2	MER535	San Luis Drain @ Terminus	Outflow
O-8	MER536	Mud Slough (N) Upstream of SLD	Internal Flow

* Location Map in Appendix B

Table 3. Water Year 1996 Grassland Watershed Monitoring Sites, Sampling Frequencies, and Parameters Measured

Site ID	Site Description	Constituent									Dissolved	Auto-
		Temp	pH	EC	Se	Mo	TE's	B	Part Min	TSS	Se	Samplers
MER501	Panoche Drain @ O'Banion Gauge Station	W	W	W	W	Q		W	M			b
MER502	Charleston Drain @ CCID Main Canal	W	W	W	W	Q		W	M			
MER504	Hamburg Drain near Camp 13 Slough	W	W	W	W	Q		W	M			
MER505	Camp 13 Slough @ Gauge Station	M	M	M	M			M	M			
MER506	Agatha Canal @ Mallard Road	M	M	M	M			M	M			
MER509	Rice Drain @ Mallard Road	M	M	M	Q			Q	Q			
MER528	Salt Slough Ditch @ Hereford Road	M	M	M	Q			Q	Q			
MER555	Almond Drive Drain	M	M	M	Q			Q	Q			
MER556	Main (Firebaugh) Drain @ Russell Ave.	W	W	W	W	Q		W	M			b
MER510	CCID Main @ Russell Ave.	M	M	M	Q			Q	Q			
MER519	Santa Fe Canal @ Henry Miller Road	M	M	M	M			M	M			
MER532	San Luis Canal @ Henry Miller Road	M	M	M	M			M	M			
MER548	Porter-Blake Bypass	M	M	M	M			M	M			
MER531	Salt Slough @ Lander Ave.	W	W	W	W	Q	Q	W	M			b
MER542	Mud Slough (N) Downstream of San Luis Drain	W	W	W	W	Q	Q	W	M			b
MER551	Mud Slough @ Newman Gun Club	M	M	M	M			M	M			
MER554	Los Banos Creek @ Hwy 140	M	M	M	Q			Q	Q			

W = weekly
M = monthly
Q = quarterly (October, January, April, and July)
b = Four day composite samples for Se and B

I= Inflow
T=Internal flow
O=Outflow

TE's: Trace Elements (Chromium, copper, lead, nickel, zinc)
Part Min = B, Cl, SO4, and Hardness
TSS=total suspended solids

Table 4. Water Year 1997 Monitoring Sites, Sampling Frequencies, and Parameters Measured: Grasslands Bypass Project

Site ID	Site Description	Constituents									Dissolved	Auto-
		Temp	pH	EC	Se	Mo	TE's	B	Part Min	TSS	Se	Samplers
MER505	Camp 13 Slough @ Gauge Station			W	W			W				c
MER506	Agatha Canal @ Mallard Road			W	W			W				c
MER519	Santa Fe Canal @ Henry Miller Road			W	W			W				
MER532	San Luis Canal @ Henry Miller Road			W	W			W				
MER536	Mud Slough (N) Upstream of San Luis Drain	W	W	W	W	M	Q	W	Q			
MER562	Inflow at San Luis Drain: Check 17			W	W			W		W	W	
MER535	San Luis Drain @ Terminus	W	W	W	W	M	Q	W	Q	W	W	a
MER542	Mud Slough (N) Downstream of San Luis Drain	W	W	W	W	M	Q	W	Q			b*
MER531	Salt Slough @ Lander Ave.	W	W	W	W	M	Q	W	Q			b*

*discontinued 3/25/97 (See appendices for miscellaneous discontinued site data)
W = weekly
M = monthly
Q = quarterly (October, January, April, and July)
a = daily composite sample for Se and B
b = Four day composite samples for Se and B
c = used intermittently between January and April 1997

I= Inflow
T=Internal flow
O=Outflow

TE's: Trace Elements (Chromium, copper, lead, nickel, zinc)
Part Min = B, Cl, SO4, and Hardness
TSS=total suspended solids

processing. Selenium, boron, and trace element samples were preserved by lowering the pH to less than 2 within 24 hours of collection, using reagent grade nitric acid. Mineral samples were kept on ice until submittal to the laboratory for analysis.

Composite Automated Samples

In addition to grab samples, four-day composite and daily sampling was conducted at selected sites through the use of automated Sigma sampling devices. During Water Year 1996, Sigma samplers were located at Panoche Drain, Firebaugh (Main) Drain, Mud Slough (north) downstream of the terminus of the San Luis Drain, and Salt Slough at Lander Avenue. Samplers were also intermittently installed at Camp 13 and Agatha Canal to allow continuous data collection when access roads were inaccessible. These samplers were phased out during Water Year 1997, as more focus was placed on the impacts from the discharge from the Grassland Bypass Project. The Panoche Drain and Firebaugh (Main) Drain autosamplers were discontinued in January 1997, and the Salt Slough, Mud Slough (north), Camp 13 and Agatha Canal autosamplers were removed after 25 March 1997. In exchange, two autosamplers (one strictly backup) were installed on the San Luis Drain to collect daily composite samples. Each daily composite is made up of six 85 ml collections pulled at four hour intervals for a total sample volume of 510 ml. During both water years, autosamplers were serviced every two weeks. Both 4-day composite and daily samples were analyzed for EC, boron and selenium. Quality control and assurance methods for the autosamplers are discussed below.

QUALITY CONTROL AND QUALITY ASSURANCE

Standard

Potential contamination from the reagent grade nitric acid used to control pH was evaluated by submitting a deionized water matrix preserved with the normal amount of acid used (1 ml nitric acid per 500 ml of sample), to the analyzing laboratories at monthly intervals to be analyzed for the trace elements of concern. All reported recoveries for these acid check samples were below the analytical detection limit.

Field and handling contamination was evaluated by submitting a travel blank on a monthly basis. The travel blank consisted of a sample of deionized water which was collected at the Regional Board laboratory, traveled through the sampling run, and was then processed with the sample set. All results for travel blanks fell below the analytical detection limits for the elements of concern.

Additional quality control and quality assurance was conducted using blind split and spiked samples. Blind split samples were collected at a ten percent frequency for each sampling event by collecting the sample in a container double the normal sample volume and splitting that sample into two equal amounts for submittal to the analyzing laboratory. On a monthly basis, half of the blind split samples were spiked with known concentrations of constituents to be analyzed. Comparing the spiked splits to the background splits provided information on analytical accuracy. Comparing data from nonspiked splits provided information on analytical precision.

To evaluate the potential for contamination and evapo-concentration in samples collected using autosampler, a series of special checks were developed. First, whenever the sampler was serviced, a deionized blank sample, without a cap, was left in the collection base to be collected on the next servicing and analyzed for potential contamination. Second, during each servicing, replicate "grab" samples were collected through the autosampler mechanism, one was left in the sampler to be collected at the next servicing and the other was processed for immediate analyses. Final results of the two grabs were evaluated to determine concentration or dilution potentials.

During WY 97, samples for dissolved selenium were collected at two locations (MER535 and MER562). These samples required field filtration through an 0.45 µm cartridge system. To prevent and evaluate potential contamination, the equipment was soaked in a two percent nitric acid solution between usages, and rinsed three times in DI water. The new filters were conditioned at the time of sampling by allowing the first 10 ml of water passed through to be discarded before the remaining

sample was collected. Approximately quarterly, filter blanks were collected using the Regional Board laboratory DI water and processing it through the standard equipment used in the field.

Only data from sample sets whose blind QA/QC met specifications outlined in Table 5 have been included in this report.

Special Studies

With the advent of the Grassland Bypass Project, a number of State and Federal agencies (US Bureau of Reclamation, US Geological Survey, US Fish and Wildlife Service, California Regional Water Quality Control Board, and California Department of Fish and Game) became involved in monitoring potential environmental impacts from the Grassland Bypass Project. A Data Collection and Reporting Team (DCRT) was formed and chaired by the US Bureau of Reclamation to coordinate activities. This team intends to utilize information presented by the Regional Board to evaluate water quality impacts from the project and raised concerns on the following issues:

--complete mixing at Mud Slough (north) downstream of the San Luis Drain discharge;
--field preservation versus laboratory preservation within 24 hours; and
--field versus laboratory filtration for dissolved selenium analyses.

Complete Mixing at Mud Slough (north) Downstream of the San Luis Drain Discharge

Prior to the initiation of the project, there was concern by some members of the DCRT, that the proposed sampling location for Mud Slough (north) downstream of the San Luis Drain (the bridge over Mud Slough [north]) may be too close to the point of discharge to ensure sufficient mixing of the two flows. To assess the extent of mixing, the Regional Board divided the width of the Mud Slough (north) into five intervals. On four separate occasions depth integrated samples were collected from the bridge at each of the intervals and at mid channel; grab samples were also collected from the stream banks. The four sampling events included the range of seasonal flow conditions. Results from the sampling are presented in Table 6.

Visual observation of the data shows almost no variability between samples within a sampling event. Coefficient of variations varied from 1.2 to 5.6 percent. This variation is well within analytical error. Also, there are no apparent trends in the distribution of selenium concentrations within a stream cross section. Statistical analysis of the data was not attempted because of the small sample size. From these results, it is concluded that the flow is sufficiently mixed at this location.

Field versus Laboratory Preservation

Samples collected for selenium require preservation with acid to a pH of 2. The Regional Board staff generally acidify samples in the laboratory within 12 hours of sample collection and not more that 24 hours after collection. Field acidification of samples, immediately after sample collection, is not routinely conducted by Regional Board staff due to safety concerns.

A special study was conducted to assess the impacts of delaying sample preservation on sample integrity. Two paired samplings were conducted in which samples were collected and immediately split into two containers by incremental pouring of small volumes and agitating between pourings. One of the splits was immediately acidified in the field and the other was acidified at a later time as per standard sample handling protocol. A set of samples was collected along the San Luis Drain (Table 7) to represent a high selenium environment. Another set of samples was collected from the San Joaquin River at Crows Landing (Table 8) to represent a low selenium environment.

Statistical analysis of the differences of the paired data was conducted. A test for normality according to the method of Shapiro and Wik (W test) (Gilber, 1987) demonstrated that the data were not normally distributed. Thus, a non-parametric technique, the sign test (Helseland Hirsch, 1997) was used to test the null hypothesis that the probability of $x>y$ is equal to 0.5, where x and y are paired results. The

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Table 5. Quality Assurance Tolerance Guidelines Used in the Regional Water Quality Control Board Agricultural Drainage Monitoring Program.

Constituent	Recovery Range at Low Levels (µg/L)*	Acceptable Split/Spike Recovery Range
Copper	1-20 ± 5	>20 70-130%
Chromium	1-20 ± 5	>20 70-130%
Lead	5-25 ± 8	>25 60-140%
Molybdenum	1-10 ± 2	>10 90-110%
Nickel	5-25 ± 6	>25 65-135%
Selenium	0.4-10 ± 0.8	>10 90-110%
Zinc	1-20 ± 6	>20 70-130%
Boron	50	85-115%
Chloride	5000	85-115%

* For certain constituents, recovery is expressed as an absolute value rather than a percentage at low levels. For example, if the result of copper analysis for a particular sample is 10 µg/L, a split analysis must fall between 5 µg/L and 15 µg/L. If the sample is greater than 20 µg/L, recovery is expressed as a percent and must be between 70 and 130%. If a recovery range is not shown at low levels, the detection limit is given.

Table 6. Assessment of Cross-Channel Mixing at Mud Slough (north) Downstream of the San Luis Drain

Date	Selenium Concentration (ug/L)							coefficient of variation
	west bank grab	7-8'	14-15'	mid-channel	23-28'	30-35'	east bank grab	
10/1/96	49.2	49.2	49.5	48.9	49.1	48.9	–	1.2
3/20/97	–	32.8	32.2	32.7	32.4	32.4	–	1.2
6/27/97	54.6	54.6	54.2	55.8	55.8	56.1	54.6	3.4
9/12/97	20.1	20.0	19.3	20.4	19.6	19.3	–	5.6

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Table 7. Study: Lab vs Field Preservation
Paired Sampling at San Luis Drain Terminus

Miles below Check 19	Selenium (ug/L) Preserved in Lab	Preserved in Field	Diff.
0.50	62.9	63.0	0.1
1.00	69.1	69.4	0.3
1.65	63.6	62.7	-0.9
3.33	62.5	61.7	-0.8
5.63	63.6	64.3	0.7
7.00	61.1	60.2	-0.9
9.50	54.1	54.2	0.1
10.96	65.1	65.2	0.1
14.16	55.4	55.1	-0.3
14.70	55.2	55.4	0.2
15.20	55.0	55.5	0.5
15.90	57.6	57.2	-0.4
18.00	53.1	52.8	-0.3
19.77	64.5	67.4	2.9
22.47	116	108	-8.0
22.62	112	112	0.0
24.44	91.7	82	-9.7
27.07	83.5	82.2	-1.3
		Mean:	-1.0
		Standard deviation:	3.0

Table 8. Study: Lab vs Field Preservation
Paired Sampling at San Joaquin River, Crows Landing

Feet from East Bank	Time Collected	Selenium (ug/L) Preserved in Lab	Preserved in Field	Diff.
east bank	930	2.41	2.40	-0.01
10	1110	2.48	2.42	-0.06
20	1120	2.42	2.44	0.02
30	1126	2.51	2.62	0.11
40	1131	2.53	2.66	0.13
50	1135	2.58	2.60	0.02
60	1141	2.58	2.61	0.03
70	1146	2.58	2.54	-0.04
80	1151	2.64	2.62	-0.02
90	1157	2.67	2.63	-0.04
100	1201	2.64	2.56	-0.08
110	1207	2.48	2.58	0.10
west pier	1246	2.66	2.63	-0.03
center pier	1247	2.63	2.58	-0.05
east pier	1248	2.58	2.64	0.06
Sigma*	1305	2.65	2.62	-0.03
west bank	1415	2.60	2.86	0.26
			Mean:	0.0
			Standard deviation:	0.1

* = composite sampler

Table 9. Study: Field vs Lab Filtering

Date	Dissolved Selenium (µg/L) Inflow to SLD Field filt.	Inflow to SLD Lab filt.	Discharge from SLD Field filt.	Discharge from SLD Lab filt.
11/8/96	61.1	61.8	42.1	43.4
11/19/96	57.0	58.8	75.2	77.3
11/26/96	39.6	42.8	56.4	58.2
12/5/96	–	–	31.0	28.8
12/10/96	56.3	54.3	39.0	36.2
12/20/96	80.2	81.0	49.0	51.1
12/27/96	91.9	92.0	61.6	63.5
1/9/97	76.6	72.4	34.2	32.4
2/4/97	70.5	70.2	61.8	61.8
2/11/97	96.6	94.2	78.4	78.4
2/18/97	78.6	89.4	83.2	76.5

SLD = San Luis Drain

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analysis failed to reject the null hypothesis at α equal to 0.01. The conclusion is that there is no difference in selenium concentrations between field and laboratory preserved samples.

Field versus Laboratory Filtration

The DCRT developed a coordinated monitoring plan which called for assessing dissolved selenium at the inflow and outflow of the San Luis Drain. This assessment requires filtering of samples through a 0.45 µm filter and analyzing the filtrate. Generally, this procedure is conducted in the field using a vacuum system or a peristaltic pump which draws sample through inert tubing into a filter apparatus. Due to resource limitations and logistical difficulties, the Regional Board did not immediately implement the collection of this sample. The Regional Board instead submitted the sample to a contract laboratory for filtration within 24 hours of collection.

A revised filtration method was later suggested. In this revised procedure, a syringe and filter cartridge apparatus is used to quickly and inexpensively filter samples in the field. This procedure overcame the resource and logistical limitations and was subsequently implemented by Regional Board staff. The revised filtration method was evaluated as follows.

To test the hypothesis of no difference in dissolved selenium concentration between samples filtered in the field and those filtered in the laboratory within 24-hours of sample collection, results for dissolved selenium were compared for paired samples filtered in the field and in the laboratory. Results of the paired results are presented on Table 9.

The difference between the paired samples was tested for normality by the W test. The null hypothesis that the difference of the paired samples are normally distributed could not be rejected. Thus, the t-test was used to test the hypothesis that there is no difference between the means. The null hypothesis could not be rejected and thus, it is concluded that there is no difference between field versus laboratory (delayed) filtration.

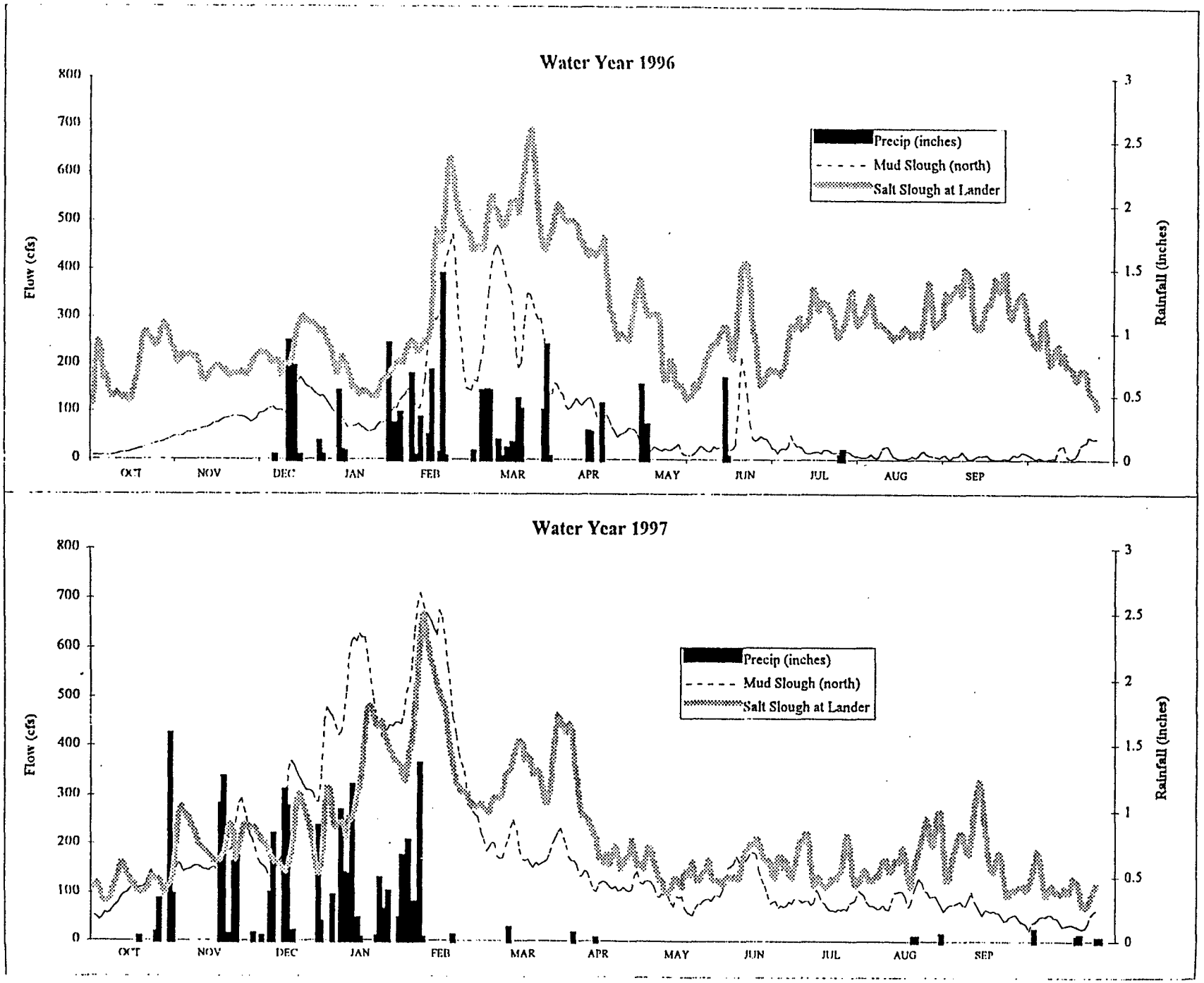
RAINFALL AND DISCHARGE PATTERNS

The San Joaquin River Index, as described in the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB, 1995) is used to classify water year type in the river basin based on runoff. The 60-20-20 Index includes one "wet" classification, two "normal" classifications (above and below normal), and two "dry" classifications (dry and critical), for a total of five water year types. Water years 1996 and 1997 were both classified as "wet" based on runoff exceeding 3.8 million acre feet.

Mud Slough (north) and Salt Slough are the main water bodies that drain the Grassland Watershed. Daily flows in both sloughs are compared to the monthly rainfall at Friant Dam for Water Years 1996 and 1997 (Figure 2). Water Year 1996 saw flows peak in February and March, while Water Year 1997 saw the flows peak in late January due to an unusual 4.60 inches of rain for the month. The peaks and sustained highs which do not correspond to rainfall events are generally a result of groundwater, wetland discharges, and surface return flows. In addition, between 3 and 17 April 1996, groundwater which had accumulated in the San Luis Drain during years of disuse, was released into Mud Slough (north) under the provisions of the National Pollutant Discharge Elimination System (NPDES), Permit No. CA0083917. The permitted discharge of the groundwater was a regulatory necessity prior to the use of the drain to transport agricultural subsurface drainage. A total of 461 acre-feet of water was discharged over the 15-day period.

The effects of the opening of the Bypass channel in September 1996, can be clearly seen in the comparison of flows from May through August in Water Years 1996 and 1997. The bulk of the subsurface drainage discharges went through Salt Slough in WY 96, whereas in WY 97, much of the discharge was rerouted through Mud Slough (north) via the San Luis Drain. High rainfall during WY 97 resulted in localized flooding which in turn resulted in the diversion of commingled agricultural subsurface and storm drainage flows from the DPA into water bodies flowing through the Grassland

Figure 2. Flows in Mud Slough (north) and Salt Slough as Compared to Rainfall at Friant Dam: Water Years 1996 and 1997



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Watershed between 27 January and 5 February 1997. An extensive summary of the hydrology of the Grassland Watershed can be found in Steensen, *et al.*, (1998).

RESULTS

Grab sample water quality results for minerals and trace elements, as well as EC, pH, and temperature at time of sampling, are listed by site in Appendices A through C. Appendix A includes sites sampled in Water Year 1996 and Appendix B contains data for the sites sampled throughout Water Year 1997. All information collected using automated Sigma samplers is presented in Appendix C. The number of sampling events and the ranges, mean and median values for each measured constituent at each site are shown in these appendices. Results are presented below by water year. Water Year 1996 has been divided into results for the inflow, internal flow and outflow sites. Data for Water Year 1997 has been divided into results for the San Luis Drain and Mud Slough (north), and wetland water supply channels and Salt Slough. Also presented is data from the autosamplers which collected either four day or daily composites depending on the location (refer to Tables 3 and 4). Tables 10 and 11 list the median constituent concentrations for all water bodies monitored in the Grassland Watershed for Water Years 1996 and 1997, respectively. Table 12 summarizes annual minimum, mean and maximum EC, boron and selenium concentrations at locations sampled in the watershed during Water Years 1996 and 1997 and compares those values to the average range in concentration during the previous ten water years of record. The previous ten years of record contained seven critically dry years and three wet years as determined using the San Joaquin River Index (SWRCB, 1995). Since both Water Years 1996 and 1997 were classified as wet water years, the previous data record's summary information, although presented in full, has also been separated into critically dry years and wet years.

Water Year 1996

Inflow Monitoring Stations

The inflow monitoring stations represent the quality of water entering the grasslands area and include the following stations: Charleston Drain, Hamburg Drain, Firebaugh (Main) Drain, Panoche Drain, Almond Drive Drain, Rice Drain, Camp 13 Slough, Agatha Canal, and Salt Slough Ditch. Salt Slough Ditch at Hereford Road flows into the North Grassland area; the others flow into the South Grassland area.

The highest combined levels of salinity (based on EC), boron, and selenium were found at the Panoche, Hamburg, Firebaugh and Charleston Drains (Table 10). These drains primarily carry subsurface agriculture drainage from the DPA. Lower concentrations were recorded for the remaining inflow sites which are not as strongly dominated by subsurface agriculture drainage. The highest EC was recorded in the Hamburg Drain on 1 March 1996 (6890 µmhos/cm) and the highest selenium concentration in the Firebaugh Drain (162 µg/L), also on 1 March 1996. The highest boron concentrations were found in the Rice Drain. The Rice Drain, sampled on a quarterly basis in WY 96, had levels of boron ranging from 5.5 mg/L to 15 mg/L, with the maximum occurring on 25 January 1996, and variable levels of selenium (3.4 to 28.4 µg/L). Data is too limited to determine if the concentrations at this site followed seasonal trends.

Camp 13 and the Agatha Canal (sampled on a monthly basis) may carry a combination of supply water and/or agricultural drainage, therefore water quality fluctuated greatly during Water Year 1996. Concentrations at the Agatha Canal at Mallard were high in December, January, February and August (peaking in December with the EC at 4490 µmhos/cm, selenium at 100 µg/L, and boron at 6.3 mg/L). Low concentrations in the Agatha Canal were observed in September and October with the EC at 324 µmhos/cm, selenium at 0.9 µg/L, and boron at 0.12 mg/L. During this time period the Agatha Canal is used exclusively for wetland water deliveries. At Camp 13 Slough, EC, boron and selenium levels were elevated from November through July; particularly in November, January and April. The peak EC occurred in January at 4660 µmhos/cm, while boron peaked in November and January at 6.9 mg/L. The maximum selenium concentration occurred in April at 88.8 µg/L. The lowest concentrations in Camp 13 occurred in September with the EC dropping to 338 µmhos/cm, boron to 0.13 mg/L, and selenium to 0.8 µg/L.

Table 10. Median Constituent Concentrations for Waterways within the Grassland Watershed: Water Year 1996.

Type	Station	EC (umhos/cm)	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	Hardness mg/L
			mg/L			ug/L							
I	*Main (Firebaugh) Drain	2870	3.4	285	1100	48.8	26	—	—	—	—	—	720
I	*Panoche Drain	4555	7.0	605	1450	76.5	13	—	—	—	—	—	1100
I	Agatha Canal	588	2.3	66	97	3.6	—	—	—	—	—	—	120
I	Hamburg Drain	4435	4.7	630	1550	57.8	6	—	—	—	—	—	1600
I	Camp 13	3760	5.7	435	1100	57.4	—	—	—	—	—	—	915
I	Charleston Drain	3940	3.5	470	1300	59.8	5	—	—	—	—	—	1000
I	Almond Drain	925	0.47	63	98	1.5	—	—	—	—	—	—	155
I	Rice Drain	2590	6.0	290	960	10.1	—	—	—	—	—	—	600
I	Salt Slough @ Hereford	744	0.27	114	103	0.8	—	—	—	—	—	—	200
T	CCID Main Canal	558	0.42	23	23	0.9	—	—	—	—	—	—	86
T	Santa Fe Canal @ Henry Miller Rd.	608	0.42	67	96	1.8	—	—	—	—	—	—	120
T	San Luis Canal @ Henry Miller Rd.	653	0.52	74	100	1.8	—	—	—	—	—	—	140
T	Porter-Blake Bypass	3155	4.4	330	920	37.8	—	—	—	—	—	—	730
O	Salt Slough @ Lander*	2060	2.0	290	520	16.0	9	12	8	14	<5	26	450
O	Mud Slough @ Newman Gun Club	1787	1.4	270	330	1.2	—	—	—	—	—	—	360
O	Los Banos Creek	1297	1.2	205	220	0.6	—	—	—	—	—	—	305
O	Mud Slough @ San Luis Drain*	1660	1.2	235	305	1.0	9	7	5	10	<5	14	370

—: Not analyzed I = Inflow O = Outflow
*Autosampler 4-day Composite Data for EC. B. and Se only. T = Internal flow

Table 11. Median Constituent Concentrations for Waterways within the Grassland Watershed: Water Year 1997.

Type	Station	EC (umhos/cm)	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	Hardness mg/L
			mg/L			ug/L							
I	Agatha Canal	432	0.2	55	43	1.2	—	—	—	—	—	—	87
I	Camp 13	520	0.4	64	49	1.6	—	—	—	—	—	—	30
T	Santa Fe Canal @ Henry Miller Rd.	833	0.83	59	54	2.1	—	—	—	—	—	—	110
T	San Luis Canal @ Henry Miller Rd.	886	0.87	—	—	2.0	—	—	—	—	—	—	—
O	Salt Slough @ Lander	1320	0.7	190	200	1.0	7	—	—	—	—	—	290
D	Inflow to San Luis Drain @ Ck 17	4390	7.5	—	—	66.4	22	—	—	—	—	—	—
D	San Luis Drain @ Terminus	4330	7.1	460	1300	60.4	26	—	—	—	—	—	1000
B	Mud Slough (N) Upstream of SLD	1160	1.0	130	130	0.8	6	—	—	—	—	—	200
O	Mud Slough dwnstrm of SLD	3100	4.4	195	330	32.4	17	—	—	—	—	—	340
D	San Luis Drain @ Terminus*	4420	7.2	—	—	61.5	—	—	—	—	—	—	—

—: Not analyzed I = Inflow O = Outflow D = agricultural drainage
*Autosampler Daily Composite Data for EC. B. and Se only. T = Internal flow B = background

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Table 12. Annual Minimum, Mean, and Maximum Electrical Conductivity, Boron, and Selenium at Monitoring Sites Within the Grassland Watershed: Water Years 86-95, 96 and 97.

Site	Count	EC (umhos/cm)			Boron (mg/L)			Selenium (ug/L)		
		Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Firebaugh (Main) Drain @ Russell Ave.										
WYs 86-95	334	255	3770	9090	0.12	5.3	23	1.0	65.0	286
WYs 86-95 (critical)	212	2050	3770	9090	1.2	5.3	23	4.0	62.3	286
WYs 86-95 (wet)	115	255	3940	8740	0.12	5.3	18	1.0	71.0	224
WY 96	50	1910	3310	6590	2.4	4.0	9.4	23.0	64.0	162
Panoche Drain										
WYs 86-95	296	2600	4560	5990	3.9	7.5	10	14.0	75.0	156
WYs 86-95 (critical)	197	2700	4580	5860	3.9	7.5	10	14.0	73.6	156
WYs 86-95 (wet)	92	3000	4640	5990	4.5	7.5	10	22.6	79.9	146
WY 96	48	3440	4520	5380	3.8	7.1	9.4	19.7	79.1	137
Hamburg Drain										
WYs 86-95	318	366	7880	7480	0.19	5.5	9.4	3.8	82.0	201
WYs 86-95 (critical)	205	2900	5070	7100	2.1	5.5	9.0	17.1	88.9	201
WYs 86-95 (wet)	107	366	4610	7480	0.6	5.5	9.4	3.8	72.6	200
WY 96	49	383	4250	6890	0.24	4.7	9.7	1.5	59.5	129
Agatha Canal										
WYs 86-95	234	162	3120	8100	0.07	5.0	20	0.8	36.0	116
WYs 86-95 (critical)	153	430	3310	8100	0.10	5.4	20	0.8	37.6	114
WYs 86-95 (wet)	74	162	2770	6600	0.12	4.3	15	1.0	34.0	120
WY 96	12	200	1940	4730	0.12	3.0	6.6	0.9	28.2	100
WY 97	43	187	518	4240	0.11	0.25	0.46	0.5	1.3	3.4
Camp 13 Slough										
WYs 86-95	264	266	3550	6700	0.18	5.0	10	0.9	52.0	144
WYs 86-95 (critical)	185	390	3690	6700	0.22	5.1	10	1.0	53.1	123
WYs 86-95 (wet)	72	266	3320	6510	0.18	4.7	9.3	0.9	50.8	144
WY 96	11	338	3410	4660	0.13	4.9	6.9	0.8	55.9	88.8
WY 97	42	172	822	3760	0.15	1.1	7.1	0.6	2.6	23.4
Charleston Drain										
WYs 86-95	246	304	4140	10200	0.15	4.0	24	1.3	65.0	129
WYs 86-95 (critical)	166	590	4170	10220	0.74	4.0	24	1.9	64.6	125
WYs 86-95 (wet)	75	304	4110	6010	0.15	3.9	7.7	1.3	66.8	129
WY 96	46	553	3600	6370	0.48	3.2	5.4	4.2	53.8	103
Almond Drive Drain										
WYs 86-95	149	70	1560	3530	<0.05	1.4	4.4	0.4	3.4	17
WYs 86-95 (critical)	128	448	1670	3530	0.16	1.5	3.9	0.4	3.5	17
WYs 86-95 (wet)	20	70	1050	3230	0.04	1.0	4.4	0.6	2.4	6.1
WY 96	4	220	1110	2700	0.10	0.68	1.7	0.7	3.0	8.4
Rice Drain										
WYs 86-95	216	1070	2980	7700	0.85	5.9	19	1.0	3.2	36.0
WYs 86-95 (critical)	172	1090	3000	7700	1.6	5.9	18	1.1	3.3	36.0
WYs 86-95 (wet)	36	1070	2950	6900	0.85	5.8	19	1.0	3.0	10.0
WY 96	4	2050	3100	6300	5.5	8.1	15	3.4	13.0	28.4
Salt Slough Ditch @ Hereford Rd.										
WYs 86-95	222	430	1040	1950	0.10	0.35	1.1	<0.4	1.1	22.0
WYs 86-95 (critical)	177	680	1090	1950	0.15	0.35	0.99	0.4	1.1	22.3
WYs 86-95 (wet)	42	430	907	1600	0.10	0.34	1.1	<0.4	1.0	4.0
WY 96	4	515	836	1260	0.20	0.3	0.34	0.6	1.0	1.7

Table 12 continued:

Site	Count	EC (umhos/cm)			Boron (mg/L)			Selenium (ug/L)		
		Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
CCID Main Canal										
WYs 86-95	214	50	719	4280	<0.05	0.5	5.8	<0.4	2.2	76.0
WYs 86-95 (critical)	166	590	4180	10220	0.74	4.0	24	1.9	64.8	125.0
WYs 86-95 (wet)	75	304	4111	6010	0.15	3.9	7.7	1.3	66.8	129.0
WY 96	3	56	526	1300	<0.05	0.61	1.3	<0.4	2.3	5.2
Santa Fe Canal										
WYs 86-95	105	318	1440	4090	0.19	1.7	5.5	<0.4	10.0	60.0
WYs 86-95 (critical)	41	410	1210	4090	0.22	1.2	5.3	0.3	7.4	59.8
WYs 86-95 (wet)	58	318	1580	3930	0.19	2.0	5.5	1.0	11.0	44.0
WY 96	12	188	675	1450	0.10	0.5	1.3	0.6	2.1	4.7
WY 97	42	339	941	1870	0.24	1.0	2.9	0.8	2.1	3.9
San Luis Canal										
WYs 86-95	114	330	1690	4850	0.19	2.1	7.4	0.7	15.0	74.0
WYs 86-95 (critical)	50	486	1220	4010	0.30	1.2	4.9	0.7	7.0	56.6
WYs 86-95 (wet)	64	330	2050	4850	0.19	2.7	7.4	0.8	20.8	74.0
WY 96	12	196	918	3560	0.10	0.82	4.4	0.8	6.5	40.8
WY 97	41	501	973	1840	0.36	1.1	3.3	1.0	2.1	6.2
Porter-Blake Bypass										
WYs 86-95	110	348	3110	4820	0.30	4.4	7.1	1.7	40.6	88.0
WYs 86-95 (critical)	66	348	3100	4630	1.06	4.4	7.1	3.4	39.4	77.8
WYs 86-95 (wet)	43	786	3120	4820	0.30	4.5	6.9	1.7	42.4	88.0
WY 96	12	532	2830	3800	0.32	3.8	5.3	2.1	36.7	66.3
Mud Slough (N) @ Newman Gun Club										
WYs 86-95	241	230	3120	7570	0.10	2.8	7.0	0.5	8.4	48.0
WYs 86-95 (critical)	206	909	3300	7570	0.30	2.9	7.0	0.5	9.0	48.0
WYs 86-95 (wet)	35	230	2040	4850	0.10	1.7	4.7	1.0	5.0	34.0
WY 96	12	758	2260	5280	0.50	1.9	8.4	0.6	2.3	15.6
Mud Slough (N) @ San Luis Drain										
WYs 86-95	288	616	3320	10900	0.06	2.8	7.9	<0.4	7.8	59.0
WYs 86-95 (critical)	340	660	3510	10860	0.20	3.1	7.9	0.4	9.4	50.0
WYs 86-95 (wet)	114	616	2250	7250	0.27	2.0	6.4	0.4	4.1	59.0
WY 96	50	588	1900	5530	0.45	1.5	8.7	<0.4	1.4	11.8
WY 97	46	1150	2870	4930	1.1	4.1	6.8	5.0	30.7	79.6
Los Banos Creek @ Highway 140										
WYs 86-95	124	641	2030	7450	0.30	1.6	6.6	<0.4	2.1	30.0
WYs 86-95 (critical)	98	669	2140	7450	0.30	1.6	6.6	0.3	2.3	30.0
WYs 86-95 (wet)	25	641	1000	3600	0.33	1.3	2.9	<0.4	1.0	2.0
WY 96	3	509	1260	3350	0.60	1.5	3.0	<0.4	0.6	1.2
Salt Slough @ Lander Ave.										
WYs 86-95	472	780	2220	4050	0.30	2.1	5.0	1.0	15.0	44.0
WYs 86-95 (critical)	351	1020	2230	4050	0.30	2.0	4.7	0.6	14.6	44.0
WYs 86-95 (wet)	115	780	2240	3970	0.43	2.2	5.0	1.0	16.0	42.0
WY 96	49	1010	2010	3000	0.47	2.0	3.5	1.0	16.0	33.5
WY 97	48	922	1370	2000	0.40	0.77	1.8	0.5	1.0	3.4
Inflow to San Luis Drain @ Check 17										
WY 97	48	2620	4460	5600	4.2	7.3	9.0	17.9	65.9	108.0
San Luis Drain @ Terminus										
WY 97	48	2720	4270	5460	4.4	6.8	8.4	17.0	59.3	107.0
Mud Slough (N) upstream of SLD										
WY 97	48	744	1390	2960	0.56	1.2	2.9	<0.4	0.8	1.7

Table 12 continued:

Site		Count	EC (umhos/cm) Min	EC (umhos/cm) Mean	EC (umhos/cm) Max	Boron (mg/L) Min	Boron (mg/L) Mean	Boron (mg/L) Max	Selenium (ug/L) Min	Selenium (ug/L) Mean	Selenium (ug/L) Max
Autosampler Data (1)											
Camp 13 Slough											
	WY 97	*	122	1030	4630	0.34	3.8	7.7	<0.4	12.4	33.0
Agatha Canal											
	WY 97	†	116	225	809	0.37	0.62	1.0	0.5	1.7	6.8
Panoche Drain											
	WY 96	85	3050	1530	5580	3.4	7.0	9.2	23.4	79.9	149
	WY 97	29	3830	4750	5320	–	–	–	35.0	72.8	116
Firebaugh (Main) Drain											
	WY 96	82	1830	3190	5520	2.1	3.8	7.6	25.2	59.7	136
	WY 97	25	2290	4110	5550	–	–	–	28.8	72.7	125
Mud Slough (N) @ SLD											
	WY 96	79	610	1880	5150	0.45	1.4	5.6	0.5	1.7	19.4
	WY 97	42	1170	2130	3760	1.3	2.5	6.2	4.5	17.1	50.6
Salt Slough at Lander Avenue											
	WY 96	95	886	2020	3170	0.47	2.0	3.0	1.2	16.0	37.8
	WY 97	43	960	1440	2070	0.47	1.0	1.9	0.5	1.3	6.3
San Luis Drain @ Terminus											
	WY 97	344	2620	4390	5880	4.1	7.0	9.3	15.2	62.4	116

Count = the minimum number of analyses out of the three constituents

(1) = All autosamplers except at the San Luis Drain site were removed by April 1997. The San Luis Drain sampler was installed in September 1996. The Camp 13 and Agatha samplers were operated intermittently between January and March 1997.

* = 75 EC, 20 selenium and 8 boron analyses were conducted

† = 67 EC, 9 selenium and 4 boron analyses were conducted

Water year type is based on the San Joaquin 60-20-20 River Index as follows:

Critical Water Year: Runoff < 2.1 million ac-ft (WYS 87-92 and 94)

Wet Water Year: Runoff > 3.81 million ac-ft (WYs 86, 93, 95, 96, and 97)

The Almond Drive Drain, as in previous years, contained low levels of the constituents of concern, as did Salt Slough Ditch at Hereford Road. These sites were sampled on a quarterly schedule and normally carry either surface tailwater or supply water.

Internal Flow Monitoring Sites

Four internal flow sites were monitored in WY 96: Santa Fe Canal at Henry Miller Road, San Luis Canal at Henry Miller Road, and Porter-Blake Bypass on a monthly basis; and CCID Main at Russell on a quarterly basis. These channels can carry supply water for both agriculture lands and wetland habitat, as well as transport agricultural tailwater and subsurface drainage. During Water Year 1996, EC in these water bodies ranged from 56 µmhos/cm to 3800 µmhos/cm, while boron ranged from <0.05 mg/L to 5.3 mg/L (Table 12). Selenium concentration ranged from <0.4 µg/L to 66.3 µg/L. The lowest concentrations occurred in the CCID Main at Russell which primarily carries supply water, while the highest concentrations occurred in the Porter-Blake Bypass, which served as a conduit when subsurface agricultural drainage was discharged into Salt Slough.

When compared to the previous ten years of available data, the Santa Fe and San Luis sites showed significant decreases for the constituents of concern, CCID Main remained at approximately the same level, and Porter-Blake concentrations increased.

Outflow Monitoring Stations

Four outflow stations were sampled during Water Year 1996. Salt Slough at Lander Avenue and Mud Slough (north) downstream of the San Luis Drain were monitored on a weekly basis. Mud Slough (north) at Newman Gun Club was sampled on a monthly basis, and Los Banos Creek at Highway 140 was sampled on a monthly basis, with boron and selenium analyses only conducted on a quarterly basis.

During Water Year 1996, the majority of subsurface drainage flowed through Salt Slough prior to discharge into the San Joaquin River. EC, boron, and selenium concentrations ranged from 1010 to 3000 µmhos/cm, 0.47 to 9.3 mg/L, and 1.0 to 33.5 µg/L, respectively (Table 12). The highest concentrations occurred on 5 May 1996, while lowest occurred the first two weeks in November. Mud Slough (north) at the San Luis Drain and Mud Slough (north) at Newman Gun Club had lower concentrations of boron and selenium than Salt Slough, but higher overall ECs. A short term spike in selenium concentrations occurred in Mud Slough (north) downstream of the San Luis Drain between 14 and 17 April 1996, during the dewatering of groundwater from the drain in preparation for the Grassland Bypass Project. During those four days, selenium concentrations in Mud Slough (north) ranged from 10 µg/L to 21 µg/L. Once the discharge ceased, selenium concentration in Mud Slough (north) dropped back below 2 ug/L.

Los Banos Creek contained consistently low concentrations of EC, boron and selenium, ranging from 509 to 3350 µmhos/cm, 0.60 to 3.0 mg/L, and <0.4 to 1.2 µg/L, respectively.

Composite Samples

Four autosamplers were in place during Water Year 1996, collecting 4-day composite samples at Panoche Drain, Firebaugh (Main) Drain, Mud Slough (north) and Salt Slough (Figures 3 and 4). Autosamplers were also installed intermittently on Camp 13 Slough and the Agatha Canal when flooding made the site inaccessible (Data presented in Appendix C).

The 4-day composite information collected at the Panoche and Firebaugh (Main) Drain, demonstrates not only the overall elevated constituent concentrations at these sites (minimum EC, boron, and selenium concentrations above 2,000 µmhos/cm, 2.5 mg/L, and 25 µg/L, respectively), but also the variability of the concentrations over the season and even within a 4-day period. Even with the few data gaps that occurred during flood events when the sites could not be accessed for maintenance, the composite record provides a more continuous data base than the weekly grab samples for water year 1996.

Figure 3. Electrical Conductivity, Boron and Selenium Concentrations in Panoche and Firebaugh Drains (Sigma Data): Water Year 1996

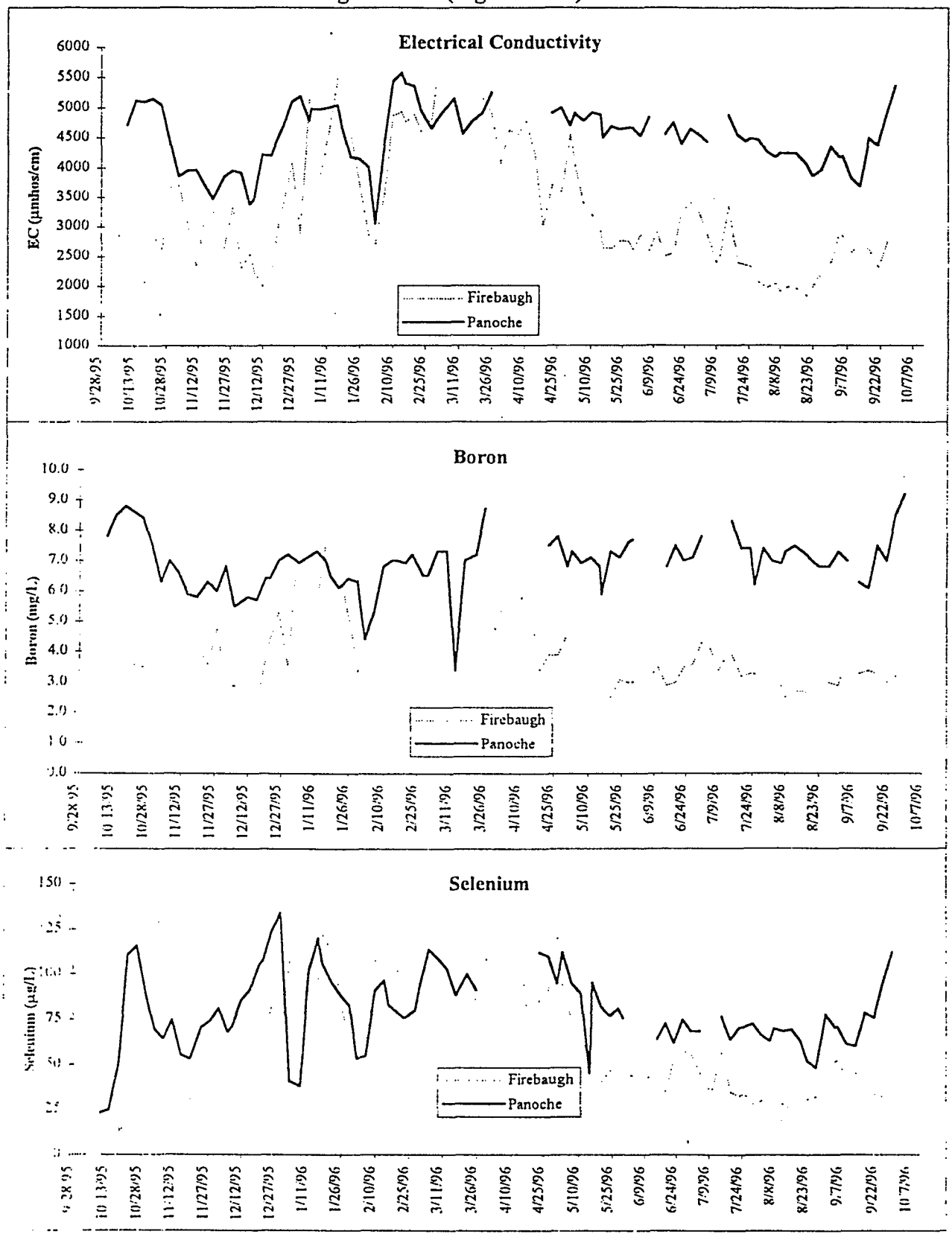
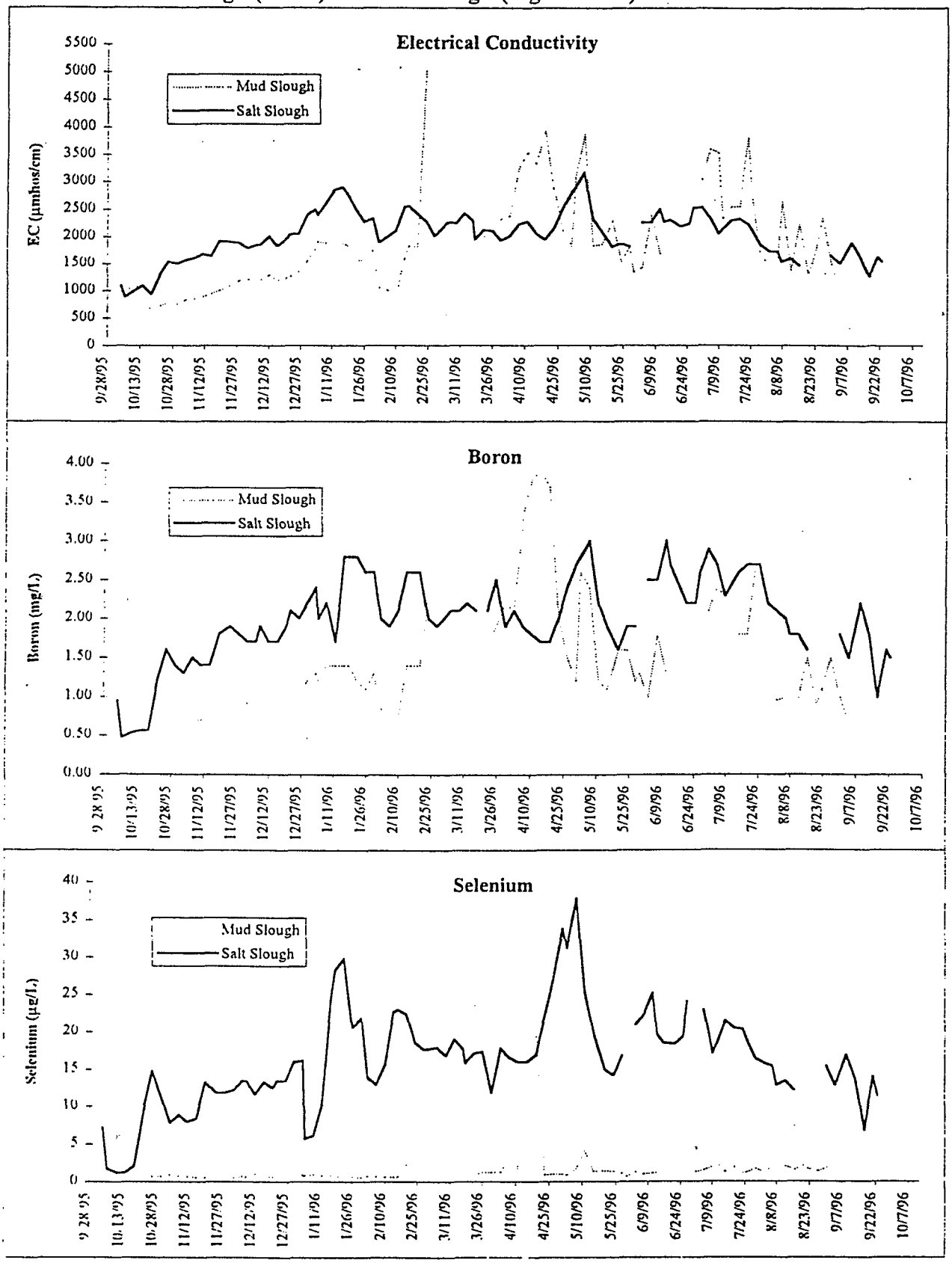


Figure 4. Electrical Conductivity, Boron and Selenium Concentrations Mud Slough (north) and Salt Slough (Sigma Data): Water Year 1996



The composite samplers installed at both Mud Slough (north) and Salt Slough, also provide an almost continuous record of EC, boron and selenium concentrations at the two sites. The Mud Slough (north) sampler was removed for a short period between the end of February and early March, when high flows in the slough threatened to submerge the device which was attached to the bridge. EC and boron concentrations in the two sloughs are comparable with rapid concentration shifts over 4-day periods. Selenium concentrations in Salt Slough remain quite elevated over Mud Slough (north) concentrations during the entire water year except for a peak evident in Mud Slough (north) during mid-April which corresponds to the dewatering of groundwater from the San Luis Drain.

Water Year 1997

With the advent of the Grassland Bypass on 26 September 1996, the focus of the monitoring program shifted from general evaluation of impacts of agricultural drainage on inflow, internal flow and outflow water bodies within the Grassland Watershed, to impacts from consolidating discharge of subsurface drainage into Mud Slough (north) and resulting water quality in wetland water supply channels.

Three new monitoring sites were added in Water Year 1997, due to the opening of the Grassland Bypass Project. One was the inflow to the San Luis Drain which represents the water quality in the Grasslands Bypass. The samples at this site were collected by Panoche Water District on a weekly schedule at a point on the San Luis Drain downstream of the Grassland Bypass inflow. The second addition was the San Luis Drain at its terminus prior to discharge into Mud Slough (north). The final addition, Mud Slough (north) upstream of the San Luis Drain, was added to furnish background data for the Mud Slough (north) site prior to the inflow from the San Luis Drain.

Several of the inflow sites monitored during Water Year 1996, were discontinued in Water Year 1997. The exceptions were Camp 13 Slough and Agatha Canal. Grab samples at these sites were collected by Panoche Water District. The frequency of sampling was increased from monthly to weekly on 3 November 1996, and automated composite samples were collected from 10 January 1997 to 25 March 1997 due to limited direct access.

Two internal sites were continued in WY 97: Santa Fe and San Luis Canals at Henry Miller Road. Weekly sampling by Panoche Water District staff began in November 1996. No data is available for January 1997.

Both the Salt Slough at Lander Avenue and the Mud Slough (north) at the San Luis Drain sites were continued during Water Year 1997. The outflow sites on Los Banos Creek and Mud Slough (north) at Newman Gun Club were discontinued.

Electrical conductivity, boron, and selenium data have been summarized in Tables 11 and 12. Remaining water quality information collected during Water Year 1997, is listed in Appendix B.

<u>San Luis Drain and Mud Slough (north)</u>

Grab samples were collected both from the inflow to and discharge from the San Luis Drain and also from Mud Slough (north) upstream and downstream of the discharge from the San Luis Drain. In addition to EC, boron, and total selenium, dissolved selenium and total suspended solids were analyzed at both San Luis Drain sites.

Concentrations at the inflow to and discharge from the San Luis Drain were similar (Figure 5). The discharge's impact on Mud Slough (north) was pronounced (Figure 6), particularly after February 1997. Elevated background concentrations of EC and boron in Mud Slough (north) upstream of the San Luis Drain discharge (reaching 2960 µmhos/cm and 2.9 mg/L, respectively) are further exacerbated by the drainage discharge, with EC and boron concentrations reaching 4930 µmhos/cm and 6.8 mg/L, respectively. The greatest impact on Mud Slough from the San Luis Drain discharge was on selenium concentrations. Selenium concentrations in Mud Slough (north) upstream of the discharge were below

Figure 5. Electrical Conductivity, Boron and Selenium Concentrations in the Inflow to and Discharge from the San Luis Drain (Grab Data): Water Year 1997.

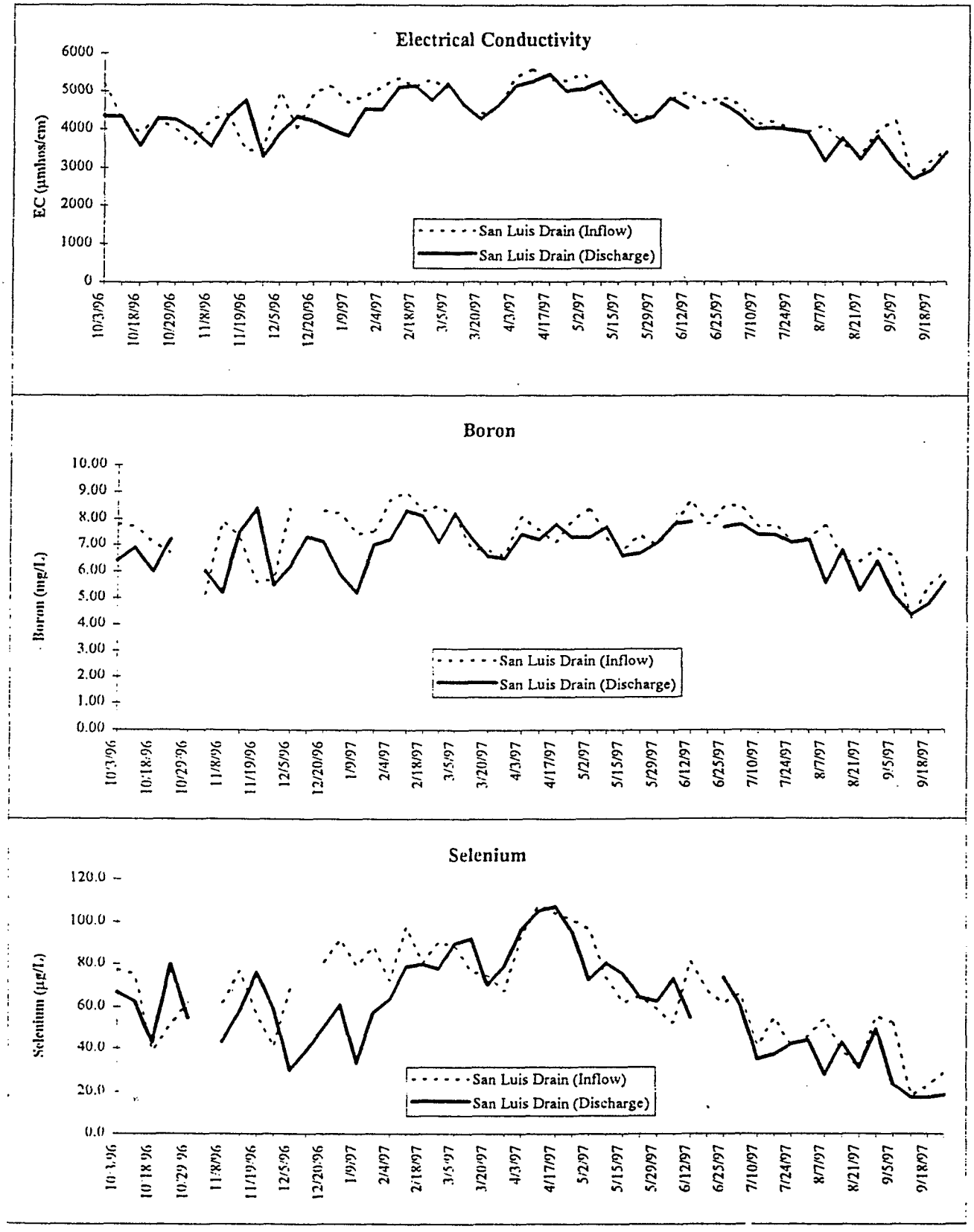
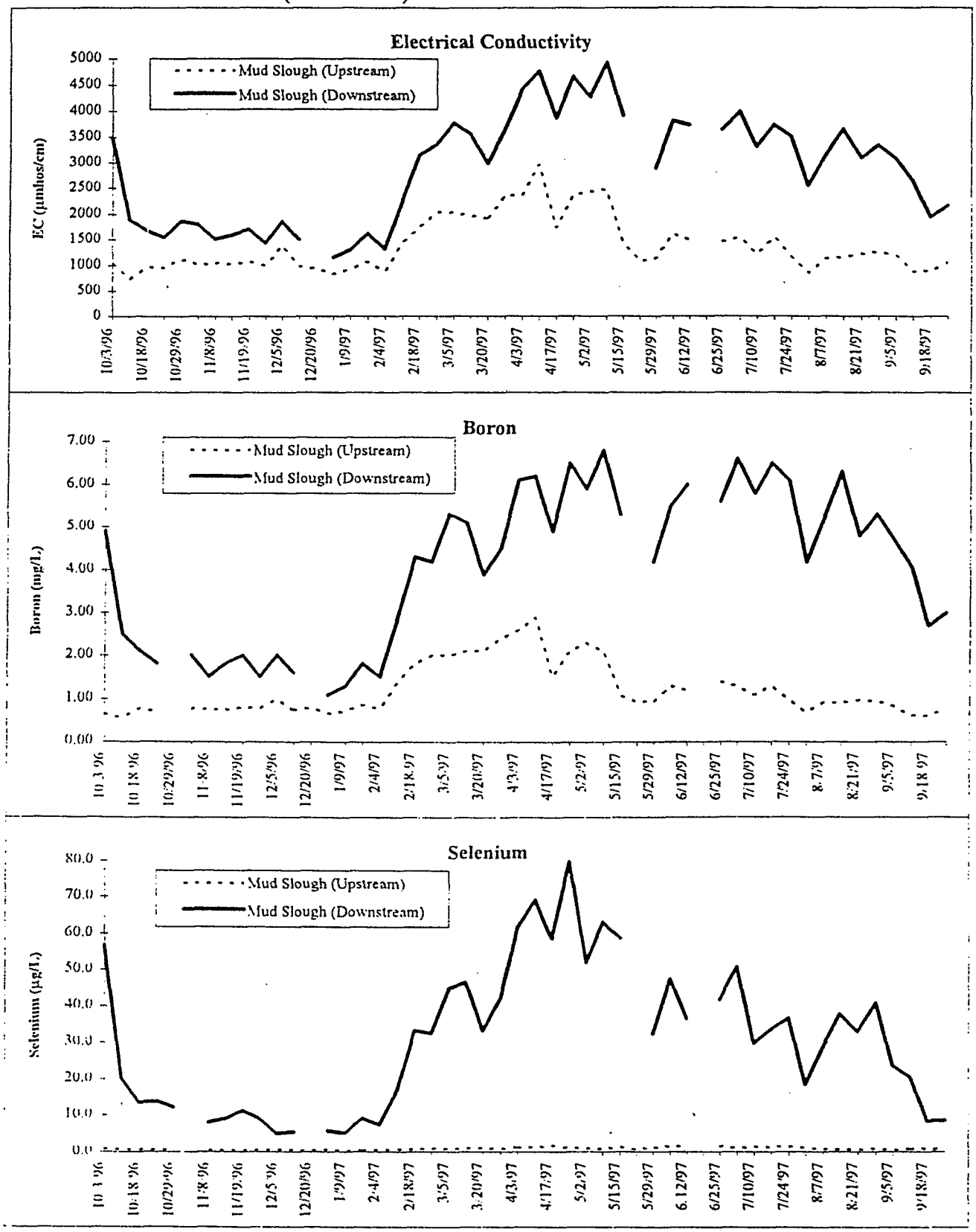


Figure 6. Electrical Conductivity, Boron and Selenium Concentrations in Mud Slough (north) Upstream and Downstream of the Discharge from the San Luis Drain (Grab Data): Water Year 1997.



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1.7 µg/L: downstream of the discharge, the mean selenium concentration was 30.7 µg/L with a maximum of 79.6 µg/L.

A comparison of total versus dissolved selenium concentrations at the two San Luis Drain sites is presented in Table 13. Concentrations of each sample pair fall within the analytical criteria of acceptable split samples, indicating that selenium in the drain is in the dissolved (aqueous) form.

Total suspended sediment was analysed on a weekly basis in the inflow to and discharge from the San Luis Drain. Summary results from the analyses are presented in Table 14 and Figure 7. Complete analytical results are listed in Appendix B. Total suspended sediment concentrations were consistently higher in the inflow to the drain than in the discharge from the drain, although actual weekly concentrations varied widely. Median concentrations in the inflow and discharge were 96 mg/L and 25 mg/L, respectively.

Wetland Water Supply Channels and Salt Slough

Weekly grab samples were collected at: Camp 13 Ditch and the Agatha Canal, major supply canals for wetlands within Grassland Water District; the San Luis Canal and Santa Fe Canal at Henry Miller Road, two internal distribution canals for wetland habitat; and at Salt Slough, a tributary of the San Joaquin River. During a brief period, between 27 January and 5 February 1997, subsurface agricultural drainage was diverted into these channels in response to a flood event. Data for this time period have been presented and discussed in a previous report (USBR, 1997) and are not included in the discussion below.

EC, boron and selenium data for Camp 13 Slough and Agatha Canal are presented in Figure 8. Concentrations were consistently higher at Camp 13 than at the Agatha, except for an EC spike recorded on 4 February 1997, during the tail end of the flood event. EC and boron levels reached their maximum in early April, reaching 3760 µmhos/cm and 7.1 mg/L, respectively, at Camp 13. Selenium showed a peak of 13.5 µg/L on 7 May 1997, at Camp 13, while the median selenium level was 1.6 µg/L. On a number of occasions, Camp 13 Slough exceeded 2.0 µg/L selenium, while the Agatha Canal reached a maximum of 3.4 µg/L and only exceeded 2.0 µg/L on five separate occasions.

Concentrations in the internal supply channels, the San Luis and Santa Fe Canals, fluctuated during Water Year 1997, as depicted in Figure 9. Aside from the storm event, the highest EC and boron concentrations occurred between the end of February and April, a primary period of wetland releases and pre-irrigation. Selenium levels did not demonstrate the same spike; however, concentrations remained above 2.0 µg/L for the majority of samples collected from February through September 1997.

The cause of the elevated selenium levels for that time period is not readily apparent but may be due to a number of different factors. Some potential sources include elevated selenium levels in supply water, releases from the DPA (both in response to flood events and seepage from gates and canals), inflows from other sources such as the Rice Drain and Almond Drive Drain, and local sources such as groundwater seepage and surface return flows.

To evaluate the potential for elevated selenium concentrations in irrigation supply water, all available selenium data since October 1996, for the Delta Mendota Canal, Mendota Pool, and the Central California Irrigation District (CCID) Main Canal, major water supplies for the Grassland Watershed, were compiled and listed in Table 15. Although the data set is extremely limited, on a number of occasions, these sources of supply water have exceeded 2.0 µg/L selenium.

During March and early April, 1997, elevated constituent concentrations were noted at Camp 13 Slough. Regional Board staff observation and discussion with Grassland Water District staff confirmed that water from the Main Drain, which contained drainage from adjacent flooded farm land, was being diverted into Camp 13 ditch during this time period. This water was not from farmland participating in the Grassland Bypass Project and staff from the water district assumed that the flood water was of good quality. Review of data collected using an automated sampler which was in place at Camp 13 Slough, until 25 March 1997, indicated that the diverted water contained elevated levels of all three constituents

Table 13. Total vs Dissolved Selenium Concentrations at the Inflow to and Discharge from the San Luis Drain.

Date	Selenium Concentration (µg/L)			
	Inflow		Outflow	
	Total	Dissolved	Total	Dissolved
9/26/96	44.8	46.0L	20.2	19.5L
10/3/96	77.4	79.1L	66.8	65.8L
10/18/96	38.6	37.5L	43.0	41.8L
10/25/96	51.4	49.5	79.8	77.2
10/29/96	62.0	61.6	54.6	54.8
11/8/96	61.3	61.1	43.2	42.1
11/19/96	56.2	57.0	75.8	75.2
11/26/96	40.6	39.6	58.9	56.4
12/5/96	68.4	69.9L	30.1	31.0
12/10/96			38.9	39.0
12/20/96	80.4	80.2	49.8	49.0
12/27/96	91.7	91.9	60.8	61.6
1/9/97	78.7	76.6	33.3	34.2
1/21/97	88.2	84.8	57.0	56.4
2/4/97	72.0	70.5	63.6	61.8
2/11/97	97.5	96.6	78.4	78.4
2/18/97	80.3	78.6	79.7	83.2
2/28/97	90.3	86.4	77.6	73.4
3/5/97	88.4	91.1	89.3	87.1
3/12/97	76.6	77.2		
3/13/97			91.8	84.4
3/19/97	74.5	71.1		
3/20/97			70.2	70.4
3/26/97	67.0	61.0		
3/27/97			78.9	78.1
4/2/97	93.0	95.8		
4/3/97			96.2	93.7
4/9/97	108	117		
4/10/97			105	102
4/16/97	104	104		
4/17/97			107	110
4/23/97	101	97.6		
4/24/97			95.2	93.6
5/1/97	96.8	96.6		
5/2/97			72.6	73.7
5/7/97	73.6	73.0		
5/8/97			80.3	78.3

Date	Selenium Concentration (µg/L)			
	Inflow		Outflow	
	Total	Dissolved	Total	Dissolved
5/14/97	61.6	57.6		
5/15/97			75.2	75.7
5/21/97	65.0	63.6		
5/23/97			64.2	64.6
5/28/97	58.5	60.6		
5/29/97			62.3	60.9
6/4/97	52.1	50.6		
6/5/97			72.8	70.4
6/11/97	81.0	78.9		
6/12/97			54.6	55.0
6/18/97	67.5	63.1		
6/25/97	61.5	60.5	73.3	73.6
7/2/97	65.8	64.1	59.9	59.8
7/9/97	40.6	40.5		
7/10/97			34.9	35.0
7/16/97	54.5	53.0		
7/17/97			37.0	37.0
7/23/97	40.5	43.5		
7/24/97			41.8	39.5
7/30/97	45.5	44.6		
7/31/97			43.7	42.4
8/6/97	53.8	50.4		
8/7/97			27.9	27.7
8/13/97	38.4	39		
8/14/97			42.3	41.7
8/20/97	30.8	30.4		
8/21/97			31.2	31.0
8/27/97	55.4	53.7	48.9	47.2
9/3/97	52.1	49.4		
9/5/97			23.4	23.3
9/10/97	17.9	16.6		
9/12/97			17.0	16.4
9/17/97	22.8	21.8		
9/18/97			17.1	17.0
9/24/97	29.0	28.0		
9/25/97			18.3	18.4

L = Lab filtered

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Table 14. Summarized Total Suspended Sediment Data for the Inflow to and Discharge from the San Luis Drain: Water Year 1997

Location	Total Suspended Sediment (mg/L)					
	Count	Min	Max	Mean	Geo Mean	Median
Inflow to San Luis Drain	43	38	190	100	92	96
Discharge from San Luis Drain	44	8	140	28	23	25

Figure 7. Total Suspended Sediment Concentration in the Inflow to and Discharge from the San Luis Drain: Water Year 1997.

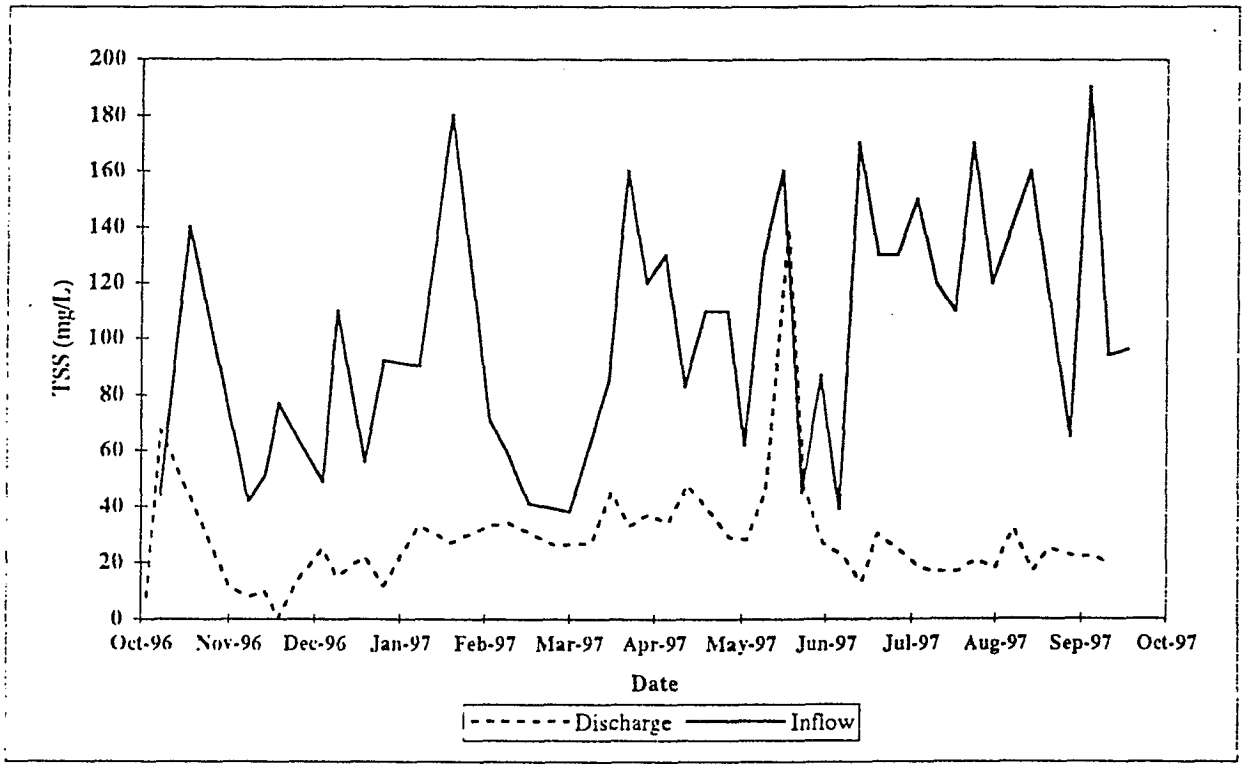

Figure 8. Electrical Conductivity, Boron and Selenium Concentrations in Camp 13 Slough and Agatha Canal (Grab Data): Water Year 1997.

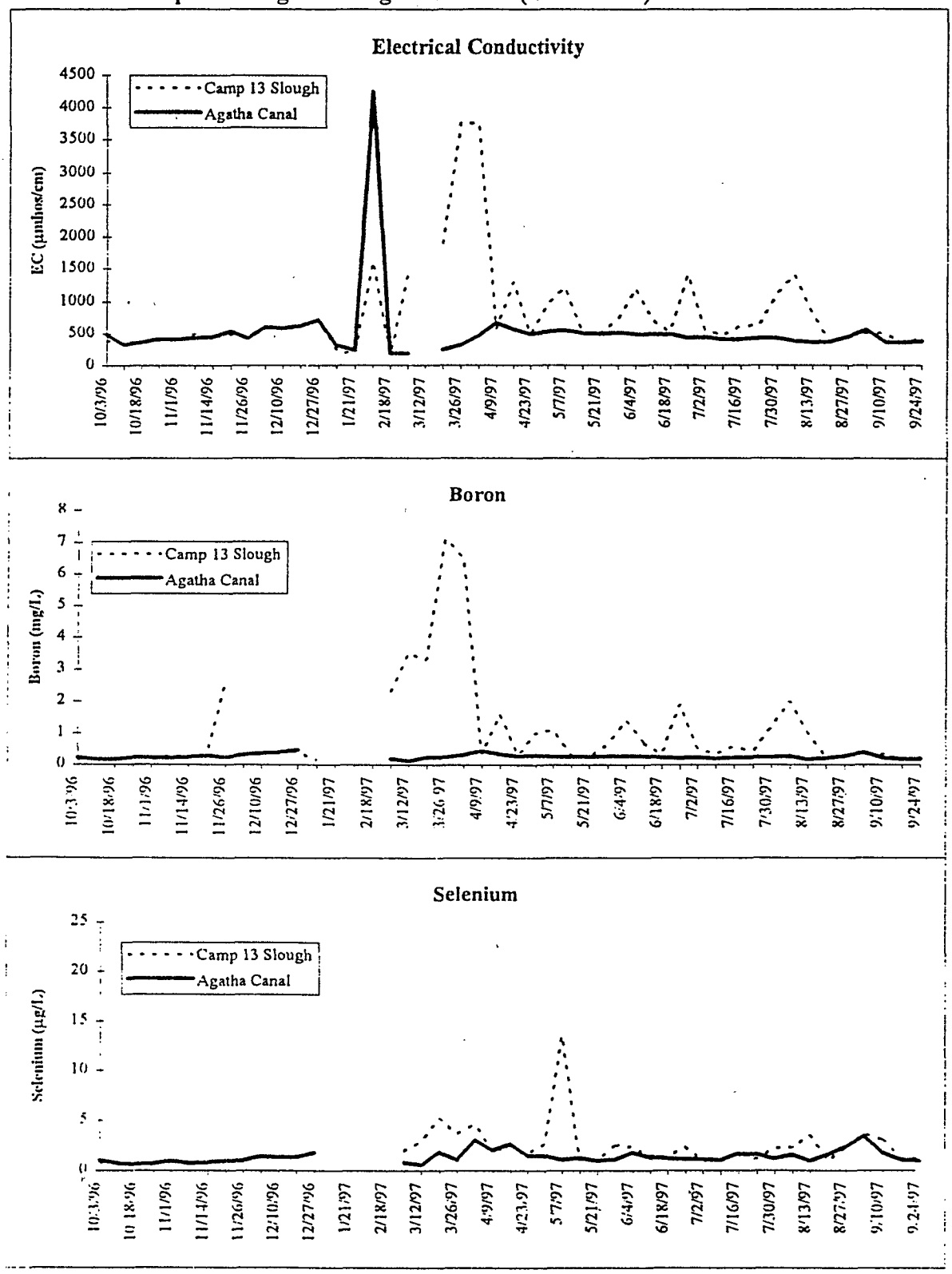

Figure 9. Electrical Conductivity, Boron and Selenium Concentrations in the San Luis Canal and Santa Fe Canal (Grab Data): Water Year 1997.

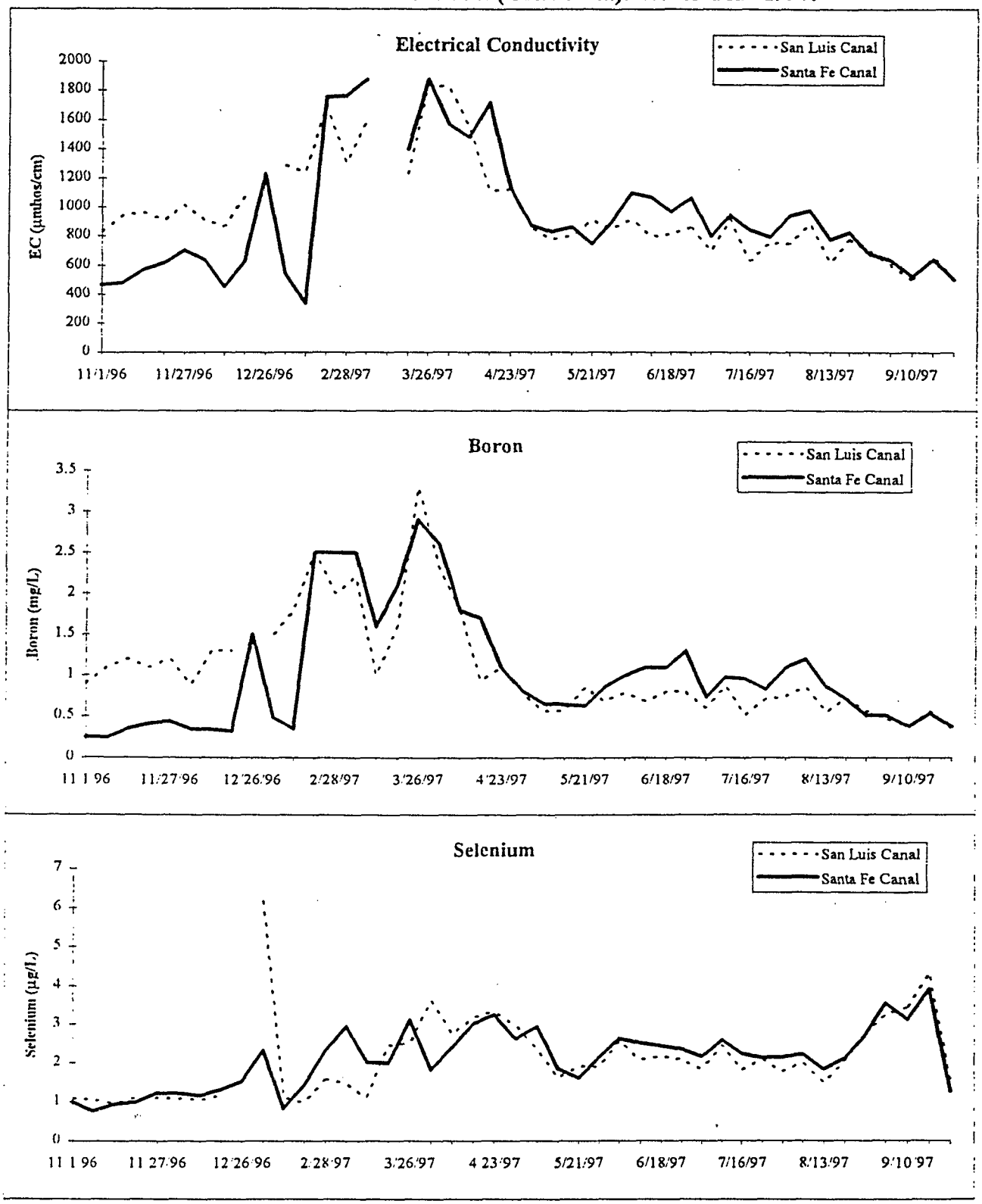

Table 15. Selenium Concentrations in Supply Water to the Grassland Watershed: October 1996 through September 1997.*

Date	Selenium Concentration (µg/L)		
	Delta Mendota Canal MP 110.12	Mendota Pool at Mowry Bridge	CCID Main Canal @ Head of San Luis Canal
10/2/96	<1	—	—
10/14/96		<2	—
11/13/96	<1	—	—
11/15/96	—	2.9	—
12/18/96	—	2.4	—
1/8/97	3	—	—
1/15/97	—	<2	<2
2/11/97	18	—	—
2/18/97	—	<2	—
3/12/97	13	—	—
3/13/97	—	<2	—
4/2/97	2	—	—
4/16/97	—	4	—
5/9/97	<2	—	—
5/15/97	—	4.8	—
6/13/97	<2	—	—
7/9/97	<2	—	—
7/11/97	—	2.2	4
8/14/97	<2	—	—
9/16/97	4	—	—

* = Data provided by Summers Engineering and the Central California Irrigation District based on internal monitoring and sampling conducted by the U.S. Bureau of Reclamation.

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of concern. Electrical conductivities reached 4600 µmhos/cm while selenium concentrations peaked at 21.2 µg/L. The automated data confirms the peaks seen during the program's weekly grab samples (Figure 10). The diversion of the ponded water ceased on 28 March 1997. Additional periods of elevated concentrations also occurred between April and September 1997. These elevated concentrations corresponded to a period of very low flow in Camp 13 Slough. Little, if any supply water was being delivered and the majority of flow was from leaks in the gates separating the slough from the main supply canal and from major drains. Reports from the San Luis Delta Mendota Water Authority (SLDMWA, 1997) indicate that between 5 and 10 gpm will leak from the Main Drain into Camp 13 Slough through the closed gates.

Another potential selenium source to the internal wetland supply canals includes elevated concentrations in the Rice Drain, which receives drainage from lands in the eastern portion of the watershed, and the Almond Drive Drain, which receives drainage from lands in the western portion of the watershed. Although these drains were not monitored during Water Year 1997, historical data indicates that both drains have contained selenium concentrations in excess of 2.0 µg/L on many occasions (Figure 11). Sources of drainage into these water bodies needs to be determined.

Other factors such as elevated concentrations in groundwater seepage and in surface drainage may also impact the quality of water in the internal canals. Further review of all factors related to the elevated selenium levels in the internal canals within the Grassland Watershed and possible source flows, is necessary.

Concentrations of electrical conductivity, boron and selenium have all decreased dramatically in Salt Slough as compared to values recorded prior to the operation of the Grassland Bypass Project (Steensen et al., 1998). Concentrations of these three constituents in Salt Slough during Water Year 1997, are depicted in Figure 12. Electrical conductivity and boron remained below 2,000 µmhos/cm and 1.8 mg/L, respectively, throughout the water year. Selenium concentration remained below 2.0 µg/L except for one spike recorded in the first part of February 1997, during the flood event, when concentrations reached 3.4 µg/L.

Daily Composite Samples

Daily composite samples were collected at the discharge from the San Luis Drain. Some inconsistencies in the quality control samples for the discharge were noted for the time period of 10 through 21 January 1997. Although the information collected was graphed, the data were not used in the summary calculations presented in Tables 11 and 12. Daily electrical conductivity, boron and selenium results are presented in Figure 13 along with grab sample data.

At the San Luis Drain discharge, EC and boron concentrations can vary widely on a daily basis. Daily EC values vary up to 1,000 µmhos/cm in a day, while boron concentrations vary up to 2 mg/L per day. Some seasonality is evident with concentrations peaking between February and April and tapering off from June through September. The results obtained from the grab and autosampler show similar means and medians of 4390 µmhos/cm and 4420 µmhos/cm, respectively for EC and 7.0 and 7.2 mg/l, respectively for boron (Tables 11 and 12).

Selenium showed greater seasonal fluctuations than EC or boron, with concentrations peaking in April at 116 µg/L and dropping off to 15.2 µg/L in September. Daily concentration fluctuations could also be high, with a 40 µg/L shift occurring between 2 and 3 October 1996. Although weekly grab samples appear to document the seasonal trends and shifting concentrations, they are unable to detect the potentially large changes in daily concentrations.

DISCUSSION

Comparison of Water Year 1996 with Water Year 1997

When the Grassland Bypass became operational at the end of September 1997, it effectively consolidated agricultural subsurface drainage from the DPA into a single channel for discharge into the

Figure 10. Corroboration of Grab Sample Data by Use of Automated Collection (Sigma) Sampler at Camp 13 Slough: Water Year 1997.

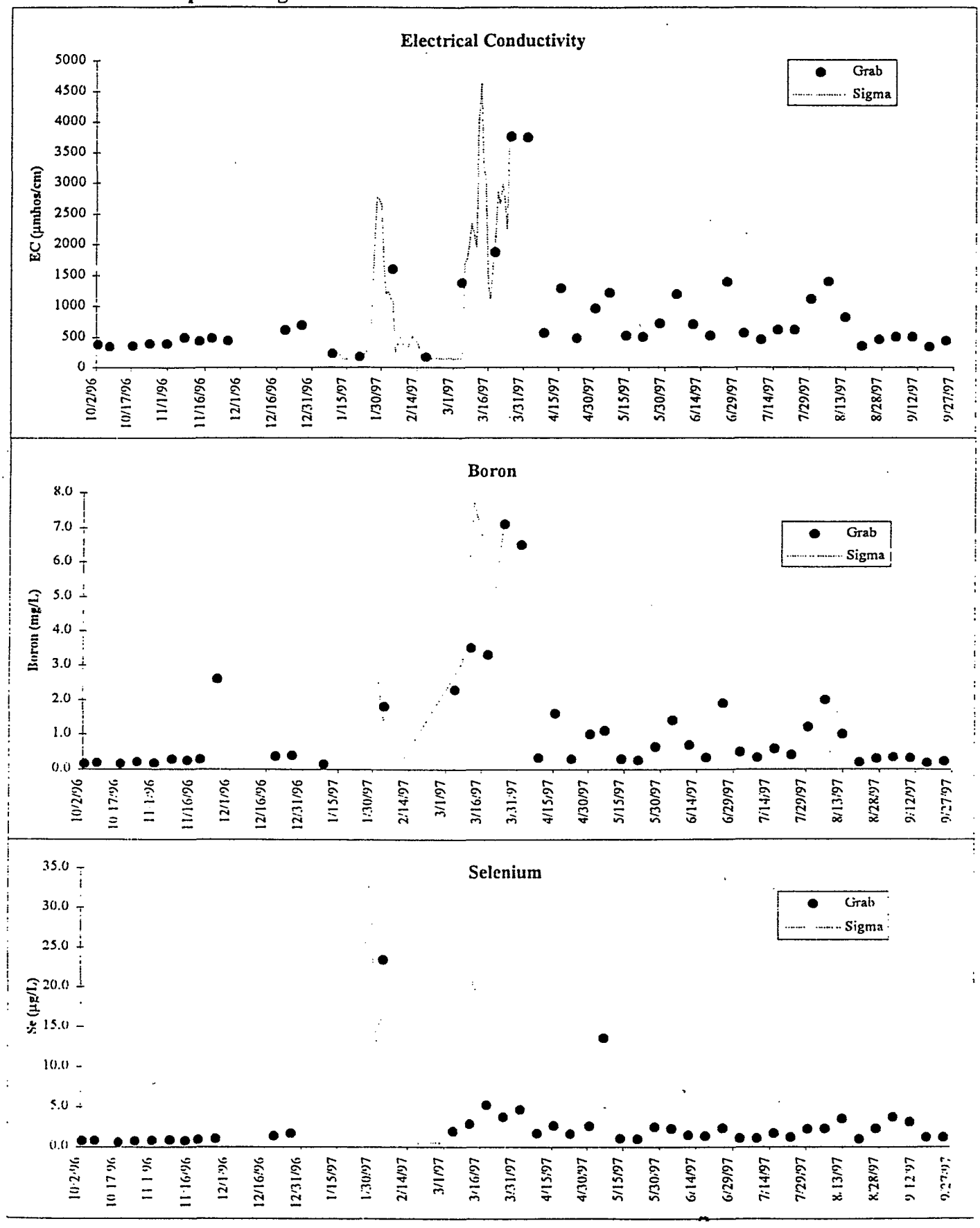
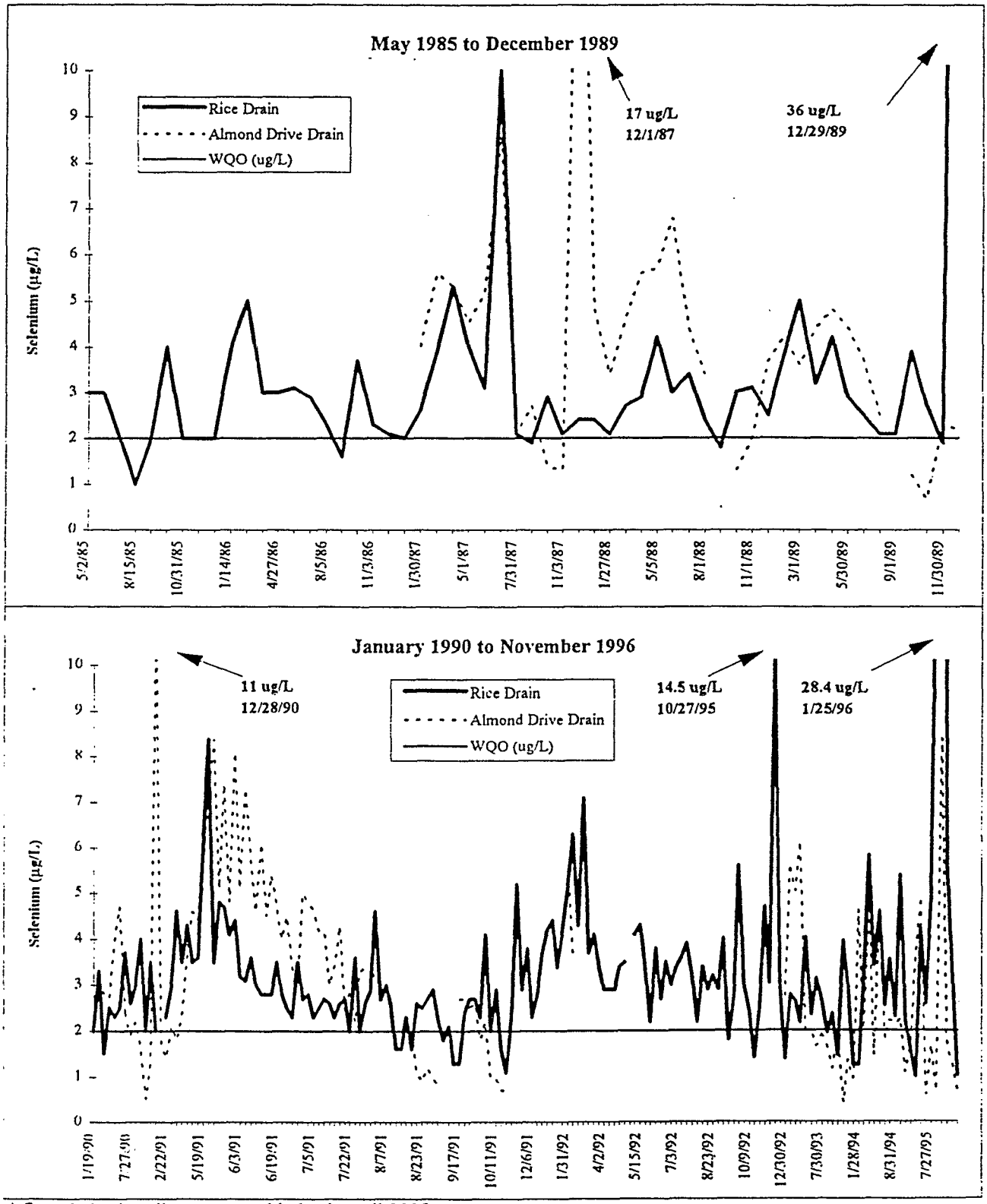


Figure 11. Selenium Concentrations in Almond Drive and Rice Drain: May 1985 to November 1996*



* Sampled primarily on a monthly basis until 1995
1991: special study (frequent sampling)
1995 and 1996: sampled quarterly

Figure 12. Electrical Conductivity, Boron and Selenium Concentrations in Salt Slough (Grab Data): Water Year 1997

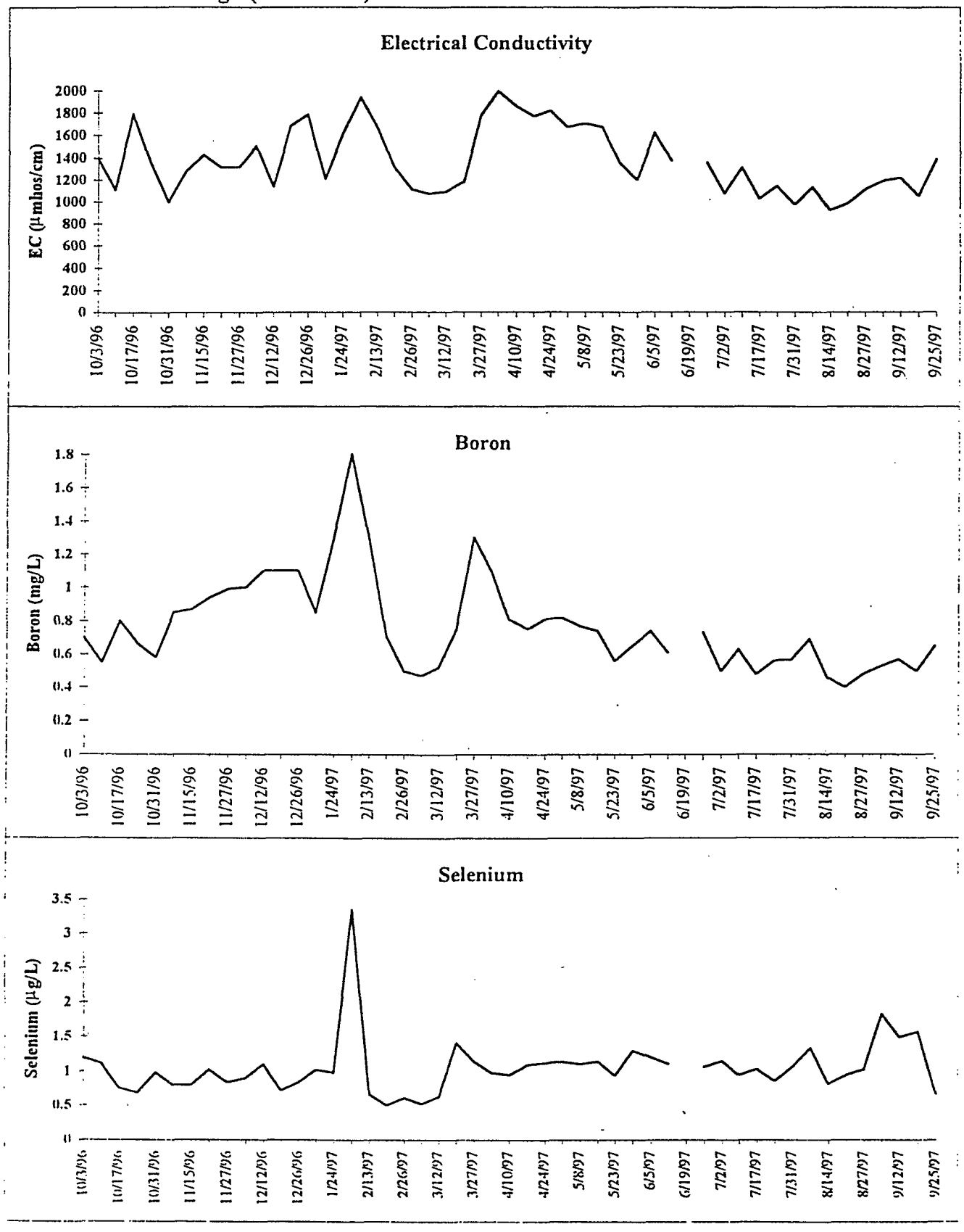
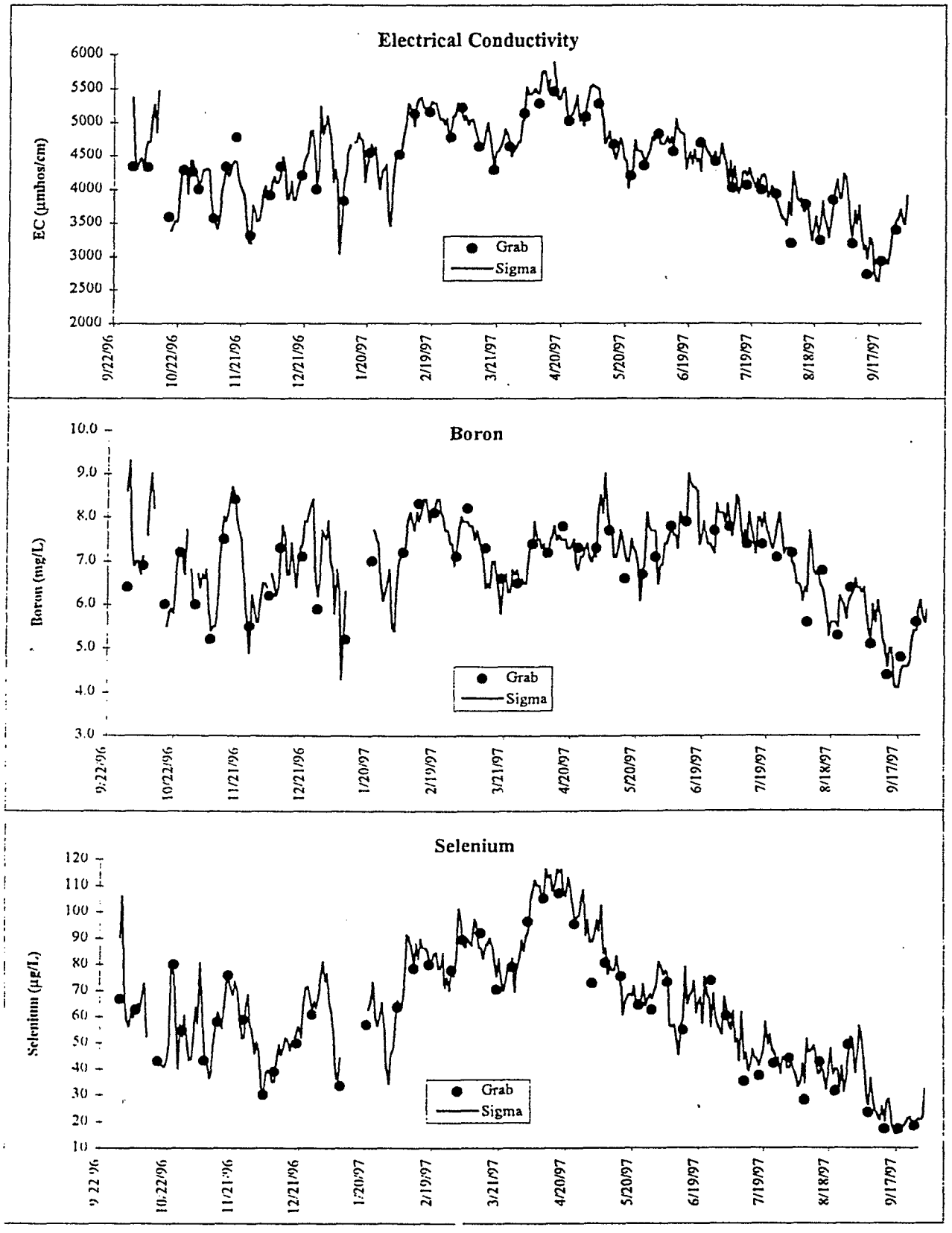


Figure 13. Comparison of Selenium, Boron and Electrical Conductivity at the San Luis Drain Using Grab Sample Data and Autosampler (Sigma) Data: Water Year 1997.



final six miles of Mud Slough (north). This consolidation removed the subsurface drainage from approximately 90 miles of internal wetland water supply channels and from Salt Slough.

Figure 14 depicts the changes in EC, boron, and selenium concentrations in Mud Slough (north) and Salt Slough for the period prior to the Bypass (Water Year 1996) and the first year following the Bypass operation (Water Year 1997). Both EC and boron concentration declined in Salt Slough and increased in Mud Slough (north) once the Bypass began operation. The most dramatic change, however, occurred with selenium concentrations. Removing the agricultural subsurface drainage from Salt Slough, reduced the selenium concentration to below 2.0 µg/L during Water Year 1997 as opposed to a range of 1.0 to 33.5 µg/L during Water Year 1996. A corresponding increase was seen in Mud Slough (north) with selenium concentrations ranging from 5.0 to 79.6 µg/L during Water Year 1997. When subsurface agricultural drainage is present, the higher overall selenium concentrations observed in Mud Slough (north), as compared to Salt Slough, is due to limited dilution potential. Mud Slough (north) has a lower baseline flow and therefore provides less dilution for agricultural subsurface drainage than Salt Slough.

Concentrations in the wetland water supply channels was more variable. Overall concentrations in Camp 13 Slough and the Agatha Canal decreased dramatically after the Bypass began operation, however, a number of concentration spikes were apparent throughout Water Year 1997 (Figure 15). Potential reasons for the concentration spikes include elevated selenium levels in supply water, releases from the DPA (seepage and flood flows), inflows from other sources such as the Rice Drain and Almond Drive Drain, and other internal sources such as groundwater seepage and surface return flows. These potential sources were discussed in more detail in the section on wetland water supply channels and Salt Slough under the results for Water Year 1997.

Concentrations in the San Luis Canal and Santa Fe Canal do not appear to have changed, with similar values recorded both prior to and after Bypass operation (Figure 16). Most subsurface agricultural drainage was diverted out of these canals and into Salt Slough through the Porter-Blake Bypass, upstream of the sampling locations, during water year 1996. Only when subsurface agricultural drainage was diverted to Mud Slough (north) or continued downstream in the San Luis Canal to the City Ditch diversion to Salt Slough, would the drainage be measured in these canals at these sampling locations. By water year 1997, the majority of subsurface drainage had been consolidated into the Grassland Bypass and lower portion of the San Luis Drain, and did not reach the two canals except during flood flows.

Comparison to Applicable Water Quality Objectives

In October 1988, the Regional Board adopted water quality objectives for boron, molybdenum and selenium for Mud Slough (north), Salt Slough and water used to maintain wetland habitat. In May 1996, the Regional Board adopted revised selenium water quality objectives for the two sloughs and for wetland water supply channels, as well as a compliance time schedule for Mud Slough (north). Water quality objectives which applied during each water year are listed in Table 16. The selenium compliance time schedule which applies to Mud Slough (north), does not require full compliance with the selenium objective until 1 October 2010. No water quality objectives have been adopted for the San Luis Drain.

Tables 17 and 18 list the exceedances of boron and selenium water quality objectives, respectively, for both Water Year 1996 and 1997. All potential selenium exceedances have been shown, whether or not they may be subject to the compliance time schedule.

Boron

The boron water quality objective remained unchanged for both water years and only applied to two water bodies, Mud Slough (north) and Salt Slough. In addition, the objective (2.0 mg/L) is applied as a monthly mean for a set time period: 15 March through 15 September. A maximum objective of 5.8 mg/L boron applies year round.

Figure 14. Comparison of Selenium, Boron and Electrical Conductivity at Salt Slough and Mud Slough (North) Downstream of the San Luis Drain: Water Years 1996 and 1997.

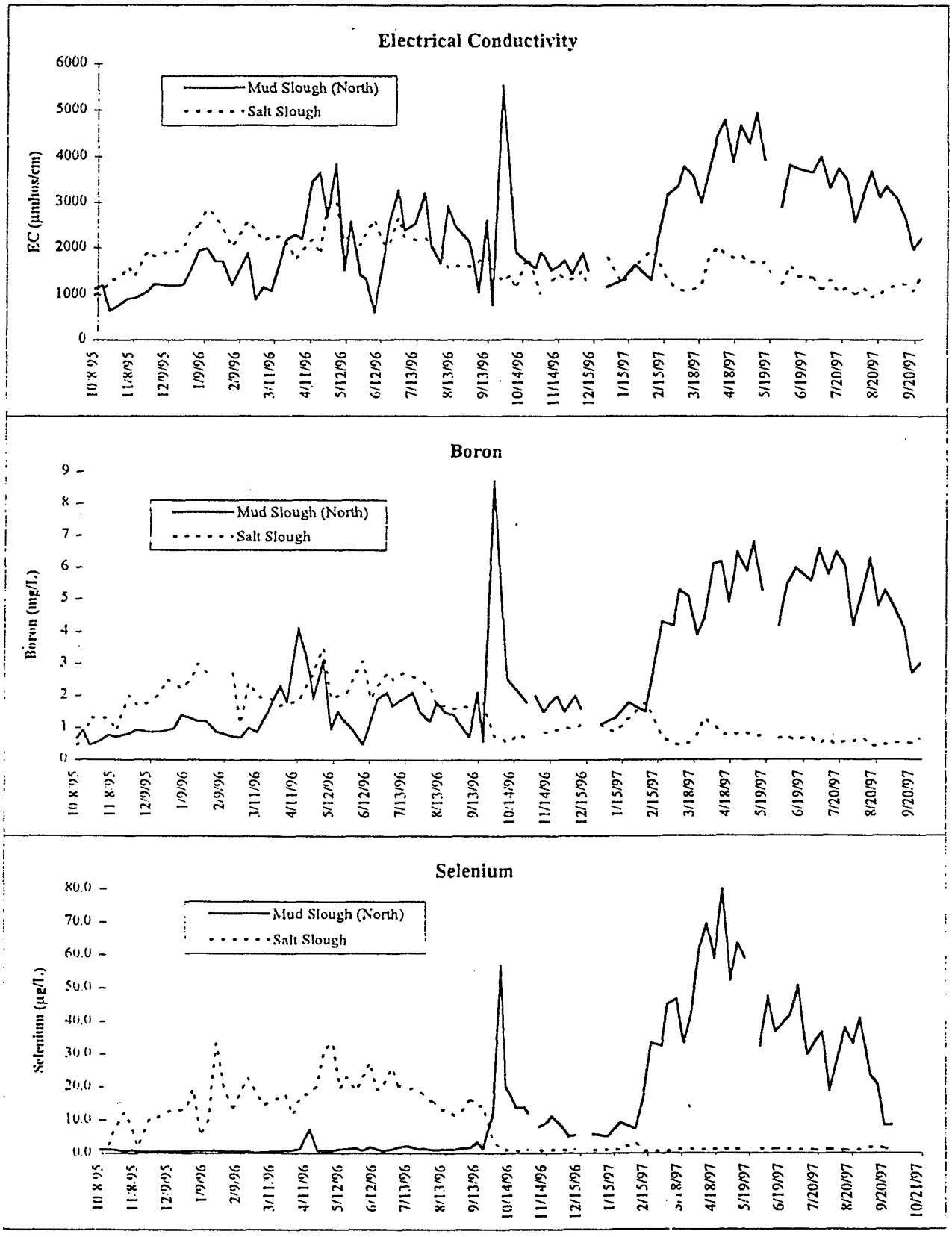


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Figure 15. Comparison of Selenium, Boron and Electrical Conductivity at Agatha Canal and Camp 13 Slough: Water Years 1996 and 1997.

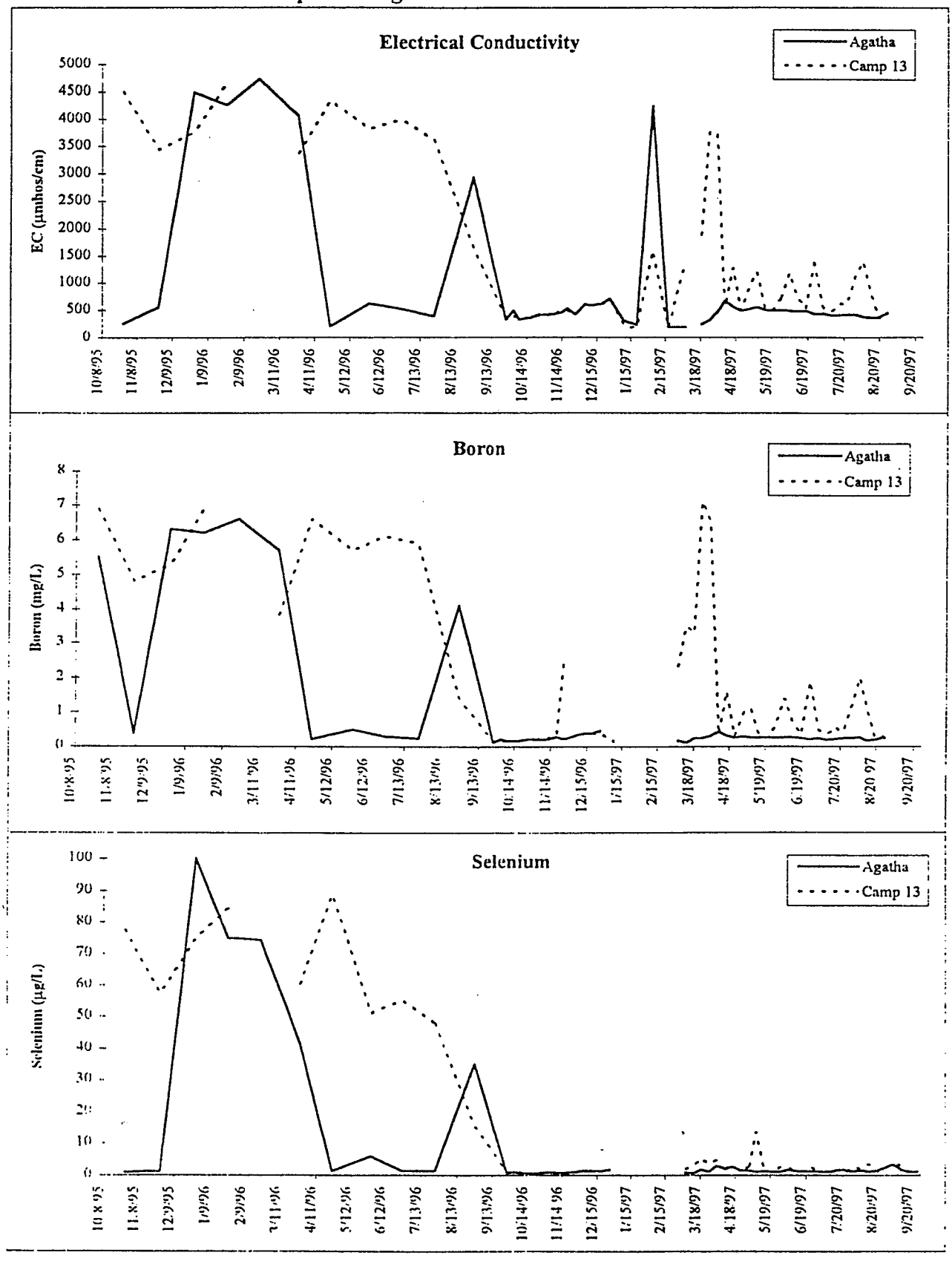

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Figure 16. Comparison of Selenium, Boron and Electrical Conductivity at San Luis Canal and Santa Fe Canal at Henry Miller Road: Water Years 1996 and 1997.

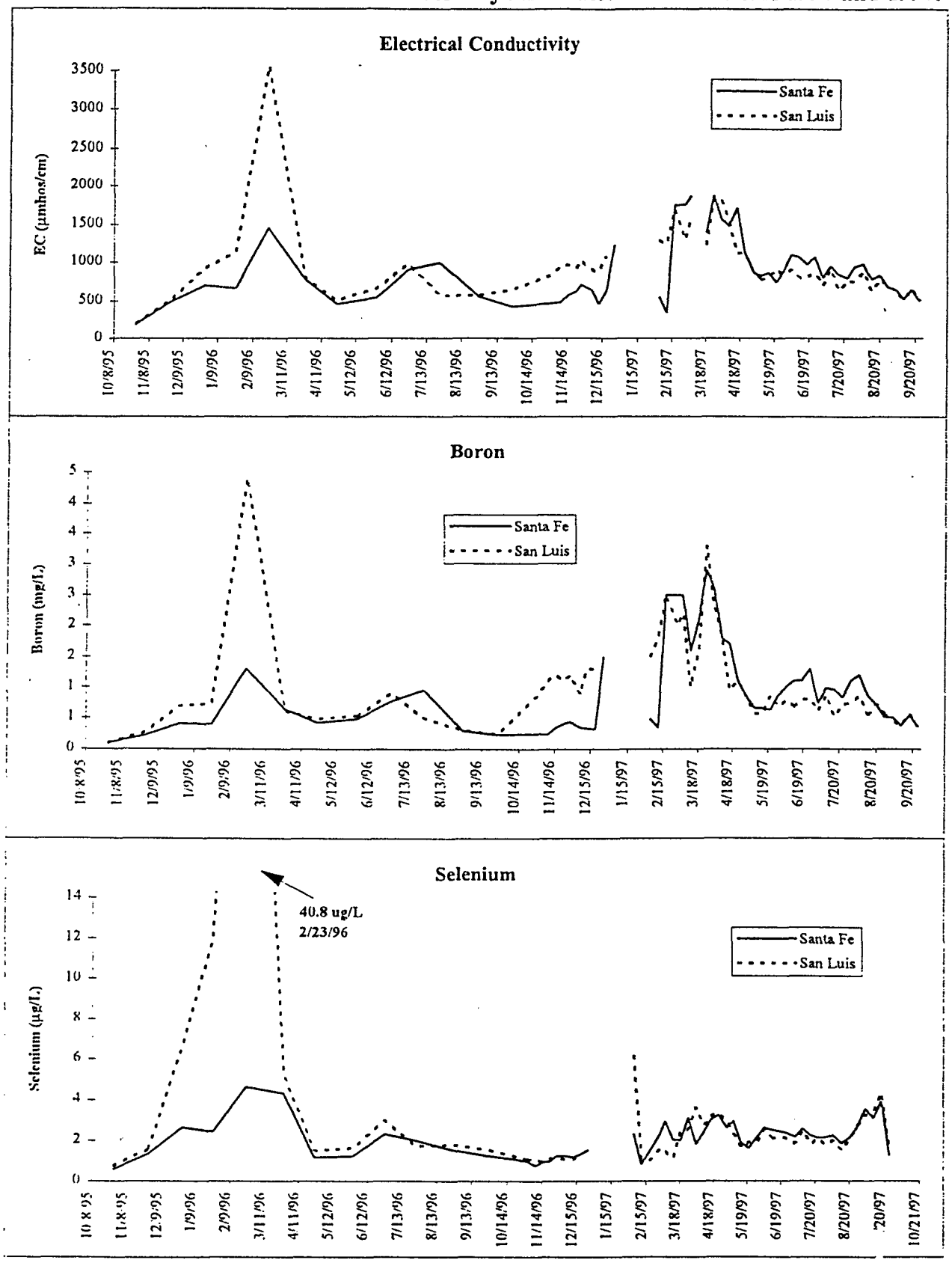

Table 16. Boron, Selenium and Molybdenum Water Quality Objectives for Water Bodies Within the Grassland Watershed. Water Years 1996 and 1997.

Water Body	Boron (mg/L)		Selenium (µg/L)		Molybdenum (µg/L)	
	Continuous	Maximum	Continuous	Maximum	Continuous	Maximum
Mud Slough (north)						
WY 1996	2.0 (monthly mean)†	5.8	10 (monthly mean)	26	19 (monthly mean)	50
WY 1997	2.0 (monthly mean)†	5.8	5 (4-day average)*	20	19 (monthly mean)	50
Salt Slough						
WY 1996	2.0 (monthly mean)†	5.8	10 (monthly mean)	26	19 (monthly mean)	50
WY 1997	2.0 (monthly mean)†	5.8	2 (monthly mean)	20	19 (monthly mean)	50
Wetland Water Supply Channels						
WY 1996	—	—	2 (monthly mean)††	—	—	—
WY 1997	—	—	2 (monthly mean)	20	—	—

† = The water quality objective only applies from 15 March through 15 September
* = Compliance time schedule adopted and in effect until October 2010
†† = as measured in water used for wetland habitat maintenance

Table 17. Boron Water Quality Objective Exceedances in the Grassland Watershed: Water Years 1996 and 1997.

Station ID	Description	Month												Monthly WQO
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Water Year 1996														
MER542	Mud Slough (N) downstream of the SLD	a	a	a	a	a								2.0
MER531	Salt Slough at Lander Ave.	a	a	a	a	a								2.0
MER542	Mud Slough (N) at SLD autosampler	a	a	a	a	a								2.0
MER531	Salt Slough at Lander Avenue autosampler	a	a	a	a	a								2.0
Water Year 1997														
MER536	Mud Slough (N) upstrm of the Drainage Discharge	a	a	a	a	a								2.0
MER542	Mud Slough (N) dwnstrm of the Drainage Discharge	a	a	a	a	a								2.0
MER531	Salt Slough at Lander Avenue	a	a	a	a	a								2.0

= water quality objective exceedance

a = objective only applies 15 March through 15 September
WQO = water quality objective

Table 18. Selenium Water Quality Objective Exceedances in the Grassland Watershed: Water Years 1996 and 1997.

Station ID	Description	Month												Monthly WQO
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Water Year 1996														
MER505	Camp 13 Slough			b	b	b	b	b	b	b	b	b		2
MER506	Agatha Canal			b	b	b	b	b	b	b	b	b		2
MER543	San Luis Canal at Henry Miller Road			b	b	b	b	b	b	b	b	b		2
MER519	Santa Fe Canal at Henry Miller Road			b	b	b	b	b	b	b	b	b		2
MER551	Mud Slough (N) at Newman Gun Club													10
MER542	Mud Slough (N) at San Luis Drain													10
MER531	Salt Slough at Lander Avenue													10
MER542	Mud Slough (N) at SLD autosampler													10
MER531	Salt Slough at Lander Avenue autosampler													10
Water Year 1997														
MER505	Camp 13 Ditch				ND									2
MER506	Agatha Canal				ND	ND								2
MER543	San Luis Canal at Henry Miller Road	ND			ND									2
MER519	Santa Fe Canal at Henry Miller Road	ND			ND									2
MER551	Mud Slough (N) upstrm of the Drainage Discharge													5
MER542	Mud Slough (N) dwnstrm of the Drainage Discharge													5
MER531	Salt Slough at Lander Avenue													2

= water quality objective exceedance ND = no data available WQO = water quality objective

b = the 2 ug/L objective only applied to wetland water supply so applied to wetland floodup (Sept. through Nov.)

Note that Table 17 is for discussion only as a compliance time schedule applies to the 5 µg/L 4-day average Se water quality objective
Beginning WY97, *the 2 ug/L objective applied to stations MER531, MER505, MER506, MER543, and MER519*

Table 19. Monthly Molybdenum Concentrations and Water Quality Objective Exceedances in the Grassland Watershed: Water Years 1996 and 1997

Station ID	Description	Molybdenum Concentration (ug/L)												Monthly WQO
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Water Year 1996														
MER556	Main (Firebaugh) Drain at Russell Ave.	45	—	—	31	—	—	20	—	—	7	—	—	na
MER501	Panoche Drain at O'Banion Gauge Station	13	—	—	8	—	—	12	—	—	15	—	—	na
MER504	Hamburg Drain near Camp 13 Slough	7	—	—	7	—	—	5	—	—	4	—	—	na
MER502	Charleston Drain at CCID Main Canal	2	—	—	5	—	—	6	—	—	5	—	—	na
MER542	Mud Slough (N) downstream of the SLD	7	—	—	6	—	—	10	—	—	11	—	—	19
MER531	Salt Slough at Lander Ave.	6	—	—	9	—	—	9	—	—	10	—	—	19
Water Year 1997														
MER536	Mud Slough (N) upstrm of the Drainage Discharge	7	—	3	3	—	7	11	5	7	3	5	10	19
MER535	San Luis Drain at the Terminus	35	30	23	22	27	29	26	23	26	25	25	35	na
MER542	Mud Slough (N) dwnstrm of the Drainage Discharge	11	8	3	6	*19*	17	*24*	17	*21*	16	*23*	*20*	19
MER531	Salt Slough at Lander Avenue	4	4	7	7	7	7	10	6	9	5	5	9	19

= water quality objective exceedance — = no data available na = no water quality objective (WQO) for this site

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During Water Year 1996, the mean monthly boron water quality objective was exceeded during April and September in Mud Slough (north) based on weekly grab samples. However, when evaluated using 4-day composite data for the same site, monthly mean boron concentrations remained below the 2.0 mg/L objective. In contrast, the boron objective was exceeded continuously from April through July in Salt Slough, based on the weekly grab samples. Review of the 4-day composite information indicates that the objective was also exceeded in March 1996, but concentrations fell just below 2.0 mg/L in April. Maximum boron concentrations remained below 5.8 mg/L in both sloughs.

During Water Year 1997, the mean monthly boron objective was exceeded in Mud Slough (north) both upstream and downstream of the San Luis Drain discharge. The exceedances upstream of the discharge may be due to a number of factors including localized elevated levels in groundwater seepage, releases from wetlands, and other surface drainage. Exceedances in the slough downstream of the discharge increased substantially over both background and previous year concentrations, with exceedances during each month that the water quality objective applied. Maximum boron concentrations in Mud Slough (north) downstream of the San Luis Drain discharge exceeded 5.8 mg/L on nine separate occations between April and August 1997. Only one mean monthly boron exceedance was recorded in Salt Slough which may reflect the diversion of subsurface agricultural drainage out of that water body. This exceedance was related to the storm event previously discussed. All measured concentrations in Salt Slough remained below 5.8 mg/L during Water Year 1997.

Selenium

Selenium water quality objectives for water bodies within the Grassland Watershed changed between water years 1996 and 1997 with the adoption of the 1996 Basin Plan Amendment. During Water Year 1996, a 10 µg/L monthly mean selenium objective applied to both Mud Slough (north) and Salt Slough, while a 2 µg/L objective applied to water which was used to maintain wetland habitat. The new objectives, which were adopted in May 1996 and went into effect during Water Year 1997, included a 2 µg/L monthly mean selenium objective for all wetland water supply channels (not just the supply water) and Salt Slough. A 5 µg/L, 4-day average objective was adopted for Mud Slough (north) along with a compliance time schedule which requires that the objective be met by 1 October 2010.

During Water Year 1996, the 2 µg/L selenium objective applied primarily from September through November, the normal period of wetland floodup. Of the supply waters sampled, only Camp 13 exceeded the 2 µg/L objective. The exceedances occurred during October and November and were likely due to the use of the channel to convey subsurface agricultural drainage through the Grassland Watershed. Most of the subsurface drainage was routed to Salt Slough during Water Year 1996, which resulted in continuous exceedances of the 10 µg/L selenium objective in that water body from December through September. Available 4-day composite data for Salt Slough confirmed the exceedances. In contrast, Mud Slough (north) remained below the 10 µg/L selenium objective throughout Water Year 1996.

During Water Year 1997, the 2.0 µg/L monthly mean selenium water quality objective was exceeded repeatedly in the supply channels (Camp 13, Agatha, San Luis Canal and Santa Fe Canal), but not in Salt Slough. As discussed earlier, a number of factors may have led to these exceedances and each must be further evaluated to determine a means of meeting the water quality objective.

Although subject to the adopted compliance time schedule, Mud Slough (north) was evaluated against the 5 µg/L, 4-day average selenium water quality objective. Mud Slough (north) downstream of the San Luis Drain Discharge continuously exceeded the objective in Water Year 1997, while there were no exceedances upstream of the discharge.

Molybdenum

Molybdenum analyses in water bodies within the Grassland Watershed were restricted to quarterly analyses in selected drains, Mud Slough (north) and Salt Slough during Water Year 1996. During Water Year 1997, molybdenum monitoring was focused on sites which would likely be influenced by the Grassland Bypass Project and included monthly analyses in Mud Slough (north) upstream and

downstream of the San Luis Drain discharge, the San Luis Drain itself, and Salt Slough. Available data is presented in Table 19.

During Water Year 1996, the monthly mean molybdenum objective (19 µg/L) only applied to Mud Slough (north) and Salt Slough, and was not exceeded based on limited, quarterly grab samples. Although the objective did not apply to upstream water bodies, information collected from the four major discharge points for the Drainage Project Area indicated elevated molybdenum concentrations in the Main (Firebaugh) Drain.

During Water Year 1997, molybdenum concentrations in Mud Slough (north) upstream of the San Luis Drain discharge and in Salt Slough resembled those recorded in Water Year 1996 and did not exceed the 19 µg/L objective. While no objective applied to the drain itself, molybdenum concentrations in the discharge were elevated, ranging from 22 µg/L to 35 µg/L. This discharge did impact the water quality in the downstream segment of Mud Slough (north), elevating molybdenum concentrations over background (upstream) concentrations. The 19 µg/L molybdenum objective was exceeded on five separate occasions at the downstream location: in February, April, June, August and September.

LOADS OF SALT, BORON AND SELENIUM

Salt, boron, and selenium loads for the Drainage Project Area (DPA), Grassland Bypass Project (GBP), and the Grassland Watershed were estimated based upon the flow weighted monthly average of the available water quality data. In Water Year 1997, loads that previously had to be summed for individual sites in the DPA were consolidated into the San Luis Drain as part of the GBP. Discharge and loads from the DPA for Water Year 1997 are therefore based on discharge and loads from the GBP. Discharge data for the DPA obtained for the individual water districts was provided by Joe McGahan (personal communication). Discharge and electrical conductivity data for the Grassland Bypass Project was obtained from the USBR (Nigel Quinn, personal communication). Preliminary daily discharge data and daily electrical conductivity for the two Grassland Watershed outflow sites, Mud Slough (north) and Salt Slough, were obtained from the USGS (Pat Shiffer, personal communication). Salt loads for the GBP and the Grassland Watershed sites are based upon daily electrical conductivity and flow measurements. Salt loads for the DPA are based upon laboratory measurement of electrical conductivity for grab samples and automatic Sigma™ samples collected by Regional Board staff. Boron and selenium loads are also based upon combined grab and automatic Sigma™ automatic sample data for the DPA and GBP sites. Only grab samples were collected and used for the Grassland Watershed sites, during Water Year 1997. The methodology used to calculate loads can be found Grober et al., 1998. Raw data used to present loads have been tabulated and are available in hard copy from the Regional Board's Sacramento office. This information can also be found at the Regional Board web site. Follow the links to view or download files from:

http://www.swrcb.ca.gov/ ~rwqcb5/home.html

The tabulated flow and water quality data used to compute loads for Water Years 1986 through 1997 are presented chronologically. Each year of data is comprised of four data tables; the first table contains mean daily flow data; the second, third and fourth contain electrical conductivity (EC), boron and selenium data, respectively. Additionally, EC, boron, and selenium data are presented for five Sigma™ automatic sampler sites for Water Years 1995, 1996 and 1997. Matrices are sparsely filled for some water quality data.

For Water Year 1996, mean daily flow data is available for Panoche Drain and Firebaugh Main Drain. Only mean monthly flow data is available for Pacheco Drain, Charleston Drain, and CCID diversions. Full matrices of mean daily flows for these sites are based on mean monthly flow estimates (Summers Engineering, Inc., 1996). Flow data for the Grassland Bypass Project for Water Year 1997 was obtained from the USBR (Nigel Quinn, personal communication). Mean daily flow for Mud Slough (north), and Salt Slough for Water Years 1996 and 1997 were obtained from the United States Geological Survey (Pat Shiffer, personal communication, 1997).

EC data for drains in the DPA are based on water quality samples collected by the Regional Board and by districts in the DPA. Mean daily EC data for the GBP was obtained from continuous EC recorders maintained by the USBR (Nigel Quinn, personal communication). EC data for Mud Slough (north). and Salt Slough are mean daily values obtained from continuous EC recorders maintained by the USGS (Pat Shiffer, personal communication, 1997). Consolidated boron and selenium concentration data presented here are from samples collected and analyzed by the Regional Board.

Monthly discharge and monthly flow weighted average concentrations and loads for the DPA were calculated for Water Year 1996 and 1997 (Table 20). Monthly discharge and monthly flow weighted average concentrations and loads for 1996 and 1997 for the Grassland Watershed are based on the combined discharge and loads for Mud Slough (north) and Salt Slough (Table 21). Annual discharge from the DPA dropped 30 percent from approximately 53,000 acre-feet in 1996 to approximately 37.500 acre-feet in 1997. Annual salt load for the DPA also dropped 30 percent from just under 200.000 tons in 1996 to 140,000 tons in 1997. Boron loads were practically identical for both years at just over 700.000 pounds. Selenium loads from the DPA dropped 30 percent from approximately 10.000 pounds in Water Year 1996, to under 7,000 pounds in Water Year 1997.

Annual discharge in the Grassland Watershed was similar in both years, increasing slightly from approximately 270.000 acre-feet in 1996 to approximately 290.000 acre-feet in 1997. Annual salt load for the Grassland Watershed was similar for both years, dropping from just over 475.000 tons to just under 450.000 tons, while boron loads increased from approximately 1.3 million pounds to 1.4 million pounds between 1996 and 1997. Selenium loads dropped almost 20 percent, from 9,500 pounds in 1996 to 7.700 pounds in 1997. Although the DPA contributes large quantities of salt and boron, it is not the only source of these constituents in the basin. The DPA is, however, the primary source of selenium in the Grassland Watershed. A higher selenium load was in fact calculated for the DPA than the Grassland Watershed in Water Year 1996. This discrepancy may be due to losses in the system or an overestimate of loads from the DPA or underestimates for the Grassland Watershed. For a full discussion of possible calculation errors or system losses see Grober et al. 1998. In 1997, the DPA accounted for 90 percent of the selenium load in the Grassland Watershed.

Monthly loads of salt for the DPA and Grassland Watershed are shown in Figure 17. Figures 18 and 19 show the monthly loads of boron and selenium, respectively. The overall pattern of loading for each area was similar in Water Years 1996 to 1997. Monthly salt loads from the DPA were higher in 1996 than 1997 for all months except January. Similarly, salt loads were also higher for the February through September period of 1996 than 1997 in the Grassland Watershed. Salt loads in the Grassland Watershed were higher during the October through January period of 1997 than 1996, particularly in January. This January peak in salt loads in the Grassland Watershed is attributable to extremely high flood flows. January to May boron loads from the GBP were slightly higher in 1997 than 1996. From June through September, boron loads were slightly lower in 1997. A similar trend is evident downstream for the Grassland Watershed, although boron loads were slightly higher in the October to December period of 1997. Once again there was markedly higher boron loading during the extremely wet January of 1997 when compared to 1996. Selenium loads from the DPA were higher for all months of 1996 than 1997 except for April. Selenium loads in the Grassland Watershed were also higher for all months of 1996 than 1997 except for October, January, April, and May.

Figure 20 shows the annual discharge for the combined Grassland Watershed outflow sites, Mud Slough (north) and Salt Slough, and for the DPA, for Water Years 1985 through 1997. Figures 21 through 23 depict the annual salt, boron, and selenium loads from the two areas for the same time period. Discharge for the DPA and Grassland Watershed for Water Years 1996 and 1997 was similar to Water Year 1995, another wet year, but significantly higher than 1991 through 1994. Water Year 1995 was the first wet year following several dry and critically dry years. High loads of all constituents in 1995 likely resulted from the leaching of salts that had accumulated in the basin during previous years. Generally lower loads of all constituents in 1996 and 1997 was likely due to lower residual salt loads in the Grassland Watershed following a series of wet years. Markedly lower selenium loads from the DPA are also attributable to district recycling and other water conservation and drainage reduction methods that were initiated in 1997 to reduce selenium loads as part of the Grassland Bypass Project.

Table 20. Monthly and Annual Discharge and Salt, Boron and Selenium Loads and Flow Weighted Concentrations for the Drainage Project Area: Water Years 1996 and 1997.

Water Year 1996		Loads			Flow Weighted Conc.		
Month	Flow (af)	Se (lbs)	B (1000 lbs)	TDS (tons)	Se (ppb)	B (ppm)	TDS (ppm)
Oct-95	1,911	313	27	6,346	60.2	5.12	2,442
Nov-95	2,192	324	29	7,017	54.3	4.87	2,354
Dec-95	2,586	578	35	9,053	82.2	4.98	2,575
Jan-96	2,647	687	44	11,148	95.4	6.10	3,097
Feb-96	5,664	1,247	78	25,872	80.9	5.09	3,359
Mar-96	4,620	1,324	67	21,107	105.4	5.32	3,359
Apr-96	4,641	1,243	73	19,431	98.5	5.81	3,079
May-96	5,626	1,145	76	22,050	74.8	4.98	2,882
Jun-96	6,825	977	89	23,387	52.6	4.78	2,520
Jul-96	6,671	992	90	23,147	54.7	4.96	2,551
Aug-96	6,339	747	74	18,758	43.3	4.32	2,176
Sep-96	3,255	459	41	10,210	51.8	4.63	2,307
WY 96 Total	52,978	10,034	723	197,526	69.6	5.02	2,742

Water Year 1997		Loads			Flow Weighted Conc.		
Month	Flow (af)	Se (lbs)	B (1000 lbs)	TDS (tons)	Se (ppb)	B (ppm)	TDS (ppm)
Oct-96	1,276	202	25	4,247	58.3	7.10	2,448
Nov-96	1,569	252	29	5,066	59.0	6.73	2,375
Dec-96	1,946	285	38	6,718	53.9	7.18	2,539
Jan-97	3,702	599	65	12,926	59.5	6.47	2,568
Feb-97	4,172	878	89	17,139	77.3	7.80	3,021
Mar-97	4,875	1,119	93	19,191	84.4	6.98	2,895
Apr-97	4,452	1,280	89	18,886	105.7	7.35	3,120
May-97	4,214	849	85	16,804	74.1	7.39	2,932
Jun-97	3,457	611	74	13,529	65.0	7.85	2,878
Jul-97	3,276	428	69	11,619	48.0	7.71	2,608
Aug-97	3,158	348	54	9,807	40.5	6.30	2,283
Sep-97	1,444	109	21	4,132	27.7	5.33	2,103
WY 97 Total	37,541	6,959	729	140,063	68.2	7.14	2,744

Table 21. Monthly and Annual Discharge and Salt, Boron and Selenium Loads and Flow Weighted Concentrations for the Grassland Watershed: Water Years 1996 and 1997.

Water Year 1996		Loads			Flow Weighted Conc.		
Month	Flow (af)	Se (lbs)	B (1000 lbs)	TDS (tons)	Se (ppb)	B (ppm)	TDS (ppm)
Oct-95	13821	248	40	15696	6.6	1.05	835
Nov-95	15894	319	56	22450	7.4	1.30	1039
Dec-95	22033	538	94	36391	9.0	1.56	1215
Jan-96	17621	625	97	37333	13.0	2.03	1558
Feb-96	47067	1466	210	80753	11.5	1.64	1262
Mar-96	43499	1451	215	83854	12.3	1.81	1418
Apr-96	19991	911	109	40429	16.7	2.00	1487
May-96	17007	851	88	31194	18.4	1.91	1349
Jun-96	17365	906	109	38354	19.2	2.30	1624
Jul-96	18650	956	123	36708	18.8	2.42	1447
Aug-96	21074	749	94	34444	13.1	1.65	1202
Sep-96	13927	470	66	20120	12.4	1.74	1062
WY 96 Total	267948	9491	1299	477725	13.0	1.78	1311

Water Year 1997		Loads			Flow Weighted Conc.		
Month	Flow (af)	Se (lbs)	B (1000 lbs)	TDS (tons)	Se (ppb)	B (ppm)	TDS (ppm)
Oct-96	13566	279	52	18084	7.6	1.42	980
Nov-96	23296	302	82	29742	4.8	1.30	939
Dec-96	31885	355	112	43003	4.1	1.30	992
Jan-97	59661	833	214	80247	5.1	1.32	989
Feb-97	40336	1055	211	69194	9.6	1.92	1261
Mar-97	32632	1169	180	57205	13.2	2.03	1289
Apr-97	15999	1205	126	39133	27.7	2.91	1799
May-97	16225	859	110	30740	19.5	2.49	1393
Jun-97	14030	586	93	26449	15.4	2.44	1386
Jul-97	15410	504	99	23926	12.0	2.37	1142
Aug-97	16021	437	80	20405	10.0	1.83	937
Sep-97	9193	138	35	10219	5.5	1.41	817
WY 97 Total	288253	7722	1396	448347	9.8	1.78	1144

Figure 17. Monthly Salt Loads Discharged from the Drainage Project Area and the Grassland Watershed, Water Years 1996 and 1997

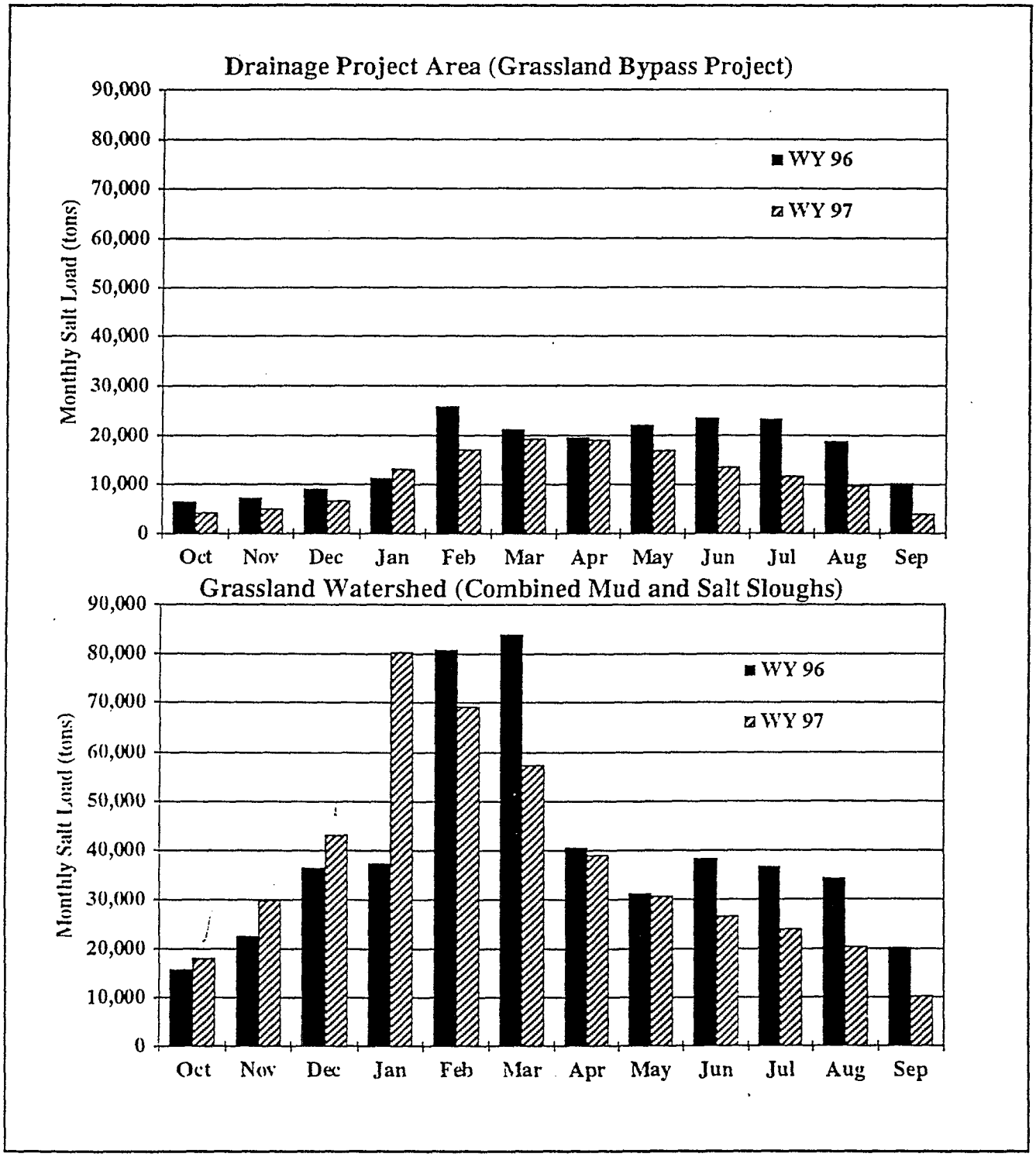

Figure 18. Monthly Boron Loads Discharged from the Drainage Project Area and the Grassland Watershed, Water Years 1996 and 1997

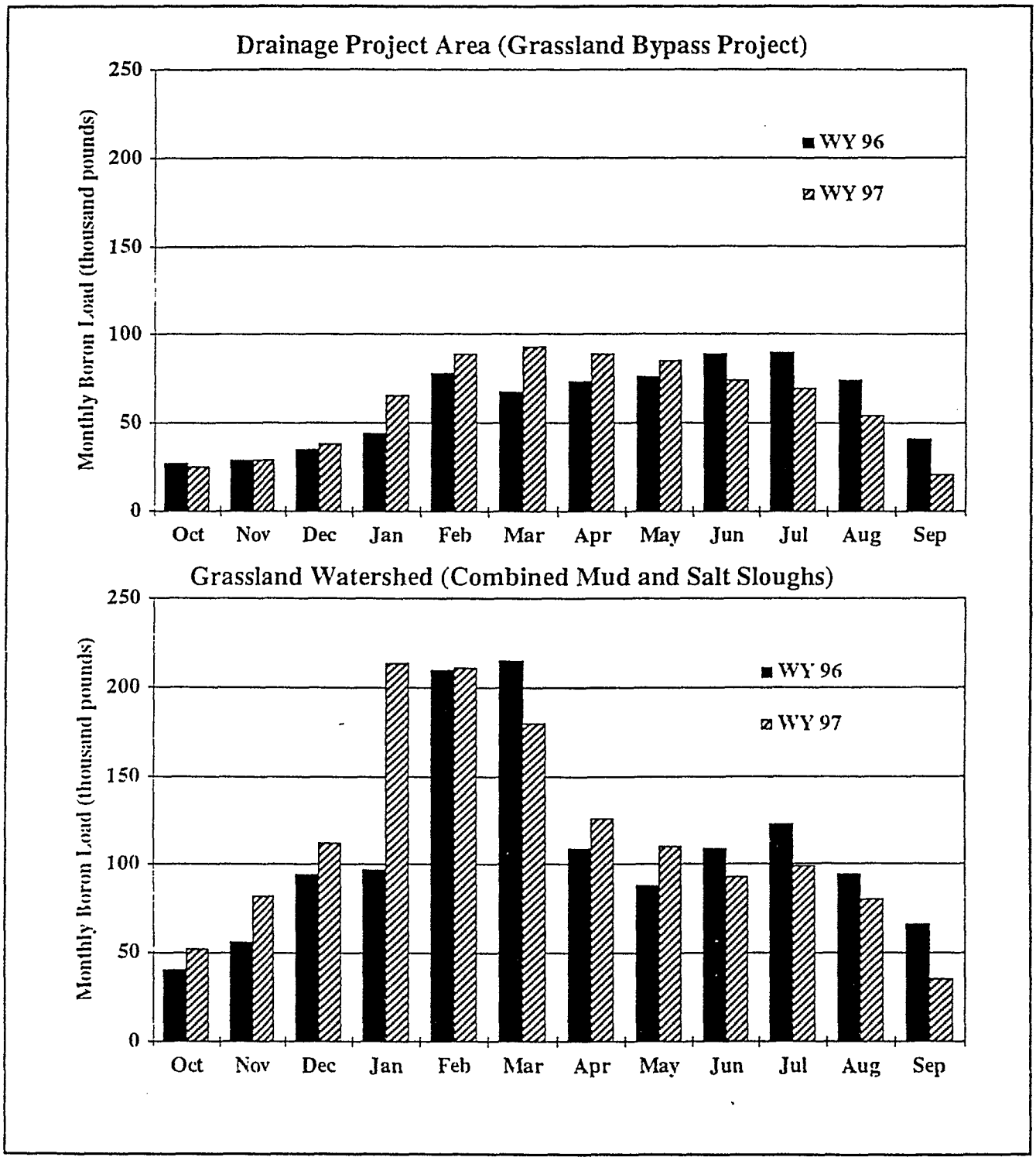

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Figure 19. Monthly Selenium Loads Discharged from the Drainage Project Area and the Grassland Watershed, Water Years 1996 and 1997

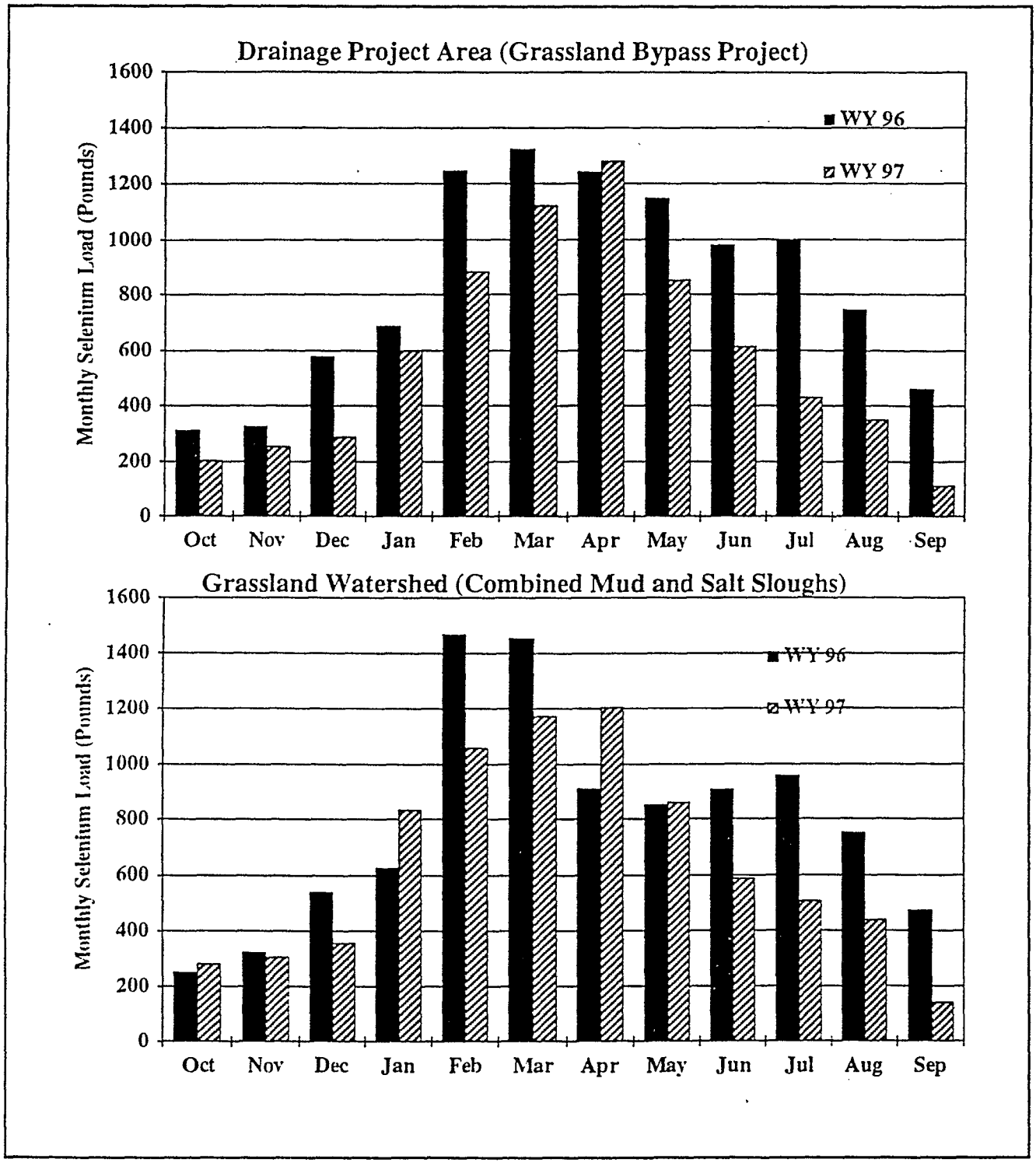

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Figure 20. Annual Discharge from the Drainage Project Area and the Grassland Watershed, Water Years 1986 through 1997

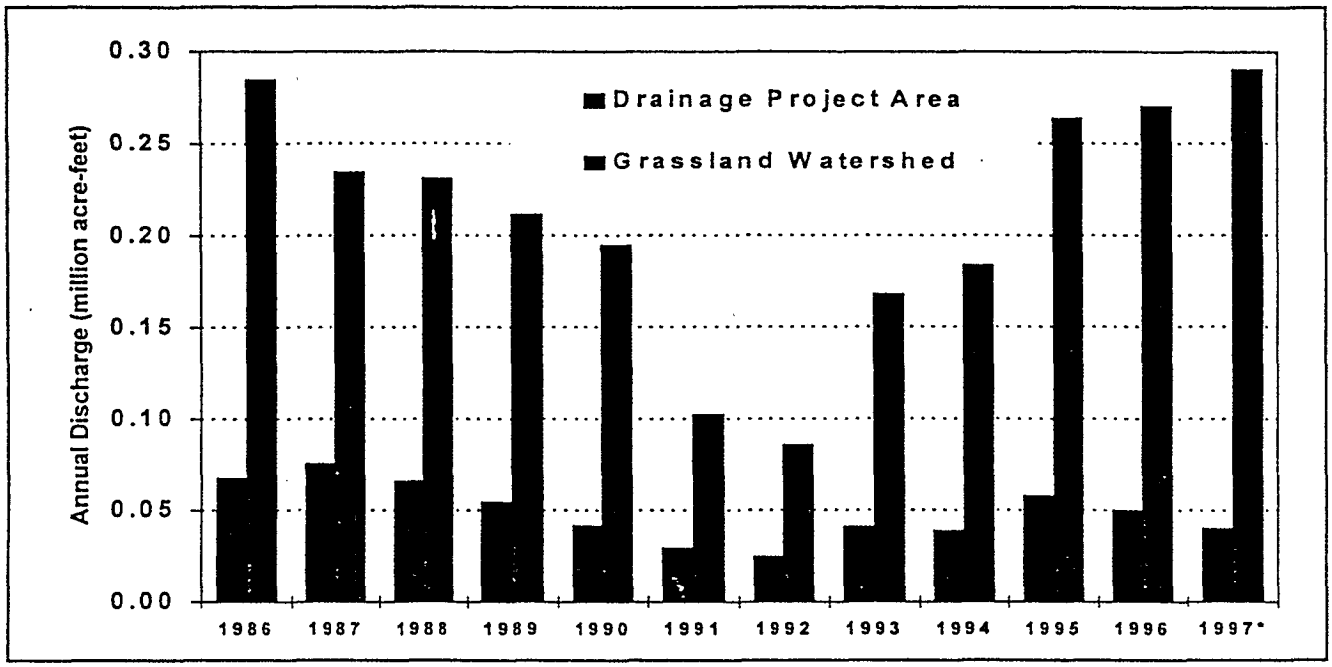


Figure 21. Annual Salt Load from the Drainage Project Area and the Grassland Watershed, Water Years 1986 through 1997

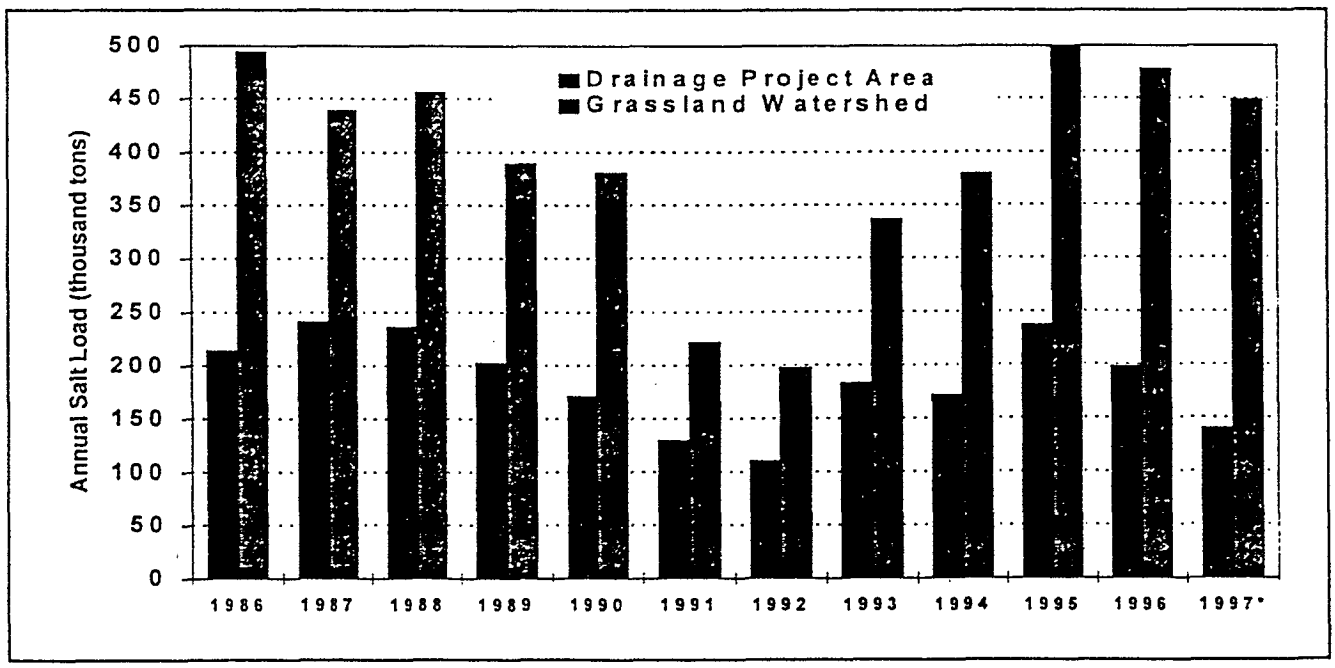


Figure 22. Annual Boron Load from the Drainage Project Area and the Grassland Watershed, Water Years 1986 through 1997

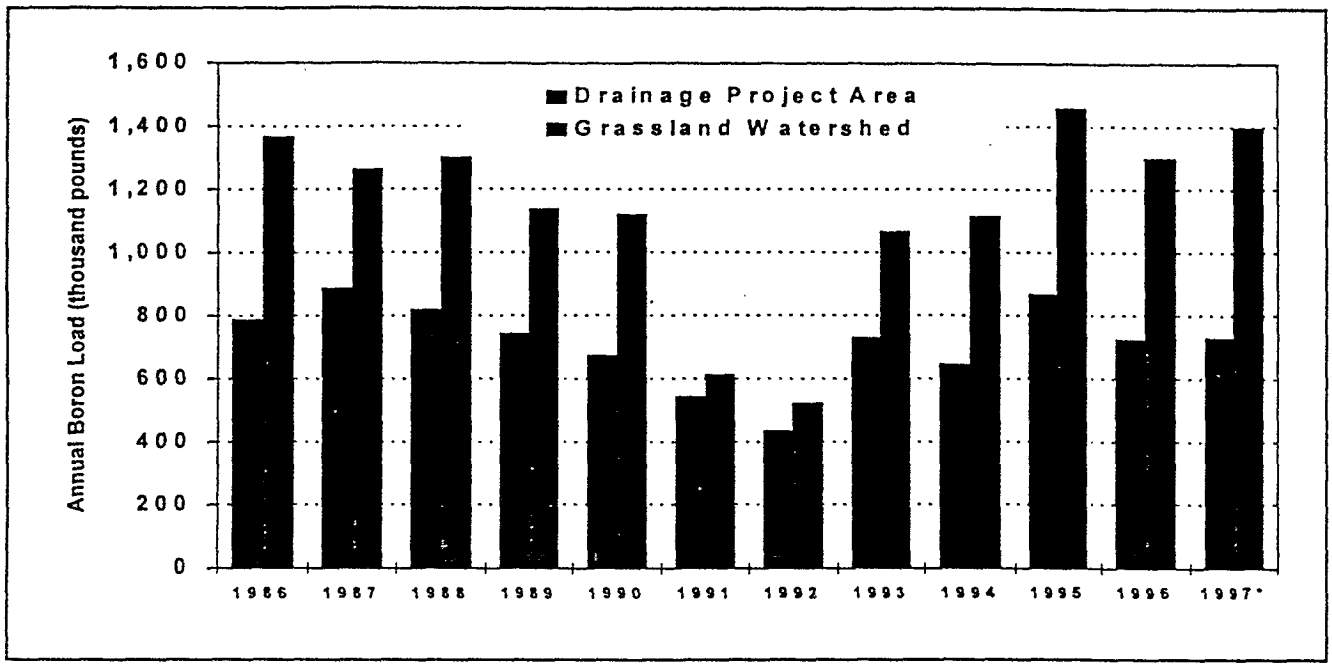
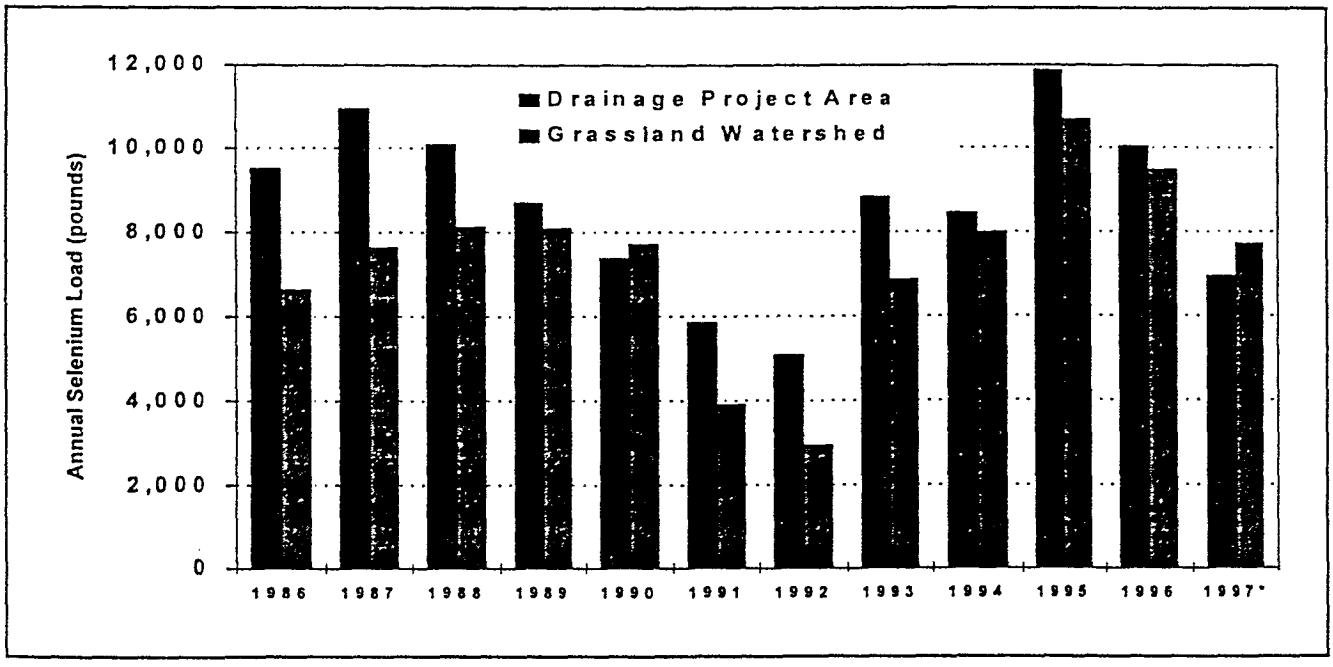


Figure 23. Annual Selenium Load from the Drainage Project Area and the Grassland Watershed, Water Years 1986 through 1997



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APPENDIX A

Water Quality Data for Grab Samples: Water Year 1996

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Legend of Abbreviations

EC	Electrical Conductivity
Se	Selenium
Mo	Molybdenum
Cr	Chromium
Cu	Copper
Ni	Nickel
Pb	Lead
Zn	Zinc
B	Boron
Cl	Chlorine
SO4	Sulfate
HDNS	Hardness

C-115065

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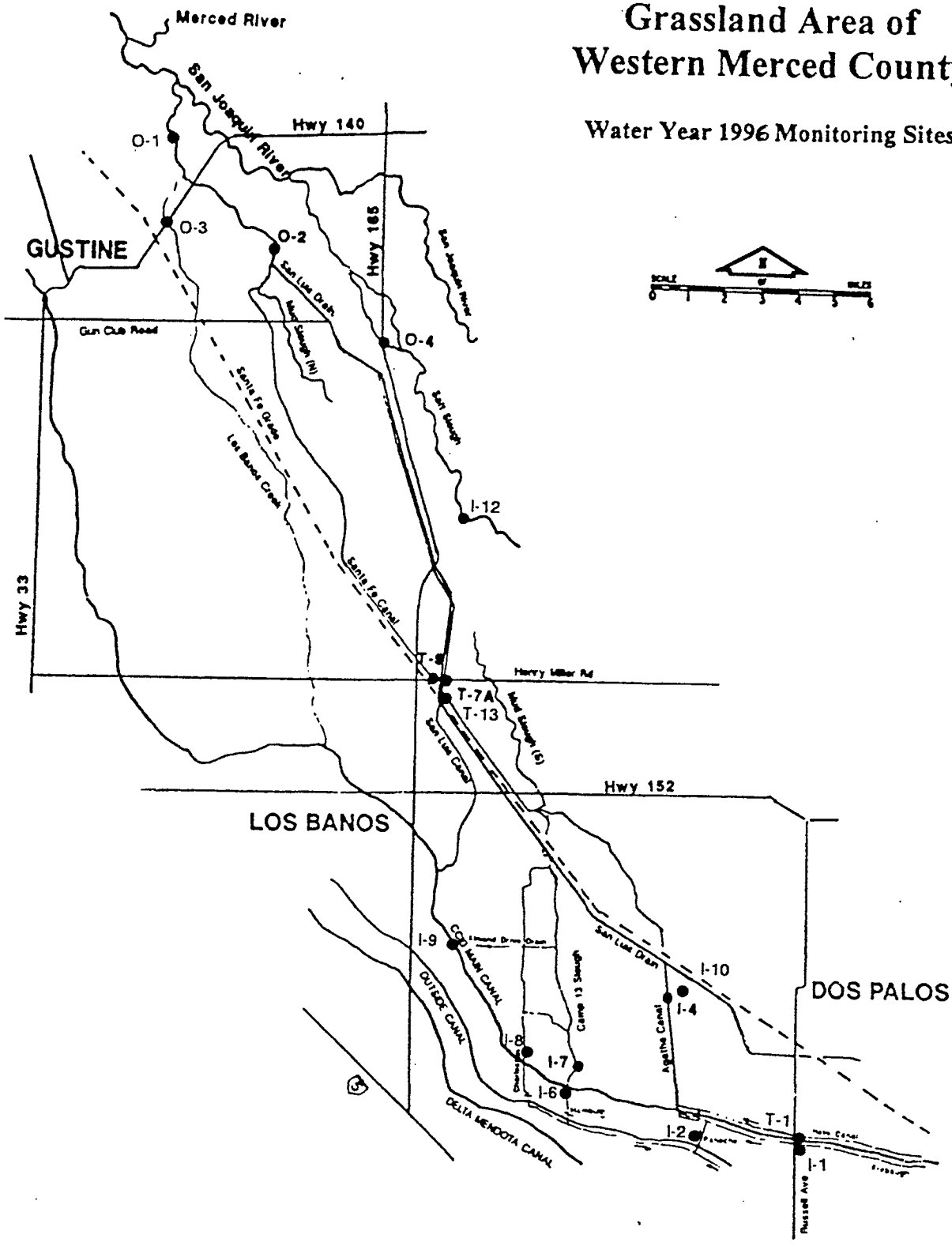
Figure A-1

Grassland Area of Western Merced County

Water Year 1996 Monitoring Sites



C-115067

C-115068

Main (Firebaugh) Drain at Russel Avenue (MER556)

Location: Latitude: 36°55'27", Longitude 120°39'11". In SW 1/4, SW 1/4, SW 1/4, Sec. 34, T.11S.,R.12E.
East side of Russel Avenue, 2.7 miles south of Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/6/95	815	64	7.6	3950	72.9		4.9					
10/12/95	803	64	7.5	1940	30.0		2.7					
10/18/95	812	64	7.8	2580	37.9		3.5					
10/27/95	1045	NA	8.0	4200	41.0	45	5.3	450	1600	1120	280	103
11/3/95	811	59	7.8	3280	40.2		4.2					
11/9/95	851	60	8.3	2220	27.1		2.9					
11/20/95	806	59	8.0	2410	29.4		3.2					
11/27/95	846	52	7.9	3320	57.8		4.7	290	1200	910	220	88
12/8/95	932	58	8.1	2590	52.2		3.1					
12/18/95	930	NA	8.0	3080	62.0		4.1					
12/22/95	850	48	8.1	3680	80.4		5.1					
12/28/95	1105	50	8.0	2720	52.8		3.4	240	980	NA	170	73
1/4/96	1020	50	8.3	6590	161		9.4					
1/11/96	908	52	8.4	3940	78.0		4.5					
1/18/96	1041	50	8.4	4490	114		5.2					
1/25/96	1029	52	7.9	3660	77.0	31	5.0	350	1200	720	180	67
2/2/96	948	56	7.9	3370	58.0		3.0					
2/9/96	NA	NA	NA	NA	NA		NA					
2/16/96	754	61	7.7	4680	89.6		4.5					
2/23/96	1001	56	7.9	4810	101		5.2	490	1700	950	234	88
3/1/96	926	52	8.1	6120	162		6.8					
3/8/96	910	60	8.3	4570	104		4.8					
3/18/96	1600	70	7.9	5380	138		6.1					
3/21/96	845	66	7.8	5610	146		5.8					
3/28/96	930	62	7.9	3960	108		4.6	450	1400	910	219	87
4/3/96	942	61	6.8	4610	120		5.1					
4/12/96	934	62	7.6	4110	96.6		4.5					
4/19/96	840	60	8.1	3220	74.2		3.8					
4/25/96	1000	66	8.1	3480	75.4	20	4.3	320	1200	770	187	74
5/3/96	828	69	7.7	4400	119		5.6					
5/10/96	910	63	7.9	3050	51.5		2.8					
5/16/96	1030	67	7.6	2560	44.0		2.4					
5/24/96	950	60	7.8	2750	42.8		3.3					
5/30/96	940	68	7.9	2820	50.2		3.2	260	870	650	156	62
6/6/96	1020	74	7.6	2640	35.6		3.3					
6/13/96	852	69	7.8	2220	30.4		2.7					
6/19/96	900	72	7.7	2640	37.7		3.5					
6/27/96	1040	68	7.8	3110	50.7		3.5	280	990	690	170	64
7/2/96	920	80	7.7	3320	60.4		3.7					
7/11/96	815	76	7.6	2870	44.1		3.8					
7/19/96	854	69	7.7	1910	23.0		2.6					
7/25/96	950	79	7.7	1990	27.2	7	2.6	160	620	460	110	46
8/2/96	940	76	8.1	2100	29.4		2.7					
8/8/96	950	74	7.4	1930	28.2		2.4					
8/15/96	830	78	7.7	2040	25.7		2.6					
8/23/96	849	72	7.9	1960	29.8		2.6					
8/28/96	1015	74	7.8	2310	30.2		2.5	200	650	460	100	51
9/5/96	931	68	7.8	2690	48.4		3.7					
9/12/96	1101	67	7.7	2650	44.0		3.5					
9/17/96	940	62	8.2	1940	28.1		2.5					
9/26/96	1120	68	7.7	2930	31.7		2.8	280	900	550	130	55
Count		48	50	50	50	4	50	12	12	11	12	12
Min		48	6.8	1910	23.0	7	2.4	160	620	460	100	46
Max		80	8.4	6590	162	45	9.4	490	1700	1120	280	103
Mean		64	7.8	3310	64.0	26	4.0	314	1109	745	180	72
Geo Mean		63	7.8	3130	54.8	21	3.8	299	1060	716	172	70
Median		64	7.8	3060	51.1	26	3.6	285	1095	720	175	70

Panoche Drain at O'Banion Gauge Station (MER501)

Location: Latitude 36°55'14", Longitude 120°41'43". In SW 1/4, SW 1/4, SW 1/4, Sec. 32, T.11S., R.12E. Located 0.5 miles south of CCID Main Canal, 1.9 miles west of Russel Road. 5.5 miles SW of Dos Palos. 3.4 miles SW of South Dos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/6/95	910	60	7.7	4390	19.7		7.3					
10/12/95	826	61	7.3	5380	26.2		9.3					
10/18/95	902	64	7.5	4920	80.6		8.2					
10/27/95	1110	NA	8.5	4990	104	13	7.8	680	1600	1180	300	105
11/3/95	847	60	7.9	3790	55.8		6.0					
11/9/95	905	60	8.1	4230	80.6		6.4					
11/20/95	853	58	7.9	3440	61.4		5.1					
11/27/95	858	52	8.0	3700	62.4		5.4	490	1100	1100	280	87
12/8/95	1010	58	7.9	3620	71.7		5.2					
12/18/95	NA	NA	NA	NA	NA		NA					
12/22/95	930	49	8.0	4430	103		8.1					
12/28/95	1121	54	8.7	5200	137		7.3	710	1700	NA	380	110
1/4/96	1040	52	7.7	5020	40.4		7.1					
1/11/96	923	52	8.0	5140	124		7.3					
1/18/96	1155	52	8.1	4450	104		6.4					
1/25/96	1059	52	7.7	4270	85.4	8	6.2	550	1200	950	270	70
2/2/96	1030	58	7.8	3940	62.0		5.0					
2/9/96	NA	NA	NA	NA	NA		NA					
2/16/96	NA	NA	NA	NA	NA		NA					
2/23/96	915	57	7.8	4810	75.4		7.0	600	1400	1100	300	77
3/1/96	1015	54	7.9	4810	89.2		7.6					
3/8/96	925	58	7.9	5250	106		3.8					
3/18/96	1635	73	7.9	3990	80.8		5.5					
3/21/96	900	62	NA	5210	117		8.0					
3/28/96	950	65	7.9	4950	62.6		9.0	730	1600	1200	325	93
4/3/96	950	62	7.2	5130	116		8.0					
4/12/96	1008	60	7.7	5330	86.6		8.4					
4/19/96	910	60	7.8	4890	115		8.6					
4/25/96	1025	66	8.0	5270	121	12	8.8	640	1600	1200	320	100
5/3/96	905	68	7.8	4920	102		9.4					
5/10/96	935	63	7.7	5110	85.6		6.6					
5/16/96	1110	66	7.8	4290	79.2		5.7					
5/24/96	1010	59	7.9	4760	83.5		7.8					
5/30/96	1010	68	7.9	5030	96.7		7.8	610	1500	1200	320	91
6/6/96	1120	80	7.8	4460	64.2		7.1					
6/13/96	907	68	7.8	4500	62.4		7.6					
6/19/96	840	68	7.4	4440	77.5		7.9					
6/27/96	1125	70	7.8	3980	65.8		6.5	470	1100	880	240	69
7/2/96	935	76	7.5	4160	63.0		7.0					
7/11/96	910	73	7.5	4620	66.6		8.0					
7/19/96	902	68	7.5	4340	60.2		6.9					
7/25/96	1035	80	7.8	4480	66.0	15	7.8	510	1300	1010	270	80
8/2/96	1000	74	7.8	4170	68.3		7.2					
8/8/96	1040	76	7.3	4060	61.0		6.2					
8/15/96	850	78	7.5	4080	60.4		6.3					
8/23/96	920	74	7.7	3610	46.0		6.2					
8/28/96	1035	78	7.9	4380	66.2		6.4	450	1200	780	190	74
9/5/96	1009	66	7.7	4150	72.7		7.1					
9/12/96	1110	66	7.7	3800	72.3		6.2					
9/17/96	1010	64	7.9	4050	94.9		7.0					
9/26/96	1130	70	7.8	5210	93.2		7.8	660	1500	950	233	89
	Count	47	47	48	48	4	48	12	12	11	12	12
	Min	49	7.2	3440	19.7	8	3.8	450	1100	780	190	69
	Max	80	8.7	5380	137	15	9.4	730	1700	1200	380	110
	Mean	64	7.8	4520	79.1	12	7.1	592	1400	1050	286	87
	Geo Mean	64	7.8	4490	74.7	12	7.0	584	1385	1040	281	86
	Median	64	7.8	4450	76.5	13	7.1	605	1450	1100	290	88

Agatha Canal at Mallard Road (MER506)

Location: Latitude: 36°56'12", Longitude 120°42'07". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R.11E.
South of Sante Fe Grade at Brito, west of Mallard Road. 4.5 miles west of Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B µg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	1135	NA	7.9	254	0.9	5.5	25	29	60	14	6
11/27/95	924	56	8.3	553	1.4	0.38	69	74	120	28	13
12/28/95	1144	54	8.8	4490	100	6.3	610	1400	NA	350	110
1/25/96	1125	56	7.8	4260	74.9	6.2	550	1200	910	250	71
2/23/96	1055	58	7.9	4730	74.3	6.6	540	1500	1100	295	84
3/28/96	1020	64	8.2	4070	41.7	5.7	580	1300	1000	260	85
4/25/96	1100	68	8.5	200	1.3	0.22	16	25	64	15	6.5
5/30/96	1100	68	8.5	622	5.8	0.50	63	120	140	32	15
6/27/96	1150	74	8.5	518	1.3	0.30	56	73	120	28	12
7/25/96	1056	82	8.6	382	1.4	0.23	38	48	100	24	9.9
8/28/96	1100	72	7.9	2930	35.0	4.1	280	800	550	130	55
9/26/96	1205	72	8.5	324	0.9	0.12	29	29	72	15	8.6
Count		11	12	12	12	12	12	12	11	12	12
Min		54	7.8	200	0.9	0.12	16	25	60	14	6
Max		82	8.8	4730	100	6.6	610	1500	1100	350	110
Mean		66	8.3	1944	28.2	3.0	238	550	385	120	40
Geo Mean		65	8.3	1016	7.0	1.2	110	186	207	59	23
Median		68	8.4	588	3.6	2.3	66	97	120	30	14

C-115071

C-115071

Hamburg Drain near Camp 13 Slough (MER504)

Location: Latitude: 36°56'20", Longitude 120°45'26". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E. 50 feet south of CCID main canal. 9.2 miles S-SE of Los Banos. 6.7 miles W-SW of South Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/6/95	755	64	8.1	479	2.0		0.32					
10/12/95	744	65	7.9	383	2.1		0.32					
10/18/95	753	62	6.8	5450	80.6		6.2					
10/27/95	910	NA	7.9	5500	79.7	7	6.5	870	1700	1800	540	109
11/3/95	753	58	7.1	5120	79.4		6.1					
11/9/95	833	58	7.6	3860	43.9		4.1					
11/20/95	750	59	7.9	3650	40.2		4.4					
11/27/95	810	52	8.1	3490	52.0		3.5	510	1000	1200	350	74
12/8/95	915	58	8.1	3760	36.8		5.0					
12/18/95	845	NA	7.9	4090	27.8		5.7					
12/22/95	825	48	8.1	3760	26.2		4.4					
12/28/95	1037	52	9.6	3360	22.3		3.3	410	1300	NA	470	62
1/4/96	910	47	8.1	3650	29.8		3.6					
1/11/96	843	48	8.1	3920	40.5		3.4					
1/18/96	1003	50	8.5	3480	27.2		3.3					
1/25/96	950	51	7.7	5790	100	7	6.0	880	1800	1700	520	100
2/2/96	825	62	7.4	5650	107		4.4					
2/9/96	945	59	7.7	5000	67.4		5.1					
2/16/96	NA	NA	NA	NA	NA		NA					
2/23/96	851	60	7.8	5960	93.6		5.9	870	1800	1700	530	102
3/1/96	910	59	7.8	6890	129		9.2					
3/8/96	855	52	8.3	3840	36.1		3.5					
3/18/96	1538	77	8.1	5590	96.4		5.9					
3/21/96	820	60	7.8	5540	106		5.2					
3/28/96	845	62	7.8	5480	110		5.4	780	1900	1900	560	120
4/3/96	919	60	6.9	5720	106		5.9					
4/12/96	914	58	6.9	4820	90.4		4.2					
4/19/96	820	59	8.1	3990	71.5		4.4					
4/25/96	915	63	7.5	5100	98.1	5	5.1	640	1700	1600	470	92
5/3/96	758	61	7.1	4620	85.0		5.4					
5/10/96	850	62	7.7	4790	76.2		4.0					
5/16/96	835	65	7.6	4550	66.2		4.3					
5/24/96	930	58	7.9	6040	116		6.8					
5/30/96	905	64	7.6	4580	57.8		5.7	620	1400	1300	390	90
6/6/96	1000	76	7.8	458	3.2		0.3					
6/13/96	835	68	7.9	3190	47.0		3.0					
6/19/96	845	68	7.3	4290	NA		4.7					
6/27/96	930	68	7.6	5530	63.6		7.7	700	1800	2000	620	100
7/2/96	905	72	6.4	5100	62.6		4.0					
7/11/96	800	69	7.2	4005	49.7		5.1					
7/19/96	840	66	6.8	4590	62.3		5.0					
7/25/96	840	74	7.6	3380	38.4	4	4.0	400	990	990	290	64
8/2/96	915	70	7.8	3960	46.4		4.7					
8/8/96	910	70	6.5	3180	38.6		3.4					
8/15/96	810	70	6.9	3330	38.4		4.1					
8/23/96	832	68	7.4	4390	60.6		4.9					
8/28/96	938	74	7.6	4480	48.2		4.6	590	1200	1000	260	88
9/5/96	915	62	6.9	5090	70.6		6.3					
9/12/96	1040	69	7.4	5340	47.8		9.7					
9/17/96	920	62	7.6	4000	33.3		6.2					
9/26/96	1050	72	8.5	446	1.5		0.24	45	59	93	21	10
Count		48	50	50	49	4	50	12	12	11	12	12
Min		47	6.4	383	1.5	4	0.24	45	59	93	21	10
Max		77	9.6	6890	129	7	9.7	880	1900	2000	620	120
Mean		62	7.7	4250	59.5	6	4.7	610	1387	1389	418	84
Geo Mean		62	7.6	3730	44.6	6	3.9	511	1124	1148	341	74
Median		62	7.7	4440	57.8	6	4.7	630	1550	1600	470	91

Camp 13 Slough at Gauge Station (MER505)

Location: Latitude 36°56'21", Longitude 120°45'22". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E. 150 feet north of CCID Main Canal, 6.4 miles west of Russel Avenue. 9.2 miles SE of Los Banos. 6.7 miles SW of South Dos Palos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	920	NA	8.3	4510	77.8	6.9	590	1500	1090	280	94
11/27/95	823	51	7.9	3440	57.4	4.8	440	1000	910	240	76
12/28/95	1044	50	8.9	3760	75.0	5.3	430	1300	NA	270	105
1/25/96	957	52	7.9	4660	84.6	6.9	570	1500	1030	270	89
2/23/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3/28/96	850	64	8.1	3360	60.1	3.8	420	1100	830	210	75
4/25/96	930	66	7.8	4340	88.8	6.6	NA	NA	1000	260	85
5/30/96	912	68	7.8	3830	51.1	5.7	440	1100	920	240	78
6/27/96	937	69	7.9	4000	55.2	6.1	450	1200	950	250	79
7/25/96	855	80	7.7	3630	48.2	5.9	400	1100	850	220	74
8/28/96	950	76	7.9	1650	15.4	1.4	190	350	350	88	32
9/26/96	1055	70	8.4	338	0.8	0.13	31	35	72	15	8.4
Count		10	11	11	11	11	10	10	10	11	11
Min		50	7.7	338	0.8	0.13	31	35	72	15	8
Max		80	8.9	4660	88.8	6.9	590	1500	1090	280	105
Mean		65	8.1	3411	55.9	4.9	396	1019	800	213	72
Geo Mean		64	8.1	2902	38.3	3.6	323	751	661	175	62
Median		67	7.9	3760	57.4	5.7	435	1100	915	240	78

Charleston Drain at CCID Main Canal (MER502)

Location: Latitude 36°56'59" Longitude 120°46'48". In NE 1/4, SE 1/4, NE 1/4, Sec. 29, T.11S., R.11E.
North Side of CCID Main Canal, 8.7 miles S-SE of Los Banos. 7.9 miles W-SW of South Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	CA mg/L	Mg mg/L
10/6/95	740	62	7.9	949	9.0		0.84					
10/12/95	732	64	7.9	553	4.2		0.48					
10/18/95	740	64	6.6	1160	11.6		1.0					
10/27/95	845	NA	7.6	1250	14.4	2	1.3	160	320	390	97	36
11/3/95	740	58	7.2	2140	26.4		2.2					
11/9/95	821	60	7.6	2180	27.2		2.0					
11/20/95	734	58	7.9	2210	24.8		2.0					
11/27/95	758	52	7.7	2110	25.1		1.9	280	570	680	190	50
12/8/95	850	58	7.4	2330	28.7		2.1					
12/18/95	830	NA	7.8	4800	77.1		4.7					
12/22/95	810	50	7.8	4950	79.2		4.9					
12/28/95	1025	52	8.4	5110	79.4		NA	700	1900	NA	460	99
1/4/96	900	52	7.3	5420	84.7		5 1					
1/11/96	833	52	7.5	5000	69.4		4.3					
1/18/96	951	52	7.7	5160	53.0		5.4					
1/25/96	936	52	7.4	4530	57.2	5	3.9	670	1300	1300	360	83
2/2/96	NA	NA	NA	NA	NA		NA					
2/9/96	935	60	7.4	6370	91.0		4.8					
2/16/96	NA	NA	NA	NA	NA		NA					
2/23/96	NA	NA	NA	NA	NA		NA	NA	NA	NA	NA	NA
3/1/96	NA	NA	NA	NA	NA		NA					
3/8/96	840	58	7.6	4810	72.9		4.0					
3/18/96	1529	71	8.0	5280	92.6		4.4					
3/21/96	805	60	NA	5080	81.6		4.2					
3/28/96	830	62	7.5	4320	69.2		3.6	560	1600	1400	430	90
4/3/96	909	59	6.0	5390	93.7		4.6					
4/12/96	900	58	5.4	5290	84.2		4.2					
4/19/96	755	58	8.1	3340	68.8		3.3					
4/25/96	900	62	6.7	5530	103	6	4.9	730	1800	1700	530	97
5/3/96	750	62	6.1	5300	98.2		5.0					
5/10/96	840	62	7.8	3960	59.8		2.9					
5/16/96	820	64	7.5	4400	60.3		4.4					
5/24/96	915	58	7.5	4890	81.3		4.4					
5/30/96	855	66	7.7	4180	69.2		3.4	470	1400	1200	370	68
6/6/96	945	72	7.2	2230	16.6		2.1					
6/13/96	818	66	7.4	4010	75.2		4.0					
6/19/96	830	70	6.8	3950	63.6		3.7					
6/27/96	920	68	7.5	3940	64.8		3.5	430	1400	1600	520	69
7/2/96	855	76	5.7	3340	46.6		2.6					
7/11/96	750	70	6.5	4300	81.5		4.6					
7/19/96	830	67	6.4	3740	61.3		3.4					
7/25/96	820	74	6.9	2780	43.0	5	2.3	290	890	800	240	48
8/2/96	900	71	7.0	3390	39.0		3.8					
8/8/96	855	70	5.8	2930	43.2		2.6					
8/15/96	800	74	6.0	2670	38.3		2.4					
8/23/96	825	73	7.2	2040	24.8		1.8					
8/28/96	920	71	7.2	2230	22.9		2.1	530	1000	530	130	49
9/5/96	903	64	6.7	2510	31.0		2.8					
9/12/96	1030	64	7.5	3730	47.2		3.8					
9/17/96	905	64	7.0	1860	20.1		1.8					
9/26/96	1040	68	7.9	1597	11.0		1.1	220	350	320	86	26
Count		45	46	47	47	4	46	11	11	10	11	11
Min		50	5.4	553	4.2	2	0.48	160	320	320	86	26
Max		76	8.4	6370	103	6	5.4	730	1900	1700	530	99
Mean		63	7.2	3600	53.8	5	3.2	458	1139	992	310	65
Geo Mean		62	7.2	3220	44.0	4	2.9	412	979	857	259	60
Median		62	7.4	3940	59.8	5	3.5	470	1300	1000	360	68

Almond Drive Drain (MER555)

Location: Latitude 36°59'55", Longitude 120°49'00". In SW 1/4, SW 1/4, SW 1/4, Sec. 6, T.11S., R.11E. North side of Almond Drive, 1.1 miles east of Mercy Springs Drain, 100 feet east of CCID Main Canal. 4.7 miles south of Los Banos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B µg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	830	NA	8.0	220	0.7	0.10	22	25	55	12	6
11/27/95	740	52	7.6	447							
12/28/95	957	52	8.1	2700							
1/25/96	915	51	7.8	1650	8.4	1.7	210	390	380	74	48
2/23/96	750	52	7.9	1690							
3/28/96	800	64	7.2	1100							
4/25/96	845	63	6.0	885	1.6	0.72	88	150	210	40	26
5/30/96	835	66	7.7	642							
6/27/96	850	68	7.8	965							
7/25/96	800	80	8.0	362	1.3	0.21	37	46	100	22	11
8/28/96	900	70	7.6	2230							
9/26/96	1030	70	8.3	402							
Count		11	12	12	4	4	4	4	4	4	4
Min		51	6.0	220	0.7	0.10	22	25	55	12	6
Max		80	8.3	2700	8.4	1.7	210	390	380	74	48
Mean		63	7.7	1108	3.0	0.68	89	153	186	37	23
Geo Mean		62	7.7	851	1.9	0.40	62	91	145	30	17
Median		64	7.8	925	1.5	0.47	63	98	155	31	19

C—115075

C-115075

Rice Drain at Mallard Road (MER509)

Location: Latitude 36°59'22" Longitude 120°42' 14". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R.11E.
South of Sante Fe Grade at Brito, 50 feet west of Mallard Road. 4.5 miles west of Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	1130	NA	7.8	3360	14.5	5.5	340	1100	630	140	68
11/27/95	931	53	7.8	2050							
12/28/95	1151	50	8.4	2540							
1/25/96	1135	52	8.2	6300	28.4	15	650	2300	1100	240	120
2/23/96	1105	57	7.8	4010							
3/28/96	1015	60	7.7	2500							
4/25/96	1050	67	8.4	2500	5.6	5.8	210	820	520	124	51
5/30/96	1105	69	7.7	3450							
6/27/96	1210	70	7.9	3180							
7/25/96	1110	80	7.9	2640	3.4	6.2	240	810	570	140	56
8/28/96	1110	71	7.7	2210							
9/26/96	1200	72	8.3	2430							
Count		11	12	12	4	4	4	4	4	4	4
Min		50	7.7	2050	3.4	5.5	210	810	520	124	51
Max		80	8.4	6300	28.4	15	650	2300	1100	240	120
Mean		64	8.0	3098	13.0	8.1	360	1257.5	705	161	74
Geo Mean		63	8.0	2947	9.4	7.4	325	1139	673	155	69
Median		67	7.9	2590	10.1	6.0	290	960	600	140	62

C-115076

C-115076

Salt Slough Ditch at Hereford Road (MER528)
Location: Latitude 37°08'30" Longitude 120°45'17". In NW 1/4, NE 1/4, NW 1/4, Sec. 22, T.9S., R.11E.
3.0 miles north on Hereford Road from Henry Miller Road.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	855	60	7.8	515	0.6	0.20	77	63	130	29	13
11/27/95	1105	54	8.1	735							
12/28/95	1254	54	8.5	1260							
1/25/96	1250	56	7.8	962	1.7	0.34	140	130	210	51	20
2/23/96	1206	58	7.7	898							
3/28/96	1155	66	7.6	741							
4/25/96	1235	70	7.9	1150	0.6	0.27	160	140	290	73	27
5/30/96	1229	70	7.4	642							
6/27/96	1345	74	8.1	951							
7/25/96	1235	84	7.8	708	1.0	0.26	87	76	190	45	18
8/28/96	1220	74	7.8	718							
9/26/96	955	70	8.0	746							
Count		12	12	12	4	4	4	4	4	4	4
Min		54	7.4	515	0.6	0.20	77	63	130	29	13
Max		84	8.5	1260	1.7	0.34	160	140	290	73	27
Mean		66	7.9	836	1.0	0.27	116	102	205	50	20
Geo Mean		65	7.9	811	0.9	0.26	111	97	197	47	19
Median		68	7.8	744	0.8	0.27	114	103	200	48	19

CCID Main at Russel Avenue (MER510)

Location: Latitude 36°55'28", Longitude 120°39'11". In SE 1/4, SE 1/4, SE 1/4, Sec. 33, T.11S., R.12E.
2.7 miles south of Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	1050	NA	8.4	243	1.1	0.12	25	27	62	13	7.2
11/27/95	840	56	8.6	372							
12/28/95	1103	50	7.8	889							
1/25/96	1023	51	8.2	1300	5.2	1.3	110	380	350	96	27
2/23/96	955	59	8.1	558							
3/28/96	930	62	8.4	608							
4/25/96	1000	66	8.8	56	<0.4	<0.05	2	1.8	25	5.1	2.9
5/30/96	930	70	8.1	595							
6/27/96	1005	72	8.5	NA							
7/25/96	920	82	8.3	228	0.7	0.42	21	19	110	26	12
8/28/96	1010	78	8.0	618							
9/26/96	1110	70	8.3	318							
Count		11	12	11	3	3	4	4	4	4	4
Min		50	7.8	56	<0.4	<0.05	2	2	25	5	3
Max		82	8.8	1300	5.2	1.3	110	380	350	96	27
Mean		65	8.3	526	2.3	0.61	40	107	137	35	12
Geo Mean		64	8.3	409	1.6	0.40	18	24	88	20	9
Median		66	8.3	558	1.1	0.42	23	23	86	20	10

Santa Fe Canal at Henry Miller Road (MER519)

Location: Latitude 37°05'59", Longitude 120°49'44". In NE 1/4, NE 1/4, Sec. 1, T.10S., R.10E. 0.3 miles east of Lander Avenue. 3.0 miles north of Gustine.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	755	60	7.6	188	0.6	0.10	20	20	49	10	5.8
11/27/95	1021	56	8.4	487	1.3	0.22	58	64	110	25	12
12/28/95	1220	52	8.9	696	2.7	0.41	86	120	NA	40	16
1/25/96	1200	54	8.4	659	2.4	0.40	75	100	150	36	15
2/23/96	1134	60	8.5	1450	4.7	1.3	180	340	310	73	30
3/28/96	1125	67	8.4	766	4.3	0.64	80	170	130	27	16
4/25/96	1135	70	8.1	456	1.2	0.43	41	73	110	21	14
5/30/96	1155	74	8.8	537	1.2	0.49	54	91	120	25	15
6/27/96	1250	82	8.7	900	2.3	0.77	97	160	220	46	25
7/25/96	1135	84	7.8	988	2.0	0.95	110	160	280	56	33
8/28/96	1138	76	8.0	556	1.5	0.30	58	70	120	24	15
9/26/96	920	69	8.5	421	1.3	0.23	42	50	93	19	11
Count		12	12	12	12	12	12	12	11	12	12
Min		52	7.6	188	0.6	0.10	20	20	49	10	6
Max		84	8.9	1450	4.7	1.3	180	340	310	73	33
Mean		67	8.3	675	2.1	0.52	75	118	154	34	17
Geo Mean		66	8.3	604	1.8	0.42	65	95	136	30	16
Median		68	8.4	608	1.8	0.42	67	96	120	26	15

C—115079

C-115079

San Luis Canal at Henry Miller Road (MER532)

Location: Latitude 37 06' 00" Longitude 120 49' 13". In SE 1/4, SW 1/4, SE 1/4, Section 36, T10s, R10E.

The site is 3 miles northeast of Los Banos at the Los Banos Wildlife Refuge.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	815	60	7.5	196	0.8	0.10	20	22	52	11	5.9
11/27/95	1031	56	8.3	507	1.6	0.27	61	69	120	26	13
12/28/95	1227	52	8.4	918	6.6	0.69	140	180	NA	54	19
1/25/96	1220	52	8.0	1120	12.0	0.73	130	230	280	76	22
2/23/96	1142	58	7.9	3560	40.8	4.4	400	1000	750	189	68
3/28/96	1130	66	8.0	790	5.3	0.61	80	190	140	28	17
4/25/96	1150	68	7.9	505	1.5	0.49	NA	NA	110	23	14
5/30/96	1205	70	7.8	660	1.6	0.54	74	100	160	33	18
6/27/96	1305	72	8.4	979	3.0	0.91	100	180	240	48	28
7/25/96	1153	84	7.9	565	1.8	0.50	57	83	160	32	20
8/28/96	1150	74	7.8	568	1.8	0.31	59	72	120	240	150
9/26/96	930	70	8.4	646	1.5	0.25	48	57	100	22	11
Count		12	12	12	12	12	11	11	11	12	12
Min		52	7.5	196	0.8	0.10	20	22	52	11	6
Max		84	8.4	3560	40.8	4.4	400	1000	750	240	150
Mean		65	8.0	918	6.5	0.82	106	198	203	65	32
Geo Mean		65	8.0	720	3.1	0.51	80	120	158	43	21
Median		67	8.0	653	1.8	0.52	74	100	140	33	19

Porter-Blake Bypass (MER548)

Location: Latitude 37°05'58.5", Longitude 120°49'14.5". In NW 1/4, Sec. 1, T.10S., R.10E. 7.5 miles east of the intersection of Henry Milller and Mercy Springs Roads. 2 miles north of Los Banos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	830	60	7.3	1738	26.6	2.3	210	500	370	94	34
11/27/95	1044	58	7.9	2200	23.9	2.8	250	620	600	150	56
12/28/95	1238	52	8.5	2600	33.2	3.6	310	750	NA	150	58
1/25/96	1235	56	7.8	3390	36.2	4.7	420	940	720	180	65
2/23/96	1152	58	7.8	3680	44.8	4.6	410	1100	760	194	68
3/28/96	1140	66	8.1	3300	34.6	4.1	390	970	730	180	71
4/25/96	1205	71	7.5	3800	66.3	5.3	NA	NA	870	228	73
5/30/96	1210	69	8.0	3310	48.5	4.7	390	930	820	220	66
6/27/96	1320	72	7.9	3480	44.9	4.9	370	1000	760	200	64
7/25/96	1215	84	7.8	3010	39.8	5.1	330	920	730	190	62
8/28/96	1200	74	7.9	2890	39.4	3.6	280	770	580	140	56
9/26/96	940	70	8.3	532	2.1	0.32	56	71	110	25	12
Count		12	12	12	12	12	11	11	11	12	12
Min		52	7.3	532	2.1	0.32	56	71	110	25	12
Max		84	8.5	3800	66.3	5.3	420	1100	870	228	73
Mean		66	7.9	2828	36.7	3.8	311	779	641	163	57
Geo Mean		65	7.9	2570	30.2	3.3	280	663	574	145	53
Median		68	7.9	3155	37.8	4.4	330	920	730	180	63

C-115081

C-115081

Mud Slough at Newman Gun Club (MER551)

Location: Latitude 37°18"33", Longitude 120°57'18". In NW 1/4, NW 1/4, SW 1/4, Sec. 23, T.7S., R.9E.
1.7 miles north of Santa Fe Grade, 1.2 miles north of Highway 140. 4.2 miles NE of Gustine.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	1430	NA	7.9	758	0.8	0.50	89	110	170	36	20
11/27/95	940	52	8.1	1130	0.7	0.78	150	160	220	41	28
12/28/95	1125	51	8.1	1650	0.8	1.1	230	270	290	52	39
1/25/96	950	46	7.9	1820	0.6	1.2	260	320	340	62	44
2/23/96	1010	47	7.8	1080	0.7	0.70	120	170	230	43	29
3/28/96	1050	62	7.7	1750	1.2	1.7	280	340	380	70	50
4/25/96	1140	66	8.1	3540	1.4	2.2	540	740	570	91	83
5/30/96	1045	72	7.9	1690	2.2	1.0	220	320	290	54	37
6/27/96	1110	70	8.4	3040	1.3	1.5	500	590	530	90	73
7/25/96	1130	85	8.6	2590	1.2	1.7	340	490	530	93	71
8/28/96	1141	78	8.1	2750	1.3	1.7	430	580	560	92	79
9/26/96	1105	70	7.4	5280	15.6	8.4	610	1800	950	200	110
Count		11	12	12	12	12	12	12	12	12	12
Min		46	7.4	758	0.6	0.50	89	110	170	36	20
Max		85	8.6	5280	15.6	8.4	610	1800	950	200	110
Mean		64	8.0	2260	2.3	1.9	314	491	422	77	55
Geo Mean		62	8.0	1970	1.3	1.4	269	369	376	69	49
Median		66	8.0	1780	1.2	1.4	270	330	360	66	47

Mud Slough (north) at San Luis Drain (MER542)

Location: Latitude 37°19'50", Longitude 120°57"03". In NW 1/4, NE 1/4, NW 1/4, Sec. 14, T.7S., R.9E. 5.0 miles east of Gustine, 3.5 miles SE of Highway 140. Located within Kesterson N. W. R.

Date	Time	Temp °F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
					µg/L												
10/6/95	1120	69	8.3	1130	1.2							0.66					
10/12/95	1018	62	7.8	1200	1.1							0.91					
10/18/95	1030	69	7.8	632	1.1							0.45					
10/27/95	1310	NA	7.7	769	0.6	7	2	4	7	<5	<1	0.60	91	100	170	34	20
11/3/95	1045	62	8.1	904	0.9							0.76					
11/9/95	1050	64	7.7	906	0.5							0.69					
11/20/95	1152	64	7.6	1060	0.4							0.81					
11/27/95	1156	54	8.1	1220	0.5							0.92	160	180	380	90	39
12/8/95	1332	60	8.1	1190	0.4							0.85					
12/18/95	1020	NA	8.9	1200	0.6							0.88					
12/22/95	1230	50	7.9	1230	0.8							0.91					
12/28/95	1332	52	8.2	1540	0.7							0.97	220	260	NA	44	33
1/4/96	1230	55	7.9	1930	0.7							1.4					
1/11/96	1114	52	7.9	1980	0.8							1.3					
1/18/96	1320	51	8.1	1710	0.8							1.2					
1/25/96	1345	54	7.8	1690	0.5	6	6	2	10	<5	<1	1.2	240	250	270	52	35
2/2/96	1235	57	8.0	1210	0.7							0.87					
2/9/96	NA	NA	NA	NA	NA							NA					
2/16/96	951	62	7.5	1880	0.5							0.73					
2/23/96	1300	60	7.8	880	<0.4							0.69	91	120	200	37	25
3/1/96	1310	62	8.1	1160	0.5							1.0					
3/8/96	1015	58	8.0	1070	0.6							0.86					
3/18/96	1145	72	8.4	1950	0.7							1.5					
3/21/96	1035	68	8.1	2160	0.7							1.8					
3/28/96	1245	66	8.2	2270	1.0							2.3	330	380	370	62	52
4/3/96	1438	64	7.5	2180	1.4							1.8					
4/12/96	1356	66	7.8	3440	7.1							4.1					
4/19/96	1120	62	8.0	3640	0.8							3.2					
4/25/96	1320	73	8.3	2670	0.9	10	8	7	9	<5	11	1.9	370	490	420	70	60
5/3/96	1216	75	7.7	3820	0.8							3.1					
5/10/96	1100	67	8.1	1510	1.2							0.95					
5/16/96	1250	66	7.9	2560	1.5							1.5					
5/24/96	1145	66	8.1	1420	1.5							1.1					
5/30/96	1335	76	8.1	1310	0.7							0.87	170	250	220	40	28
6/6/96	1300	88	7.8	588	2.0							0.49					
6/13/96	1224	78	8.2	1610	1.1							1.2					
6/19/96	1025	74	7.9	2520	0.7							1.9					
6/27/96	1445	80	8.1	3250	1.2							2.1	440	720	500	81	72
7/2/96	1125	86	7.3	2360	1.8							1.7					
7/11/96	1204	82	7.8	2520	2.1							1.9					
7/19/96	1245	78	8.3	3190	1.3							2.1					
7/25/96	1345	90	8.3	2020	1.4	11	12	6	15	<5	16	1.5	260	390	370	65	51
8/2/96	1200	82	8.2	1650	1.0							1.2					
8/8/96	1235	82	7.9	2900	1.1							1.8					
8/15/96	1045	79	8.0	2460	1.2							1.5					
8/23/96	1200	80	8.1	2250	1.2							1.4					
8/28/96	1320	80	8.3	2110	1.6							1.1	230	350	300	51	43
9/5/96	1306	72	8.1	1040	1.7							0.71					
9/12/96	945	66	7.7	2580	3.4							2.1					
9/17/96	1330	76	8.5	749	1.3							0.58					
9/26/96	830	69	8.2	5530	11.8							8.7	600	1900	890	192	100
Count		48	50	50	49	4	4	4	4	4	4	50	12	12	11	12	12
Min		50	7.3	588	<0.4	6	2	2	7	<5	11	0.45	91	100	170	34	20
Max		90	8.9	5530	11.8	11	12	7	15	<5	16	8.7	600	1900	890	192	100
Mean		68	8.0	1890	1.4	9	7	5	10	<5	7	1.5	267	449	372	68	47
Geo Mean		68	8.0	1680	1.0	8	6	4	10	<5	3	1.2	231	322	335	60	42
Median		67	8.1	1700	1.0	9	7	:	10	<5	6	1.2	235	305	370	57	41

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Los Banos Creek at State Highway 140 (MER554)
Location: Latitude 37°16'35", Longitude 120°57'14". In NE 1/4, SW 1/4, SW 1/4, Sec., 35, T.7S., R.9E.
South side of highway 140, 2.9 miles NE of Gustine.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/27/95	1025	58	7.7	1340	0.5	0.60	210	130	250	48	31
11/27/95	903	54	8.0	709							
12/28/95	1045	50	8.0	1460							
1/25/96	756	45	6.7	1450	<0.4	1.0	200	200	260	46	35
2/23/96	914	47	7.6	515							
3/28/96	925	61	6.5	509							
4/25/96	930	62	6.8	3350	0.7	3.0	450	670	600	94	88
5/30/96	1109	73	7.9	850							
6/27/96	1145	71	8.4	1250							
7/25/96	1205	84	8.5	1530	1.2	1.4	180	240	350	64	45
8/28/96	1203	76	8.6	1600							
9/26/96	1020	68	7.5	548							
Count		12	12	12	3	4	4	4	4	4	4
Min		45	6.5	509	<0.4	0.60	180	130	250	46	31
Max		84	8.6	3350	1.2	3.0	450	670	600	94	88
Mean		62	7.7	1259	0.6	1.5	260	310	365	63	50
Geo Mean		61	7.7	1080	0.5	1.3	242	254	342	60	46
Median		61	7.8	1300	0.6	1.2	205	220	305	56	40

C-115084

C-115084

Salt Slough at Lander Avenue (State Highway 165) (MER531)

Location: Latitude 37°14'55", Longitude 120°51'04". In NW 1/4, SE 1/4, SE 1/4, Sec. 10, T.8S., R.10E. 13.0 miles north of Los Banos. 5.0 miles south of Highway 140.

Date	Time	Temp °F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS	Ca	Mg
					µg/L							mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
10/6/95	1210	70	8.2	1010	1.1							0.47					
10/12/95	1040	68	7.8	1070	1.0							0.58					
10/18/95	1125	70	7.1	1300	6.8							1.3					
10/25/96	930	62	7.6	1360	12.4	6	12	6	15	<5	16	1.3	170	310	260	63	26
11/3/95	1241	64	7.9	1590	7.7							1.3					
11/9/95	955	64	8.1	1370	1.9							0.88					
11/20/95	1029	63	7.8	1930	10.6							2.0					
11/27/95	825	54	8.0	1810	10.9							1.7	240	410	380	90	39
12/8/95	1132	60	7.9	1920	12.8							1.8					
12/18/95	1230	NA	7.8	1920	13.1							2.1					
12/22/95	1055	50	7.9	2010	13.4							2.5					
12/28/95	1005	51	7.7	2380	19.3							2.4	330	560	490	115	49
1/4/96	1300	55	7.7	2490	5.2							2.2					
1/11/96	1016	52	7.7	2850	10.0							2.5					
1/18/96	1353	52	7.9	2690	33.3							3.0					
1/25/96	836	46	7.6	2430	19.5	9	NA	NA	NA	NA	NA	2.7	320	590	500	118	49
2/2/96	1320	56	7.8	2010	13.6							NA					
2/9/96	NA	NA	NA	NA	NA							NA					
2/16/96	1030	62	7.6	2580	22.7							2.7					
2/23/96	830	47	6.9	2340	18.6							1.1	300	570	240	59	23
3/1/96	1410	58	7.8	2130	14.5							2.4					
3/8/96	1035	62	7.7	2250	15.8							2.0					
3/18/96	1325	68	7.4	2220	16.9							1.9					
3/21/96	1125	68	NA	2120	17.8							1.9					
3/28/96	950	61	7.4	1720	11.6							1.7	280	430	450	102	45
4/3/96	1455	67	7.6	1920	17.2							1.8					
4/12/96	1146	64	7.8	2170	18.0							1.8					
4/19/96	1140	62	8.0	1840	20.3							2.3					
4/25/96	1030	65	7.7	2850	31.6	9	12	9	11	<5	26	2.7	370	670	580	144	54
5/3/96	1015	72	7.9	3000	33.5							3.5					
5/10/96	1115	66	7.7	2110	19.4							1.9					
5/16/96	1350	70	7.7	2320	23.0							2.0					
5/24/96	1220	64	7.8	2030	18.7							2.1					
5/30/96	1200	70	7.6	2330	22.0							2.6	300	570	520	130	47
6/6/96	1230	80	7.8	2610	27.5							3.1					
6/13/96	1055	75	7.8	2120	18.8							1.9					
6/19/96	1050	75	7.8	2020	20.6							2.3					
6/27/96	1215	68	7.7	2650	25.8							2.7	360	660	510	130	46
7/2/96	1030	83	7.4	2210	20.4							2.5					
7/11/96	1050	77	7.6	2160	19.6							2.7					
7/19/96	1040	74	7.5	2210	19.4							2.6					
7/25/96	1300	84	7.9	2020	17.3	10	15	8	14	<5	26	2.5	220	480	450	110	42
8/2/96	1240	82	7.8	1830	15.6							2.3					
8/8/96	1315	78	8.2	1560	13.4							1.7					
8/15/96	1140	82	8.0	1610	13.0							1.7					
8/23/96	1225	80	7.9	1580	11.4							1.6					
8/28/96	1238	75	8.0	1590	12.5							1.6	190	360	330	75	35
9/5/96	1120	70	7.2	1710	16.4							1.7					
9/12/96	750	68	6.9	1800	14.1							9.3*					
9/17/96	1430	70	8.0	1540	14.4							1.8					
9/26/96	935	68	5.8	1250	3.8							0.75	170	200	230	49	26
Count		49	49	50	50	4	3	3	3	<5	3	48	12	12	12	12	12
Min		46	5.8	1010	1.0	6	12	6	11	<5	16	0.47	170	200	230	49	23
Max		84	8.2	3000	33.5	10	15	9	15	<5	26	3.5	370	670	580	144	54
Mean		66	7.7	2010	16.0	9	13	8	13	<5	23	2.0	271	484	412	99	40
Geo Mean		66	7.7	1960	13.4	8	13	8	13	<5	22	1.9	262	460	393	94	39
Median		68	7.8	2020	16.1	9	12	8	14	<5	26	2.0	290	520	450	106	44

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APPENDIX B

Water Quality Data for Grab Samples: Water Year 1997

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* Sampling discontinued in December 1996

† Data only available for November 1996

SLD = San Luis Drain

Legend of Abbreviations

EC	Electrical Conductivity
Se	Selenium
Mo	Molybdenum
Cr	Chromium
Cu	Copper
Ni	Nickel
Pb	Lead
Zn	Zinc
B	Boron
Cl	Chlorine
SO4	Sulfate
HDNS	Hardness

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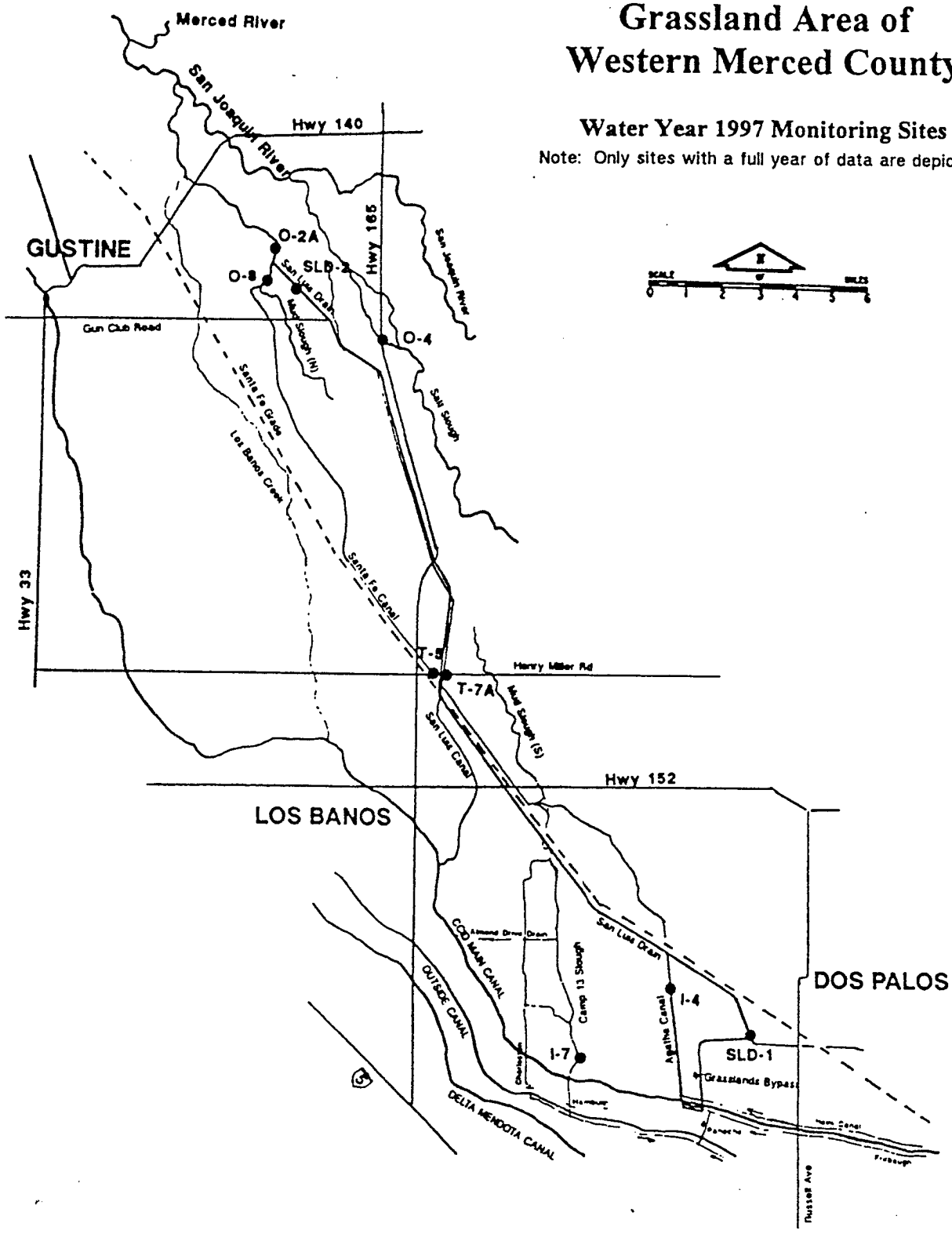
Figure B-1

Grassland Area of Western Merced County

Water Year 1997 Monitoring Sites

Note: Only sites with a full year of data are depicted.



C—115090

C-115090

Main (Firebaugh) Drain at Russel Avenue (MER556)
Location: Latitude: 36°55'27", Longitude 120°39'11". In SW 1/4, SW 1/4, SW 1/4, Sec. 34, T.11S.,R.12E.
East side of Russel Avenue, 2.7 miles south of Dos Palos.

Date	Time	Temp F	pH	Lab EC (µmhos/cm)	Se (µg/L)	Boron (mg/L)
10/3/96	1045	68	7.8	4780	95.7	7.7
10/8/96	1150	72	7.4	4150	74.6	7.4
10/18/96	1140	60	7.7	4780	78.8	8.0
10/25/96	1335	61	7.6	3990	45.2	5.8
11/1/96	1400	60	7.9	2430	26.2	3.1
11/8/96	1135	55	7.7	5350	84.4	9.5
11/14/96	1035	58	8.0	3190	47.6	4.7
11/19/96	1110	61	8.0	2190	32.6	2.8
11/26/96	1200	58	7.7	4160	87.8	6.5
12/5/96	1053	NA	7.8	4150	88.2	6.5
12/10/96	1415	58	7.5	3440	73.2	5.2
12/20/96	1035	47	7.8	5130	104	8.3
12/27/96	0830	51	7.6	5870	134	9.5
Count		12	13	13	13	13
Min		47	7.4	2190	26.2	2.8
Max		72	8.0	5870	134	9.5
Mean		59	7.7	4124	74.8	6.5
Geo Mean		59	7.7	3973	68.2	6.1
Median		59	7.7	4150	78.8	6.5

Panoche Drain at O'Banion Gauge Station (MER501)
Location: Latitude 36°55'14", Longitude 120°41'43". In SW 1/4, SW 1/4, SW 1/4, Sec. 32, T.11S., R.12E. Located 0.5 miles south of CCID Main Canal. 1.9 miles west of Russel Road. 5.5 miles SW of Dos Palos. 3.4 miles SW of South Dos

Date	Time	Temp F	pH	Lab EC (µmhos/cm)	Se (µg/L)	Boron (mg/L)
10/3/96	1115	68	7.9	5720	120	8.9
10/8/96	1220	74	8.0	4470	66.5	8.5
10/18/96	1155	60	7.9	4900	49.6	8.8
10/25/96	1430	62	8.3	5050	96.6	8.8
11/1/96	1430	68	7.2	4560	62.3	7.6
11/8/96	1230	60	7.8	5150	89.6	8.7
11/14/96	1050	58	7.5	5400	98.0	9.6
11/26/96	1237	60	7.5	4080	27.7	7.0
12/5/96	1131	NA	7.6	4690	32.5	7.8
12/20/96	1155	50	7.9	4870	83.4	7.8
Count		9	10	10	10	10
Min		50	7.2	4080	27.7	7.0
Max		74	8.3	5720	120	9.6
Mean		62	7.7	4890	72.6	8.4
Geo Mean		62	7.7	4870	66.0	8.3
Median		60	7.8	4880	75.0	8.6

Agatha Canal at Mallard Road (MER506)

Location: Latitude: 36°56'12", Longitude 120°42'07". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R.11E.
South of Sante Fe Grade at Brito, west of Mallard Road. 4.5 miles west of Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/3/96	1215	70	8.5	481	1.0	0.21					
10/8/96	1315	74	8.7	324	0.7	0.16					
10/18/96	1240	64	7.9	358	0.6	0.16					
10/25/96	1510	59	8.6	412	0.7	0.21					
11/1/96	1238	62	7.7	407	1.0	0.21					
11/8/96	1355	57	6.6	427	0.7	0.20					
11/14/96	1145	59	8.5	445	0.8	0.23					
11/19/96	1030	61	8.5	528	0.9	0.28					
11/26/96	1120	60	8.3	418	1.0	0.21	55*	43*	87	18	10
12/5/96	1243	NA	8.3	601	1.4	0.31					
12/10/96	1430	56	7.8	573	1.3	0.36					
12/20/96	NA	NA	NA	612	1.3	0.39					
12/27/96	1040	54	7.0	704	1.8	0.46					
1/9/97	1103	52	8.0	305	NA	NA					
1/21/97	1400	56	8.1	231	NA	0.39					
2/4/97	0715	56	6.1	4240	NA	NA					
2/18/97	1310	55	8.4	193	NA	NA					
3/5/97	1433	NA	NA	187	0.8	0.18					
3/12/97	1035	NA	NA	NA	0.5	0.11					
3/19/97	1111	NA	NA	235	1.8	0.24					
3/26/97	1140	NA	NA	317	1.0	0.24					
4/2/97	1143	NA	NA	457	3.0	0.31					
4/9/97	1145	NA	NA	661	2.0	0.43					
4/16/97	1240	NA	NA	559	2.6	0.32					
4/23/97	1258	NA	NA	481	1.5	0.26					
5/1/97	1141	NA	NA	520	1.5	0.30					
5/7/97	1240	NA	NA	547	1.1	0.25					
5/14/97	1238	NA	NA	497	1.3	0.25					
5/21/97	1135	NA	NA	486	1.0	0.25					
5/28/97	1240	NA	NA	504	1.1	0.26					
6/4/97	1150	NA	NA	481	1.7	0.27					
6/11/97	1155	NA	NA	476	1.3	0.27					
6/18/97	1151	NA	NA	484	1.2	0.24					
6/25/97	1240	NA	NA	423	1.1	0.20					
7/2/97	1320	NA	NA	436	1.1	0.24					
7/9/97	1240	NA	NA	396	1.0	0.19					
7/16/97	1245	NA	NA	406	1.6	0.22					
7/23/97	1240	NA	NA	419	1.6	0.24					
7/30/97	1245	NA	NA	419	1.2	0.24					
8/6/97	1240	NA	NA	373	1.5	0.27					
8/13/97	1245	NA	NA	354	1.0	0.16					
8/20/97	1240	NA	NA	368	1.5	0.20					
8/27/97	1245	NA	NA	442	2.3	0.26					
9/3/97	1050	NA	NA	553	3.4	0.38					
9/10/97	1240	NA	NA	358	1.8	0.21					
9/17/97	1130	NA	NA	354	1.1	0.17					
9/24/97	956	NA	NA	379	1.0	0.19					
Count		15	16	46	43	44	0	0	1	1	1
Min		52	6.1	187	0.5	0.11			87	18	10
Max		74	8.7	4240	3.4	0.46			87	18	10
Mean		60	7.9	518	1.3	0.25			87	18	10
Geo Mean		59	7.9	441	1.2	0.24			87	18	10
Median		59	8.2	432	1.2	0.24			87	18	10

Hamburg Drain near Camp 13 Slough (MER504)
Location: Latitude: 36°56'20", Longitude 120°45'26". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E. 50 feet south of CCID main canal. 9.2 miles S-SE of Los Banos. 6.7 miles W-SW of South Dos Palos.

Date	Time	Temp F	pH	Lab EC (µmhos/cm)	Se (µg/L)	Boron (mg/L)
10/3/96	1015	69	8.5	476	1.3	0.24
10/8/96	1125	81	8.7	598	2.3	0.59
10/18/96	1105	62	8.0	3530	19.8	4.2
10/25/96	1130	59	8.4	3430	19.8	4.2
11/1/96	1505	79	8.2	3450	18.8	3.9
11/8/96	1055	62	8.4	3510	19.8	4.4
11/14/96	1010	59	8.3	3350	18.2	4.2
11/19/96	1237	66	8.3	3410	17.2	4.2
11/26/96	1330	68	8.2	3250	17.6	4.2
12/20/96	0955	46	7.5	3580	18.4	4.2
12/27/96	1700	52	8.0	3610	22.6	4.4
Count		11	11	11	11	11
Min		46	7.5	476	1.3	0.2
Max		81	8.7	3610	22.6	4.4
Mean		64	8.2	2930	16.0	3.5
Geo Mean		63	8.2	2460	12.4	2.7
Median		62	8.3	3430	18.4	4.2

Camp 13 Slough at Gauge Station (MER505)

Location: Latitude 36°56'21", Longitude 120°45'22". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E. 150 feet north of CCID Main Canal, 6.4 miles west of Russel Avenue. 9.2 miles SE of Los Banos. 6.7 miles SW of South Dos Palos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/3/96	1020	69	8.3	382	0.8	0.16					
10/8/96	1135	72	8.7	347	0.8	0.18					
10/18/96	1110	64	8.5	360	0.6	0.16					
10/25/96	1145	59	8.7	394	0.8	0.21					
11/1/96	1500	63	9.0	394	0.8	0.17					
11/8/96	1110	56	7.5	491	0.9	0.28					
11/14/96	1020	59	8.7	434	0.7	0.25					
11/19/96	1230	61	8.4	483	0.9	0.28					
11/26/96	1320	61	8.1	445	1.0	2.6	64*	49*	30	9	1.8
12/5/96	NA	NA	NA	NA	NA	NA					
12/10/96	NA	NA	NA	NA	NA	NA					
12/20/96	1005	46	8.4	612	1.4	0.37					
12/27/96	NA	NA	NA	689	1.7	0.40					
1/9/97	0929	50	8.5	224	NA	0.15					
1/21/97	NA	NA	NA	178	NA	NA					
2/4/97	0838	58	7.6	1600	23.4	1.8					
2/18/97	1409	56	7.9	172	NA	NA					
3/5/97	1400	58	6.6	1380	2.0	2.3					
3/12/97	0800	NA	NA	NA	2.8	3.5					
3/19/97	0837	NA	NA	1880	5.2	3.3					
3/26/97	0840	NA	NA	3760	3.7	7.1					
4/2/97	0840	NA	NA	3750	4.7	6.5					
4/9/97	0842	NA	NA	560	1.7	0.33					
4/16/97	0943	NA	NA	1290	2.7	1.6					
4/23/97	0920	NA	NA	480	1.6	0.30					
5/1/97	0927	NA	NA	955	2.6	1.0					
5/7/97	0925	NA	NA	1210	13.5	1.1					
5/14/97	1000	NA	NA	520	1.0	0.30					
5/21/97	0917	NA	NA	496	1.0	0.26					
5/28/97	0920	NA	NA	715	2.5	0.64					
6/4/97	1005	NA	NA	1190	2.3	1.4					
6/11/97	1051	NA	NA	703	1.5	0.69					
6/18/97	1034	NA	NA	519	1.4	0.33					
6/25/97	0953	NA	NA	1390	2.3	1.9					
7/2/97	1042	NA	NA	563	1.1	0.49					
7/9/97	1023	NA	NA	460	1.1	0.33					
7/16/97	1050	NA	NA	614	1.6	0.58					
7/23/97	1030	NA	NA	614	1.2	0.41					
7/30/97	1054	NA	NA	1110	2.2	1.2					
8/6/97	1050	NA	NA	1400	2.2	2.0					
8/13/97	1048	NA	NA	815	3.5	1.0					
8/20/97	1027	NA	NA	352	1.0	0.20					
8/27/97	1032	NA	NA	459	2.3	0.31					
9/3/97	1000	NA	NA	502	3.6	0.35					
9/10/97	1022	NA	NA	496	3.1	0.32					
9/17/97	1015	NA	NA	341	1.2	0.18					
9/24/97	800	NA	NA	439	1.2	0.23					
Count		14	14	44	42	43	0	0	1	1	1
Min		46	6.6	172	0.6	0.15			30	9	1.8
Max		72	9.0	3760	23.4	7.1			30	9	1.8
Mean		59	8.2	822	2.6	1.1			30	9	1.8
Geo Mean		59	8.2	634	1.8	0.58			30	9	1.8
Median		59	8.4	520	1.6	0.37			30	9	1.8

C-115094

C-115094

Charleston Drain at CCID Main Canal (MER502)

Location: Latitude 36°56'59" Longitude 120°46'48". In NE 1/4, SE 1/4, NE 1/4, Sec. 29, T.11S., R.11E.
North Side of CCID Main Canal, 8.7 miles S-SE of Los Banos. 7.9 miles W-SW of South Dos Palos.

Date	Time	Temp F	pH	Lab EC (µmhos/cm)	Se (µg/L)	Boron (mg/L)
10/3/96	1005	68	8.2	979	6.7	0.71
10/8/96	1110	72	7.7	870	7.5	0.83
10/18/96	1050	62	7.1	1650	14.4	1.4
10/25/96	1115	58	7.8	1690	14.2	1.5
11/1/96	1510	63	8.6	1680	14.6	1.4
11/8/96	1045	56	7.5	1790	15.9	1.7
11/14/96	1000	58	8.0	1790	15.8	1.6
11/19/96	1300	62	8.7	1880	16.0	1.7
11/26/96	1345	60	8.4	1900	17.6	1.8
12/20/96	0945	48	7.5	2470	24.1	2.4
Count		10	10	10	10	10
Min		48	7.1	870	6.7	0.7
Max		72	8.7	2470	24.1	2.4
Mean		61	7.9	1670	14.7	1.5
Geo Mean		60	7.9	1600	13.8	1.4
Median		61	7.9	1740	15.2	1.6

Almond Drive Drain (MER555)

Location: Latitude 36°59'55", Longitude 120°49'00". In SW 1/4, SW 1/4, SW 1/4, Sec. 6, T.11S., R.11E.
North side of Almond Drive. 1.1 miles east of Mercy Springs Drain, 100 feet east of CCID Main Canal. 4.7 miles south of Los Banos

Date	Time	Temp F	pH	Lab EC (µmhos/cm)	Se (µg/L)	Boron (mg/L)
11/1/96	1530	63	8.7	360	0.6	0.14
11/26/96	1405	62	8.2	436	NA	NA
12/27/96	0758	51	6.8	588	NA	NA

Rice Drain at Mallard Road (MER509)

Location: Latitude 36°59'22" Longitude 120°42' 14". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R.11E.
South of Sante Fe Grade at Brito, 50 feet west of Mallard Road. 4.5 miles west of Dos Palos.

Date	Time	Temp F	pH	Lab EC (µmhos/cm)	Se (µg/L)	Boron (mg/L)
11/1/96	1230	60	7.3	1550	1.0	3.0
11/26/96	1125	59	7.7	1830	NA	NA
12/27/96	1030	54	7.5	2790	NA	NA

Salt Slough Ditch at Hereford Road (MER528)

Location: Latitude 37°08'30" Longitude 120°45'17". In NW 1/4, NE 1/4, NW 1/4, Sec. 22, T.9S., R.11E.
3.0 miles north on Hereford Road from Henry Miller Road.

Date	Time	Temp F	pH	Lab EC (µmhos/cm)	Se (µg/L)	Boron (mg/L)
11/1/96	1140	60	7.9	741	0.5	0.20
11/27/96	950	55	7.1	758	NA	NA
12/26/96	1420	48	8.0	1110	NA	NA

CCID Main at Russel Avenue (MER510)

Location: Latitude 36°55'28", Longitude 120°39'11". In SE 1/4, SE 1/4, SE 1/4, Sec. 33, T.11S., R.12E.
2.7 miles south of Dos Palos.

Date	Time	Temp F	pH	Lab EC (µmhos/cm)	Se (µg/L)	Boron (mg/L)
11/1/96	1405	61	8.4	352	0.7	0.13
11/26/96	1205	60	8.1	431	NA	NA
12/27/96	1835	51	7.8	599	NA	NA

Santa Fe Canal at Henry Miller Road (MER519)
Location: Latitude 37°05'59", Longitude 120°49'44". In NE 1/4, NE 1/4, Sec. 1, T.10S., R.10E. 0.3 miles east of Lander Avenue. 3.0 miles north of Gustine.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
11/1/96	1100	60	8.7	467	1.0	0.25	59	54	110	24	13
11/8/96	0940	54	7.0	482	0.8	0.24					
11/15/96	0937	57	7.3	573	0.9	0.35					
11/22/96	0930	63	6.9	620	1.0	0.41					
11/27/96	845	55	6.5	705	1.2	0.44					
12/6/96	0935	50	6.7	638	1.2	0.35					
12/12/96	1155	58	7.7	455	1.2	0.34					
12/19/96	1305	52	7.6	630	1.3	0.32					
12/26/96	1350	48	7.9	1230	1.5	1.5					
2/4/97	1110	58	8.4	544	2.3	0.49					
2/11/97	1240	58	7.9	339	0.8	0.35					
2/18/97	1200	55	7.5	1750	1.4	2.5					
2/28/97	1030	54	8.4	1760	2.3	2.5					
3/5/97	1530	NA	NA	1870	2.9	2.5					
3/12/97	1115	NA	NA	NA	2.0	1.6					
3/19/97	1145	NA	NA	1400	2.0	2.1					
3/26/97	1255	NA	NA	1870	3.1	2.9					
4/2/97	1326	NA	NA	1570	1.8	2.6					
4/9/97	1256	NA	NA	1480	2.4	1.8					
4/16/97	1320	NA	NA	1720	3.0	1.7					
4/23/97	1336	NA	NA	1130	3.2	1.1					
5/1/97	1310	NA	NA	870	2.6	0.81					
5/7/97	1314	NA	NA	825	2.9	0.66					
5/14/97	1321	NA	NA	861	1.9	0.65					
5/21/97	1335	NA	NA	746	1.6	0.63					
5/28/97	1315	NA	NA	892	2.1	0.86					
6/4/97	1340	NA	NA	1100	2.6	1.0					
6/11/97	1320	NA	NA	1070	2.5	1.1					
6/18/97	1330	NA	NA	968	2.4	1.1					
6/25/97	1325	NA	NA	1060	2.4	1.3					
7/2/97	1410	NA	NA	799	2.2	0.74					
7/9/97	1320	NA	NA	946	2.6	0.98					
7/16/97	1330	NA	NA	841	2.2	0.96					
7/23/97	1340	NA	NA	797	2.1	0.83					
7/30/97	1335	NA	NA	938	2.1	1.1					
8/6/97	1340	NA	NA	976	2.2	1.2					
8/13/97	1330	NA	NA	776	1.9	0.86					
8/20/97	1320	NA	NA	825	2.1	0.71					
8/27/97	1340	NA	NA	682	2.7	0.52					
9/3/97	1330	NA	NA	640	3.5	0.51					
9/10/97	1340	NA	NA	521	3.1	0.38					
9/17/97	1240	NA	NA	642	3.9	0.54					
9/24/97	1025	NA	NA	499	1.3	0.38					
Count		13	13	42	43	43	1	1	1	1	1
Min		48	6.5	339	0.8	0.24	59	54	110	24	13
Max		63	8.7	1870	3.9	2.9	59	54	110	24	13
Mean		56	7.6	941	2.1	1.0	59	54	110	24	13
Geo Mean		55	7.5	859	2.0	0.81	59	54	110	24	13
Median		55	7.6	833	2.1	0.83	59	54	110	24	13

San Luis Canal at Henry Miller Road (MER532)
Location: Latitude 37 06' 00" Longitude 120 49' 13". In SE 1/4, SW 1/4, SE 1/4, Section 36, T10s, R10E.
The site is 3 miles northeast of Los Banos at the Los Banos Wildlife Refuge.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L
11/1/96	1105	60	8.2	828	1.1	0.90
11/8/96	0950	55	7.5	943	1.1	1.1
11/15/96	0945	58	7.4	967	1.0	1.2
11/22/96	0940	63	7.1	910	1.1	1.1
11/27/96	925	56	7.1	1020	1.1	1.2
12/6/96	0950	50	7.0	911	1.1	0.88
12/12/96	1200	57	7.5	868	1.1	1.3
12/19/96	1315	52	7.6	1080	1.2	1.3
12/26/96	1410	NA	NA	NA	NA	NA
2/4/97	1120	60	7.9	1290	6.2	1.5
2/11/97	1250	59	7.2	1240	1.1	1.8
2/18/97	1210	55	7.7	1700	1.0	2.5
2/28/97	1040	52	8.2	1300	1.6	2.0
3/5/97	1520	NA	NA	1590	1.5	2.2
3/12/97	1125	NA	NA	NA	1.1	1.0
3/19/97	1150	NA	NA	1230	2.5	1.6
3/26/97	1115	NA	NA	1840	2.5	3.3
4/2/97	1340	NA	NA	1820	3.6	2.3
4/9/97	1315	NA	NA	1550	2.7	1.8
4/16/97	1307	NA	NA	1110	3.2	0.94
4/23/97	1328	NA	NA	1120	3.3	1.1
5/1/97	1320	NA	NA	860	3.0	0.78
5/7/97	1320	NA	NA	775	2.3	0.57
5/14/97	1315	NA	NA	803	1.6	0.57
5/21/97	1345	NA	NA	908	1.9	0.86
5/28/97	1307	NA	NA	848	1.9	0.69
6/4/97	1350	NA	NA	909	2.6	0.79
6/11/97	1315	NA	NA	798	2.1	0.69
6/18/97	1306	NA	NA	813	2.2	0.80
6/25/97	1315	NA	NA	860	2.1	0.80
7/2/97	1400	NA	NA	698	1.9	0.61
7/9/97	1310	NA	NA	917	2.5	0.87
7/16/97	1321	NA	NA	628	1.8	0.52
7/23/97	1320	NA	NA	762	2.1	0.71
7/30/97	1320	NA	NA	750	1.8	0.75
8/6/97	1330	NA	NA	886	2.0	0.86
8/13/97	1310	NA	NA	619	1.5	0.55
8/20/97	1311	NA	NA	781	2.0	0.73
8/27/97	1330	NA	NA	708	2.7	0.57
9/3/97	1300	NA	NA	605	3.2	0.47
9/10/97	1331	NA	NA	501	3.4	0.38
9/17/97	1150	NA	NA	660	4.3	0.57
9/24/97	1020	NA	NA	507	1.6	0.36
Count		12	12	41	42	42
Min		50	7.0	501	1.0	0.36
Max		63	8.2	1840	6.2	3.3
Mean		56	7.5	973	2.1	1.1
Geo Mean		56	7.5	924	1.9	0.94
Median		57	7.5	886	2.0	0.87

C-115097

C-115097

Porter-Blake Bypass (MER548)

Location: Latitude 37°05'58.5", Longitude 120°49'14.5". In NW 1/4, Sec. 1, T.10S., R.10E. 7.5 miles east of the intersection of Henry Milller and Mercy Springs Roads. 2 miles north of Los Banos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B mg/L
11/1/96	1120	62	8.00	832	1.0	0.92
11/27/96	910	55	6.86	1050	1.1	1.3

Mud Slough (north) at San Luis Drain (MER542)

Location: Latitude 37°19'50", Longitude 120°57"03". In NW 1/4, NE 1/4, NW 1/4, Sec. 14, T.7S., R.9E. 5.0 miles east of Gustine, 3.5 miles SE of Highway 140. Located within Kesterson N. W. R.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/3/96	0840	68	7.0	3490	56.7		4.9					
10/8/96	0950	73	8.0	1890	20.3		2.5					
10/18/96	0835	59	6.0	1680	13.5		2.1					
10/25/96	0930	58	8.0	1540	13.8		1.8					
10/29/96	1135	56	7.4	1880	12.2	11	NA					
11/1/96	0835	59	6.4	1810	NA		2.0	210	390	410	98	39
11/8/96	0830	54	7.6	1510	8.0		1.5					
11/14/96	0815	58	6.5	1590	9.1		1.8					
11/19/96	0915	62	6.5	1710	11.2		2.0					
11/26/96	0830	59	6.5	1430	9.0	8	1.5	180	270	270	59	30
12/5/96	0809	NA	6.5	1860	5.0		2.0					
12/10/96	1145	56	7.3	1500	5.5		1.6					
12/27/96	1158	56	7.4	1150	5.7	3	1.1					
1/9/97	1342	54	7.7	1280	5.0		1.3					
1/21/97	0940	53	7.7	1620	9.2	6	1.8					
2/4/97	1231	62	7.5	1310	7.4		1.5					
2/11/97	0955	55	7.8	2250	16.8		2.9					
2/18/97	0935	52	7.8	3140	33.2		4.3					
2/28/97	0758	51	8.1	3350	32.4	19	4.2					
3/5/97	1710	58	8.5	3770	44.8		5.3					
3/13/97	0810	61	8.2	3560	46.5		5.1					
3/20/97	0800	64	7.9	2980	33.2		3.9					
3/27/97	1425	72	8.3	3640	42.4	17	4.5					
4/3/97	1247	60	8.1	4420	61.9		6.1					
4/10/97	0730	58	7.4	4770	69.1		6.2					
4/17/97	1210	72	8.0	3870	58.6		4.9					
4/24/97	1116	64	8.4	4660	79.6	24	6.5					
5/2/97	0945	64	8.4	4280	52.0		5.9					
5/8/97	0725	67	8.1	4930	63.1		6.8					
5/15/97	1415	83	8.6	3920	58.7		5.3					
5/29/97	0935	76	8.5	2890	32.3	17	4.2					
6/5/97	1113	74	8.3	3810	47.2		5.5					
6/12/97	1110	78	8.5	3730	36.4		6.0					
6/19/97	NA	NA	NA	NA	NA		NA					
6/25/97	1115	76	8.2	3640	41.6	21	5.6					
7/2/97	1300	77	8.4	3990	50.4		6.6					
7/10/97	1144	78	8.3	3310	29.7		5.8					
7/17/97	1140	82	8.4	3730	33.3		6.5					
7/24/97	1148	82	7.9	3510	36.4		6.1					
7/31/97	1245	80	7.2	2550	18.4	16	4.2					
8/7/97	0947	81	8.0	3150	28.6		5.2					
8/14/97	1220	80	7.6	3650	37.5		6.3					
8/21/97	1537	84	7.8	3100	32.9		4.8					
8/27/97	1145	78	6.0	3340	40.6	23	5.3					
9/5/97	0915	80	7.2	3080	23.6		4.7					
9/12/97	0930	73	7.4	2640	20.4		4.1					
9/18/97	1252	78	7.8	1950	8.4		2.7					
9/25/97	1505	84	8.0	2170	8.6	20	3.0					
Count		46	47	47	46	12	46	2	2	2	2	2
Min		51	6.0	1150	5.0	3	1.1	180	270	270	59	30
Max		84	8.6	4930	79.6	24	6.8	210	390	410	98	39
Mean		68	7.7	2870	30.7	15	4.1	195	330	340	79	35
Geo Mean		67	7.6	2660	23.3	13	3.6	194	324	333	76	34
Median		66	7.8	3100	32.4	17	4.4	195	330	340	79	35

Los Banos Creek at State Highway 140 (MER554)

Location: Latitude 37°16'35", Longitude 120°57'14". In NE 1/4, SW 1/4, SW 1/4, Sec., 35, T.7S., R.9E.
South side of highway 140, 2.9 miles NE of Gustine.

Date	Time	Temp F	pH	Lab EC (µmhos/cm)	Se (µg/L)	Boron (mg/L)
10/31/96	1055	58	7.0	725	0.3	0.52
11/27/96	1130	57	7.1	1140	NA	NA
12/26/96	1250	48	7.8	1320	NA	NA

Salt Slough at Lander Avenue (State Highway 165) (MER531)
Location: Latitude 37°14'55", Longitude 120°51'04". In NW 1/4, SE 1/4, SE 1/4, Sec. 10, T.8S., R.10E. 13.0 miles north of Los Banos. 5.0 miles south of Highway 140.

Date	Time	Temp °F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS	Ca	Mg
					µg/L							mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
10/3/96	0745	67	5.6	1400	1.2							0.70					
10/8/96	1030	72	7.9	1110	1.1							0.55					
10/17/96	1025	65	6.7	1790	0.8							0.80					
10/24/96	0900	59	6.1	1360	0.7							0.66					
10/31/96	0950	57	5.7	1000	1.0	4						0.58	130	130	240	53	25
11/7/96	0740	58	5.3	1280	0.8							0.85					
11/15/96	1005	57	7.5	1420	0.8							0.87					
11/22/96	1010	64	7.4	1320	1.0							0.94					
11/27/96	1040	58	7.1	1320	0.8	4						0.99	190	200	290	65	31
12/6/96	1010	51	7.2	1500	0.9							1.0					
12/12/96	1135	58	6.9	1130	1.1							1.1					
12/19/96	1230	54	7.0	1680	0.7							1.1					
12/26/96	1322	48	7.4	1780	0.8	7						1.1					
1/9/97	1225	52	8.0	1200	1.0							0.85					
1/24/97	1255	52	7.0	1610	1.0	7						1.3	240	290	350	76	39
2/7/97	1420	57	7.4	1930	3.4							1.8					
2/13/97	1310	54	7.8	1670	0.7							1.3					
2/21/97	1010	56	7.3	1310	0.5							0.71					
2/26/97	1250	53	7.4	1110	0.6	7						0.50					
3/5/97	1615	57	7.8	1070	0.5							0.47					
3/12/97	1820	59	7.8	1090	0.6							0.52					
3/20/97	1030	66	8.0	1180	1.4							0.75					
3/27/97	1310	70	7.5	1780	1.1	7						1.3					
4/3/97	1020	60	7.7	2000	1.0							1.1					
4/10/97	0820	58	8.1	1860	1.0							0.81					
4/17/97	1020	70	8.0	1770	1.1							0.75					
4/24/97	1012	62	7.5	1820	1.1	10						0.81	280	250	360	77	41
5/2/97	0800	61	8.2	1670	1.1							0.82					
5/8/97	0821	69	7.9	1700	1.1							0.77					
5/15/97	0905	75	7.9	1670	1.1							0.74					
5/23/97	1200	72	8.2	1360	0.9							0.56					
5/29/97	1050	78	8.4	1200	1.3	6						0.65					
6/5/97	0952	70	6.6	1620	1.2							0.74					
6/12/97	1240	80	8.1	1370	1.1							0.61					
6/19/97	NA	NA	NA	NA	NA							NA					
6/25/97	1010	76	7.8	1350	1.1	9						0.73					
7/2/97	1150	74	7.7	1070	1.1							0.50					
7/10/97	0932	75	7.8	1310	0.9							0.63					
7/17/97	1100	78	8.6	1030	1.0							0.48					
7/24/97	0945	78	8.2	1140	0.9							0.56					
7/31/97	1045	78	8.4	975	1.1	5						0.57	110	120	200		
8/7/97	0834	79	7.3	1130	1.3							0.69					
8/14/97	1135	80	7.8	922	0.8							0.46					
8/21/97	1214	80	7.6	982	0.9							0.40					
8/27/97	1430	80	6.0	1110	1.0	5						0.48					
9/5/97	1050	82	8.1	1190	1.8							0.53					
9/12/97	0815	74	6.7	1200	1.5							0.57					
9/18/97	1039	74	7.0	1050	1.6							0.50					
9/25/97	1600	85	8.0	1380	0.7	9						0.65					
Count		48	48	48	48	12	0	0	0	0	0	48	5	5	5	4	4
Min		48	5.3	922	0.5	4						0.40	110	120	200	53	25
Max		85	8.6	2000	3.4	10						1.8	280	290	360	77	41
Mean		67	7.4	1370	1.0	7						0.77	190	198	288	68	34
Geo Mean		66	7.4	1340	1.0	6						0.73	179	187	281	67	33
Median		67	7.6	1320	1.0	7						0.72	190	200	290	71	35

Mud Slough Upstream of San Luis Drain (MER536)

Location: Latitude 37°19'50", Longitude 120°57"03". In NW 1/4, NE 1/4, NW 1/4, Sec. 14, T.7S., R.9E. 5.0 miles east of Gustine, 3.5 miles SE of Highway 140. Located within Kesterson N. W. R.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/3/96	0830	65	6.3	1050	0.7		0.65					
10/8/96	1010	71	8.0	744	0.6		0.56					
10/18/96	0825	58	5.2	967	0.8		0.77					
10/25/96	0955	57	7.8	953	0.5		0.71					
10/29/96	1135	56	7.8	1120	0.5	7	NA	NA	NA	NA	NA	NA
11/1/96	0820	59	5.4	1020	NA		0.77					
11/8/96	0810	54	7.3	1050	0.4		0.76					
11/14/96	0805	58	6.1	1020	0.4		0.75					
11/19/96	0900	62	6.5	1070	0.4		0.81					
11/26/96	0905	59	7.3	1000	0.5	NA	0.79	140	120	180	34	23
12/5/96	0801	NA	5.9	1380	0.5		1.0					
12/10/96	1215	58	7.4	983	0.5		0.75					
12/20/96	0835	46	7.9	950	0.4		0.80					
12/27/96	1150	56	7.4	828	0.5	3	0.67					
1/9/97	1331	54	7.5	921	<0.4		0.72					
1/21/97	0920	53	7.6	1070	0.4	3	0.87	120	140	210	39	27
2/4/97	1219	62	7.5	875	0.5		0.77					
2/11/97	0930	56	7.2	1430	0.7		1.4					
2/18/97	0925	52	7.6	1730	0.7		1.8					
2/28/97	0741	50	7.6	2040	1.0	NA	2.0					
3/5/97	1725	60	8.3	2030	0.8		2.0					
3/13/97	0750	51	7.1	1970	1.0		2.1					
3/20/97	0739	64	6.8	1910	1.0		2.1					
3/27/97	1415	72	8.1	2350	0.9	7	2.4					
4/3/97	1311	66	8.2	2350	1.1		2.6					
4/10/97	0718	54	6.8	2960	1.3		2.9					
4/17/97	1225	72	8.2	1720	1.7		1.5					
4/24/97	1140	62	8.4	2360	1.2	11	2.1	320	490	430	74	59
5/2/97	1010	63	8.2	2430	0.9		2.3					
5/8/97	0711	63	8.4	2470	0.8		2.1					
5/15/97	1435	84	8.5	1430	1.4		1.1					
5/23/97	1040	70	7.9	1080	0.7		0.95					
5/29/97	0950	76	8.3	1130	1.2	5	0.94					
6/5/97	1128	74	8.3	1610	1.6		1.3					
6/12/97	1125	78	8.3	1500	1.5		1.2					
6/19/97	NA	NA	NA	NA	NA		NA					
6/25/97	1105	76	7.9	1460	1.7	7	1.4					
7/2/97	1245	79	8.4	1540	1.0		1.3					
7/10/97	1205	77	8.1	1200	1.4		1.1					
7/17/97	1200	80	8.3	1550	1.3		1.3					
7/24/97	1204	83	8.1	1160	1.5		1.0					
7/31/97	1300	80	8.0	859	1.1	3	0.70	93	120	190		
8/7/97	1002	81	8.3	1130	0.8		0.92					
8/14/97	1210	82	7.3	1160	0.6		0.91					
8/21/97	1556	89	8.2	1220	0.6		0.98					
8/27/97	1135	78	5.8	1260	1.1	5	0.96					
9/5/97	0900	76	7.4	1190	0.6		0.85					
9/12/97	0920	78	7.3	873	0.7		0.62					
9/18/97	1307	79	8.1	881	1.0		0.60					
9/25/97	1455	84	7.6	1050	0.6	10	0.77					
Count		48	49	49	48	10	48	4	4	4	3	3
Min		46	5.2	744	<0.4	3	0.56	93	120	180	34	23
Max		89	8.5	2960	1.7	11	2.9	320	490	430	74	59
Mean		67	7.5	1390	0.8	6	1.2	168	218	253	49	36
Geo Mean		66	7.5	1300	0.8	6	1.1	150	177	236	46	33
Median		65	7.8	1160	0.8	6	0.96	130	130	200	39	27

Inflow at San Luis Drain: check 17 (MER562)

Location: Latitude: 36°57.980', Longitude 120°40.238'. In Sec. 21, T.11S., R.12E. Just west of South Dos Palos.
Slightly downstream of point where the Grasslands Bypass empties into the San Luis Drain.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Diss Se ug/L	TSS mg/L
10/3/96	1200	70	8.1	5210	77.4		7.8				79.1	
10/8/96	1300	78	8.3	4220	75.5		7.7					44
10/18/96	1230	62	7.1	3940	38.6		7.1				37.5	140
10/25/96	1450	58	8.3	4270	51.4		6.7				49.5	
10/29/96	1400	54	8.1	4020	62.0	27	NA				61.6	
11/1/96	1310	62	7.4	3610	NA		5.1					
11/8/96	1330	58	6.8	4250	61.3		7.9				61.1	42
11/14/96	1130	58	8.1	4390	76.8		7.3					51
11/19/96	1100	64	7.7	3460	56.2		5.6				57.0	77
11/26/96	1140	60	7.4	3470	40.6		5.7				39.6	64
12/5/96	1222	NA	7.7	5000	68.4		8.4				69.9	49
12/10/96	1400	58	7.0	4020	NA		NA				56.3	110
12/20/96	1305	48	8.5	4970	80.4		8.3				80.2	56
12/27/96	0945	55	7.8	5130	91.7		8.2				91.9	92
1/9/97	0854	50	8.0	4710	78.7		7.4				76.6	90
1/21/97	1315	61	8.0	4870	88.2	16	7.5				84.8	180
2/4/97	1006	62	8.0	5140	72.0		8.7				70.5	71
2/11/97	1355	59	7.9	5360	97.5		9.0				96.6	58
2/18/97	1245	55	7.9	5140	80.3		8.3				78.6	41
2/28/97	1124	54	8.0	5330	90.3		8.5				86.4	
3/5/97	1435	58	7.5	5100	88.4		8.1				91.1	38
3/12/97	0950	NA	NA	NA	76.6		6.9				77.2	
3/19/97	1050	NA	NA	4420	74.6		6.8				71.1	85
3/26/97	1100	NA	NA	4580	67.0		6.6				61.0	160
4/2/97	1115	NA	NA	5370	93.0		8.1				95.8	120
4/9/97	1115	NA	NA	5600	108		7.6				117	130
4/16/97	1140	NA	NA	5310	104		7.1				104	83
4/23/97	1125	NA	NA	5290	101		8.0				97.6	110
5/1/97	1113	NA	NA	5480	96.8		8.4				96.6	110
5/7/97	1220	NA	NA	4930	73.6		7.3				73.0	62
5/14/97	1130	NA	NA	4380	61.6		6.8				57.6	130
5/21/97	1100	NA	NA	4380	65.0		7.4				63.6	160
5/28/97	1130	NA	NA	4330	58.5		7.0				60.6	45
6/4/97	1055	NA	NA	4780	52.1		7.8				50.6	87
6/11/97	1120	NA	NA	4980	81.0		8.7				78.9	39
6/18/97	1112	NA	NA	4690	67.5		7.8				63.1	170
6/25/97	1141	NA	NA	4850	61.5		8.5				60.5	130
7/2/97	1123	NA	NA	4660	65.8		8.5				64.1	130
7/9/97	1117	NA	NA	4140	40.6		7.7				40.5	150
7/16/97	1123	NA	NA	4220	54.5		7.8				53.0	120
7/23/97	1119	NA	NA	4050	40.5		7.1				43.5	110
7/30/97	1134	NA	NA	3950	45.5		7.3				44.6	170
8/6/97	1130	NA	NA	4130	53.8		7.8				50.4	120
8/13/97	1122	NA	NA	3650	38.4		6.4				39.0	140
8/20/97	1106	NA	NA	3330	30.8		6.4				30.4	160
8/27/97	1110	NA	NA	3990	55.4		6.9				53.7	
9/3/97	0900	NA	NA	4250	52.1		6.6				49.4	65
9/10/97	1130	NA	NA	2620	17.9		4.2				16.6	190
9/17/97	1050	NA	NA	3160	22.8		5.5				21.8	94
9/24/97	945	NA	NA	3460	29.0		6.0				28.0	96
Count		20	21	49	48	2	48	0	0	0	47	43
Min		48	6.8	2620	17.9	16	4.2				16.6	38
Max		78	8.5	5600	108	27	9.0				117	190
Mean		59	7.8	4460	65.9	22	7.3				64.5	100
Geo Mean		59	7.8	4405	61.7	21	7.3				60.0	92
Median		58	7.9	4390	66.4	22	7.5				61.6	96

San Luis Drain @ Terminus (MER535)

Location: Latitude 37°19'50", Longitude 120°57"03". In NW 1/4, NE 1/4, NW 1/4, Sec. 14, T.7S., R.9E. 5.0 miles east of Gustine, 3.5 miles SE of Highway 140. Located within Kesterson N. W. R.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L	Diss Se µg/L	TSS mg/L
10/3/96	0915	70	7.9	4340	66.8		6.4						65.8	
10/8/96	0930	74	7.3	4330	62.5		6.9							8
10/18/96	0935	62	6.9	3590	43.0		6.0						41.8	67
10/25/96	0859	58	8.0	4280	79.8		7.2						77.2	NA
10/29/96	1045	54	7.6	4260	54.6	35	NA	460	1200	1000	280	79	54.8	
11/1/96	0915	60	7.4	4010	NA		6.0							
11/8/96	0900	55	8.0	3570	43.2		5.2						42.1	12
11/14/96	0850	58	7.6	4330	58.0		7.5						NA	8
11/19/96	0930	62	7.2	4770	75.8		8.4						75.2	10
11/26/96	0950	60	7.4	3300	58.9	30	5.5	390	1100	860	230	69	56.4	<1
12/5/96	840	NA	7.1	3910	30.1		6.2						31.0	14
12/10/96	1110	56	6.5	4330	38.9		7.3						39.0	25
12/20/96	0945	46	8.1	4200	49.8		7.1						49.0	15
12/27/96	1321	57	7.6	4000	60.8	23	5.9						61.6	22
1/9/97	1505	56	7.9	3830	33.3		5.2						34.2	12
1/21/97	1050	54	7.9	4530	57.0	22	7.0	520	1400	1100	280	92	56.4	33
2/4/97	1315	62	7.6	4510	63.6		7.2						61.8	27
2/11/97	1050	58	7.8	5110	78.4		8.3						78.4	33
2/18/97	1020	54	8.1	5150	79.7		8.1						83.2	34
2/28/97	0905	50	8.3	4770	77.6	27	7.1						73.4	
3/5/97	1700	58	8.3	5210	89.3		8.2						87.1	26
3/13/97	0925	58	7.1	4630	91.8		7.3						84.4	
3/20/97	0925	64	8.4	4280	70.2		6.6						70.4	27
3/27/97	1445	72	8.5	4630	78.9	29	6.5						78.1	45
4/3/97	1050	59	8.1	5130	96.2		7.4						93.7	33
4/10/97	0755	58	7.6	5270	105		7.2						102	37
4/17/97	1055	71	8.2	5460	107		7.8						110	34
4/24/97	1048	65	8.0	5020	95.2	26	7.3	600	1700	1200	320	100	93.6	48
5/2/97	0830	63	8.4	5080	72.6		7.3						73.7	39
5/8/97	0750	67	8.3	5270	80.3		7.7						78.3	29
5/15/97	0940	76	8.5	4670	75.2		6.6						75.7	28
5/23/97	1105	74	8.2	4200	64.2		6.7						64.6	46
5/29/97	0915	78	8.2	4350	62.3	23	7.1						60.9	140
6/5/97	1018	74	8.0	4820	72.8		7.8						70.4	46
6/12/97	1015	76	8.5	4560	54.6		7.9						55.0	27
6/19/97	NA	NA	NA	NA	NA		NA						71.3	23
6/25/97	1135	76	8.3	4690	73.3	26	7.7						73.6	13
7/2/97	1230	76	8.4	4410	59.9		7.8						59.8	30
7/10/97	1118	78	8.3	4030	34.9		7.4						35.0	25
7/17/97	1120	80	8.2	4060	37.0		7.4						37.0	18
7/24/97	1011	81	8.0	4000	41.8		7.1						39.5	17
7/31/97	1200	78	6.3	3940	43.7	25	7.2	420	1300	920			42.4	17
8/7/97	0856	81	7.6	3190	27.9		5.6						27.7	21
8/14/97	1235	80	8.0	3780	42.3		6.8						41.7	18
8/21/97	1430	82	7.2	3240	31.2		5.3						31.0	32
8/27/97	1200	78	7.2	3840	48.9	25	6.4						47.2	17
9/5/97	0930	82	8.1	3190	23.4		5.1						23.3	25
9/12/97	1020	78	7.9	2720	17.0		4.4						16.4	22
9/18/97	1225	78	7.3	2920	17.1		4.8						17.0	22
9/25/97	1535	82	8.0	3390	18.3	35	5.6						18.4	19
Count		48	49	49	48	12	48	5	5	5	4	4	47	44
Min		46	6.3	2720	17.0	22	4.4	390	1100	860	230	69	16.4	8
Max		82	8.5	5460	107	35	8.4	600	1700	1200	320	100	110	140
Mean		67	7.8	4270	59.3	27.167	6.8	478	1340	1016	278	85	58.7	28
Geo Mean		66	7.8	4220	54.0	26.867	6.7	472	1325	1009	276	84	53.4	23
Median		66	8.0	4330	60.4	26	7.1	460	1300	1000	280	86	60.9	25

APPENDIX C

Water Quality Data from Sigma Autosamplers: Water Years 1996 and 1997

Map Index	RWQCB Site I.D.	Site Name	Period of Record	Page
I-1	MER556S	Main (Firebaugh) Drain @ Russell Ave.	10/95-12/96	99
I-2	MER501S	Panoche Drain	10/95-1/97	101
I-4	MER506S	Agatha Canal @ Mallard Road	1/97-3/97	103
I-7	MER505S	Camp 13 Slough	1/97-3/97	104
O-2	MER542S	Mud Slough (N) downstream of San Luis Drain	10/95-3/97	105
O-4	MER531S	Salt Slough @ Lander Avenue	10/95-3/97	107
SLD-2	MER535S	San Luis Drain @ Terminus	9/96-9/97	109

Legend of Abbreviations

EC	Electrical Conductivity
Se	Selenium
B	Boron

C—115106

C-115106

Main (Firebaugh) Drain at Russel Avenue (MER556S)

Location: Latitude: 36°55'27", Longitude 120°39'11". In SW 1/4, SW 1/4, SW 1/4, Sec. 34, T.11S.,R.12E.
East side of Russel Avenue, 2.7 miles south of Dos Palos.

AUTOSAMPLER DATA : 4 day composite samples

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se g/L	B mg/L
10/4/95	2120	33.7	2.8	4/7/96	4540	119	5.4
10/6/95	2870	50.7	NA	4/11/96	4770	120	5.8
10/10/95	2630	56.4	3.4	4/15/96	4230	104	5.3
10/14/95	2250	36.4	3.0	4/19/96	2990	61.9	3.4
10/18/95	2060	27.4	2.9	4/23/96	3710	85.6	3.9
10/22/95	2870	34.5	3.6	4/27/96	3590	90.8	3.9
10/26/95	2630	29.4	3.5	5/1/96	4550	122	4.6
10/30/95	3670	38.4	4.7	5/3/96	4030	94.0	NA
11/3/95	3700	40.3	4.4	5/7/96	3390	74.3	3.6
11/7/95	3060	42.8	4.2	5/11/96	3200	64.5	3.3
11/11/95	2320	31.0	3.1	5/15/96	2920	54.6	3.0
11/15/95	3140	48.0	4.6	5/16/96	2640	49.5	NA
11/19/95	3250	30.1	4.2	5/20/96	2640	40.0	2.5
11/24/95	2640	47.2	3.6	5/24/96	2770	46.2	3.1
11/28/95	3330	60.4	4.8	5/28/96	2760	48.8	3.0
12/2/95	2310	38.8	2.8	5/30/96	2610	44.5	3.0
12/6/95	2550	53.3	2.9	6/3/96	2870	43.6	3.4
12/8/95	2220	42.6	2.6	6/7/96	2600	35.4	3.2
12/12/95	2000	31.9	2.1	6/11/96	2910	43.1	3.5
12/16/95	2200	35.4	2.3	6/15/96	2510	34.6	2.9
12/20/95	3070	57.8	3.8	6/19/96	2570	34.9	3.0
12/22/95	3390	65.2	4.4	6/23/96	3250	52.2	3.5
12/26/95	4080	81.8	5.3	6/27/96	3410	57.4	3.6
12/30/95	2890	56.4	3.5	7/1/96	3240	55.0	4.3
1/3/96	5150	108	6.9	7/5/96	2870	44.8	4.1
1/4/96	NA	NA	NA	7/9/96	2400	36.2	3.4
1/8/96	3890	NA	NA	7/11/96	2530	35.8	3.7
1/12/96	4600	83.8	5.7	7/15/96	3350	57.4	3.9
1/16/96	5520	94.4	7.6	7/19/96	2400	34.2	3.2
1/18/96	NA	122	NA	7/23/96	2350	32.2	3.3
1/22/96	4540	112	6.7	7/25/96	2330	33.3	3.3
1/26/96	3680	87.9	5.2	7/29/96	2060	27.8	2.8
1/30/96	2870	55.6	3.4	8/2/96	1970	29.4	2.5
2/2/96	2710	53.4	2.7	8/6/96	2040	31.0	2.9
2/6/96	3560	63.2	3.4	8/8/96	1910	28.6	2.5
2/10/96	4870	108	NA	8/12/96	1990	27.9	2.7
2/14/96	4930	98.2	NA	8/16/96	1960	25.2	2.7
2/16/96	4760	95.9	4.4	8/20/96	1830	26.0	2.6
2/20/96	4890	102	NA	8/23/96	1980	30.2	2.7
2/23/96	4600	101	NA	8/27/96	2270	31.7	3.0
2/28/96	4820	104	NA	8/31/96	2410	38.2	2.9
3/1/96	5460	130	NA	9/4/96	2890	51.4	3.8
3/5/96	NA	NA	NA	9/5/96	2850	52.0	NA
3/9/96	NA	NA	NA	9/9/96	2570	41.2	3.3
3/13/96	NA	NA	NA	9/13/96	2730	44.8	3.4
3/17/96	NA	NA	NA	9/17/96	2610	36.7	3.3
3/22/96	5160	136	6.2	9/21/96	2320	33.4	3.0
3/26/96	4910	130	5.7	9/25/96	2740	31.8	3.2
3/30/96	4070	108	4.7	9/29/96	3280	35.0	3.7
4/3/96	4610	121	5.7				

Count	93	93	82
Min	1830	25.2	2.1
Max	5520	136	7.6
Mean	3185	59.7	3.8
Geo Mean	#NUM!	52.9	3.6
Median	2870	48.8	3.4

Main (Firebaugh) Drain at Russel Avenue (MER556S)
Location: Latitude: 36°55'27", Longitude 120°39'11". In SW 1/4, SW 1/4, SW 1/4, Sec. 34, T.11S.,R.12E.
East side of Russel Avenue, 2.7 miles south of Dos Palos.
AUTOSAMPLER DATA : 4 day composite samples

Date	EC µmhos/cm	Se µg/L	B mg/L
10/3/96	4500	68.0	6.2
10/7/96	4290	71.4	
10/8/96	4490	96.8	
10/12/96	2750	36.3	
10/16/96	3700	56.2	
10/20/96	4530	76.2	
10/24/96	3760	40.9	
10/25/96	4050	40.8	
10/29/96	4490	58.4	
11/2/96	2690	28.8	
11/6/96	4360	64.0	
11/8/96	5210	80.5	
11/12/96	4040	61.0	
11/16/96	3170	51.8	
11/19/96	2290	40.0	
11/23/96	2550	45.4	
11/27/96	3740	70.4	
12/1/96	4740	108.0	
12/5/96	5210	118.0	
12/9/96	3410	72.4	
12/13/96	3670	73.0	
12/17/96	4800	103.0	
12/20/96	5260	109.0	
12/24/96	5420	122.0	
12/26/96	5550	125.0	
Count	25	25	1
Min	2290	28.8	6.2
Max	5550	125.0	6.2
Mean	4107	72.7	6.2
Geo Mean	3996	67.2	6.2
Median	4290	70.4	6.2

Panoche Drain at O'Banion Guage Station (MER501S)

Location: Latitude 36°55'14", Longitude 120°41'43". In SW 1/4, SW 1/4, SW 1/4, Sec. 32, T.11S., R.12E. Located 0.5 miles south of CCID Main Canal, 1.9 miles west of Russel Road. 5.5 miles SW of Dos Palos.

AUTOSAMPLER DATA: 4 DAY COMPOSITE SAMPLES

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se µg/L	B mg/L
10/2/95	5220	149	7.9	4/7/96	NA	NA	NA
10/6/95	NA	NA	NA	4/11/96	NA	NA	NA
10/10/95	4710	23.4	7.8	4/15/96	NA	NA	NA
10/14/95	5120	25.0	8.5	4/19/96	NA	NA	NA
10/18/95	5100	50.5	8.8	4/23/96	4910	112	7.5
10/22/95	5150	111	8.6	4/27/96	5000	110	7.8
10/26/95	5050	116	8.4	5/1/96	4700	94.6	6.8
10/30/95	4430	89.2	7.5	5/3/96	4910	112	7.3
11/3/95	3860	69.6	6.3	5/7/96	4780	95.0	6.9
11/7/95	3950	64.6	7.0	5/11/96	4920	89.0	7.1
11/11/95	3970	74.7	6.6	5/15/96	4880	44.9	6.8
11/15/95	3720	55.6	5.9	5/16/96	4500	95.0	5.9
11/19/95	3480	53.0	5.8	5/20/96	4680	81.8	7.3
11/24/95	3840	70.6	6.3	5/24/96	4630	76.9	7.1
11/28/95	3950	74.2	6.0	5/28/96	4660	80.8	7.6
12/2/95	3910	81.2	6.8	5/30/96	4660	75.4	7.7
12/6/95	3380	68.1	5.5	6/3/96	4520	NA	NA
12/8/95	3470	71.4	5.6	6/7/96	4830	NA	NA
12/12/95	4220	85.2	5.8	6/11/96	NA	NA	NA
12/16/95	4190	91.2	5.7	6/13/96	NA	NA	NA
12/20/95	4530	105	6.4	6/17/96	4550	64.1	6.8
12/22/95	4690	108	6.4	6/21/96	4750	72.4	7.5
12/26/95	5100	124	7.0	6/25/96	4390	61.8	7.0
12/30/95	5190	134	7.2	6/27/96	4640	74.6	7.1
1/3/96	4780	40.2	7.0	7/1/96	4540	68.1	7.8
1/4/96	4980	40.2	6.9	7/5/96	4420	68.3	NA
1/8/96	4970	37.6	7.1	7/9/96	NA	NA	NA
1/12/96	5000	102	7.3	7/11/96	NA	NA	NA
1/16/96	5040	120	7.0	7/15/96	4870	76.0	8.3
1/18/96	4670	106	6.5	7/19/96	4540	63.6	7.4
1/22/96	4180	95.6	6.1	7/23/96	4430	69.8	7.4
1/26/96	4140	88.6	6.4	7/25/96	4480	70.4	6.2
1/30/96	4010	82.8	6.3	7/29/96	4460	72.2	7.4
2/2/96	3050	53.2	4.4	8/2/96	4260	66.2	7.0
2/6/96	4380	54.8	5.3	8/6/96	4180	62.6	6.9
2/10/96	5440	90.8	6.8	8/8/96	4240	69.5	7.3
2/14/96	5580	96.4	7.0	8/12/96	4250	68.2	7.5
2/18/96	5410	83.1	7.0	8/16/96	4230	69.0	7.3
2/22/96	5360	79.1	6.9	8/20/96	4060	62.8	7.0
2/23/96	4960	75.8	7.2	8/23/96	3860	51.7	6.8
2/27/96	4650	80.0	6.5	8/27/96	3970	47.6	6.8
3/1/96	4780	92.3	6.5	8/31/96	4350	77.2	7.3
3/5/96	4980	114	7.3	9/4/96	4170	70.2	7.0
3/9/96	5150	109	7.3	9/5/96	4190	70.7	NA
3/13/96	4560	103	3.4	9/9/96	3830	61.1	6.3
3/17/96	4760	88.2	7.0	9/13/96	3690	60.0	6.1
3/18/96	3810	86.2	NA	9/17/96	4490	78.4	7.5
3/22/96	4920	100	7.2	9/21/96	4370	75.6	7.0
3/26/96	5250	91.1	8.7	9/25/96	4890	94.9	8.5
3/30/96	NA	NA	NA	9/29/96	5370	112	9.2
4/3/96	NA	NA	NA				
				Count	90	88	85
				Min	3050	23.4	3.4
				Max	5580	149	9.2
				Mean	4530	79.9	7.0
				Geo Mean	4500	76.2	6.9
				Median	4560	76.5	7.0

Panoche Drain at O'Banion Gauge Station (MER501)

Location: Latitude 36°55'14", Longitude 120°41'43". In SW 1/4, SW 1/4, SW 1/4, Sec. 32, T.11S., R.12E. Located 0.5 miles south of CCID Main Canal, 1.9 miles west of Russel Road. 5.5 miles SW of Dos Palos.

AUTOSAMPLER DATA : Four day composite samples

Date	EC µmhos/cm	Se µg/L	B mg/L
10/3/96	5320	112.0	9.0
10/7/96	4860	69.0	
10/8/96	4710	66.2	
10/12/96	4940	84.2	
10/16/96	4880	100.6	
10/20/96	4980	70.6	
10/24/96	4870	65.2	
10/25/96	4760	52.6	
10/29/96	5070	88.9	
11/2/96	4560	77.6	
11/6/96	4960	83.1	
11/8/96	5080	89.2	
11/12/96	5160	116.0	
11/16/96	5170	112.0	
11/20/96	4800	100.0	
11/24/96	4340	92.1	
11/26/96	4420	65.5	
11/30/96	4610	37.4	
12/4/96	4910	38.8	
12/5/96	4750	35.0	
12/9/96	4750	35.4	
12/13/96	4390	35.5	
12/17/96	4710	60.4	
12/20/96	5030	91.4	
12/24/96	4330	76.4	
12/28/96	4840	79.0	
1/1/97	4580	79.4	
1/5/97	3830	45.8	
1/9/97	4330	51.0	
Count	29	29	1
Min	3830	35.0	9.0
Max	5320	116.0	9.0
Mean	4757	72.8	9.0
Geo Mean	4746	68.4	9.0
Median	4800	76.4	9.0

C-115110

C-115110

Agatha Canal at Mallard Road (MER506S)

Location: Latitude: 36°56'12", Longitude 120°42'07". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R.11E.
South of Sante Fe Grade at Brito, west of Mallard Road. 4.5 miles west of Dos Palos.

AUTOSAMPLER DATA : 12 hour daily composite samples

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se µg/L	B mg/L
1/9/97			0.41	2/22/97	246		
1/10/97	275			2/23/97	225	1.0	
1/11/97	264			2/24/97	208		
1/12/97	286			2/25/97	211		
1/13/97	312			2/26/97	204		
1/14/97	257			2/27/97	205		
1/15/97	258			2/28/97	194		
1/16/97	259			3/1/97	196		
1/17/97	244			3/2/97	199		
1/18/97	243			3/3/97	203	1.3	
1/19/97	236			3/4/97	195		
1/20/97	230			3/5/97	195		
1/21/97	227			35495	187		
1/22/97	244			3/7/97	161		
1/23/97	262			3/8/97	156	0.7	
1/24/97	260			3/9/97	154		
1/25/97	285			3/10/97	148		
1/26/97	308			3/11/97	149		
1/27/97	342			3/12/97	145		
2/5/97	809	6.8	1.0	3/13/97	157	0.7	
2/6/97	235			3/14/97	148		
2/7/97	119			3/15/97	148		
2/8/97	116			3/16/97	138		
2/9/97	125			3/17/97	232		
2/10/97	182			3/18/97	244		
2/11/97	235			3/19/97	235		
2/12/97	255	0.5	0.70	3/20/97	215		
2/13/97	246			3/21/97	178		
2/14/97	229			3/22/97	173	0.8	
2/15/97	221			3/23/97	196		
2/16/97	205			3/24/97	275		
2/17/97	198			3/25/97	308	1.6	
2/18/97	202						
2/19/97	168						
2/20/97	158						
2/21/97	323	1.5	0.37				

Count	67	9	4
Min	116	0.5	0.37
Max	809	6.8	1.0
Mean	225	1.7	0.62
Geo Mean	214	1.2	0.57
Median	215	1.0	0.56

Camp 13 Slough at Gauge Station (MER505S)

Location: Latitude 36°56'21", Longitude 120°45'22". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E. 150 feet north of CCID Main Canal, 6.4 miles west of Russel Avenue. 9.2 miles SE of Los Banos. 6.7 miles SW of S. Dos Palos

AUTOSAMPLER DATA : 12 hour daily composite samples

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se µg/L	B mg/L
1/10/97	125			2/20/97	151		
1/11/97	150			2/21/97	149		
1/12/97	209			2/22/97	152		
1/13/97	147			2/23/97	149		
1/14/97	128			2/24/97	150		
1/15/97	140			2/25/97	144		
1/16/97	122			2/26/97	150		
1/17/97	142			2/27/97	158	0.5	
1/18/97	145			2/28/97	152		
1/19/97	144			3/1/97	142		
1/20/97	148			3/2/97	143		
1/21/97	161			3/3/97	148		
1/22/97	176			3/4/97	146		
1/23/97	226			3/5/97	151	<0.4	
1/24/97	269			3/6/97	1690		
1/25/97	375			3/7/97	1770		
1/26/97	681	2.3		3/8/97	2030	4.2	3.1
1/27/97	1980	19.2		3/9/97	2350	4.6	
1/28/97	2770	30.8		3/10/97	2150		
1/29/97	2750	33.0	4.6	3/11/97	1960		
1/30/97	2640	31.0		3/12/97	3990		
1/31/97	1700	18.6		3/13/97	4630	21.2	7.7
2/1/97	1210	12.6		3/14/97	3340		
2/2/97	1230	15.3		3/15/97	2960		
2/3/97	1120	16.0	1.5	3/16/97	1370		
2/4/97	1120	14.1		3/17/97	1100		
2/5/97	263			3/18/97	1650		
2/6/97	388			3/19/97	2140		
2/7/97	497	0.6	0.67	3/20/97	2860	6.2	
2/8/97	395			3/21/97	2670		
2/9/97	335			3/22/97	2990	10.2	5.2
2/10/97	307			3/23/97	2750		
2/11/97	407			3/24/97	2260		
2/12/97	513	0.5	0.34	3/25/97	3760	6.3	6.9
2/13/97	467						
2/14/97	420						
2/15/97	329						
2/16/97	183						
2/17/97	168						
2/18/97	163						
2/19/97	158						

	EC	Se	B
Count	75	20	8
Min	122	<0.4	0.34
Max	4630	33.0	7.7
Mean	1030	12.4	3.8
Geo Mean	505	6.1	2.5
Median	375	11.4	3.9

Mud Slough (north) at San Luis Drain (MER542S)
Location: Latitude 37°19'50", Longitude 120°57"03". In NW 1/4, NE 1/4, NW 1/4, Sec. 14, T.7S., R.9E.
5.0 miles east of Gustine, 3.5 miles SE of Highway 140. Located within Kesterson N. W. R.
AUTOSAMPLER DATA: 4 DAY COMPOSITE SAMPLES

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se µg/L	B mg/L
10/4/95	987	0.9	0.61	4/7/96	3230	3.0	3.3
10/6/95	978	1.0	0.64	4/11/96	3540	1.7	3.8
10/10/95	1120	1.0	0.75	4/15/96	3320	18.4	3.9
10/14/95	985	0.9	0.69	4/19/96	3940	19.4	3.7
10/18/95	610	1.0	0.45	4/23/96	2870	0.9	2.0
10/22/95	732	0.8	0.53	4/27/96	2130	1.0	1.5
10/26/95	791	0.7	0.58	5/1/96	1820	1.0	1.2
10/30/95	756	0.7	0.58	5/3/96	3070	0.9	2.6
11/3/95	837	1.0	0.66	5/7/96	3880	1.7	2.4
11/7/95	858	0.7	0.71	5/11/96	1840	4.2	1.2
11/11/95	889	0.7	0.70	5/15/96	1860	1.3	1.1
11/15/95	952	0.6	0.76	5/20/96	2300	1.4	1.6
11/19/95	1010	0.6	0.73	5/24/96	1530	1.4	1.6
11/24/95	1100	0.5	0.81	5/28/96	1810	1.1	1.2
11/28/95	1190	0.5	0.90	5/30/96	1340	0.7	1.3
12/2/95	1210	0.5	0.92	6/3/96	1420	1.3	1.0
12/6/95	1150	0.7	0.84	6/7/96	2410	1.0	1.8
12/8/95	1200	0.6	0.85	6/11/96	1700	1.1	1.3
12/12/95	1290	1.1	0.90	6/13/96	1570	1.2	NA
12/16/95	1190	0.7	0.83	6/16/96	NA	NA	NA
12/20/95	1230	0.6	0.89	6/17/96	NA	NA	NA
12/22/95	1260	0.8	0.85	6/21/96	NA	NA	NA
12/26/95	1340	0.7	1.0	6/25/96	NA	NA	NA
12/30/95	1550	1.1	1.2	6/27/96	NA	NA	NA
1/3/96	1760	0.8	1.3	7/1/96	3030	1.3	2.1
1/4/96	1910	0.8	1.2	7/5/96	3600	1.5	2.4
1/8/96	1880	0.9	1.4	7/9/96	3530	1.9	2.3
1/12/96	2000	0.8	1.4	7/11/96	2330	2.4	NA
1/16/96	1870	0.8	1.4	7/15/96	2550	1.3	1.8
1/18/96	1840	0.7	1.4	7/19/96	2550	1.9	1.8
1/22/96	1570	0.7	1.2	7/23/96	3810	1.1	2.7
1/26/96	1550	0.6	1.1	7/25/96	2690	1.2	NA
1/30/96	1750	0.6	1.3	7/29/96	1640	1.7	1.1
2/2/96	1050	0.7	0.85	8/2/96	1500	1.2	0.96
2/6/96	1010	0.7	0.81	8/6/96	1620	1.9	1.0
2/10/96	910	0.6	0.75	8/8/96	2640	1.2	NA
2/14/96	1590	0.6	1.4	8/12/96	1370	2.0	0.99
2/16/96	1830	0.6	1.4	8/16/96	2240	1.5	1.5
2/20/96	1810	2.2	1.4	8/20/96	1290	2.1	0.91
2/24/96	5150	2.1	2.3	8/23/96	1660	1.6	1.1
3/5/96	NA	NA	NA	8/27/96	2360	1.3	1.5
3/9/96	NA	NA	NA	8/31/96	1500	1.9	1.0
3/13/96	NA	NA	NA	9/4/96	967	1.9	0.66
3/17/96	NA	NA	NA	9/9/96	NA	NA	NA
3/18/96	NA	NA	NA	9/13/96	NA	NA	NA
3/22/96	2010	0.8	1.7	9/17/96	NA	NA	NA
3/26/96	2120	1.2	1.9	9/21/96	NA	NA	NA
3/30/96	2330	1.2	2.2	9/23/96	NA	NA	NA
4/3/96	2380	1.3	2.1	9/27/96	3670	7.1	5.6
				Count	83	83	79
				Min	610	0.5	0.45
				Max	5150	19.4	5.6
				Mean	1880	1.7	1.4
				Geo Mean	1680	1.1	1.2
				Median	1660	1.0	1.2

Mud Slough (north) at San Luis Drain (MER542S)
Location: Latitude 37°19'50", Longitude 120°57"03" In NW 1/4, NE 1/4, NW 1/4, Sec.14, T.7S., R.9E
5 miles east of Gustine, 3.5 miles SE of Highway 140. Located within Kesterson N. W. R.
AUTOSAMPLER DATA : Four day composite samples

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se µg/L	B mg/L
10/1/96	3760	31.4	6.2	1/4/97	1570	9.9	2.0
10/3/96	3340	50.6	4.9	1/8/97	NA	NA	NA
10/7/96	2380	27.8	3.1	1/9/97	1200	4.6	NA
10/11/96	1950	17.6	2.5	1/13/97	1380	5.7	1.6
10/15/96	1960	15.8	2.6	1/17/97	1900	12.2	2.2
10/18/96	1830	14.0	2.5	1/21/97	1620	9.5	1.8
10/22/96	1480	7.4	1.8	1/25/97	1620	9.6	1.8
10/26/96	1460	7.7	1.7	1/29/97	1280	7.6	1.4
10/29/96	1720	8.4	2.1	2/2/97	1170	4.5	1.3
11/2/96	1860	11.4	2.2	2/4/97	1290	6.7	1.5
11/6/96	1740	10.0	2.0	2/8/97	1680	9.9	2.0
11/10/96	1520	8.8	1.7	2/11/97	2240	17.5	2.7
11/14/96	1520	6.7	1.7	2/15/97	2780	27.8	3.3
11/18/96	1640	9.2	2.2	2/19/97	3150	31.5	4.2
11/22/96	1610	10.4	2.1	2/23/97	3500	36.4	4.8
11/26/96	1460	9.3	1.8	2/27/97	3420	33.0	4.3
11/30/96	1480	7.3	1.5	2/28/97	3300	32.4	NA
12/4/96	1660	6.6	1.8	3/4/97	3620	25.6	3.4
12/8/96	1790	5.0	1.9	3/8/97	3750	44.2	5.1
12/10/96	1650	4.5	1.7	3/12/97	3660	43.4	5.1
12/14/96	1420	4.9	1.6	3/13/97	3500	44.4	
12/18/96	1360	5.5	1.5	3/17/97	3460	42.2	
12/22/96	1510	7.2	1.7	3/21/97	3210	33.5	
12/26/96	1490	7.2	1.7	3/25/97	3140	28.4	
12/31/96	1300	7.1	1.4				

Count	48	48	42
Min	1170	4.5	1.3
Max	3760	50.6	6.2
Mean	2130	17.1	2.5
Geo Mean	1980	12.9	2.3
Median	1700	9.9	2.0

Salt Slough at Lander Avenue (MER531S)
Location: Latitude 37°14'55", Longitude 120°51'04". In NW 1/4, SE 1/4, SE 1/4, Sec. 10, T.8S., R.10E.
13.0 miles north of Los Banos. 5.0 miles south of Highway 140.
AUTOSAMPLER DATA: 4 DAY COMPOSITE SAMPLES

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se µg/L	B mg/L
10/4/95	1090	7.2	0.95	4/7/96	2230	16.6	1.9
10/6/95	886	1.8	0.47	4/11/96	2280	16.0	1.8
10/10/95	1000	1.2	0.53	4/15/96	2060	16.0	1.7
10/14/95	1090	1.3	0.56	4/19/96	1950	17.0	1.7
10/18/95	938	2.1	0.56	4/23/96	2140	22.1	2.0
10/22/95	1300	9.2	1.2	4/27/96	2520	27.2	2.4
10/26/95	1540	14.8	1.6	5/1/96	2800	33.8	2.7
10/30/95	1500	11.2	1.4	5/3/96	2890	31.2	2.8
11/3/95	1570	7.8	1.3	5/7/96	3170	37.8	3.0
11/7/95	1610	8.9	1.5	5/11/96	2320	25.2	2.2
11/11/95	1680	7.9	1.4	5/15/96	2100	19.9	1.9
11/15/95	1640	8.4	1.4	5/16/96	2310	20.8	NA
11/19/95	1920	13.2	1.8	5/20/96	1810	15.0	1.6
11/24/95	1910	11.9	1.9	5/24/96	1870	14.2	1.9
11/28/95	1890	11.8	1.8	5/28/96	1820	16.8	1.9
12/2/95	1790	12.2	1.7	6/1/96	2260	20.9	2.5
12/6/95	1850	13.4	1.7	6/5/96	2260	22.2	2.5
12/8/95	1860	13.4	1.9	6/9/96	2510	25.1	3.0
12/12/95	2010	11.6	1.7	6/13/96	2270	19.6	2.7
12/16/95	1830	13.3	1.7	6/17/96	2310	18.5	2.5
12/20/95	1960	12.5	1.9	6/21/96	2190	18.3	2.2
12/22/95	2040	13.4	2.1	6/25/96	2250	19.3	2.2
12/26/95	2060	13.4	2.0	6/27/96	2530	24.0	2.6
12/30/95	2410	16.0	2.2	7/1/96	2540	NA	2.9
1/3/96	2500	16.2	2.4	7/5/96	2350	22.8	2.7
1/4/96	2400	5.7	2.0	7/9/96	2060	17.1	2.3
1/8/96	2620	6.1	2.2	7/11/96	2140	18.4	2.4
1/12/96	2850	10.4	1.7	7/15/96	2300	21.4	2.6
1/16/96	2900	24.2	2.8	7/19/96	2330	20.4	2.7
1/18/96	2780	28.2	2.8	7/23/96	2240	20.2	2.7
1/22/96	2510	29.8	2.8	7/25/96	2120	18.8	2.7
1/26/96	2270	20.6	2.6	7/29/96	1860	16.4	2.2
1/30/96	2340	21.8	2.6	8/2/96	1740	15.8	2.1
2/2/96	1900	14.0	2.0	8/6/96	1730	15.4	2.0
2/6/96	2000	12.9	1.9	8/8/96	1530	12.8	1.8
2/10/96	2110	15.7	2.1	8/12/96	1600	13.4	1.8
2/14/96	2550	22.6	2.6	8/15/96	1470	12.1	1.6
2/16/96	2570	23.0	2.6	8/19/96	NA	NA	NA
2/20/96	2420	22.4	2.6	8/23/96	NA	NA	NA
2/24/96	2290	18.6	2.0	8/27/96	NA	NA	NA
2/28/96	2020	17.6	1.9	8/28/96	NA	NA	NA
3/1/96	2070	15.8	2.0	9/1/96	1650	15.4	1.8
3/5/96	2260	17.9	2.1	9/5/96	1510	12.8	1.5
3/9/96	2250	16.9	2.1	9/9/96	1890	16.9	2.2
3/13/96	2430	19.0	2.2	9/12/96	1630	13.6	1.8
3/17/96	2300	17.7	2.1	9/16/96	1260	6.8	1.0
3/18/96	1960	15.9	NA	9/20/96	1630	14.0	1.6
3/22/96	2130	17.1	2.1	9/24/96	1540	11.4	1.5
3/26/96	2110	17.4	2.5	9/26/96	1280	7.4	1.0
3/30/96	1940	11.8	1.9	9/30/96	1160	1.5	0.6
4/3/96	2020	17.8	2.1				
				Count	97	96	95
				Min	886	1.2	0.47
				Max	3170	37.8	3.0
				Mean	2020	16.0	2.0
				Geo Mean	1970	13.9	1.9
				Median	2060	16.0	2.0

Salt Slough at Lander Avenue (State Highway 165) (MER531S)
Location: Latitude 37°14'55", Longitude 120°51'04". In NW 1/4, SE 1/4, SE 1/4, Sec. 10, T.8S., R.10E.
13.0 miles north of Los Banos. 5.0 miles south of Highway 140.
AUTOSAMPLER DATA : Four day composite samples

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se µg/L	B mg/L
10/4/96	1210	1.5	0.64	1/4/97	1810	1.5	1.7
10/8/96	1260	1.1	0.66	1/8/97	1840	0.9	1.3
10/9/96	960	1.4	NA	1/9/97	1350	1.1	
10/13/96	1020	1.2	0.52	1/13/97	1160	1.0	0.93
10/17/96	1350	0.9	0.68	1/17/97	1460	0.9	1.2
10/21/96	1460	0.8	0.71	1/21/97	1580	1.0	1.3
10/24/96	1190	0.8	0.59	1/24/97	1610	1.0	1.3
10/28/96	1510	1.5	0.85	1/28/97	1650	1.0	1.2
11/1/96	1150	0.8	0.65	2/1/97	2070	6.3	1.9
11/5/96	1090	0.9	0.74	2/5/97	1980	4.6	1.7
11/7/96	1210	0.9	0.87	2/7/97	2060	5.9	1.9
11/11/96	1380	1.0	1.0	2/11/97	1723	1.4	1.4
11/15/96	1490	0.9	1.0	2/15/97	1660	0.8	1.2
11/19/96	1360	1.2	0.92	2/19/97	1650	0.6	1.0
11/22/96	1280	1.3	0.92	2/21/97	1460	0.5	0.82
11/26/96	1540	1.1	1.0	2/25/97	1160	0.6	0.57
11/30/96	1350	1.0	1.0	3/1/97	1070	0.7	0.53
12/4/96	1400	1.0	1.0	3/5/97	1020	0.6	0.47
12/6/96	NA	NA	NA	3/9/97	1170	0.7	0.51
12/10/96	1500	1.1	1.1	3/13/97	1180	0.8	0.52
12/14/96	1460	1.1	1.1	3/17/97	1230	1.2	0.72
12/18/96	1590	1.0	1.1	3/21/97	1120	1.6	
12/19/96	1620	0.86	NA	3/25/97	1360	1.2	
12/23/96	1690	1.0	1.1				
12/27/96	1810	0.8	1.2				
12/31/96	1810	0.9	1.2				
				Count	48	48	43
				Min	960	0.5	0.47
				Max	2070	6.3	1.9
				Mean	1440	1.3	1.0
				Geo Mean	1410	1.1	0.93
				Median	1430	1.0	1.0

San Luis Drain @ Terminus (MER535S)
Location: Latitude 37°19'50", Longitude 120°57"03". In NW 1/4, NE 1/4, NW 1/4, Sec. 14, T.7S., R.9E.
5.0 miles east of Gustine, 3.5 miles SE of Highway 140. Located within Kesterson N. W. R.
AUTOSAMPLER DATA : 12 hour daily composite samples

Date	EC µmhos/cm	Selenium µg/L	Boron mg/L
9/13/96	7410		
9/14/96	7120		
9/15/96	7340		
9/16/96	8680		
9/17/96	7160		
9/18/96	7330		
9/19/96	7570		
9/20/96	7720		
9/21/96	7730		
9/22/96	7780		
9/23/96	9790		
9/24/96	8510		
9/25/96	9030		
9/26/96	7850		
9/27/96	4660	56.9	
9/28/96	4570	71.6	
9/29/96	5050	77.8	
9/30/96		86.5	
Count	17	4	0
Min	4570	56.9	
Max	9790	86.5	
Mean	7371	73.2	
Geo Mean	7220	72.4	
Median	7570	74.7	

C-115117

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San Luis Drain @ Terminus (MER535S)
Location: Latitude 37°19'50", Longitude 120°57"03". In NW 1/4, NE 1/4, NW 1/4, Sec. 14, T.7S., R.9E.
5.0 miles east of Gustine, 3.5 miles SE of Highway 140. Located within Kesterson N. W. R.
AUTOSAMPLER DATA : 12 hour daily composite samples

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se µg/L	B mg/L
10/1/96	5360	90.3	8.6	11/24/96	3510	61.4	6.1
10/2/96	4400	106	9.3	11/25/96	3200	51.8	5.5
10/3/96	4340	66.3	7.3	11/26/96	3180	52.4	4.9
10/4/96	4440	59.0	6.9	11/27/96	3750	63.9	6.2
10/5/96	4460	56.4	7.0	11/28/96	3670	68.2	6.0
10/6/96	4290	61.3	7.0	11/29/96	3520	57.3	5.6
10/7/96	4610	59.8	6.7	11/30/96	3540	53.3	5.6
10/8/96	4710	63.0	7.1	12/1/96	3720	46.1	6.1
10/9/96	4710	64.8	NA	12/2/96	3960	50.2	6.5
10/10/96	5030	63.5	7.6	12/3/96	4040	46.2	6.5
10/11/96	5250	69.6	8.5	12/4/96	3850	31.6	6.4
10/12/96	4850	72.6	9.0	12/5/96	3890	29.5	NA
10/13/96	5460	52.6	8.2	12/6/96	4100	38.3	6.7
10/14/96	NA	NA	NA	12/7/96	4170	39.3	6.5
10/15/96	NA	NA	NA	12/8/96	4080	38.2	6.2
10/16/96	NA	NA	NA	12/9/96	4110	34.8	6.4
10/17/96	NA	NA	NA	12/10/96	4190	34.7	7.1
10/18/96	NA	NA	NA	12/11/96	4470	42.4	7.8
10/19/96	3380	41.8	5.5	12/12/96	4320	49.2	7.6
10/20/96	3470	41.4	5.8	12/13/96	3850	45.3	6.7
10/21/96	3530	40.8	5.9	12/14/96	3870	48.3	6.7
10/22/96	3520	43.7	5.8	12/15/96	4100	51.8	7.4
10/23/96	3900	49.8	6.7	12/16/96	3850	50.9	6.9
10/24/96	4260	78.4	7.1	12/17/96	3840	47.2	6.4
10/25/96	4360	78.8	7.3	12/18/96	4020	50.8	6.9
10/26/96	4260	59.8	7.2	12/19/96	4140	51.1	7.3
10/27/96	3940	40.3	6.7	12/20/96	4190	54.8	7.4
10/28/96	4420	56.8	7.7	12/21/96	4400	56.1	7.9
10/29/96	4420	52.3	NA	12/22/96	4470	51.9	7.9
10/30/96	4240	60.3	6.8	12/23/96	4530	63.4	8.1
10/31/96	4200	51.9	6.1	12/24/96	4860	71.0	8.3
11/1/96	4080	43.6	NA	12/25/96	4870	71.3	8.4
11/2/96	4120	43.9	6.7	12/26/96	4580	67.3	6.6
11/3/96	4270	53.4	6.4	12/27/96	4040	62.9	6.2
11/4/96	4290	63.2	6.7	12/28/96	4290	65.7	6.6
11/5/96	4300	57.5	6.6	12/29/96	5220	63.0	7.7
11/6/96	4270	80.3	6.8	12/30/96	4820	67.9	7.6
11/7/96	3790	59.2	5.9	12/31/96	4930	74.6	7.5
11/8/96	3510	45.0	5.4	1/1/97	5080	80.8	7.9
11/9/96	3500	43.6	5.5	1/2/97	4870	73.6	7.0
11/10/96	3410	36.6	5.5	1/3/97	4740	76.6	6.8
11/11/96	3560	38.3	5.9	1/4/97	4100	65.0	5.8
11/12/96	3970	50.9	6.9	1/5/97	4280	61.8	6.8
11/13/96	4130	56.6	7.5	1/6/97	4100	53.9	6.3
11/14/96	4330	61.5	8.0	1/7/97	3040	36.6	4.3
11/15/96	4190	59.4	7.9	1/8/97	3510	35.8	5.3
11/16/96	4220	55.5	8.1	1/9/97	4080	44.1	6.3
11/17/96	4380	63.8	8.5	1/10/97	4250	47.2*	6.6*
11/18/96	4410	73.6	8.7	1/11/97	4550	60.0*	7.5*
11/19/96	4400	75.2	8.5	1/12/97	4650	64.0*	7.3*
11/20/96	4170	69.6	8.0	1/13/97	NA	NA	NA
11/21/96	4050	68.2	7.7	1/14/97	4700	63.6*	7.8*
11/22/96	4000	73.4	7.5	1/15/97	4710	66.3*	7.8*
11/23/96	3900	69.8	6.9	1/16/97	4830	66.8*	8.2*

C—115118

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San Luis Drain @ Terminus (MER535S) continued

Date	EC µmhos/cm	Se µg/L	B mg/L
1/17/97	4740	76.4*	7.3*
1/18/97	4730	70.3*	7.7*
1/19/97	4110	55.7*	5.6*
1/20/97	4360	55.2*	6.9*
1/21/97	4510	55.6*	NA
1/22/97	4650	62.8	7.7
1/23/97	4540	66.2	7.5
1/24/97	4620	73.0	7.4
1/25/97	4170	59.7	6.5
1/26/97	4010	56.4	6.1
1/27/97	4270	59.6	6.3
1/28/97	4300	65.1	6.6
1/29/97	4360	57.0	6.8
1/30/97	3570	40.6	5.5
1/31/97	3450	34.2	5.4
2/1/97	4160	45.8	6.5
2/2/97	4430	47.4	7.0
2/3/97	4550	58.2	7.1
2/4/97	4550	65.8	7.2
2/5/97	4570	62.3	7.3
2/6/97	4810	65.9	7.9
2/7/97	5020	72.8	8.1
2/8/97	5260	91.2	7.9
2/9/97	5230	90.5	7.7
2/10/97	5080	86.2	8.1
2/11/97	4940	79.1	7.9
2/12/97	5270	87.8	8.1
2/13/97	5340	81.8	8.4
2/14/97	5360	89.5	8.4
2/15/97	5230	86.0	8.1
2/16/97	5200	86.0	7.9
2/17/97	5210	85.3	8.1
2/18/97	5220	80.9	8.2
2/19/97	5300	81.0	8.4
2/20/97	5270	83.7	8.4
2/21/97	5280	84.4	8.1
2/22/97	5160	78.3	8.0
2/23/97	5040	78.4	7.7
2/24/97	5050	84.0	7.7
2/25/97	4970	71.1	7.4
2/26/97	5050	74.8	7.4
2/27/97	4700	70.0	6.9
2/28/97	4890	77.4	7.2
3/1/97	5080	75.4	7.7
3/2/97	5090	82.4	8.0
3/3/97	5270	101	7.9
3/4/97	5200	97.9	7.9
3/5/97	5140	87.8	7.9
3/6/97	5030	86.4	7.8
3/7/97	5090	89.8	7.8
3/8/97	4960	88.4	7.5
3/9/97	5030	87.2	7.7
3/10/97	5030	96.9	7.5
3/11/97	4910	95.5	7.3
3/12/97	4800	86.3	7.0
3/13/97	4650	86.2	6.4
3/14/97	4610	82.2	6.5
3/15/97	4600	87.4	6.4
3/16/97	4860	87.6	7.0
3/17/97	4980	89.9	7.0
3/18/97	4780	86.8	6.6
3/19/97	4580	81.4	6.2
3/20/97	4300	75.6	5.8
3/21/97	4550	82.1	6.6
3/22/97	4560	74.5	6.7
3/23/97	4630	69.8	6.3
3/24/97	4710	72.7	6.3
3/25/97	4890	79.0	6.8
3/26/97	4840	78.2	6.7
3/27/97	4710	82.0	6.8
3/28/97	4490	69.4	6.5
3/29/97	4580	78.0	6.6
3/30/97	4610	82.4	6.5
3/31/97	4710	89.0	6.5
4/1/97	4700	85.0	7.0
4/2/97	5020	90.6	7.4
4/3/97	5060	92.6	7.3
4/4/97	5510	104	7.9
4/5/97	5410	108	7.5
4/6/97	5420	112	7.5
4/7/97	5440	110	7.3
4/8/97	5490	110	7.4
4/9/97	5430	106	7.1
4/10/97	5420	106	7.1
4/11/97	5720	116	7.5
4/12/97	5760	113	7.6
4/13/97	5750	114	7.8
4/14/97	5480	108	7.5
4/15/97	5630	110	7.6
4/16/97	NA	116	7.5
4/17/97	5880	115	7.5
4/18/97	5530	116	7.5
4/19/97	5350	108	7.3
4/20/97	5350	106	7.3
4/21/97	5480	113	7.4
4/22/97	5510	110	7.5
4/23/97	5220	103	6.9
4/24/97	5010	96.6	6.8
4/25/97	5090	97.6	7.1
4/26/97	5120	98.6	7.1
4/27/97	5260	104	7.3
4/28/97	5390	108	7.4
4/29/97	5020	91.0	7.1
4/30/97	5090	96.6	7.0
5/1/97	4950	88.8	7.2
5/2/97	5170	88.4	7.1
5/3/97	5370	91.1	8.2
5/4/97	5520	96.6	8.5
5/5/97	5550	92.6	8.1
5/6/97	5530	102	9.0
5/7/97	5510	84.0	8.2
5/8/97	5490	85.7	7.8
5/9/97	5300	76.3	7.8
5/10/97	5050	79.1	7.1
5/11/97	4690	77.4	7.1
5/12/97	4760	77.9	7.3
5/13/97	4860	82.7	7.7

San Luis Drain @ Terminus (MER535S) continued

Date	EC µmhos/cm	Se µg/L	B mg/L	Date	EC µmhos/cm	Se µg/L	B mg/L
5/14/97	4660	77.5	7.5	7/12/97	4120	39.0	7.8
5/15/97	4570	72.4	7.2	7/13/97	3950	41.0	7.5
5/16/97	4450	60.7	7.0	7/14/97	4050	46.9	7.2
5/17/97	4550	65.8	7.0	7/15/97	4240	44.1	8.0
5/18/97	4750	67.8	7.5	7/16/97	4260	43.8	8.0
5/19/97	4690	68.4	7.3	7/17/97	4200	41.0	7.8
5/20/97	4440	67.6	7.2	7/18/97	4300	44.1	8.1
5/21/97	4420	71.4	6.9	7/19/97	4190	47.1	7.8
5/22/97	4030	63.8	6.1	7/20/97	4110	57.4	7.6
5/23/97	4230	64.4	6.8	7/21/97	4030	49.0	7.4
5/24/97	4270	65.0	6.9	7/22/97	4150	52.8	7.3
5/25/97	4720	72.0	8.1	7/23/97	4090	47.0	7.5
5/26/97	4580	63.9	7.8	7/24/97	4190	46.2	7.8
5/27/97	4570	66.6	7.7	7/25/97	4220	43.6	8.1
5/28/97	4560	68.2	7.7	7/26/97	4180	44.0	7.8
5/29/97	4460	66.5	7.7	7/27/97	3900	37.9	7.2
5/30/97	4400	70.0	6.5	7/28/97	3950	44.0	7.3
5/31/97	4520	72.0	6.9	7/29/97	4050	44.3	7.3
6/1/97	4580	80.4	6.9	7/30/97	4000	40.0	7.3
6/2/97	4770	78.8	7.4	7/31/97	3850	40.2	7.0
6/3/97	4730	75.8	7.4	8/1/97	3760	42.6	6.9
6/4/97	4820	77.2	7.6	8/2/97	3620	39.2	6.5
6/5/97	4800	75.7	7.8	8/3/97	3570	36.6	6.5
6/6/97	4680	56.7	7.6	8/4/97	3540	32.9	6.4
6/7/97	4660	55.8	7.6	8/5/97	3460	34.7	6.1
6/8/97	4680	56.5	7.3	8/6/97	3810	41.2	6.4
6/9/97	4780	51.3	8.1	8/7/97	3610	34.0	6.3
6/10/97	4680	45.4	8.0	8/8/97	4250	51.0	7.7
6/11/97	4770	56.8	8.0	8/9/97	4090	46.1	7.3
6/12/97	4590	58.4	7.9	8/10/97	3880	46.9	6.8
6/13/97	5040	78.6	9.0	8/11/97	3830	48.4	6.7
6/14/97	4910	64.4	8.8	8/12/97	3870	46.0	6.8
6/15/97	4850	67.8	8.7	8/13/97	3680	37.8	6.5
6/16/97	4840	69.0	8.7	8/14/97	3730	38.4	6.4
6/17/97	4820	73.0	8.6	8/15/97	3710	41.6	6.2
6/18/97	4300	61.2	7.4	8/16/97	3430	35.6	5.8
6/19/97	4440	65.4	7.6	8/17/97	3240	32.0	5.3
6/20/97	4540	66.7	7.9	8/18/97	3430	40.3	5.6
6/21/97	4380	57.2	7.6	8/19/97	3590	47.4	5.6
6/22/97	4580	74.7	7.4	8/20/97	3330	37.8	5.6
6/23/97	4410	67.7	7.4	8/21/97	3470	39.7	5.5
6/24/97	4450	66.2	7.3	8/22/97	3820	39.5	6.2
6/25/97	4260	55.8	7.2	8/23/97	3550	32.7	6.1
6/26/97	4680	68.1	8.3	8/24/97	3450	40.5	6.0
6/27/97	4650	59.1	8.1	8/25/97	3270	31.0	5.7
6/28/97	4570	56.8	8.1	8/26/97	3540	35.7	6.1
6/29/97	4530	54.2	8.1	8/27/97	3790	45.2	6.2
6/30/97	4470	53.0	7.9	8/28/97	4020	51.6	6.3
7/1/97	4480	66.8	8.3	8/29/97	4140	50.8	6.6
7/2/97	4540	62.8	7.9	8/30/97	3880	38.3	6.4
7/3/97	4400	57.4	7.6	8/31/97	3870	43.2	6.4
7/4/97	4430	54.8	7.8	9/1/97	4230	55.8	6.3
7/5/97	4670	61.4	8.5	9/2/97	4180	52.0	6.4
7/6/97	4510	49.9	8.4	9/3/97	3920	43.0	5.8
7/7/97	4350	51.1	7.9	9/4/97	3440	29.3	5.4
7/8/97	4090	42.9	7.4	9/5/97	3290	26.6	5.2
7/9/97	4410	61.2	7.7	9/6/97	3680	36.0	6.0
7/10/97	4060	43.4	7.5	9/7/97	3480	27.7	5.6
7/11/97	4330	45.8	8.1	9/8/97	3760	24.3	6.1

San Luis Drain @ Terminus (MER535S) continued

Date	EC µmhos/cm	Se µg/L	B mg/L
9/9/97	3410	22.1	5.8
9/10/97	3100	20.6	5.2
9/11/97	3150	25.4	5.1
9/12/97	2960	20.1	4.6
9/13/97	3260	27.4	5.0
9/14/97	3240	28.2	5.0
9/15/97	2740	18.4	4.2
9/16/97	2630	16.5	4.1
9/17/97	2620	15.2	4.1
9/18/97	2950	16.6	4.5
9/19/97	2980	18.4	4.6
9/20/97	2940	18.0	4.6
9/21/97	2890	19.0	4.6
9/22/97	3070	20.9	4.7
9/23/97	3320	21.6	5.2
9/24/97	3440	19.9	5.4
9/25/97	3520	20.0	5.4
9/26/97	3590	20.1	5.9
9/27/97	3700	20.9	6.1
9/28/97	3530	20.7	5.7
9/29/97	3470	22.0	5.6
9/30/97	3900	32.2	5.9
Count	358	348	344
Min	2620	15.2	4.1
Max	5880	116	9.3
Mean	4390	62.4	7.0
Geo Mean	4340	57.7	6.9
Median	4420	61.5	7.2

* Data under review

C—115122

C-115122

1350 Continued

RECD JUN 12 1978

Public Hearing
STATE WATER RESOURCES CONTROL BOARD
STATE OF CALIFORNIA

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In the Matter of Draft Water Quality)
Control Plan for Sacramento-San)
Joaquin Delta and Suisun Marsh, and)
Draft Environmental Impact Report)
)
- -)

San Joaquin County
Flood Control and
Water Conservation District
Office of County Counsel

---oOo---

Held in:

Resources Building
Sacramento, California

---oOo---

Tuesday, May 30, 1978
9:00 a.m.

---oOo---

ALICE BOOK
CERTIFIED SHORTHAND REPORTER
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SDWA 45

MR. BRYSON: All right.

MR. HILDEBRAND: Now, Mr. Chairman and members of the Board, my name is Alex Hildebrand. I am a farmer, and as Mr. Wilson says, a secretary and member of the board of the South Delta Water Agency.

At this hearing, the Board is attempting to perform both a water quality control function and a water right function. In the draft of the plan, it is stated that the Board proposes to develop under its full authority ". . . a single comprehensive set of water quality objectives to protect beneficial uses of Delta water supplies." In the opinion of the Board of Directors of South Delta Water Agency, the draft of the Water Quality Control Plan fails to provide the Southern Delta the protection to which it is entitled if considered as a "water quality control plan," and fails to give recognition to water rights in the Southern Delta if considered as a "water rights decision."

First, consider the record made in this proceeding by the South Delta Water Agency. It may be summarized as follows:

1. The water quality of the San Joaquin River inflow to the Southern Delta was generally better during the pre-project period than during the post-project period, i.e., an average at Mossdale of about 299 TDS during the pre-project decade as compared to an average of about 521 during the post-project decade.

The Bureau subsequently raised some questions regarding our choice of years for the decade, but if we take a different choice which would meet their objections, the numbers are

hardly changed.

During the period 1930 to 1976, the water quality in the two pre-project lowest flow years, 1931-1934, was better than in any of the thirteen post-project lowest flow years.

2. The San Joaquin River flows into the Southern Delta during the pre-project period were on the average greater than during the post-project period, i.e., an average of about 6200 cubic feet per second during the pre-project decade as compared with an average of about 3100 cubic feet per second during the post-project decade. During the period 1930 to 1976, 13 of the 15 lowest flow years were post-project, after 1944.

3. In years of low San Joaquin River inflow to the Southern Delta during the pre-project period, the quality was relatively good, but in years of low inflow during the post-project period, the quality has been very poor. During the period 1930 to 1976, the water quality of the San Joaquin River coming into the Southern Delta in 24 of the 32 post-project years was poorer than in any of the pre-project years. Low flows are far less damaging when they are of good quality, thereby permitting more reuse of Southern Delta return flows. Delta lands add very little salt. They merely concentrate the salt dumped on us from upstream.

4. To sustain the agricultural economy in the Southern Delta, which was fully developed during the pre-project period, the quality of the in-channel water supply must

in normal years be not less than 450 parts per million TDS on a 30-day average and 400 parts per million TDS on an annual average.

These conclusions were based on testimony which I gave and which were in turn based upon the testimony presented by the UC Extension Service and the U. S. Salinity Laboratory.

5. The operations of the Federal Central Valley Project have caused a reduction of the San Joaquin River inflow to the Southern Delta.

Our data indicates that the reduction attributable to the Central Valley Project is approximately 1.25 million acre-feet per year.

6. The operations of the Federal Central Valley Project have caused a deterioration in the quality of the inflow of the San Joaquin River to the Southern Delta.

There are many proofs of this including internal Bureau documents which acknowledge that degradation.

7. The operations of the Federal Central Valley Project, referring particularly to the Delta-Mendota Canal, annually import great quantities of salt into the San Joaquin River basin which eventually is brought into the Southern Delta in the San Joaquin River inflow.

8. The operation of the Federal Central Valley Project and State Water Project pumps near Tracy have had a detrimental effect upon the water supply in the Southern Delta in that such operations have reduced channel depths thereby reducing channel flow capacity, reduced tidal flushing, and increased the salinity of the in-

channel water supply.

The conclusions to be drawn from the evidence presented by South Delta Water Agency are that:

1. The Southern Delta had a better in-channel water supply during the pre-project period than during the post-project period.

2. To sustain maximum yields and crop diversity, the Southern Delta must have a dependable in-channel water supply greater in flows and better in quality than has occurred during the post-project period.

3. The combined effects of the State and Federal projects have had a detrimental effect on the in-channel water supply in the Southern Delta.

Further studies by South Delta Water Agency since the hearing substantiate and augment the testimony presented, particularly regarding the Central Valley Project's responsibility for the degradation of the San Joaquin River inflow to the Southern Delta.

Against this record made by the South Delta Water Agency at this hearing, it may be seen that the draft of the Water Quality Control Plan falls short of providing the Southern Delta the protection to which it is entitled and which it must have.

First, considering the draft as a set of water quality objectives.

Water Code Section 13050(h) states that "Water quality objectives" means the levels of water quality constituents which are established for the reasonable protection of beneficial

uses of water.

The water quality objectives in the draft, i. e., 500 parts per million TDS at Vernalis after New Melones is operational and 0.7 EC for the period April 1 to August 31, and 1.0 EC for the period September 1 to March 31, after the completion of suitable circulation and water supply facilities, at page VI-31, by no means meet the definition in Section 13050(h) of the Water Code. It is to be noted that no flow objectives are included.

This means there will be no Water Quality Control Plan for the Southern Delta for an indefinite period, and at some future time a water quality objective that is neither the equivalent of the historical water supply nor adequate to protect and sustain the agricultural economy in the area.

The effect of the adoption of such an objective at this time wwould be to make the negotiations of the South Delta Water Agency with the Department of Water Resources and the Bureau more difficult by the use of values which are not adequate, are not supported by the record in this proceeding, and are not supported by reference to the historical water supply.

It should also be noted that there is no justification for the arbitrary periods used for quality objectives after the complation of undefined circulation and water supply facilities. Some irrigation takes place in all months of at least some years, and the irrigation season normally runs from the first of March through October.

Irrigation diversions are roughly one-half as great in

March and October as in the peak month of July. Salt sensitive crops such as beans are often irrigated in September. A water quality of not to exceed 450 parts per million TDS in the Southern Delta channels is needed throughout the entire irrigation season.

Second, considering the draft as a "water rights decision," it seems apparent that the water rights of the lands and water users in the Southern Delta have been almost entirely ignored.

The authorities relating to the Delta's water rights were reviewed in the brief filed on behalf of South Delta Water Agency in this proceeding. The net effect of these authorities found in the State Constitution, the statutes of the State and the decisions of the courts, is to vest in the Delta a priority, commonly referred to as the "Delta's priority."

Not only must the Delta's priority be recognized in this hearing, but it must be fully satisfied before export of water from the Delta to other areas is permitted. This applies to the entire Delta. The proposed Water Quality Plan does neither -- it fails to give recognition to any water rights in the Southern Delta and provides no assurance that the Southern Delta will have an adequate and suitable water supply.

Turning to a few more specific comments regarding the Draft of the Water Quality Control Plan:

a) In Chapter I, page 7, it is said that the rights of riparian lands and appropriators extend to water quality and quantity which would have been available in the absence of the projects. The proposed draft neither acknowledges nor protects these rights in the Southern Delta.

EFFECTS OF THE CVP
UPON THE SOUTHERN DELTA WATER SUPPLY
SACRAMENTO-SAN JOAQUIN RIVER DELTA, CALIFORNIA

JUNE 1980

Prepared jointly by the
Water and Power Resources Service
and the South Delta Water Agency

SDWA EXHIBIT No. 4

REPORT

ON

EFFECTS OF THE CVP

UPON THE SOUTHERN DELTA WATER SUPPLY

THE PARTICIPATING PARTIES

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Billy E. Martin, Director, Mid-Pacific Region,

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VII-7	Ratio of Flow at Two Locations on San Joaquin River as Influenced by Delta-Mendota Canal Pumping
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APPENDICES

Appendix No.	Title
1	Monthly flow data (KAF) and monthly chloride data (p/m)
2	Chloride load-flow regression curves
3	Salt (chloride) balances by representative months
4	Summary of network analysis of the lower Sacramento-San Joaquin Delta

EFFECTS OF THE FEDERAL CVP UPON THE QUALITY AND VOLUME OF THE INFLOW OF THE SAN JOAQUIN RIVER TO THE SACRAMENTO-SAN JOAQUIN DELTA AND UPON THE IN-CHANNEL WATER SUPPLY IN THE SOUTHERN DELTA

CHAPTER I

INTRODUCTION AND DEFINITIONS

Over the last several years in the course of the discussions between representatives of the South Delta Water Agency (SDWA) and representatives of the United States Water and Power Resources Service (Service), formerly the United States Bureau of Reclamation (USBR), the parties have found that the available technical data relative to the impact of the Federal Central Valley Project (CVP) upon the San Joaquin River inflow to the Sacramento-San Joaquin Delta (Delta) and the effect of the operation of the Federal CVP and California State Water Project (SWP) export pumps near Tracy on the in-channel water supply in the southern Delta was limited and had never been thoroughly studied and evaluated.

At a meeting held in Washington, D.C., on July 17, 1978, attended by representatives of the Department of the Interior, a technical analysis and evaluation of the effect was authorized and undertaken. The State Department of Water Resources of the State of California (DWR) was invited to participate and did so to a limited extent. Since July, 1978, the technical staffs of the SDWA and the Service have engaged in a detailed study of subject matter, and committees representing the participating parties, from time to time, met for the purpose of reviewing progress of the technical advisors and generally directing the areas in which technical research should be conducted.

The purpose of this document is to set forth a report by the SDWA and the Service of the factual technical findings and the conclusions to this date resulting from such research and studies.

For purposes of this report, where substantial areas of disagreement exist between the SDWA and the Service on the interpretation of data, the differences will be noted and the differing views of the parties set forth.

In order to facilitate brevity and to assist in the understanding of this report, the following definitions are intended unless the context or express provision requires otherwise.

1. "South Delta Water Agency" (SDWA) is an agency created by the South Delta Water Agency Act (Cal. Stats. 1973, c. 1089, p. 2207) for the purposes therein described.

2. The "United States Water and Power Resources Service" (Service) is the agency responsible for the operation of the Federal Central Valley Project (CVP). Prior to November 6, 1979, this agency was known as the United States Bureau of Reclamation (USBR).

3. "Southern Delta" is defined as the area within the boundaries of the SDWA as defined in Cal. Stats. 1973, c. 1089, p. 2214, sec. 9.1 (California Water Code Appendix Chapter 116).

4. "Central Valley Project" (CVP) is defined as the Federal Central Valley Project in California.

5. "State Water Project" (SWP) is the State Water Resources Development System as defined in Section 12931 of the California State Water Code.

6. The "Delta Mendota Canal" (DMC) is a conveyance facility of the CVP by means of which water is exported from the Delta near Tracy and delivered on the west side of the San Joaquin Valley and to the Mendota pool in the San Joaquin River.

7. The "State Aqueduct" is a conveyance facility of the SWP by means of which water from the Delta is exported through Clifton Court Forebay near Tracy to the San Joaquin Valley and Southern California.

8. "Export Pumps" are defined as the CVP and SWP pumps located at the diversion point of the DMC and the State Aqueduct. They are operated as part of the CVP and the SWP for the purpose of diverting and exporting from the Delta via the canals.

9. "Delta" or the "Sacramento-San Joaquin Delta" is defined as all of the lands within the boundaries of the Sacramento-San Joaquin Delta as described in Section 12220 of the Water Code of the State of California on January 1, 1974.

10. "New Melones Project" is the Federal project on the Stanislaus River authorized by Public Law 78-534, dated December 22, 1944, as modified by Public Law 87-874, dated October 23, 1962.

11. "Vernalis" is defined as the San Joaquin River gaging station just below the mouth of the Stanislaus River at the Durham Ferry Bridge.

12. "Pre-1944" is defined as the years 1930 to 1943, inclusive, unless otherwise indicated.

13. "Post-1947" is defined as the years 1948 to 1969, inclusive.

14. "Total Dissolved Solids" (TDS) is defined as the concentration in milligrams per liter of a filtered water sample of all inorganic or organic constitutents in solution determined in accordance with procedures set forth in the publication entitled "Standard Methods for the Examination of Water and Waste Water" published jointly by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation, 13th Edition, 1971.

15. "Cubic Foot Per Second" (ft^3/s) or (CFS) is the flow of 1 cubic foot of water per second past a given point.

16. "p/m" or "ppm" is defined as parts per million, and is used synonomously with mg/L is this report.

17. "mg/L" is defined as milligrams per liter.

18. "KAF" is 1,000 acre-feet.

19. "Mendota Pool" is a small storage reservoir impounded by a diversion dam on the San Joaquin River about 30 miles west of Fresno into which the Delta-Mendota Canal discharges water conveyed from the Tracy Pumping Plant.

20. "Unimpaired Rim Flow" is defined as the sum of gaged flows, adjusted for upstream storage, at four stations on the major tributaries as follows:

SAN JOAQUIN RIVER AT FRIANT DAM
MERCED RIVER AT EXCHEQUER DAM
TUOLUMNE RIVER AT DON PEDRO DAM
STANISLAUS RIVER AT NEW MELONES DAM

The sum of these gaged flows is also used in this report as the Vernalis unimpaired flow.

21. The "Lower San Joaquin River" is defined as that portion of the San Joaquin River downstream of the mouth of the Merced River.

22. The "Upper San Joaquin River" is defined as that portion of the San Joaquin River and basin upstream of the mouth of the Merced River.

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CHAPTER II

PURPOSES OF INVESTIGATIONS

The purpose of the investigation was to analyze and prepare a written report upon the following:

(a) The effect of the operation of the CVP upon the San Joaquin River inflow (quality and volume) to the Delta;

(b) The effect of the operation of the CVP export pumps near Tracy upon the in-channel water supply in the Southern Delta.

While all water supply development in the San Joaquin River basin has the effect of reducing the annual flow of the San Joaquin River at Vernalis, this report is directly concerned only with the effects of the CVP on the in-channel water supply in the southern Delta. The available data has been reviewed and analyzed to determine what, if any, changes have occurred affecting the southern Delta in-channel water supply since the CVP began operation in 1947. The two agencies preparing the report have not agreed on the legal obligation of the Federal Government to the southern Delta. In addition, there are several other issues on which agreement has not been reached and further discussion and study will be needed. Therefore, the report does not include consideration of the following:

1. Water rights, priorities, or legal status of any party related to the in-channel water supply in the southern Delta, including water users in the southern Delta.
2. Economic consequences of any impacts discussed on southern Delta agriculture and other uses.

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3. Alternative solutions to improve the in-channel water supply in the southern Delta.

4. The impact on the Southern Delta in-channel water supply of the operation of the CVP New Melones Reservoir.

The impacts of developments other than the CVP affecting the in-channel water supply in the southern Delta have been attributed to specific other developments when such impacts are clearly identifiable. The impact of the operation of the SWP export pumps has been specifically included. The impacts other than CVP have been determined incidentally to the principal purposes of this report.

While development other than the CVP has occurred in the upper San Joaquin River basin (as defined in Chapter I) since 1947, it was assumed in the investigation that the impact of other development is negligible. Consequently, for this report, the effects on San Joaquin River inflow to the Delta (both quantity and quality) of all development in the upper San Joaqin River basin since 1947 are considered as effects due to the CVP.

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CHAPTER III

DESCRIPTION OF THE SAN JOAQUIN RIVER SYSTEM INCLUDING THE FEDERAL CENTRAL VALLEY PROJECT THE SOUTHERN DELTA, AND DATA SOURCES

A. PRINCIPAL FEATURES

1. General

The San Joaquin River basin lies between the crests of the Sierra Nevada Mountains and the Coast Ranges, and extends north from the northern boundary of the Tulare Lake Basin near Fresno to the Sacramento-San Joaquin Delta (see Figure III-1). It is drained by the San Joaquin River and its tributary system. The basin has an area of about 14,000 square miles extending about 100 miles from the crest of Sierra Nevada Range to the crest of the Coast Ranges and about 120 miles from the northern to the southern boundry. The Sierra Nevada Mountains have an average crest elevation of about 10,000 feet with occasional peaks higher than 14,000 feet. The Coast Ranges crest elevations reach up to about 5,000 feet. The San Joaquin valley area measures about 100 miles by 50 miles and slopes gently from both sides towards a shallow trough somewhat west of the center of the valley. Valley floor elevations range from about 250 feet at the south to near sea level at the north. The trough forms the channel for the Lower San Joaquin River and has an average slope of about 0.8 foot per mile between the Merced River and Paradise Cut.

Major tributary streams, from north to south, are the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced Rivers. These streams, plus the San Joaquin River, contribute the major portion of the surface inflow to the valley. Minor streams on the east side of the valley are the Fresno and Chowchilla Rivers and Burns, Bear, Owens, and Mariposa Creeks. Panoche, Little

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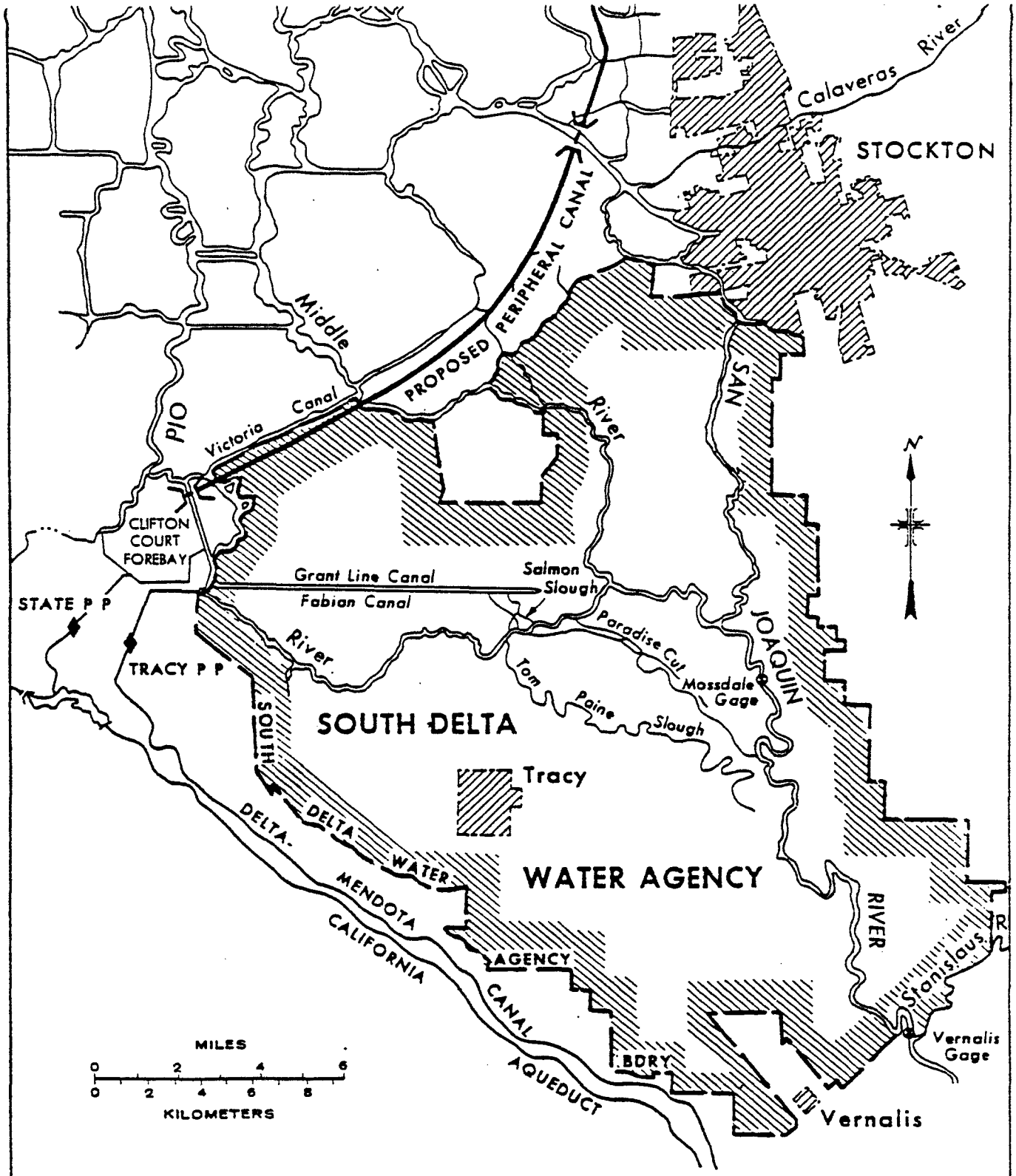

SOUTH DELTA WATER AGENCY

FIGURE III-2

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Panoche, Los Banos, San Luis, Orestimba, and Del Puerto Creeks comprise the minor streams on the west side. These west side streams contribute very little to the runoff of the San Joaquin River. Numerous other small foothill channels carry water only during intense storms. During high runoff periods a distributary channel of Kings River (called James Bypass) discharges water into the San Joaquin River at Mendota. In addition, floodwater is diverted to the San Joaquin River from Big Dry Creek Reservoir near Fresno. Flows from rivers and creeks are significantly reduced by storage, diversions, and channel seepage losses as they cross the valley floor so that only a portion of the water at the foothill line reaches the San Joaquin River.

2. Southern Delta

The boundaries of the South Delta Water Agency (SDWA) are set forth in section 9.1 of the South Delta Water Agency Act (Cal. Stats. 1973, c. 1089, p. 2207). The area encompassed therein is located in the southeastern part of the Sacramento-San Joaquin Delta as illustrated in Figure III-2. It contains approximately 231 square miles or roughly 148,000 acres. Of this area, about 123,000 acres are devoted to agricultural uses and the remainder is comprised of waterways, levees, and lands devoted to residential, industrial and municipal uses. The area within SDWA is generally known as the Southern Delta.

The lands in the southern Delta are generally mineral soils with low permeability. The agricultural lands in the Southern Delta are fully developed, irrigated and highly productive. The agricultural lands are dependent primarily upon the in-channel water supply in the area for irrigation, and for irrigation purposes about 450,000 acre-feet per year are diverted from the channels.

There are about 75 miles of channels in the southern Delta and these are of great importance. They not only serve as water supply sources for irrigation,

but also as drainage canals for drainage water, important habitat and migration routes for fish, waterways for commercial shipping and recreational boating, and avenues for the passage of floodwaters.

3. Existing Water Resource Development

a. General

Development of the water resources of the San Joaquin River basin was initiated more than 120 years ago. This development ranges from small local diversions from the rivers and streams to large multiple-purpose reservoirs and extensive levee and channel improvements. Because of this development the flow regime of the San Joaquin River has significantly changed from that which would occur under natural conditions. The major reservoirs in the basin are tabulated below:

Major Reservoirs
San Joaquin River Basin

Name of Reservoir	Operating Agency	Year Completed	Purpose	Capacity (AF)
Stanislaus River				
Union	PG&E	1902	P	2,000
Utica	PG&E	1908	P	2,400
Relief	PG&E	1910	P	15,600
Strawberry	PG&E	1916	P	18,300
Woodward	South San Joaquin I.D.	1918	I	36,000
*Melones	Oakdale & SSJ I.D.	1926	I,P	112,500
Spicer Meadows	PG&E	1929	P	4,100
Lyons	PG&E	1932	P	5,500
Beardsley	Oakdale & SSJ I.D.	1957	I,P	98,300
Donnells	Oakdale & SSJ I.D.	1958	I,P	64,700
Tulloch	Oakdale & SSJ I.D.	1958	I,P	68,200
New Melones	U.S.C.E.	1979	FC,I,P,P,F&W,WQ	2,400,000
Tuolumne River				
Modesto Reservoir	Modesto I.D.	1911	I	27,000
Turlock Lake	Turlock I.D.	1915	I	4,900
Lake Eleanor	City & Co. of S.F.	1918	M&I,P	26,100
Hetch Hetchy	City & Co. of S.F.	1923	M&I,P	360,000
Cherry Valley	City & Co. of S.F.	1956	M&I,P	268,000
**Don Pedro	Modesto & Turlock I.D.	1923	I,P	290,400
New Don Pedro	Modesto & Turlock I.D.	1971	FC,I,P,R	2,030,000

*Inundated by New Melones Reservoir.
**Inundated by New Don Pedro Reservoir.

Major Reservoirs
San Joaquin River Basin
(Cont'd)

Name of Reservoir	Operating Agency	Year Completed	Purpose	Capacity (AF)
Merced County Streams				
Yosemite Lake	Merced I.D.	1888	I	7,000
Mariposa	USCE	1948	FC	15,000
Owens	USCE	1949	FC	3,600
Burns	USCE	1950	FC	6,800
Bear	USCE	1954	FC	7,700
Merced River				
McSwain	Merced I.D.	1966	I,P,R	9,500
***Lake McClure	Merced I.D.	1926	I,P	280,900
New Exchequer	Merced I.D.	1967	FC,I,P,R	1,025,000
Chowchilla & Fresno Rivers				
Madera Lake	Madera Co.	1958	R	4,700
Hensley Lake	USCE	1975	FC,I,R	90,000
H.V. Eastman Lake	USCE	1975	FC,I,R	150,000
San Joaquin River				
Crane Valley	PG&E	1910	P	45,100
Huntington Lake	SCE	1917	P	89,200
Kerckhoff	PG&E	1920	P	4,300
Florence Lake	SCE	1926	P	64,400
Shaver Lake	SCE	1927	P	135,300
Millerton Lake	WPRS	1941	FC,I,M&I	520,500
Big Dry Creek	USCE	1948	FC	16,250
Redinger Lake	SCE	1951	P	35,500
Lake Thomas A. Edison	SCE	1954	P	125,000
Mammoth Pool	SCE	1960	P	123,000
Westside Streams				
Los Banos	WPRS/DWR	1966	I,M&I,P,R	34,600
Little Panoche	WPRS/DWR	1966	I,M&I,P,R	5,600
O'Neill Forebay	WPRS/DWR	1967	FC	56,400
San Luis	WPRS/DWR	1967	FC,R	2,041,000

*** Inundated by New Exchequer Reservoir

b. Irrigation Projects

Major irrigation canals consisting of the Delta-Mendota Canal and the California Aqueduct have been constructed to transport water from the

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Sacramento-San Joaquin Delta to water deficient areas in the San Joaquin Valley, Tulare Lake Basin, and Southern California. These canals are located along the west side of the San Joaquin Valley and are shown on Figure III-1. Numerous irrigation distribution systems have been constructed throughout the valley floor area to convey irrigation water to the farms.

c. Delta Export Facilities

Central Valley Project

Tracy Pumping Plant. The Tracy Pumping Plant, located near Tracy at the southern edge of the Delta (Figure III-2) lifts water via an intake channel from Old River some 197 feet into the Delta-Mendota Canal. The six pumps at Tracy are capable of pumping a total of approximately 4,600 ft^3/s. The plant has been operational since 1951. The pumping plant operates on demand and therefore diverts water from the Delta continuously regardless of tidal phase.

Delta-Mendota Canal. The Delta-Mendota Canal is a major canal of the Central Valley Project (CVP). It carries water south from the Tracy Pumping Plant along the west side of the San Joaquin Valley. In addition to water service along the canal, the canal is used both to transport water to the San Luis Unit of the CVP and to partially replace San Joaquin River water stored by Friant Dam and utilized in the Madera and Friant-Kern Canal systems. The canal and pumping plant began operation in 1951. The canal is 117 miles long and terminates at the San Joaquin River in the Mendota Pool near the city of Fresno. The conveyance capacity of the canal varies from 4,600 ft^3/s at the intake to 3,200 ft^3/s at its terminus.

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State Water Project

Clifton Court Forebay. The Clifton Court Forebay (Figure III-2) is a 30,000 acre-foot reservoir. The forebay, completed in 1969, buffers the effects of aqueduct pumping on the Delta. It also provides forebay storage for the Delta Pumping Plant to permit a large part of the pumping to be done with offpeak power. Advantage is also taken of the high-tide elevations to admit water into the forebay.

Delta Pumping Plant. The unlined intake channel conveys water from Clifton Court Forebay to the Delta Pumping Plant. The Delta Pumping Plant lifts water from sea level to an elevation of 224 feet where it flows by gravity through the State Aqueduct to the San Luis Division. The pumping plant, completed in 1967, houses seven pumping units, providing an aggregate hydraulic capacity of 6,300 ft^3/s. From the pump discharge lines, the concrete-lined State Aqueduct, with a capacity of 10,300 ft^3/s, conveys water south to the service areas of the State Water Projects.

d. Interbasin Transfers

There are two major diversions from the San Joaquin Basin. The interbasin transfer from the Tuolumne River through the Hetch Hetchy aqueduct to the city of San Francisco began in October 1934. A record of these annual diversions from the Tuolumne Basin was obtained from the files of the city of San Francisco and are presented on Table III-2.

In 1950 diversions from the San Joaquin River through the Friant-Kern Canal to the Tulare Lake Basin were begun by Friant Division of the CVP. A year later, the CVP began to import water into the San Joaquin Basin from the Sacramento-San Joaquin Delta through the Delta-Mendota Canal. Records of these two diversions by the Service are published in the USGS Water Supply Papers.

TABLE III-2

HETCH HETCHY AQUEDUCT
DIVERSION FROM TUOLUMNE RIVER

CALENDAR YEAR	ACRE-FEET
1934	11,211
1935	38,843
1936	56,814
1937	7,236
1938	1,692
1939	53,233
1940	24,090
1941	18,965
1942	14,087
1943	25,333
1944	47,533
1945	60,241
1946	61,710
1947	69,356
1948	68,812
1949	67,443
1950	75,425
1951	81,450
1952	49,796
1953	94,492
1954	112,850
1955	124,699
1956	80,029
1957	123,619
1958	70,286
1959	167,325
1960	166,623
1961	17,438
1962	158,488
1963	127,020
1964	185,600
1965	164,738
1966	198,425
1967	182,170
1968	223,221
1969	197,844
1970	198,766
1971	213,277
1972	260,359
1973	205,556
1974	215,501
1975	228,551
1976	263,727
1977	222,734
1978	161,304

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TABLE III-3

INTERBASIN TRANSFERS SAN JOAQUIN RIVER SYSTEM

	San Joaquin River at Friant 1,000 AF		Friant-Kern Canal 1,000 AF		Madera Canal 1,000 AF		Delta-Mendota Canal at Tracy 1,000 AF		Delta-Mendota Canal to Mendota Pool 1,000 AF	
	Annual	Apr-Sept	Annual	Apr-Sept	Annual	Apr-Sept	Annual	Apr-Sept	Annual	Apr-Sept
1938-39	1,077	616								
40	1,829	1,250								
41	2,589	1,255								
42	2,254	1,329								
43	2,068	1,281								
44	1,102	791			48	48				
45	1,885	1,364			110	106				
46	1,662	1,063			119	92				
47	1,155	816			102	76				
48	1,[illegible]06	802			76	72				
49	1,068	838			152	150				
50	974	743	198	180	118	118				
51	1,216	588	368	345	142	140	164	164	139	139
52	2,084	1,570	462	431	179	179	167	141	122	99
53	351	184	741	592	193	179	784	714	668	615
54	262	138	811	717	212	207	1,004	852	825	720
55	107	57	805	674	219	199	1,131	945	927	780
56	1,225	462	1,322	976	239	226	726	592	519	429
57	149	54	990	793	242	229	1,181	968	920	761
58	1,180	1,067	1,145	952	244	238	663	548	447	367
59	79	57	809	536	208	169	1,341	1,066	1,029	814
60	96	67	582	429	144	124	1,389	1,089	1,009	786
61	100	57	442	324	103	91	1,489	1,189	1,021	817
62	75	46	1,370	1,151	277	268	1,357	1,144	991	837
63	85	58	1,513	1,300	270	262	1,344	1,037	966	744
64	70	48	838	543	228	187	1,667	1,240	1,066	817
65	63	40	1,631	1,051	324	285	1,472	1,075	995	736
66	62	45	1,066	628	442	173	1,599	1,259	1,060	819
67	1,269	1,185	1,413	1,047	389	351	1,258	865	572	340
68	58	41	967	503	170	114	1,997	1,476	1,032	787

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A portion of the water imported through the Delta-Mendota Canal was delivered to the Mendota Pool in the San Joaquin River near Mendota to replace a portion of the water diverted from the basin at Friant Dam. Records of the amounts of water delivered to Mendota Pool were obtained from the Service files.

A listing of these interbasin transfers is presented on Table III-3.

4. Climate

The climate of the basin is characterized by wet, cool winters, dry, hot summers, and relatively wide variations in relative humidity. In the valley area relative humidity is very low in summer and high in winter. The characteristic of wet winters and dry summers is due principally to a seasonal shift in the location of a high pressure airmass ("Pacific high") that usually exists a thousand or so miles west of the mainland. In the summer the high blocks or deflects storms; in the winter it often moves southward and allows storms to reach the mainland.

a. Precipitation

Normal annual precipitation in the basin varies from 6 inches on the valley floor near Mendota to about 70 inches at the headwaters of the San Joaquin River. Most of the precipitation occurs during the period November through April. Precipitation is negligible during the summer months, particularly on the valley floor. The Sierra Nevada and Coast Ranges have a marked orographic effect on the precipitation. Precipitation increases with altitude, but basins on the east side of the Coast Ranges lie in a rain shadow and receive considerably less precipitation than do basins of similar altitude on the west side of the Sierra Nevada. Mean monthly and annual precipitation at several stations in the basin are tabulated below:

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Average Monthly Precipitation (in.)

Station --	Dudleys	Merced FS2	Sonora RS	So. Ent. Yosemite	Stockton WSO
Elev (ft)--	3000	169	1749	5120	22
Jan	7.05	2.24	5.69	8.23	2.91
Feb	5.87	1.92	4.88	7.09	2.11
Mar	5.74	1.74	4.92	6.39	1.96
Apr	3.87	1.41	3.19	4.50	1.37
May	1.28	.45	1.19	1.80	.42
Jun	0.44	.07	.33	.56	.07
Jul	.03	.01	.03	.08	.01
Aug	.05	.02	.05	.07	.03
Sep	.37	.11	.35	.57	.17
Oct	1.65	.55	1.49	2.03	.72
Nov	5.05	1.61	4.21	6.33	1.72
Dec	6.90	2.09	5.61	8.14	2.68
Mean Ann.	38.30	12.22	31.94	45.79	14.17

b. Snowfall

Winter precipitation usually falls as snow above the 5,000-foot elevation and as rain and/or snow at lower elevations. Snow cover below 5,000-feet is generally transient, and may accumulate and melt several times during the winter season. Normally the snow accumulates at higher elevations until about the first of April when the melt rates exceed snowfall. Surveys of the snowpack are conducted by the State of California starting in January of each year. Average April 1 water content at several snow courses is listed in the following tabulation*:

Station	Basin	Elev (ft)	Ave. 1 April Water Content (in)
Soda Cr. Flat	Stanislaus	7,800	22.0
Dana Meadows	Tuolumne	9,850	30.0
Snow Flat	Merced	8,700	42.0
Piute Pass	San Joaquin	11,300	35.0

*SOURCE: "Hydrology, lower San Joaquin River" office report Sacramento District, Corps of Engineers, December 1977.

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5. Storm Characteristics

Winter storms affecting the area are cyclonic wave disturbances along the polar front and usually originate in the vicinity of the Aleutian Islands. The normal trajectory of the waves is toward the southeast; however, the storms producing the greatest amount of precipitation have maintained a more easterly trajectory across the Pacific Ocean. The Coast Range Mountains form a barrier that reduces the moisture in the airmass moving inland. Most of the water carried past this barrier is precipitated by orographic effect on the western slope of the Sierra Nevada.

Major storms over the area normally last from 2 to 4 days and consist of two or more waves of relatively intense precipitation with lesser rates between the waves. Warm storms that combine intense precipitation with temperatures above freezing level at high elevations produce major floods from the Sierra Mountains. Rainfall during some of these major storms has occurred up to about the 11,000-foot level.

6. Data Sources

a. Stream Gages

Streamflow and reservoir level records have been maintained by United States Geological Survey (USGS), the California Department of Water Resources (DWR) and others for varying periods dating from 1901. A summary of the principal stations of interest in this investigation is presented in Table III-4 and their locations are indicated in figure III-3.

b. Water Quality Stations

Water quality data for the San Joaquin River system are rather limited.

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Although some data are available for tributary streams dating back to 1938, the records are sparse. The most reliable data are those collected by the USGS on a monthly frequency since 1951 (except for the Stanislaus River, on which sampling began in 1956). These generally include analyses for the principal cations and anions and determinations of TDS, EC, pH and Total Hardness. A record of 4-day sampling for chlorides in the San Joaquin River at Mossdale dates from 1929 through mid-1971. In recent years--since about 1959--continuous recordings of electrical conductivity have been made at selected stations in the Delta, including the San Joaquin River at Vernalis.

The locations of the principal water quality stations referenced in this report are indicated in figure III-4.

c. Unimpaired Flow Estimates

Development has affected the flow of all the major streams in the San Joaquin Basin. Estimates of the "unimpaired" flow of the San Joaquin River at Friant have been made by the Water and Power Resources Service for the period 1873-1978. Estimates for the other major streams in the basin were made by the Corps of Engineers (USCE). A list of the stations and the period of record is presented below:

Station	Estimate By	Period of Record
San Joaquin at Friant Dam	SERVICE	1873-1978
Merced River at Exchequer Dam	USCE	1906-1978
Tuolumne River at Don Pedro Dam	USCE	1901-1978
Stanislaus River at New Melones Dam	USCE	1901-1978

For the purposes of this report the unimpaired flow of the San Joaquin River at Vernalis was assumed to be the sum of the unimpaired flows at the four stations above.

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Table III-4 STREAM GAGES IN THE SAN JOAQUIN RIVER SYSTEM

Station	Operating 1/ Agency	D.A. (sq.mi.)	Period of record
San Joaquin River			
Millerton Lake	USBR	1638	1941 to date
bel. Friant	USGS	1676	1907 to date
nr. Mendota	USBR	4310 3/	1939 to date
nr. Dos Palos 2/	USBR	5630 3/	1940 to date
at Fremont Ford Bridge	DWR	7615 3/	1937 to date
nr. Newman	USGS	9520 3/	1912 to date
nr. Crows Landing	DWR	-	1965 to 1972
at Patterson Br.	DWR	9760 3/	1938 to 1966 1969 to date
at Maze Rd. Br.	DWR	12400 3/	1943 to date
nr. Vernalis	USGS	13536 3/	1922 to date
Merced River			
Lake McClure	MID	1037	1926 to date
bel. Merced Falls Dam, nr. Snelling	USGS	1061	1901 to date
bel. Snelling	DWR	1096	1958 to date
at Cressey	DWR	1224	1941 to date
nr. Livingston	MID	1245	1922 to 1944
nr. Stevinson	USGS	1273	1940 to date
Tuolumne River			
Don Pedro Reservoir	USGS	1533	1923 to date
abv. LaGrange Dam nr. LaGrange	USGS	1532	1895 to 1970
bel. LaGrange Dam nr. LaGrange	USGS	1538	1970 to date
at Modesto	USGS	1884	1940 to date
at Tuolumne City	DWR	1896	1930 to date
Stanislaus River			
Melones Lake	WPRS	904	1926 to date
bel. Melones Powerhouse	USGS	905	1931 to 1967
Tulloch Reservoir	TRI-DAMS	980	1957 to date
bel. Goodwin Dam	USGS	986	1957 to date
at Ripon	USGS	1075	1940 to date
Westside Streams			
Panoche Cr. bel. Silver Cr.	USGS	293	1949 to 1953 1958 to 1970
Orestimba Cr. nr. Newman	USGS	134	1932 to date
Del Puerto Cr. nr. Patterson	USGS	72.6	1958 to date
Los Banos Cr. nr. Los Banos	USGS	159	1958 to 1966

1/ USGS - United States Geological Survey, USBR - United States Bureau of Reclamation, USCE - United States Corps of Engineers, DWR - State of Calif., Dept. of Water Resources, MID - Merced Irrigation District

2/ Measures most of low flows and only part of flood peaks

3/ Includes Kings River basin

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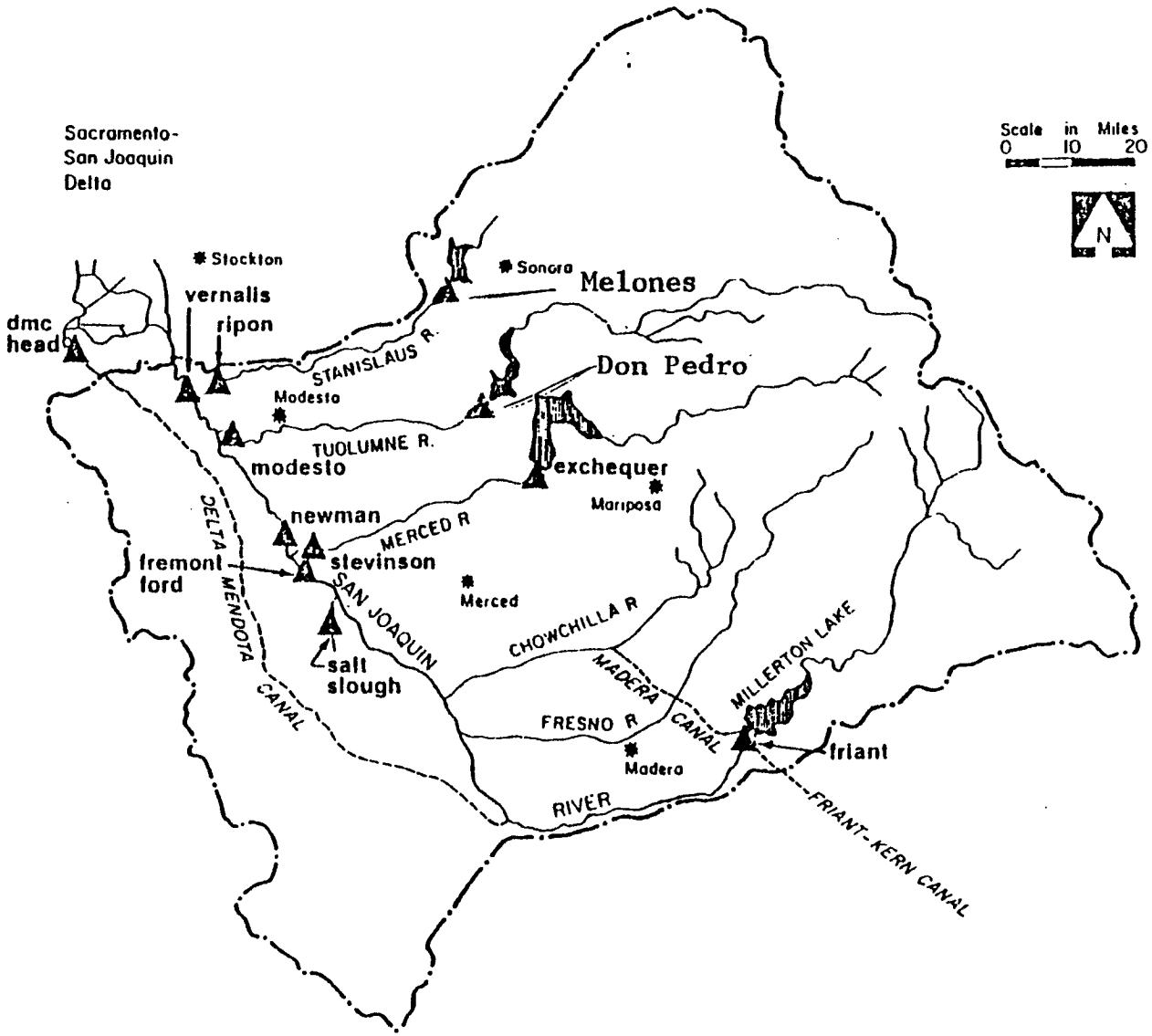

Figure III-3 SAN JOAQUIN RIVER BASIN STREAM FLOW GAGING STATIONS

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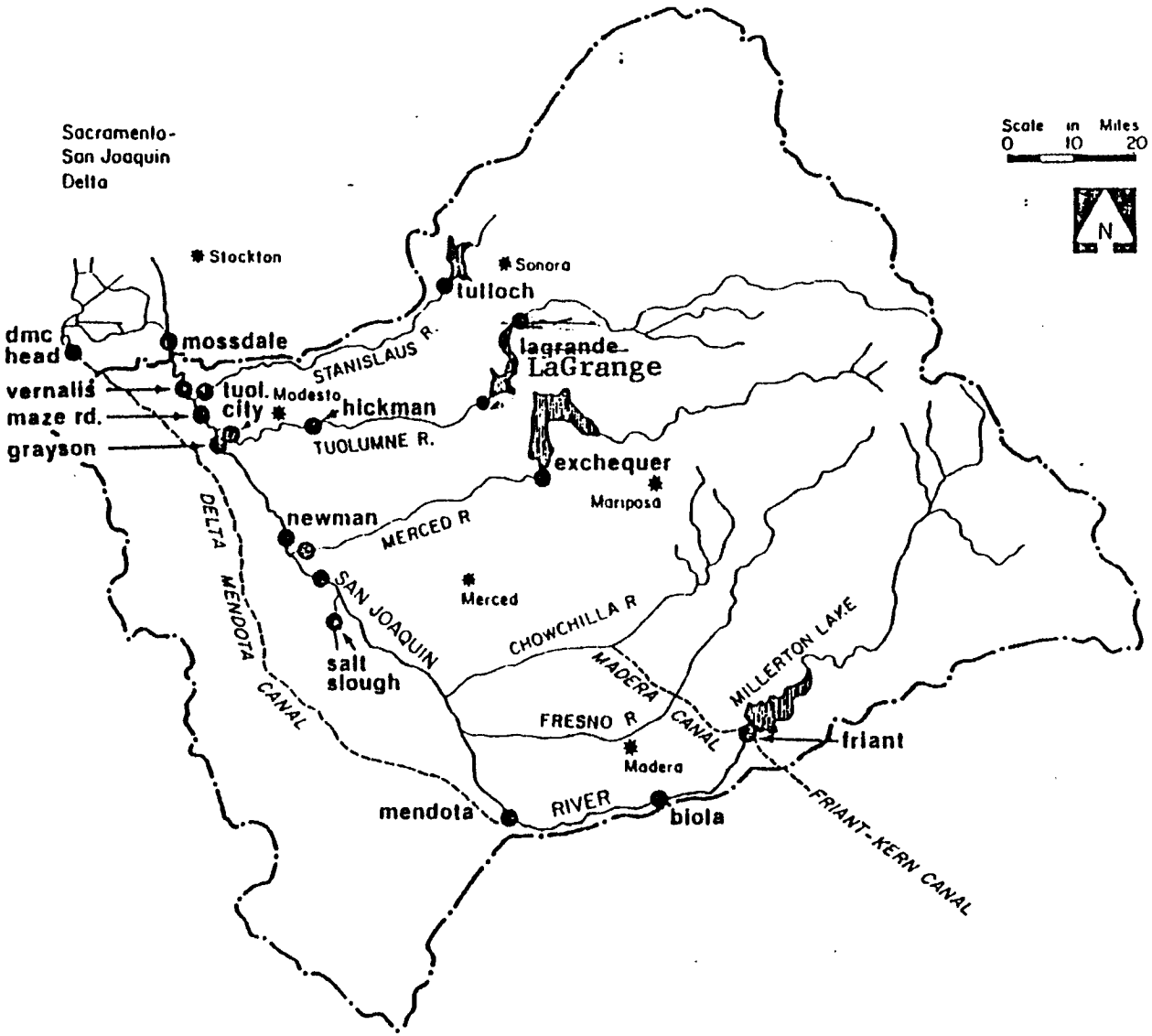

Figure III-4 SAN JOAQUIN RIVER BASIN WATER QUALITY SAMPLING STATIONS

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7. Return Flows

There have been few direct measurements of drainage return flows, only occasional gagings associated with special studies. In this report return flows were estimated by water balance calculations between stream gages where the change in flow could be attributed to drainage accretions.

8. Water Levels

Data on water levels in the Delta channels were derived from continuous recorders operated by the Department of Water Resources. The location of water level stations used in this report are shown in Figure III-5.

9. Channel Depths

Data on channel depths were derived primarily from hydrographic charts of the U.S. Coastal and Geodetic Survey and special surveys conducted in 1974 and 1975 by the Department of Water Resources.

10. Other

Additional data on flows, water quality and water levels were derived from reports of special studies and Service files.

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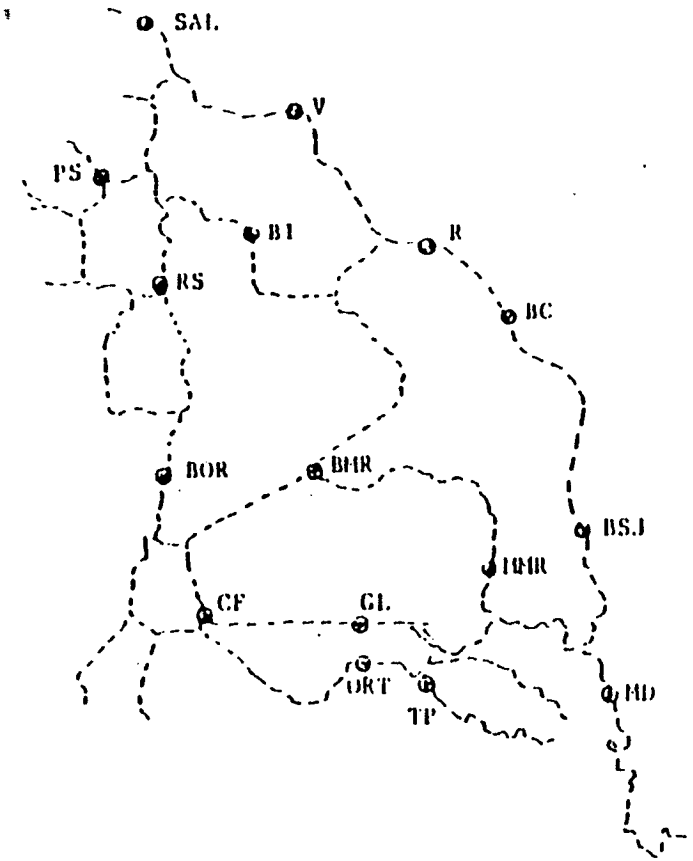

SAL - San Andreas Landing
V - Venice Island
PS - Piper Slough
BI - Bacon Island
R - Rindge
BC - Burns Cutoff
RS - Rock Slough
BOR - Byron
BHR - Borden
CF - Clifton Ferry
GL - Grant Line
HWR - Howry
BSJ - Brandt
ORT - Old River Tracy
TP - Tom Paine
MD - Mossdale

Figure III-5 WATER LEVEL STATIONS IN THE SOUTHERN DELTA

Source: California Department of Water Resources

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CHAPTER IV

INVESTIGATION PROCEDURE

A. SELECTION OF HYDROLOGIC AND WATER QUALITY RECORD PERIODS

Since the primary objective of this investigation is to determine the effect of the Central Valley Project on the quantity and quality of the in-channel water supply in the Southern Delta, the period of record was selected to include representative periods both before and after the implementation of CVP operations in the San Joaquin Valley. The pre-1944 spanned 14 years, 1930-1943 inclusive. The post-1947 spanned 22 years, 1948-1969 inclusive. Data records were assembled for the period 1930-1969, although the records for 1944 through 1947, when the CVP was being brought "on-line," were generally excluded from analysis.

B. ESTIMATION OF UNIMPAIRED RUNOFF

For the purposes of this investigation "unimpaired runoff" means the natural runoff of the river basin, absent the influence of man. Generally, this quantity is estimated by determining the aggregate runoff of all gaged streams in the drainage area above the highest point of development and adding an amount estimated to correspond to accretions from precipitation (ungaged) at lower levels if the watershed were entirely undeveloped, i.e., in virgin condition.

However, for reasons of simplicity it was decided to exclude the estimate of valley floor accretions (the ungaged flow from developed lands) and utilize only the gaged runoff of the four principal streams above the major projects. This runoff, which was used to estimate the impact of post-1947 development and operation, is referred to in this report as "unimpaired" rimflow.

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Unimpaired runoff at Friant, Exchequer, Don Pedro, and New Melones represent the rim station flows of the San Joaquin, Merced, Tuolumne, and Stanislaus Rivers, respectively. Vernalis unimpaired flow as referred to in this report is the sum of the four unimpaired rim station flows. This definition of Vernalis unimpaired flow is the commonly used form.

C. IDENTIFICATION OF KEY STATIONS FOR WATER BALANCE AND SALT BALANCE

The impacts of upstream development on the inflow to the Delta are measured mainly in the flow and quality of the San Joaquin River at Vernalis, hence data for this location are crucial to the investigation. Development of the CVP has occurred primarily in the upper portion of the San Joaquin River basin, at Friant, near Mendota and along the reach of the San Joaquin River above its confluence with the Merced River. Thus, the gaging station on the San Joaquin River near Newman, situated just below the mouth of the Merced, is important for the information it provides on the changes in runoff that may be attributed to the CVP. This runoff quantity has been corrected for the contribution of the Merced River and Merced Slough to produce a synthetic record of runoff of the upper San Joaquin River basin above the Merced River, which figures prominently in water balance computations. For the purposes of this report changes in runoff from the upper San Joaquin River basin, i.e., above the mouth of the Merced River, that have occurred since 1944 are attributed entirely to the CVP.

Other key stations for both the water quantity and water quality analysis, in addition to Vernalis, include stations on the eastside tributaries just upstream of their confluences with the main stem of the San Joaquin and the major westside tributary, Salt Slough for which good water quality data are available. Several stations along the Tuolumne River, at LaGrange, Hickman, and Tuolumne City serve to assess the contribution of the gas wells to the

river's salt burden.* Upstream stations at Friant, Exchequer, LaGrange, and Tulloch provide water quality data that are useful for comparison wi h westside drainage quality and the quality of water in the main stem of the San Joaquin.

D. ESTIMATION OF WATER BALANCE

Changes in water balance in the San Joaquin River for the pre-1944 and post-1947 periods have been assessed by several different techniques as follows:

1. By comparison of average annual, seasonal and monthly runoff at key locations for similar hydrologic periods.

2. By comparison of double mass plots of annual and seasonal runoff for key locations; either in chronological sequence or in order of magnitude sequence. Data for double mass diagrams were fitted with regression equations, that were then used in determining flow reductions.

Since no two-years or other chronological periods are hydrologically identical, an effort was made to classify seasons, years, or groups of years according to the magnitude of unimpaired (rim) runoff. Considering the four-station runoff total** as an estimate of the unimpaired flow of the San Joaquin River at Vernalis, an analysis of the record 1906-1977 (72 years) showed that hydrologic years could be grouped conveniently into four general categories of about equal size as shown on Table IV-1.

Dry	(19 years)	less than 3,500,000 AC/yr
Below normal	(18 years)	3,500,000 to 5,600,000 AC/yr
Above normal	(20 years)	5,600,000 to 7,500,000 AC/yr
Wet	(15 years)	greater than 7,500,000 AC/yr

*During the 1920's a series of gas wells were drilled in the region of the lower Tuolumne River. These wells penetrated water bearing formations, including some with high salinity. When these wells were later abandoned, some that penetrated artesian strata continued to flow, adding significant amounts of salt to the Tuolumne River in the lower section below Hickman. The wells were sealed in 1976-1977 so that the accretions of salt to the Tuolumne River were reduced. Data are not yet available to determine the extent of the salt load reduction and its impact on the San Joaquin River.

**San Joaquin River at Friant, Merced River at Exchequer, Tuolumne River at Exchequer, and Stanislaus River at Melones.

TABLE IV-1

UNIMPAIRED FLOW, SAN JOAQUIN RIVER AT VERNALIS, 1906-1979

Year	Flow 1,000 AF	Year	Flow 1,000 AF	Year	Flow 1,000 AF
1977	1,014	1918	4,587	1914	8,692
1924	1,504	1950	4,656	1909	8,971
1931	1,660	1971	4,870	1952	9,312
1976	1,928	1925	5,505	1956	9,679
1961	2,100	1923	5,512	1967	9,993
1934	2,288	1970	5,587	1938	11,248
1929	2,844	1962	5,618	1911	11,480
1939	2,909	1946	5,734	1907	11,824
1968	2,958	1921	5,901	1969	12,295
1960	2,960	1975	6,114	1906	12,427
1959	2,986	1963	6,250		
1913	2,995	1915	6,405		
1964	3,151	1935	6,418		
1930	3,254	1973	6,467		
1908	3,325	1936	6,495		
1933	3,356	1927	6,499		
1947	3,424	1937	6,530		
1912	3,458	1940	6,596		
1926	3,493*	1945	6,612		
1955	3,512	1932	6,622		
1972	3,571	1910	6,645		
1949	3,799	1917	6,662		
1944	3,933	1974	7,146		
1966	3,985	1951	7,262		
1919	4,096	1943	7,283		
1920	4,097	1942	7,370		
1948	4,218	1922	7,681		
1957	4,292	1941	7,945		
1954	4,313	1965	8,108		
1953	4,554	1916	8,229		
1928	4,365	1958	8,367		

* Bars divide the data according to year classifications, dry, below normal, above normal and wet.

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This division puts approximately the same number of years during the 1906-1978 period into each category. Each category was not equally represented in the two study periods as the following table illustrates:

	1906-1977	1906-1929	1930-1943	1948-1969	1970-1977
Dry	19	6	5	5	2
Below normal	18	6	0	8	3
Above normal	20	5	7	3	3
Wet	15	7	2	6	0
Total	72	24	14	22	8

A similar breakdown of the runoff of the San Joaquin River at Friant indicated that this year classification system was consistent for the smaller tributary area as well.

Additional relationships were developed comparing flow of a station to flow at an adjacent station. These relationships are used throughout this report when specific dates are not designated. The data, graphs, and mathematical equations that are not included in the body of this report may be found in the files of the CVOCO offices of the Mid-Pacific Region of the Service.

"Other" flows are determined by changes in flow at adjacent stations not contributed by measured tributaries. "Other" flows for several reaches of the main stem of the San Joaquin River have been determined using this water balance method.

E. EVALUATION OF WATER QUALITY EFFECTS

1. Salt Balance

Data is available for the stations studied, to prepare salt load-flow relationships. These relationships are used throughout this report when specific dates are not indicated. The data, graphs, and mathematical equations that are not included in the body of this report may be found in the files of the Offices of the Mid-Pacific Region of the Service.

With the salt load known at key locations, any change in load between stations not caused by measured tributaries can be attributed to "other" sources. "Other" loads are determined using this method for several reaches along the main stem of the San Joaquin River.

2. Chemical Composition

Because the geologic, topographic and hydrologic characteristics of the east and west sides of the San Joaquin Valley are distinctly different, it was expected that detailed water quality analysis of waters derived from the several sources would serve to identify their separate and proportional contributions to the San Joaquin River salt burden. For this purpose USGS data on water quality for selected stations along the main stem of the San Joaquin River were compared to those for the principal tributaries and sources known to contribute drainage water to the system. Comparisons were made on the basis of the proportions of principal cations and anions, especially sulfate ion ($SO_4^{=}$) known to be derived from soils on the westside of the valley and characteristic of both wells and drainage waters from this area. Also, noncarbonate hardness and boron concentration, that tend to distinguish waters from the westside of the valley from those of the major Sierra streams, are used to "fingerprint" the composite drainage water of the San Joaquin River. Comparisons are also made with water imported into the westside of the Valley by the Delta-Mendota Canal.

F. ESTIMATION OF RETURN FLOWS

In the absence of direct measurement of return flows, it was necessary to estimate aggregate returns by either water balance methods or by a combination of water balance and salt balance computation. Details of individual drainage

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contributions, known to exist along the San Joaquin and the lower reaches of major tributaries (DWR, 1960) are not determinable by either method. The question of the relative contributions of east and westside sources, however, was addressed by considering both chemical composition and water balance.

G. EVALUATION OF EXPORT PUMPING EFFECTS (CVP AND SWP)

1. On Channel Depths

For purposes of evaluating effects of CVP export on South Delta Channels, comparisons were made of channel cross sections and average depths, before the advent of the CVP and after. Data for this purpose were derived from USCGS and DWR sources.

2. On Water Levels

Water level effects were assessed in three ways; from actual records of tidal fluctuation during pumping, from the results of pumping tests designed to determine drawdown due to pumping, and by application of a mathematical model that simulates the hydrodynamic behavior of Delta channels during actual or hypothetical pumping episodes.

3. On Water Quality

Water quality effects of export pumping were not measurable directly, but were assessed in general terms from changes in circulation induced by pumping. Channel discharges, velocities and net circulations were determined from the results of simulations using the mathematical model.

4. Mathematical Modeling

The mathematical model employed as a tool in this investigation is a version of the hydrodynamic simulator developed by Water Resources Engineers, Inc. and employed by DWR and others in a variety of special studies of Delta hydraulics. It was adapted for this investigation, using detailed data on channel geometry and water levels provided by the DWR.

CHAPTER V

WATER QUANTITY EFFECTS OF UPSTREAM DEVELOPMENT

This section of the report discusses the effect of upstream development on lower San Joaquin River flows. It attempts to identify the impact of the CVP by assuming that all development on the upper San Joaquin River (that portion of the San Joaquin River upstream of the mouth of the Merced River) since 1947 is due to the CVP. While some development in addition to the CVP has occurred in the upper San Joaquin basin it is not extensive and for the purpose of this report, is considered negligible.

It is obvious from the records of San Joaquin River flows at Vernalis that development of water resources in the basin upstream has decreased the quantity of flow in the lower San Joaquin River. Figure V-1 shows the average reduction in runoff in the April-September period between two historic periods, 1930-1944 and 1952-1966. The figure demonstrates that the flow of the San Joaquin River at the Vernalis gage during the April-September period averaged 1,020,000 acre-feet less in the 1952-1966 period than in the 1930-1944 period when adjusted for the difference in unimpaired rim flow.

Figure V-2 similarly shows the average reduction in flows of the upper San Joaquin River during the April-September period. When adjusted for the difference in unimpaired rim flow, the average flow in the upper San Joaquin River has decreased by 444,600 acre-feet during the April-September period.

Although development has had a significant effect on the average flow in the lower San Joaquin River it is evident from the streamflow records of the San Joaquin basin rivers, that the magnitude of the annual unimpaired flow of the San Joaquin River is important in determining the impact of the CVP on the flow of the river into the southern Delta area.

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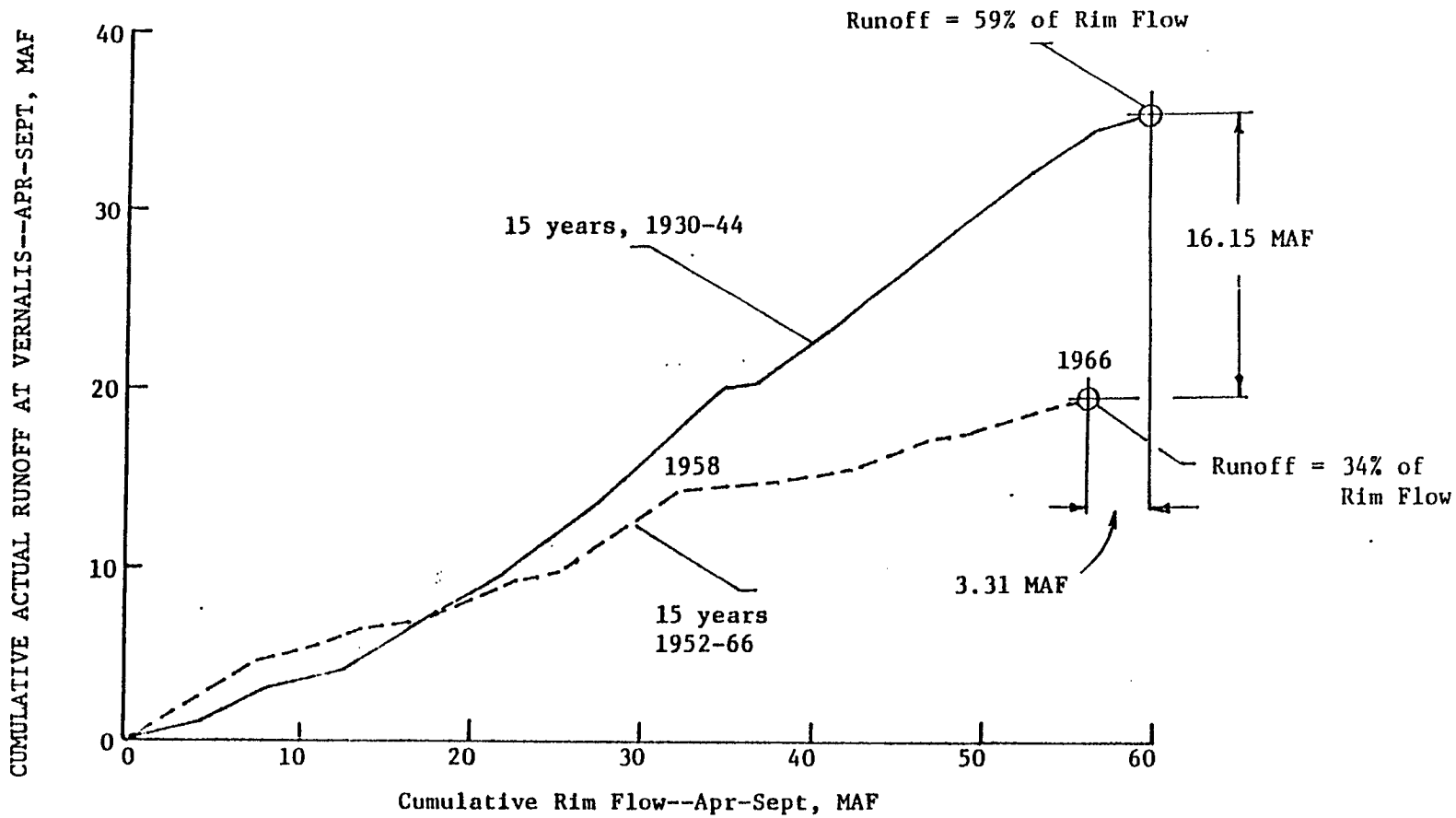
AVG. ANNUAL DECREMENT IN APR-SEPT RUNOFF BETWEEN TWO HISTORIC PERIODS (Adjusted for difference in rim flow) $= \frac{16.15}{15} \times \frac{56.1}{59.4} \times 10^6 = 1{,}020{,}000$ a.f.



CUMULATIVE RUNOFF AT VERNALIS FOR APRIL-SEPTEMBER PERIOD
PRE-CVP (1930-44) AND POST-CVP (1952-66)

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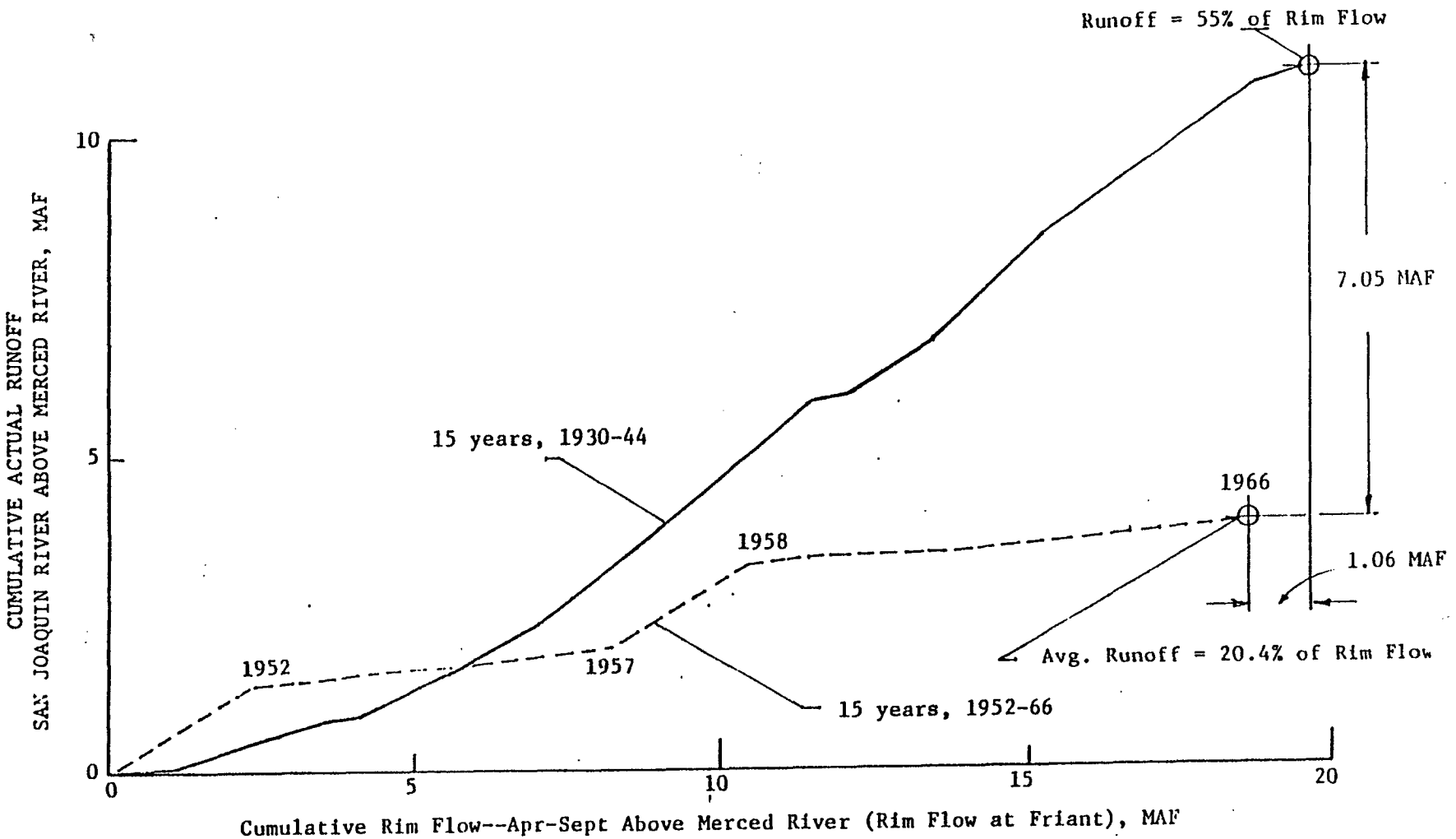
AVG. ANNUAL DECREMENT IN APR-SEPT RUNOFF BETWEEN TWO HISTORIC PERIODS (Adjusted for difference in rim flow) $= \frac{7.05}{15} \times \frac{18.57}{19.63} \times 10^6 = 444{,}600$ a.f.



CUMULATIVE RUNOFF IN SAN JOAQUIN RIVER ABOVE MERCED RIVER DURING THE APRIL-SEPTEMBER PERIOD PRE-CVP (1930-44) AND POST-CVP (1952-66)

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To evaluate more effectively the impact of the CVP in years of differing hydrology runoff, records for the period 1906-1977, inclusive, were studied to determine a logical year classification system. The analysis resulted in classification of hydrologic years into four groupings by magnitude of unimpaired flow as summarized in Table V-1.

Figures V-3 and V-4 show a comparison by year type of actual San Joaquin River flow near Vernalis to the sum of unimpaired rim station flow for the annual and April through September periods, respectively. Figure V-5 presents a comparison by year type of the actual flow of the upper San Joaquin River and the unimpaired flow of the San Joaquin River at Friant Dam for the April through September period. The importance of year type in determining the impact of the CVP can be seen by comparing figures V-3, V-4 and V-5. For example, while figures V-3 and V-4 show that there has been a reduction of flow at Vernalis in dry years, figure V-5 indicates that there has been relatively small changes in the flows of the upper San Joaquin River during the April through September period of dry years.

Since the type of year is important in determining the impact of the CVP on net runoff at Vernalis, the following discussion of impact treats each of the four-year types separately.

DRY YEARS

San Joaquin Basin Above Vernalis

There were five years in each of the pre-1944 and post-1947 periods for which the total rim station unimpaired flow was less than 3,500,000 acre-feet per year. Tables V-2, V-3, V-4, and V-5 summarize the hydrologic conditions for these 10 dry years.

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Table V-1
Year Classifications for the San Joaquin River System

Year Class	Unimpaired Flow[1] acre-feet/year
Dry	less than 3,500,000
Below Normal	3,500,000 - 5,600,000
Above Normal	5,600,000 - 7,500,000
Wet	greater than 7,500,000

[1] Sum of runoff of four major tributaries to the San Joaquin Basin.

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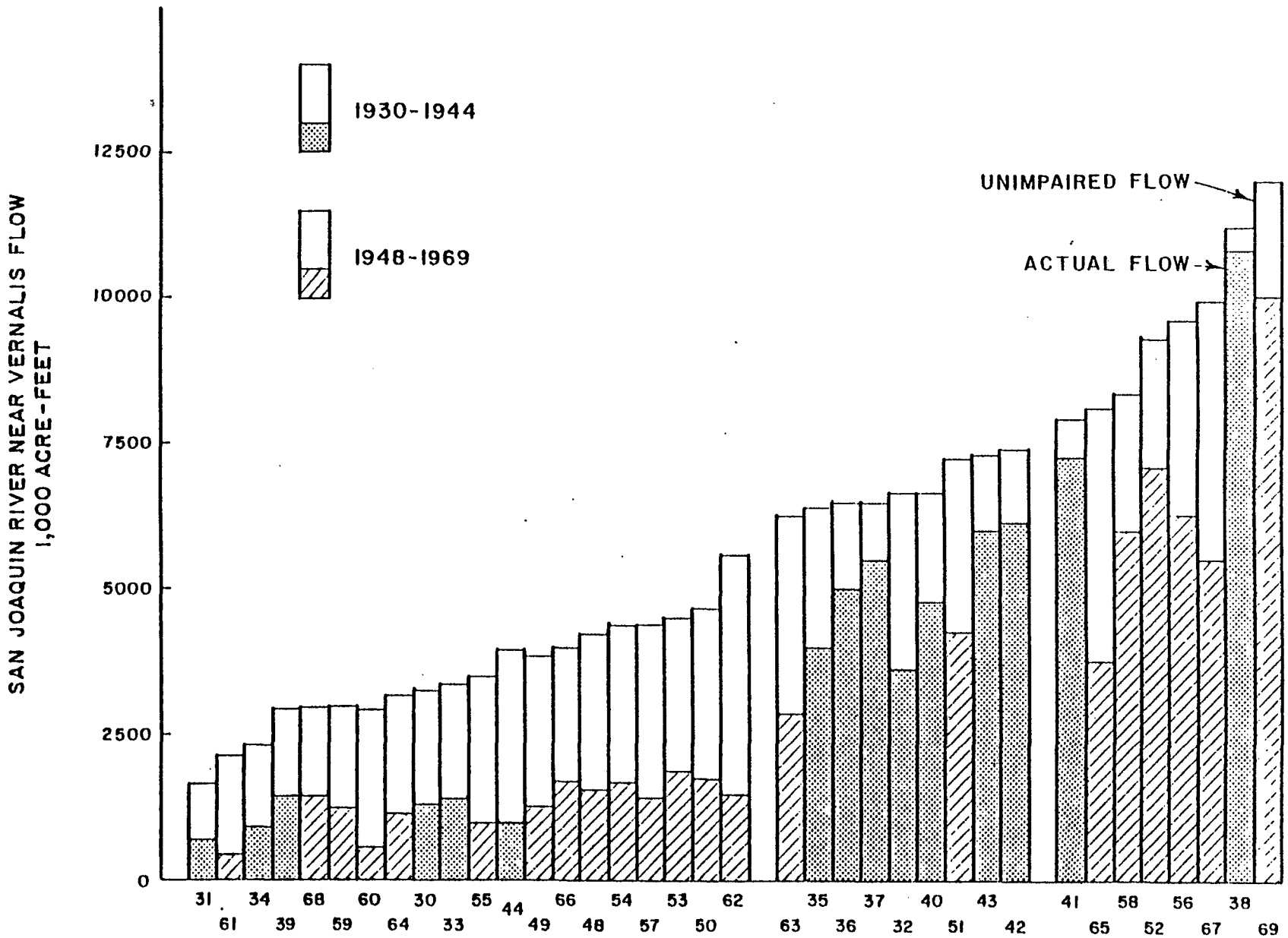

SAN JOAQUIN RIVER NEAR VERNALIS ANNUAL FLOW
PRE-1944 (1930-1944) AND POST 1947 (1948-1969)

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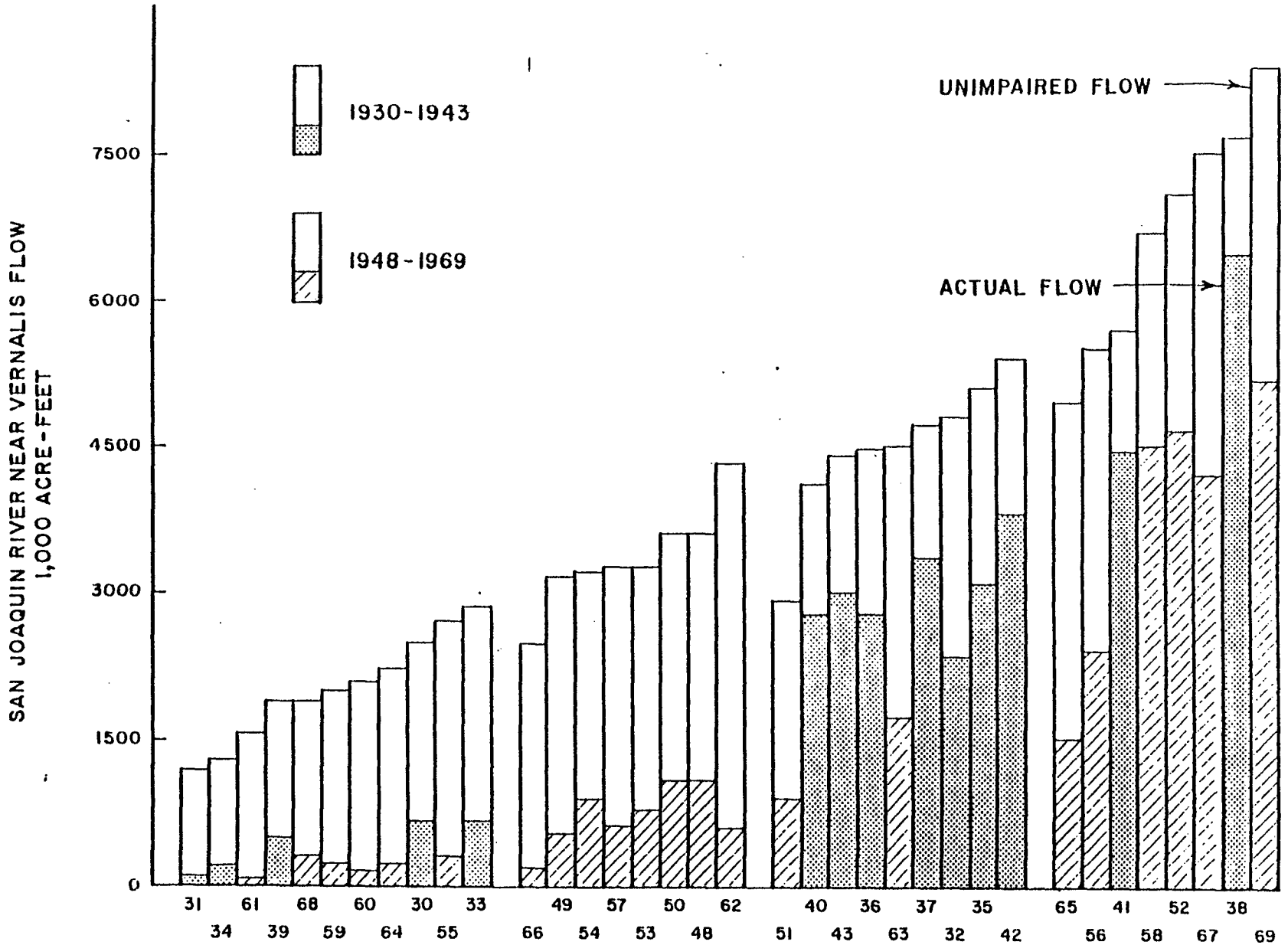

SAN JOAQUIN RIVER NEAR VERNALIS, APRIL-SEPT PERIOD
PRE-1944 (1930-1943) AND POST 1947 (1948-1969)

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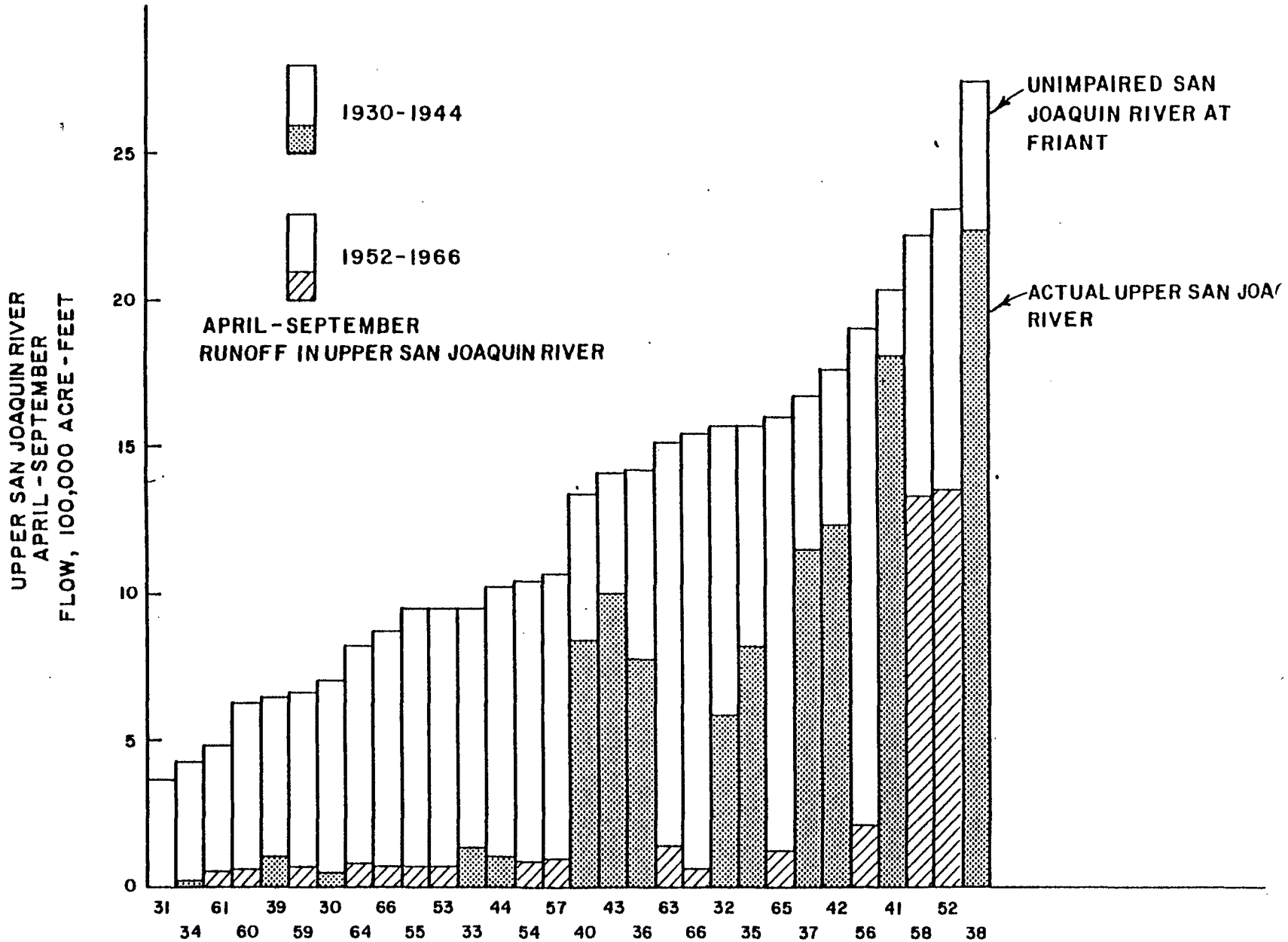

UPPER SAN JOAQUIN RIVER DURING APRIL-SEPT PERIOD
PRE-CVP (1930-44) AND POST-CVP (1952-66)

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As the information presented on Table V-2 demonstrates, the annual loss of flow at Vernalis due to post-1947 upstream development as estimated by the double-mass diagram method described on page IV-3, is in the range of 254,000 to 688,000 acre-feet in dry years.

Table V-2 also shows that the city of San Francisco diversion from the Tuolumne River basin through Hetch Hetchy Aqueduct increased from an average of 10,000 acre-feet in pre-1944 dry years (1930, 31, 33, 34 and 39) to an average of 183,000 acre-feet in post-1947 dry years (1959, 60, 61, 64 and 68). CVP operations during post-1947 dry years resulted in importation of an average of 1,031,000 acre-feet through the Delta-Mendota Canal into the Mendota Pool and diversion of an average of 728,000 acre-feet through the Friant-Kern Canal and 171,000 acre-feet through the Madera Canal.

Table V-3 shows that during the April-September period, the estimated flow reduction in the San Joaquin River at Vernalis due to post-1947 development upstream from Vernalis ranged from 149,000 to 594,000 acre-feet in dry years. The table also shows that estimated loss due to the development in the upper San Joaquin basin ranged from 2,000 to 11,000 acre-feet in the April-September period of dry years.

A comparison of the unimpaired flow of the San Joaquin River at Vernalis and the actual flow at the Vernalis station was made as a check on the change in losses* estimated by the double mass diagram method. As shown on Table V-2, in the dry years the average net loss at Vernalis increased from 1,501,000 acre-feet in the pre-1944 years to 1,87[illegible],000 acre-feet in the post-1947 years. When the pre-1944 average is adjusted for the difference in average unimpaired flow between pre-1944 and post-1947 periods the average annual increase in

* The terms "loss" or "losses" refer to the difference between the upstream unimpaired flow and the actual flow at the point in question.

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TABLE V-2

ESTIMATES OF ANNUAL WATER LOSSES AT VERNALIS IN DRY YEARS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Dry Years	Rim Station Unimpaired KAF	Vernalis Actual KAF	Net Loss @ Vernalis KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Above Vernalis - KAF	Hetch Hetchy KAF	Friant Unimpaired KAF	San Joaquin @ Friant KAF	Actual Upper San Joaquin KAF	Net Loss @ Newman KAF	Estimated Loss at Vernalis Due to Post 1947 Development in Upper San Joaquin - KAF	Madera Canal Diversion KAF	Friant-Kern Canal Diversion KAF	Delta-Mendota Canal Delivery to Mendota Pool KAF	Net Central Valley Project Inter-Basin Transfer KAF
1930	3,254	1,270	1,984		0	859	N.A.	109	750					
1931	1,660	677	983		0	480	N.A.	72	408					
1933	3,356	1,380	1,976		0	1,111	N.A.	295	816					
1934	2,288	927	1,361		0	691	N.A.	195	496					
1939	2,909	1,708	1,201		53	921	1,077	433	488					
Avg.	2,693	1,192	1,501		10	812		221	591					
1959	2,986	1,244	1,742	492	167	949	79	111	838	90	208	809	1,029	+220
1960	2,960	550	2,410	688	167	829	96	105	724	160	144	582	1,009	+427
1961	2,100	437	1,663	254	174	648	100	88	560	111	103	442	1,021	+579
1964	3,151	1,124	2,027	656	186	922	70	164	758	184	228	838	1,066	+220
1968	2,938	1,429	1,509	506	223	862	58	210	652	146	170	967	1,032	+ 65
Avg.	2,827	957	1,870	519	183	842	81	136	706	138	171	728	1,031	+303

Adjusted Loss San Joaquin Basin $= 1870 - \left[1501 \times \frac{2827}{2693}\right] = 294$

Adjusted Loss Upper San Joaquin Basin $= 706 - \left[591 \times \frac{842}{812}\right] = 93$

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TABLE V-3

ESTIMATES OF APRIL TO SEPTEMBER WATER LOSSES AT VERNALIS

IN DRY YEARS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Dry Years	Vernalis Unimpaired KAF	Vernalis Actual KAF	Net Loss @ Vernalis KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Above Vernalis - KAF		Friant Unimpaired KAF	San Joaquin @ Friant KAF	Actual Upper San Joaquin KAF	Net Loss Upper San Joaquin-KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Upper San Joaquin - KAF	Madera Canal Diversion KAF	Friant - Kern Canal Diversion KAF	Delta-Mendota Canal Delivery to Mendota Pool KAF	Net Central Valley Project Inter-Basin Transfer KAF
1930	2,490	672	1,818			706	N.A.	45	661					
1931	1,203	121	1,082			368	N.A.	0	368					
1933	2,856	647	2,209			945	N.A.	137	808					
1934	1,303	196	1,107			430	N.A.	16	414					
1939	1,909	483	1,426			641	616	100	541					
Avg.	1,952	424	1,528			618		60	558					
1959	1,995	219	1,776	297		664	57	56	608	11	169	536	814	+278
1960	2,108	138	1,970	535		632	67	39	593	2	124	428	786	+358
1961	1,562	82	1,480	149		487	57	38	449	4	91	324	817	+493
1964	2,216	231	1,985	594		816	48	67	749	10	187	543	817	+274
1968	1,918	309	1,609	510		583	41	77	506	2	114	503	787	+284
Avg.	1,959	196	1,764	417		636		55	581	6	137	467	804	+28[illegible]

Adjusted Loss = 230*

= 7*

*Computed per example in Table V-2

C-115179

C-115179

TABLE V-4

ACTUAL AND UNIMPAIRED ANNUAL FLOWS AT RIM STATIONS IN DRY YEARS

	STANISLAUS		TUOLUMNE		MERCED		SAN JOAQUIN	
Dry Years	Unimpaired at Melones KAF	Actual at Ripon KAF	Unimpaired at Don Pedro KAF	Actual at Modesto KAF	Unimpaired at Modesto KAF	Actual at Stevinson KAF	Unimpaired at Friant KAF	Actual Upper San Joaquin KAF
1930	732	474	1,151	527	513	89	859	109
1931	315	611	603	368	262	70	480	72
1933	609	304	1,119	504	516	158	1,111	295
1934	424	134	812	387	361	95	691	195
1939	526	286	985	551	477	224	921	433
AVG.	521	361	934	467	426	127	812	221
1959	584	241	997	627	455	115	949	111
1960	594	92	1,056	293	483	89	829	105
1961	404	81	736	223	312	57	648	88
1964	643	212	1,139	540	447	92	922	164
1968	640	268	1,010	553	426	205	862	210
AVG.	573	179	988	447	425	112	842	136
ADJUSTED LOSS		218*		47*		15*		93*

TOTAL SUB-BASIN LOSS = 373

*Example:

$$\text{Adjusted loss} = \text{Ave. loss in post-1947 years} - \text{Average loss in pre-1944 years} \times \frac{\text{Average unimpaired flow for post-1947 years}}{\text{Average unimpaired flow for pre-1944 years}}$$

$$\text{(Stanislaus Basin)} = (573-179) - \left[(521-361) \times \frac{573}{521}\right] = 218$$

C-115180

C-115180

TABLE V-5

ACTUAL AND UNIMPAIRED APRIL TO SEPTEMBER FLOWS AT RIM STATIONS IN DRY YEARS

	STANISLAUS		TUOLUMNE		MERCED		SAN JOAQUIN	
Dry Years	Unimpaired at Melones KAF	Actual at Ripon KAF	Unimpaired at Don Pedro KAF	Actual at Modesto KAF	Unimpaired at Modesto KAF	Actual at Stevinson KAF	Unimpaired at Friant KAF	Upper San Joaquin KAF
1930	524	324	869	246	391	50	706	45
1931	216	38	426	73	193	30	368	0
1933	528	203	953	219	430	58	945	137
1934	222	31	456	97	195	42	430	16
1939	354	124	614	142	300	60	641	100
AVG.	369	144	663	155	302	48	618	60
1959	364	52	661	86	307	47	664	56
1960	401	41	731	74	344	37	632	39
1961	301	26	544	53	231	17	487	38
1964	440	46	781	60	312	40	816	67
1968	400	66	652	77	284	51	583	77
AVG.	381	46	673	70	296	38	636	55
ADJUSTED LOSS		103		87		9		7

TOTAL SUB-BASIN LOSS = 206 KAF

* Computed as per example in Table V-4

C-115181

C-115181

losses at the Vernalis gage was 294,000 acre-feet with 230,000 acre-feet occurring in the April-September period (see Table V-3).

A further check on change in losses occurring in the San Joaquin River basin was made by analyzing the losses of four subbasins. Tables V-4 and V-5 summarize the hydrologic data for the subbasins during the 10 dry years studied. The sum of the adjusted subbasin losses is 373,000 acre-feet for the annual period. During the April-September period the sum of the adjusted subbasin losses is 206,000 acre-feet (see Table V-5).

The table below summarizes the results of the three methods of analysis.

	Estimated Loss At Vernalis, KAF	
	Annual	April-Sept
Double mass diagram	519	417
Basin comparison	294	230
Subbasin comparison	373	206

Upper San Joaquin Basin

In the upper San Joaquin River basin post-1947 development affected the annual flows in dry years, but had no measurable effect on the flows during the April-September period. In the five pre-1944 dry years the actual annual flow of the upper San Joaquin River ranged from 72,000 to 433,000 acre-feet with an average of 221,000 acre-feet, while the unimpaired annual flows at Friant ranged from 480,000 to 1,110,000 acre-feet. Post-1947 dry-year flows in the upper San Joaquin River ranged from 88,000 to 210,000 acre-feet with an average of 136,000 acre-feet while unimpaired annual flows at Friant ranged from 647,000 to 949,000 acre-feet. There was an average decrease in the annual post-1947 flow in dry years in the upper San Joaquin River of about 138,000 acre-feet as estimated by the double mass diagram method (see Column 11, Table V-2).

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With adjustment for the difference in unimpaired annual dry-year flow at Friant, the average decrease in flow from pre-1944 to post-1947 years in the upper San Joaquin River is about 133,000 acre-feet. This is about 60 percent of the pre-1944 flow in the upper San Joaquin River.

During the April-September period there was no significant change from the pre-1944 dry years to the post-1947 dry years in the upper San Joaquin River (see Column 11, Table V-3).

Estimated reduction in flow
in the upper San Joaquin River, KAF

Method	Annual	April-Sept
Double Mass Diagram	133	6
Basin Comparison	93	7

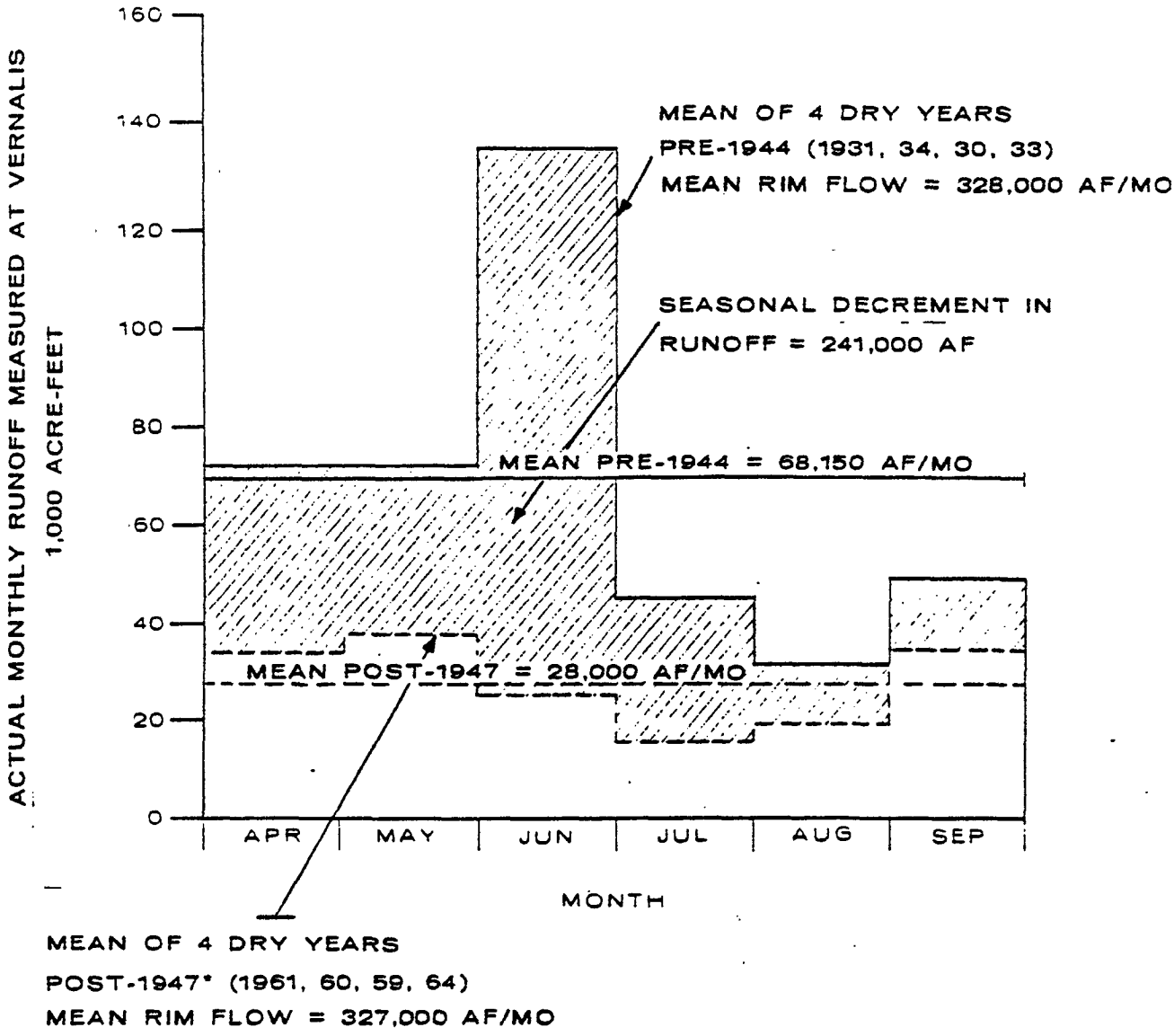
Figure V-6 shows a comparison of actual runoff at Vernalis during the April-September period for dry years in the pre-1944 and post-1947 periods. During four pre-1947 dry years of 1930, 31, 33 and 34 the flow at Vernalis averaged 68,150 acre-feet/month during the April-September period. This was about 40,000 acre-feet/month more than for the same period of the four post-1947 dry years of 1959, 60, 61 and 64.* The April-September decrement in runoff was about 241,000 acre-feet.

The same comparison in the upper San Joaquin River is made on figure V-7. In dry years the average flow in the upper San Joaquin River during the April-September period increased slightly in five of the six months within the period. In June the average flow decreased from 25,000 acre-feet to 8,300 acre-feet. This difference in average flow in June is attributed to an unusually high runoff in June 1933.

* The two sets of dry years were chosen for comparison so that the average unimpaired rim flows were nearly equal, e.g., 328,000 acre-feet/year for the pre-1944 years v. 327,000 acre-feet/year for the post-1947 years.

C—115183

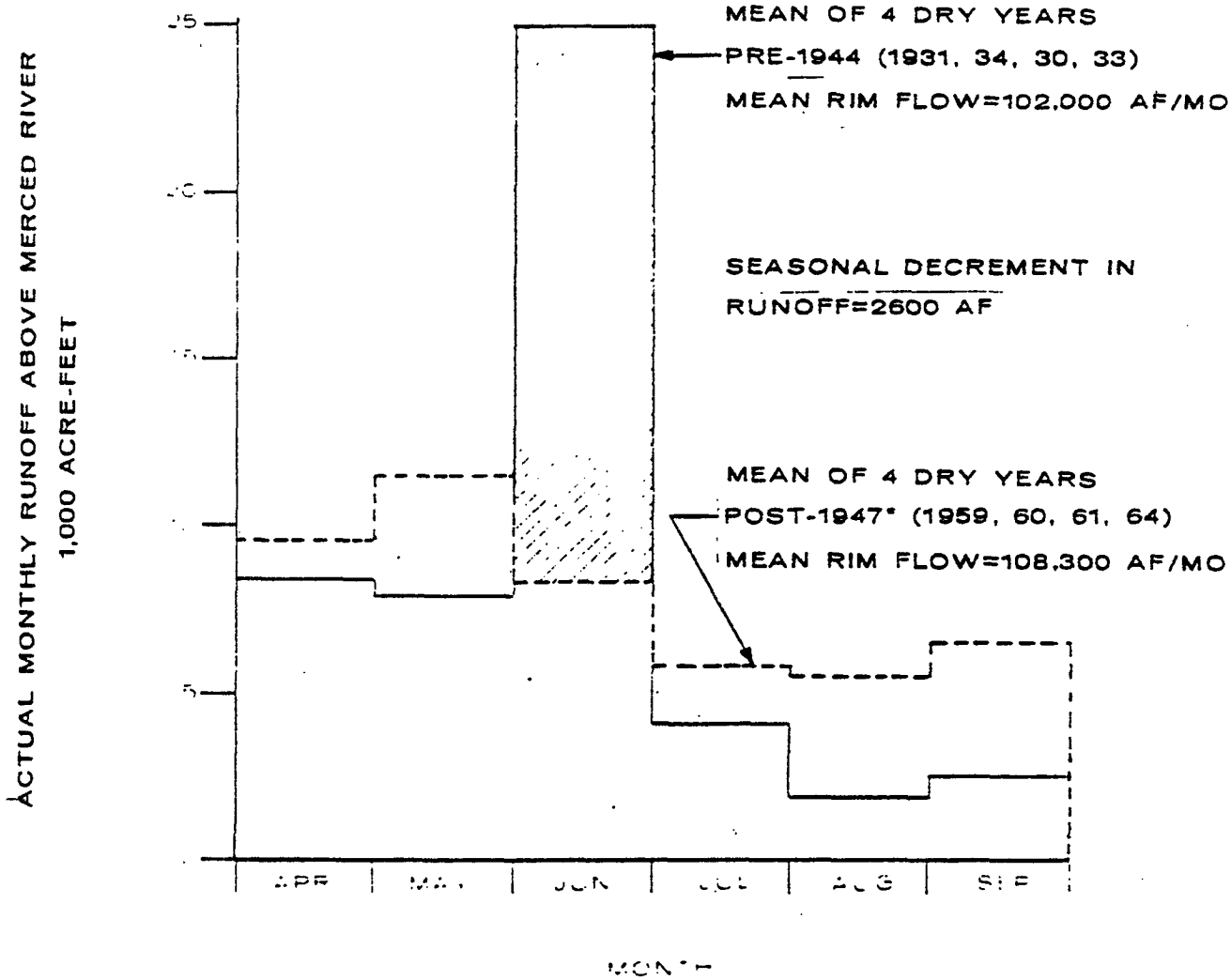
C-115183



ACTUAL RUNOFF AT VERNALIS DURING APRIL-SEPTEMBER PERIOD IN DRY YEARS

PRE-1944 (1931, 34, 30, 33) AND POST-1947 (1961, 60, 59, 64)

* NO ADJUSTMENT



ACTUAL RUNOFF UPPER SAN JOAQUIN RIVER BASIN DURING APRIL-SEPTEMBER PERIOD IN DRY YEARS

PRE-1944 (1930, 31, 33, 34) AND POST-1947 (1959, 60, 61, 64)

* ADJUSTED TO PRE-CVP BASE BY RATIO OF RIM FLOWS

When adjusted for the difference in unimpaired flow at Friant, the April-September period reduction in runoff during the post-1947 period is 2,600 acre-feet or about 400 acre-feet/month in the upper San Joaquin River.

Summary of Impacts - Dry Years

In summary, the data indicates that in dry years the impact of the CVP on the San Joaquin River at Vernalis was as follows:

a. On an annual basis the estimated decrease in flow ranged from 93,000 to 133,000 acre-feet which is about 8 to 11 percent of the pre-1944 average dry-year annual flow at Vernalis.

b. During the April-September period, the reduction in flow attributable to the CVP ranged from 2,600 to 7,000 acre-feet, which is about 0.6 to 1.6 percent of the pre-1944 average dry-year April-September flow at Vernalis.

BELOW NORMAL

The evaluation of the below normal years was the most difficult and probably the least accurate. While the four-year types were almost equally distributed in the 72-year period 1906-1977, there were no below normal years from 1930 through 1943. In contrast, over one-third or eight of the post-1947 years were classified as below normal. When available, information for the below normal years of 1923, 1925, and 1928 were included in Tables V-6, V-7, V-8, and V-9 for comparison purposes.

Based on the double-mass diagram method of calculation, the average annual reduction at Vernalis since 1947 during below normal years is estimated as 1,219,000 acre-feet. Most of the reduction, about 1,064,000 acre-feet, occurred during the April-September period. The average flow reduction due to CVP development on the upper San Joaquin River was about

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TABLE V-6

ESTIMATES OF ANNUAL WATER LOSSES AT VERNALIS
IN BELOW NORMAL YEARS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Below Normal Year	Vernalis Unimpaired KAF	Vernalis Actual KAF	Net Loss @ Vernalis KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Above Vernalis - KAF		Friant Unimpaired KAF	San Joaquin @ Friant KAF	Actual Upper San Joaquin KAF	Net Loss Upper San Joaquin KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Upper San Joaquin - KAF	Madera Canal Diversion KAF	Friant-Kern Canal Diversion KAF	Delta-Mendota Canal Delivery to Mendota Pool KAF	Net Central Valley Project Inter-Basin Transfer KAF
1923	5,512	N.A.				1,654	N.A.	N.A.						
1925	5,505	N.A.				1,439	N.A.	N.A.						
1928	4,365	N.A.				1,154	N.A.	228	926					
Avg.*														
1948	4,218	1,553	2,665	1,186		1,215	1,006	103	1,112	473	76	0	0	0
1949	3,799	1,247	2,552	1,044		1,164	1,068	119	1,045	578	152	0	0	0
1950	4,656	1,786	2,870	1,559		1,311	974	108	1,203	699	118	198	0	-198
1953	4,554	1,891	2,663	950		1,227	351	211	1,016	404	193	741	668	- 73
1954	4,315	1,717	2,598	1,370		1,314	262	179	1,135	569	212	811	824	+ 13
1955	3,512	975	2,537	1,195		1,161	107	145	1,016	448	219	805	927	+122
1957	4,292	1,442	2,850	1,400		1,327	149	205	1,122	547	242	990	919	- 71
1966	3,985	1,696	2,289	1,053		1,299	62	247	1,052	628	442	1,066	1,059	- 7
Avg.	4,166	1,538	2,628	1,219		1,252		165	1,088	543	207	833	879	- 3

*Note: Since there were no data for Vernalis flows in 1923, 1925, and 1928 no adjustments were possible for flow restrictions.

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TABLE V-7

ESTIMATES OF APRIL TO SEPTEMBER WATER LOSSES AT VERNALIS
IN BELOW NORMAL YEARS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Below Normal Year	Vernalis Unimpaired KAF	Vernalis Actual KAF	Net Loss @ Vernalis KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Above Vernalis - KAF		Friant Unimpaired KAF	San Joaquin @ Friant KAF	Actual Upper San Joaquin KAF	Net Loss Upper San Joaquin KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Upper San Joaquin KAF	Madera Canal Diversion KAF	Friant-Kern Canal Diversion KAF	Delta-Mendota Canal Delivery to Mendota Pool KAF	Net Central Valley Project Inter-Basin Transfer KAF
1923	4,123	N.A.				1,303	N.A.	838	465					
1925	4,056	N.A.				1,163	N.A.	N.A.						
1928	2,675	N.A.				801	N.A.	200	601					
Avg.	3,618					1,052		519	533					
1948	3,652	1,093	2,559	1,202		1,077	801	67	1,010	383	72	0	0	0
1949	3,177	573	2,604	947		1,016	838	53	963	491	150	168	0	-168
1950	3,631	1,062	2,569	1,311		1,044	743	42	1,002	511	118	180	0	-180
1953	3,275	780	2,495	898		944	184	67	877	210	179	592	615	+ 23
1954	3,216	902	2,314	1,002		1,045	138	82	963	412	207	717	720	+ 3
1955	2,723	302	2,421	973		941	57	66	875	318	199	674	780	+106
1957	3,269	630	2,639	1,240		1,071	54	94	977	389	229	793	761	- 32
1966	2,492	246	2,246	942		870	45	57	813	373	173	628	819	+191
Avg.	3,180	699	2,481	1,064		1,001	358	66	935	386	166	579	739	- 8

*See note in Table V-6

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TABLE V-8

ACTUAL AND UNIMPAIRED APRIL TO SEPTEMBER FLOWS AT RIM STATIONS IN BELOW NORMAL YEARS

	STANISLAUS		TUOLUMNE		MERCED		SAN JOAQUIN	
Below Normal Years	Unimpaired at Melones KAF	Actual at Ripon KAF	Unimpaired at Don Pedro KAF	Actual at Modesto KAF	Unimpaired at Modesto KAF	Actual at Stevinson KAF	Unimpaired at Friant KAF	Actual Upper San Joaquin KAF
1923	820	624	1,310	421	690	520	1,303	838
1925	855	690	1,381	914		N.A.		N.A.
1928	416	394	792	406	391	212	725	200
AVG.	697	569	1,161	580	540	366	1,052	519
1948	781	492	1,192	359	603	211	1,077	67
1949	615	286	1,035	141	511	113	1,016	53
1950	846	535	1,187	361	553	139	1,045	42
1953	736	374	1,141	266	455	67	944	67
1954	650	335	1,037	253	484	185	1,046	82
1955	513	138	851	86	418	48	941	66
1957	661	199	1,038	152	499	169	1,071	94
1966	429	47	784	79	409	39	870	57
AVG.	654	301	1,033	212	491	121	1,001	66
ADJUSTED LOSS*		233		304		212		428

*Computed as per example in Table V-4

TOTAL SUB-BASIN LOSS = 1,177

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TABLE V-9

ACTUAL AND UNIMPAIRED ANNUAL FLOWS AT RIM STATIONS IN BELOW NORMAL YEARS

	STANISLAUS		TUOLUMNE		MERCED		UPPER SAN JOAQUIN	
Below Normal Years	Unimpaired at Melones KAF	Actual at Ripon KAF	Unimpaired at Don Pedro KAF	Actual at Modesto KAF	Unimpaired at Modesto KAF	Actual at Stevinson KAF	Unimpaired at Friant KAF	Actual Upper San Joaquin KAF
1923	1,130	947	1,786	833	942	786	1,654	N.A.
1925	1,224	1,111	1,932	1,096	910	N.A.	1,439	N.A.
1928	950	777	1,525	1,028	737	390	1,154	228*
AVG.	1,101	945	1,748	986	840	588		
1948	898	584	1,418	599	688	262	1,215	103
1949	745	433	1,252	1,035	638	195	1,164	119
1950	1,076	706	1,551	696	719	232	1,311	108
1953	967	581	1,534	728	626	243	1,227	211
1954	888	500	1,445	648	668	263	1,314	179
1955	681	311	1,136	369	534	109	1,161	145
1957	894	328	1,424	529	648	255	1,327	205
1966	703	429	1,315	734	669	211	1,299	247
AVG.	856	484	1,384	667	649	221	1,252	165
ADJUSTED LOSS*		273		115		233		

*Note: There is only a single observation for the below normal years (1928) hence it was not feasible to determine an adjusted loss for the Upper San Joaquin River basin.

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543,000 acre-feet in below normal years (see Column 11, Table V-6). Approximately 386,000 acre-feet of this reduction occurred during the April-September period (see Column 11, Table V-7).

Although 1923, 1925 and 1928 are not within the study period, information from these years was used to check the results of the double-mass diagram method. The information from these 3 years on an annual basis was inadequate to give a good check. As a result, the annual evaluation of the subbasins gave unreasonable results. However, the data for the April-September period seemed to be reasonable and checked the double-mass diagram method quite well.

The loss at Vernalis during the April through September period due to post-1947 development (see Table V-7), estimated by the double mass diagram method is 1,064,000 acre-feet. The total subbasin reduction in flow was computed to be 1,177,000 acre-feet (Table V-8). Using the subbasin method of evaluation, the estimated reduction in the upper San Joaquin River was about 428,000 acre-feet. The percentage at Vernalis attributed to each subbasin is as follows:*

	Percent of total reduction in flow April through September
Stanislaus	20%
Tuolumne	26%
Merced	18%
San Joaquin River above Merced River (CVP)	36%

* Subbasin riverflows are measured upstream from the actual mouths of the Tuolumne and Stanislaus Rivers. There may be some net accretions or diversions between these gaging stations and the lower San Joaquin River which could affect the proportion of losses attributed to each subbasin.

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Summary of Impacts - Below Normal Years

In summary, the data indicate that in below normal years the effect of the CVP on the San Joaquin River at Vernalis has been as follows:

a. On an annual basis the estimated decrease in flow was 543,000 acre-feet, which is 26 percent of the calculated pre-1944 average below normal year flow at Vernalis.

b. During the April-September period, the decrease in flow ranged from 386,000 to 428,000 acre-feet, which corresponds to 35-38 percent of the calculated pre-1944 April-September flow at Vernalis.

ABOVE NORMAL YEARS

Seven of the 14 pre-1944 years were above normal, while only three of the post-1947 years were in this classification. Tables V-10, V-11, V-12, V-13 and Figure V-8 present the hydrologic data for the above normal years.

As indicated in Table V-10 the average Vernalis unimpaired flow during the seven pre-1944 years was 6,763,000 acre-feet, about 485,000 acre-feet greater than the average for the three post-1947 above normal years. The actual flow at Vernalis during the pre-1944 years was 5,021,000 acre-feet for an average loss of 1,742,000 acre-feet or 25.7 percent of rim station unimpaired flow. Losses increased in the post-1947 period to 3,364,000 acre-feet or 47.3 percent of the rim station unimpaired flow. When adjusted for the difference in the unimpaired flows of the two periods, the increase in loss between the two periods is 1,721,000 acre-feet annually. (See column 4 and footnote, Table V-10.)

Using the same type of analysis, the average reduction in flow in the upper San Joaquin River (Table V-11) is estimated at 1,076,000 acre-feet in above normal years. This increase in flow reduction corresponds to 21 percent of the average above normal year flow at pre-1944 Vernalis.

TABLE V-10

ESTIMATES OF ANNUAL WATER LOSSES AT VERNALIS
IN ABOVE NORMAL YEARS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Above Normal Year	Vernalis Unimpaired KAF	Vernalis Actual KAF	Net Loss at Vernalis KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Above Vernalis - KAF		Friant Unimpaired KAF	San Joaquin @ Friant KAF	Actual Upper San Joaquin KAF	Net Loss-Upper San Joaquin KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Upper San Joaquin - KAF	Madera Canal Diversion KAF	Friant-Kern Canal Diversion KAF	Delta-Mendota Canal Delivery to Mendota Pool KAF	Net Central Valley Project Inter-Basin Transfer KAF
1932	6,622	3,660	2,962			2,047	N.A.	989	1,058					
1935	6,418	4,030	2,388			1,923	N.A.	1,076	847					
1936	6,495	4,985	1,510			1,853	N.A.	1,467	386					
1937	6,530	5,484	1,046			2,208	N.A.	2,059	149					
1940	6,596	4,768	1,828			1,881	1,829	1,485	396					
1942	7,398	6,160	1,238			2,254	2,254	2,127	127					
1943	7,283	6,060	1,223			2,054	2,068	2,125	- 71					
Avg.	6,763	5,021	1,742			2,031		1,618	413					
1951	7,262	4,738	2,524	710		1,859	1,216	750	1,109	718	142	368	139	-229
1962	5,618	1,487	4,131	1,891		1,924	75	268	1,656	720	277	1,370	991	-379
1963	6,250	2,813	3,437	1,598		1,945	83	316	1,629	867	271	1,513	966	-547
Avg.	6,377	3,013	3,364	1,400		1,909		445	1,464	768	230	1,084	699	-385

Adjusted Loss = 1,721* = 1,076*

*Com ed as per example in Table V-2

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TABLE V-11

ESTIMATES OF APRIL TO SEPTEMBER WATER LOSSES AT VERNALIS

IN ABOVE NORMAL YEARS

Above Normal Years	Vernalis Unimpaired KAF	Vernalis Actual KAF	Net Loss @ Vernalis KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Above Vernalis - KAF		Friant Unimpaired KAF	San Joaquin @ Friant KAF	Actual Upper San Joaquin KAF	Net Loss-Upper San Joaquin KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Upper San Joaquin - KAF	Madera Canal Diversion KAF	Friant-Kern Canal Diversion KAF	Delta-Mendota Canal Delivery to Mendota Pool KAF	Net Central Valley Project Inter-Basin Transfer KAF
1932	4,829	2,388	2,441			1,578	N.A.	588	990					
1935	5,152	3,131	2,021			1,579	N.A.	816	763					
1936	4,489	2,801	1,688			1,410	N.A.	765	645					
1937	4,746	3,372	1,374			1,670	N.A.	1,144	526					
1940	4,107	2,827	1,280			1,336	1,250	836	500					
1942	5,461	3,834	1,627			1,762	1,329	1,222	540					
1943	4,417	3,020	1,397			1,407	1,281	1,011	396					
Avg.	4,743	3,053	1,690			1,534		911	623					
1951	2,909	919	1,990	1,783		960	588	74	886	308	140	345	139	- 206
1962	4,358	647	3,711	1,832		1,558	46	51	1,507	470	268	1,151	837	- 314
1963	4,560	1,753	2,807	1,581		1,515	58	159	1,356	542	262	1,300	744	- 556
Avg.	3,942	1,106	2,836	1,732		1,344		95	1,250	440	223	864	573	359

Adjusted Loss = 1,432* = 704*

*Computed as per example in Table V-2

C-115194

C-115194

TABLE V-12

ACTUAL AND UNIMPAIRED ANNUAL FLOWS AT RIM STATIONS IN ABOVE NORMAL YEARS

Above Normal Years	STANISLAUS Unimpaired at Melones KAF	STANISLAUS Actual at Ripon KAF	TUOLUMNE Unimpaired at Don Pedro KAF	TUOLUMNE Actual at Modesto KAF	MERCED Unimpaired at Modesto KAF	MERCED Actual at Stevinson KAF	SAN JOAQUIN Unimpaired at Friant KAF	SAN JOAQUIN Actual Upper San Joaquin KAF
1932	1,353	939	2,109	1,097	1,113	549	2,047	989
1935	1,214	974	2,110	1,251	1,171	735	1,923	1,076
1936	1,322	1,075	2,168	1,418	1,152	757	1,853	1,467
1937	1,109	869	1,998	1,383	1,215	828	2,208	2,059
1940	1,400	1,152	2,221	1,322	1,095	706	1,881	1,485
1942	1,485	1,247	2,373	1,786	1,287	965	2,254	2,127
1943	1,566	1,268	2,376	1,712	1,289	973	2,054	2,125
AVG.	1,350	1,075	2,194	1,424	1,189	788	2,031	1,618
1951	1,694	1,436	2,484	1,668	1,225	801	1,859	750
1962	995	407	1,773	365	928	380	1,924	268
1963	1,268	861	2,053	990	984	505	1,945	316
AVG.	1,319	901	2,103	1,008	1,046	562	1,909	445
ADJUSTED LOSS		149*		357*		131*		1,076*

TOTAL SUB-BASIN LOSS = 1,713

*Computed as per example in Table V-4

C-115195

C-115195

TABLE V-13

ACTUAL AND UNIMPAIRED APRIL TO SEPTEMBER FLOWS AT RIM STATIONS IN ABOVE NORMAL YEARS

Above Normal Years	STANISLAUS Unimpaired at Melones KAF	STANISLAUS Actual at Ripon KAF	TUOLUMNE Unimpaired at Don Pedro KAF	TUOLUMNE Actual at Modesto KAF	MERCED Unimpaired at Modesto KAF	MERCED Actual at Stevinson KAF	SAN JOAQUIN Unimpaired at Friant KAF	SAN JOAQUIN Actual Upper San Joaquin KAF
1932	996	674	1,515	770	740	310	1,578	588
1935	1,014	791	1,647	1,040	912	580	1,579	816
1936	884	671	1,452	795	743	481	1,410	765
1937	827	622	1,441	868	808	531	1,670	1,144
1940	799	615	1,315	714	657	475	1,336	836
1942	1,063	826	1,705	1,133	931	675	1,762	1,222
1943	872	623	1,400	792	738	498	1,407	1,011
AVG.	922	689	1,496	873	790	507	1,534	911
1951	545	286	957	350	443	193	964	74
1962	794	256	1,337	109	670	202	1,558	51
1963	876	616	1,477	505	692	376	1,515	159
AVG.	738	386	1,257	321	602	257	1,344	95
ADJUSTED LOSS		165*		412*		129*		700*

TOTAL SUB-BASIN LOSS = 1,406

*Computed as per example in Table V-4

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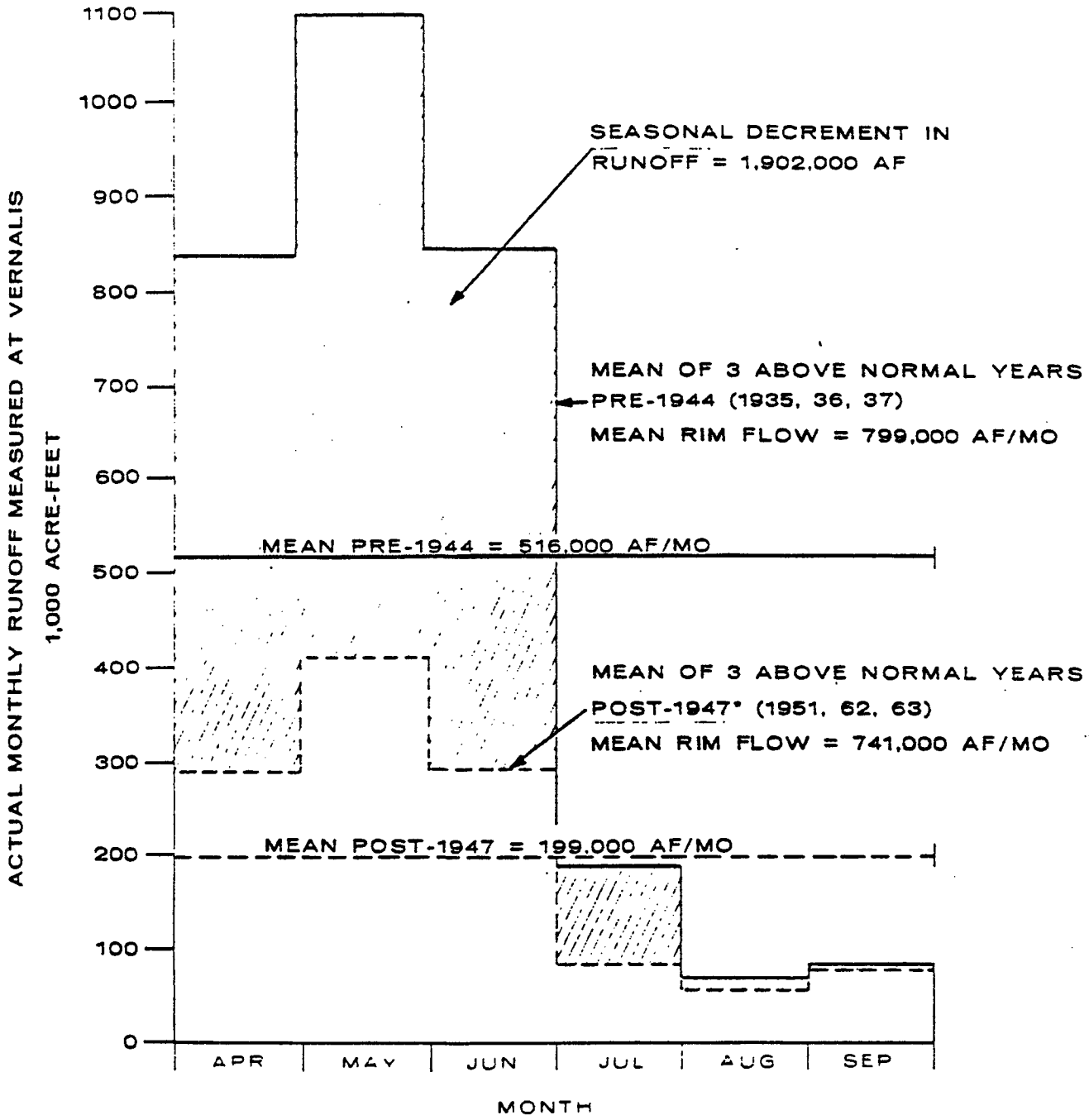

ACTUAL RUNOFF AT VERNALIS DURING APRIL-SEPTEMBER PERIOD IN ABOVE NORMAL YEARS PRE-1944 (1935, 36, 37) AND POST-1947 (1951, 62, 63)
* ADJUSTED TO PRE-1944 BASE BY RATIO OF RIM FLOWS

Estimation by the double mass diagram method indicates the average annual loss at Vernalis to be 1,400,000 acre-feet in above normal years with the contribution from above the upper San Joaquin River being 768,000 acre-feet.

The subbasin analysis for annual flows, summarized in Table V-12 produced the following results:

	Increased Losses KAF
Stanislaus	149,000
Tuolumne	357,000
Merced	131,000
San Joaquin	1,076,000
Total	1,713,000

In the evaluation of the April through September period of the above normal years (Tables V-11 and V-13), the basin analysis and the subbasin analysis were again in close agreement with the double mass diagram method producing appreciably different results. The table below summarizes results obtained by the three methods of analysis:

	Estimated reduction flow at Vernalis, KAF	
Method	Annual	April-Sept
Double mass diagram	1400	1732*
Basin comparison	1721	1400
Subbasin comparison	1713	1406

	Estimated reduction in flow in the Upper San Joaquin River, KAF	
Method	Annual	April-Sept
Double mass diagram	768	440
Basin comparison	1076	704

* Analysis by the double mass diagram method gives a higher estimate for the April-September period than for the annual period. This anomaly results from the statistical treatment of the data, i.e., fitting data with a regression line.

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As the above table indicates, the flow reduction at Vernalis due to post-1947 development averaged from 1,400,000 to 1,721,000 acre-feet with almost all the reduction occurring in the April through September period. The reduction at Vernalis due to development in the upper San Joaquin River basin is estimated to range from 768,000 to 1,076,000 acre-feet in above normal years. About 440,000 to 700,000 acre-feet of the reduction occurs in the April-September period. The following table indicates the percentage of the April-September reduction attributable to the various river basins.

Stanislaus	12 percent
Tuolumne	29 percent
Merced	9 percent
Upper San Joaquin	50 percent

Summary of Impacts - Above Normal Years

In summary, the data indicate that in above normal years the effect of the CVP on the San Joaquin River at Vernalis has been as follows:

a. On an annual basis, the estimated decrease in flow ranged from 768,000 to 1,076,000 acre-feet, which corresponds to 15 - 21 percent of pre-1944 average above normal flows at Vernalis.

b. During the April-September period, the estimated decrease in flow ranged from 440,000 to 704,000 acre-feet, which corresponds to 14 - 23 percent of pre-1944 average above normal flows at Vernalis during the period.

WET YEARS

Six of the post-1947 years and two of the pre-1944 years are classified as wet. Tables V-14, V-15, V-16, and V-17 present the hydrologic data for these years.

Analysis of wet year hydrologic data is somewhat complicated by the contribution of unmeasured flows to the valley floor. Consequently, the sum of rim station unimpaired flows is not necessarily a good estimate of available water. Nevertheless, for comparison purposes the same procedures were applied as for other year classes.

The unimpaired flow at Vernalis during pre-1944 wet years averaged 9,596,000 acre-feet; in the post-1947 wet years the average was 9,626,000 acre-feet. According to the double mass diagram method, substantial reduction in runoff resulted in the post-1947 period, averaging (after adjustment) about 2,609,000 acre-feet for the full year. In the April-September period the corresponding reduction in flow between pre-1944 and post-1947 years was about 1,742,000 acre-feet. (See Tables 14 and 15, calculation of adjusted losses.)

Analysis of the data for the upper San Joaquin basin by the double mass diagram method indicates average reduction in flow to the valley floor of 1,706,000 acre-feet for the annual period and 965,000 acre-feet during the April-September period.

Analysis by the subbasin comparison methods, as summarized in Tables V-16 and V-17, indicates relatively higher proportions of the reduction in flow attributed to development in the upper San Joaquin basin. On an annual basis the adjusted reduction was 2,916,000 acre-feet for the four subbasins, 2,014,000 acre-feet, or 69 percent of which is attributed to the CVP. In the April-September period the reduction in valley floor runoff was 1,760,000 acre-feet for the four subbasins, and 960,000 acre-feet, or 55 percent of which was attributed to the CVP.

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TABLE V-14

ESTIMATES OF ANNUAL WATER LOSSES AT VERNALIS
IN WET YEARS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Wet Year	Vernalis Unimpaired KAF	Vernalis Actual KAF	Net Loss @ Vernalis KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Above Vernalis - KAF		Friant Unimpaired KAF	San Joaquin @ Friant KAF	Actual Upper San Joaquin KAF	Net Loss - Upper San Joaquin KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Upper San Joaquin - KAF	Madera Canal Diversion KAF	Friant-Kern Canal Diversion KAF	Delta-Mendota Canal Delivery to Mendota Pool KAF	Net Central Valley Project Inter-Basin Transfer KAF
1938	11,248	10,840	408			3,688	N.A.	4,992	-1,304					
1941	7,945	7,298	647			2,652	2,589	3,244	- 592					
Avg.	9,596	9,069	527			3,170		4,118	- 622					
1952	9,312	7,144	2,168	215		2,840	2,084	2,090	750	935	179	462	122	-340
1956	9,679	6,305	3,374	840		2,960	1,225	1,319	1,641	551	239	1,322	519	-803
1958	8,367	6,056	2,311	561		2,631	1,180	1,657	974	514	244	1,145	447	-698
1965	8,108	3,795	4,313	1,994		2,272	63	397	1,875	448	324	1,631	995	-636
1967	9,993	5,561	4,432	2,230		3,232	1,269	1,601	1,631	1,250	389	1,422	572	-841
1969	12,295	10,070	2,225			4,040	2,208	4,202	- 162	930	404	1,082	378	-704
Avg.	9,626	6,488	3,138	1,168		2,996		1,878	1,118	771	356	1,177	607	-607

Adjusted Loss = 2,608* = 1,705*

*Computed as per example in Table V-2

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TABLE V-15

ACTUAL AND UNIMPAIRED ANNUAL FLOWS AT RIM STATIONS IN WET YEARS

Wet Years	STANISLAUS Unimpaired at Melones KAF	STANISLAUS Actual at Ripon KAF	TUOLUMNE Unimpaired at Don Pedro KAF	TUOLUMNE Actual at Modesto KAF	MERCED Unimpaired at Modesto KAF	MERCED Actual at Stevinson KAF	SAN JOAQUIN Unimpaired at Friant KAF	SAN JOAQUIN Actual Upper San Joaquin KAF
1941	1,338	1,176	2,500	1,750	1,454	1,083	2,652	3,244
1938	2,045	1,836	3,435	2,595	2,080	1,690	3,688	4,992
AVG.	1,692	1,506	2,968	2,172	1,767	1,387	3,170	4,118
1952	1,919	1,529	2,989	2,116	1,563	1,141	2,840	2,090
1956	1,883	1,542	3,162	1,999	1,675	1,158	2,960	1,319
1958	1,678	1,180	2,649	1,855	1,409	1,058	2,631	1,657
1965	1,702	1,192	2,748	1,333	1,386	690	2,272	397
1967	1,932	1,355	3,113	1,751	1,716	718	3,232	1,601
1969	2,210	1,707	3,856	2,422	2,188	1,260	4,040	4,202
AVG.	1,887	1,418	3,086	1,913	1,656	1,004	2,996	1,878
ADJUSTED LOSS		261*		345*		296*		2,014*

TOTAL SUB-BASIN LOSS = 2,916

*Computed as per example in Table V-4

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TABLE V-16

ESTIMATES OF APRIL TO SEPTEMBER WATER LOSSES AT VERNALIS IN WET YEARS

Wet Years	Vernalis Unimpaired KAF	Vernalis Actual KAF	Net Loss @ Vernalis KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Above Vernalis - KAF		Friant Unimpaired KAF	San Joaquin @ Friant KAF	Actual Upper San Joaquin KAF	Net Loss- Upper San Joaquin KAF	Estimated Loss @ Vernalis Due to Post 1947 Development Upper San Joaquin - KAF	Madera Canal Diversion KAF	Friant-Kern Canal Diversion KAF	Delta-Mendota Canal Delivery to Mendota Pool KAF	Net Central Valley Project Inter-Basin Transfer KAF
1938	7,668	6,494	1,174			2,744	N.A.	N.A.	500[E]					
1941	5,718	4,444	1,274			2,035	1,855	1,810	225					
Avg.	6,693	5,469	1,224			2,389			362					
1952	7,124	4,678	2,446	431		2,315	1,570	1,354	961	416	179	431	99	- 322
1956	5,535	2,404	3,131	925		1,899	462	212	1,687	317	226	976	429	- 547
1958	6,691	4,448	2,243	561		2,216	1,067	1,330	886	379	237	952	367	- 585
1965	4,971	1,545	3,426	2,072		1,594	40	116	1,478	724	285	1,051	735	- 316
1967	7,527	4,192	3,335	1,503		2,548	1,185	1,370	1,178	913	351	1,047	340	- 707
1969	8,421	5,181	3,240	518		3,075	1,250	1,976	1,099	577	356	1,023	280	- 743
Avg.	6,712	3,741	2,970	1,002		2,275		1,060	1,215	554	272	913	375	- 537

Adjusted Loss = 1,742* = 965*

*Computed as per example in Table V-2

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TABLE V-17

ACTUAL AND UNIMPAIRED APRIL TO SEPTEMBER FLOWS AT RIM STATIONS IN WET YEARS

Wet Years	STANISLAUS Unimpaired at Melones KAF	STANISLAUS Actual at Ripon KAF	TUOLUMNE Unimpaired at Don Pedro KAF	TUOLUMNE Actual at Modesto KAF	MERCED Unimpaired at Modesto KAF	MERCED Actual at Stevinson KAF	SAN JOAQUIN Unimpaired at Friant KAF	SAN JOAQUIN Actual Upper San Joaquin KAF
1941	953	804	1,746	1,096	984	750	2,035	1,810
1938	1,387	1,174	2,240	1,594	1,297	974	2,744	N.A.
AVG.	1,170	989	1,993	1,345	1,140	862		
1952	1,481	1,080	2,217	1,264	1,110	830	2,316	1,354
1956	1,007	733	1,727	808	902	536	1,899	212
1958	1,307	897	2,073	1,140	1,095	861	2,216	1,330
1965	977	514	1,593	468	807	331	1,594	116
1967	1,423	971	2,258	1,085	1,298	671	2,548	1,370
1969	1,426	868	2,518	1,225	1,401	718	3,076	1,976
AVG.	1,270	844	2,064	998	1,102	658	2,275	1,060
ADJUSTED LOSS		230*		395*		175*		960*

TOTAL SUB-BASIN LOSS = 1,760

*Computed as per example in Table V-4

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FLOW DURATION ANALYSIS

Reductions in the flow of the San Joaquin River at Vernalis do not always of themselves adversely affect the southern Delta. Much of the flow reduction occurred in above normal and wet years, providing a necessary flood control function for the lower San Joaqauin River. Some of the flow reduction occurs at times when the water is not required to maintain a minimum flow requirement at Vernalis. Therefore, it is useful to determine the frequency and duration of flows below certain thresholds. While specific requirements for the San Joaquin River at Vernalis have not been established, flow-duration curves provide useful information for impact assessment. Figures V-9, V-10, V-11, and V-12 graphically illustrate the percentage of the time the San Joaquin River flow at Vernalis is less than any given assumed level of flow. The example in Figure V-9 demonstrates how the flow-duration curves can be used to compare the pre-1944 and post-1947 conditions at Vernalis. For example, during the pre-1944 dry years the flow was less than 1,100 ft^3/s 36 percent of the time. In the post-1947 dry years flow was less than 1,100 ft^3/s 60 percent of the time.

Comparisons can be made for any flow value during all year types except below normal years. There were no pre-1944 below normal years in the study period.

It is not within the scope of this report to determine the level of San Joaquin River flow at Vernalis below which the impact on the southern Delta water supply becomes a damaging impact in relation to adequacy of downstream

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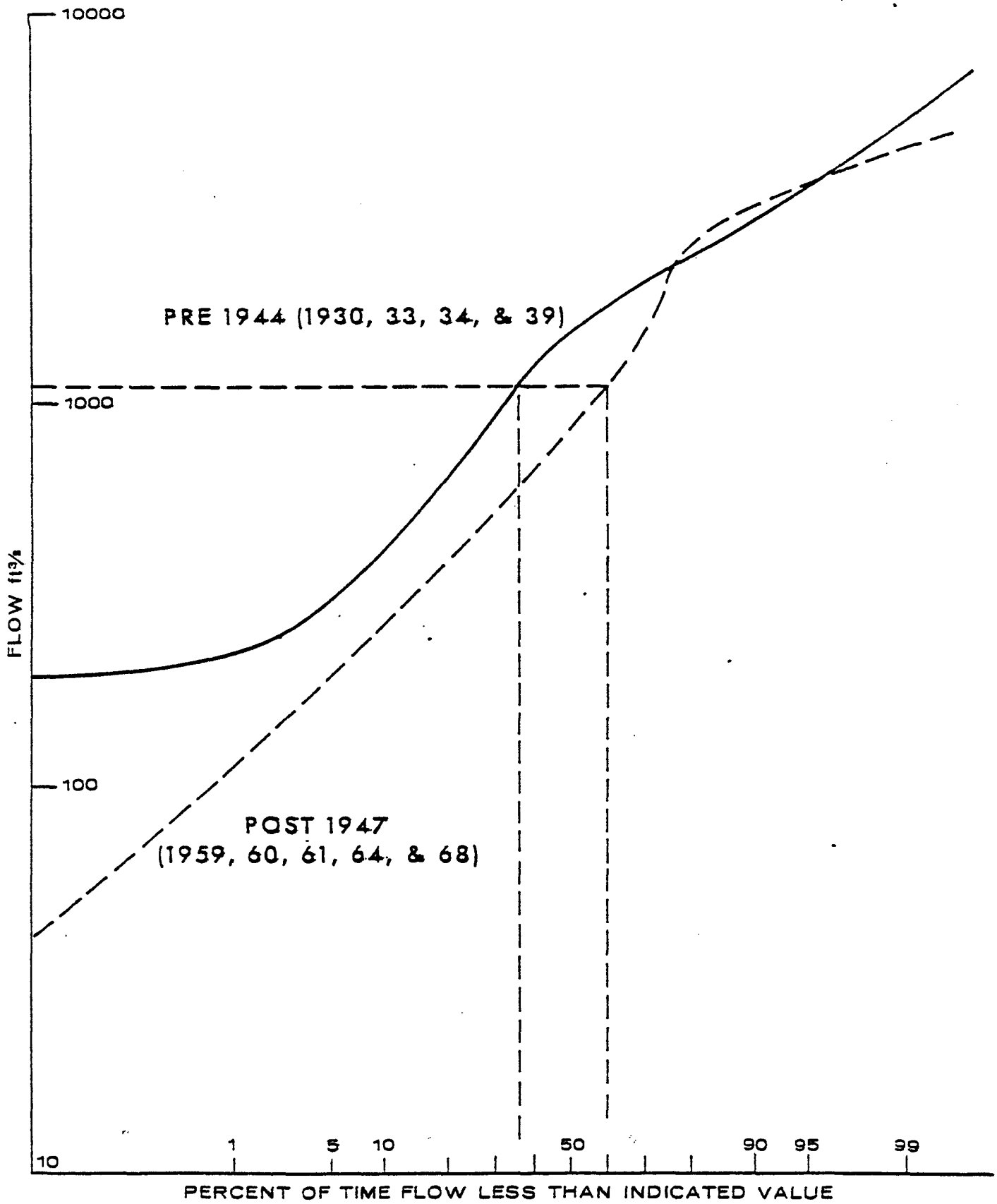
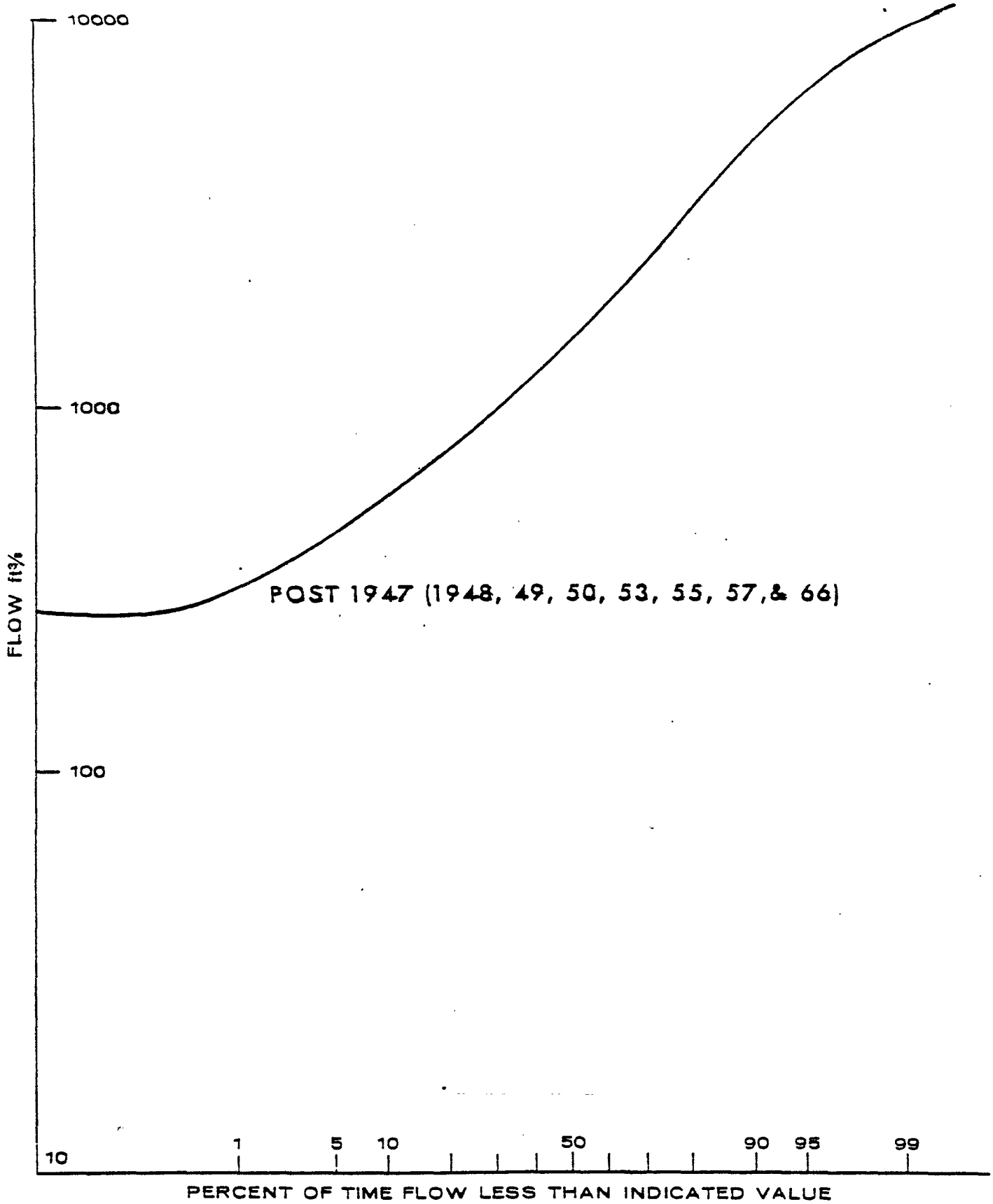
FIGURE V-9



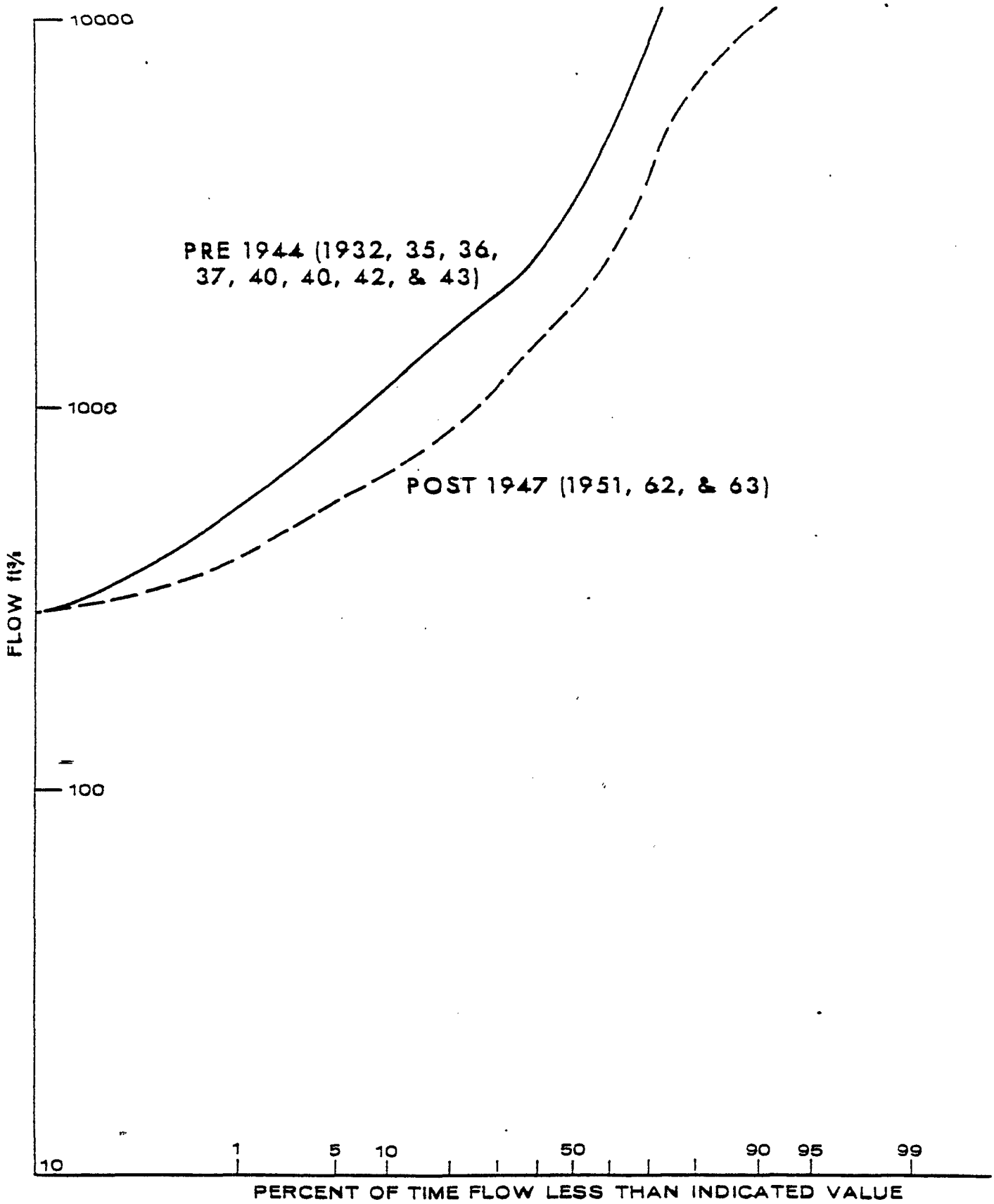
SAN JOAQUIN RIVER NEAR VERNALIS
DRY YEARS FLOW DURATION

FIGURE V-10



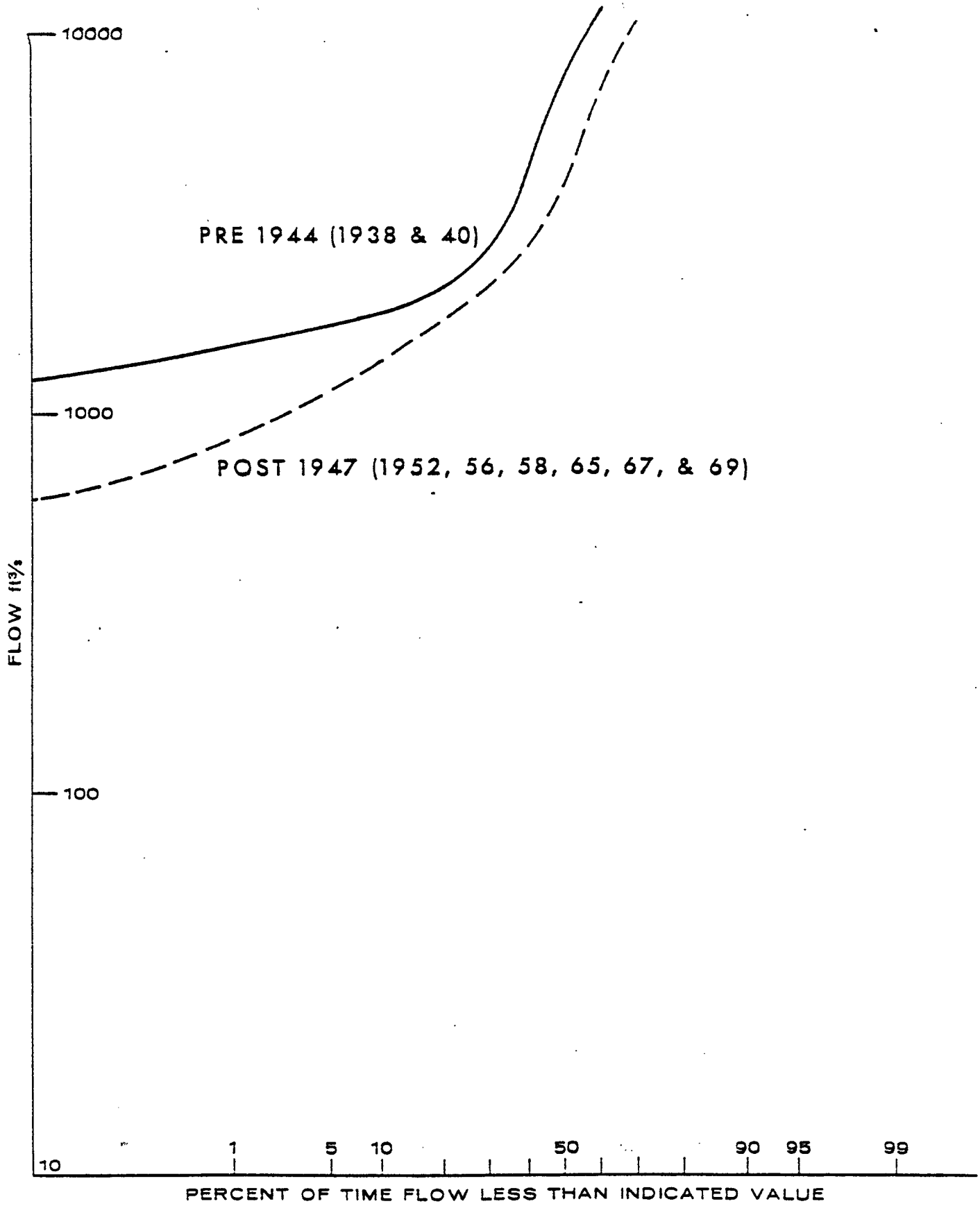
SAN JOAQUIN RIVER NEAR VERNALIS
BELOW NORMAL FLOW DURATION

FIGURE V-11



SAN JOAQUIN RIVER NEAR VERNALIS
ABOVE NORMAL YEARS FLOW DURATION

FIGURE V-12



SAN JOAQUIN RIVER NEAR VERNALIS
WET YEARS FLOW DURATION

channel flow for removal of incoming salt load, or in relation to dilution of incoming salts, or in relation to adequate channel water depth for pump draft, etc. The flow required to prevent damage will depend, among other things, on the quality of the water.

However, the Service developed a procedure to estimate the flow reduction attributable to the CVP which might cause the flow of the San Joaquin River near Vernalis to drop below required minimums. Since the minimum flow requirements have not yet been established, the procedure was used to produce curves which relate total loss and minimum flow requirement. Curves representing dry, below normal, above normal and wet years for the October-March period, the April-September period and the annual total, are presented on Figures V-13, V-14 and V-15, respectively.

The procedure utilized generalized equations developed using the double-mass diagram method to estimate the flow at Vernalis at a pre-1944 level of development for the 1948 through 1969 period. A similar method was used to estimate the flow at Vernalis with pre-1944 development in the lower San Joaquin River basin and post-1947 development in the upper San Joaquin River basin for the same 1948 through 1969 period. The values calculated using the procedure were then compared to the actual flows recorded at Vernalis to determine the effect of total post-1944 development and the effect of CVP.

Table V-20 is an example of the results of computation. Column 1 is the actual flow recorded at Vernalis for the month of October of the indicated water year. The corresponding flow estimated for a pre-1944 level of development is listed in column 2. Column 3 is the estimated flow at Vernalis assuming pre-1944 level of development in the lower San Joaquin River basin and a post-1947 level of devlopment in the upper San Joaquin River basin.

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TABLE V-18

SAN JOAQUIN RIVER NEAR VERNALIS

YEAR	(1) ACTUAL HISTORIC FLOW (KAF)	(2) ESTIMATED FLOW PRE 1944 LEVEL OF DEVELOPMENT (KAF)	(3) ESTIMATED FLOW WITH POST 1947 DEVELOPMENT ABOVE NEWMAN ONLY (KAF)	(4) DEVELOPMENT ABOVE MERCED RIVER POST 1947 IMPACT (KAF)	(5) DEVELOPMENT ABOVE MERCED RIVER CONTRIBUTION TO VERNALIS FLOW REDUCTION BELOW 1,500 ft^3/s (KAF)
1948	80.8	32.4	22.8	9.6	9.6
1949	95.2	101.0	96.6	4.4	
1950	77.9	117.8	113.7	4.1	1.5
1951	81.4	49.3	42.2	7.2	7.2
1952	109.7	118.0	112.8	5.2	
1953	114.7	123.3	116.2	7.1	
1954	100.2	106.4	102.5	3.9	
1955	32.3	67.8	65.3	2.5	2.5
1956	49.2	82.4	79.9	2.6	2.6
1957	122.9	85.7	74.6	11.0	
1958	126.4	136.8	129.9	6.9	
1959	174.3	183.2	176.4	6.8	
1960	53.9	62.6	54.9	7.7	7.7
1961	43.8	75.2	71.7	3.6	3.6
1962	25.2	61.0	56.9	4.1	4.1
1963	89.4	58.3	50.9	7.4	7.4
1964	164.6	131.7	121.0	10.7	
1965	86.8	48.8	44.5	4.2	4.2
1966	181.0	189.9	182.5	7.3	
1967	67.7	74.5	71.8	2.7	2.7
1968	167.6	139.7	128.4	11.3	
1969	85.1	93.7	87.4	6.3	5.3

COLUMNAR EXPLANATION:

(4)=(2)-(3)

IF (2) GREATER THAN (6): (5)=[(4)/[(2)-(1)]]*[(6)-(1)]

IF (2) LESS THAN (6): (5)=(2)-(3)

(6)=(02.2)

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An estimate of the total flow reduction at Vernalis due to development in the upper San Joaquin basin was then made by subtracting column 3 from column 2. The actual historic flow at Vernalis is then compared to the Vernalis target flow, in the case of this example, 1,500 ft^3/s or 92,200 acre-feet for the month. If column 2 is less than the target flow, the contribution to the Vernalis flow reduction by development in the upper San Joaquin River basin is estimated as column 2 - column 3. If column 2 is greater than the target flow, the contribution is computed as a percentage of the total reduction at Vernalis using the equation on table V-18.

The procedure was used to estimate the contribution to flow reduction below various target flows at Vernalis for the 1948-1969 period. Figures V-13, V-14, and V-15 show the curves prepared for the development in the upper San Joaquin River basin average contribution to the reduction of flow at Vernalis below the indicated target flow.

These curves provide a method of estimating CVP impact on flows below a target flow at Vernalis during various year types. For example, if the target flow at Vernalis during April-September was 1,500 ft^3/s, the average CVP contribution to a flow reduction below the target flow as determined from Figure V-14 would be:

In wet years	1,000 acre-feet
In above normal years	20,000 acre-feet
In below normal years	13,000 acre-feet
In dry years	9,000 acre-feet

It is the position of SDWA that the damaging CVP impact on San Joaquin River flow at Vernalis is the difference between the actual flow at Vernalis at

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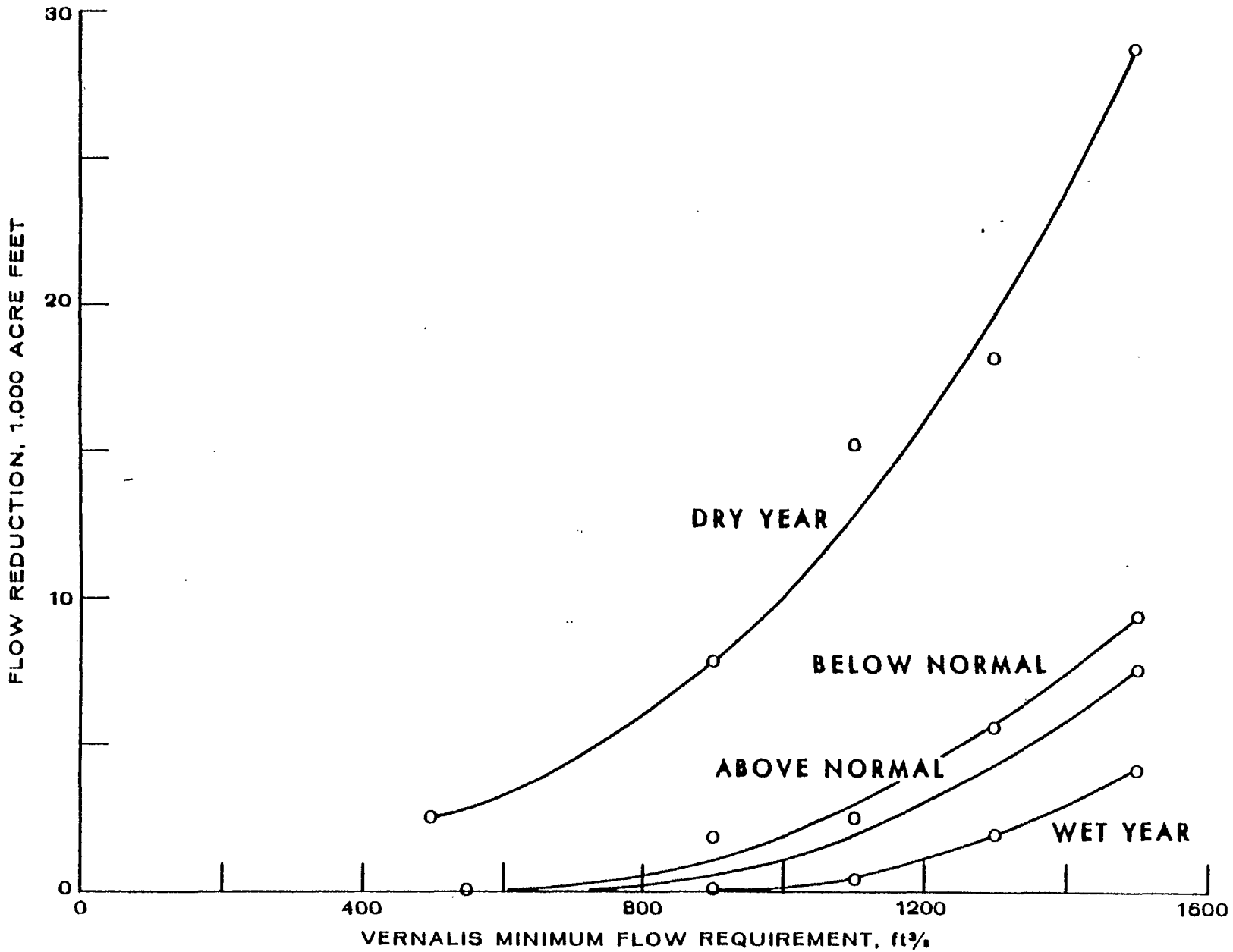

VERNALIS FLOW REQUIREMENT VS ESTIMATED CONTRIBUTION TO VERNALIS REDUCTION BELOW FLOW REQUIREMENT DUE TO DEVELOPMENT IN UPPER SAN JOAQUIN OCTOBER THROUGH MARCH

FIGURE V-13

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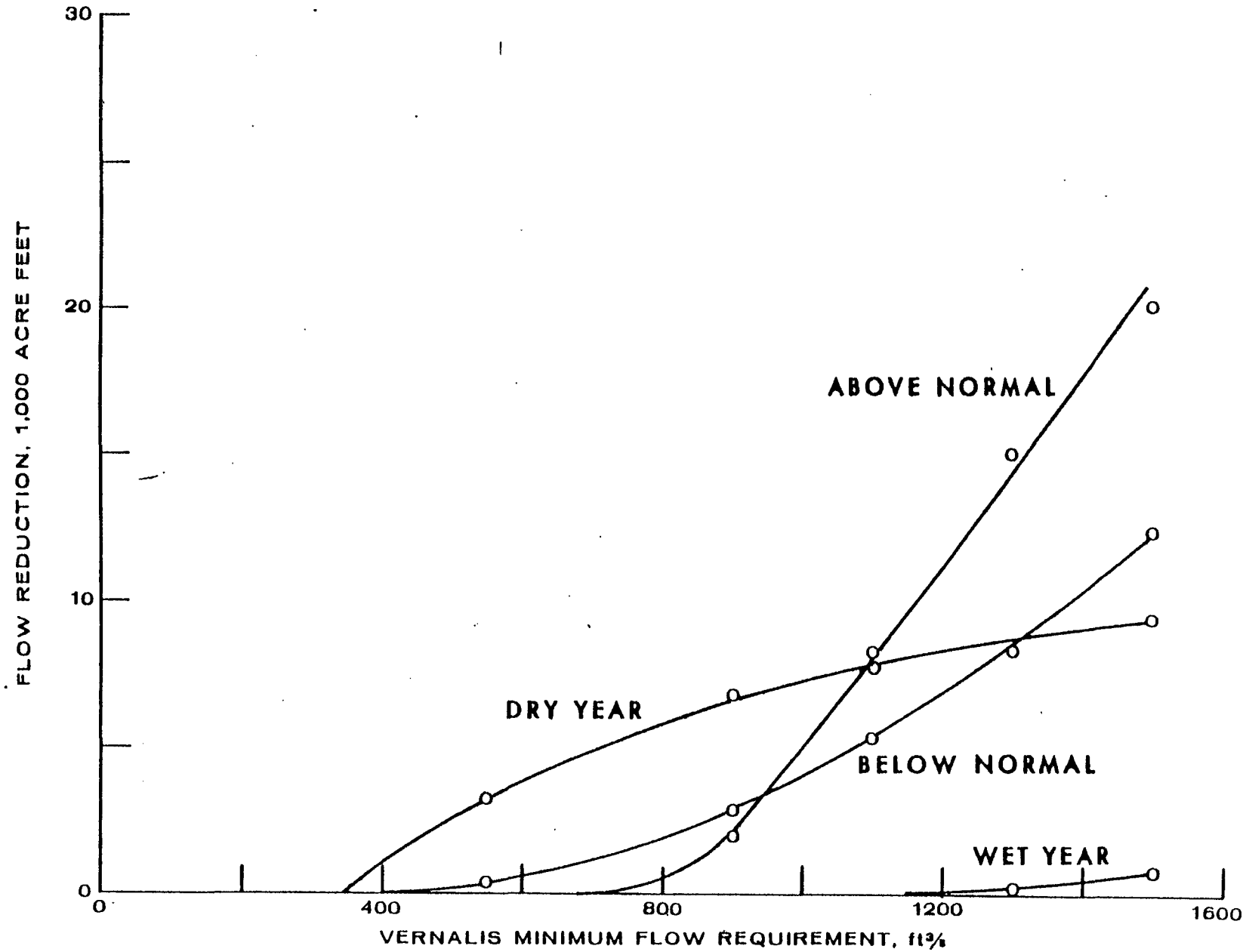
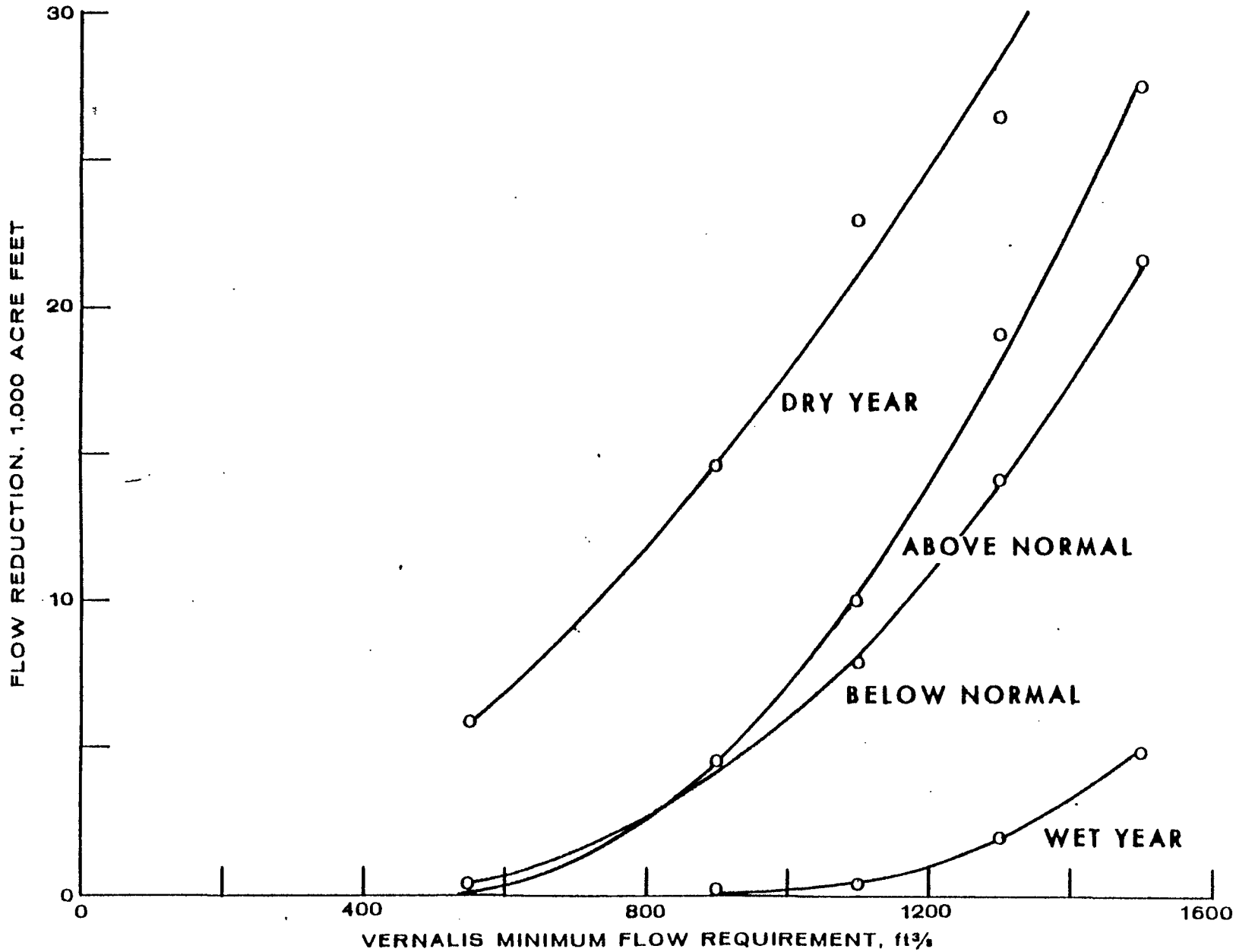


VERNALIS FLOW REQUIREMENT VS ESTIMATED CONTRIBUTION TO VERNALIS REDUCTION BELOW FLOW REQUIREMENT DUE TO DEVELOPMENT IN UPPER SAN JOAQUIN APRIL THROUGH SEPTEMBER

FIGURE V-14



VERNALIS FLOW REQUIREMENT VS ESTIMATED CONTRIBUTION TO VERNALIS REDUCTION BELOW FLOW REQUIREMENT DUE TO DEVELOPMENT IN UPPER SAN JOAQUIN ANNUAL TOTAL

FIGURE V-15

C-115215

any time and the flow which would have occurred if the CVP did not exist in so far as these flows are below needed levels. The Service's analysis does not conform to this definition. There are times when the non-CVP developments actually increase Vernalis flows. At such times the Service's analysis uses part of that enhancement to offset the impact of the CVP flow decreases even when the remaining net flow is inadequate.

SUMMARY OF HYDROLOGIC DATA

Hydrologic data for the San Joaquin River at Vernalis for the periods 1930-1944 and 1947-1969 are summarized in Table V-19. Information presented includes unimparied rim flows, actual flows at Vernalis, and losses, determined as the difference between unimpaired and actual flows. Averages are given for dry, below normal, above normal and wet years. Minima, medians, maxima, and average values are given for all years in each of the two periods, pre-1944 and post-1947. It will be noted that the former period includes 14 years, while the latter includes 22 years of record.

Table V-20 provides an additional summary of flow reduction in the 1948-1969 period that have resulted from development in the entire San Joaquin basin above Vernalis and in the upper San Joaquin basin. Averages of unimpaired and actual flows are given by year type for each basin in each of two calendar periods, annual and April-September. Net losses are also given.

Estimates of flow reduction due to post-1947 development were derived from the several determinations made by the double mass balance, basin comparison and subbasi comparison methods, details of which are given in Tables V-2 through V-17. Ir general, the values given in Table V-19 are the averages of the highest and lowest values computed by the three methods. For example, for

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TABLE V-19

SUMMARY OF HYDROLOGIC DATA, 1930-1944 AND 1947-1969
SAN JOAQUIN RIVER NEAR VERNALIS

Pre-1944

	Unimpaired Rim		Actual		Losses	
	Annual KAF	Apr-Sept KAF	Annual KAF	Apr-Sept KAF	Annual KAF	Apr-Sept KAF
DRY						
1931	1,660	1,203	677	121	983	1,082
1934	2,288	1,303	927	196	1,361	1,107
1939	2,909	1,909	1,708	483	1,201	1,426
1930	3,254	2,490	1,268	672	1,986	1,818
1933	3,356	2,856	1,376	647	1,980	2,209
AVG.	(2,693)	(1,952)	(1,191)	(424)	(1,502)	(1,528)
BELOW NORMAL						
No Pre-1944 years in the below normal year type.						
ABOVE NORMAL						
1935	6,418	5,152	4,038	3,131	2,380	2,021
1936	6,495	4,489	4,953	2,787	1,543	1,702
1937	6,530	4,746	5,483	3,372	1,047	1,374
1940	6,596	4,107	4,710	2,786	1,886	1,321
1932	6,622	4,829	3,660	2,388	2,962	2,441
1943	7,283	4,417	6,060	3,020	1,223	1,397
1942	7,398	5,461	6,160	3,834	1,238	1,627
AVG.	(6,763)	(4,743)	(5,009)	(3,045)	(1,754)	(1,698)

Post-1947

	Unimpaired Rim		Actual		Losses	
	Annual KAF	Apr-Sept KAF	Annual KAF	Apr-Sept KAF	Annual KAF	Apr-Sept KAF
DRY						
1961	2,100	1,562	437	82	1,663	1,480
1968	2,938	1,918	1,428	309	1,510	1,609
1960	2,960	2,108	550	139	2,410	1,969
1959	2,986	1,995	1,243	219	1,743	1,776
1964	3,151	2,216	1,124	232	2,027	1,984
AVG.	(2,827)	(1,960)	(957)	(196)	(1,870)	(1,764)
BELOW NORMAL						
1955	3,512	2,723	943	303	2,569	2,420
1949	3,799	3,177	1,247	573	2,552	2,604
1966	3,985	2,492	1,697	246	2,288	2,246
1948	4,218	3,652	1,553	1,094	2,665	2,558
1957	4,292	3,269	1,442	630	2,850	2,639
1954	4,315	3,216	1,717	902	2,598	2,314
1953	4,354	3,275	1,891	780	2,463	2,495
1950	4,656	3,631	1,786	1,062	2,870	2,569
AVG.	(4,141)	(3,179)	(1,534)	(699)	(2,607)	(2,480)
ABOVE NORMAL						
1962	5,618	4,358	1,487	848	4,131	3,510
1963	6,250	4,560	2,812	1,752	3,438	2,808
1951	7,262	2,906	4,738	919	2,524	1,987
AVG.	(6,377)	(3,941)	(3,012)	(1,173)	(3,364)	(2,768)

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TABLE V-13

SUMMARY OF HYDROLOGIC DATA, 1930-1944 AND 1947-1969
SAN JOAQUIN RIVER NEAR VERNALIS (Continued)

	Pre-1944							Post-1947						
	Unimpaired Rim		Actual		Losses			Unimpaired Rim		Actual		Losses		
	Annual KAF	Apr-Sept KAF	Annual KAF	Apr-Sept KAF	Annual KAF	Apr-Sept KAF		Annual KAF	Apr-Sept KAF	Annual KAF	Apr-Sept KAF	Annual KAF	Apr-Sept KAF	
WET							WET							
1941	7,945	5,718	7,298	4,444	647	1,274	1965	8,108	4,971	3,796	1,545	4,312	3,426	
1938	11,248	7,668	10,837	6,494	411	1,174	1958	8,367	6,691	6,056	4,449	2,311	2,242	
							1952	9,312	7,123	7,143	4,685	2,169	2,438	
							1956	9,679	5,534	6,304	2,404	3,375	3,130	
							1967	9,993	7,527	5,560	4,192	4,433	3,335	
							1969	12,295	8,540	10,073	5,181	2,222	3,269	
AVG.	(9,597)	(6,693)	(9,067)	(5,469)	(529)	(1,224)	AVG.	(9,626)	(6,716)	(6,489)	(3,743)	(3,137)	(2,973)	
ALL YEARS														
Min.	1,660	1,203	677	121	411	1,082		2,100	1,582	437	82	1,510	1,480	
Med.	6,513	4,453	4,374	2,787	1,300	1,412		4,335	3,272	1,707	875	2,538	2,467	
Max.	11,248	7,668	10,837	6,494	2,962	2,441		12,295	8,540	10,073	5,181	4,433	3,510	
Avg.	(5,333)	(3,756)	(3,943)	(2,292)	(1,390)	(1,465)		(5,643)	(3,471)	(2,956)	(1,480)	(2,687)	(2,491)	

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Table V-20

SUMMARY OF FLOWS, LOSSES AND FLOW REDUCTIONS
SAN JOAQUIN RIVER NEAR VERNALIS
1948-1969

	ANNUAL						APRIL--SEPTEMBER					
				Estimated Flow Reduction Due to Post-1947 Devel.						Estimated Flow Reduction Due to Post-1947 Devel.		
Year Type	Avg.Rim Station Unimpair KAF	Actual Flow KAF	Net Loss KAF	KAF	% of Rim Station	% of Pre-1944	Station Unimpair KAF	Actual Flow KAF	Net Loss KAF	KAF	% of Rim Station	% of Pre-1944
Dry	2,827	957	1,870	410	14	34	1,960	196	1,764	320	16	75
Below Normal	4,141	1,534	2,607	1,220	29	33	3,179	699	2,480	1,060	33	52
Above Normal	6,377	3,012	3,364	1,560	24	31	3,941	1,173	2,768	1,580	40	52
Wet	9,626	6,489	3,137	1,890	20	21	6,716	3,743	2,973	1,370	20	25

UPPER SAN JOAQUIN RIVER BASIN
1948-1969

	ANNUAL						APRIL--SEPTEMBER					
				Estimated Flow Reduction Due to Post-1947 Devel.						Estimated Flow Reduction Due to Post-1947 Devel.		
Year Type	San Joaquin @ Friant Unimpair KAF	Actual Flow KAF	Net Loss KAF	KAF	% of Friant	% of Pre-1944 @ Vern.	San Joaquin @ Friant Unimpair KAF	Actual Flow KAF	Net Loss KAF	KAF	% of Friant	% of Pre-1944 @ Vern.
Dry	842	136	706	120	14	10	636	55	581	7	1.1	1.6
Below Normal	1,252	165	1,088	540	43	24	1,001	66	935	390	39	30
Above Normal	1,909	445	1,464	920	48	18	1,344	95	1,250	570	42	17
Wet	2,996	1,878	1,118	1,240	41	14	2,275	1,060	1,215	760	33	14

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dry years at Vernalis an average annual flow reduction of 410,000 acre-feet* was determined from the average of 519,000 acre-feet estimated by the double mass balance method and 294,000 acre-feet estimated by adjustment of average basin losses to a common reference of unimpaired flow. (See table V-2.) Exceptions to this procedure are values given for below normal years which were taken as estimates computed by the double mass diagram method.

Additional information presented in Table V-18 is flow reduction expressed as percentage of the unimpaired rim station flow and the actual Vernalis flow, pre-1944.

SUMMARY

Reductions in runoff that have occurred in the San Joaquin River basin as a result of development subsequent to 1947 are summarized in Table V-21. Data presented in the table are derived from Table V-2 through V-17, which present estimates of water losses for each of the 4-year classifications computed for both the entire San Joaquin River basin and the upper San Joaquin River basin. Reductions in flow are determined as the difference in "losses" between the rim stations and Vernalis. Reductions attributable to the CVP are identified as equivalent to the difference in losses occurring in the upper San Joaquin River basin alone. For purposes of comparison, reductions are expressed both in terms of volumne of runoff in the April-September and annual periods and as percentages of the flow that actually occurred at Vernalis.

The principal conclusions reached from the study of water quantity effects are as follows:

1. For the entire San Joaquin River basin, flows at Vernalis were reduced by post-1947 development,

* Rounded to nearest 10

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a. in dry years by amounts ranging from 300,000 to 500,000 acre-feet, about 75 percent of which reduction occurred in the April-September period,

b. in below normal years* by amounts exceeding 1,200,000 acre-feet, about 85 percent of which reduction occurred in the April-September period,

c. in above normal years by amounts exceeding 1,400,000 acre-feet, all of which occurred in the April-September period, and

d. in wet years by amounts ranging from 1,100,000 to 2,900,000 acre-feet, about 60-85 percent of which occurred in the April-September period.

2. For the upper San Joaquin River basin, where the impact is attributable to the CVP, flows at Vernalis were reduced by post-1947 development;

a. in dry years by 90,000 to 130,000 acre-feet, a relatively small proportion of which (about 4 to 8 percent) occurred in the April-September period,

b. in below normal years* by more than 500,000 acre-feet, of which about three-quarters occurred during the April-September period,

c. in above normal years by 750,000 to 1 million acre-feet, about 60 percent of which occurred during the April-September period, and

d. in wet years by 750,000 to 2 million acre-feet, of which about half occurred during the April-September period.

3. The greatest impact of flow reductions at Vernalis occurred during the April-September period of below normal and above normal years when from 14-24

* Data are limited for these years. Refer to analysis below normal years on page V-18.

percent of the flow reduction at Vernalis (on a pre-1944 basis) was attributed to development by the CVP in the upper San Joaquin basin. The impact in dry years was small, less than 2 percent of the pre-1944 flow at Vernalis. In the April-September period of wet years, reductions were in the range of 10-18 percent of the pre-1944 flow at Vernalis.

Table V-21

SUMMARY OF REDUCTIONS IN RUNOFF OF SAN JOAQUIN RIVER AT VERNALIS FROM PRE-CVP TO POST-CVP

YEAR TYPE & PERIOD	EFFECT OF ALL POST-CVP UPSTREAM DEVELOPMENT ON RUNOFF AT VERNALIS		EFFECT OF CVP ON RUNOFF AT VERNALIS		
	Reduction in Runoff KAF[1]	Post 1947 Reduction as Percent of Pre-1944 Actual Runoff	Reduction in Runoff KAF[1]	Reduction at Vernalis as Percent of Pre-1944 Flow	Reduction at Vernalis as Percent of Post-1947 Flow
DRY					
April-Sept	206- 417	49-67[2]	6- 7	1.4- 1.6	3.0- 3.6
Full Year	294- 519	25-44	93- 138	8 - 12	10 - 14
BELOW NORMAL					
April-Sept	1064-1177	60-68[2]	386- 428	22 - 24[2]	55 - 61
Full Year	1219	44[2]	543	- 20[2]	35
ABOVE NORMAL					
April-Sept	1406-1732	47-57	440- 704	14 - 23	40 - 64
Full Year	1400-1721	28-34	768-1076	15 - 21	25 - 36
WET					
April-Sept	1002-1760	19-32	554- 965	10 - 18	15 - 26
Full Year	1168-2916	13-32	771-2014	9 - 22	12 - 31
AVERAGE OF ALL YEARS[3]					
April-Sept	920-1272	44-56	347- 526	12 - 17	28 - 39
Full Year	1020-1594	28-39	544- 943	13 - 19	21 - 29

[1] Range of estimates by all methods of analysis. See Tables V-2 through V-17
[2] Pre-CVP "actual" is assumed to be post-1947 actual plus pre-1944 to post-1947 loss
[3] Assumes that each year class occupies one-quarter of period

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CHAPTER VI

WATER QUALITY EFFECTS OF UPSTREAM DEVELOPMENT

INTRODUCTION

There are several complications in analyzing the water quality changes due to upstream development. It is, therefore, necessary that the results of the analysis acknowledge a range of impacts on Southern Delta water quality. Part of the uncertainty in interpretation relates to insufficient and/or unreliable data, and part to differences in approach to the analysis. Each manner of investigation has an aspect of validity, but each must be weighed in light of its assumptions and available data.

Two factors affect water quality, flow and salt load. Chapter V has identified the changes in flow at Vernalis, and this chapter equates these changes in flow with an amount of degradation at Vernalis. This chapter also examines historic salt loads and concentrations at Vernalis to determine changes associated with develoment along the San Joaquin River and its tributaries. Sections A, B, C, and D of this chapter contain the development and results of several studies on different sets of data. Because of the length of the first four sections and the amount of material contained therein, Sections E and F consolidate the results and define the impacts of upstream development. A more detailed explanation of each section follows.

Section A of this chapter presents an analysis of the composition of the salts reaching Vernalis and relates this to composition of salts originating from identifiable sources, e.g., tributary streams, imported water and drainage returns from irrigated lands. These chemical analyses are then used as "finger-

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prints" in an attempt to identify the principal sources and their relative contributions to the total salts reaching Vernalis. Also included in this section are the results of salt balance computations using this data for a single dry year, 1961.

Section B of this chapter addresses three questions pertaining to water quality at Vernalis. First, has there been a change in salt load at Vernalis? By comparing the TDS salt loads at Vernalis over the period of record, increasing or decreasing trends in loading can be identified. Second, regardless of any change in loading, has a change in TDS concentration occurred? A comparison of the TDS concentrations is used to determine if any degradation has taken place through the period of record. Third, has the source of salt changed? Salt balance computations, utilizing data from identified sources, are employed to judge whether in the years after 1950, the percent of Vernalis salt load contributed by these sources has changed. Section B deals with trends in the data in a qualitative rather than quantitative manner.

Section C of this chapter presents the record of quality degradation in the San Joaquin River as it enters the Delta near Vernalis. Due to limitations of the Vernalis data, two methods of estimating Vernalis quality are developed and used to synthesize an artificial record for periods when none exists. By constructing the complete set of TDS concentrations, similar hydrologic years before and after upstream development can be compared to estimate water quality degradation.

Section D of this chapter is a discussion of the Tuolumne River gas wells and their contribution to the quality problem. Because the Tuolumne River contributes a significant amount of the salt load at Vernalis, and the gas

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wells are the source of much of the Tuolumne load, Section D deals with the water quality of discharges from these wells.

Section E of this chapter allows the reader who may not be interested in the development of the individual studies, to forego reading Sections A, B, C, and D. Section E summarizes the results of the four preceeding sections and analyzes the impact of upstream development on quality degradation at Vernalis.

Section F of this chapter is a summary of quality impacts at Vernalis resulting from CVP development.

Various methods of analysis utilizing different data sets are presented in this chapter. Due to the type and availability of data, one method of analysis may not use the same chronological division of data as used by another method. For purposes of water quality, generally the period prior to 1950 is considered indicative of conditions in the lower San Joaquin River before CVP development. Each analysis refers to a period preceding a specific year or succeeding a specific year. Although the specific year may vary from analysis to analysis, the implication is that prevalues refer to that period used as a base condition and postvalues refer to that period in which some change has occurred to the lower San Joaquin River basin. Using this assumption, pre- and postvalues calculated by one method can be compared to pre- and postvalues computed by another method, regardless of actual period of record.

SECTION A. IDENTIFICATION OF SOURCES OF SALT BURDEN--CHEMICAL CHARACTERISTICS

Figure VI-1 is a schematic representation of the San Joaquin Valley System showing the location of stream gaging, water quality sampling stations and principal drainage accretions.

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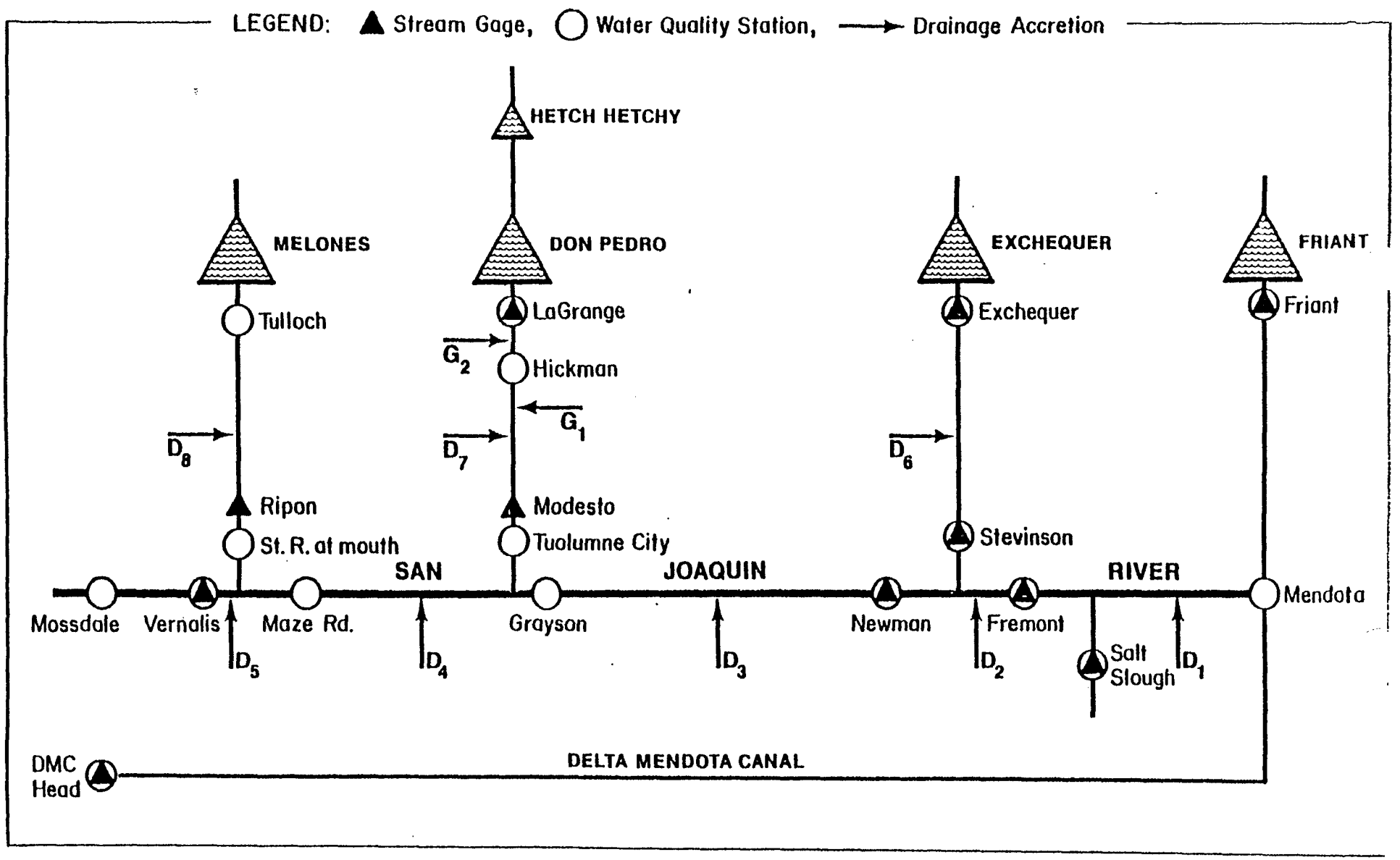

Figure VI-1 SAN JOAQUIN VALLEY SYSTEM

Stream gaging, water quality sampling stations and principal drainage accretions

Characteristics of High Sierra Streams

In order to provide a perspective of quality characteristics of San Joaquin flows, it is necessary to identify the distinguishing chemical properties of the principal sources of runoff. Table VI-1 gives a representative analysis of the four major tributaries at locations corresponding approximately to the location of rim flow gaging stations.

The quality of these high Sierra streams is generally characterized by low levels of total dissolved solids and of each of the principal mineral constituents, low electrical conductivity and a slightly alkaline pH. These waters are very soft, bicarbonate concentrations are relatively high compared to other constituents and sulfates are virtually nil. Carbonate does not occur at the pH of these waters. Chlorides are very low. Traces of iron and fluoride are occasionally noted. Boron is found in measurable concentrations ($\geq$ 0.1 mg/L) in only a few samples. Iron is virtually absent. Distinguishing properties of high Sierra waters are the almost total lack of sulfates and noncarbonate hardness and extremely low boron concentrations.

Characteristics of Sierra Streams at Confluence with San Joaquin Main Stem

Table VI-2 illustrates the quality of the east side tributaries, together with the main stem of the San Joaquin near Mendota during the month of May 1961. Lower in the drainage system the Sierra streams show increased concentrations of most constituents, with relatively larger increases in Na^+, K^+, Cl^- and $SO_4^=$ than of Ca^{++}, Mg^{++} and HCO_3^-. An exception is the Tuolumne River which has picked up an unusually large accretion of saline water from gas wells between Hickman and Modesto. In this case, large increases in Na^+, K^+ and Cl^- are noted, with corresponding changes in TDS, hardness, SAR

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Table VI-1. REPRESENTATIVE WATER QUALITY OF HIGH SIERRA STREAMS*

		San Joaquin at Friant	Merced @ Exchequer	Tuolumne @ La Grange	Stanislaus @ Tulloch
1.	Date	6 Sep 61	6 Sep 61	12 Sep 61	8 Sep 61
2.	Mean discharge (cfs)	146	143	2120	
3.	Silica	10	9.3	4.8	8.9
4.	Iron	0.0			
5.	Calcium	3.6	12	2.5	5.6
6.	Magnesium	1.6	2.4	0.5	2.8
7.	Sodium	5.4	3.2	1.2	2.6
8.	Potassium	0.7	0.7	0.4	0.3
9.	Bicarbonate	24	48	12	35
10.	Carbonate				
11.	Sulfate	0.0	3.0	0.2	0.0
12.	Chloride	6.0	3.2	-	1.2
13.	Fluoride	0.1	0.1	0.1	0.1
14.	Nitrate	0.4	0.8	0.4	0.3
15.	Boron	0.1	0.0	0.0	0.0
16.	TDS	40	59	16	39
17.	Ca + Mg hardness	16	40	8	26
18.	Non-carb. "	0	1	0	0
19.	SAR	0.6	0.2	0.2	0.2
20.	EC, µmhos/cm	59	95	22	63
21.	pH	7.3	7.6	6.7	7.3

* mg/L except as noted

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Table VI-2. REPRESENTATIVE WATER QUALITY OF TRIBUTARIES AT CONFLUENCE WITH SAN JOAQUIN *

		San Joaquin nr. Mendota	Merced nr. Stevinson	Tuolumne nr. Tuol.City	Stanislaus nr. mouth
1.	Date	4 May 61	4 May 61	9 May 61	4 May 61
2.	Mean discharge (cfs)		71	235	12
3.	Silica	17	26	41	34
4.	Iron	0.1	0.02	0.04	0.01
5.	Calcium	17	22	53	30
6.	Magnesium	9.0	7.1	16	12
7.	Sodium	23	30	102	19
8.	Potassium	0.9	2.0	8.0	2.1
9.	Bicarbonate	84	132	147	182
10.	Carbonate		0	0	
11.	Sulfate	27	15	10	10
12.	Chloride	26	20	207	9.0
13.	Fluoride	0.2	0.1	0.0	0.1
14.	Nitrate	0.9	3.4	3.1	0.6
15.	Boron	0.2	0.1	0.0	0.1
16.	TDS	162	191	512	207
17.	Ca + Mg hardness	80	84	198	126
18.	Non-carb. "	11	0	77	0
19.	SAR	1.1	1.4	3.2	0.7
20.	EC, µmhos/cm	260	294	911	315
21.	pH	7.5	7.8	7.8	7.7

* mg/L except as noted

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and EC. However, if these concentrated sources of salinity are eliminated then the quality of the Tuolumne inflow would probably be little different from those of the other major tributaries. Note, for example, that the concentration of sulfate is virtually the same as for the Stanislaus and less than for either the Merced or the San Joaquin at Mendota.

Westside Drainage Water Quality

Drainage waters from the west side of the San Joaquin Valley are characterized by generally high concentrations of total dissolved solids, dominated by Na^+, Cl^- and $SO_4^=$. TDS levels commonly range from 800 to over 1,200 mg/L and EC's may exceed 2,000 umhos/cm in some waters. Some surface drainage is of a quality similar to ground waters that have been used historically as principal sources for irrigation. Surface streams are ephemeral, with few exceptions, so there is a paucity of data on surface accretions from the west side of the valley. However, a fair indication of west side water quality is seen in observations of Salt Slough near Los Banos, some examples of which are described in table VI-3. It is noted that these waters are high in boron and sulfates; noncarbonate hardness is more than 40 percent of total hardness.

Quality Variations Along the Main Stem

A general picture of the pattern of quality along the main stem of the San Joaquin, in relation to the quality of its principal tributaries, is presented in figures VI-2 through VI-6.

Cation-Anion balance. Figure VI-2 shows the cation composition of the river and tributaries during the period May 3-9, 1966, and figure VI-3 shows the corresponding distribution of the principal anions.

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Table VI-3. WATER QUALITY OF SALT SLOUGH*

1.	Date	4 May 61	7 Sep 61	4 May 66
2.	Mean discharge (cfs)	65	73	98
3.	Silica	25	25	17
4.	Iron	0.0		
5.	Calcium	56	52	54
6.	Magnesium	29	32	25
7.	Sodium	146	157	123
8.	Potassium	4.8	5.0	4.6
9.	Bicarbonate	160	174	152
10.	Carbonate	0	0	0
11.	Sulfate	135	129	123
12.	Chloride	220	232	172
13.	Fluoride	0.5	0.3	
14.	Nitrate	2.8	2.4	3.4
15.	Boron	0.4	0.7	0.6
16.	TDS	698	721	628
17.	Ca + Mg hardness	260	260	236
18.	Non-carb. "	129	117	111
19.	SAR	3.9	4.2	3.5
20.	EC, µmhos/cm	1210	1300	1060
21.	pH	7.8	7.4	7.6

* mg/L except as noted

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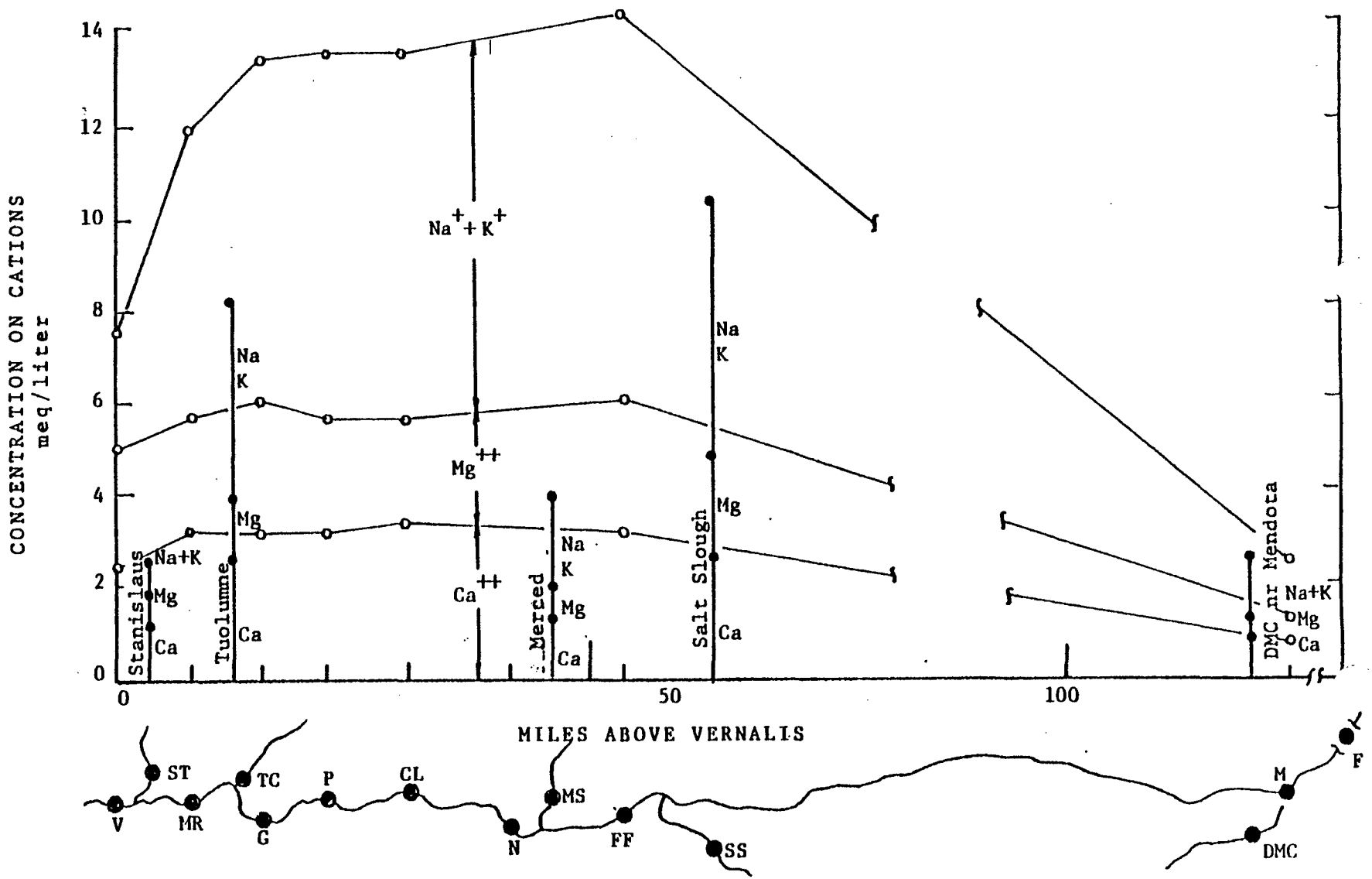

Figure VI- 2 CONCENTRATIONS OF PRINCIPAL CATIONS IN THE SAN JOAQUIN RIVER AND ITS MAJOR TRIBUTARIES. PERIOD: 3-9 MAY 1966

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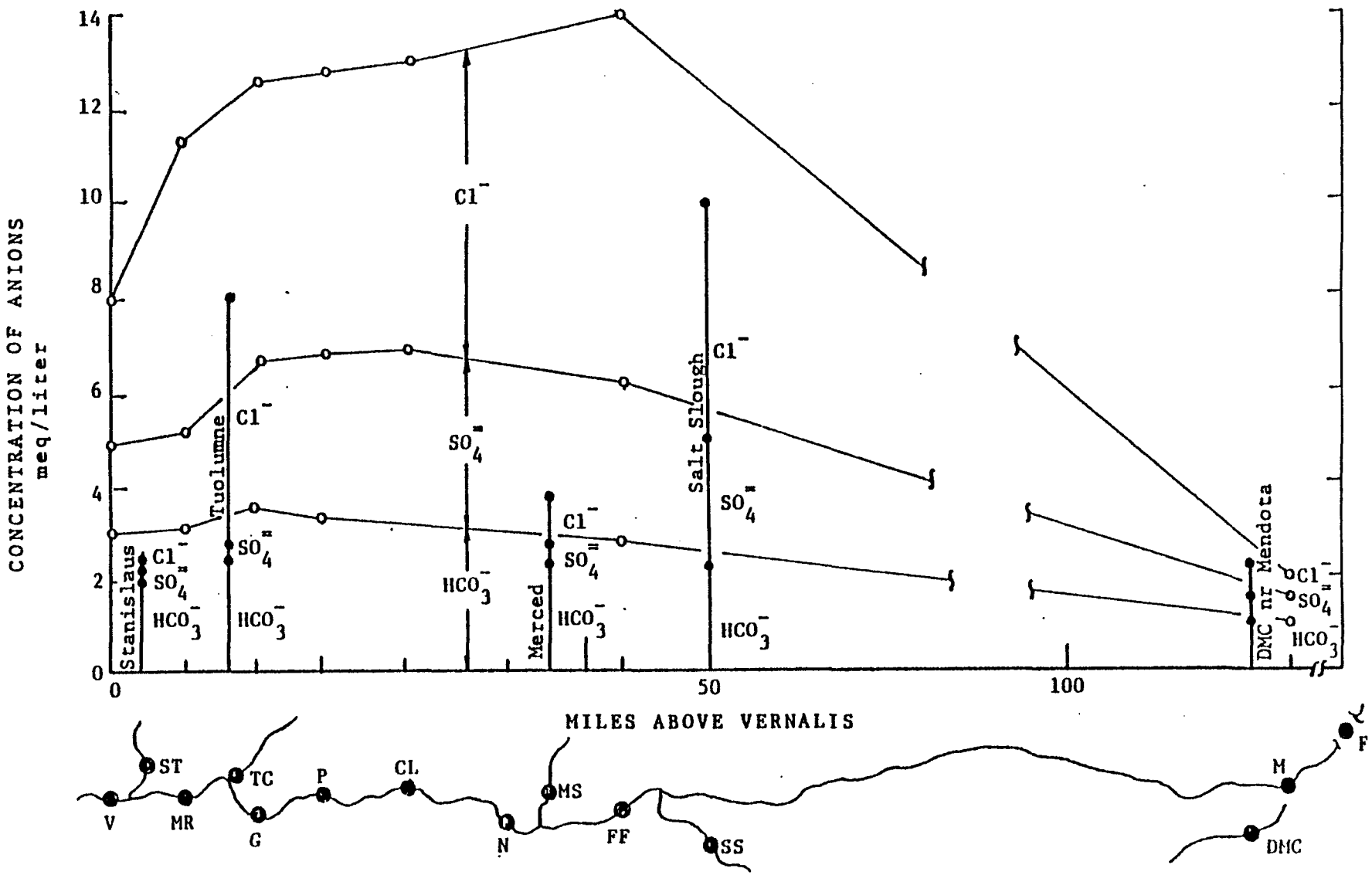

Figure VI- 3 CONCENTRATIONS OF PRINCIPAL ANIONS IN THE SAN JOAQUIN RIVER AND ITS MAJOR TRIBUTARIES. PERIOD: 3-9 MAY 1966

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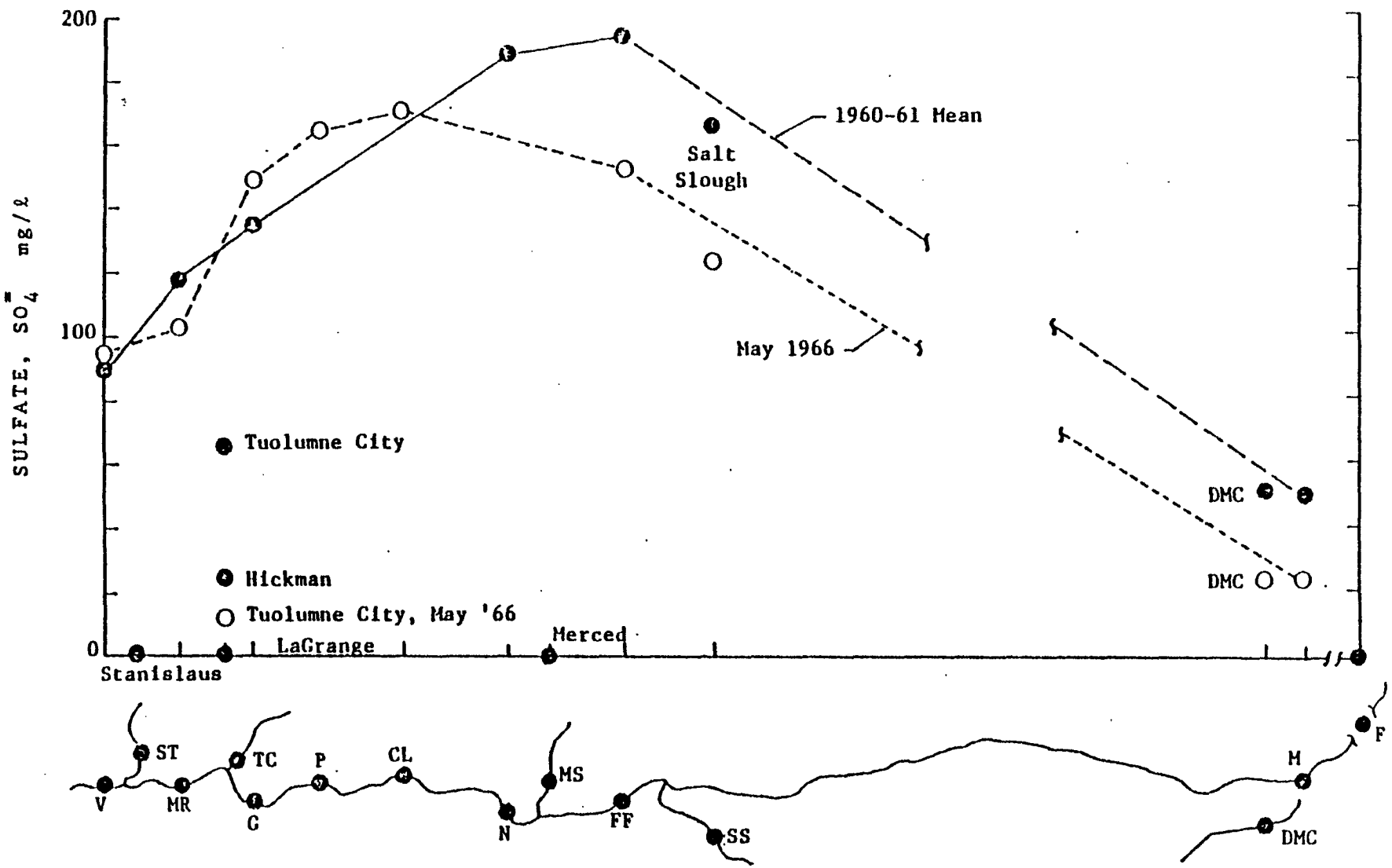

Figure VI- 4 SULFATE CONCENTRATION IN SAN JOAQUIN RIVER SYSTEM 1960-61 AND MAY 1966

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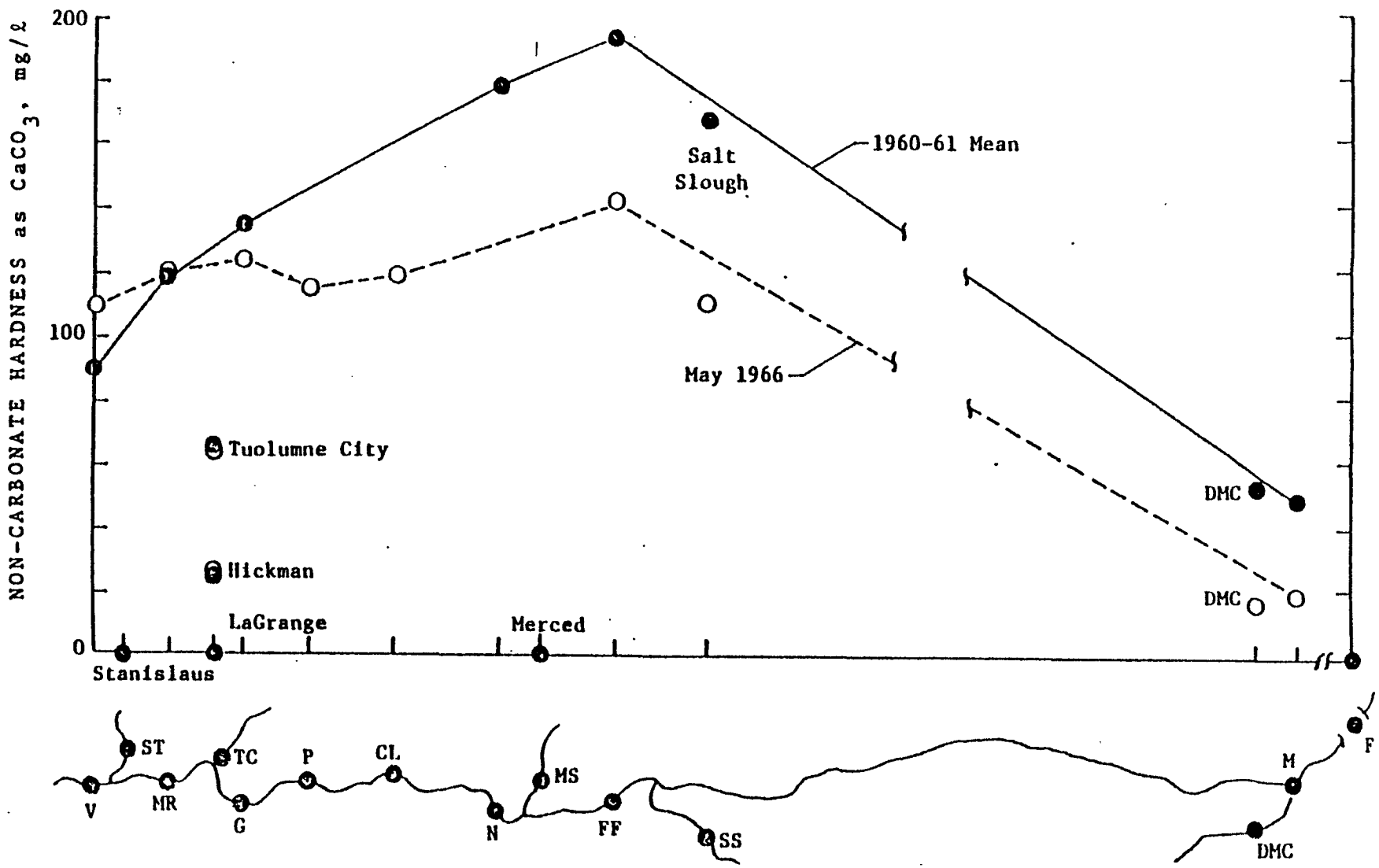

Figure VI- 5. NONCARBONATE HARDNESS IN SAN JOAQUIN RIVER SYSTEM 1960-61 AND MAY 1966

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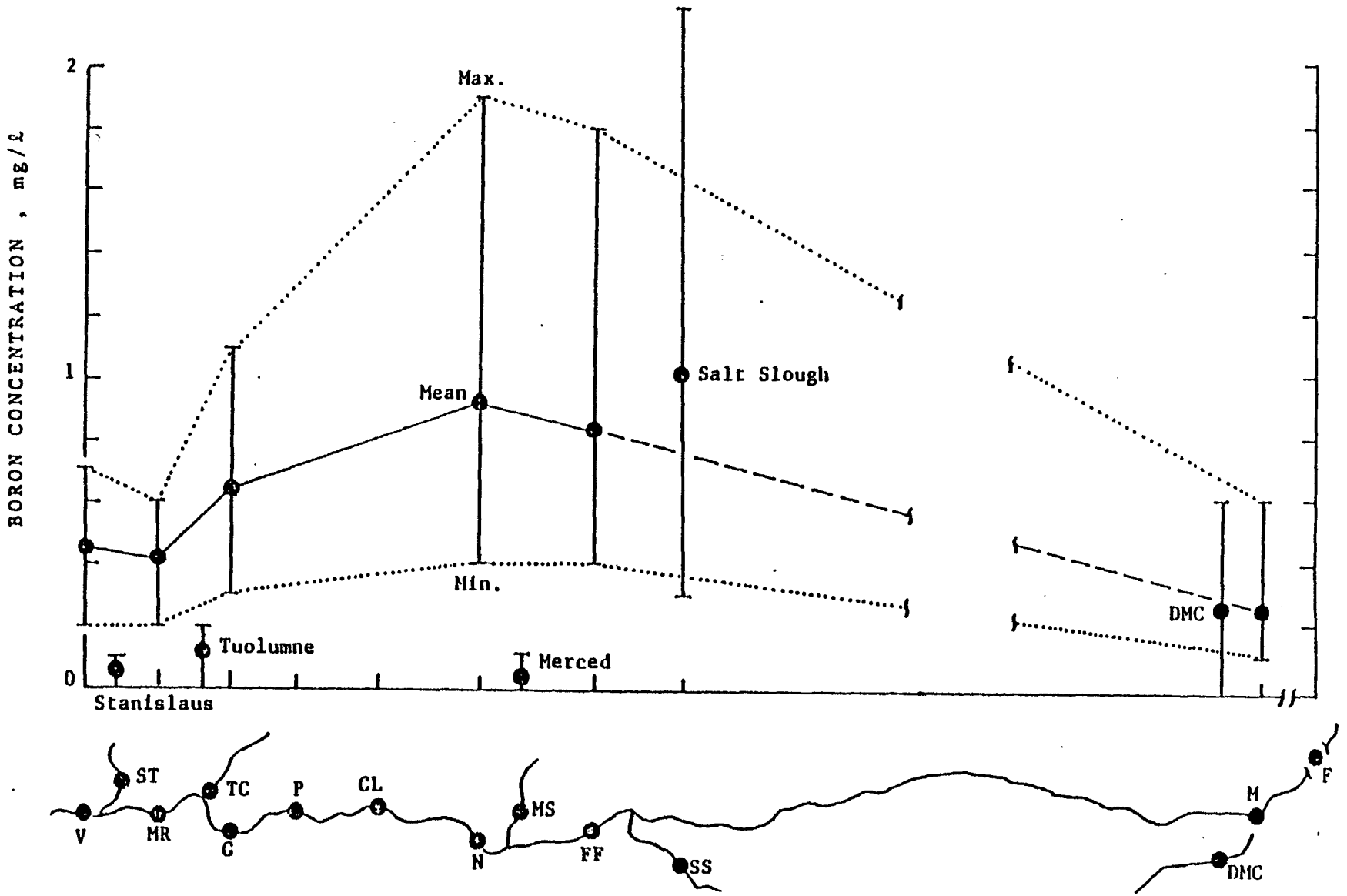

Figure VI-6 BORON CONCENTRATION IN SAN JOAQUIN RIVER SYSTEM 1960-61

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Due to the lack of data in the reach between Mendota (Mile 129 above Vernalis) and Fremont Ford Bridge just downstream from the mouth of Salt Slough, it is not clear how the pattern develops over the upper 70 miles or so. Nevertheless, it is clear that the composition of San Joaquin River water at Fremont Ford Bridge (FF) corresponds closely to that of Salt Slough. If principal cations and anions are expressed as percentages of the sum of milliequivalents per liter, then the similarity of these waters becomes even more evident, as can be seen in the following example:

	San Joaquin River @ Fremont Ford 5-5-66 $Q = 175\ ft^3/s$	Salt Slough 5-4-66 $Q = 98\ ft^3/s$
Cations (percent of total)		
Ca^{++}	22.5	26.4
Mg^{++}	19.7	20.2
Na^{+}	56.7	52.2
K^{+}	1.1	1.2
	100.0	100.0
Anions (percent of total)		
HCO_3^{-}	22.2	25.2
$CO_3^{=}$	0	0
$SO_4^{=}$	22.9	25.8
Cl^{-}	54.9	49.0
	100.0	100.0

It should be noted that the additional drainage accretion to Fremont Ford is about 77 ft^3/s (175 minus 98). The chemical composition of salts in this water must be very similar to that of Salt Slough since the chemical composition of the salts in the blended flows is so little different from that measured in the slough.

Referring once again to figures VI-2 and VI-3, it is noted that downstream of Fremont Ford the pattern remains more or less steady until the flow reaches the vicinity of the mouth of the Tuolumne. At this point an influx of water of superior overall quality, although high in Na^+, K^+ and Cl^-, accelerates a general decline in salt concentration. The proportion of Cl^- to total anions increases notably while the proportion of $SO_4^=$ in the San Joaquin (more or less constant in the Tuolumne) decreases. A further striking improvement in San Joaquin quality is noted between Maze Road and Vernalis with the addition of flow (157 ft^3/s at Ripon) of very high quality.

Sulfates. Table VI-4 summarizes the principal anion composition of the San Joaquin System for the dry year 1960-61. Data shown represent averages of all observations over the year for all USGS stations at which samples were collected.

As noted previously, a distinctive difference in the quality of east side streams and the quality of the main stem below Mendota is the concentration of sulfate ion, $SO_4^=$. East side streams, with the exception of the Tuolumne below the gas wells, contain very little sulfate while the main stem and the principal west side tributary, Salt Slough, are very rich in this anion. The pattern along the river, shown in figure VI-4, highlights these differences, showing clearly that for this period, at least (when flows were generally very low) the river water quality, in terms of chemical composition of salts, was similar to drainage from the west side. Some lowering of $SO_4^=$ concentrations appears to occur below Newman, possibly due to return flows from the irrigated areas on the eastern side of the valley. However, sulfates are sustained at high levels along most of the river from Fremont Ford to Vernalis.

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Table VI-4. CONCENTRATIONS OF PRINCIPAL ANIONS, SAN JOAQUIN RIVER SYSTEM, 1960-61

Station		No. of	Principal Anions, mg/L			
USGS No.	Location	Obs.[1]	HCO_3^-	$SO_4^=$	Cl^-	% SO_4[2]
2510	SJR below Friant	12	22.3	0.5	5.1	1.8
2540	SJR nr Mendota	13	97.7	36.3	98.0	15.7
2580	Fresno R.	8	51.5	0.0	28.4	0.0
2590	Chowchilla R.	7	102.0	3.0	64.4	2.0
2603	Bear Cr.	11	139.4	6.0	5.7	6.9
2610	Salt Slough	12	201.3	242.3	280.5	33.1
2615	SJR, Fremont Fd.	15	208.9	233.8	345.3	31.4
2700	Merced @ Exch.	12	50.1	2.5	4.2	6.7
2725	Merced @ Stev.	11	145.5	13.5	22.1	7.7
2740	SJR nr Newman	13	221.6	252.0	318.4	32.0
2747	SJR nr Grayson	12	229.2	159.3	244.7	26.4
2880	Tuol @ LaGrange	11	14.1	0.6	1.1	4.5
2898	Tuol nr Hickman	11	83.9	2.8	81.1	1.2
2902	Tuol nr Tuol City	11	130.4	9.4	204.0	2.4
2905	SJR @ Maze Rd	12	178.7	87.7	241.6	16.3
2999.98	Stan @ Tulloch	12	35.0	1.0	1.0	1.4
3034	Stan nr mouth	10	151.5	10.0	9.1	5.0
3035	SJR nr Vernalis	39	151.0	81.0	176.0	19.9
3042	SJR nr Mossdale	13	163.2	65.3	192.3	14.0
3048	SJR, Garwood Br.	12	144.6	45.0	145.6	13.1
3127	Old R. nr Tracy	12	167.4	86.5	198.6	17.9
3129.9	DMC above PP	10	101.6	23.5	100.6	12.8
3130.1	DMC below PP	28	94.0	39.0	89.0	17.6
3130.5	DMC nr Mendota	13	110.5	36.0	110.6	15.6
3132	Grantline Canal	12	149.1	65.5	182.2	15.0
3132.5	Old R. @ Cl.Ct.	12	103.5	21.0	103.9	12.3

[1] Corresponds to maximum, usually for HCO_3^- and Cl^-; $SO_4^=$ analyses were made less frequently

[2] Percentage based only on samples analyzed for all three anions, since $SO_4^=$ analyses were made less frequently

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A similar pattern is seen for a set of data taken during the period May 3-9, 1966, although in this case the sulfate concentration of the Tuolumne River at Tuolumne City was very much lower than for 1960-61, a fact that probably accounts for the sharp drop in $SO_4^{=}$ between Grayson and Maze Roads.

Noncarbonate hardness. Noncarbonate hardness, a measure of hardness attributed to the chloride and sulfate compounds with calcium and magnesium, also reveals a distinctive difference between east side streams and the main stem plus Salt Slough. This is illustrated in the data of table VI-5 and figure VI-5. Once again the main stem quality, in terms of chemical composition of salts, is closely identified with drainage returns from the west side, i.e., Salt Slough, while the east side streams are virtually devoid of NCH (the exception being the lower reach of the Tuolumne where the gas wells add calcium and magnesium sulfate). Even the DMC carries a relatively high NCH, a condition that is also reflected in the quality of water in the San Joaquin River near Mendota since the DMC is the principal source of water in the main stem at this location.

Boron. Boron concentrations in east side streams are generally very low, while this is a common constituent of west side waters and also of the main stem during periods of low runoff. Data on boron concentrations for 1960-61 are summarized in table VI-6 and figure VI-6.

In these examples, boron concentrations are noted to vary widely with location along the main stem, but at all locations the concentrations are substantially greater than for any of the east side streams. Even the DMC delivers water with more than double the boron concentrations of the highest east side source (Tuolumne River). Maximum boron concentrations in the east side streams are no greater than the least values recorded for the main stem from Fremont Ford to Vernalis.

Table VI-5. TOTAL AND NONCARBONATE HARDNESS
SAN JOAQUIN RIVER SYSTEM, 1960-61

Station		No. of	Hardness as $CaCO_3$, mg/L		
USGS No.	Location	Obs.	Ca + Mg	NHC	% @ NHC
2510	SJR below Friant	12	17.0	0.5	2.9
2540	SJR nr Mendota	13	128.1	47.9	37.4
2580	Fresno R.	8	43.8	4.3	9.8
2590	Chowchilla R.	7	101.8	18.3	18.0
2603	Bear Cr.	11	112.2	1.6	1.4
2610	Salt Slough	12	332.9	167.8	50.4
2615	SJR, Fremont Fd.	15	366.3	194.3	53.0
2700	Merced @ Exch.	12	44.4	3.8	8.5
2725	Merced @ Stev.	11	93.6	0.0	0.0
2740	SJR nr Newman	13	370.8	188.6	50.9
2747	SJR nr Grayson	12	327.2	135.5	41.4
2880	Tuol @ LaGrange	11	10.9	0.5	4.8
2898	Tuol nr Hickman	11	94.2	25.5	27.1
2902	Tuol nr Tuol City	11	173.9	66.5	38.2
2905	SJR @ Maze Rd	12	265.9	118.2	44.5
2999.98	Stan @ Tulloch	12	28.2	0.9	3.2
3034	Stan nr mouth	10	110.9	0.0	0.0
3035	SJR nr Vernalis	39	210.0	88.0	41.9
3042	SJR nr Mossdale	13	229.4	95.1	41.5
3048	SJR, Garwood Br.	12	178.1	60.2	33.8
3127	Old R. nr Tracy	12	247.5	110.3	44.6
3129.9	DMC above PP	10	131.8	48.3	36.6
3130.1	DMC below PP	28	115.0	38.0	33.0
3130.5	DMC nr Mendota	13	143.8	52.7	36.6
3132	Grantline Canal	12	206.8	84.3	40.8
3132.5	Old R. @ Cl.Ct.	12	132.2	55.8	42.2

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Table VI-6. BORON CONCENTRATION, SAN JOAQUIN RIVER SYSTEM

Station		No. of	Boron Concentration, mg/L			
USGS No.	Location	Obs.	Min.	Max.	Mean	Median
2510	SJR below Friant	12	0.0	0.1	0.03	0.0
2540	SJR nr Mendota	13	0.0	0.6	0.23	0.2
2580	Fresno R.	8	0.0	0.2	0.05	0.0
2590	Chowchilla R.	7	0.0	0.1	0.04	0.0
2603	Bear Cr.	11	0.0	0.1	0.02	0.0
2610	Salt Slough	12	0.3	2.2	1.00	0.75
2615	SJR, Fremont Fd.	15	0.4	1.8	0.83	0.70
2700	Merced @ Exch.	12	0.0	0.1	0.03	0.0
2725	Merced @ Stev.	11	0.0	0.1	0.03	0.0
2740	SJR nr Newman	13	0.4	1.9	0.92	0.8
2747	SJR nr Grayson	12	0.3	1.1	0.63	0.6
2880	Tuol @ LaGrange	11	0.0	0.1	0.04	0.0
2898	Tuol nr Hickman	11	0.0	0.1	0.05	0.0
2902	Tuol nr Tuol City	11	0.0	0.2	0.11	0.1
2905	SJR @ Maze Rd	12	0.2	0.6	0.42	0.4
2999.98	Stan @ Tulloch	12	0.0	0.1	0.02	0.0
3034	Stan nr mouth	10	0.0	0.1	0.04	0.0
3035	SJR nr Vernalis	39	0.2	0.7	0.44	0.4
3042	SJR nr Mossdale	13	0.0	0.5	0.28	0.3
3048	SJR, Garwood Br.	12	0.0	0.5	0.26	0.3
3127	Old R. nr Tracy	12	0.0	0.7	0.39	0.4
3129.9	DMC above PP	10	0.1	0.6	0.21	0.1
3130.1	DMC below PP	28	0.1	0.8	0.22	0.1
3130.5	DMC nr Mendota	13	0.1	0.6	0.22	0.1
3132	Grantline Canal	12	0.0	0.5	0.27	0.4
3132.5	Old R. @ Cl.Ct.	12	0.0	0.5	0.14	0.1

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Summary. These data were developed to facilitate identification of the locations and relative strengths of the major contributions to the salt burden carried by the San Joaquin River from the vicinity of the Mendota Pool to Vernalis.

In general, the data on quality constituents show the following:

1. There are distinctive differences between the qualities of east side streams and the quality of water carried by the San Joaquin River along its main stem. East side streams are generally of high quality from source to mouth (an exception being the lower reaches of the Tuolumne River). They are lower in TDS, lower in boron and uniquely deficient in sulfate and noncarbonate hardness compared to the San Joaquin River into which they discharge.
2. In the 1960's there is comparatively little difference between the quality and chemical composition of salts in drainage returns from the west side of the valley and the quality of water carried in the San Joaquin River from Mendota to Vernalis. West side drainage is high in TDS, chlorides, sodium, sulfate, noncarbonate hardness and boron, all of these properties being identified with soils of the area.
3. The quality of water and chemical composition of salts in the San Joaquin from Mendota to Vernalis is similar to the quality of west side accretions to the river. The effect of the flow from east side tributaries has been largely one of dilution of increased salt loads carried by the river.
4. The lower Tuolumne River received substantial accretions of salt (primarily in the form of sodium chloride) during the period studied as a result of drainage from abandoned gas wells. However,

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even in 1961, the average annual quality of the Tuolumne at its mouth near Tuolumne City was superior to that in the main stem of the San Joaquin above the confluence of the two rivers (Note: Recently, an attempt to reduce the salt load of the Tuolumne River was initiated by sealing of the wells, although the effectiveness of this control measure has not yet been assessed quantitatively.)

While the properties of the salts carried by the San Joaquin River during periods of low flow appear to be dominated by west side accretions, to a degree that they are hardly indistinguishable, it is not possible on the basis of quality alone to determine the relative contribution of the several sources without considering the flow itself. This leads to the second phase of the quality problem--salt load--the product of flow times concentration.

SECTION B. SALT BALANCE OBSERVATIONS AT VERNALIS

The water quality at Vernalis may be affected by a change in salt load. Generally, an increase in load can be expected to cause quality degradation. (The exception would be an increase in load accompanied by an increase in flow.) An increase in load can be the result of importation of salts, either applied to the soil in the form of fertilizers, soil conditioners, etc., or as in the case of the DMC, with water diverted from the Delta. These salts along with those occurring naturally in the soil are carried in return flows to the San Joaquin River and may increase the total yearly salt load at Vernalis.

A second means of changing the salt load is through a shift of load with time. In such a case, the salt burden may be temporarily detained in the basin during one period but released subsequently with return flow. This mechanism

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may not change the total annual salt load, merely redistribute it with respect to time, or delay its occurrence at the lower limit of the basin.

This section attempts to determine if additional salts have been introduced into the system, if a change in salt load pattern has occurred, or both.

Historical Trends of Salt Load at Vernalis

In figures VI-7 through VI-10 are presented the monthly average salt loads (tons per month) actually occurring at Vernalis during several decades since the 1940's* plotted as functions of the unimpaired ("rimflow") runoff at Vernalis (1,000's acre-feet) for each of four different months--October, January, April and July. Regression lines of a power funtion form

$$TDS = \text{Constant } (KAF)^n$$

where

TDS = tons per month

KAF = unimpaired Vernalis runoff, 1,000 acre-feet

n = exponent

that best fit the data are also shown.

In general, the data tend to indicate that the salt load has increased through the decades. It is noted that the lines represent "best fits" for a decade of data (up to 10 data points) and, hence, in some cases the correlations are not very strong, 0.5 or less. The curves do not necessarily describe the cause-effect relationship between salt load at Vernalis and the unimpaired runoff. Apparently, in those cases where correlations are poor

* Data were not considered sufficient to permit computation of monthly averages for the 1930's.

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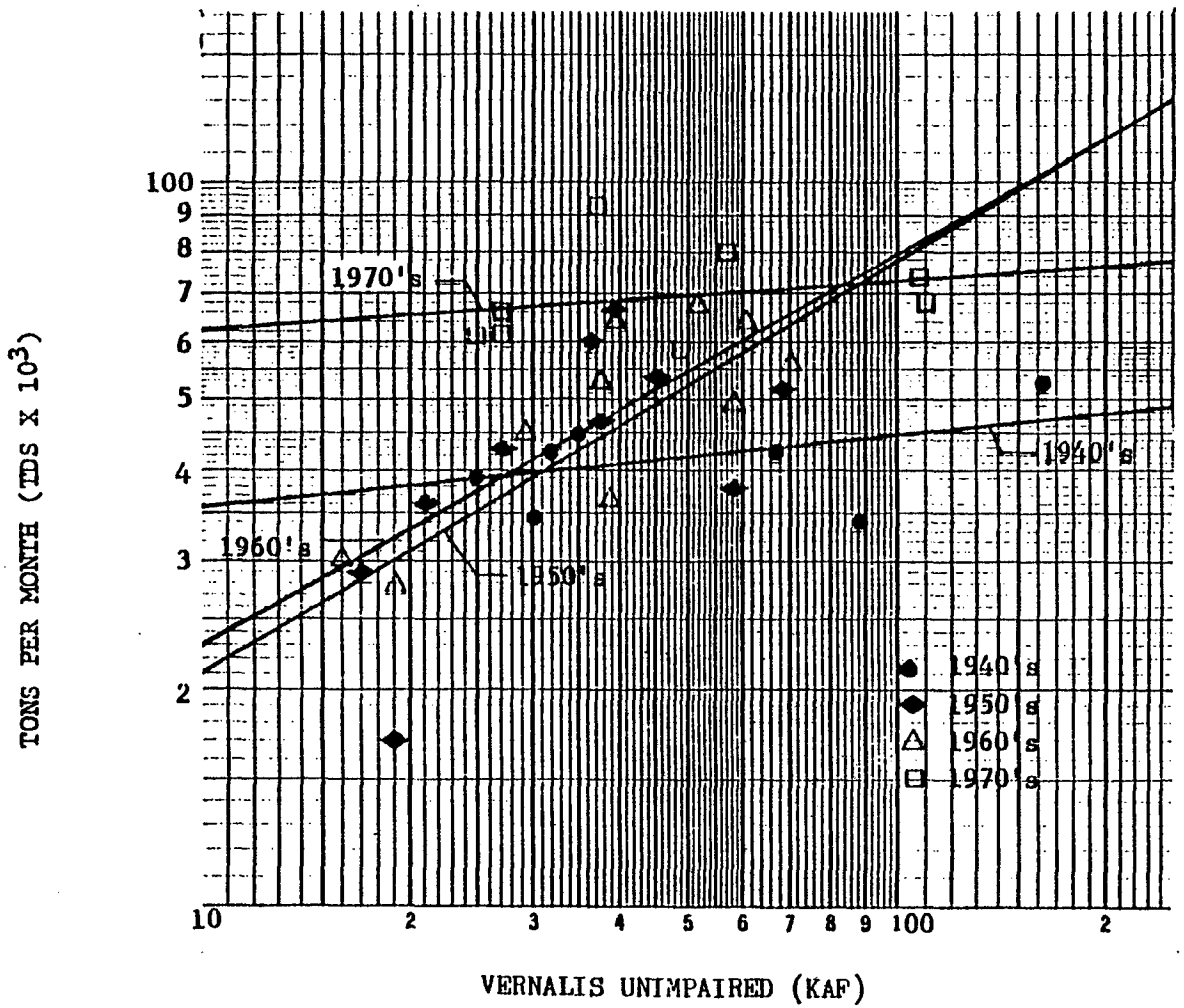

Figure VI-7 AVERAGE MONTHLY SALT LOAD (TDS) AS A FUNCTION OF UNIMPAIRED RUNOFF AT VERNALIS - OCTOBER

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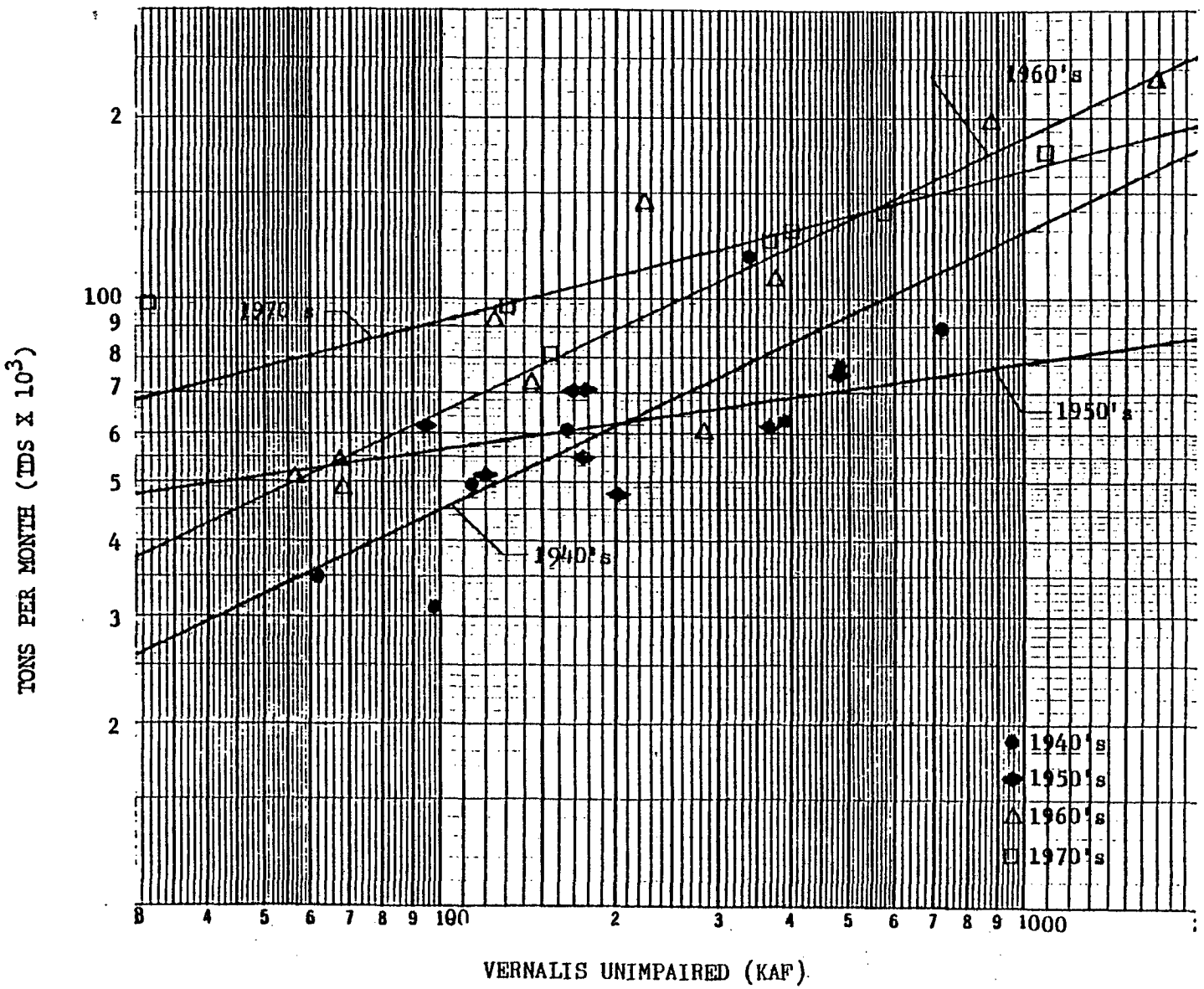

Figure VI-8 AVERAGE MONTHLY SALT LOAD (TDS) AS A FUNCTION OF UNIMPAIRED RUNOFF AT VERNALIS - JANUARY

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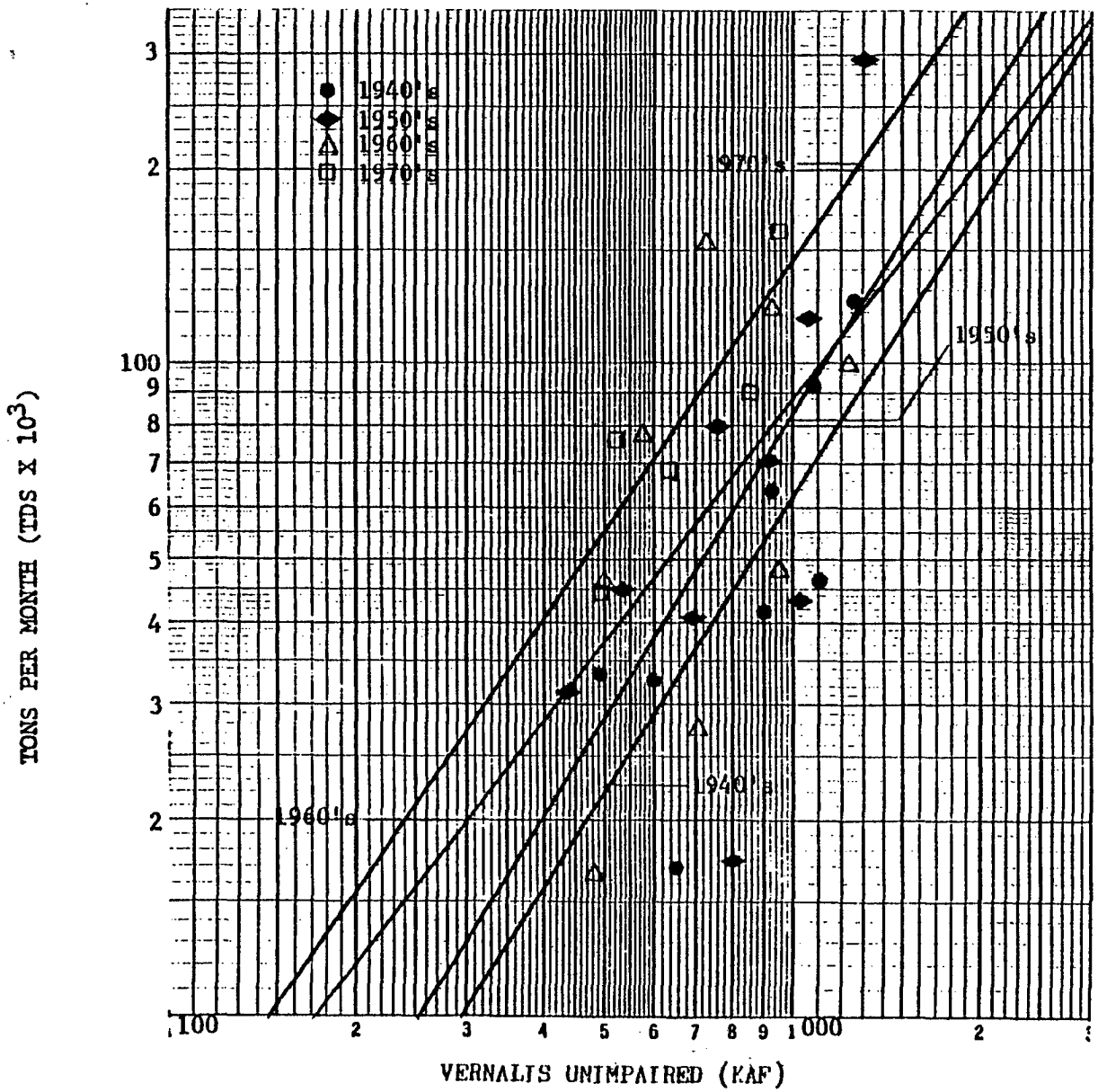

Figure VI-9 AVERAGE MONTHLY SALT LOAD (TDS) AS A FUNCTION OF UNIMPAIRED RUNOFF AT VERNALIS - APRIL

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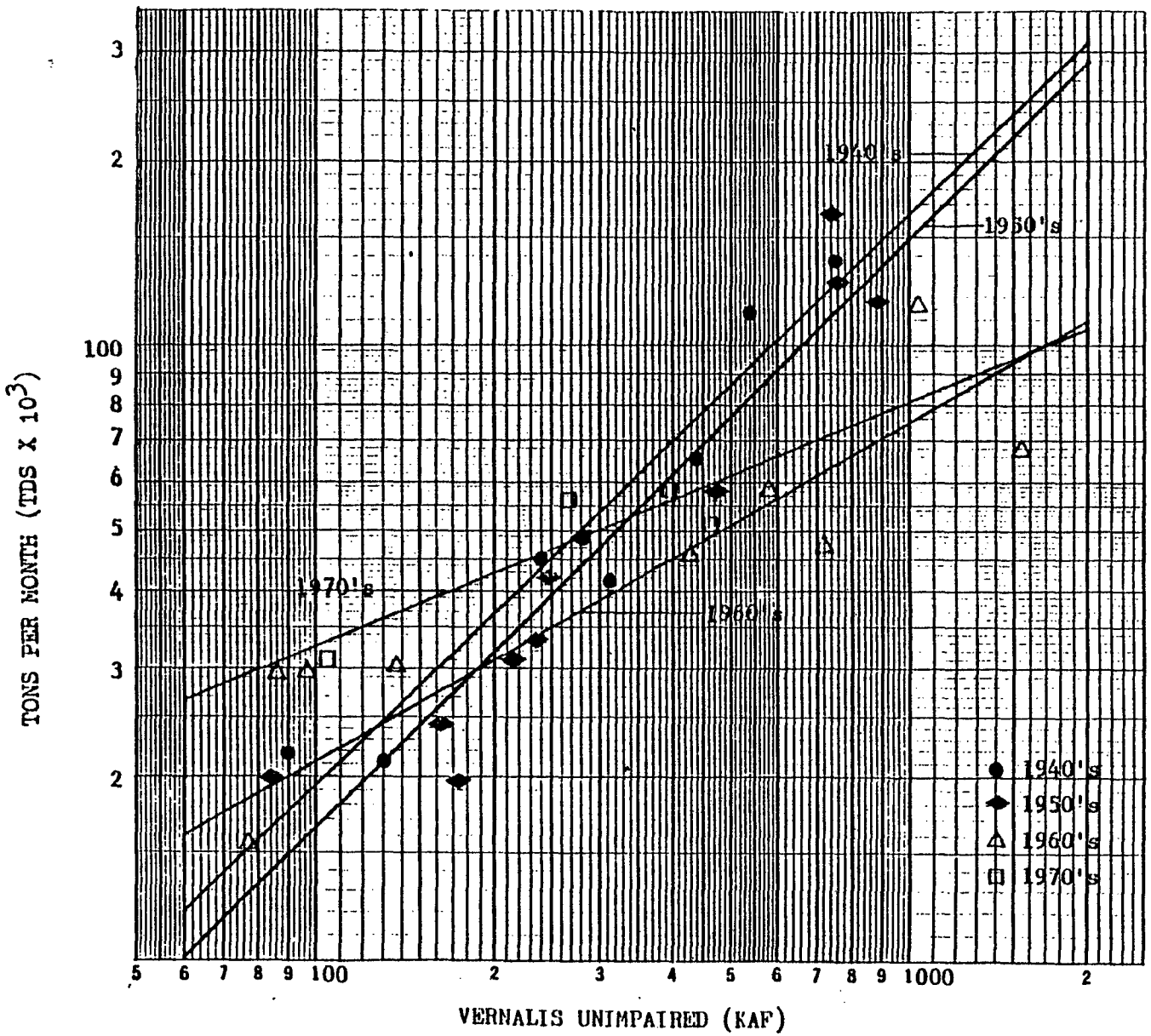

Figure VI-10 AVERAGE MONTHLY SALT LOAD (TDS) AS A FUNCTION OF UNIMPAIRED RUNOFF AT VERNALIS - JULY

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other mechanisms than those assumed are needed to explain the observed increases in salt load that have occurred at Vernalis over the period since the 1940's.

Historical Trends in Salt Concentration at Vernalis

The Water and Power Resources Service has established a continuous EC recorder at the Vernalis stream gage and records are available, with some minor gaps, almost continuously for the period since September 1952. These are generally in the form of EC measurements from recorders, averaged over the daily cycle and converted to TDS and chlorides by conversion equations periodically updated by comparison of EC measurements with laboratory determinations of TDS and Cl^-. The most recent equations employed by the Water and Power Resources Service for Vernalis are:

$$TDS = 0.62\ EC + 18.0 \qquad (1)$$
$$0 < EC < 2000$$

$$Cl^- = 0.15\ EC - 5.0 \qquad (2a)$$
$$0 < EC < 500$$

$$Cl^- = 0.202\ EC - 31.0 \qquad (2b)$$
$$500 < EC < 2000$$

By relating TDS to Cl^- for constant EC, there result the following relationships between these two quality constituents:

$$TDS = 3.07\ (Cl^-) + 113 \qquad (3)$$
$$70 < Cl^-$$

$$TDS = 4.13\ (Cl^-) + 38.7 \qquad (4)$$
$$0 < Cl^- < 70$$

Using the above equations, and what chloride data are available for the 1930's and 1940's, figures VI-11, VI-12, VI-13, and VI-14 were developed. Also shown in these figures are the actual TDS data for the 1950's and 1960's.

Generally, during periods of lower flows, the 1950's and 1960's have a higher TDS value. These concentration versus flow curves are also of the power function form.

Salt (Chloride) Balances by River Reaches

Like the station at Vernalis, most water quality stations along the San Joaquin River and its tributaries provided only spotty information prior to 1952. Of the data available for earlier years, the record of chloride concentration is the most complete for the greatest number stations. Therefore, these data were used to develop relationships of chloride load versus flow at various water quality stations.

Curves were plotted of total monthly flow at the station versus total monthly chloride load. Preliminary work indicated that seasonal similarities in the data existed, and to simplify the task of verifying data for all months, only October, January, April, and July curves were formulated. Because of the shortage of data prior to 1952, all years prior to 1950 were considered as pre-CVP. Since the Delta-Mendota Canal did not go into operation until after 1950, no major source of imported salt existed to influence the analysis. For Vernalis one additional data point was included to insure that the curves did not exceed known limits. This additional point represented an extreme low flow condition for the San Joaquin River at Vernalis, when the TDS would likely correspond to drainage return flows. For this analysis a flow of 0.5 KAF and a TDS of 1,000 mg/L were assumed. Thus, when used as predictors the curves would not produce estimates of TDS higher than about 1,000 mg/L, the maximum observed during the 1977 drought.

Figures VI-15 and VI-16 are examples of chloride load versus flow curves for the month of July on the Tuolumne River at Tuolumne City. The actual data

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points used to define the curves are shown on the figures. Additional curves are in appendix 2. Table VI-7 summarizes the characteristics of regression curves of chloride load versus flow for each month of both the pre-1950 and post-1949 periods of analysis for the station at Vernalis.

Using the chloride load-flow curves thus developed, it is possible to perform a salt balance for any given flow at Vernalis.

Salt (Chloride) Balances by Representative Months

Chloride balances (concentration x flow x 1.36), expressed as tons per month, were calculated for the months of October, January, April, and July for a series of river reaches from above Newman to Vernalis. A typical summary of the calculation is presented in figure VI-17 where data are presented for both pre-1950 and post-1949 project periods. The principal tributary streams and stations along the main stem are identified between Newman and Vernalis. "Other" in the figure refers to accretions or subtractions occurring between stations at which both flow and chloride data were sufficient to make the salt balance calculation. Additional calculations are found in appendix 3.

In order to illustrate the changes in salt burden by year type, the data have been grouped, as in the case of water balance calculations, by reference to the Vernalis "unimpaired" flow. Average values of unimpaired flows at Vernalis by year type were calculated. Estimated actual flows at Vernalis were calculated using the average of actual Vernalis flows for a particular period and year type.

As a means of checking the appropriateness of results based on the average of actual flows, and only four representative months, each year of record was evaluated for all months using regression curves and actual flows at Vernalis. An average "actual" load was then calculated for each year type and period. Results for comparison are in table VI-8.

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TABLE VI - 7
CHLORIDE LOAD VS. FLOW COEFFICIENTS AT VERNALIS

1930 - 1950

MONTH	C1	C2	# OF PAIRS*	R
OCTOBER	.3416451758E+03	.7238303788	7	.993
NOVEMBER	.3393044927E+03	.6880766404	6	.987
DECEMBER	.3639052910E+03	.6787756342	7	.972
JANUARY	.3928349175E+03	.6231583178	10	.965
FEBRUARY	.5368474514E+03	.5675747831	9	.914
MARCH	.4968879101E+03	.6035477710	10	.951
APRIL	.3866605718E+03	.5624873484	9	.942
MAY	.3805863844E+03	.5399998219	9	.920
JUNE	.6355065225E+03	.5175446121	9	.849
JULY	.6038658134E+03	.6219848451	8	.900
AUGUST	.3874538954E+03	.7410226741	8	.991
SEPTEMBER	.3500905302E+03	.7524035817	8	.989

* # OF PAIRS DOES NOT INCLUDE RESTRICTION POINT (.5,200)

$y = C1*(X)^{C2}$

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Table VI-8
UNIMPAIRED FLOW OF THE SAN JOAQUIN RIVER
AT VERNALIS

	October	January	April	July
Average Vernalis unimpaired flow				
Dry year	39.7	110.5	601.4	101.4
Below normal	49.3	167.3	794.9	224.9
Above normal	42.4	352.5	1055.7	425.1
Wet year	29.8	695.7	1169.0	921.0
Estimated actual Vernalis flow				
Pre-years*				
Dry year	110	150	86	46
Below normal	101	119	113	64
Above normal	98	279	805	235
Wet year	107	410	1175	730
Post-years**				
Dry year	120	133	44	18
Below normal	104	202	150	46
Above normal	65	263	264	72
Wet year	87	714	1000	300

* 1930-1949

** 1950-1969

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The salt load estimated for Vernalis by month and year classification is summarized in table VI-9. In this summary, the salt load varies with time and year classification. Salt loads tended, of course, to be sensitive both to runoff and concentration. In the pre-1950 period, for example, the greater loads occurred in the wetter years, and generally in the month of July.

In the post-1949 period, salt loads are estimated to be generally higher in all months except July. The average annual salt burden at Vernalis appears to have remained unchanged in wet years and increased by 35 percent in below normal years. The total average annual load in dry years has increased by about 18 percent. In the April-September period, salt loads were unchanged from pre to post dry years; increased in below normal years; decreased in above normal years and decreased slightly in wet years. This can probably be explained by lower flows and loads in the summer months. These estimates are based on "actual loads" as identified in table VI-9.

Salt Balances for a Dry Year

Additional insight to salt balance estimation is provided by an evaluation of the salt load distribution along the San Joaquin River for the dry year 1961, as illustrated by figures VI-18 through VI-21.

In figure VI-18 is shown a schematic representation of the average amounts (thousand tons per year) of chlorides delivered over the year by each of the several discrete sources, previously identified in figure VI-1, "The San Joaquin Valley System." The figure shows the dominance of the salt load at Vernalis by the principal drainage accretions in the upper San Joaquin River. It also shows, in the case of this particular constituent,* the important contribution of the Tuolumne gas wells. According to this analysis of the load

* The principal salt emitted by the gas wells is sodium chloride.

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TABLE VI-9. CHLORIDE SALT LOAD AT VERNALIS (TONS)

	Dry years				Below normal years			
	Average flow*		Actual load**		Average flow*		Actual load**	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Oct	10,260	14,290	10,191	12,703	9,650	12,920	9,631	12,663
Jan	8,920	10,420	8,784	10,284	7,720	12,730	7,650	12,320
Apr	4,740	6,030	4,496	5,754	5,520	11,080	5,502	10,329
Jul	6,530	4,540	6,254	4,434	8,020	7,700	7,877	7,500
Apr-Sept	33,810	31,710	33,580	33,106	40,620	56,340	46,482	54,595
Year	91,350	105,840	88,712	104,428	92,730	133,290	98,701	133,617

	Above Normal Years				Wet Years			
	Average flow*		Actual load**		Average flow*		Actual load**	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Oct	9,440	9,280	9,238	9,051	10,060	11,400	10,051	11,291
Jan	13,130	14,450	12,926	12,611	16,690	23,320	16,666	21,689
Apr	16,660	14,670	16,434	13,934	20,620	28,410	20,569	27,638
Jul	18,020	9,910	17,498	9,766	36,470	22,130	36,236	21,378
Apr-Sept	104,040	73,740	90,217	71,332	171,270	151,620	136,420	127,626
Year	171,750	144,930	177,146	181,840	251,520	255,780	258,249	258,216

* Load based on regression of average flow for month.

** Load based on average of loads from regression of all flows for month.

NOTE: "Pre" refers to years 1930-1949
"Post" refers to years 1950-1969

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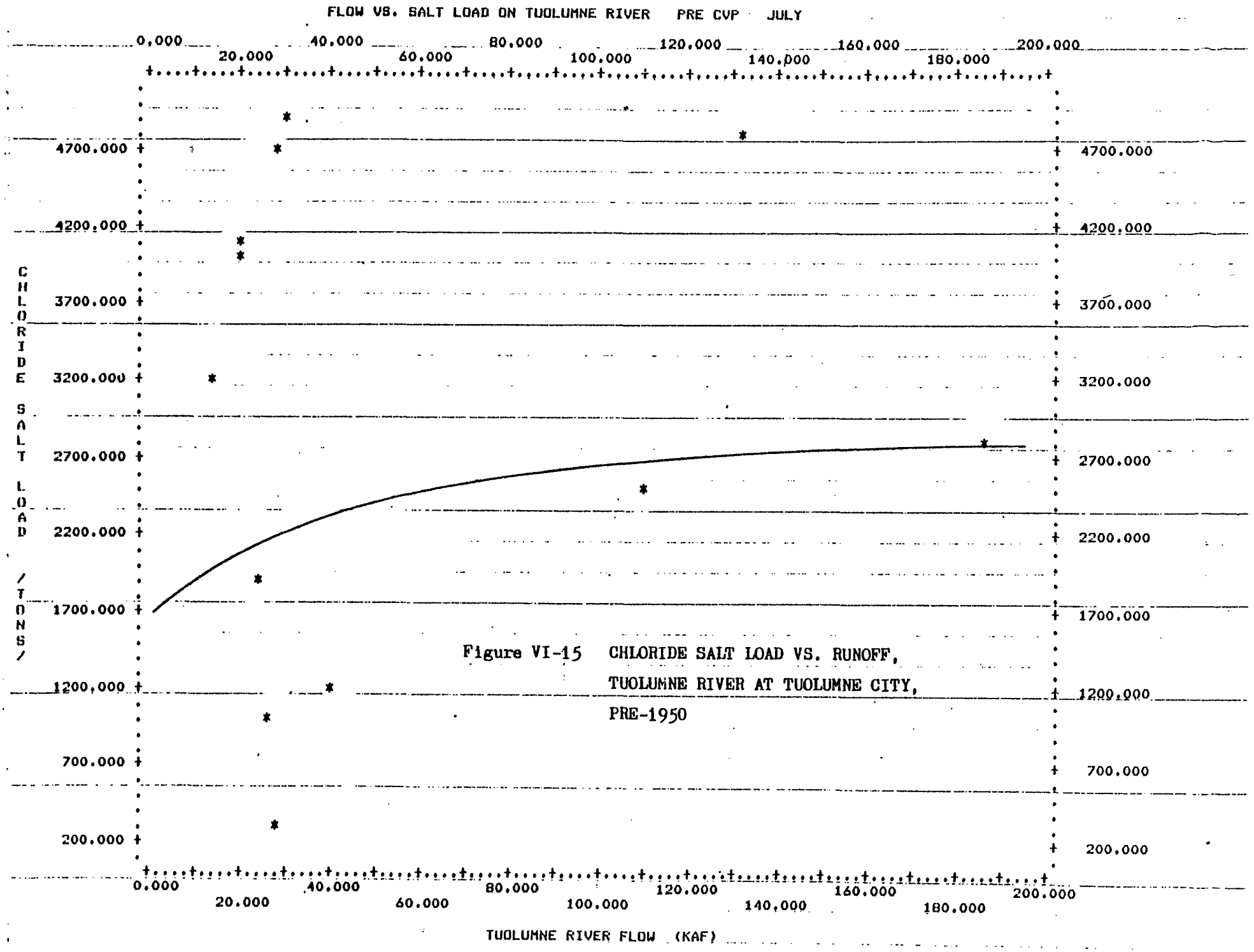

Figure VI-15 CHLORIDE SALT LOAD VS. RUNOFF, TUOLUMNE RIVER AT TUOLUMNE CITY, PRE-1950

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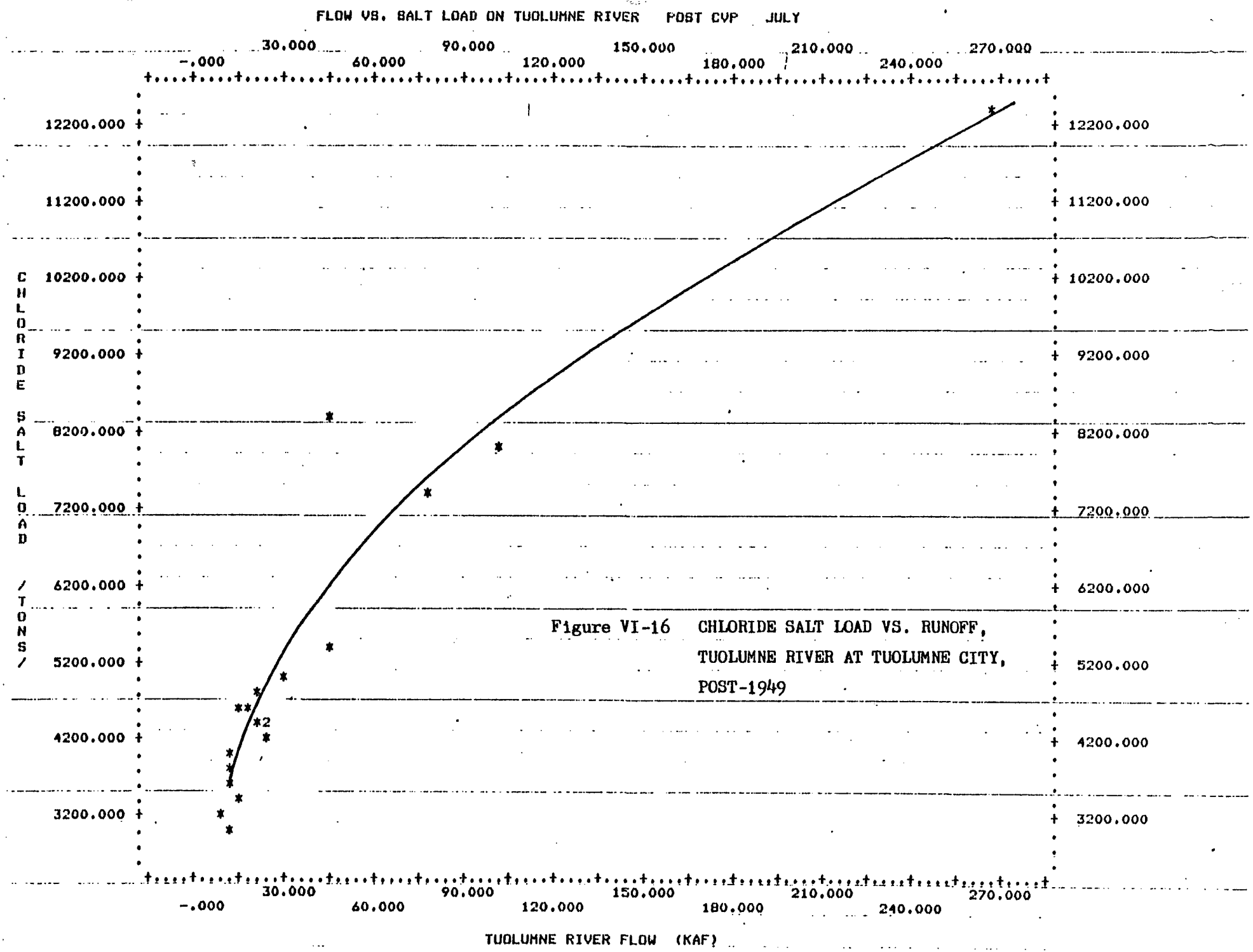

Figure VI-16 CHLORIDE SALT LOAD VS. RUNOFF, TUOLUMNE RIVER AT TUOLUMNE CITY, POST-1949

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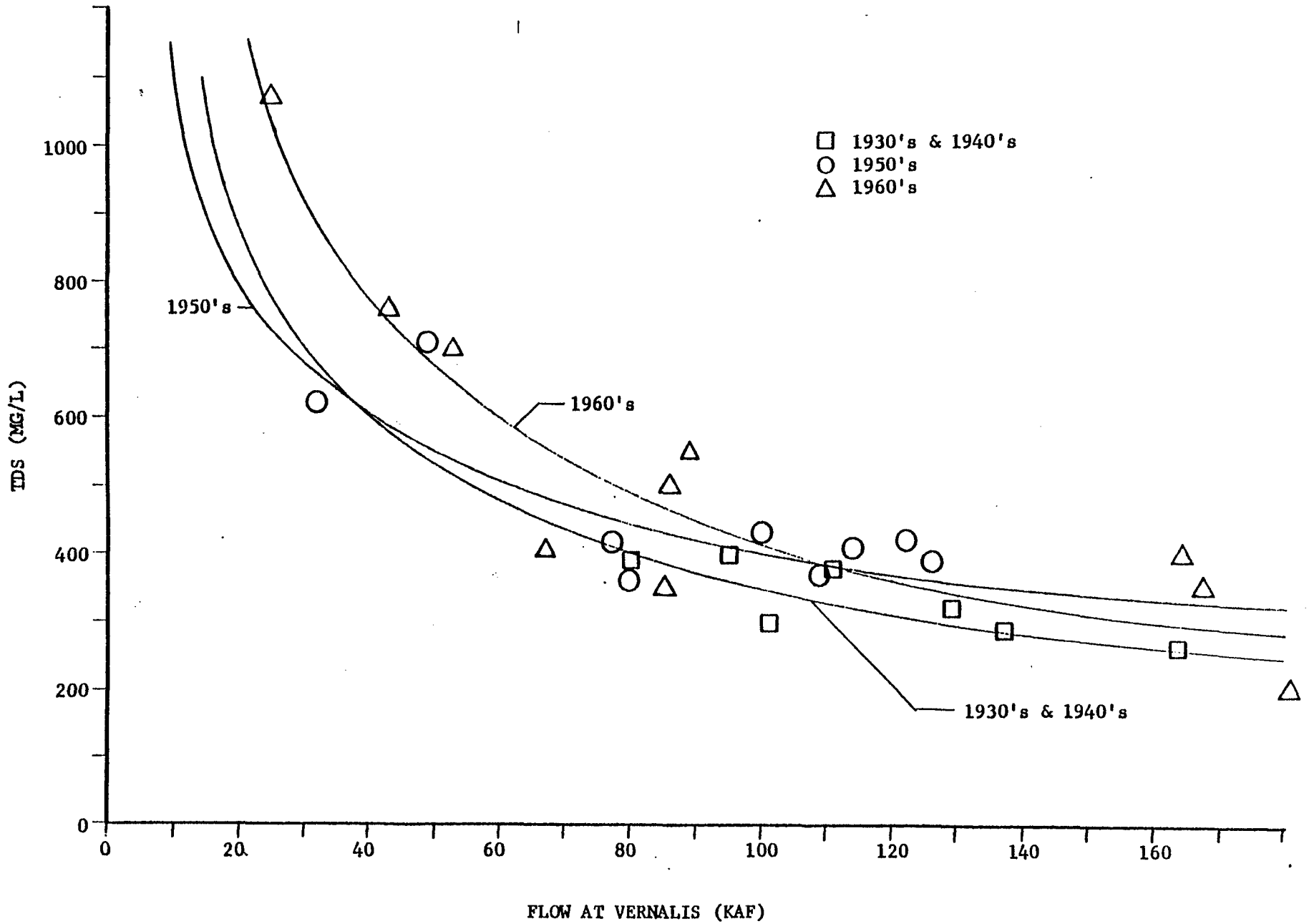

Figure VI-11 QUALITY-FLOW RELATIONSHIPS
SAN JOAQUIN RIVER AT VERNALIS - OCTOBER

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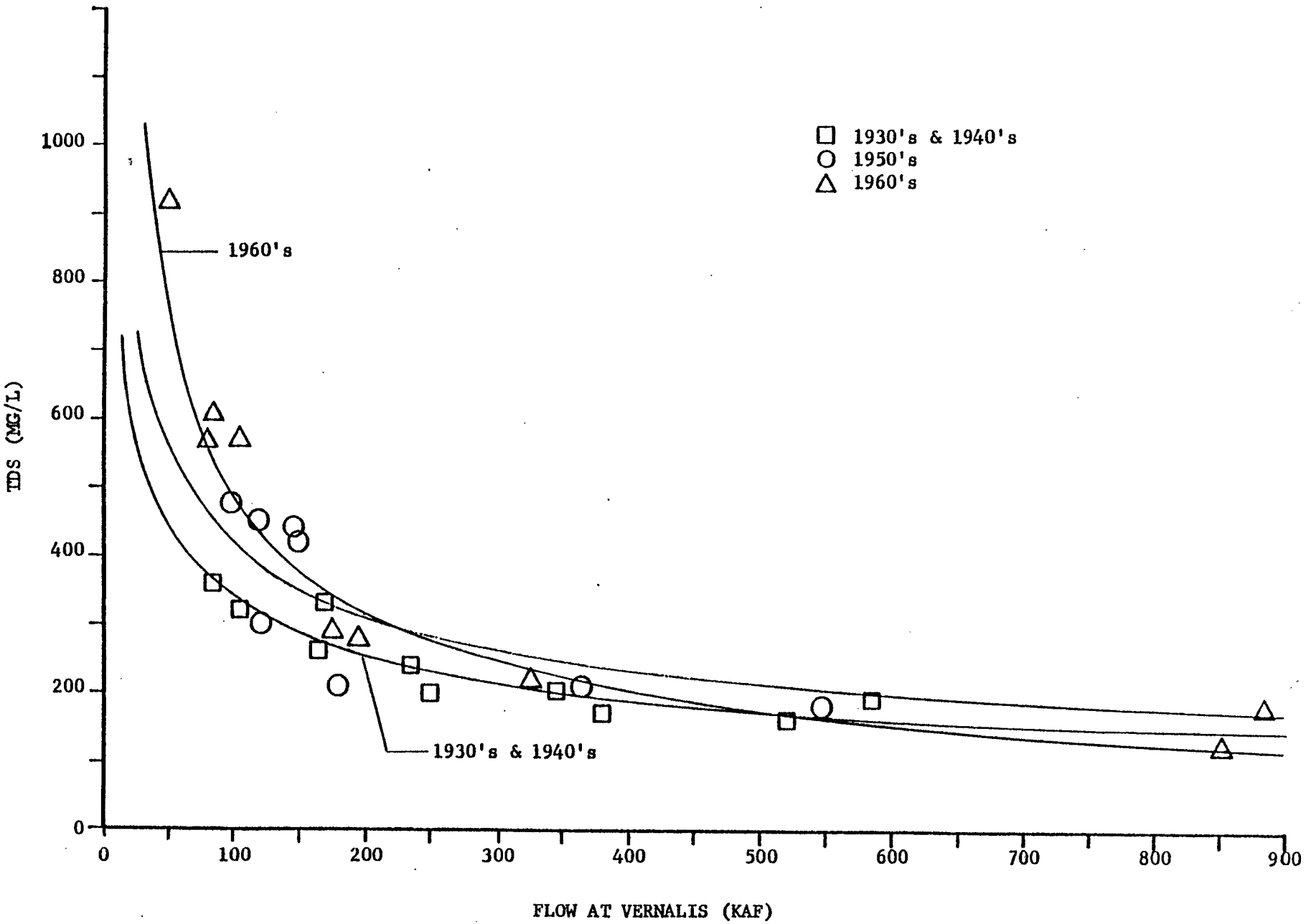

Figure VI-12 QUALITY-FLOW RELATIONSHIPS
SAN JOAQUIN RIVER AT VERNALIS - JANUARY

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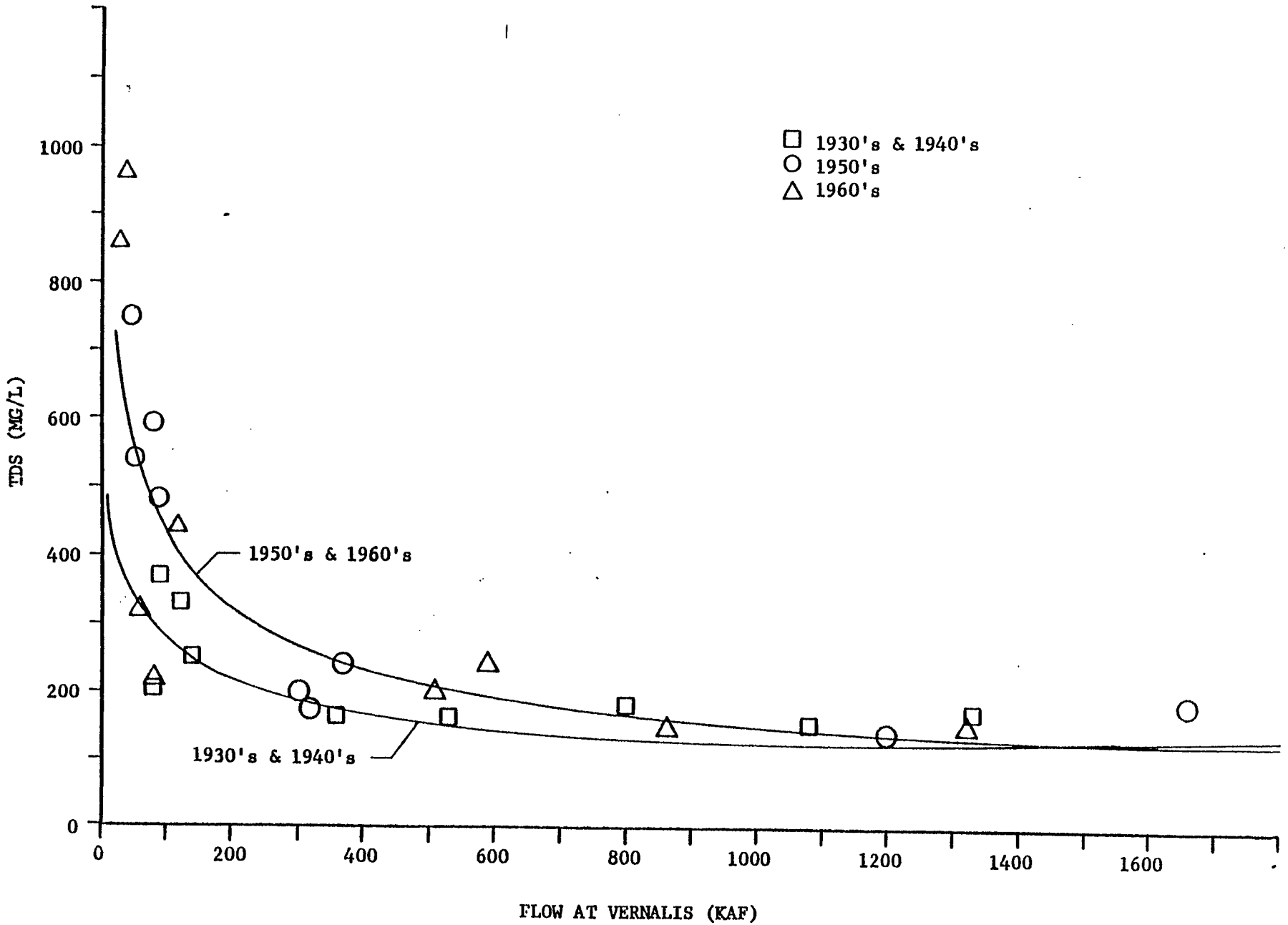

Figure VI- 13 QUALITY-FLOW RELATIONSHIPS
SAN JOAQUIN RIVER AT VERNALIS - APRIL

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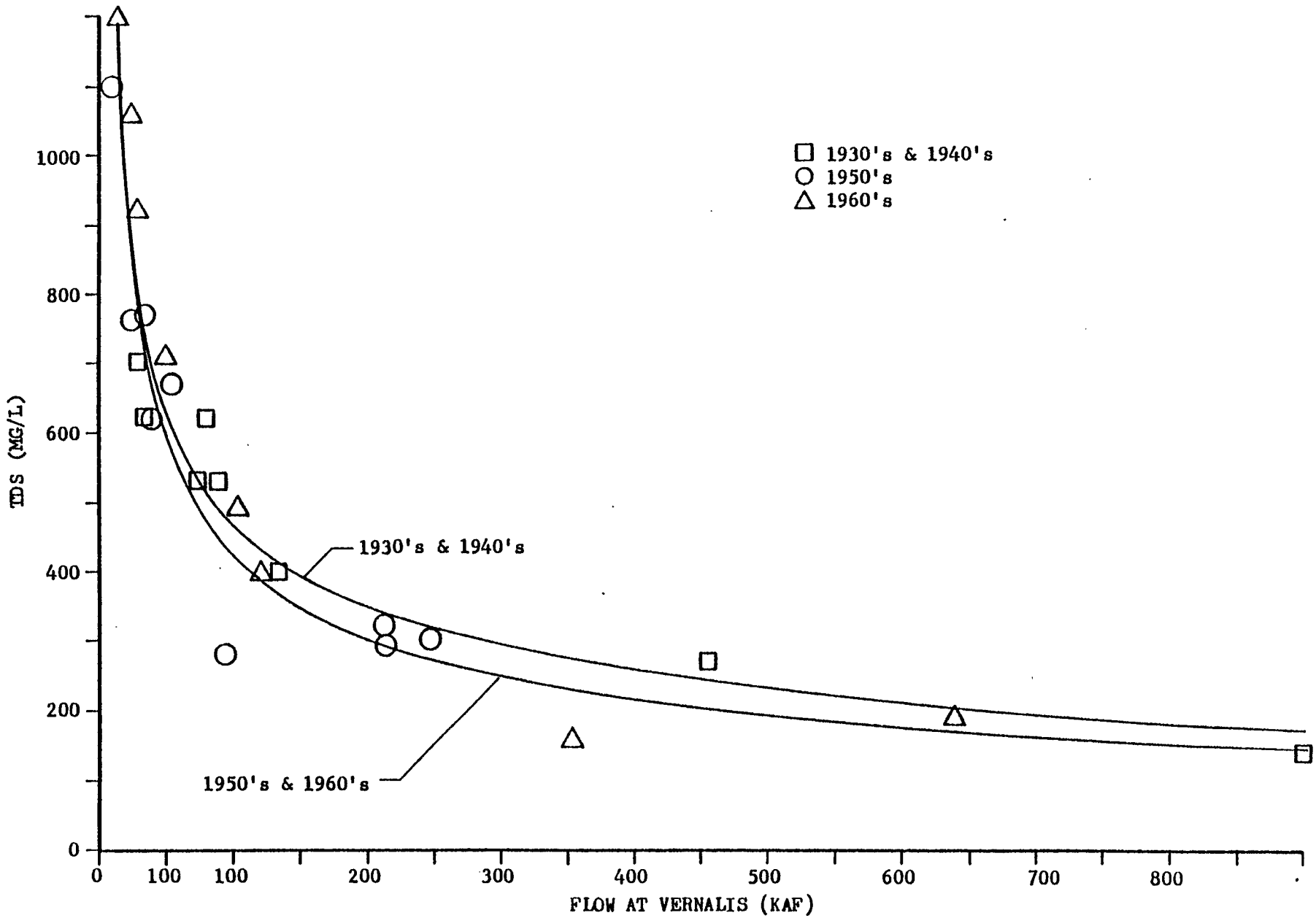

Figure VI-14 QUALITY-FLOW RELATIONSHIPS
SAN JOAQUIN RIVER AT VERNALIS - JULY

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80/05/16. 11.17.58. OCTOBER 39.7 KAF UNIMPAIRED AT VERNALIS

DRY YEAR

FLOW (KAF) PRE-1950	FLOW (KAF) POST-1949	STATION	CHLORIDES PRE-1950 (TONS)	CHLORIDES PRE-1950 (PCT)	CHLORIDES POST-1949 (TONS)	CHLORIDES POST-1949 (PCT)
24.	20.	NEWMAN	3040.	30.	4170.	29.
16.	16.	OTHER	1960.		2820.	
39.	36.	GRAYSON	5000.	49.	6990.	49.
55.	51.	TUOLUMNE	3830.	37.	5050.	35.
5.	9.	OTHER	1210.		2540.	
99.	96.	MAZE ROAD	10040.	98.	14570.	102.
14.	17.	STANISLAUS	260.	3.	200.	1.
-3.	7.	OTHER	-40.		-470.	
110.	120.	VERNALIS	10260.	100.	14290.	100.
		TOT. OTHERS	3130.	31.	4890.	34.
		NMN. + OTH.	6170.	60.	9060.	63.

QUALITY PPM (CL) / (TDS)

PRE PPM = 69. / 324.
POST PPM = 88. / 383.
DEGRADATION = 19. / 59.

Figure VI-17 SAMPLE OF COMPUTER PRINTOUT, SALT BALANCE COMPUTATION

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

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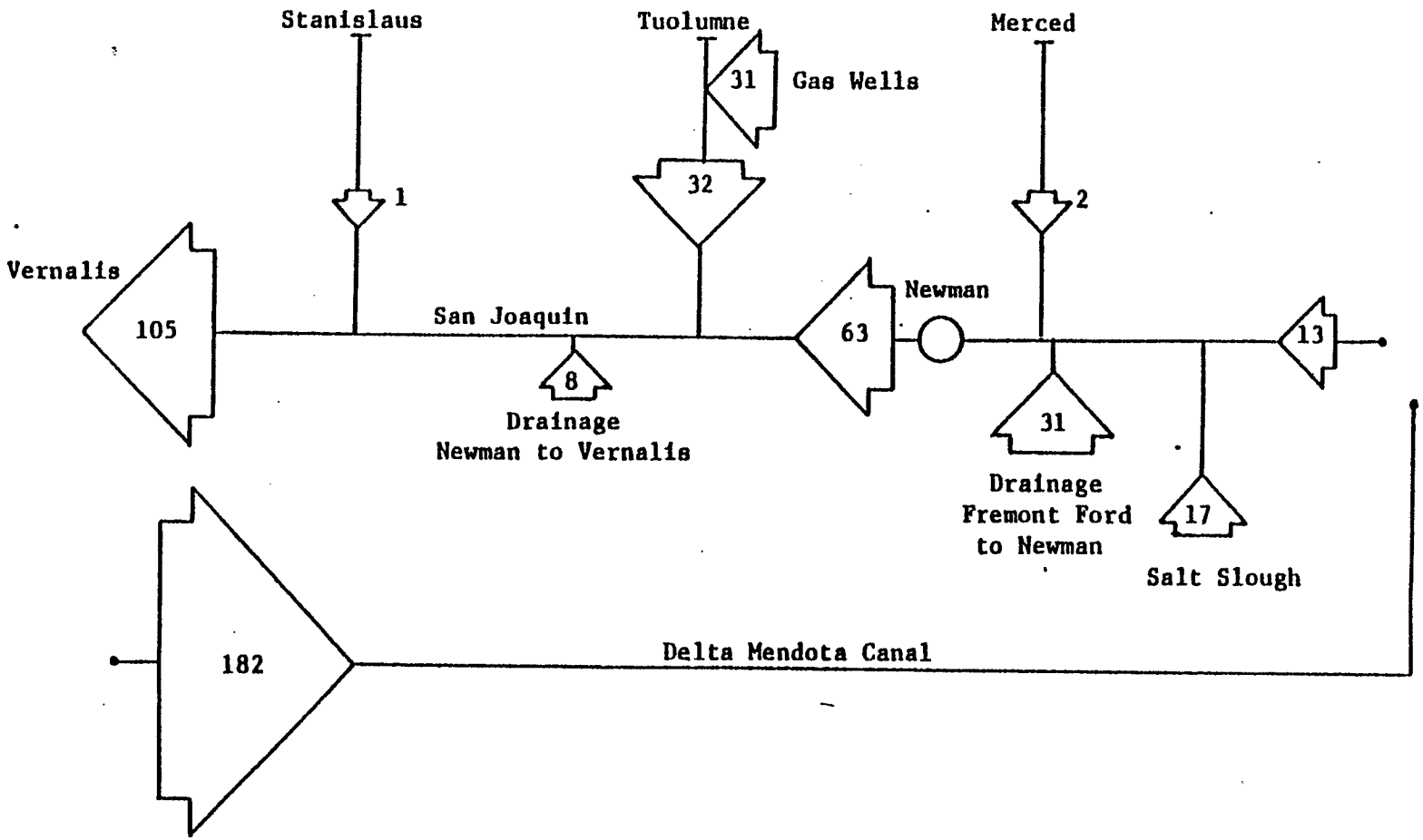

Figure VI-18 CHLORIDE SALT BALANCE--SAN JOAQUIN RIVER SYSTEM, 1960-61

(Numbers indicate salt load in thousand tons per year)

C-115265

of chlorides that reaches Vernalis, about 60 percent of the load originates above the mouth of the Merced River, 30 percent with the gas wells and 10 percent from other sources, including the two east side tributaries and local drainage between Newman and Vernalis. About 30 percent of the total originates upstream of Fremont Ford (Salt Slough plus sources upstream to Mendota) and 30 percent enters in the comparatively short reach between Fremont Ford and Newman (less than 10 miles).

Figures VI-19 through VI-21 give a somewhat clearer picture of the relative contribution of the other drainage sources, exclusive of the unique influence of the Tuolumne gas wells. Since the wells are low in sulfate and the principal irrigated lands on the west side of the valley are high in this constituent, the sulfate balance depicted in figure VI-19 identifies a very large contribution from the drainage above the mouth of the Merced River. Very little sulfate load is contributed by either the east side streams or the gas wells. In this particular example, it appears that there is even a net export of sulfate to irrigated lands below Newman, not an unlikely occurrence in a dry year of max-irrigation water use and reuse. According to these analyses, about 57 percent of the sulfate load of the upper San Joaquin River (that apparently accounts for virtually all that arrives at Vernalis) originates between Fremont Ford and Newman, and about 30 percent comes from Salt Slough.

A very similar picture is presented by figure VI-20, for noncarbonate hardness (the equivalent of hardness originating from such salts as calcium and magnesium sulfate). It is noted in this case, however, that the gas wells do contribute about 20 percent of the total to Vernalis, while 71 percent originates in the upper San Joaquin River. The east side streams have virtually no noncarbonate hardness.

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Finally, a boron balance is shown in figure VI-21 (note that values are in tons per year, not thousand tons, as in the previous examples). Again, although some boron is found in most waters tributary to the valley floor, the dominant sources are in the upper San Joaquin River basin about 69 percent of that which eventually passes Vernalis. In this case, local drainage between Newman and Vernalis contributes about 22 percent of the total.

It should be noted that for reference purposes, since it is a part of the valley system, the Delta-Mendota Canal's contribution is indicated in the figures. The imported salt load to the San Joaquin Valley is noted to range from 147 to 173 percent of that leaving at Vernalis for this dry year, 1961.

Summary of Salt Balance Calculations

Salt balances have been performed for two purposes: (1) to identify trends in load that have occurred with time, e.g., between the pre-1944 and post-1947 periods, and (2) to determine the relative contribution of the various sources of salt, including the contribution of the Tuolumne gas wells.

The salt load at Vernalis has changed between the pre-1944 and post-1947 periods, the amount varying with the year classification. Based on chloride data that extend back to the 30's, it appears that loads in the dry years increased 18 percent and below normal year loads increased 35 percent. Little or no load change is apparent in above normal and wet years. In the dry and below normal years the biggest increase in load occurred in April when spring runoff is probably flushing the basin of some accumulated salts. Consistent with this observation, loads in July have also decreased in dry and below normal years apparently due to a reduction in runoff. In general it appears that in drier years, salts are accumulated in the basin during low flow summer and early fall months and then released during the high flow winter and spring

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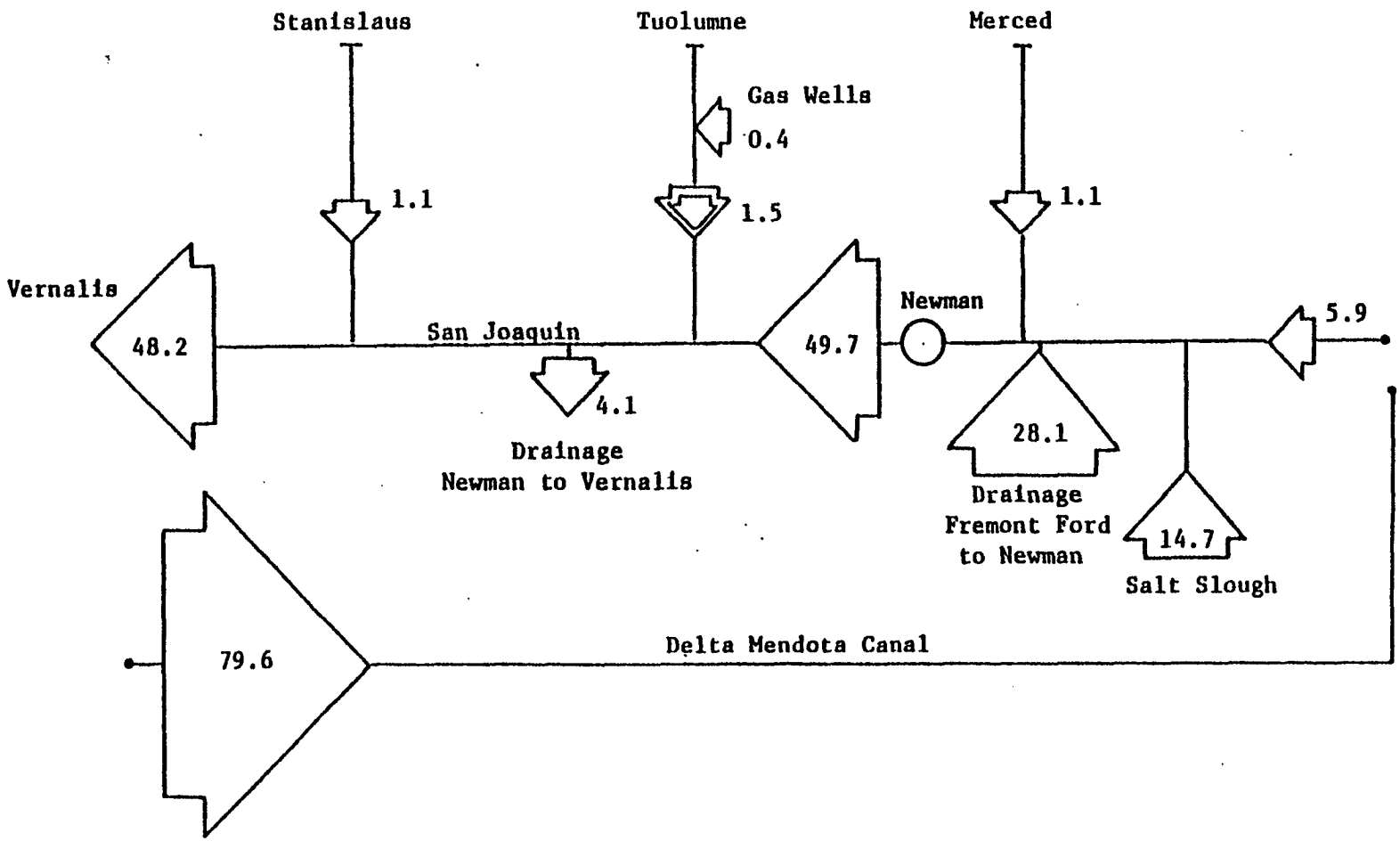

Figure VI-19 SULFATE SALT BALANCE FOR SAN JOAQUIN RIVER SYSTEM, 1960-61

(Numbers indicate salt load in thousand tons per year)

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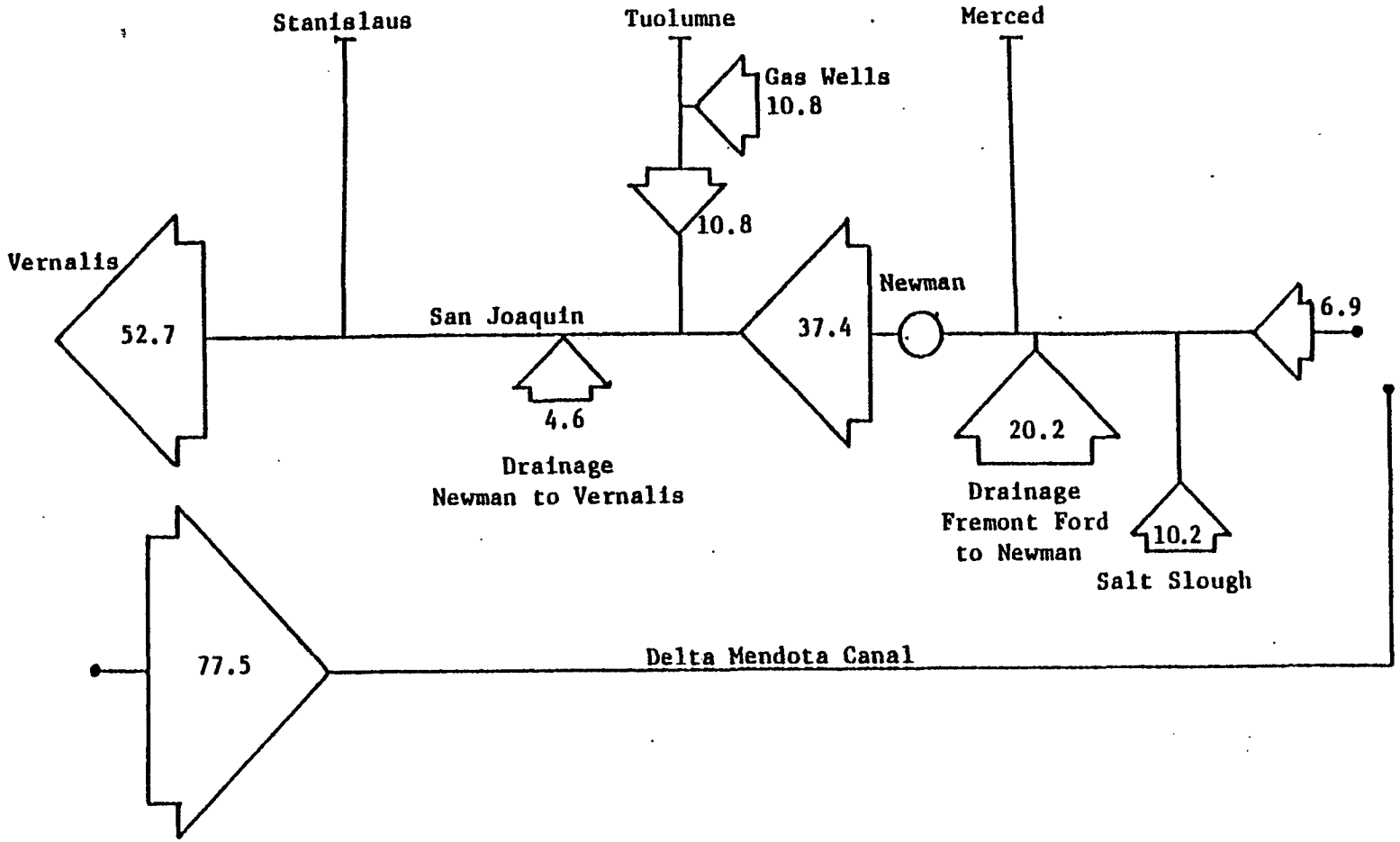

Figure VI-20 NONCARBONATE HARDNESS SALT BALANCE
SAN JOAQUIN RIVER SYSTEM, 1960-61

(Numbers indicate salt load in thousand tons per year)

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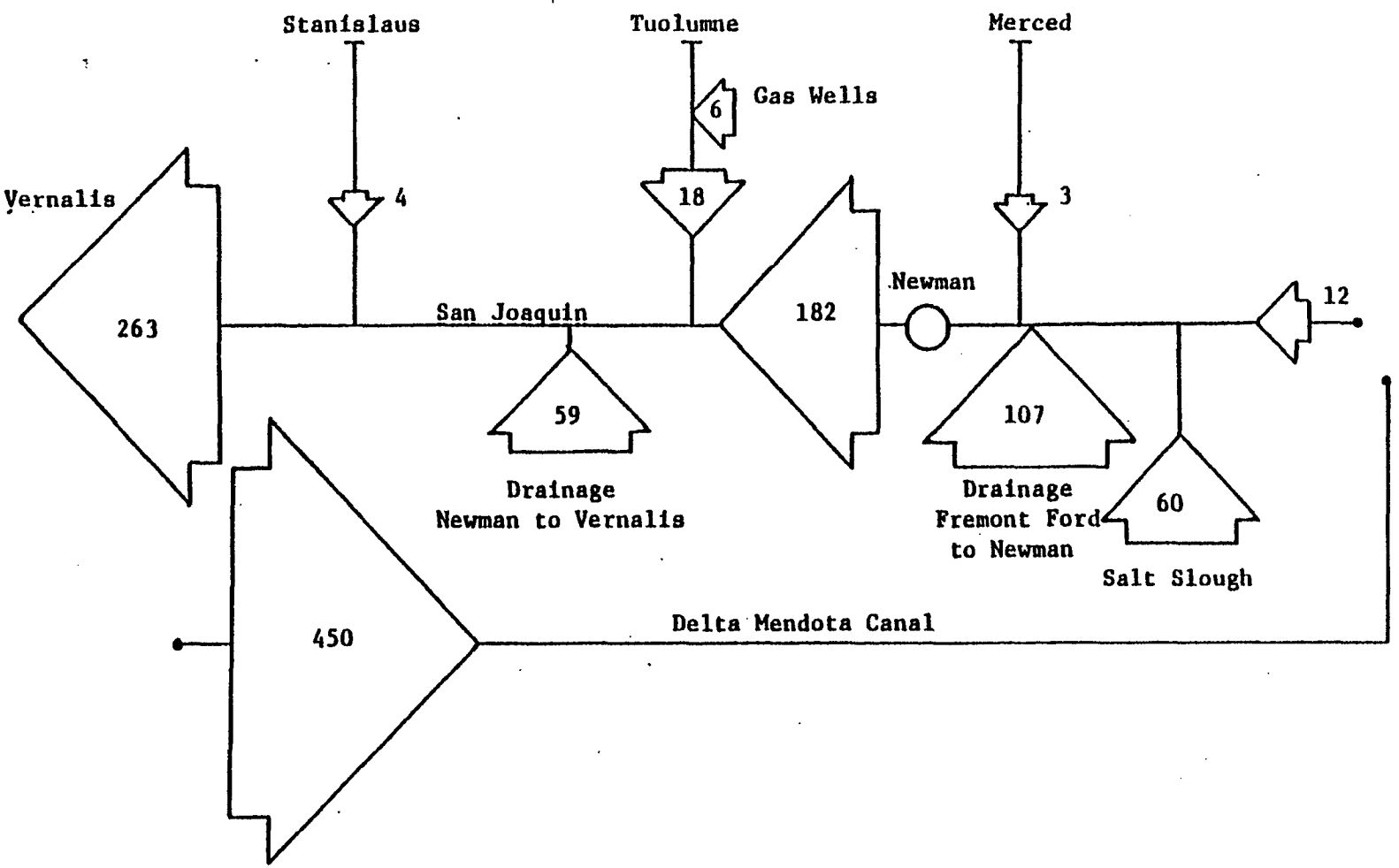

Figure VI- 21 BORON SALT BALANCE--SAN JOAQUIN RIVER SYSTEM, 1960-61

(Numbers indicate salt load in tons per year)

C-115270

months. Because a net increase in load has occurred, it seems likely that sources of salt are adding to the annual burden at Vernalis in dry and below normal years. Without reference to year classification, and comparing the 1950's and 1960's to the average of the 1930-49 period, it is noted further that the greater proportion of the post-1949 increase seems to have occurred in the more recent decade, i.e., the trend toward an increased salt burden is itself increasing, despite an apparent continuing decline in the total runoff at Vernalis.

A summary comparison of relative increase in salt burden at Vernalis by year classification is presented in table VI-10.

The relative contributions of various sources to the salt load at Vernalis were determined by performing water balances and mass balances for selected sections of the San Joaquin River system. Depending on the constituent selected and the particular hydrology used, the relative contribution of each source to the load at Vernalis can be expected to vary somewhat. For the dry year 1960-61 a breakdown in the percentage contribution from the various sources in the San Joaquin system is as shown in table VI-11.

Some highlights of this 1961 salt balance analysis are as follows:

1. About one-half of the salt load carried in the San Joaquin River at Newman originates in the reach between Mendota and Newman. (Based on chloride balance.)
2. About 20 percent of the salt load that passes Newman is contributed between Mendota and Salt Slough.
3. Salt Slough is a major contributor to salt load accounting for one-third to one-half of the load at Newman.
4. The salt load that enters the San Joaquin River above Newman is equivalent to 60 to 100 percent of that observed at Vernalis.

Table VI-10
PERCENTAGE CHANGE IN SALT LOAD (CHLORIDES)
AT VERNALIS BETWEEN PRE-1950 AND POST-1949 AS A
FUNCTION OF TIME OF YEAR AND YEAR CLASSIFICATION

Year Class	PERCENT CHANGE*				
	MONTH				
	October	January	April	July	Year
Dry	25	17	28	-29	18
Below normal	31	61	88	-5	35
Above normal	-2	-2	-15	-44	3
Wet	12	30	34	-41	0

* ((Salt load post-1949/salt load pre-1949)-1) x 100.

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TABLE VI-11. PERCENTAGE CONTRIBUTION OF SOURCES TO SALT LOAD ESTIMATES AT VERNALIS

Source	Percent of Total at Vernalis			
	Constituent*			
	Cl	SO_4	NC	B
Mendota to Salt Slough	12.3	12.2	13.0	4.5
Salt Slough	16.2	30.5	19.4	22.8
Merced River	2.0	2.2	0	1.1
Drainage: Fremont Ford to Newman	29.5	58.3	38.4	40.7
San Joaquin at Newman	60.0	103.2	70.8	69.2
Tuolumne River above gas wells	1.0	1.9	0	4.6
Tuolumne River Gas Wells	29.5	1.0	20.5	2.3
Tuolumne River	30.5	2.9	20.5	6.9
Drainage: Newman to Vernalis	7.5	-8.4	8.7	22.4
Stanislaus River	2.0	2.3	0	1.5
San Joaquin River at Vernalis	100.0	100.0	100.0	100.0

* Cl = chlorides; SO_4 = sulfates; NC = noncarbonate hardness; B = boron

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5. Of the chloride salt load carried by the river at Vernalis, less than 6 percent was contributed by the three major tributaries--the Merced, the Tuolumne (excluding the gas wells) and the Stanislaus.
6. The Tuolumne gas wells contributed chloride salt load equal to about 30 percent of the total at Vernalis, but only about 1 percent of the sulfates.
7. The sulfates entering the system above Newman exceeded the total load at Vernalis, i.e., the area above Newman accounted for virtually all of the downstream sulfate load.

SECTION C. WATER QUALITY CHANGES AT VERNALIS

This section deals with the effects any changes in flow or load may have had on Vernalis water quality. Due to the sparse data available prior to 1953, two different methods were developed to predict the quality in the years prior to 1953. The first of these methods utilizes a very complete record of chloride values taken at Mossdale, to predict the pre-1953 TDS at Vernalis. The second method utilizes the flow versus load equations developed for salt balance computations and the relationship between chlorides and TDS at Vernalis to estimate TDS for the pre-1950 and post-1949 periods based on Vernalis flow. Results of both methods are discussed and where results are substantially different comparisons are made.

Estimation based on Mossdale Data

Because of the sparse data prior to 1953, one means of determining the Vernalis quality was developed based on chloride observations at Mossdale on the San Joaquin River approximately 16 river miles downstream of Vernalis. These observations, made as a part of the Department of Water Resources' extensive 4-day sampling program, cover a period from June 1929 through March

1971, overlapping for about 17 full years the Service monitoring of EC at Vernalis. The data developed in the DWR program, however, represent grab samples collected a 4-day intervals (about 8 times per month in most months) at or near conditions of slack water (approximately 1.5 hours after high tide). Thus, they tend to reflect the highest levels of chloride that would likely be observed as a result of tidal action at the Mossdale station.

Significant reversals in tide occur at Mossdale where the tidal range is normally about 2.5 to 3 feet. The Vernalis gage, on the other hand, is above tidal influence at most levels of riverflow.

The special value of the Mossdale data which are summarized in table VI-12, is that they cover periods both before and after the construction of the CVP and therefore can be used to predict changes that have occurred from 1930 through 1967, the period selected for the present study of CVP impacts on water quality in the San Joaquin River system.

However, because the station at Vernalis is about 16 miles upstream of Mossdale, it is necessary to demonstrate that there is a relationship between observations taken at the two locations. This is accomplished by correlation of the mean monthly TDS at Vernalis (table VI-13) with the mean monthly slack water chloride values (8 grab samples) at Mossdale (table VI-12), as shown in figure VI-22. Data shown are for the period April through September, as defined for use in this investigation, and cover the period 1953 through 1970, except for a few months for which no data existed.

As may be clearly seen from the array of data in figure VI-22, the correlation between TDS (Vernalis) and chlorides (Mossdale) is strong. This is not unexpected due to the proximity of the two stations and the apparent lack of intervening processes that could lead to a disproportionate balance between

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TABLE VI-12. MEAN MONTHLY SHLORIDES AT MOSSDALE[1], MG/LITER BASED ON DWR 4-DAY GRAB SAMPLE PROGRAM

	O	N	D	J	F	M	A	M	J	J	A	S
1929									74	120	108	56
1930	61	74	84	60	71	67	47	46	40	71	68	58
1931	65	73	61	71	70	124	114	95	93	100	90	80
1932	80	94	71	20	10	34	18	12	10	30	104	80
1933	63	47	58	54	47	89	113	89	19	75	102	77
1934	67	70	-	-	-	-	-	-	128	94	108	138
1935	168	66	49	18	24	29	17	14	18	53	103	78
1936	54	61	39	72	23	14	20	12	15	74	105	81
1937	58	59	47	38	69	14	15	10	12	79	108	78
1938	61	76	34	34	17	28	33	20	21	19	45	106
1939	71	69	35	56	37	33	83	76	84	113	119	100
1940	103	103	93	76	76	38	48	31	32	76	94	108
1941	114	69	86	48	39	48	46	39	36	50	-	-
1942	-	-	-	19	16	29	32	15	9	13	90	68
1943	56	80	38	-	-	-	-	-	-	-	-	-
1944	-	-	-	-	-	-	-	38	49	91	109	103
1945	71	58	58	47	25	21	24	18	15	56	84	69
1946	50	54	45	26	40	63	28	13	50	96	107	97
1947	87	65	42	64	84	74	103	60	115	146	159	101
1948	95	81	93	94	181	186	86	25	21	85	126	103
1949	90	116	106	96	111	37	64	34	78	155	165	149
1950	120	95	100	90	41	79	31	30	44	145	153	129
1951	121	69	15	33	33	51	101	44	64	154	159	133
1952	108	112	66	26	20	23	20	25	12	72	104	90
1953	96	88	51	38	66	143	131	60	32	92	145	122
1954	102	100	101	104	91	59	29	27	135	174	181	172
1955	139	119	100	67	89	126	154	130	93	185	180	175
1956	163	151	70	10	26	57	42	16	13	84	100	96
1957	92	82	76	104	135	87	137	90	62	139	160	134
1958	78	73	74	96	56	35	27	14	16	86	110	88
1959	74	51	68	100	96	136	181	169	212	225	217	183
1960	174	140	129	133	138	245	204	192	220	173	221	247
1961	184	141	121	131	175	258	264	242	261	197	165	278
1962	277	207	207	220	117	56	96	69	57	194	204	169
1963	151	116	84	112	44	120	22	21	36	-	-	-
1964	-	64	61	83	142	212	212	217	182	261	296	179
1965	-	-	-	30	33	45	23	45	60	130	141	-
1966	103	56	-	80	86	140	-	195	229	247	251	218
1967	135	144	65	98	43	65	18	15	12	37	104	97
1968	72	55	57	90	103	76	153	176	214	220	186	166
1969	127	129	79	43	21	24	18	13	12	49	106	61
1970	43	45	55	46	34	63	133	81	70	143	142	126
1971	131	-	50	45	63	81	-	-	-	-	-	-

[1]Average of up to 8 observations taken at roughly 4-day intervals at approximately one and one-half hours after high tide at Mossdale Bridge

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TABLE VI-13. MEAN MONTHLY TOTAL DISSOLVED SOLIDS AT VERNALIS *

Year	O	N	D	J	F	M	A	M	J	J	A	S
1953				124	201	400	463	207	128	300	425	373
53-54	317	334	342	365	328	220	124	136	443	539	540	515
54-55	378	354	285	223	254	341	474	388	264	449	464	476
55-56	439	403	302	NR	NR	214	148	69	81	279	295	318
56-57	312	295	254	381	464	330	417	331	203	455	479	451
57-58	316	271	282	346	249	202	149	97	89	289	417	315
58-59	280	198	258	366	331	428	546	538	589	634	620	557
59-60	502	446	428	461	482	654	585	582	673	710	640	682
60-61	520	460	402	447	591	715	846	715	794	936	941	807
61-62	805	661	690	713	440	238	325	237	183	516	565	496
62-63	415	370	267	413	145	395	108	93	125	369	477	405
63-64	287	238	201	301	458	578	562	564	571	756	774	615
64-65	472	340	281	163	189	247	150	194	169	422	494	401
65-66	258	243	243	332	346	NR	NR	598	662	729	727	698
66-67	485	469	260	402	222	264	123	104	86	162	365	354
67-68	299	222	240	367	401	325	486	576	659	665	599	568
68-69	458	481	329	198	129	146	118	86	84	221	363	249

*Average of continuous EC recording converted to TDS by relationships of the form TDS = $C_1 \times EC + C_2$

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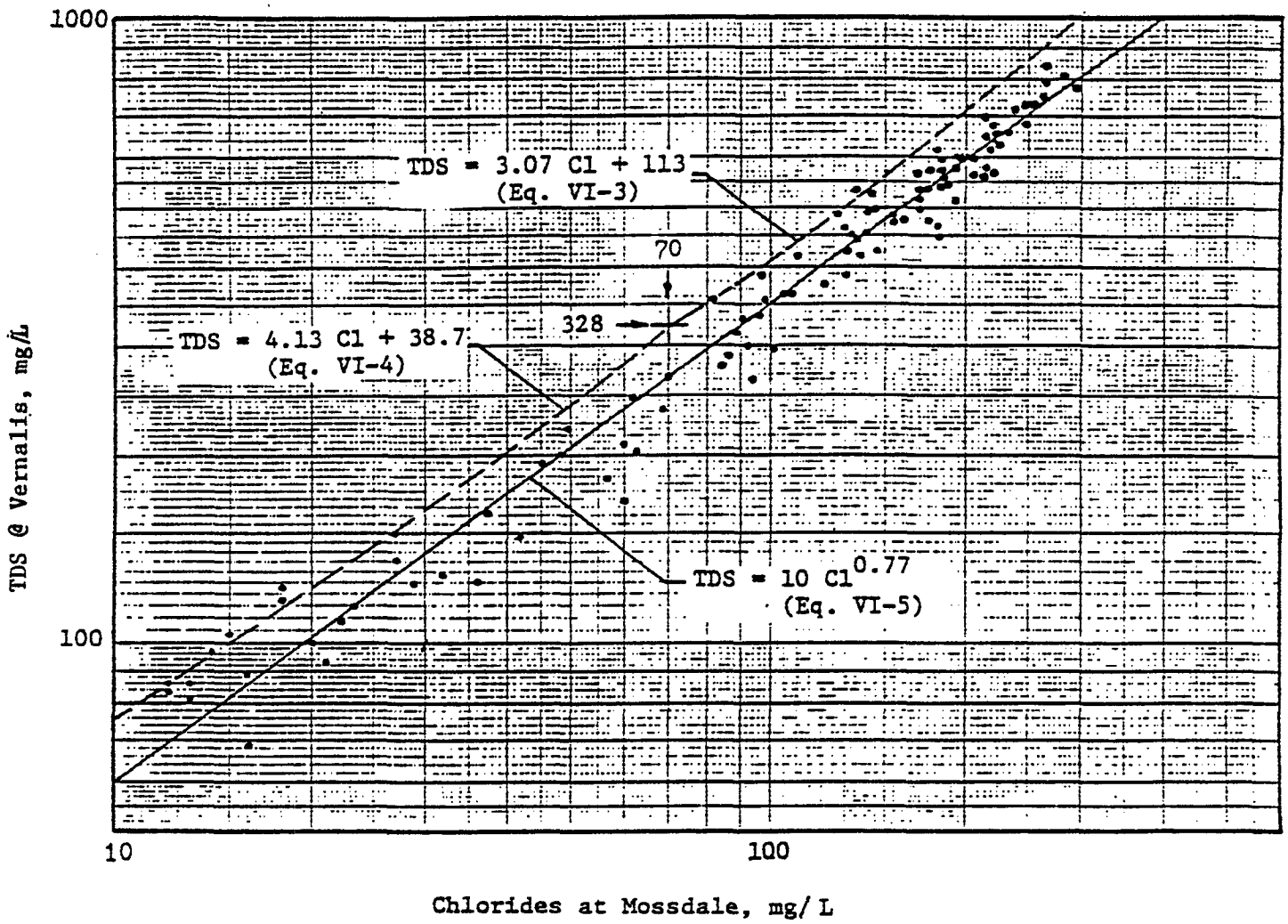

Figure VI-22 RELATIONSHIP BETWEEN TOTAL DISSOLVED SOLIDS AT VERNALIS AND CHLORIDES AT MOSSDALE

Data are for April-Sept, 1953-1970
Monthly mean concentrations, mg/L

chlorides and total salts over the historic period considered. The relationship between these quality constituents is given best by the equation:

$$TDS = 10\ (Cl^-)^{0.77} \qquad (5)$$

where

TDS = total dissolved solids, mg/L

Cl^- = chlorides, mg/L

With the aid of this equation, it is now possible to relate the 4-day chloride data at Mossdale with the corresponding values of TDS at Vernalis and vice versa, recognizing of course that the chloride values are for average high tide, slack water conditions, while the TDS values are averages over the 24-hour daily period.

Historical Changes in TDS at Vernalis

The pattern of TDS change that has occurred at Vernalis is illustrated in figure VI-23 which shows in the lower section the chlorides history actually observed at Mossdale and in the upper section the parallel pattern of TDS at Vernalis estimated by means of Equation 5. To supplement the information on TDS at Vernalis provided in table VI-13, the earlier record of TDS based on the Mossdale experience and the predictor Equation 5 is summarized in table VI-14 covering the hydrologic years 1930 through December 1953. Together, tables VI-13 and VI-14 provide a continuous record of water quality experience at Vernalis from 1930 through 1969.

This water quality experience can be summarized in several ways.

Graphical summary. The graphical history of water quality at Vernalis is illustrated by average monthly TDS in figure VI-23, which shows the long term as well as the seasonal variability. The long-term changes are depicted by the 3-year moving average line presented in the plot of monthly TDS's at Vernalis. The short-term seasonal variations are evident in the month-by-month fluctuations.

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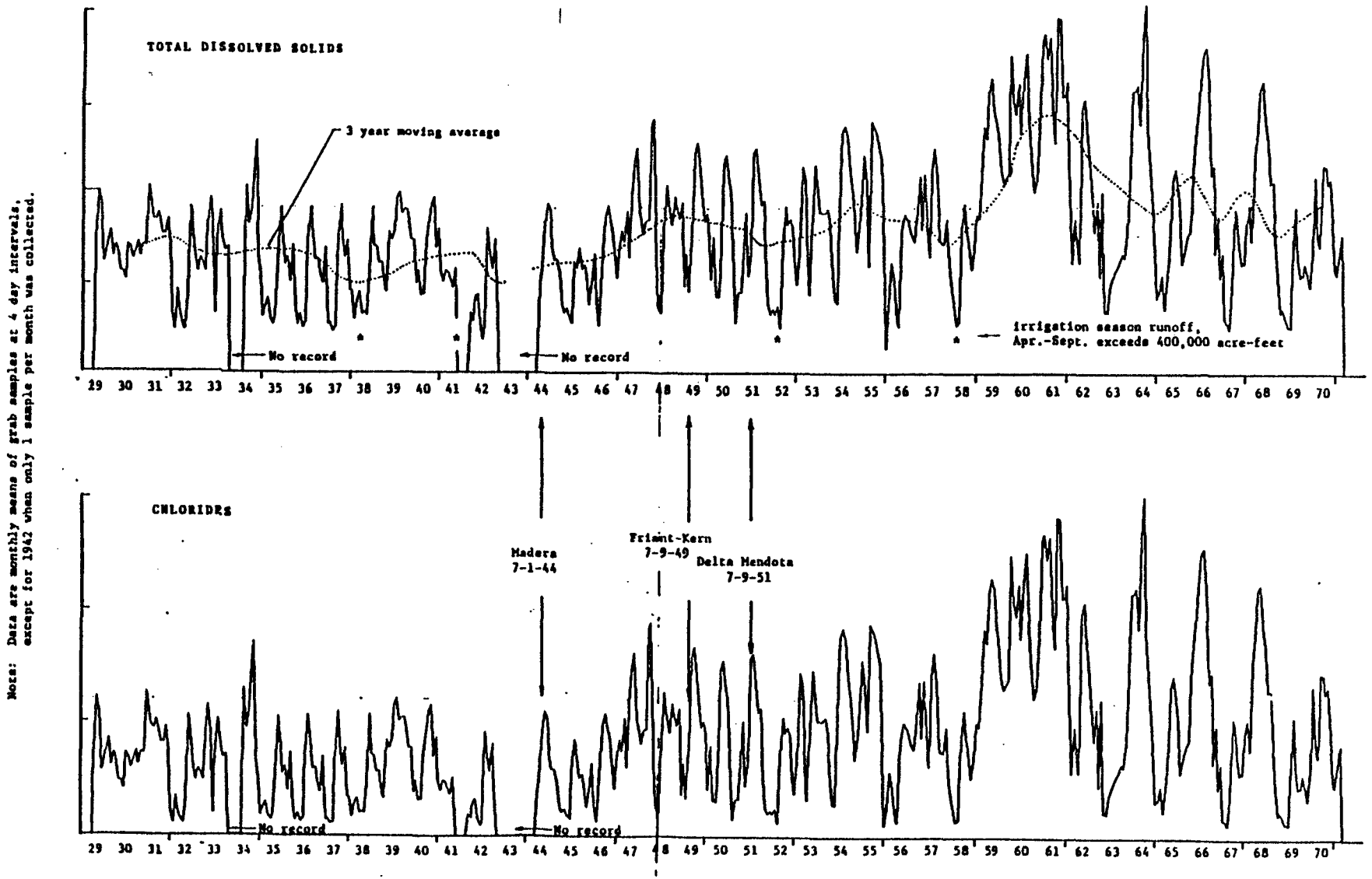

Figure VI-23 OBSERVED CHLORIDES AT MOSSDALE AND ESTIMATED TOTAL DISSOLVED SOLIDS AT VERNALIS 1929-1971

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Table-VI-14. MEAN MONTHLY TOTAL DISSOLVED SOLIDS AT VERNALIS*, mg/liter
Based on TDS (Vernalis): Chloride (Mossdale) Correlation
for period 1953-1970

Year	O	N	D	J	F	M	A	M	J	J	A	S
1929-30	237	275	303	234	266	255	194	191	171	266	258	228
30-31	249	272	234	266	263	409	383	333	328	347	320	292
31-32	292	331	266	100	59	151	93	68	59	137	357	292
32-33	243	194	228	216	194	317	381	317	97	278	352	283
33-34	254	263	-	-	-	-	-	-	419	301	368	444
34-35	517	251	200	93	116	134	89	76	93	213	355	286
35-36	216	237	168	269	112	76	100	68	80	275	360	295
36-37	228	231	194	165	261	76	80	59	68	289	367	286
37-38	237	281	151	151	89	130	148	100	104	97	187	363
38-39	266	260	219	222	158	148	300	280	303	381	396	347
39-40	355	355	328	281	281	165	197	141	144	281	330	368
40-41	384	261	309	197	168	197	191	168	158	203	-	-
41-42	-	-	-	97	85	134	144	80	54	72	320	258
42-43	222	292	165	-	-	-	-	-	-	-	-	-
43-44	-	-	-	-	-	-	-	165	200	322	370	355
44-45	266	228	228	194	119	104	116	93	80	222	303	261
45-46	203	216	187	123	171	243	130	72	203	336	365	338
46-47	311	249	178	246	303	275	355	234	386	464	496	349
47-48	333	295	328	331	548	559	309	119	104	306	414	355
48-49	320	389	362	336	376	161	246	151	286	486	510	471
49-50	399	333	347	320	175	289	141	137	184	462	481	422
50-51	402	261	80	148	148	206	349	184	246	483	496	432
51-52	368	378	252	123	100	112	100	119	68	269	357	310
52-53	336	314	206	165	252	457	426	234	144	325	462	404

*Estimated from the equation: TDS (Vern) $= 10[Cl(Moss)]^{0.77}$

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Extreme values--maximum monthly TDS. Maximum monthly TDS values by year over the period 1930-1966 are depicted in the graph of figure VI-24. The figure summarizes the extremes in quality and flow during each year of record as tabulated in table VI-15. The triangles in the lower portion of the graph indicate the most critical quality (i.e., maximum TDS) occurrences in each of the indicated years within the period 1930-1944. The solid circles, largely occupying the upper portion of the graph, correspond to the critical occurrences in each of the years, 1952-1966. 1943-1951 are not plotted for reasons of clarity, although they generally are distributed in the region bounded by TDS values of 303 to 510 mg/L as will be seen in table VI-15.

Since a comparison of the pre-1944 and post-1947 conditions is germane, it may be noted further that the means and ranges corresponding to the two data sets* are as given in table VI-16 following.

Mean monthly values of TDS by decades. Using the average monthly values of TDS from tables VI-13 and VI-14 covering the period 1930 through 1969, it is possible to summarize the general trends of changes that have occurred for each month of the year. These trends are given by the mean 10-year values for each of the decades of the 1930's, 1940's, 1950's, and 1960's in table VI-17.

In a few cases, only 8 or 9 observations are included in the averages. These are noted by the asterisks ** and *. Also given in the table for later reference are the corresponding values of the mean monthly runoff by months (KAF) at Vernalis in the San Joaquin River.

* It will be recalled that the mean annual unimpaired (rimflow) runoffs during the season April through September for these two periods, pre-1944 and post-1947, are comparable, the post-1947 period being slightly drier by approximately 5.6 percent.

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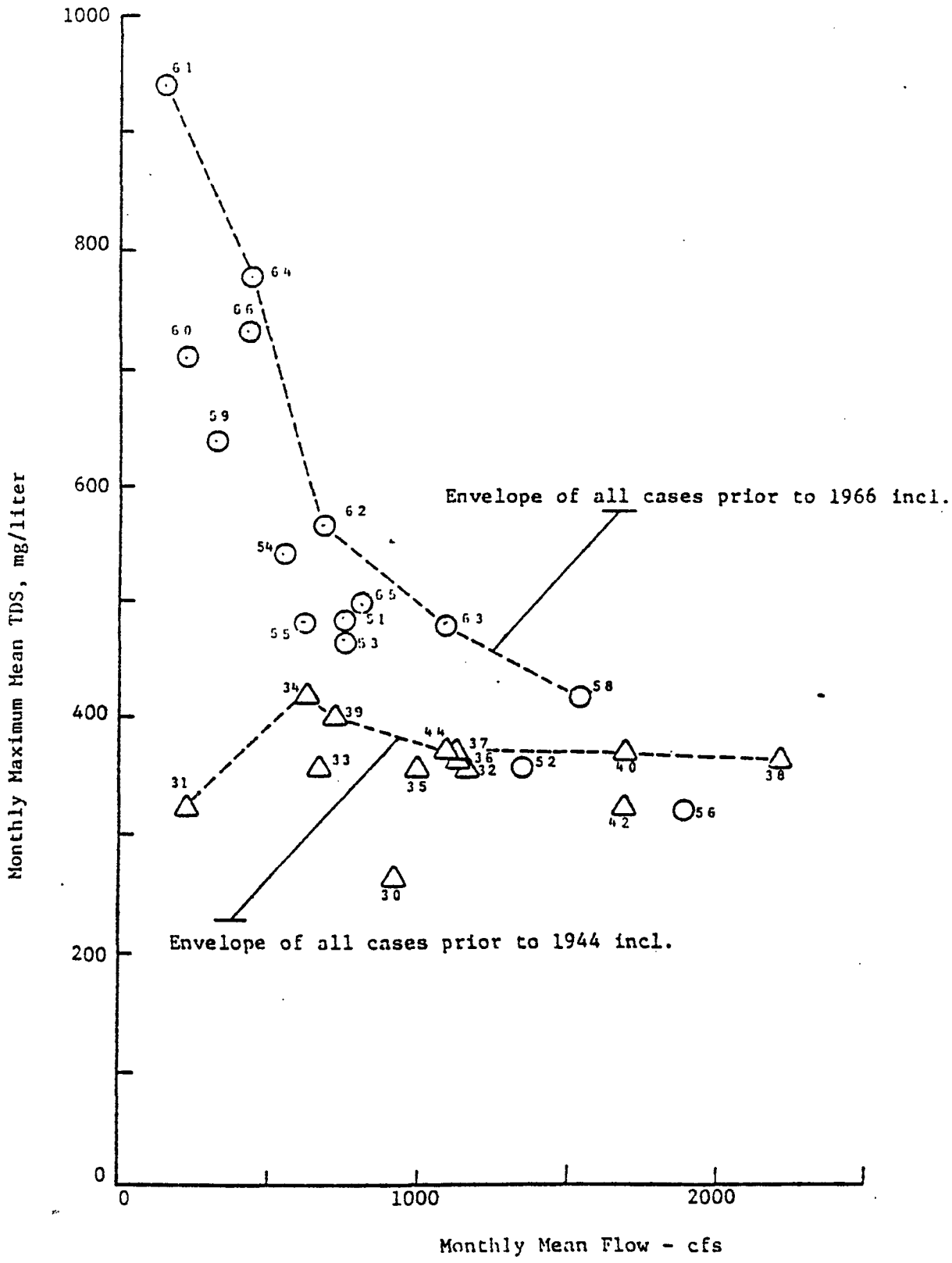

Figure VI- 24 WATER QUALITY AND FLOW EXTREMES AT VERNALIS
1930 - 1966

Table VI-15. EXTREME VALUES OF TDS AND FLOW AT VERNALIS, 1930-1966

Year	Maximum Monthly Mean TDS*	Minimum Monthly Mean Flow	
	MG/L	AF x 1000	CFS
1930	266	56.6	922
1931	320	14.0	228
1932	357	71.3	1161
1933	352	41.0	668
1934	419	37.3	628
1935	355	61.2	996
1936	360	69.0	1124
1937	367	69.4	1130
1938	363	132.0	2222
1939	396	44.0	717
1940	368	100.4	1690
1941	no data	114.0	1919
1942	320	103.6	1687
1943	no data	94.8	1544
1944	370	67.1	1093
1945	303	109.4	1782
1946	365	75.2	1263
1947	496	35.0	570
1948	414	44.6	726
1949	510	37.0	602
1950	481	38.2	622
1951	496	46.7	760
1952	357	83.3	1357
1953	462	46.0	749
1954	540	33.6	547
1955	476	36.3	611
1956	318	112.2	1887
1957	479	46.3	754
1958	417	94.4	1537
1959	634	19.2	313
1960	710	13.7	223
1961	941	9.3	151
1962	565	42.7	695
1963	477	67.4	1098
1964	774	27.1	441
1965	494	75.0	804
1966	729	27.0	439

*Extreme values occurred within the period June-Sept. Flow values correspond to the month in which maximum TDS occurred, 1930-1953 values based on Mossdale data.

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TABLE VI-16. SUMMARY OF EXTREME WATER QUALITY CONDITION
APRIL - SEPTEMBER PERIOD

	1930-1944*	1952-1966
CRITICAL WATER QUALITY		
Monthly Mean TDS Mg/L		
Maximum for period	419	941
Mean for period	355	558
Minimum for period	266	318
LOW FLOW CONDITIONS		
Average daily flow ft^3/s corresponding to critical TDS		
Maximum	628	151
Mean	1182	774
Minimum	2222	1887

* Based on Mossdale data.

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TABLE VI-17. MEAN MONTHLY RUNOFF AND TDS AT VERNALIS BY DECADES 1930-1969

Month	1930's ***		1940's ***		1950's		1960's	
	R KAF	TDS mg/L	R KAF	TDS mg/L	R KAF	TDS mg/L	R KAF	TDS mg/L
Oct	99	274	110	299**	102	355	98	460
Nov	107	260	129	258**	154	314	117	393
Dec	152	218*	194	261**	344	261	197	334
Jan	200	191*	299	225**	262	271*	294	379
Feb	455	169*	391	256**	280	256*	401	340
Mar	530	188*	505	230**	342	280	385	396*
Apr	503	196*	502	211**	429	287	397	368*
May	678	166*	639	136*	451	223	404	375
Jun	620	172	675	179*	376	231	393	401
Jul	204	258	191	299*	101	418	139	549
Aug	66	332	75	389	56	461	58	595
Sep	70	312	85	344	72	420	76	528
Mean	282.5	228	316.3	257	247.4	315	238.3	427

* Only 9 observations in 10 year period

** Only 8 observations in 10 year period

***Based on Mossdale data

Note: Although 10 runoff observations were recorded for each 10-year period, the values shown are averages for the same series for which TDS values are given.

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Figure VI-25 shows graphically the trend of mean monthly TDS at Vernalis on a seasonal basis by decades, from the 1930's through the 1960's.

Relationship Between Mean Runoff and Mean TDS

Data presented in table VI-17 permit illustration of the changes in runoff and corresponding TDS values that have occurred during each of the decades since the 1930's. The relationships between these quantities are shown graphically in figures VI-26A, B, C, and D. The individual data points are identified by a number corresponding to the month of the year. Coordinates for each point were determined as the average monthly TDS and average monthly runoff without regard for year type (i.e., dry, below normal, above normal, wet).

Using figure VI-26A as illustrative of a normal pre-1950 cycle, it is noted that during the year the lowest runoff-highest TDS month is August (which is the case, incidentally, for all four decades). In succeeding months the TDS gradually drops as the average flow increases, although not in a linear fashion. The curve connecting the monthly points follows in a fairly smooth sequence through the winter and into the spring when the best quality is identified with the greatest monthly runoff (point 5 corresponding to May, the month of maximum runoff in the pre-1950 period). Thereafter the flow declines as the TDS level rises gradually, but at generally higher levels through the summer months. A somewhat similar pattern is seen for the 1940's (see figure 26B), although in this case the early spring months seem to reflect somewhat higher TDS levels. The range of flows and TDS are comparable to the 1930's. In the 1950's (see figure 26C) some of the same characteristics are noted although flows are less and TDS values higher. Also, less variation in TDS in relation to flow is noted during the winter and early spring months. In the 1960's (see figure 26D), the pattern is shifted decidedly upward and toward the left,

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Figure VI-25 MEAN MONTHLY TDS AT VERNALIS BY DECADES
1930-1969
*Based on Mossdale chloride data
**Based on actual observations

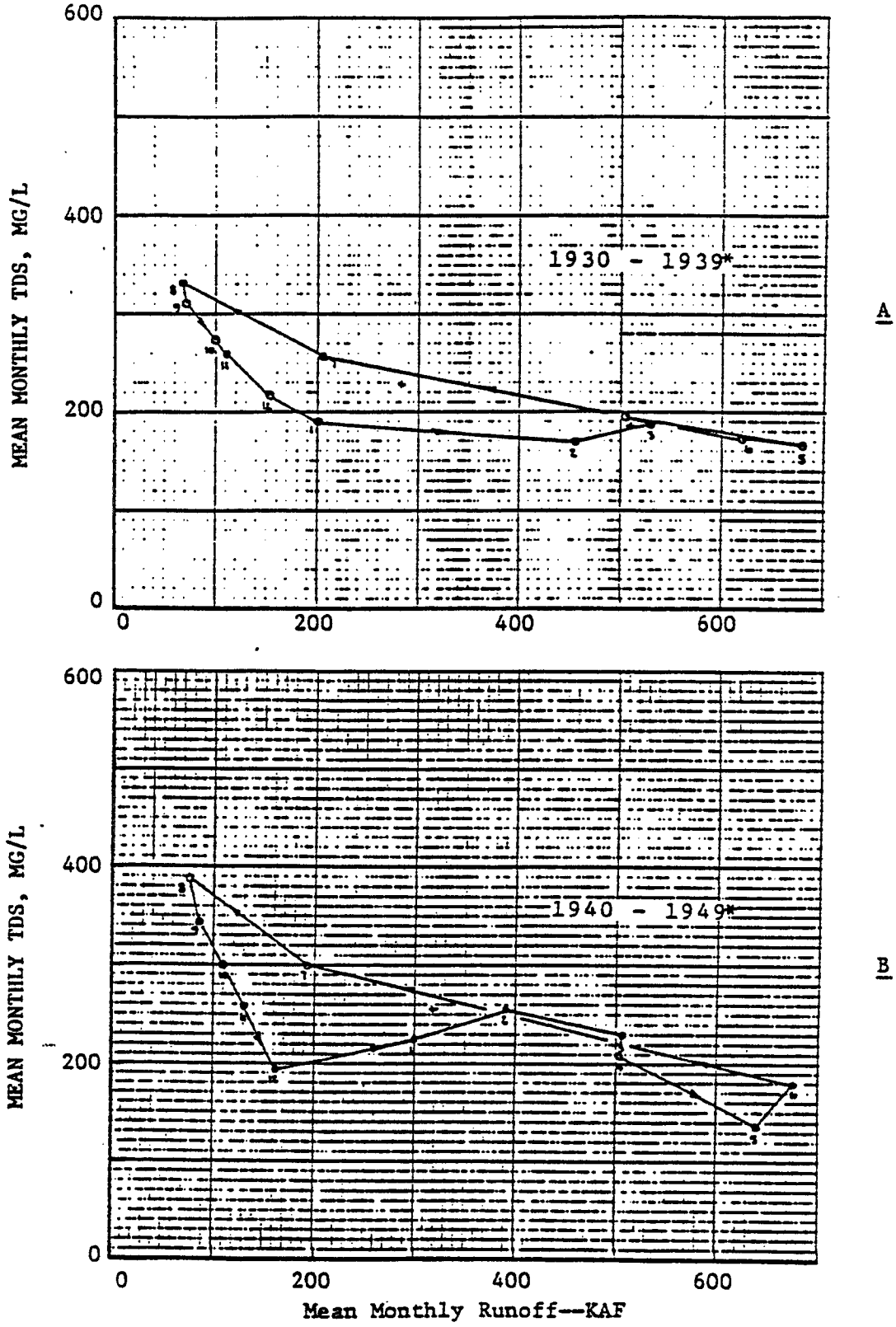

Figure VI-26 MEAN MONTHLY TDS (MG/L) VS. MEAN MONTHLY RUNOFF (KAF) FOR FOUR DECADES, 1930-1969

* Based on Mossdale data.

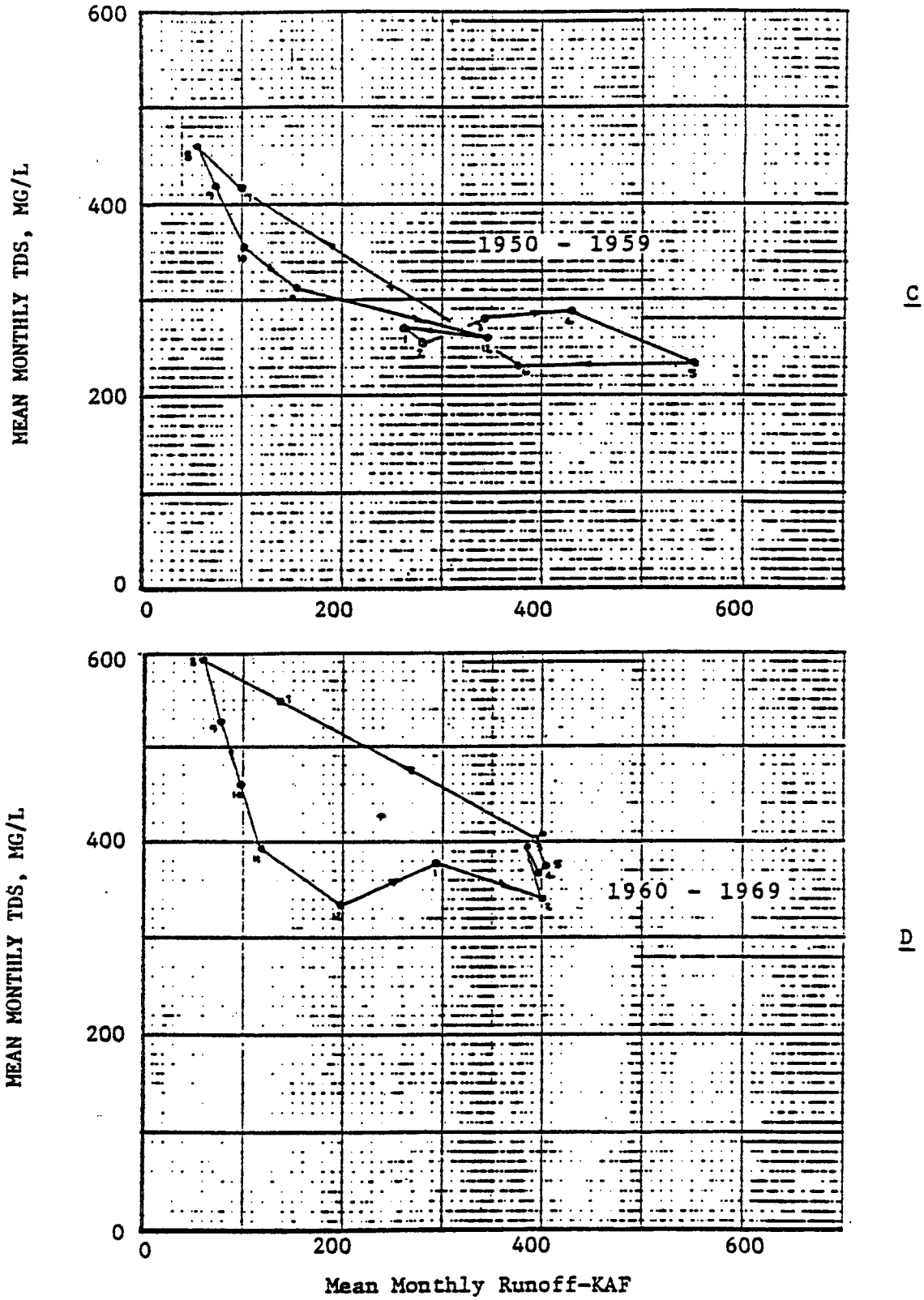

Figure VI-26 (Continued)

indicating substantial increases in salt load for the same levels of flow, and a generally decreased runoff, especially during the late winter and spring months (February through June). In all cases it is of interest to note:

1. The lowest runoff and poorest quality occurred in August.
2. The greatest runoff occurred in May or June (three times in May, one time in June).
3. A regular pattern of improving quality with increasing flow is identified with the period September through December.
4. Late spring and early summer months always show a tendency toward increased TDS as the flow decreases approaching the maximum in August.

Estimation Based on Chloride Load-Flow Relationships

To broaden the approach to prediction of pre-1953 water quality conditions at Vernalis on the San Joaquin River, an alternative method of analysis was developed. This method utilized chloride observations derived from monthly grab samplings at Vernalis for the period subsequent to 1938*. These data were combined with mean monthly flows to determine mean monthly chloride loads that, in turn, were correlated with Vernalis runoff to produce linear regressions of the power function form. Correlations were made for each month of record for the periods 1938 through 1949 and 1950 through 1969, respectively. Because these regression lines were fitted to a limited set of data (from six to ten data points in the 1938 to 1949 period) they were generally limited to the range of the data used, e.g., they were not considered reliable for very

* With the exception of some months during World War II when no samplings were made.

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low flows, where they tended to give TDS predictions larger than had been observed historically. To correct for this limitation a new set of regression equations, the coefficients for which are summarized in table VI-7 for the Vernalis station, were prepared using an additional hypothetical chloride load-flow point corresponding to a TDS of 1,000 mg/L and a monthly flow of 0.5 KAF. Including this value in the data set had the effect of precluding TDS concentrations in excess of 1,000 mg/L*.

Although plots similar to figures VI-15 and VI-16 express quality in tons of chlorides, the chloride concentration in p/m is given by the following formula:

$$p/m = \frac{\text{Load}}{\text{Flow} \times 1.36}$$

where,

p/m = parts per million Cl^-
Load = chloride load in tons
Flow = 1,000's of acre-feet

Table VI-18 tabulates the mean monthly TDS values for the years 1930-1953 based on the chloride load flow regressions.

The extreme water quality conditions at Vernalis for the years 1930-66 are presented in table VI-19. A comparison of the pre-project years with post-project years is presented in table VI-20. These tables indicate that extreme water quality conditions at Vernalis are poorer for the post-project years, in terms of higher TDS concentrations and lower daily flows.

Applying the regression curves to the pre-1950 and 1950-1952 years and using actual data for the post-1952 years, table VI-21 can be used to compare the mean monthly water quality at Vernalis for the four decades being studied.

* Approximately the maximum mean monthly TDS during the 1977 drought.

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TABLE VI-18. MEAN MONTHLY TOTAL DISSOLVED SOLIDS AT VERNALIS, MG/LITER, BASED ON CHLORIDE LOAD-FLOW REGRESSIONS FOR PERIOD 1930-1949

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
1930	338	309	310	241	267	245	168	159	204	378	421	376
1931	327	286	278	253	274	344	334	292	429	616	555	494
1932	417	359	314	199	140	196	138	95	111	238	403	396
1933	327	275	279	233	217	275	224	189	159	390	447	391
1934	333	291	261	211	241	277	270	253	364	523	501	456
1935	372	306	292	194	205	208	99	87	110	305	415	380
1936	312	273	256	200	135	141	103	86	123	293	405	383
1937	318	273	249	200	135	145	100	82	110	286	405	378
1938	318	272	211	166	112	111	89	76	86	179	333	349
1939	293	229	232	187	194	262	171	164	309	434	441	399
1940	335	296	293	187	150	140	97	90	124	335	402	366
1941	330	282	245	159	133	127	95	81	99	206	362	366
1942	306	260	217	152	134	164	102	87	99	217	376	358
1943	305	260	222	170	133	124	94	89	121	326	383	366
1944	310	273	262	213	218	197	176	132	188	378	407	388
1945	329	256	231	191	141	161	114	90	122	270	373	355
1946	290	234	207	147	171	214	128	92	154	362	399	374
1947	321	252	234	211	235	253	204	164	315	481	461	396
1948	343	280	287	262	342	384	209	122	134	372	441	395
1949	332	294	298	244	286	219	182	136	231	472	456	426
1950	420	351	351	288	269	343	192	174	169	506	566	514
1951	415	211	166	144	180	219	258	156	203	468	538	505
1952	390	342	293	153	174	181	117	92	93	298	464	458
1953	386	323	280	179	265	414	329	216	171	385	538	498

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TABLE VI-19. EXTREME VALUES OF TDS AND FLOW AT VERNALIS 1930-1966

Year	Maximum monthly mean TDS* mg/L	Minimum monthly mean flow KAF	Minimum monthly mean flow ft^3/s
1930	421	56.6	921
1931	616	14.0	228
1932	403	71.3	1160
1933	447	41.0	667
1934	523	23.6	384
1935	415	61.2	995
1936	405	69.0	1122
1937	405	69.4	1129
1938	349	132.4	2225
1939	441	44.0	716
1940	402	72.9	1186
1941	366	100.3	1686
1942	376	103.6	1685
1943	383	94.8	1542
1944	407	67.1	1091
1945	373	109.4	1779
1946	399	75.3	1225
1947	481	32.4	527
1948	441	44.6	725
1949	472	34.6	563
1950	566	38.2	621
1951	538	46.7	760
1952	464	83.3	1355
1953	538	46.0	748
1954	540	33.6	547
1955	476	36.3	611
1956	318	112.2	1887
1957	479	46.3	754
1958	417	94.4	1537
1959	634	19.2	313
1960	710	13.7	223
1961	941	9.3	151
1962	565	42.7	695
1963	477	67.4	1098
1964	774	27.1	441
1965	494	75.0	804
1966	729	27.0	439

*Extreme values occurred within the period June-September. Flow values correspond to the month in which maximum TDS occurred. 1930-53 values based on load-flow regressions.

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TABLE VI-20. SUMMARY OF EXTREME WATER QUALITY CONDITION
APRIL - SEPTEMBER PERIOD

	1930-1944*	1952-1966
CRITICAL WATER QUALITY		
Monthly mean TDS mg/L		
Maximum for period	616	941
Mean for period	424	558
Minimum for period	349	318
LOW FLOW CONDITIONS		
Average daily flow ft^3/s corresponding to critical TDS		
Maximum	228	151
Mean	1107	774
Minimum	2225	1887

* Based on load-flow regression curves.

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TABLE VI-21. MEAN MONTHLY RUNOFF AND TDS AT VERNALIS BY DECADES 1930-1969

Month	1930's***		1940's***		1950's		1960's	
	R KAF	TDS mg/L	R KAF	TDS mg/L	R KAF	TDS mg/L	R KAF	TDS mg/L
Oct	99	336	115	320	102	355	98	460
Nov	107	287	129	269	154	314	117	393
Dec	152	268	200	250	344	261	197	334
Jan	197	208	291	194	262	271*	294	379
Feb	420	192	401	194	280	256*	401	340
Mar	488	220	564	209	342	280	385	396*
Apr	457	170	518	140	429	287	397	368*
May	613	148	667	108	451	223	404	375
Jun	620	201	590	159	376	231	393	401
Jul	204	364	185	342	101	418	139	549
Aug	66	433	75	406	56	461	58	595
Sept	70	400	85	379	72	420	76	528
Mean	291	269	318	248	247	315	238	427

* —Only 9 observations in 10 year period

** Only 8 observations in 10 year period

*** Based on load-flow regression curves

NOTE: Although 10 runoff observations were recorded for each 10-year period, the values shown are averages for the same series for which TDS values are given.

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monthly water quality at Vernalis for the four decades being studied. Figure VI-27 presents graphically the same data. It is apparent that during the 1950's and 1960's water quality at Vernalis has experienced some degradation. Particularly notable is the decade of the 1960's in which mean monthly water quality is poorer in all months to the extent of several hundred mg/L TDS in some months.

Data presented in table VI-21 illustrate the changes in runoff and corresponding TDS values that have occurred during each of the decades since the 1930's. The relationships between these quantities are shown graphically in figures VI-28A and B, for the 1930's and 1940's. The 1950's and 1960's data are the same as those used in the Mossdale discussion (see figures VI-26C & D). Individual data points are identified by a number corresponding to the month of the year. Coordinates for each point were determined as the average monthly TDS and average monthly runoff without regard for year type (i.e., dry, below normal, above normal, wet).

As an illustration of a pre-1950 cycle, figure VI-28A shows that the lowest runoff - highest TDS month is August. With succeeding months the TDS drops as the flow increases until May when the best quality is identified with a high average runoff. In June, runoff is about that of May; however, the TDS concentration begins to increase. July and August both show a reduction of runoff and an increase in TDS concentration with the greatest changes occurring in July. A similar pattern is exhibited in the 1940's with some slight changes in the March through June period. A description of the 1950's and 1960's is contained in the discussion of results based on the Mossdale chloride data. In each of the decades the following statements are valid for average conditions:

1. The lowest runoff and poorest quality occurred in August.
2. The greatest runoff occurred in May or June.

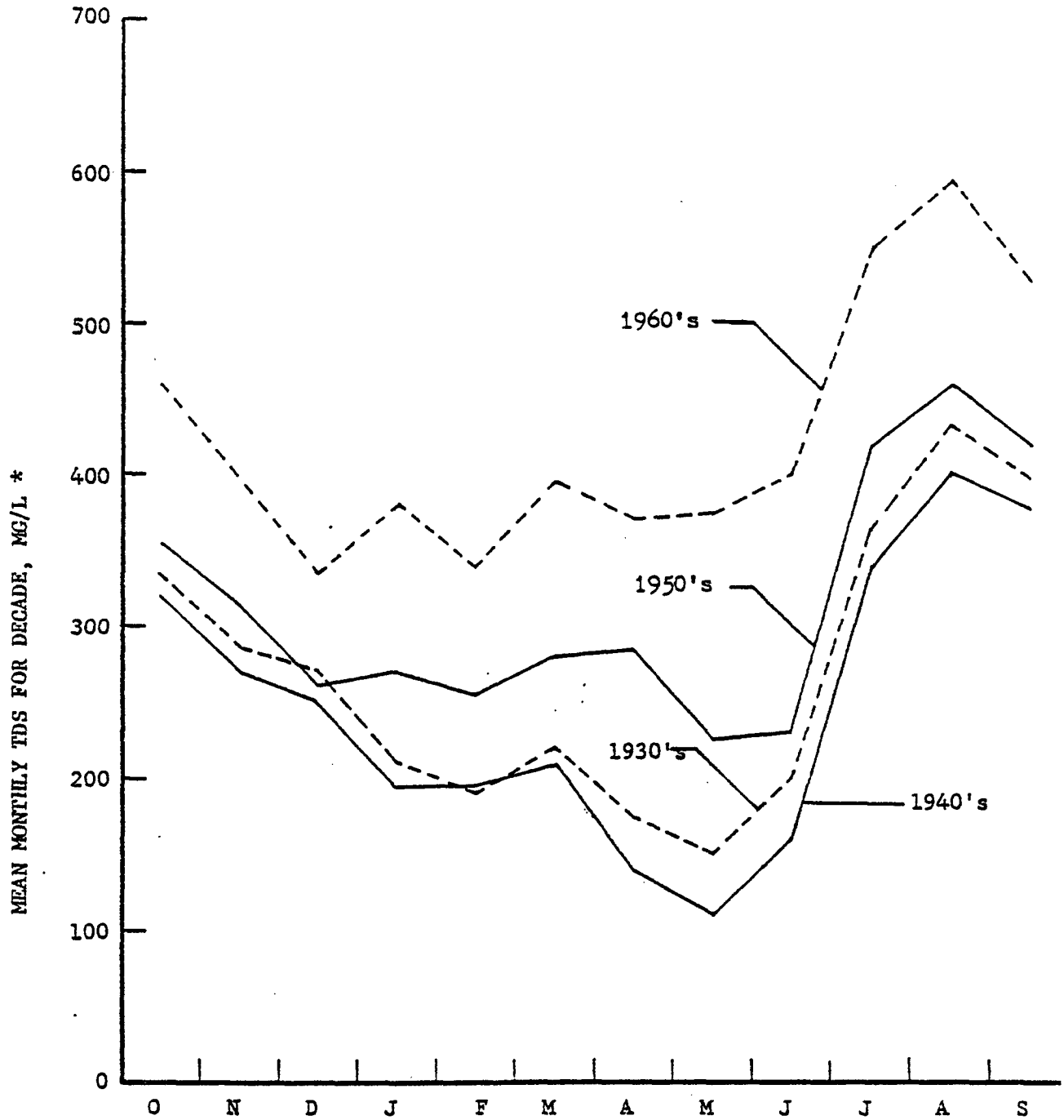

Figure VI-27 MEAN MONTHLY TDS AT VERNALIS BY DECADES 1930-1969

* Estimated by chloride load-flow regressions for 30's and 40's.

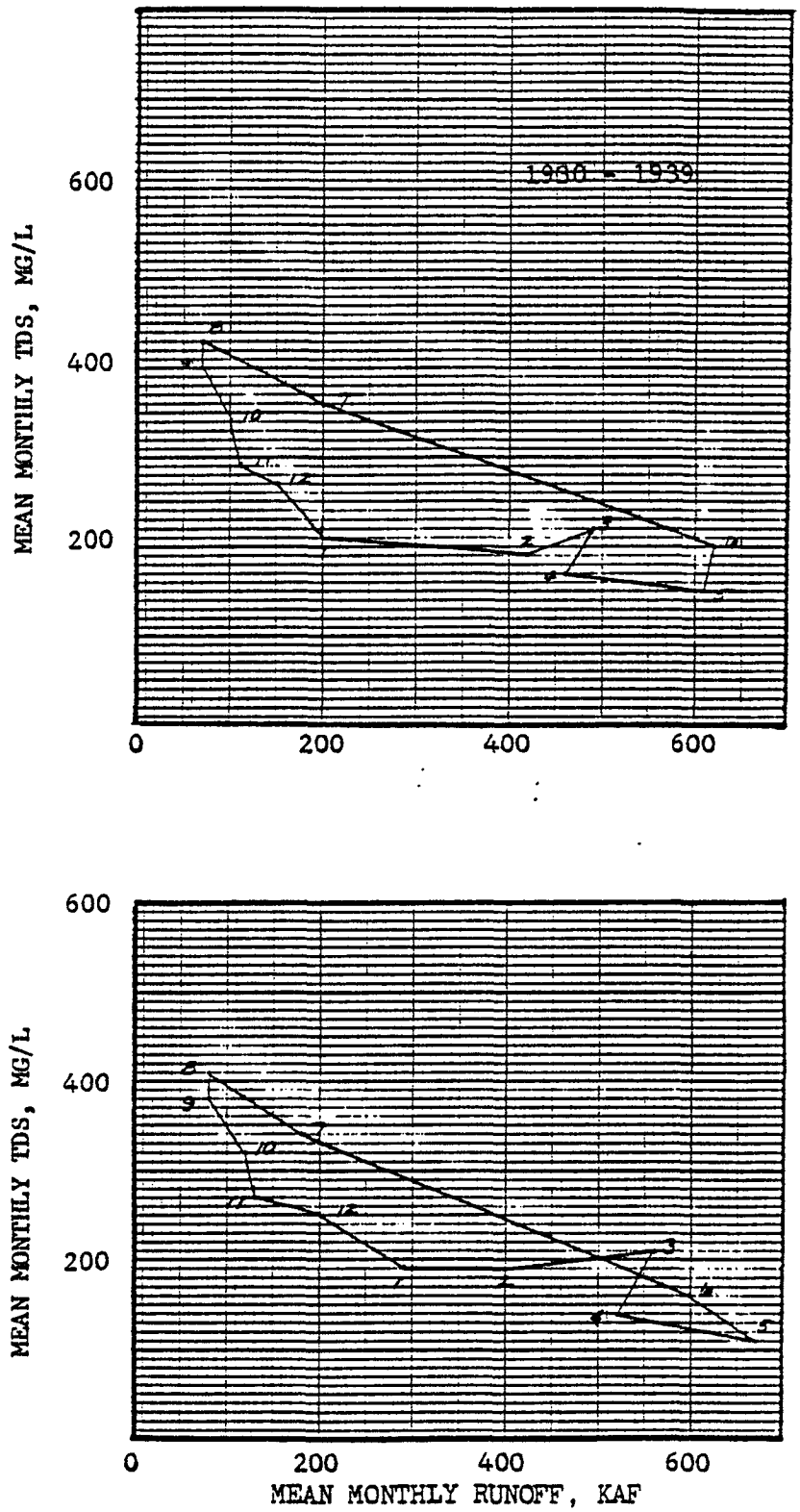

Figure VI-28 MEAN MONTHLY TDS (mg/L) VS. MEAN MONTHLY RUNOFF (KAF) FOR TWO DECADES, 1930-1949, BASED ON CHLORIDE LOAD-FLOW RELATIONSHIPS

3. A regular pattern of improving quality with increasing flow is identified with the period September through December.

4. Late spring and early summer months show a tendency toward increased TDS as the flow decreases approaching a maximum in August.

SECTION D. EFFECT OF TUOLUMNE GAS WELLS

Since the 1920's and until very recently, a group of about 10 exploratory gas wells, located along the Tuolumne River in the reach from Hickman to the mouth, have been contributing flows of very saline water to the river. The salt contribution of these wells, which has been estimated to range from 7,000 to 10,000 tons per month of TDS, is reflected in an overall increase in the salinity of the Tuolumne River, which depends upon the discharge from upstream sources not affected by the wells and to a lesser extent upon local returns of irrigation drainage water. In turn, because the Tuolumne contributes to the San Joaquin flow, there is an impact of these gas wells on the quality of water reaching Vernalis. It is not known whether there has been a significant change in the salt output of the wells over the period studied, i.e., from 1930 through 1966, but in 1977 concerted efforts were made to seal the wells and thus reduce the contribution of salts to the river. The effectiveness of these efforts has not yet been assessed.

The variation in salt concentration (represented by electrical conductivity, EC) in the Tuolumne River in relation to flow is summarized for three different locations in figure VI-29. The actual data shown are for the period 1960-1965, inclusive, and correspond to grab samples collected by the USGS at the several locations (approximately 1 sample per month). Curves of hyperbolic form are plotted to represent the data, indicating generally that as flows in the river increase (the gas wells flows are considered nearly constant over the

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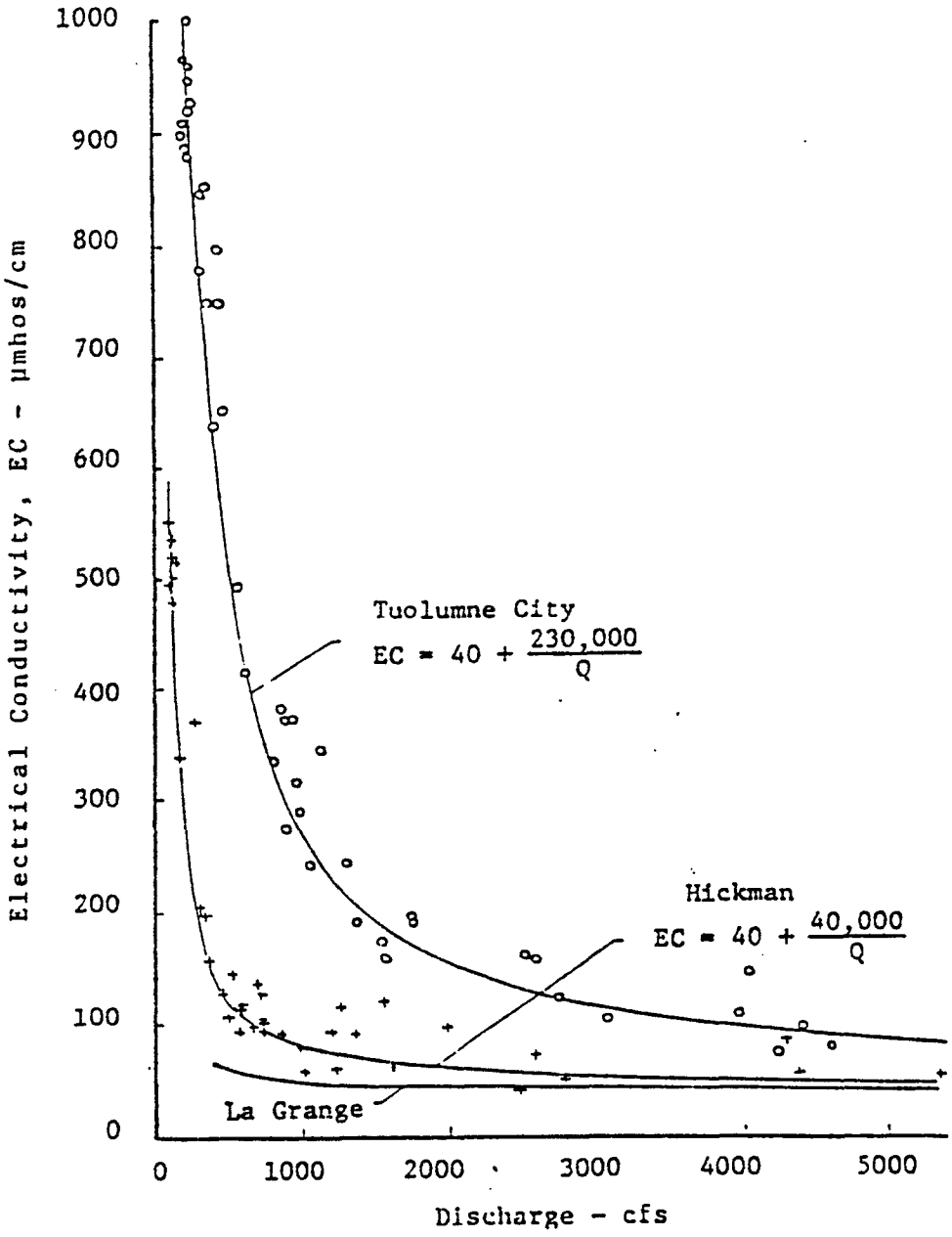

Figure VI- 29 QUALITY-FLOW RELATIONSHIPS
TUOLUMNE RIVER

year) the quality improves, but at very low flows the quality may be dominated by the gas well salt load. Assuming a constant accretion of salt (tons per month), it is estimated that about one-sixth of the salt is contributed by two wells above Hickman and the remaining five-sixths by the several wells between Hickman and Tuolumne City, near the river's mouth. This analysis, which presumes a constant strength of the wells, indicates a total load as high as 10,800 tons TDS per month, although estimates by the Central Valley Regional Water Quality Control Board, based on direct sampling and analysis of the well water, indicate smaller loads--about 6,000 tons per month. Differences between these estimates may be attributed, in part, to the effects of drainage returns in the lower reach of the river. These are reflected, however, by the total salt load estimated at Tuolumne City (see figures VI-18 to 21).

Analysis of chloride data for the period 1938 through 1969, for four seasonal periods (November-January, February- April, May-July, and August-October) indicate similar relationships between chloride concentration and flow in the Tuolumne to those depicted in figure VI-29 for EC versus flow. Results of this analysis, which characterizes C1 versus flow in the form of

$$Cl^- = C_1 \, (Flow)^{C_2} \qquad \text{(VI-6)}$$

where

Cl^- = monthly average concentration of chlorides, mg/L

Flow = average monthly runoff, cfs

C_1, C_2 = constants

are summarized in table VI-22.

The coefficients given correspond to the statistical "best fit" lines of the relationship presumed in equation VI-6. The coefficient of correlation, R, indicates the reliability of the equation in predicting the values actually observed, R = 1.0, corresponding to a perfect fit.

year) the quality improves, but at very low flows the quality may be dominated by the gas well salt load. Assuming a constant accretion of salt (tons per month), it is estimated that about one-sixth of the salt is contributed by two wells above Hickman and the remaining five-sixths by the several wells between Hickman and Tuolumne City, near the river's mouth. This analysis, which presumes a constant strength of the wells, indicates a total load as high as 10,800 tons TDS per month, although estimates by the Central Valley Regional Water Quality Control Board, based on direct sampling and analysis of the well water, indicate smaller loads--about 6,000 tons per month. Differences between these estimates may be attributed, in part, to the effects of drainage returns in the lower reach of the river. These are reflected, however, by the total salt load estimated at Tuolumne City (see figures VI-18 to 21).

Analysis of chloride data for the period 1938 through 1969, for four seasonal periods (November-January, February- April, May-July, and August-October) indicate similar relationships between chloride concentration and flow in the Tuolumne to those depicted in figure VI-29 for EC versus flow. Results of this analysis, which characterizes C1 versus flow in the form of

$$Cl^- = C_1 \, (Flow)^{C_2} \qquad \text{(VI-6)}$$

where

Cl^- = monthly average concentration of chlorides, mg/L

Flow = average monthly runoff, cfs

C_1, C_2 = constants

are summarized in table VI-22.

The coefficients given correspond to the statistical "best fit" lines of the relationship presumed in equation VI-6. The coefficient of correlation, R, indicates the reliability of the equation in predicting the values actually observed, R = 1.0, corresponding to a perfect fit.

A summary of predicted values of chlorides for ious levels of flow, corresponding to each of the seasonal and chronological periods, studied, is presented in table VI-23. Estimates are also shown for electrical conductivity (EC) based on the relationship

$$EC = 8.82\ (Cl^-)^{0.88} \qquad \text{(VI-7)}$$

where

EC = electrical conductivity, umhos/cm @ 25 °C

Cl = chlorides, mg/L

which was derived from USGS data for the period 1960-65. For purposes of graphical comparison, the resulting EC versus flow relationships are shown in figure VI-30, together with the 1960-1965 data for Tuolumne City, shown also in figure VI-29.

SECTION E. IMPACT OF UPSTREAM DEVELOPMENT ON QUALITY DEGRADATION OF THE SAN JOAQUIN RIVER SYSTEM

The preceding sections of this chapter have dealt with the changes that have occurred historically in the San Joaquin River system, dating from about 1930 and extending through the 1960's. Data has been presented to indicate the changes in quality that have been experienced at the lower extremity of the system, near Vernalis and at Mossdale 16 miles downstream and within the South Delta Water Agency. Data on the composition and quantity of salt accretion to the river system from various sources from Mendota downstream to Vernalis have been described. Finally, two methods of estimating the missing quality data for the early years of the study have been developed. For the benefit of the reader who may have elected not to read sections A, B, C, and D, a summary of each section is included here.

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Table VI-23. PREDICTED CHLORIDE CONCENTRATIONS IN THE TUOLUMNE RIVER AT TUOLUMNE CITY, AUGUST THROUGH OCTOBER, FOR SEVERAL CHRONOLOGICAL PERIODS

Flow	CHRONOLOGICAL PERIOD					
	1938-49		1950-59		1960-69	
cfs	Cl*	EC**	Cl	EC	Cl	EC
250	164	784	189	889	194	909
500	87	449	114	570	109	548
1000	46	258	68	361	61	329
2000	25	148	41	232	34	196
3000	17	107	30	176	25	147
5000	11	73	21	129	16	101

* From regression equation, Aug-Oct, Table VI-22, mg/L

** By correlation Cl vs EC, equation VI-7, μmhos/cm @ 25°C

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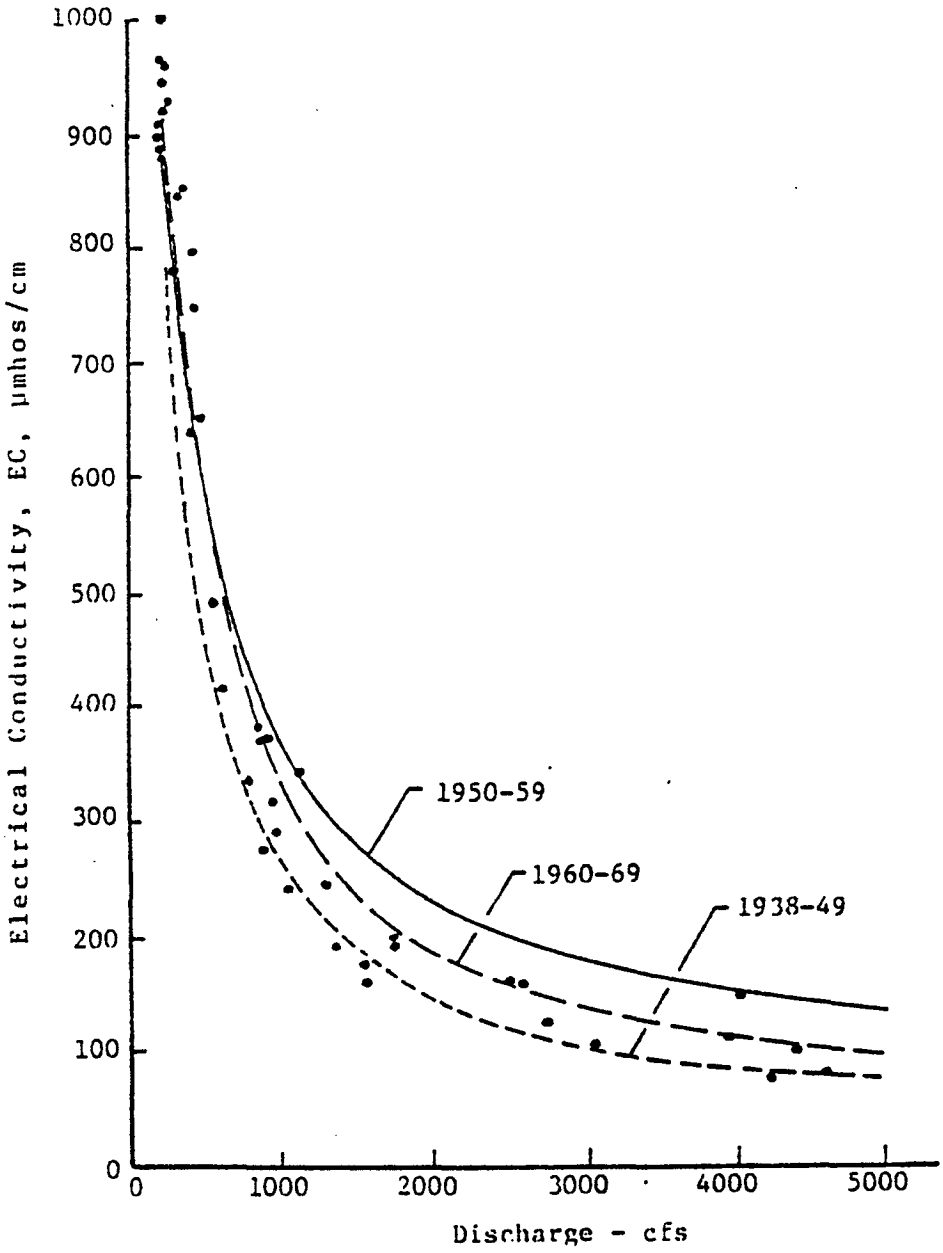

Figure VI-30 QUALITY-FLOW RELATIONSHIPS
TUOLUMNE RIVER, 1938-1969 (August-October)

Data shown are for period 1960-65, regression lines are described in Table VI-22

Data for Section A were developed to facilitate identification of the locations and the relative strengths of major contributions to the salt burden carried by the San Joaqin River from the vicinity of the Mendota Pool to Vernalis. This study of quality constituents was used in an effort to "fingerprint" the waters of various sources. In general, the data on quality constituents show the following:

1. There are distinctive differences between the qualities of eastside streams and the quality of water carried by the San Joaquin River along its main stem.
2. In the 1960's there is comparatively little difference between the quality and chemical composition of salts in drainage returns from the westside of the valley and the quality of water carried in the San Joaquin River from Mendota to Vernalis. Westside drainage is high in TDS, chlorides, sodium, sulfate, noncarbonate hardness, and boron, all of these properties being identified with soils of the area.
3. The effect of the flow from eastside tributaries has been largely one of dilution of salt loads carried by the river.

The properties of the salts carried by the San Joaquin River during periods of low flow appear to be dominated by westside accretions during the 1960's to a degree that they are hardly indistinguishable. To determine the relative contribution of several sources, the salt balance computations of Section B were performed.

Section B data were examined to determine trends in TDS salt load and TDS concentration at Vernalis. A study of monthly TDS load v. monthly Vernalis

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unimpaired rimflow was performed for the four months of October, January, April, and July. By grouping the data into subsets by decades, the results indicate that in general, the salt load has increased at Vernalis. Lines describing the "best fit" of the data oftentimes do not correlate very strongly but, the indication is that the salt loads have probably increased, while the magnitude of the load is not strongly dependent on unimparied rimflow (see figures VI-7 through VI-10).

A second study contained in Section B compares the TDS concentrations at Vernalis for various actual flows. Again, the data was divided into subsets by decades and "best fit" curves derived (see figures VI-11 through VI-14). Only the four representative months were studied, but the data supports a trend of higher TDS concentrations in the 1950's and 1960's than occurred in the 1940's and 1930's. An exception to this general statement is the month of July although no ready explanation is available for this difference from the other three months. the purpose of these first two studies was not to gain a quantitative description, but merely a qualitative insight to the situation at Vernalis.

The third portion of Section B, the salt balance computations, is used to determine the relative contribution of the several sources by combining the effects of flow and concentration. For comparison purposes, the years were grouped into water year classifications e.g., dry, below normal, above normal, and wet. Post-1947 results were then compared to pre-1944 years of the same type, much the same as was done in the water balance computations of Chapter 5.

The salt load at Vernalis has changed between the pre-1944 and post-1947 periods, the amount varying with the year classification. It appears that

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annual loads in the dry years increased 18 percent and below normal year annual loads increased 35 percent. Little or no annual load change is evident in above normal and wet years. In the dry and below normal years the biggest increase in load occurred in April when spring runoff is probably flushing the basin of some accumulated salts. Consistent with this observation, loads in July have decreased in dry and below normal years apparently due to a reduction in runoff. In general, it appears that in drier years, salts are accumulated in the basin during low flow summer and early fall months and then released during the high flow winter and spring months. Because a net increase in load has occurred, it seems likely that sources of salt are adding to the annual burden at Vernalis in dry and below normal years.

In order to evaluate the changes in TDS concentration that have occurred at Vernalis, a complete record of monthly values is necessary. Due to gaps in the Vernalis data two methods of estimating the missing values were developed in Section C. The first of these methods estimates Vernalis TDS based on a correlation with Mossdale chloride data. The second method estimates the Vernalis TDS based on actual flow at Vernalis. Results of the two methods vary slightly but generally compare favorably. For average conditions, the following statements are valid:

1. The lowest runoff and poorest quality occurred in August.
2. The greatest runoff occurred in May or June.
3. A regular pattern of improving quality with increasing flow is identified with the period September through December.
4. Late spring and early summer months show a tendency toward increased TDS as the flow decreases approaching a maximum in August.

The Tuolumne gas wells are a significant source of salt. The exploratory wells have been contributing highly saline flows since the 1920's estimated to be as much as 7,000 to 10,000 tons per month of TDS. The study contained in Section D indicates that no significant change has occurred in the contribution of the wells through the 1960's.

An attempt to seal the wells was instituted in 1977 but insufficient data are available to evaluate the effectiveness of the effort.

The remainder of Section E is a discussion of impacts on water quality at Vernalis utilizing the results of the preceeding sections. Because the impacts are based on the 1930's and 1940's period, and two methods were used to estimate the data for those years, two sets of results will be discussed, one based on Mossdale chloride data and one based on Vernalis chloride load-flow data.

The changes in quality that have occurred at Vernalis have been most notable during the drier years of record, especially during the spring and summer months of such years. Using the Mossdale data, extreme values of monthly average TDS followed a more or less regular pattern in the period prior to about 1944, ranging roughly between 300 and 400 mg/L, only slightly affected by the magnitude of runoff during the month (refer to figure VI-24). Since the predictions from regression curves are based on runoff, the magnitude of estimated TDS at Vernalis is affected by the flow and the lower envelope shown in figure VI-24 is modified upward.

The analysis of Mossdale data indicates that if there were any highly saline return flows during the 1930's-1940's period, they diminished in flow during dry periods in comparable degree to the reduction in flow of high

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quality waters. Chloride load-flow regression data indicate that, in the 1930's and 1940's, the quality of Vernalis water deteriorated with a reduction in flow, more or less as it did in the 1950's and 1960's, however, not as dramatically. For the years prior to 1950, the average difference in maximum monthly TDS estimated by both methods is 17 percent. Load-flow regression TDS values are, in most years, higher than Mossdale values, ranging from -10 percent in 1939, a dry year, to +93 percent in 1931, a dry year.

In the period subsequent to 1951, in distinct contrast, data indicates that a change occurred that was manifested by occasional very high levels of TDS correlatable to a high degree with a diminished flow in the river. Concentrations rose to 700 mg/L and above in several instances and exceeded 900 mg/L in 1961. This phenomenon was most evident in the late summer months--in almost every instance July or August proved to be the critical month--but it can be seen in the data of more recent years to be associated with the late spring and early summer periods when upstream diversions were most likely to influence the runoff reaching Vernalis.

A comparison of the four decades--the 1930's through the 1960's (see table VI-17)--indicates that the quality at Vernalis deteriorated at an accelerating rate relative to the decline in runoff. While the period (1930-1949) produced approximately the same annual average unimpaired runoff as the 1950-1969 period, the quality-flow relationship shifted markedly after the end of the earlier period. The average monthly runoff at Vernalis, which was about 300,000 acre-feet in the 1930's and 1940's, dropped by about 19 percent--to 243,000 acre-feet in the 1950's and 1960's (an average difference of 684,000 acre-feet per year). Over the same time span the average monthly TDS (over the

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entire year based on Mossdale chlorides for the 1930-1949 period) increased 53 percent--from about 243 mg/L to 371 mg/L. Comparing the 1950's and 1960's to the earlier two decades, the TDS increases are about 30 percent and 76 percent of the 1930-1949 average, respectively.

For a constant salt load it may be expected that a decrease in runoff at Vernalis would result in an increase in TDS. Comparing the average monthly TDS (over the entire year), load-flow regressions show a 1950-1969 increase of 43 percent--from 259 mg/L to 371 mg/L. For the 1950's alone, the percentage increase is about 22 percent and for the 1960's, 65 percent.

From these same data it is possible to estimate the proportionate degradation that occurred as a result of reduction of flow and as a result of added salt load in the system. Using the Mossdale data for the decades of the 1930's and 1940's as a base of reference (mean monthly runoff = 299.4 KAF and mean TDS = 242.5 mg/L), and assuming, first, no change in salt load, we find that due to runoff reduction alone in the 1950's we could expect an increase in TDS of about 40.5 mg/L. The difference in this increase and that which actually occurred, 72.5 mg/L, is 32.0 mg/L and must be attributed to an increase in salt burden carried by the river. Thus, according to this analysis, in this first decade after the CVP went into operation, about 56 percent of the increase in average TDS was caused simply by a reduction in flow from upstream sources; the remaining 44 percent was a result of increased salt burden, perhaps associated with an expansion of irrigated lands in the basin. Similarly, in the 1960's (compared to the 1930's and 1940's) about 27 percent of the average increase in TDS (184.5 x 0.27 = 50.0) can be accounted for by a reduction in flow and 73 percent attributed to increased salt burden. It is of interest to note here

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that the absolute change apparently caused by reduction in flow changed relatively little from the 1950's to the 1960's (from 41 to 50 mg/L) while that charged to an increase in salt burden increased about four times (from 33 to 134.5 mg/L). This is consistent with other analyses that indicate a progressive buildup in salt load in the San Joaquin system.*

Based on the load-flow regressions data for the 1930's and 1940's, the proportionate degradation that has occurred due to decreased flow and increased load is also calculated.*

1930' & 1940's average load = 747,740 tons**

1950's reduction due to flow = (50) (690) = 34,500 tons

1950's TDS increase due to flow = $\frac{747,740 - 34,500}{2,969} - 204 = 36$ mg/L TDS

1950's TDS increase due to load = (277 - 36) - (204) = 37 mg/L TDS

1960's reduction due to flow = (50) x (700) = 35,000 tons

1960's TDS increase due to flow = $\frac{747,740 - 35,000}{2,959} - 204 = 37$ mg/L TDS

1960's TDS increase due to load = (393 - 37) - (204) = 152 mg/L TDS

According to this analysis, in the 1950's a quality degradation of 36 mg/L TDS is due to a reduction in flow. The calculations show a slight degradation of 37 mg/L TDS due to load, or about 50 percent. The degradation due to load change is significantly greater in the 1960's, 152 mg/L TDS, while the degradation due to reduced flow, 37 mg/L TDS, is about the same as for the 1950's.

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* It is assumed in this analysis that water lost from the system would have a TDS of about 50 mg/L.

** Obtained by summation of average monthly saltloads for the period 1930-1949.

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The chronological shifts in TDS concentration and salt loads, calculated by the Mossdale method, are depicted graphically in figures VI-31 and VI-32, in which the changes that have occurred (see table VI-17) in the 1950's and 1960's are related to the average of the earlier period. The relative concentration is noted to be greater than unity throughout the year in both decades, the maximum occurring in late spring and early summer. The rate of increase over time, indicated by the spacing between the curves, is seen as increasing in all months from the 1950's through the 1960's, with the greatest rate differences occurring in May and June.

Changes in salt load, i.e., the product of runoff and concentration, are indicated in figure VI-32 to have changed relatively little between the 1950's and the 1930's-1940's period. However, the salt load at Vernalis for the 1960's increased substantially in all months of the year, by amounts 40 percent or greater than for the period of the 1930's and 1940's, despite the fact that flows in this period were substantially reduced by upstream development. The average for the 12-month period of the 1960's was about 152 percent of the 1930's-1940's level. For the 1950's, the average was about 110 percent.

Chronological shifts in TDS concentration and salt loads as determined by the load-flow regressions are presented in figures VI-33 and VI-34. Monthly changes that have occurred in the 1950's and 1960's (see table VI-21) are related to the average of the 1930's and 1940's. Relative concentrations are greater than unity for all months in the 1950's and 1960's. The greatest rate of increase over time for both the 1950's and 1960's is seen in April and May.

The changes in salt load, i.e., the product of runoff and concentration, are indicated in figure VI-34. The 1950's show some change in load over the

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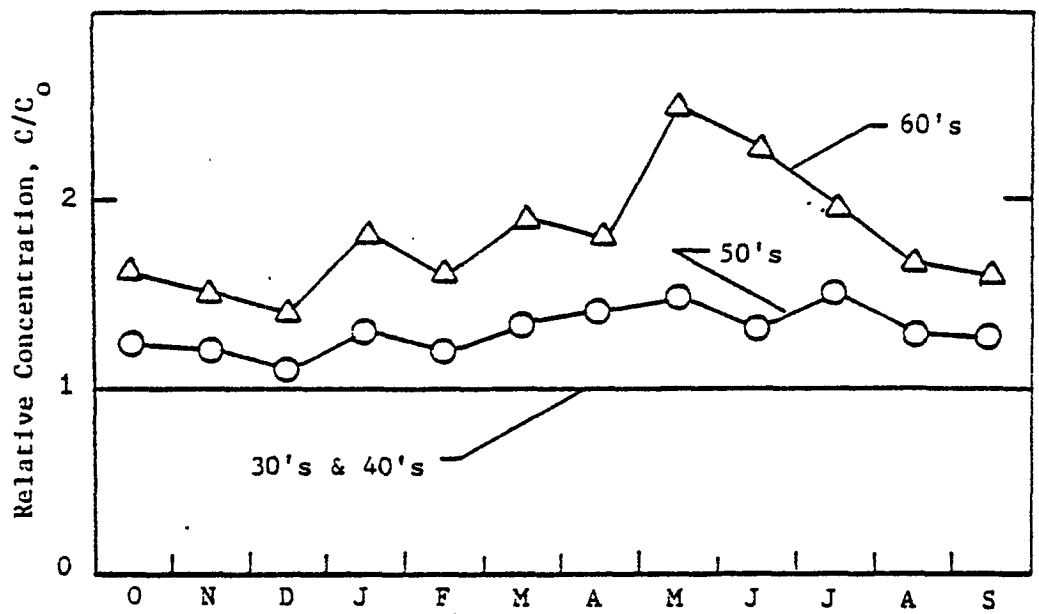

Figure VI-31 RELATIVE TDS CONCENTRATION AT VERNALIS BY DECADES, 1930-1969

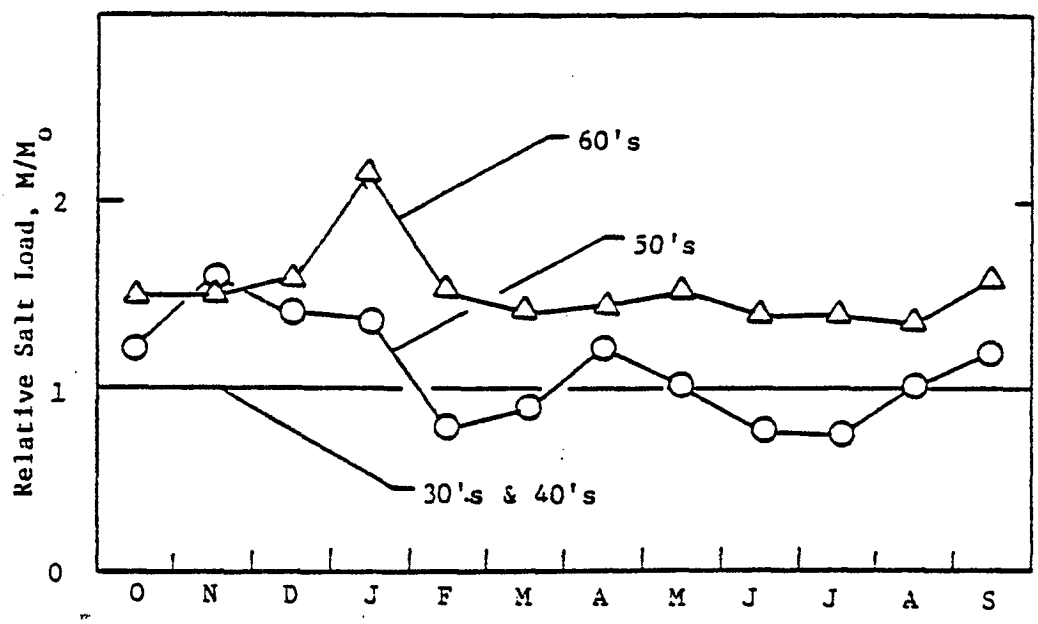

Figure VI- 32 RELATIVE TDS SALT LOAD AT VERNALIS BY DECADES, 1930-1969

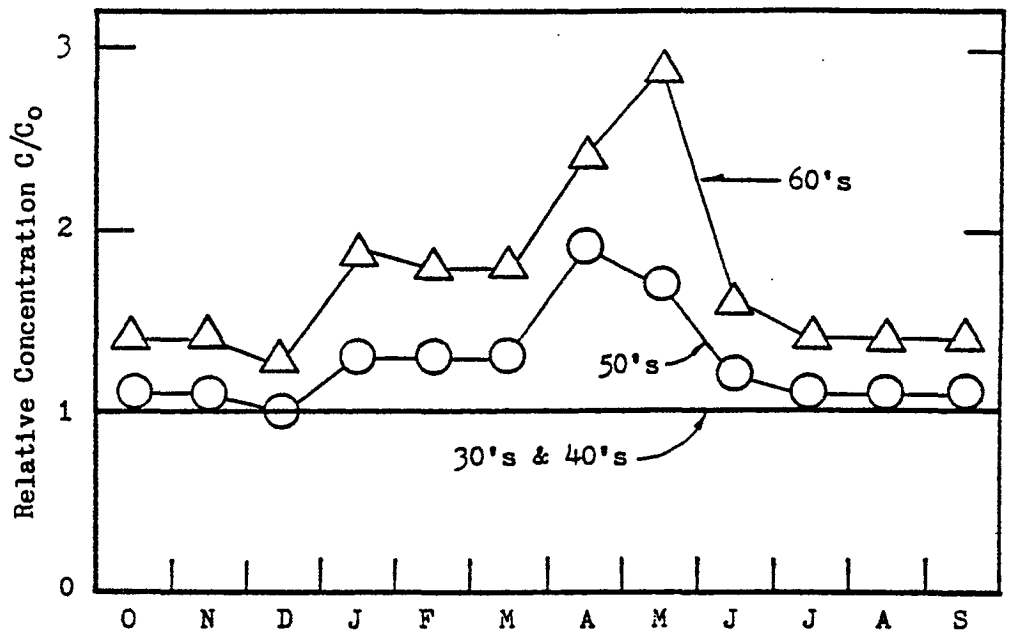

Figure VI-33 RELATIVE TDS CONCENTRATION AT VERNALIS BY DECADES, 1930-1969*

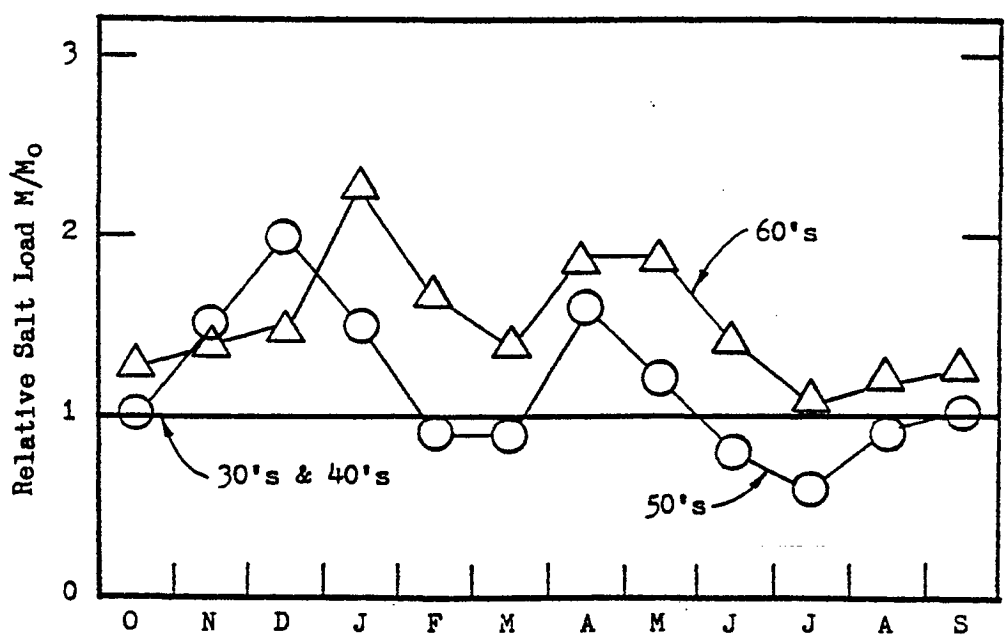

Figure VI-34 RELATIVE SALT LOAD AT VERNALIS BY DECADES, 1930-1969*

*Based on chloride load-flow relationships.

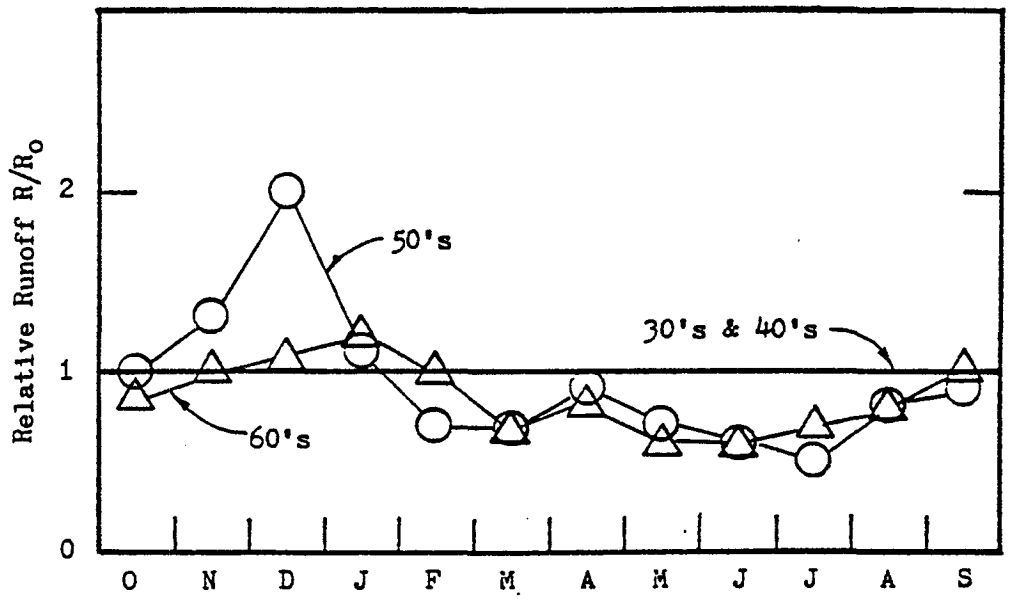

Figure VI-35 RELATIVE RUNOFF AT VERNALIS BY DECADES, 1930-1969

year, and a substantial chronological shift is evident. Loads are greater in the months of November, December, January, and April. The months of February, March, June, July, and August, show relative loads less than unity. For the 12-month period, loads in the 1950's were about 116 percent of the 1930's-1940's period. During the 1960's salt loads were much higher than those of the 1930's and 1940's. For the January through May period the monthly loads were as much as 240 percent of the 1930's and 1940's. Overall the salt loads for the 1960's were about 153 percent of the pre-1950 years. Figure VI-35 depicts the relative runoff at Vernalis in the same manner as figure VI-33 and VI-34. Both the 1950's and 1960's have relative runoffs generally less than unity. Exceptions are the months of November, December, and January; however, these increases are offset by reductions in the remaining months. The 1960's relative flow was about the same as the 1950's, while at the same time the relative load was greater than the 1950's. This supports the calculations indicating that an additional salt burden has been placed on the system.

Comparisons of quality changes by year classification is possible from the Mossdale data presented in tables VI-13, 14 and 15. These are summarized in tables VI-24 and VI-25, for the April through September period, and for the extremes of high TDS and corresponding flows experienced in each of the study years. Data are presented as averages for each of the several year classifications. It is noted that because of the scarcity of "Below Normal" years in the 1930-1944 period and "Above Normal" years in the 1952-1966 period averages are presented also for "Below and Above Normal" year classifications.

The summary of Mossdale results shown in table VI-24 for the April through September period shows clearly the impact of post-1952 upstream development of

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TABLE VI-24. MEAN TDS AND RUNOFF AT VERNALIS BY YEAR CLASSIFICATION, APRIL-SEPTEMBER PERIOD,

Year Class	Mean TDS MG/L		Mean Period Runoff AF x 1000	
	Pre*	Post**	Pre	Post
Dry	314	677	424	168
Below Normal	282	419	788	735
Above Normal	190	325	3046	1201
Combined: Below & Above Normal	203	396	2764	851
Wet	180	209	5469	3845
All Years	227	434	2344	1268

* 1930-1944, data from Table VI-14, based on Mossdale chlorides.

** 1952-1966, data from Tables VI-13 and VI-14.

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TABLE VI-25. EXTREME VALUES OF HIGH TDS AND LOW FLOWS AT VERNALIS BY YEAR CLASSIFICATION

Year Class	Maximum Monthly Mean TDS MG/L		Minimum Monthly Mean Flow AF x 1000	
	Pre*	Post**	Pre	Post
Dry	351	765	38.6	17.3
Below Normal	370	530	67.1	44.0
Above Normal	355	521	81.4	55.0
Combined: Below & Above Normal	357	528	79.6	46.8
Wet	363	364	123.0	96.6
All Years	354.8	558.2	71.7	48.9

* 1930-1944, data from Table VI-15, based on Mossdale chlorides

** 1952-1966, data from Table VI-15

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the San Joaquin Basin's water resources on both the quantity and quality of water reaching Vernalis. This effect is especially notable in the dry years, where a reduction of about 60 percent in the average April through September runoff corresponds to approximately 115 percent increase in average TDS--from 314 mg/L pre-1944 period to 677 mg/L post-1952 period. In the below and above normal years, the impact is similar, a reduction in average runoff of about 69 percent corresponds to an average increase in TDS of roughly 95 percent. In wet years, although flow reductions were substantial--about 30 percent of pre-1944 levels--the quality changes were minor, as would be expected. Considering all years, a reduction in runoff of 41 percent (959,000 acre-feet for the April-September period) corresponded to a 84 percent increase in TDS concentration in the runoff at Vernalis.

Comparisons of quality changes by year classification for the pre-1944 period and post-1952 period using load-flow regression data are presented in tables VI-26 and VI-27. Data summarized in those tables are found in tables VI-13, 18, and 19. The impact of upstream development is apparent in reduced flows and increased TDS concentration at Vernalis for all year types. Like results from the Mossdale method, the estimated April-September flow reductions are about 60 percent in the drier years and about 30 percent in the wet years. The loadflow regressions give an average TDS increase in dry years of 93 percent, in below and above normal years 69 percent, and in wet years 8 percent. Considering all years together, the degradation of quality amounted to an increase of 63 percent coupled with a 46 percent reduction in flow for the April-September period.

The same comparisons using the extreme TDS month is summarized in table VI-27.

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TABLE VI-26. MEAN TDS AND RUNOFF AT VERNALIS BY YEAR CLASSIFICATION, APRIL-SEPTEMBER PERIOD

Year class	Mean TDS mg/L		Mean period runoff, KAF	
	Pre*	Post**	Pre	Post
Dry	350	677	424	168
Below normal	278	419	788	735
Above normal	228	325	3046	1201
Combined Below normal & above normal	234	396	2764	851
Wet	194	209	5469	3845
All years	267	434	2344	1394

* 1930-1944, data from table VI-18 based on flow-load regression data.

** 1952-1966, data from table VI-13 and VI-14.

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TABLE VI-27. EXTREME VALUES OF HIGH TDS AND LOW FLOW AT VERNALIS BY YEAR CLASSIFICATION

Year Class	Maximum monthly mean TDS mg/L		Minimum monthly mean flow AF x 1000	
	Pre*	Post**	Pre	Post
Dry	490	765	35.8	17.3
Below normal	407	530	67.1	44.0
Above normal	398	521	77.5	55.0
Combined above & below normal	399	528	76.2	46.8
Wet	358	364	116.4	96.6
All years	424	561	68.1	48.9

* 1930-1944, data from table VI-19, based on load-flow regression data.

** 1952-1966, data from table VI-15.

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F. SUMMARY OF QUALITY IMPACTS

Generally, the water quality at Vernalis has deteriorated since the 1930's. How much degradation has occurred and what have been the principal causes, have been the topics of this chapter. In the analysis of data and interpretation of results, several methods have been employed, sometimes with differing results. The discussion that follows attempts to summarize results and reconcile differences wherever possible. In cases where the methods yield disparate results, ranges are given to include all estimates.

Changes that have occurred in the quality of water at Vernalis between the pre-1944 and post-1952 periods are summarized in tables VI-28 and VI-29. The tables present data derived from the records of mean monthly TDS at Vernalis (mg/L) given in tables VI-13, VI-14, and VI-18. Maximum and mean values are given for three periods--the maximum month, the April-September period and the entire water year--and for each type of year--dry, below normal, above normal and wet.

Data presented in the tables indicate that the TDS at Vernalis has increased in almost all categories listed. The greatest effect is shown in the drier years and the least in the wettest years. Table VI-30 is a composite of tables VI-28 and VI-29, showing the range of estimated impacts at Vernalis. Using the April-September period in a dry year as an example, the mean TDS increased somewhere between 327 and 363 mg/L from pre-1944 to post-1952 years. This increase corresponded to 93 to 116 percent of the pre-1944 period TDS.

As noted in previous discussion, the general deterioration in quality at Vernalis is identified both with reductions in flows along the main stem of the San Joaquin and increases in salt burden transferred to the river. When

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Table VI-28. SUMMARY OF IMPACTS ON QUALITY AT VERNALIS*
PRE-1944 AND POST-1952

YEAR TYPE & PERIOD	Total Dissolved Solids, mg/L PRE-1944		POST-1952		Percent Increase PRE-1944 to POST-1952	
	Max	Mean	Max	Mean	Max	Mean
DRY						
Max.month	444	387	941	765	112	98
April-Sept	383	314	840	677	119	116
Full Year	342	288	681	549	99	91
BELOW NORMAL						
Max.month	370	370	729	544	97	47
April-Sept	282	287	683	419	142	46
Full Year	282	261	502	364	78	40
ABOVE NORMAL						
Max.month	517	382	805	641	56	68
April-Sept	244	260	387	325	59	52
Full Year	269	233	489	394	82	69
WET						
Max.month	384	374	462	439	20	17
April-Sept	180	173	226	209	26	21
Full Year	224	197	252	237	13	20
ALL YEARS						
Max.month	517	381	941	584	82	53
April-Sept	383	239	840	433	119	81
Full Year	342	234	651	392	99	68

*BASED ON MOSSDALE DATA

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TABLE VI-29. SUMMARY OF IMPACTS ON QUALITY AT VERNALIS
PRE-1944 AND POST-1952

	Total dissolved solids, mg/L				Percent increase	
	PRE-1944		POST-1952		PRE-1944 to POST-1952	
Year type and period	Max	Mean	Max	Mean	Max	Mean
DRY						
Max month	616	490	941	765	53	56
Apr-Sept	453	350	840	677	85	93
Full year	374	310	681	549	82	77
BELOW NORMAL						
Max month	407	407	729	544	79	34
Apr-Sept	278	278	683	419	146	51
Full year	262	262	502	364	92	39
ABOVE NORMAL						
Max month	415	398	805	641	94	61
Apr-Sept	236	228	387	325	64	43
Full year	251	229	489	394	95	72
WET						
Max month	366	358	462	439	26	23
Apr-Sept	202	194	226	209	12	8
Full year	207	200	252	237	22	19
ALL YEARS						
Max month	616	424	941	588	53	39
Apr-Sept	453	267	840	434	85	63
Full year	372	254	681	383	82	51

* Based on load-flow regression data.

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TABLE VI-30. RANGE OF ESTIMATED IMPACTS* ON QUALITY AT VERNALIS (1930-1944) to (1952-1966)

Year type & period	Total dissolved solids, mg/L		Percent increase	
	Max	Mean	Max	Mean
DRY				
Max month	325 - 497	275 - 378	53 - 112	56 - 98
Apr-Sept	387 - 457	327 - 363	85 - 119	93 - 116
Full year	307 - 339	239 - 261	82 - 99	77 - 91
BELOW NORMAL				
Max month	322 - 359	137 - 174	79 - 97	34 - 47
Apr-Sept	401 - 405	132 - 141	142 - 146	46 - 51
Full year	220 - 240	102 - 103	78 - 92	39 - 40
ABOVE NORMAL				
Max month	288 - 390	243 - 259	56 - 94	61 - 68
Apr-Sept	143 - 151	65 - 97	59 - 64	25 - 43
Full year	220 - 238	161 - 165	82 - 95	69 - 72
WET				
Max month	78 - 96	65 - 81	20 - 26	17 - 23
Apr-Sept	24 - 46	15 - 36	12 - 26	8 - 21
Full year	45 - 59	37 - 40	22 - 31	19 - 20
ALL YEARS				
Max month	325 - 497	164 - 203	53 - 112	39 - 53
Apr-Sept	387 - 457	167 - 194	85 - 119	63 - 81
Full year	307 - 339	129 - 158	82 - 99	51 - 68

* Based on results from Mossdale data and load-flow regression data. See tables VI-28, VI-29.

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the total change in quality at Vernalis that has occurred between the two eriods is distributed between reduced flow and increased salt load, it is noted that the effect of increased salt load is becoming relatively more important in recent years. Tables VI-31 and VI-32 summarize the changes in total salt load that have occurred in the two decades 1950-59 and 1960-69 in relation to the period of 1930-49.

In the 1950's, the estimated increased in annual TDS load at Vernalis. In the 1960's the load increased 530 to 569 kilotons TDS per year. This increase between the 1950's and 1960's, a 50-56 percent jump, indicates the more recent impact on water quality at Vernalis. During the 1960's the average annual runoff at Vernalis was about 710,000 acre-feet lower than for the 1930-1949 period while the total TDS load actually increased.

In the 1950's the estimated increase in the April-September TDS load at Vernalis ranged from -18 to +21 kilotons TDS. In the 1960's the load increased +251 to 290 kilotons TDS per year. This increase, 44 to 54 percent of 1930-1949 is indicative also of more recent impacts on Vernalis water quality. During the 1960's the average April-September runoff at Vernalis was about 610 thousand acre-feet lower than in the 1930-1949 period.

A similar analysis based on chloride data summarized in table VI-10, indicates an overall increase in salt load (as chlorides) of about 0-35 percent in the post-1949 years depending on year classification, the dry and below normal years showing the greatest change.

Analysis of the sources of salt load contributing to the San Joaquin River, and which account for, in part, the increases noted at Vernalis, indicates that about 45 to 85 percent of the total load, depending somewhat on the

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Table VI-31. SUMMARY OF CHANGES IN TDS LOAD AT VERNALIS, 1930-1969

Month of Year	TDS Load, Tons x 10^3		
	1930-49 *	1950-59	1960-69
Oct	41	49	61
Nov	42	66	63
Dec	57	81	90
Jan	71	97	152
Feb	122	98	186
Mar	148	131	208
Apr	140	168	199
May	136	137	207
Jun	155	119	215
Jul	75	58	104
Aug	35	35	47
Sep	35	41	55
Apr-Sep	576	558	827
Percent change from 1930-49	0	-3	44
Year	1057	1080	1587
Percent Change from 1930-49	0	2	50

* Based on Mossdale chloride data

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TABLE VI-32. SUMMARY OF CHANGES IN TDS LOAD AT VERNALIS, 1930-1969

Month of year	TDS load, tons x 10^3		
	1930-49*	1950-59	1960-69
Oct	48	49	61
Nov	44	66	63
Dec	62	81	90
Jan	66	97	152
Feb	108	98	186
Mar	153	131	208
Apr	102	168	199
May	111	137	207
Jun	149	119	215
Jul	94	58	104
Aug	40	35	47
Sept	41	41	55
Apr-Sept	537	558	827
% Change from 1930-49	0	4	54
Year	1018	1080	1587
% Change from 1930-49	0	6	56

* Based on load-flow regression data.

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quality constituent considered and the year type, enters within upper San Joaquin River basin. The remaining fraction includes the contributions of the Tuolumne gas wells that have been the subject of efforts by the State of California to reduce point source salt accretions to the river, local drainage returns between Newman and Vernalis and runoff from the east side streams.

Table VI-33 is a summary of the results obtained from salt balances using chloride data for the four representative months of October, January, April, and July. The tabulated results show that virtually no change has occurred in the proportion of salt load contributed by the upper San Joaquin River basin. The table shows that the most apparent changes have taken place on the Tuolumne River and in "other" flows, the unidentified sources and sinks of salt load within the San Joaquin River basin.

Table VI-33 summarizes estimated impacts on the water quality of the San Joaquin River at Vernalis as determined by the two methods, one utilizing the Mossdale chloride data and the second based on chloride load-flow regressions. Data presented in the summary table were derived from various tables presented earlier in this chapter; specifically tables VI-9, 30, 31, 32, and 33 were utilized. Footnotes on table VI-34 describe the procedures used in calculation of the values given.

The effects of upstream development, both in the entire San Joaquin River basin and in the upper San Joaquin River basin as given in table VI-34, are outlined briefly for each year classification as follows:

Dry Years

In dry years the average TDS increase at Vernalis, resulting from development upstream after 1947, was estimated at about 350 mg/L for the April-September

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Table VI-33 PERCENT OF VERNALIS CHLORIDE LOAD AND THEIR ORIGINS*

	Upper San Joaquin River Basin %		"Others" %		Stanislaus River %		Tuolumne River %		Upper San Joaquin plus "others" %	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
DRY										
Apr-Sep	107	86	-67	-55	4	2	57	69	40	30
Full Year	72	71	-22	-28	3	2	47	56	50	43
BELOW NORMAL										
Apr-Sep	83	81	-28	-49	3	2	43	66	55	32
Full Year	61	67	-1	-21	3	2	38	52	59	46
ABOVE NORMAL										
Apr-Sep	59	63	17	1	2	3	23	35	75	63
Full Year	51	55	22	9	2	2	26	34	72	64
WET										
Apr-Sep	68	56	37	25	2	3	16	21	82	77
Full Year	47	49	31	25	2	2	21	26	78	73
ALL YEARS										
Apr-Sep	78	73	-11	-24	3	2	35	51	63	48
Full Year	58	62	7	-7	2	2	33	44	65	55

*Based on load-flow regression salt balances.
Pre refers to 1930-1944 period with 5-Dry, 1-B.Norm., 7-A.Norm., 2-Wet
Post refers to 1952-1966 period with 4-Dry, 5-B.Norm., 2-A.Norm., 4-Wet

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TABLE VI-34. SUMMARY OF ESTIMATED IMPACTS ON THE QUALITY OF THE SAN JOAQUIN RIVER AT VERNALIS

1	2	3	4	5	6	7	8
	Total increase in TDS mg/L at Vernalis	Increase in TDS mg/L due to decreased flow		Increase in total salt load			
				Vernalis total		Increased caused by CVP	
Year Type & Period		Percent of Pre-CVP	Percent due to CVP	Increase Tons x 10^3	% of Pre-CVP	Increase Tons x 10^3	% of Pre-CVP
DRY							
Apr-Sep	327 - 363	84 - 100	1.8 - 2.1	68	49	58	42
Full Year	239 - 261	22 - 26	6.3 - 7.4	143	55	102	39
BELOW NORMAL							
Apr-Sep	132 - 141	100	36	95	57	77	46
Full year	102 - 103	100	45	193	62	129	41
ABOVE NORMAL							
Apr-Sep	65 - 97	100	37	33	39	21	25
Full year	161 - 165	100	59	72	46	40	26
WET							
Apr-Sep	15 - 36	81 - 100	45 - 55	76	46	43	26
Full year	37 - 40	65 - 73	44 - 50	143	46	70	23
ALL YEARS							
Apr-Sep	167 - 194	90 - 100	30 - 33	73	49	54	36
Full year	129 - 158	70 - 73	37 - 39	147	53	91	33

Col. 2 - See Table VI-30.
3 - Obtained by assuming no change in salt load and flow reduction TDS=50 mg/L.
4 - Col 3 x ratio of upper San Joaquin flow reductions to total San Joaquin flow reduction.
5 - Obtained by pro-rating average TDS load increase between 1960's and 1930-49 period (Tables VI-31 and 32) in proportion to salt load increase in each year type (Table VI-9) and number of years of each year type in 1950-69 period.
6 - Col 5 salt load for 1930-49 period x proportion of years in each class.
7 - Col 5 x proportion of total chloride load contributed by upper San Joaquin basin (Table VI-33)
8 - Col 7 x proportion of years in each year class.

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Table VI-33 PERCENT OF VERNALIS CHLORIDE LOAD AND THEIR ORIGINS*

	Upper San Joaquin River Basin %		"Others" %		Stanislaus River %		Tuolumne River %		Upper San Joaquin plus "others" %	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
DRY										
Apr-Sep	107	86	-67	-55	4	2	57	69	40	30
Full Year	72	71	-22	-28	3	2	47	56	50	43
BELOW NORMAL										
Apr-Sep	83	81	-28	-49	3	2	43	66	55	32
Full Year	61	67	-1	-21	3	2	38	52	59	46
ABOVE NORMAL										
Apr-Sep	59	63	17	1	2	3	23	35	75	63
Full Year	51	55	22	9	2	2	26	34	72	64
WET										
Apr-Sep	68	56	37	25	2	3	16	21	82	77
Full Year	47	49	31	25	2	2	21	26	78	73
ALL YEARS										
Apr-Sep	78	73	-11	-24	3	2	35	51	63	48
Full Year	58	62	7	-7	2	2	33	44	65	55

*Based on load-flow regression salt balances.
Pre refers to 1930-1944 period with 5-Dry, 1-B.Norm., 7-A.Norm., 2-Wet
Post refers to 1952-1966 period with 4-Dry, 5-B.Norm., 2-A.Norm., 4-Wet

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TABLE VI-34. SUMMARY OF ESTIMATED IMPACTS ON THE QUALITY OF THE SAN JOAQUIN RIVER AT VERNALIS

1	2	3	4	5	6	7	8
	Total increase in TDS mg/L at Vernalis	Increase in TDS mg/L due to decreased flow		Increase in total salt load			
				Vernalis total		Increased caused by CVP	
Year Type & Period		Percent of Pre-CVP	Percent due to CVP	Increase Tons x 10^3	% of Pre-CVP	Increase Tons x 10^3	% of Pre-CVP
DRY							
Apr-Sep	327 - 363	84 - 100	1.8 - 2.1	68	49	58	42
Full Year	239 - 261	22 - 26	6.3 - 7.4	143	55	102	39
BELOW NORMAL							
Apr-Sep	132 - 141	100	36	95	57	77	46
Full year	102 - 103	100	45	193	62	129	41
ABOVE NORMAL							
Apr-Sep	65 - 97	100	37	33	39	21	25
Full year	161 - 165	100	59	72	46	40	26
WET							
Apr-Sep	15 - 36	81 - 100	45 - 55	76	46	43	26
Full year	37 - 40	65 - 73	44 - 50	143	46	70	23
ALL YEARS							
Apr-Sep	167 - 194	90 - 100	30 - 33	73	49	54	36
Full year	129 - 158	70 - 73	37 - 39	147	53	91	33

Col. 2 - See Table VI-30.
3 - Obtained by assuming no change in salt load and flow reduction TDS=50 mg/L.
4 - Col 3 x ratio of upper San Joaquin flow reductions to total San Joaquin flow reduction.
5 - Obtained by pro-rating average TDS load increase between 1960's and 1930-49 period (Tables VI-31 and 32) in proportion to salt load increase in each year type (Table VI-9) and number of years of each year type in 1950-69 period.
6 - Col 5 salt load for 1930-49 period x proportion of years in each class.
7 - Col 5 x proportion of total chloride load contributed by upper San Joaquin basin (Table VI-33)
8 - Col 7 x proportion of years in each year class.

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period and 250 mg/L for the full year. Of this increase the proportion due to reduced flow from all sources was 90 percent in the April-September period, but only 25 percent for the entire year. The impact of the CVP on water quality (as expressed by changes in TDS) in dry years, caused by flow reductions in the upper San Joaquin basin, was relatively small, only 2 percent in the April-September period and 7 percent for the entire year.

Salt loads at Vernalis in dry years were estimated to have increased in the period subsequent to 1947, by 68,000 tons in the April-September period and by 143,000 tons for the whole year. These increases corresponded to roughly 49 percent and 55 percent, respectively, of the pre-1944 TDS loads at Vernalis. The CVP salt load impact in dry years was estimated at 58,000 tons in the April-September period and 102,000 tons for the full year, corresponding to 42 percent and 39 percent increases, respectively, of pre-1944 salt loads at Vernalis.

Below Normal Years

In below normal years, the increase in average TDS concentration at Vernalis between the pre- and post-CVP periods was estimated at about 135 mg/L for the April-September period and slightly more than 100 mg/L for the full year. Virtually all of this increase is attributed to reductions in flow from all sources. The impact due to reduced flow attributed to the CVP was about 36 percent in the April-September period and 45 percent for the full year.

TDS load increases in below normal years subsequent to 1947 are estimated at 95,000 tons for the April-September period and 193,000 tons for the year. Of this increase, 77,000 tons and 129,000 tons, respectively, were estimated to have been derived from the upper San Joaquin basin. The proportionate impact

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of the CVP on salt loads at Vernalis was largest for below normal years, 46 percent of the total increase at Vernalis in the April-September period and 41 percent for the whole year.

Above Normal Years

In above normal years the average TDS increase at Vernalis, resulting from development upstream after 1947, was estimated at about 80 mg/L for the April-September period and 165 mg/L for the full year. Of this increase, the proportion due to reduced flow from all sources was 100 percent in both the April-September and full year periods. The impact of the CVP on water quality (as expressed by changes in TDS) in above normal years, caused by flow reductions in the upper San Joaqin basin, was 37 percent in the April-September period and 59 percent for the entire year.

Salt loads at Vernalis in above normal years were estimated to have increased in the period subsequent to 1947 by 33,000 tons in the April-September period and by 72,000 tons for the entire year. These increases correspond to roughly 39 percent and 46 percent, respectively, of pre-1944 TDS loads at Vernalis. The CVP salt load impact in above normal years was estimated at 21,000 tons in the April-September period and 40,000 tons for the full year, corresponding to 25 and 26 percent increases respectively, in pre-1944 salt loads at Vernalis.

Wet Years

In wet years, the increase in average TDS concentration at Vernalis between the pre- and post-CVP periods was estimated at about 25 mg/L for the April-September period and about 40 mg/L for the full year. Of this increase the proportion due to reduced flow from all sources was 90 percent in the April-September period, and 70 percent for the entire year. The impact due to

reduced flow attributed to the CVP was about 50 percent for both the April-September and full year periods.

TDS load increases in wet years subsequent to 1947 are estimated at 76,000 tons for the April-September period and 143,000 tons for the year. Of this increase, 43,000 tons and 70,000 tons, respectively, were estimated to have been derived from the Upper San Joaquin Basin. The proportionate impact of the CVP on salt loads at Vernalis was 26 percent of the total increase at Vernalis in the April-September period and 23 percent for the full year.

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CHAPTER VII

EFFECTS OF OPERATION OF CVP AND SWP EXPORTS PUMPS NEAR TRACY

CHANNEL DEPTHS AND CROSS SECTIONS

The geometry of the channels within the southern Delta was studied to determine whether the channel cross sections and bottom elevations have changed since the 1930's in such a way as to alter water circulation patterns and water depths to a degree that modifies the southern Delta water supply.

Channel Surveys

Prior to 1913, most existing channels within the South Delta Water Agency were well defined, due in part to the sidedraft clamshell dredge which was used over many years to construct the levee system within the South Delta and to keep channels clean of sediment. Since 1913 most of the channels in the South Delta have been surveyed several times. The results of surveys are summarized if figure VII-1.

Available survey data include:

Date of survey	Channels surveyed	Source of data
1913	Old River - Middle River to Victoria Canal Middle River - Old River to Victoria Canal Grant Line and Fabian Canals	USCE
1933-34	All SDWA channels	USC&GS
1957	Grant Line and Fabian Canals, plus Salmon Slough and Paradise Cut	DWR
1965	Grant Line and Fabian Canals	USCE
1973	Old River-San Joaquin River to Victoria Canal Middle River-Old River to Victoria Canal Grant Line and Fabian Canals	DWR
1976	San Joaquin River-Vernalis to Mossdale	DWR

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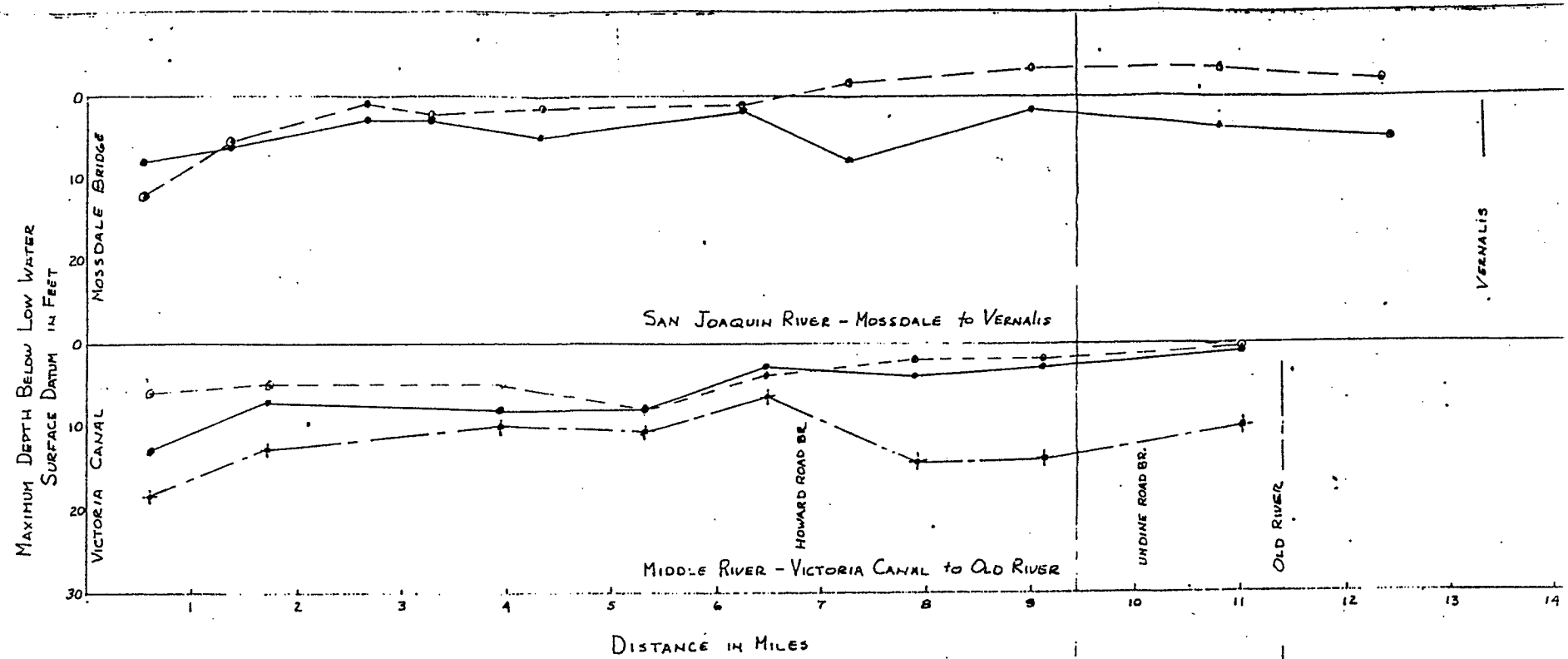

SOUTH DELTA CHANNEL DEPTH SURVEYS

WATER AND POWER RESOURCES SER

DATED APRIL 1980 FIGURE
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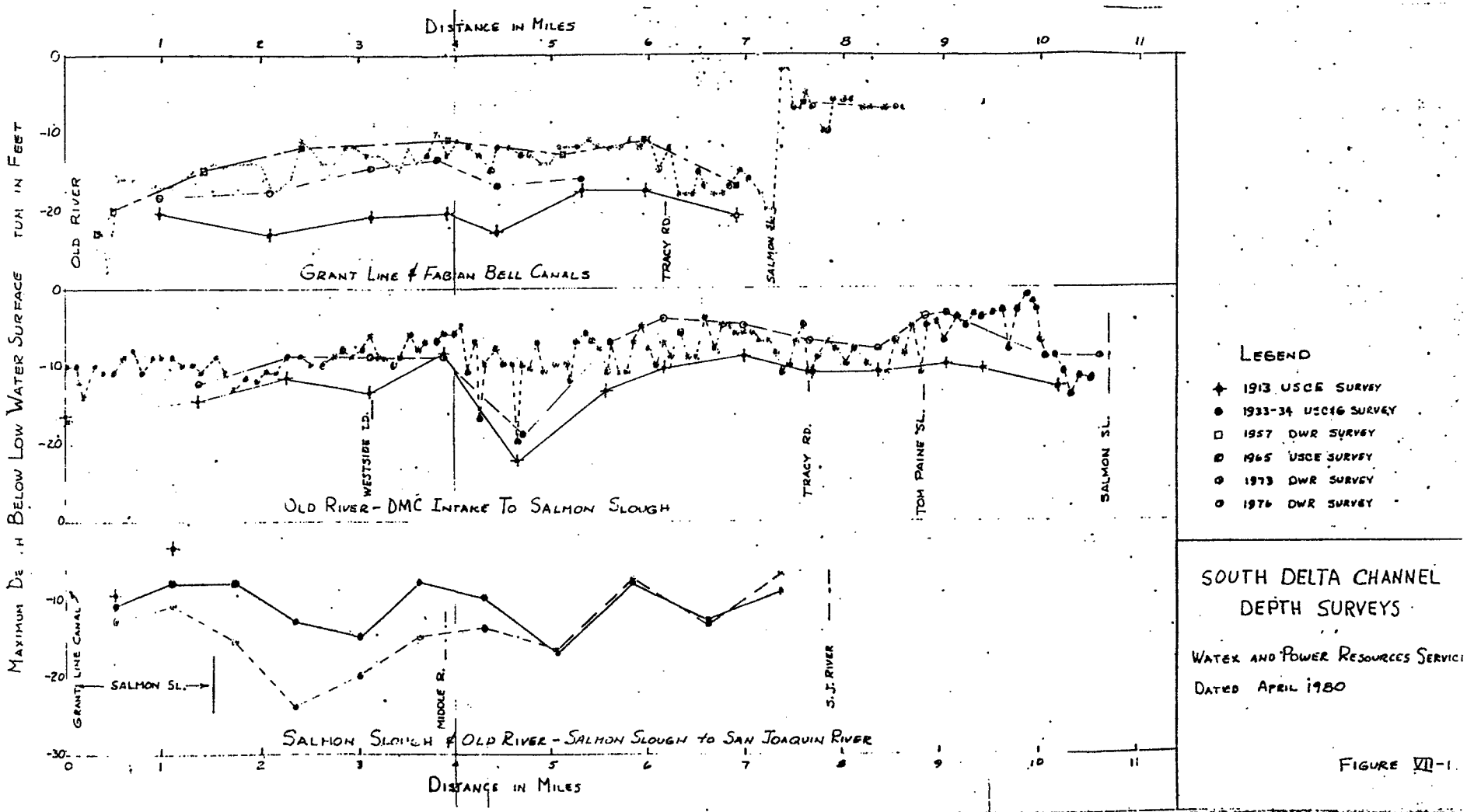

SOUTH DELTA CHANNEL DEPTH SURVEYS

Water and Power Resources Service

Dated April 1980

Figure VII-1

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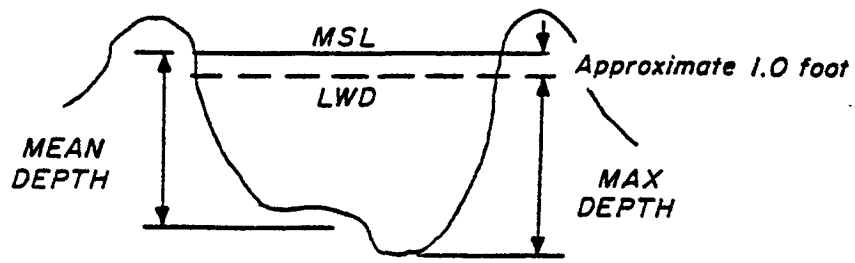
reach of Old River between Clifton Court and the San Joaquin River is presented in figure VII-2.

The diagram below illustrates the differences between average and maximum depths and between LWD and MSL.



Bottom elevations of the major channels were further analyzed in relationship to the survey dates and the initial operations of the Federal and State pumping plants.

San Joaquin River--Vernalis to Mossdale Bridge. Most of this reach has aggraded since the 1933-34 surveys. By 1976 the elevation of the stream bottom had risen 0.5 to 9.5 feet above the 1933-34 levels, with an average increase of about 4.0 feet. The bottom elevation of the reach from Vernalis to a point approximately 4.8 miles north of the San Joaquin River club varied from 2 to 7 feet below the LWD in 1933 and varied from 1.5 to 3.5 feet above LWD in 1976. This aggradation generally causes a corresponding reduction in water depth.

Old River, San Joaquin River to and including Salmon Slough. In 1973, streambed elevations of this 7.5-mile reach were equal to or below that measured in the 1933-34 survey. The 1973 elevations ranged from 8 to 24 feet below LWD with an average of about 14 feet; the 1933-34 elevations varied from 8 to 17 feet with an average of about 10 feet. Therefore, during the intervening

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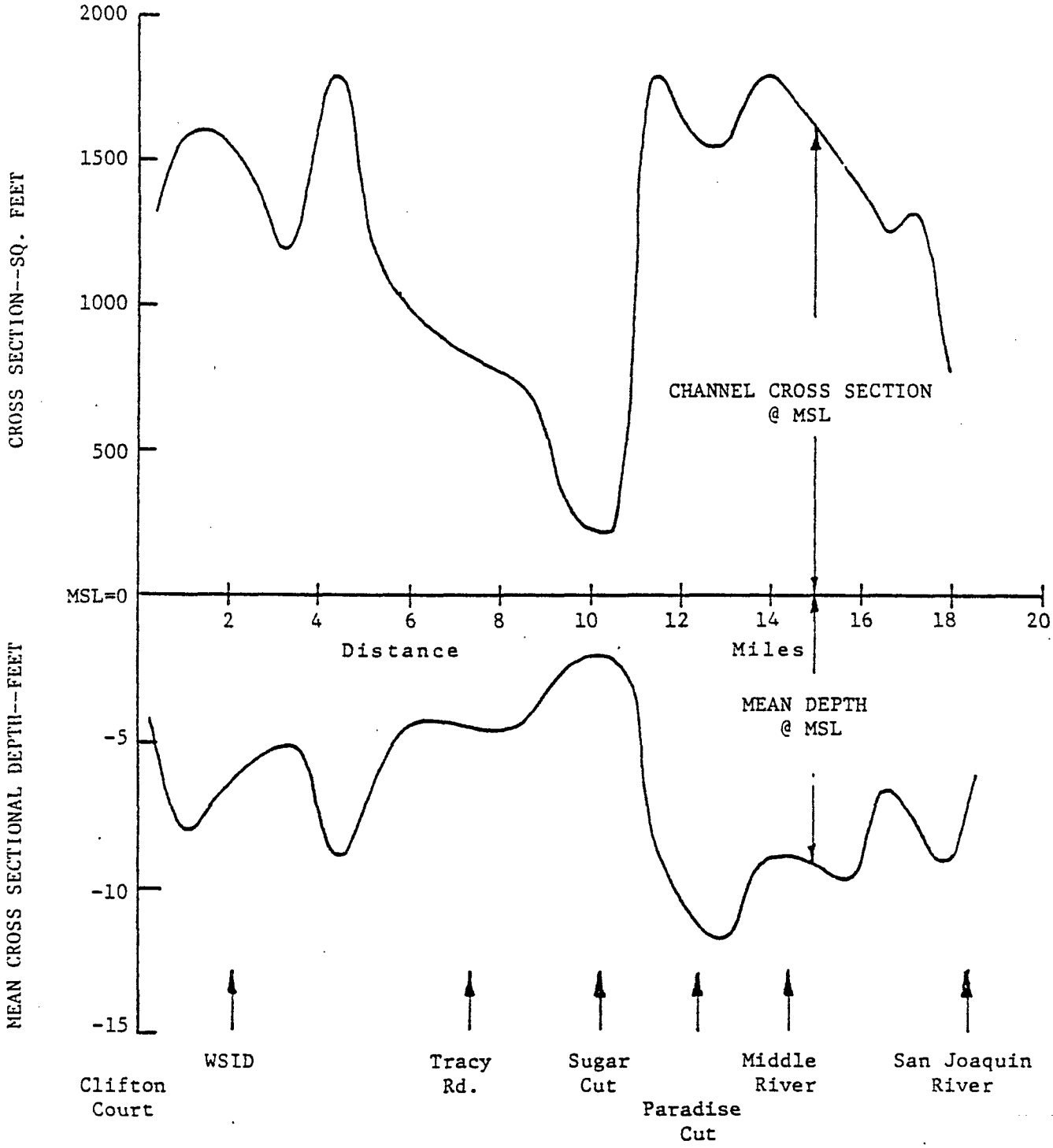

Figure VII-2 CHANNEL PROPERTIES, OLD RIVER, CLIFTON COURT TO SAN JOAQUIN RIVER
(Data from 1973 DWR Survey, Datum is Mean Sea Level)

40 years, the channel had degraded an average of 4 feet, but with very little change in the upstream 1/3 of the reach.

Old River, to Salmon Slough to Delta-Mendota Canal Intake Channel. Bottom elevations of this 11-mile channel averaged 12 feet in 1913, with a range of 9 to 22 feet below LWD. The channel had displayed a 3.5-foot aggradation by the 1933-34 survey. However, the channel had not had any further significant change by the 1973 survey. The 1933-34 and the 1973 surveys each indicated a similar channel restriction near the bifurcation of Old River and Tom Paine Slough. Maximum cross sectional depths measured in 1973 through the 4-mile restricted section averaged about 6 feet with a minimum of 4 feet with reference to LWD elevation. The mean elevation of the bottom of the most restricted area is about 2 feet below mean sea level as shown in figure VII-2. Where as the maximum depth below LWD was about 3.7 feet.

Grant Line and Fabian Canals--In 1913 the elevation of these paralleling 7-mile channels averaged more than 20 feet below LWD. By 1957 they had aggraded about 8 feet with an average depth of 12 feet below LWD, remaining at that depth until after the 1965 survey. By the 1973 survey, however, the channels had degraded to an average of about 16 feet below LWD. The channel depths could have been influenced by maintenance dredging and/or increases in channel velocities due to operation of Clifton Court Forebay. Flow restrictions have not been apparent in these channels.

Middle River--Old River to Victoria Canal--In 1913, the channel elevation of this 11.5-mile reach of Middle River varied between 7 and 18 feet below LWD with an average of about 12 feet below LWD. By the 1933-34 survey, channel bed had aggraded to an average of about 6 feet below LWD elevation. Further

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aggradation was shown by the 1973 survey to an average depth of 4 feet below LWD elevation. However, the 6-mile reach directly north of Old River has only aggraded about 0.5 feet since the 1933-34 survey. Both the 1933-34 and 1973 surveys recorded a restriction 0.4 of a mile north of the head of Middle River with maximum depths of 1.0 in 1933-34 and 0.5 feet in 1973, below LWD elevation.

Calculated Hydraulic Resistance in Old River

The resistance to flow, assuming present channel geometry in Old River, was studied as a basis for examination of the effect of reduced water levels on water circulation through this channel.

Using channel cross section data obtained by the DWR in 1973, the hydraulic resistance characteristics were estimated for some 22 channel segments of Old River between Clifton Court and the main stem of the San Joaquin River. It can be shown by open channel flow hydraulics that resistance, the relationship between head loss and channel discharge, is proportional to the square of channel width and the 10/3 power of the mean depth. In essence, this means that a narrow, shallow channel greatly restricts flow--much more dramatically than might at first appear to be the case by inspection in the field. For example, simply reducing channel width and depth by one-half each, thereby reducing the effective area to one-quarter, increases hydraulic resistance for the same length and roughness more than 40 times. These effects are especially evident in the central section of Old River in the vicinity of Tom Paine Slough where mean channel depths below mean sea level average less than 3 feet and widths are less than 100 feet.

The channel cross sections and depths along Old River are illustrated graphically in figure VII-2. In figure VII-3 the cumulative hydraulic resistance

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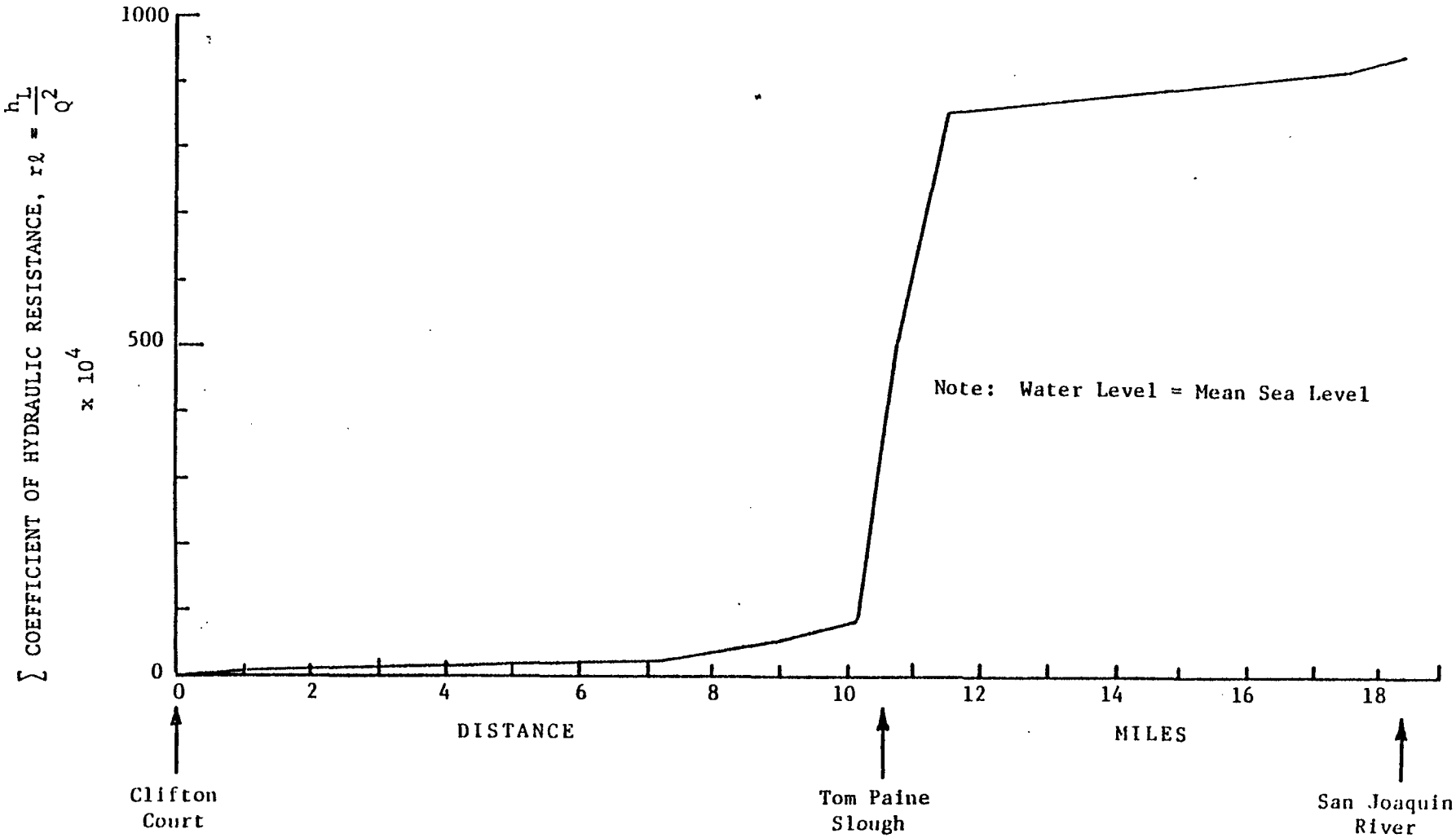

Figure VII-3 CUMULATIVE HYDRAULIC RESISTANCE IN OLD RIVER, CLIFTON COURT TO SAN JOAQUIN RIVER

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to flow is plotted for the entire channel from Clifton Court to the San Joaquin River. The same data are visually keyed to a partial map of Old River in figure VII-4. It is noted that most of the effect, about 90 percent of the total, is concentrated in a short section about 2 miles long in the vicinity of Tom Paine Slough. This restriction was evident during the 1933-34 channel survey. Obviously, this area controls the rate of flow in an east-west direction through Old River. Actually, it forces the largest proportion of the east to west flow through Grant Line and Fabian-Bell Canals rather than through the westerly section of Old River.

Sediment Movement

In 1950, the USBR improved the operation of the Delta-Mendota Canal intake channel by dredging the Old River Channel to a minus 17-foot elevation from the Delta-Mendota Canal headworks downstream to approximately Grant Line Canal. By 1969 the dredged channel was nearly obliterated by sediment which continued to move into the Delta-Mendota Canal Intake Channel. The Old River Channel was dredged again in 1969 and in 1974. Another example of sediment movement is the accumulation of 60,000 cubic yards of sediment in Clifton Court Forebay during the first 4 years of its operation.

During the same period a large but unestimated amount of sediment was pumped into the Delta-Mendota Canal as suspended load and deposited within the canal, O'Neill Forebay and Mendota Pool. The available suspended solids data for both the DMC and State Aqueduct and vicinity are located in STORET, a Federal data storage system, and summarized below for the period of record:

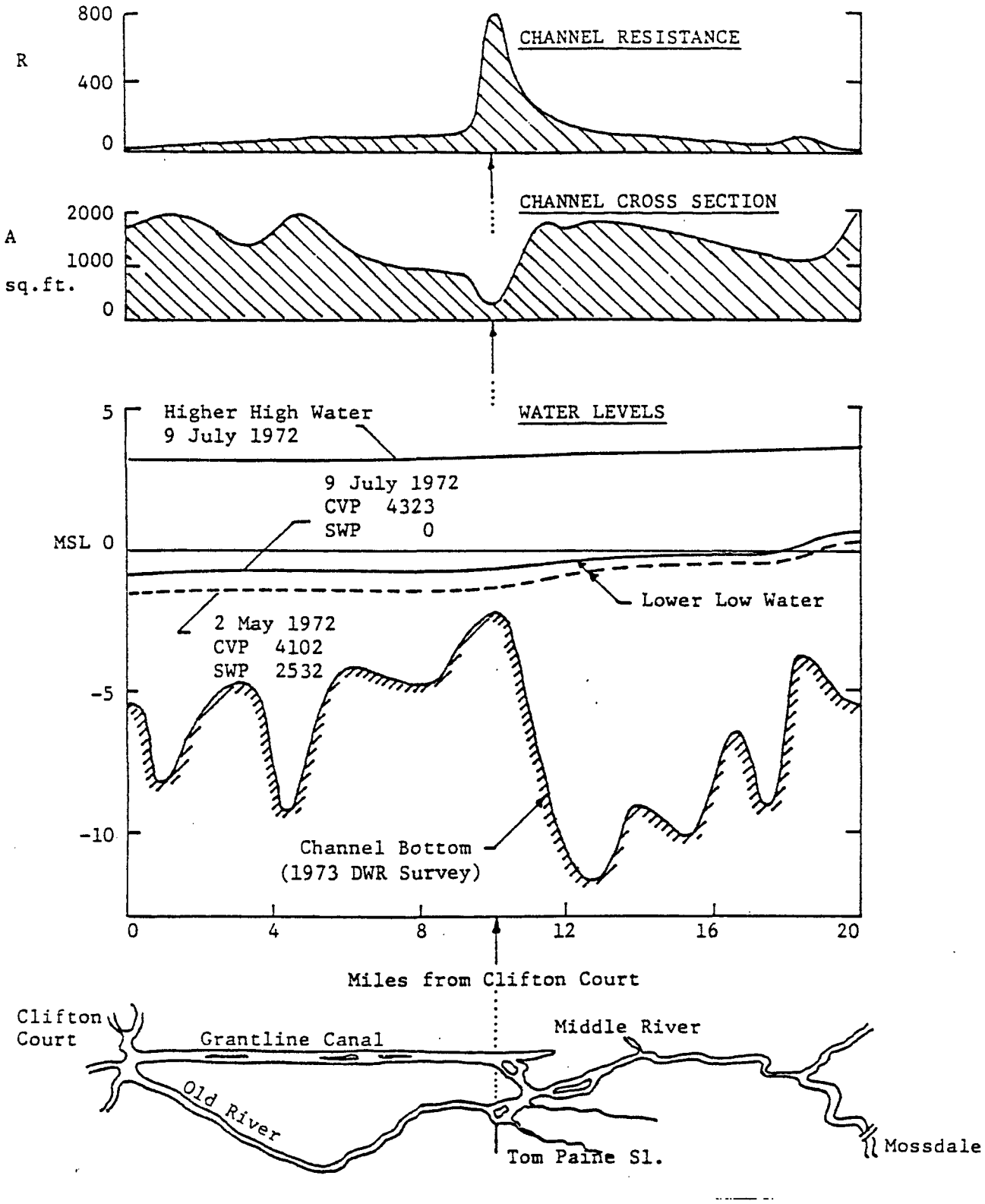

Figure VII-4 WATER LEVELS AND CHANNEL CHARACTERISTICS
OLD RIVER--SOUTH DELTA

Stations	Period of record	Average total suspended solids mg/L	pounds/acre-foot
DMC near Head	1973 - 1974	42.0	115
Delta Pumping Plant Headworks	1973 - 1979	21.3	58
Clifton Court	1973 - 1979	41.6	114
Old River at Mouth of Clifton Court Intake	1973 - 1974	44.1	120
Old River at Mossdale Bridge	1973 - 1978	48.0	123
Old River opposite Rancho Del Rio (near Rock Slough)	1973 - 1979	23.0	63

The Service and the Department of Water Resources established a Scour Monitoring Program primarily in Old and Middle Rivers north of the pumps to identify any channel scouring. The Department makes soundings repetitively at selected cross sections and the Service makes an annual aerophotographic survey of channels contiguous to the export pumps. Results indicate some degradation and aggradation at the selected cross sections north of the pumping plants, but no overall erosion or scour patterns. There are no stations east of Tracy Road in the South Delta Water Agency in the program.

IMPACT OF EXPORT PUMPS ON SOUTHERN DELTA WATER LEVELS, WATER DEPTHS, AND WATER QUALITY

Impact of Export Pumping on Water Levels and Water Depths

Any diversion from the Delta, including export pumping, lowers the water levels to some distance from the point of diversion, and the lowering of level is superimposed on whatever level would otherwise result from the combination of tides and net advective or downstream flows. The effect of large

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diversions from Delta channels is a depression in channel water surface which provides the gradient for the movement of water in all connecting channels toward the pumps. The distribution of flow and the water level drawdown among connecting channels is a function of channel geometry, roughness, pumping rate and in the instance of the SDWA channels, the flows in the San Joaquin River. A generalized impact of operating the CVP and SWP export pumps is a reduction of water levels and a modification of channel flows in the southern Delta.

The Clifton Court Forebay was incorporated into the SWP primarily to allow the use of offpeak power to pump water into the State Aqueduct and to prevent channel scouring prior to the creation of a Delta transfer facility.

Water level data are available in considerable detail at a number of stations throughout the Delta, including nine stations within the southern Delta. Since the drawdown of water level by the export pumps is superimposed on the water level fluctuations that would otherwise occur, two approaches have been used to determine the degree and spatial extent of the drawdown caused by the export pumps. These methods of determination include field tests and mathematical modeling.

Field tests--Steady export pumping field tests were made in May and August of 1968 wherein levels were measured at high and low export pumping rates with other conditions substantially the same. These tests were precipitated by concerns that export pumping was a contributing cause of reductions in water level such that the operation of agricultural pumps in Tom Paine Slough and in the southern portion of Middle River was restricted during low tide, and siphons around Victoria Island were losing prime. Reductions in pump capacity due to low water levels were also reported at the Westside Irrigation

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District intake on Old River south of Fabian Tract. The test evaluations were limited to low tide levels which were considered by the project operators to represent the periods when steady export pumping has the maximum effect on southern Delta water supply. However, the reduction in channel water supply is also influenced by the reduction in tidal prism upstream from the export pumps and this is related to water level reductions at all levels of tide.

The flows in the San Joaquin River near Vernalis were about 700 and 900 ft^3/s for the May and August testing period, respectively.

These 1968 tests are described and the results summarized in two cooperative reports by DWR and the USBR, both titled "Summary of Effect of Export Pumping on Water Levels in the Southern Delta." One report describes the May 25-30, 1968 tests and was issued in July 1968. The other report describes the August 29 to September 9, 1968 tests and was issued in December 1968. Results of these tests indicated that steady export pumping at the rates observed in the tests lowered the lower low tide level at Clifton Court by 0.07 to 0.08 foot for each 1,000 ft^3/s of export pumping.

The effects of water level depression due to State and Federal export pumping extends northward and eastward from the points of diversion. The 1968 test results in vicinity of Clifton Court, after correction by a constant amount for the normal tidal fluctuation at Antioch (assumed to be outside of the influence of the pumps), are presented in table VII-1.

The general effect of export pumping is to reduce local water levels, creating a gradient toward the point of diversion and redistributing flows in the principal channels of the southern Delta. Depending on the level of export and rate of inflow to the Delta near Vernalis, the effect is sometimes to

TABLE VII-1

1968 PUMP TESTS RESULTS

Stations	1 May Test 6725 to 1950 ft^3/s Differential ($4775\ ft^3/s$) Water Level Depression Feet	Ft/1000 ft^3/s	2 Aug/Sep Test 6934 to 800 ft^3/s Differential ($6134\ ft^3/s$) Water Level Depression Feet	Ft/1000 ft^3/s	3 Difference in water level depression between pump tests Col. 1 Col. 2 Feet
Old River at Clifton Court	0.33	0.07	0.47	0.08	0.13
Old River at Tracy Road	0.30	0.063	0.40	0.065	0.10
Tom Paine Slough above Mouth	0.29	0.06	0.35	0.06	0.06
Grant Line at Tracy Road	0.30	0.06	0.38	0.06	0.08
Middle River at Bacon Island	0.12	0.03	0.10	0.02	-0.02
San Joaquin River at Mossdale	0.14	0.03	--	--	--
San Joaquin River at Brant Bridge	0.16	0.03	0.12	0.02	-0.04
Old River near Byron	0.29	0.06	0.32	0.05	0.03
Old River near Rock Slough	0.08	0.02	0.12	0.02	0.04
Middle River at Borden Hwy.	0.29	0.06	0.30	0.05	0.01
Rock Slough at CCC Intake	0.15	0.03	0.14	0.02	-0.01

1/ This column illustrates that with an increase in diversion rate of about 1,400 ft^3/s the water level depression either decreased or increased only slightly at stations beyond Tom Paine Slough. This is indicative of the significance of pumping impact during the tests at these outlying stations.

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reverse the net flow downstream of the bifurcation of the San Joaquin and Old Rivers.

Another examination of recorded water levels was made for the June 14-30, 1972 period. Dr. G. T. Orlob's November 15, 1978 memorandum to the SDWA Board examined the hydraulic depression created by the export pumps and the gradient toward the export pumps along various channels during this period. Table VII-2 and figure VII-5 are taken from pages 8 and 10 of that memorandum. Table VII-2 shows the drawdown of HHW indicated for various dates and export rates. The period of June 22-25 was used to develop figure VII-5. During this period only the CVP steady export pumping was being made. Figure VII-5 shows the difference between Bacon Island tide levels and Clifton ferry tide levels as a function of CVP export rates. The figure also indicates a high tide level depression at Clifton Court of 0.1 foot for each 1,000 ft^3/s of steady export pumping.

Data collected in 1977 was used by the DWR to compare two 15-day periods with markedly different export rates and with other pertinent conditions only moderately different (see table VII-3). The period October 17-31, 1977 included an average export of about 300 ft^3/s and a San Joaquin River flow at Vernalis of about 250 ft^3/s. The period December 17-31, 1977 included an average export rate of about 9,400 ft^3/s and a San Joaquin River flow at Vernalis of 470 to 600 ft^3/s. Table VII-4 compares the differences in the 15 day means of each tidal phase between the selected control station at Rock Slough and stations in the South Delta for the two periods. About 5,800 ft^3/s of this average export rate was by the SWP which diverted at high tide. Therefore, the differences in water level depression near Clifton Court was greatest during the high tidal phase. The comparison between the October and December

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TABLE VII-2

EXAMPLE OF TIDAL ELEVATION DATA
FOR SOUTH DELTA - JUNE 1972

Date	Export, ft^3/s		HHW, feet MSL		ΔH, feet
	SWP	CVP	Bacon Island	Clifton Ferry	
6-16-72	2109	4191	2.79	1.67	-1.12
6-17-72	2090	4196	2.34	1.18	-1.16
6-18-72	2382	4204	2.81	1.56	-1.25
6-19-72	2331	4180	3.45	2.28	-1.17
6-20-72	2411	4233	3.42	2.22	-1.20
6-21-72 1/	2362	3561	3.39	1.85	-1.54
6-22-72	0	2558	2.93	2.51	-0.42
6-23-72	0	1173	3.46	3.25	-0.21
6-24-72	0	923	3.25	3.07	-0.18
6-25-72	0	926	3.45	3.28	-0.17
6-26-72	487	947	3.69	3.52	-0.17
6-27-72	911	968	3.68	3.37	-0.31
6-28-72	945	965	3.52	3.17	-0.35
6-29-72	1564	963	3.35	2.98	-0.37
6-30-72	1682	1041	2.98	2.34	-0.64
6-30-72	1682	1041	3.10	2.38	-0.72

1/ Andrus and Brannon Islands were filling due to a levee failure June 21 at about 0030. The effect on the tidal elevation at Bacon Island is indicated in figure VII-6, where a small depression in the water level curve is noted for about an hour following the break. It may be expected that this effect would have had only a minor influence in the water levels in the Southern Delta.

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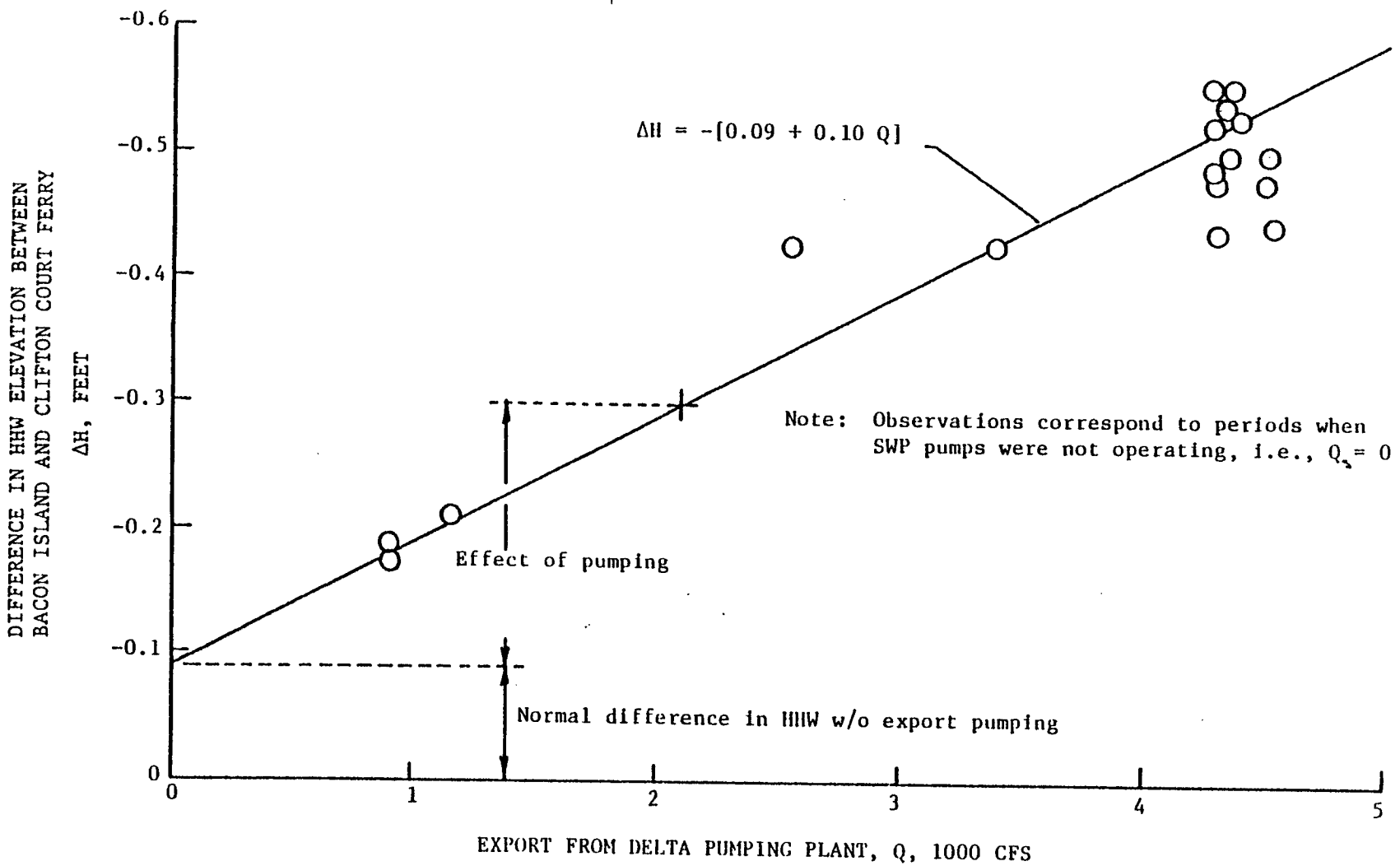

Figure VII-5 DEPRESSION IN HWL AT CLIFTON COURT RELATIVE TO MIDDLE RIVER AT BACON ISLAND AS A RESULT OF CVP EXPORT PUMPING AT TRACY

TABLE VII-3

CLIFTON COURT FOREBAY

Daily Operation of Gates

Month October, 1977

DATE	TIME OPENED	TIME CLOSED	DAILY AMOUNT OF INFLOW IN ACRE-FEET
17			0
18	1010	1325	198
19	1800	1848	99
20	2000	2050	99
21	1311	1625	595
22	1733	2000	595
23			0
24			0
25	1041	1217	298
26			0
27			0
28	0842	1000	298
29	0855	0945	298
30	0853	1012	298
31	1015	1250	1,388

Month December, 19 77

DATE	TIME OPENED	TIME CLOSED	DAILY AMOUNT OF INFLOW IN ACRE-FEET
17	0016		13,231
18	0807 2204	0430 1845	10,468
19	0840 2325	0617 1836	10,163
20		2007	11,615
21	0005	2050	8,866
22	0015 1120	0740 1645	9,332
23	0723	1640	7,735
24	0219 0910	0710 1905	10,897
25	0300	2153	13,095
26	0330	2200	12,473
27	0330	2200	11,974
28	0445		11,931
29	0517	0005	12,083
30	0530	0042	11,382
31	0555	0021	10,963

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TABLE VII-4

EXPORT EFFECTS ON TIDE STAGES[1/]

Delta Tide Stations	Tidal Stage	15 Day Mean Tidal Differences between Old River at Rock Slough and indicated locations — 1977 Oct. 17-31 296 ft^3/s[2/]	1977 Dec. 17-31 9,368 ft^3/s[2/]
1. Old River near Byron	HH	0.10	0.55
	LH	0.10	0.49
	HL	0.16	0.41
	LL	0.10	0.23
2. Middle River at Borden Hwy.	HH	0.02	0.52
	LH	0.03	0.44
	HL	0.10	0.36
	LL	0.06	0.18
3. Old River at Clifton Court Ferry	HH	0.04	1.08
	LH	0.06	0.95
	HL	0.17	0.47
	LL	0.09	0.32
4. Grantline Canal at Tracy Road Bridge	HH	0.12	1.04
	LH	0.12	0.88
	HL	-0.04	0.30
	LL	-0.30	-0.07
5. Middle River at Mowry Bridge	HH	-0.13	0.55
	LH	-0.11	0.42
	HL	-0.31	0.00
	LL	-0.67	-0.60
6. Old River near Tracy Road Bridge	HH	0.25	1.20
	LH	0.62	0.99
	HL	-0.55	0.08
	LL	-0.93	-0.61
7. Tom Paine Slough above Mouth	HH	0.13	1.05
	LH	0.13	0.88
	HL	-0.12	-0.30
	LL	-0.32	-0.13
8. San Joaquin River at Mossdale	HH	0.02	0.57
	LH	-0.10	0.37
	HL	-0.18	-0.42
	LL	-1.35	-1.01

/ Range of San Joaquin River flows near Vernalis was 232-268 ft^3/s and 470-600 ft^3/s during the Oct 17-31 period, and the Dec 17-31 period, respectively.

/ Tracy Pumping Plant and Clifton Court Intake combined 15 day mean diversion rate.

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periods demonstrates, in general, that reductions in 15 day average water levels due to an increase in export as measured in the prototype are of the same order as those obtained in mathematical model studies to be discussed later in the text. The reduction in 15 day average water level at high tide at Clifton Court is a composite effect of high tide diversion into Clifton Court Forebay and steady diversion into the Delta-Mendota Canal. The impact of steady pumping is estimated to be about an average of 0.08 foot depression at Clifton Court Ferry per 1,000 ft^3/s based on the analysis of the 1977 data. The impact of intermittent diversion into Clifton Court Forebay at high tide is approximately 0.14 foot per 1,000 ft^3/s of average daily diversion. The combined effect of steady and intermittent pumping was to depress the high tide level by about 1.1 feet. Table VII-5 discusses the data and describes the procedures used to calculate these estimates.

The above tests showed that water level drawdown was about the same in Old River near Tracy Road and at Clifton Court. A depression in water level was evident as far away as Mossdale. However, an exact effect at Mossdale cannot be determined by tests in which San Joaquin River flows and agricultural diversions upstream from the export pumps vary between test periods. For example, in December 1977 the San Joaquin River flow was two to three times greater, and the agricultural diversions were presumably less than in October 1977.

A graphic presentation of the effect of intermittent export pumping on water levels at high tide is shown in figure VII-6. This figure shows the tide levels during the upper portion of the tide at Clifton Court and at Old River at Tracy Road on June 20-21, 1972, and compares them to the Bacon Island tide level. During this period, the average daily export rates were 2,362 ft^3/s

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Table VII-5. Impact of CVP and SWP export on water levels in Old River at Clifton Court Forebay[1]

Observation period	CVP-SWP mean daily diversion rate in ft^3/s		Mean 15-day tidal elevation difference between Old River at Rock Slough and Clifton Court Forebay in feet			
	CVP	SWP	HH	LH	HL	LL
October 17-31, 1977	180	140	0.04	0.06	0.17	0.09
December 17-31, 1977	3,600	5,800	1.08	0.95	0.47	0.32
Differential	3,420	5,660	1.04	0.89	0.30	0.23

$$\text{Steady pumping impact} = \frac{\dfrac{\text{HL Diff.} + \text{LL Diff.}}{2}}{\text{average DMC Diversion in } 1{,}000\ ft^3/s}$$

$$= \frac{\dfrac{0.30 + 0.23}{2}}{3.42} = 0.08\ ft/1{,}000\ ft^3/s$$

$$\text{Intermittent pumping impact} = \frac{\text{HH Diff.} - \text{steady pumping impact}}{\text{average daily diversion to CCFB in } 1{,}000\ ft^3/s}$$

$$= \frac{1.04 - \dfrac{0.08 \times 3{,}420}{1{,}000}}{5.66} = 0.14 \text{ ft per } 1{,}000\ ft^3/s \text{ of average daily diversion}$$

$$\text{Intermittent pumping impact} = \frac{\text{HH} - \text{Steady pumping impact}}{\text{Average daily diversion to CCFB} \times \dfrac{24 \text{ hours}}{\text{Diversion period}}}$$

= feet per 1,000 ft^3/s of intermittent diversion.

$$= \frac{1.04 - 0.08 \times 3.42}{5.66 \times \frac{24}{17}} = \frac{1.04 - 0.27}{7.99} = 0.096 \text{ or } 0.10 \text{ feet per } 1{,}000\ ft^3/s$$

Total impact at high high tide = 0.08 x 3.42 + 0.14 x 5.66 = 0.27 + 0.79

= 1.06 feet as compared to the measured value of 1.04 feet.

[1]The rates of impacts identified in this analysis are approximations only.

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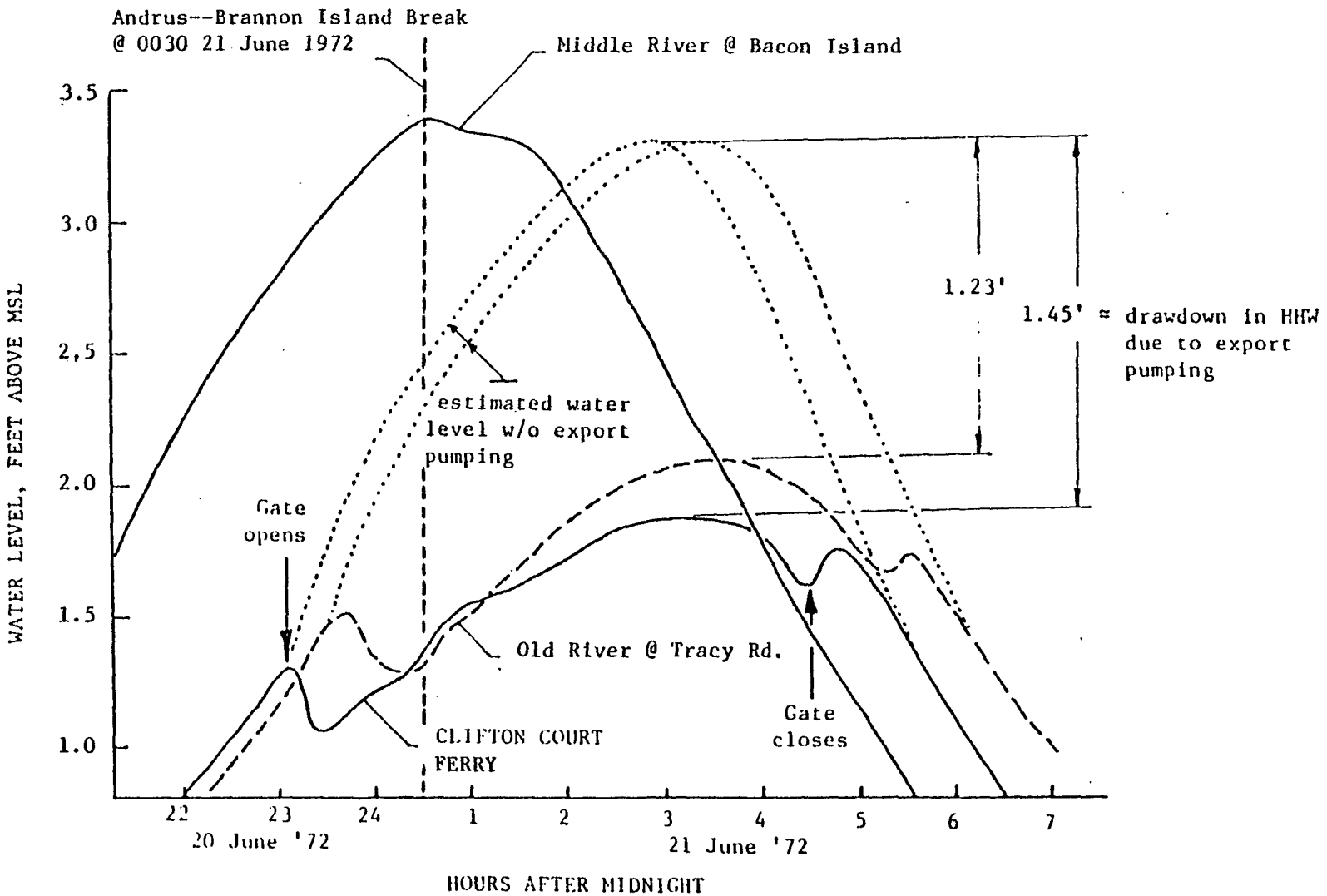

Figure VII-6 WATER LEVELS IN SOUTHERN DELTA, 20-21 JUNE 1972

CVP Export = 4233 cfs SWP Export (Avg) = 2411 cfs

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for the SWP and 3,561 ft^3/s for the CVP. The southern Delta tide levels would probably have been about the same height as the Bacon Island tide in the absence of pumping. Using the indicated difference between HH water at Bacon Island and Clifton Court as the effect of pumping and the procedure outined in table VII-5, it is estimated that the intermittent pumping impact was about 0.5 feet per 1,000 ft^3/s of average daily diversion and 0.122 feet per 1,000 ft^3/s of actual intermittent diversion rate. The total impact was a reduction in water level at high tide of about 1.5 feet, extending as far upstream on Old River to Tom Paine Slough.

The comparison of the impact of intermittent pumping rates on the water levels near Clifton Court in feet per 1,000 ft^3/s of average daily diversion is appropriate when the periods of diversion are approximately the same. Comparing the impact of intermittent pumping during the June 20-21, 1972 period with the October 17-31, 1977 and December 17-31, 1977 periods, in feet per 1,000 ft^3/s of average daily diversion will give a distorted result. During the 1972 period the actual diversion of 10,300 ft^3/s occurred over a period of 5.5 hours whereas during the 1977 period the actual diversion of 7,990 ft^3/s was sustained for 17 hours. The maximum pumping water level drawdown on June 21, 1972, between Bacon Island and Clifton Court was 1.26 feet; during the 1977 period between Rock Slough and Clifton Court the drawdown was 0.77 foot. Expressing these drawdowns in terms of actual rates of diversion for each period results in 0.122 foot per 1,000 ft^3/s and 0.10 foot per 1,000 ft^3/s, respectively.

The impact of export pumping on water levels in the vicinity of Clifton Court Forebay is relatively insensitive to the flows in the San Joaquin River

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at Vernalis. However, the effects of export pumping on the hydraulic gradient between Clifton Court Ferry and the San Joaquin River does vary with the riverflows. The project impact on net flow rates and water levels in this reach are greatest at low rates of inflow.

A mathematic procedure (Hardy Cross network analysis) was used to describe the relationship between head loss within individual channels and the average exports and flows in the San Joaquin River. A memorandum dated February 16, 1951, summarized the network analyses of the Lower Sacramento-San Joaquin Delta that were made in connection with the design of the Delta Cross Channel. Copy of this memorandum is included in Appendix 4. A simplified technique, based on the assumption of steady flow with no tidal fluctuation was used to demonstrate the effect of San Joaquin River inflow on the distribution of drawdown related to a constant export. This procedure assumes no agriculture diversion within the southern Delta. (During periods of low flow this is seldom a realistic assumption.)

For the semi-quantitative use the various channels were combined into four equivalent channels as shown. The ship channel because of its relatively large cross-section was assumed to act as a manifold at a constant level. The resistance values represent channel resistance coefficients such that head loss (h) = 5.543×10^{-8} rQ^2 where the constant was derived from the Manning equation.

Flow distributions were developed: Case A with 4,600 ft^3/s export and a downstream flow at Mossdale of 1,000 ft^3/s, and Case B with the same export (4,600 ft^3/s), but a downstream flow of 300 ft^3/s.

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Case A

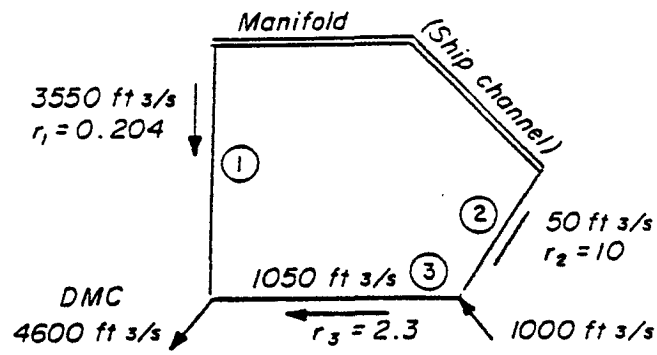
Q_1 in channel 1 = 3,550 ft^3/s

Q_2 in channel 2 = 50 ft^3/s

Q_3 in channel 3 = 1,050 ft^3/s

$\Delta h_1 = 0.145$, $\Delta h_2 = 0.00014$

and $\Delta h_3 = 0.1405$



The junction of channel 2 and 3 which represents Mossdale approximately is subject to negligible drawdown (1 percent of drawdown at Tracy).

Case B

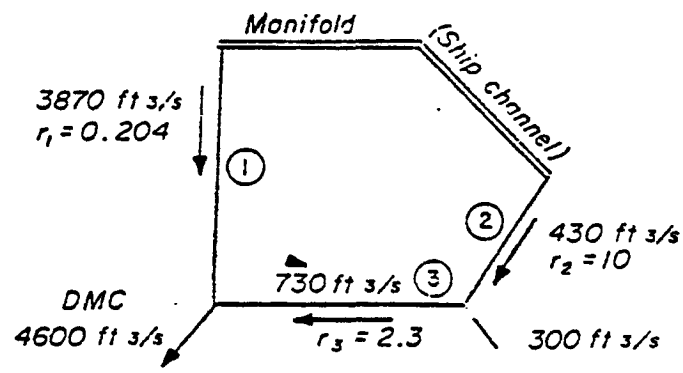
Q_1 = 3,870 ft^3/s

Q_2 = 430 ft^3/s

Q_3 = 730 ft^3/s

$\Delta h_1 = 0.169$, $\Delta h_2 = 0.102$

and $h_3 = 0.068$



At Mossdale the drawdown (Δh_2) is 0.102 or 60 percent of the drawdown at the DMC intake.

The analysis indicated that when the flows at Mossdale are less than 500 ft^3/s and the pumping is approximately 4,600 ft^3/s, the gradient between the pumps and the bifurcation was very flat. Therefore, depression of the water levels at Clifton Court would be felt as far away as the bifurcation and even upstream beyond Mossdale. However, with riverflows at Mossdale of a magnitude of about 1,000 ft^3/s, the gradient is much steeper and, therefore, the pumping impact is less at the bifurcation.

Model studies--Tests such as those just described in 1968 and 1977 are difficult to arrange. They are, therefore, limited in the range of condi-

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tions tested. Furthermore, conditions of tide, riverflow, and agricultural diversions vary during the tests, thereby modifying results, particularly for points far upstream of the export pumps. Therefore, it was necessary to develop a mathematical model in order to examine a wider range of conditions and to avoid the uncertainties of test data wherein conditions other than export rates vary during the tests. A mathematical model for this purpose was developed for SDWA by Dr. G. T. Orlob per his report entitled "Investigation of Water Level Problems in the Southern Delta - Model Studies" and dated May 14, 1979. The model is a refinement of an earlier Delta-wide model which was developed under Dr. Orlob's direction and commonly referred to as the WRE model.

It was first necessary to establish a reference station for southern Delta tides. Delta tides do not correlate reliably with ocean tides for various reasons. (See DWR-USBR report dated September 1970 and titled "Sacramento--San Joaquin River Delta Low Tides of April--May 1970.") The Bacon Island tide station was, therefore, chosen as being reliably related to the southern Delta tide levels which would occur in the absence of all pumping.

The model was calibrated so as to obtain a close a match as possible between model results and the measured data from southern Delta tide gages during various conditions of tide, export diversion, and riverflow. Comparison of the model's predictions and actual tidal curves for conditions of steady diversion indicate that the model is a useful tool for water level studies. The model still requires verification for some special cases . However it improves understanding of the interrelationships between water level changes and export pumping under the dynamic conditions induced by tides in the southern Delta.

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Table VII-6 shows the model's predicted change in water level due to export pumping at various southern Delta points and for various export rates. With a CVP export rate of 4,323 ft^3/s and no SWP export and a 550 ft^3/s riverflow rate at Vernalis, the drawdown of water levels by the export pumps is calculated to be 0.52 foot at HHW and 0.40 foot at LLW at the CVP intake channel; 0.51 at HHW and 0.47 at LLW at the Westside Irrigation District intake channel on Old River; 0.41 foot at HHW and 0.37 foot at LLW at Old River and Tom Paine Slough; 0.35 foot at HHW and 0.31 foot at LLW at Old River and Middle River; and 0.34 foot at HHW and 0.13 at LLW at Mossdale. Steady pumping impacts predicted by the mathematical model presented in table VII-6 is compared to the LLW value calculated using the 1968 pumping test rated of depression presented on table VII-1.

	Model Run	May 1968 Test[1,2] Results
Old River at Clifton Court Ferry	-.40	-.30
Old River at Tracy Road	-.39	-.27
Grant Line at Tracy Road	-.44	-.27
Tom Paine Slough	-.37	-.27
San Joaquin River at Mossdale	-.13	-.13

[1]The May 1968 test results were adjusted to reflect the same rate of diversion as simulated in the model run, i.e., the 1968 test results were multiplied by the factor of $\frac{4,323}{4,775}=0.90$.

[2]During the 1968 test 10 to 31 percent of the flows diverted from the Delta by the SWP were withdrawn from Italian Slough not Clifton Court Forebay as simulated in the model study.

With the same CVP export rate and the same riverflow rate at Vernalis, but with a 4,800 ft^3/s average daily SWP export rate (drawn off the high

TABLE VII-6

SUMMARY OF WATER LEVEL CHANGES IN THE SOUTHERN DELTA DUE TO EXPORT PUMPING BY THE CVP AND SWP 1/

		RUN SD-29A			RUN SD-29B			RUN SD-30			RUN SD-32		
		Q_e 2/ (DMC) = 4323 Q_e(SWP) = 0			Q_e(DMC) = 4323 Q_e(SWP) = 1600 Q_{ep} 3/ (SWP) = 2000			Q_e(DMC) = 4323 Q_e(SWP) = 2800 Q_{ep}(SWP) = 7000			Q_e(DMC) = 4323 Q_e(SWP) = 4800 Q_{ep}(SWP) = 12,000		
Node	Location	HHW	MTL	LLW	HHW	MTL	LLW	HHW	MTL	LLW	HHW	MTL	LLW
1	Bacon Isl. (Input)	0	0	0	0	0	0	0	0	0	0	0	0
20	Clifton Ct.	-0.36	-0.35	-0.34	-0.89	-0.47	-0.36	-1.08	-0.58	-0.34	-1.74	-0.77	-0.26
22	Old R. @ DMC	-0.52	-0.49	-0.40	-1.01	-0.59	-0.40	-1.17	-0.70	-0.39	-1.83	-0.89	-0.32
26	WSID	-0.51	-0.47	-0.47	-1.01	-0.58	-0.49	-1.17	-0.68	-0.46	-1.84	-0.87	-0.38
32	Old R. @ Tracy Rd.	-0.43	-0.43	-0.39	-0.97	-0.54	-0.40	-1.12	-0.64	-0.37	-1.81	-0.83	-0.29
115	Grantline @ Tracy Rd.	-0.44	-0.40	-0.44	-0.93	-0.60	-0.46	-1.09	-0.61	-0.43	-1.76	-0.80	-0.36
34	Tom Paine Sl.	-0.41	-0.42	-0.37	-0.92	-0.53	-0.40	-1.11	-0.62	-0.39	-1.78	-0.81	-0.34
35	Salmon Sl.	-0.40	-0.39	-0.33	-0.90	-0.50	-0.37	-1.06	-0.59	-0.36	-1.73	-0.79	-0.31
39	Old R. @ Middle R.	-0.35	-0.33	-0.31	-0.81	-0.46	-0.35	-1.00	-0.56	-0.34	-1.63	-0.74	-0.31
44	Old R. @ San Joaquin	-0.31	-0.27	-0.18	-0.65	-0.38	-0.24	-0.89	-0.46	-0.26	-1.32	-0.61	-0.29
139	San Joaquin @ Moesdale	-0.34	-0.26	-0.13	-0.66	-0.38	-0.22	-0.87	-0.46	-0.27	-1.33	-0.65	-0.37

1/ Based on mathematical model analysis using a version of the WRE Model
2/ Q_e is the average daily diversion
3/ Q_{ep} is the actual diversion during HHW
Note: Vernalis flow rate 550 rfs.

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tide at about 12,000 ft^3/s), the drawdown at the CVP intake channel is increased to 1.83 feet at HHW and 0.32 foot at LLW; at Old River and Tom Paine Slough it is 1.78 feet at HHW and 0.34 foot at LLW; and at Mossdale it is 1.33 feet at HHW and 0.37 foot at LLW. The intermittent pumping impact at Clifton Court was calculated at 0.127 foot per 1,000 ft^3/s at HHW, which compares favorably with the rate calculated using the June 21-22, 1972 data (0.122 ft/1,000 ft^3/s).

Impact of Export Pumping and Channel Configuration on Water Circulation and Water Quality

Circulation of water in southern Delta channels and the related water quality in those channels is influenced by tidal activity, export and local pumping, inflow and channel configuration. Tidal activity is the dominant factor influencing circulation for short time periods. For longer periods, net flow direction governed primarily by export pumping and inflows becomes the major influence. The tidal circulation is determined by the excursion and the volume of displacement during a tidal cycle, which are related to the tidal prism upstream from any given station, taken together with the cross sectional area at that station. Values of excursion from a low slack to a high slack tide range to as much as 3 miles in the southern Delta.

Net flow direction is markedly changed by various physical works such as pumps, siphons, and tidal gates. Circulation changes have been studied in the field and by models, both physical and mathematical. A relationship between the division of flow at the head of Old River and export pumping has been developed per figure VII-7. This figure is a modification of plate 11 of the appendix to DWR Bulletin 76. This plot depicts the flow split at the

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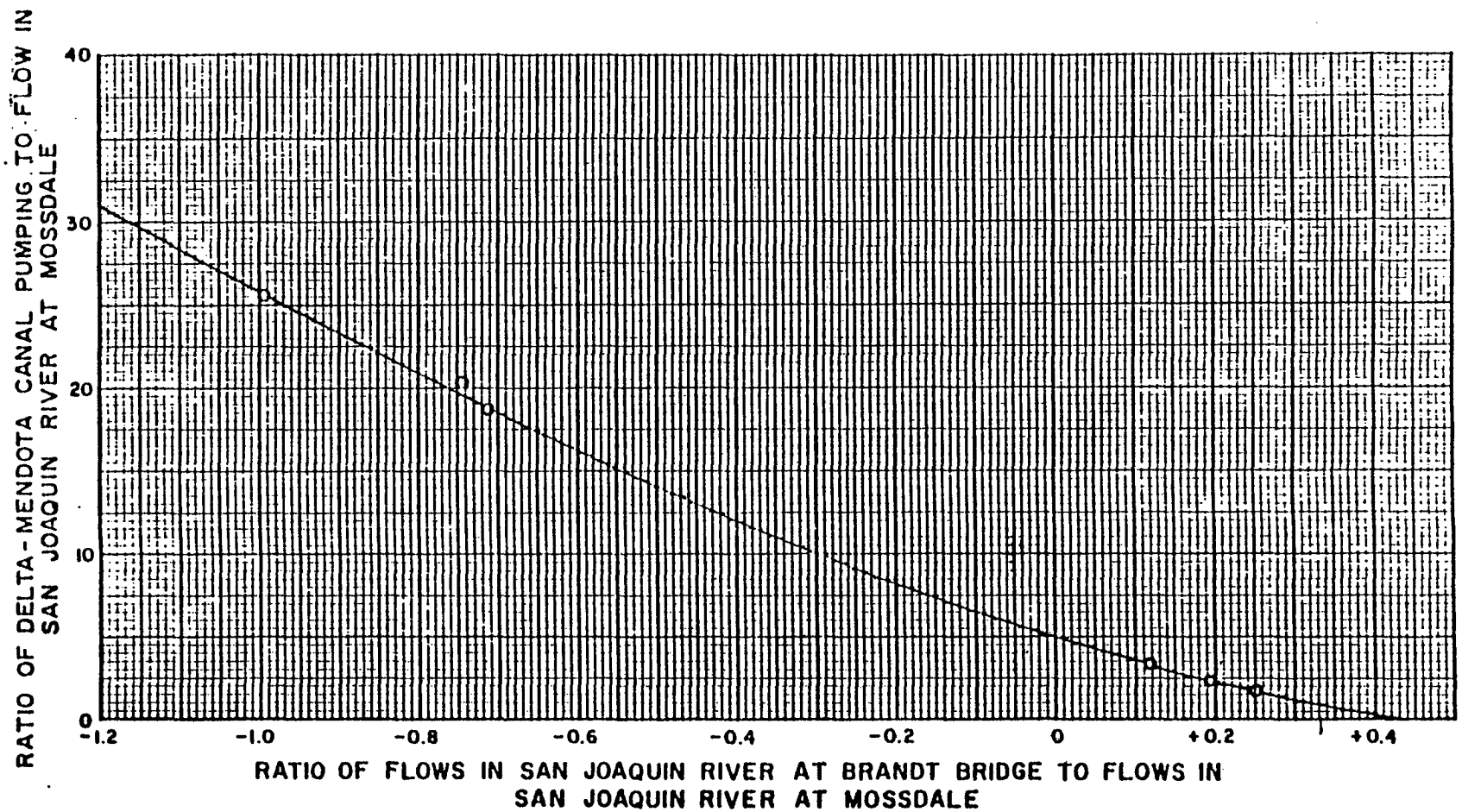

NOTE: Flows in northwesterly direction in San Joaquin River at Brant Bridge positive and in opposite direction negative.

This is plate 11 from the California Department of Water Resources' Report entitled Salinity Incursion and Water Resources Bulletin No. 76 Appendix on Delta Water Facilities dated April 1962.

RATIO OF FLOW AT TWO LOCATIONS ON SAN JOAQUIN RIVER AS INFLUENCED BY DELTA-MENDOTA CANAL PUMPING

APRIL 1962

Figure VII-7

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bifurcation of Old River and the San Joaquin River in relationship to the rate of export pumping. This determination of the relationship is an approximation because it does not account for the seasonally varying channel depletions between Vernalis and the head of Old River and because net flows are difficult to determine in tidal channels. However, the approximation is useful in analyses of the circulation and water quality. Depending upon the rate of export and local pumping, varying percentages of the San Joaquin inflow are drawn toward the export pumps even to the extent of reversing the normal downstream flow of the San Joaquin River below its bifurcation with Old River.

The induced flow toward the export pumps is carried mainly by Salmon Slough and Grant Line and Fabian Canals. Downstream flows in Middle River and Old River west of Salmon Slough have serious impediments to flow in the form of width and/or depth constrictions as previously discussed. These limitations are exacerbated to some degree by the lowering of water levels at the entrance of these channels.

Hydraulic restrictions in Middle River and portions of Old River tend to limit circulation and increase the likelihood of stagnation and poor water quality. These conditions may be aggravated further by reductions in water level, depth and/or tidal prism. Such occurrences are illustrated by the behavior of Old River between Salmon Slough and the DMC intake channel during July 1976, as shown in figure VII-8. The average monthly TDS concentration in Old River between Salmon Slough and the Westside Irrigation District intake generally exceeded 1,000 mg/L, while at the DMC intake the TDS averaged 312 mg/L. The rather large gradient of TDS between these two locations indicates that the effects of tidal mixing, and any available advective flow is not

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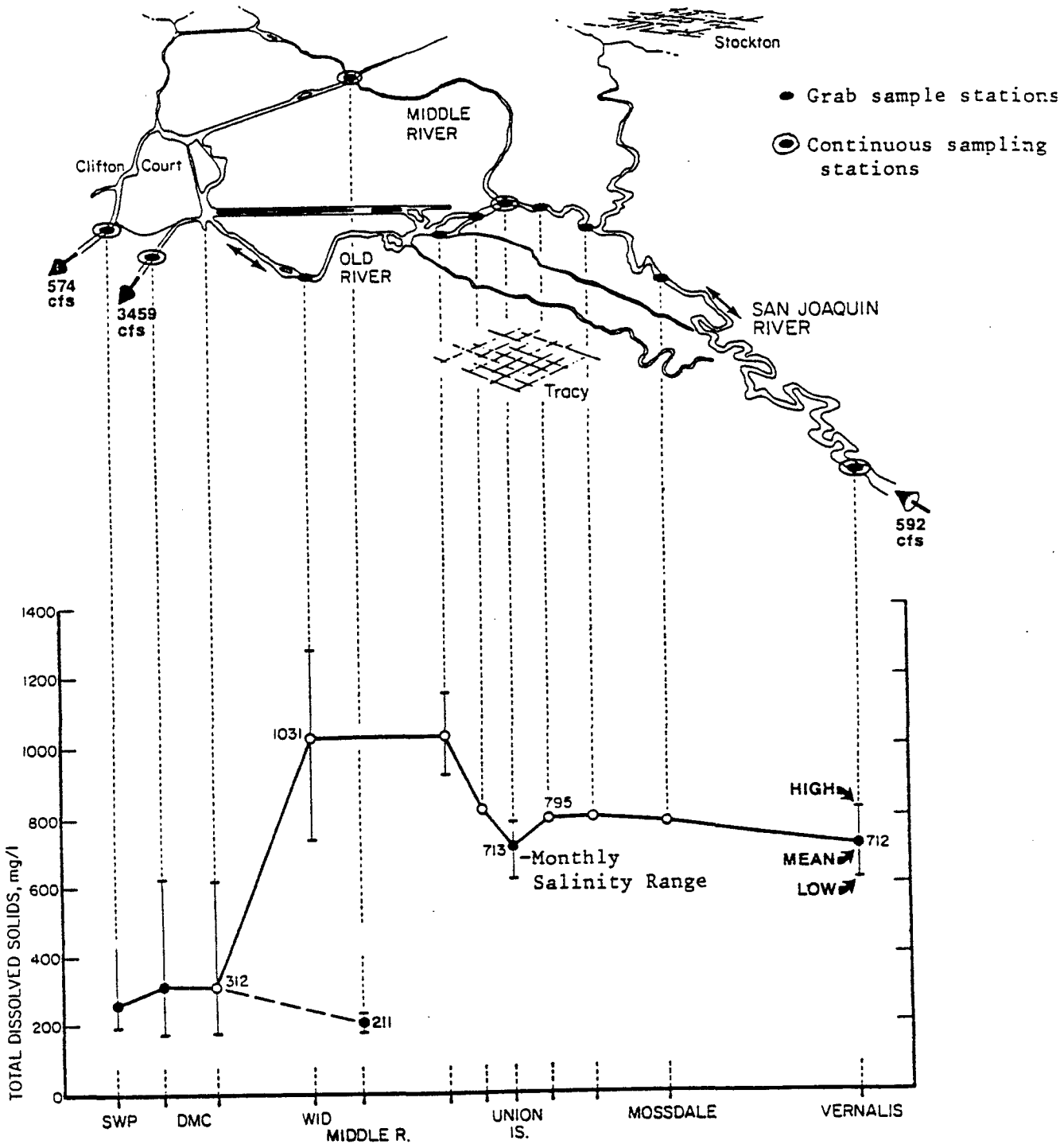
Figure VII-8 TOTAL DISSOLVED SOLIDS IN THE SOUTH DELTA CHANNELS*
JULY 1976



Sources: WPRS continuous EC recorders, grab samples by Westside Irrigation District, Reclaimed Islands Land Co., Piscadero Reclamation District and Nelson Laboratories.

*Where ranges are indicated, they represent extreme values of daily observation or continuous records during the month. Where no range is indicated, data correspond to a very small number of samples.

sufficient to offset the effect of salt accumulation in this channel. Such circulation as did exist may have been aided by the Westside Irrigation District diversion since there are no other significant diversions between the district's intake and the DMC intake.

The operation of the export pumps draws water from all contributing channels, including the Old River--Salmon Slough--Grantline Canal principal channel through which water from the San Joaquin River enters the zone affected by export. Data derived from the Service's continuous EC monitors show that at low tide following a downstream tidal excursion the EC near Clifton Court is generally higher than at high tide when cross Delta flows from the Sacramento River are most likely to be dominant. As an illustration the quality of water in San Joaquin River at Vernalis between July 9 and July 18, 1978, averaged about 635 umhos EC with no tidal variation whereas the quality in the Delta-Mendota Canal intake channel varied about threefold between the high and low tidal stages. The 10-day average qualities in each tidal phase in umhos at the various tidal phases between July 9 through July 18, 1978 were as follows:

Tidal phase	Water quality (micromhos)
HH	323
LH	212
LL	631
HL	385

C-115371

C-115371

Middle River--Old River to Victoria Canal

This channel has aggraded since the 1933 survey from an average maximum bottom elevation of 6 feet below LWD to an average maximum bottom elevation of 4 feet below LWD. About 55 percent of the reach, that immediately north of Old River, has aggraded an average of 0.5 foot since 1933-34. The most restrictive section is now about 0.5 foot below LWD as compared to the previous 1 foot below LWD. The channel conveyance capacity is quite low and often less than the agricultural diversion rate. There is no evidence of recent channel maintenance dredging (access to 55 percent of the most restrictive sections is hampered by two fixed span bridges).

Old River--Salmon Slough to DMC Intake Channel

This channel also has restrictive cross sections with maximum depths of about 3.5 feet below LWD and a minimum mean depth of about 2 feet below LWD. There has been little change since the 1933-34 survey.

Changes in channel cross sections that have been observed since 1933-34 are a consequence of modifications in the hydraulic regimen of the southern Delta: export pumping by the CVP initiated in 1951, intermittent diversions by the SWP commencing in 1968, and reduced San Joaquin River inflows at Vernalis. The analysis of channel depths within the South Delta Water Agency does not establish whether or not export pumping has caused appreciable siltation or scour within the SDWA channels. Channel degradation in the reach of Old River between Salmon Slough and the San Joaquin River is unexplainable. The channel degradation within Grant Line--Fabian Canals could be attributed to export pumping and/or dredging. This channel carries the largest proportion of San Joaquin River flows which are drawn to the export pumps. The decrease in

C-115372

C-115372

the bifurcation with Old River. When the riverflows at the bifurcation are less than 1,000 ft^3/s, the gradient between the pumps and the bifurcation flattens and the pumping effect is increased whereas at 1,000 ft^3/s the effect is relatively insignificant.

IMPACT OF EXPORT PUMPING ON WATER CIRCULATION AND QUALITY

During most summer periods, the San Joaquin River flows are now less than the net rate of channel depletion within the SDWA. The induced flow toward the export pumps which is caused by the drawdown of levels, is carried mainly by Salmon Slough and Grant Line and Fabian Canals. Downstream advective flows into the reach of Middle River between Old River and Victoria Canal and in the reach of Old River west of Tom Paine Slough are generally less than the agricultural diversions from those channels during dry seasons, thereby causing water to flow into these reaches from both ends permitting accumulation of salts from local return flows as illustrated in figure VII-8. Both of these channels have serious impediments to flow in the form of width and/or depth constrictions as previously discussed. However, it is apparent that substantial portions of low summer San Joaquin River flows pass through the upstream end of Old River and Grant Line and Fabian Canals and are diverted with the export.

The increase in net unidirectional flow from the San Joaquin River toward the pumps reduces the accumulation of drainage salts in the upper end of Old River and in Grant Line and Fabian Canals. However, the drawdown which causes this increase in flow does not necessarily induce net daily unidirectional flows through Middle River in the southern Delta, or in Old River from Tom Paine Slough west toward the DMC intake channel as discussed above.

C—115373

C-115373

6. Reduction in tidal prism with resultant decrease of tidal flows and of tidal flushing of salts, particularly in shallow, or stagnant, or blind channels.

This report does not attempt to quantify all of these export pump impacts or to determine the water levels, hydraulic capacities, and salinity levels needed in southern Delta channels. Water level drawndown, of the magnitude indicated, obviously has an impact on water availability in the shallowest channels, but determining the net effect on salinity due to changes in advective and tidal flow would require additional study of the net effect in each channel. Furthermore, the impact of export pumping also varies with the degree to which San Joaquin River flow and salinity at Vernalis are altered.

APPENDIX 1

MONTHLY FLOW DATA (KAF) AND

MONTHLY CHLORIDE DATA (P/M)

THIS IS THE DATA FILE OF ACTUAL SAN JOAQUIN RIVER FLOWS (KAF) AT VERNALIS.

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	VN	86.70	73.20	79.30	111.00	94.40	151.00	154.00	136.00	164.00	76.20	56.60	85.10
1931	VN	103.00	97.60	117.00	95.30	88.90	54.20	23.10	27.30	23.30	14.30	14.00	19.00
1932	VN	29.40	39.30	76.90	205.00	621.00	301.00	286.00	713.00	898.00	356.00	71.30	63.70
1933	VN	103.00	113.00	115.00	124.00	167.00	107.00	68.40	84.80	316.00	68.20	41.00	68.40
1934	VN	94.10	91.00	148.00	169.00	124.00	105.00	41.80	39.30	37.30	24.30	23.60	29.80
1935	VN	52.20	76.80	98.80	223.70	196.30	250.60	878.20	1007.00	938.80	165.90	61.20	80.30
1936	VN	125.10	115.40	155.90	203.20	688.00	878.10	773.10	1020.00	661.60	187.40	69.00	76.20
1937	VN	116.20	116.60	175.60	202.40	688.30	812.20	860.60	1233.00	925.70	200.50	69.40	83.10
1938	VN	116.70	117.80	326.40	381.20	1301.00	2100.00	1333.00	1743.00	2181.00	898.30	206.60	132.40
1939	VN	163.90	226.00	227.50	251.50	231.60	124.60	146.80	125.20	59.00	46.50	44.00	61.50
1940	VN	91.30	85.40	97.60	254.00	493.10	902.30	965.20	879.30	645.60	122.70	72.90	100.40
1941	VN	98.60	102.00	185.20	438.60	727.90	1302.00	1017.00	1309.00	1327.00	562.10	128.80	100.30
1942	VN	135.20	138.60	293.70	518.40	706.90	533.40	798.20	1017.00	1323.00	478.20	103.60	114.00
1943	VN	137.50	138.80	268.40	347.20	725.80	1422.00	1075.00	920.60	693.40	135.80	94.80	100.50
1944	VN	129.60	116.20	146.80	165.40	164.60	294.70	136.90	235.30	201.40	76.60	67.10	71.40
1945	VN	101.40	147.20	232.90	237.60	604.30	566.70	534.80	855.60	673.80	238.60	109.40	120.90
1946	VN	169.60	207.30	352.50	584.80	330.70	229.60	357.90	802.90	344.10	90.10	75.30	88.30
1947	VN	111.60	155.70	222.40	171.10	133.70	138.90	88.50	125.80	56.10	32.40	35.00	63.90
1948	VN	80.80	105.50	104.20	85.10	47.50	36.80	82.90	307.50	512.10	81.70	44.60	64.70
1949	VN	95.20	88.80	91.40	107.00	78.60	213.30	122.40	217.00	119.20	34.60	37.00	42.50
1950	VN	77.90	94.10	96.60	122.90	196.70	135.60	319.30	308.20	298.30	42.30	38.20	56.30
1951	VN	81.40	482.10	1545.00	632.10	600.50	477.70	157.80	401.20	198.60	53.50	46.70	61.60
1952	VN	109.70	104.90	192.80	544.20	661.90	845.30	1202.00	1699.00	1389.00	215.10	83.30	96.40
1953	VN	114.70	129.50	225.00	365.70	204.00	71.50	90.40	188.10	292.40	98.60	46.00	65.00
1954	VN	100.20	98.90	108.30	101.90	131.00	274.30	301.00	412.90	76.50	33.30	33.60	44.90
1955	VN	32.30	82.50	111.50	182.30	136.10	96.00	54.60	70.70	89.00	25.60	26.50	36.30
1956	VN	49.20	63.70	670.60	1663.00	993.90	460.30	372.60	859.30	729.00	214.20	116.90	112.20
1957	VN	122.90	131.60	154.00	118.10	97.90	187.80	78.90	158.70	223.70	53.80	46.30	68.30
1958	VN	126.40	133.80	153.30	148.80	301.80	743.60	1661.00	1379.00	929.30	251.60	94.40	133.40
1959	VN	174.30	216.10	181.70	143.40	181.50	127.20	48.30	48.60	31.70	19.20	24.70	46.70
1960	VN	53.90	62.60	72.80	85.80	99.10	36.60	30.80	38.00	17.40	13.70	16.50	22.90
1961	VN	43.80	60.30	79.10	82.30	62.10	27.30	11.90	23.40	12.30	6.40	9.30	19.10
1962	VN	25.20	35.30	43.80	49.50	320.90	364.80	124.10	161.20	208.10	52.60	42.70	59.10
1963	VN	89.40	97.80	149.70	107.80	454.60	160.30	512.70	574.20	396.50	112.00	67.40	90.20
1964	VN	164.60	179.80	217.20	176.60	97.60	57.10	45.50	43.20	38.70	23.60	27.10	53.50
1965	VN	86.80	140.20	371.20	894.80	440.30	327.50	596.70	325.60	336.20	121.30	75.10	99.90
1966	VN	181.00	216.80	383.80	323.90	227.20	117.70	58.40	53.10	33.90	27.00	30.70	43.20
1967	VN	67.70	79.10	269.00	197.30	353.40	401.90	862.50	1252.00	1190.00	642.50	124.20	120.70
1968	VN	167.60	206.70	223.50	180.80	150.50	190.20	85.40	54.80	35.20	30.90	47.20	55.80
1969	VN	85.10	95.50	155.70	849.40	1808.00	1898.00	1316.00	1513.00	1659.00	356.80	142.90	193.70
1970	VN	274.40	275.40	246.70	683.50	510.50	441.50	99.53	147.20	160.90	81.79	64.22	78.51

C-115376

THIS IS THE DATA FILE FOR STANISLAUS RIVER FLOW AT RIPON.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1931 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1932 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1933 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1934 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1935 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1936 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1937 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1938 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1939 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1940 RP	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1941 RP	15.19	18.40	28.29	52.11	72.00	186.10	178.90	386.50	173.90	36.34	14.73	13.63
1942 RP	15.46	27.82	53.31	77.20	175.90	71.01	215.00	294.30	232.10	56.69	13.33	14.70
1943 RP	16.51	27.44	52.74	113.80	122.20	313.20	265.30	203.30	108.20	17.13	14.71	13.87
1944 RP	16.51	17.46	26.32	31.60	17.42	81.66	31.01	104.40	51.71	14.11	11.97	11.69
1945 RP	13.40	31.88	60.44	55.84	105.40	111.40	125.80	265.20	152.00	25.57	14.42	13.41
1946 RP	16.30	30.36	74.98	146.90	50.39	64.93	155.20	234.30	61.95	15.50	13.59	12.54
1947 RP	11.83	21.40	38.42	11.56	11.15	37.56	52.60	82.53	15.35	9.70	9.37	9.59
1948 RP	10.72	16.19	25.94	17.35	12.07	10.46	53.08	216.70	180.30	21.01	10.90	9.76
1949 RP	12.14	14.62	14.11	24.34	12.62	68.69	44.82	158.70	52.26	10.85	9.86	9.80
1950 RP	11.78	11.38	13.60	37.55	53.77	42.70	152.40	235.50	112.30	13.36	11.36	10.38
1951 RP	11.39	268.90	467.40	152.90	122.10	127.60	81.59	130.90	38.28	13.55	11.01	10.18
1952 RP	23.12	21.25	54.38	78.75	116.60	155.00	224.90	473.60	294.80	57.17	15.56	14.01
1953 RP	15.91	20.93	35.03	84.12	39.03	12.43	56.38	109.50	153.60	30.36	12.19	11.73
1954 RP	15.30	21.20	21.35	13.62	22.92	70.90	146.00	147.50	13.96	9.62	9.99	8.93
1955 RP	11.97	15.36	33.63	47.53	28.22	35.62	13.14	37.40	63.93	8.67	7.98	7.14
1956 RP	8.32	9.77	275.70	317.50	117.40	80.34	147.90	312.30	187.90	62.18	12.01	10.71
1957 RP	23.82	27.18	21.32	17.86	7.96	30.62	11.10	73.48	81.53	12.04	10.30	10.69
1958 RP	14.07	10.43	10.46	32.43	78.41	136.90	242.80	362.20	217.00	36.62	18.55	20.04
1959 RP	19.91	29.56	49.61	28.05	23.29	38.99	9.97	9.16	7.85	6.98	7.96	9.71
1960 RP	9.17	8.69	9.00	8.24	9.70	6.83	7.21	8.64	6.66	5.96	6.09	6.10
1961 RP	7.65	9.66	11.02	11.18	8.71	6.50	5.58	5.38	3.84	3.15	3.74	4.56
1962 RP	5.61	6.34	6.87	6.63	54.76	70.77	49.61	73.72	103.40	11.44	8.73	9.24
1963 RP	13.48	14.84	19.22	11.40	133.50	42.46	177.80	288.80	118.10	16.34	11.24	13.74
1964 RP	24.04	17.54	32.15	54.94	24.78	12.03	10.23	8.16	7.15	6.37	6.53	7.98
1965 RP	9.99	13.12	189.30	254.40	109.30	102.40	202.00	131.20	124.20	25.84	13.72	16.75
1966 RP	24.47	47.96	86.83	90.41	65.17	16.00	11.39	9.95	7.82	6.11	5.54	6.07
1967 RP	8.26	9.35	60.27	70.59	97.84	137.00	225.40	267.20	329.10	107.20	19.36	23.00
1968 RP	29.79	36.09	52.79	38.72	15.90	28.53	28.00	9.38	7.68	6.29	7.01	7.44
1969 RP	11.59	11.70	13.34	309.90	266.70	225.70	187.10	359.40	233.60	41.12	17.09	29.64

END OF FILE

1mh

THIS IS THE DATA FILE FOR THE ACTUAL FLOW AT MAZE ROAD BRIDGE (KAF).

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1931	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1932	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1933	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1934	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1935	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1936	0.00	0.00	0.00	162.20	564.30	668.20	574.60	767.60	503.80	150.60	55.10	64.10
1937	102.50	106.60	161.00	176.70	617.40	722.80	708.90	970.30	818.80	177.60	52.30	71.80
1938	110.50	100.80	0.00	341.20	1268.00	2077.00	1092.00	1265.00	1798.00	776.40	185.20	123.00
1939	140.70	206.70	206.80	216.00	212.40	114.60	90.20	84.70	43.10	34.10	36.20	51.50
1940	84.20	76.40	83.80	194.70	394.30	707.20	727.90	643.40	527.20	99.80	57.90	91.20
1941	87.80	88.70	166.60	388.00	660.50	1094.00	819.20	990.00	1202.00	510.10	116.30	93.40
1942	118.70	113.10	241.60	464.30	547.30	468.20	572.00	737.20	1113.40	427.50	88.80	101.50
1943	124.10	115.90	210.10	247.20	578.00	1088.20	773.60	683.60	565.20	113.80	79.10	85.70
1944	110.70	101.20	127.70	135.80	144.20	218.60	100.50	140.20	146.20	58.10	49.20	58.40
1945	96.40	117.10	169.20	166.20	496.00	466.90	400.00	600.80	538.90	214.80	95.90	104.40
1946	150.50	177.60	288.60	451.60	278.00	171.60	217.50	557.40	282.70	79.50	62.10	74.20
1947	97.60	131.40	178.80	162.00	118.40	106.60	37.30	52.10	40.30	26.10	27.30	60.60
1948	71.30	89.00	80.40	65.90	34.70	25.40	29.30	123.90	323.80	61.10	36.20	56.20
1949	88.80	73.20	77.20	82.40	61.60	154.50	83.50	83.90	75.30	24.80	30.80	35.90
1950	66.50	82.40	84.20	88.90	145.60	88.70	172.50	99.00	178.70	33.00	30.60	46.00
1951	73.40	341.40	1003.00	455.90	474.60	351.30	93.20	271.90	159.50	41.80	35.40	50.80
1952	82.20	74.80	140.60	445.40	546.00	698.40	942.50	1402.50	1006.30	171.80	76.50	79.20
1953	88.40	94.00	175.30	279.70	158.40	59.90	48.70	66.90	161.10	73.70	35.00	51.20
1954	80.20	73.20	81.90	84.10	104.00	201.60	179.60	270.20	60.70	33.20	31.40	38.20
1955	51.60	59.30	72.70	131.70	102.20	61.00	43.30	42.20	37.30	23.50	23.10	30.40
1956	37.90	47.40	394.60	1303.00	768.60	342.90	244.20	609.00	555.20	148.60	103.30	97.00
1957	94.90	96.00	116.30	100.10	85.00	149.80	70.20	103.30	154.90	43.80	43.40	53.40
1958	101.90	114.20	130.20	103.50	239.40	668.00	1583.00	1121.00	719.60	236.70	87.20	112.90
1959	149.40	209.60	134.20	116.30	137.70	89.80	42.80	43.80	29.00	19.90	22.80	39.20
1960	45.50	52.50	61.40	81.40	90.10	37.00	29.30	32.20	17.90	16.00	17.40	20.80
1961	37.90	52.10	69.70	76.10	55.60	25.30	15.00	24.40	13.50	9.60	12.00	20.00
1962	22.40	30.60	39.20	43.60	271.10	255.40	72.90	87.90	109.00	41.20	36.00	46.70
1963	64.30	70.30	101.80	83.50	374.70	110.40	384.70	410.40	293.40	77.90	48.80	65.30
1964	136.10	155.60	173.80	120.20	70.30	40.90	37.00	38.60	33.80	24.40	27.70	45.00
1965	0.00	0.00	240.60	555.70	324.90	236.90	400.90	227.20	233.90	91.20	63.20	80.40
1966	151.90	173.80	297.00	245.60	169.30	100.10	48.90	42.80	26.90	22.30	24.60	35.40
1967	57.40	67.40	220.60	146.30	267.90	279.40	685.10	970.30	906.60	485.50	101.50	86.80
1968	120.90	162.10	157.10	123.40	122.30	149.30	56.10	45.10	29.10	27.80	42.80	48.10
1969	65.70	75.10	137.10	633.60	1559.0	1622.0	1117.00	1120.00	1350.00	272.10	98.00	147.80

C—115378

THIS IS DATA FILE FOR THE TUOLUMNE RIVER FLOW AT TUOLUMNE CITY.

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	TC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.20	47.00	37.00	58.70
1931	TC	59.30	0.00	0.00	0.00	0.00	0.00	0.00	16.50	15.70	15.50	15.40	15.40
1932	TC	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.60	23.40
1933	TC	60.80	0.00	0.00	0.00	0.00	0.00	0.00	19.80	90.80	25.70	19.70	39.50
1934	TC	62.50	0.00	0.00	0.00	0.00	0.00	0.00	19.00	17.90	17.70	18.00	17.10
1935	TC	33.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41.60	23.80	40.90
1936	TC	49.70	0.00	0.00	72.90	231.10	247.60	199.20	328.10	258.60	56.30	25.00	30.60
1937	TC	55.90	54.70	79.30	59.80	161.30	210.30	222.30	388.50	222.20	34.00	23.40	36.00
1938	TC	59.50	70.30	0.00	88.10	402.10	444.10	342.70	398.40	620.00	186.10	45.80	56.60
1939	TC	67.30	125.90	88.40	70.90	58.00	38.40	23.90	28.90	20.10	27.50	27.10	29.50
1940	TC	50.50	52.00	50.40	58.60	159.00	293.20	264.20	213.20	184.10	26.70	27.70	52.80
1941	TC	47.90	64.10	83.30	88.30	132.90	270.90	225.90	319.90	390.40	109.00	47.30	45.70
1942	TC	63.50	68.30	107.60	144.80	118.90	141.10	172.80	255.30	445.90	131.80	42.30	52.80
1943	TC	63.40	54.40	132.60	95.30	179.20	378.80	231.70	251.90	214.30	39.40	33.70	44.20
1944	TC	59.10	61.70	78.70	55.20	48.50	74.80	35.20	63.60	40.90	23.20	22.00	21.80
1945	TC	46.50	71.00	118.10	70.20	183.00	167.90	119.90	127.90	238.20	83.00	29.60	35.90
1946	TC	53.50	85.90	121.60	145.50	85.90	58.10	118.80	282.50	119.30	30.10	28.20	24.60
1947	TC	51.10	93.50	86.20	55.30	48.30	49.00	20.60	18.10	16.50	15.20	17.30	39.80
1948	TC	48.40	67.60	53.10	41.90	17.80	18.10	20.90	79.30	174.20	37.40	21.50	24.20
1949	TC	48.30	47.50	52.40	43.70	32.10	80.50	51.10	31.00	23.00	20.60	20.80	19.50
1950	TC	45.60	63.90	63.70	51.80	79.70	51.30	148.70	69.10	113.40	24.00	21.90	21.30
1951	TC	41.80	250.00	522.20	205.70	160.10	181.20	39.70	164.20	108.40	25.10	23.20	21.70
1952	TC	54.30	48.80	98.00	209.90	168.20	277.50	390.70	481.50	302.30	50.00	26.10	26.50
1953	TC	41.70	67.30	132.20	128.20	93.90	30.30	29.70	36.00	120.20	68.50	22.80	20.10
1954	TC	49.10	48.10	52.70	54.10	47.30	134.00	85.00	125.90	24.60	20.50	18.80	18.50
1955	TC	31.40	38.90	46.40	72.10	69.60	37.90	20.40	19.00	17.20	16.30	16.20	22.00
1956	TC	22.00	34.80	294.80	507.00	236.10	145.20	108.80	204.30	190.80	69.50	59.40	52.30
1957	TC	51.30	64.10	80.40	58.60	37.60	70.30	29.30	33.40	51.10	21.90	20.70	21.40
1958	TC	60.60	88.90	96.80	55.60	95.10	288.10	530.50	444.30	305.00	106.00	28.60	46.90
1959	TC	93.90	162.00	96.10	66.70	92.60	46.10	21.40	20.50	17.40	16.40	15.60	16.80
1960	TC	26.20	34.20	42.20	48.50	39.60	21.70	16.40	15.40	13.40	13.40	13.20	14.10
1961	TC	27.40	35.80	52.10	43.20	23.90	14.80	11.00	10.90	9.90	8.80	10.50	13.60
1962	TC	14.60	20.30	16.60	12.60	102.20	120.20	37.90	22.30	18.60	17.90	19.20	23.00
1963	TC	42.50	60.10	105.50	54.10	0.00	0.00	155.20	125.20	122.10	44.60	25.10	23.40
1964	TC	69.30	131.10	147.30	73.10	37.80	19.30	16.50	15.50	14.30	12.50	12.60	14.40
1965	TC	21.90	82.80	189.40	378.40	209.80	97.70	240.10	89.00	107.50	45.80	25.90	0.00
1966	TC	115.60	120.00	159.40	113.00	96.60	56.70	21.10	18.30	14.40	13.50	13.10	13.10
1967	TC	34.40	40.10	164.70	80.90	144.80	201.50	341.10	238.40	326.80	218.50	25.00	23.10
1968	TC	49.70	116.60	94.70	63.70	59.80	92.10	20.80	14.90	12.00	12.40	15.30	15.20
1969	TC	23.50	30.00	98.10	359.20	437.60	289.70	285.10	376.80	458.20	88.60	16.50	35.20

END OF FILE

C-115379

THIS IS THE DATA FILE FOR SAN JOAQUIN RIVER FLOW AT NEWMAN.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 NM	8.90	8.50	9.70	26.30	19.70	29.80	19.00	20.10	18.90	12.70	12.40	12.30
1931 NM	11.10	10.90	14.60	28.80	28.70	17.10	7.30	7.10	6.80	3.60	2.60	3.10
1932 NM	4.50	5.10	24.80	151.00	309.00	141.00	96.40	223.00	339.00	164.00	21.20	19.60
1933 NM	19.70	13.80	24.60	62.10	98.90	38.90	24.30	27.40	94.60	21.60	12.90	14.50
1934 NM	11.70	9.90	21.00	86.10	62.20	40.90	15.80	12.10	10.90	8.20	5.60	5.60
1935 NM	7.10	8.40	18.50	110.[illegible]	118.80	152.60	368.30	430.00	375.30	78.80	22.80	20.50
1936 NM	31.80	38.00	58.40	79.20	388.90	349.50	368.80	451.40	222.90	77.40	26.90	26.30
1937 NM	28.20	36.40	77.60	104.60	490.10	439.10	413.00	528.50	479.10	109.60	26.30	26.30
1938 NM	28.60	21.00	174.10	233.80	797.00	1445.00	683.00	941.20	1250.00	530.30	107.30	45.70
1939 NM	43.50	63.30	89.[illegible]	120.90	135.60	41.80	57.10	38.60	19.80	14.40	13.80	16.50
1940 NM	13.90	11.2[illegible]	[illegible].00	135.10	260.80	411.70	394.80	426.40	324.30	55.50	22.80	23.00
1941 NM	20.10	12.8[illegible]	[illegible].50	278.60	538.90	769.90	548.20	689.50	755.90	345.50	44.40	29.60
1942 NM	25.20	25.[illegible]0	26.00	314.30	380.60	285.70	370.90	427.80	657.10	249.70	37.30	30.40
1943 NM	33.60	4[illegible]0	79.80	163.70	405.10	762.90	555.00	437.30	325.20	52.80	27.50	26.80
1944 NM	29.50	[illegible].0	37.80	74.10	87.20	129.00	51.90	61.10	88.40	31.40	25.60	25.80
1945 NM	31.10	35.00	45.10	82.80	311.80	274.30	257.70	414.80	301.50	107.70	51.80	47.20
1946 NM	67.00	74.30	155.60	278.10	178.10	83.30	93.90	259.80	128.90	40.80	29.00	34.30
1947 NM	26.90	30.30	81.80	92.00	60.70	54.00	25.60	40.00	28.80	20.10	17.40	19.80
1948 NM	14.10	14.70	16.10	18.00	11.80	13.10	21.90	35.70	136.60	20.00	20.10	28.40
1949 NM	20.70	13.20	13.20	21.90	19.80	59.80	29.20	38.90	49.80	14.60	15.60	15.70
1950 NM	10.60	11.00	12.50	29.40	60.60	34.00	33.90	34.10	60.90	13.70	14.20	18.40
1951 NM	12.60	61.10	408.70	253.40	295.30	142.30	47.40	110.00	42.80	20.60	18.60	23.00
1952 NM	16.90	14.80	30.60	250.60	316.80	386.80	525.60	687.00	625.30	71.20	34.50	36.40
1953 NM	28.10	17.00	58.70	149.90	45.70	21.00	22.80	31.40	28.10	14.30	14.80	22.30
1954 NM	15.60	12.40	14.70	23.60	54.50	54.90	58.40	121.20	32.60	17.80	17.30	17.50
1955 NM	10.80	12.40	16.10	50.10	29.30	21.40	22.40	26.50	20.50	15.20	14.50	14.40
1956 NM	10.10	9.70	198.20	711.40	508.40	186.10	78.90	284.50	261.10	46.70	26.70	30.60
1957 NM	26.70	15.60	15.10	26.40	37.10	75.70	45.40	48.50	104.20	21.00	21.70	22.50
1958 NM	19.40	12.60	17.70	43.90	111.70	318.70	827.30	659.40	426.10	84.60	31.50	37.00
1959 NM	25.90	13.10	16.90	35.00	42.90	28.90	24.90	26.80	16.20	11.00	11.40	12.90
1960 NM	9.80	9.90	12.80	24.30	42.50	18.50	16.40	19.70	12.00	9.80	10.40	7.80
1961 NM	6.40	9.50	13.40	24.60	21.80	13.80	11.20	14.50	10.40	6.00	6.30	6.60
1962 NM	5.60	8.30	17.60	28.30	193.90	141.10	33.20	64.90	94.40	22.30	19.30	18.90
1963 NM	15.40	15.90	19.10	25.80	156.40	53.50	133.40	200.40	126.20	27.50	22.60	25.10
1964 NM	37.20	23.40	23.30	31.20	18.70	15.70	18.30	21.60	19.90	13.00	13.40	20.50
1965 NM	38.50	41.10	61.40	247.70	91.10	129.20	155.70	118.50	113.30	32.00	27.40	31.00
1966 NM	19.50	52.80	130.10	97.70	37.00	24.40	23.10	21.60	16.60	12.60	11.10	11.30
1967 NM	10.30	17.00	52.00	38.80	96.40	62.90	376.50	716.00	539.10	277.50	63.70	44.50
1968 NM	48.90	33.80	58.80	55.10	52.20	38.20	27.10	25.90	14.70	13.80	22.30	23.70
1969 NM	29.30	35.20	38.90	332.40	979.40	1129.00	750.00	758.30	830.70	149.40	63.10	89.00

END OF FILE

C—115380

THIS IS THE DATA FILE FOR SAN JOAQUIN RIVER FLOW AT NEWMAN.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 NM	8.90	8.50	9.70	26.30	19.70	29.80	19.00	20.10	18.90	12.70	12.40	12.30
1931 NM	11.10	10.90	14.60	28.80	28.70	17.10	7.30	7.10	6.80	3.60	2.60	3.10
1932 NM	4.50	5.10	24.80	151.00	309.00	141.00	96.40	223.00	339.00	164.00	21.20	19.60
1933 NM	19.70	13.80	24.60	62.10	98.90	38.90	24.30	27.40	94.60	21.60	12.90	14.50
1934 NM	11.70	9.90	21.00	86.10	62.20	40.90	15.80	12.10	10.90	8.20	5.60	5.60
1935 NM	7.10	8.40	18.50	110.40	118.80	152.60	368.30	430.00	375.30	78.80	22.80	20.50
1936 NM	31.80	38.00	58.40	79.20	388.90	349.50	368.80	451.40	222.90	77.40	26.90	26.30
1937 NM	28.20	36.40	77.60	104.60	490.10	439.10	413.00	528.50	479.10	109.60	26.30	26.30
1938 NM	28.60	21.00	174.10	233.80	797.00	1445.00	683.00	941.20	1250.00	530.30	107.30	45.70
1939 NM	43.50	63.30	89.30	120.90	135.60	41.80	57.10	38.60	19.80	14.40	13.80	16.50
1940 NM	13.90	11.30	26.00	135.10	260.80	411.70	394.80	426.40	324.30	55.50	22.80	23.00
1941 NM	20.10	12.80	79.50	278.60	538.90	769.90	548.20	689.50	755.90	345.50	44.40	29.60
1942 NM	25.20	25.00	126.00	314.30	380.60	285.70	370.90	427.80	657.10	249.70	37.30	30.40
1943 NM	33.60	43.00	79.80	163.70	405.10	762.90	555.00	437.30	325.20	52.80	27.50	26.80
1944 NM	29.50	19.70	37.80	74.10	87.20	129.00	51.90	61.10	88.40	31.40	25.60	25.80
1945 NM	31.10	35.00	45.10	82.80	311.80	274.30	257.70	414.80	301.50	107.70	51.80	47.20
1946 NM	67.00	74.30	155.60	278.10	178.10	83.30	93.90	259.80	128.90	40.80	29.00	34.30
1947 NM	26.90	30.30	81.80	92.00	60.70	54.00	25.60	40.00	28.80	20.10	17.40	19.80
1948 NM	14.10	14.70	16.10	18.00	11.80	13.10	21.90	35.70	136.60	20.00	20.10	28.40
1949 NM	20.70	13.20	13.20	21.90	19.80	59.80	29.20	38.90	49.80	14.60	15.60	15.70
1950 NM	10.60	11.00	12.50	29.40	60.60	34.00	33.90	34.10	60.90	13.70	14.20	18.40
1951 NM	12.60	61.10	408.70	253.40	295.30	142.30	47.40	110.00	42.80	20.60	18.60	23.00
1952 NM	16.90	14.80	30.60	250.60	316.80	386.80	525.60	687.00	625.30	71.20	34.50	36.40
1953 NM	28.10	17.00	58.70	149.90	45.70	21.00	22.80	31.40	28.10	14.30	14.80	22.30
1954 NM	15.60	12.40	14.70	23.60	54.50	54.90	58.40	121.20	32.60	17.80	17.30	17.50
1955 NM	10.80	12.40	16.10	50.10	29.30	21.40	22.40	26.50	20.50	15.20	14.50	14.40
1956 NM	10.10	9.70	198.20	711.40	508.40	186.10	78.90	284.50	261.10	46.70	26.70	30.60
1957 NM	26.70	15.60	15.10	26.40	37.10	75.70	45.40	48.50	104.20	21.00	21.70	22.50
1958 NM	19.40	12.60	17.70	43.90	111.70	318.70	827.30	659.40	426.10	84.60	31.50	37.00
1959 NM	25.90	13.10	16.90	35.00	42.90	28.90	24.90	26.80	16.20	11.00	11.40	12.90
1960 NM	9.80	9.90	12.80	24.30	42.50	18.50	16.40	19.70	12.00	9.80	10.40	7.80
1961 NM	6.40	9.50	13.40	24.60	21.80	13.80	11.20	14.50	10.40	6.00	6.30	6.60
1962 NM	5.60	8.30	17.60	28.30	193.90	141.10	33.20	64.90	94.40	22.30	19.30	18.90
1963 NM	15.40	15.90	19.10	25.80	156.40	53.50	133.40	200.40	126.20	27.50	22.60	25.10
1964 NM	37.20	23.40	23.30	31.20	18.70	15.70	18.30	21.60	19.90	13.00	13.40	20.50
1965 NM	38.50	41.10	61.40	247.70	91.10	129.20	155.70	118.50	113.30	32.00	27.40	31.00
1966 NM	19.50	52.80	130.10	97.70	37.00	24.40	23.10	21.60	16.60	12.60	11.10	11.30
1967 NM	10.30	17.00	52.00	38.80	96.40	62.90	376.50	716.00	539.10	277.50	63.70	44.50
1968 NM	48.90	33.80	58.80	55.10	52.20	38.20	27.10	25.90	14.70	13.80	22.30	23.70
1969 NM	29.30	35.20	38.90	332.40	979.40	1129.00	750.00	758.30	830.70	149.40	63.10	89.00

END OF FILE

JOB ACTIVE.
list,f=vufile
THIS IS THE DATA FILE OF UNIMPAIRED FLOW AT VERNALIS.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 VU	9.70	12.20	57.20	102.10	182.50	400.50	713.70	796.30	773.60	152.50	34.04	20.46
1931 VU	27.36	51.51	33.67	70.02	107.90	167.30	422.95	563.45	151.50	36.70	17.60	10.19
1932 VU	12.00	24.20	316.80	236.00	680.60	524.40	817.60	1673.20	1628.70	561.60	112.10	35.40
1933 VU	29.60	22.80	38.30	81.40	91.40	237.10	535.20	794.20	1200.30	245.70	54.50	25.70
1934 VU	12.10	28.90	125.70	163.90	230.60	425.00	544.90	420.40	239.70	56.20	24.20	16.80
1935 VU	33.30	108.50	130.40	300.40	290.10	404.30	1414.60	1728.90	1538.80	348.80	91.30	28.90
1936 VU	34.90	52.20	50.40	234.90	1009.00	625.40	1250.40	1662.00	1096.00	376.40	82.00	21.90
1937 VU	26.30	33.20	94.00	112.00	863.50	655.90	956.30	2149.40	1212.80	335.00	70.10	21.60
1938 VU	27.30	47.00	844.40	291.00	945.80	1425.20	1389.00	2498.80	2459.60	990.10	243.20	86.60
1939 VU	119.87	117.63	97.90	118.67	152.39	393.74	850.90	638.68	253.55	83.48	36.58	45.47
1940 VU	111.58	47.24	50.10	614.27	698.75	967.46	1055.72	1780.52	1005.96	206.31	45.40	13.40
1941 VU	32.20	39.90	361.60	348.00	659.20	785.50	866.60	2202.30	1705.30	745.50	156.20	42.70
1942 VU	47.20	97.50	409.60	478.10	431.20	473.70	1075.90	1577.10	1890.70	749.60	133.50	34.70
1943 VU	31.56	209.75	236.59	715.74	490.72	1181.94	1254.17	1591.95	997.98	434.53	106.38	32.44
1944 VU	34.92	47.17	62.51	113.60	215.08	406.96	487.09	1372.99	803.72	313.03	61.72	20.05
1945 VU	30.02	232.17	214.58	162.62	911.63	524.49	926.16	1529.06	1387.33	533.99	120.24	39.28
1946 VU	162.65	257.53	555.41	339.16	206.58	479.22	1091.18	1521.44	793.04	239.60	60.20	28.08
1947 VU	67.02	197.81	241.00	138.66	229.90	392.55	604.57	1055.02	370.13	89.69	22.12	16.44
1948 VU	88.06	67.42	50.83	96.56	74.83	188.55	649.70	1380.41	1271.07	285.30	46.27	19.42
1949 VU	25.05	33.85	57.56	61.96	107.02	336.65	890.61	1359.82	736.33	130.67	38.89	20.83
1950 VU	20.80	43.23	45.12	200.66	348.87	366.58	1037.36	1419.17	901.25	215.82	38.69	19.14
1951 VU	58.29	1395.26	1494.97	478.82	429.31	501.43	763.11	1080.94	753.76	235.20	54.14	16.88
1952 VU	35.92	78.22	322.04	617.42	418.42	716.58	1393.43	2647.17	1910.71	885.42	218.67	67.97
1953 VU	37.20	49.17	151.67	367.88	180.56	292.57	798.35	785.41	1124.88	479.18	65.00	22.44
1954 VU	27.02	50.33	60.65	116.59	258.36	585.84	1063.52	1371.46	569.67	163.93	31.12	16.19
1955 VU	18.50	49.04	124.84	176.51	169.95	249.94	439.02	1128.28	925.17	177.11	36.61	16.96
1956 VU	17.30	40.00	1831.30	1207.30	494.10	555.00	923.60	1846.70	1761.00	759.90	176.70	66.90
1957 VU	67.70	75.60	69.00	94.70	294.00	422.30	540.30	1188.10	1209.10	250.70	55.20	25.80
1958 VU	45.14	61.08	133.25	169.38	491.84	774.83	1319.13	2535.83	1822.49	722.78	217.41	73.65
1959 VU	38.65	37.69	33.39	174.57	330.68	375.87	694.22	667.98	410.46	82.76	21.29	118.67
1960 VU	37.82	26.55	30.64	68.38	291.52	398.28	703.09	847.07	443.46	77.27	23.20	13.63
1961 VU	16.37	57.31	92.03	56.44	119.50	195.99	481.55	606.47	353.92	57.17	43.76	19.51
1962 VU	18.65	32.64	66.90	68.87	673.90	399.52	1240.79	1217.04	1362.56	427.62	81.69	28.67
1963 VU	56.49	31.68	66.20	285.40	907.54	343.03	728.87	1683.95	1386.11	575.68	128.36	56.85
1964 VU	59.85	256.78	134.83	143.59	133.16	206.91	495.68	903.16	612.32	135.85	45.18	23.77
1965 VU	69.12	153.05	1143.86	877.22	437.81	455.60	964.37	1381.29	1423.25	710.37	353.72	138.32
1966 VU	38.66	350.81	238.94	223.72	202.78	438.75	940.10	1066.90	322.48	96.33	41.29	24.95
1967 VU	29.44	132.56	663.70	377.93	349.53	912.80	930.90	2165.70	2487.10	1517.20	309.30	116.57
1968 VU	50.70	53.60	94.00	125.90	352.60	343.90	572.30	801.80	392.20	86.40	43.40	21.70
1969 VU	37.40	182.00	219.70	1677.70	919.70	808.10	1564.90	3217.00	2321.80	1036.50	241.60	68.90

READY

C—115382

C-115382

THIS IS THE DATA FILE FOR UNIMPAIRED SAN JOAQUIN RIVER FLOW (KAF) AT FRIANT.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930 FR	5.00	6.20	8.30	18.20	35.60	80.00	165.10	213.50	243.60	60.80	16.90	5.90
1931 FR	10.60	13.40	10.20	16.00	23.40	38.90	100.20	173.50	59.70	16.00	11.10	7.20
1932 FR	5.90	8.40	71.80	58.90	167.70	156.60	238.10	491.50	543.60	238.80	51.40	14.70
1933 FR	12.60	8.90	14.60	26.50	30.00	73.40	159.00	213.40	410.10	118.90	29.30	14.70
1934 FR	6.80	10.30	38.10	46.80	50.30	109.40	166.10	146.20	68.90	27.30	13.40	7.90
1935 FR	12.60	26.60	36.20	72.50	85.20	110.90	356.60	496.80	519.20	144.20	43.80	18.60
1936 FR	13.60	15.80	16.40	38.30	195.90	163.50	348.60	510.00	347.70	150.50	42.10	10.90
1937 FR	10.90	12.60	36.40	34.90	252.70	190.60	303.80	704.80	456.80	159.70	34.00	10.80
1938 FR	9.80	12.30	210.70	70.90	207.30	433.80	434.20	795.00	912.70	431.20	127.90	42.60
1939 FR	38.90	33.10	28.70	32.70	43.30	102.80	239.90	208.80	110.30	43.40	24.80	14.10
1940 FR	34.80	14.20	11.40	134.10	139.80	210.00	290.00	558.60	362.90	96.60	21.20	7.00
1941 FR	10.10	11.70	98.40	105.80	182.80	208.60	242.40	711.20	641.50	330.90	85.80	23.30
1942 FR	21.50	30.30	96.00	113.10	102.60	128.50	298.50	465.40	632.60	284.00	64.70	16.70
1943 FR	10.10	42.50	43.40	169.70	113.30	267.70	335.10	502.50	325.10	178.80	49.90	15.60
1944 FR	10.50	15.10	19.80	31.20	55.40	111.60	140.80	408.20	279.50	142.60	35.00	15.70
1945 FR	12.70	58.40	56.10	44.10	237.70	147.90	275.90	476.80	487.60	240.20	73.90	26.80
1946 FR	59.10	65.60	118.30	78.90	53.80	125.80	310.40	463.90	279.90	117.80	36.90	19.10
1947 FR	28.50	64.90	84.50	47.70	64.00	100.30	171.00	347.70	145.80	42.70	16.80	11.60
1948 FR	22.80	18.20	15.40	18.90	20.20	42.60	164.60	390.60	372.60	107.90	26.00	15.00
1949 FR	10.50	7.90	14.60	16.20	25.90	73.00	234.50	409.50	268.30	63.20	25.60	14.90
1950 FR	9.80	16.10	17.20	43.20	90.10	89.60	280.10	379.00	262.90	87.00	21.70	13.80
1951 FR	17.10	247.00	300.40	111.20	104.20	119.20	201.90	321.90	278.00	114.70	31.70	11.70
1952 FR	12.30	20.40	83.40	133.00	98.70	176.70	385.20	819.90	640.80	335.30	101.40	33.00
1953 FR	16.90	18.70	42.90	85.00	48.00	71.50	197.20	211.30	320.20	171.60	30.20	13.20
1954 FR	9.40	16.60	16.60	33.40	65.40	127.20	278.40	439.50	217.60	80.40	20.20	9.10
1955 FR	6.00	17.80	31.20	41.60	48.90	74.10	126.50	337.80	348.20	87.90	29.60	11.40
1956 FR	6.10	13.20	460.50	271.20	140.80	169.50	278.30	568.00	613.80	317.80	86.50	34.40
1957 FR	26.30	21.70	20.70	29.50	66.90	90.10	142.20	326.70	439.90	115.00	31.70	15.90
1958 FR	16.40	18.50	43.30	42.60	112.50	181.40	362.60	795.50	622.30	287.50	107.90	40.50
1959 FR	16.10	14.60	14.60	37.00	89.60	113.60	203.10	208.10	153.00	41.50	16.80	41.40
1960 FR	18.40	9.70	9.50	18.00	55.00	86.10	177.90	240.70	146.90	42.60	16.40	7.50
1961 FR	8.50	22.30	31.20	19.00	30.80	48.90	124.60	171.60	128.00	27.40	24.80	10.40
1962 FR	9.80	14.90	23.10	23.50	184.80	109.90	381.00	396.90	505.20	202.60	51.70	20.20
1963 FR	17.60	10.80	10.70	81.90	207.90	101.40	191.90	464.20	492.40	264.20	70.70	31.40
1964 FR	25.50	64.30	36.40	31.20	30.80	51.80	126.70	256.90	200.00	59.30	28.70	10.50
1965 FR	10.10	34.00	203.90	187.80	114.10	128.20	250.80	431.20	472.20	266.70	137.80	35.10
1966 FR	17.50	101.10	66.50	61.80	55.50	125.80	276.90	361.60	147.70	50.40	25.00	8.80
1967 FR	6.40	29.70	212.70	92.50	100.70	243.00	249.60	659.90	823.50	594.30	154.20	66.80
1968 FR	26.90	22.90	34.30	36.90	75.40	82.90	146.10	231.10	131.20	43.80	22.10	8.40
1969 FR	15.10	40.00	52.20	396.60	233.60	227.20	464.50	1096.40	874.20	462.80	137.10	40.50
1970 FR	32.60	31.70	47.10	159.40	83.30	136.90	146.00	375.80	278.50	106.60	36.70	11.00

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list,1  ernali
THIS IS THE DATA FILE CHLORIDES (PPM) AT VERNALIS
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	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	20	0	18	18	10	7	8	53	82
1939	47	32	41	30	31	84	0	0	0	0	0	0
1940	0	0	0	0	0	0	0	0	0	0	0	0
1941	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	17	21	23	9	8	8	52	78	72
1943	59	43	26	27	11	13	10	7	24	88	80	64
1944	66	66	48	49	35	49	42	23	86	120	98	78
1945	61	52	37	43	19	17	14	18	7	0	0	0
1946	0	0	0	26	31	66	16	10	62	120	100	110
1947	83	59	62	71	77	78	80	63	140	160	150	76
1948	85	84	94	77	180	160	29	10	14	140	120	100
1949	88	0	96	68	130	30	70	60	110	140	130	140
1950	93	100	100	62	37	63	18	16	76	140	140	110
1951	78	10	0	0	0	0	0	0	0	0	0	0
1952	80	86	52	21	15	18	10	9	10	58	106	83
1953	89	78	48	32	72	147	108	66	23	54	134	123
1954	94	97	94	107	80	45	28	23	132	177	167	160
1955	140	113	94	33	79	106	121	142	71	174	170	159
1956	163	143	63	13	25	57	40	14	14	68	92	89
1957	93	84	64	100	124	61	133	100	39	152	151	135
1958	84	72	70	93	52	34	21	16	16	62	125	100
1959	0	0	50	97	83	109	172	178	201	256	240	172
1960	161	138	124	138	125	236	199	193	263	281	272	263
1961	175	140	110	129	168	252	348	253	315	407	401	286
1962	250	194	196	213	110	49	96	55	67	162	186	154
1963	124	101	67	129	44	97	27	15	36	109	167	130
1964	87	70	50	58	95	209	223	171	146	248	259	182
1965	112	108	92	21	35	46	42	32	21	88	153	122
1966	28	32	11	36	37	112	66	52	90	0	110	112
1967	89	37	31	53	25	35	12	12	9	26	34	101
1968	75	56	50	32	108	35	32	82	0	214	188	179
1969	75	42	94	2	6	15	13	8	4	17	49	35

READY.

list,f=staflow

THIS IS THE DATA FILE OF CHLORIDES (PPM) FROM THE STANISLAUS

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	20	20	10	10
1937	10	10	0	0	0	0	0	0	10	10	10	10
1938	10	10	0	0	0	0	0	0	15	10	10	10
1939	25	0	0	0	40	10	20	20	3	20	20	20
1940	30	6	3	25	55	15	23	10	20	20	15	20
1941	20	10	10	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	0	0
1943	0	0	0	0	0	0	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	2	4	3	2	3	9	12	11	12
1947	10	7	13	12	12	3	4	3	12	13	13	4
1948	9	5	8	3	8	9	1	1	1	9	9	16
1949	7	0	12	2	12	5	8	1	8	11	8	9
1950	12	7	8	4	4	7	2	2	10	16	11	17
1951	51	15	4	2	8	3	4	3	1	10	10	15
1952	8	12	8	8	9	2	6	9	2	13	15	12
1953	11	16	14	0	0	0	0	0	0	0	0	0
1954	7	3	5	12	3	1	2	0	0	0	0	8
1955	10	7	6	4	2	2	8	10	2	9	8	8
1956	8	8	5	0	0	0	0	0	0	2	0	0
1957	0	0	5	5	10	3	9	2	0	9	10	7
1958	8	7	9	8	0	0	0	0	0	3	10	5
1959	8	8	4	5	9	4	10	9	9	9	8	13
1960	14	9	9	8	11	12	8	7	7	10	0	0
1961	9	7	5	3	7	7	11	9	24	10	12	9
1962	10	10	9	9	9	2	8	2	2	7	9	7
1963	11	5	8	8	2	12	1	2	2	9	8	6
1964	6	7	4	3	3	12	8	9	8	8	10	6
1965	9	6	6	1	1	2	2	1	1	6	6	5
1966	4	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0

THIS IS THE DATA FILE OF CHLORIDES (PPM) AT MAZE ROAD BRIDGE.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	90	56	146	108	106	94
1940	78	82	72	35	15	24	11	10	9	54	126	66
1941	73	85	74	24	0	15	21	13	7	46	79	79
1942	67	75	49	0	17	0	0	0	0	50	0	90
1943	62	0	39	0	0	0	0	0	0	120	0	99
1944	0	0	0	0	0	0	68	0	0	0	107	0
1945	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0
1947	91	74	0	66	0	211	0	187	170	162	0	0
1948	0	87	0	111	0	0	213	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	75	13	37	92	60	46
1952	0	58	31	8	11	9	0	0	0	116	136	65
1953	0	70	0	34	73	0	0	72	69	33	166	0
1954	0	117	120	0	0	230	31	31	95	196	194	194
1955	188	135	137	0	0	0	213	216	199	198	191	187
1956	206	174	124	18	23	0	0	19	20	154	127	91
1957	103	117	84	142	150	45	205	154	42	172	165	140
1958	82	74	88	67	24	60	23	17	16	80	164	81
1959	110	55	109	119	120	146	195	210	240	295	0	262
1960	227	132	104	135	175	190	280	250	285	278	246	269
1961	260	144	132	122	0	287	325	206	258	344	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0
1964	89	80	60	89	151	271	218	0	0	265	0	180
1965	139	132	98	49	42	25	52	0	76	117	0	25
1966	66	82	22	74	67	126	220	222	190	244	0	245
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0

END OF FILE

list,f-tuoflow

THIS IS THE DATA FILE OF CHLORIDES (PPM) FROM THE TUOLUMNE

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	30	0	18	0	7	13	8	3	11	35	41
1939	31	16	28	37	37	41	46	23	12	9	13	12
1940	7	9	14	11	4	5	5	2	5	27	36	13
1941	25	20	22	20	5	7	7	6	2	17	40	17
1942	25	13	12	10	16	9	9	7	9	27	49	30
1943	25	52	11	33	10	12	17	41	24	22	42	27
1944	49	37	34	52	60	83	20	31	110	60	60	110
1945	51	32	26	38	35	14	21	77	6	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	9	15	62	48	79
1952	29	30	17	0	7	0	0	0	0	13	38	27
1953	0	10	13	10	20	0	0	88	54	24	114	122
1954	0	0	74	34	34	90	13	7	61	130	62	0
1955	69	45	37	63	62	72	195	186	151	150	146	151
1956	155	121	74	7	20	28	38	11	79	56	95	73
1957	74	63	46	70	108	20	166	170	74	178	183	153
1958	54	38	44	63	10	25	9	13	18	42	176	68
1959	85	23	66	75	54	67	171	169	210	206	0	222
1960	238	86	62	73	107	112	223	236	235	238	210	218
1961	232	94	70	65	0	218	0	207	255	298	283	179
1962	189	196	162	170	190	9	45	136	135	138	184	164
1963	0	0	39	61	11	66	24	24	34	0	168	181
1964	69	31	21	38	70	185	192	172	0	222	0	202
1965	152	66	48	21	12	27	21	0	76	76	134	30
1966	38	36	20	35	17	38	143	198	185	216	0	209
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	176	0	0	0	0	0	0	0	0	0	0	0

READY

C-115387

list,f=graflow

THIS IS THE DATA FILE OF CHLORIDES (PPM) AT GRAYSON

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	195	199	213	240	202	0
1935	0	0	0	0	0	0	0	0	0	0	159	0
1936	0	0	0	0	0	0	0	0	0	0	189	0
1937	0	0	0	0	0	0	0	0	0	0	0	100
1938	112	0	0	23	0	22	0	12	8	9	54	99
1939	89	54	57	73	50	180	50	31	88	135	124	111
1940	97	184	110	39	22	24	13	3	9	80	131	87
1941	113	187	117	26	20	23	20	9	6	40	153	100
1942	98	137	52	19	28	19	16	11	7	38	130	112
1943	93	130	66	69	19	14	10	16	16	118	91	94
1944	0	0	88	52	34	49	66	56	73	130	84	69
1945	78	100	110	62	17	18	29	13	9	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0
1947	66	168	0	56	0	206	0	148	127	185	0	0
1948	0	207	0	175	0	0	246	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	123	35	148	146	184	95
1952	169	205	97	16	22	35	13	6	8	116	127	76
1953	153	168	130	36	161	232	180	103	134	190	159	91
1954	106	192	212	250	119	174	41	21	96	168	155	170
1955	210	224	209	116	174	218	177	114	176	191	159	184
1956	234	222	191	17	25	78	120	28	12	132	154	122
1957	118	192	198	191	170	102	179	131	36	159	146	128
1958	162	218	192	66	65	100	0	18	12	111	165	100
1959	112	216	240	160	250	277	218	220	228	235	0	0
1960	181	225	280	250	205	306	248	213	248	210	191	238
1961	270	239	225	235	0	318	288	180	175	200	256	257
1962	295	298	205	233	292	53	220	232	39	158	161	158
1963	208	0	282	309	42	210	0	70	37	114	168	148
1964	115	231	225	186	238	343	240	155	162	216	0	154
1965	115	204	208	57	127	21	118	0	65	126	156	116
1966	122	245	30	96	228	305	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0

READY

list,f-newman

THIS IS THE DATA FILE OF CHLORIDES (PPM) AT NEWMAN

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1930	0	0	0	0	0	0	[illegible]	0	0	0	0	0
1931	0	0	0	0	0	0	[illegible]	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0		0	0	0	0	0	0
1935	0	0	0	0	0		0	0	0	0	0	0
1936	0	0	0	0	0		0	0	0	119	171	92
1937	73	0	45	0	0	[illegible]	0	0	0	73	168	95
1938	77	0	0	23	33	[illegible]4	0	9	8	4	86	70
1939	59	43	44	50	44	110	56	76	130	160	120	78
1940	160	170	51	39	2	40	22	6	8	52	150	88
1941	120	140	0	34		28	20	10	6	39	140	77
1942	82	66	31	26		10	22	8	4	27	120	80
1943	77	29	25	63	[illegible]9	28	14	19	11	100	77	57
1944	88	46	92	5[illegible]	66	74	86	68	80	220	110	56
1945	53	78	74		12	14	39	8	8	0	0	0
1946	0	0	0		34	150	84	13	24	200	71	70
1947	120	200	47	[illegible]	84	190	170	130	110	130	110	110
1948	140	170	200	0	280	0	195	75	12	1100	47	40
1949	110	0	0	0	0	33	0	0	84	0	78	81
1950	120	150	34	100	150	84	130	180	83	89	190	61
1951	300	17	13	0	25	100	240	54	150	200	140	130
1952	320	260	150	27	24	23	14	10	10	150	140	81
1953	130	180	84	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	187
1956	237	281	257	25	30	104	132	58	15	143	180	98
1957	98	190	217	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	44	0	9	33	137	121	178
1959	135	222	232	161	349	197	213	205	163	235	209	304
1960	277	388	445	490	165	280	214	0	223	219	222	290
1961	262	325	420	238	390	449	436	234	235	302	318	212
1962	280	365	230	198	233	165	351	194	52	124	150	162
1963	143	226	274	240	120	422	133	202	62	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0

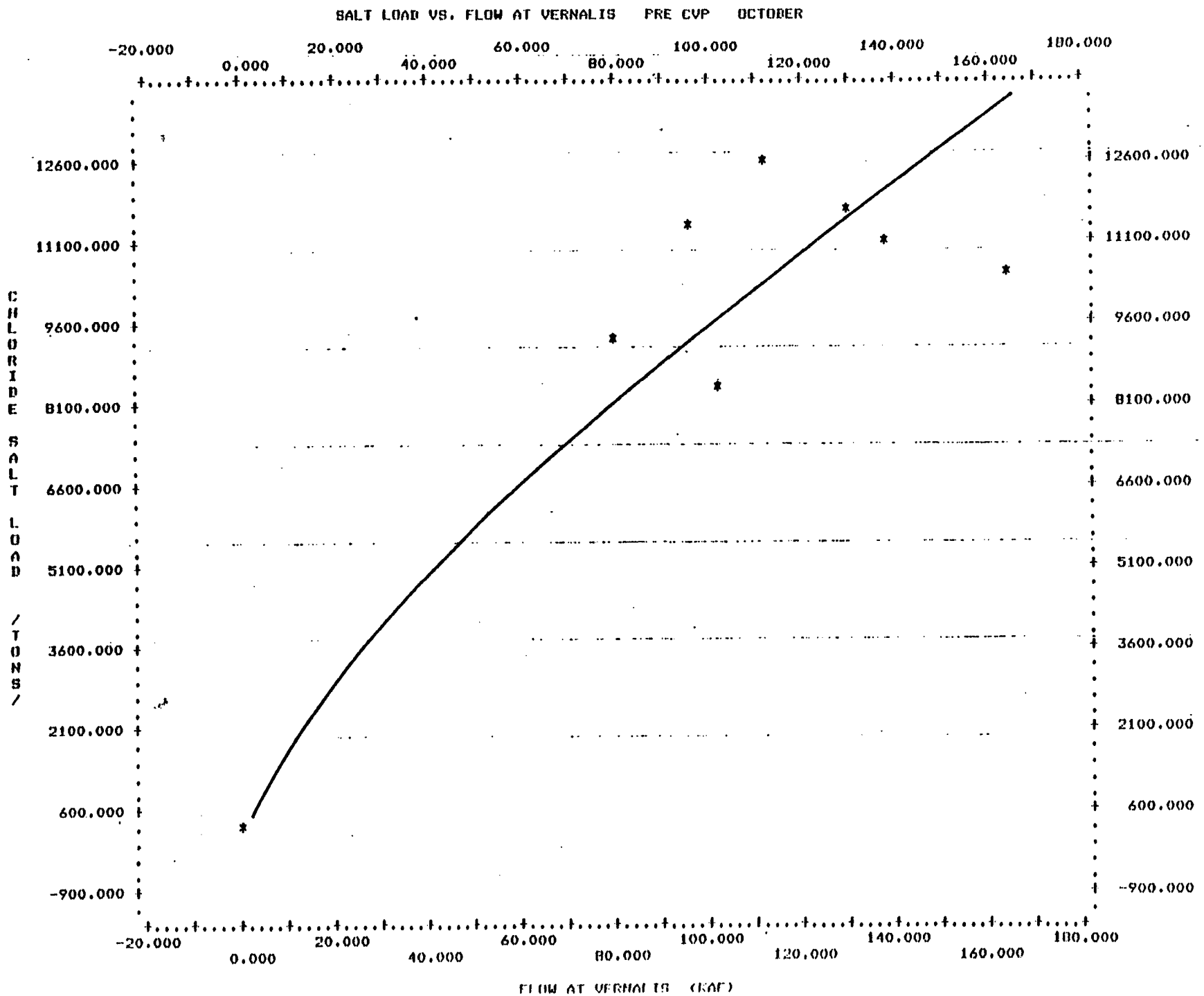
READY

C—115389

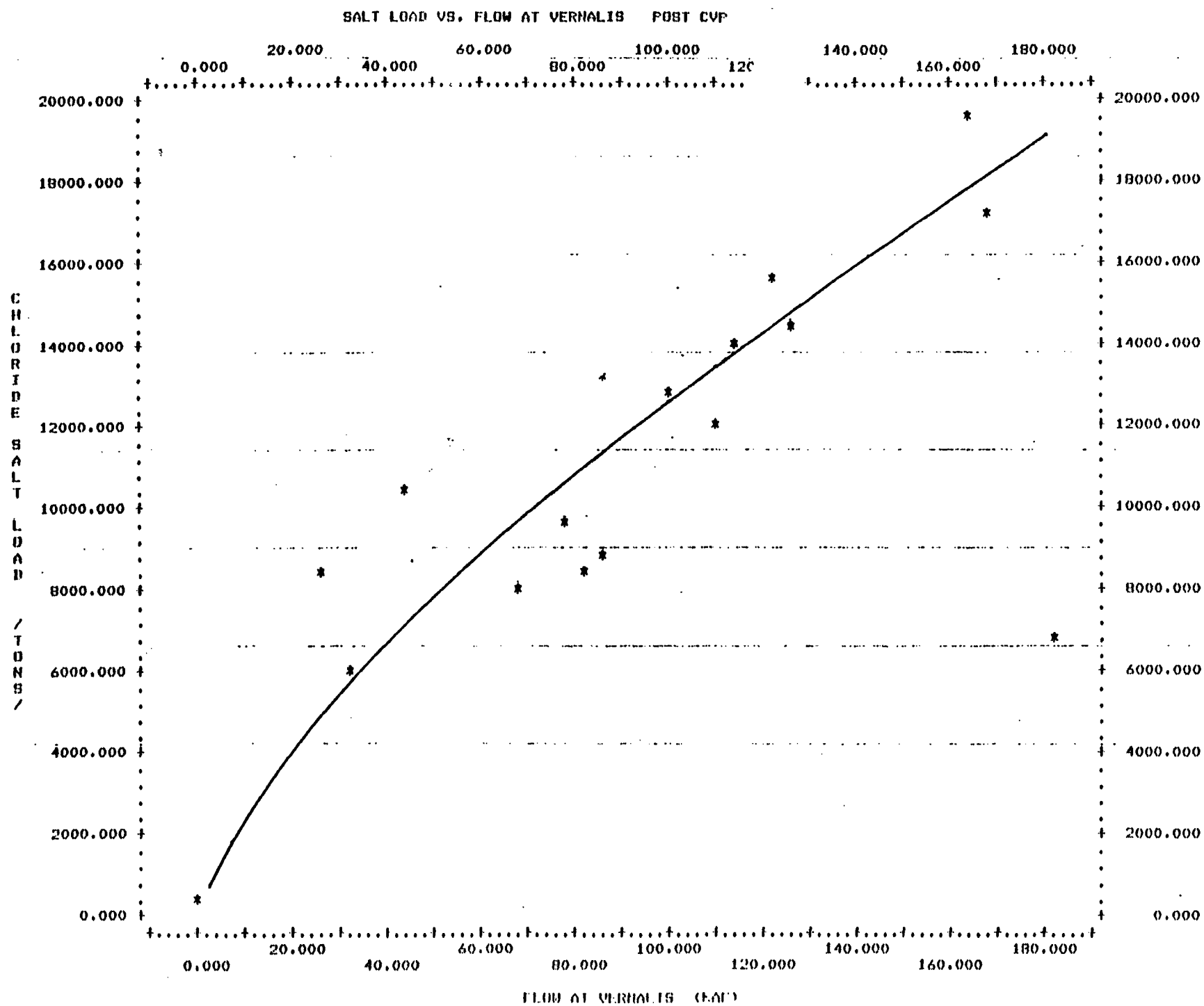
APPENDIX 2

CHLORIDE LOAD-FLOW REGRESSION

CURVES


SALT LOAD VS. FLOW AT VERNALIS PRE CVP OCTOBER
CHLORIDE SALT LOAD /TONS/
FLOW AT VERNALIS (KAF)
-20.000
0.000
20.000
40.000
60.000
80.000
100.000
120.000
140.000
160.000
180.000
12600.000
11100.000
9600.000
8100.000
6600.000
5100.000
3600.000
2100.000
600.000
-900.000

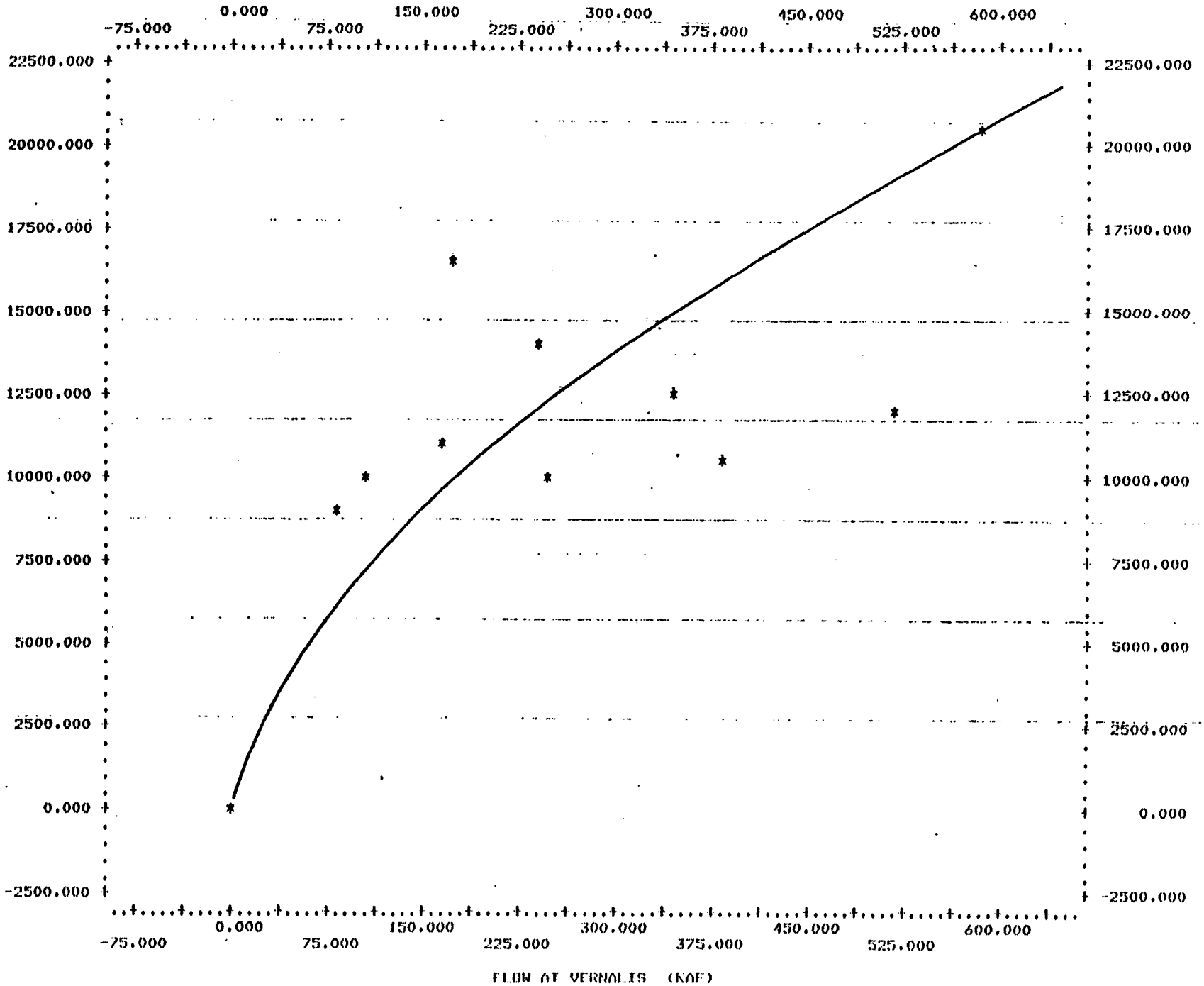
C—115391



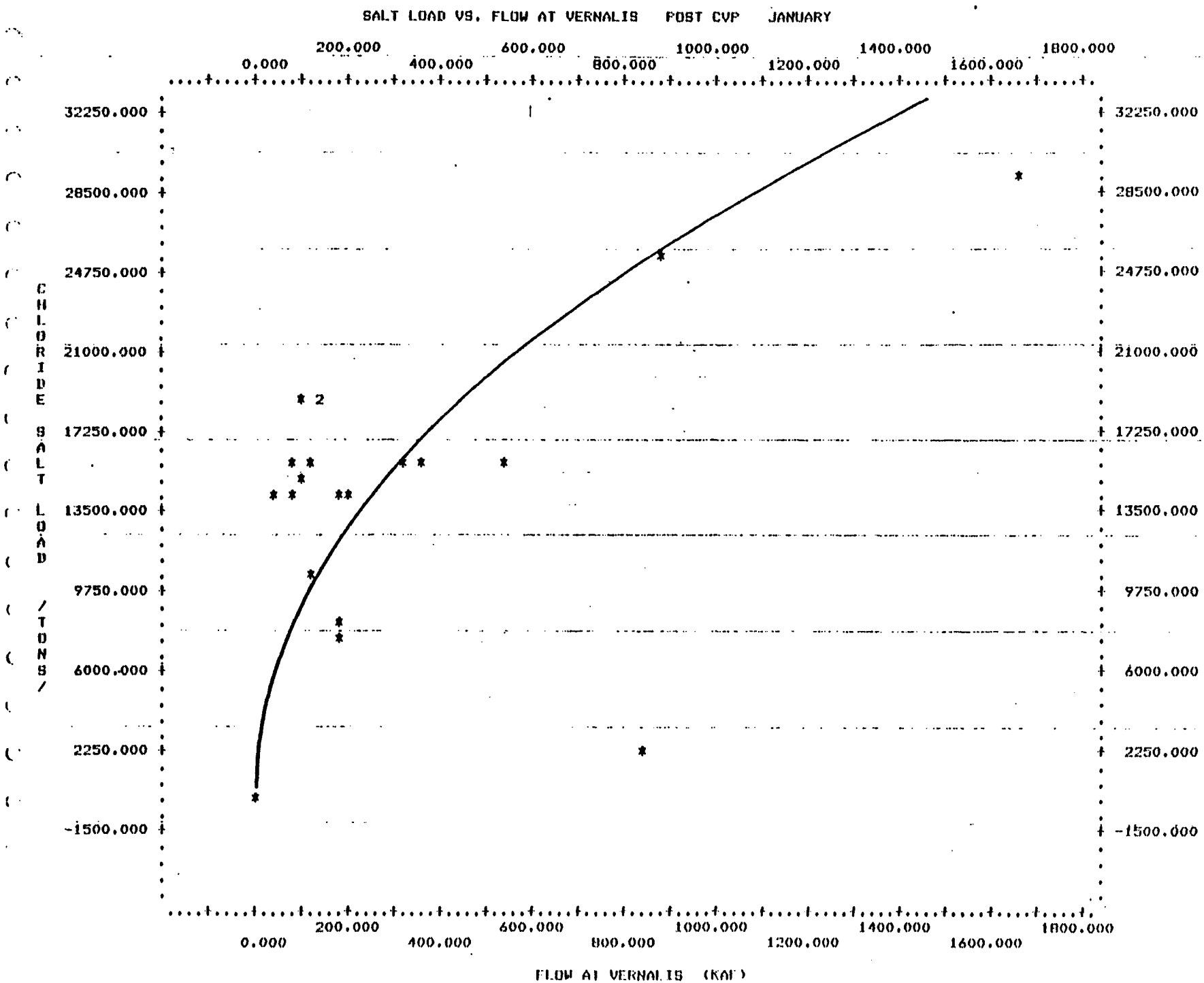
C-115392

C-115392

SALT LOAD VS. FLOW AT VERNALIS PRE CVP JANUARY

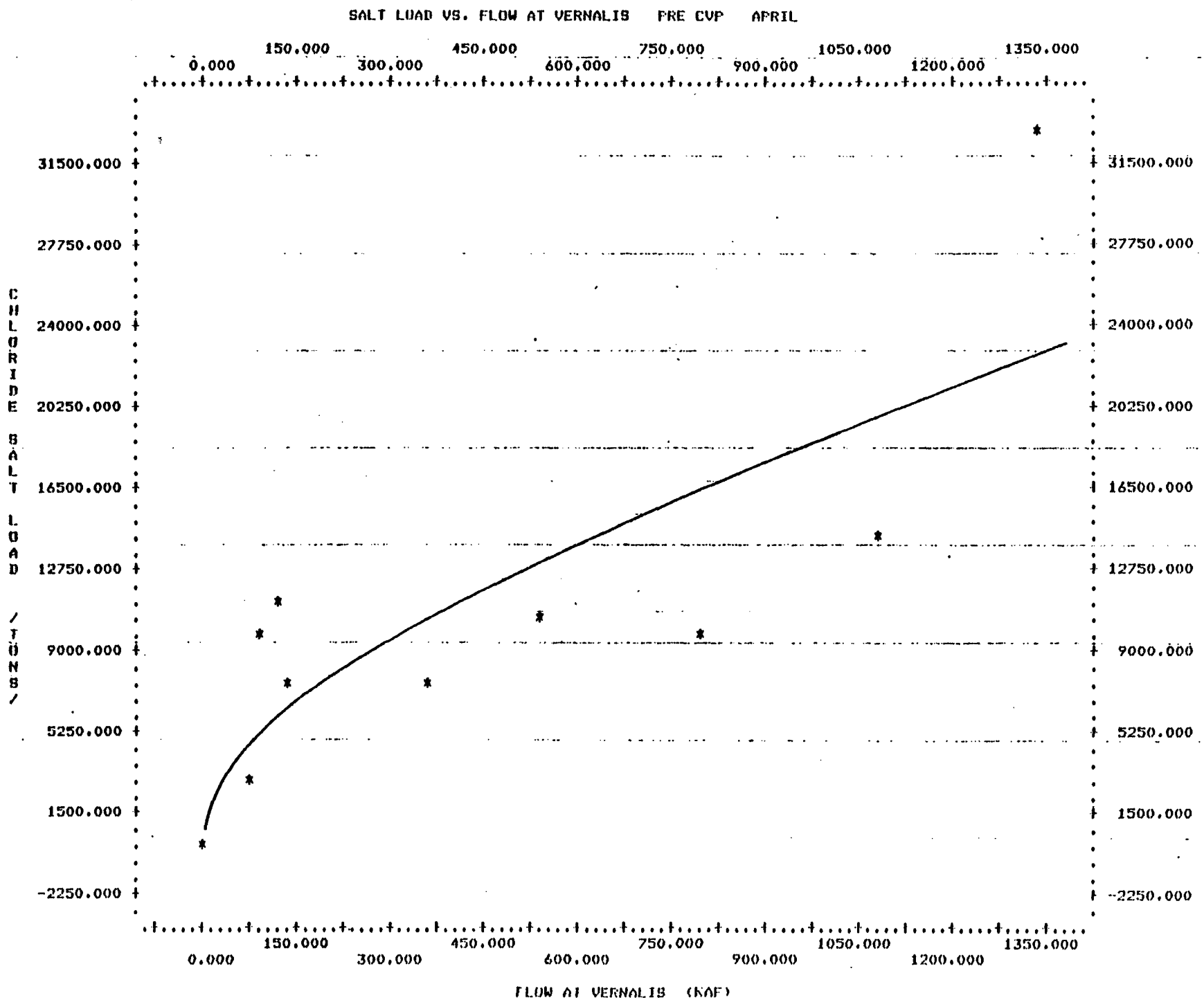


C-115393



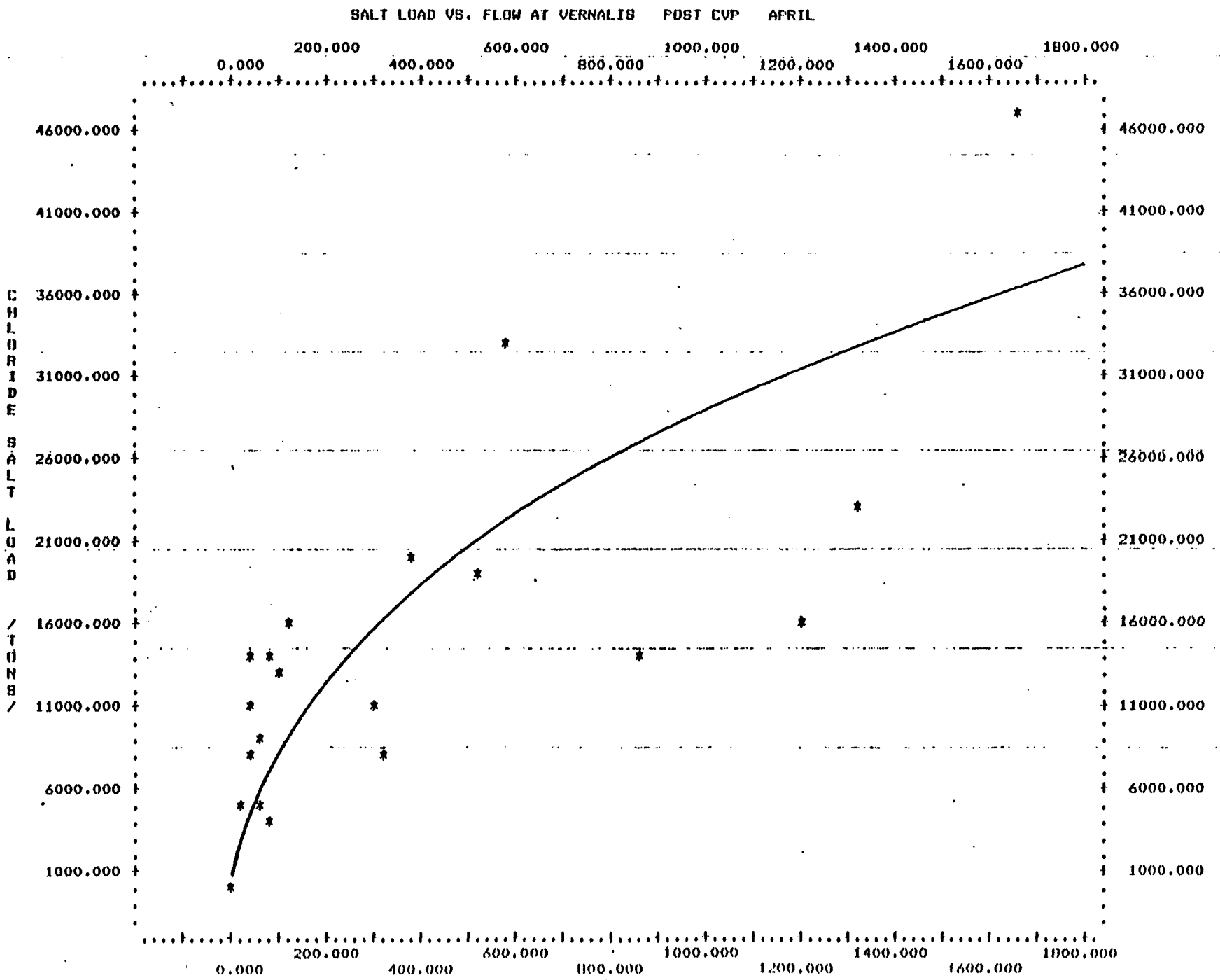
C—115394

C-115394

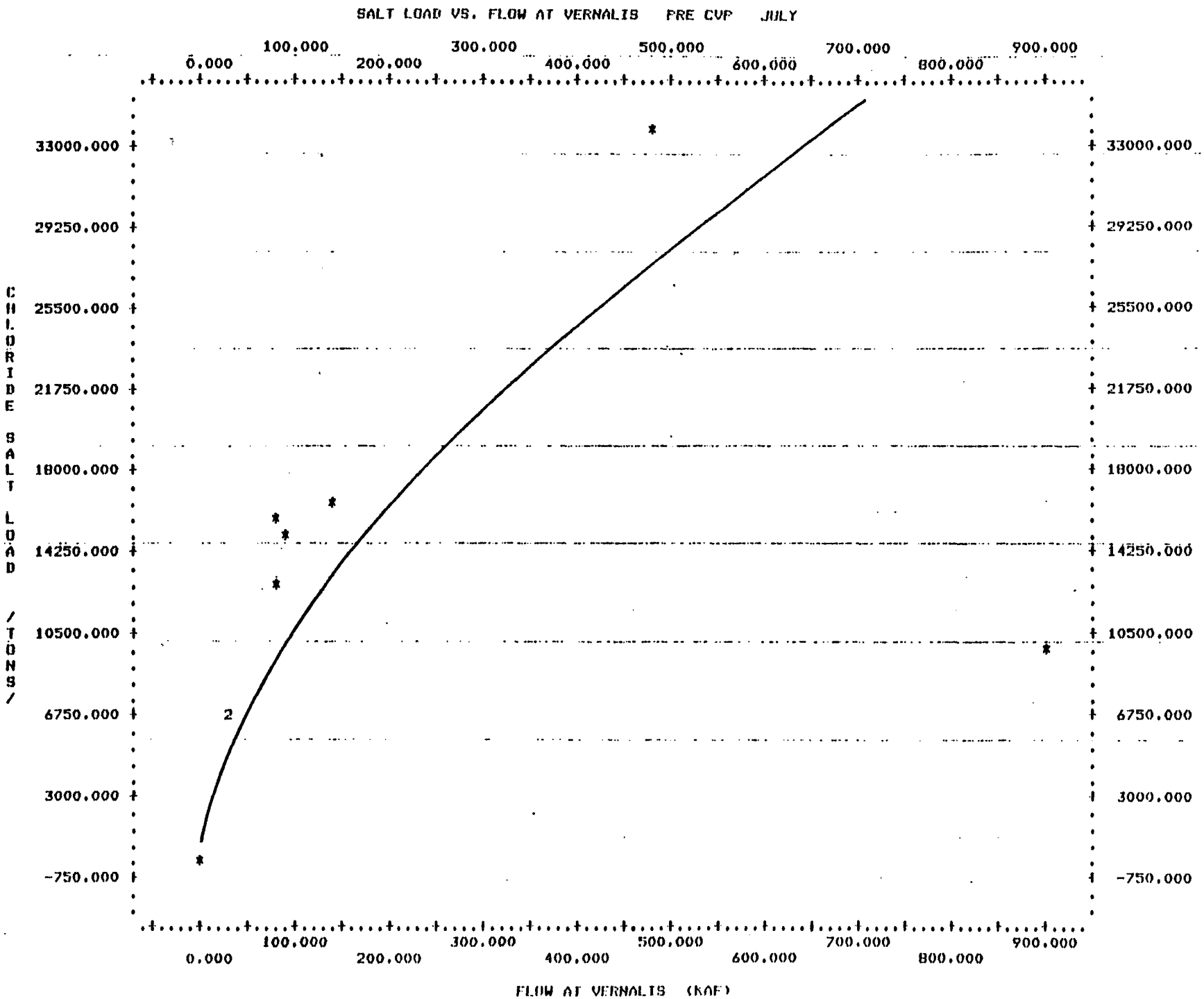


C-115395

C-115395

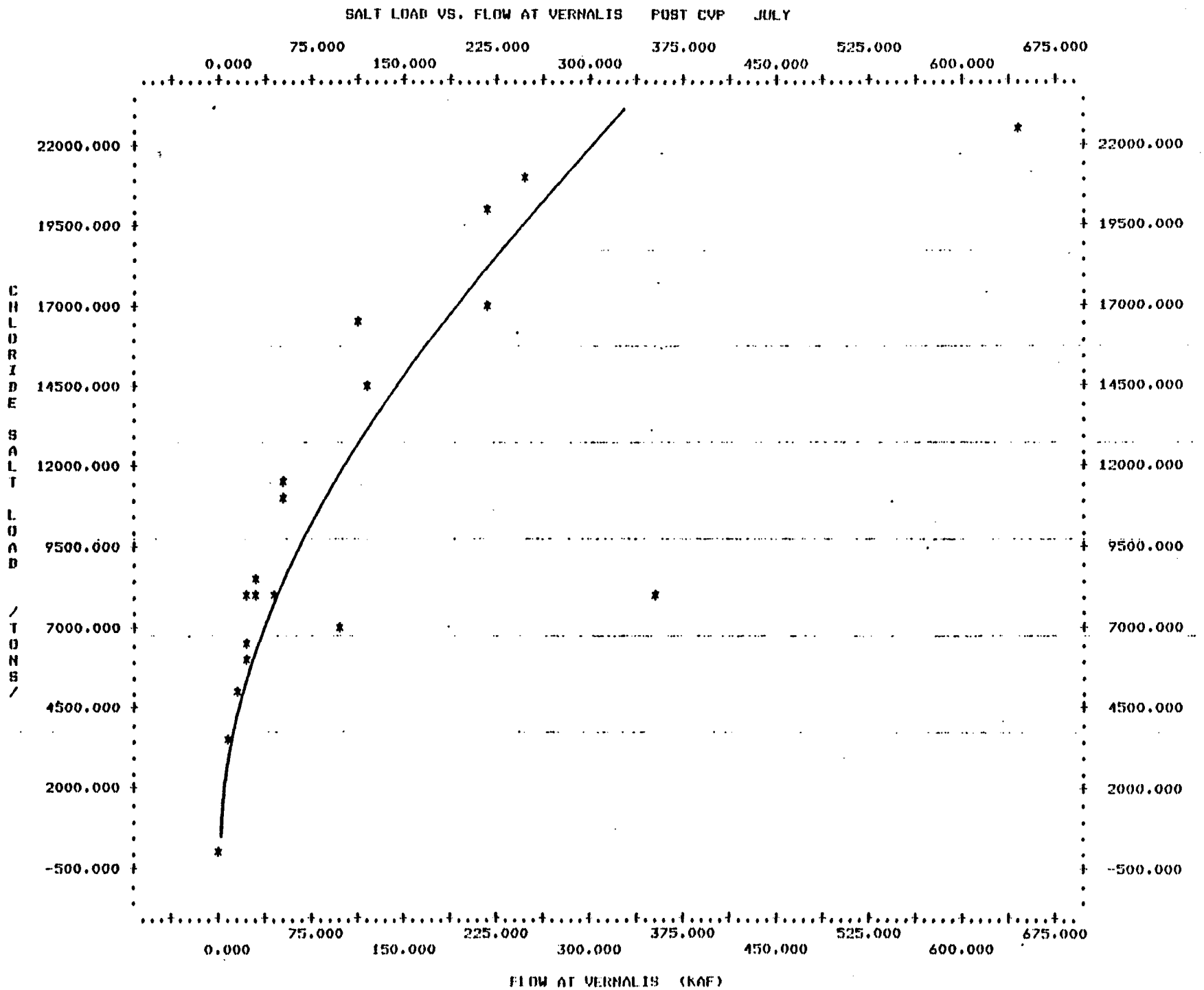

SALT LOAD VS. FLOW AT VERNALIS POST CVP APRIL
CHLORIDE SALT LOAD /TONS/
0.000
200.000
400.000
600.000
800.000
1000.000
1200.000
1400.000
1600.000
1800.000
1000.000
6000.000
11000.000
16000.000
21000.000
26000.000
31000.000
36000.000
41000.000
46000.000

C-115396



C-115397

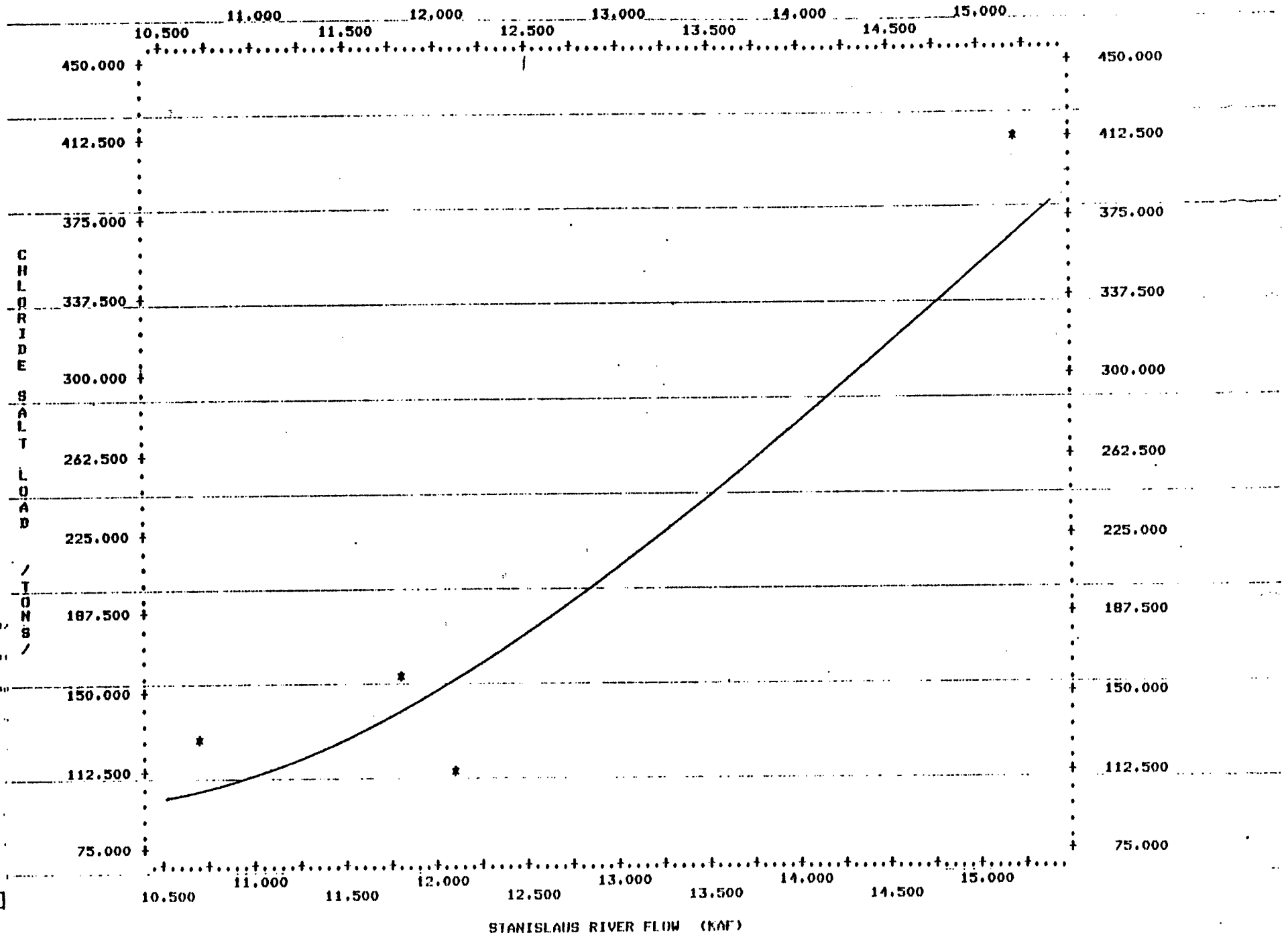
C-115397



C-115398

C-115398

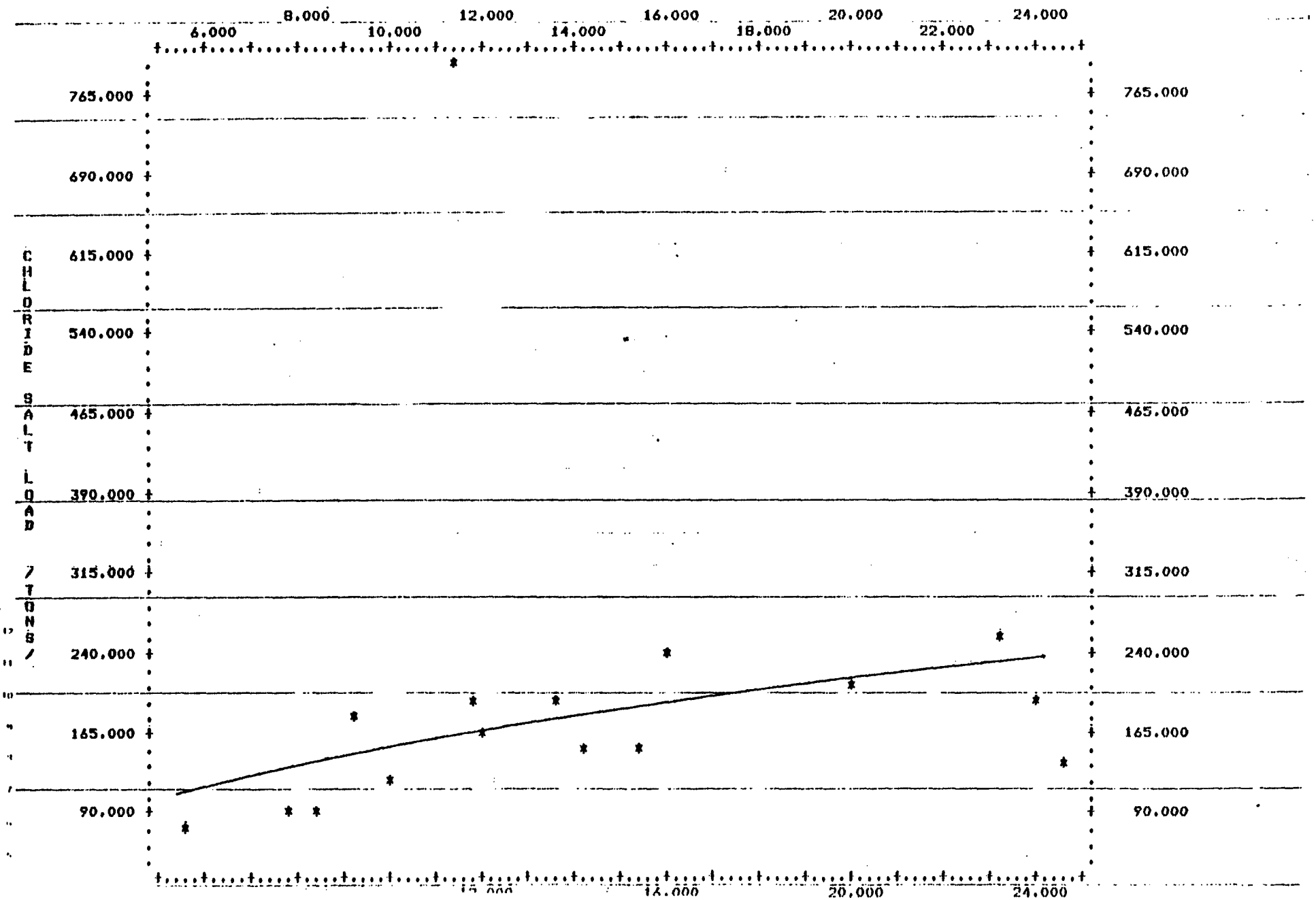
FLOW VS. SALT LOAD ON STANISLAUS RIVER PRE CVP OCTOBER



C-115399

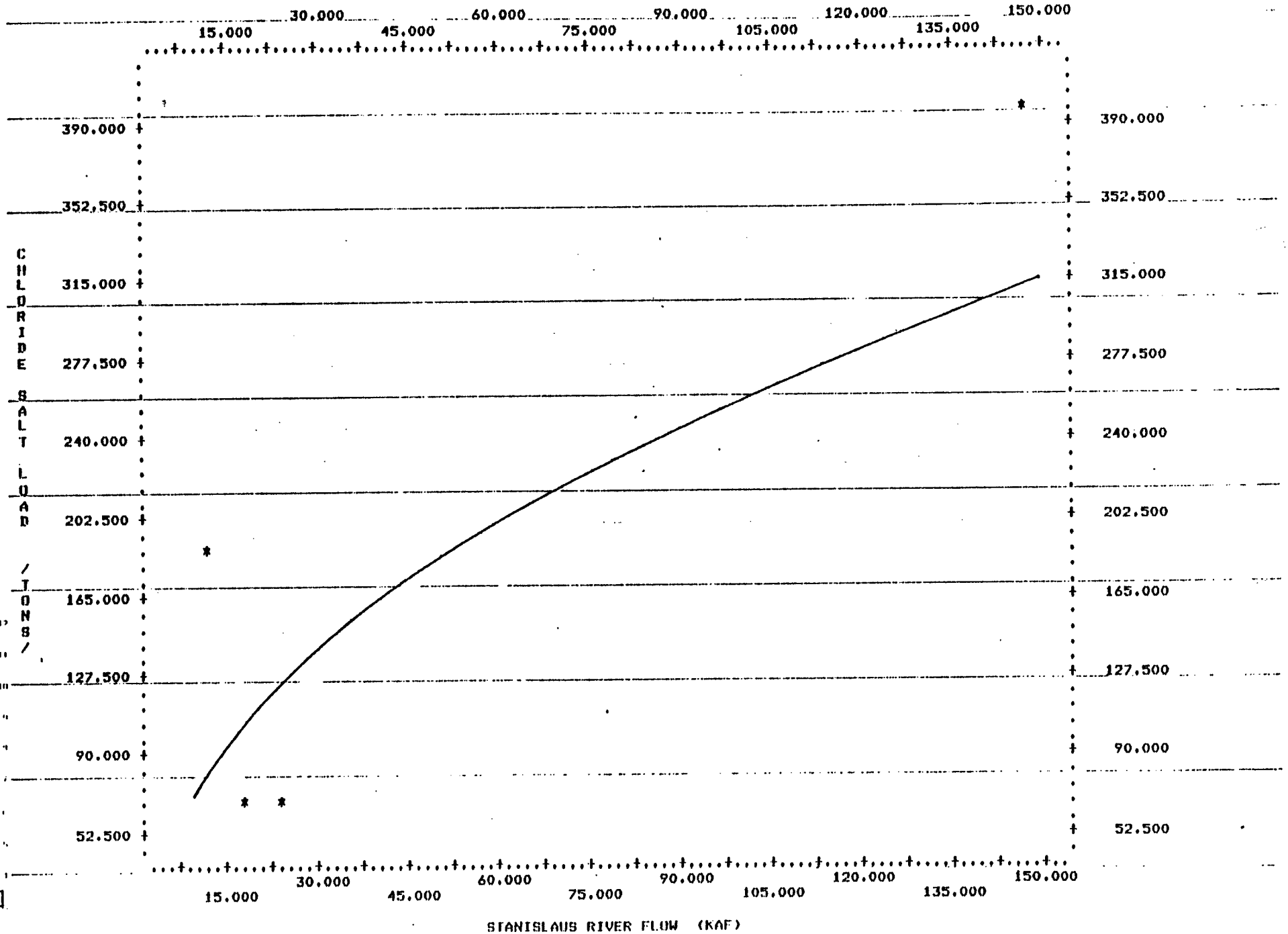
C-115399

FLOW VS. SALT LOAD ON STANISLAUS RIVER POST CVP OCTOBER



C-115400

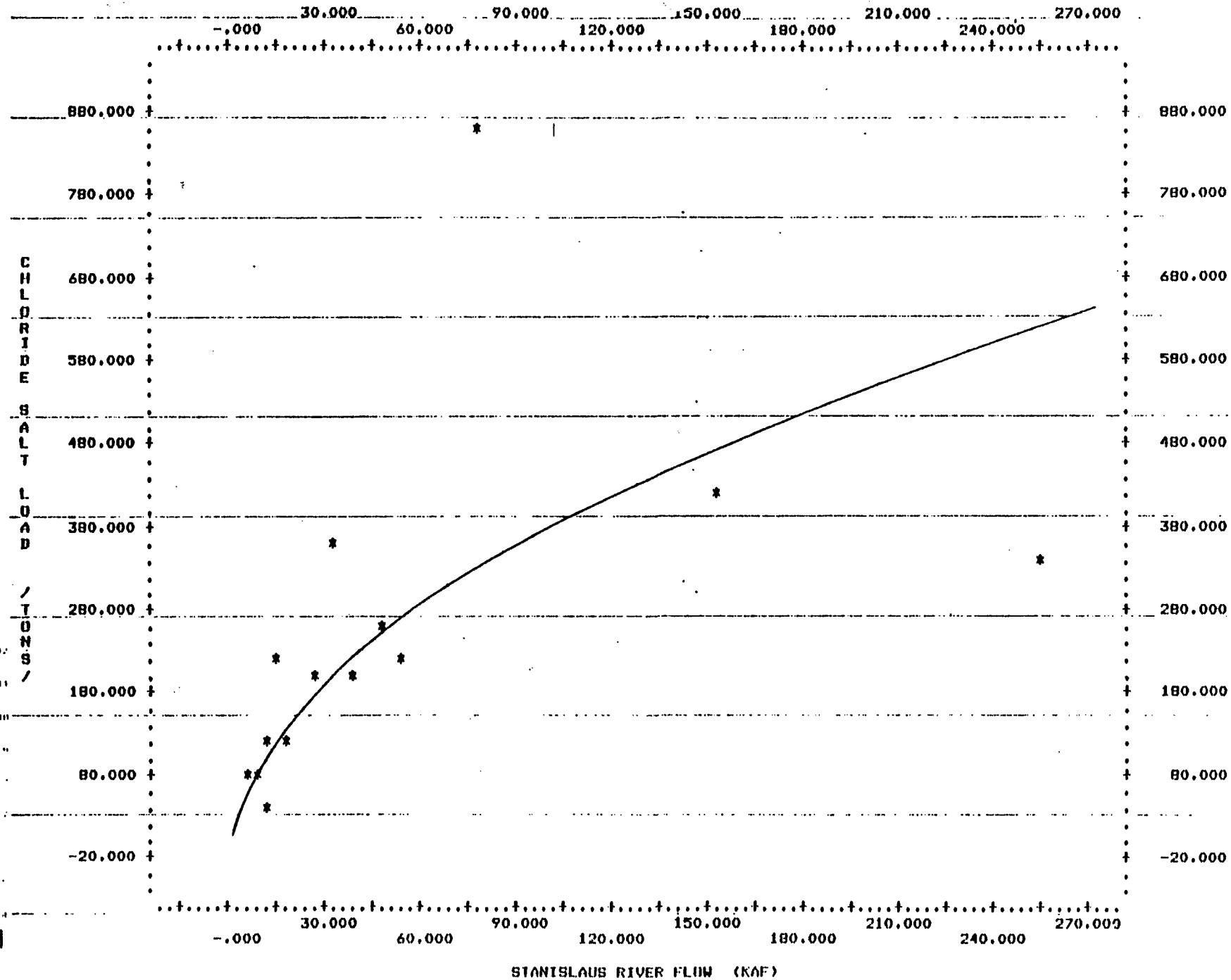
FLOW VS. SALT LOAD ON STANISLAUS RIVER PRE CVP JANUARY



C-115401

C-115401

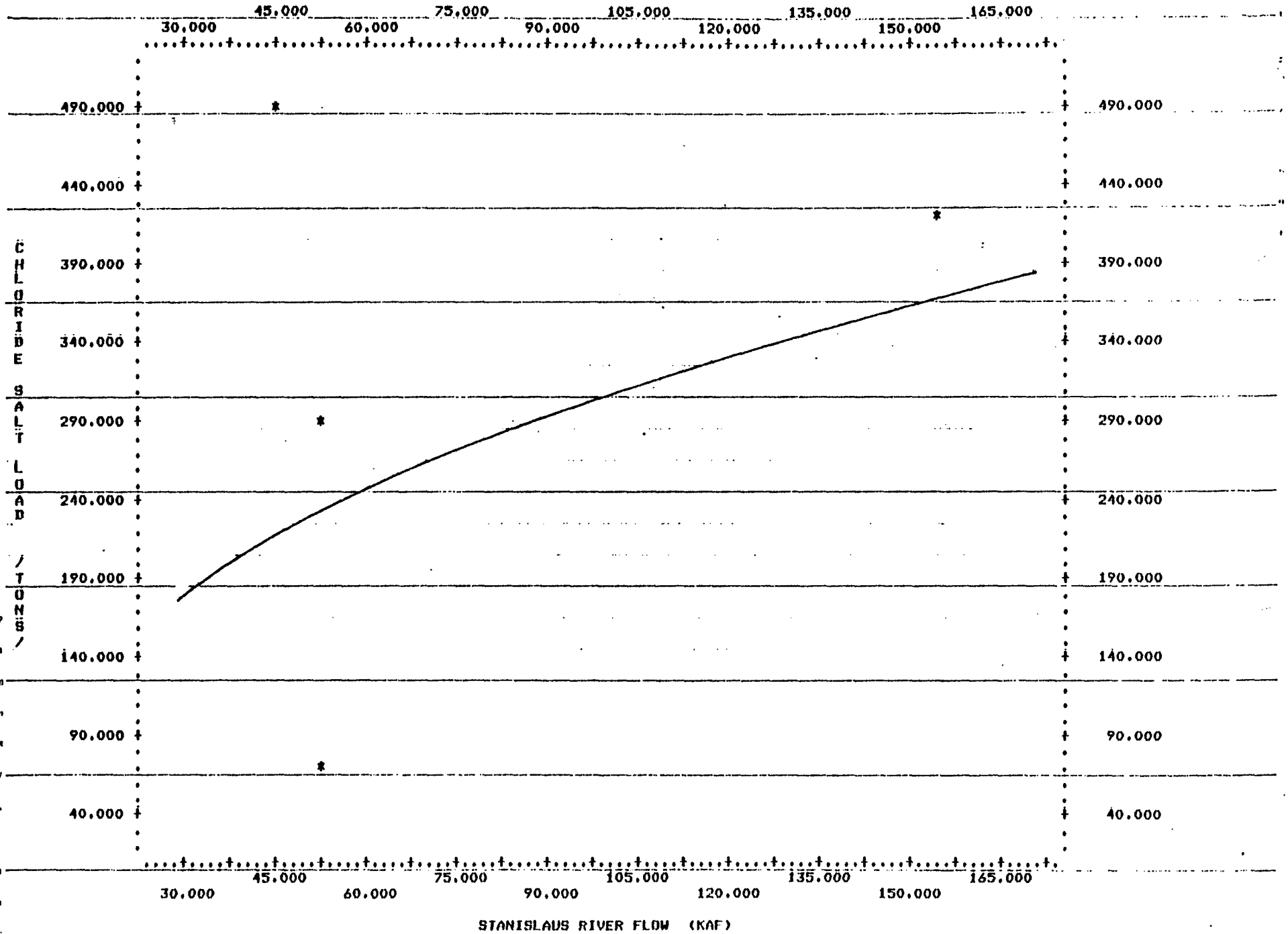
FLOW VS. SALT LOAD ON STANISLAUS RIVER POST CVP JANUARY



C-115402

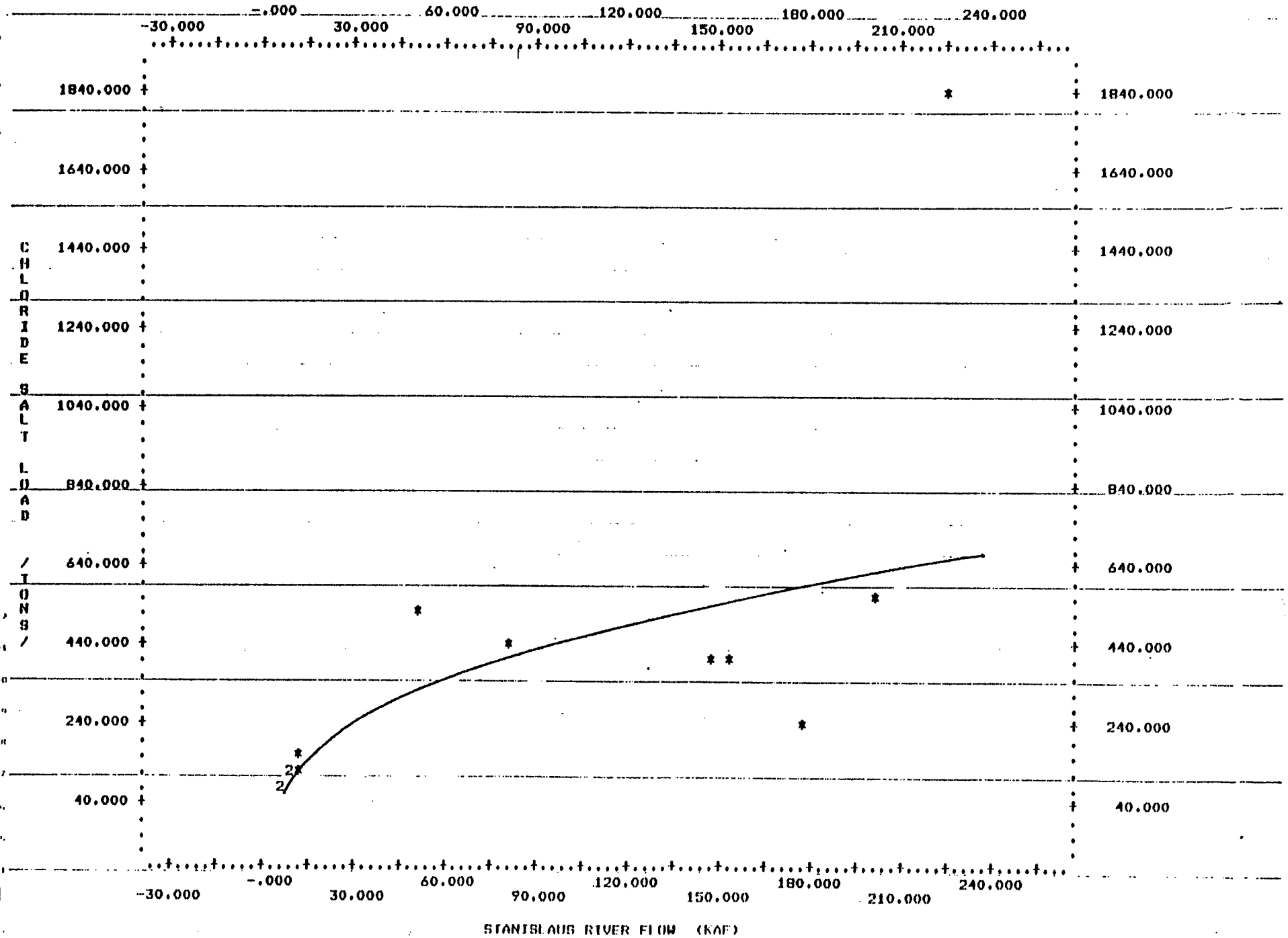
C-115402

FLOW VS. SALT LOAD ON STANISLAUS RIVER PRE CVP APRIL



C-115403

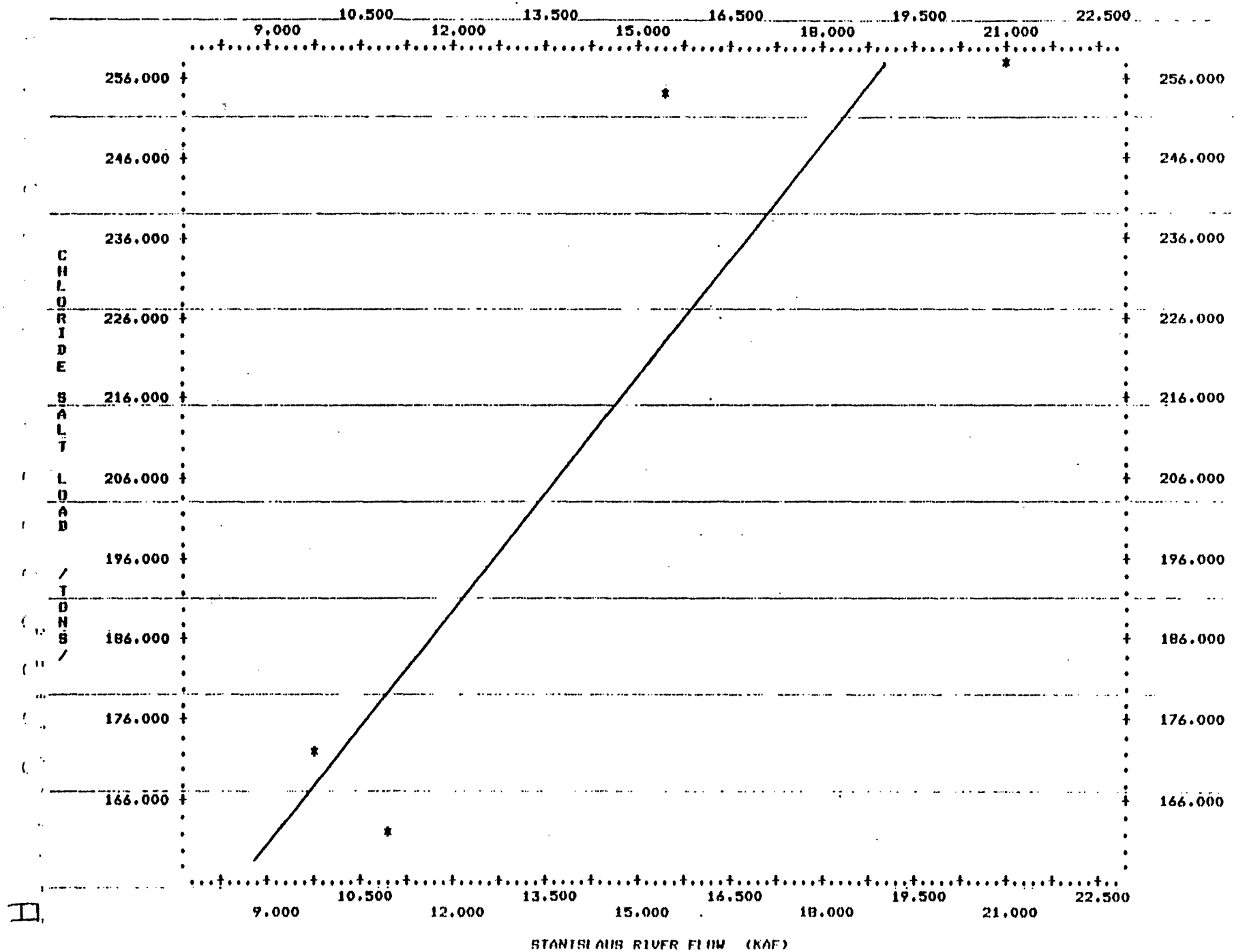
FLOW VS. SALT LOAD ON STANISLAUS RIVER POST CVP APRIL



C-115404

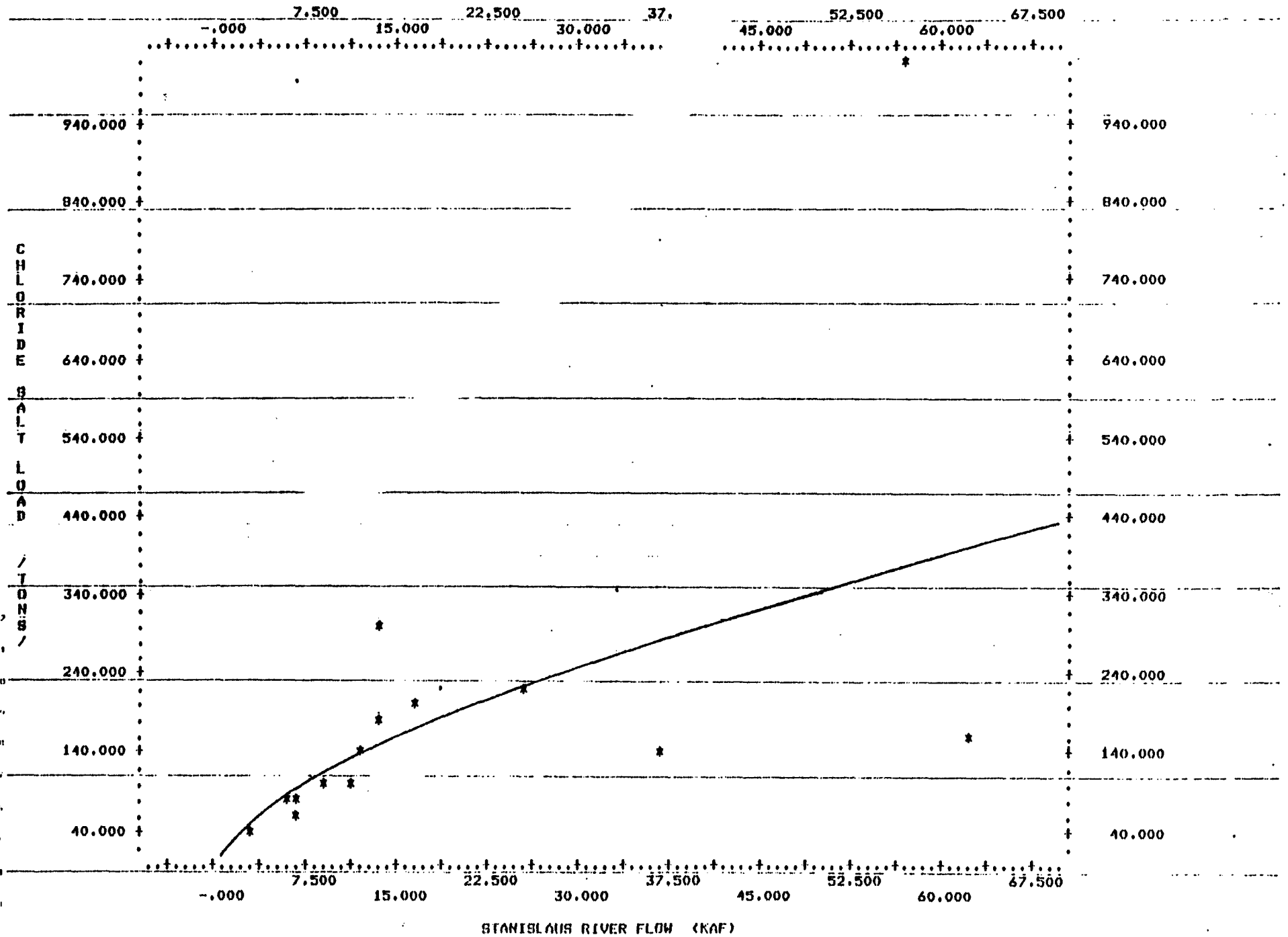
C-115404

FLOW VS. SALT LOAD ON STANISLAUS RIVER PRE CVP JULY



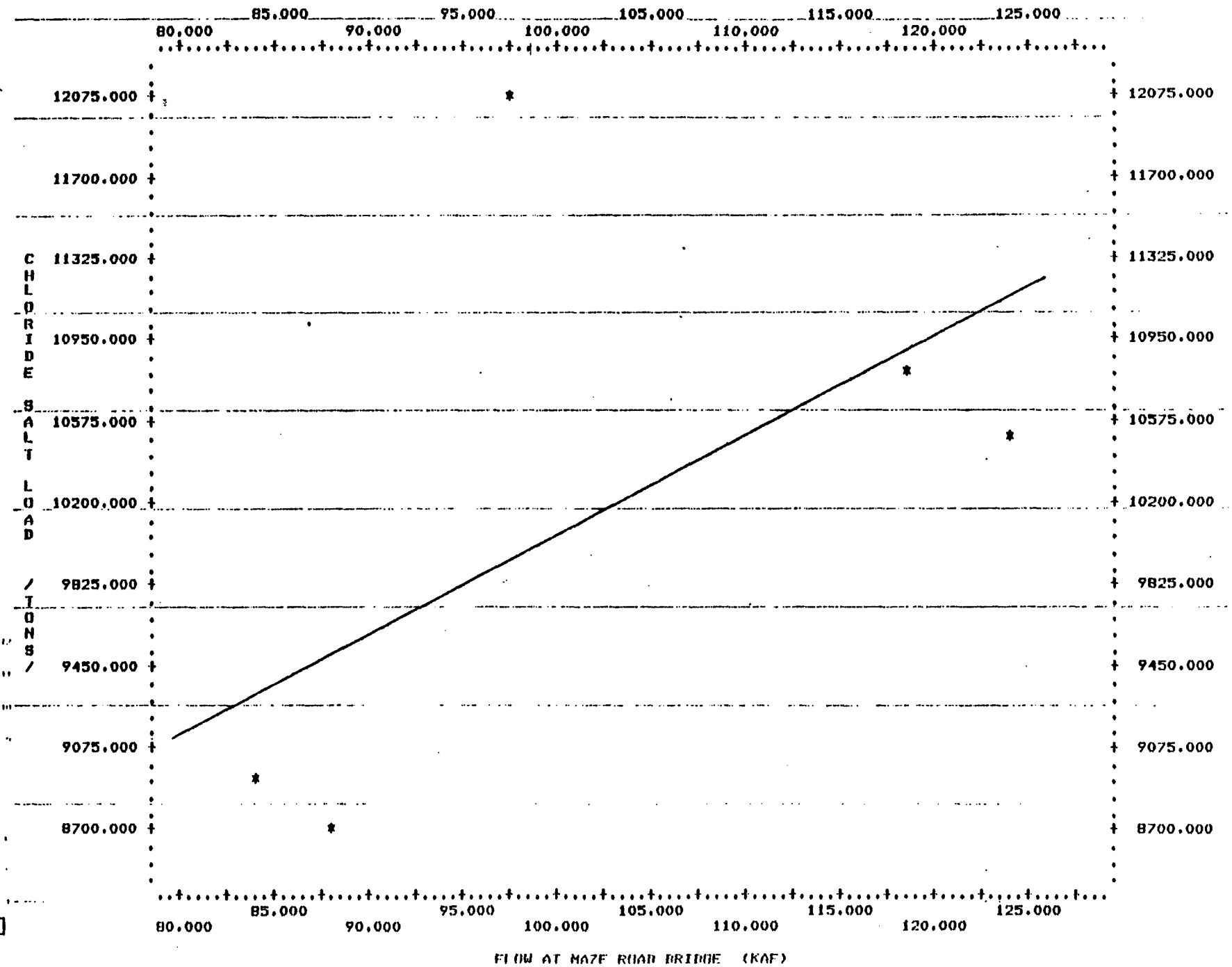
C-115405

FLOW VS. SALT LOAD ON STANISLAUS RIVER JULY



C—115406

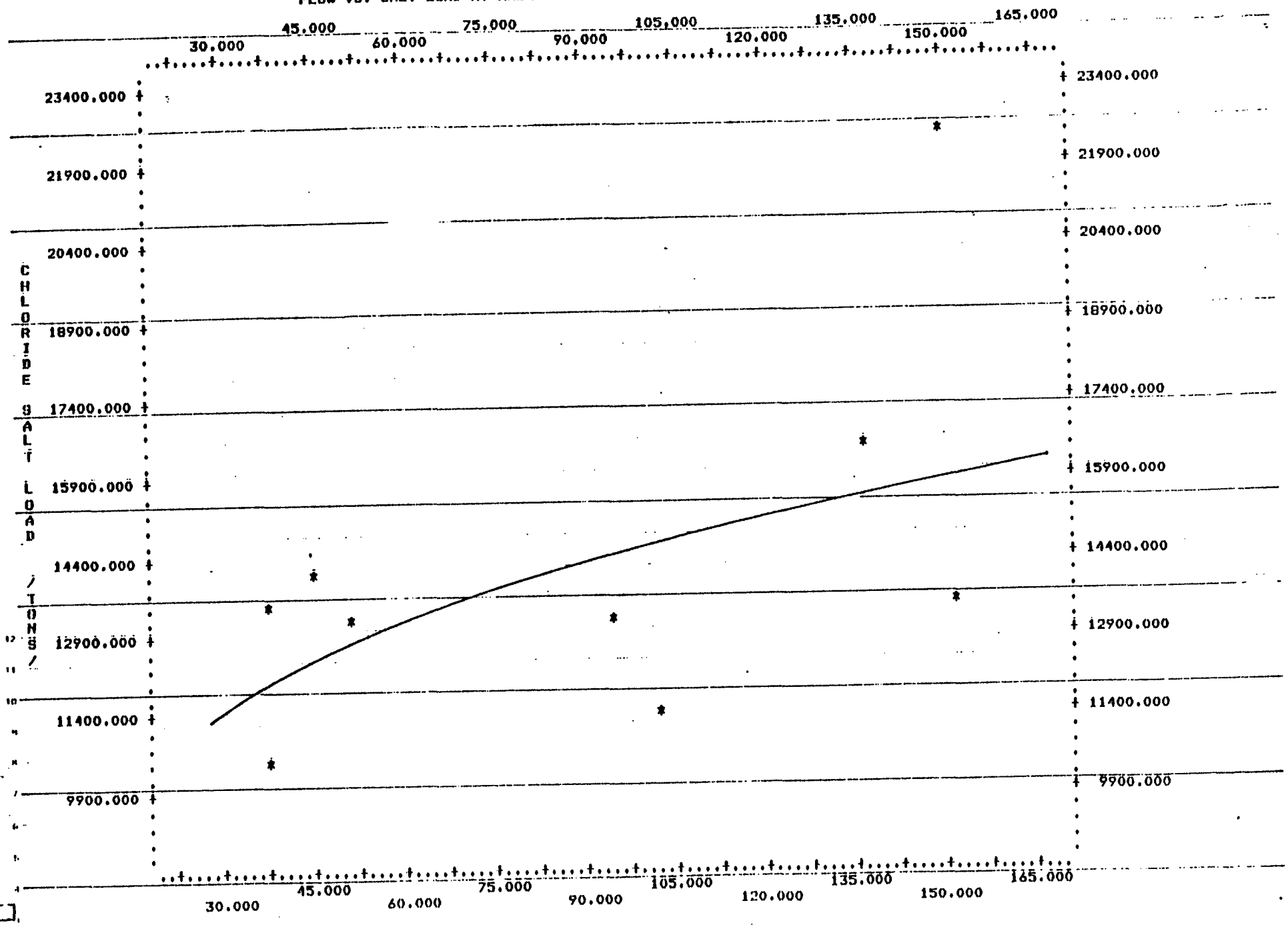
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE PRE CVP OCTOBER



C-115407

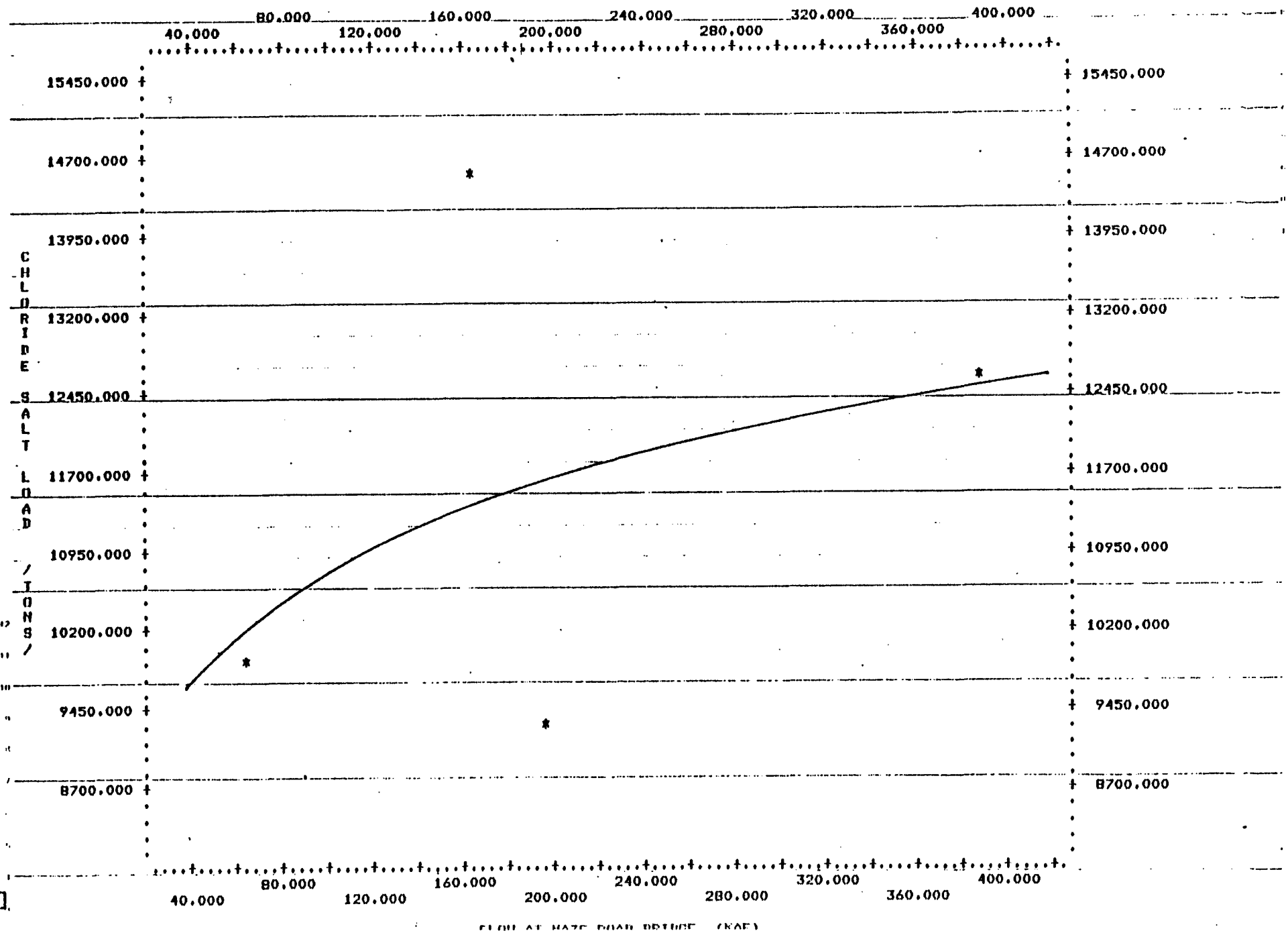
C-115407

FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE POST CVP OCTOBER



C-115408

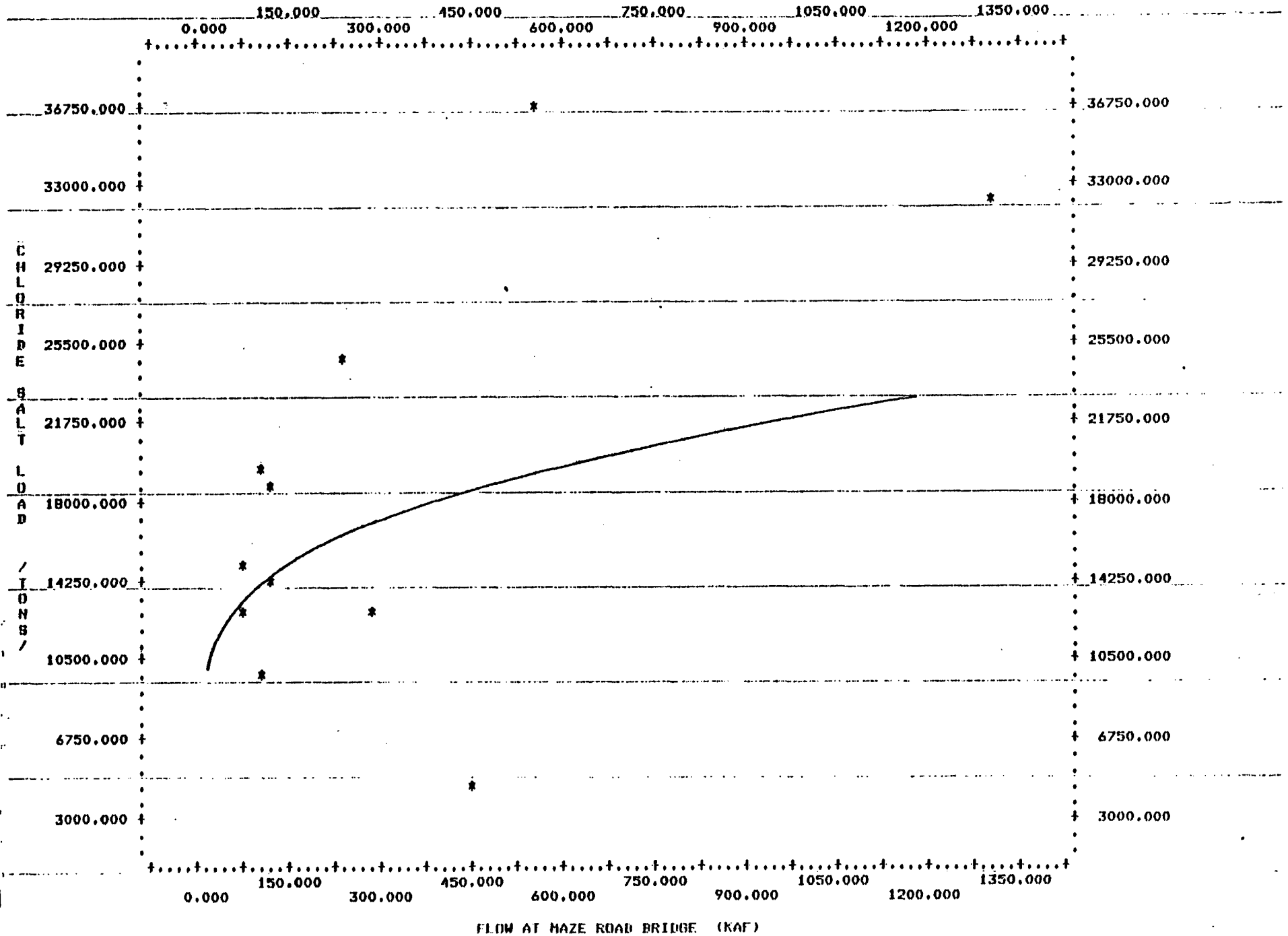
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE . PRE CVP JANUARY



C-115409

C-115409

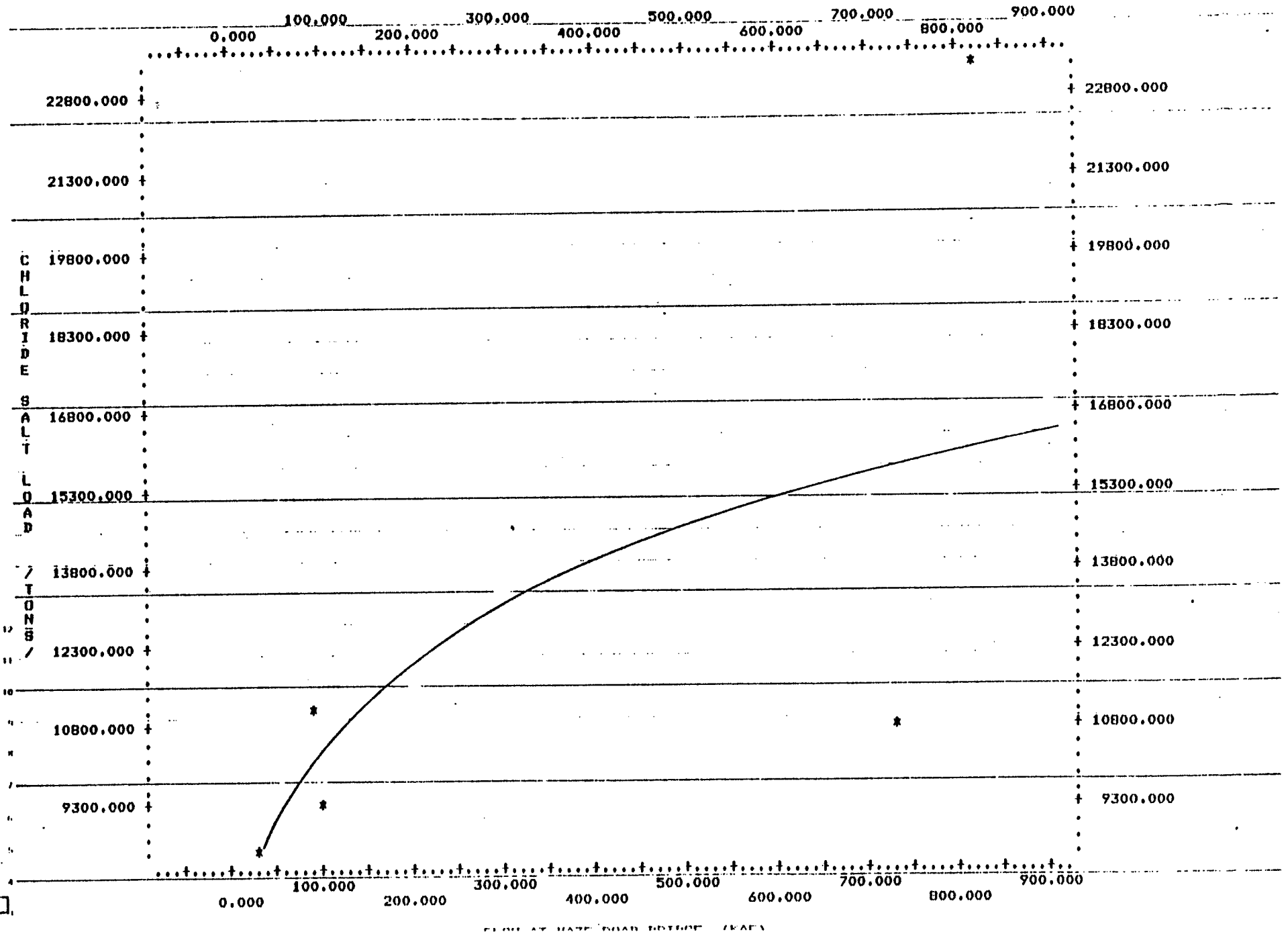
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE POST CVP JANUARY



C-115410

C-115410

FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE PRE CVP APRIL

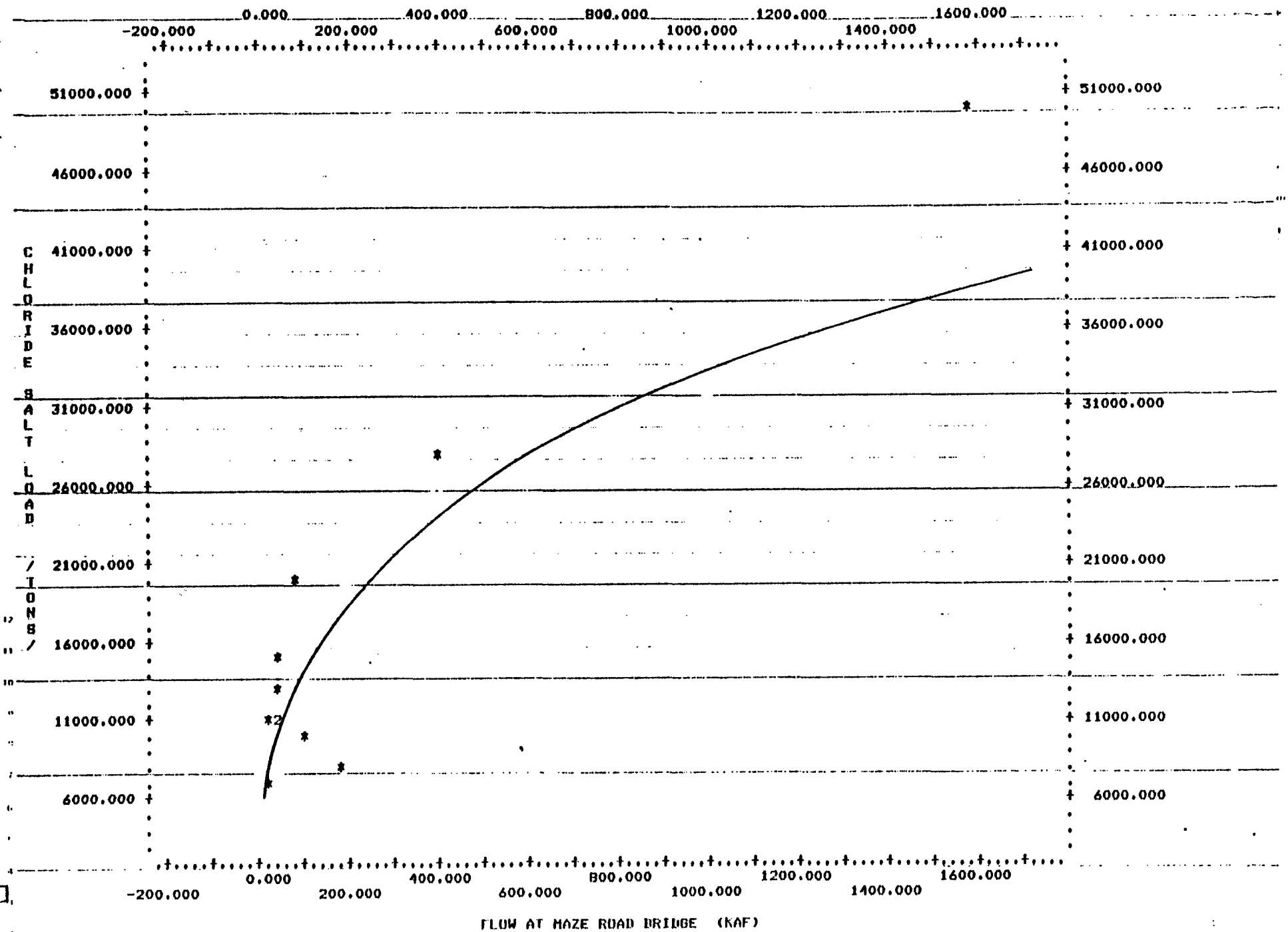


FLOW AT MAZE ROAD BRIDGE (KAF)

C-115411

C-115411

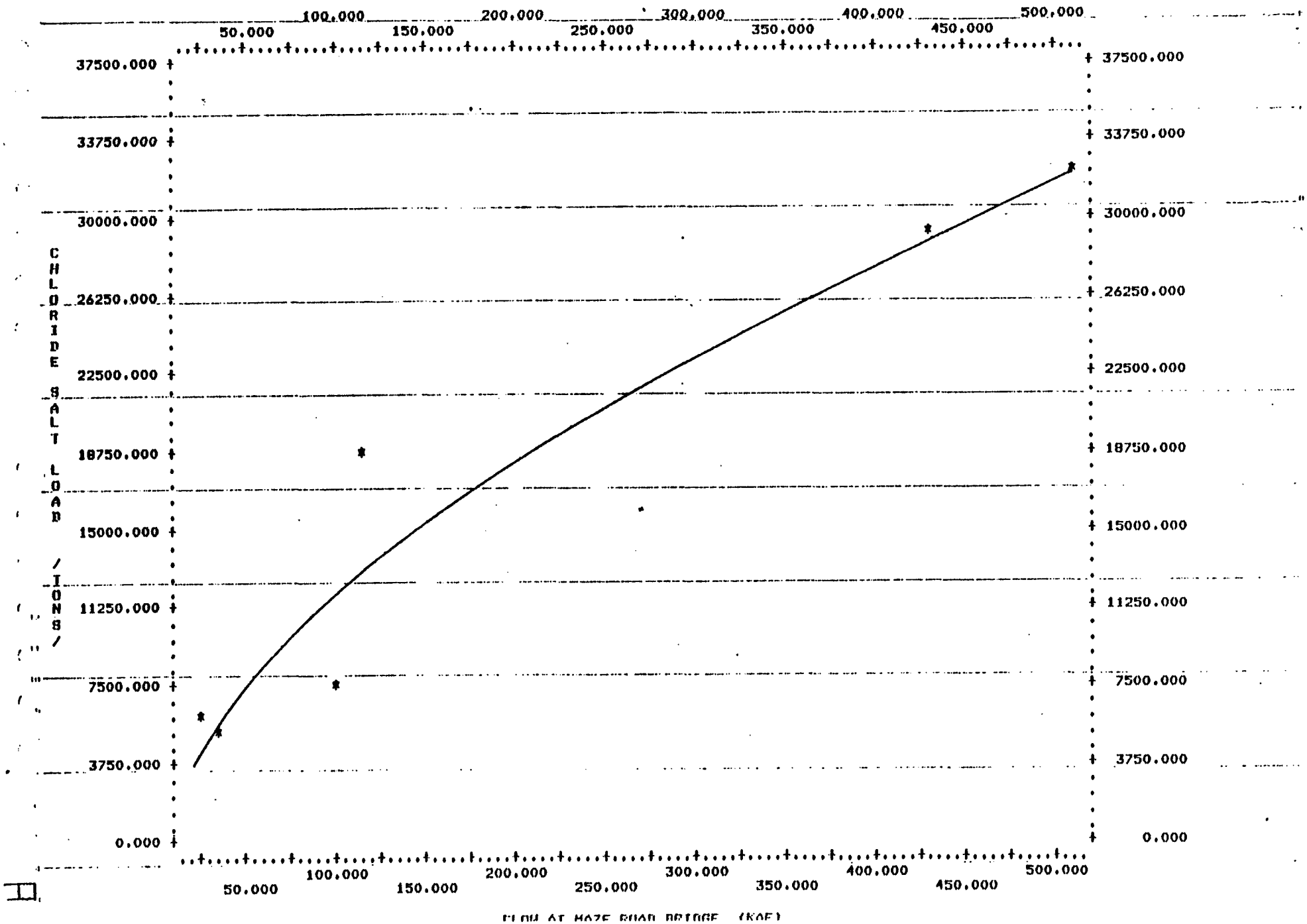
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE POST CVP APRIL



C-115412

C-115412

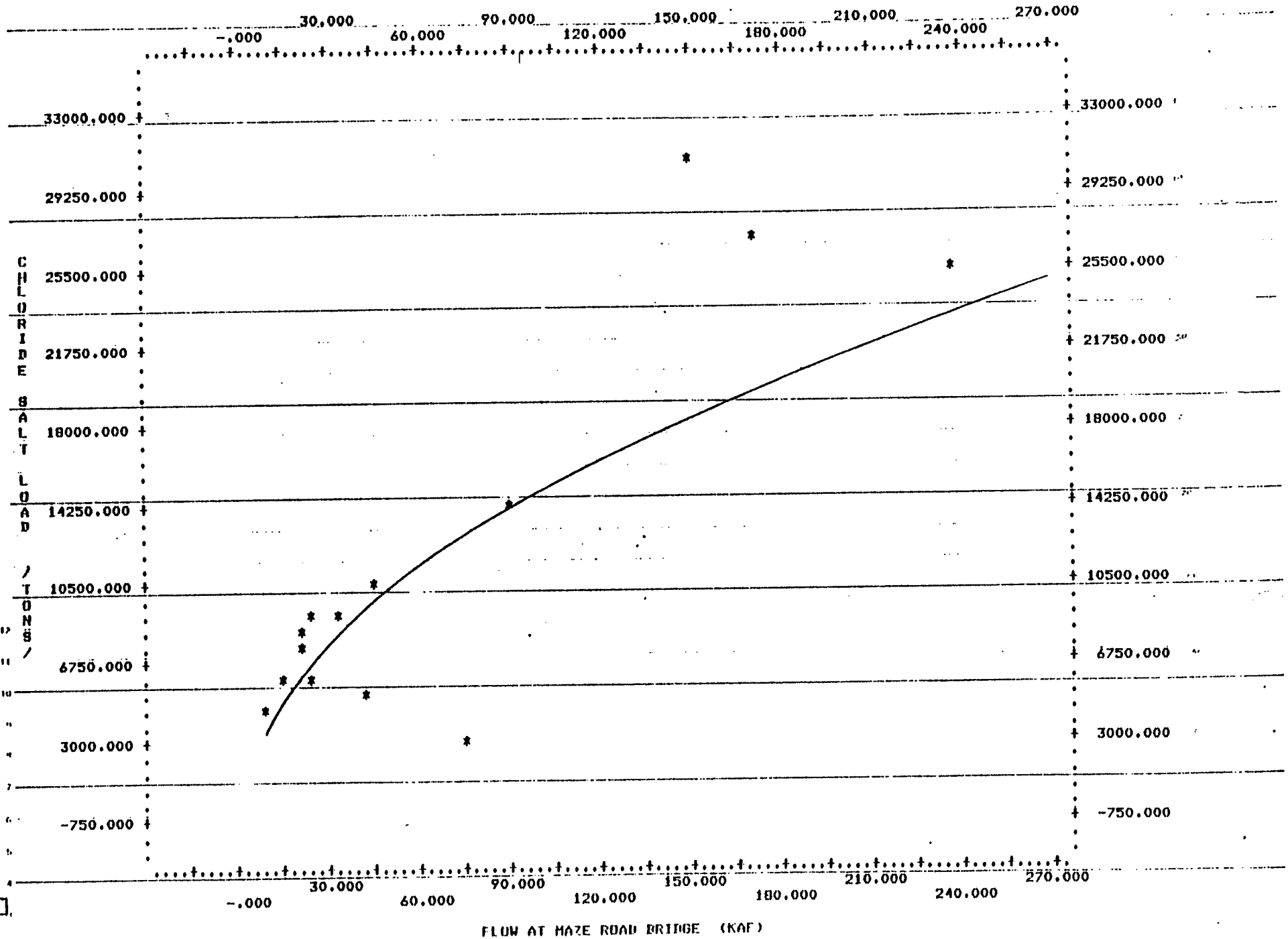
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE PRE CVP JULY



C-115413

C-115413

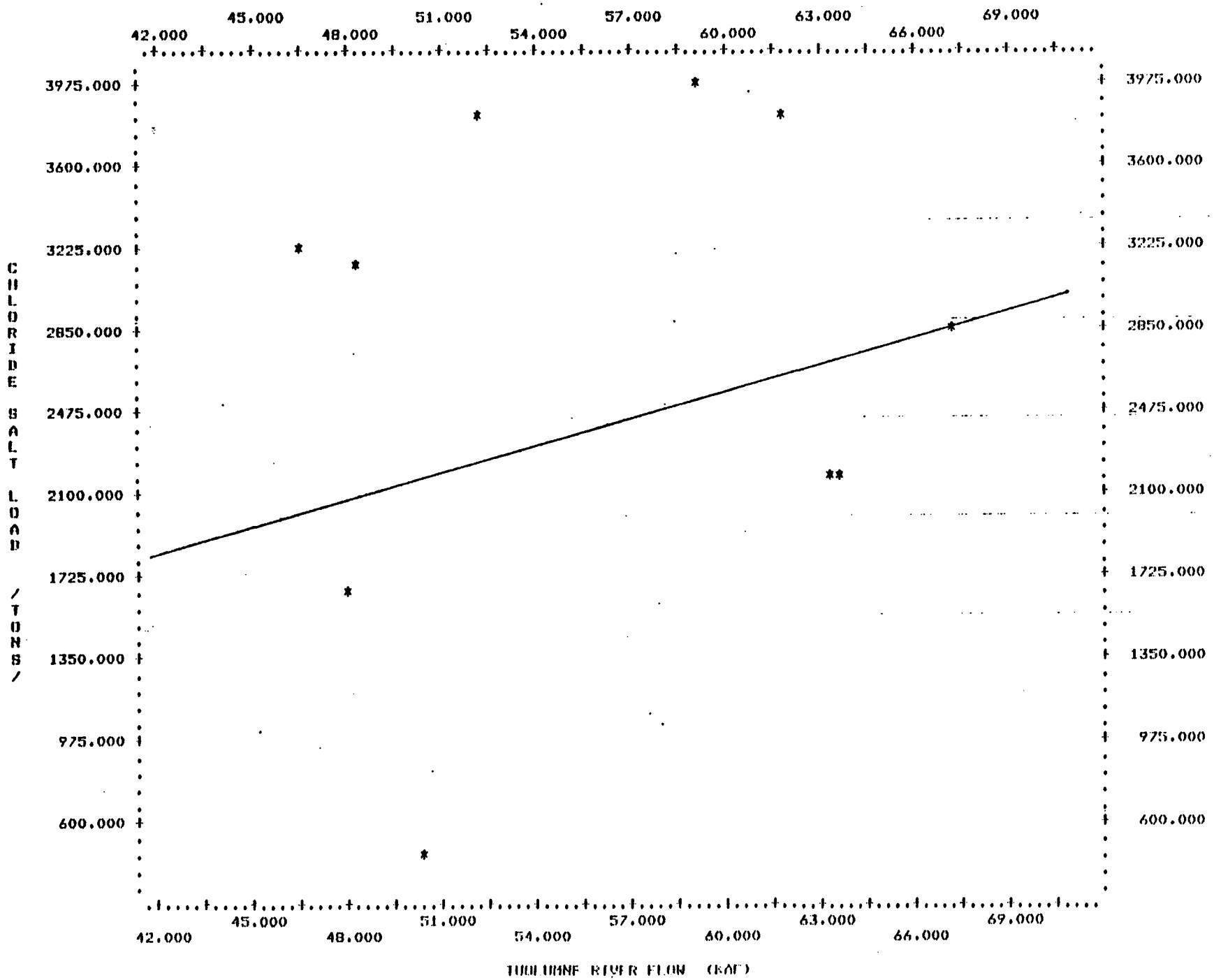
FLOW VS. SALT LOAD AT MAZE ROAD BRIDGE POST CVP JULY



C-115414

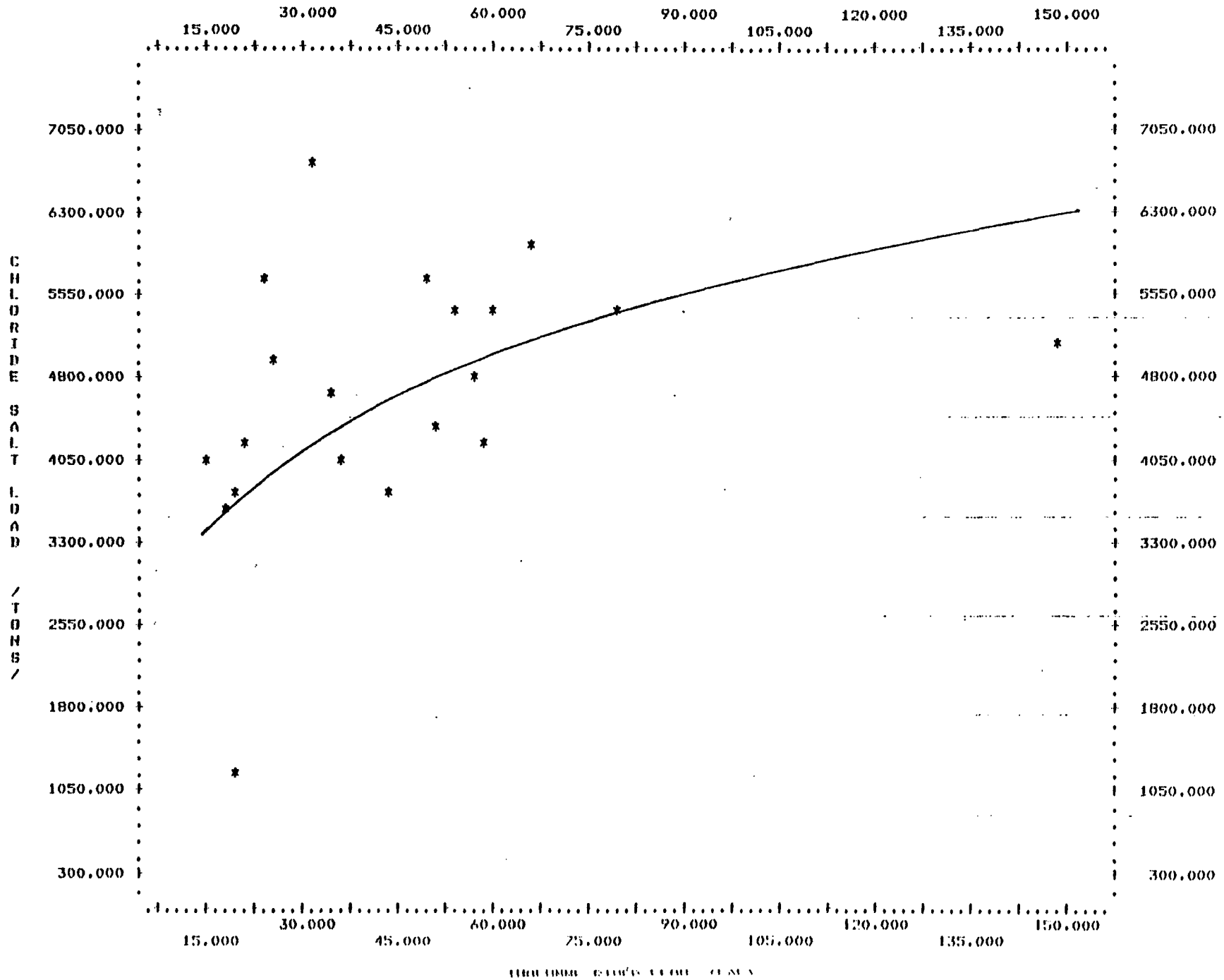
C-115414

FLOW VS. SALT LOAD ON TUOLUMNE RIVER PRE CVP OCTOBER

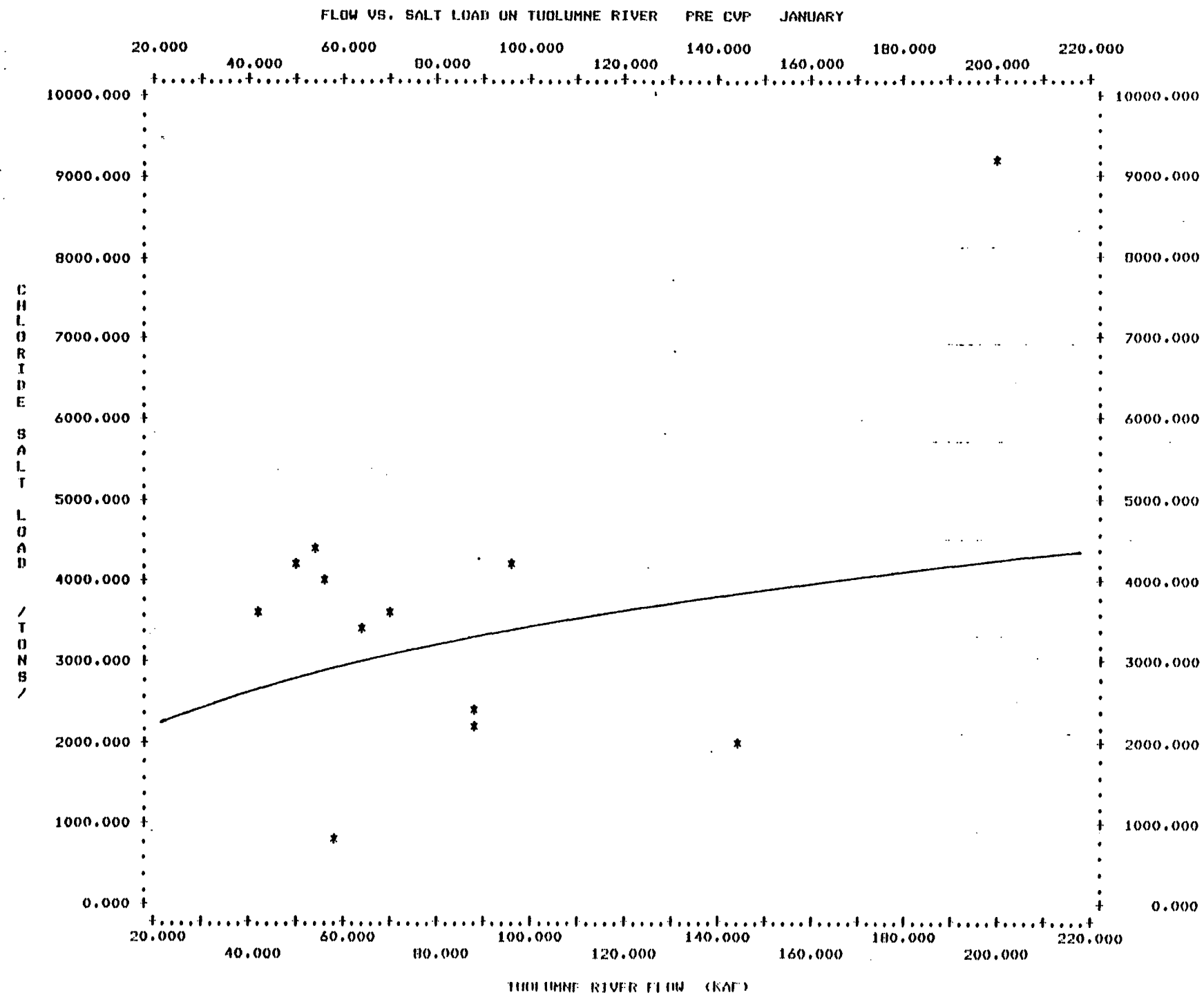


C-115415

FLOW VS. SALT LOAD ON TUOLUMNE RIVER POST CVP OCTOBER



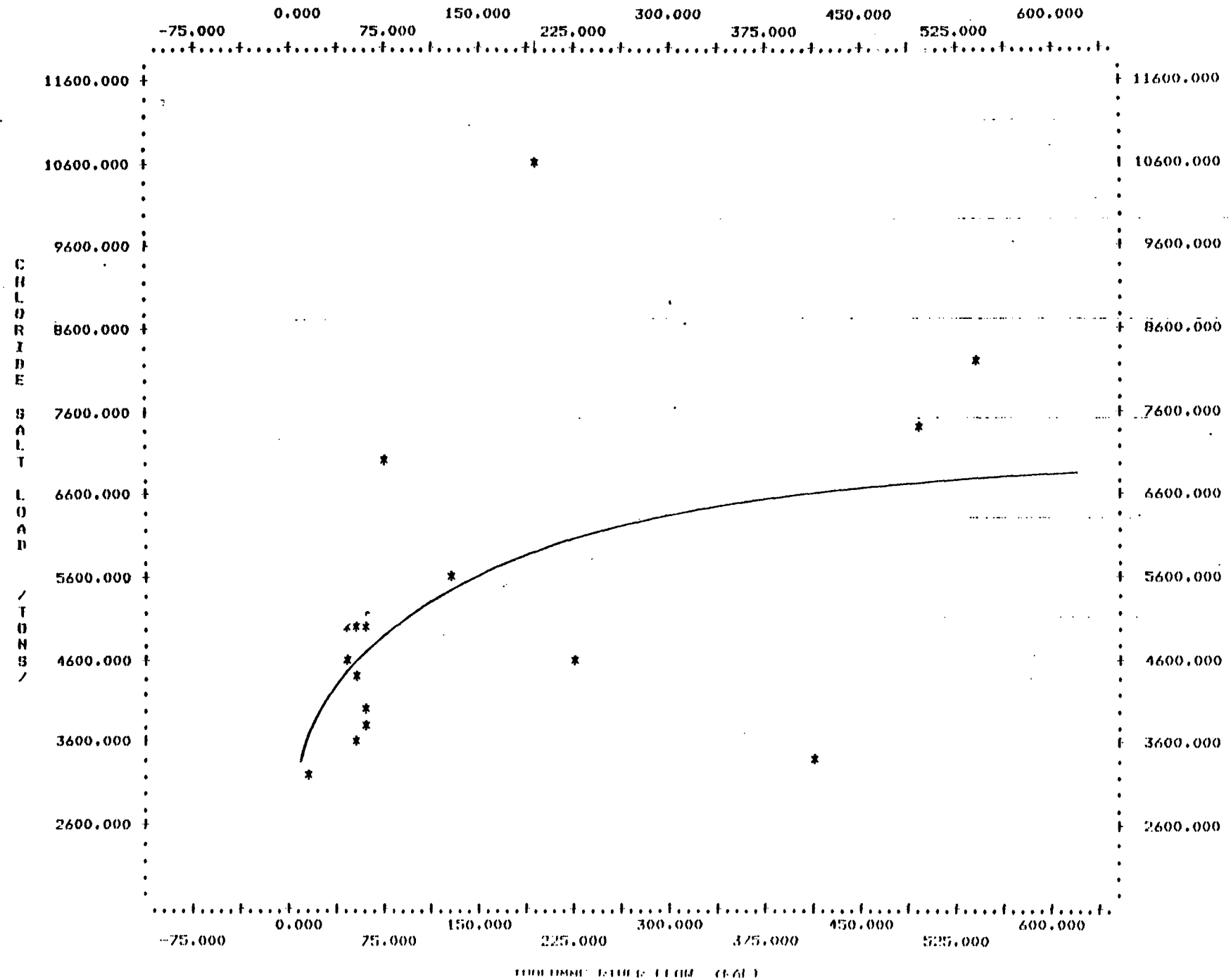
C-115416



C-115417

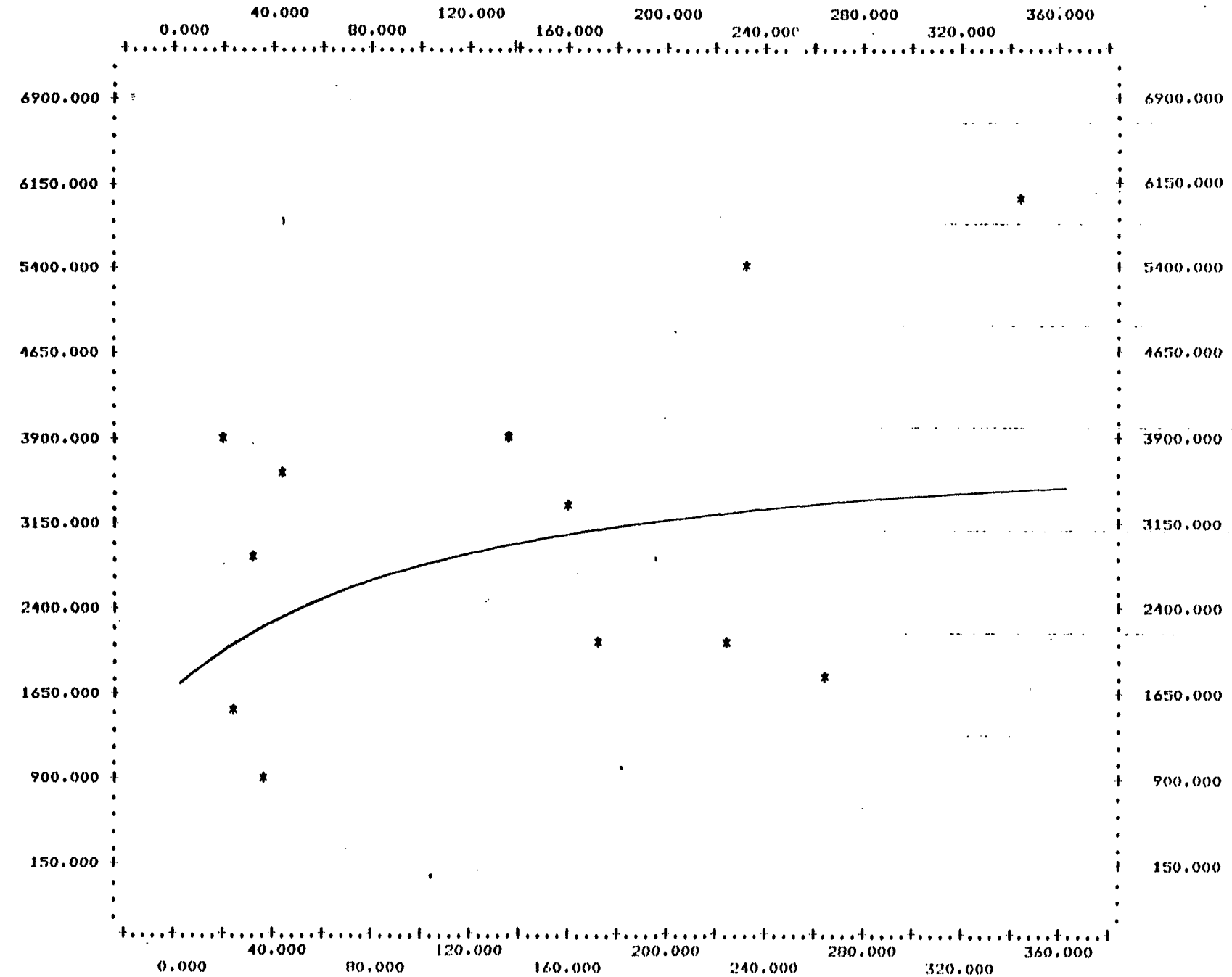
C-115417

FLOW VS. SALT LOAD ON TUOLUMNE RIVER POST CVP JANUARY



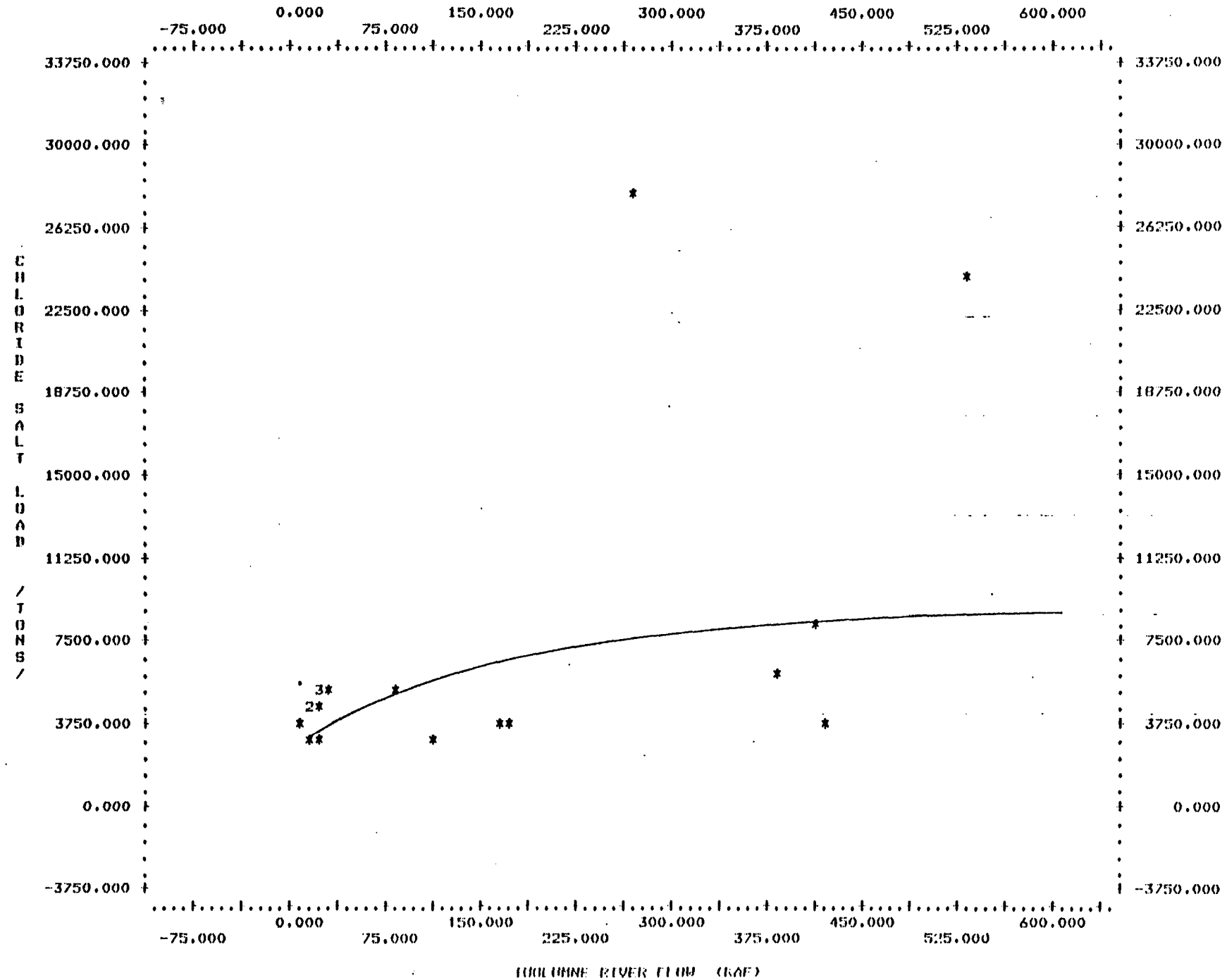
C-115418

FLOW VS. SALT LOAD ON TUOLUMNE RIVER PRE CVP APRIL



C-115419

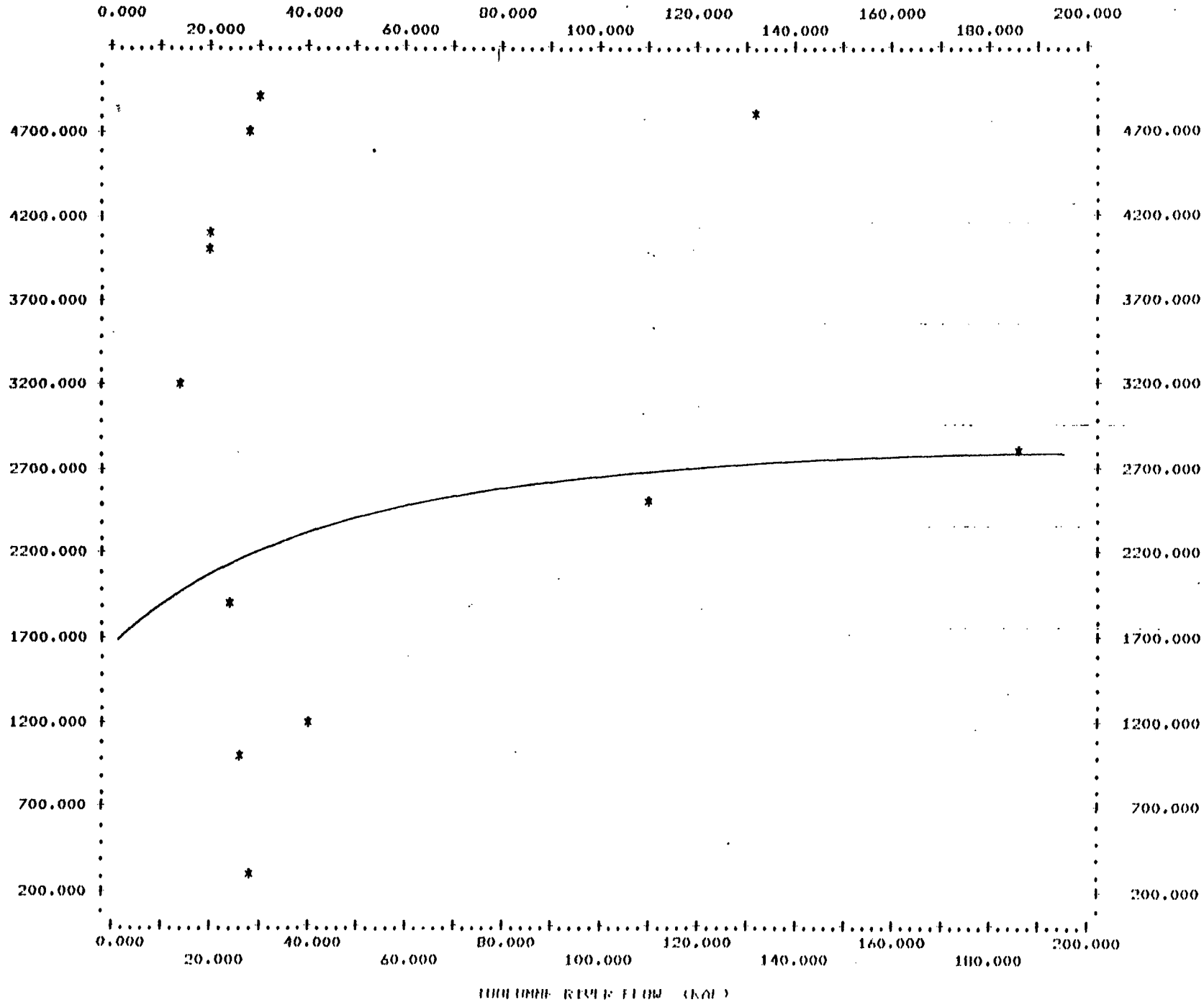
FLOW VS. SALT LOAD ON TUOLUMNE RIVER POST CVP APRIL



C-115420

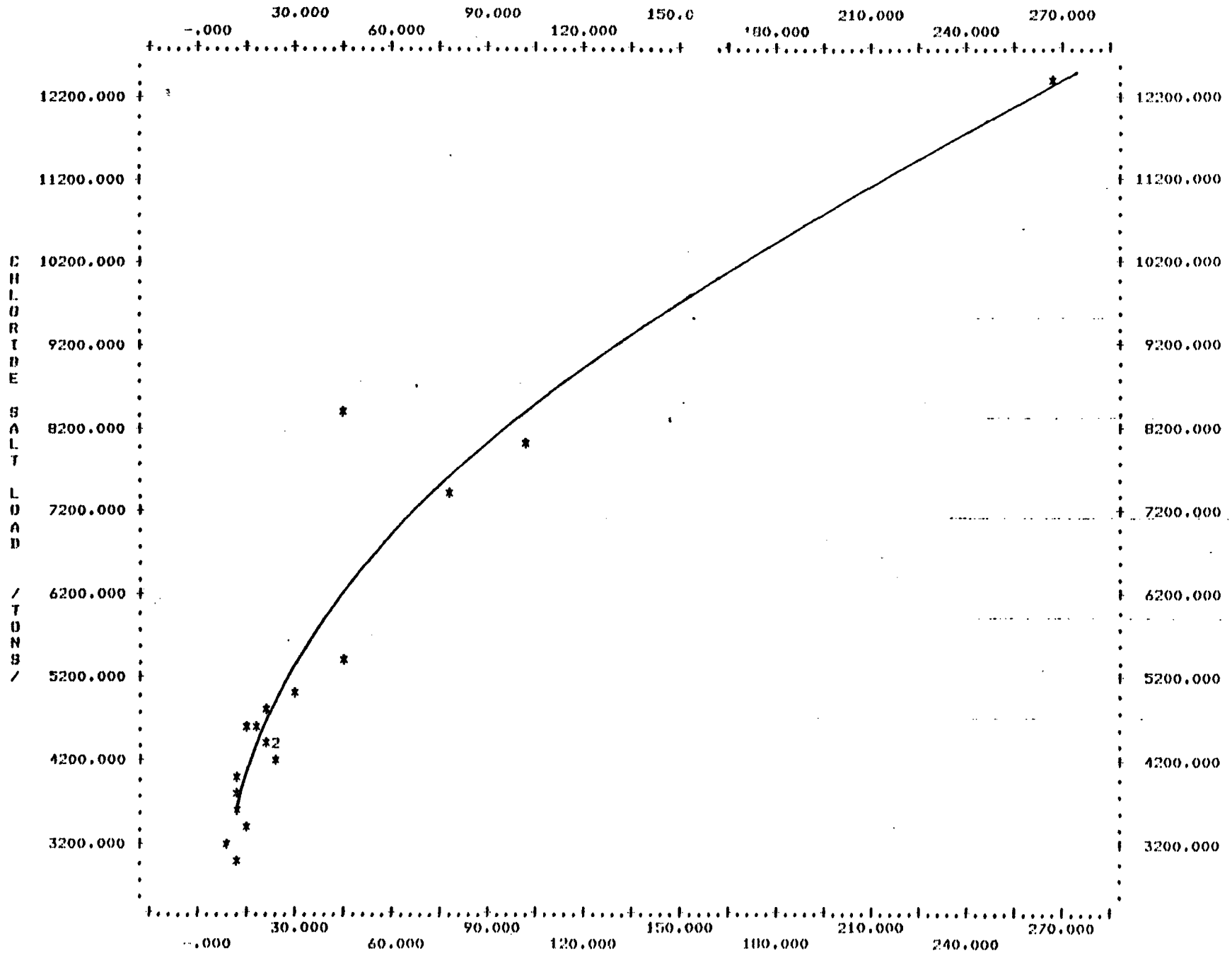
C-115420

FLOW VS. SALT LOAD ON TUOLUMNE RIVER PRE CVP JULY



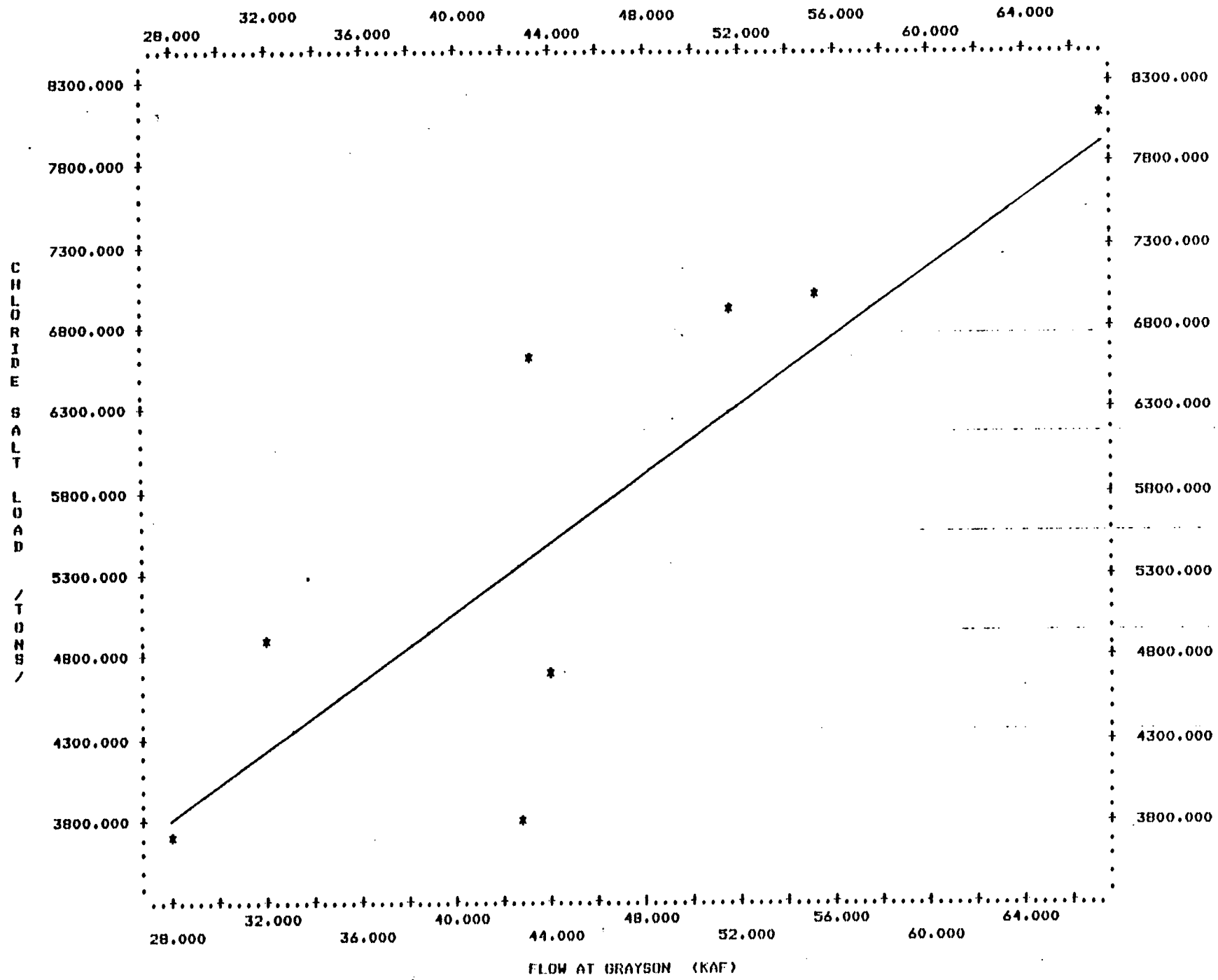
C-115421

FLOW VS. SALT LOAD ON TUOLUMNE RIVER POST CVP JULY



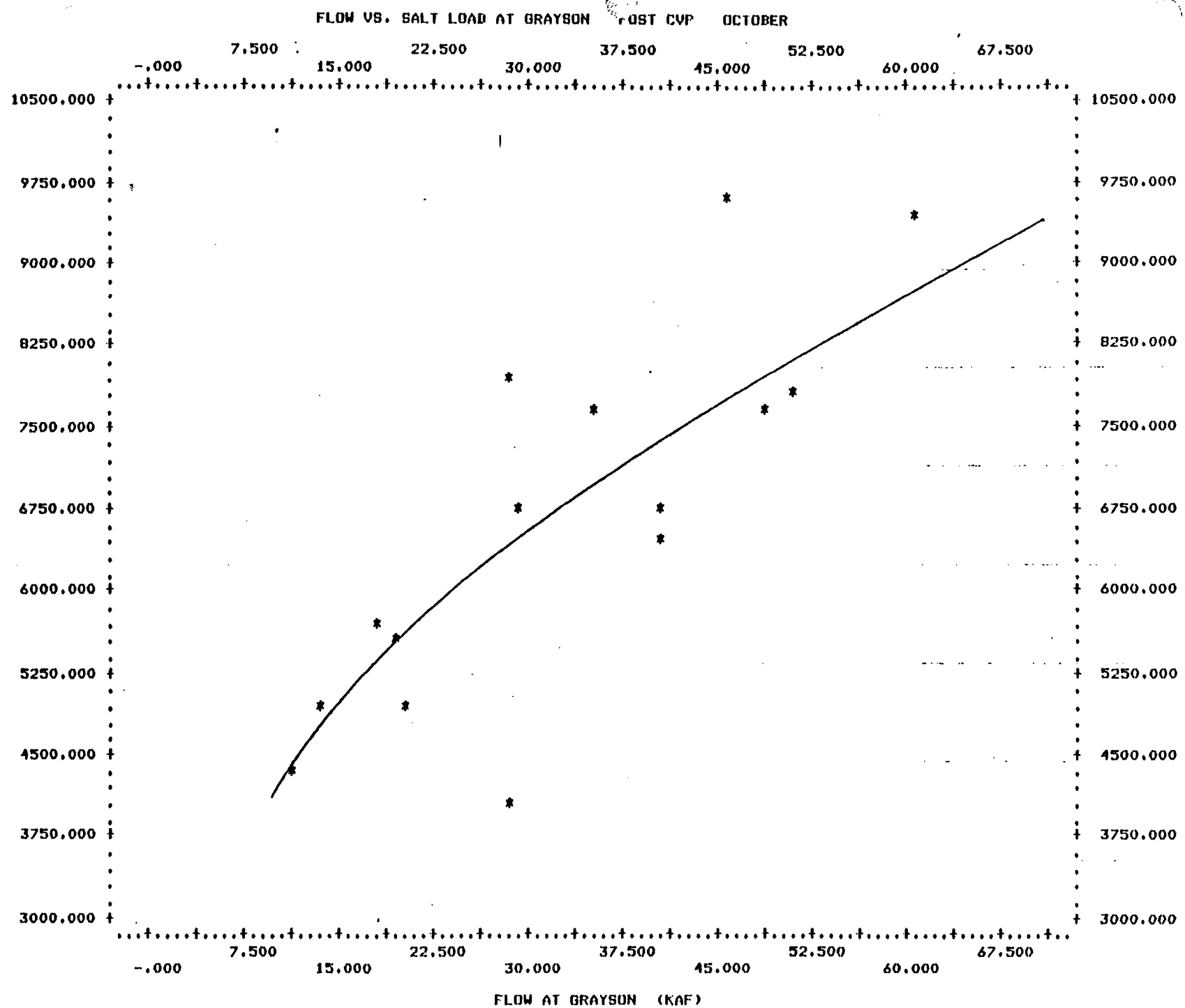
C-115422

FLOW VS. SALT LOAD AT GRAYSON PRE CVP OCTOBER



C-115423

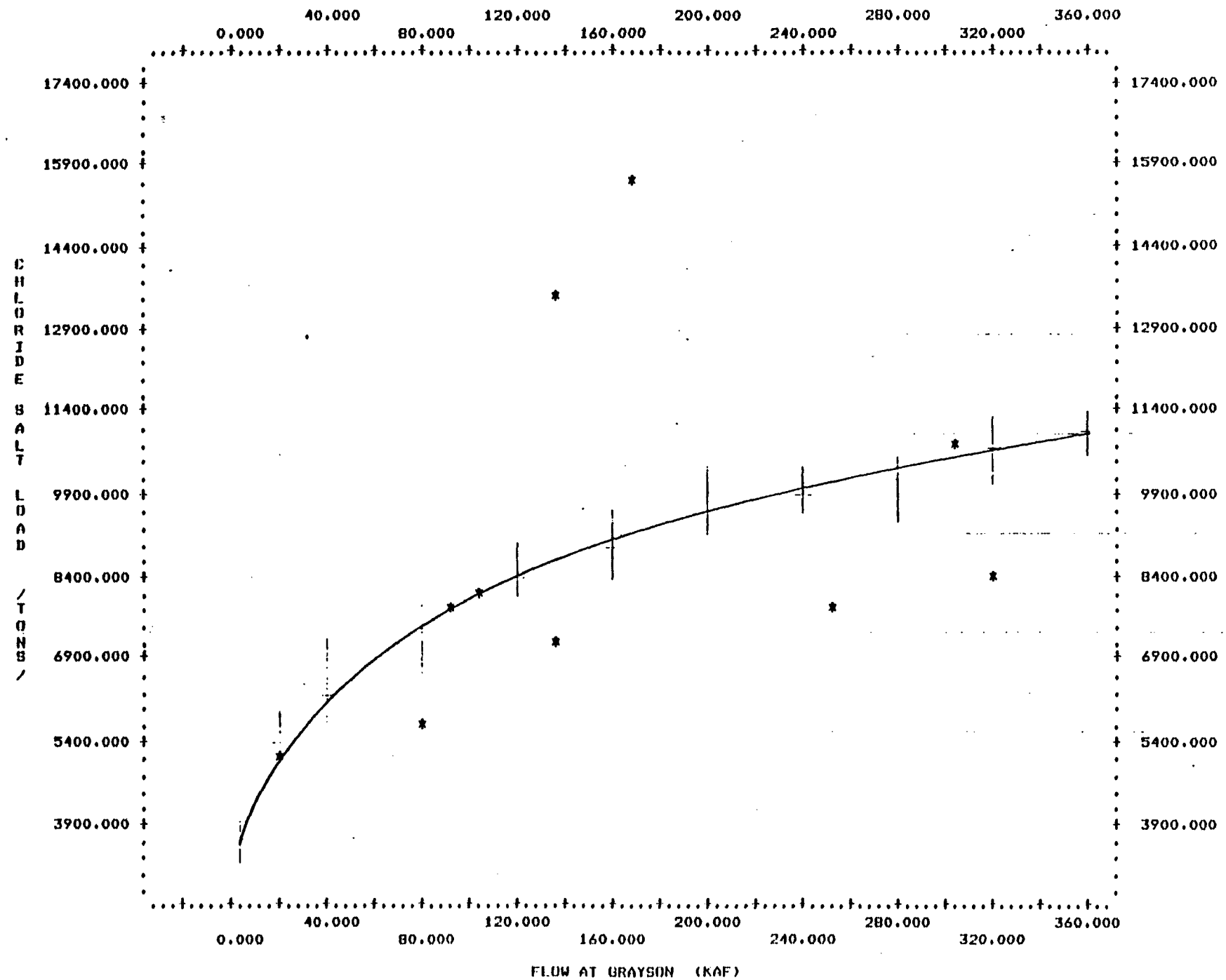
C-115423



C-115424

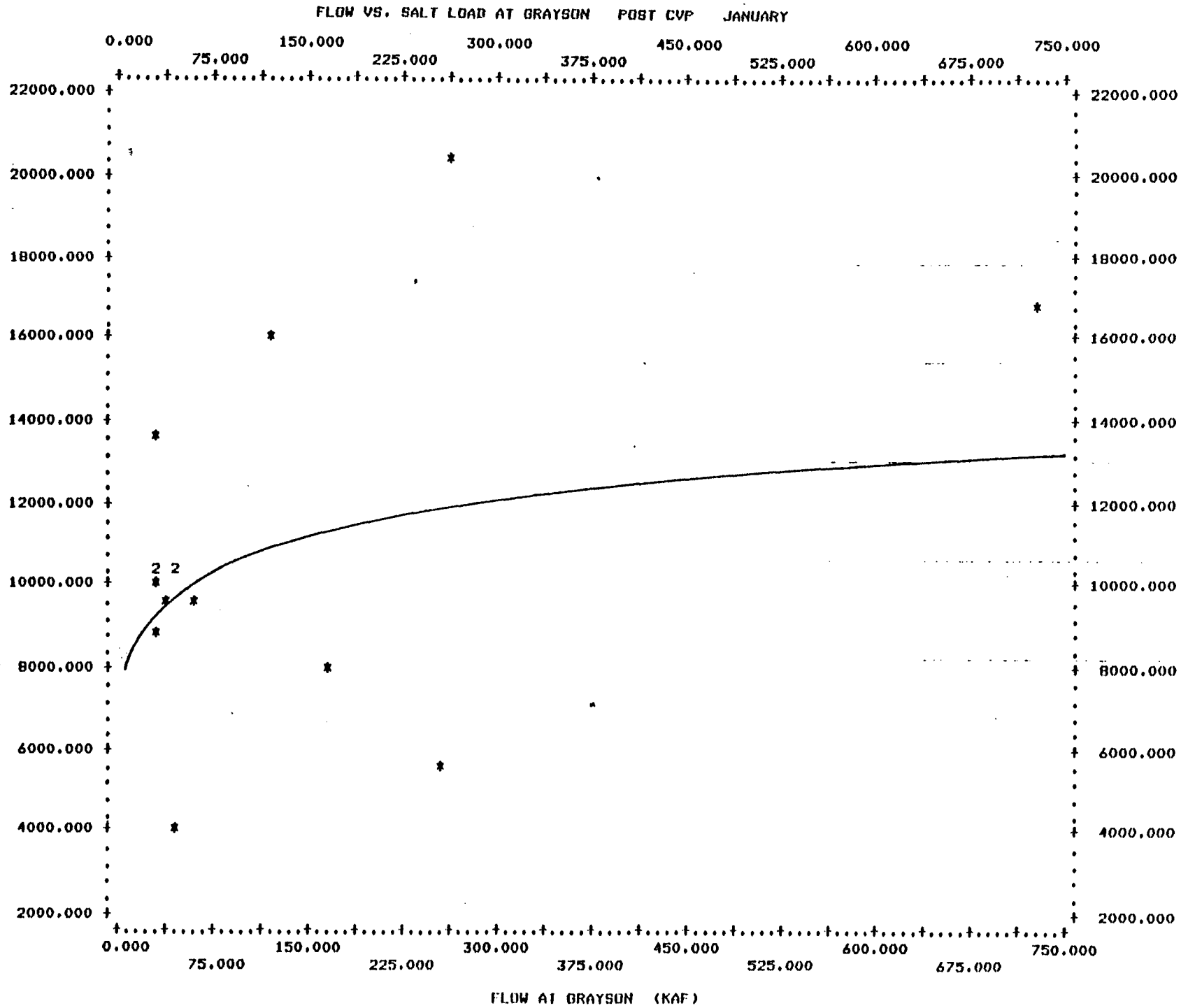
C-115424

FLOW VS. SALT LOAD AT GRAYSON PRE CVP JANUARY



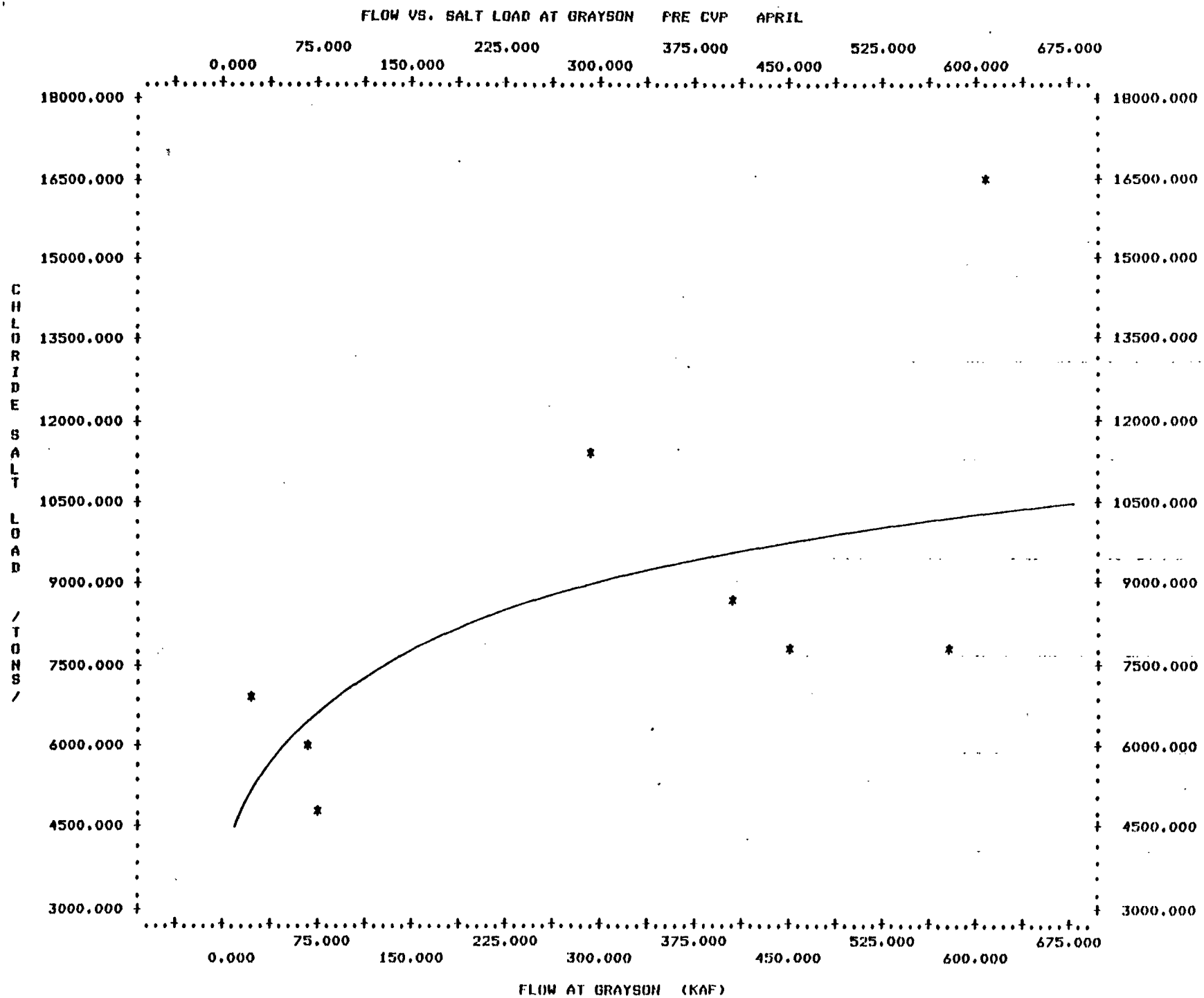
C-115425

C-115425

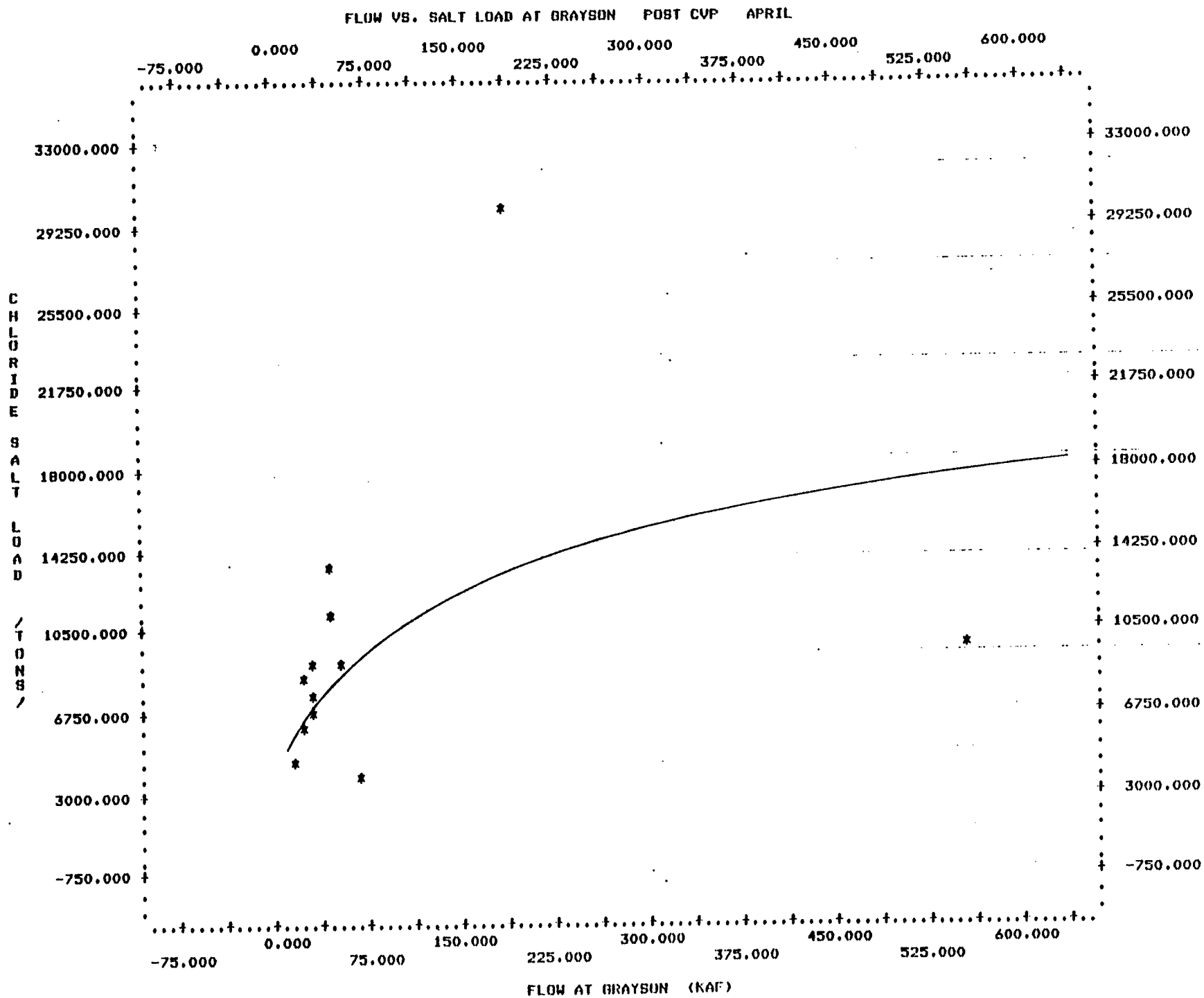


C-115426

C-115426

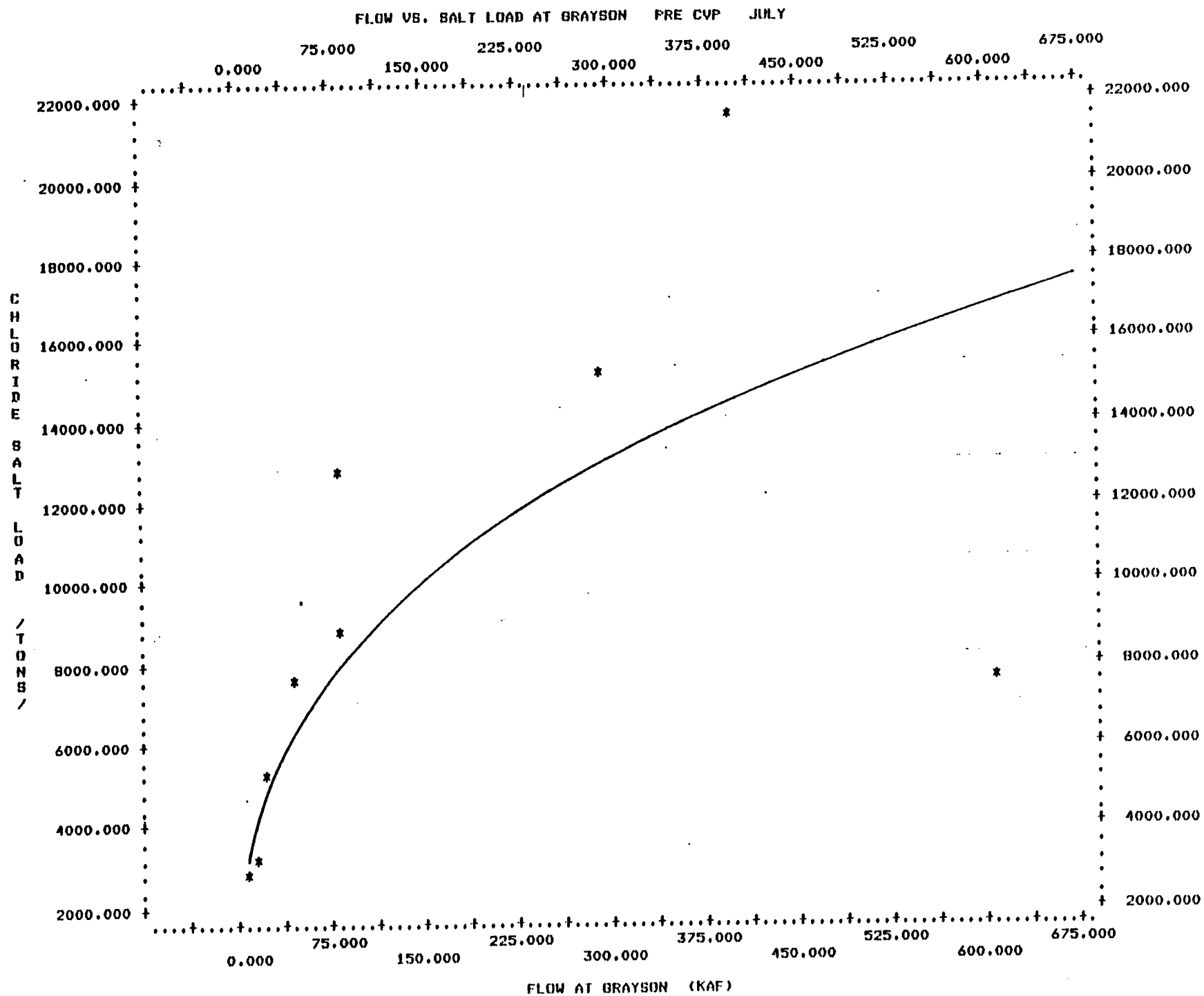

FLOW VS. SALT LOAD AT GRAYSON PRE CVP APRIL
CHLORIDE SALT LOAD /TONS/
FLOW AT GRAYSON (KAF)
0.000
75.000
150.000
225.000
300.000
375.000
450.000
525.000
600.000
675.000
3000.000
4500.000
6000.000
7500.000
9000.000
10500.000
12000.000
13500.000
15000.000
16500.000
18000.000

C—115427



C-115428

C-115428



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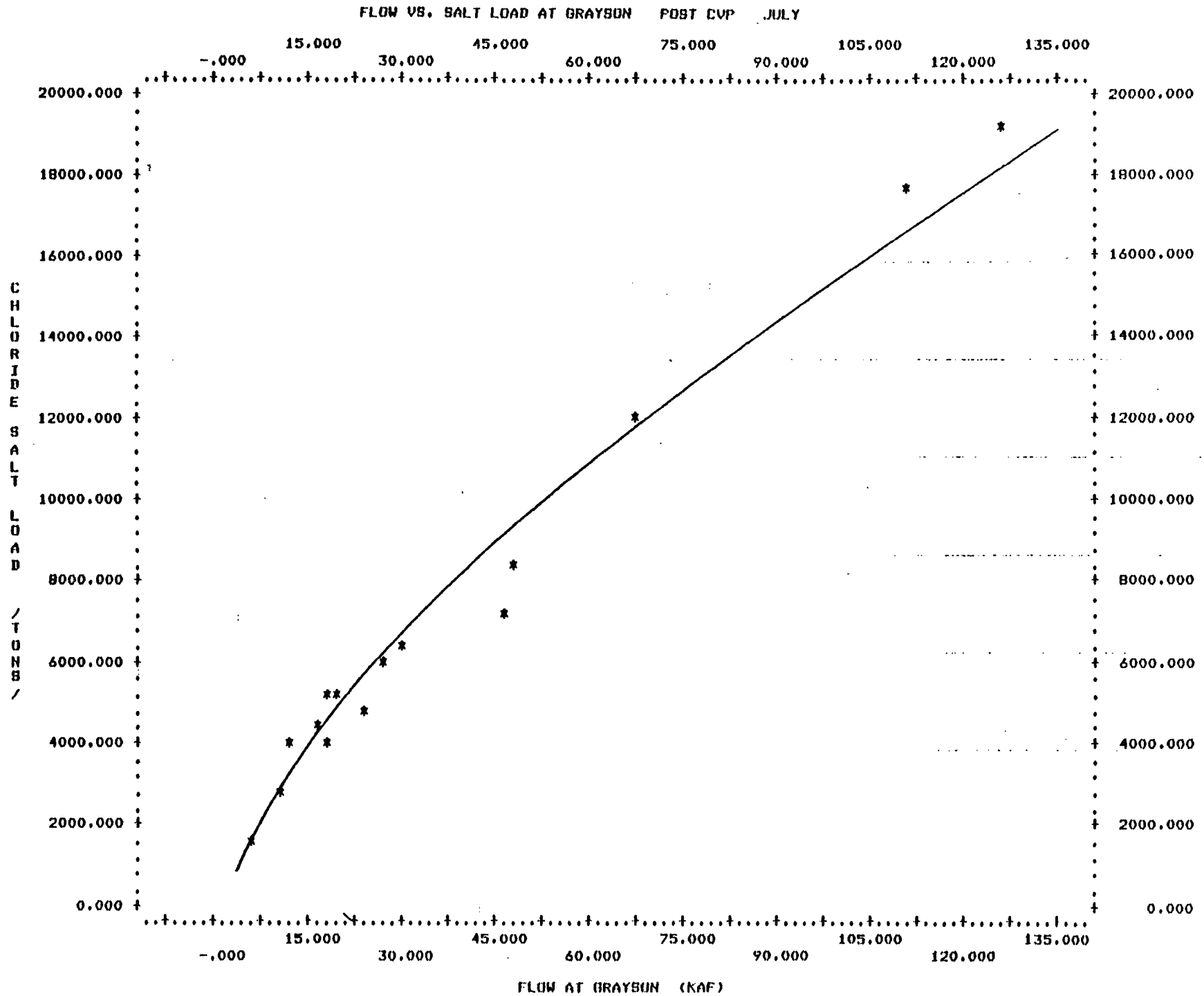
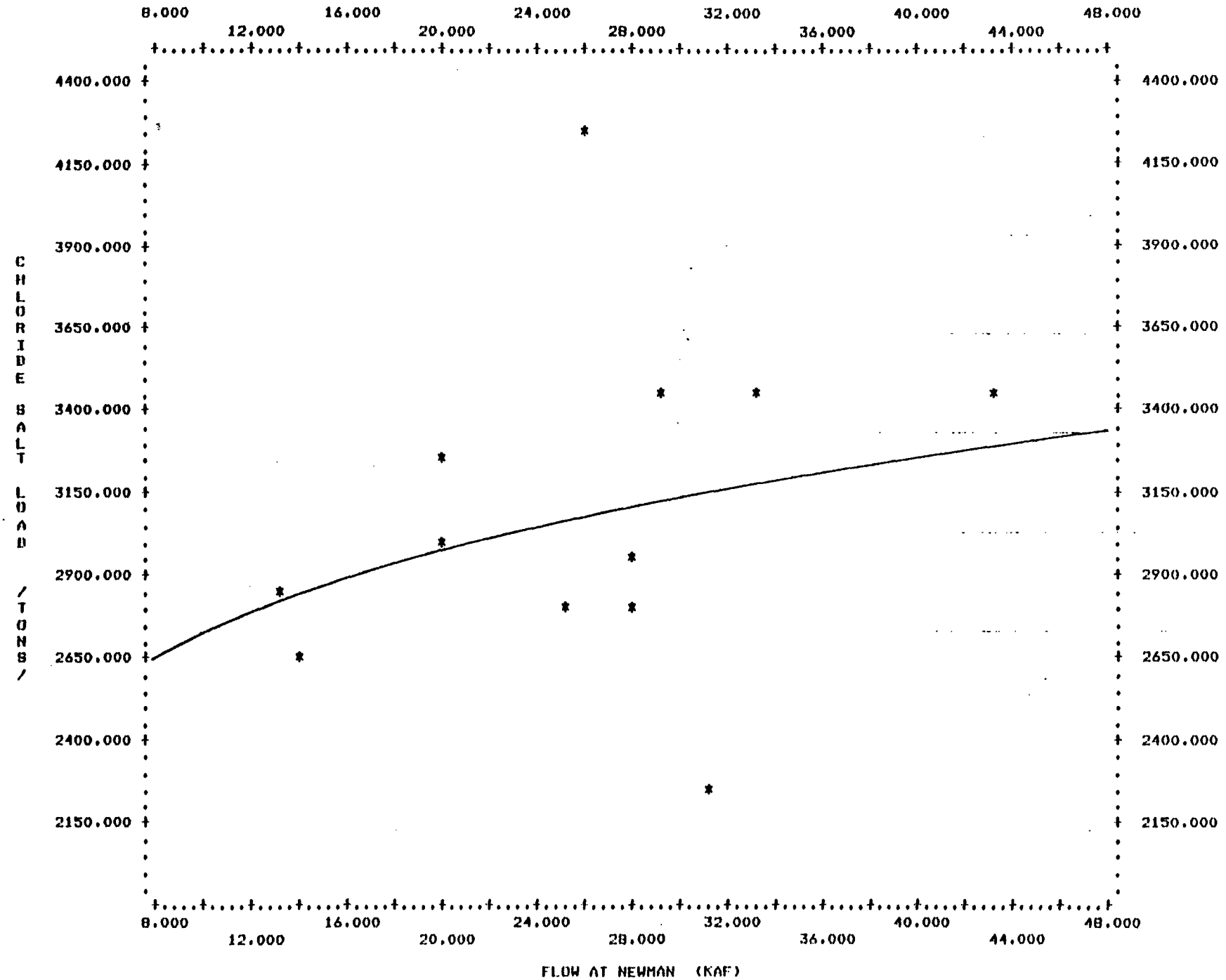


C-115430

C-115430

FLOW VS. SALT LOAD AT NEWMAN PRE CVP OCTOBER



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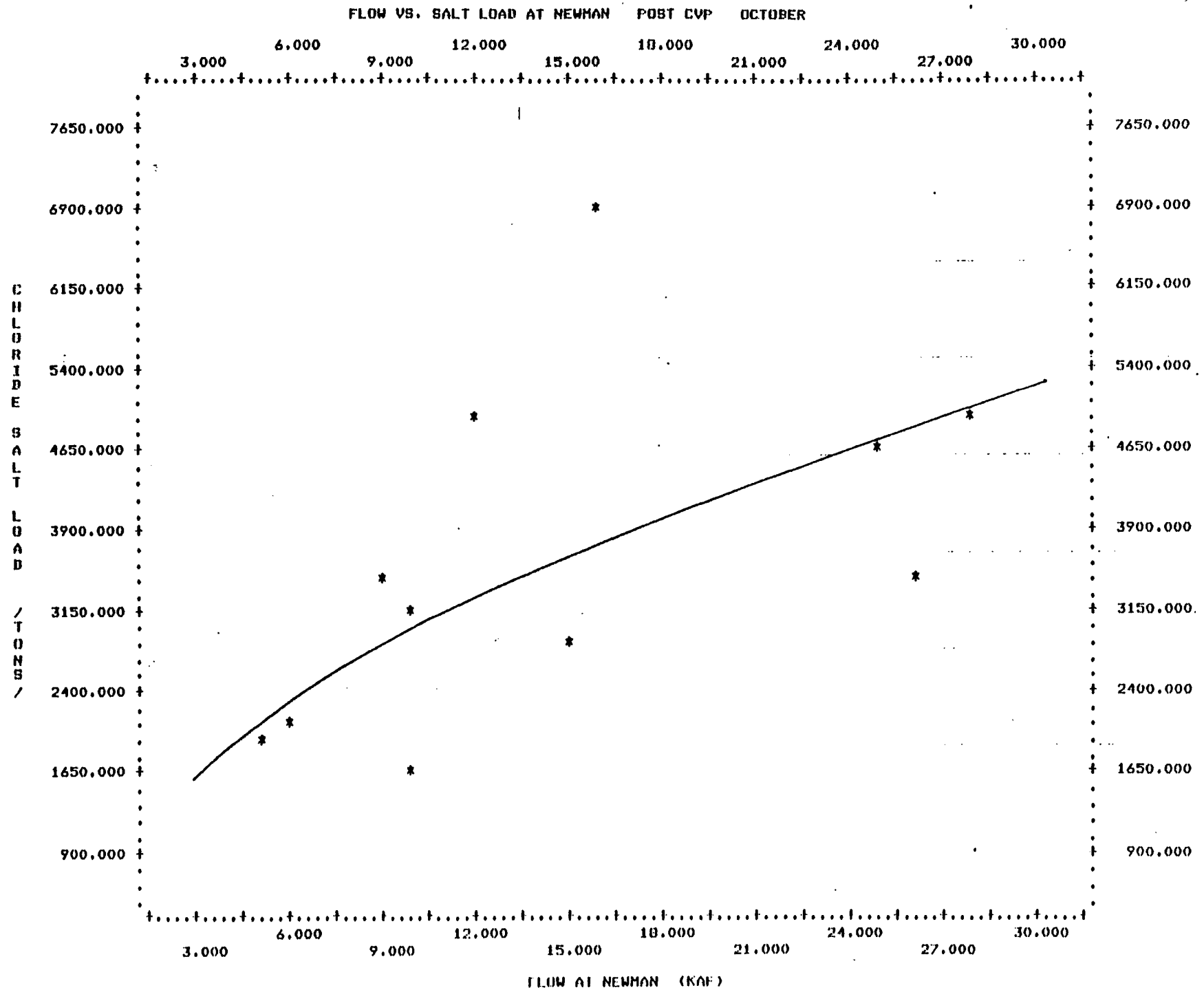
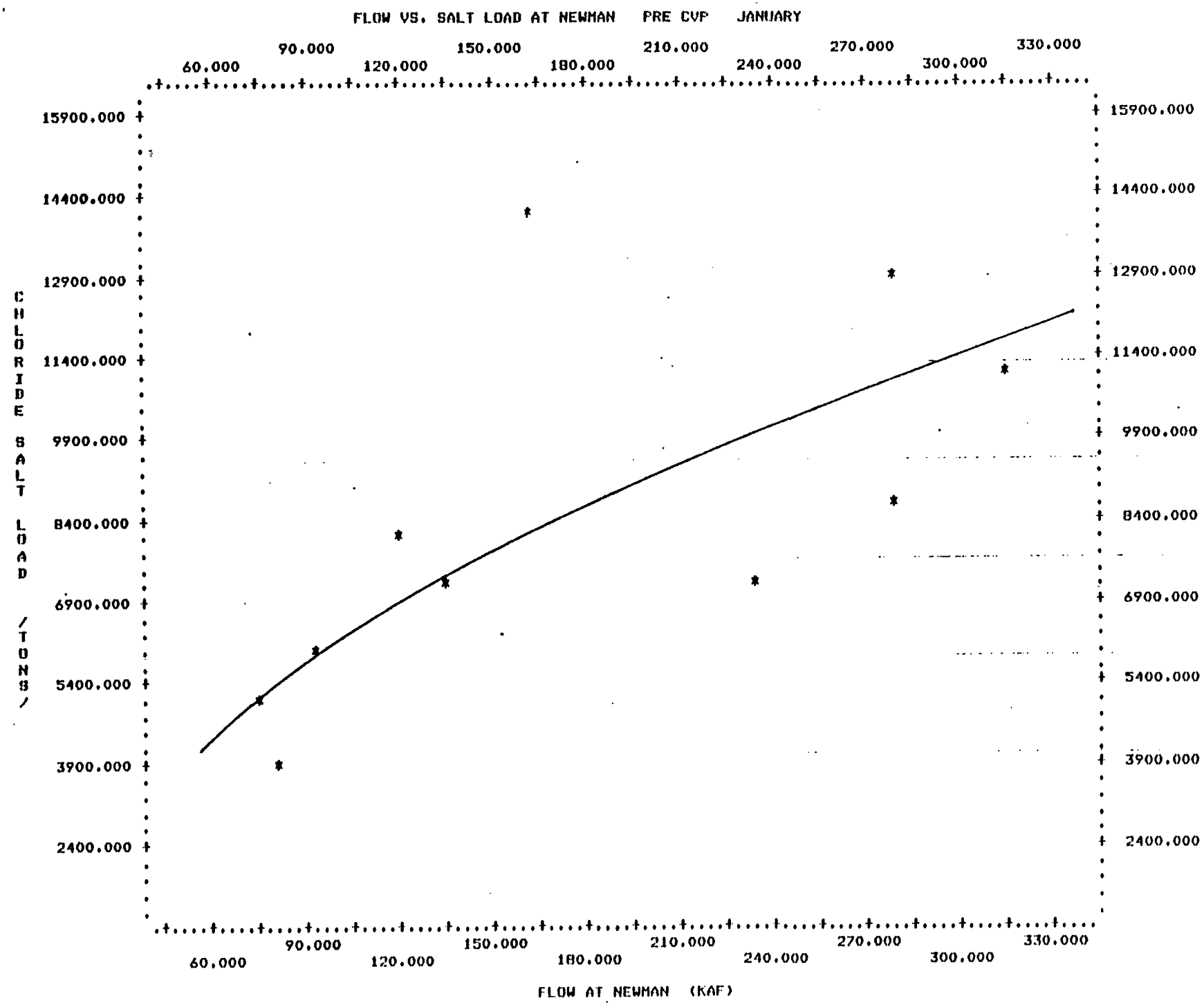
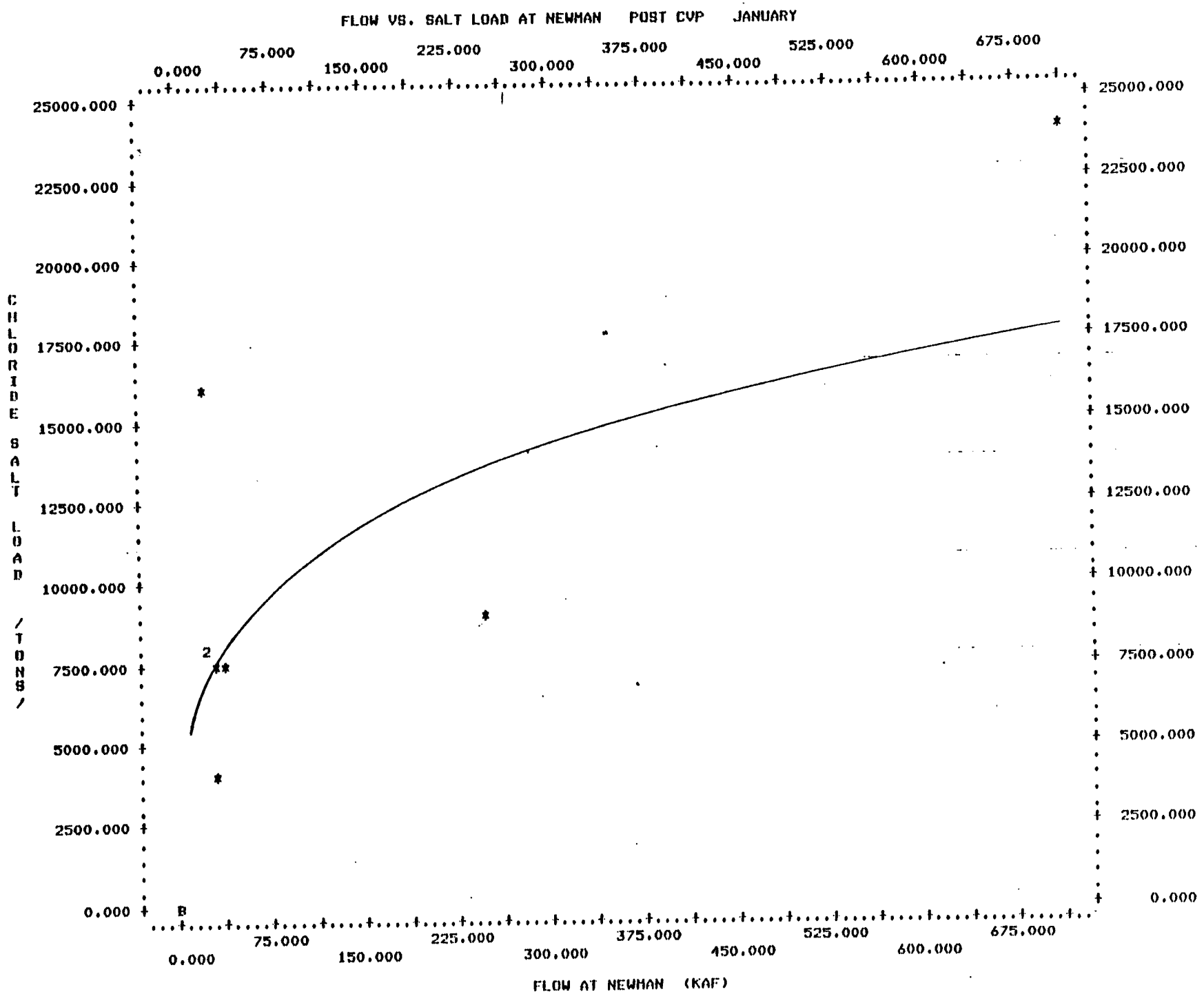

FLOW VS. SALT LOAD AT NEWMAN POST CVP OCTOBER
3.000
6.000
9.000
12.000
15.000
18.000
21.000
24.000
27.000
30.000
7650.000
6900.000
6150.000
5400.000
4650.000
3900.000
3150.000
2400.000
1650.000
900.000
CHLORIDE SALT LOAD /TONS/
FLOW AT NEWMAN (KAF)

C—115432


FLOW VS. SALT LOAD AT NEWMAN PRE CVP JANUARY
60.000
90.000
120.000
150.000
180.000
210.000
240.000
270.000
300.000
330.000
15900.000
14400.000
12900.000
11400.000
9900.000
8400.000
6900.000
5400.000
3900.000
2400.000
CHLORIDE SALT LOAD /TONS/
FLOW AT NEWMAN (KAF)

C—115433



C—115434

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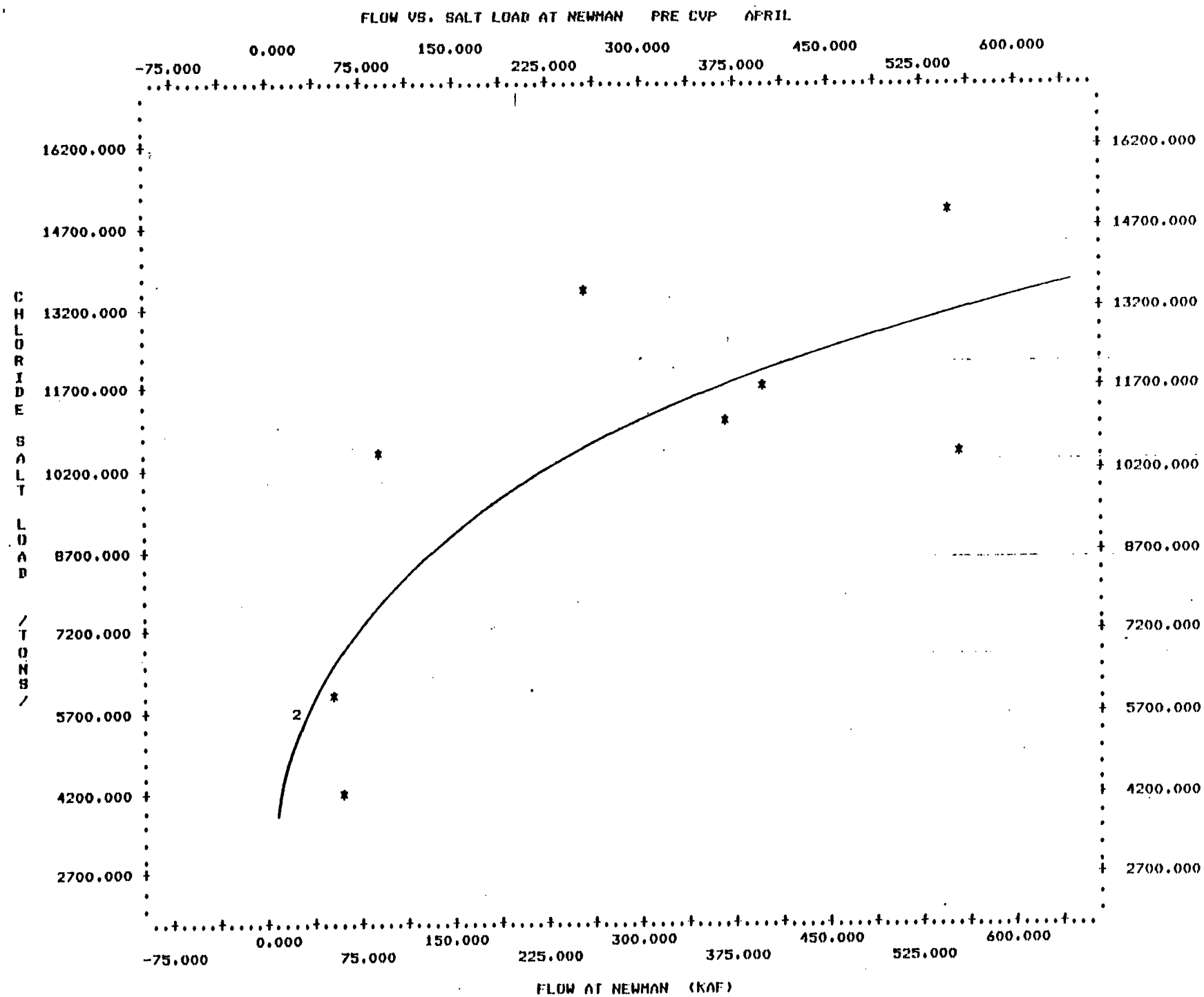
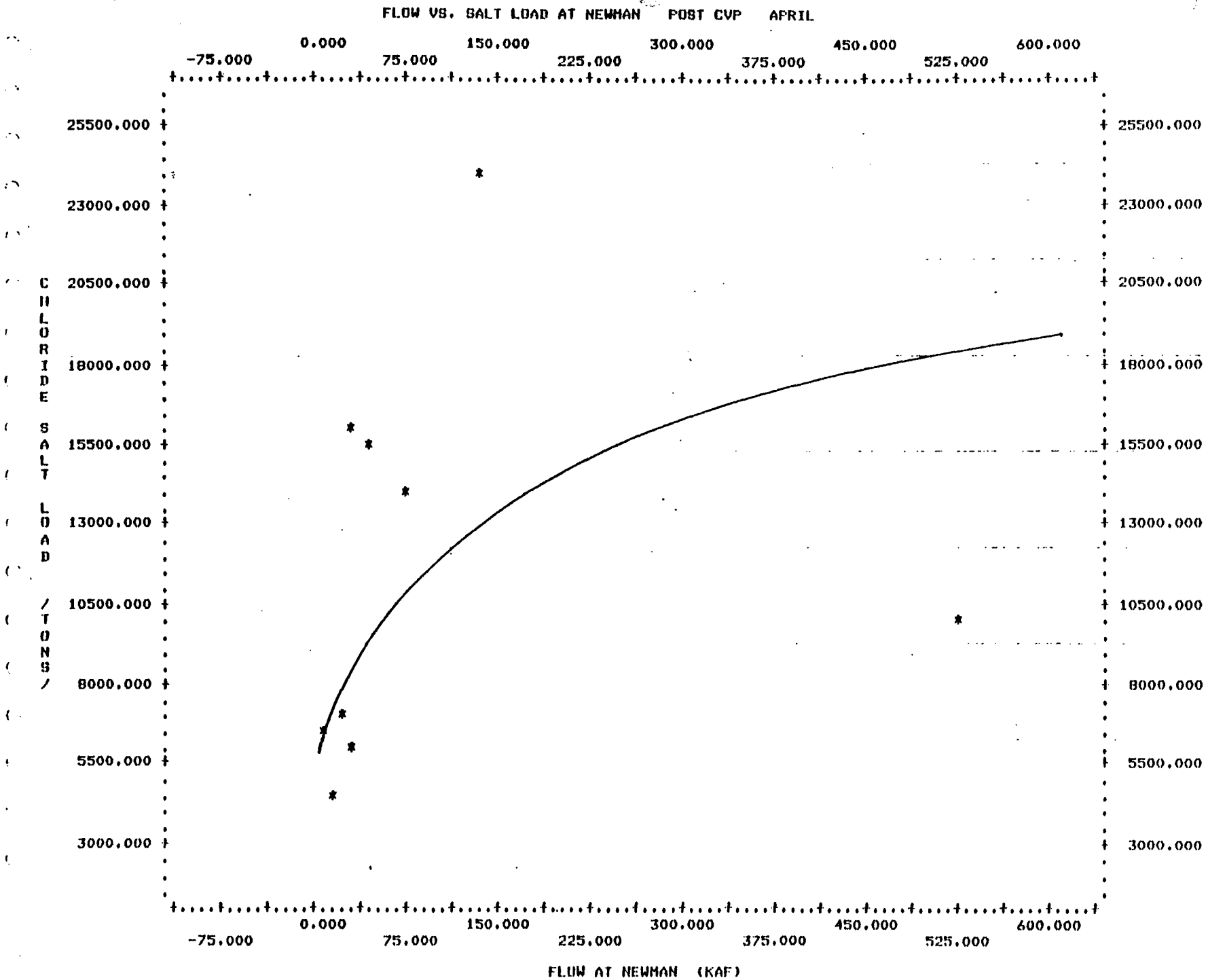
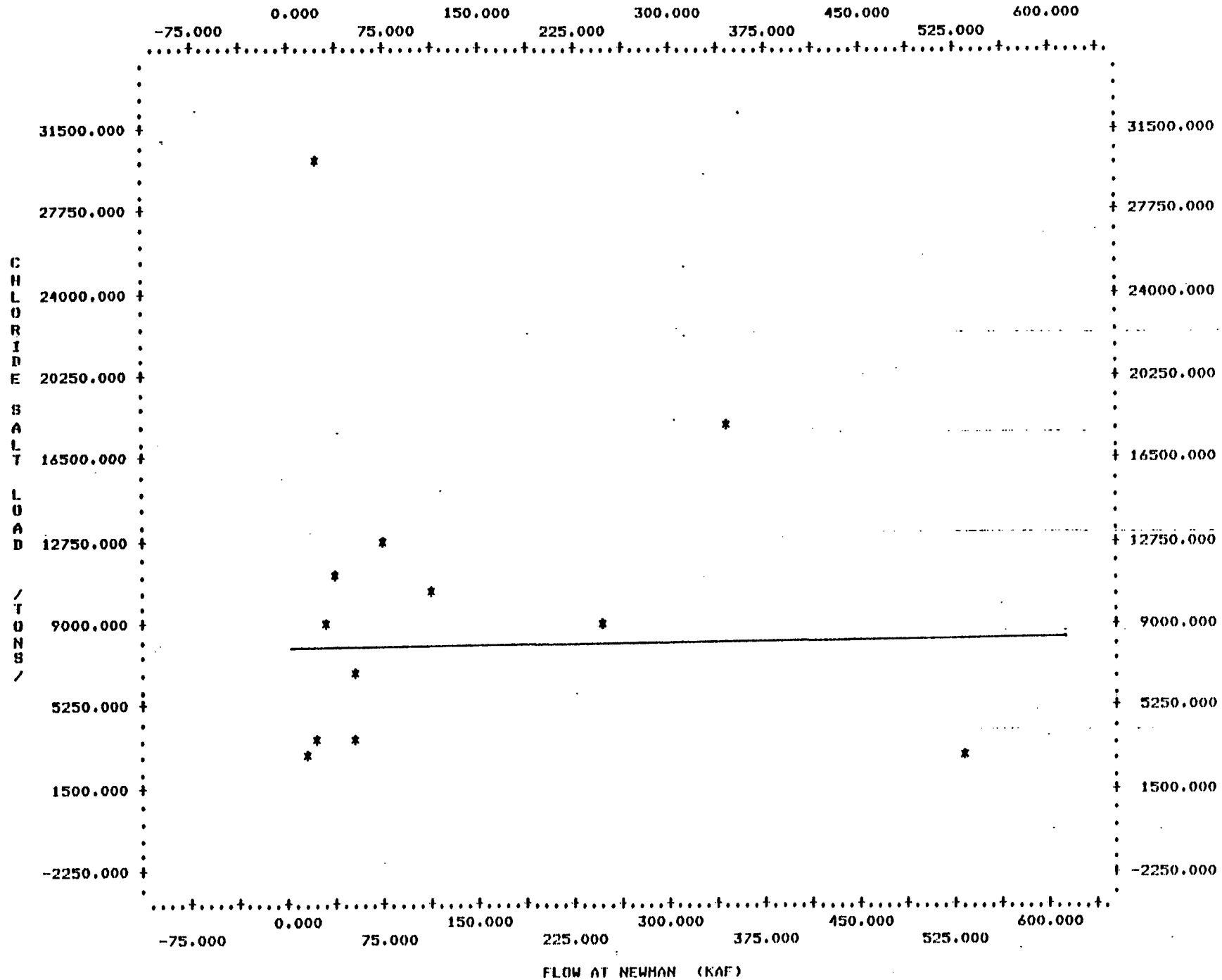


C-115435

C-115435

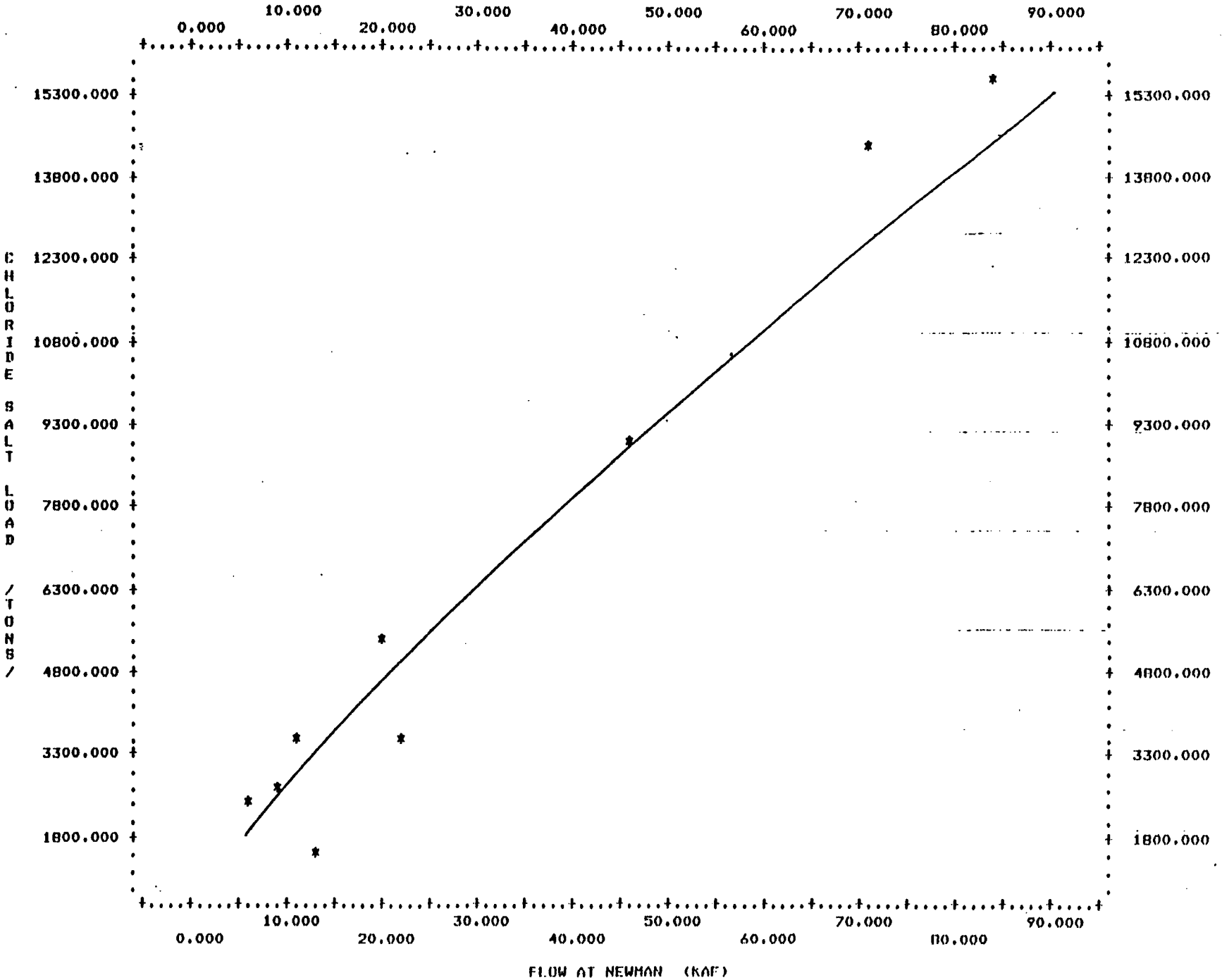

FLOW VS. SALT LOAD AT NEWMAN POST CVP APRIL
-75.000
0.000
75.000
150.000
225.000
300.000
375.000
450.000
525.000
600.000
25500.000
23000.000
20500.000
18000.000
15500.000
13000.000
10500.000
8000.000
5500.000
3000.000
CHLORIDE SALT LOAD /TONS/
FLOW AT NEWMAN (KAF)

FLOW VS. SALT LOAD AT NEWMAN PRE CVP JULY



C—115437

FLOW VS. SALT LOAD AT NEWMAN POST CVP JULY



C-115438

APPENDIX 3

SALT (CHLORIDE) BALANCES BY REPRESENTATIVE MONTHS

80/05/12. 13.40.05. OCTOBER 39.7 KAF UNIMPAIRED AT VERNALIS

DRY YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
24.	20.	NEWMAN	3040.	30.	4170.	29.
16.	16.	OTHER	1960.		2820.	
39.	36.	GRAYSON	5000.	49.	6990.	49.
55.	51.	TUOLUMNE	3830.	37.	5050.	35.
5.	9.	OTHER	1210.		2540.	
99.	96.	MAZE ROAD	10040.	98.	14570.	102.
14.	17.	STANISLAUS	260.	3.	200.	1.
-3.	7.	OTHER	-40.		-470.	
110.	120.	VERNALIS	10260.	100.	14290.	100.
		TOT. OTHERS	3130.	31.	4890.	34.
		NMN. + OTH.	6170.	60.	9060.	63.

QUALITY PPM (CL) / (TDS)

PRE PPM = 69. / 324.
POST PPM = 88. / 383.
DEGRADATION = 19. / 59.

* NOTE:

C-115440

80/05/12. 13.50.38. JANUARY 110.5 KAF UNIMPAIRED AT VERNALIS

DRY YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
51.	37.	NEWMAN	4240.	48.	8380.	80.
7.	9.	OTHER	2690.		1310.	
58.	46.	GRAYSON	6930.	78.	9690.	93.
54.	55.	TUOLUMNE	3490.	39.	4740.	45.
9.	4.	OTHER	580.		-330.	
121.	106.	MAZE ROAD	11010.	123.	14100.	135.
27.	24.	STANISLAUS	130.	1.	170.	2.
2.	3.	OTHER	-2220.		-3850.	
150.	133.	VERNALIS	8920.	100.	10420.	100.
		TOT. OTHERS	1050.	12.	-2870.	-27.
		NMN. + OTH.	5290.	59.	5510.	53.

QUALITY PPM (CL) / (TDS)

PRE PPM = 44. / 221.
POST PPM = 58. / 291.
DEGRADATION = 14. / 71.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

C-115441

C-115441

80/05/12. 14.01.24. APRIL 601.4 KAF UNIMPAIRED AT VERNALIS

DRY YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
23.	18.	NEWMAN	5210.	110.	7830.	130.
5.	4.	OTHER	410.		-580.	
28.	22.	GRAYSON	5630.	119.	7250.	120.
26.	21.	TUOLUMNE	3410.	72.	4420.	73.
-9.	-7.	OTHER	-190.		-1340.	
43.	36.	MAZE ROAD	8830.	186.	10310.	171.
41.	14.	STANISLAUS	210.	4.	150.	2.
1.	-6.	OTHER	-4300.		-4430.	
86.	44.	VERNALIS	4740.	100.	6030.	100.
		TOT. OTHERS	-4080.	-86.	-6350.	-105.
		NMN. + OTH.	1130.	24.	1480.	25.

QUALITY PPM (CL) / (TDS)

PRE PPM = 41. / 208.
POST PPM = 101. / 423.
DEGRADATION = 60. / 215.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

80/05/12. 14.12.25. JULY 101.4 KAF UNIMPAIRED AT VERNALIS

DRY YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
19.	10.	NEWMAN	7610.	117.	2670.	59.
4.	2.	OTHER	-2540.		490.	
23.	12.	GRAYSON	5070.	78.	3160.	70.
18.	12.	TUOLUMNE	3690.	57.	3810.	84.
-5.	-5.	OTHER	-2800.		-1020.	
36.	19.	MAZE ROAD	5950.	91.	5940.	131.
12.	6.	STANISLAUS	190.	3.	80.	2.
-1.	-6.	OTHER	390.		-1480.	
46.	18.	VERNALIS	6530.	100.	4540.	100.
		TOT. OTHERS	-4950.	-75.	-2010.	-44.
		NMN. + OTH.	2660.	41.	660.	15.

QUALITY PPM (CL) / (TDS)

PRE PPM = 104. / 432.
POST PPM = 185. / 681.
DEGRADATION = 81. / 249.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

C-115443

C-115443

80/05/12. 13.42.33. OCTOBER 49.3 KAF UNIMPAIRED AT VERNALIS

BELOW NORMAL YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
20.	17.	NEWMAN	2980.	31.	3920.	30.
14.	15.	OTHER	1470.		2780.	
34.	32.	GRAYSON	4450.	46.	6700.	52.
53.	46.	TUOLUMNE	3820.	40.	4930.	38.
5.	7.	OTHER	1420.		2580.	
92.	85.	MAZE ROAD	9690.	100.	14220.	110.
13.	16.	STANISLAUS	220.	2.	190.	1.
-3.	3.	OTHER	-260.		-1480.	
101.	104.	VERNALIS	9650.	100.	12920.	100.
		TOT. OTHERS	2630.	27.	3880.	30.
		NMN. + OTH.	5610.	58.	7800.	60.

QUALITY PPM (CL) / (TDS)

PRE PPM = 70. / 328.
POST PPM = 91. / 392.
DEGRADATION = 21. / 64.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

C-115444

80/05/12. 13.53.13. JANUARY 167.3 KAF UNIMPAIRED AT VERNALIS

BELOW NORMAL YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
36.	60.	NEWMAN	3500.	45.	9430.	74.
6.	12.	OTHER	2880.		750.	
42.	71.	GRAYSON	6370.	83.	10190.	80.
46.	85.	TUOLUMNE	3400.	44.	4950.	39.
7.	0.	OTHER	950.		100.	
95.	157.	MAZE ROAD	10720.	139.	15230.	120.
21.	40.	STANISLAUS	120.	2.	230.	2.
2.	5.	OTHER	-3110.		-2730.	
119.	202.	VERNALIS	7720.	100.	12730.	100.
		TOT. OTHERS	720.	9.	-1880.	-14.
		NMN. + OTH.	4220.	55.	7550.	59.

QUALITY PPM (CL) / (TDS)

PRE PPM = 48. / 237.
POST PPM = 46. / 254.
DEGRADATION = -2. / 17.

* NOTE:
POST COLUMN TO PERCENT OF VERNALIS.

C-115445

80/05/12. 14.15.13. JULY 224.9 KAF UNIMPAIRED AT VERNALIS

BELOW NORMAL YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
27.	19.	NEWMAN	7690.	96.	4370.	57.
7.	5.	OTHER	-1890.		1060.	
34.	24.	GRAYSON	5790.	72.	5430.	71.
23.	23.	TUOLUMNE	3720.	46.	4260.	55.
-5.	-5.	OTHER	-2090.		-480.	
51.	42.	MAZE ROAD	7420.	93.	9210.	120.
14.	12.	STANISLAUS	210.	3.	140.	2.
0.	-8.	OTHER	390.		-1640.	
64.	46.	VERNALIS	8020.	100.	7700.	100.
		TOT. OTHERS	-3590.	-44.	-1060.	-13.
		NMN. + OTH.	4100.	51.	3310.	43.

QUALITY PPM (CL) / (TDS)

PRE PPM = 92. / 396.
POST PPM = 123. / 491.
DEGRADATION = 31. / 95.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS

C-115446

80/05/12. 13.45.43. OCTOBER 42.4 KAF UNIMPAIRED AT VERNALIS

ABOVE NORMAL YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
19.	12.	NEWMAN	2960.	31.	3190.	34.
13.	11.	OTHER	1310.		2650.	
33.	23.	GRAYSON	4270.	45.	5840.	63.
52.	32.	TUOLUMNE	3820.	40.	4580.	49.
4.	2.	OTHER	1480.		2700.	
89.	57.	MAZE ROAD	9570.	101.	13120.	141.
13.	11.	STANISLAUS	210.	2.	160.	2.
-4.	-3.	OTHER	-330.		-3990.	
98.	65.	VERNALIS	9440.	100.	9280.	100.
		TOT. OTHERS	2460.	26.	1360.	15.
		NMN. + OTH.	5420.	57.	4550.	49.

QUALITY PPM (CL) / (TDS)

PRE PPM = 71. / 331.
POST PPM = 105. / 435.
DEGRADATION = 34. / 104.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

C-115447

80/05/12. 13.56.03. JANUARY 352.5 KAF UNIMPAIRED AT VERNALIS

ABOVE NORMAL YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
130.	80.	NEWMAN	7130.	54.	10160.	70.
11.	14.	OTHER	1560.		350.	
141.	94.	GRAYSON	8700.	66.	10510.	73.
81.	111.	TUOLUMNE	3750.	29.	5080.	35.
6.	-4.	OTHER	-630.		400.	
229.	201.	MAZE ROAD	11810.	90.	16000.	111.
51.	56.	STANISLAUS	180.	1.	270.	2.
0.	6.	OTHER	1140.		-1820.	
279.	263.	VERNALIS	13130.	100.	14450.	100.
		TOT. OTHERS	2070.	16.	-1070.	-7.
		NMN. + OTH.	9200.	70.	9090.	63.

QUALITY PPM (CL) / (TDS)

PRE PPM = 35. / 183.
POST PPM = 40. / 236.
DEGRADATION = 5. / 53.

* NOTE:
SET EQUAL TO PERCENT OF VERNALIS

C-115448

80/05/12. 14.06.23. APRIL 1055.7 KAF UNIMPAIRED AT VERNALIS

ABOVE NORMAL YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
366.	84.	NEWMAN	11730.	70.	11570.	79.
46.	17.	OTHER	-2170.		-450.	
413.	102.	GRAYSON	9550.	57.	11110.	76.
199.	98.	TUOLUMNE	3880.	23.	4950.	34.
-2.	-3.	OTHER	1730.		2610.	
609.	196.	MAZE ROAD	15160.	91.	18680.	127.
190.	74.	STANISLAUS	400.	2.	370.	3.
5.	-6.	OTHER	1100.		-4370.	
805.	264.	VERNALIS	16660.	100.	14670.	100.
		TOT. OTHERS	660.	4.	-2210.	-15.
		NMN. + OTH.	12390.	74.	9360.	64.

QUALITY PPM (CL) / (TDS)

PRE PPM = 15. / 101.
POST PPM = 41. / 239.
DEGRADATION = 26. / 138.

* NOTE:

C-115449

80/05/12. 14.17.48. JULY 425.1 KAF UNIMPAIRED AT VERNALIS

ABOVE NORMAL YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
108.	25.	NEWMAN	8000.	44.	5540.	56.
33.	9.	OTHER	1830.		1510.	
141.	34.	GRAYSON	9830.	55.	7040.	71.
55.	31.	TUOLUMNE	3860.	21.	4490.	45.
3.	-3.	OTHER	4010.		-170.	
200.	62.	MAZE ROAD	17710.	98.	11360.	115.
28.	17.	STANISLAUS	330.	2.	170.	2.
7.	-7.	OTHER	-10.		-1620.	
235.	72.	VERNALIS	18020.	100.	9910.	100.
		TOT. OTHERS	5830.	32.	-280.	-2.
		NMN. + OTH.	13830.	77.	5260.	53.

QUALITY PPM (CL) / (TDS)

PRE PPM = 56. / 270.
POST PPM = 101. / 423.
DEGRADATION = 45. / 153.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

C-115450

C-115450

80/05/12. 13.48.12. OCTOBER 29.8 KAF UNIMPAIRED AT VERNALIS

WET YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
22.	15.	NEWMAN	3020.	30.	3620.	32.
15.	13.	OTHER	1800.		2740.	
38.	28.	GRAYSON	4820.	48.	6360.	56.
54.	40.	TUOLUMNE	3830.	38.	4800.	42.
5.	5.	OTHER	1280.		2630.	
97.	73.	MAZE ROAD	9930.	99.	13790.	121.
14.	14.	STANISLAUS	240.	2.	180.	2.
-3.	0.	OTHER	-110.		-2570.	
107.	87.	VERNALIS	10060.	100.	11400.	100.
		TOT. OTHERS	2970.	30.	2800.	25.
		NMN. + OTH.	5990.	60.	6420.	56.

QUALITY PPM (CL) / (TDS)

PRE PPM = 69. / 324.
POST PPM = 96. / 408.
DEGRADATION = 27. / 84.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

C—115451

80/05/12. 13.58.57. JANUARY 695.7 KAF UNIMPAIRED AT VERNALIS

WET YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
233.	246.	NEWMAN	9850.	59.	13480.	58.
13.	22.	OTHER	160.		-1630.	
246.	268.	GRAYSON	10010.	60.	11850.	51.
104.	310.	TUOLUMNE	3910.	23.	5630.	24.
-10.	-61.	OTHER	-1590.		1770.	
339.	516.	MAZE ROAD	12330.	74.	19250.	83.
75.	185.	STANISLAUS	220.	1.	530.	2.
-4.	13.	OTHER	4140.		3540.	
410.	714.	VERNALIS	16690.	100.	23320.	100.
		TOT. OTHERS	2710.	16.	3680.	16.
		NMN. + OTH.	12560.	75.	17160.	74.

QUALITY PPM (CL) / (TDS)

PRE PPM = 30. / 163.
POST PPM = 24. / 187.
DEGRADATION = -6. / 24.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS

C-115452

80/05/12. 14.09.13. APRIL 1169.0 KAF UNIMPAIRED AT VERNALIS

WET YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
585.	267.	NEWMAN	13450.	65.	15470.	54.
67.	47.	OTHER	-3000.		-190.	
652.	314.	GRAYSON	10450.	51.	15270.	54.
281.	306.	TUOLUMNE	3960.	19.	5390.	19.
19.	73.	OTHER	2190.		8380.	
952.	693.	MAZE ROAD	16600.	81.	29040.	102.
246.	256.	STANISLAUS	450.	2.	720.	3.
-23.	51.	OTHER	3560.		-1340.	
1175.	1000.	VERNALIS	20620.	100.	28410.	100.
		TOT. OTHERS	2750.	13.	6850.	24.
		NMN. + OTH.	16200.	79.	22320.	79.

QUALITY PPM (CL) / (TDS)

PRE PPM = 13. / 92.
POST PPM = 21. / 178.
DEGRADATION = 8. / 85.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

C-115453

80/05/12. 14.20.10. JULY 921.0 KAF UNIMPAIRED AT VERNALIS

WET YEAR

FLOW (KAF) PRE	FLOW (KAF) POST	STATION	CHLORIDES PRE (TONS)	CHLORIDES PRE (PCT)	CHLORIDES POST (TONS)	CHLORIDES POST (PCT)
365.	65.	NEWMAN	8280.	23.	11740.	53.
129.	40.	OTHER	7300.		4360.	
494.	105.	GRAYSON	15580.	43.	16100.	73.
119.	80.	TUOLUMNE	3980.	11.	5320.	24.
49.	29.	OTHER	18210.		720.	
662.	214.	MAZE ROAD	37780.	104.	22140.	100.
50.	51.	STANISLAUS	480.	1.	360.	2.
17.	34.	OTHER	-1780.		-360.	
730.	300.	VERNALIS	36470.	100.	22130.	100.
		TOT. OTHERS	23730.	65.	4720.	21.
		NMN. + OTH.	32010.	88.	16460.	74.

QUALITY PPM (CL) / (TDS)

PRE PPM = 37. / 192.
POST PPM = 54. / 279.
DEGRADATION = 17. / 87.

* NOTE:
PCT COLUMN IS PERCENT OF VERNALIS.

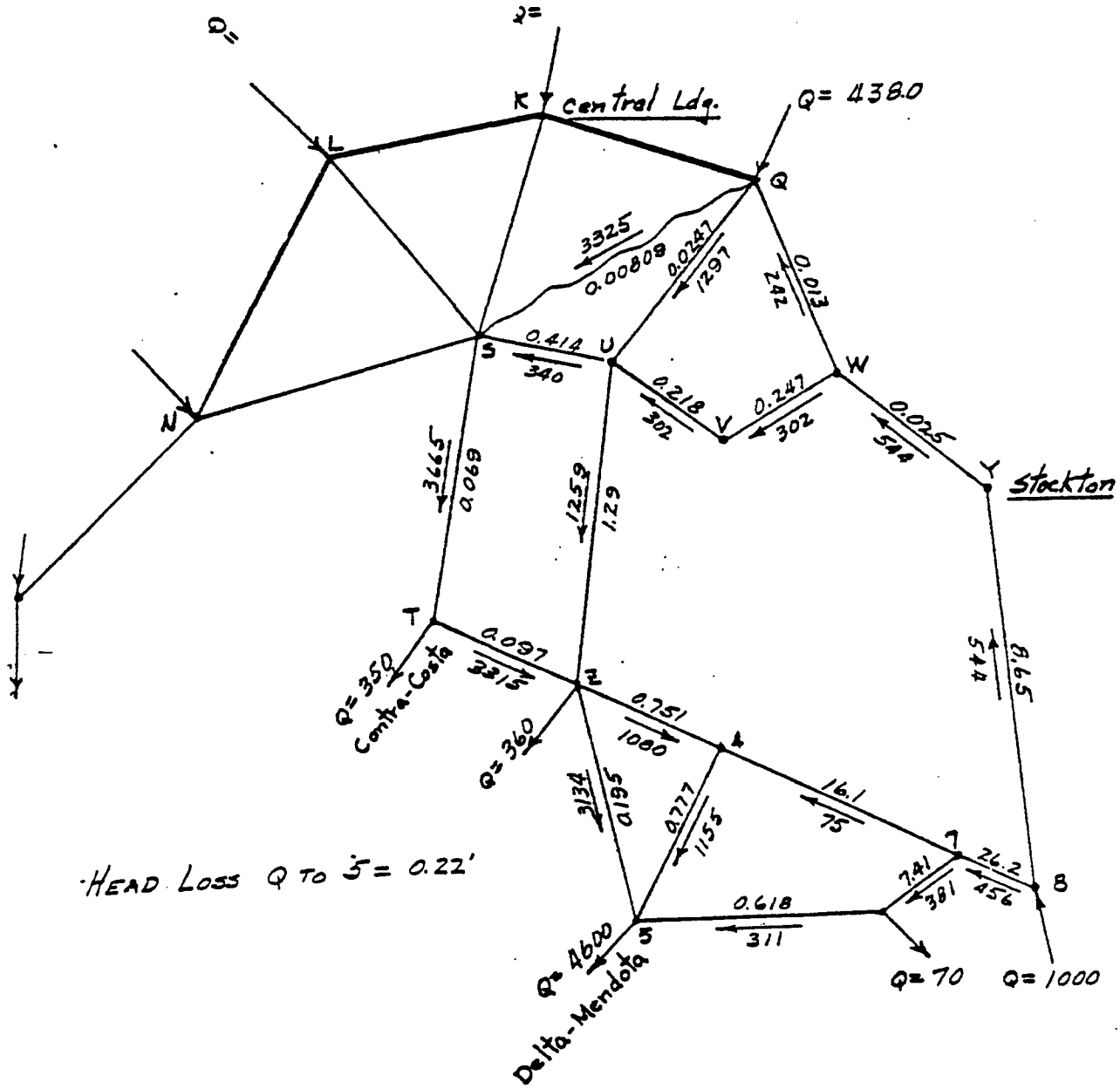
C-115454

APPENDIX 4

SUMMARY OF NETWORK ANALYSES OF THE

LOWER SACRAMENTO-SAN JOAQUIN DELTA

DELTA NETWORK ANALYSIS



SCHEME 8 TRIAL FINAL

R. F. Blanks February 16, 1951

D. J. Hebert and W. B. McBirney

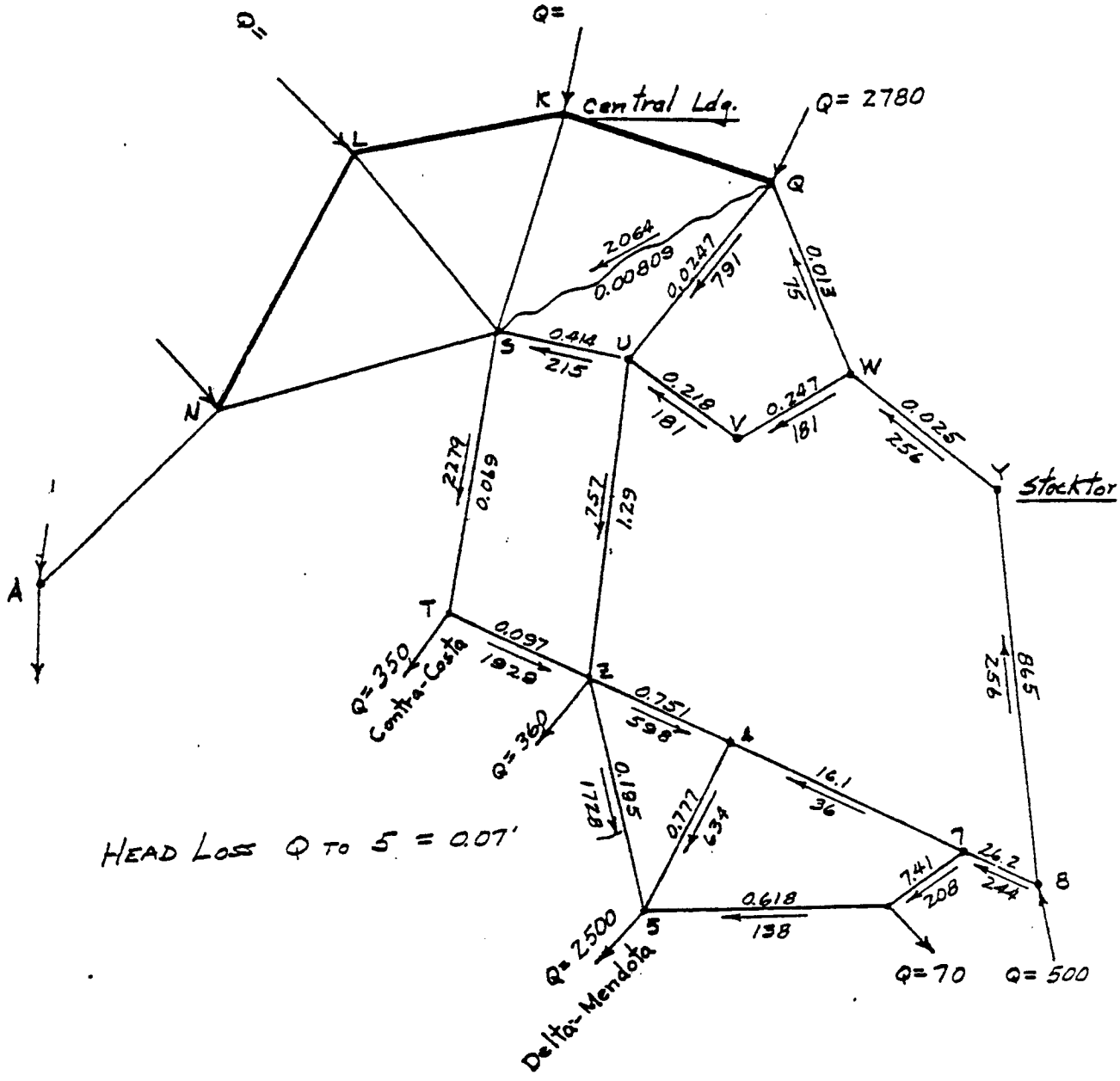
Summary of network analyses of lower Sacramento-San Joaquin Delta

1. The results of all network analyses of the lower Sacramento-San Joaquin Delta have been summarized on the six diagrams attached. Rate and direction of flow are shown on one side of a channel, and a resistance value based on channel characteristics is given on the other side. Resistances were computed from $\frac{r=L \times 10^4}{b^2 d^{10/3}}$. Three channels NL, LK, and KQ, are very large and have been assumed at constant level regardless of discharge. Computations made to test this premise show that a large increase in discharge can be accommodated by a negligible increase in slope. The wavy connection shown from S to Q represents channels NS, LS, and KS, and the resistance value used is the hydraulic equivalent of the three channels having S as a common point and terminating at N, L, K, or Q.

2. The first few schemes tried made use of resistance values which were derived from channel cross-sections as shown on available maps. It became evident they gave a division of flow which was contrary to that actually prevailing, and therefore at points such as 7 and 8, the resistances of connecting channels were arbitrarily adjusted until the division was more nearly correct. Thus, in channel (7-8) the resistance was changed to 26.2 and to 0.832 from 239.0, and in channel 8-Y, the resistance was increased to 10.0 from 8.65. Resistance in channel 6-7 was decreased to 2.0 from 7.41.

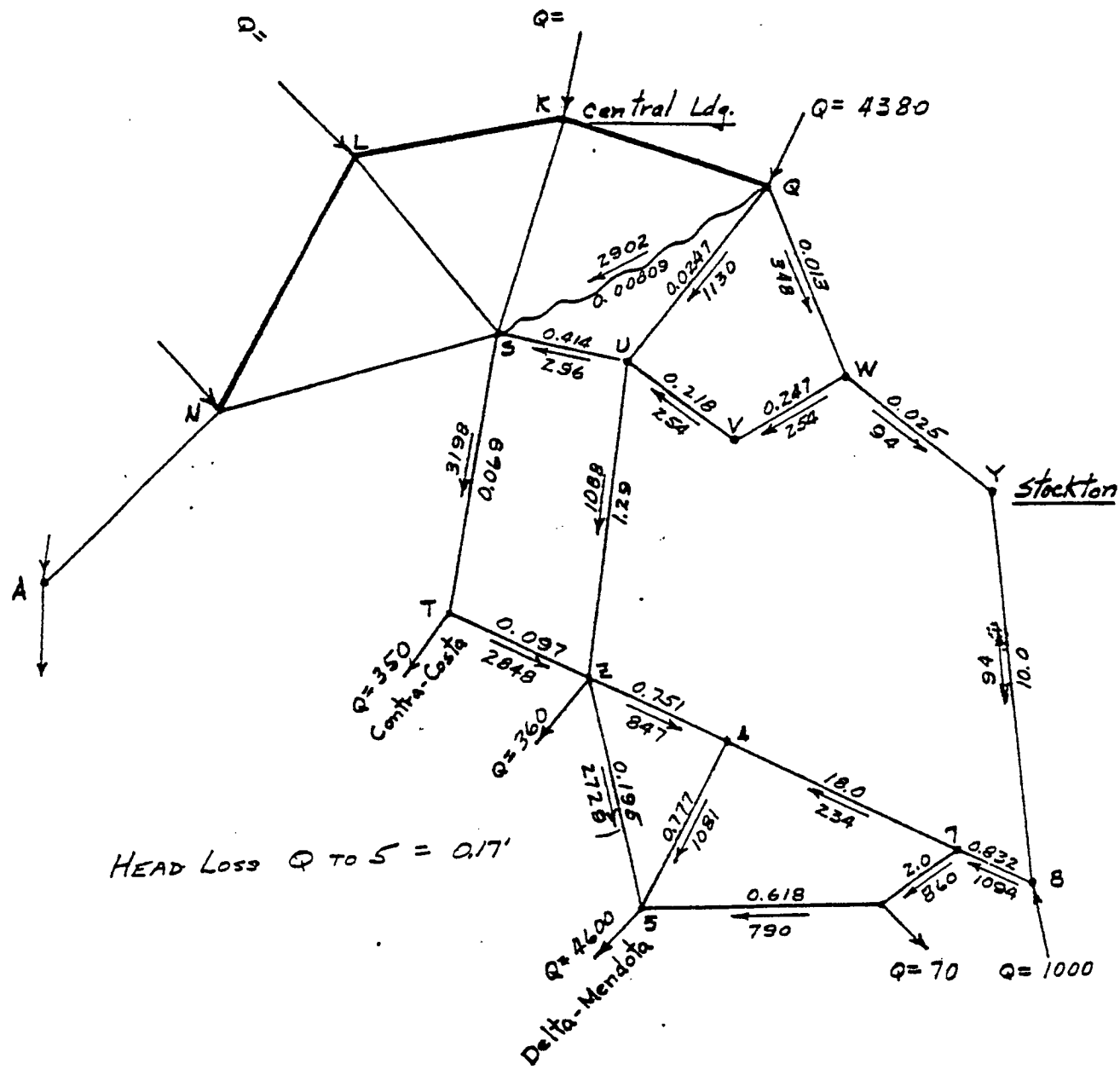
3. The results of the network analysis can be used to estimate the drop in water surface from Central Landing to Tracy Pumping Plant when the pumps are working at design capacity of 4,600 cubic feet per second. For mean tide height in the lower Delta this drop has been estimated to be 0.25 foot. Were the levels to be at mean low tide height an increase to approximately 0.34 foot may be expected. Making allowance for indeterminate factors, it is thought the maximum head loss, or draw-down, to Tracy Pumping Plant will be about 0.5 foot.

DELTA NETWORK ANALYSIS



SCHEME 11 TRIAL FINAL

DELTA NETWORK ANALYSIS



SCHEME 14 TRIAL FINAL

Analysis of Adding 15 TAF Purchase from OID into New Melones Storage

15 TAF applied to agricultural lands yields approximately 30-40% return flow to Stanislaus River (and eventually San Joaquin River).

$$15{,}000 \times .3 = 5{,}000 \text{ AF}$$

15 TAF added to 2,000,000 AF (inflow plus storage) increase water availability for water quality releases as follows:

$$\frac{80{,}000 \text{ AF}}{2{,}000{,}000 \text{ AF}} = \frac{X}{2{,}015{,}000 \text{ AF}}$$

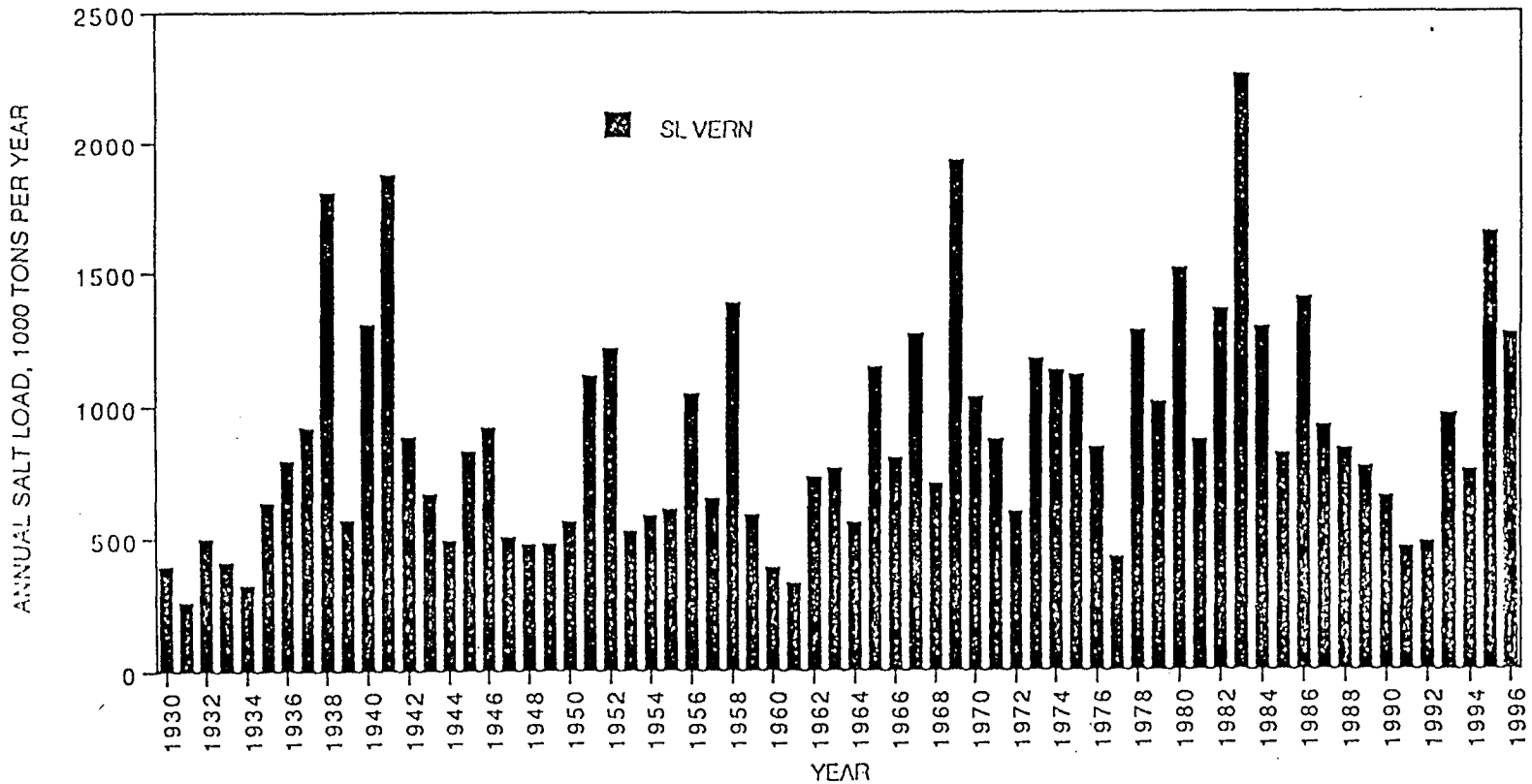
$$X = \frac{(80{,}000 \times 2{,}015{,}000)}{2{,}000{,}000}$$

$$X = 80{,}600 \text{ AF}$$

Additional water quality flow is 600 AF.

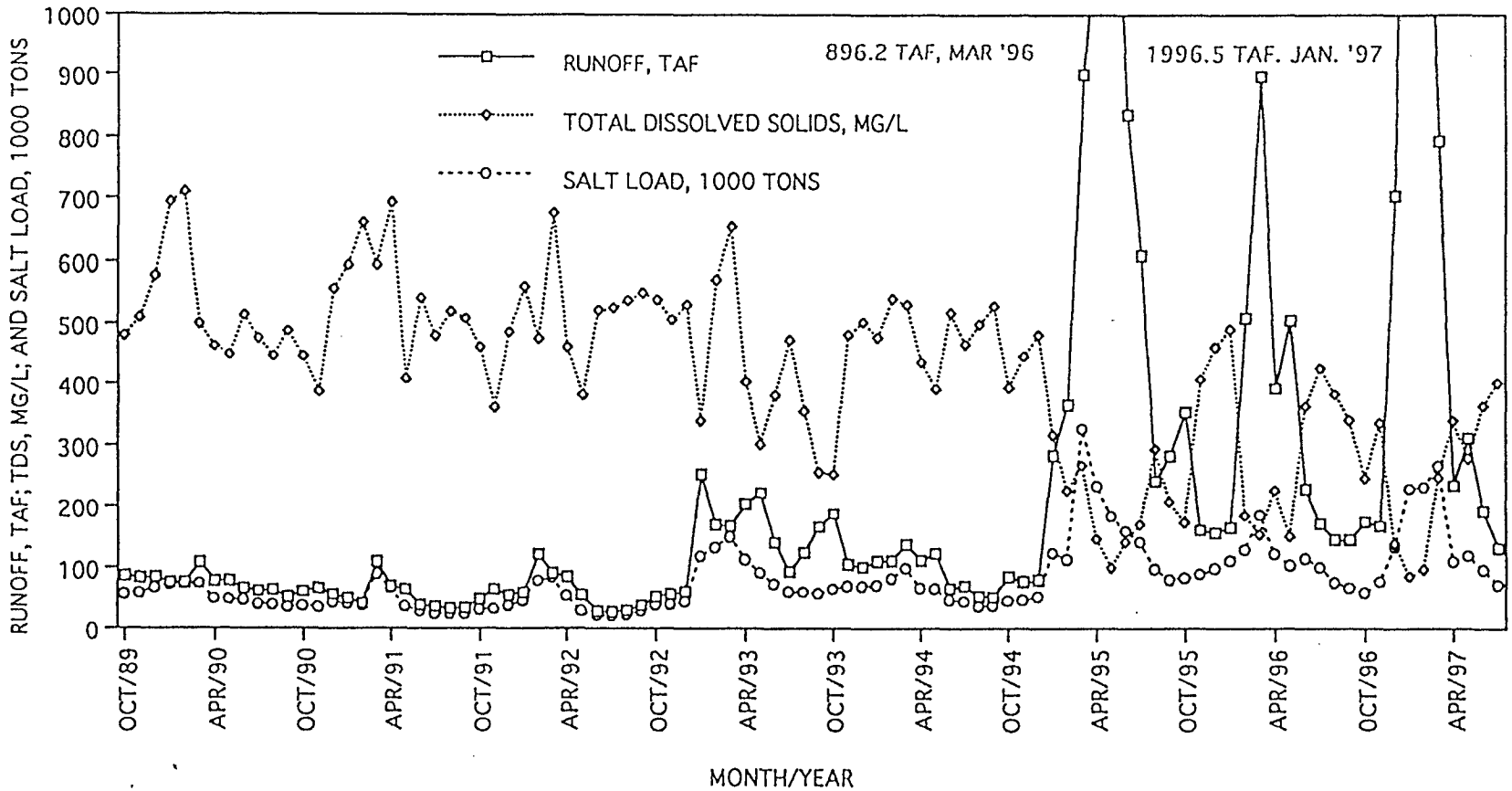
Table 2
(1,000 acre-feet)
(measured at Goodwin)

New Melones Storage plus Inflow		Fishery		Vernalis Water Quality		Bay-Delta		CVP Contractors	
From	To	From	To	From	To	From	To	From	To
1,400	2,000	98	125	70	80	0	0	0	0
2,000	2,500	125	345	80	175	0	0	0	59
2,500	3,000	345	467	175	250	75	75	90	90
3,000	6,000	467	467	250	250	75	75	90	90



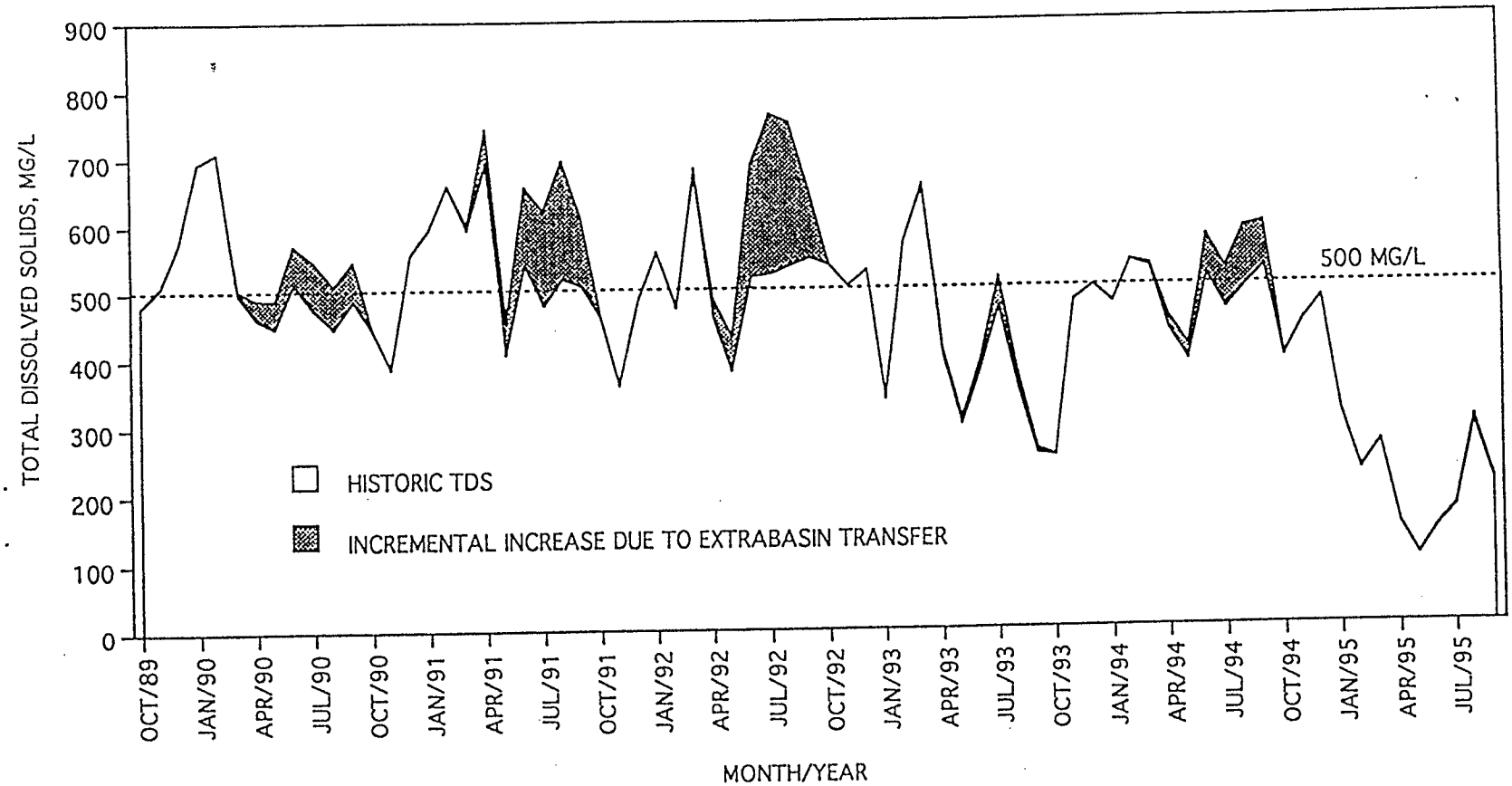
ANNUAL SALT LOAD
SAN JOAQUIN RIVER NEAR VERNALIS, 1930 TO 1996

Figure 4



MONTHLY RUNOFF, MEAN TDS AND SALT LOAD
SAN JOAQUIN RIVER NEAR VERNALIS, 1990 -1997

Figure 8



CHANGE IN WATER QUALITY DUE TO WATER TRANSFER FROM STANISLAUS BASIN
SAN JOAQUIN RIVER NEAR VERNALIS, 1990 - 1995

Figure 9

SOUTH DELTA WATER AGENCY

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Robert K. Ferguson
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Engineer:
Gerald T. Orlob

January 30, 1998

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Executive Director
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Control Board
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California Dept. of Fish & Game
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Mr. Wayne White
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2800 Cottage Way
Sacramento, CA 95825

Col. Dorothy Klasse
U. S. Corps of Engineers
1325 J Street
Sacramento, CA 95814-2922

Mr. Robert Potter
Deputy Director
Dept. of Water Resources
1416 Ninth Street
Sacramento, CA 95814

Gentlemen and Col, Klasse:

The South Delta Water Agency urges your serious consideration of the attached memo by Alex Hildebrand and Bill Loudermilk. The memo is entitled, "Developing a Conceptual Design and Operating Plan to address Serious Agricultural and Fishery Management Issues in the Lower San Joaquin River and South Delta, with Particular Regard to the Proposed Use of Channel Barriers."

The memo describes the issues that need resolution, some of the inter-relations of those issues, the role that South Delta Barriers can play in resolving the issues, and some conceptual design and operating features to optimize the role of the barriers in addressing various needs. The memo postulates that the normal permit process fails to achieve mutual understanding of the inter-related issues, and the hydrology; and that it does not result in a joint effort to develop compatible solutions. The authors propose that a series of about four informal facilitated meetings be convened in which the parties involved in the planning, permitting, and implementing process would exchange information and design and operating plan features for resolving the in-channel problems in the South Delta. The memo is offered as a point of departure for such a discussion.

SDWA 11

The memo proposes that DWR and fish and Game jointly convene these meetings during the next two months, and that there be a chairperson who is both knowledgeable and neutral. DWR and Fish and Game are asked to format the meeting and attendance.

We also ask DWR to distribute this memo to the CalFed Ops Group.

South Delta Water Agency urges your concurrence in the author's proposal.

Sincerely yours,

John Herrick

JH/dd
Enclosure
cc: Mr. Allen Short
Mr. Dan Fults
Mr. Mike Ford

Preliminary Staff Report of the
State of California
CALIFORNIA DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN DISTRICT

SJRIO Studies of San Joaquin River Recirculation and Reoperation of Wetland Discharge and Tile Drainage

Preliminary Draft Report
Prepared by:

Jo Anne Kipps
Associate Water Resource Engineer

January 1998

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Introduction

The San Joaquin River Input-Output Model (SJRIO), a mass balance water quality model for the SJR, was used to quantify the water quality impact of two water quality control actions in the SJR Basin:

- Using the Delta-Mendota Canal to recirculate San Joaquin River flows when additional water is required to meet SJR spring pulse flow targets required under the May 1995 Water Quality Control Plan Delta Standards.

- Reoperating tile drainage releases and/or wetland discharge into main stem San Joaquin River from the Grassland watershed to take advantage of the dilution flow provided by DMC recirculation.

This preliminary report is based on the August 1997 draft staff report of the California Regional Water Quality Control Board, Central Valley Region, entitled, "SJRIO Wetland Discharge and Tile Drainage Reoperation Studies," by Leslie F. Grober. The tables are presented at the end of the text portion of this report.

Background

SJRIO is a mass balance water quality model that calculates mean monthly discharge and water quality for a sixty mile reach of the lower San Joaquin River from Lander Avenue to Vernalis. The model was originally developed by State Water Resources Control Board and University of California, Davis staff (Kratzer et al. 1987) to quantify the impact of agricultural drainage on SJR water quality as part of work performed for the Technical Committee Report on the Regulation of Agricultural Drainage to the San Joaquin River (SWRCB 1987). The model was later updated so that probabilistic, Monte Carlo simulations could be performed (Grober et al. 1992). In Monte Carlo simulation mode, the model can be run using multiple year inputs based on data supplied by operations models such as the United States Bureau of Reclamation's San Joaquin Area Simulation Model or the Department of Water Resources Simulation Model (DWRSIM).

Model components include major east side and minor west side tributaries, combined discharge of Mud and Salt sloughs from the Grassland watershed, riparian and appropriative pumping, surface (tail water) and subsurface (tile drainage) agricultural discharges along the main stem of the SJR, groundwater accretions and depletions, municipal and industrial discharges, evaporation and precipitation, and evapo-transpiration (Table 1). Model parameters are mean monthly discharge, and mean monthly concentrations of Total Dissolved Solids, boron, and selenium. Although the model considers the combined discharge from Mud and Salt sloughs, it is possible to separate the discharge from the sloughs into its component sources, if such data is available. Component sources include surface and subsurface agricultural return flows from the DSA of the Grasslands watershed, wetland discharges, non-DSA surface agricultural return flows, groundwater accretions, and flood flows.

C-115468

C-115468

Methodology

SJRIO model runs in this analysis were run in Monte Carlo simulation mode, using discharge data for the major east side tributaries supplied by DWRSIM. TDS for these tributaries was calculated in SJRIO using site specific equations based upon linear regressions of historical log TDS versus log discharge. Discharge and water quality for Mud and Salt sloughs varied according to water year type (Table 2). DMC TDS varied according to water year type: 225 milligrams per liter (mg/l) for wet years, 255 mg/l for above normal, normal and below normal years, and 300 mg/l for dry and critically-dry water years. These values are based on DMC TDS data dating from 1977 to 1994 assembled by the California Regional Water Quality Control Board, Central Valley Region. Discharge and water quality for all other model components were estimated within the model based upon similar year hydrological data. Classification of water years was based on the hydrologic series supplied by the operations model input.

Only discharge and TDS were considered in this analysis. No boron or selenium concentrations were calculated. SJRIO calculates salinity by performing a mass balance of TDS; a coefficient of 0.6 is used to convert TDS in milligrams per liter(mg/l) to electrical conductivity in micro Siemens per centimeter (µS/cm) (i.e., TDS = EC*0.6).

Base case hydrology for the major east side tributaries was based upon DWRSIM operation Study 468a, a modification of DWRSIM study performed to evaluate SWRCB Alternative 3, Study 1. In this study, DWRSIM Study 469, New Melones Reservoir shares responsibility for meeting Vernalis pulse flow and salinity objectives promulgated in the May 1995 Water Quality Control Plan (SWRCB 1995) . Instead of imposing a 70 thousand acre-feet per year cap on water quality releases, DWRSIM Study 469 assumes additional water is provided to help meet salinity and pulse flow requirements from the SJR upstream of its confluence with the Stanislaus. DWRSIM Study 469 assumptions were modified as follows for DWRSIM Study 468a:

- No minimum flow and pulse flow requirements at Vernalis.
- Available capacity below Goodwin Dam set at 1,500 cubic feet per second.
- No additional water provided from the SJR system.

The output of this run — SJR at Vernalis flow — was compared to the required Vernalis flow targets to meet the May 1995 WQCP Delta Standards. The result of this comparison is a table of additional flows (addwater) from the SJR system required to meet Delta Standards. The April and May values in this table represent the additional flows required to meet May 1995 WQCP Delta Standards flow requirements. Approximately ninety percent of this addwater goes towards fulfilling the target fishery 30-day pulse flow requirements from April 16 to May 15. This study substitutes SJR recirculation (via the DMC) for this additional water for spring pulse flows. In this study, this additional water is supplied by SJR recirculation via the DMC and the Newman wasteway (capacity of about 3,300 cfs). The recirculated flows are recaptured for re-export concurrently, although water may be borrowed from San Luis Reservoir to prime the system at the beginning and returned at the end of the recirculation period.

The hydrology for DWRSIM control points 649, 665, and 675 are assumed to be approximately equivalent to the east side tributary boundary conditions used by SJRIO (Merced, Tuolumne, and Stanislaus rivers, respectively, upstream of their confluence with the main stem of the SJR). Control point 675 (Stanislaus River at mouth) includes DWRSIM Study 468a releases to meet Vernalis salinity objectives. Control point 691 is approximately equivalent to the SJR at Lander Avenue, just upstream of the inflows from Mud and Salt sloughs of the Grassland watershed and the DSA.

Once these initial monthly flows are assigned as SJRIO tributary inflow, additional preprocessing is necessary because these points are not spatially equivalent and the methodology used to calculate accretions and depletions downstream of these locations is different in DWRSIM and SJRIO. Differences in discharge were corrected using the following methodology.

SJRIO was initially run using DWRSIM control point discharge directly for east side tributary discharges. Differences in Vernalis discharge calculated by SJRIO and DWRSIM were then distributed in a prorated fashion between the Tuolumne River, Merced River, and SJR at Lander Avenue. For example, say the input flows for a given month are 25 TAF for SJR at Lander, 50 TAF for the Merced River and 75 TAF for the Tuolumne River. After the first pass of running SJRIO with these input flows, the SJRIO-computed Vernalis flow for the same month is 10 TAF greater than that computed by DWRSIM. The input flows are adjusted as follows. SJR at Lander would be decreased by the result of 10 * 25/(25 + 50+ 75), or 1.7 TAF. Similarly, the Merced River input flow would be reduced by 3.3 TAF, the Tuolumne River input flow, by 5 TAF. In the second pass at running SJRIO, the new input flows for that month would be 23.2 TAF for SJR at Lander, 46.7 TAF for the Merced River and 70 TAF for the Tuolumne River flow inputs would then be 23.2, 46.7, and 70 TAF, respectively. Only two passes were necessary until SJRIO-calculated Vernalis flows closely approximated those calculated by DWRSIM (e.g., within two percent on an annual basis).

Several runs were performed to simulate the changes in flow associated with the spring pulse (i.e., from April 16 through May 15). In these runs, called "split month analysis runs," one run was made to simulate base conditions, the other, pulse conditions. The resulting output — Vernalis flow and additional New Melones releases required to meet Vernalis salinity objectives — was combined as a composite output data set. Under base conditions, the only change was the Tuolume River spring pulse flow. Runs simulating DMC recirculation employed April and May values determined by DWRSIM Study 468a as additional water required to meet May 1995 WQCP Delta Standards. Because most of the addwater goes towards fulfilling the half-month fish pulse flow requirement, the actual input to the runs simulating DMC recirculation was doubled that determined by DWRSIM Study 468a. The resulting output was averaged with the base run that simulated base April and May flows to generate a composite output data set.

The allocation of Tuolumne River flows to base or pulse flow was based on a schedule of required minimum flows provided by Hamid Kharazi. In this schedule, four values of flow quantities are presented for each water year in the study period: (1) base April release (April 1-15), (2) pulse April release (April 16-30), (3) pulse May release (May 1-

15), and (4) base May release (May 16-15). The required base release for both April and May is always less than 10 TAF in all water years, while the required pulse release ranges from 10 TAF in critically dry years and 53.9 TAF in wet years. In all years, the amount of required release in any one month (i.e., sum of base and pulse volumes) is less than that indicated in the DWRSIM Study 468a flow table for Control Point 665. The volume remaining after fulfilling the base and pulse flow requirements was added to the base volume. Because these volumes refer to releases required for a half-month period, to use SJRIO, the input volumes were doubled in both instances, so that the composite output (base and pulse flow conditions) would reflect the total amount released during the month. As in full-month analysis runs, two passes were necessary to generate SJRIO-calculated Vernalis discharge that approximated DWRSIM-calculated values.

Base case discharge and TDS concentrations for Mud and Salt sloughs were varied according to water year type (Table 2). The monthly discharge and water quality for the sloughs are based on the historical discharge and water quality in the sloughs for two critically dry water years, 1989 and 1990, and a wet year, 1993. The two resultant data sets (critically dry and wet) were averaged to yield a third data set representing water years that are above normal, normal and below normal.

Discharge and TDS for the combined Mud and Salt sloughs were next disaggregated into DSA subsurface agricultural discharges (tile drainage), DSA surface agricultural discharges (tailwater), historical wetland discharges, and 'other', non-DSA and non-wetland discharges. An additional wetland discharge component was also added to reflect discharges resulting from the implementation of the Central Valley Project Improvement Act. DSA components were estimated using historical flow and quality information for combined DSA tile drainage and tailwater. The DSA tile drainage volume was estimated based on the assumption that most of the selenium in the sloughs is derived from tile drainage, combined with an estimate of mean selenium concentration of tile drainage. This DSA tile drainage was assigned a fixed TDS concentration of 4,750 mg/L based on a flow weighted average of tile drainage TDS concentrations from the DSA. The difference between total DSA combined tile drainage and tailwater discharges and estimated DSA tile drainage was assigned to DSA tailwater discharge. This DSA tailwater was assigned a monthly variable TDS concentration based on the difference between the total DSA load and tile drainage DSA load.

Discharge for the historical wetland component was estimated based upon a simple model that assumed a thirty percent return flow of water that was historically applied to wetlands. Water quality was based upon limited historical information for the southern subarea of Grassland Water District (GWD). Since the TDS concentration of wetland discharges from the southern GWD is likely higher than the TDS concentration of wetland discharges from northern GWD and the state and federal refuges, the total salt load associated with wetlands used in this analysis is likely higher than the actual wetland component. It is used here to represent the moderate to worst case conditions associated with dry periods. The 'other' component of the sloughs represents flows and loads attributed to non-DSA tailwater, groundwater, flood flows, minor tributary

flows, as well as errors in methods used to account for flows and loads. The sum of the DSA tile drainage, DSA tailwater, historical wetland, and other components, is equal to the average discharge and salt load of the historical combined Mud and Salt sloughs for water years 1989, 1990, and 1993. A final component was added to this composite to account for new CVPIA wetland water supplies that were not fully represented in water years 1989, 1990, and 1993. A factor of thirty-five percent return flow of CVPIA supply water was used to estimate this additional wetland discharge volume. The TDS of discharges attributed to these additional supplies is set at roughly half that of the historical wetland release to account for reduced evapoconcentration and salt mobilization that would be likely with these additional supplies.

Tile drainage reoperation is simulated in both full-month and split-month analysis runs. In full-month runs, drainage is withheld in March and April by a set percentage (e.g., 100% or 50%). The quantity of withheld drainage is released in May along with what would normally be released in that month. As such, the sum of drainage discharged over the course of March, April and May in the reoperation runs would equal that discharged under base conditions. In split month runs, one run simulated the withholding flows, the other, the saline pulse flows. In both runs, drainage is withheld during the month of March. The withholding run continued withholding drainage during the entire month of April, then, in May, the drainage released was the same as that under base conditions. In the drainage pulse runs, the drainage released in April and May was comprised of that which would have been released under base conditions, plus the pulse flow consisting of 6-weeks-worth of drainage withheld (i.e., March 1 to April 15) distributed over a 30-day period. Because the pulse flow event spans from mid-April to mid-May, the amount of drainage distributed in pulse runs is doubled. The end result is a composite run output set consisting of the average values generated by the withholding and the pulse runs. The average of drainage discharged in March, April and May in these two runs equals the combined amount of drainage discharged in these three months under base conditions.

Other SJRIO model components vary according to water year types that are based on the hydrology of the major tributaries. It was not possible to calibrate SJRIO water quality results with DWRSIM.

Model Run Descriptions

Table 3 lists the SJRIO model runs made to assess the water quality impact of DMC recirculation and reoperation of wetland discharge and tile drainage. The terms "base run" and "base conditions" refer to scenarios without DMC recirculation or reoperation. Several SJRIO runs made to evaluate DMC recirculation and drainage reoperation assume that the April 16-May 15 pulse occurs entirely in May. Accordingly, April and May values in DWRSIM 468a addwater required to meet 1995 May WQCP Delta Standards were combined and treated as May addwater. Run 1 has DMC recirculation occurring entirely in May and no reoperation. Runs 2 through 4 add tile drainage and/or wetland discharge reoperation such that 100% of such discharge is withheld during March and April for release in May.

Run 5 is a sensitivity analysis to assess whether Vernalis salinity conditions are improved by substituting DMC recirculation for all DWRSIM 468a addwater to meet Delta Standards. Runs 6 though 10 are preliminary sensitivity analyzes that assess various addwater and reoperation scenarios. Runs 13 through 15 were a variant of Runs 2 through 4 that employed a 50% reduction factor in tile drainage and/or wetland discharge. Runs 16 through 18 were, in turn, a variant of Runs 13 and 15, in which reoperation was in effect only when DMC recirculation occurred in both April and May.

Composite Runs 11 and 12, which are the focus of this study, represent an attempt to apply the monthly time step feature of SJRIO to simulate changing flow conditions from April 1 to May 31 (i.e., April's base/pulse and May's pulse/base). The reoperation runs attempt to simulate the withholding of tile drainage for a six-week period from March 1 through April 14 for discharge during the pulse flow. Reoperation of tile drainage only occurs in years with both April and May addwater requirements as stipulated by DWRSIM 468a addwater to meet Delta Standards.

Run 11a simulates base conditions and April and May base Tuolumne River flows. Run 11b also simulates base conditions, but with April and May Tuolumne River pulse flows. Run 11c adds April and May DMC recirculation to conditions simulated by Run 11b. Runs 12a and 12b simulate tile drainage reoperation in this fifty percent of tile drainage is withheld from March 1 to April 15, then discharged from April 16 to May 15. Run 12a, the withholding run, utilizes base Tuolumne River flow conditions. Run 12b, the saline discharge pulse run, utilizes pulse Tuolumne River flow conditions and DMC recirculation. Table 4 presents on a 'per water year type' basis, average monthly tile drainage input under base conditions, and for Runs 12a and 12b. Also depicted are the differences in Runs 12a and 12b input compared to base conditions. Note that the amount of drainage withheld in Run 12a (as indicated by the difference from base conditions) equals the amount released as a pulse in Run 12b, and the average combined discharge of Runs 12a and 12b for March, April and May equals the combined discharged during these months under base conditions.

Table 5 presents the average input on a 'water year type basis' of the combined flow of the four major SJR tributaries (i.e., Stanislaus River, Tuolumne River, Merced River and the SJR at Lander Avenue), for the months of April and May, as well as the sum of April and May flows. Also presented in a similar manner is DMC recirculation flows for April and May (and again, the sum of April and May flows), as per the table of additional water required to meet May 1995 WQCP Delta Standards computed by DWRSIM Study 468a. The largest amount of average addwater required in both April and May is 105 TAF. This average decreases to 88 TAF and 79 TAF in dry and above normal years, respectively. In critically dry years, this average decreases to 19 TAF. Table 5 also presents the average percent contribution that DMC recirculation would have if it were utilized as the addwater source and treated as a major SJR tributary. In wet years, DMC recirculation would account for three percent of the April-May flow. In above normal years, this contribution increases to 14% percent. The largest contribution occurs in normal and dry water years, when DMC recirculation accounts for 27% and 30% for the major tributary inflow, respectively. In critically dry years, DMC recirculation would account for ten percent of the major SJR tributary inflow.

Model Run Results

Table 6 presents the results generated by SJRIO of the split month analysis runs. Values generated by runs employing base conditions (i.e., Runs 11a and 11b) are presented along with values expressing the difference from base conditions when DMC recirculation is added (Run 11c), and when DMC recirculation is added along with tile drainage reoperation (Runs 12a and 12b). Positive values indicate that the result generated by the alternate condition is greater than base conditions. The results depicted consist of (1) average monthly Vernalis flow (i.e., SJR flow near Vernalis), (2) average monthly Crows Landing flow (i.e., SJR flow at Crows Landing Bridge), (3) average Vernalis EC, (4) average Crows Landing EC, (5) percentage of months over the 73-year study period in which SJRIO-computed Vernalis EC exceeds compliance targets (i.e., 1,000 μS/cm from September 1 to March 30, and 700 μS/cm from April 1 to August 31), and (6) average amount of New Melones releases required to meet Vernalis salinity objectives (this calculation assumes a constant EC of 80 μS/cm for Stanislaus River water quality). The results are presented in five columns: (1) March, (2) April 1 to 15, (3) April 16 to 30, (4) May 1 to 15, and (5) May 16 to 31. Note that values of flow are presented as TAF/mo. No attempt is made to present flow in terms of actual volumes in Table 6.

In Table 6, DMC recirculation increases the flow at Vernalis and Crows Landing by an average of 44 TAF/mo during the first half of the spring pulse, and 77 TAF/mo during the second half. As such, the average increase in the volume of SJR flow over the course of the 30-day pulse flow event is (44/2 + 77/2) or 60.6 TAF. Tile drainage reoperation decreases SJR flow by 1 TAF/mo in March and 1 TAF/mo during the first half of April. The discharge of withheld drainage increases Vernalis flow by 1 TAF/mo during the 30-day pulse period.

During the 30-day pulse event, DMC recirculation results in a slight improvement of water quality at Vernalis, and a substantial improvement at Crows Landing. With DMC recirculation, Vernalis EC is decreased by 15 μS/cm or less, and Crows Landing EC is decreased by over 475 μS/cm. Tile drainage reoperation runs improve water quality during the period drainage is withheld: Vernalis EC decreases by over 50 μS/cm and Crows Landing EC, by over 100 μS/cm. When the withheld drainage is released during the pulse, however, average Vernalis EC does increase slightly (less than 15 μS/cm). At Crows Landing, however, coupling the DMC recirculation with the pulse of withheld tile drainage still results in a net average EC decrease ranging from 335 to 429 μS/cm.

DMC recirculation results in a small decrease in the frequency with which the Vernalis salinity objective is exceeded. The addition of tile drainage reoperation improves compliance during the period when drainage is withheld (19% compared to 29% under base conditions in March). And, during the drainage pulse coinciding with DMC recirculation, the frequency with which the Vernalis salinity objective is exceeded is more-or-less unchanged from base conditions. As such, net benefit over the three-month period is a significant improvement in water quality compliance. Similarly, DMC recirculation decreases the amount of additional releases required from New Melones to meet Vernalis salinity objectives by 2 TAF over the course of the 30-day pulse period

(i.e., the combined savings of 3.4 TAF/mo from April 15 to 30 and 0.6 TAF/mo from May 1 to 15). The savings increases slightly to 2.2 TAF when tile drainage reoperation is added to DMC recirculation. This is the net savings due to tile drainage reoperation, resulting from subtracting additional releases required (1.1 TAF/mo from April 15 to 30 and 0.9 TAF/mo from May 1 to 15) from the combined savings from the withholding period (2.4 TAF/mo in March, 3.1 TAF/mo from April 1 to 15, and 0.5 TAF/mo from May 16 to 31). The savings in the later part of May due to tile drainage reoperation is as yet unaccounted for, and may reflect some delayed response by SJRIO.

Table 8 summarizes the SJRIO results of runs made for both tile drainage and wetland discharge reoperation scenarios. The results consist of average, maximum, and total amount of additional New Melones releases required to meet Vernalis salinity objectives, and the percentage of months in which the Vernalis salinity objective is exceeded. The average annual and total amount of New Melones releases required under base conditions is 49 TAF and 3,584 TAF, respectively. Note that the SJRIO Stanislaus River input from DWRSIM included releases made to meet Vernalis salinity objectives. As such, the addwater calculated by SJRIO for meeting Vernalis salinity standards is above that determined by DWRSIM Study 468a.

Run 1 shows improved salinity conditions resulting from DMC recirculation and a modest water savings (i.e., 1 TAF annually and 95 TAF total less New Melones releases are required to meet Vernalis salinity objectives. Significant water quality improvements are shown in March and April from runs that employ 100% tile drainage and/or wetland discharge reoperation (Runs 2 through 4). However, the resulting pulse of saline discharge in May worsened water quality conditions and required substantially more New Melones releases overall. Modest water savings and improved March and April salinity conditions resulted from runs that employed 50% tile drainage and/or wetland discharge reoperation in all years (Runs 13 through 15). The greatest water savings, and improved March and April salinity conditions, resulted from reoperating tile drainage and/or wetland discharges only in years with DMC recirculation (Runs 16 through 18). Tile drainage reoperation (Run 16) resulted in an annual and total savings of 6 TAF and 373 TAF, respectively. Wetland discharge reoperation (Run 17) resulted in similar annual savings (6 TAF) and a total savings of 365 TAF. Finally, tile drainage and wetland reoperation (Run 18) resulted in an average annual and total savings of 2 TAF and 32 TAF, respectively. While all three reoperation runs resulted in improved salinity conditions in March and April, the pulse of withheld drainage in May coinciding with DMC recirculation resulted in a net negative impact on Vernalis water quality.

Two tables are presented to complete the documentation of this SJR recirculation modeling study. Table 8 is the monthly Vernalis EC under for base conditions. Table 9 is the monthly additional New Melones releases required to meet Vernalis salinity objectives under the following scenarios: base conditions (Table 9A), base conditions simulated by split month analysis (Table 9B), base conditions with DMC recirculation (Table 9C), and tile drainage reoperation coupled with DMC recirculation (Table 9D).

Summary and Conclusions

When interpreting these model results, it is important to consider the assumptions that are built into the analysis. Following are some of the more important assumptions:

- Base case hydrology is derived from DWRSIM operation study 468a. SJRIO inputs were calibrated to match this hydrology, but the component flows from various sources are not necessarily identical to component flows in DWRSIM.

- Individual components of the flow and water quality for Mud and Salt sloughs were estimated based on historical data for three years: 1989, 1990, and 1993. This data, even though modified to account for drawdown of expected CVPIA wetland deliveries, may not be representative of actual current or future conditions. The wetland component of Mud Slough and Salt Slough flows and loads was based on very limited historical data and the simple assumption that wetland return flows equal roughly thirty percent of applied water.

- Results of this analysis are limited by the fact that all calculations are made on a monthly time step. Most likely, increased water savings would be possible if calculations were made for a daily or weekly time step.

- The usual disclaimer applies to the use and abuse of model results. These model results are best used to evaluate the relative impact that changes from the base would have on SJR water quality. The results should not be used to directly estimate the water quality that would result in the SJR with the implementation of the various scenarios. This is the reason, for example, that SJRIO water quality model results cannot be compared directly with the results obtained using DWRSIM. Results from each model are based on different sets of assumptions. This makes direct comparison of results from the two models difficult and of dubious value. Each set of model results should be evaluated based on the strengths of the individual model and comparisons should be made only between individual runs using the same model.

In conclusion, the addwater required to meet May 1995 WQCP Delta Standards that could be supplied by DMC recirculation ranges from 3 TAF in wet water years to over 100 TAF in normal water years. If DMC recirculation can be employed for all or some of this addwater, then what flows that would have been supplied by east side tributaries for this purpose can be saved for other uses. This modeling study demonstrated that DMC recirculation during the spring pulse flow period results in slightly improved water quality conditions at Vernalis, and consequently less releases required from New Melones for meeting Vernalis salinity objectives (an average of 2 TAF less annually). At Crows Landing, DMC recirculation results in substantial improvement in water quality (e.g., average EC decrease from 1,249 μS/cm to 773 μS/cm from May 1 to 15). Greater improvements in water quality conditions (and greater water savings) result from combining DMC recirculation with tile drainage reoperation. In this scenario, the net average savings in New Melones releases is 2.2 TAF./yr

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Table 1 SJRIO Model Components	
Model Component	**Number of Inputs**
East-side Tributaries (Stanislaus, Tuolumne, Merced, SJR at Lander Avenue)	4
West-side Tributaries (Orestimba, Del Puerto, Hospital/Ingram Creeks)	3
Grassland Watershed (Mud Slough North and Salt Slough)	Subdivided into components shown in Table 2
Appropriative and Riparian SJR Pumping	41
Surface Return Flows (Tail Water)	35
Surface Return Flows (Tail Water)	35
Subsurface Return Flows (Tile Drainage)	9
Groundwater	every mile
Municipal and Industrial	2
Evaporation and Precipitation	every 5 miles
Evapotranspiration	every 5 miles

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Table 2
Grassland Watershed Input Data Components Per Water Year Type

Water Year Type:		Wet		Above and Below Normal		Dry and Critical	
Component	Month	Flow acre-feet	TDS mg/L	Flow acre-feet	TDS mg/L	Flow acre-feet	TDS mg/L
DSA Subsurface Agricultural Discharges (Tile Drainage)	10	536	4,750	637	4,750	738	4,750
	11	653	4,750	704	4,750	755	4,750
	12	996	4,750	966	4,750	936	4,750
	1	1,605	4,750	1,523	4,750	1,441	4,750
	2	2,427	4,750	2,214	4,750	2,001	4,750
	3	3,069	4,750	2,739	4,750	2,410	4,750
	4	2,782	4,750	2,388	4,750	1,994	4,750
	5	2,460	4,750	2,163	4,750	1,867	4,750
	6	2,283	4,750	2,017	4,750	1,752	4,750
	7	2,361	4,750	2,056	4,750	1,751	4,750
	8	2,059	4,750	1,786	4,750	1,513	4,750
	9	1,219	4,750	1,039	4,750	858	4,750
DSA Surface Agricultural Discharges (Tail Water)	10	1,042	1,495	1,114	1,390	1,186	1,298
	11	1,365	1,215	1,412	1,185	1,458	1,156
	12	1,012	1,515	1,070	1,489	1,128	1,466
	1	1,487	519	1,448	863	1,410	1,226
	2	2,664	1,760	2,717	1,746	2,770	1,732
	3	3,243	1,425	2,878	1,641	2,512	1,919
	4	2,535	1,203	2,428	1,401	2,322	1,617
	5	3,010	1,294	2,899	1,492	2,788	1,705
	6	4,103	1,388	3,815	1,453	3,526	1,529
	7	4,671	1,467	4,456	1,434	4,241	1,399
	8	4,820	1,191	4,287	1,208	3,754	1,230
	9	2,285	1,208	2,057	1,276	1,829	1,360

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Table 2
Grassland Watershed Input Data Components Per Water Year Type

Water Year Type:		Wet		Above and Below Normal		Dry and Critical	
Component	Month	Flow acre-feet	TDS mg/L	Flow acre-feet	TDS mg/L	Flow acre-feet	TDS mg/L
Other Non-DSA and Non-Wetland Discharges (Groundwater, Tail Water and Flood Flows)	10	6,666	450	8,162	460	9,657	466
	11	5,498	757	8,077	809	10,656	836
	12	8,954	960	8,168	964	7,383	970
	1	15,049	1,060	10,832	1,156	6,615	1,374
	2	19,307	1,079	14,443	1,077	9,578	1,074
	3	24,348	815	19,615	894	14,882	1,021
	4	15,894	858	12,267	852	8,640	840
	5	12,836	372	11,053	498	9,269	673
	6	11,311	414	10,083	509	8,855	629
	7	14,398	463	11,891	475	9,385	494
	8	16,605	483	13,616	508	10,627	546
	9	11,292	520	9,080	485	6,867	428
Estimated Historical Wetland Discharges	10	1,000	1,900	1,000	1,900	1,000	1,900
	11	2,000	1,900	1,500	1,900	1,000	1,900
	12	2,000	1,900	2,000	1,900	2,000	1,900
	1	3,000	1,900	2,500	1,900	2,000	1,900
	2	4,000	1,900	3,000	1,900	2,000	1,900
	3	7,000	1,900	6,000	1,900	5,000	1,900
	4	6,000	1,900	5,000	1,900	4,000	1,900
	5	4,000	1,900	2,000	1,900	0	1,900
	6	0	1,900	0	0	0	1,900
	7	0	1,900	0	0	0	1,900
	8	0	1,900	0	0	0	1,900
	9	0	1,900	500	1,900	1,000	1,900
Estimated Additional (CVPIA) Wetland Discharges	10	1,000	960	750	960	500	960
	11	2,000	960	1,500	960	1,000	960
	12	5,000	960	3,750	960	2,500	960
	1	5,000	960	3,750	960	2,500	960
	2	7,000	960	5,250	960	3,500	960
	3	10,000	960	7,500	960	5,000	960
	4	10,000	960	7,500	960	5,000	960
	5	7,000	960	5,250	960	3,500	960
	6	4,000	960	3,000	960	2,000	960
	7	2,000	960	1,500	960	1,000	960
	8	1,000	960	750	960	500	960
	9	1,000	960	750	960	500	960

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Table 3 SJRIO Run Descriptions	
Run	**Description**
Base	SJRIO run equivalent to 73-year DWRSIM 468a study but with different water quality results; employs all DWRSIM 468a study New Melones releases to meet Vernalis salinity objective.
1	Base run with April and May DWRSIM 468a additional water to meet May 1995 WQCP Delta Standards combined as May DMC recirculation and added to Grassland watershed input data.
2	Run 1 with 100% March and April tile drainage withheld and released in May.
3	Run 1 with 100% March and April wetland discharge withheld and released in May.
4	Run 1 with 100% March and April tile drainage and wetland discharge withheld and released in May.
5	Base run with all DWRSIM 468a additional water to meet May 1995 WQCP Delta Standards as DMC recirculation.
6 - 10	Preliminary SJRIO runs exploring the use of DMC recirculation for DWRSIM 468a additional water to meet May 1995 WQCP Delta Standards when Vernalis salinity objective is met. Runs also explore various tile drainage and wetland discharge reoperation scenarios.
11a	Base run with April and May base Tuolumne flows.
11b	Base run with April and May pulse Tuolumne flows.
11c	Run 11b with DMC recirculation employed as April and May DWRSIM 468a addwater to meet May 1995 WQCP Delta Standards.
12a	Run 11a with 50% tile drainage withheld in March and April; occurs only in years of both April and May DMC recirculation.
12b	Run 11c with 50% tile drainage withheld in March and withheld tile drainage (50% March and 25% April) divided equally between April and May tile drainage; occurs only in years of both April and May DMC recirculation.
13	Run 1 with 50% tile drainage withheld in March and April and released in May in all years.
14	Run 1 with 50% wetland discharge withheld in March and April and released in May in all years.
15	Run 1 with 50% tile drainage and wetland discharge withheld in March and April and released in May in all years
16	Run 1 with 50% tile drainage withheld in March and April and released in May only in years of DMC recirculation.
17	Run 1 with 50% wetland discharge withheld in March and April and released in May only in years of DMC recirculation.
18	Run 1 with 50% tile drainage and wetland discharge withheld in March and April and released in May only in years of DMC recirculation.

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Table 4

Tile Drainage Input Data for Split Month Analysis Runs

Two runs simulate the two tile drainage reoperation periods: the six week withholding period (March 1 to April 15) during which 50% of the tile drainage flow is withheld, and the 30-day pulse period (April 16 to May 15) during which the withheld drainage is released and diluted by DMC recirculation. The differences between the base input run for these two runs are shown below. *Positive values mean more tile drainage flow than base. Note that the same quanitity withheld is released during the pulse.*

	Water year type	Wet		Above and Below Normal		Dry and Critical	
Tile drainage flow conditions	Month and three-month sum	Monthly Flow (af)	Difference from base	Monthly Flow (af)	Difference from base	Monthly Flow (af)	Difference from base
Base tile drainage input	March	3,069		2,739		2,410	
	April	2,782		2,388		1,994	
	May	2,460		2,163		1,867	
	SUM	8,311		7,291		6,270	
Input for tile drainage reoperation during the withholding period	March	1,535	-1,535	1,370	-1,370	1,205	-1,205
	April	1,391	-1,391	1,194	-1,194	997	-997
	May	2,460	0	2,163	0	1,867	0
	SUM	5,386	-2,926	4,727	-2,564	4,068	-2,202
Input for tile drainage reoperation during the pulse period	March	1,535	-1,535	1,370	-1,370	1,205	-1,205
	April	5,012	2,230	4,354	1,967	3,697	1,703
	May	4,690	2,230	4,130	1,967	3,570	1,703
	SUM	11,237	2,926	9,854	2,564	8,472	2,202

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Table 5
Average DMC Recirculation Contribution Per Water Year Type

	Water Year Type	April	May	Total
Average major SJR tributary input (TAF) Sum of four east side tributaries: SJR at Lander Avenue, Merced River, Tuolumne River and Stanislaus River	Wet	624	636	1,260
	Above Normal	283	205	488
	Normal	162	116	278
	Dry	114	88	202
	Critically Dry	92	79	171
Average DMC recirculation input (TAF)	Wet	14	22	37
	Above Normal	17	62	79
	Normal	39	66	105
	Dry	42	46	88
	Critically Dry	8	11	19
DMC contribution to major SJR tributary inflow Calculated by: $\left\lvert \frac{DMC}{(4\text{-trib} + DMC)} \right\rvert * 100$	Wet	2%	3%	3%
	Above Normal	6%	23%	14%
	Normal	19%	36%	27%
	Dry	27%	34%	30%
	Critically Dry	8%	12%	10%

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Table 6

SJRIO Results of Split Month Analysis Runs

These results show (1) base case output, (2) the effect of adding DMC recirculation during the spring pulse (4/15 to 5/15), and (3) the effect of adding both DMC recirculation and tile drainage reoperation. Positive values mean more than base.		Period of tile drainage reoperation and DMC recirculation				
		March	April 1 to April 15	April 16 to April 30	May 1 to May 15	May 16 to May 31
Average Vernalis Flow (TAF/mo)	Base tributary input results	377	339	311	300	293
	Add DMC recir (difference from base)	0	0	44	77	0
	Add DMC recirculation and tile drainage reop (difference from base)	-1	-1	45	78	0
Average Crows Landing Flow (TAF/mo)	Base tributary input results	175	122	122	155	155
	Add DMC recir (difference from base)	0	0	44	77	0
	Add DMC recirculation and tile drainage reop (difference from base)	0	-1	45	78	0
Average Vernalis EC (uS/cm)	Base tributary input results	738	561	538	504	564
	Add DMC recir (difference from base)	0	0	-15	-8	0
	Add DMC recirculation and tile drainage reop (difference from base)	-55	-32	5	13	29
Average Crows Landing EC (uS/cm)	Base tributary input results	1,234	1,465	1,465	1,249	1,249
	Add DMC recir (difference from base)	0	0	-375	-476	0
	Add DMC recirculation and tile drainage reop (difference from base)	-119	-116	-335	-429	-33
Months Vernalis EC exceeded	Base tributary input results	29%	33%	23%	11%	22%
	Add DMC recir	29%	33%	22%	8%	22%
	Add DMC recirculation and tile drainage reop	19%	21%	23%	12%	22%
Average New Melones addwater (TAF/mo)	Base tributary input results	5.6	8.2	5.3	2.0	4.9
	Add DMC recir (difference from base)	0.0	0.0	-3.4	-0.6	0.0
	Add DMC recirculation and tile drainage reop (difference from base)	-2.4	-3.1	1.1	0.9	-0.5

The average annual savings of New Melones releases required to meet Vernalis salinity objectives are 2 TAF with DMC recirculation and 2.2 TAF with DMC recirculation and tile drainage reoperation.

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Table 7

Tile Drainage and Wetland Discharge Reoperation Results Summary

Base Run	March	April	May	Sum
Average	6	6	3	15
Maximum	46	75	44	165
Sum	412	461	224	1,096
% Exceed	29%	25%	16%	

This table indicates the average, maximum and total amount of New Melones water required to meet Vernalis salinity objectives (in TAF) and the percentage of months in which the Vernalis EC objective is exceeded in 73-year Study Period. Results given for March, April, May, and three-month sum.

These two runs add DMC recirculation to the Base Run

Run 1	April & May addwater in May			
	March	April	May	Sum
Average	6	6	2	14
Maximum	46	75	38	159
Sum	412	461	128	1,001
% Exceed	29%	25%	10%	

Run 5	All addwater as DMC recirculation			
	March	April	May	Sum
Average	6	6	3	15
Maximum	46	75	44	165
Sum	412	461	224	1,096
% Exceed	29%	25%	16%	

Run 1 combines April and May addwater for release as DMC recirculation in May. Run 5 employs DMC recirculation as addwater in all months indicated by DWRSIM 468a. Despite the addition of DMC recirculation in Run 5, the results are no different from the base run.

These three runs add tile drainage reoperation to Run 1

Run 2	100% withheld in all years			
	March	April	May	Sum
Average	2	2	14	4
Maximum	24	51	82	74
Sum	141	146	1,016	287
% Exceed	15%	14%	44%	

Run 13	50% withheld in all years			
	March	April	May	Sum
Average	3	4	5	7
Maximum	34	63	59	97
Sum	254	281	399	536
% Exceed	18%	22%	25%	

Run 16	50% withheld in DMC recirc years			
	March	April	May	Sum
Average	3	4	5	12
Maximum	32	63	59	153
Sum	233	276	361	870
% Exceed	19%	22%	23%	

These runs add wetland discharge reoperation to Run 1

Run 3	100% withheld in all years			
	March	April	May	Sum
Average	2	2	15	4
Maximum	27	49	82	76
Sum	168	118	1,120	286
% Exceed	15%	11%	44%	

Run 14	50% withheld in all years			
	March	April	May	Sum
Average	4	4	6	7
Maximum	35	62	59	97
Sum	270	258	420	528
% Exceed	18%	21%	26%	

Run 17	50% withheld in DMC recirc years			
	March	April	May	Sum
Average	3	3	5	12
Maximum	34	62	59	154
Sum	248	252	378	877
% Exceed	19%	21%	25%	

These runs add tile drainage and wetland discharge reoperation to Run 1

Run 4	100% withheld in all years			
	March	April	May	Sum
Average	0	1	48	1
Maximum	11	26	140	37
Sum	22	37	3,504	59
% Exceed	5%	4%	66%	

Run 15	50% withheld in all years			
	March	April	May	Sum
Average	2	2	15	4
Maximum	25	50	82	75
Sum	155	133	1,078	288
% Exceed	15%	14%	44%	

Run 18	50% withheld in DMC recirc years			
	March	April	May	Sum
Average	2	2	13	17
Maximum	25	50	82	157
Sum	140	130	940	1,210
% Exceed	15%	12%	41%	

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Table 8
Vernalis Electrical Conductivity (uS/cm)
Base Case Results

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVE
1922	551	564	500	713	479	627	436	519	308	639	867	612	568
1923	335	586	376	435	562	910	390	697	801	671	684	645	591
1924	293	795	765	785	950	1,044	781	632	814	597	597	595	721
1925	787	720	977	1,433	831	1,035	457	530	992	884	629	702	831
1926	447	710	807	854	530	1,269	484	542	791	950	691	563	720
1927	446	608	583	991	408	735	477	379	607	713	580	333	572
1928	206	585	483	617	727	773	471	546	580	659	555	629	569
1929	690	718	854	846	984	963	753	541	556	619	413	574	709
1930	502	853	902	986	871	1,004	686	904	616	825	546	682	781
1931	449	832	890	1,089	1,151	1,232	1,060	490	1,108	399	803	570	839
1932	466	822	417	472	317	572	416	521	828	928	444	516	560
1933	284	723	814	692	711	1,042	893	612	915	858	707	625	739
1934	522	808	828	848	687	1,038	824	713	1,089	523	772	575	769
1935	674	534	899	541	652	841	346	318	442	655	649	455	584
1936	324	717	601	709	236	476	336	401	627	815	610	467	527
1937	271	478	757	713	259	348	387	398	534	836	650	540	514
1938	357	618	350	340	189	190	248	188	188	534	710	450	363
1939	202	359	399	473	506	853	516	637	653	574	733	575	540
1940	631	739	792	524	302	257	474	451	776	558	877	508	574
1941	403	500	354	481	253	323	274	348	378	581	521	555	414
1942	204	419	307	290	321	424	392	348	345	673	878	532	428
1943	183	321	375	289	314	238	370	362	422	563	832	683	413
1944	240	396	543	781	552	901	547	620	797	772	605	778	628
1945	432	620	687	869	309	404	402	418	515	899	800	468	568
1946	256	385	249	317	356	663	547	569	720	701	921	456	511
1947	583	443	449	571	703	1,074	562	916	733	633	534	517	643
1948	548	740	1,138	1,044	1,465	1,375	631	609	823	705	727	703	876
1949	651	647	976	1,092	1,043	1,012	726	598	916	547	437	770	785
1950	540	713	905	932	758	1,179	652	711	629	636	940	717	776
1951	605	198	193	222	250	425	461	603	705	906	718	563	487
1952	454	451	629	320	355	268	333	268	198	602	746	491	426
1953	230	345	407	339	378	812	709	665	737	575	688	543	536
1954	588	590	794	987	983	1,184	487	759	650	436	497	519	706
1955	454	794	851	772	1,045	1,129	513	759	688	712	771	592	757
1956	433	550	207	169	279	438	471	495	336	501	742	606	436
1957	185	498	658	598	669	707	623	567	957	553	406	620	587
1958	483	549	859	1,057	605	339	224	253	258	614	621	535	533
1959	245	417	497	498	383	562	670	585	715	556	612	699	537
1960	547	888	927	909	868	916	654	658	564	791	624	594	745

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Table 8
Vernalis Electrical Conductivity (uS/cm)
Base Case Results

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVE
1961	651	744	839	850	1,261	1,273	816	574	632	363	679	507	766
1962	485	993	933	1,442	431	552	522	648	897	788	484	641	735
1963	601	551	843	932	344	902	317	516	682	858	480	625	638
1964	299	481	605	572	831	824	901	543	684	535	708	580	630
1965	714	478	304	219	362	599	384	405	504	893	671	580	509
1966	242	289	261	338	477	678	851	809	966	647	586	636	565
1967	454	505	563	708	628	411	275	279	188	310	625	373	443
1968	201	362	314	417	430	654	875	589	829	753	719	627	564
1969	567	573	815	201	186	279	246	188	202	611	609	453	411
1970	162	357	334	209	326	367	455	440	542	672	684	638	432
1971	401	654	492	609	543	612	687	561	828	805	550	675	618
1972	488	760	734	716	935	967	828	546	986	633	626	631	737
1973	664	683	840	554	332	309	404	370	747	609	585	565	555
1974	284	336	461	306	408	430	417	455	587	769	791	541	482
1975	233	433	498	660	395	388	394	362	255	750	697	587	471
1976	228	577	610	727	811	1,330	788	578	937	715	464	677	703
1977	402	519	632	909	985	1,279	601	838	766	899	713	767	776
1978	628	694	846	701	461	402	298	350	357	719	764	479	558
1979	250	504	808	478	247	324	421	459	1,148	888	789	588	575
1980	322	611	899	214	194	309	505	399	332	371	575	390	427
1981	193	373	505	443	549	715	745	744	651	640	624	584	564
1982	468	610	732	248	193	251	195	242	243	550	744	360	403
1983	185	233	203	192	173	172	250	210	135	184	782	280	250
1984	206	198	160	204	273	358	550	629	715	627	740	568	436
1985	323	375	542	662	495	928	808	748	763	486	571	721	618
1986	462	599	665	959	204	204	360	336	322	831	809	556	526
1987	262	387	498	735	770	916	786	528	908	821	549	551	642
1988	691	752	791	956	1,092	1,429	773	727	1,004	568	573	722	840
1989	586	843	900	973	1,329	1,012	599	524	956	913	612	689	828
1990	652	750	872	876	1,159	1,226	537	501	531	518	484	577	724
1991	652	788	790	948	981	1,041	532	850	887	700	405	540	759
1992	795	899	871	1,082	799	930	753	632	656	712	499	528	763
1993	487	572	829	427	739	902	674	505	508	791	656	593	640
1994	269	591	735	828	900	1,338	687	588	1,141	720	772	611	765
Average	427	579	640	656	596	738	547	531	655	669	654	575	
Max	795	993	1,138	1,442	1,465	1,429	1,060	916	1,148	950	940	778	

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Table 9A
Additional New Melones Releases (TAF) Required to Meet Vernalis Salinity Objectives
Base Case Results

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	0	0	0	0	0	0	0	0	0	0	33	0	33
1923	0	0	0	0	0	0	0	0	23	0	0	0	23
1924	0	0	0	0	0	5	15	0	20	0	0	0	40
1925	0	0	0	33	0	6	0	0	60	33	0	0	132
1926	0	0	0	0	0	34	0	0	16	41	0	0	91
1927	0	0	0	0	0	0	0	0	0	3	0	0	3
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	11	0	0	0	0	0	11
1930	0	0	0	0	0	1	0	40	0	20	0	0	60
1931	0	0	0	7	13	23	75	0	80	0	18	0	215
1932	0	0	0	0	0	0	0	0	30	44	0	0	74
1933	0	0	0	0	0	6	46	0	38	32	1	0	123
1934	0	0	0	0	0	4	24	2	70	0	11	0	112
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	23	0	0	23
1937	0	0	0	0	0	0	0	0	0	30	0	0	30
1938	0	0	0	0	0	0	0	0	0	0	2	0	2
1939	0	0	0	0	0	0	0	0	0	0	7	0	7
1940	0	0	0	0	0	0	0	0	17	0	37	0	54
1941	0	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	38	0	38
1943	0	0	0	0	0	0	0	0	0	0	29	0	29
1944	0	0	0	0	0	0	0	0	19	15	0	0	34
1945	0	0	0	0	0	0	0	0	0	41	20	0	60
1946	0	0	0	0	0	0	0	0	4	0	45	0	49
1947	0	0	0	0	0	10	0	44	6	0	0	0	61
1948	0	0	12	4	38	46	0	0	26	1	5	0	132
1949	0	0	0	7	4	2	8	0	38	0	0	0	60
1950	0	0	0	0	0	29	0	3	0	0	50	0	81
1951	0	0	0	0	0	0	0	0	1	39	3	0	43
1952	0	0	0	0	0	0	0	0	0	0	9	0	9
1953	0	0	0	0	0	0	3	0	7	0	0	0	10
1954	0	0	0	0	0	31	0	16	0	0	0	0	47
1955	0	0	0	0	5	16	0	13	0	2	13	0	48
1956	0	0	0	0	0	0	0	0	0	0	9	0	9
1957	0	0	0	0	0	0	0	0	53	0	0	0	53
1958	0	0	0	7	0	0	0	0	0	0	0	0	7
1959	0	0	0	0	0	0	0	0	3	0	0	0	3
1960	0	0	0	0	0	0	0	0	0	18	0	0	18

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Table 9A
Additional New Melones Releases (TAF) Required to Meet Vernalis Salinity Objectives
Base Case Results

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1961	0	0	0	0	21	26	22	0	0	0	0	0	69
1962	0	0	0	36	0	0	0	0	38	15	0	0	89
1963	0	0	0	0	0	0	0	0	0	34	0	0	34
1964	0	0	0	0	0	0	46	0	0	0	2	0	47
1965	0	0	0	0	0	0	0	0	0	39	0	0	39
1966	0	0	0	0	0	0	39	24	55	0	0	0	117
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	43	0	24	9	4	0	80
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	26	19	0	0	44
1972	0	0	0	0	0	0	26	0	58	0	0	0	85
1973	0	0	0	0	0	0	0	0	11	0	0	0	11
1974	0	0	0	0	0	0	0	0	0	14	18	0	32
1975	0	0	0	0	0	0	0	0	0	10	0	0	10
1976	0	0	0	0	0	40	18	0	42	3	0	0	102
1977	0	0	0	0	0	24	0	27	10	31	2	0	94
1978	0	0	0	0	0	0	0	0	0	6	13	0	18
1979	0	0	0	0	0	0	0	0	94	41	16	0	152
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	13	9	0	0	0	0	23
1982	0	0	0	0	0	0	0	0	0	0	9	0	9
1983	0	0	0	0	0	0	0	0	0	0	16	0	16
1984	0	0	0	0	0	0	0	0	3	0	8	0	11
1985	0	0	0	0	0	0	28	10	11	0	0	0	49
1986	0	0	0	0	0	0	0	0	0	26	23	0	49
1987	0	0	0	0	0	0	18	0	34	20	0	0	72
1988	0	0	0	0	7	40	14	5	45	0	0	0	112
1989	0	0	0	0	26	1	0	0	46	42	0	0	116
1990	0	0	0	0	13	22	0	0	0	0	0	0	35
1991	0	0	0	0	0	7	0	30	32	0	0	0	69
1992	0	0	0	7	0	0	13	0	0	2	0	0	21
1993	0	0	0	0	0	0	0	0	0	19	0	0	19
1994	0	0	0	0	0	37	0	0	80	4	13	0	134
Average	0	0	0	1	2	6	6	3	15	9	6	0	49
Max	0	0	12	36	38	46	75	44	94	44	50	0	1,994
Sum	0	0	12	101	127	412	461	224	1,121	673	455	0	3,584

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Table 9B
Additional New Melones Releases (TAF) Required to Meet Vernalis Salinity Objectives
Run 11a and 11b Composite (Base Conditions)

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	0	0	0	0	0	0	0	0	0	0	33	0	33
1923	0	0	0	0	0	0	0	15	23	0	0	0	38
1924	0	0	0	0	0	5	15	0	20	0	0	0	40
1925	0	0	0	33	0	6	0	0	60	33	0	0	132
1926	0	0	0	0	0	34	0	0	16	41	0	0	91
1927	0	0	0	0	0	0	0	0	0	3	0	0	3
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	10	0	0	0	0	0	10
1930	0	0	0	0	0	1	4	37	0	20	0	0	61
1931	0	0	0	7	13	23	75	0	80	0	18	0	215
1932	0	0	0	0	0	0	0	0	30	44	0	0	74
1933	0	0	0	0	0	6	46	0	38	32	1	0	123
1934	0	0	0	0	0	4	24	2	70	0	11	0	112
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	23	0	0	23
1937	0	0	0	0	0	0	0	0	0	30	0	0	30
1938	0	0	0	0	0	0	0	0	0	0	2	0	2
1939	0	0	0	0	0	0	0	0	0	0	7	0	7
1940	0	0	0	0	0	0	0	0	17	0	37	0	54
1941	0	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	38	0	38
1943	0	0	0	0	0	0	0	0	0	0	29	0	29
1944	0	0	0	0	0	0	0	0	19	15	0	0	34
1945	0	0	0	0	0	0	0	0	0	41	20	0	60
1946	0	0	0	0	0	0	0	0	4	0	45	0	49
1947	0	0	0	0	0	10	0	42	6	0	0	0	58
1948	0	0	12	4	38	46	0	0	26	1	5	0	132
1949	0	0	0	7	4	2	9	0	38	0	0	0	60
1950	0	0	0	0	0	29	2	11	0	0	51	0	93
1951	0	0	0	0	0	0	0	0	1	39	3	0	43
1952	0	0	0	0	0	0	0	0	0	0	9	0	9
1953	0	0	0	0	0	0	9	4	7	0	0	0	20
1954	0	0	0	0	0	31	0	17	0	0	0	0	48
1955	0	0	0	0	5	16	0	13	0	2	13	0	48
1956	0	0	0	0	0	0	0	0	0	0	9	0	9
1957	0	0	0	0	0	0	0	0	53	0	0	0	53
1958	0	0	0	10	0	0	0	0	0	0	0	0	10
1959	0	0	0	0	0	0	2	0	3	0	0	0	4
1960	0	0	0	0	0	0	0	0	0	18	0	0	18

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Table 9B
Additional New Melones Releases (TAF) Required to Meet Vernalis Salinity Objectives
Run 11a and 11b Composite (Base Conditions)

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1961	0	0	0	0	21	26	22	0	0	0	0	0	69
1962	0	0	0	36	0	0	0	3	38	15	0	0	92
1963	0	0	0	0	0	0	0	0	0	34	0	0	34
1964	0	0	0	0	0	0	46	0	0	0	2	0	47
1965	0	0	0	0	0	0	0	0	0	39	0	0	39
1966	0	0	0	0	0	0	38	24	55	0	0	0	117
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	43	0	24	9	4	0	80
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	8	0	23	20	0	0	50
1972	0	0	0	0	0	0	26	0	58	0	0	0	84
1973	0	0	0	0	0	0	0	0	11	0	0	0	11
1974	0	0	0	0	0	0	0	0	0	14	18	0	32
1975	0	0	0	0	0	0	0	0	0	10	0	0	10
1976	0	0	0	0	0	40	17	0	42	3	0	0	102
1977	0	0	0	0	0	24	0	27	10	31	2	0	94
1978	0	0	0	0	0	0	0	0	0	5	12	0	17
1979	0	0	0	0	0	0	0	0	94	41	16	0	152
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	13	9	0	0	0	0	22
1982	0	0	0	0	0	0	0	0	0	0	9	0	9
1983	0	0	0	0	0	0	0	0	0	0	16	0	16
1984	0	0	0	0	0	0	0	3	3	0	8	0	15
1985	0	0	0	0	0	0	28	10	11	0	0	0	49
1986	0	0	0	0	0	0	0	0	0	26	23	0	49
1987	0	0	0	0	0	0	18	0	34	20	0	0	72
1988	0	0	0	0	7	40	14	5	45	0	0	0	112
1989	0	0	0	0	26	1	0	0	46	42	0	0	116
1990	0	0	0	0	13	22	0	0	0	0	0	0	35
1991	0	0	0	0	0	7	0	30	32	0	0	0	69
1992	0	0	0	7	0	0	12	0	0	2	0	0	21
1993	0	0	0	0	0	0	8	0	0	19	0	0	27
1994	0	0	0	0	0	37	3	0	80	4	13	0	136
Average	0	0	0	1	2	6	7	3	15	9	6	0	50
Max	0	0	12	36	38	46	75	42	94	44	51	0	215
Sum	0	0	12	104	127	412	491	252	1,119	673	455	0	3,644

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Table 9C
Additional New Melones Releases (TAF) Required to Meet Vernalis Salinity Objectives
Run 11a and 11c Composite (Base Conditions with DMC Recirculation)

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	0	0	0	0	0	0	0	0	0	0	33	0	33
1923	0	0	0	0	0	0	0	15	23	0	0	0	38
1924	0	0	0	0	0	5	15	0	20	0	0	0	40
1925	0	0	0	33	0	6	0	0	60	33	0	0	132
1926	0	0	0	0	0	34	0	0	16	41	0	0	91
1927	0	0	0	0	0	0	0	0	0	3	0	0	3
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	10	0	0	0	0	0	10
1930	0	0	0	0	0	1	4	37	0	20	0	0	60
1931	0	0	0	7	13	23	71	0	80	0	18	0	212
1932	0	0	0	0	0	0	0	0	30	44	0	0	74
1933	0	0	0	0	0	6	35	0	38	32	1	0	112
1934	0	0	0	0	0	4	26	2	70	0	11	0	113
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	23	0	0	23
1937	0	0	0	0	0	0	0	0	0	30	0	0	30
1938	0	0	0	0	0	0	0	0	0	0	2	0	2
1939	0	0	0	0	0	0	0	0	0	0	7	0	7
1940	0	0	0	0	0	0	0	0	17	0	37	0	54
1941	0	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	38	0	38
1943	0	0	0	0	0	0	0	0	0	0	29	0	29
1944	0	0	0	0	0	0	0	0	19	15	0	0	34
1945	0	0	0	0	0	0	0	0	0	41	20	0	60
1946	0	0	0	0	0	0	0	0	4	0	45	0	49
1947	0	0	0	0	0	10	0	29	6	0	0	0	46
1948	0	0	12	4	38	46	0	0	26	1	5	0	132
1949	0	0	0	7	4	2	8	0	38	0	0	0	60
1950	0	0	0	0	0	29	2	11	0	0	51	0	93
1951	0	0	0	0	0	0	0	0	1	39	3	0	43
1952	0	0	0	0	0	0	0	0	0	0	9	0	9
1953	0	0	0	0	0	0	9	4	7	0	0	0	20
1954	0	0	0	0	0	31	0	17	0	0	0	0	48
1955	0	0	0	0	5	16	0	11	0	2	13	0	46
1956	0	0	0	0	0	0	0	0	0	0	9	0	9
1957	0	0	0	0	0	0	0	0	53	0	0	0	53
1958	0	0	0	10	0	0	0	0	0	0	0	0	10
1959	0	0	0	0	0	0	2	0	3	0	0	0	4
1960	0	0	0	0	0	0	0	0	0	18	0	0	18

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Table 9C
Additional New Melones Releases (TAF) Required to Meet Vernalis Salinity Objectives
Run 11a and 11c Composite (Base Conditions with DMC Recirculation)

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1961	0	0	0	0	21	26	24	0	0	0	0	0	71
1962	0	0	0	36	0	0	0	3	38	15	0	0	92
1963	0	0	0	0	0	0	0	0	0	34	0	0	34
1964	0	0	0	0	0	0	38	0	0	0	2	0	40
1965	0	0	0	0	0	0	0	0	0	39	0	0	39
1966	0	0	0	0	0	0	23	15	55	0	0	0	92
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	26	0	24	9	4	0	64
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	8	0	23	20	0	0	50
1972	0	0	0	0	0	0	17	0	58	0	0	0	75
1973	0	0	0	0	0	0	0	0	11	0	0	0	11
1974	0	0	0	0	0	0	0	0	0	14	18	0	32
1975	0	0	0	0	0	0	0	0	0	10	0	0	10
1976	0	0	0	0	0	40	18	0	42	3	0	0	102
1977	0	0	0	0	0	24	0	26	10	31	2	0	94
1978	0	0	0	0	0	0	0	0	0	5	12	0	17
1979	0	0	0	0	0	0	0	0	94	41	16	0	152
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	5	9	0	0	0	0	13
1982	0	0	0	0	0	0	0	0	0	0	9	0	9
1983	0	0	0	0	0	0	0	0	0	0	16	0	16
1984	0	0	0	0	0	0	0	3	3	0	8	0	15
1985	0	0	0	0	0	0	26	10	11	0	0	0	47
1986	0	0	0	0	0	0	0	0	0	26	23	0	49
1987	0	0	0	0	0	0	18	0	34	20	0	0	72
1988	0	0	0	0	7	40	14	5	45	0	0	0	112
1989	0	0	0	0	26	1	0	0	46	42	0	0	116
1990	0	0	0	0	13	22	0	0	0	0	0	0	35
1991	0	0	0	0	0	7	0	30	32	0	0	0	69
1992	0	0	0	7	0	0	12	0	0	2	0	0	21
1993	0	0	0	0	0	0	8	0	0	19	0	0	27
1994	0	0	0	0	0	37	3	0	80	4	13	0	136
Average	0	0	0	1	2	6	6	3	15	9	6	0	49
Max	0	0	12	36	38	46	71	37	94	44	51	0	212
Sum	0	0	12	104	127	412	422	228	1,119	673	455	0	3,550

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Table 9D
Additional New Melones Releases (TAF) Required to Meet Vernalis Salinity Objectives
Run 12a and 12b Composite (Tile Drainage Reoperation and DMC Recirculation)

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	0	0	0	0	0	0	0	0	0	0	28	0	28
1923	0	0	0	0	0	0	0	12	19	0	0	0	31
1924	0	0	0	0	0	0	19	5	20	0	0	0	43
1925	0	0	0	24	0	0	0	0	56	31	0	0	111
1926	0	0	0	0	0	24	0	0	16	41	0	0	81
1927	0	0	0	0	0	0	0	0	0	2	0	0	2
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	10	0	0	0	0	0	10
1930	0	0	0	0	0	0	0	44	0	20	0	0	64
1931	0	0	0	7	13	15	76	0	80	0	18	0	209
1932	0	0	0	0	0	0	0	0	25	43	0	0	68
1933	0	0	0	0	0	0	40	0	38	32	1	0	110
1934	0	0	0	0	0	0	30	11	70	0	11	0	122
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	21	0	0	21
1937	0	0	0	0	0	0	0	0	0	25	0	0	25
1938	0	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0	0	0	7	0	7
1940	0	0	0	0	0	0	0	0	12	0	34	0	46
1941	0	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	31	0	31
1943	0	0	0	0	0	0	0	0	0	0	21	0	21
1944	0	0	0	0	0	0	0	0	16	13	0	0	29
1945	0	0	0	0	0	0	0	0	0	39	17	0	56
1946	0	0	0	0	0	0	0	0	0	0	42	0	43
1947	0	0	0	0	0	1	0	41	6	0	0	0	48
1948	0	0	10	0	33	25	0	0	22	0	3	0	93
1949	0	0	0	0	0	0	0	0	36	0	0	0	36
1950	0	0	0	0	0	10	0	8	0	0	47	0	65
1951	0	0	0	0	0	0	0	0	0	37	1	0	38
1952	0	0	0	0	0	0	0	0	0	0	3	0	3
1953	0	0	0	0	0	0	0	2	3	0	0	0	5
1954	0	0	0	0	0	8	0	15	0	0	0	0	22
1955	0	0	0	0	5	6	0	15	0	2	13	0	41
1956	0	0	0	0	0	0	0	0	0	0	4	0	4
1957	0	0	0	0	0	0	0	0	49	0	0	0	49
1958	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	3	0	0	0	3
1960	0	0	0	0	0	0	0	0	0	18	0	0	18

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Table 9D
Additional New Melones Releases (TAF) Required to Meet Vernalis Salinity Objectives
Run 12a and 12b Composite (Tile Drainage Reoperation and DMC Recirculation)

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1961	0	0	0	0	21	19	28	1	0	0	0	0	68
1962	0	1	0	27	0	0	0	1	35	13	0	0	77
1963	0	0	0	0	0	0	0	0	0	32	0	0	32
1964	0	0	0	0	0	0	43	0	0	0	2	0	45
1965	0	0	0	0	0	0	0	0	0	34	0	0	34
1966	0	0	0	0	0	0	12	12	52	0	0	0	76
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	31	0	24	9	4	0	69
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	19	18	0	0	37
1972	0	0	0	0	0	0	12	0	58	0	0	0	70
1973	0	0	0	0	0	0	0	0	7	0	0	0	7
1974	0	0	0	0	0	0	0	0	0	10	12	0	22
1975	0	0	0	0	0	0	0	0	0	7	0	0	7
1976	0	0	0	0	0	32	21	0	42	3	0	0	97
1977	0	0	0	0	0	15	2	36	10	31	2	0	96
1978	0	0	0	0	0	0	0	0	0	0	6	0	6
1979	0	0	0	0	0	0	0	0	91	39	15	0	144
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	14	9	0	0	0	0	23
1982	0	0	0	0	0	0	0	0	0	0	2	0	2
1983	0	0	0	0	0	0	0	0	0	0	10	0	10
1984	0	0	0	0	0	0	0	0	0	0	5	0	5
1985	0	0	0	0	0	0	31	10	11	0	0	0	52
1986	0	0	0	0	0	0	0	0	0	22	16	0	38
1987	0	0	0	0	0	0	18	0	34	20	0	0	72
1988	0	0	0	0	7	32	18	16	45	0	0	0	118
1989	0	0	0	0	26	0	0	0	46	42	0	0	114
1990	0	0	0	0	13	14	0	0	0	0	0	0	26
1991	0	0	0	0	0	7	0	30	32	0	0	0	69
1992	0	0	0	7	0	0	12	0	0	2	0	0	21
1993	0	0	0	0	0	0	0	0	0	16	0	0	16
1994	0	0	0	0	0	27	2	0	80	4	13	0	125
Average	0	0	0	1	2	3	6	4	14	9	5	0	43
Max	0	1	10	27	33	32	76	44	91	43	47	0	209
Sum	0	1	10	65	118	233	420	267	1,057	625	369	0	3,164

January 30, 1998

Developing a Conceptual Design and Operating Plan to Address Serious Agricultural and Fishery Management Issues in the Lower San Joaquin River and San Joaquin Delta with Particular Regard to the Proposed Use of Channel Barriers

by

Alex Hildebrand and Bill Loudermilk

Introduction

The lower San Joaquin River and San Joaquin River Delta ecosystem no longer functions adequately to support conventional agricultural and water management practices. Similarly, it no longer functions adequately to sustain anadromous and resident fisheries. Fish and farming interests in the South Delta area rely on the volume, depths and quality of water flowing in the natural river channels. These provide aquatic habitat and support riparian diversions to produce crops. Fishery and irrigation needs occur there at some level every month of the year. Fish populations are determined in part by the spatial and temporal nature of habitat conditions, the water quality and the biological interactions which exist in these river channels throughout the year. Finally, California State and Federal Water Projects divert large quantities of water from these same channels in the South Delta throughout the year to meet agricultural, industrial and domestic needs south and west of the Delta. The challenge we all face is to develop and implement programs that adequately protect each of these beneficial uses consistent with law and policy. It is important that we recognize the many projects or programs that are underway and planned, and that we address each aspect of these activities in the perspective of the broader need to protect all beneficial uses over the short and longer term. Each incremental step must eventually add up to the whole.

To this end we suggest a process and a "straw plan" for your consideration in the hope that it will a) help facilitate a more focused understanding of the interrelated issues needing greater attention, and b) help lead to Barrier Program (TBP & ISDP) design and operation plans acceptable to different interests.

Issues Affecting Beneficial Uses

The current condition of the lower San Joaquin River and San Joaquin River Delta ecosystem is detrimental to both fish and agriculture in several respects. Factors influencing this condition include the following:

1) Water surface elevations in the vicinity of the State and Federal export pumps are significantly lowered by the operation of the pumps. This results in drawing down the water levels to varying degrees over much of the South Delta area. There is then inadequate water depth to operate existing agricultural diversion pumps, particularly during low tides. Resident and anadromous fish in these areas, although generally accustomed to natural tidal influences in the habitat, are influenced directly and indirectly by the effects of intensive pumping operations in the South Delta. Shallow channels are also a problem for navigation.

2) In the absence of a spring barrier at the Head of Old River (HOR), intensive pumping and associated drawdown causes most, and frequently all, of the inflow of the San Joaquin River at Vernalis to flow through Old River and Grantline Canal directly to the export pumps unless the three tidal barriers are operated to provide much of the same protection. This drafts anadromous fish (e.g. San Joaquin fall-run chinook salmon fry and smolt from January through June, striped bass, America Shad and others) and resident fish into less viable habitat areas and subjects them to higher mortality rates. To the extent that overall pumping demand typically exceeds San Joaquin River flows at Vernalis, water from the north is therefore generally drafted to the South Delta. This can draw San Joaquin salmon and resident fish (e.g. Delta smelt, longfin smelt, splittail) and Sacramento River fishes (e.g. winter- and spring-run chinook salmon) into less viable habitats, exposing them to higher mortality rates.

3) Since export pumping exceeds the San Joaquin inflow in many months of most years, there is typically a reverse flow pattern in the main channel of the San Joaquin River from Stockton to the head of Old River. The direction and net downstream velocity in other channels of the South Delta are also influenced. This reversal typically

contributes to less viable fish habitat conditions (e.g. inadequate dissolved oxygen (DO) for adult salmon to pass Stockton in the fall or slower fish passage rates in the spring).

4) The Delta Mendota Canal imports roughly a million tons of salt into the San Joaquin watershed in a year of full SWP and CVP contractual deliveries. Part of this salt load is substantially concentrated by San Joaquin Valley farm and wetland use and then drains into the San Joaquin River upstream of Vernalis, largely via Salt and Mud Sloughs. Under current tributary streamflow regimes and in the absence of tidal barriers in the South Delta, a large portion of this load of drainage salt in the river is then drawn back to the Federal pumps and reexported (i.e. recirculated and concentrated). This salt load causes a very high salinity in the river downstream, especially between the confluences of the Merced and Stanislaus Rivers. It also accumulates in stagnant reaches in South Delta channels where there is sometimes no net unidirectional flushing flow as a result of the distortion of circulation in these channels. Agricultural practices and the fish present are impacted by this poor quality water in the absence of barriers in combination with the effect of water level drawdown.

5) Another consequence of this recirculating salt load that occurs in the absence of the barriers is that a regulatory requirement is imposed on New Melones Reservoir to release dilution water down the Stanislaus River to meet the salinity standard on the San Joaquin River at Vernalis. These required releases influence the instream habitat conditions on the Stanislaus River and can take water that is urgently needed at other times for instream and other beneficial uses of Stanislaus water.

6) The San Joaquin River along the valley floor south of Stockton is receiving an average of roughly two million yards of sediment each year. This has aggraded substantial portions of the channel along the valley floor and in portions of the South Delta channels with six to eight feet of sediment in recent decades. This sediment moves into and is deposited in the Delta primarily during flood events. This aggradation of channels exacerbates

the problem of inadequate water depth and high temperatures in South Delta channels. There is no program for control of this aggradation in San Joaquin and South Delta channels north of the Merced River. If it is not controlled it will continue to fill Delta channels because it is not conveyed beyond deep tidal channels toward the ocean.

7) Anadromous fishery populations in the San Joaquin basin have declined to seriously low levels and sport fishing opportunity in the valley has been eliminated due to these declines. The long term genetic health of these populations may be jeopardized due to the selective nature of protective measures.

<u>Listed Fish Species and Protection of "Unlisted" Anadromous Fish</u>

We now have California and Federal listing of Sacramento Winter run salmon (Oncorhychus tshawytscha), and Delta smelt (Hypomesus transpacificus) under the Endangered Species Acts. We also have the formal State candidate status of Spring run Chinook salmon, and the potential Federal candidacy of Splittail (Pogonichthys macrolepidotus) and especially steelhead (Oncorhynchus mykiss). These and the potential listing of other aquatic species will continue to challenge our collective ingenuity to protect all the beneficial uses of water. One of the most illusive challenges is to remain focused on the listed/candidate species pursuant to these laws while avoiding impact to other species or uses of water.

Implementation of the State and Federal Endangered Species Acts (CESA and FESA, respectively) is generally initiated with informal or formal consultation upon submittal of project plans, new operational plans or standards, a change in the status of listed species, or new listings. The process requires a specific focus on the status and needs of the species in question in relation to the proposed projects based on the best information available. Considering the overlapping needs of multiple listed species (e.g. Winter run Chinook and Delta smelt) and protective measures ascribed in Biological Opinions under both CESA and FESA is challenge enough. Effective protection of unlisted fish species, farming and other industries adds to the challenge.

It has long been recognized that efforts to restore Fall run Chinook salmon originating in the San Joaquin basin tributaries must include improved protection during adult and juvenile migrations through the South Delta. Significant water and funding resources are being committed in upstream areas to affect this restoration pursuant to State and Federal mandates. Other laws require further mitigation associated with existing or new projects. Yet the level of South Delta

protection during juvenile emigration can severely limit the benefit of these public and private investments.

Measures to improve salmon smolt survival during emigration through the South Delta such as installation and operation of the HOR barrier appear good on the surface. Many people assume this barrier is doing the job in spite of the brief periods of installation. Operable barriers would simply be opened to protect listed species, thus eliminating the protective mechanisms assumed for unlisted species. Survival rate studies thus far have focused on short time periods in the spring and the results are quite variable, some suggesting no benefits while others are quite encouraging. However, on a population basis the information available indicates that only limited protection has so far been afforded natural outmigrant smolts by the HOR barrier because a) the installation is too late (April 15), b) the removal is too soon (May 15), and c) even after late installations the operational periods are further truncated or minimized to protect other species (e.g., HOR barrier operation in 1994 was delayed until April 23 and then removed in 25 days when smolt emigration occurred over 190 days). These operations can not only limit the physical protection intended, and the benefit of upstream actions to protect salmon, but can actually take the form of additional selective pressure (temporal selection) on these weak stocks. If pulse flow management in the tributaries focuses attention on a relatively narrow time period (31 days) but HOR barrier operations during that same time period are brief or truncated the two actions (tributary and Delta) are not compatible and may no longer represent an effective overall management strategy.

With the exception of high flow conditions at Vernalis, the operational periods for the HOR barrier are generally driven by the Biological Opinions for listed species. The net effect is that the very basic needs of the fish and farmers along the Lower San Joaquin River and South Delta are not satisfied in many years.

Other Background

The Department of Water Resources, U.S. Bureau of Reclamation and SDWA entered into an agreement on a framework for settling the 1982 litigation brought by SDWA. They agreed to work together to develop a mutually acceptable long term solution to the water supply problems of SDWA users as they relate to operations of the CVP and SWP.

Under the Framework Agreement the parties developed a long term contract committing the three agencies to construct and operate three permanent tidal barriers in Middle River, Old River near Tracy, and Grantline Canal, subject to obtaining necessary permits and approvals. Several other minor improvements were implemented. We can review the extensive studies that have been made in methods of protecting the South Delta's shallow channels from reductions in water

depth and from stagnation caused by inadequate circulation. Barriers have so far been the only effective method that has been devised, and they have proven to be very effective in solving that problem.

Since the late 1980's the SWP, CVP, and South Delta Water Agency (SDWA) have pursued the design, permitting and use of tidal barriers to ameliorate the effects of water project operations on water levels and water quality in the South Delta. Currently, these efforts consist of the "Temporary Barriers Project" (TBP) and more permanent structures under the "Interim South Delta Project" (ISDP). Concurrent with this endeavor to resolve issues of concern to SDWA, SWP, and CVP, several fish species have been listed under State and/or Federal Endangered Species Acts, and major new anadromous fish restoration laws and policies have been established. There is now broad public involvement in ecosystem restoration efforts. In addition, the level of monitoring and study of the San Joaquin tributaries, lower San Joaquin River and the San Joaquin Delta has intensified. Adequate fishery protection in conjunction with the remedial use of barriers to resolve water level and water quality issues in the South Delta is more urgent than ever. Implementation of this barrier program is underway through several venues, including the TBP and ISDP, but we have not yet devised adequate fish protective measures, in part due to a basic lack of understanding. There is now a major State and Federal "ecosystem restoration" initiative underway under the CALFED Bay Delta Program. Significant funding and support is feasible through this program if consensus is reached on an approach.

Finally, the Vernalis Adaptive Management Program (VAMP) is being developed to improve habitat conditions for a thirty-one day period in the San Joaquin River, its tributaries and the South Delta. The purpose is to test the independent and dependent influence of Vernalis flows and Delta exports on San Joaquin salmon smolt survival with barrier operation.

The design and permit process for the four South Delta barriers under the TBP has not been effective thus far in resolving key issues. Monitoring results documenting the benefits and effects of the proposed barriers have not been conclusive due in part to the protocols used and a lack of consistent physical conditions during the monitoring efforts. The process has not resulted in a good mutual understanding of physical and biological objectives to be achieved, the hydraulics of the modified system, or of the interaction between barrier operation and upstream flow and geographic improvement in water quality. It has not effectively examined the potential for designing and operating the barriers in a manner that optimizes the compatible resolution of various needs. We may face the same dilemma under the ISDP.

Conceptual Design and Operating Plan for Barriers

We believe that tidal barriers in the South Delta can contribute to resolving these problems, if we understand enough about the site and resources and design and operate them appropriately in conjunction with other actions (e.g. VAMP, CALFED Ecosystem Restoration, AFRP actions, etc.). Again, the incremental parts must add up to the whole. Some tradeoffs or mitigation measures are inevitable in developing compatible solutions. To become effective, the barriers must be designed and operated in a manner that does not solve one problem at the expense of another, or create unacceptable new problems. They must also be developed and operated in context with the other programs influencing conditions in the South Delta, to be part of a cumulative improvement effort. No single action can resolve ecosystem-level problems such as these. Perhaps a sequence of necessary actions including the barriers program can be defined such that each action is in context with long term restoration. On the ground considerations in meeting these objectives should include the following as a starting point:

1) When the Middle River (MR) and Old River near Tracy (ORT) tidal barriers are functioning good quality water and water depths are maintained and circulation in the shallow portions of Old River and Middle River within the South Delta improves, and water export pumping can continue. These barriers have little effect (when operated by themselves) on water circulation outside of South Delta channels. They in some degree augment flow through the Salmon Slough area between Old River and Grantline Canal. They therefore assist in dispersing the Tracy sewage outfall and maintaining adequate DO in that area. The permanent barriers when fully open will permit boat and fish passage during rising tides. The tidal gates in the temporary barriers open during rising tides and are designed to overtop during the peak of high tide.

2) If the HOR barrier is operated by itself as a "tight" barrier, it assists in correcting the fall DO problem downstream of Old River in the San Joaquin River. In the spring it shunts salmon smolts away from direct diversion to the export pumps via Old River. It also largely prevents the salt load which drains into the river from the CVP service area from being reexported by the Federal pumps. However, that barrier greatly exacerbates the problem of inadequate water depth, and of water quality below the Tracy sewage outfall and in stagnant channels downstream of the barrier. It is, therefore, necessary to mitigate these impacts of the barrier's operations by letting a controlled amount of water over, around or through the HOR barrier. The barrier must be designed to pass this water with a minimum entrainment of fish, as is discussed later in this memo. Fish losses may need to be mitigated as well. The amount of water that must be let through can be substantially reduced by simultaneous full operation of the MR and ORT barriers, and by operating the Grantline (GL) barrier as a flow restrictor or low weir so as to make a modest increase in water elevation between it and the HOR barrier

during low tides. When the export pumping rates are high and the agricultural diversion needs are at summer levels it would probably not be feasible to mitigate adequately the impact of the HOR barrier even with a reasonable amount of controlled flow past the barrier. (However, operation of all three tidal barriers at those times can provide much of the same protection.) Retaining the ecological values in this area while operating such a system is the real challenge we all face.

3) When the HOR barrier is not functioning, the GL barrier can help mitigate the drawdown of the export pumps. However, it is expected to be opened intermittently during high-low tides to flush water and control DO. It would also be open during rising tides. The GL barrier can be operated with some spill when river flows are too great to permit the use of the HOR barrier. Boat locks must be provided for use during ebb tides.

4) All of the barriers must be open during flood flows and must be designed to cause no flow restriction during such flows.

5) When either the HOR barrier or the fully operated GL barrier is functioning the circulation of water is affected beyond the South Delta. Modeling and analyses suggest that this change in circulation would be beneficial to San Joaquin salmon because they are not drawn directly to the Federal export pumps. Monitoring and duration of installation of the HOR barrier has been too meager to illustrate this benefit in terms of salmon population recovery. The change in circulation caused by these barriers also reduces DO problems downstream of the head of Old River. Furthermore, since it reduces the salt load that is recirculated via the DMC it is expected to reduce the need to use New Melones dilution water to meet the Vernalis salinity standard. However, the flow of San Joaquin water does not then go direct to the export pumps and the flow of water from the Central Delta toward the export pumps is correspondingly increased when either the HOR or GL barrier is functioning. This may at times be detrimental to Delta smelt or other species. It is, therefore, necessary to maintain and perhaps improve the system of discerning when the risk of an incremental impact on endangered and unlisted species is caused by this change in circulation. Judgements are necessary to protect listed and unlisted species but should also take into consideration the full breadth of those decisions as they affect the benefits for other fish, for quality, for export, for South Delta inchannel water supply, and for reducing the burden on New Melones. When exports must be reduced to protect endangered species, the need for the HOR and GL barriers is also reduced, but they are still needed to the extent that the drawdown of water levels by a reduced level of export must still be mitigated. The "no net loss" provision in the Delta Accord must not result in exports that damage third parties.

As a starting point for discussion, the potential conflict among protection of Delta smelt and winter run salmon, protection of San Joaquin fall run salmon, protection of South Delta in-channel water supply, and continuation of Project

export rates may be minimized when endangered fish species are at risk by the following measures:

a) Open the HOR barrier. Operate fully the MR and ORT barriers. Close the GL barrier only during portions of tidal cycles and only to the extent necessary to avoid periods when the water depth upstream of that barrier would otherwise fall too low for operation of local diversion pumps. The extent to which this operating plan would reduce the flow of San Joaquin water through Old River and Grantline Canal and increase flow toward Stockton (as compared to fully opening both the GL and HOR barriers) would depend on the Vernalis flow, tidal energy and direction, the export rate, the local diversion rate, and the water level needed to provide adequate water depth. Data is available regarding the frequency that water levels have dropped below any proposed minimum level. Information on the timing of fall run salmon, splittail, and Delta smelt are also available.

b) The water level needed for adequate water depth can be reduced if the accumulating sediments are removed from the shallowest channel reaches where diversion pumps have inadequate draft.

6) The barriers should not cause channel aggradation. However, the aggradation exacerbates the need for barriers. It is essential that a program of channel maintenance be undertaken. Channel maintenance alone can not solve the problems we have discussed, but if there is no channel maintenance the barriers will gradually become an inadequate solution.

<u>Fish friendly barrier designs</u>

The design of the HOR barrier must be capable of passing a controlled amount of water into Old River while avoiding losses and optimizing the fishery benefits of the barrier. The amount of water let through must be varied with river flow, diversions, and tides to minimize the amount of through flow needed to protect diversions and DO downstream of the barrier. It is also necessary to design and operate the barriers to permit upstream and downstream migration of salmon and other species through the barrier locations. This is admittedly difficult. We propose the following approach to meeting these objectives.

<u>HOR barrier</u>

Unless an as yet unknown substitute is devised, the design of the HOR barrier must permit adequate water supplies to flow from the San Joaquin channel into Old River with a minimum entrainment of salmon smolts and a minimum

disturbance of their progress downstream toward the Central Delta. This may be accomplished by (a) encouraging a sweeping velocity parallel to the head of Old River (avoid back eddies or perpendicular flows) and (b) minimizing the velocity of water approaching the barrier openings through which water flows. There are probably several alternative approaches to meeting these objectives. A redesign of the channels at this important flow split may be necessary. Substantial avoidance of eddies and reduction of fish entrainment should be technically feasible. For example, an array of baffles or vanes could be provided at the entrance to Old River positioned so that smolts tend to go on downstream with the majority flow which is toward Stockton. The openings through the barrier would then be dispersed over a large surface area so that there is no concentrated flow at one or a few points. The barrier openings or bypasses would be selectively located in the water column if it is determined to improve fish passage efficiency. The amount of total flow through the barrier would be controlled to the minimum needed to maintain a specified minimum water level and help maintain a minimum DO as monitored in Salmon Slough or at one or more representative but more accessible locations.

In the fall, it may be desirable either to have a fish ladder or an intermittent opening of the barrier in order to avoid trapping upstream fish migrants.

<u>Grantline (GL) barrier</u>

The GL barrier can be operated as a full tidal barrier when the HOR barrier is not operating, except when it causes an endangered species or some other problem, or when its full operation causes a DO problem in channels upstream of the barrier. During full operation it would provide a hydraulic barrier to keep San Joaquin River salts and downstream fish migrants from being drawn into Old River. These latter objectives would be partially achieved even when the barrier is operated only to avoid extreme low water levels.

When the HOR barrier is operating the GL barrier would be operated to the extent necessary to mitigate the loss of water depth caused by the HOR barrier but with a minimum of flow through the HOR barrier as previously discussed. This would require that a controlled flow be passed through or across the GL barrier based on maintaining a specified water depth and minimum DO in the South Delta channels.

When it is deemed that full operation of the barrier would cause an increase in the "take" of listed species or other species at the pumps, this barrier could be operated as discussed above. However, any level of exports that is allowed must always be mitigated to maintain adequate water levels. Exports and measures to mitigate export impacts should be viewed as a single package.

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Barriers in Middle River (MR) and in Old River near Tracy (ORT)

These barriers would be operated at all times that they are needed to mitigate either the drawdown by the export pumps in those channels and/or the dewatering caused by the HOR barrier. The same would be true of the GL barrier except for the situations discussed above.

Recommendation

The staff for the Temporary Barrier Program, the Interim South Delta Program, the Anadromous Fishery Restoration Program and other programs are involved in ongoing but separate processes to implement programs involving barriers. Relative to but separate from these programs we propose a series of about four facilitated non-adversarial and structured discussions during the next two months focused on the suite of Barrier Program Objectives, the benefits of beneficial uses, the additional information needed in order to design and operate the barriers appropriately, possible alternative solutions, etc. This memo is offered only as a point of departure for the discussions. It is not intended to bias the proposed discussions in regard to matters of policy or management preference We would hope that all parties will work together to develop compatible and balanced solutions to meeting the various needs which the barriers can help provide. We propose that these discussions be convened by DWR and Fish and Game to include the U.S. Fish and Wildlife Service, SDWA, the U.S. Corps of Engineers, and others involved in the planning, permitting, and implementation process. We suggest that the meeting be chaired by a neutral but knowledgeable person with facilitation skills.

We believe that this can lead to better communication and mutual understanding at both technical and policy levels. It should help reduce adversarial attitudes and, thereby, enhance the development of optimally compatible solutions. The authors of this memo will assist in any appropriate manner.

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TABLE V-18 (1950)

SUMMARY OF REDUCTIONS IN RUNOFF OF SAN JOAQUIN RIVER AT VERNALIS FROM PRE-CVP TO POST-CVP

YEAR TYPE & PERIOD	EFFECT OF ALL POST-CVP UPSTREAM DEVELOPMENT ON RUNOFF AT VERNALIS		EFFECT OF CVP ON RUNOFF AT VERNALIS		
	Reduction in Runoff acre-feet[1]	Post CVP Reduction as Percent of Pre-CVP Actual Runoff	Reduction in Runoff, acre-feet[1]	Reduction at Vernalis as Percent of Pre-CVP Flow	Reduction at Vernalis as Percent of Post CVP Flow
DRY					
April-Sept	417,000	68[2]	6,000	1.4	3.0
Full Year	519,000	45	128,000[3]	11	13
BELOW NORMAL					
April-Sept	1,064,000	60[2]	386,000	22[2]	55
Full Year	1,219,000	44[2]	543,000	20[2]	35
ABOVE NORMAL					
April-Sept	1,732,000	57	440,000	15	40
Full Year	1,400,000	28	768,000	15	25
WET					
April-Sept	1,000,000	19	554,000	15	10
Full Year	1,168,000	13	771,000	9	12
AVERAGE OF ALL YEARS					
April-Sept	1,053,000	40	345,000	13	24
Full Year	1,076,000	24	553,000	12	19

1. From Tables 2, 4, 6, 8, 10, 12, 14, 16
2. Pre-CVP "actual" is assumed to be post-CVP actual plus pre-CVP to post-CVP loss per Tables 4, 6, and 10
3. Co[illegible]cted for difference in pre-CVP and post[illegible] unimpaired flow

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	SDWA ACREAGE 1971-75	FLOW BASIS (% OF POTENTIAL)	IRRIGATION WATER QUALITY REQUIRED [1] Requirement per U.C. Exhibit 2 (Uniform soil and "as needed" irrigation frequency)		Requirement with allowance for soil variability		Requirement with variable soil and with a 4 day delay in alternate irrigations from "as needed" schedule	
			Field-average Leach Ratio [2] (% of applied water)	Irrigation Water Quality Needed	Corresponding minimum LR for 90% of Typical Field [3]	Irrigation Water Quality Needed		
COLUMN A	B	C	D	E	F	G	H	REMARKS
		%	%	EC (TDS)	%	EC (TDS)	(TDS)	
Alfalfa	27,900	100	10	1.0 (640)	7.4	0.7 (450)	Better than 450	
		100	10 (annual average with zero June July, Aug. and 2 irrigations/mon.)	Better than 1.0 (640)	7.4	Better than 0.7 (450)	Better than 450	
		90	5	1.0 (640)	3.8	0.64 (410)	Better than 410	
		90	5 (see note above)	Better than 1.0 (640)	3.8	Better than 0.64 (410)	Better than 410	
Tomatoes	17,200	100	15	1.7 (1080)	11.	1.5 (950)	Better than 900	
		90	6	1.0 (640)	4.4	0.75 (480)	Better than 450	
Sugar Beets	12,800	100	15	4.7	11.			
Beans	9,400	100	16	0.7 (450)	12.	0.62 (400)	Better than 400	Similar for carrots and strawberries
		90	10	0.7 (450)	7.4	0.63 (400)		
Corn	7,700	100	15	1.1 (700)	11.	1.0 (640)	Better than 600	Similar for potatoes
		90	8	.85 (550)	6.	0.7 (450)	Better than 450	
Grapes		100	15	1.0 (640)	11.	0.75 (480)		
		90	6	0.7 (450)	4.4	0.55 (350)		
Walnuts, Peaches, Apricots,	6,200	100	13	1.0 (640)	9.5	0.75 (480)		Similar for pears
		90	6.5	0.7 (450)	4.8	0.55 (350)		
Lettuce and onions		100	15	0.85 (540)	11.	0.75 (480)	Better than 480	
Seedlings Tomatoes Sugar Beets Onions Lettuce [4]	31,000	Good Survival and vigorous growth	The difficulty of achieving good survival increases as water qualities become poorer than 350 TDS and as necessary planting dates involve higher temperatures, winds, and low humidity. Depends also on facility with given soil of shaping and maintaining accurate seed bed shapes.					

1. All cases assume best common irrigation practices with flood and furrow irrigation, and reasonable provision of drain ditches and drainage pumps. All cases assume no long range salinity build up.
2. Average leach ratio, Col. D, determines input to groundwater. Removal of groundwater becomes more difficult when permissible groundwater levels must be below deep root zones and when elevations are near sea level.
3. U.C. Southern Delta Salinity Survey data is assumed to be representative and is used to determine a leach ratio in Col. F which will be achieved or exceeded in 90% of a typical field which has the average leach ratio in Col. D. This Col. F leach ratio determines the crop yield for 90% of the field with full yield water quality.
4. Seedlings germinated with best established methods on raised row beds by furrow irrigation and planted at appropriate dates for crop.
5. Assumes adequate leach by irrigation, i.e., does not assume rain leach.

Abbreviations EC, TDS, LR are those used in U.C. Exhibit 2.
* See: Exhibit U.C. 7

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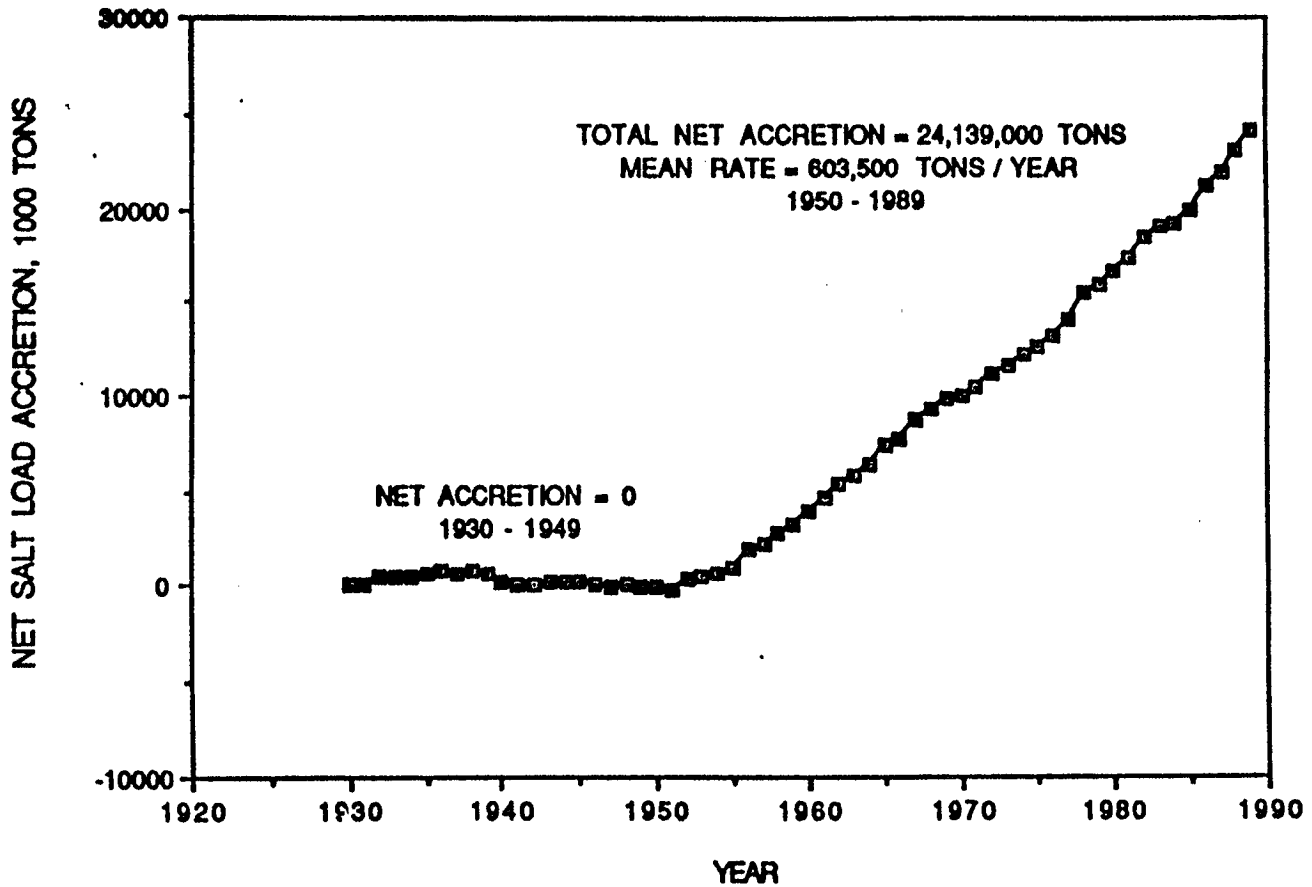

NET SALT LOAD ACCUMULATION

SAN JOAQUIN BASIN, 1930 - 1989

GTO 2/90

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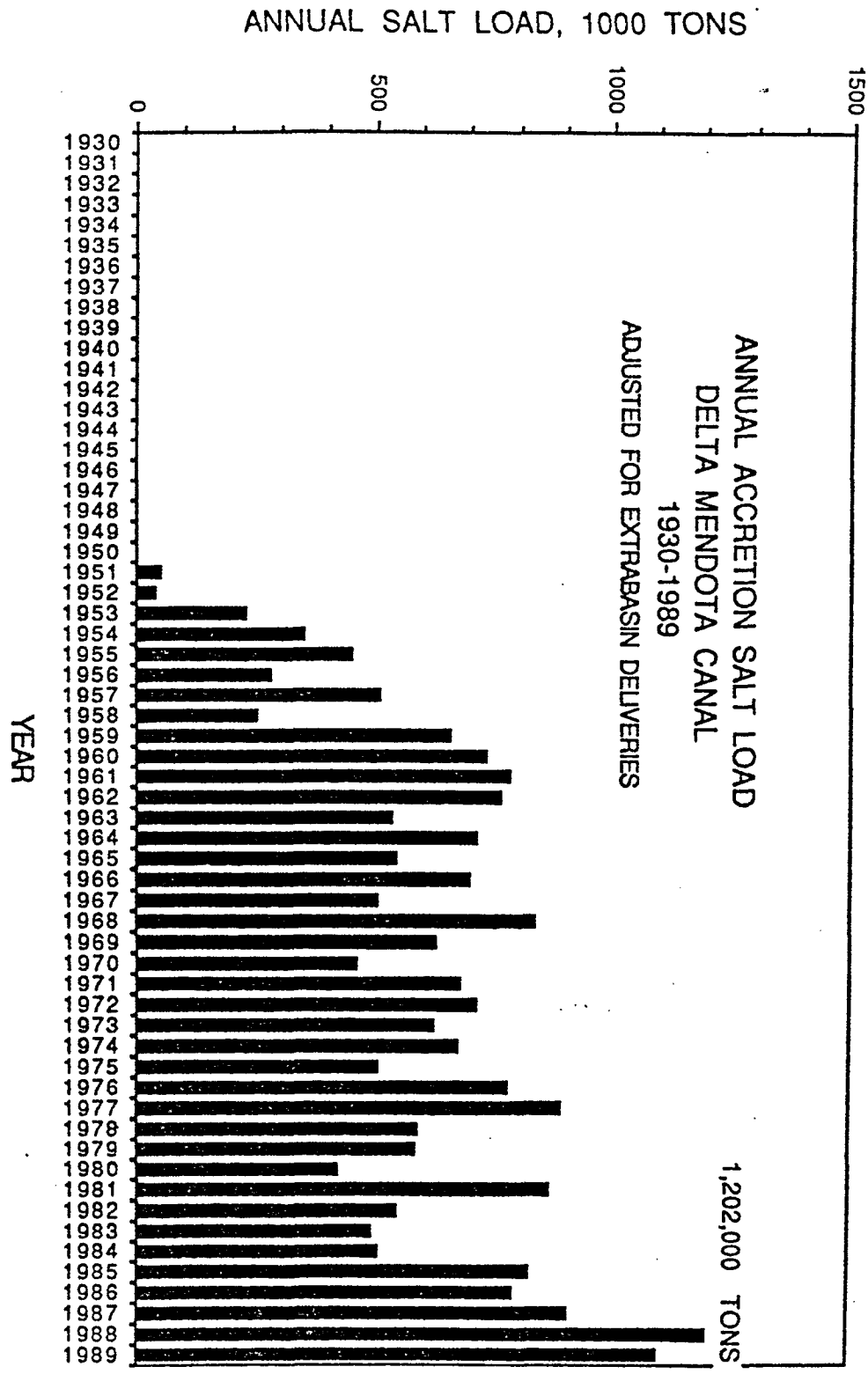

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SDWA-WQCP-21

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SUMMARY OF THE EFFECTS OF THE CVP ON THE QUANTITY AND QUALITY OF THE SAN JOAQUIN RIVER INFLOW TO THE SOUTHERN DELTA AT VERNALIS AVERAGE FOR DECADE OF THE 1960s

Item	Units	Year Classification			
		Dry	Below Normal	Above Normal	Wet
1. Post-CVP flow	1000 acre-feet				
A-S		190	246	1200	3639
O-M		695	1450	950	2836
Year		885	1696	2150	6475
2. Reduction in flow due to CVP	1000 acre-feet				
A-S		6.5	407*	572	760
O-M		109.0	136	350	633
Year		115.5	543	922	1393
3. Post-CVP TDS	mg/L				
A-S		673	683	326	225
O-M		418	284	461	308
Year		546	484	394	267
4. Reduction in Post-CVP TDS due to restoring CVP reduction in flow	mg/L				
A-S		21	395	89	30
O-M		50	20	111	47
Year		57	105	103	38
5. Increase in Salt Load due to CVP, through decade of 1960s	1000 tons				
A-S		58	77	21	43
O-M		44	52	19	27
Year		102	129	40	70
6. Reduction in Post-CVP TDS due to removal of CVP contribution to salt load increase	mg/l				
A-S		224	230	13	9
O-M		47	26	15	7
Year		85	56	14	8
7. Reduction in Post-CVP TDS due to restoring CVP flow reduction and removing CVP contribution to salt load increase	mg/L				
A-S		238	481**	98	37
O-M		90	44	121	53
Year		132	148	113	45
8. TDS that would have existed on the average in the absence of the CVP	mg/L				
A-S		435	202	228	188
O-M		328	240	340	255
Year		414	336	281	222

Notes:

1. Based on Tables V-2 through V-17 for decade of 1960s
2. From Table V-21, using average values over the ranges indicated
3. From Table VI-13
4. Reduction = Post-CVP TDS - $\frac{\text{Post-CVP flow x Post-CVP TDS + 50 x CVP flow reduction}}{\text{Post-CVP flow + CVP flow reduction}}$

   $= (3) - \frac{(1) \times (3) + 50 \times (2)}{(1) + (2)}$
5. From Table VI-34; Average Increase Caused by CVP in 1960s; Pre-CVP salt load = $\frac{\text{Salt Load Increase}}{\text{Percent of Pre-CVP}} \times 100$
6. Reduction = $\frac{\text{Salt Load Increase Due to CVP}}{1.36 \times \text{Post-CVP flow}} = \frac{(5) \times 1000}{1.36\ (1)}$
7. Reduction = Post-CVP TDS - $\frac{\text{Post-CVP flow x Post-CVP TDS - Salt Load Incr./1.36 + 50 x CVP flow reduction}}{\text{Post-CVP flow + CVP flow reduction}}$

   $= (3) - \frac{(1) \times (3) - (5) \times 1000/1.36 + 50 \times (2)}{(1) + (2)}$
8. TDS without CVP = Post-CVP TDS - Reduction due to CVP = (3) - (7)

* Flow reduction for an average "below normal" year in the April--September period; this may be high for the single "below normal" year (1966) that occurred in the 1960s

** This estimate is probably high for the reason given above (*). The actual effect would probably not exceed about 385 mg/L.

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✓ GMC · Amend WRC

SOUTH DELTA WATER AGENCY

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July 15, 1997

Ms. Stacey Gianoli
State Water Resources Control Board
Bay-Delta Division
P. O. Box 100
Sacramento, CA 95812-0100

Re: South Delta Channel Depletion Requirements
Development of 1995 WQCP EIR

Dear Ms. Gianoli:

Enclosed please find the channel depletion requirements for the South Delta for all months except July as developed by Mr. Jerry Orlob, Engineer for SDWA. As we discussed, the calculation for these amounts is predicated on the South Delta tidal barriers being installed and operated. The channel depletion amounts for the South Delta in the absence of the barriers are unknown but would be higher.

It is my understanding that you have the amounts for the month of July, as they are included in an exhibit to the Draft Contract between SDWA, USBR, and DWR which seeks to settle the 1982 lawsuit. These amounts for other months were produced at the request of USBR during our ongoing negotiations. It is my understanding that USBR and DWR would agree that these numbers are accurate because SDWA's engineer developed them from the calculations set forth in the Draft Contract. However, I do not believe DWR or USBR have confirmed their accuracy.

Very truly yours,

BREWER, PATRIDGE & HERRICK
Attorneys At Law

By _____
JOHN HERRICK

JH/dd
Enclosure
cc: Mr. Al Candlish, Bureau of Reclamation
Mr. Fred Bachman, DWR

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TABLE 2 MINIMUM REQUIRED FLOWS FOR THE SOUTH DELTA WATER AGENCY

Mean Monthly Flows, cubic feet per second

Month	Inside Barrier	Total SDWA	At Vernalis
Jan	169	234	573
Feb	111	154	483
Mar	151	209	548
Apr	293	406	745
May	368	519	849
Jun	586	785	1124
Jul	765	1051	1400*
Aug	717	995	1334
Sep	518	718	1057
Oct	406	563	902
Nov	303	420	759
Dec	274	380	719

* Vernalis base flow for evaluation of barrier performance includes 339 cfs flushing flow in addition to channel depletion requirements.

Plan Prorate
PRSM B33

Oct-Sep Frcst (TAF) From	To	OID/SSJID (TAF) From	To
0	600	200	600
600	6000	600	600
6000	N/A	600	600
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Mar-Sep Frcst Plus Feb. EOM Storage (TAF) From	To	Annual Fish Release (TAF) From	To
0	1400	0	98
1400	2000	98	135
2000	2500	135	309
2500	3000	309	467
3000	6000	467	467

Mar-Sep Frcst Plus Feb. EOM Storage (TAF) From	To	Max. Ann WQ Release (TAF) From	To
0	1400	0	70
1400	2000	70	80
2000	2500	80	150
2500	3000	150	250
3000	6000	250	250

Mar-Sep Frcst Plus Feb. EOM Storage (TAF) From	To	Max. Ann BD Fsh Rel (TAF) From	To
0	1400	0	0
1400	2000	0	0
2000	2500	0	0
2500	3000	1000	1000
3000	6000	1000	1000

Mar-Sep Frcst Plus Feb. EOM Storage (TAF) From	To	Annual CSJ Deliv. (TAF) From	To
0	1400	0	0
1400	2000	0	0
2000	2500	0	49
2500	3000	80	80
3000	6000	80	80

Mar-Sep Frcst Plus Feb. EOM Storage (TAF) From	To	Annual SEWD Div (TAF) From	To
0	1400	0	0
1400	2000	0	0
2000	2500	0	10
2500	3000	20	20
3000	6000	10	10

Mar-Sep Frcst Plus Feb. EOM Storage (TAF) From	To	Increased WQ Standard (Ratio) From	To
0	1400	1	1
1400	2000	1	1
2000	2500	1	1
2500	3000	1	1
3000	6000	1	1

Range From	To	Name	Counts
0	1400	Low	5
1400	2000	Med-Low	20
2000	2500	Med	22
2500	3000	Med-High	13
3000	6000	High	11
		Sum	71

Max. Release Below Goodwin In CF 1500

Goodwin Rel. Data		
Avg. Ann. (TAF)		409
Max. Ann. (TAF)		0
Min. Ann. (TAF)		0

Minimum Storage (TAF)	80

Avg. Ann. Spill (TAF)	87

OID/SSJID Deliveries		
Avg. Ann. (TAF)		582
No. of Years >=	500	56

Stanislaus Instream Fish		
No. of Years >=	90.0	66
No. of Years >=	155.0	45
No. of Years >=	400.0	14
No. of Years >=	450.0	0

WQ (Comprd to Specified Stndrds)	
Avg. Ann. Deficit (TAF)	20
Avg. Ann. Deficit in Deficient Yrs. (TAF)	46
Max. Ann. Deficit in Deficient Yrs. (TAF)	101
Min. Ann. Deficit (TAF)	0
Deficient Yrs. Count	31

WQ	
Sep-Mar Target (PPM)	650
Apr-Aug Target (PPM)	455
Avg. Ann. Deficit (TAF)	20
Avg. Ann. Deficit in Deficient Yrs. (TAF)	46
Max. Ann. Deficit in Deficient Yrs. (TAF)	101
Min. Ann. Deficit (TAF)	0
Deficient Yrs. Count	31

BD Flow	
Avg. Ann. Deficit (TAF)	55
Avg. Ann. Deficit in Deficient Yrs. (TAF)	76
Max. Ann. Deficit in Deficient Yrs. (TAF)	209
Min. Ann. Deficit (TAF)	0
Deficient Yrs. Count	51

CVP Deliveries		
Avg. Ann. Delivery (TAF)		35
No. of Years >=	10.0	44
No. of Years >=	20.0	38
No. of Years >=	49.0	24
No. of Years >=	80.0	24

Optional Diversions		
Avg. Ann. Delivery (TAF)		7
No. of Years >=	10.0	24
No. of Years >=	20.0	13
No. of Years >=	50.0	0
No. of Years >=	75.0	0

TESTIMONY OF JERRY ROBINSON
BEFORE THE STATE WATER RESOURCES CONTROL BOARD

I am Jerry Robinson and I am a farmer in San Joaquin County with acreage located on Roberts Island, Union Island, Rio Blanco Tract, and also some acreage in the Lathrop area. I have lived in the area since 1944 and farmed with others or on my own for 35 years.

I am currently the President of the South Delta Water Agency, the Vice President of the Delta Water Users Association, and am on the Board of Directors of Reclamation Districts 544 and 2114.

I am a riparian diverter drawing water from Middle River and Old River and am familiar with the flows on the waterways through the Delta channels in my area, especially those bordering the properties I farm. I have seen the changes in those flows due to the addition of the State and Federal Projects' export pumps.

Either currently or in the past, I have grown alfalfa, wheat, corn, safflower, and oat hay. In order to adequately irrigate these crops, I divert water from March through October and typically have pre-irrigation during the months of November, December, January and February. Depending on the amount of rainfall and flow in the channels, diversions for irrigations can occur at any time of the year and not just those months that I listed above. Depending on availability of water, we flood various fields in order to help flush the salts out of the ground that has accumulated due to the high saline water coming down the San Joaquin River.

As you know from previous hearings and workshops, the export pumps seriously change the flows in the South Delta. Those pumps drop water levels up to two feet, cause reverse flows, and create stagnant or null zones. The results from this can be very serious. Lower water levels can actually prevent the operation of syphons and pumps. The intakes of these syphons and pumps obviously cannot be resting on the channel bed, and since they are not easily moved, the water can drop below the pumps intake. Of course, when the channels of the rivers become dry, it is not possible to pump any water. In addition, even if the pump can still pull water, lower water levels can and do cause cavitation and/or will result in sand being sucked into the pumps both of which stress the pumps and wear them out sooner then normal. All of these things have occurred to me personally as well as my neighbors.

You are also aware of the poor quality and diminished flow now coming down the San Joaquin River. Though we have had a year of excess runoff, that does not change the fact that at some times the flow of water entering the South Delta is insufficient to satisfy riparian and other channel depletion needs. I believe Mr. Alex Hildebrand of the South Delta Water Agency has or is giving you specific information on these matters.

You are also aware that the Bureau of Reclamation does not always release a sufficient amount of water from New Melones to meet the Vernalis standard, even though that is a condition of its permits. During certain year types especially during the recent drought, the

Bureau was unable to or chose not to release sufficient amounts of water in order to meet the Vernalis water quality standard.

During the time that WR 95-6 has been in effect, I have continued to experience difficulties in diverting water when necessary. As you may recall, last year was a wet year even though there was little if any rainfall after the January storms. During summer months as well as fall months, there were various times when water levels dropped to the point where they interfered with my need to divert water for irrigation purposes. In the fall, three factors affect your ability to divert water. The first of course is that the export pumps, depending on their rate of export, impair the ability of incoming tides to raise water levels to normal depths. The second is the amount of flow coming down the San Joaquin River. As this Board may recall, the South Delta Barrier Program attempts to address these issues by trapping incoming tidal flows. However, those tidal barriers are only adequate when they are operating and if a certain amount of flow is coming down the San Joaquin River.

The third thing that affects our ability to divert is the existence of the Head of Old River fish barrier. As the Board recalls, the fish barrier attempts to redirect out migrating Salmon smelts away from the State and Federal pumps and move them towards the Central Delta, hoping to increase their survivability. At the current time, the South Delta is attempting to insure that each year the Head of Old River Barrier is installed (or on a permanent basis) it will allow sufficient flow of the San Joaquin River to continue on to Old River and Middle River in order to insure that sufficient amounts of water are available for riparian diverters.

Last year I recall that sufficient flow normally did pass through the Head of Old River barrier so that our problems with diversions were much rarer than before (though the problems did occur). In the prior year (1996), an insufficient amount of water was allowed to pass through the barrier, and we experienced extreme conditions. During the fall timeframe, there were regular periods when parts of Old River and Middle River were dry. You should note that I am not overstating this, and it's not that there was some water in the river, but that portions of the rivers were actually dry with no water available. [I regret not having kept complete records, but attached to my written testimony are Exhibits SDWA 25 which are photographs of a few of these instances.] Obviously, if the Head of Old River barrier does not allow water to pass through, and if the export pumps are at a certain rate, and if the tide is going out, the net effect is that levels of water in Middle and Old River will be lowered to the extreme. Unfortunately for agricultural diverters like myself, that extreme turns out to be no water in the river. It is my understanding that the Board and other parties in their various analyzes of the effects on diverters such as myself, assume that the irrigation season lasts from approximately April through August or September. Such an assumption is specifically wrong and should be corrected. Without any doubt, the lowered water levels in Middle and Old River in 1996 adversely affected my ability to irrigate my crops and specifically caused decreases in yields.

I believe it raises a serious issue that the Department of Fish and Game and the Fish and Wildlife Service take no action to remedy this. A dry Delta channel cannot be good for fish and wildlife (whether endangered or not). It certainly is not good for any other beneficial use.

Although the South Delta Water Agency continues to seek solutions to this problem, I believe it is ultimately this Board's responsibility to insure that riparian diverters such as myself are protected. I realize that there are all sorts of arguments as to who and how much water upstream can be used or should be allowed to pass, but I would like to bring the Board's attention to the Delta Protection Act. That Act found in the Water Code at 12200 et seq. requires the State and Federal projects to provide a sufficient amount of water in the Delta for current and future beneficial uses including agriculture. I therefore request that this Board insure that whatever action it takes in these proceedings or in any other proceedings, those provisions of the Delta Protection Act are enforced as well as our riparian rights. Since it is my understanding that this first phase of hearings deals with whether or not WR 95-6 should be extended, I respectfully request the Board insure that any such extension contain additional restrictions on the actions of the State and Federal projects so that Delta riparians are not injured. I do not think the riparian diverters should have to argue or prove injury or potential injury. The burden should be on the project, each and every day, to show they will not harm us. Isn't that what the law requires?

Through my participation in the South Delta Water Agency, I understand that in the last three years the Bureau and the State have asked the Board to approve a joint point of diversion in order to make up for lost exports. In each of those instances, the Bureau and the State represented to the Board that their make-up pumping would result in no harm to Delta interests. It is my firm belief, based on my daily agricultural activities, that the operations of the projects in the last three years have resulted in decreased crop yields due to water shortages. I am not familiar with the specific months each year in which the projects were allowed to conduct make-up pumping, however I do believe that at least some of the problems I regularly experienced in fall months occurred during make-up pumping operations.

Regardless of any addition harm caused by the make-up pumping, I also request that the Board insure that "normal" export operations under any extension of WR 95-6 also make sure that local diverters are not harmed.

Attached to my written testimony as Exhibits SDWA 26 are copies of letters SDWA's attorney has provided which indicate the various correspondence over the past few years regarding make-up pumping and its effect on local diverters.

Thank you for your time, and I am available for questions by the Board or other parties in these proceedings.

Dated:

Jerry Robinson

C:\SDWA\Comments\Robinson, Jerry, water right hearings

STATE OF CALIFORNIA
[illegible]
STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER RIGHTS

PERMIT FOR DIVERSION AND USE OF WATER

AMENDED PERMIT 16597

Application 14858A of U. S. Department of the Interior, Bureau of Reclamation, Region 2

2800 Cottage Way, Sacramento, CA 95825

filed on June 16, 1952, has been approved by the State Water Resources Control Board SUBJECT TO VESTED RIGHTS and to the limitations and conditions of this Permit.

Permittee is hereby authorized to divert and use water as follows:

1. Source: Stanislaus River — Tributary to: San Joaquin River

2. Location of point of diversion:	40-acre subdivision of public land survey or projection thereof	Section	Township	Range	Base and Meridian
New Melones Dam - North 29°34' East, 1,075 feet from SW corner of Section 11	SW¼ of SW¼	11	1N	13E	MD

Counties of Calaveras and Tuolumne

3. Purpose of use:	4. Place of use:	Section	Township	Range	Base and Meridian	Acres
Irrigation	within the counties of					
Domestic	Stanislaus, Calaveras,					
Municipal	Tuolumne and San Joaquin					
Industrial						
Recreational	New Melones Reservoir		3N	14E	MD	
Water Quality and	and downstream reaches of		2N	13E	MD	
Preservation and Enhance-	the Stanislaus and San		2N	13E	MD	
ment of Fish and Wildlife	Joaquin Rivers		1N	13E	MD	
			1N	14E	MD	

The place of use is shown on map filed with the State Water Resources Control Board.

WRCB 14 (11-72)

SDWA 38

C—115519

C-115519

5. The water appropriated shall be limited to the quantity which can be beneficially used and shall not exceed 980,000 acre-feet per annum by storage to be collected from November 1 of each year to June 30 of the succeeding year. (0000008)

This permit does not authorize collection of water to storage outside of the specified season to offset evaporation and seepage losses or for any other purpose.

6. The amount authorized for appropriation may be reduced in the license if investigation warrants. (0000006)

7. Complete application of the water to the proposed use shall be made on or before December 1, 1990. (0000009)

8. Permittee shall allow representatives of the State Water Resources Control Board and other parties as may be authorized from time to time by said Board reasonable access to project works to determine compliance with the terms of this permit. (0000011)

9. Progress reports shall be submitted promptly by Permittee when requested by the State Water Resources Control Board until license is issued. (0000010)

10. Pursuant to California Water Code Sections 100 and 275, all rights and privileges under this permit and under any license issued pursuant thereto, including method of diversion, method of use, and quantity of water diverted, are subject to the continuing authority of the State Water Resources Control Board in accordance with law and in the interest of the public welfare to prevent waste, unreasonable use, unreasonable methods of use, or unreasonable method of diversion of said water.

The continuing authority of the Board may be exercised by imposing specific requirements over and above those contained in this permit with a view to minimizing waste of water and to meeting the reasonable water requirements of Permittee without unreasonable draft on the source. Permittee may be required to implement such programs as (1) reusing or reclaiming the water allocated; (2) using water reclaimed by another entity instead of all or part of the water allocated; (3) restricting diversions so as to eliminate agricultural tailwater or to reduce return flow; (4) suppressing evaporation losses from water surfaces; (5) controlling phreatophytic growth; and (6) installing, maintaining, and operating efficient water measuring devices to assure compliance with the quantity limitations of this permit and to determine accurately water use as against reasonable water requirements for the authorized project. No action will be taken pursuant to this paragraph unless the Board determines, after notice to affected parties and opportunity for hearing, that such specific requirements are physically and financially feasible and are appropriate to the particular situation. (0000012)

11. In compliance with Fish and Game Code Section 5943, Permittee shall accord to the public, for the purpose of fishing, reasonable right of access to the waters impounded by the dam under this permit during the open season for the taking of fish, subject to the regulations of the Fish and Game Commission. (0030064)

12. Permittee shall install and maintain an outlet pipe of adequate capacity in his dam as near as practicable to the bottom of the natural stream channel, or provide other means satisfactory to the State Water Resources Control Board, in order that water entering the reservoir which is not authorized for appropriation under this permit may be released. (0050043)

13. In accordance with the requirements of Water Code Section 1393, Permittee shall clear the site of the reservoir of all structures, trees and other vegetation which would interfere with the use of the reservoir for water storage and recreational purposes. This provision, however, shall not preclude the Permittee from retaining vegetation cover in selected areas as required for the protection of wildlife. Clearing operations shall be coordinated with authorized increases in storage levels. (0120050)

14. Rights under this permit are, and shall be, subject to existing rights determined by the Stanislaus River Adjudication, Superior Court, San Joaquin County dated November 14, 1929, Action No. 16873 with supplemental decrees dated February 24, 1930; March 8, 1934; May 8, 1935 and November 29, 1960, insofar as said adjudicated rights are maintained, and such other rights as may presently exist. (0000023)

15. The quantity of water diverted under this permit and under any license issued pursuant thereto is subject to modification by the State Water Resources Control Board if, after notice to the Permittee and an opportunity for hearing, the Board finds that such modification is necessary to meet water quality objectives in water quality control plans which have been or hereafter may be established or modified pursuant to Division 7 of the Water Code. No action will be taken pursuant to this paragraph unless the Board finds that (1) adequate waste discharge requirements have been prescribed and are in effect with respect to all waste discharges which have any substantial effect upon water quality in the area involved, and (2) the water quality objectives cannot be achieved solely through the control of waste discharges. (0000013)

16. In order to prevent degradation of the quality of water during and after construction of the project, Permittee shall file a report pursuant to Water Code Section 13260 and shall comply with any waste discharge requirements imposed by the California Regional Water Quality Control Board, Central Valley Region Region, or by the State Water Resources Control Board. (0000300)

17. Permittee shall impound in new Melones Reservoir such water as is necessary to provide (a) not in excess of 98,000 acre-feet per annum for the preservation and enhancement of fish and wildlife to be released at a rate specified by the California Department of Fish and Game, plus (b) such additional water as is necessary to maintain the water quality conditions set forth in Paragraph 19. The above amounts are in addition to water stored for satisfaction of prior rights at existing Melones Reservoir and for flood control. The Board reserves jurisdiction for the purpose of establishing dry year criteria. (0400500)

18. Permittee shall file with the Board a reservoir operation study showing the water level elevations required to provide the yield specified in Paragraph 17. A reservoir operation schedule shall be submitted by the Permittee which shall be subject to approval of the Board. The study shall be updated at least once every five years until further order of the Board. (0490500)

19. Releases of conserved water from New Melones Reservoir for water quality control purposes shall be scheduled so as to maintain a mean monthly total dissolved solids concentration in the San Joaquin River at Vernalis of 500 parts per million or less and a dissolved oxygen concentration in the Stanislaus River as specified in Water Quality Control Plan (interim), San Joaquin River Basin 5c, State Water Resources Control Board, June 1971.

In the event that the water quality control plan (interim) is amended or superseded, the foregoing water quality objectives shall be modified to conform to then current criteria. (0000500)

20. The State Water Resources Control Board reserves jurisdiction over this permit for the purpose of revising water release requirements for water quality objectives and fish releases and for establishing dry year criteria pursuant to studies to be conducted by the Permittee and other parties in an effort to better define water needs. (0000600)

21. Permittee shall file with the Board at least biennially a report of water diversions and use along the Stanislaus River and San Joaquin River between New Melones Dam and the Vernalis Gage which will show any increased diversions subsequent to the beginning of releases of water under this permit, which diversions may be encroaching on the water supply provided for preservation and enhancement of fish and wildlife and for water quality control, and will show what steps, if any, Permittee is taking to prevent any such encroachment. (0110700)

22. Permittee shall file with the Board an annual report showing (a) daily storage level in New Melones Reservoir, (b) daily record of total dissolved solids at Vernalis, and (c) daily record of minimum dissolved oxygen level for the day at Ripon or at an alternate location approved by the Board. (0110700)

23. This permit shall be subject to appropriation by storage upstream from New Melones Reservoir for stockwatering and recreational purposes, provided the individual capacities of reservoirs for such purposes do not exceed 10 acre-feet and the reservoirs are kept free of phreatophytes. (0460800)

24. This permit shall be subject to the following agreements between the Permittee and other parties:

(A) The "Agreement and Stipulation" dated October 24, 1972 and executed by the Permittee, Oakdale Irrigation District and South San Joaquin Irrigation District.

(B) The agreement between the Permittee and Tuolumne County Water District No. 2 dated November 29, 1972.

(C) The agreement dated July 31, 1972 between Permittee and Calaveras County Water District. (0000077)

Reference to the above three agreements shall not be construed as a finding by the State Water Resources Control Board with respect to the rights of any of the parties involved.

25. This permit does not authorize the use of any water outside the counties of origin which is necessary for the development of the counties. (0000800)

26. Permittee shall consult with the Division of Water Rights and the Department of Water Resources, and develop and implement a water conservation plan or actions. The proposed plan or actions shall be presented to the Board for approval by March 8, 1984. A progress report on the development of a water conservation plan may be required by the Board within this period. (0000029)

27. Before making any change in the project determined by the State Water Resources Control Board to be substantial, Permittee shall submit such change to the Board for its approval in compliance with Water Code Section 10504.5 (A). (0000119)

This permit is issued and permittee takes it subject to the following provisions of the Water Code:

Section 1390. A permit shall be effective for such time as the water actually appropriated under it is used for a useful and beneficial purpose in conformity with this division (of the Water Code), but no longer.

Section 1391. Every permit shall include the enumeration of conditions therein which in substance shall include all of the provisions of this article and the statement that any appropriator of water to whom a permit is issued takes it subject to the conditions therein expressed.

Section 1392. Every permittee, if he accepts a permit, does so under the conditions precedent that no value whatsoever in excess of the actual amount paid to the State therefor shall at any time be assigned to or claimed for any permit granted or issued under the provisions of this division (of the Water Code), or for any rights granted or acquired under the provisions of this division (of the Water Code), in respect to the regulation by any competent public authority of the services or the price of the services to be rendered by any permittee or by the holder of any rights granted or acquired under the provisions of this division (of the Water Code) or in respect to any valuation for purposes of sale to or purchase, whether through condemnation proceedings or otherwise, by the State or any city, city and county, municipal water district, irrigation district, lighting district, or any political subdivision of the State, of the rights and property of any permittee, or the possessor of any rights granted, issued, or acquired under the provisions of this division (of the Water Code).

Dated: JULY 25 1983

STATE WATER RESOURCES CONTROL BOARD

Chief, Division of Water Rights

WRCB 14-2 (1-79)

C—115522

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER RIGHTS

PERMIT FOR DIVERSION AND USE OF WATER

AMENDED PERMIT 16600

Application 19304 of U. S. Department of the Interior, Bureau of Reclamation, Region 2

2800 Cottage Way, Sacramento, CA 95825

filed on March 11, 1960, has been approved by the State Water Resources Control Board SUBJECT TO VESTED RIGHTS and to the limitations and conditions of this Permit.

Permittee is hereby authorized to divert and use water as follows:

1. Source: Stanislaus River

Tributary to: San Joaquin River

2. Location of point of diversion:	40-acre subdivision of public land survey or projection thereof	Section	Township	Range	Base and Meridan
New Melones Dam - North 29°34' East, 1,075 feet from SW corner of Section 11	SW¼ of SW¼	11	1N	13E	MD

Counties of Calaveras and Tuolumne

3. Purpose of use:	4. Place of use:	Section	Township	Range	Base and Meridan	Acres
Irrigation	within the counties of					
Domestic	Stanislaus, Calaveras,					
Municipal	Tuolumne and San Joaquin					
Industrial						
Recreational	New Melones Reservoir		3N	14E	MD	
Water Quality and	and downstream reaches of		2N	13E	MD	
Preservation and Enhance-	the Stanislaus and San		2N	14E	MD	
ment of Fish and Wildlife	Joaquin Rivers		1N 1N	13E 14E	MD MD	

The place of use is shown on map filed with the State Water Resources Control Board.

WRCB 14 (11-72)

C-115523

C-115523

5. The water appropriated shall be limited to the quantity which can be beneficially used and shall not exceed 1,420,000 acre-feet per annum by storage to be collected from November 1 of each year to June 30 of the succeeding year.

This permit does not authorize collection of water to storage outside of the specified season to offset evaporation and seepage losses or for any other purpose. (0000005)

6. The amount authorized for appropriation may be reduced in the license if investigation warrants. (0000006)

7. Complete application of the water to the proposed use shall be made on or before December 1, 1990. (0000007)

8. Permittee shall allow representatives of the State Water Resources Control Board and other parties as may be authorized from time to time by said Board reasonable access to project works to determine compliance with the terms of this permit. (0000008)

9. Progress reports shall be submitted promptly by Permittee when requested by the State Water Resources Control Board until license is issued. (0000010)

10. Pursuant to California Water Code Sections 100 and 275, all rights and privileges under this permit and under any license issued pursuant thereto, including method of diversion, method of use, and quantity of water diverted, are subject to the continuing authority of the State Water Resources Control Board in accordance with law and in the interest of the public welfare to prevent waste, unreasonable use, unreasonable methods of use, or unreasonable method of diversion of said water.

The continuing authority of the Board may be exercised by imposing specific requirements over and above those contained in this permit with a view to minimizing waste of water and to meeting the reasonable water requirements of Permittee without unreasonable draft on the source. Permittee may be required to implement such programs as (1) reusing or reclaiming the water allocated; (2) using water reclaimed by another entity instead of all or part of the water allocated; (3) restricting diversions so as to eliminate agricultural tailwater or to reduce return flow; (4) suppressing evaporation losses from water surfaces; (5) controlling phreatophytic growth; and (6) installing, maintaining, and operating efficient water measuring devices to assure compliance with the quantity limitations of this permit and to determine accurately water use as against reasonable water requirements for the authorized project. No action will be taken pursuant to this paragraph unless the Board determines, after notice to affected parties and opportunity for hearing, that such specific requirements are physically and financially feasible and are appropriate to the particular situation. (0000012)

11. In compliance with Fish and Game Code Section 5943, Permittee shall accord to the public, for the purpose of fishing, reasonable right of access to the waters impounded by the dam under this permit during the open season for the taking of fish, subject to the regulations of the Fish and Game Commission. (0000014)

12. Permittee shall install and maintain an outlet pipe of adequate capacity in his dam as near as practicable to the bottom of the natural stream channel, or provide other means satisfactory to the State Water Resources Control Board, in order that water entering the reservoir which is not authorized for appropriation under this permit may be released. (0000013)

13. In accordance with the requirements of Water Code Section 1393, Permittee shall clear the site of the reservoir of all structures, trees and other vegetation which would interfere with the use of the reservoir for water storage and recreational purposes. This provision, however, shall not preclude the Permittee from retaining vegetation cover in selected areas as required for the protection of wildlife. Clearing operations shall be coordinated with authorized increases in storage levels. (0000030)

14. Rights under this permit are, and shall be, subject to existing rights determined by the Stanislaus River Adjudication, Superior Court, San Joaquin County dated November 14, 1929, Action No. 16873 with supplemental decrees dated February 24, 1930; March 8, 1934; May 8, 1935 and November 29, 1960, insofar as said adjudicated rights are maintained, and such other rights as may presently exist. (0000023)

15. The quantity of water diverted under this permit and under any license issued pursuant thereto is subject to modification by the State Water Resources Control Board if, after notice to the Permittee and an opportunity for hearing, the Board finds that such modification is necessary to meet water quality objectives in water quality control plans which have been or hereafter may be established or modified pursuant to Division 7 of the Water Code. No action will be taken pursuant to this paragraph unless the Board finds that (1) adequate waste discharge requirements have been prescribed and are in effect with respect to all waste discharges which have any substantial effect upon water quality in the area involved, and (2) the water quality objectives cannot be achieved solely through the control of waste discharges. (0490300)

16. In order to prevent degradation of the quality of water during and after construction of the project, Permittee shall file a report pursuant to Water Code Section 13260 and shall comply with any waste discharge requirements imposed by the California Regional Water Quality Control Board, Central Valley Region Region, or by the State Water Resources Control Board. (0490300)

17. Permittee shall impound in new Melones Reservoir such water as is necessary to provide (a) not in excess of 98,000 acre-feet per annum for the preservation and enhancement of fish and wildlife to be released at a rate specified by the California Department of Fish and Game, plus (b) such additional water as is necessary to maintain the water quality conditions set forth in Paragraph 19. The above amounts are in addition to water stored for satisfaction of prior rights at existing Melones Reservoir and for flood control. The Board reserves jurisdiction for the purpose of establishing dry year criteria. (0490300)

18. Permittee shall file with the Board a reservoir operation study showing the water level elevations required to provide the yield specified in Paragraph 17. A reservoir operation schedule shall be submitted by the Permittee which shall be subject to approval of the Board. The study shall be updated at least once every five years until further order of the Board. (0490300)

19. Releases of conserved water from New Melones Reservoir for water quality control purposes shall be scheduled so as to maintain a mean monthly total dissolved solids concentration in the San Joaquin River at Vernalis of 500 parts per million or less and a dissolved oxygen concentration in the Stanislaus River as specified in Water Quality Control Plan (interim), San Joaquin River Basin 5c, State Water Resources Control Board, June 1971.

In the event that the water quality control plan (interim) is amended or superseded, the foregoing water quality objectives shall be modified to conform to then current criteria. (0490300)

20. The State Water Resources Control Board reserves jurisdiction over this permit for the purpose of revising water release requirements for water quality objectives and fish releases and for establishing dry year criteria pursuant to studies to be conducted by the Permittee and other parties in an effort to better define water needs. (0490300)

21. Permittee shall file with the Board at least biennially a report of water diversions and use along the Stanislaus River and San Joaquin River between New Melones Dam and the Vernalis Gage which will show any increased diversions subsequent to the beginning of releases of water under this permit, which diversions may be encroaching on the water supply provided for preservation and enhancement of fish and wildlife and for water quality control, and will show what steps, if any, Permittee is taking to prevent any such encroachment. (0490300)

22. Permittee shall file with the Board an annual report showing (a) daily storage level in New Melones Reservoir, (b) daily record of total dissolved solids at Vernalis, and (c) daily record of minimum dissolved oxygen level for the day at Ripon or at an alternate location approved by the Board. (0490300)

23. This permit shall be subject to appropriation by storage upstream from New Melones Reservoir for stockwatering and recreational purposes, provided the individual capacities of reservoirs for such purposes do not exceed 10 acre-feet and the reservoirs are kept free of phreatophytes.

24. This permit shall be subject to the following agreements between the Permittee and other parties:

Application 19304 Permit 16600

(A) The "Agreement and Stipulation" dated October 24, 1972 and executed by the Permittee, Oakdale Irrigation District and South San Joaquin Irrigation District.

(B) The agreement between the Permittee and Tuolumne County Water District No. 2 dated November 29, 1972.

(C) The agreement dated July 31, 1972 between Permittee and Calaveras County Water District.

Reference to the above three agreements shall not be construed as a finding by the State Water Resources Control Board with respect to the rights of any of the parties involved. [illegible]

25. This permit does not authorize the use of any water outside the counties of origin which is necessary for the development of the counties. [illegible]

26. Permittee shall consult with the Division of Water Rights and the Department of Water Resources, and develop and implement a water conservation plan or actions. The proposed plan or actions shall be presented to the Board for approval by March 8, 1984. A progress report on the development of a water conservation plan may be required by the Board within this period. [illegible]

This permit is issued and permittee takes it subject to the following provisions of the Water Code:

Section 1390. A permit shall be effective for such time as the water actually appropriated under it is used for a useful and beneficial purpose in conformity with this division (of the Water Code), but no longer.

Section 1391. Every permit shall include the enumeration of conditions therein which in substance shall include all of the provisions of this article and the statement that any appropriator of water to whom a permit is issued takes it subject to the conditions therein expressed.

Section 1392. Every permittee, if he accepts a permit, does so under the conditions precedent that no value whatsoever in excess of the actual amount paid to the State therefor shall at any time be assigned to or claimed for any permit granted or issued under the provisions of this division (of the Water Code), or for any rights granted or acquired under the provisions of this division (of the Water Code), in respect to the regulation by any competent public authority of the services or the price of the services to be rendered by any permittee or by the holder of any rights granted or acquired under the provisions of this division (of the Water Code) or in respect to any valuation for purposes of sale to or purchase, whether through condemnation proceedings or otherwise, by the State or any city, city and county, municipal water district, irrigation district, lighting district, or any political subdivision of the State, of the rights and property of any permittee, or the possessor of any rights granted, issued, or acquired under the provisions of this division (of the Water Code).

Dated: JULY 25 1983

STATE WATER RESOURCES CONTROL BOARD

Chief, Division of Water Rights

WRCB 14-2 (1-79)

C-115526

C-115526

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER RIGHTS

ORDER

APPLICATION 19304 PERMIT 16600 LICENSE

ORDER APPROVING THE ADDITION OF
POINTS OF REDIVERSION AND AMENDING THE PERMIT

WHEREAS:

1. A petition to add points of rediversion on the Stanislaus River has been filed with the State Water Resources Control Board.

2. The Board has determined that the petitioned changes do not constitute the initiation of a new right nor operate to the injury of any other lawful user of water.

NOW, THEREFORE, IT IS ORDERED THAT:

1. Paragraph 2 of this amended permit regarding points of diversion is amended to read as follows:

   Point of Diversion:

   New Melones Dam: North 29° 34' East, 1,075 feet from SW corner of Section 11, T1N, R13E, MDB&M, being within SW¼ of SW¼ of said Section 11.

   Points of Rediversion:

   1) Goodwin Dam: North 10° West, 2,825 feet from SE corner of Section 10, T1S, R12E, MDB&M, being within SE¼ of NE¼ of said Section 10.
   2) Knights Ferry Diversion Dam: North 24° 20' West, 3,000 feet from SE corner of Section 21, T1S, R12E, MDB&M, being within SW¼ of NE¼ of said Section 21.
   3) Tracy Pumping Plant: North 481,100 and East 1,694,500, California Coordinate System, Zone 3, being within E½ of projected Section 29, T1S, R4E, MDB&M.
   4) Points of rediversion on the Stanislaus River between:
      (a) New Melones Dam: North 29° 34' East, 1,075 feet from SW corner of Section 11, T1N, R13E, MDB&M, and
      (b) San Joaquin River: within the NE¼ of Section 19, T3S, R7E, MDB&M.

   No rediversion of stored water from this reach of the Stanislaus River for beneficial use under this permit shall be made until a description of the location of each point of rediversion and statement of the quantity of water to be rediverted is filed with the State Water Resources Control Board.

2. Paragraph 10 of this amended permit is deleted. A new Paragraph 10 is added as follows:

   Pursuant to California Water Code Sections 100 and 275, and the common law public trust doctrine, all rights and privileges under this permit and under any license issued pursuant thereto, including method of diversion, method of use, and quantity of water diverted, are subject to the continuing authority of the State Water Resources Control Board in accordance with law and in the interest of the public welfare to protect public trust uses and to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of said water.

133 (2-83)

The continuing authority of the Board may be exercised by imposing specific requirements over and above those contained in this permit with a view to eliminating waste of water and to meeting the reasonable water requirements of permittee without unreasonable draft on the source. Permittee may be required to implement a water conservation plan, features of which may include but not necessarily be limited to: (1) reusing or reclaiming the water allocated; (2) using water reclaimed by another entity instead of all or part of the water allocated; (3) restricting diversions so as to eliminate agricultural tailwater or to reduce return flow; (4) suppressing evaporation losses from water surfaces; (5) controlling phreatophytic growth; and (6) installing, maintaining, and operating efficient water measuring devices to assure compliance with the quantity limitations of this permit and to determine accurately water use as against reasonable water requirements for the authorized project. No action will be taken pursuant to this paragraph unless the Board determines, after notice to affected parties and opportunity for hearing, that such specific requirements are physically and financially feasible and are appropriate to the particular situation. The continuing authority of the Board also may be exercised by imposing further limitations on the diversion and use of water by the permittee in order to protect public trust uses. No action will be taken pursuant to this paragraph unless the Board determines, after notice to affected parties and opportunity for hearing, that such action is consistent with California Constitution Article X, Section 2; is consistent with the public interest and is necessary to preserve or restore the uses protected by the public trust.

3. Paragraph 27 is added to this amended permit as follows:

   This order shall not be construed as conferring upon the permittee the right of access to the points of rediversion. (000022)

4. Paragraph 28 is added to the amended permit as follows:

   Until further order of the Board, use of water under this amended permit is authorized only in the counties of Stanislaus, Calaveras, Tuolumne and San Joaquin. (000300)

Dated: AUGUST 9 1985

Raymond Walsh

Raymond Walsh, Chief
Division of Water Rights

Cal/EPA

State Water Resources Control Board

Division of Water Rights

Mailing Address:
P.O. Box 2000
Sacramento, CA
95812-2000

901 P Street
Sacramento, CA
95814
(916) 657-1931
FAX (916) 657-1485

Pete Wilson
Governor

JUNE 30 1997

In Reply Refer to:341:SO:14858A

Mr. John Herrick
South Delta Water Agency
P.O. Box 70383
Stockton, CA 95267

Dear Mr. Herrick:

PERMITS 16597, 16598, 16599, 16600, AND 20245 (APPLICATIONS 14858A, 14859, 19303, 19304, AND 14858B) STANISLAUS RIVER IN CALAVERAS, TUOLUMNE, AND STANISLAUS COUNTIES

This is in response to your letter dated May 22, 1997 requesting copies of notifications received by our office from the U. S. Bureau of Reclamation (Bureau) each time that the Bureau failed to meet the Vernalis water quality standard. Enclosed are copies of the Bureau's notifications in our files regarding their failure to meet the total dissolved solids monthly average at Vernalis as set forth in Decision 1422.

If you have any questions, please write or call Shige Okada of my staff at (916) 657-1931.

Sincerely,

Gerald E. Johns

for Edward C. Anton, Chief
Division of Water Rights

Enclosures

EXHIBIT SDWA 40

Recycled Paper

Our mission is to preserve and enhance the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations.

United States Department of the Interior

BUREAU OF RECLAMATION
Mid-Pacific Regional Office
2800 Cottage Way
Sacramento, California 95825-1898

IN REPLY REFER TO:

MP-2800
RES-9.00

JUL 19 1994

With DRB

10/24/94
Met with Roger Johnson, Tom Hu
Jerry Johns & Barbara Leidigh. Con
cluded that no reply to this lett
is necessary.
DRB.

Mr. Edward C. Anton
Chief, Division of Quality and Water Rights
State Water Resources Control Board
PO Box 2000
Sacramento, California 95810

Subject: Water Quality Standards for San Joaquin River near Vernalis

Dear Mr. Anton:

This is to inform you that the monthly mean of total dissolved solids (TDS) at the San Joaquin River gage near Vernalis exceeded the value of 500 parts per million (ppm) as required by Order 5 of Decision 1422 for the months of February, March, and June of 1994. These monthly data are as follows:

TDS Levels at Vernalis and Goodwin Releases			
Month	February	March	June
Monthly Mean TDS (ppm)	538	529	516
Goodwin Release Monthly Total in thousands of acre-feet	15.0	51.9	28.5

Throughout this period our operational decisions have been strongly affected by the knowledge that the storage in New Melones reservoir is low, and as we progressed through this runoff season it became clear that the season's inflow would not affect a recovery in New Melones storage levels. Although this situation has caused us to develop an operational strategy that has been conservative in terms of attempting to save water we have done a creditable job of meeting the monthly 500 ppm TDS level at Vernalis.

February's average TDS level was affected by the need to reduce Goodwin releases from 300 ft^3/s (the required fishery flow that month) to under 200 ft^3/s for a one week period to allow for completion of construction in the Goodwin pool. This was coordinated between Tri-Dam Project, U.S. Fish and Wildlife Service, California Department of Fish and Game, and South Delta Water Agency.

Early in both March and June TDS levels exceeded the standard. As the initial days of these months passed we increased Goodwin releases but the quality of water in San Joaquin above the confluence with the Stanislaus progressively degraded. By the time we "caught up" with this degrading water quality meeting the monthly standard would have required releases which would resulted in daily TDS levels at Vernalis considerably lower than the 500 ppm standard and would have used considerable quantities of New Melones water. We did maintain a sub-500 ppm TDS level for the last half of each of these months.

If you have any questions, please call Lloyd Peterson of my staff at (916) 978-5230.

Sincerely,

Lowell F. Ploss

Lowell F. Ploss
Chief, Central Valley Project Water
and Power Operations Office

cc: David Whitridge
Counsel, South Delta Water Agency
504 Bank of Stockton Building
311 East Main Street
Stockton CA 95202

Alex Hildebrand
Farmer
South Delta Water Agency
23443 South Hays Road
Manteca CA 95336

United States Department of the Interior

BUREAU OF RECLAMATION
Mid-Pacific Regional Office
2800 Cottage Way
Sacramento, California 95825-1898

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

MP-2800
RES-3.20

Mr. Edward C. Anton
Chief, Division of Quality and Water Rights
State Water Resources Control Board
P.O. Box 2000
Sacramento CA 95810

Subject: Total Dissolved Solids, San Joaquin River near Vernalis (Water Quality)

Dear Mr. Anton:

This is to inform you that the monthly mean of total dissolved solids (TDS) for the San Joaquin River near Vernalis exceeded the value of 500 parts per million (ppm) for March and February of 1993. This exceeded the limit of 500 ppm as described in Order 5 of Decision 1422. The monthly means are:

TDS Levels on the San Joaquin River at Vernalis (ppm) - 1993				
Month	January	February	March	April
Level	338	569	652	402

The TDS levels in May have been far better than the standard (average for the month 263 ppm as of May 20). This is primarily due to the large spring pulse flows for fishery purposes.

We have had and continue to have regular discussions with Mr. Alex Hildebrand, of the South Delta Water Agency, on the Vernalis TDS level. In the interest of conserving water and because of the wet weather (which allowed the South Delta users to forego pumping), we did not attempt to meet the standard during February and March. This decision was coordinated with Mr. Hildebrand and made with his concurrence.

As the pulse flow is discontinued in June, the TDS level will again rise and we expect to be required to augment San Joaquin River flow with New Melones releases for the rest of the summer. We will be communicating regularly with Mr. Hildebrand in this effort with the goals of providing quality water and conserving New Melones storage.

If you have any questions, please call Mr. Lloyd E. Peterson at (916) 978-5230.

Sincerely,

Lowell F. Ploss

Lowell F. Ploss
Chief, Central Valley Operations
Coordinating Office

cc: Mr. David Whitridge
Wilson, Hoslett & Whitridge
504 Bank of Stockton Building
311 East Main Street
Stockton CA 95202

Mr. Alex Hildebrand
23443 S. Hayes Road
Manteca CA 95336

United States Department of the Interior

BUREAU OF RECLAMATION
MID-PACIFIC REGIONAL OFFICE
2800 COTTAGE WAY
SACRAMENTO, CALIFORNIA 95825-1898

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IN REPLY REFER TO:
MP-2800
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JAN 27 1992

RECEIVED
JAN 31 1992
EXECUTIVE OFFICE

Mr. Walter G. Pettit
Executive Director
State Water Resources Control Board
PO Box 2000
Sacramento CA 95810

Subject: Total Dissolved Solids, San Joaquin River near Vernalis (Water Quality)

Dear Mr. Pettit:

This letter is to inform you that the total dissolved solids (TDS) for the San Joaquin River near Vernalis will most likely exceed a monthly average of 500 parts per million (ppm) for January 1992. This will exceed the limits of 500 ppm as described in Order 5 of Decision 1422.

As of January 23, 1992, the monthly average was approximately 548 ppm. The monthly average TDS for December was 485 ppm. Last season, we released approximately 50,000 acre-feet of water for the maintenance of water quality at the Vernalis stream gauge. Minimum releases from the New Melones Reservoir were due to the very low inflow last year and the continuing dry conditions. Storage in New Melones is currently 330,000 acre-feet, 53,000 acre-feet less than the storage last year at this time.

We have had several discussions with Mr. Alex Hildebrand of the South Delta Water Agency regarding water quality. Mr. Hildebrand has indicated he did not feel that TDS levels, as high as in the order of 550 ppm, would not pose any problems to the South Delta Water Agency through the winter, and that available water supplies for water quality maintenance be rescheduled to later this year. He is concerned that if water supplies in the San Joaquin River improve just enough to provide a full supply to upstream irrigators, salts stored during the last 5 years of drought may be released at a rapid rate to the San Joaquin River, causing high TDS values at Vernalis. He would then want as much water as possible available for dilution purposes. On January 21, we talked to Mr. Hildebrand and informed him that the TDS values were approaching 600 ppm. He informed us that he would still prefer that the remaining water in storage be saved for later use.

If you should have any questions, please call Mr. David M. Haisten at (916) 978-5230.

Sincerely,

ACTING FOR
Roger K. Patterson
Regional Director

2-7-92

C-115534

C-115534

cc: Mr. David Whitridge
Wilson, Hoslett & Whitridge
504 Bank Of Stockton Building
311 East Main Street
Stockton CA 95202

Mr. Alex Hildebrand
23443 S. Hays Road
Manteca CA 95336

United States Department of the Interior

BUREAU OF RECLAMATION
MID-PACIFIC REGIONAL OFFICE
2800 COTTAGE WAY
SACRAMENTO, CALIFORNIA 95825-1898

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FILES

IN REPLY REFER TO:
MP-2800
RES-3.20

NOV 2 1990

Delivery 14858

Mr. Jesse Diaz
Chief, Division of Water Quality and Water Rights
State Water Resources Control Board
PO Box 2000
Sacramento CA 95810

Subject: Total Dissolved Solids at Vernalis (Water Quality)

Dear Mr. Diaz:

This letter is to inform you that we will not be making water quality releases from New Melones Reservoir to meet 500 parts per million (ppm) monthly average total dissolved solids (TDS) at Vernalis. The only releases from New Melones Reservoir will be the minimum flows required for fish and wildlife habitat requirements. If the average daily TDS should exceed 700 ppm, the need for additional water quality releases will be reevaluated.

New Melones Reservoir storage is in critical condition, and we have been working closely with all users to conserve water while maintaining acceptable flows. Unless water is conserved this year, and we have an above-normal water year, a high probability exists that New Melones storage will drop to the minimum power pool in 1991. South Delta Water Agency (SDWA) has relaxed their quality and quantity requirements at Vernalis this year. SDWA has requested that no additional releases be made from their water quality release account until next irrigation season as long as the daily TDS is below 700 ppm. Their efforts could result in a savings of approximately 55,000 acre-feet. Due to the extremely low storage level in New Melones Reservoir, we believe that it is more beneficial to conserve the remaining water quality supply for the benefit of all the users in future years. We will continue to closely monitor the quality at Vernalis and will promptly notify SDWA if the average daily TDS exceeds 700 ppm. If you should have any questions, please contact Paul Fujitani at (916) 978-5232.

Sincerely,

Donald L. Paff

Donald L. Paff
Chief, Central Valley Operations
Coordinating Office

cc: David Whitridge
Wilson, Hoslett and Whitridge
504 East Main Street
Stockton CA 95202

State of California

Memorandum

To : Walt Pettit
Roger Johnson

Date : JUN 2 7 1983

Jerry Johns
Assistant Division Chief
From : DIVISION OF WATER RIGHTS
STATE WATER RESOURCES CONTROL BOARD

Subject: COMPLIANCE WITH VERNALIS WATER QUALITY STANDARDS

Paul Fujitani of the Bureau of Reclamation (978-5232) called today to inform us that the Bureau will not be meeting the 500 TDS requirement at Vernalis for June. Evidently, fairly high salt levels were experienced earlier this month. To obtain the 500 mg/l TDS would require salinities around 400 TDS for the remainder of the month. The Bureau has talked to Alex Hildebrand. According to them, Alex stated that the South Delta Water Agency will not complain provided the Bureau meets a daily TDS of about 500 mg/l.

Mr. Fujitani also stated that the Bureau intends to try to meet 500 TDS only on a daily basis but not on the monthly average as set forth in Decision 1422. They will not concern themselves with meeting the monthly standard. I stated that this is a significant policy issue that the Division needs to address and we may communicate to the Bureau the need to make their operations of New Melones more consistent with D 1422. I stated I would discuss this issue with you next week and get back to them as soon as possible on the State Board's position.

cc: Dave Beringer
Glenn Mork
Files (A 14858)

United States Department of the Interior

BUREAU OF RECLAMATION
MID-PACIFIC REGIONAL OFFICE
2800 COTTAGE WAY
SACRAMENTO, CALIFORNIA 95825-1898

TAKE PRIDE IN AMERICA

cc: JT
DEB

IN REPLY
REFER TO:
MP-2800
RES-3.20

JAN 2 1990

Mr. Walter G. Pettit
Chief, Division of Water Rights
State Water Resources Control Board
PO Box 2000
Sacramento CA 95810

Enclosures

Subject: Total Dissolved Solids at Vernalis (Water Quality)

Dear Mr. Pettit:

This letter is to inform you that the total dissolved solids (TDS) at Vernalis will most likely exceed a monthly average of 500 ppm for December. As of December 28, the monthly average was approximately 563 ppm. The monthly average TDS for November was 509 ppm. We have discussed the November figure with Mr. Jerry Johns of the State Water Resources Control Board and Mr. Alex Hildebrand of the South Delta Water Agency and neither felt the quality would pose problems.

Mr. Hildebrand did indicate that if the dry conditions continue, early irrigation may require improved water quality. However, until additional water quality releases are required for irrigation or additional water is required to meet minimum San Joaquin River flow at Vernalis, we anticipate only releasing water for fishery releases, power, and possibly flood control. The water quality releases of 70,000 acre-feet (af) and 150,000 af were exhausted in April and September, respectively. The minimum releases are due in part to the dry year we are currently experiencing and our limited storage at New Melones Reservoir. The New Melones storage is at about 757,000 af, less than at this time last year and approximately 31 percent of capacity.

If you should have any questions, please call Paul Fujitani at (916) 978-5232.

Sincerely,

NEIL W. SCHILD
ACTING REGIONAL DIRECTOR

cc: Mr. Dave Whitridge
Wilson, Hoslett & Whitridge
504 Bank of Stockton Building
311 East Main Street
Stockton CA 95202

1-25-90

INTRODUCTION

The purpose of this Introduction is to explain the southern Delta's water problems, to summarize the southern Delta's water requirements, to outline the agricultural importance of needs in the southern Delta, to explain why a large portion of the water requirements in the southern Delta must be met with Stanislaus River water, and to emphasize the fact that the proposed "water quality releases" from New Melones Reservoir would provide only a small portion of the required flows.

I.

The Southern Delta

The southern Delta is an area lying in the southeastern part of the Sacramento - San Joaquin Delta containing about 148,000 acres. There are about 75 miles of river channels in that area. This portion of the Delta is now included within the boundaries of the South Delta Water Agency (South Delta Water Agency Act, Stats. 1973, c. 1089, sec. 9.1).

II.

Lands In The Southern Delta

The lands in the southern Delta are primarily of a silty - loam type. There is very little "peat" land in this area. Most of the land is at or near sea level. Agriculture is the primary use of the lands in the southern Delta.

Due to a combination of favorable climate, fertile soil and an adequate supply of water of suitable quality, the southern Delta has historically produced in abundance a wide variety of crops.

Irrigation for agriculture in the southern Delta has been provided, primarily, from the water in the numerous channels in the area. To irrigate the lands, water is pumped from the channels, the crops are surface irrigated and the drainage water is returned to the channels. The productive capacity of the lands (both with regard to variety and yields) in the southern Delta is now

jeopardized by a water supply which has been, and is, deteriorating in both quality and quantity. A reduction in crop yield and versatility as a result of a reduction in the quality or quantity of the water supply is economically disastrous. A ten percent (10%) reduction in yield of a given crop may be the difference between profit and loss. The economics of agriculture are such that a reduction in crop versatility reduces the opportunity for profitable production and thereby the value of the land itself.

III.

Nature of the Water Problem In The Southern Delta

The in-channel water supply in the southern Delta is primarily controlled by the inflow of the San Joaquin River at Vernalis. The western and northern portions of the southern Delta are influenced by Sacramento River flows as these flows come across the Delta. The degree of the influence of the Sacramento River is to a large extent determined by the volume of the San Joaquin River inflows and the volume of water exported by State and Federal Projects near Tracy (where water is pumped from the Delta into the Delta Mendota Canal and the California Aqueduct).

The water problem in the southern Delta is an insufficient in-channel supply of water of suitable quality to meet the needs of the lands in that area. The quantity and quality of the in-channel water supply are interrelated in an inseparable manner.

Over the last 30 or more years since the commencement of CVP operations in about 1944, the operation of water projects on the San Joaquin River system and water uses in the San Joaquin Valley upstream from Vernalis have diminished the flow in the lower San Joaquin River. At the same time, the return flows which come back into the San Joaquin River from the water used on lands in the San Joaquin Valley bring with them the salts leached from the lands. This water is reused as it comes down the San Joaquin River and each time some of the quantity is diminished by the use and more salts are leached from the soils and added by the return flows to the diminishing quantity of water in the San Joaquin River. Thus when the lower San Joaquin River enters the southern Delta at Vernalis, the quantity of water has been diminished and the salts are concentrated therein. At present, these diminished flows in the San Joaquin River bring into the southern Delta channels about 1,000,000 tons of salt a year. The result is an in-channel water supply which is both insufficient in quantity and an unsuitable quality for use on the lands in the southern Delta.

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It is difficult to determine precisely the degree to which the Central Valley Project has contributed to the greatly diminished flows and increased salt content of the lower San Joaquin River. This difficulty stems from the complex hydraulics and hydrology of the San Joaquin River System, the lack of accurate data on other diversions from the river system, the seasonal fluctuations, the time delays in return water and salt flows, etc. However, it is clear that the deterioarting effect is substantial.

The State Water Resources Control Board (SWRCB) found in Decision 1422 (at p. 11) that TDS exceeded 500 ppm in the San Joaquin River at Vernalis 38% of the time during the irrigation season. The salt concentration (measured as parts per million of total dissolved solids) is appreciably greater in extensive portions of southern Delta channels than it is at Vernalis.

The operation of the Federal and State export pumps near Tracy also has an adverse impact upon the in-channel water supply in the southern Delta. The operation of those pumps lowers the mean water levels in the channels connected to the pump in-takes in order to create the hydraulic gradient which supplies the flow of water to the pumps. The lowering of the in-channel water levels reduces the volume of inflow of tidal waters into the many miles of southern Delta channels with the consequence that there is less in-channel water available at low tides, water levels at times become inadequate for irrigation pump drafts, water quality is degraded because there is less salt removed by tidal flushing, and stagnant zones are created where there is neither adequate tidal flushing nor a net daily unidirectional flow. The adverse impact resulting from the operation of the export pumps upon the fishery seems to be acknowledged, but little attention, if any, has been given to the adverse impact of the operation of the export pumps upon the agricultural water supply in the southern Delta.

The river channels in the southern Delta are near or below sea level. When the incoming flow in the San Joaquin River during the summer irrigation season is low, it often does not equal, or does not substantially exceed, the water being consumptively used in the southern Delta for irrigation. As a result, there is often an insufficient volume and flow in the channels in the southern Delta to carry the salty water through the Delta to the ocean. The salty water, or a considerable portion of it, remains trapped in the southern Delta where it is reused again and again causing further deterioration in quality and reduction in quantity. At times the water levels in the channels fall below adequate depths for pumping.

Speaking primarily from the standpoint of agriculture, an insufficient in-channel water supply of less than suitable quality causes two distinct types of damage. These may be summarized as follows:

a) Damage to crops:

1. Poor quality water (too much salt) reduces crop yields (production) and reduces crop diversity (the number of crops which can be successfully produced).

2. Insufficient water supply (quantity) reduces crop yields.

b) Damage to lands:

When crops are irrigated, a large portion of the irrigation water is consumed by the plant or evaporates. When the irrigation water is of poor quality (salty), this process leaves a residue of salt in the ground. As the process is repeated, the residue of salt increases and the land is in time ruined - turned into a salt marsh not capable of either abundant or diverse production of crops.

Both types of damage are now occurring in the southern Delta and will continue at an increasing rate unless the water problem in the southern Delta is solved in the very near future.

The solution to the water problem in the southern Delta must recognize the relationship between the quantity and the quality of the inflows. There must be an adequate quantity of water of suitable quality in the San Joaquin River flowing into the southern Delta to permit diversions for beneficial uses and to carry the salt brought in by the San Joaquin River through the Delta and into the ocean - a net daily downstream flow, over and above diversions, of water of suitable quality.

IV.

WATER REQUIREMENTS OF THE SOUTHERN DELTA

To maintain the agricultural economy of the southern Delta, there must be a water flow in lower San Joaquin River channels coming into the Delta sufficient to provide, first, the 400,000 to 500,000 acre feet of good quality water needed

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annually for irrigation diversions, and second, sufficient carrier water to convey upstream San Joaquin River salts through the Delta. These salts cause serious degradation of water quality within the southern Delta when concentrated by the agricultural evapotranspiration to which southern Delta lands are entitled. There must, therefore, be enough carrier water to convey this incoming salt through the southern Delta at concentrations which will not diminish agricultural productivity. The total flow must, accordingly, be well over a million acre feet per year, of which about 400,000 to 500,000 acre feet are consumptively used with the remainder available for export at the Tracy pumps, Delta outflow, and other beneficial uses, including fish and wildlife.

The proposed "water quality release" from New Melones is now stated to be a maximum of 70,000 acre feet in any year and an estimated average of only about 17,000 acre feet per year (see: page IV - 52 and 53, Folsom South - Lower American River Alternatives Special Report dated November, 1975, prepared by the Bureau of Reclamation). A release of 70,000 acre feet annually from New Melones would not solve the water problem in the southern Delta. A 17,000 acre feet release annually would produce almost no measureable beneficial result.

To satisfy the water requirements of the southern Delta, a substantial amount of the water for such purpose must come from New Melones. The reasons for this may be summarized as follows:

a) To provide the water from the Delta - Mendota Canal (DMC), via the Westley Wasteway into the San Joaquin River, a pumping lift (from the Delta into the DMC) of over 200 feet is required. For this, about 289 kilowatt-hours of electricity would be required to pump 1 acre-foot.

b) The amount of water from the DMC to dilute San Joaquin River water at Vernalis would be much greater than the amount of water from New Melones for such purpose because of the poorer quality of DMC water. It is estimated that with the Peripheral Canal in operation, about 27,000 acre-feet of DMC water would be needed to accomplish the same "quality" result as 17,000 acre/feet of New Melones water; without the Peripheral Canal, about 75,000 acre/feet of DMC water would be needed for the same result.

c) Expressed as a ratio, to accomplish the same "quality" purpose, if water is released from the DMC rather than from New

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Melones, about 1.5 times as much water must be released if there is a Peripheral Canal, and over 4 times as much if there is no Peripheral Canal. Corresponding amounts of energy would be about 4.9 million and 21.6 million kilowatt-hours respectively (See page IV - 53, "Folsom South - Lower American River Alternatives", Special Report, dated November, 1975, prepared by the Bureau of Reclamation).

Another important reason why New Melones water must be used relates to the agricultural requirements of the southern Delta. The control of monthly average salt concentration in the channels to acceptable levels could probably be accomplished, although inefficiently, from sources other than New Melones, but the control of short term fluctuations can not. Permissible short term peak salt concentrations are somewhat higher than permissible monthly averages, but must be controlled because young plants can be killed or stunted by even a single saline irrigation. It is feasible to provide short term salinity control with high quality Stanislaus water released from New Melones and introduced at Vernalis. On the other hand, control would be extremely difficult to achieve with saltier Delta Mendota Canal water introduced with more time delay via the channel of the salty San Joaquin River south of Vernalis.

An additional reason for the use of New Melones water is that, if the fishery is to be provided with San Joaquin River system water in southern Delta channels at certain times of the year, then all agricultural water during those periods must also originate from San Joaquin River system sources.

The maintenance of 500 mg/l TDS water quality in the San Joaquin River only at Vernalis, only on a monthly average basis, does not satisfy the southern Delta's requirements - it does not even come close. A 17,000 acre feet average annual release (or even a 70,000 acre feet annual peak release) introduced at Vernalis can have no significant beneficial effect on water quality for most of the southern Delta's water users. There are about 75 miles of channel, and diversions occur throughout. Water quality must be improved in all of the channels of the lower San Joaquin River and the southern Delta, not just at a single location at Vernalis.

The in-channel water supply in the southern Delta serves many uses and purposes. The improvement of the water quality and an increase in the flows of the channels of the southern Delta will serve a number of additional beneficial uses. For example, fish and wildlife would be benefited, the quality of the

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water at the Tracy pumps would be improved, the concentration of salt in the San Joaquin River would be reduced and carried through the Delta and into the San Francisco Bay, greater portions of the necessary Delta outflow would be provided by the San Joaquin River, downstream users would be benefited, etc.

It is clear that the southern Delta's water requirements are important and substantial; that they can most efficiently be satisfied with New Melones releases; that a substantial portion of the needs must be met with Stanislaus water; that the water quality problem of the southern Delta is caused by factors beyond the southern Delta's control, and that the use of New Melones water in the southern Delta optimizes the multiple use of that water.

IV.

BASIC MINIMUM WATER QUALITY REQUIREMENTS OF THE SOUTHERN DELTA IN A NORMAL YEAR

After two and one-half years of intensive study and negotiations with the U.S. Bureau of Reclamation and the State Department of Water Resources, the SDWA has concluded that the southern Delta must have an in-channel water supply in normal years which meets the following water quality criteria:

Three-day running average of daily mean values at Vernalis not to exceed	500 ppm TDS
Thirty-day running average of daily mean values in all principal channels not to exceed	450 ppm TDS
Water year average of monthly mean values in all principal channels not to exceed	400 ppm TDS

CONCLUSION

The water problems of the Delta may be best solved by the execution by the various Delta Water Agencies (including the SDWA) of contracts with the United States and the State which will firmly assure in an enforceable manner a dependable, suitable and adequate water supply in the channels of the Delta within the boundaries of those Agencies. The negotiating parties to such contracts are best equipped to undertake this task and achieve a satisfactory result.

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Such a result will protect the Delta's"priority" to its water supply. The State Water Resources Control Board, together with other interested governmental agencies, should provide all the assistance and encouragement within its power toward this objective.

In closing this introduction, it must be emphasized that the southern Delta must not enter another year without the firm assurance that it will have an adequate and suitable in-channel water supply to which it is entitled. The experiences of the summer of 1976 should make this clearly evident to everyone.

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CROP	AVERAGE SDWA ACREAGE 1971-75	YIELD BASIS (% OF POTENTIAL)	IRRIGATION WATER QUALITY REQUIRED [1]					
			Requirement per U.C. Exhibit 2 (Uniform soil and "as needed" irrigation frequency)		Requirement with allowance for soil variability		Requirement with variable soil an with a 4 day del in alternate irrigations from "as needed" schedule	
			Field-average Leach Ratio [2] (% of applied water)	Irrigation Water Quality Needed	Corresponding minimum LR for 90% of Typical Field [3]	Irrigation Water Quality Needed		
COLUMN A	B	C	D	E	F	G	H	
		%	%	EC (TDS)	%	EC (TDS)	(TDS)	
Alfalfa	27,900	100	10	1.0 (640)	7.4	0.7 (450)	Better than 450	
		100	10 (annual average with zero June July, Aug. and 2 irrigations/mon.)	Better than 1.0 (640)	7.4	Better than 0.7 (450)	Better than 450	
		90	5	1.0 (640)	3.8	0.64 (410)	Better than 410	
		90	5 (see note above)	Better than 1.0 (640)	3.8	Better than 0.64 (410)	Better than 410	
Tomatoes	17,200	100 90	15 6	1.7 (1080) 1.0 (640)	11. 4.4	1.5 (960) 0.75 (480)	Better than 900 Better than 450	
Sugar Beets	12,800	100	15	4.7	11.			
Beans	9,400	100 90	16 10	0.7 (450) 0.7 (450)	12. 7.4	0.62 (400) 0.63 (400)	Better than 400	Similar for carrots and strawberries
Corn	7,700	100 90	15 8	1.1 (700) .85 (550)	11. 6.	1.0 (640) 0.7 (450)	Better than 600 Better than 450	Similar for potatoes
Grapes		100 90	15 6	1.0 (640) 0.7 (450)	11. 4.4	0.75 (480) 0.55 (350)		
Nuts, peaches, apricots,	6,200	100 90	13 6.5	1.0 (640) 0.7 (450)	9.5 4.8	0.75 (480) 0.55 (350)		Similar for pears
Lettuce and onions		100	15	0.85 (540)	11.	0.75 (480)	Better than 480	
Seedlings Tomatoes Sugar Beets Onions Lettuce [4]	31,000	Good Survival and vigorous growth	The difficulty of achieving good survival increases as water qualities become poorer than 350 TDS and as necessary planting dates involve higher temperatures, winds, and low humidity. Depends also on facility with given soil of shaping and maintaining accurate seed bed shapes.					

1. All cases assume best common irrigation practices with flood and furrow irrigation, and reasonable provision of drain ditches and drainage pumps. All cases assume no long range salinity build up.
2. Average leach ratio, Col. D, determines input to groundwater. Removal of groundwater becomes more difficult when permissible groundwater levels must be below deep root zones and when elevations are near sea level.
3. U.C. Southern Delta Salinity Survey data*is assumed to be representative and is used to determine a leach ratio in Col. F which will be achieved or exceeded in 90% of a typical field which has the average leach ratio in Col. D. This Col. F leach ratio determines the crop yield for 90% of the field with full yield water quality.
4. Seedlings germinated with best established methods on raised row beds by furrow irrigation and planted at appropriate dates for crop.
5. Assumes adequate leach by irrigation, i.e., does not assume rain leach .

Abbreviations EC, TDS, LR are those used in U.C. Exhibit 2.
* See: Exhibit U.C. 7

EXHIBIT No. IV-E P. 1

SDWA 42

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RECD DEC 13 1976

Before The

STATE WATER RESOURCES CONTROL BOARD

STATE OF CALIFORNIA

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In the Matter of WATER QUALITY PLAN for the Protection of Beneficial Uses in the Sacramento-San Joaquin Delta and Suisun Marsh and Permit 12720 (Application 5625) and other Permits of the U. S. BUREAU OF RECLAMATION for the Federal Central Valley Project and of CALIFORNIA DEPARTMENT OF WATER RESOURCES for the State Water Project	Errata pg 12, 13, 50, 84, 86, 97, 105, [illegible]

San Joaquin County
Flood Control and
Water Conservation District
Office of County Counsel

---oOo---

Resources Building
Sacramento, California

---oOo---

TUESDAY, DECEMBER 7, 1976

9:00 A. M.

---oOo---

VOLUME XIV

SDWA 43

ALICE BOOK
CERTIFIED SHORTHAND REPORTER
P.O. BOX 710, COLUMBIA, CALIFORNIA 95310
PHONES: 916 457-7326 & 209 532-2018

C—115548

C-115548

TUESDAY, DECEMBER 7, 1976, 9:00 A.M.

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MR. BRYSON: Good morning.

MR. WILSON: Our next witness, Mr. Chairman, we are back to Mr. Hildebrand and he will be discussing for your reference primarily the areas covered in the binder that we have earlier handed out with the additional exhibits in Section Four.

He will be referring in some cases for illustrative purposes to exhibits that were in Section Five.

Mr. Hildebrand has been sworn and his first topic will be a discussion of an analysis of the water quality required primarily for agricultural requirements in the Southern Delta. He has some slides. I don't know whether he wants to commence with them.

MR. HILDEBRAND: Yes, I would like to start with the slides.

MR. WILSON: His testimony will be with reference to that so you will have a little background of the subject matter he is talking about. Mr. Hildebrand has been sworn.

Do you want to proceed?

MR. BRYSON: Mr. Wilson, let me interrupt for just a minute. As I look at Section Four of the materials you submitted, it appears that Section Four are recommendations of water quality that you feel are required. If that's the

case, it would be more appropriate for Phase II rather than Phase I.

MR. WILSON: Well, as we interpret it, in Phase I we wanted criteria. These are criteria which we believe are necessary to support agriculture. It ties into the testimony that we spent a good deal of time on with your consultants, the UC Committee, and our work is tied back to that for illustrative purposes. It can't very well be torn apart. We would like to present it now.

MR. BRYSON: Well, the notion is, that Phase II will build on the factual data developed in Phase I.

MR. WILSON: This is to support that criteria. We understood the issues as they were laid out that criteria was one and objective comes in Phase II. I do confess I have a hard time distinguishing.

MR. BRYSON: It's a little difficult to draw the line. We recognized that when we set up the phasing, but we thought it would be helpful to have the break.

MR. WILSON: But there's another reason that this becomes important. The Bureau and the Department of Water Resources' testimony also related to the water year and that also ties in with this. We would like to proceed. I don't think it will take too long and if in the Chairman and the Board's mind we are getting too far afield, I don't believe we are, then, of course, we will have to hold off.

1 MR. BRYSON: Let me seek the advice of the Staff
2 on this.
3 MR. CAMPOS: Mr. Chairman, Phase I, the subject for
4 Phase I is trying to get an idea of water quality criteria.
5 The first six factors make up the considerations of water
6 quality objectives. Three of these factors are to be con-
7 sidered in Phase I, beneficial uses, water quality conditions,
8 and water quality criteria. We are not looking for
9 recommendations as to water quality objectives in Phase I,
10 but we are looking for water quality criteria necessary
11 to protect beneficial uses at various levels.
12 MR. WILSON: In Phase I.
13 MR. CAMPOS: During Phase I.
14 MR. WILSON: That's what we want to talk about,
15 necessary to sustain agriculture in the Southern Delta.
16 MR. CAMPOS: But with this qualification, that we
17 are not looking at what level agriculture should necessarily
18 be sustained, but trying to get an idea at various levels
19 of protection, this would be the criteria necessary to
20 protect that beneficial use.
21 MR. WILSON: That's what we intend to set forth
22 and to describe.
23 MR. BRYSON: Well, I don't know -- Have you
24 reviewed Section Four there, Mike? It looks to me that
25 these appear to be recommendations.

1 MR. WILSON: This is what the Board, the South
2 Delta Board, has found. We have discussed this at great
3 length. It gets into definitions of water years. This is
4 necessary --
5 MR. BRYSON: All right, Mr. Wilson, if you can
6 identify the levels of agriculture associated with the
7 criteria that is set out, you may proceed.
8 (Thereupon MR. HILDEBRAND resumed the stand
9 and testified as follows:)
10 DIRECT EXAMINATION CONTINUED
11 By MR. WILSON:
12 Q Mr. Hildebrand, then do you want to proceed?
13 MR. HILDEBRAND: Will someone work the projector
14 for me? I have just a very few slides here to give you a
15 little visualization of the situation we are now experien-
16 cing. Could somebody douse the lights part way at least?
17 What we have here are just a very few examples of
18 the consequences of the kind of water we are using now.
19 This field here was planted to tomatoes, a late
20 planting for the green tomato market. It is on the east
21 side of the San Joaquin River near the river about, I
22 guess, halfway from Vernalis down to the Paradise
23 bifurcation. These tomatoes were planted and the seedlings
24 did not survive through a substantial portion of the field.
25 If you look particularly here, you find some

1 plants survived and in some areas there was almost complete
2 kill and in other areas they did somewhat better. The
3 operator of this field is a very competent successful
4 farmer. He is not an imprudent operator at all.
5 The consequences of this is that many of the plants
6 in the field did not survive at all. A good many of those
7 that did survive did not mature at the same time as the
8 others and in the present day you can't go through a field
9 and pick numerous times and those that aren't ready to
10 market when the rest of them are ready to market are just
11 wasted, so there's a very substantial crop loss in this
12 kind of situation.
13 May I have the next slide, please.
14 MR. TEERINK: When was that planted, Alex?
15 MR. HILDEBRAND: I can't give you the exact
16 planting date, but it was probably the first of July, maybe
17 a little before that.
18 MR. JOHNS: Were the fields around there using the
19 same water supply?
20 MR. HILDEBRAND: Yes.
21 MR. JOHNS: They seemed to be all green.
22 MR. HILDEBRAND: Yes, I can explain that. If you
23 want to go back to the other slide -- the main thing I am
24 depicting here is a seedling kill and we will talk about
25 the problem of seedling survival. Your established plants

can stand in general particularly in the vegetable crops, somewhat more salt than the seedlings can, plus the fact that it's more easy to avoid having salt concentrations in the root zone of deeper roots than the ones that are near the surface where you are getting surface evaporation.

Now these here were beets. Actually these beets were having a very serious problem when they were first terminated, but by dint of a great deal of operation from a lot of farmers, we were able to get some Stanislaus water return flow and pipe it all the way down here for this poor guy and bail him out on that. And once beets get through the seedling stage they are fairly salt-tolerant. It's a problem of getting them started.

This alfalfa field is an established alfalfa field and generally the salinities we get won't kill alfalfa, just retard its growth. You get substantial yield loss, but you don't see that in the picture very well. The picture can show you the seedling losses, it can show you the major variations in yield, and you do see that this is not a uniform situation. But in general it won't kill an established stand of alfalfa.

Furthermore, you would have to have a more on the ground analysis to say exactly what the situation was here and we didn't examine this field. We did examine this field and this one in some detail.

1 Going to the next slide, that picture was taken
2 in late July and there were some other pictures that I
3 will be showing were taken about a month later. This again
4 is a tomato field on the west side of the river.
5 And you can just see the very poor yield of the
6 tomatoes. This is merely taken at ground level so you can
7 see the consequences better. So this is just a disaster
8 for a man to have this kind of situation.
9 MRS. AUER: What year is that?
10 MR. HILDEBRAND: This year, 1976. All these were
11 taken in 1976.
12 MR. MACAULAY: When was this particular crop
13 planted?
14 MR. HILDEBRAND: Again, I don't have the exact
15 planting date.
16 MR. MACAULAY: I wondered how old the plants were?
17 MR. HILDEBRAND: This would have been planted some
18 time in June, probably fairly early June.
19 MR. MACAULAY: The plants were a month or two old
20 at that time?
21 MR. HILDEBRAND: Yes. You see the plants that got
22 through the seedling stage are somewhat larger.
23 Next slide, please. This is down on Middle Roberts.
24 This is Middle River here and here again is a beet field.
25 You can see the severe seedling kill that was experienced

1 here, but again the beets after they are established can
2 stand quite a bit of salt, so that this is a typical
3 situation that we saw this year in the beet fields.
4 There is a heavy loss on the seedling survival,
5 but those plants that got through the seedling stage didn't
6 do too badly.
7 Now to avoid this kind of situation, what some of
8 the growers are doing -- although these pictures were taken
9 this year, our salt situation was not greatly different
10 this year than in other recent years. The situation that
11 we have depicted over here is fairly common now except in
12 rather wet years.
13 By summer and fall we have so little flow in the
14 San Joaquin River and so much salt coming down that we
15 typically have these situations. So what has begun to
16 happen is that some of the beet growers start planting
17 their beets quite early because you have less of a seedling
18 problem early for two reasons. One is usually the water
19 quality is better early and the other is the weather being
20 cooler, you do not have as much surface evaporation and
21 you don't get the concentration of salts in the seedling
22 zone.
23 However, when the beet grower plants his beets too
24 early, he causes a problem both for himself and for others
25 relative to some virus problems. It's not a good thing to

1 plant beets that early and it creates severe problems to
2 distort the planting schedule by this means of getting by
3 with poor water on beets.
4 This is another tomato field and again you can see
5 the problem there, and in the case of tomatoes, they are not
6 as salt-tolerant as the beets, so that the problems go on
7 past the seedling stage to a considerable degree.
8 I don't recall what was in this field, but you can
9 see again that it was a pretty bad situation.
10 Now if you went out Wing Levee Road on Middle
11 Roberts, you would see a whole lot of fields that look like
12 this. These are not just isolated examples. I am only
13 showing you a few slides, but we would like to have presented
14 you with a portfolio of two or three dozen slides, but we
15 just couldn't afford to reproduce fifty copies.
16 One more, please. This picture was taken the 20th
17 of August. This is also on Middle Roberts. I show this,
18 this is the sort of thing we have seen before and I show
19 this to show you what's happening to a walnut grove. This
20 is a fairly young grove. The problems that result from a
21 situation where the farmer is caught between the fact that
22 if he doesn't leach heavily, he gets too much salt in the
23 root zone, and if he does leach heavily he gets too high
24 a water table and the walnuts being deep-rooted can't
25 stand the water table, so this field is being managed so

that he gets part of each trouble and you can see what it is doing to him.

If these were older trees the problem would be worse because of the deeper root system.

Next slide, please. This is a vineyard up near Vernalis. It is taken from a sufficiently great altitude in order to show the whole field so you can't see too well the close-up of the plants, but you can see there's a large variation in growth here from one area to another.

The main reason we show this picture is it illustrates the fact that our soils are not uniform. We get different results over the field, different ratios and consequently the water that might be all right down here is not all right here, and when we start talking about water quality to meet the agricultural needs of a field, a man can't stay in business if he can only grow his grapes down here. He has to be able to grow them over nearly all the field, so we will come back to that point.

I think we have one or two more, don't we? This is a cornfield on the east side of the San Joaquin River downstream -- well, I will put it the other way, it's upstream maybe three or four miles from the Paradise Cut bifurcation. You can see again the great variation in growth here.

This was a small field. The same operator has another field not far away that was planted at an earlier

1 date because this one had to wait for some grain to come
2 off. The other field looked pretty good. His yield wasn't
3 what it should have been but you wouldn't have visually
4 seen anything, but corn and some other plants, once it is
5 damaged like this, there's nothing you can do later on
6 that will give you a good yield.
7 You could have distilled water later and it still
8 wouldn't recover. The end result was that it only paid
9 him to harvest about two-thirds of the field and he would
10 have lost money even on that. It was a very poor crop.
11 That's all. That just gives you an illustration
12 with a few slides of the sort of thing we are talking about.
13 Now, of course, we don't contend that all of the
14 fields look that bad, but many of them did and again I come
15 back to the point that you only see the catastrophes in the
16 photo.
17 The alfalfa farmer who is getting two-thirds of
18 the crop he should get, you could look at the field and
19 you wouldn't know it.
20 MR. WILSON: Q Mr. Hildebrand, you have made an
21 analysis of the material presented by UC Extension Service
22 Committee and their report?
23 A Yes.
24 Q And with particular reference to the Southern
25 Delta soils and crops, is that correct?

1 A That's correct.
2 Q And is that for the purpose of ascertaining the
3 necessary water quality criteria to sustain those crops?
4 A That's correct.
5 Q Is that analysis set forth in Exhibit 5 E?
6 A That's right.
7 Q Mr. Chairman, it was in one of the exhibits that
8 was distributed yesterday, IV-E.
9 Would you discuss and explain that exhibit, Mr.
10 Hildebrand?
11 A Yes. Before discussing the calculations on that
12 exhibit, however, I would like to make some background
13 comments that relate to it.
14 In the first place, there is no precise answer to
15 the question of what water quality is needed in a channel.
16 There's not even a precise answer to the question of what
17 water quality is needed for a particular crop on a particular
18 field because there's so many variables, other matters.
19 Perhaps I could illustrate this by taking some hypothetical
20 answers that have fewer variables. Suppose you were asked
21 to determine how heavy a bean sack a farmer could lift off
22 the ground. This would depend a lot on various things, and
23 you couldn't come up with a precise answer, and suppose
24 further, you decide that the farmer must pick this up with
25 his right hand at the same time that he balances a stick

1 on his nose, juggles three balls with his left hand, and
2 kicks the dog that is biting his left ankle. That's more
3 comparable to the situation we are faced with.
4 The farmer is urged to use saline water, but he
5 must conserve engery, control the water table, control weeds,
6 have sufficient time between irrigations for cultural
7 harvest requirements; plant crops suitable to the soil,
8 climate and market; plant at seasons appropriate to the
9 crops and so on and so on.
10 Now many of these requirements are conflicting,
11 so you can't fully optimize any one of them.
12 And the question then comes down to what is a
13 reasonable expectation for his optimization of the uses of
14 saline water, and it can't be viewed logically independently
15 of the other requirements that are placed upon him in his
16 management.
17 He is faced with the very complex management
18 problem.
19 So there are two ways then that one might arrive
20 or approach the question of what is a reasonable water
21 quality to meet the needs of raising this farmer's crops.
22 The first approach which I think deserves con-
23 siderable credence is that people best able to determine
24 this are the farmers who utilize the best irrigation
25 practices that are found to be technically and economically

1 practicable in substantial commercial practice and
2 represents Southern Delta lands and crops.
3 Now it is these people and people like them else-
4 where who produce most of the food you eat. The ones who
5 are incompetent eventually go out of business and before
6 they do, they don't raise much food anyway.
7 Now 30 years ago the farmers in the Southern Delta
8 didn't have any experiences using saline water. They
9 didn't have to do it. You can see from these charts we
10 didn't have that kind of water in those days.
11 As the water quality began to average more than
12 about 350 parts per million TDS, the problems began to arise,
13 and about something like 10 years ago, there began to be
14 a pretty good concensus agmong the kind of farmers I
15 described, that 500 TDS was a reasonable maximum, but they
16 were not thinking of this as a figure they would have to
17 live with all the time.
18 They were thinking of it as an intermittent high,
19 not a sustained figure. And I think it's fair to say that
20 the prevalent view among the kind of farmers I described
21 is that 350 would be best, 500 should be tops, and the
22 average should lie somewhere in between if they are to
23 continue to have an economically viable operation which
24 makes good use of the land resources and the inputs that
25 they have to have of labor and fertilizers and so forth.

1 If they get poor yields they are getting a poor
2 return on all of these resources which are not only
3 important to the farmers' economy, but in the utilization
4 of these resources in behalf of the nation.
5 Now another approach is the one just referred to,
6 and the one that was discussed by the UC representatives
7 yesterday, and that is to take the latest experimental
8 and theoretical data from the soil and water scientists
9 and calculate the water required for Southern Delta crops
10 and soil situations.
11 Do you recall that the group said several times
12 that the UC guidelines are based on some rather favorable
13 assumptions as to the situation to which the water is
14 applied, and that if one has some different situation, one
15 must then calculate a new set of guidelines that apply to
16 that specific situation.
17 Now the purpose of IV-E is to show that one can
18 for the Southern Delta do exactly that and arrive at a new
19 set of guidelines that would be appropriate in the Southern
20 Delta. So first you have to list the crops, in column A,
21 and we have listed not all, but a number of the same crops
22 that we discussed as being crops important to the Southern
23 Delta yesterday.
24 Again in column B, I refresh your memory on the
25 current acreages of those, but as I pointed out, those are

1 subject to variation with time, market and for other
2 reasons.
3 Now then, in order to make this calculation that
4 the UC people have talked about, one has to make some
5 assumptions regarding the yield that is to be required,
6 and I don't know any way to do this without discussing a
7 little bit what are reasonable figures to put in that column.
8 Now if you want to put in some other figures and arrive at
9 some different answers, that can be done by the same
10 method, but let me illustrate with the figures that seem
11 to us to be reasonable.
12 Bear in mind that the cost of raising, for example,
13 one of these tomato crops I showed you, is almost the same
14 up to harvest time whether you get a full yield or whether
15 you get a 20-percent yield. Your equipment has to go all
16 over the farm, you have already put on your fertilizers,
17 your herbicides, and your costs are almost the same.
18 Even your harvest costs do not go down anywhere
19 near in proportion to the yield loss because your equipment
20 still with a poor stand has to traverse the field and
21 there are many reasons why the costs, even though it may
22 go down somewhat, will not go down in proportion.
23 Bear in mind, also, that the significant figure
24 in terms of economic viability is not the gross return, it is
25 the net return, and the net return has to be viewed not on

1 a particular crop, but on a reasonable crop rotation.

2 If you try to make a calculation based, for example,
3 just on tomatoes, you will come up with a fallacious answer
4 because you can't grow tomatoes year in and year out on the
5 same land.

6 You may grow it for a couple of years and then you
7 have to turn to another crop. Sometimes a crop is grown
8 that is actually a loser, but it is necessary in order to
9 clean up your soil situation from the previous crop and
10 prepare it for the next crop, so you have to look at an
11 entire crop cycle and consider the net return on the whole
12 crop cycle and not on a single crop.

13 The farmer must also make enough return to take
14 care of the unnecessary and unforeseen things that happen,
15 not only the drought years, but the cannery strikes, the
16 times when it rains in August when it shouldn't rain and
17 rots his tomatoes before he can get them into the cannery,
18 and this sort of thing.

19 So if figures are made based on growing a single
20 crop with everything growing perfectly, they just aren't
21 realistic figures.

22 Now just what a typical net return is, is a very
23 hard thing to get at because it gets down to the question
24 of what returns should you be getting on your land invest-
25 ment and many other things. But I think you will find that

1 most thorough and objective analysts will come out with
2 numbers that are not more than about ten percent.
3 Consequently, it seems to us unreasonable to be
4 looking at reductions in crop yields of more than about
5 10-percent if you expect to have the farmer go on growing
6 your food.
7 On the other hand, we accept that with the
8 variable soils we have and the efficient use of water you
9 can't expect to have water quality such that you can grow
10 a full yield on every spot of land in every field. So we
11 have tried to make some allowance for that and if you look
12 first at the vegetable crops, we have said, well, let's
13 say that those farmers that can get a 15-percent leach
14 ratio or better without a water table problem should have
15 a 100-percent yield on all but the poor spots in their
16 field, and that those who get less than that we will say
17 will have to have a 90-percent return yield if they are
18 going to stay in business.
19 You recall that the soil salinity survey, while it
20 is a small sampling and it may or may not be representative,
21 did show that about a third of the fields would fall in
22 this category of being less than 100-percent yield if you
23 do this, and incidentally, we are assuming now in, you
24 might say, a normal year, because the situation is going
25 to vary somewhat. All right. Then on the deep-rooted

1 crops, however, we have a more severe problem in two
2 respects.
3 On the walnuts, for example, and other tree crops,
4 you have to keep your water table lower. The lower you
5 have to keep it, the more difficult it is to keep it there,
6 and therefore, the more difficult it is to live with a
7 high leach ratio, and so we have shown a somewhat lesser
8 amount of leach allowance there, although we probably
9 haven't reduced it as much as we should in this example.
10 Q Which figure are you referring to, Mr. Hildebrand?
11 A We are talking now to Column D, what figures to
12 put into Column D as reasonable.
13 Q Walnuts?
14 A Walnuts, peaches and apricots, -- it would be
15 about the same for pears, and the cherry people tell me
16 that they need better water than the other people. They
17 apparently have more trouble in their cherries down in the
18 Tracy area. But this is sort of an average figure for the
19 tree crops.
20 In the case of alfalfa, you have a specialized
21 problem which we alluded to a little bit the other day, and
22 that is that the mechanics of harvesting an alfalfa crop
23 inevitably compacts the soil. You have to run your bailers
24 and your mowers and your rakes and all that equipment over
25 the field once a month during the life of the stand

1 practically and this tends to compact the surface, so that
2 in addition to having a deep-root zone you have a more
3 difficult penetration job, and you will recall that it was
4 mentioned by the UC people the other day, that when you
5 get to the second, third and fourth year of alfalfa, you
6 have increasing difficulty holding your salt load down
7 because of the difficulty of getting a penetration.
8 So we have not assumed that a very large percentage
9 of the fields can have more than 10-percent leach ratio in
10 the case of alfalfa. Now then we have made some assumptions
11 which we feel are reasonable from an economic basis in
12 Column C and are reasonable in Column D based on what
13 you have seen in the UC Salinity Survey.
14 So then we come to the question that if these
15 leach ratios were uniform throughout the field and if all
16 the other assumptions that underlie the guidelines applied,
17 then what correction would you have to make in the guide-
18 lines just to take care of the cases where the leach ratio
19 is less than 15-percent?
20 So now you turn to UC Exhibit Number II, and it's
21 about pages 26 through 31, and you will recall that there is
22 a table of the allowable root zone soil salinity tolerance
23 for various crops.
24 So what we have to do is take that column and see
25 what applied water, what EC, what figure would apply now

1 in a revised guideline that takes care of this reduced
2 leach ratio but still assumes all of the favorable
3 circumstances.
4 Now to do that you turn to the graph on page 17,
5 Figure II, which gives you a method of converting the
6 guideline assumptions to some other leach ratio, assuming
7 still an average through the field.
8 Now at this point we ran into a little problem
9 because Dr. Ayers told us in putting this back together
10 there was an error made and this graph is not compatible
11 with the table on page 96 and the table on page 96 has
12 better figures, so instead of actually using the graph we
13 used a table that was very kindly prepared for me by Dr.
14 Ayers, which in effect expands that table on 96 to make it
15 more usable.
16 So that I could pick off the table then the leach
17 ratios or the water qualities that would be required for
18 these leach ratios and these crops and take them directly
19 off his chart.
20 So the figures than that I have filled in on
21 Column E are the figures taken off Mr. Ayers' chart which
22 as I say is an expansion of the one on page 96, which
23 replaces the graph on page 17 because that one happens to
24 be in error.
25 Now that then tells us what water quality we would

1 need to achieve the yields shown in Column C if we had the
2 leach ratios in Column D. Now the leach ratios in Column D
3 are the significant figures as regards the input to the
4 water table which as you recall is a problem in about half
5 the fields in our UC Salinity Survey.
6 And the amount of water that gets down to the
7 water table is going to depend on the average leach ratio
8 in the field, not on the leach ratio at one or two points.
9 So when we are worrying about maintaining a water
10 table, those are the figures we have to look at. But when
11 you are worrying about how much crop hield you are going
12 to get, you still haven't got the answer because there is
13 still the next assumption we will have to modify in order
14 to fit our conditions is this assumption that you have a
15 uniform leach ratio throughout the field and as you have
16 seen both from their test data in here and from the
17 pictures I have shown you, we are a long way from having
18 a uniform leach ratio.
19 For example, you could just look at this picture
20 on the last page of the salinity survey --
21 Q What table and what exhibit are you referring to?
22 A This is UC-VII, pardon me.
23 Q And what is that?
24 A These are the salinity profiles at the various
25 locations and I'll refer you at the moment, say, to look

1 at the last four pages which shows salinity profiles. It
2 also shows the standard deviations that were found in it
3 as they went through the field.
4 Now bear in mind that what you are seeing here
5 is not a measurement of the actual leach ratio directly.
6 You are looking at the resulting salinity changes which
7 were caused by variations in the leach ratio.
8 To take the last chart, for example, look at the
9 two dotted lines. One is the median or the mean leach ratio
10 in that field at a particular date. The one that goes way
11 off to the right is the maximum, and if they had plotted
12 the minimum it would be about the same direction off to the
13 left.
14 So you see that the difference among different
15 points in a field was in the proportion of something like
16 four out of seven. There was a rather large range.
17 Now a particular plant doesn't care what the leach
18 ratio was in the whole field. The plant is interested in
19 what is happening to its own root system, and so the yield
20 of the plant is going to respond to the leach ratio at the
21 site of the plant and not the average leach ratio for the
22 field.
23 So if you are to -- We will come back to the
24 question of just how this is done, but you now calculate
25 a leach ratio such that 90-percent of the plants in the

1 field would achieve that leach ratio when the field average
2 is whatever it is.
3 Take, for example, the top figure in Column D,
4 10-percent leach ratio for alfalfa. Now if you assume that
5 the figures shown in UC-VII are typical for the Southern
6 Delta, and whether they are or not we don't know, it is
7 not a big sampling, but if you assume that it is, and it
8 would cost a few million dollars to find out something
9 better, then you can calculate a reduced leach ratio such
10 that 90-percent of the plants in the field would experience
11 that leach ratio and hence would have a full yield providing
12 the water quality was adequate for that reduced leach ratio.
13 And so we come up with a figure of 7.4 percent.
14 So if you have a water quality which is adequate for a
15 leach ratio of 7.4 percent, you will then still get 100-
16 percent yield of 90-percent of the plants in the field.
17 The other 10-percent will have a lesser yield. You will
18 take a loss on those.
19 So we can then again go back into Mr. Ayers'
20 chart and again put down the water quality figures which
21 would be required to give you a hundred-percent yield of
22 alfalfa in a field with a 10-percent average leach ratio.
23 Now let me come back a minute to the question of
24 how did we get from 10 to 7.4. That's a rather intricate
25 thing.

1 MR. BRYSON: Let me suggest that if there's some
2 way to maybe bring this to an end it ought to be done.
3 This is an important chart and I think the Board understands
4 it pretty well.
5 A The only point I was going to make really, you
6 could have a long erudite discussion of how you get from
7 this data to Column F and if someone wants to interrogate
8 Dr. Orlob at length on this, he can give them a treatise
9 on the subject. I doubt the Board wishes this.
10 But I submit any reasonable analysis would come out
11 with numbers such as we have here. They are at least
12 illustrative of the kind of situation.
13 Now we still have not made some other corrections
14 needed to make a new guideline that would be appropriate
15 in the Southern Delta.
16 If we turn now to -- let me see if I get my page
17 reference here -- page 36 of UC-II. You see on page 36 the
18 guidelines assume that you have a salinity profile such
19 as shown in this graph and that by having such a profile
20 the plants will be enabled to take its water.
21 MR. WILSON: Q. Which chart are you referring to
22 now?
23 A UC-II, page 36.
24 Q Thank you.
25 A This is another one of the assumptions in the

1 guideline which we need to modify to fit our situation.
2 The assumption in the guidelines is that you will
3 have a salinity profile such as shown in that graph and
4 that because you have that salinity profile the plant can
5 take 40-percent of its water out of the top 25-percent of
6 the root zone, and so on down to 10-percent in the bottom
7 quarter of the root zone.
8 Now if you will recall the figures we were just
9 looking at in UC-VII, the last four pages, you remember
10 that those graphs don't look anything like that guideline
11 graph. They aren't that shape at all.
12 The plant can't take its water up in the manner
13 assumed in the guidelines. So we need to make a correction
14 for that. The problem we run into is that the soil science
15 hasn't been taken to the point yet where one can make this
16 correction.
17 So that all we can say is that to allow for that
18 factor we will have to have water quality better than that
19 shown in G, but we can't calculate a number for it. It's
20 an important problem. It can't be ignored just because we
21 can't calculate it, but the fact is that we don't know how
22 to calculate it at this time.
23 And in that connection I again come back to the
24 particular problem with alfalfa because that is our
25 biggest crop in terms of acreage and a very important crop

in terms of our crop rotations, and in the case of alfalfa, we have a further problem of the same general nature, in that the compaction I referred to of the surface prevents your getting a penetration at an adequate rate to keep up with the evaporation from the plant during the summer months.

Some years ago, before we knew as much about this as we know now, I observed this problem in portions of my field. I put tensiometers down with the assistance of the UC people at different depths to find out how much penetration I was getting of my moisture and I found during June, July and August of a typical year I couldn't get moisture down as far as three feet and alfalfa has a root that goes down eight feet or more.

So what is happening is during those months you are continuing to accumulate and concentrate salts in the middle of your root zone and you have to let the surface part dry in order to go in and harvest your hay, so that the plant is in a rather badly stressed condition during the harvest period in those months and you consequently get a retardation of growth in alfalfa.

Again we don't know just how to correct that, but it is a serious problem. In order to not have to assume any credibility of my own comments on this, let me refer to the statement by Mr. Robert Sheesley, a UC Farm Advisor

1 in Fresno County who is considered somewhat of an authority
2 on alfalfa, and just recently he was calling attention to
3 this problem and he stated, and I quote, "In summary,
4 it is usually not possible to get water down through the
5 root zone without scalding the stand through lack of
6 oxygen in the root zone."
7 I won't take your time to read it, but you would
8 also find some further comments on that on page 21 near
9 the lower part of the page in UC-II.
10 Last, but not least, we come down to the bottom of
11 the chart --
12 Q First, finish your alfalfa. What do you arrive at
13 then?
14 A Again, we don't know how to calculate it, so all
15 we can say is the numbers shown in this chart are too high.
16 It will need better water quality than you can pick out of
17 the guidelines. You don't know how much better, but the
18 numbers are inadequate.
19 Q Is it better than 450 TDS? Is that what you are
20 saying?
21 A Yes, and I don't know how much better, but you
22 do not get full yield according to the guidelines, and
23 according to our observations if you look at the alfalfa
24 yields that are obtained under optimum conditions, and they
25 are considerably above the average yields that we actually

1 experience, and this is surely one of the factors that
2 enters into the fact that commercially we have not been able
3 to achieve, except in rare instances, the kinds of yields
4 we should be getting.
5 And again, I remind you that the reduced yields
6 constitute a very poor use of our resources of land and
7 fertilizer and labor and so forth.
8 Coming down then to the bottom of the chart, back
9 to this seedling problem, you can't grow the crop if you
10 can't start it. The seedling problem relates primarily
11 to those plants that have small seeds that must be planted
12 at shallow depth and particularly if they must be planted
13 in the warm portions of the year.
14 These are plants such as tomatoes, sugar beets,
15 onions are usually planted in the winter, but it applies to
16 them to a lesser degree, lettuce, and there are others.
17 These plants are planted in row beds. You will see in UC-II,
18 pages 44 to 46 a discussion of the techniques for minimizing
19 this problem in these beds, the manner in which you shape
20 the beds, the manner in which you place the seeds in the
21 beds, and these are good methods and they are used very
22 carefully by the farmers.
23 They have an elaborate machine for forming these
24 beds carefully, but as with most things they work out a
25 little better on paper than they do in practice, so even

1 though they help the problem, they do not entirely alleviate
2 it. They fall short for two reasons. One is that you
3 can't hold the shape of the beds perfectly and this gets
4 back in part to the question of the soil variability. You
5 get a little different settlement of the levels of the beds
6 as they become wet. You get a certain amount of slumping
7 of the sides of the beds, a certain amount of washing from
8 the flow of the water in the furrows, and even if they
9 weren't worked optimally, you still get a concentration
10 of the salts due to surface evaporation and this can be
11 quite severe in hot weather.
12 In starting a tomato crop in hot weather, for
13 example, a farmer may have to irrigate evvery five days,
14 or about four times in a row, before he has established
15 plants, and in the interim between these times, as the
16 soil dries and crusts and cracks, and the salt is con-
17 centrated in this very shallow zone where this seedling is
18 trying to get his toes down and get started in life. So
19 again, though, we are faced with the fact that there
20 presently is no way to make a calculation to assess the
21 importance or the degree of this need as to what water
22 you should really have, so that all we can say is that we
23 begin to have problems and the management begins to become
24 more and more difficult as you go over about 350 TDS, and
25 it becomes almost intolerable when you get up to some of

1 the levels that we were using as you saw in the pictures
2 here.
3 Now when you make calculations, of course, you
4 always have to address yourself to the question of so what,
5 how good are the calculations after you have made them.
6 On page 9 of UC-II, the guidelines are only
7 claimed by their authors to be good somewhere between plus
8 or minus 10-percent and plus or minus 20-percent. Some
9 people have suggested that under these circumstances
10 adjustments of less than 20-percent to meet local conditions
11 are not very meaningful, but if that's true, then you have
12 to also accept that where the chart calculations show
13 450, maybe the real need is 360, and it's not logical to
14 say on the one hand that the calculated adjustments are
15 not meaningful and on the other hand to say that the guide-
16 lines are meaningful.
17 You can't have it both ways. Now as you will see
18 from the numbers we came up with, there's actually a pretty
19 good mutual corroboration between the practical experience
20 of the farmers who say that the figures should lie between
21 350 and 500, the average should be somewhere in between,
22 and the guidelines as we have just calculated them come
23 out to give you about that same answer, so they do cor-
24 roborate each other and give considerable mutual credence,
25 you might say.

1 Now when you talk about water quality, you can't
2 quite stop there. The crops aren't the only problem. One
3 thing you have to consider is that there is still some
4 level of ignorance here. We are still learning. We are
5 still gaining experience in the field.
6 The soil sciences are still improving their
7 techniques. Every year they are making them a little
8 better. But we are faced with the fact that institutionally
9 it is going to be almost impossible to upgrade whatever we
10 come up with, so we better not have figures of questionable
11 adequacy.
12 Another consideration is that the consumption of
13 water in the Southern Delta will be almost the same for
14 really suitable water as it is for water of marginal quality.
15 I will discuss this a little bit more later, but the suit-
16 ability of the water in the Southern Delta, providing
17 suitable water there will not significantly reduce the
18 volume of water available in the Delta pool. We are
19 talking about a circulation of water to equalize water
20 quality. We are not talking primarily about any increase
21 in consumption.
22 Another aspect of the problem which I mentioned
23 earlier is that although most of the leach water gets back
24 to the channels, some of it gets down to those aquifers
25 that are used for rural domestic wells, and if these all

1 become salted up with excessively salty leach water, it's
2 going to be a rather major problem for the rural establish-
3 ments relative to their domestic wells, and wells that
4 are used to wash asparagus and so forth.
5 Last, but not least, there is still not much known
6 about the long-range mechanisms of soil damage from salt.
7 But we do know that highly saline leach water will deposit
8 calcium carbonate and calcium sulfate in the pores of the
9 soils below the root zone and I emphasize below because
10 depositing solids in the pores below the cultivation, I
11 don't mean below the root zone, below the cultivation zone
12 -- that's a very different thing from depositing the same
13 materials on the surface and stirring them into the soil.
14 When you deposit them in the soil you have no control of
15 reopening those pores below the cultivation zone.
16 When I was director of oil field research, we did
17 a lot of work on the deposition of solids in the pores of
18 the structures which impeded the flow of water and oils in
19 the wells, and there is a tendency, we found, for the
20 mechanisms of deposition to be such that the permeability
21 is blocked, the percolation capacity is blocked more than
22 you would assume by just taking a volume filling of pores.
23 We do know there is a long worldwide history of soils
24 with loads of salt where the irrigation water was too
25 great to handle it. They started having this problem way

1 back in the days of Mesopotamia and they have had serious
2 problems in places in Russia in the '40's, and we have had
3 it in some places in this country, and in India. We also
4 know that some of these lands often have never been re-
5 claimed.
6 If you will look in UC Exhibit I-A, you will find
7 a statement quoted in there as follows:
8 "The eventual consequences of salt build-up within
9 any basins such as the San Joaquin Valley is known
10 with absolute certainty, that is deterioriation
11 of water quality, decreasing agricultural yields,
12 and eventually collapse of food sources as we
13 presently know them."
14 And the publication goes on to say that we know
15 how to avoid this. The question is will we.
16 MR. BRYSON: Let me inquire how much more you have
17 to cover, and what the subjects are and how long you expect
18 it to take.
19 A Just a little more on criteria and then a little
20 bit on the water levels and flows. I would say another
21 fifteen minutes.
22 MR. BRYSON: I think it ought to be as succinct as
23 possible.
24 A All right. Now considering all these factors then
25 as we said in the beginning, you can't come up with a

1 precise answer, but we came up with the answers that would
2 seem to us to meet all these questions of need if we are
3 to retain our ability to have economically viable crops
4 in the Southern Delta, and those figures are shown on
5 Exhibit IV-A.
6 I call your attention particularly to the figures
7 for a normal year, 500 maximum water quality --
8 MR. WILSON: Q. That was at Vernalis?
9 A At Vernalis because it is difficult to regulate the
10 short term quality farther down, a 450, 30-day average
11 throughout the channels so that the water quality at some
12 one point doesn't mean much to us; and then a water year
13 average of 400. Now we indicate a relaxation of those.
14 We wouldn't hope to achieve full crop yields in dry years
15 and we allow some relaxation in the lefthand column. In
16 the wet year we would like to see some offsetting of this
17 to get the salts back out of our orchard roots, for example,
18 and so we call for a better annual average in a wet year
19 which should not be much of a stumbling block.
20 Now the TDS which is the figure the farmers are
21 most familiar with, and the EC's which are the most meaning-
22 ful relative to osmotic pressure in the plants are both
23 shown there, the principal ones we have talked about, and
24 we do, however, have to worry about this business of plant
25 toxicity to various things. We have to worry about the

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1 fact we have livestock drinking this water, so we have
2 shown in the subsequent pages some other criteria, but I
3 won't go into those unless you wish me to do so. They are
4 pretty well taken out of the UC limits.
5 I would like to talk a little, though, about the
6 definitions which would trigger relaxations of quality.
7 The dry year definition, which is shown in this exhibit,
8 is one that was first proposed to us by the Department of
9 Water Resources in the first of our three years of fruitless
10 negotiation.
11 We understood that that definition would retain
12 the statistical frequencies in the Shasta definitions. The
13 definition is certainly subject to reconsideration, but any
14 definition used as a basis for water quality in the Southern
15 Delta should have an appropriate input of Southern Delta
16 hydrology because as you have seen, the San Joaquin River
17 system is the input to our system and it doesn't seem to us
18 to make much sense to base a relaxation in the Southern
19 Delta on criteria that has no input from the principal
20 source of our water.
21 Furthermore, it is our contention that the statis-
22 tical frequency of occurrence which was discussed by the
23 Department of Water Resources for any designation uses for
24 water quality relaxations should not be altered from the
25 present Shasta definitions when applied to the entire period

1 of record.

2 The original decision to designate a certain per-
3 centage of years as dry was a fundamentally arbitrary
4 decision. There is no way you can consider it otherwise.

5 Now the Department presented a very erudite
6 statistical analysis as the rationale for increasing the
7 statistical frequency of dry years, but the basis for this
8 analysis was also arbitrary and when the method first led
9 to what the Department of Water Resources thought was too
10 great an increase in frequency, they added an arbitrary
11 adjustment to it. I don't think we can be expected to
12 believe that the Department would have used this particular
13 rationale if it had led to a reduction rather than an
14 increase.

15 MR. SINTON: Mr. Chairman, I kind of object to the
16 rebuttal that is taking place here. I thought we were all
17 under the same rules with regard to rebuttal and if so, I
18 thought maybe it might be appropriate --

19 MR. BRYSON: Yes, I don't think this is the
20 presentation of factual matter.

21 MR. SINTON: I don't have any objection to them
22 suggesting they would like to see the San Joaquin River in,
23 but then going further and attacking seems to be beyond --

24 MR. WILSON: I think it is for the purpose of
25 contrasting. We had a lot of discussion from the Department

1 of Water Resources as to the statistical frequency and the
2 reason for it and I think it is pertinent to what has
3 already come before.
4 A Let me just say the point I was trying to make is
5 that I don't think that existing rules should be changed in
6 an arbitrary manner to benefit one party at the expense of
7 another. I will stop there.
8 Now we turn to the question of monitoring. I want
9 to merely remind you that Dr. Orlob's testimony is that it
10 is quite clear since our diversions are throughout the
11 channels, the criteria must be throughout the channels and
12 we think it would take about these many monitoring points
13 to accomplish any assurance of protection for the growers
14 as a group.
15 MR. WILSON: Q. That is set forth, Mr. Hildebrand,
16 on Exhibit IV-B?
17 A IV-B.
18 MR. WILSON: Pages 1 and 2, correct?
19 A Yes.
20 MR. CAMPOS: I wish to point out that the monitoring
21 points, the monitoring surveillance points shown in pink and
22 green aren't shown on Exhibit IV-B. They do not appear.
23 Q Actually, let me amend what I just said. We feel
24 if we had all those that are in the dark colors, that would
25 do it. These are existing ones that were available for

1 preparing our data, but there could be some substitution
2 back and forth. We picked these other points as being
3 better points.
4 MR. MACAULAY: The ones that are numbered?
5 A The ones that are numbered on our exhibit aren't the
6 ones I am referring to. There were additional points Dr.
7 Orlob used because they related to the data on his charts,
8 since there is no data available from some of these sites.
9 Now another way to assess the suitability of the
10 water qualities that we have come up with here is to see
11 how they compare to what others have done.
12 If you look at Exhibit IV-C, you will see that as
13 compared to the State Water Project figures, that our
14 monthly average comes out to be just about the same except
15 that we are proposing to agree to a dry year relaxation
16 whereas they don't seem to have any such thing. Their long-
17 term figure of 220 is far better than anything we have
18 suggested for ourselves.
19 Furthermore, the hydrography of the system is such
20 that the exported water quality will usually be substantially
21 better than the objectives that the Department has, whereas,
22 in the Southern Delta if the criteria were adopted such as
23 the numbers we have come up with here, they would probably
24 be what we would experience a great deal of the time.
25 It's been argued that the export waters must be of

1 high quality to avoid recycling salt within the valley, but
2 a very substantial portion of the entitlement of export
3 water is outside the Central Valley and the salt in that
4 water is removed from the watershed.
5 Furthermore, we don't have the option that they
6 have when they reuse their water of using the good water
7 on the sensitive needs and using the return water on less
8 sensitive needs.
9 Our water has all been heavily recycled before we
10 get it, so that this again is a situation to our detriment.
11 Now another comparison is to look at the existing
12 water quality criteria and see how they relate and give
13 credence or otherwise to ours.
14 The earliest water quality criteria and the ones
15 that the Bureau seems to be observing are those known as
16 the November 19 Criteria. Now those criteria constitute
17 in our judgment a valuable conceptual step in broad outline
18 and in broad outline they were a realistic approach toward
19 water quality control and monitoring in the Delta.
20 However, the authors developed an overall approach,
21 but they did not refine it to fit the detailed hydrography
22 and land needs of each portion of the Delta.
23 The author stated that the criteria were only
24 proposed and I quote, "As an appropriate basis for further
25 negotiations."

1 In the Southern Delta the authors have not yet
2 seen the full effect of export pump drawdown or the growing
3 salt load and diminishing flows in the San Joaquin River.
4 They apparently thought the two monitoring points would
5 be representative of the Southern Delta water quality in
6 75 miles of channel, whereas, this assumption has been
7 thoroughly disproven. They did not have the benefit of
8 present day data on fishery needs or on crop salt sensi-
9 tivity. They did not anticipate present day problems with
10 Southern Delta water levels and salt balances.
11 They probably thought of the limiting quality
12 proposed as infrequent occurrences whereas it is now clear
13 that any limiting Southern Delta criteria adopted will
14 prevail much of the time.
15 They apparently assumed either that the Southern
16 Delta water quality improvement had to be contingent on
17 new facilities or that those facilities would be constructed
18 before serious problems arose.
19 Both assumptions have proven to be wrong as I will
20 indicate later.
21 If you will turn to Decision 1379, which is
22 summarized insofar as it applies to the Southern Delta,
23 on Exhibit IV-D, you see that 1379 does provide absolutely
24 no protection of any sort for the Southern Delta. The only
25 nearby point is at Clifton Court which is a rather academic

1 point now because the water quality there is regulated for
2 the benefit of the export people rather than for the
3 benefit of the Delta, but if those numbers were to apply
4 within the Southern Delta, if you convert the numbers to
5 TDS numbers with which most of us are more familiar, you
6 would see that they run from 560 up to 900 or more, and
7 as we have discussed, we just can't grow our crops with that
8 kind of water.
9 Decision 1422 also does nothing for the Southern
10 Delta until New Melones is operational and then provides
11 water quality protection only at Vernalis, and as you have
12 seen from here, what happens at Vernalis doesn't have very
13 much to do with what happens throughout a good deal of our
14 area.
15 It has no provision for water level requirements,
16 no provision for direction or quantity of flows.
17 Now the currently pertinent data are in the Basin
18 Plan which are somewhat better, but the Basin Plan hasn't
19 been implemented in the Southern Delta.
20 The Department has stated repeatedly, both here and
21 in public statements, that they are operating as required by
22 the Basin Plan.
23 The Basin Plan, as you see, requires 500 parts
24 per million at Vernalis, and positive downstream flows
25 through the major Southern Delta channels. It also was

1 brought out that in the earlier discussions in this hearing,
2 there's no significant physical difficulty that would
3 prevent the State Project and the Central Valley Project,
4 a joint state project and Central Valley Project operation
5 making releases to the San Joaquin River for the purpose
6 of approaching compliance with the Basin Plan.
7 But the necessary arrangements with the Bureau have
8 not been made as they have for other areas in the Delta.
9 This means that substantial compliance with the
10 Basin Plan in the Southern Delta should be implemented
11 before the next irrigation season. I believe you indicated
12 a proper part of Phase I was to address ourselves to the
13 situation we are faced with this coming summer.
14 We feel very strongly that that should be done.
15 Now although the existing Basin Plan should be implemented
16 now, it should also be revised in Phase II to take cogni-
17 zance of the needs we have indicated to you if we are to
18 continue providing food for the state and nation in the
19 Southern Delta and continue to make good use of our lands
20 and other resources.
21 We need the criteria to protect these resources
22 which must, however, go somewhat beyond just the question
23 of water quality. The question of quantity and quality,
24 as you have seen, are closely interrelated. You can't
25 divorce them entirely; but it is possible, for example,

1 under a system that makes no water quantity requirements
2 and has inadequate monitoring points to have a situation
3 which we had briefly last January when the Basin Plan was
4 being met at Vernalis and we had 1900 parts water down
5 in this area, and areas where there was so little water
6 we couldn't run the pumps.
7 We have to have protection against these low water
8 levels and we have to have the downstream flows that will
9 provide more uniform water levels.
10 I remind you that the salt we are concerned about
11 is not our salt. It comes down the river. There is some-
12 where between a million and a million and a half tons a
13 year of salt coming down the San Joaquin River now, and it
14 has to be carried through the Southern Delta at concen-
15 trations that we can live with, and even when you look at
16 a thing like this --
17 MR. WILSON: Q. Referring to what chart?
18 A V-I. Chart V-I shows these humps in water quality
19 we get here. Well, that is because in order to use this
20 water we have to evaporate the water out through the leaves
21 of our plants. We are not adding any significant amount
22 of salt in the channel. It is just the salt that was
23 already there.
24 So this isn't a consequence of our salt, it's a
25 consequence of the salt that came down the river, and

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1 there's no way we can use the water without concentrating
2 it further. With our mineral soils and our farm operations,
3 the salt input from our land is a trivial percentage of the
4 amount of salt in the channels.
5 You may recall back in the 1379 hearings, a
6 picture of one of our Directors, Albert Muller, taken about
7 here --
8 Q You are referring to what area, Mr. Hildebrand?
9 A Middle River, standing and leaning on a shovel right
10 in the middle of the channel in the middle of the irrigation
11 season. There wasn't any water there. That situation
12 prevails frequently now in summer months, and it's not an
13 isolated occurrence.
14 So we do have to have protection against that.
15 Now so far as the quantities required to achieve such
16 protection, if you will look at Exhibit V-H, this chart is
17 based on the rates of channel depletion as it is called
18 which were prepared by the Department of Water Resources.
19 These are the rates of net consumption or diversion of
20 water from the channels which they estimate in the Southern
21 Delta for the months shown in this chart, so that much
22 water which is given here in cubic feet per second as flow
23 rates and which comes to between 4 and 5 hundred thousand
24 acre feet per year has to be supplied in order to meet the
25 consumptive needs of the Southern Delta.

1 In addition to that then we have to have what
2 sometimes has been called carrier water to control and
3 equalize the water quality and maintain the water levels,
4 and that is the requirement to pick up this salt in the
5 river and carry it on through and at the same time to by
6 virtue of having a downstream flow we avoid these hydraulic
7 depressions that are created by the diversions and we get
8 away from the water level problems.
9 These water level problems as you heard have been
10 aggravated by the drawdown of the export pumps and in the
11 absence of downstream flows they also reduce this tidal
12 flushing in here which would otherwise assist in coming in
13 and picking up some of this and taking it out. But the
14 real solution is that there must be a through flow of water
15 and it will simultaneously then take care of our creating
16 a uniform water quality or more nearly uniform, correcting
17 the water level problem and transporting that incoming salt
18 on through.
19 Now Exhibits V-A and B, which you have already been
20 over, give you a visual impression of the frequency and
21 magnitude of the need for supplementary water circulation
22 to accomplish this and so I shall not go into that any
23 more than you wish.
24 It depends on the year. Some years we need a great
25 deal. Some years we need less, and it depends on the

1 MR. HILDEBRAND: I have to give you a sort of a
2 yes and no answer to that.
3 Q Try the yes, first.
4 MR. HILDEBRAND: Yes, we would very much prefer
5 that the water quality were actually somewhat better than
6 these numbers during the season of the year when you are
7 planting seedlings. However, when you are faced with the
8 fact that with the numerous crops we have, we are planting
9 crops throughout a great portion of the year, really the
10 period from about the middle of July until about the
11 middle of September, the first of September perhaps, is
12 the only period of year when there aren't significant
13 acres of seedling growth involved.
14 Q On your Table IV-A, as between Items 1 and 2, for
15 total dissolved solids, as far as your seed germination
16 period is concerned, I take it from your last explanation
17 that you are more interested in the second, that is the
18 38 running average of daily mean values of water quality
19 that's better than the 450 parts per million TDS shown
20 on your Exhibit V-A?
21 MR. HILDEBRAND: No, I wouldn't say that. In
22 connection with seedlings, assuming that you had done a
23 proper job of land preparation before you plant, the
24 significant thing is the quality of the water at the time
25 you pump it, not what it was two weeks ago. We recognize

1 that the water qualities don't tend to fluctuate as
2 rapidly down in the lower central portions of the Southern
3 Delta because of the time lags involved, and that it
4 would also be more difficult to regulate the water quality
5 on a short term basis. Therefore, as a matter of realism,
6 we propose that the short term water quality be applied
7 to the input point at Vernalis, the regulation there,
8 so that we will never get more than the 3-day figure on
9 a seedling crop, and that we don't require that it be
10 monitored and controlled on that scale down here. It's
11 less likely to fluctuate rapidly and by the same token,
12 we have concerns in that you get some salt build-ups in
13 a more mature crop like our alfalfa during the course of
14 the season.
15 Here, however, you don't care quite so much about
16 a specific irrigation, but you still do care about what
17 kind of water you have in July versus what kind you have
18 in April, hence an annual figure as well as a monthly figure.
19 Q So regardless of the fact that on VI-A you are
20 showing running averages, you are still talking about
21 better water quality than was reflected here procedurally?
22 MR. HILDEBRAND: The A-1, you mean?
23 Q Yes.
24 MR. HILDEBRAND: Yes, that's right, to be sure
25 that we don't get a slug of salt coming down just when you

you can never harvest the hay. You couldn't pay for the sprinkler system with the kind of profits. So it's a rather hypothetical question.

Q Could you just put more water on in the winter?

MR. HILDEBRAND: In the case of alfalfa, for example, you have a severe problem there because you make your last cutting, say, in early October on your alfalfa, and now you can go in and irrigate it once, maybe twice, without holding the water on it too long and causing damage, but one or two irrigations will not leach you down ~~to~~ through the root zone in the second and third years of alfalfa, and after you go ahead and you do this again in November, and then the weather man turns out to be wrong and it rains all the following week and it keeps the ground soaked, you kill your plants because they can't, they are deprived of oxygen and they can't grow, so you have a rather limited alternative.

If you knew for sure it was going to be a dry year, you could go on and do some more leaching. On the other hand, nobody is that good yet.

MR. BRYSON: I'm going to have to interrupt at this point. We need to break now because several of us have meetings. We will take up again at 1:30.

(The noon recess was taken.)

-oOo-

A Yes, I would.

MR. SCHULZ: That's all I have.

MR. BRYSON: Mr. Sinton, do you feel the need for a second round of cross-examination?

MR. SINTON: No.

MR. BRYSON: All right, Staff.

MR. CAMPOS: Mr. Chairman, a lot of the concerns of Staff have been addressed. We do have a few questions.

EXAMINATION

By MR. CAMPOS:

Q I would like to start out with Mr. Hildebrand. You mentioned to Mr. Nakagawa that the monthly irrigation withdrawals in Exhibit V-H would not change substantially from year to year. My question is, is early irrigation practiced in dry or critical years such as in 1976?

MR. HILDEBRAND: Oh, yes, if you are looking at the early part of the year, it makes quite a bit of difference whether it was a dry winter or not, because for example, this year, in the absence of rain there was a great deal of irrigation done in January which would not normally have been done. Normally in January you would have some leaching irrigation going on of lands that were between crops, for example, where you weren't going to hurt the plants by too much water. But you wouldn't have any

1 significant amount of irrigation going on to just soak up
2 the soil to prepare for planting.
3 Q I would like to refer to Exhibit IV-E and
4 specifically column D.
5 MR. HILDEBRAND: Yes.
6 Q Do the leaching ratios shown in this column D
7 represent the soil types over which these crops are usually
8 grown?
9 MR. HILDEBRAND: We feel that the data available
10 both from farm experience and from UC Exhibit VII indicate
11 that these are reasonable leaching practices for the soils
12 we have, yes. Now there are some of our poor soils, poorer
13 than this, and then there are ones that would be better,
14 but this would be representative of a substantial percent-
15 age of the total.
16 Q In your Exhibit III-C, you present detailed
17 average crop acreage for the period 1971 to 1975.
18 MR. HILDEBRAND: Yes.
19 Q Do you have more detailed information on cropping
20 acreages in various areas of the South Delta Agency for
21 roughly the same period, and if so, would it be possible
22 to get this information?
23 MR. HILDEBRAND: We don't, I believe, have it
24 available. I would have to go back to the source of these.
25 I don't believe we had this data segregated by years very

Before the

STATE WATER RESOURCES CONTROL BOARD
STATE OF CALIFORNIA

--oOo--

JUN 2 1977 REC'D

In the Matter of: WATER QUALITY CONTROL PLAN for the Protection of Beneficial Uses in the Sacramento-San Joaquin Delta and Suisun Marsh. and Permit 12720 (Application 5625) and other permits of the U. S. BUREAU OF RECLAMATION for the Federal Central Valley Project and of CALIFORNIA DEPARTMENT OF WATER RESOURCES for the State Water Project.	Phase II Hearing

San Joaquin County
Flood Control & Water Conservation District
Office of County Counsel

--oOo--

Resources Building
Sacramento, California

--oOo--

Wednesday, June 22, 1977
9:00 O'Clock, A. M.

--oOo--

VOLUME XXVIII

--oOo--

Reported by:

CLARA MAE MATHIS, CSR #2832

can experience a minimum leach of 12 per cent or better? This amount of leach can't actually be achieved in all of the fields, but beans can be planted in chiseled land and can be more readily drained than some of the other crops that we have discussed.

Under these conditions we have shown that beans can be grown with a nearly full yield using .62 EC water, that's 400 TDS on an average, water year average, basis, and .70, 150 TDS. That is on a monthly average basis.

It should be noted, however, that the cost of growing beans with those waters will be greater than the cost of growing beans was preproject with the better water qualities.

There would be more management required to do so, more expenditure of energy in growing a crop.

Now, if we turn to alfalfa, which you will recall is our largest crop by far and which is a very important crop relative to our associated livestock industry, you can see from that Chart 4-E in Phase I that about the same water quality is required for a full yield of alfalfa on many of our soils.

You will recall that we explained the problems with this very essential perennial crop.

These problems result from low soil permeability, from a deep-root system, from an inability to chisel the soil annually, from cultural limitations, and irrigation

1 frequency, and from the sensitivity of alfalfa to root rot,
2 and other problems which severely limit the soaking time
3 that you can use on an alfalfa crop.
4 The magnitude of some of the water quality
5 limitations cannot be calculated with the technology
6 available to us. We showed, however, during Phase I that
7 the water quality required for a full yield with a prevalent
8 10 per cent average leach would be something better than
9 .7 EC such that .62 EC is a reasonable figure. That is
10 the same water quality that is required for beans, and
11 carrots, and strawberries.
12 And, incidentally, there have been times in the
13 Southern Delta when there have been a good many carrots
14 grown.
15 You will recall Dr. Hoffman of the U. S. Salinity
16 Laboratory testified that the salinity tolerance data on
17 which the U.C. guidelines are based made no pretense of
18 assessing problems such as those we have just mentioned for
19 alfalfa.
20 The Staff also suggested that tree crops could be
21 more or less ignored in setting the criteria because they
22 were alleged to be located wherever water quality is good,
23 the permeability is high, and/or where water was available
24 from the DMC.
25 I think this is an exaggeration. Most of the
26 tree crops in our agency that do receive DMC water receive

1 of distribution of these depositions will be and hence the
2 amount of solid deposit that you can tolerate before the
3 soil damage becomes serious.
4 But it should be quite obvious that it's not
5 a uniform deposition, and it has potential of being very
6 serious.
7 The most expertise I'm aware of in connection
8 with the deposition -- the destruction of permeability
9 by the deposition of solids is actually in the oil field
10 research laboratories. They are talking about usually some-
11 what different solids that precipitate for somewhat
12 different reasons, but the physics of it is rather allied.
13 And so I refer you to those laboratories for what expertise
14 is available, laboratories such as the one I was formerly
15 a laboratory director.
16 To summarize, then, regarding our water quality
17 needs, our needs are about the same for several purposes,
18 not just for one.
19 The water quality needed for beans and carrots
20 on our more permeable soils is also needed on our less
21 permeable and less uniform soils for alfalfa, tree crops,
22 corn, melons, tomatoes, and other vegetable crops.
23 Furthermore, this quality is needed in spring
24 and early summer for seed germination and survival. It is
25 needed to minimize the potential loss of permeability in
26 soils that are already tight such that any further loss of

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1 permeability would create a need for an even higher water
2 quality to sustain productivity.
3 Now, there is a tendency for people, in consider-
4 ing the question of whether our figures on water quality
5 needs are reasonable, to persist in using the applied water
6 quality tables in the U.C. guidelines without the corrections
7 indicated in Exhibit U.C. 1-2, and without allowance for
8 errors and uncertainties, and without allowance for the
9 basic inadequacies of the data.
10 This, in our opinion, is unreasonable
11 oversimplification of a very complex subject and ignores
12 the following points with misleading results: First, as
13 testified by Dr. Hoffman, the basic root zone salinity
14 tolerance data on which the tables were based are only to
15 be relative among crops.
16 They are not intended to be absolute magnitudes.
17 Furthermore, they are difficult to relate to field
18 conditions as noted in U.C. 2-2, Page 2.
19 They were based in large part on tests using
20 weekly irrigation and 50 per cent leach ratios on highly
21 permeable soils.
22 Secondly, the basic data was not developed with
23 any pretense of coping with such factors as variations in
24 salinity tolerances at growth stages with cultural soil
25 compaction, one of the problems in alfalfa, with commercial
26 irrigation frequency, or with variations in leach fraction

C-115604

1 to touch on some of the definitions which are Part 2, Page
2 9, 10, 11, and 12, Mr. Hildebrand, so would you pick up
3 with the criteria section, Mr. Hildebrand.
4 THE WITNESS: As Mr. Wilson says, the criteria
5 we are proposing are shown on the Exhibit No. 2.
6 I'll ask you to turn first to Page 3 as the
7 criteria in recognition of the fact that there are some
8 limitations on feasibility at the present moment, are
9 phased in stages so we'd like to start with the final stage,
10 the final criteria which we propose, the Phase III
11 criteria which begin on Page 3.
12 It deals first with the water quality criteria
13 in terms of EC, and we show the TDS equivalents.
14 The first item is a three-day running average of
15 daily mean values at Vernalis. Now, the reason for that
16 three-day running average at Vernalis is because the salts
17 in the San Joaquin River are from man-caused sources and
18 subject to manipulation.
19 There is a hazard that a slug of salt comes down
20 the river when he is irrigating his tomatoes or something,
21 and he doesn't know it, and he gets in trouble. This can
22 be taken care of by monitoring the salt load at Patterson
23 or even further south since most of the salt load comes
24 from further south, and adjusting the New Melones releases
25 so the carrier water required to handle that salt arrives
26 at Vernalis at the same time the salt gets there.

This gives us protection against short-term fluctuations.

The 30-day running average of mean values, which is the second item here, is the figure that protects the farmer in terms of monthly average salt load he is putting on his crop during the irrigation season, and the annual average is the figure that protects him in terms of his soil salinity, his longer-term problems.

Now, you will note that we have provided dry year relaxations in these. Our basic number, you might say, is the annual number. We start with the normal year, .62 EC or 400 TDS which, as we have shown, is, in our opinion, required to get full yields on a number of crops in our situation.

We permit a relaxation of that in a dry year up to 450, but we ask that it be offset, then, in a wet year by going down to 350 so that we can get some flushing and keep our long-term soil salinity down, minimize our soil permeability problems.

Also, these long-term figures have a lot to do with the kind of water that gets on down in the aquifers we use for our domestic wells as we referred to in Phase I.

Similarly, on the 30-days figure, we -- I believe the figure should be 450 -- we relax it to 500 in the dry year, and we permit the same figure for the irrigation season in a wet year even though the annual would be

1 reduced.

2 By reducing the annual, we will tend to get

3 better water in the winter leaching season and winter

4 planting season.

5 MR. CAMPOS: What definition are you using for

6 dry, normal, and wet?

7 THE WITNESS: I will come to that, Mike, in a

8 little while.

9 Now, as we have discussed before, the EC values

10 have to do primarily with the relationship of the osmotic

11 ability of the plants to take up water, but it provides

12 no direct protection against toxicty from particular ions,

13 one of which is chloride ions. And since the salts we have

14 don't have a predictable long-range deposition as would be

15 the case with seawater or even somewhat with the east side

16 return flows, we have to have a protection of chloride ions

17 in the event that the deposition of salts in the future

18 might be changed significantly from what they are now.

19 The figure we have here for chloride ions is the

20 same as the monthly average figure in the State Water

21 Project contracts I believe.

22 They, however, have a -- we are permitting a

23 relaxation of that figure in dry years which they don't

24 permit, and they have a far lower year average chloride

25 figure than we are asking for.

26 Another toxic ion is sodium, and it has the

1 problems both of toxicity to plants and also of soil
2 damage due to what's known as sodification.
3 And without going into a lecture on that subject,
4 I refer you to the U.C. guidelines.
5 They propose a sodium absorption ratio to
6 measure the sodium ion content in terms of its potential
7 for sodification, and we are merely using the figures that
8 they have proposed in their guidelines in that regard.
9 We are assuming for the moment at least that in
10 protecting ourselves against sodification we will also have
11 adequate protection against sodium toxicity.
12 Now, there are other ions which can be toxic
13 to plants such as boron and still other ions which could be
14 damaging to our livestock industry in that these waters are
15 used also for livestock drinking water.
16 So though not indicated in the exhibit here, we
17 also propose that the minimum trace mineral objectives that
18 are listed in the U.C. guidelines for water quality be
19 imposed as objectives, both as regards the limitations for
20 crop irrigation and the limitations for livestock drinking
21 water.
22 This, again, is particularly necessary because
23 there is a lot of boron in this west side leach water and
24 because things that men may decide to do like spreading
25 sewage sludge on farmlands could cause drastic changes in
26 the mineral content of some of the ions listed in those

1 guidelines.

2 Moving on, then, to the water-quantity type

3 criteria, our criteria call for maintaining a net daily

4 unit directional flow at all times through each of the

5 principal Delta channels.

6 This differs from the Basin Plan which calls

7 for net daily downstream flow in all channels, our reasons

8 being that an examination of the ways in which our water

9 needs can most readily be met in deference to the needs

10 of others indicate that it will probably be desirable in

11 one way or another to reverse flows in Middle and/or Old

12 Rivers, and by making a unit directional flow, we still

13 get the flushing we need, the avoidance of stagnant zones,

14 and we provide more flexibility to the operators in how

15 it is accomplished.

16 The magnitude of the unit of directional flow

17 must be such as to maintain adequate pump drafts so we can

18 operate our pumps -- that's a severe problem this year --

19 and to maintain the water quality criteria.

20 We propose that the pump drafts -- the water

21 depths to provide pump draft in the San Joaquin River may

22 be achieved either by adequate flow levels which we

23 stipulate or by installation of removable weirs to retain

24 adequate water depth without releasing any waters beyond

25 those required for our consumptive needs and the

26 maintenance of the water quality.

1 Q. With that background, Mr. Hildebrand, can you
2 proceed through this Exhibit Roman Numeral II and call to the
3 Board's attention the highlighting of your explanation,
4 the way South Delta Water Agency recommends the criteria
5 be established?
6 A. You refer to the phasing of them?
7 Q. Yes.
8 And just calling their attention to the reasons
9 for the phase, and the criteria used in each phase, and
10 the differences generally.
11 A. In the water quantities or both the water
12 quantity --
13 MR. MAUGHAN: You have already gone through
14 the water quality pretty well.
15 THE WITNESS: Yes, well, I didn't mention the
16 quality in the early phases.
17 In recognition of the fact that without New
18 Melones, we do not have good, easy access to a reliable
19 supply of good quality water, and in recognition of the
20 fact that water flows from the DMC involve quite a bit of
21 energy, we are proposing to accept a lesser level of
22 criteria initially.
23 Q. BY MR. WILSON: Would you explain those dates.
24 This is from Page 1, Phase I.
25 A. Phase I would be from now until the New Melones
26 project is completed. The Phase II would be the period

during which New Melones is being filled, and during that period we would assume that the fish releases, which I'll refer to later, and the currently promised water quality releases would be made, but that the releases of what might be termed "contractable yield" would not be made. So this is an interim situation, again, which permits significant improvement in our water situation but still does not achieve the flow accomplishment of our criteria which would have to await the completion of New Melones project including sufficient filling.

Now, in terms of water flows, again, in the interim period, we do need some flow supplements. We can't live with the kind of a situation we have this year and have had in some other years like 1961 where the inflow at Vernalis is pitifully close to zero, where, as a third of our consumptive needs come out of that stretch of river, from there down to the portions of the agency that have more ready access to reverse flows.

The amount of release that we have proposed here of 900 cfs can, of course, be diminished and still give us the depth we need if we have removable weirs. Same basic concept as in the emergency program that's being installed right now for this year.

In Phase II, we are in an interim situation where there will be somewhat more water available out of New Melones, but the volumes available are strictly small so

1 we would ask that we take advantage of those added volumes
2 but not back off of the other provisions that would be made
3 pending completion of New Melones.
4 Q. I notice, Mr. Hildebrand, in the quality there
5 are three phases -- Phase I, Phase II, and Phase III for
6 quality criteria whereas the quantity criteria you have
7 only two phases.
8 Would you explain those differences, please.
9 A. Well, the -- during this interim period before we
10 get adequate flows, availability of adequate quality water,
11 we are accepting that there must be some inadequacies
12 of water quality, but we don't feel we should be subjected
13 to that same degree of inadequacy of flow.
14 Q. Wait a minute. Would you state that again.
15 A. During this interim period between now and the
16 time New Melones is completed, we are accepting that we
17 will have rather inadequate water quality as indicated by
18 the proposed Phase I quality criteria, but we don't feel
19 it necessary to make that much distinction in the situation
20 with respect to quantity because the quantity can be
21 provided in manners different than the quality.
22 Q. You do have, however, a Phase I quantity criteria
23 on Page 5 for the same period; do you not?
24 A. Yes, but the Phase II and the quantities would
25 apply both to the filling period of New Melones and also
26 subsequently.

Q. In other words, Phase II of the quantity criteria on Page 5 relates to that period from and after the date that New Melones project is completed?

A. Yes.

Q. Whereas in the quality criteria you have both Phase II and III, Phase II taking up to the date -- from the date the project is completed until it's operational, and Phase III is after it's operational; is that correct?

A. Yes. In terms of quantity, we haven't distinguished between the filling period at New Melones and the subsequent period in terms of quality.

Q. Now, in response to Mr. Campos' question, I call to your attention the definitions which commence on Section Roman Numeral II, Page 9, and run to Page 12, and I wonder if you would comment on the water year definitions and also -- the water year definitions and the unimpaired runoff definitions, and then the definitions which trigger these phases which are all set forth on those four pages.

A. As Dr. Orlob has shown, the primary source of our water still is and will continue to be the flows of the San Joaquin River system whether they be natural flows or return flows.

And a water year classification that ignores the hydrology of the San Joaquin River system seems to us inappropriate for applications of the Southern Delta.

Delta Agricultural Diversion Evaluation 1992 Pilot Study

Stephani Spaar
Department of Water Resources

Technical Report 37
May 1994

Interagency Ecological Program
for the
San Francisco Bay/Delta Estuary

A Cooperative Program of:

California Department of Water Resources
State Water Resources Control Board
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers

California Department of Fish and Game
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency

SDWA 52

C-115614

C-115614

Abstract

The objectives of this study are to:

- Develop reliable entrainment estimates for various fish species and life stages to Delta agricultural diversions during the irrigation season.
- Describe the susceptibility of various fish species to the diversions relative to their abundance and life stages in adjacent channels.

This pilot study focused on refining sampling techniques and assessing the suitability of four diversion sites. The McDonald Tract site was included to test the effectiveness of a fish screen installed on that intake. Sampling was conducted in diversions and adjacent channels from April through October 1992 for eggs and larvae, with some sampling for juveniles and older fish. Density and entrainment were estimated for eggs and larvae, and estimates of juvenile and older fish entrained were extrapolated where possible. The Wilcoxon signed-ranks test was used to compare diversion and channel densities of eggs and larvae by species at diversion sites and for the fish screen test.

Results indicate vulnerability of eggs and larval fish to entrainment tends to vary between species and appears to depend on seasonal occurrence, abundance, and distribution of a species in the adjacent Delta channel and on operations of the diversion. Larval threadfin shad at McDonald Tract were more susceptible to entrainment than channel density indicated. Density in the diversions was significantly ($P<0.01$) higher than in the channel. Larvae of threadfin shad (other sites), centrarchids, cyprinids, and logperch were as susceptible to entrainment as channel density indicated. Threadfin shad (2 sites) and centrarchid (all sites) diversion density was not significantly different from channel densities, and no difference was found for cyprinids and logperch at Bacon Island. Chameleon goby, striped bass, and prickly sculpin larvae were less vulnerable to diversions than channel density indicated. Diversion density was significantly ($P<0.01$) lower than channel density for these species at Bacon Island and for chameleon goby at other sites. Chameleon goby, threadfin shad, and centrarchids were the most abundant larval species entrained by the diversions.

Fish screen test results indicated no significant difference between unscreened and screened density of threadfin shad eggs. Density of larval threadfin shad and chameleon goby was significantly lower with screens ($P<0.01$) than without ($P<0.05$); the same was true for centrarchids ($P<0.05$). The screen was effective in reducing entrainment of larvae 4-5 mm TL and larger.

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Acknowledgments

I thank all the people who helped in this first year effort. Leo Winternitz helped get this study off the ground in its early stages and provided guidance throughout. Larry Chee obtained entry permits to the diversion sites, flowmeters and their installation, and miscellaneous sampling gear. The crew of the *Beowulf II*, Ron Lunsford, Pam Casselman, and Teresa MacColl, spent long days collecting channel samples. Rory Fagan, Kelly Cohen, and Katie Wadsworth also spent many long days collecting diversion samples. We received a lot of valuable assistance from the Department of Fish and Game, Stockton, in evaluating the sampling procedures and gear. Curtis Hagen and Jim Starr helped immensely with their electrofishing efforts during these evaluations. Johnson Wang provided invaluable services on identification and enumeration of our egg and larval samples.

I thank Randy Brown, Steve Ford, Leo Winternitz, and Lloyd Hess, who provided helpful comments on the draft report. I also thank Vera Tharp for her editorial and layout efforts that make these technical reports a reality.

C—115619

C-115619

Introduction

The peak agricultural diversion season in the Sacramento-San Joaquin Delta is April through August. This coincides with months when large numbers of young Chinook salmon[1], striped bass, American shad, delta smelt, and other fish species are present in the system. Entrainment to agricultural diversions may be a substantial source of mortality for early life stages of some Delta fish species.

Little is known about the extent of entrainment to agricultural diversions or the factors affecting losses. Brown[2] estimated striped bass losses to be several hundred million for fish less than 16 mm SL[3]. Chinook salmon losses were estimated to be a few hundred thousand. Based on a limited study on Sherman Island adjacent to the San Joaquin River, Allen[4] reported that concentrations of striped bass eggs and young from the diversions were statistically identical to those in the adjacent river channel (up to 5.8 eggs/cubic meter and 2 fish/cubic meter of water). Although there was no significant difference between the daily mean length of young collected in the river (3-34 mm SL) and those diverted (4-16 mm SL), bass between 17 and 34 mm were taken only in the river. Allen indicated the most plausible explanation was that larger young bass swim well enough to avoid the influence of operating siphons.

Due to concerns about water diversions and impacts on fishery resources, fish screening requirements are covered in three sections of the California Fish and Game Code. These sections cover screening requirements for diversions over 250 cfs (Section 5980), diversions 250 cfs or less (Section 6020), and new diversions installed since January 1, 1972 (Section 6100). In addition, National Marine Fisheries Service is considering proposing regulations that would establish screening requirements for water diversions from the Sacramento River and Delta to protect threatened winter-run Chinook salmon[5].

The Delta Agricultural Diversion Evaluation is designed to estimate fish entrainment at representative agricultural diversions. The objective is to develop reliable entrainment estimates of various fish species and life stages to agricultural diversions during the irrigation season, and to describe their susceptibility to these diversions, relative to their abundance and life stages in adjacent channels. The knowledge gained from the study will be used to design and evaluate mitigation proposals to reduce entrainment, such as consolidating or screening agricultural diversions and modifying water use patterns on Delta islands.

As the first year of a 3-year study, 1992 focused on refining sampling techniques and assessing the suitability of the selected sites to meet the study objective. Parts of this study were mandated by the U.S. Army Corps of Engineers permit for the Temporary Barriers Project[6] in the southern Delta and by the Delta Smelt Study Plan[7].

1 Scientific names of fish that may be mentioned in this and other Interagency Program reports are printed inside the back cover.
2 R.L. Brown. *Screening Agricultural Diversions in the Sacramento-San Joaquin Delta.* Department of Water Resources, Internal Report. 1982. 42 pp.
3 Definitions of abbreviations commonly used in Interagency Program reports are printed inside the back cover.
4 D.H. Allen. *Loss of Striped Bass Eggs and Young through Small, Agricultural Diversions in the Sacramento-San Joaquin Delta.* Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report 75-3. 1975.
5 Federal Register, Vol. 28, No. 199, issued October 18, 1993.
6 Permit 199101051, effective March 30, 1992.
7 D.A. Sweetnam and D.E. Stevens. *Delta Smelt Study Plan.* Department of Fish and Game. October 1991. 46 pp.

C-115620

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In March 1992, four sites were selected in the central and southern Delta as representative agricultural diversions (Figure 1). In compliance with the Temporary Barriers Project permit, two agricultural diversion study sites (2 and 4) were selected based on the following criteria:

- Location south and west of the San Joaquin River.
- Right-of way-clearance.
- Landside sampling accessibility.
- Diversion equipment, operation, and volume representative of southern Delta agricultural diversions.
- Availability of channel fishery data.
- Feasibility of diversion for remedial action, if warranted by study.

One site (Site 2) was in the central Delta on the east side of Bacon Island, adjacent to Middle River. The other (Site 4) was in the southern Delta south of Fabian Tract and Old River within Naglee Burk Irrigation District.

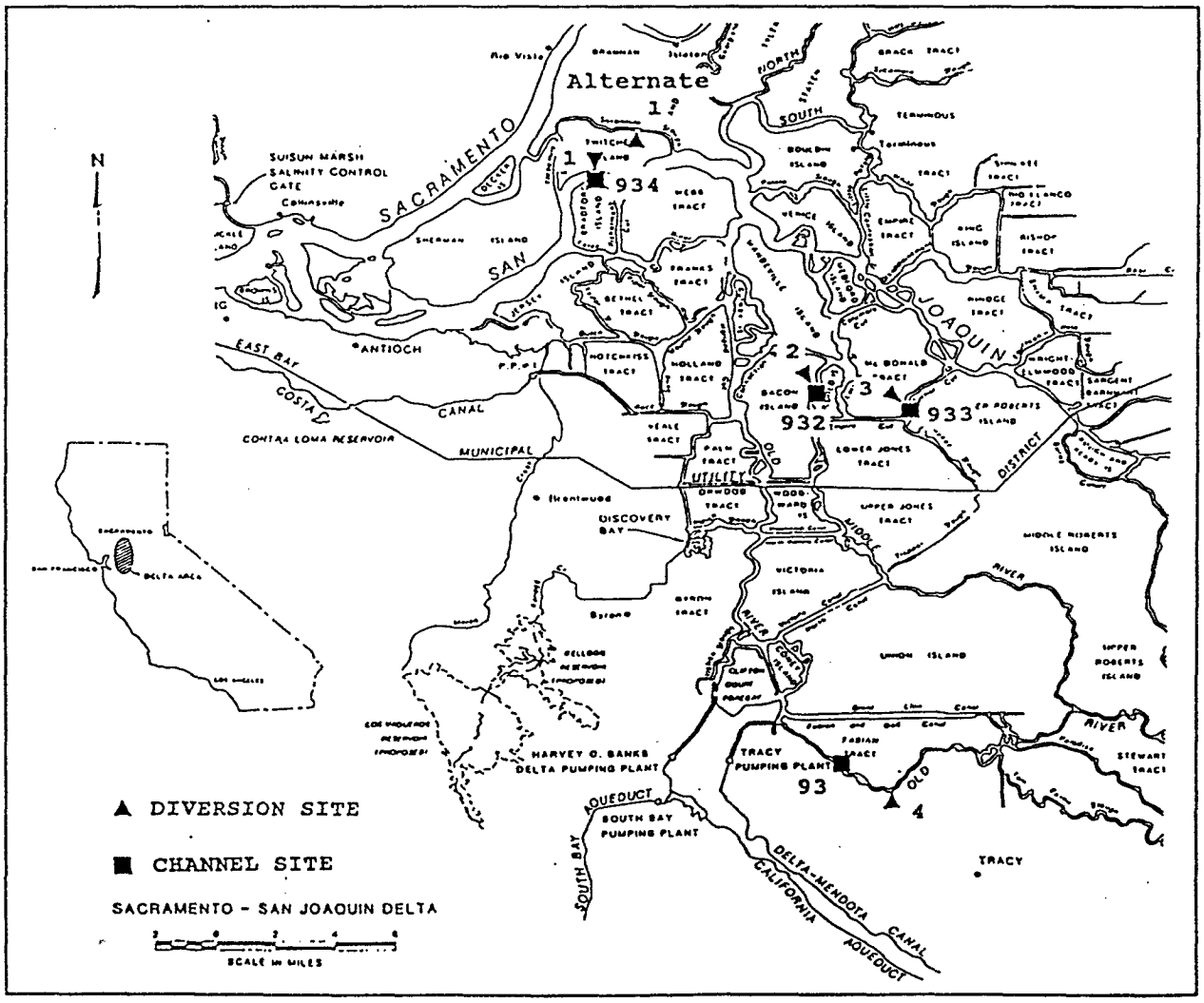

Figure 1
DIVERSIONS AND ADJACENT CHANNEL SITES SAMPLED
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

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Two additional sites were selected based on the same general criteria. At least one site was to be adjacent to a known area of delta smelt abundance. The diversion site on Twitchell Island (Site 1) was near an area of the San Joaquin River where delta smelt have been abundant in past years. The Department of Water Resources owns the property at this site, thus providing access. The site on McDonald Tract (Site 3) was chosen because the landowners had installed an experimental fish screen for testing.

In the Delta, two general types of agricultural diversions are used, siphons or pumps, depending on the elevation of the land under irrigation. Siphons are common on Delta islands and low lying adjoining tracts. Pumps are more common in outlying areas with higher land surface elevations. Siphons are usually 10-18 inches in diameter (range: 6-66 inches), and pump intakes are 6-16 inches in diameter (range: 6-54 inches)[8]. Intakes are unscreened and draw water from 2 to 3 feet above the channel bottom, but position may vary due to changing bottom conditions or other causes. Diversions are usually not metered, so exact volumes diverted are unknown. Water is siphoned or pumped from the channel, applied to fields by a system of ditches, and then pumped back into the channel. Operations vary with the type of crop under cultivation, which may change seasonally or yearly.

Twitchell Island

Site 1 was on the southern edge of Twitchell Island adjacent to the San Joaquin River and an area of known delta smelt abundance. Water was diverted at this site by a 16-inch-diameter siphon. This site could not be sampled in 1992 because no irrigation water was needed except for a 2-week period in August, during which time the site was inaccessible due to major levee repairs in the area.

An alternative site on the northern side of the island was selected when it became obvious problems would hinder sampling at Site 1. At this site, water was diverted from Sevenmile Slough by an 18-inch siphon into a concrete box that emptied into a small pond. One irrigation ditch carried water south and a second to the east. The diversion rate varied depending on agricultural needs and was not continuous for the season. Since this was an alternative site, no flowmeter was installed on the siphon.

Bacon Island

Located on the eastern side of Bacon Island, this site was on an outside bend of Middle River. Two siphons diverted water into a common dirt ditch. One siphon was 14 inches in diameter and the other was 16 inches. These siphons provided agricultural water for land under cultivation for corn and potatoes.

At least one siphon, usually the larger one, diverted 24 hours a day during the April-through-September irrigation season. The smaller siphon diverted early in the season, when more water was needed, or when the larger siphon needed repairs. The diversion rate varied depending on agricultural needs but was continuous for the season. Propeller flowmeters[9] with flow indicator (cfs) and totalizer (acre-feet) were installed on both siphons on May 4, 1992.

McDonald Tract

Site 3 was on the southeastern side of McDonald Tract adjacent to Turner Cut. Water was diverted through a 12-inch-diameter siphon into a dirt ditch. A flowmeter[10] with flow indicator (gpm) and totalizer (gallons) was installed on the discharge line on May 7, 1992. No agricultural diversions were needed during the study period, so water was diverted only during sampling. This site was not typical of normal irrigation practices.

This siphon was included in the study to test the effectiveness of an experimental fish screen installed on the intake for the Central Delta Water Agency Fish Screen Test Project. Two cylindrical

8 Department of Water Resources, unpublished data.
9 Ketema McCrometer Model M0300.
10 Ketema McCrometer Model M0300.

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fish screens[11] were installed on a hinged pipe tee (Figure 2).

The hinged tee was a modification of the swivel joint used by the screen manufacturer (Figure 3). The screen was made of stainless steel mesh with 2.3-mm diagonal openings.

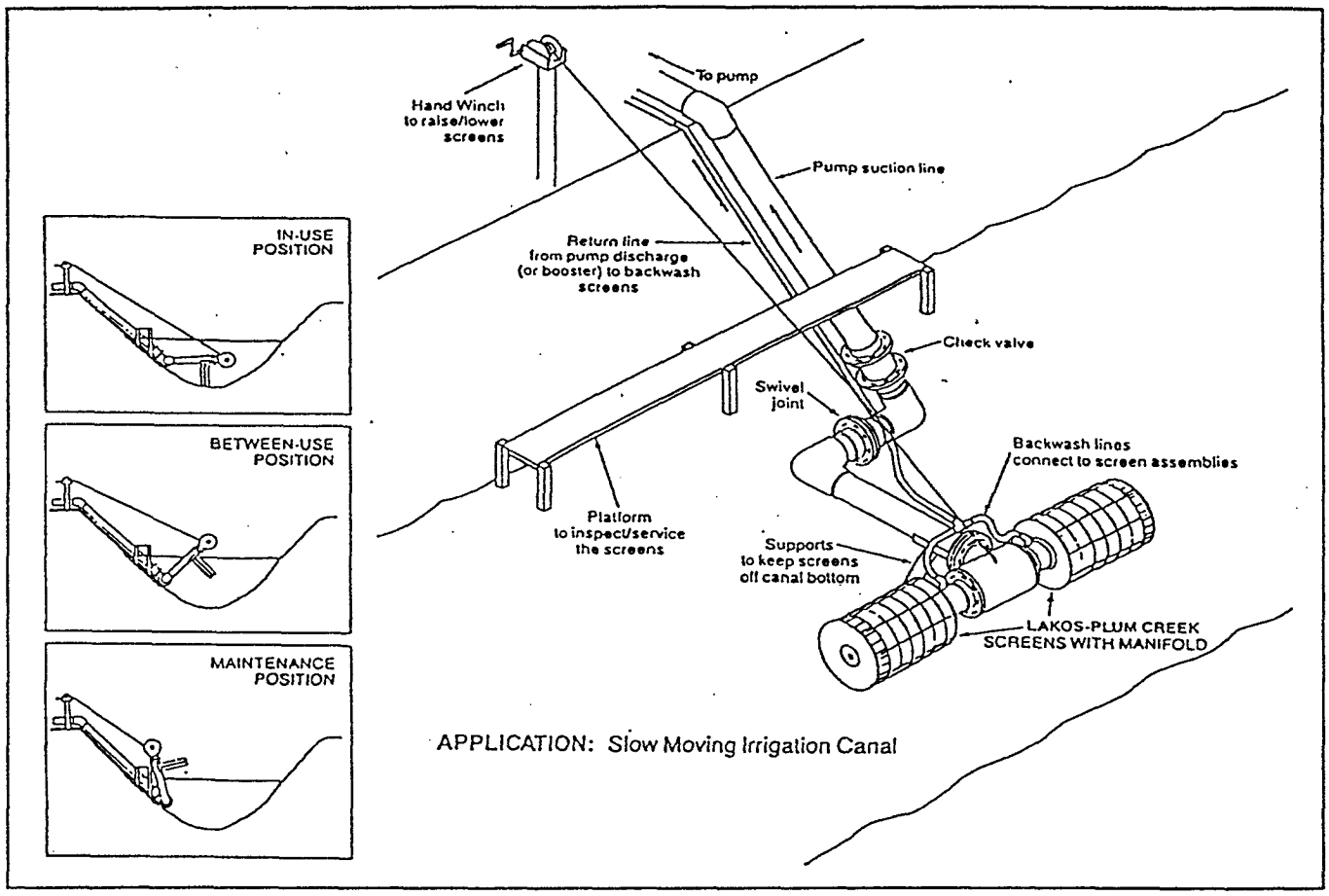

Figure 2
LAKOS-PLUM CREEK SELF-CLEANING PUMP INTAKE SCREEN INSTALLED ON MCDONALD TRACT
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

11 Lakos-Plum Creek type.

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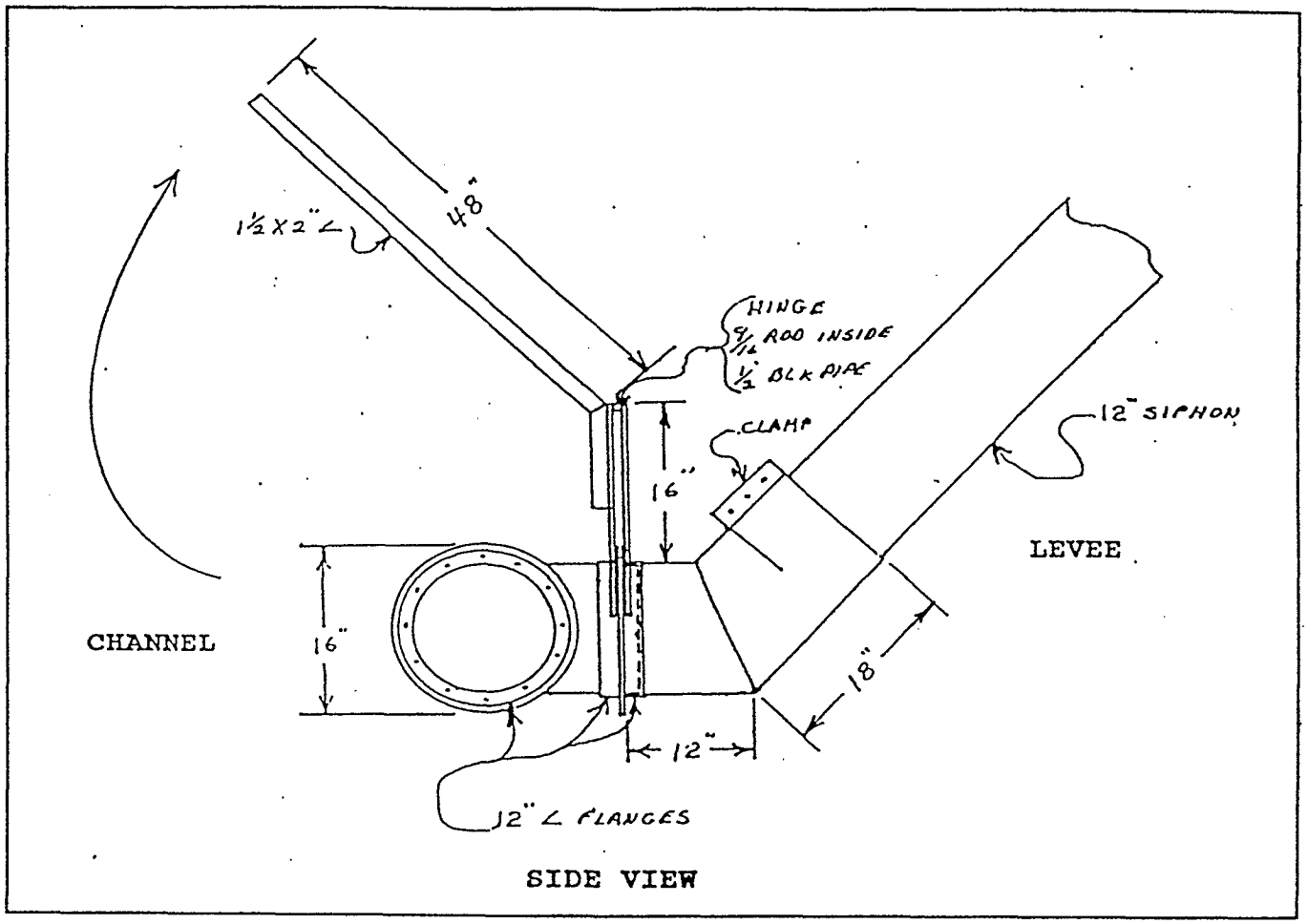

Figure 3
MODIFIED SWIVEL JOINT INSTALLED ON THE LAKOS-PLUM CREEK INTAKE SCREEN ON MCDONALD TRACT
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

Naglee Burk

Site 4 was on an outside bend of Old River upstream of the temporary barrier site near Tracy Pumping Plant. At this site, water was diverted by a pump with a 12-inch-diameter intake into a 20-inch-diameter discharge pipe and into a concrete box that allowed water to be released to the south or east. The main irrigation ditch was concrete lined and carried water southwesterly to agricultural fields under cultivation for alfalfa and corn. A smaller, secondary concrete ditch carried water to the northeast, along the toe of the levee, to an area under cultivation for sugar beets.

The irrigation period for this diversion was about mid-April through mid-November. The diversion rate varied between 15 and 20 cfs, depending on agricultural needs. Water diversion was not continuous at this site, and the pump was completely shut down for periods of 7 to 10 days or longer. Water was primarily released into the south ditch, but occasional releases were also made to the east ditch. A propeller flowmeter[12] with flow indicator (cfs) and totalizer (acre-feet) was installed on the discharge line on September 4, 1992. Installation was delayed due to coordination difficulties between the ditch tender and the company contracted to install the meter.

12 Ketema McCrometer Model M0300.

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The pilot study focused on two general life stages of fish: eggs/larvae and juveniles/older fish. Sampling for these life stages was conducted at the diversion and in the adjacent channel. Most of the 1992 sampling effort focused on eggs and larvae due to delays in obtaining sampling gear for larger fish.

Sampling was conducted from April through October, depending on location and type of sampling (Table 1). Generally, two or three samples were collected each week at each site if the site was diverting.

Sampling Eggs and Larvae

Egg and larval samples were collected in the irrigation ditches using a 0.5-meter-diameter, conical plankton net, 8 feet long, made of 505-micron mesh Nitex netting. A quart plastic collecting jar, screened with 470-micron mesh bolting cloth, was attached at the cod end to collect samples. Each net was fished with a bridle and line from a catwalk spanning the ditch. A digital flowmeter[13], mounted in the mouth of the net, was used to measure flow through the net and subsequently compute the cubic meters of water sampled. When available, flowmeter readings from the diversion pipe were recorded with each sample as flow and total volume diverted. Water temperature (degrees Fahrenheit) and surface specific conductance (µS/cm) were measured at each site.

Egg and larval data from channels adjacent to the agricultural diversion sites were collected at stations 93 (Naglee Burk), 932 (Bacon Island), 933 (McDonald Tract), and 934 (Twitchell Island) (Figure 1). Station 93 was part of the South Delta Egg and Larval Study and was 2.5 miles downstream of the Naglee Burk diversion. The station was moved downstream of the temporary barrier on Old River near Tracy on April 28, when the original site became inaccessible due to closure of the barrier. Stations 932-934 were added to the egg and larval survey for this study.

Sampling at station 93 began February 20 and ended July 15, 1992. Stations 932-934 were sampled from early-April to late September (Table 1). Samples were taken at each station every 4 days until April 4

Table 1
SUMMARY OF
SITE CHARACTERISTICS, PERIOD OF SAMPLING, AND TYPE OF SAMPLING
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

Site No.	Location	Diversion Type	Diversion Size	Diversion Operation		Sampling Period Diversion	Sampling Period Channel
1	Twitchell Island[1]	Siphon	18"	Intermittent	EL:	Jun 24-Sep 22	Apr 14-Sep 23
					JUV:	Jul 9; Sep 21-22; Oct 7, 9	Jul 21-Sep 8
2	Bacon Island	Siphon	16"/14"	Continuous	EL:	Apr 22-Oct 23	Apr 6-Sep 23
					JUV:	Jun 29-Oct 23	Jul 21-Sep 8
3	McDonald Tract	Siphon	12"	Intermittent	EL:	May 6-Aug 19	Apr 6-Sep 23
					JUV:	Jun 30; Jul 6-9; Aug 19	Jul 21-Sep 8
4	Naglee Burk	Pump	20"; 30 hp	Intermittent	EL:	May 6-Oct 2	Feb 20-Jul 15
					JUV:	Aug 5-Oct 2	Jul 21-Sep 6

1 Alternative site on Sevenmile Slough
EL = Eggs and Larvae; JUV = Juvenile and Older Fish

13 General Oceanics Model 2030.

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and then every other day until July 15. After July 15, stations 932-934 were sampled at least once a week until late September.

Channel samples were collected by making a single 10-minute oblique tow, regardless of tidal stage, at each station using an egg and larval net mounted on a towing frame with skis.[14] Sampling methods are essentially identical to those used by the Department of Fish and Game in its Delta-wide striped bass egg and larval sampling program.

At the end of each channel tow or ditch sample, contents of the net were rinsed into a collecting jar, and the samples were preserved in 5% formalin. Rose bengal dye was added to make the eggs and larvae more visible.

The Department of Water Resources contracted the egg and larval laboratory work to consultant Dr. Johnson Wang, National Environmental Sciences, Inc. In the lab, samples were rinsed thoroughly with water through a No. 50 sieve (300-micron mesh) to remove formalin, excess dye, and algae. Each sample was sorted under a magnifying illuminator, and all eggs and larvae were removed and counted. Eggs were identified to species, where possible, and counted; striped bass eggs were further classified as dead, morula, early embryo, or late embryo. Fish larvae were classified to species, and in some cases only to genus or family. Larvae were measured to the nearest millimeter total length.

Sampling Juveniles and Older Fish

Juvenile sampling began June 29, 1992. Sampling was delayed because the nets ordered in March did not arrive until late June. Some extended sampling was conducted during daylight and evening hours to provide information regarding tidal effects and nighttime activity.

Juvenile samples were generally collected using a 1x1-meter net, 16 feet long, made of 1/8-inch Delta-type mesh with 10-foot wings attached. The nets were set in the irrigation channels and fished 100% of the flow at Naglee Burk and about 90-95% of the flow at Bacon Island. Three sizes of live boxes were used throughout the season to determine the best size for future sampling. Two of the live boxes were large versions of cod-end jars and were 4.5 inches and 6.625 inches in diameter with 1000-micron mesh Nitex netting. The third box was 2x2x4 feet and made of 1/8-inch mesh netting with a 1-inch PVC pipe frame.

Two other sampling methods were also tested. A 1.4x1-meter net, 18-1/2 feet long, of 1/8-inch Delta-type mesh on a stainless steel frame was used to sample the siphon outfall directly at Bacon Island. Also, DFG tested electrofishing with a backpack shocker at both sites, in conjunction with the channel nets.

All fish caught were identified to species, enumerated, and measured to the nearest millimeter total length or fork length, depending on the species. If identification was not possible, the fish were returned to the lab for positive identification. The volume of water sampled was determined from the flowmeters installed on the diversion outfall.

A tow-net was obtained from DFG on June 20 to sample juveniles in adjacent channels. Tow-net methods were essentially the same as those used by DFG in the Delta-wide tow-net survey. Sampling did not begin until July 21 due to modifications required for this gear on the sampling boat. Tow-net sampling was conducted at stations 932-934 through September 8 about once or twice a week. The Naglee Burk site was inaccessible to the sampling boat due to the temporary barrier at Old River near Tracy. However, DFG sampled monthly at a nearby site by hoop-netting and electrofishing.

14 S.A. Spaar. *1992 Entrainment of Striped Bass Eggs and Larvae to the State Water Project and Central Valley Project Intakes in the Sacramento-San Joaquin Delta.* Department of Water Resources Memorandum, May 28, 1990.

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Data Analysis

Sampling data were analyzed to determine susceptibility of fish species and life stages to the agricultural diversions through the coordination of diversion studies with sampling in adjacent channels from which water was diverted.

Densities (organisms per cubic meter) were estimated for all eggs and larvae for each sample site by sample day. Estimates of the number of eggs and larvae entrained by the agricultural diversions were derived from the landside density estimates of eggs and larvae at the sample sites. Estimates of the number of juvenile and older fish entrained were extrapolated from the landside numbers of fish captured per volume of water diverted over the sample period. Diversions at each site were multiplied by the appropriate density of eggs and larvae or numbers of fish to estimate entrainment.

The Wilcoxon signed-ranks test was used to analyze and compare diversion and channel densities of eggs and larvae by species at each diversion site except Twitchell Island.[15] Paired samples of diversion and channel densities for the same date were tested. If no channel data were available for a given diversion sample date, channel densities for each species were estimated as the mean of densities on the date preceding and following the diversion sample date (only if within 1-2 days). Similarly, paired samples of eggs and larvae under screened and unscreened conditions at McDonald Tract were tested.

15 R.R. Sokal and F.J. Rohlf. *Biometry*. W.H. Freeman and Company, New York. 1981. 859 pp.

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The pilot study results are separated into three areas: eggs and larvae, juvenile and older fish, and McDonald Tract fish screen test. Results include species occurrence, species distribution and abundance, entrainment estimates where possible, and size distribution of the catch.

Eggs and Larvae

Results from sampling in the diversions and adjacent Delta channels indicate eggs and larval fish are susceptible to entrainment into agricultural diversions. The degree of vulnerability to entrainment tends to vary between species. Entrainment appears to depend largely on seasonal occurrence, abundance, and distribution of a species in the adjacent channel and operations of the diversion.

Species Occurrence

Larval species collected from the agricultural diversions appear to be a subset of the species present in the adjacent channels (Table 2). This does not apply to results from Twitchell Island where the channel sampling was not adjacent to the alternative diversion sampled. The species represented in the channel catch at Twitchell Island are indicative of species potentially diverted if samples could have been obtained at Site 1. Among these species were striped bass (eggs and larvae), delta smelt, and splittail.

At Bacon Island, most of the nine species collected in the adjacent channel of Middle River were also collected on land (Table 2). Exceptions were delta smelt and Sacramento sucker. In addition, American shad larvae were collected from the diversion but not the channel. No eggs of any species were collected in Middle River or in the diversion.

At both the McDonald Tract and Naglee Burk sites, the occurrence of species in the diversion was a smaller subset of those found in the channel. At McDonald Tract, of eight larval species collected in Turner Cut, only three were found in the diversion: chameleon goby, threadfin shad, and centrarchids. Larvae of prickly sculpin, striped bass, bigscale logperch, cyprinids, and delta smelt were found in the channel but not in the diversion. In contrast, threadfin shad eggs and mosquitofish young were found only in the diversion.

Similarly, of the eleven species found in Old River near the Naglee Burk site, only five were actually collected from the diversion: chameleon goby, threadfin shad, centrarchids, bigscale logperch, and cyprinids. Eggs of striped bass, prickly sculpin, and cyprinids were collected in the channel but not in the diversion, as were larval striped bass, prickly sculpin, inland silverside, splittail, mosquitofish (juveniles), and ictalurids. In contrast, threadfin shad eggs and Sacramento sucker larvae were found in the diversion but not nearby in Old River.

Species Distribution and Abundance

Overall, several species were very abundant in the channel and diversion collections (Tables 2 and 3). Chameleon goby and threadfin shad were very abundant in both channel and diversion samples. Striped bass were also a very abundant channel species at Twitchell Island and prickly sculpin in Old River near the Naglee-Burk site. At all sites, prickly sculpin were moderate to highly abundant in channel samples but not in diversion samples.

A comparison of diversion and channel results could not be made for Twitchell Island. However, channel results indicate chameleon goby larvae and striped bass eggs and larvae were very abundant in the San Joaquin River adjacent to the diversion site (Figures 4 and 5; Appendix C). Both eggs and larvae (primarily 3-6 mm) of striped bass were abundant when sampling began in mid-April. Eggs were abundant through mid-May and larvae into early June. Delta smelt, prickly sculpin, and bigscale logperch larvae were collected from mid-April into May (Figure 4). Threadfin shad and chameleon goby were collected from April through August. Splittail were noted in mid-April only (Appendix C).

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Table 2
SPECIES CATCH SUMMARY OF FISH EGGS AND LARVAE COLLECTED
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

(Blank spaces indicate zero catch.)

	Number Caught							
	Diversion Sites[1]				Channel Sites			
Species	1 Twitchell Island	2 Bacon Island	3 McDonald Tract	4 Naglee Burk	934 Twitchell Island	932 Bacon Island	933 McDonald Tract	93 Naglee Burk
Larvae:								
Chameleon goby		193	1865	130	5647	6491	20621	5299
Threadfin shad	8	90	1826	303	738	810	1744	1008
Prickly sculpin		8			413	748	530	2322
Striped bass		24			2956	326	37	25
Centrarchids	10	3	9	19	10	18	21	36
Bigscale logperch		6		1	17	30	73	52
Inland silverside	3							21
American shad		4						
Cyprinids		2		1	29	7	8	5
Delta smelt					19	7	3	
Sacramento splittail					1			3
Sacramento sucker				1		2		
Mosquitofish			3					2
Ictalurids								1
Yellowfin goby					4			
Total Larvae	21	330	3703	455	9834	8439	23037	8774
Eggs:								
Striped bass					689			
Striped bass (dead)								2
Threadfin shad			18	2				
Prickly sculpin								26
Cyprinid								1
Total Eggs	0	0	18	2	689	0	0	29

1 Site 1 alternative site sampled was a siphon diversion on Sevenmile Slough.

Table 3
TOTAL CATCH DENSITY OF FISH EGGS AND LARVAE COLLECTED
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

(Blank spaces indicate zero catch.)

	Number per Cubic Meter[1]							
	Diversion Sites[2]				Channel Sites			
Species	1 Twitchell Island	2 Bacon Island	3 McDonald Tract	4 Naglee Burk	934 Twitchell Island	932 Bacon Island	933 McDonald Tract	93 Naglee Burk
Larvae:								
Chameleon goby		19.95	35.19	4.07	55.25	50.30	203.62	34.83
Threadfin shad	1.13	12.26	42.17	10.12	6.17	5.96	15.19	6.16
Prickly sculpin		0.15			6.82	4.79	5.00	10.50
Striped bass		1.35			77.28	4.47	0.47	0.16
Centrarchids	1.19	2.24	0.17	0.90	0.11	0.13	0.19	0.21
Bigscale logperch		0.27		0.09	0.21	0.34	0.57	0.27
Inland silverside	5.70							0.10
American shad		0.04						
Cyprinids		0.14		0.22	0.68	0.10	0.19	0.02
Delta smelt					0.34	0.10	0.05	
Sacramento splittail					0.03			0.02
Sacramento sucker				0.58		0.05		
Mosquitofish			0.05					0.01
Ictalurids								0.01
Yellowfin goby					0.14			
Eggs:								
Striped bass					12.71			
Threadfin shad			0.11	0.60				
Prickly sculpin								0.10
Cyprinid								0.01
Number of Samples	7	69	30	30	44	52	52	46

1 Density ÷ 1233.49 acre-feet = number per acre-foot.
2 Site 1 alternative site sampled was a siphon diversion on Sevenmile Slough.

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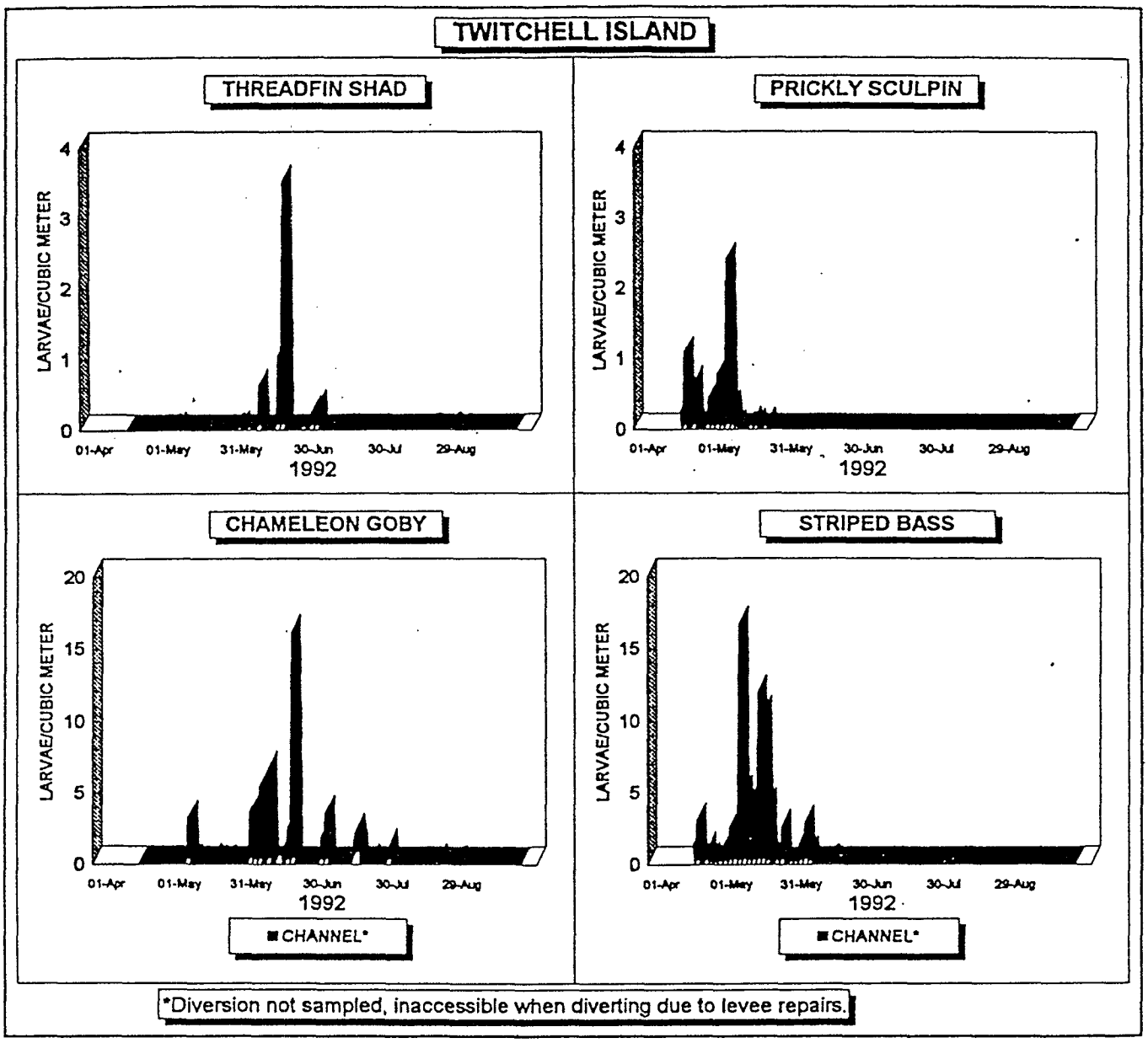

Figure 4
ESTIMATED DENSITY OF LARVAE IN THE SAN JOAQUIN RIVER
ADJACENT TO TWITCHELL ISLAND DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

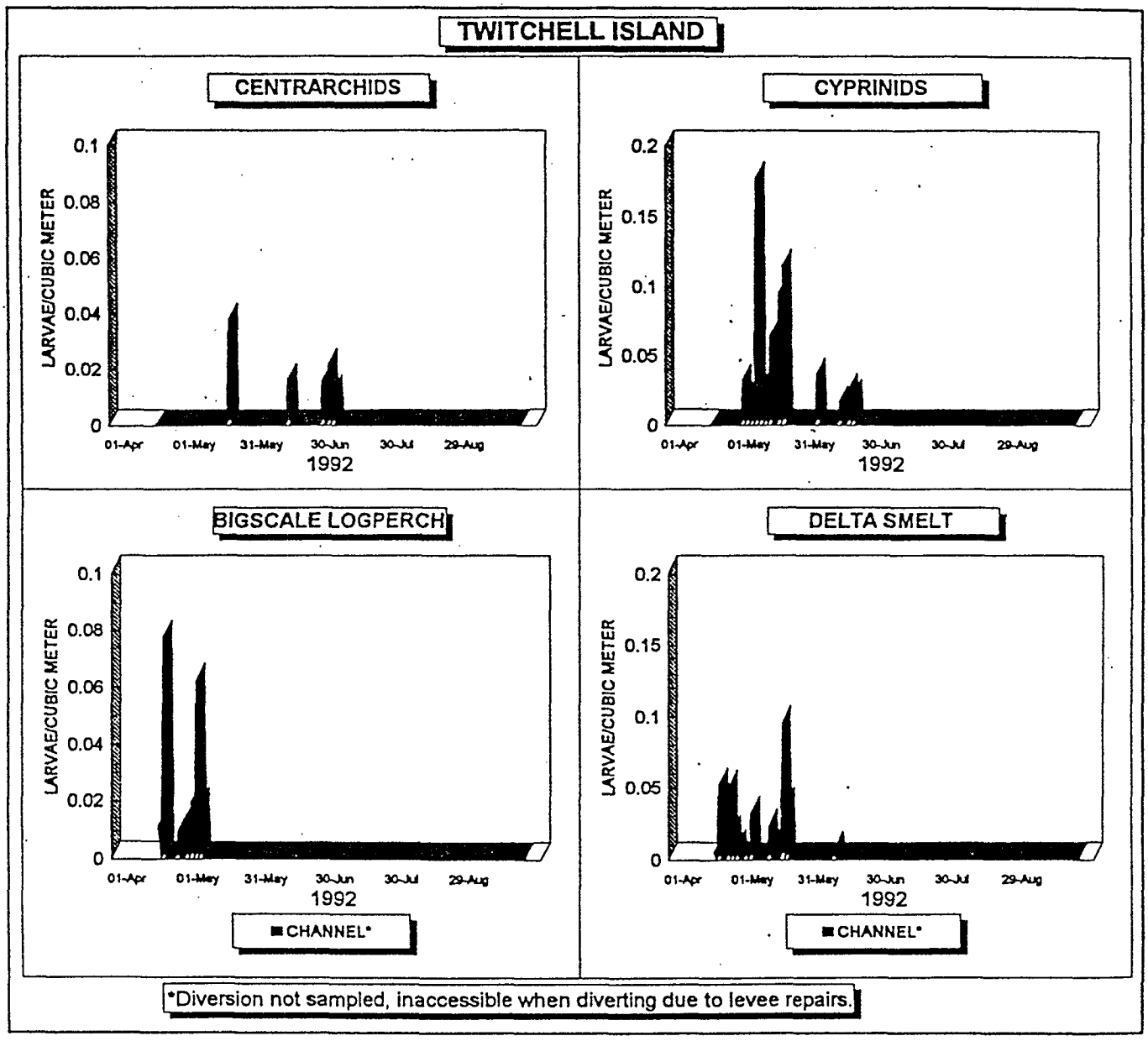

Figure 4 (continued)
ESTIMATED DENSITY OF LARVAE IN THE SAN JOAQUIN RIVER
ADJACENT TO TWITCHELL ISLAND DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

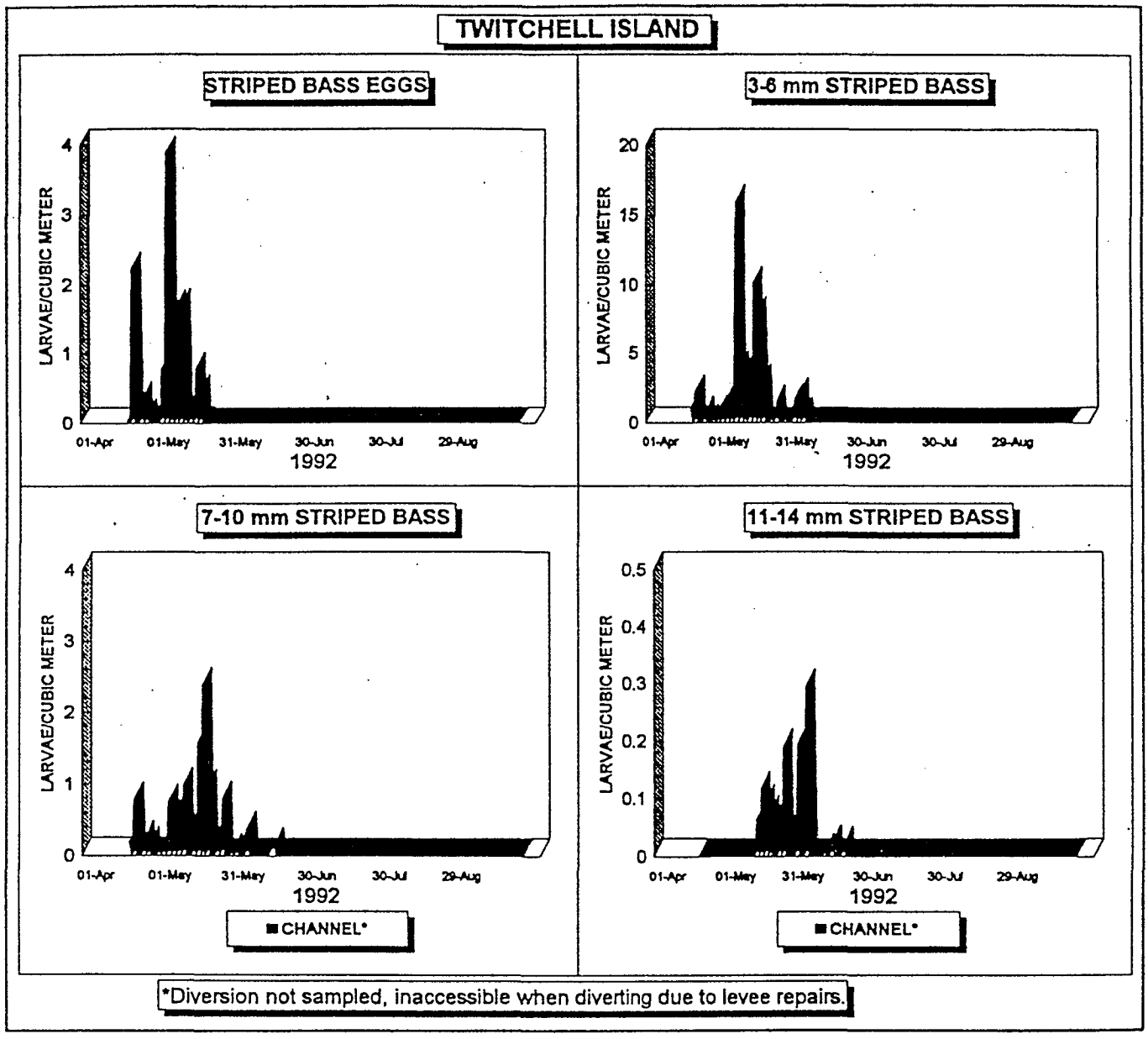

Figure 5
ESTIMATED DENSITY OF STRIPED BASS EGGS AND LARVAE IN THE SAN JOAQUIN RIVER ADJACENT TO TWITCHELL ISLAND DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

At the Bacon Island site, several larval species occurred in Middle River and in the diversion over similar periods during the diversion season: threadfin shad, chameleon goby, cyprinids, logperch, and striped bass (Figures 6 and 7). Prickly sculpin were present in the channel before the diversion season and about a month later than in the diversion itself (Appendixes B and C). Delta smelt and Sacramento sucker occurred in Middle River before and during the diversion season but were not collected from the diversion. No longfin smelt or splittail were collected at either location (Tables 2 and 3).

Densities of chameleon goby, prickly sculpin, and striped bass larvae were significantly higher ($P<0.01$) in samples taken in Middle River compared to those taken in the diversion (Table 4). In contrast, no difference was found in the densities for

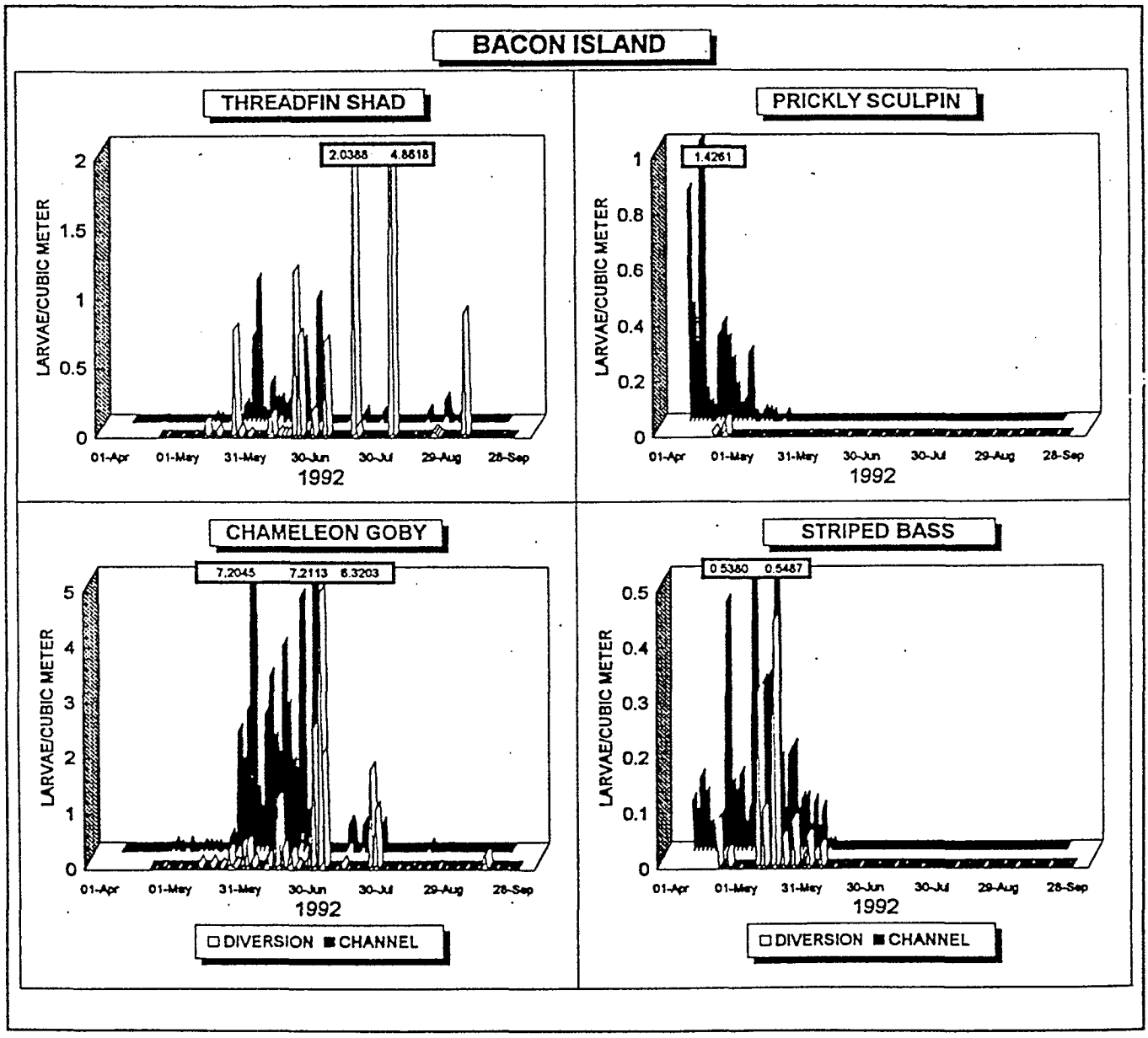

Figure 6
ESTIMATED DENSITY OF LARVAE IN MIDDLE RIVER
AND AT BACON ISLAND DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

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threadfin shad, centrarchids, cyprinids, and logperch between Middle River and the diversion.

A comparison of striped bass channel and diversion densities indicates the occurrence of striped bass larvae in the Bacon Island diversion was sporadic when compared with their occurrence in Middle River (Figure 7). Channel densities were significantly greater ($P<0.01$) than diversion densities (Table 4). Larvae (3-20 mm) occurred from April into June in both the channel and diversion. Larvae in the 3-6 mm and 7-10 mm size groups occurred much less frequently in the diversion than in the channel, but densities appear to be of similar magnitude on days when they were collected in both areas. No 11-14 mm (and up to 20 mm) larvae were collected in the diversion, but they were collected from the channel.

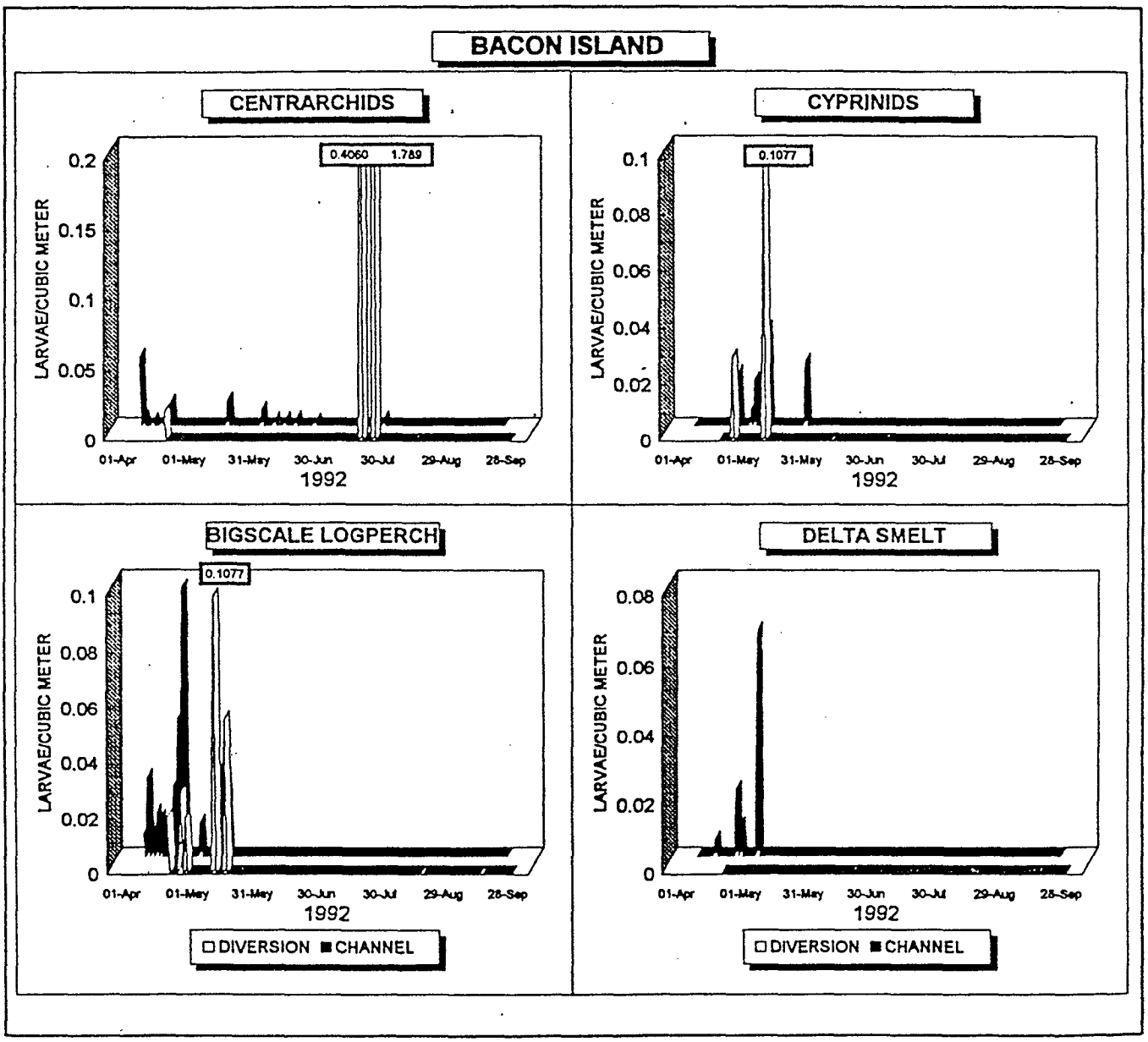

Figure 6 (continued)
ESTIMATED DENSITY OF LARVAE IN MIDDLE RIVER
AND AT BACON ISLAND DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

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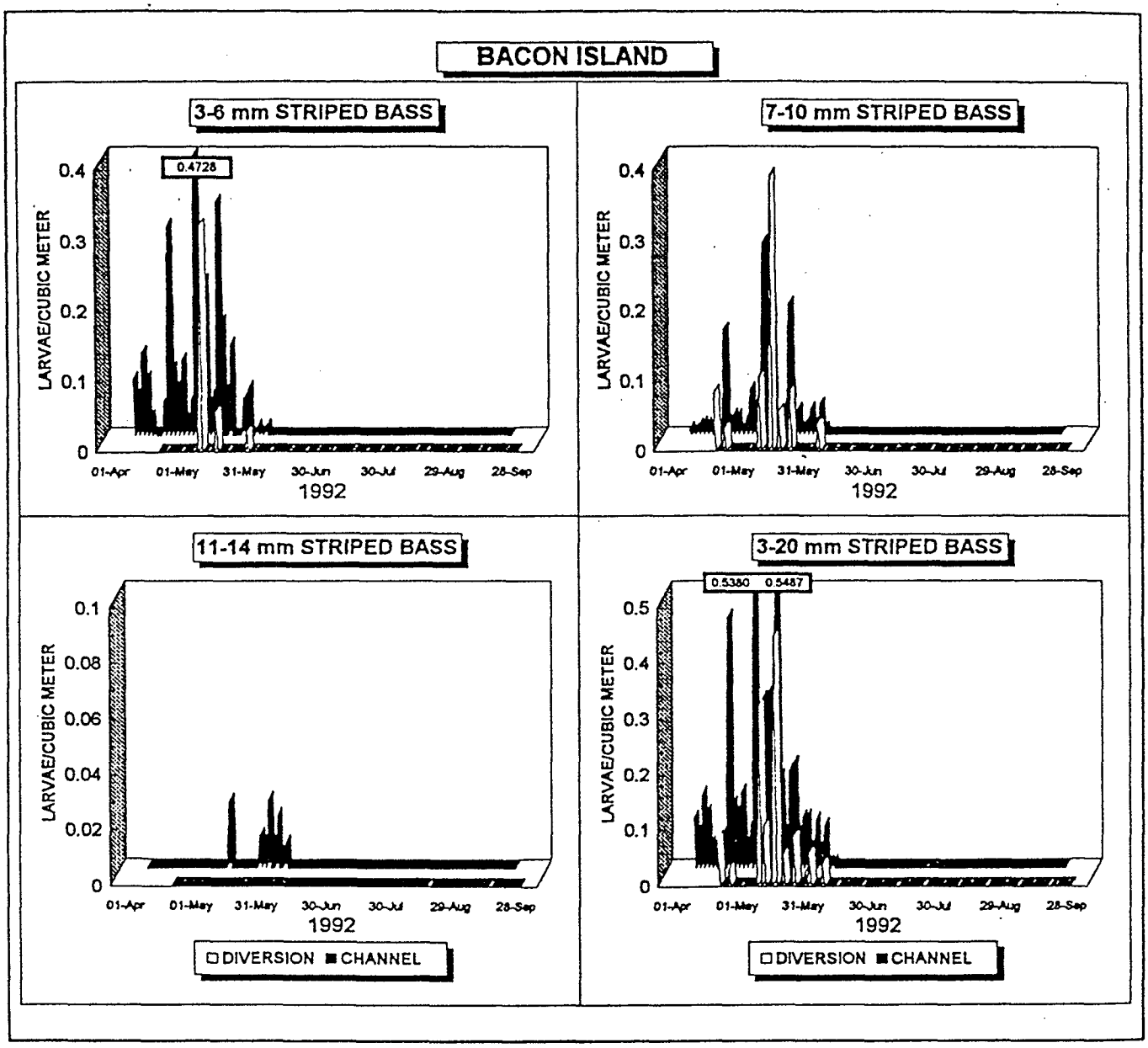

Figure 7
ESTIMATED DENSITY OF STRIPED BASS LARVAE IN MIDDLE RIVER
AND AT BACON ISLAND DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

Table 4
PAIRED COMPARISONS OF
EGG AND LARVAL DENSITY IN AGRICULTURAL DIVERSIONS AND ADJACENT DELTA CHANNELS
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

Values shown are the significance levels from the Wilcoxon Signed-Ranks Test.
Asterisks denote significance (P<0.05, P<0.01**).*
Blank spaces indicate either zero catch during paired sampling or
an insufficient number of paired samples (n<6) to test with nonzero differences.

Species	Bacon Island	McDonald Tract	Naglee Burk	Screen Test
Larvae:				
Chameleon goby	0.000**	0.001**	0.031*	0.027*
Threadfin shad	0.053	0.003**	0.170	0.000**
Prickly sculpin	0.004**			
Striped bass	0.004**			
Centrarchids	1.000	0.477	0.142	0.036*
Bigscale logperch	0.760			
Cyprinids	0.933			
Eggs:				
Threadfin shad				0.208

Abundance and distribution of larval fish in the McDonald Tract diversion in comparison to the adjacent channel (Turner Cut) also appear to vary for some species. Threadfin shad densities were significantly higher (P<0.01) in the diversion than the channel (Figure 8; Table 4). In contrast, chameleon goby were significantly more abundant (P<0.01) in the channel than in the diversion. There was no significant difference in centrarchid density between these two areas (Table 4). The remaining larval species collected in Turner Cut were not collected in the diversion: prickly sculpin, delta smelt, cyprinids, logperch, and striped bass (Tables 2 and 3; Figures 8 and 9).

At the Naglee Burk site, all species except centrarchids were present in Old River before the diversion season. Channel sampling was from February to July, and landside sampling was from May to September. The channel site was downstream and not directly adjacent to the diversion pump, which may account for some catch differences.

During the diversion season, threadfin shad, chameleon goby, and centrarchids occurred over a similar period (May-July) in Old River and in the diversion (Figure 10). There was no significant difference between either threadfin shad or centrarchid densitites in the diversion compared with those in the adjacent channel (Table 4). Chameleon goby densities were significantly higher (P<0.05) in the channel than in the diversion. Prickly sculpin, splittail, inland silverside, and striped bass occurred in Old River before and during the diversion season but were not collected from the diversion (Figures 10 and 11). No delta smelt or longfin smelt were collected at either location. One larval Sacramento sucker was collected from the diversion in early July (Table 2).

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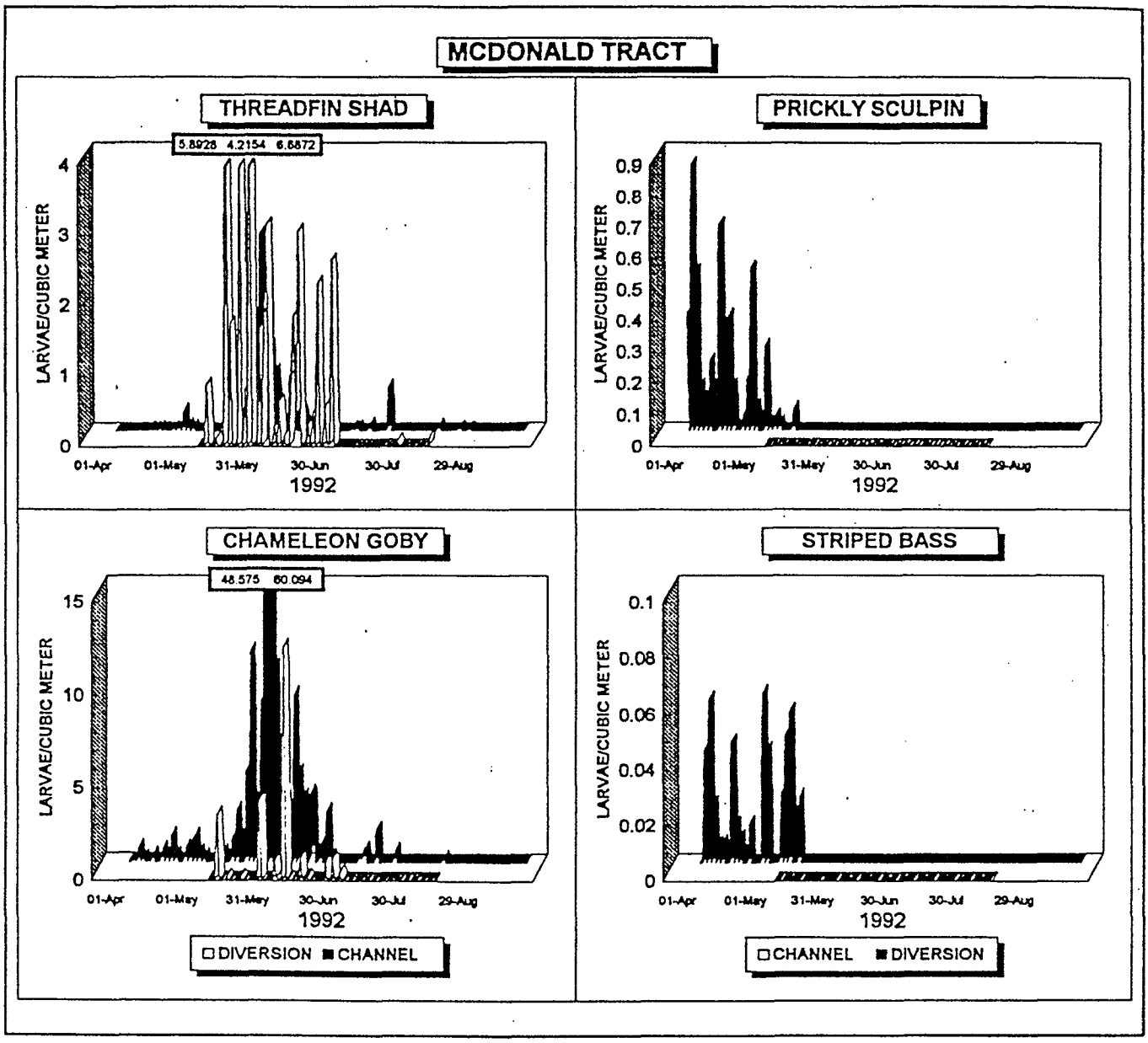

Figure 8
ESTIMATED DENSITY OF LARVAE IN TURNER CUT
AND AT MCDONALD TRACT DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

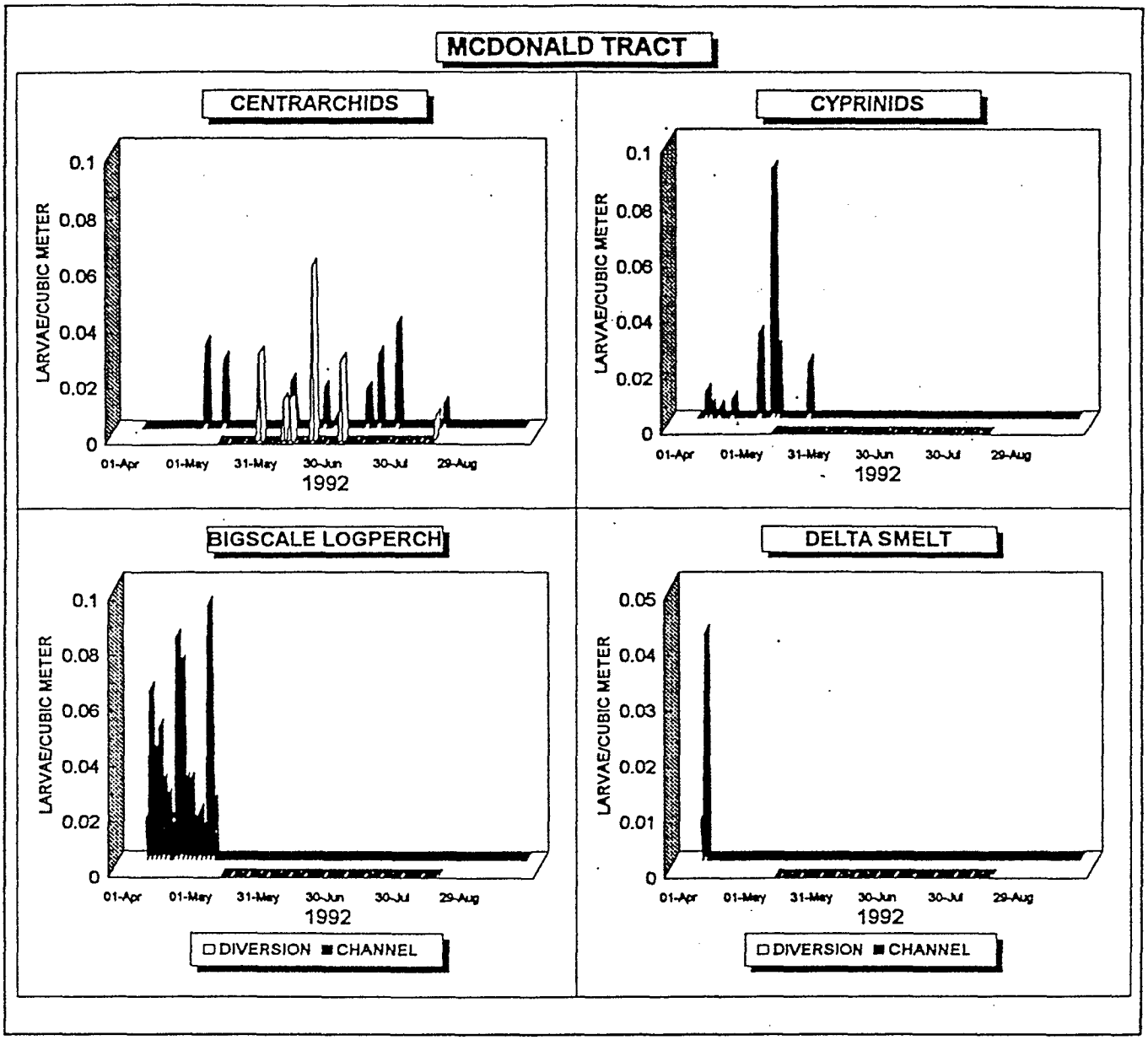

Figure 8 (continued)
ESTIMATED DENSITY OF LARVAE IN TURNER CUT
AND AT MCDONALD TRACT DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

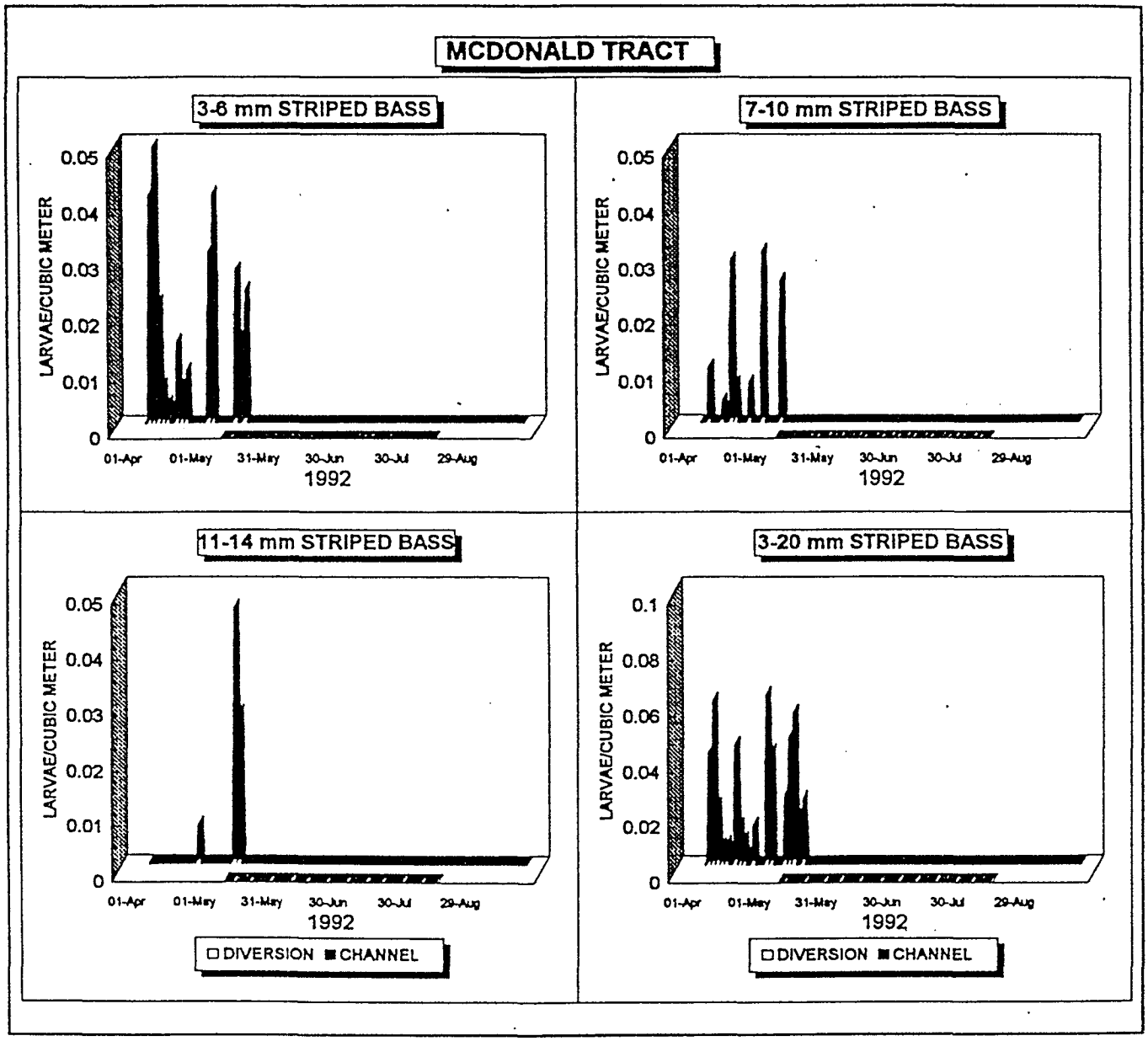

Figure 9
ESTIMATED DENSITY OF STRIPED BASS LARVAE IN TURNER CUT
AND AT MCDONALD TRACT DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

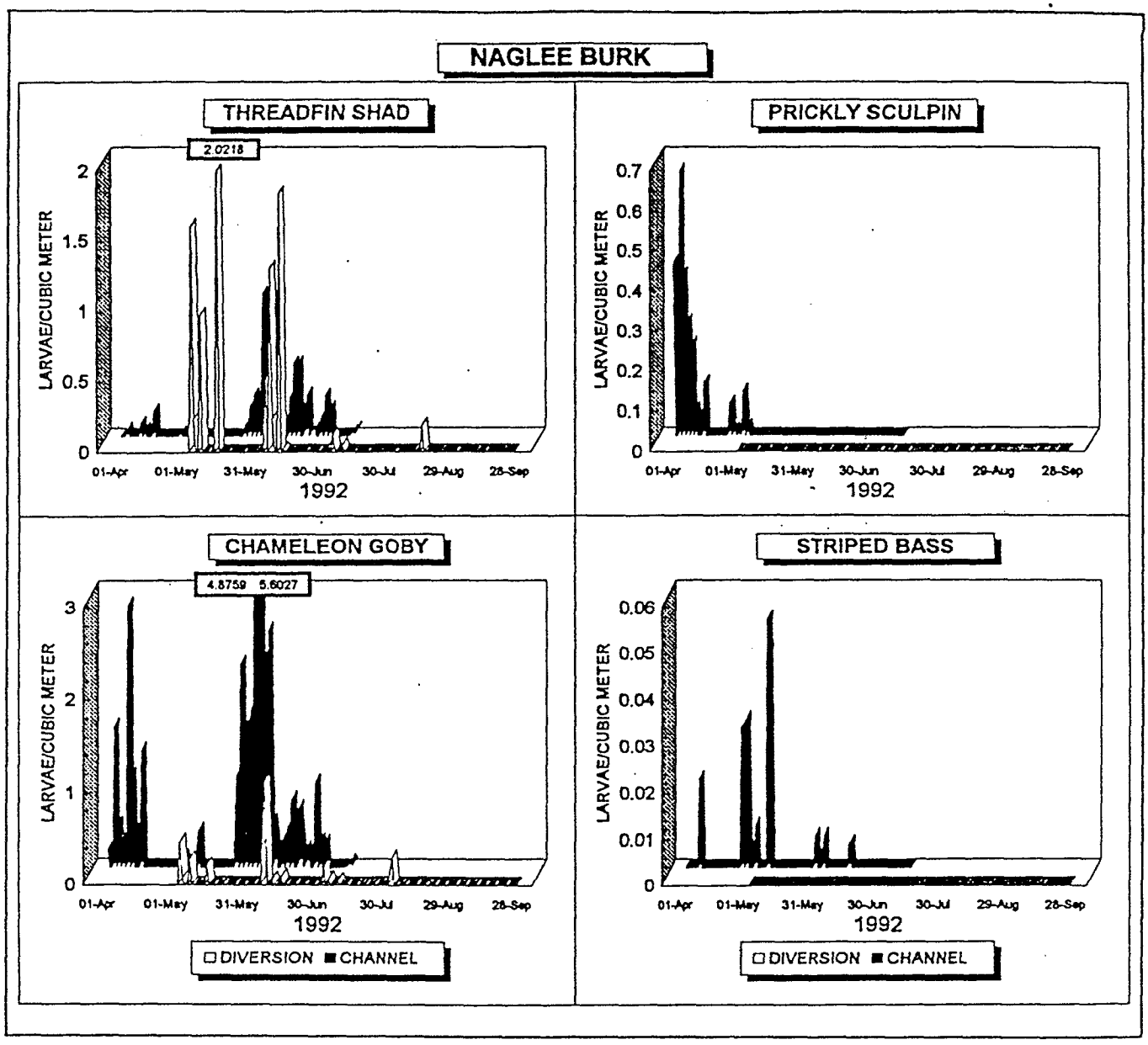

Figure 10
ESTIMATED DENSITY OF LARVAE IN OLD RIVER
AND AT NAGLEE BURK DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

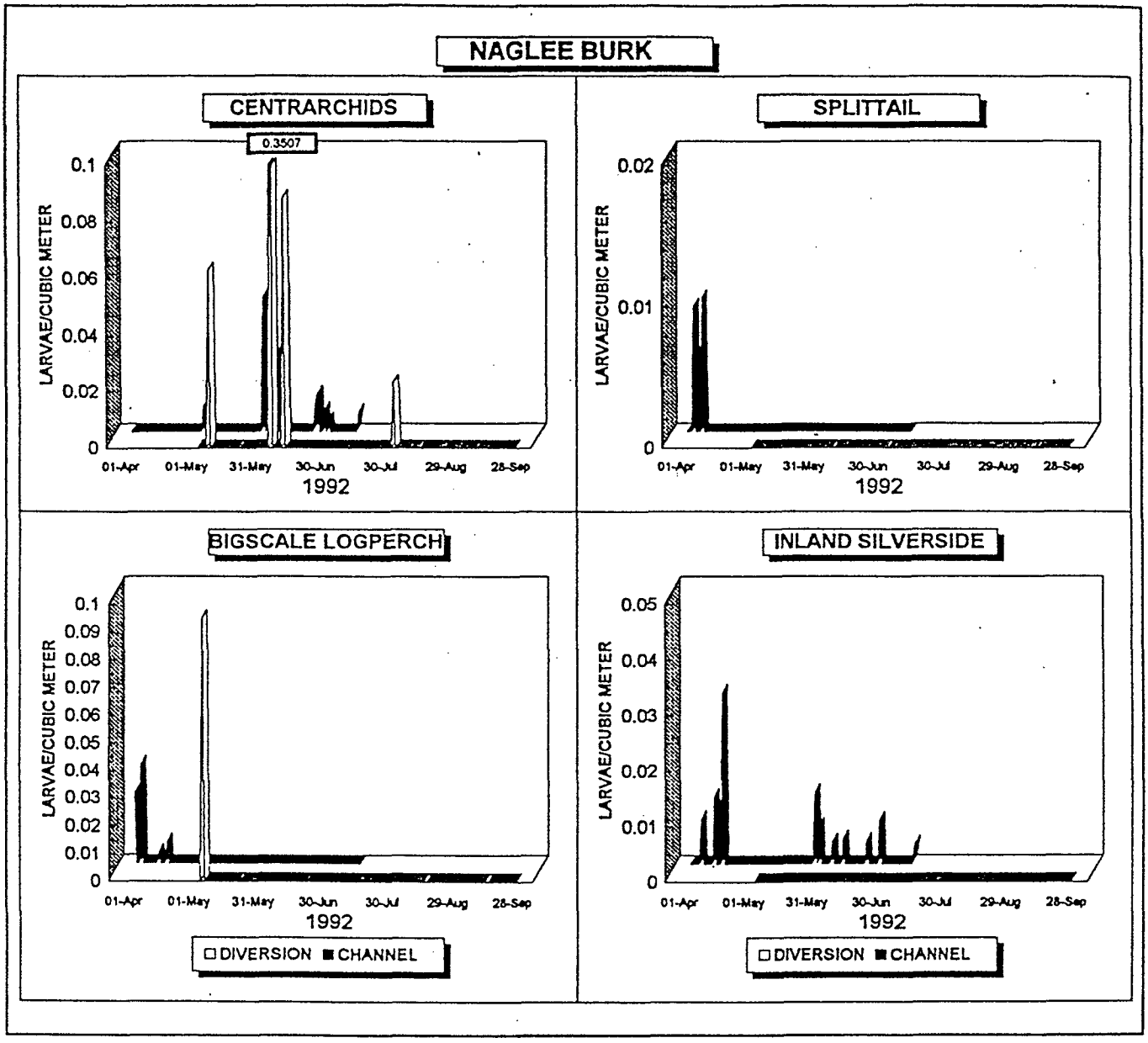

Figure 10 (continued)
ESTIMATED DENSITY OF LARVAE IN OLD RIVER
AND AT NAGLEE BURK DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

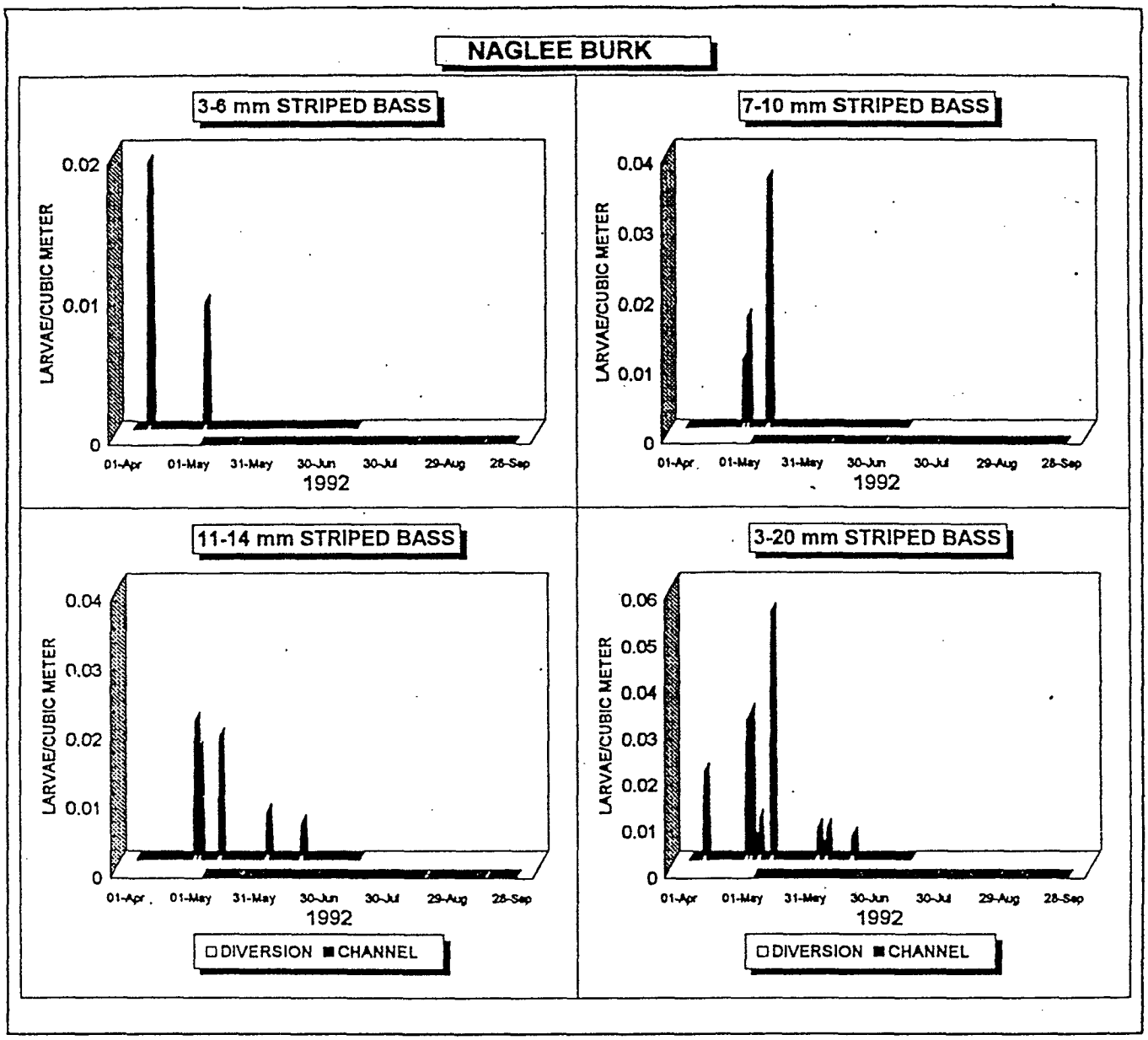

Figure 11
ESTIMATED DENSITY OF STRIPED BASS LARVAE IN OLD RIVER
AND AT NAGLEE BURK DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

Estimated Entrainment

Entrainment of eggs and larvae was estimated for Bacon Island, McDonald Tract, and Naglee Burk (Table 5; Appendix D). Entrainment was not estimated for the alternative Twitchell Island site because diversion rates were not available.

Total entrainment of larvae at Bacon Island was highest for threadfin shad (696,278 larvae), chameleon goby (635,606 larvae), and striped bass (197,487 larvae) (Table 5). Threadfin shad were entrained from mid-May to early September, with highest losses in early August (Appendix D). Entrainment of chameleon goby stretched from late April to mid-September, with the bulk of the losses in May and June. Striped bass were entrained from the start of diversion in mid-April until early June. No delta smelt, longfin smelt, or splittail were estimated to be entrained.

At McDonald Tract, total entrainment was highest for threadfin shad (639 eggs; 11,147 larvae) and chameleon goby (9,073 larvae) (Table 5). Most entrainment occurred from mid-May through mid-July (Appendix D). An estimated 40 centrarchid larvae were entrained in June and early July. No striped bass, delta smelt, longfin smelt, or splittail were estimated to have been entrained.

At the Naglee Burk site, total entrainment was highest for threadfin shad (917,885 larvae) and chameleon goby (385,046 larvae) (Table 5). The bulk of the entrainment occurred in May through mid-June (Appendix D). No striped bass, delta smelt, longfin smelt, or splittail were estimated to be entrained. No eggs or larvae of any species were entrained after August 19.

Size Distribution of Larvae

Length-frequency distributions of all larval species combined were examined at all sites. Size distributions for all channel sites were similar, reflecting the catch curve of the egg and larval net (Figure 12).

Characteristics of the channel length-frequency distributions were:

- Size Range: 2-16 mm TL, with very few greater than 16 mm TL.
- Peak Distribution: 3-6 mm TL.

Table 5
SUMMARY OF
ESTIMATED ENTRAINMENT OF EGGS AND LARVAL FISH, BY SPECIES, FOR THE BACON ISLAND, MCDONALD TRACT, AND NAGLEE BURK SITES
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

	Number of Fish Entrained		
Species	Bacon Island	McDonald Tract	Naglee Burk
Chameleon goby	635,606	9,073	385,046
Threadfin shad	696,278	11,147	917,885
Prickly sculpin	9,893	0	0
Striped bass	197,487	0	0
Centrarchids	45,141	40	52,790
Bigscale logperch	59,052	0	11,992
Inland silverside	0	0	0
American shad	524	0	0
Cyprinids	37,552	0	27,649
Delta smelt	0	0	0
Sacramento splittail	0	0	0
Sacramento sucker	0	0	24,288
Mosquitofish	0	11	0
Miscellaneous eggs	0	639	27,253

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- Chameleon goby dominated the 2-4 mm TL (some 5 mm TL) catch.
- Threadfin shad dominated the 5 mm TL and larger catch.
- Efficiency of the channel gear appears to drop off at 10-12 mm TL and above.

Characteristics of the diversion length-frequency distributions were:

- Size Range: 2-16 mm TL, with a few greater than 16 mm TL.
- Peak Distribution: Bacon 4-6 mm TL; McDonald and Naglee Burk, bimodal distribution, 3-4 mm TL (mostly chameleon goby) and 6-10 mm TL (mostly threadfin shad).

- Chameleon goby dominated the 2-4 mm TL (some 5 mm TL) catch.
- Threadfin shad dominated the 5 mm TL and larger catch.

A comparison of the length-frequency distributions for channel and diversion catches at Bacon Island, McDonald Tract, and Naglee Burk indicate length distributions were similar for these sites (Figure 12), varying primarily in magnitude, most likely as a reflection of the differences in larval abundance between sites. The channel distributions were composed largely of chameleon goby, threadfin shad, and prickly sculpin, whereas prickly sculpin were lacking in all diversions. At Bacon Island, both channel and diversion distributions included a moderate abundance of striped bass.

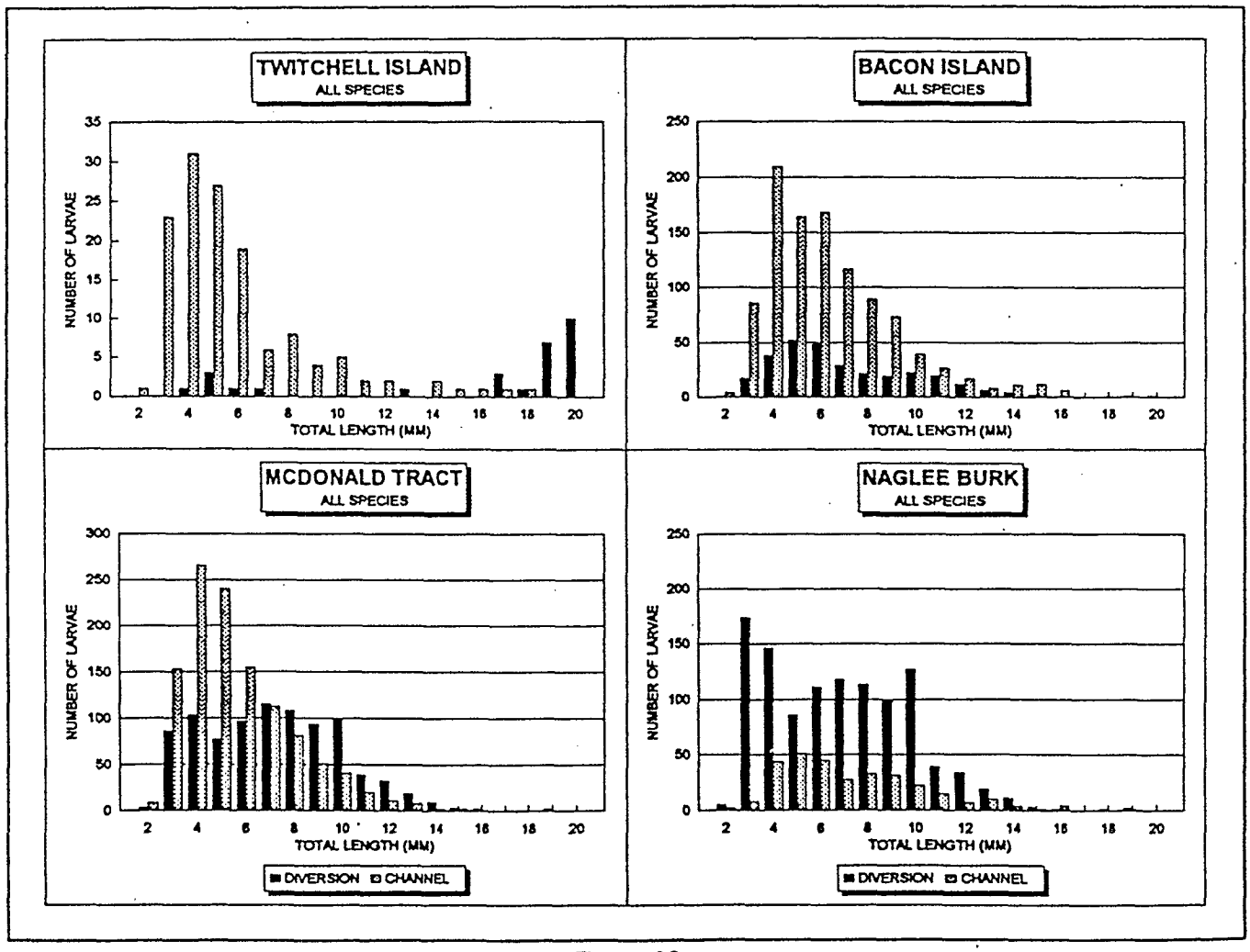

Figure 12
LENGTH-FREQUENCY DISTRIBUTION OF ALL 2-20 MM TL FISH FOR ALL DIVERSION AND CHANNEL SITES
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

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Juveniles and Older Fish

Entrainment of juvenile and older fish could not be estimated for Twitchell Island, Bacon Island, or McDonald Tract. The initial sampling method, using a winged fyke-type net fished in the diversion channel, proved unreliable for calculating catch per unit effort and estimating entrainment. Gear was tested at Bacon Island using a bag-net to cover the mouth of the siphon and sample the total diversion flow while the fyke-net was fished. No fish were caught in the bag-net, but fish were still being caught in the in-channel fyke-net, indicating fish already residing in the diversion ditch were those being caught. Results from additional sampling with the bag-net only for late September through October indicated no fish were being diverted during the September-October sampling period (Appendix E).

Qualitative results are available for Twitchell Island, Bacon Island, and McDonald Tract. Sampling with the in-channel net and electrofishing in the diversion ditches indicate a variety of species were residing at these sites (Table 6). At Twitchell Island, four species were collected: bluegill, threadfin shad, inland silverside, and golden shiner. At Bacon Island, a wider variety of species were caught, primarily striped bass (juveniles) and chameleon goby. A smallmouth bass and a tuleperch were also found. On McDonald Tract, only three species were collected: mosquitofish, bluegill, and green sunfish.

Entrainment losses were estimated for all juvenile and older fish caught at the Naglee Burk site (Appendix E). At this site, the diversion ditch dried out between diversion periods, thus ensuring that fish caught had been recently diverted. From August through October, only 24 fish and 5 species were caught (Table 6). Entrainment was estimated for the following species caught:

Species	Estimated Number of Fish Entrained
Chameleon goby	555
Threadfin shad	127
Bluegill	341
Mosquitofish	72
White catfish	182
Total	1,277

Chameleon goby and bluegill had the highest estimated entrainment. In comparison, estimated entrainment for white catfish and threadfin shad was moderate.

The length-frequency distributions of juvenile fish varied between sites (Figure 13). The fish collected at Twitchell Island, Bacon Island, and McDonald Tract were not collected directly as entrained fish and were residing in the diversion ditches. At Twitchell Island, the fish caught made up two distinct peaks at 20-30 mm FL and 50-70 mm FL. In contrast, most fish collected at Bacon Island were 50-140 mm FL. McDonald Tract was similar to Twitchell Island with most juveniles between 20-50 mm FL. Fish entrained at Naglee Burk were between 20-90 mm FL.

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Table 6
SPECIES CATCH SUMMARY OF
JUVENILE AND OLDER FISH COLLECTED
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

Blank spaces indicate zero catch.
NS indicates the site was not sampled for juvenile fish.

	Number of Fish							
	Diversion Sites				Channel Sites (Tow-Net)			
Species	1 Twitchell Island[1]	2 Bacon Island	3 McDonald Tract	4 Naglee Burk	934 Twitchell Island	932 Bacon Island	933 McDonald Tract	93 Naglee Burk
Chameleon goby		81		9				NS
Threadfin shad	21	4		3		1		NS
Prickly sculpin		3						NS
Striped bass		184			3	1		NS
Bluegill	200	1	2	7				NS
Green sunfish			2					NS
Bigscale logperch		9						NS
Inland silverside	3				7	1		NS
American shad								NS
Cyprinids								NS
Delta smelt								NS
Sacramento splittail								NS
Sacramento sucker								NS
Mosquitofish			27	2				NS
White catfish		1		3	1			NS
Yellowfin goby		2			1			NS
Smallmouth bass		1						NS
Tule perch		1						NS
Golden shiner	1							NS
Total Fish	**225**	**228**	**31**	**24**	**12**	**3**	**0**	**NS**

1 Alternative site on Sevenmile Slough.

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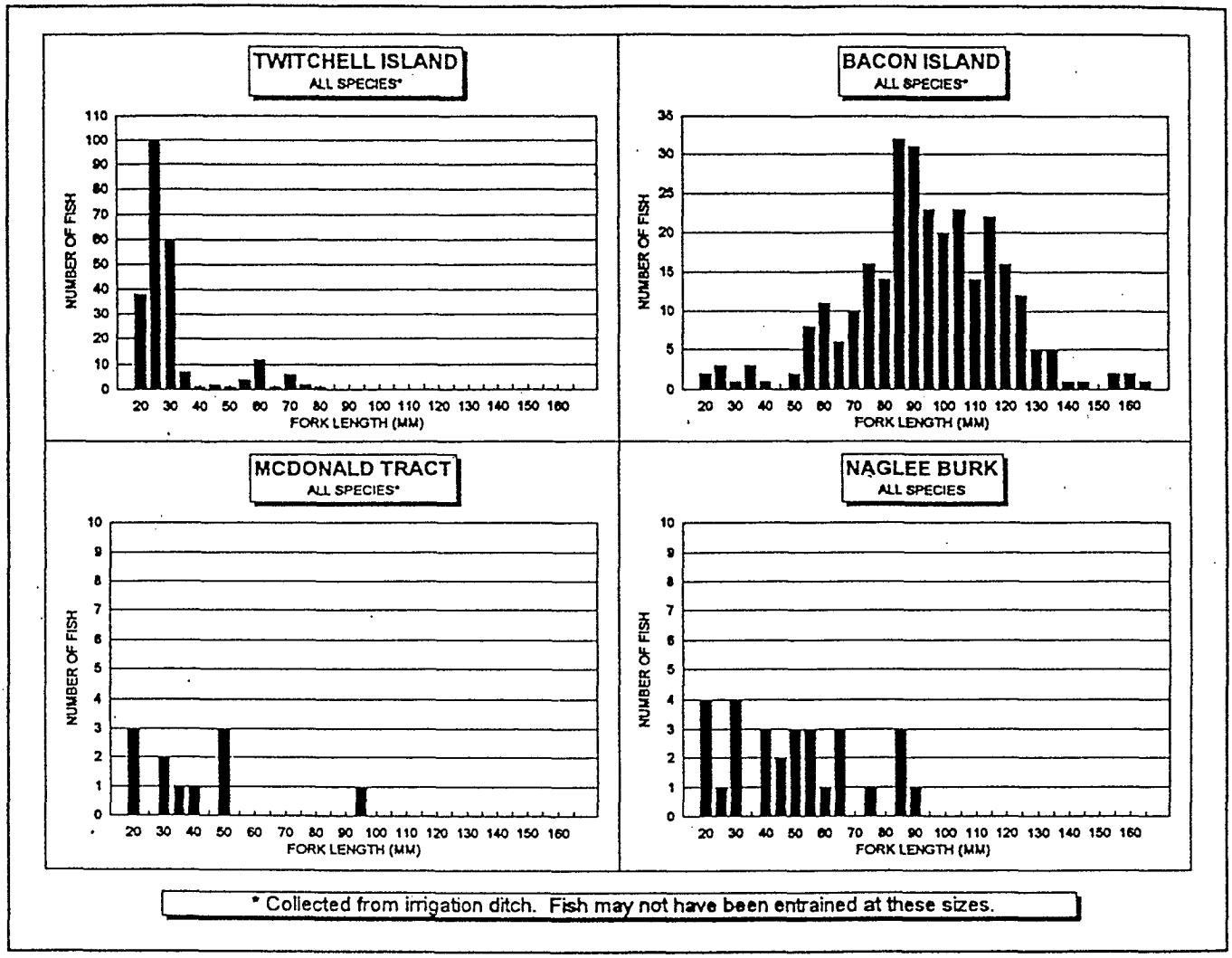

Figure 13
LENGTH-FREQUENCY DISTRIBUTION OF ALL 20-165 MM TL FISH FOR ALL DIVERSION SITES
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

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McDonald Tract Fish Screen Test

Due to unreliable results from the juvenile gear, only data obtained from the egg and larval sampling gear were usable for testing the effectiveness of the fish screen. Larvae and eggs of threadfin shad and larvae of chameleon goby were the only species caught under both screened and unscreened conditions (Figure 14). Larval centrarchids were caught only under unscreened conditions.

Test results indicate no significant difference between the unscreened and screened catch densities of threadfin shad eggs (Table 4). However, screened densities were significantly lower than unscreened densities for larval threadfin shad ($P<0.01$), chameleon goby ($P<0.05$), and centrarchids ($P<0.05$). Results indicate that at times chameleon goby can be entrained at moderate to high densities under screened conditions. However, these were very small larvae (3-4 mm TL).

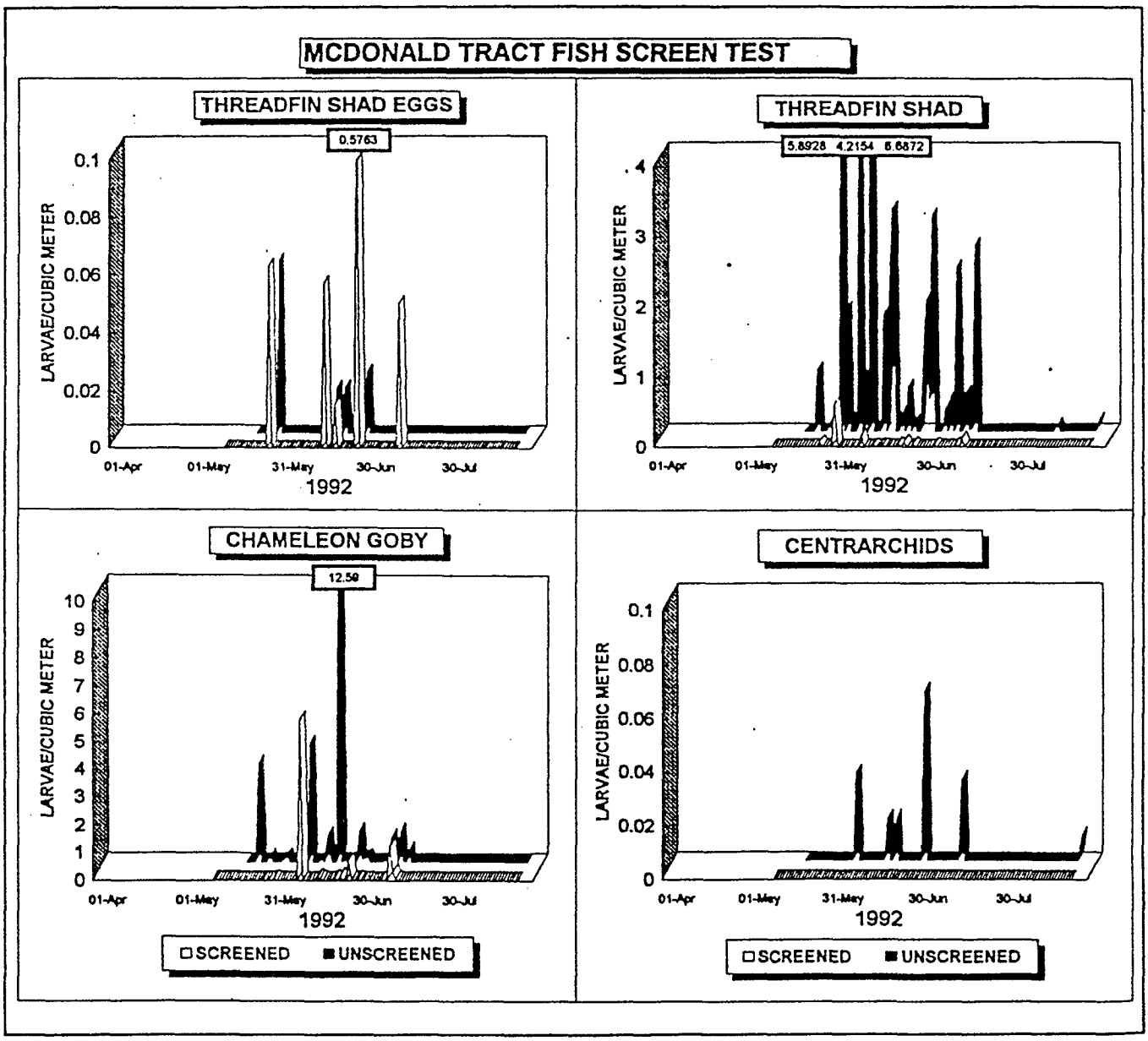

Figure 14
ESTIMATED DENSITY OF LARVAE UNDER SCREENED AND UNSCREENED CONDITIONS AT THE MCDONALD TRACT DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

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The size distribution of larvae was compared under screened and unscreened conditions and with the channel distribution (Figure 15). The distribution for the unscreened diversion is similar to that for the channel, except over the 3-6 mm size range. Under screened conditions, the diversion appears to have entrained mostly very small larvae. For the most part, these small larvae were newly or recently hatched chameleon gobies, which could account for density peaks under screened conditions. Larvae larger than about 5 mm TL diverted by the unscreened diversion were primarily threadfin shad. The screen appears to become effective at screening larvae and fish when they are about 4-5 mm TL.

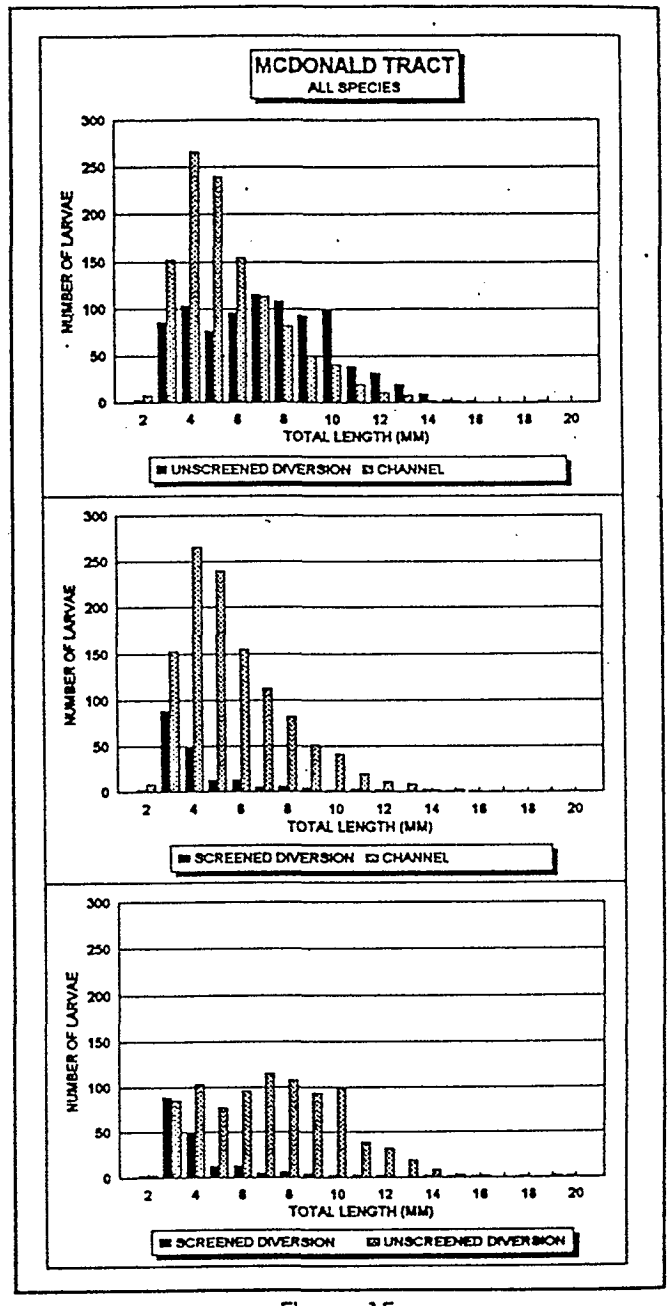

Figure 15
LENGTH-FREQUENCY DISTRIBUTION OF ALL 2-20 MM TL FISH UNDER SCREENED AND UNSCREENED CONDITIONS AT MCDONALD TRACT DIVERSION SITE
Delta Agricultural Diversion Evaluation, 1992 Pilot Study

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The degree of vulnerability to entrainment appears to vary with species and life stage. Entrainment appears to depend largely on life stage, seasonal occurrence, abundance, and distribution of a species in the adjacent channel and on operations of the diversion (seasonal timing, frequency and duration, and flow and volume). Tidal influence and time of day (day *vs* night) could also affect entrainment, but those factors were not investigated in this pilot study.

Results from sampling in the Delta agricultural diversions and adjacent channels indicate that eggs, larvae, juveniles, and older fish are susceptible to entrainment into the diversions. In general, eggs and larvae are the life stages most vulnerable to entrainment. Species whose life stages use nearshore areas for spawning and rearing are particularly vulnerable, because intakes of agricultural siphons and pumps are usually located off levees in these areas. Seasonal timing of diversions is important in that high volumes of diversions may coincide with periods of high abundance of egg and larval stages, resulting in high entrainment. For example, Bacon Island had high diversion volumes in late April through mid-June, when striped bass larvae were present and abundant. The impact of diversions would be lower later in the season, when fish are larger and less vulnerable to entrainment.

Based on results from this study, eggs of broadcast spawners, such as threadfin shad, are susceptible to entrainment. Although the sample size was too small ($n<6$ paired samples with nonzero differences) to statistically test whether there was a difference between channel and diversion densities, threadfin shad eggs were entrained at McDonald Tract and Naglee Burk but were not found in any of the channel samples. Threadfin shad spawn in areas of shallow water with vegetation below the surface[16], so their eggs and larvae are less likely to be collected by present sampling methods. This type of habitat was present at the both the McDonald Tract and Naglee Burk diversions.

No conclusion can be reached on the vulnerability of striped bass eggs to agricultural diversions. Striped bass eggs were collected only off Twitchell Island, on the San Joaquin River. No diversion samples could be obtained at the siphon at this site. However, Allen[17] found that concentrations of striped bass eggs in Sherman Island diversions did not vary statistically from and were of the same general magnitude as those in the adjacent San Joaquin River.

Larval fish were the predominant life stage entrained and appear to be the most vulnerable to these diversions. Generally, they are more abundant than juveniles or older fish due simply to the impact of mortality on a population before they can reach the later stages. Larvae are also poor swimmers and, if near ar. intake, would probably be unable to avoid entrainment. Species collected in the agricultural diversions were usually a subset of larval species in adjacent channels.

Based on comparisons between diversion and channel abundance, the larval species most susceptible to entrainment appear to be threadfin shad, centrarchids, cyprinids, and logperch. Statistically, diversion densities consistently did not vary from channel densities. However, at McDonald Tract, threadfin shad had higher densities in the diversion than in the adjacent channel. The siphon intake at this site is probably in or near an area of threadfin shad spawning.

16 J.C.S. Wang. *Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Stages.* Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary, Technical Report 9. Department of Water Resources. 1986.

17 D.H. Allen. 1975. Previously cited.

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Chameleon goby, striped bass, and prickly sculpin appear to be less vulnerable to diversions than their channel densities would indicate. They were abundant in the channel but, except for chameleon goby, generally not in the diversions. These species consistently had diversion densities significantly lower than their channel densities. However, Allen[18] found that concentrations of striped bass larvae in Sherman Island diversions did not vary statistically and were of the same general magnitude as those in the adjacent San Joaquin River.

In general, chameleon goby, threadfin shad, and centrarchids were the most abundant species entrained by the diversions. Threadfin shad and chameleon goby had the highest entrainment at all sites and were also abundant in the adjacent channels. These species may be vulnerable to entrainment due to their preference for spawning or rearing habitat in shallow-water, edge-type habitat with cover.

Striped bass were entrained only at Bacon Island, from April 20 to June 9. Total entrainment was 197,487 larvae. In comparison, total entrainment was 40 to 60 times higher at the SWP (7,948,000 larvae) and CVP (11,271,000 larvae).[19] It would require about 50 agricultural diversions with volume and operations similar to the Bacon Island siphon, and in an area of similar striped bass density, to equal the magnitude of losses at the SWP or CVP. With about 1,850 agricultural diversions in the Delta, at least 50 are likely similar to the one at Bacon Island.

Results from this pilot study provide no evidence of delta smelt, longfin smelt, or splittail larval entrainment. Delta smelt and splittail abundances were low and catches were infrequent in the channels. No delta smelt or splittail were caught in the diversions, and no longfin smelt were collected in either area. The infrequent occurrence of these species in the areas and diversions under study indicates these may not be the best sites for focusing on diversion impacts to these species.

Entrainment estimates for juvenile and older fish were possible only at Naglee Burk, due to gear problems at the other sites. Chameleon goby, threadfin shad, bluegill, mosquitofish, and white catfish were entrained at Naglee Burk. They ranged from 20 to 90 mm FL.

For the screen test at McDonald Tract, test results were usable for eggs and larvae only. The fish screen appears to be effective in reducing entrainment of 4-5 mm TL and larger larvae. However, the effects of screen impingement on the larvae are not known. Small (3-4 mm TL) chameleon goby larvae were not screened effectively. Threadfin shad larvae (5 mm TL and larger) were screened effectively.

Characteristics of larval length-frequency distribution were similar between channel and diversion catches. The size range for both areas was 2-16 mm TL, with very few greater than 16 mm TL. Efficiency of the gear appears to decline at 10-12 mm TL and above. The peak distribution in the channel was 3-6 mm TL, which was similar to the diversion. However, McDonald and Naglee Burk had bimodal distributions at 3-4 mm TL (mostly chameleon goby) and 6-10 mm TL (mostly threadfin shad).

Problems Encountered

Meters on Diversions

- For most of the season at Naglee Burk, the rate and amount of diversions had to be estimated based on diversions in September. Due to coordination difficulties between the ditch tender and the company installing the meter, the meter was not installed until September 4.
- At Bacon Island, flowmeters malfunctioned several times in late summer due to vegetation and fishing line becoming entangled on the propellers.
- Diversion flows (cfs) were often too high for the range of the flowmeter and, above that range, had to be estimated.

18 D.H. Allen, 1975. Previously cited.
19 S.A. Spaar, 1993. Previously cited.

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Sampling Problems

- At times, ditch flows were so low it was difficult to fish the egg and larval net. A net meter with a low-flow propeller is needed.
- The juvenile nets were not received until late June.
- The in-channel juvenile sampling method did not provide usable data for Bacon Island or McDonald Tract.
- Available gear for sampling juveniles in adjacent channels (tow-net) was not appropriate for the period of use, because the juvenile fish had grown too large to be susceptible to the gear. A midwater or otter trawl would have been more effective.
- The channel directly adjacent to the Naglee Burk site is inaccessible to the survey boat due to shallows. Station 93 was inaccessible after the temporary barrier was installed.
- On Twitchell Island, the siphon to be sampled did not divert until August — and then for only 2 weeks. We were not notified when diversion began and were not able to get to the siphon due to major levee repairs.

Preparation and Analysis of Data

- Time available for staff to prepare and analyze the data was not sufficient to produce a report before the next sampling season.

Recommendations

- For juvenile sampling, use bag or fyke-type nets that completely cover the end of the diversion outfall.
- Increase juvenile sampling effort at the diversion and in adjacent channels. For channel sampling, use a trawl, tow-net, beach seine, or electrofishing as appropriate for the site.
- Decrease egg and larval sampling effort to once or twice a week at the diversion and in adjacent channels. Discontinue egg and larval sampling in mid-July, similar to other Delta egg and larval studies. This will also allow the laboratory to provide all results in time for the annual monitoring report to the U.S. Army Corps of Engineers.
- Discontinue sampling before October 31 or extend the due date for the Corps of Engineers monitoring report.
- Locate dependable sites near known areas of abundance for delta smelt and native species to assess impacts to these fishes.

Additional Data Needs

- Landside and channel data on juvenile and older fish covering the entire diversion season.
- Complete data on amount and duration of diversions, including when diversions begin and end.

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Appendix A

ESTIMATED DAILY DIVERSION AT STUDY SITES

Delta Agricultural Diversion Evaluation
1992 Pilot Study

Appendix A. (Cont.) ESTIMATED DAILY DIVERSION (acre-feet) AT STUDY SITES FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

MCDONALD ISLAND UNSCREENED DIVERSIONS

VOLUME DIVERTED
(Acre-Feet)

DAY	APR	MAY	JUN	JUL	AUG	SEP	OCT
1	*	0	0.16	0.22	0	*	*
2	*	0	0	0	0	*	*
3	*	0	0.25	0.25	0	*	*
4	*	0	0	0	0	*	*
5	*	0	0.13	0	0.14	*	*
6	*	0	0	0.42	0.18	*	*
7	*	0	0	0.57	0	*	*
8	*	0	0	0.25	0	*	*
9	*	0	0.16	0.24	0	*	*
10	*	0	0	0	0	*	*
11	*	0	0.26	0	0	*	*
12	*	0	0.24	0	0	*	*
13	*	0	0	0	0	*	*
14	*	0.01	0	0	0	*	*
15	*	0	0.15	0	0	*	*
16	*	0	0	0	0	*	*
17	*	0	0.21	0	0	*	*
18	*	0.18	0	0	0	*	*
19	*	0	0.27	0	0.23	*	*
20	*	0	0	0	0	*	*
21	*	0	0	0	0	*	*
22	*	0.11	0.32	0	0	*	*
23	*	0	0.17	0	0	*	*
24	*	0	0.37	0	0	*	*
25	*	0	0.18	0	0	*	*
26	*	0.13	0	0	*	*	*
27	0	0.18	0	0	*	*	*
28	0	0.15	0	0	*	*	*
29	0	0	0.23	0	*	*	*
30	0	0	0.18	0	*	*	*
31		0		0	*		*
TOTAL	0.00	0.76	3.27	1.94	0.56	0.00	0.00
GRAND TOTAL							6.52

* Diversions unknown, monitoring period 4-27-92 to 7-25-92.

Appendix A. ESTIMATED DAILY DIVERSION (acre-feet) AT STUDY SITES FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

BACON ISLAND

VOLUME DIVERTED
(Acre-Feet)

DAY	APR	MAY	JUN	JUL	AUG	SEP	OCT
1	0	25.19	32.05	6.84	4.51	10.91	3.77
2	0	25.19	32.05	6.84	4.51	10.91	3.14
3	0	25.19	31.72	7.37	4.51	10.91	3.14
4	0	23.21	31.72	7.37	4.51	10.91	3.14
5	0	23.21	31.65	7.37	12.50	10.91	3.25
6	0	21.43	31.65	9.68	12.50	10.91	4.38
7	0	21.43	31.65	6.57	12.50	10.91	4.38
8	0	21.61	31.65	6.57	12.50	10.91	4.38
9	0	21.61	32.81	6.51	12.50	10.91	4.38
10	0	21.61	32.81	5.02	12.50	10.91	4.38
11	0	22.93	25.04	5.02	12.50	10.91	4.38
12	0	28.51	31.48	5.02	12.50	10.91	4.38
13	0	53.74	31.48	13.41	12.50	10.91	4.38
14	0	53.74	31.48	13.41	12.50	10.91	4.38
15	0	53.74	28.78	15.47	12.50	10.91	5.81
16	0	53.74	28.78	15.47	12.50	12.74	4.45
17	0	53.74	21.52	15.67	12.50	12.74	4.45
18	0	50.51	21.52	15.67	12.50	12.74	4.45
19	0	50.51	18.48	15.67	12.50	12.74	6.57
20	25.19	50.51	18.48	9.74	16.46	12.74	5.61
21	25.19	50.51	18.48	9.59	16.46	10.71	6.57
22	25.19	29.49	17.06	10.49	16.46	11.13	6.79
23	25.19	29.49	17.49	10.01	16.46	9.71	5.55
24	25.19	29.49	16.14	10.01	19.83	7.02	0
25	25.19	29.49	15.81	10.01	19.76	7.02	0
26	25.19	30.59	15.81	10.01	12.62	7.02	0
27	25.19	30.73	15.81	10.01	11.90	7.02	0
28	25.19	31.65	15.81	8.00	11.90	5.81	0
29	25.19	31.65	5.11	8.00	11.90	4.52	0
30	25.19	31.65	5.11	4.51	11.90	4.10	0
31		31.65		4.51	11.90		0
TOTAL	277.09	1057.67	719.39	289.81	383.02	301.40	106.11

GRAND TOTAL 3134.50

Appendix A. (Cont.) ESTIMATED DAILY DIVERSION (acre-feet) AT STUDY SITES FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

MCDONALD ISLAND SCREENED DIVERSIONS

VOLUME DIVERTED
(Acre-Feet)

DAY	APR	MAY	JUN	JUL	AUG	SEP	OCT
1	*	0	0.24	0.21	0	*	*
2	*	0	0	0	0	*	*
3	*	0	0.14	0.25	0	*	*
4	*	0	0	0	0	*	*
5	*	0	0.24	0	9.53	*	*
6	*	27.40	0	0.36	22.57	*	*
7	*	0	0	0.29	22.57	*	*
8	*	0	0	24.18	22.57	*	*
9	*	0	0.38	15.65	22.57	*	*
10	*	0	0	0	22.57	*	*
11	*	0	0.19	0	0	*	*
12	*	0	0.16	0	0	*	*
13	*	0	0	0	0	*	*
14	*	0	0	0	0	*	*
15	*	0	0.20	0	0	*	*
16	*	0	0	0	0	*	*
17	*	0	0.14	0	0	*	*
18	*	0.23	0	0	0	*	*
19	*	0	0.14	0	0.49	*	*
20	*	0	0	0	0	*	*
21	*	0	0	0	0	*	*
22	*	0.22	0.19	0	0	*	*
23	*	0	0.27	0	0	*	*
24	*	0	0.10	0	0	*	*
25	*	0	0.29	0	0	*	*
26	*	0.16	0	0	*	*	*
27	0	0.10	0	0	*	*	*
28	0	0.20	0	0	*	*	*
29	0	0	0.10	0	*	*	*
30	0	0	0.19	0	*	*	*
31		0		0	*		*
TOTAL	0.00	28.30	2.97	40.94	122.88	0.00	0.00
GRAND TOTAL							195.10

* Diversions unknown, monitoring period 4-27-92 to 7-25-92.

Appendix A. (Cont.) ESTIMATED DAILY DIVERSION (acre-feet) AT STUDY SITES FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

NAGLEE BURK

VOLUME DIVERTED*
(Acre-Feet)

DAY	APR	MAY	JUN	JUL	AUG	SEP	OCT
1	0	0	0	0	0	0	39.89
2	0	0	0	0	0	0	39.07
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	34.17	0	0	34.17	0	0
6	0	34.17	0	34.17	34.17	0	0
7	0	34.17	0	34.17	34.17	0	0
8	0	34.17	34.17	34.17	34.17	64.27	0
9	0	34.17	34.17	34.17	34.17	64.27	0
10	0	34.17	34.17	34.17	0	29.75	0
11	0	34.17	34.17	34.17	0	0	0
12	0	0	34.17	34.17	0	0	0
13	0	0	34.17	34.17	0	0	0
14	0	0	34.17	0	0	27.27	0
15	0	0	34.17	0	34.17	61.32	0
16	0	0	34.17	0	34.17	33.03	0
17	0	0	34.17	0	34.17	33.03	0
18	0	34.17	34.17	0	0	0	0
19	0	34.17	34.17	0	34.17	0	0
20	0	34.17	0	0	31.27	0	0
21	0	34.17	0	0	31.27	0	0
22	0	0	0	0	31.27	0	0
23	0	0	0	0	31.27	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0
28	0	0	0	0	0	38.25	0
29	0	0	0	0	0	17.06	0
30	0	0	0	0	0	40.16	0
31		0			0		0
TOTAL	0.00	375.82	409.98	273.32	432.58	408.41	78.96

GRAND TOTAL 1979.08

* April-August estimates based on observed and estimated dates of diversions and flowmeter readings after installion (9-4-92).

Appendix B

ESTIMATED DENSITY OF EGGS AND LARVAE, BY DIVERSION SITE

Delta Agricultural Diversion Evaluation
1992 Pilot Study

Appendix B. ESTIMATED EGG AND LARVAL DENSITIES BY DIVERSION SITE COLLECTED UNDER THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 1 - TWITCHELL ISLAND
(Sevenmile Slough Diversion)

DENSITIES
(Number per Cubic Meter)

DATE	MISC EGGS	LARVAE: ASHAD	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRARC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS
24-Jun-92	0	0	0.1911	0	0	0	0.9557	0	0	0	0	0	0	0	0	0	0
25-Jun-92	0	0	0.4149	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09-Jul-92	0	0	0.1035	0	0	0	0.0518	0	0	0	0	0	0	0	0	0	0
20-Jul-92	0	0	0.4176	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-Sep-92	0	0	0	0	0	0	0.1775	0	0.04	0	0	0	0	0	0	0	0
22-Sep-92	0	0	0	0	0	0	0	0	5.66	0	0	0	0	0	0	0	0
TOTALS	0	0	1.1272	0	0	0	1.185	0	5.7	0	0	0	0	0	0	0	0

Appendix B. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY DIVERSION SITE COLLECTED UNDER THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 2 - BACON ISLAND

DENSITIES
(Number per Cubic Meter)

DATE	MISC EGGS	LARVAE: ASHAD	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRARC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS
20-Apr-92	* 0	0	0	0	0.0211	0	0.0211	0	0	0	0	0.0211	0	0	0	0	0.0843
22-Apr-92	0	0	0	0	0.0211	0	0.0211	0	0	0	0	0.0211	0	0	0	0	0.0843
27-Apr-92	0	0	0	0	0.0519	0	0	0	0	0	0	0.0104	0	0	0	0.0104	0.0311
28-Apr-92	0	0	0	0	0.0595	0.0297	0	0	0	0	0	0.0297	0	0	0	0	0
30-Apr-92	0	0	0	0	0	0	0	0	0	0	0	0.0208	0	0	0	0	0
04-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3236
12-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13-May-92	0	0	0.1077	0	0	0.1077	0	0	0	0	0	0.1077	0	0	0	0.1077	0.1077
18-May-92	0	0	0.0562	0	0	0	0	0	0	0	0	0.0562	0	0	0	0.1124	0.4497
22-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0569	0.0569
26-May-92	0	0	0.7795	0	0	0	0	0	0	0	0	0	0	0	0	0.3298	0
27-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0436	0.0872
28-May-92	0	0	0.0582	0	0	0	0	0	0	0	0	0	0	0	0	0.0874	0
01-Jun-92	0	0	0.0262	0	0	0	0	0	0	0	0	0	0	0	0	0.4194	0.0262
03-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4604	0.0576
05-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1625	0
09-Jun-92	0	0	0.0383	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0383
11-Jun-92	0	0	0.1423	0	0	0	0	0	0	0	0	0	0	0	0	0.1627	0
12-Jun-92	0	0	0.1584	0	0	0	0	0	0	0	0	0	0	0	0	0.2262	0
15-Jun-92	0	0	0.0367	0	0	0	0	0	0	0	0	0	0	0	0	0.3482	0
17-Jun-92	0	0	0.0314	0	0	0	0	0	0	0	0	0	0	0	0	1.2565	0
19-Jun-92	0	0	0.0301	0	0	0	0	0	0	0	0	0	0	0	0	0.3914	0
22-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2413	0
23-Jun-92	0	0	1.1963	0	0	0	0	0	0	0	0	0	0	0	0	0.2991	0
24-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-Jun-92	0	0	0.7445	0	0	0	0	0	0	0	0	0	0	0	0	0.0827	0
29-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1417	0
01-Jul-92	0	0	0.1889	0	0	0	0	0	0	0	0	0	0	0	0	0.5666	0
03-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5623	0
06-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.3203	0
07-Jul-92	0	0	0.692	0	0	0	0	0	0	0	0	0	0	0	0	2.076	0
09-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1084	0
17-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-Jul-92	0	0	2.0388	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-Jul-92	0	0.0443	0.0776	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Jul-92	0	0	0	0	0	0	0.406	0	0	0	0	0	0	0	0	0	0
23-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Jul-92	0	0	0	0	0	0	1.7888	0	0	0	0	0	0	0	0	1.7888	0
30-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0866	0
05-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06-Aug-92	0	0	4.8618	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Aug-92	0	0	0.0084	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-Aug-92	0	0	0.0467	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-Aug-92	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0.0172	0
27-Aug-92	0	0	0.0132	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08-Sep-92	0	0	0.8986	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2279	0
16-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2583	0
17-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	0	0.0443	12.262	0	0.1535	0.1375	2.2369	0	0	0	0	0.267	0	0	0	19.953	1.3469

* No sample taken, densities estimated in order to calculate entrainment.

Appendix B. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY DIVERSION SITE COLLECTED UNDER THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 2 -BACON ISLAND

STRIPED BASS DENSITIES
(Number per Cubic Meter)

DATE	SITE#	EGGS	LARVAE: SIZE GROUP 3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm	3-20 mm
20-Apr-92 *	2	0	0	0.0843	0	0	0	0.0843
22-Apr-92	2	0	0	0.0843	0	0	0	0.0843
27-Apr-92	2	0	0	0.0311	0	0	0	0.0311
28-Apr-92	2	0	0	0	0	0	0	0
30-Apr-92	2	0	0	0	0	0	0	0
04-May-92	2	0	0	0	0	0	0	0
06-May-92	2	0	0	0	0	0	0	0
07-May-92	2	0	0	0	0	0	0	0
08-May-92	2	0	0	0	0	0	0	0
11-May-92	2	0	0.3236	0	0	0	0	0.3236
12-May-92	2	0	0	0	0	0	0	0
13-May-92	2	0	0	0.1077	0	0	0	0.1077
18-May-92	2	0	0.0562	0.3935	0	0	0	0.4497
22-May-92	2	0	0	0.0569	0	0	0	0.0569
26-May-92	2	0	0	0	0	0	0	0
27-May-92	2	0	0	0.0872	0	0	0	0.0872
28-May-92	2	0	0	0	0	0	0	0
01-Jun-92	2	0	0.0262	0	0	0	0	0.0262
03-Jun-92	2	0	0	0	0	0.0288	0.0288	0.0576
05-Jun-92	2	0	0	0	0	0	0	0
09-Jun-92	2	0	0	0.0383	0	0	0	0.0383
11-Jun-92	2	0	0	0	0	0	0	0
12-Jun-92	2	0	0	0	0	0	0	0
15-Jun-92	2	0	0	0	0	0	0	0
17-Jun-92	2	0	0	0	0	0	0	0
19-Jun-92	2	0	0	0	0	0	0	0
22-Jun-92	2	0	0	0	0	0	0	0
23-Jun-92	2	0	0	0	0	0	0	0
24-Jun-92	2	0	0	0	0	0	0	0
25-Jun-92	2	0	0	0	0	0	0	0
29-Jun-92	2	0	0	0	0	0	0	0
01-Jul-92	2	0	0	0	0	0	0	0
03-Jul-92	2	0	0	0	0	0	0	0
06-Jul-92	2	0	0	0	0	0	0	0
07-Jul-92	2	0	0	0	0	0	0	0
09-Jul-92	2	0	0	0	0	0	0	0
10-Jul-92	2	0	0	0	0	0	0	0
13-Jul-92	2	0	0	0	0	0	0	0
15-Jul-92	2	0	0	0	0	0	0	0
17-Jul-92	2	0	0	0	0	0	0	0
20-Jul-92	2	0	0	0	0	0	0	0
21-Jul-92	2	0	0	0	0	0	0	0
22-Jul-92	2	0	0	0	0	0	0	0
23-Jul-92	2	0	0	0	0	0	0	0
28-Jul-92	2	0	0	0	0	0	0	0
30-Jul-92	2	0	0	0	0	0	0	0
05-Aug-92	2	0	0	0	0	0	0	0
06-Aug-92	2	0	0	0	0	0	0	0
11-Aug-92	2	0	0	0	0	0	0	0
13-Aug-92	2	0	0	0	0	0	0	0
18-Aug-92	2	0	0	0	0	0	0	0
19-Aug-92	2	0	0	0	0	0	0	0
20-Aug-92	2	0	0	0	0	0	0	0
24-Aug-92	2	0	0	0	0	0	0	0
25-Aug-92	2	0	0	0	0	0	0	0
26-Aug-92	2	0	0	0	0	0	0	0
27-Aug-92	2	0	0	0	0	0	0	0
01-Sep-92	2	0	0	0	0	0	0	0
02-Sep-92	2	0	0	0	0	0	0	0
03-Sep-92	2	0	0	0	0	0	0	0
08-Sep-92	2	0	0	0	0	0	0	0
14-Sep-92	2	0	0	0	0	0	0	0
15-Sep-92	2	0	0	0	0	0	0	0
16-Sep-92	2	0	0	0	0	0	0	0
17-Sep-92	2	0	0	0	0	0	0	0
21-Sep-92	2	0	0	0	0	0	0	0
22-Sep-92	2	0	0	0	0	0	0	0
23-Sep-92	2	0	0	0	0	0	0	0
24-Sep-92	2	0	0	0	0	0	0	0
TOTALS		0	0.406	0.8834	0	0.0288	0.0288	1.3469

* No sample taken, densities estimated in order to calculate entrainment.

Appendix B. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY DIVERSION SITE COLLECTED UNDER THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 3 - MCDONALD ISLAND (Unscreened)

DENSITIES (Number per Cubic Meter)

DATE	MISC EGGS	LARVAE: ASHAD	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRARC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS
14-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-May-92	0	0	0.8743	0	0	0	0	0	0	0	0	0	0	0	0	3.5518	0
22-May-92	0.0595	0	0.1191	0	0	0	0	0	0	0	0	0	0	0	0	0.1786	0
26-May-92	0	0	5.8928	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0642	0
28-May-92	0	0	1.7602	0	0	0	0	0	0	0	0	0	0	0	0	0.176	0
01-Jun-92	0	0	4.2154	0	0	0	0.0327	0	0	0	0	0	0	0	0	0	0
03-Jun-92	0	0	0.8146	0	0	0	0	0	0	0	0	0	0	0	0	0.0354	0
05-Jun-92	0	0	6.6872	0	0	0	0	0	0	0	0	0	0	0	0	4.2882	0
09-Jun-92	0	0	1.6722	0	0	0	0	0	0	0	0	0	0	0	0	0.1174	0
11-Jun-92	0	0	1.8992	0	0	0	0	0	0	0.02	0	0	0	0	0	0.9744	0
12-Jun-92	0.0156	0	3.1591	0	0	0	0.0156	0	0	0	0	0	0	0	0	0.172	0
15-Jun-92	0.0158	0	0.2836	0	0	0	0.0158	0	0	0.03	0	0	0	0	0	12.59	0
17-Jun-92	0	0	0.6366	0	0	0	0	0	0	0	0	0	0	0	0	0.0653	0
19-Jun-92	0	0	0.1539	0	0	0	0	0	0	0	0	0	0	0	0	0.0616	0
22-Jun-92	0	0	1.0179	0	0	0	0	0	0	0	0	0	0	0	0	1.129	0
23-Jun-92	0.0212	0	1.8685	0	0	0	0	0	0	0	0	0	0	0	0	0.1062	0
24-Jun-92	0	0	0.4617	0	0	0	0	0	0	0	0	0	0	0	0	0.1204	0
25-Jun-92	0	0	3.0661	0	0	0	0.0634	0	0	0	0	0	0	0	0	0.1692	0
29-Jun-92	0	0	0.3205	0	0	0	0	0	0	0	0	0	0	0	0	0.0247	0
30-Jun-92 *	0	0	0.3205	0	0	0	0	0	0	0	0	0	0	0	0	0.0247	0
01-Jul-92	0	0	0.4992	0	0	0	0	0	0	0	0	0	0	0	0	0.0713	0
03-Jul-92	0	0	2.3236	0	0	0	0	0	0	0	0	0	0	0	0	0.9295	0
06-Jul-92	0	0	0.5643	0	0	0	0	0	0	0	0	0	0	0	0	1.1286	0
07-Jul-92	0	0	0.0299	0	0	0	0	0	0	0	0	0	0	0	0	0.0597	0
08-Jul-92	0	0	0.0302	0	0	0	0.0302	0	0	0	0	0	0	0	0	0	0
09-Jul-92	0	0	2.6457	0	0	0	0	0	0	0	0	0	0	0	0	0.441	0
05-Aug-92	0	0	0.0892	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Aug-92	0	0	0.1649	0	0	0	0.0097	0	0	0	0	0	0	0	0	0	0
TOTALS	0.1122	0	41.57	0	0	0	0.1674	0	0	0.05	0	0	0	0	0	26.479	0

* Densities estimated in order to estimate entrainment.

Appendix B. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY DIVERSION SITE COLLECTED UNDER THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 3 - MCDONALD ISLAND (Screened)

DENSITIES
(Number per Cubic Meter)

DATE	MISC EGGS	LARVAE: ASHAD	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRARC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS
06-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-May-92	0.0633	0	0.0633	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27-May-92	0	0	0.6122	0	0	0	0	0	0	0	0	0	0	0	0	0.0557	0
28-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Jun-92	0	0	0.1643	0	0	0	0	0	0	0	0	0	0	0	0	5.791	0
09-Jun-92	0	0	0.0154	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-Jun-92	0.0573	0	0.0191	0	0	0	0	0	0	0	0	0	0	0	0	0.1146	0
12-Jun-92	0	0	0.0182	0	0	0	0	0	0	0	0	0	0	0	0	0.0727	0
15-Jun-92	0.0157	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Jun-92	0	0	0.0383	0	0	0	0	0	0	0	0	0	0	0	0	0.0766	0
19-Jun-92	0	0	0.0775	0	0	0	0	0	0	0	0	0	0	0	0	0.1551	0
22-Jun-92	0	0	0.042	0	0	0	0	0	0	0	0	0	0	0	0	0.6719	0
23-Jun-92	0.1181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0169	0
24-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.041	0
29-Jun-92	0	0	0.025	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30-Jun-92 *	0	0	0.025	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0313	0
06-Jul-92	0	0	0.0363	0	0	0	0	0	0	0	0	0	0	0	0	1.2718	0
07-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3075	0
08-Jul-92	0.0505	0	0.1263	0	0	0	0	0	0	0	0	0	0	0	0	0.0505	0
08-Jul-92	0.0505 *	0	0.1263	0	0	0	0	0	0	0	0	0	0	0	0	0.0505	0
09-Jul-92 *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Aug-92 *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06-Aug-92 *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Aug-92	0	0	0.0112	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	0.3555	0	1.4004	0	0	0	0	0	0	0	0	0	0	0	0	8.7069	0

* Densities estimated in order to estimate entrainment.

Appendix B. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY DIVERSION SITE COLLECTED UNDER THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 4 - NAGLEE BURK

DENSITIES
(Number per Cubic Meter)

DATE	MISC EGGS	LARVAE: ASHAD	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRARC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS
05-May-92 *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07-May-92	0	0	1.6125	0	0	0	0	0	0	0	0	0.0949	0	0	0	0.4743	0
08-May-92	0	0	0.2418	0	0	0	0	0	0	0	0	0	0	0	0	0.0726	0
11-May-92	0	0	0.9816	0	0	0	0.0633	0	0	0	0	0	0	0	0	0.285	0
18-May-92	0	0	2.0218	0	0	0	0	0	0	0	0	0	0	0	0	0.2186	0
08-Jun-92 *	0	0	0.5261	0	0	0	0.3507	0	0	0	0	0	0	0	0	0.0438	0
09-Jun-92	0	0	0.5261	0	0	0	0.3507	0	0	0	0	0	0	0	0	0.0438	0
10-Jun-92 *	0	0	0.3401	0	0	0	0.0267	0	0	0	0	0	0	0	0	0.2134	0
11-Jun-92	0	0	1.3122	0	0	0.2187	0	0	0	0	0	0	0	0	0	0.4374	0
12-Jun-92	0	0	0.2403	0	0	0	0	0	0	0	0	0	0	0	0	1.1213	0
15-Jun-92	0	0	1.843	0	0	0	0.0888	0	0	0	0	0	0	0	0	0.0666	0
17-Jun-92	0	0	0.0235	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0944	0
06-Jul-92 *	0	0	0.0485	0	0	0	0	0	0	0	0	0	0	0	0	0.1938	0
07-Jul-92	0	0	0.0485	0	0	0	0	0	0	0	0	0	0	0	0	0.1938	0
09-Jul-92	0.0235	0	0.1173	0	0	0	0	0	0	0	0	0	0	0	0	0.0704	0
10-Jul-92	0.5763	0	0	0	0	0	0	0	0	0	0	0	0	0	0.576	0	0
13-Jul-92	0	0	0.0488	0	0	0	0	0	0	0	0	0	0	0	0	0.0488	0
05-Aug-92	0	0	0	0	0	0	0.0234	0	0	0	0	0	0	0	0	0.1872	0
06-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3047	0
15-Aug-92 *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Aug-92	0	0	0.1879	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	0.5998	0	10.12	0	0	0.2187	0.9037	0	0	0	0	0.0949	0	0	0.576	4.0699	0

* No sample taken, densities estimated in order to calculate entrainment.

Appendix C

ESTIMATED DENSITY OF EGGS AND LARVAE, BY CHANNEL SITE

Delta Agricultural Diversion Evaluation
1992 Pilot Study

Appendix C. ESTIMATED EGG AND LARVAL DENSITIES BY CHANNEL SITE COLLECTED FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, FEBRUARY-SEPTEMBER

STATION 934 - SAN JOAQUIN RIVER (Twitchell Island)

DENSITIES (Number per Cubic Meter)

	EGGS:	LARVAE:													
DATE	MISC.	STRIPED BASS	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRAC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER
14-Apr-92	0	0.029	0	0.0058	0.2434	0	0	0	0	0	0	0.0116	0	0	0
16-Apr-92	0	2.246	0	0.0516	1.0843	0	0	0.0516	0	0	0	0.0774	0	0.0258	0
20-Apr-92	0	0.3708	0	0.0501	0.6715	0	0	0	0	0	0	0	0	0	0
22-Apr-92	0	0.1513	0	0.0189	0.0284	0	0	0	0	0	0	0.0095	0	0	0
24-Apr-92	0	0	0	0.0096	0.0431	0	0	0.0048	0	0	0	0	0	0	0
26-Apr-92	0	0.0224	0	0	0.4481	0	0	0	0	0	0	0.0149	0	0	0
28-Apr-92	0	0.7773	0.0065	0.0065	0.1568	0.0327	0	0	0	0	0	0.0196	0	0	0
30-Apr-92	0	3.8928	0	0.0311	0.7786	0.0156	0	0	0	0	0	0.0623	0	0	0
02-May-92	0	0.2038	0.0093	0	0.2594	0.0278	0	0	0	0	0	0.0185	0	0	0
04-May-92	0	1.705	0.0355	0	2.4154	0.1776	0	0	0	0	0	0	0	0	3.
06-May-92	0	1.7246	0	0	0.3338	0.0278	0	0	0	0	0	0	0	0	0
08-May-92	0	0.0914	0	0.0229	0.0686	0.0229	0	0	0	0	0	0	0	0	0.
10-May-92	0	0.1932	0	0	0	0.0644	0	0	0	0	0	0	0	0	0
12-May-92	0	0.7897	0	0	0.0292	0	0	0	0	0	0	0	0	0	0
14-May-92	0	0.4765	0	0.0953	0.0953	0.0953	0	0	0	0	0	0	0	0	0
16-May-92	0	0.0385	0	0.0385	0.0769	0.1154	0.0385	0	0	0	0	0	0	0	0.
20-May-92	0	0	0	0	0.0829	0	0	0.0829	0	0	0	0	0	0	0
22-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-May-92	0	0	0.0275	0	0	0	0	0	0	0	0	0	0	0	0
30-May-92	0	0	0.047	0	0	0	0	0	0	0	0	0	0	0	3.
01-Jun-92	0	0	0	0	0	0.0368	0	0	0	0	0	0	0	0	2.
03-Jun-92	0	0	0.0495	0	0	0	0	0	0	0	0	0	0	0	5.
07-Jun-92	0	0	0.6387	0.0073	0	0	0	0	0	0	0	0	0	0	6.
09-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.
11-Jun-92	0	0	0	0	0	0.0167	0.0167	0	0	0	0	0	0	0	0
12-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Jun-92	0	0	1.0511	0	0	0.0258	0	0	0	0	0	0	0	0	2
17-Jun-92	0	0	3.5313	0	0	0.0215	0	0	0	0	0	0	0	0	1
26-Jun-92	0	0	0.0798	0	0	0	0.016	0	0	0	0	0	0	0	0
29-Jun-92	0	0	0.2583	0	0	0	0.022	0	0	0	0	0	0	0	1
01-Jul-92	0	0	0.3435	0	0	0	0.0127	0	0	0	0	0	0	0	3
13-Jul-92	0	0	0.0053	0	0	0	0	0	0	0	0	0	0	0	1
14-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
15-Jul-92	0	0	0.0059	0	0	0	0	0	0	0	0	0	0	0	1
20-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Jul-92	0	0	0.0074	0	0	0	0	0	0	0	0	0	0	0	1
18-Aug-92	0	0	0.0144	0	0	0	0	0	0	0	0	0	0	0	0
26-Aug-92	0	0	0.0211	0	0	0	0	0	0	0	0	0	0	0	0
27-Aug-92	0	0	0.0254	0	0	0	0	0	0	0	0	0	0	0	0
31-Aug-92	0	0	0.0115	0	0	0	0	0	0	0	0	0	0	0	0
16-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	0	12.712	6.1691	0.3377	6.8156	0.6801	0.1058	0.1394	0	0	0	0.2138	0	0.0258	0 5

HAM OBY	STRIPED BASS
116	1.2864
774	3.0205
301	1.0223
0	0.4065
383	0.3688
597	0.926
718	0.8426
557	2.5693
463	2.5661
323	16.694
947	5.0625
229	1.2343
0	5.0233
0	11.874
906	10.483
769	4.1156
829	0.8295
0	2.6092
0	0.3669
0	0.4131
866	1.6672
052	2.8684
977	0.7428
582	0.0073
175	0.0087
533	0.0666
443	0.1804
826	0.0064
143	0.0215
2074	0
3742	0
5322	0
4764	0
2708	0
2586	0
1653	0
2258	0
1945	0
0506	0
1186	0
0154	0
0	0
0	0
0	0
.249	77.284

Appendix C. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY CHANNEL SITE COLLECTED FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, FEBRUARY-SEPTEMBER 1992.

STATION 934 - SAN JOAQUIN RIVER (Twitchell Island)

STRIPED BASS DENSITIES (Number per Cubic Meter)

DATE	STA#	EGGS	LARVAE: 3-6 mm	SIZE GROUP 7-10 mm	11-14 mm	15-18 mm	19-20 mm	3-20 mm
14-Apr-92	934	0.029	1.0894	0.197	0	0	0	1.2864
16-Apr-92	934	2.246	2.246	0.7745	0	0	0	3.0205
20-Apr-92	934	0.3708	0.7918	0.2305	0	0	0	1.0223
22-Apr-92	934	0.1513	0.2552	0.1513	0	0	0	0.4065
24-Apr-92	934	0	0.3545	0.0144	0	0	0	0.3688
26-Apr-92	934	0.0224	0.8364	0.0896	0	0	0	0.926
28-Apr-92	934	0.7773	0.6793	0.1633	0	0	0	0.8426
30-Apr-92	934	3.8928	1.8218	0.7474	0	0	0	2.5693
02-May-92	934	0.2038	2.0936	0.4725	0	0	0	2.5661
04-May-92	934	1.705	15.984	0.7104	0	0	0	16.694
06-May-92	934	1.7246	4.089	0.9736	0	0	0	5.0625
08-May-92	934	0.0914	1.2115	0.0229	0	0	0	1.2343
10-May-92	934	0.1932	4.4437	0.5152	0.0644	0	0	5.0233
12-May-92	934	0.7897	10.178	1.5793	0.117	0	0	11.874
14-May-92	934	0.4765	8.0052	2.3825	0.0953	0	0	10.483
16-May-92	934	0.0385	3.0771	0.9616	0.0769	0	0	4.1156
20-May-92	934	0	0.4147	0.3318	0.0829	0	0	0.8295
22-May-92	934	0	1.5504	0.7941	0.1891	0.0378	0.0378	2.6092
26-May-92	934	0	0.3057	0.0611	0	0	0	0.3669
28-May-92	934	0	0.0826	0.1102	0.1928	0.0275	0	0.4131
30-May-92	934	0	1.6202	0.047	0	0	0	1.6672
01-Jun-92	934	0	2.0593	0.3677	0.2942	0.1103	0.0368	2.8684
03-Jun-92	934	0	0.7428	0	0	0	0	0.7428
07-Jun-92	934	0	0	0.0073	0	0	0	0.0073
09-Jun-92	934	0	0	0	0.0087	0	0	0.0087
11-Jun-92	934	0	0	0.0666	0	0	0	0.0666
12-Jun-92	934	0	0	0.1466	0.0226	0.0113	0	0.1804
15-Jun-92	934	0	0	0.0064	0	0	0	0.0064
17-Jun-92	934	0	0	0	0.0215	0	0	0.0215
26-Jun-92	934	0	0	0	0	0	0	0
29-Jun-92	934	0	0	0	0	0	0	0
01-Jul-92	934	0	0	0	0	0	0	0
13-Jul-92	934	0	0	0	0	0	0	0
14-Jul-92	934	0	0	0	0	0	0	0
15-Jul-92	934	0	0	0	0	0	0	0
20-Jul-92	934	0	0	0	0	0	0	0
28-Jul-92	934	0	0	0	0	0	0	0
18-Aug-92	934	0	0	0	0	0	0	0
26-Aug-92	934	0	0	0	0	0	0	0
27-Aug-92	934	0	0	0	0	0	0	0
31-Aug-92	934	0	0	0	0	0	0	0
16-Sep-92	934	0	0	0	0	0	0	0
17-Sep-92	934	0	0	0	0	0	0	0
23-Sep-92	934	0	0	0	0	0	0	0
TOTALS		12.712	63.932	11.925	1.1653	0.187	0.0746	77.284

Appendix C. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY CHANNEL SITE COLLECTED FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, FEBRUARY-SEPTEMBER 1992.

STATION 932 - MIDDLE RIVER (Bacon Island Diversion) DENSITIES (Number per Cubic Meter)

	EGGS:		LARVAE:														
DATE	MISC.	STRIPED BASS	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRAC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS
06-Apr-92	0	0	0	0	0.8295	0	0.0488	0	0	0	0	0.0081	0	0	0	0	0.0895
08-Apr-92	0	0	0	0	0.4103	0	0.0057	0	0	0	0	0.0285	0	0	0	0	0.0684
10-Apr-92	0	0	0	0	0.1647	0	0	0	0	0	0	0.0084	0	0	0	0	0.1309
12-Apr-92	0	0	0	0	1.4261	0	0.004	0	0	0	0	0.0159	0	0	0	0	0.0996
14-Apr-92	0	0	0	0.0048	0.1	0	0	0	0	0	0	0.0143	0	0	0	0.0048	0.0429
16-Apr-92	0	0	0	0	0.0619	0	0.0044	0	0	0	0	0	0	0	0	0	0.0177
20-Apr-92	0	0	0.0085	0	0.3069	0	0.0171	0	0	0	0	0.0256	0	0	0	0	0.0682
22-Apr-92	0	0	0	0	0.3502	0	0	0	0	0	0	0.05	0	0	0.05	0	0.4503
24-Apr-92	0	0	0	0.0194	0.2903	0	0	0	0	0	0	0.0968	0	0	0	0	0.1161
26-Apr-92	0	0	0	0.0093	0.2146	0.0187	0	0	0	0	0	0	0	0	0	0.0187	0.1026
28-Apr-92	0	0	0	0	0.122	0	0	0	0	0	0	0	0	0	0	0.1084	0.1355
30-Apr-92	0	0	0	0	0.0537	0	0	0	0	0	0	0	0	0	0	0.0493	0.0314
02-May-92	0	0	0	0	0.0788	0.0061	0	0	0	0	0	0.0121	0	0	0	0.0061	0.0788
04-May-92	0	0	0	0.0652	0.2445	0.0163	0	0	0	0	0	0	0	0	0	0.1141	0.538
06-May-92	0	0	0	0	0.0227	0	0	0	0	0	0	0	0	0	0	0	0.1812
08-May-92	0	0	0	0	0	0	0	0	0	0	0	0.0276	0	0	0	0	0.3039
10-May-92	0	0	0	0	0.0345	0.0345	0	0	0	0	0	0	0	0	0	0.0689	0.3101
12-May-92	0	0	0.0325	0	0.0325	0	0	0	0	0	0	0.0325	0	0	0	0.0651	0.2278
14-May-92	0	0	0.0239	0	0.0239	0	0	0	0	0	0	0.0239	0	0	0	0.0477	0.5487
16-May-92	0	0	0	0	0	0	0.0182	0	0	0	0	0	0	0	0	0.0547	0.1641
20-May-92	0	0	0.0216	0	0.0216	0	0	0	0	0	0	0	0	0	0	0.0649	0.1731
22-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2607	0.1862
26-May-92	0	0	0.1255	0	0	0	0	0	0	0	0	0	0	0	0	2.1692	0.0896
28-May-92	0	0	0.0906	0	0	0.0226	0	0	0	0	0	0	0	0	0	1.6193	0.0906
30-May-92	0	0	0.6209	0	0	0	0	0	0	0	0	0	0	0	0	2.5524	0.0296
01-Jun-92	0	0	1.0223	0	0	0	0.0122	0	0	0	0	0	0	0	0	7.2045	0.0852
03-Jun-92	0	0	0.0738	0	0	0	0	0	0	0	0	0	0	0	0	1.0654	0.0184
05-Jun-92	0	0	0.0372	0	0	0	0	0	0	0	0	0	0	0	0	0.6445	0.0744
07-Jun-92	0	0	0.2778	0	0	0	0.0044	0	0	0	0	0	0	0	0	2.4874	0.0088
09-Jun-92	0	0	0.1506	0	0	0	0	0	0	0	0	0	0	0	0	3.1628	0.0086
11-Jun-92	0	0	0.1593	0	0	0	0	0	0	0	0	0	0	0	0	2.04	0
12-Jun-92	0	0	0.1002	0	0	0	0.0046	0	0	0	0	0	0	0	0	1.4618	0
15-Jun-92	0	0	0.1475	0	0	0	0	0	0	0	0	0	0	0	0	3.7246	0
17-Jun-92	0	0	0.2368	0	0	0	0.0055	0	0	0	0	0	0	0	0	2.6153	0
19-Jun-92	0	0	0.1954	0	0	0	0	0	0	0	0	0	0	0	0	1.586	0
22-Jun-92	0	0	0.5765	0	0	0	0	0	0	0	0	0	0	0	0	1.3196	0
23-Jun-92	0	0	0.3332	0	0	0	0	0	0	0	0	0	0	0	0	4.6089	0
25-Jun-92	0	0	0.0138	0	0	0	0	0	0	0	0	0	0	0	0	0.6474	0
26-Jun-92	0	0	0.0839	0	0	0	0.0034	0	0	0	0	0	0	0	0	0.4296	0
29-Jun-92	0	0	0.8958	0	0	0	0	0	0	0	0	0	0	0	0	7.2113	0
01-Jul-92	0	0	0.2152	0	0	0	0	0	0	0	0	0	0	0	0	0.9538	0
13-Jul-92	0	0	0.0085	0	0	0	0	0	0	0	0	0	0	0	0	0.0127	0
14-Jul-92	0	0	0.0204	0	0	0	0	0	0	0	0	0	0	0	0	0.4973	0
15-Jul-92	0	0	0.0262	0	0	0	0	0	0	0	0	0	0	0	0	0.3667	0
20-Jul-92	0	0	0.0704	0	0	0	0	0	0	0	0	0	0	0	0	0.4714	0
28-Jul-92	0	0	0.0609	0	0	0	0.0051	0	0	0	0	0	0	0	0	0.4671	0
18-Aug-92	0	0	0.0755	0	0	0	0	0	0	0	0	0	0	0	0	0.0874	0
26-Aug-92	0	0	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0.013	0
27-Aug-92	0	0	0.0544	0	0	0	0	0	0	0	0	0	0	0	0	0.0145	0
31-Aug-92	0	0	0.0307	0	0	0	0	0	0	0	0	0	0	0	0	0.0038	0
16-Sep-92	0	0	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	0	0	5.9556	0.0987	4.7887	0.0981	0.1333	0	0	0	0	0.3438	0	0	0.05	50.301	4.4703

Appendix C. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY CHANNEL SITE COLLECTED FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, FEBRUARY-SEPTEMBER 1992.

STATION 932 - MIDDLE RIVER (Bacon Island)

STRIPED BASS DENSITIES (Number per Cubic Meter)

DATE	STA#	EGGS	LARVAE: SIZE GROUP 3-6 mm	7-10 mm	11-14 mm	15-18 mm	19-20 mm	3-20 mm
06-Apr-92	932	0	0.0813	0.0081	0	0	0	0.0895
08-Apr-92	932	0	0.0627	0.0057	0	0	0	0.0684
10-Apr-92	932	0	0.1183	0.0127	0	0	0	0.1309
12-Apr-92	932	0	0.0837	0.0159	0	0	0	0.0996
14-Apr-92	932	0	0.0286	0.0143	0	0	0	0.0429
16-Apr-92	932	0	0.0044	0.0133	0	0	0	0.0177
20-Apr-92	932	0	0.0512	0.0171	0	0	0	0.0682
22-Apr-92	932	0	0.3002	0.1501	0	0	0	0.4503
24-Apr-92	932	0	0.0968	0.0194	0	0	0	0.1161
26-Apr-92	932	0	0.0746	0.028	0	0	0	0.1026
28-Apr-92	932	0	0.1084	0.0271	0	0	0	0.1355
30-Apr-92	932	0	0.0224	0.009	0	0	0	0.0314
02-May-92	932	0	0.0545	0.0242	0	0	0	0.0788
04-May-92	932	0	0.4728	0.0652	0	0	0	0.538
06-May-92	932	0	0.1586	0.0227	0	0	0	0.1812
08-May-92	932	0	0.2211	0.0829	0	0	0	0.3039
10-May-92	932	0	0.0345	0.2756	0	0	0	0.3101
12-May-92	932	0	0.0651	0.1627	0	0	0	0.2278
14-May-92	932	0	0.334	0.1909	0.0239	0	0	0.5487
16-May-92	932	0	0.1641	0	0	0	0	0.1641
20-May-92	932	0	0.1299	0.0433	0	0	0	0.1731
22-May-92	932	0	0	0.1862	0	0	0	0.1862
26-May-92	932	0	0.0538	0.0359	0	0	0	0.0896
28-May-92	932	0	0.0679	0.0113	0.0113	0	0	0.0906
30-May-92	932	0	0	0.0197	0.0099	0	0	0.0296
01-Jun-92	932	0	0.0122	0.0365	0.0243	0.0122	0	0.0852
03-Jun-92	932	0	0.0046	0.0138	0	0	0	0.0184
05-Jun-92	932	0	0.0124	0.0434	0.0186	0	0	0.0744
07-Jun-92	932	0	0	0.0088	0	0	0	0.0088
09-Jun-92	932	0	0	0	0.0086	0	0	0.0086
11-Jun-92	932	0	0	0	0	0	0	0
12-Jun-92	932	0	0	0	0	0	0	0
15-Jun-92	932	0	0	0	0	0	0	0
17-Jun-92	932	0	0	0	0	0	0	0
19-Jun-92	932	0	0	0	0	0	0	0
22-Jun-92	932	0	0	0	0	0	0	0
23-Jun-92	932	0	0	0	0	0	0	0
25-Jun-92	932	0	0	0	0	0	0	0
26-Jun-92	932	0	0	0	0	0	0	0
29-Jun-92	932	0	0	0	0	0	0	0
01-Jul-92	932	0	0	0	0	0	0	0
13-Jul-92	932	0	0	0	0	0	0	0
14-Jul-92	932	0	0	0	0	0	0	0
15-Jul-92	932	0	0	0	0	0	0	0
20-Jul-92	932	0	0	0	0	0	0	0
28-Jul-92	932	0	0	0	0	0	0	0
18-Aug-92	932	0	0	0	0	0	0	0
26-Aug-92	932	0	0	0	0	0	0	0
27-Aug-92	932	0	0	0	0	0	0	0
31-Aug-92	932	0	0	0	0	0	0	0
16-Sep-92	932	0	0	0	0	0	0	0
17-Sep-92	932	0	0	0	0	0	0	0
23-Sep-92	932	0	0	0	0	0	0	0
TOTALS		0	2.8178	1.5437	0.0966	0.0122	0	4.4703

Appendix C. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY CHANNEL SITE COLLECTED FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, FEBRUARY-SEPTEMBER 1992.

STATION 933 - TURNER CUT (McDonald Island Diversion) DENSITIES (Number per Cubic Meter)

	EGGS:		LARVAE:														
DATE	MISC.	STRIPED BASS	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRAC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS
06-Apr-92	0	0	0	0.0073	0.374	0	0	0	0	0	0	0.0147	0	0	0	0.0073	0
08-Apr-92	0	0	0	0.0407	0.8541	0	0	0	0	0	0	0.061	0	0	0	0.1017	0.0407
10-Apr-92	0	0	0	0	0.5113	0.0098	0	0	0	0	0	0.0393	0	0	0	0.7276	0.059
12-Apr-92	0	0	0	0	0.1469	0.0043	0	0	0	0	0	0.0475	0	0	0	0.2074	0.0216
14-Apr-92	0	0	0	0	0.1157	0	0	0	0	0	0	0.0281	0	0	0	0.0245	0.007
16-Apr-92	0	0	0.0115	0	0.2219	0.0038	0	0	0	0	0	0.023	0	0	0	0.3787	0.0077
20-Apr-92	0	0	0.0217	0	0.6592	0	0	0	0	0	0	0.0797	0	0	0	0.6737	0.0435
22-Apr-92	0	0	0.0212	0	0.3457	0.0071	0	0	0	0	0	0.0705	0	0	0	0.5009	0.0141
24-Apr-92	0	0	0.0376	0	0.3669	0	0	0	0	0	0	0.0282	0	0	0	1.4016	0.0094
26-Apr-92	0	0	0.0236	0	0.1462	0	0	0	0	0	0	0.0283	0	0	0	0.3914	0
28-Apr-92	0	0	0.0071	0	0.0071	0	0	0	0	0	0	0.0141	0	0	0	0.0071	0.0141
30-Apr-92	0	0	0.0343	0	0.0515	0	0	0	0	0	0	0.0172	0	0	0	0.7385	0
02-May-92	0	0	0.0656	0	0.1639	0	0	0	0	0	0	0.0109	0	0	0	0.9726	0
04-May-92	0	0	0.2753	0	0.5199	0.0306	0.0306	0	0	0	0	0.0918	0	0	0	1.3763	0.0612
06-May-92	0	0	0.0818	0	0.0818	0	0	0	0	0	0	0.0205	0	0	0	0.5318	0.0409
08-May-92	0	0	0.0605	0	0	0	0	0	0	0	0	0	0	0	0	0.3146	0
10-May-92	0	0	0	0	0.2666	0.0889	0	0	0	0	0	0	0	0	0	0	0
12-May-92	0	0	0	0	0.0253	0.0253	0.0253	0	0	0	0	0	0	0	0	0.0506	0.0253
14-May-92	0	0	0.1849	0	0.0462	0	0	0	0	0	0	0	0	0	0	1.1094	0.0462
16-May-92	0	0	0	0	0.0273	0	0	0	0	0	0	0	0	0	0	0.5461	0.0546
20-May-92	0	0	0.119	0	0	0	0	0	0	0	0	0	0	0	0	1.3086	0.0238
22-May-92	0	0	0.4041	0	0.0674	0	0	0	0	0	0	0	0	0	0	2.8289	0
26-May-92	0	0	0.8432	0	0	0.0206	0	0	0	0	0	0	0	0	0	4.9562	0
28-May-92	0	0	0.3972	0	0	0	0	0	0	0	0	0	0	0	0	11.385	0
30-May-92	0	0	1.1617	0	0	0	0	0	0	0	0	0	0	0	0	2.9488	0
01-Jun-92	0	0	1.0218	0	0	0	0	0	0	0	0	0	0	0	0	8.757	0
03-Jun-92	0	0	1.6732	0	0	0	0	0	0	0	0	0	0	0	0	48.575	0
05-Jun-92	0	0	2.7994	0	0	0	0	0	0	0	0	0	0	0	0	60.094	0
07-Jun-92	0	0	0.7619	0	0	0	0	0	0	0	0	0	0	0	0	10.59	0
09-Jun-92	0	0	1.1914	0	0	0	0.0056	0	0	0	0	0	0	0	0	3.4782	0
11-Jun-92	0	0	0.834	0	0	0	0.017	0	0	0	0	0	0	0	0	3.8014	0
12-Jun-92	0	0	0.459	0	0	0	0.0042	0	0	0	0	0	0	0	0	2.3497	0
15-Jun-92	0	0	0.1016	0	0	0	0	0	0	0	0	0	0	0	0	9.0912	0
17-Jun-92	0	0	0.7678	0	0	0	0	0	0	0	0	0	0	0	0	4.873	0
19-Jun-92	0	0	0.1957	0	0	0	0	0	0	0	0	0	0	0	0	3.6385	0
22-Jun-92	0	0	0.266	0	0	0	0	0	0	0	0	0	0	0	0	3.7605	0
23-Jun-92	0	0	0.1587	0	0	0	0	0	0	0	0	0	0	0	0	3.2638	0
26-Jun-92	0	0	0.144	0	0	0	0.0144	0	0	0	0	0	0	0	0	0.9286	0
29-Jun-92	0	0	0.0814	0	0	0	0	0	0	0	0	0	0	0	0	2.7692	0
01-Jul-92	0	0	0.043	0	0	0	0.0039	0	0	0	0	0	0	0	0	0.301	0
13-Jul-92	0	0	0.0306	0	0	0	0	0	0	0	0	0	0	0	0	0.3212	0
14-Jul-92	0	0	0.0155	0	0	0	0	0	0	0	0	0	0	0	0	0.1657	0
15-Jul-92	0	0	0.0508	0	0	0	0.0138	0	0	0	0	0	0	0	0	0.7155	0
20-Jul-92	0	0	0.0859	0	0	0	0.0264	0	0	0	0	0	0	0	0	1.7708	0
28-Jul-92	0	0	0.6097	0	0	0	0.0369	0	0	0	0	0	0	0	0	0.6097	0
18-Aug-92	0	0	0.0702	0	0	0	0.0083	0	0	0	0	0	0	0	0	0.2146	0
26-Aug-92	0	0	0.0093	0	0	0	0	0	0	0	0	0	0	0	0	0.0187	0
27-Aug-92	0	0	0.0373	0	0	0	0	0	0	0	0	0	0	0	0	0.0124	0
31-Aug-92	0	0	0.0262	0	0	0	0	0	0	0	0	0	0	0	0	0.0337	0
16-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	0	0	15.185	0.048	4.9988	0.1904	0.1866	0	0	0	0	0.5747	0	0	0	203.62	0.4691

Appendix C. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY CHANNEL SITE COLLECTED FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, FEBRUARY-SEPTEMBER 1992.

STATION 933 - TURNER CUT (McDonald Island)

STRIPED BASS DENSITIES (Number per Cubic Meter)

DATE	STA#	EGGS	LARVAE: 3-6 mm	SIZE GROUP 7-10 mm	11-14 mm	15-18 mm	19-20 mm	3-20 mm
06-Apr-92	933	0	0	0	0	0	0	0
08-Apr-92	933	0	0.0407	0	0	0	0	0.0407
10-Apr-92	933	0	0.0492	0.0098	0	0	0	0.059
12-Apr-92	933	0	0.0216	0	0	0	0	0.0216
14-Apr-92	933	0	0.007	0	0	0	0	0.007
16-Apr-92	933	0	0.0038	0.0038	0	0	0	0.0077
20-Apr-92	933	0	0.0145	0.029	0	0	0	0.0435
22-Apr-92	933	0	0.0071	0.0071	0	0	0	0.0141
24-Apr-92	933	0	0.0094	0	0	0	0	0.0094
26-Apr-92	933	0	0	0	0	0	0	0
28-Apr-92	933	0	0	0.0071	0.0071	0	0	0.0141
30-Apr-92	933	0	0	0	0	0	0	0
02-May-92	933	0	0	0	0	0	0	0
04-May-92	933	0	0.0306	0.0306	0	0	0	0.0612
06-May-92	933	0	0.0409	0	0	0	0	0.0409
08-May-92	933	0	0	0	0	0	0	0
10-May-92	933	0	0	0	0	0	0	0
12-May-92	933	0	0	0.0253	0	0	0	0.0253
14-May-92	933	0	0	0	0.0462	0	0	0.0462
16-May-92	933	0	0.0273	0	0.0273	0	0	0.0546
20-May-92	933	0	0.0238	0	0	0	0	0.0238
22-May-92	933	0	0	0	0	0	0	0
26-May-92	933	0	0	0	0	0	0	0
28-May-92	933	0	0	0	0	0	0	0
30-May-92	933	0	0	0	0	0	0	0
01-Jun-92	933	0	0	0	0	0	0	0
03-Jun-92	933	0	0	0	0	0	0	0
05-Jun-92	933	0	0	0	0	0	0	0
07-Jun-92	933	0	0	0	0	0	0	0
09-Jun-92	933	0	0	0	0	0	0	0
11-Jun-92	933	0	0	0	0	0	0	0
12-Jun-92	933	0	0	0	0	0	0	0
15-Jun-92	933	0	0	0	0	0	0	0
17-Jun-92	933	0	0	0	0	0	0	0
19-Jun-92	933	0	0	0	0	0	0	0
22-Jun-92	933	0	0	0	0	0	0	0
23-Jun-92	933	0	0	0	0	0	0	0
26-Jun-92	933	0	0	0	0	0	0	0
29-Jun-92	933	0	0	0	0	0	0	0
01-Jul-92	933	0	0	0	0	0	0	0
13-Jul-92	933	0	0	0	0	0	0	0
14-Jul-92	933	0	0	0	0	0	0	0
15-Jul-92	933	0	0	0	0	0	0	0
20-Jul-92	933	0	0	0	0	0	0	0
28-Jul-92	933	0	0	0	0	0	0	0
18-Aug-92	933	0	0	0	0	0	0	0
26-Aug-92	933	0	0	0	0	0	0	0
27-Aug-92	933	0	0	0	0	0	0	0
31-Aug-92	933	0	0	0	0	0	0	0
16-Sep-92	933	0	0	0	0	0	0	0
17-Sep-92	933	0	0	0	0	0	0	0
23-Sep-92	933	0	0	0	0	0	0	0
TOTALS		0	0.2758	0.1127	0.0806	0	0	0.4691

Appendix C. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY CHANNEL SITE COLLECTED FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, FEBRUARY-SEPTEMBER 1992.

STATION 93 - OLD RIVER (Naglee Burk Diversion)

DENSITIES (Number per Cubic Meter)

	EGGS:	LARVAE:														
DATE	MISC.	STRIPED BASS	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRAC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS
20-Feb-92	0	0	0	0	0.2047	0	0	0	0	0	0	0	0	0	0	0	0
25-Feb-92	0	0	0	0	0.4857	0	0	0	0	0	0	0	0	0	0	0	0
28-Feb-92	0	0	0	0	0.386	0	0	0	0	0	0	0.0112	0	0	0	0	0
03-Mar-92	0.0962	0	0	0	0.2627	0	0	0	0.0037	0	0	0	0	0	0	0	0
07-Mar-92	0	0	0	0	0.7048	0	0	0	0	0	0	0.0146	0	0	0	0	0
11-Mar-92	0	0	0	0	1.334	0	0	0	0	0	0	0.0078	0	0	0	0	0
15-Mar-92	0	0	0	0	0.4695	0	0	0	0	0	0	0.0172	0	0	0	0	0
19-Mar-92	0	0	0	0	1.2061	0	0	0	0	0	0	0.0081	0	0	0	0	0
23-Mar-92	0	0	0	0	2.122	0	0	0	0	0	0	0.1188	0	0	0	0	0
27-Mar-92	0	0	0	0	0.8798	0	0	0	0	0	0	0.0187	0	0	0	0	0
01-Apr-92	0	0	0	0	0.4313	0	0	0	0	0	0	0.0254	0	0	0	0.1966	0
04-Apr-92	0	0	0.0535	0	0.6601	0	0	0	0	0	0	0.0357	0	0.0089	0	1.5164	0
06-Apr-92	0	0	0.008	0	0.4021	0.004	0	0	0.008	0	0	0	0	0	0	0.4786	0
08-Apr-92	0	0	0.0048	0	0.2851	0	0	0	0	0	0	0	0	0.0095	0	0.1948	0.019
10-Apr-92	0	0	0.0898	0	0.2295	0.005	0	0	0	0	0	0	0	0	0	2.8337	0
12-Apr-92	0	0	0.0521	0	0.0681	0	0	0	0.012	0	0	0.004	0	0	0	1.0058	0
16-Apr-92	0	0	0.1769	0	0.1308	0.0077	0	0	0.0308	0	0	0.0077	0	0	0	1.2538	0
28-Apr-92	0.0101	0	0.0201	0	0.0805	0	0	0	0	0	0	0	0	0	0	0	0.0302
30-Apr-92	0	0	0	0	0.0159	0	0	0	0	0	0	0	0	0	0	0	0.0319
02-May-92	0	0	0	0	0.0044	0	0	0	0	0	0	0	0	0	0	0.0177	0
04-May-92	0	0	0.0455	0	0.1092	0	0.0091	0	0	0	0	0	0	0	0	0.1092	0.0091
06-May-92	0	0	0.0144	0	0.0239	0.0048	0.0048	0	0	0	0	0	0	0	0	0.0575	0
10-May-92	0	0	0.0089	0	0	0	0	0	0	0	0	0	0	0	0	0.3922	0.0535
26-May-92	0	0	0.0767	0	0	0	0	0	0	0	0	0	0	0	0	0.9866	0
28-May-92	0	0	0.2121	0	0	0	0	0	0	0	0	0	0	0	0	2.1918	0
30-May-92	0	0	0.2928	0	0	0	0	0	0.0127	0	0	0	0	0	0	1.5406	0
01-Jun-92	0	0	0.2811	0	0	0	0.048	0	0.0069	0	0	0	0	0	0	1.6932	0.0069
03-Jun-92	0	0	1.0158	0	0	0	0.0127	0	0	0	0	0	0	0	0	4.8759	0
05-Jun-92	0	0	0.3429	0	0	0	0.0549	0	0	0	0	0	0	0	0	5.6027	0.0069
07-Jun-92	0	0	0.3574	0	0	0	0.0278	0	0.004	0	0	0	0	0	0	2.2438	0
09-Jun-92	0	0	0.3888	0	0	0	0.0061	0	0	0	0	0	0	0	0	2.5515	0
11-Jun-92	0	0	0.1325	0	0	0	0.0044	0	0	0	0	0	0	0	0	0.4992	0
12-Jun-92	0	0	0.0725	0	0	0	0	0	0.0045	0	0	0	0	0	0	0.3125	0
15-Jun-92	0	0	0.2692	0	0	0	0	0	0	0	0	0	0	0	0	0.3114	0
17-Jun-92	0	0	0.5115	0	0	0	0	0	0	0	0	0	0.0052	0	0	0.428	0.0052
19-Jun-92	0	0	0.514	0	0	0	0	0	0	0	0	0	0	0	0	0.7293	0
22-Jun-92	0	0	0.1337	0	0	0	0	0	0	0	0	0	0	0	0	0.633	0
23-Jun-92	0	0	0.2903	0	0	0	0	0	0.0041	0	0	0	0	0	0	0.2488	0
25-Jun-92	0	0	0.0286	0	0	0	0.0095	0	0	0	0	0	0	0	0	0.2094	0
26-Jun-92	0	0	0.0548	0	0	0	0.0137	0	0	0	0	0	0	0	0	0.1234	0
29-Jun-92	0	0	0.1408	0	0	0	0.0078	0	0.0078	0	0	0	0	0	0	0.9151	0
01-Jul-92	0	0	0.2843	0	0	0	0.0044	0	0	0	0	0	0	0	0	0.2975	0
03-Jul-92	0	0	0.1987	0	0	0	0	0	0	0.0075	0	0	0	0	0	0.27	0
13-Jul-92	0	0	0.0277	0	0	0	0	0	0	0	0	0	0	0	0	0.0198	0
14-Jul-92	0	0	0.0144	0	0	0	0	0	0	0	0	0	0	0	0	0.0622	0
15-Jul-92	0	0	0.0499	0	0	0	0.0071	0	0.0036	0	0	0	0	0	0	0.0285	0
TOTALS	0.1062	0	6.1645	0	10.496	0.0215	0.2103	0	0.0982	0.0075	0	0.2693	0.0052	0.0184	0	34.83	0.1626

Appendix C. (Cont.) ESTIMATED EGG AND LARVAL DENSITIES BY CHANNEL SITE COLLECTED FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, FEBRUARY-SEPTEMBER 1992.

STATION 93 - OLD RIVER (Naglee Burk Diversion)

STRIPED BASS DENSITIES (Number per Cubic Meter)

DATE	STA#	EGGS	LARVAE: 3-6 mm	SIZE GROUP 7-10 mm	11-14 mm	15-18 mm	19-20 mm	3-20 mm
20-Feb-92	93	0	0	0	0	0	0	0
25-Feb-92	93	0	0	0	0	0	0	0
28-Feb-92	93	0	0	0	0	0	0	0
03-Mar-92	93	0	0	0	0	0	0	0
07-Mar-92	93	0	0	0	0	0	0	0
11-Mar-92	93	0	0	0	0	0	0	0
15-Mar-92	93	0	0	0	0	0	0	0
19-Mar-92	93	0	0	0	0	0	0	0
23-Mar-92	93	0	0	0	0	0	0	0
27-Mar-92	93	0	0	0	0	0	0	0
01-Apr-92	93	0	0	0	0	0	0	0
04-Apr-92	93	0	0	0	0	0	0	0
06-Apr-92	93	0	0	0	0	0	0	0
08-Apr-92	93	0	0.019	0	0	0	0	0.019
10-Apr-92	93	0	0	0	0	0	0	0
12-Apr-92	93	0	0	0	0	0	0	0
16-Apr-92	93	0	0	0	0	0	0	0
28-Apr-92	93	0	0	0.0101	0.0201	0	0	0.0302
30-Apr-92	93	0	0	0.0159	0.0159	0	0	0.0319
02-May-92	93	0	0	0	0	0	0	0
04-May-92	93	0	0.0091	0	0	0	0	0.0091
06-May-92	93	0	0	0	0	0	0	0
10-May-92	93	0	0	0.0357	0.0178	0	0	0.0535
26-May-92	93	0	0	0	0	0	0	0
28-May-92	93	0	0	0	0	0	0	0
30-May-92	93	0	0	0	0	0	0	0
01-Jun-92	93	0	0	0	0.0069	0	0	0.0069
03-Jun-92	93	0	0	0	0	0	0	0
05-Jun-92	93	0	0	0	0	0.0069	0	0.0069
07-Jun-92	93	0	0	0	0	0	0	0
09-Jun-92	93	0	0	0	0	0	0	0
11-Jun-92	93	0	0	0	0	0	0	0
12-Jun-92	93	0	0	0	0	0	0	0
15-Jun-92	93	0	0	0	0	0	0	0
17-Jun-92	93	0	0	0	0.0052	0	0	0.0052
19-Jun-92	93	0	0	0	0	0	0	0
22-Jun-92	93	0	0	0	0	0	0	0
23-Jun-92	93	0	0	0	0	0	0	0
25-Jun-92	93	0	0	0	0	0	0	0
26-Jun-92	93	0	0	0	0	0	0	0
29-Jun-92	93	0	0	0	0	0	0	0
01-Jul-92	93	0	0	0	0	0	0	0
03-Jul-92	93	0	0	0	0	0	0	0
13-Jul-92	93	0	0	0	0	0	0	0
14-Jul-92	93	0	0	0	0	0	0	0
15-Jul-92	93	0	0	0	0	0	0	0
TOTALS		0	0.0281	0.0616	0.066	0.0069	0	0.1626

Appendix D

ESTIMATED ENTRAINMENT OF EGGS AND LARVAE AND WATER VOLUME DIVERTED, BY DIVERSION SITE

Delta Agricultural Diversion Evaluation
1992 Pilot Study

Appendix D. ESTIMATED EGG AND LARVAL ENTRAINMENT LOSSES AND DIVERSIONS BY DIVERSION SITE FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 2 - BACON ISLAND

ENTRAINMENT (Number of Fish)

DATE	MISC EGGS	LARVAE: ASHAD	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRARC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS	* DIVERSION PERIOD (Ac-Ft)
20-Apr-92	0	0	0	0	1310	0	1309.9	0	0	0	0	1310	0	0	0	0	5239.8	50.38
22-Apr-92	0	0	0	0	3275	0	3274.9	0	0	0	0	3275	0	0	0	0	13099	125.95
27-Apr-92	0	0	0	0	1613	0	0	0	0	0	0	322.5	0	0	0	322.52	967.56	25.19
28-Apr-92	0	0	0	0	3696	1848	0	0	0	0	0	1848	0	0	0	0	0	50.38
30-Apr-92	0	0	0	0	0	0	0	0	0	0	0	2583	0	0	0	0	0	100.76
04-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46.41
06-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.43
07-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.43
08-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64.82
11-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9151.7	22.93
12-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.51
13-May-92	0	0	35704	0	0	35704	0	0	0	0	0	35704	0	0	0	35704	35704	268.68
18-May-92	0	0	14009	0	0	0	0	0	0	0	0	14009	0	0	0	28019	112074	202.04
22-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8271.1	8271.1	117.94
26-May-92	0	0	29414	0	0	0	0	0	0	0	0	0	0	0	0	12444	0	30.59
27-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1653.4	3306.7	30.73
28-May-92	0	0	9094.5	0	0	0	0	0	0	0	0	0	0	0	0	13642	0	126.59
01-Jun-92	0	0	2072.4	0	0	0	0	0	0	0	0	0	0	0	0	33159	2072.4	64.10
03-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36024	4503	63.43
05-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25372	0	126.60
09-Jun-92	0	0	3097.2	0	0	0	0	0	0	0	0	0	0	0	0	0	3097.2	65.63
11-Jun-92	0	0	4396.7	0	0	0	0	0	0	0	0	0	0	0	0	5024.8	0	25.04
12-Jun-92	0	0	18446	0	0	0	0	0	0	0	0	0	0	0	0	26352	0	94.43
15-Jun-92	0	0	2602.2	0	0	0	0	0	0	0	0	0	0	0	0	24721	0	57.55
17-Jun-92	0	0	1668.1	0	0	0	0	0	0	0	0	0	0	0	0	66724	0	43.05
19-Jun-92	0	0	2058.4	0	0	0	0	0	0	0	0	0	0	0	0	26760	0	55.43
22-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5077.6	0	17.06
23-Jun-92	0	0	25808	0	0	0	0	0	0	0	0	0	0	0	0	6452	0	17.49
24-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.14
25-Jun-92	0	0	58069	0	0	0	0	0	0	0	0	0	0	0	0	6452.1	0	63.23
29-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1784.7	0	10.21
01-Jul-92	0	0	3186.7	0	0	0	0	0	0	0	0	0	0	0	0	9560.2	0	13.68
03-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69912	0	22.12
06-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75466	0	9.68
07-Jul-92	0	0	11216	0	0	0	0	0	0	0	0	0	0	0	0	33648	0	13.14
09-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.51
10-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15.06
13-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26.81
15-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4138.9	0	30.94
17-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47.01
20-Jul-92	0	0	24495	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.74
21-Jul-92	0	524.4	917.62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.59
22-Jul-92	0	0	0	0	0	0	5253.6	0	0	0	0	0	0	0	0	0	0	10.49
23-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50.03
28-Jul-92	0	0	0	0	0	0	35303	0	0	0	0	0	0	0	0	35303	0	16.00
30-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36228	0	27.03
05-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.50
06-Aug-92	0	0	374686	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62.48
11-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.99
13-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62.48
18-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.50
19-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.50
20-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65.85
24-Aug-92	0	0	205.76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19.83
25-Aug-92	0	0	1138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19.76
26-Aug-92	0	0	467.75	0	0	0	0	0	0	0	0	0	0	0	0	267.29	0	12.62
27-Aug-92	0	0	972.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59.50
01-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10.91
02-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10.91
03-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54.55
08-Sep-92	0	0	72553	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65.45
14-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10.91
15-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3066.6	0	10.91
16-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4058.8	0	12.74
17-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50.95
21-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.26
22-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11.13
23-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.71
24-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.09
TOTALS	0	524.4	696278	0	9893	37552	45141	0	0	0	0	59052	0	0	0	635606	197487	3012.51

* Diversions for period of estimated entrainment, estimated 0 losses 9-25-92 to 10-24-92. SEASON TOTAL = 3133.05 AF

Appendix D. (Cont.) *ESTIMATED EGG AND LARVAL ENTRAINMENT LOSSES AND DIVERSIONS BY DIVERSION SITE FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.*

SITE 3 - MCDONALD ISLAND (Unscreened)

ENTRAINMENT (Number of Fish)

DATE	LARVAE: MISC EGGS	ASHAD	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRARC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS	* DIVERSION PERIOD (Ac-Ft)
14-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01
18-May-92	0	0	191.95	0	0	0	0	0	0	0	0	0	0	0	0	779.81	0	0.18
22-May-92	8.338	0	16.676	0	0	0	0	0	0	0	0	0	0	0	0	25.014	0	0.11
26-May-92	0	0	936.89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13
27-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.579	0	0.18
28-May-92	0	0	319.83	0	0	0	0	0	0	0	0	0	0	0	0	31.983	0	0.15
01-Jun-92	0	0	813.81	0	0	0	6.3086	0	0	0	0	0	0	0	0	0	0	0.16
03-Jun-92	0	0	249.78	0	0	0	0	0	0	0	0	0	0	0	0	10.86	0	0.25
05-Jun-92	0	0	1088.5	0	0	0	0	0	0	0	0	0	0	0	0	698	0	0.13
09-Jun-92	0	0	322.84	0	0	0	0	0	0	0	0	0	0	0	0	22.655	0	0.16
11-Jun-92	0	0	603.91	0	0	0	0	0	0	5.25	0	0	0	0	0	309.83	0	0.26
12-Jun-92	4.558	0	920.82	0	0	0	4.5585	0	0	0	0	0	0	0	0	50.143	0	0.24
15-Jun-92	2.863	0	51.537	0	0	0	2.8631	0	0	5.73	0	0	0	0	0	2287.7	0	0.15
17-Jun-92	0	0	163.87	0	0	0	0	0	0	0	0	0	0	0	0	16.807	0	0.21
19-Jun-92	0	0	51.847	0	0	0	0	0	0	0	0	0	0	0	0	20.739	0	0.27
22-Jun-92	0	0	400.74	0	0	0	0	0	0	0	0	0	0	0	0	444.45	0	0.32
23-Jun-92	4.421	0	389.02	0	0	0	0	0	0	0	0	0	0	0	0	22.103	0	0.17
24-Jun-92	0	0	213.21	0	0	0	0	0	0	0	0	0	0	0	0	55.621	0	0.37
25-Jun-92	0	0	673.17	0	0	0	13.928	0	0	0	0	0	0	0	0	37.14	0	0.18
29-Jun-92	0	0	90.991	0	0	0	0	0	0	0	0	0	0	0	0	6.9993	0	0.23
30-Jun-92	0	0	72.793	0	0	0	0	0	0	0	0	0	0	0	0	5.5994	0	0.18
01-Jul-92	0	0	134.17	0	0	0	0	0	0	0	0	0	0	0	0	19.168	0	0.22
03-Jul-92	0	0	703.68	0	0	0	0	0	0	0	0	0	0	0	0	281.47	0	0.25
06-Jul-92	0	0	290.52	0	0	0	0	0	0	0	0	0	0	0	0	581.04	0	0.42
07-Jul-92	0	0	21.017	0	0	0	0	0	0	0	0	0	0	0	0	42.035	0	0.57
08-Jul-92	0	0	9.1565	0	0	0	9.1565	0	0	0	0	0	0	0	0	0	0	0.25
09-Jul-92	0	0	781.18	0	0	0	0	0	0	0	0	0	0	0	0	130.2	0	0.24
05-Aug-92	0	0	15.191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14
06-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.18
19-Aug-92	0	0	47.434	0	0	0	2.7903	0	0	0	0	0	0	0	0	0	0	0.23
TOTALS	20.18	0	9574.5	0	0	0	39.605	0	0	11	0	0	0	0	0	5893.9	0	6.52

* Diversions for period of estimated entrainment, diversions ended for season on 8-19-92.

Appendix D. (Cont.) ESTIMATED EGG AND LARVAL ENTRAINMENT LOSSES AND DIVERSIONS BY DIVERSION SITE FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 3 - MCDONALD ISLAND (Screened)

ENTRAINMENT (Number of Fish)

DATE	MISC EGGS	LARVAE: ASHAD	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRARC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT-TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS	* DIVERSION PERIOD (Ac-Ft)
06-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.40
18-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.23
22-May-92	17.01	0	17.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.22
26-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.16
27-May-92	0	0	71.839	0	0	0	0	0	0	0	0	0	0	0	0	6.5308	0	0.10
28-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20
01-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.24
03-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14
05-Jun-92	0	0	47.885	0	0	0	0	0	0	0	0	0	0	0	0	1687.9	0	0.24
09-Jun-92	0	0	0.6427	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03
09-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35
11-Jun-92	13.23	0	4.4109	0	0	0	0	0	0	0	0	0	0	0	0	26.466	0	0.19
12-Jun-92	0	0	3.5791	0	0	0	0	0	0	0	0	0	0	0	0	14.317	0	0.16
15-Jun-92	3.862	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20
17-Jun-92	0	0	6.8137	0	0	0	0	0	0	0	0	0	0	0	0	13.627	0	0.14
19-Jun-92	0	0	13.208	0	0	0	0	0	0	0	0	0	0	0	0	26.415	0	0.14
22-Jun-92	0	0	9.8551	0	0	0	0	0	0	0	0	0	0	0	0	157.68	0	0.19
23-Jun-92	38.91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.5585	0	0.27
24-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10
25-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.882	0	0.29
29-Jun-92	0	0	3.1285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10
30-Jun-92	0	0	5.783	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.19
01-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.21
03-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.8258	0	0.25
06-Jul-92	0	0	15.956	0	0	0	0	0	0	0	0	0	0	0	0	558.47	0	0.36
07-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	110.57	0	0.29
08-Jul-92	20.46	0	51.145	0	0	0	0	0	0	0	0	0	0	0	0	20.458	0	0.33
08-Jul-92	525.8	0	1314.5	0	0	0	0	0	0	0	0	0	0	0	0	525.79	0	8.44
09-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30.81
09-Jul-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
05-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.21
05-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.32
06-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.10
06-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	112.77
19-Aug-92	0	0	6.7111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.49
TOTALS	619.3	0	1572.4	0	0	0	0	0	0	0	0	0	0	0	0	3178.5	0	195.10

* Diversions for period of estimated entrainment, diversions ended for season on 8-19-92. SEASON TOTAL = 195.10 AF

Appendix D. (Cont.) ESTIMATED EGG AND LARVAL ENTRAINMENT LOSSES AND DIVERSIONS BY DIVERSION SITE FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 4 - NAGLEE BURK

ENTRAINMENT (Number of Fish)

DATE	MISC EGGS	LARVAE: ASHAD	TFSHAD	DELTA SMELT	PRICKLY SCULPIN	CY-PRIN	CEN-TRARC	YF GOBY	ISS	MISC	LONGFIN SMELT	LOG-PERCH	CAT-FISH	SPLIT TAIL	SAC SUCKER	CHAM GOBY	STRIPED BASS	* DIVERSION PERIOD (Ac-Ft)
05-May-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34.17
06-May-92	0	0	203863	0	0	0	0	0	0	0	0	11992	0	0	0	59960	0	34.17
07-May-92	0	0	10192	0	0	0	0	0	0	0	0	0	0	0	0	3057.6	0	34.17
08-May-92	0	0	165470	0	0	0	10676	0	0	0	0	0	0	0	0	48040	0	102.50
11-May-92	0	0	85203	0	0	0	0	0	0	0	0	0	0	0	0	9211.1	0	34.17
18-May-92	0	0	22171	0	0	0	14780	0	0	0	0	0	0	0	0	1847.5	0	136.66
08-Jun-92	0	0	22171	0	0	0	14780	0	0	0	0	0	0	0	0	1847.5	0	34.17
09-Jun-92	0	0	14334	0	0	0	1124.3	0	0	0	0	0	0	0	0	8994	0	34.17
10-Jun-92	0	0	165895	0	0	27649	0	0	0	0	0	0	0	0	0	55298	0	34.17
11-Jun-92	0	0	20252	0	0	0	0	0	0	0	0	0	0	0	0	94510	0	34.17
12-Jun-92	0	0	155339	0	0	0	7486.2	0	0	0	0	0	0	0	0	5614.7	0	102.50
15-Jun-92	0	0	988.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68.33
17-Jun-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3976.4	0	68.33
19-Jun-92	0	0	4084.7	0	0	0	0	0	0	0	0	0	0	0	0	16339	0	34.17
06-Jul-92	0	0	2042.3	0	0	0	0	0	0	0	0	0	0	0	0	8169.3	0	34.17
07-Jul-92	2965	0	14827	0	0	0	0	0	0	0	0	0	0	0	0	8896	0	68.33
09-Jul-92	24288	0	0	0	0	0	0	0	0	0	0	0	0	0	24288	0	0	34.17
10-Jul-92	0	0	2057.3	0	0	0	0	0	0	0	0	0	0	0	0	2057.3	0	102.50
13-Jul-92	0	0	0	0	0	0	3943.6	0	0	0	0	0	0	0	0	31548	0	34.17
05-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25680	0	34.17
06-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	136.66
15-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68.33
17-Aug-92	0	0	28995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34.17
19-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34.17
20-Aug-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125.09
08-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128.54
10-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.75
14-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.27
15-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	61.32
17-Sep-92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66.06
TOTALS	27253	0	917885	0	0	27649	52790	0	0	0	0	11992	0	0	24288	385046	0	1804.64

* Diversions for period of estimated entrainment, estimated 0 losses 9-18-92 to 10-2-92. SEASON TOTAL = 1979.08 AF

Appendix E

ESTIMATED ENTRAINMENT OF JUVENILE AND OLDER FISH AND WATER VOLUME DIVERTED, BY DIVERSION SITE

Delta Agricultural Diversion Evaluation
1992 Pilot Study

Appendix E. ESTIMATED ENTRAINMENT LOSSES AND DIVERSIONS FOR JUVENILE AND OLDER FISH BY DIVERSION SITE FOR THE 1992 PILOT STUDY OF THE DELTA AGRICULTURAL DIVERSION EVALUATION, APRIL-OCTOBER 1992.

SITE 2 - BACON ISLAND

BAG NET SAMPLING

DATE	START TIME	SAMPLE LENGTH (Minutes)	CATCH (# Fish)
24-Sep-92	1106	30	0
24-Sep-92	1136	46	0
24-Sep-92	1222	54	0
28-Sep-92	1415	30	0
28-Sep-92	1450	30	0
29-Sep-92	1705	30	0
29-Sep-92	1740	30	0
29-Sep-92	1815	30	0
29-Sep-92	1850	30	0
29-Sep-92	1925	30	0
29-Sep-92	2000	60	0
30-Sep-92	1425	30	0
30-Sep-92	1500	30	0
01-Oct-92	930	90	0
01-Oct-92	1100	23	0
01-Oct-92	1124	47	0
01-Oct-92	1216	45	0
02-Oct-92	913	45	0
02-Oct-92	958	52	0
02-Oct-92	1100	47	0
02-Oct-92	1149	84	0
02-Oct-92	1235	34	0
05-Oct-92	1220	30	0
05-Oct-92	1250	30	0
05-Oct-92	1320	45	0
05-Oct-92	1405	30	0
05-Oct-92	1435	45	0
05-Oct-92	1520	40	0
06-Oct-92	1750	30	0
06-Oct-92	1825	45	0
06-Oct-92	1910	45	0
06-Oct-92	1955	770	0
15-Oct-92	1348	30	0
15-Oct-92	1418	30	0
15-Oct-92	1448	30	0
15-Oct-92	1518	30	0
15-Oct-92	1548	30	0
15-Oct-92	1618	60	0
15-Oct-92	1718	60	0
15-Oct-92	1818	930	0
16-Oct-92	948	60	0
16-Oct-92	1050	60	0
16-Oct-92	1150	60	0
16-Oct-92	1250	60	0
19-Oct-92	1215	30	0
19-Oct-92	1245	30	0
19-Oct-92	1315	30	0
19-Oct-92	1345	30	0
19-Oct-92	1415	30	0
20-Oct-92	1330	60	0
20-Oct-92	1430	60	0
20-Oct-92	1530	45	0
21-Oct-92	1145	60	0
21-Oct-92	1245	60	0
21-Oct-92	1345	60	0
21-Oct-92	1445	60	0
21-Oct-92	1545	15	0
22-Oct-92	1215	60	0
22-Oct-92	1315	60	0
22-Oct-92	1415	60	0
22-Oct-92	1515	20	0
23-Oct-92	1215	60	0
23-Oct-92	1315	60	0
23-Oct-92	1415	60	0
23-Oct-92	1515	60	0
	TOTAL		0

SITE 4 - NAGLEE BURK

JUVENILE CATCH (Number of Fish)

DATE	THREADFIN SHAD	BLUEGILL	MOSQUITO-FISH	WHITE CATFISH	CHAMELEON GOBY
05-Aug-92	0	0	0	0	0
06-Aug-92	0	0	0	0	0
15-Aug-92 *	0	0	0	0	1
17-Aug-92	0	0	0	0	1
19-Aug-92	0	0	0	0	0
20-Aug-92	0	0	0	0	0
08-Sep-92	2	0	0	0	0
10-Sep-92	0	0	0	1	0
14-Sep-92	0	0	0	0	0
15-Sep-92	0	0	0	1	2
17-Sep-92	1	0	0	0	0
28-Sep-92	0	5	0	0	0
29-Sep-92	0	2	0	0	0
30-Sep-92	0	0	0	0	1
01-Oct-92	0	0	2	1	3
02-Oct-92	0	0	0	0	2
TOTALS	3	7	2	2	9

* No sample, catch estimated in order to calculate entrainment.

SITE 4 - NAGLEE BURK

JUVENILE ENTRAINMENT (Number of Fish)

DATE	THREADFIN SHAD	BLUEGILL	MOSQUITO-FISH	WHITE CATFISH	CHAMELEON GOBY	* DIVERSION PERIOD (Ac-Ft)
05-Aug-92	0	0	0	0	0	34.17
06-Aug-92	0	0	0	0	0	136.66
15-Aug-92	0	0	0	0	96	68.33
17-Aug-92	0	0	0	0	48	34.17
19-Aug-92	0	0	0	0	0	34.17
20-Aug-92	0	0	0	0	0	125.09
08-Sep-92	64	0	0	0	0	128.54
10-Sep-92	0	0	0	69	0	29.75
14-Sep-92	0	0	0	0	0	27.27
15-Sep-92	0	0	0	77	155	61.32
17-Sep-92	63	0	0	0	0	66.06
28-Sep-92	0	289	0	0	0	38.25
29-Sep-92	0	52	0	0	0	17.06
30-Sep-92	0	0	0	0	51	40.16
01-Oct-92	0	0	72	36	109	39.89
02-Oct-92	0	0	0	0	96	39.07
TOTALS	127	341	72	182	555	919.95

SEASON TOTAL = 1979.08 AF

* Diversions for period of estimated entrainment.

COMMON ABBREVIATIONS AND METRIC CONVERSIONS

Area

km^2	square kilometers; to convert to square miles, multiply by 0.3861
m^2	square meters; to convert to square feet, multiply by 10.764

Length

cm	centimeters; to convert to inches, multiply by 0.3937
FL	fork length; length from the most anterior part of a fish to the median caudal fin rays (fork in the tail)
km	kilometers; to convert to miles, multiply by 0.62139
m	meters; to convert to feet, multiply by 3.2808
mm	millimeters; to convert to inches, multiply by 0.03937
SL	standard length; tip of upper jaw of a fish to crease formed when tail is bent sharply upward
TL	total length; length from the most anterior part of a fish to the end of the tail

Volume

AF	acre-foot; equal to 43,560 cubic feet
L	liters; to convert to quarts, multiply by 1.05668; to convert to gallons, multiply by 0.26417
mL	milliliters

Flow

cfs	cubic feet per second; to convert to acre-feet per day, multiply by 1.98
gpm	gallons per minute
mgd	million gallons per day

Velocity

fps	feet per second
m/s	meters per second; to convert to feet per second, multiply by 3.2808

Mass

kg	kilograms; to convert to pounds, multiply by 2.2046

Concentration

mg/L	milligrams per liter; equals parts per million (ppm)
µg/L	micrograms per liter; equals parts per billion (ppb)

Specific Conductance

µS	microsiemens; equivalent to micromhos
µS/cm	microsiemens per centimeter

Temperature

°C	degrees Celsius; to convert to °F, multiply by 1.8 then add 32
°F	degrees Fahrenheit; to convert to °C, subtract 32 degrees then divide by 1.8

Mathematics and Statistics

df	degrees of freedom
e	base of natural logarithm
E	expected value
log	logarithm
N	sample size
NS	not significant
%	percent
‰	per thousand
P	probability
r	correlation or regression coefficient (simple)
R	correlation or regression coefficient (multiple)
SD	standard deviation
SE	standard error
V	variance

General

CPUE	catch per unit effort
eg	for example *(exempli gratia)*
et al	and others *(et alii)*
etc	and so on *(et cetera)*
ie	that is *(id est)*

Interagency Program Members

COE	U.S. Army Corps of Engineers
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
EPA	U.S. Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service
SWRCB	California State Water Resources Control Board
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey

SCIENTIFIC NAMES OF FISH

American eel	*Anguilla rostrata*
American shad	*Alosa sapidissima*
bay goby	*Lepidogobius lepidus*
bigscale logperch	*Percina macrolepida*
black bullhead	*Ameiurus melas*
black crappie	*Pomoxis nigromaculatus*
blue catfish	*Ictalurus furcatus*
bluegill	*Lepomis macrochirus*
brown bullhead	*Ameiurus nebulosus*
brown trout	*Salmo trutta*
California halibut	*Paralichthys californicus*
California roach	*Hesperoleucus symmertricus*
chameleon goby	*Tridentiger trigonocephalus*
channel catfish	*Ictalurus punctatus*
Chinook salmon	*Oncorhynchus tshawytscha*
common carp	*Cyprinus carpio*
delta smelt	*Hypomesus transpacificus*
English sole	*Pleuronectes vetulus*
fathead minnow	*Pimephales promelas*
golden shiner	*Notemigonus crysoleucas*
goldfish	*Carassius auratus*
green sturgeon	*Acipenser medirostris*
green sunfish	*Lepomis cyanellus*
hardhead	*Mylopharodon conocephalus*
hitch	*Lavinia exilicauda*
inland silverside	*Menidia beryllina*
jacksmelt	*Atherinopsis californiensis*
largemouth bass	*Micropterus salmoides*
longfin smelt	*Spirinchus thaleichthys*
mosquitofish	*Gambusia affinis*
northern anchovy	*Engraulis mordax*
Pacific herring	*Clupea pallasii*
Pacific lamprey	*Lampetra tridentata*
pink salmon	*Oncorhynchus gorbuscha*
plainfin midshipman	*Porichthys notatus*
prickly sculpin	*Cottus asper*
pumpkin seed	*Lepomis gibbosus*
rainwater killifish	*Lucania parva*
redear sunfish	*Lepomis microlophus*
red shiner	*Cyprinella lutrensis*
riffle sculpin	*Cottus gulosus*
river lamprey	*Lampetra ayresii*
Sacramento blackfish	*Orthodon microlepidotus*
Sacramento perch	*Archoplites interruptus*
Sacramento splittail	*Pogonichthys macrolepidotus*
Sacramento squawfish	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentalis*
shiner surfperch	*Cymatogaster aggregata*
silver salmon	*Oncorhynchus kisutch*
smallmouth bass	*Micropterus dolomieu*
speckled dace	*Rhinichthys osculus*
speckled sanddab	*Citharichthys stigmaeus*
splittail	*Pogonichthys macrolepidotus*
staghorn sculpin	*Leptocottus armatus*
starry flounder	*Platichthys stellatus*
steelhead trout	*Oncorhynchus mykiss*
striped bass	*Morone saxatilis*
striped mullet	*Mugil cephalus*
surf smelt	*Hypomesus pretiosus*
threadfin shad	*Dorosoma petenense*
threespine stickleback	*Gasterosteus aculaetus*
tui chub	*Gila bicolor*
tule perch	*Hysterocarpus traski*
wakasagi	*Hypomesus nipponensis*
warmouth	*Lepomis gulosus*
white catfish	*Ameiurus catus*
white crappie	*Pomoxis annularis*
white croaker	*Genyonemus lineatus*
white sturgeon	*Acipenser transmontanus*
yellow bullhead	*Ameiurus natalis*
yellow perch	*Perca flavescens*
yellowfin goby	*Acanthogobius flavimanus*

Delta Agricultural Diversion Evaluation Summary Report, 1993 - 1995

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Interagency Ecological Program
for the
San Francisco Bay/Delta Estuary

A Cooperative Program of:

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State Water Resources Control Board
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers
California Department of Fish and Game
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency
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Introduction

Approximately 2,200 agricultural diversions with maximum flow rates of up to 250 cubic feet per second (cfs) occur within the Sacramento-San Joaquin Delta (Raquel pers. comm.). Diversions are active mostly during the agricultural season, generally occurring from late March or early April through September when water is needed for spring and summer crops (Brown 1982).

The length of the season, however, varies from year to year depending on rainfall and crop type. Diversions may also occur at other times of the year. For example, during fall and early winter, water may be diverted to leach salts from soils, break down post-harvest corn stubble, and flood land to attract waterfowl. During winter, water may also be diverted for winter wheat, and in drought years, for perennial crops including orchards and vineyards.

During the agricultural season, in-delta diversions may collectively transfer water at an estimated mean monthly rate of 2,000 to 5,000 cfs from delta channels (Brown 1982). These diversions are located in some sections of rivers and waterways used by migratory and resident fish, including endangered and threatened species such as winter-run chinook salmon (*Oncorhynchus tshawytscha*) and delta smelt (*Hypomesus transpacificus*).

Major crop irrigation coincides with the season when most fish are migrating and/or reproducing, and, therefore, when large numbers of larval, juvenile and adult fish are present in delta channels. Most agricultural diversions are not screened and losses due to entrainment may be a significant cause of the decline in abundance of some Delta fish. Potential factors influencing the rate and magnitude of fish entrainment in agricultural diversions are presented in Table 1.

Most small diversion intakes are situated two to three feet above the river bottom (Allen 1975). Species and/or life stages of species that tend to orient themselves near the bottom of the channel are potentially more susceptible to entrainment in these diversions than midwater or surface-oriented species. However, benthic species (e.g., sculpins (Cottidae) and gobies (Gobiidae) may not be highly susceptible to entrainment if they use the boundary layer as a velocity refuge or can hold on to the substrate with specialized body parts (Urquhart pers. comm.).

In other species, where vertical distribution may vary both temporally and spatially, susceptibility to entrainment may also vary. Young salmon in the Sacramento River system, for example, may occur near the surface (Hatton 1940; Hallock and Van Woert 1959; Sasaki 1966) but have been reported to migrate at greater depths as the season progresses and as they move down the estuary (Gritz and Stevens 1971). Within the delta, the distribution of young salmon in the water column may also vary at night (Wickwire and Stevens 1971).

Concerns about agricultural diversion impacts to delta fish populations prompted fish screening requirements under three sections of the California Department of Fish and Game (DFG) Code Division 6, Part 1, Chapter 3, Articles 3, 4 and 5 comprised of DFG Code Section 5930 B 6100. Covered in the code are requirements for diversions over 250 cfs (Section 5980), diversions under 250 cfs (Section 6020) and diversions installed after January 1, 1972 (Section 6100).

In 1992, the Interagency Ecological Program for the Sacramento-San Joaquin Estuary (IEP) initiated The Delta Agricultural Diversion Evaluation to investigate the effects of in-delta diversions on resident and anadromous fish. Portions of the evaluation were required under the U.S. Army Corps of Engineers permit (No. 199101051, effective March 30, 1992) for the Southern Delta Temporary Barriers

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Project and the Delta Smelt Study Plan (Sweetnam and Stevens 1991). Overall, the study goal was to obtain information about fish entrainment in delta agricultural diversions that could assist in the evaluation of projects designed to reduce entrainment.

Such projects could include plans to consolidate and/or screen agricultural diversions or to modify water use patterns of in-delta agricultural diversions. Study objectives were: (1) to develop reliable means of estimating fish entrainment; (2) to evaluate entrainment losses of resident and migratory fish species at several agricultural diversion sites; and (3) to determine the susceptibility of fish species to entrainment relative to their abundance and life stages in adjacent delta channels.

A pilot study for the Delta Agricultural Diversion Evaluation was conducted by the California Department of Water Resources (DWR) in 1992 (Spaar 1994). This report presents the results obtained from the program during the years 1993, 1994 and 1995.

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Methods

Description of Diversion Sites

Sampling focused on the collection of eggs, larvae, juvenile and adult fish. The number of diversions sampled varied across years. Five sites (1, 2, 2B, 4, and 10) in the south and west delta were sampled in 1993 (Figure 1). Four of those (Sites 1, 2, 4 and 10) were sampled in 1994 and three (Sites 1, 2, and 4) in 1995. Sites were numbered sequentially from 1 through 4.

Site 10 was numbered arbitrarily so as to leave site numbers available for possible additional study locations in the south delta. Site 2B was originally an alternate site for Site 2. Site 3 was included in the pilot study of 1992 (Spaar 1994) but was then dropped from the program.

Site 1 was located in the west delta on Twitchell Island (Reclamation District 1601). The diversion consisted of a 16-inch siphon that draws water from the San Joaquin River. The diversion is not normally active during the irrigation season, but was operated intermittently for purposes of this study, except in 1994, when the farmer used some of the diverted water to irrigate about 350 acres of corn for a few days (Beck pers. comm.). A propeller flowmeter (Ketema McCrometer model M0300) with flow indicator (in cfs) and totalizer (in acre-feet (af)) was installed on the siphon in 1993 to record velocity and sample volume measurements. The maximum flow capacity from this diversion was approximately 22 cfs but actual flows were typically less than this, varying over time.

Sites 2 and 2B were located in the south delta on the eastern side of Bacon Island (Reclamation District 2028). During the study, these two siphons diverted water from the Middle River into a ditch to irrigate about 350 to 380 acres of potatoes, as well as several acres of corn and sunflower (Campbell pers. comm.).

From April through October, a 16-inch siphon (Site 2) diverted water continuously 24 hours a day. A 14-inch siphon (Site 2B) diverted additional water when needed or when the larger siphon needed repairs. Diversions, therefore, were not continuous at this site. Maximum flow capacity for the 16- and 14-inch siphons was approximately 22 and 17 cfs, respectively, though actual flows were variable and typically lower. Propeller flowmeters (Ketema McCrometer model M0300) were installed in both siphons on May 4, 1992.

Site 4 was located in the south delta, within the Naglee Burk Irrigation District, south of Fabian Tract on Old River. A 30 horsepower pump diverted water from Old River through a 20-inch intake pipe at up to 20 cfs into a concrete distribution box. The box distributed water to the south or east to alfalfa and corn fields. During this study, water was diverted intermittently from May through August; however, the pump was frequently shut down for periods of several days. A flowmeter (Ketema McCrometer model M0300) was installed on the discharge line on September 4, 1992.

Site 10 was located in the east delta on Bouldin Island (Reclamation District 756). The two 24-inch siphons diverted water intermittently off the South Fork of the Mokelumne River to corn and wheat fields. During sampling from June through August 1993, a flowmeter (Marsh-McBirney, Inc. model 2000) was placed directly in the water flow at the mouth of the sampling net.

This site was intended primarily as a sampling site for concurrent efforts by DFG—also to evaluate diversion impacts on delta fish. It was sampled a total of 6 days in the latter portion of the season by DWR and DFG personnel. Because the sample size is small and temporal compari-

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sons could not be made with other sites, data from Site 10 is presented separately in Appendix A. More substantial data from this site (and others) is reported elsewhere (DeLeón 1994; Griffin 1993).

Description of Channel Sites

Three delta channel sites, located in the vicinity of diversion Sites 1, 2, and 4, were also sampled. The sites were coded after DFG Egg and Larval Survey sampling stations. They included Site 49 located on the San Joaquin River at Oulton point adjacent to the Twitchell Island diversion (Site 1), Site 932 on Middle River near the Bacon Island diversions (Sites 2 and 2B), and Site 93 on Old River near the Naglee Burk diversion (Site 4) (Figure 1).

Categorization of Fish by Length

A length criterion was developed to compare entrainment susceptibility between fish. Delta smelt, one of the primary species of special concern for this study, was used as a model to distinguish fish able to pass through a certain net mesh size from those unable to. By 30 mm TL delta smelt are in juvenile stages (ie. when young take on the appearance of the adult) (Wang 1986)). Thirty mm Delta smelt are retained by a 3 mm mesh net (Young and Cech 1994).

From these observations it was determined, for purposes of this study, that fish measuring 30 mm TL and above would be classified as later-life stage fish and those under 30 mm TL would be classified as early-life stage fish. Note, however, that because different species exhibit substantial size variability and morphology at different life stages, not all life stages of some species can accurately be classified under the conditions of these length criteria.

Diversion Sampling for Early-life Stage Fish using an Egg and Larval Net

A 2.4 m egg and larval net made of 505 micron nylon mesh with a 0.3 m2 opening was used to collect early-life stage fish. At all diversion sites, the net was mounted on a plastic pipe frame and staked in the ditch a few feet downstream of the area of turbulent flow. Therefore, only a portion of the total volume of water diverted was sampled. It was assumed that early-life stage fish were uniformly distributed in the water column. A flowmeter (General Oceanics model 2030) was mounted in the mouth of the net to estimate the volume of water sampled in cubic meters. These measurements were later converted to acre-feet.

Water temperature (in degrees Fahrenheit) and electrical conductivity (in microSiemens per cm) were recorded with each sample. Fish were collected in a 0.95 liter collecting jar, screened with 470 micron wire mesh attached to the cod end of the net. Sampling periods were approximately five to ten minutes depending on debris load. Total sampling effort varied across sites and years (Table 2). After collection, the samples were transferred to 0.95 liter storage jars.

A solution of 5 percent formalin was used to preserve the specimens for later identification by an independent contract laboratory. Rose bengal dye was added to increase specimen visibility. Eggs and larvae were counted and identified to species. Striped bass eggs were recorded as dead, in morula, or in early- or late-embryonic stages. Larval fish were identified to species, though in some cases, they were only identified to genus or family. Larvae were measured to the nearest tenth of a millimeter total length (TL). Delta smelt and striped bass measurements were also recorded in standard length (SL).

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Sampling days were planned for approximately two days per week but varied substantially over time, infrequently approximating this schedule except during several periods at Site 2. At all sites, but particularly at Sites 1 and 4, total sampling effort was frequently less than one 10-minute sample per week. All diversion sites were sampled for eggs and early- and later-life stage fish in 1993.

Sampling effort across years varied substantially and was comparable only at Site 2. Sampling at Site 1 for eggs and early-life stage fish was limited in 1993 and 1994 due to persistent silt loading within the diversion causing destruction of eggs and early-life stage fish. For this reason sampling was discontinued after May 12, 1994. Sampling at Site 2B did not occur in 1994 or 1995 because that siphon was not operated in those years. Sampling for early-life stage fish was not conducted at Site 4 in 1994 or 1995.

Diversion Sampling using a Fyke Net

A 7-m fyke net made of 3.2 mm nylon mesh was used to collect later-life stage fish at Sites 1 and 2. This net also collected many early-life stage fish. Sampling frequency varied from one to two days per week to once per month. A wooden live box was attached to the end of the net. The mouth of the fyke net was attached as close to the mouth of the diversion as possible in an effort to sample 100 percent of the outfall. At Site 2, 100 percent of the outfall was passed through the fyke net.

At Site 1, it was not possible to capture the entire outfall due to the architecture of the diversion. Furthermore, the live boxes at both Sites 1 and 2 were too heavy to lift when full. Therefore, prior to lifting them, some of the water was drained out and during this time fish may have escaped. For these reasons, the actual proportion of the fish captured is unknown.

At Site 4 the 7-m net could not be used due to the unique size and shape of the outfall. Instead, a 4.9-m fyke net was used. This net was made of 3.2 mm mesh with 2.7 m flanked wings and a nylon 3.2 mm (one-eighth inch) mesh live box at its end. The net was positioned as close as possible to the mouth of the outfall to sample most of the flow. Sandbags also were placed along the bottom edges of its frame and wings to discourage fish from escaping from the net. The distance of the net from the mouth of the outflow varied and was never adequate to capture 100 percent of the outfall. The proportion of outfall sampled, therefore, is unknown.

The fyke nets were generally deployed for three to six hours during each sampling period. Occasionally, longer sampling periods were conducted (up to 24 hours) to provide data for comparing day and night catches. Fish were collected from the live boxes every one to two hours, transferred to 0.95 liter storage jars or 20 milliliter vials depending on the size of the fish, and preserved in 5 percent formalin.

Despite variations across sites, the sampling effort using the fyke net was substantially greater than the effort for sampling early-life stage fish in the diversions using the egg and larval net (Tables 2 and 3).

Simultaneous Channel and Diversion Sampling

On seven days in 1994, sampling was simultaneously conducted in the channels and at two nearby diversion sites. Sampling for early-life stage fish was conducted using an egg and larval net in both the channels and diversions. Sampling for later-life stage fish was conducted using a fyke net in the diversions and either a townet or a midwater trawl in the channels.

The townet consisted of a 4 m net made of 1.3 cm stretch nylon mesh. The midwater trawl was made of nine 1.5 m sections, which graduated in mesh size from 20.3 cm at its mouth to 1.3 cm at its

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cod end. The net measured 18 m with a 3.7 m2 mouth opening. Early-life stage fish were simultaneously sampled at Sites 2 and 932 on May 5, 1994. Later-life stage fish were simultaneously sampled at Sites 2 and 932 on July 7, 1994 and at Sites 1 and 49 on July 11, September 29,October 5 and October 17, 1994. No simultaneous sampling for early-life stage fish was conducted at Site 1 due to silt loads in the diversion. No simultaneous sampling of either early- or later-life stage fish was conducted at Site 4 due to placement of a temporary barrier within the channel that prevented boat access to the channel site.

Townet gear was used in the channel at Site 49 on July 11, 1994 and at Site 932 on July 7, 1994. Midwater trawl gear was used at Site 49 on the remaining days that simultaneous sampling was conducted (May 11, September 29, October 5 and October 17, 1994). Mesh sizes differed between gears used to capture later-life stage fish. For example, mesh size of the townet was 2.46 times larger than that of the fyke net. Mesh sizes of the midwater trawl nets were up to 6,344 times larger than that of the fyke net. These substantial differences must be considered when reviewing the capture results as catch efficiency and mean lengths of fish captured may vary significantly across gear types (Rozas and Minello 1997).

The water volume applied to the townet data was 0.596 af per tow. This is the amount estimated by the U.S. Fish and Wildlife Service (USFWS) for a 10 minute townet sample using a similarly sized net. Water volumes sampled by the midwater trawl were calculated using the formula totalmeter x area x k, where totalmeter equals the number of revolutions from a flowmeter (General Oceanics Model 2030) attached to the net, area equals the area of the mouth of the net (13.69m^2), and k is a constant (26873/999999) which converts flowmeter revolutions to distance in meters.

Regardless of tidal stage or net type, nets were deployed in oblique tows in the channels for either five or ten minutes. All fish collected were identified to species (where possible), counted, and measured to the nearest millimeter TL. Those fish that could not be identified in the field were preserved in five-percent formalin and sent to an independent contract laboratory for identification. Water velocity (in cfs), volume sampled (in af), temperature (in degrees Fahrenheit) and electrical conductivity (in microSiemens per cm) were also recorded at the time diversion and channel samples were collected.

Additional Channel Sampling

Channel sampling that was not simultaneous with diversion sampling was also conducted. This data is provided as a qualitative demonstration of how catch results can vary over time and space. Note that variation in catch results, however, is also gear dependent and gear efficiencies can vary substantially (Rozas and Minello 1997). Additional channel sampling was conducted at Sites 49, 93 and 932 for early-life stage fish each year between 1993 and 1995 using a 505 micron egg and larval net (Appendix B).

In 1993, Channel Sites 49 and 932 were sampled by midwater trawl for later-life stage fish on two days in late August, by townet on seven days during summer months, and by otter trawl on one day in late September (Appendix C).

Data Treatment

Net efficiencies within the diversions were not determined. Therefore, neither the fyke net nor the egg and larval net's effectiveness in collecting different sized fish from the diversions is known. Lack of knowledge about net efficiencies and the rate of net avoidance by fish both affected the ability to estimate total entrainment. For these reasons, only catch per unit effort (CPUE) (the number of fish captured per af of water sampled) is reported. Note that CPUE represents minimum capture

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rates. Due to inherent, but unquantified gear variability, combined with site-specific habitat differences, catch and CPUE reported from the diversions should only be compared within sites.

Efficiencies for the townets and midwater trawls used in the channels were also not determined. However, these channel sampling methods are known in general to have low efficiency and high variability (Rozas and Minello 1997). Therefore CPUE reported from the channel samples is only useful for indicating some of the species present in the channels and their relative abundance with respect to capture rates. Because of habitat variation across time and space, and behavioral variation among fish species and life stages, relative within sample abundances probably varied across time and location, and are, therefore, not comparable.

For each diversion site CPUE, calculated from samples collected during the day, were compared with those collected at night. If sampling began after sunset but before sunrise, the sample was termed a "night" sample. If sampling began between sunrise and sunset, the sample was termed a "day" sample.

The two groups were analyzed using a t-test for dependent samples to determine if there was a significant difference between CPUE. A p-value of less than or equal to 0.05 was chosen as the determining criteria. Note however that this analysis too was conducted under the assumption of low variability in gear efficiency.

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Results

Diversion Sampling for Early-life Stage Fish using an Egg and Larval Net

Data collected from Sites 1, 2B, and 4 were not analyzed because of small sample sizes and unequal effort across sites (Table 2), but are presented separately in Appendix D.

Total CPUE at Site 2 varied across years from 792.5 in 1993 to 144.6 in 1994 to 547.0 in 1995 (Tables 5 - 7). Catch per unit effort for individual species also varied (Tables 5 - 7). In 1993 threadfin shad and bigscale logperch were the two most abundant species captured. Prickly sculpin and shimofuri goby were the most abundant species captured in 1994. In 1995 threadfin shad and centrarchids were the most abundant fish captured. The total number of taxa recorded was 8 in 1993, 7 in 1994 and 5 in 1995. In 1993, five early-life stage delta smelt were recorded (Table 5). No early-life stage chinook salmon, longfin smelt or splittail were recorded.

Length frequency distributions were somewhat similar across years (Figure 2). Median standard lengths were 6 mm in 1993 and 1995 and 8 mm in 1994. Distributions in all years were skewed towards smaller sizes.

Diversion Sampling using a Fyke Net

More than ninety percent of fish captured at Sites 1, 2, and 4 during the study period were early-life stage size (Tables 8-10). As a result, catch per unit effort of later-life stage fish was substantially less overall than for early-life stage fish. At Sites 1 and 2, CPUE was also relatively more consistent across years (Tables 8-10). Less than 1 fish total was recorded per af of water sampled at any site each year. Total CPUE was highest at Site 1 in all years except in 1993. That year, CPUE at Site 1 was equal to that at Site 4. CPUE of all fish also appeared to vary somewhat across years and sites but small observed numbers of later life-stage fish, uncertain gear efficiencies, and spatial variability do not permit statistical comparisons.

The observed number of species of later-life stage fish varied across diversion sites. However, within sites, the total numbers of species remained relatively consistent between years (Tables 8 – 10). The total number of species captured was greatest at Site 1. At least 15 species were captured at Site 1 per year, compared to at least 7 at Site 2, and 5 each year at Site 4.

One chinook salmon was recorded at Site 1 in 1994 and 1995 (Tables 9–10). Lengths were 90 and 105 mm TL respectively (Figure 3). At Site 1, four later-life stage delta smelt measuring 30 to 36 mm TL were recorded in 1994 (Table 9 and Figure 3). In 1995 one splittail measuring 52 mm TL was recorded at Site 2 (Table 10 and Figure 4). Catch per unit effort of later-life stage striped bass ranged from 0.02 to 0.04 at Site 1, and 0 to 0.1 at Sites 2 and 4 (Tables 8–10).

Later-life stage fish observed in relatively higher densities at Site 1 were mosquitofish (CPUE = 0.15) and inland silversides (0.08) in 1993 (Table 8), yellowfin gobies and shimofuri gobies (CPUE = 0.15 and 0.12 respectively) in 1994 (Table 9) and threadfin shad (CPUE = 0.09) in 1995 (Table 10). At Site 2, these were yellowfin gobies (CPUE = 0.07) in 1993 (Table 8), white catfish and shimofuri gobies (CPUE = 0.04 and 0.04 respectively) in 1994 (Table 9) and bluegill (CPUE = 0.05) in 1995 (Table 10). At Site 4, highest observed densities were of threadfin shad and white catfish (CPUE = 0.31 and 0.17 respectively) in 1993 (Table 8), prickly sculpins and white catfish (CPUE = 0.02 and 0.02 respectively) in 1994 (Table 9)

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and white catfish (CPUE = 0.17) in 1995 (Table 10).

Sixteen fish were recorded at Site 2B in 1993. Fourteen were early-life stage fish, including shimofuri goby, yellowfin goby, striped bass, threadfin shad and centrarchids. The others were two later-life stage fish, a yellowfin goby and a shimofuri goby.

Length ranges of later-life stage fish within sites were somewhat similar between years (Figures 3–5). Length ranges at Site 1 were 30 to 390 mm TL in 1993, 30 to 330 mm TL in 1994 and 30 to 334 mm TL in 1995 (Figure 3). At Site 2, fish measured 30 to 347 mm TL in 1993, 30 to 335 mm TL in 1994 and 30 to 265 mm TL in 1995 (Figure 4). Length ranges at Site 4 were 30 to 170 mm TL in 1993, 31 to 250 mm TL in 1994, and 30 to 140 mm TL in 1995 (Figure 5).

Simultaneous Channel and Diversion Sampling

Species recorded from simultaneous sampling appeared to differ between the channel and diversion. At least seven species of early-life stage fish were collected in the channel (Site 932) compared to two in the diversion (Site 2) (Table 11). Prickly sculpin was most common (CPUE = 67.1) in the channel followed by shimofuri goby (CPUE = 65.2) and striped bass (CPUE = 28.0). Two delta smelt (CPUE = 1.0) were also collected in the channel. Two prickly sculpin and two bigscale logperch (CPUE = 12.0 each) were observed in the diversion. Median body lengths were similar (7 mm TL) for fish collected at both sites (Figure 6).

Length range, number of species and total number of later-life stage fish captured during simultaneous sampling differed between the channel (Site 932) and diversion (Site 2). Seven species measuring 24 to 89 mm TL were observed in channel samples (Table 12 and Fig.7). Striped bass was most common in the channel followed by catfish. Data was not available to calculate CPUE for channel samples.

Of the six species observed during simultaneous sampling at Sites 1 and 49 on July 11, 1994, five were observed in channel samples compared to four in the diversion (Figure 8). Threadfin shad had the highest relative capture rate in the diversion but were not captured with the townet in the channel. Fish collected with the townet measured 26 to 66 mm TL. Fish captured in the diversion measured 16 to 34 mm TL.

Species captured showed little overlap between the channel (Site 49) and the diversion (Site 1) when midwater trawl gear was used in the channel. Species observed in the diversion were not observed in the channel, with the exception of threadfin shad on September 29 and October 5, 1994 and striped bass on May 11, 1994 (Table 13). On September 29, October 5, and October 17, 1994, when capture of American and threadfin shad was relatively high in channel samples, observed entrainment of this species in the diversion was relatively low.

Species compositions at Site 49 appeared to vary seasonally (Table 13). For example, delta smelt, prickly sculpin, yellowfin goby and ictalurids were only captured in May. Chinook salmon and cyprinids were captured in the channel in May, September, and October. Threadfin and American shad and shimofuri gobies were only captured during September and October. Simultaneous sampling, however, only occurred on one day in May, July and September and on two days in October. Because of these small sample sizes, no valid conclusions can be drawn about seasonal variation of species composition in the diversion at Site 1.

During simultaneous sampling using the midwater trawl, the relative magnitude of catch per unit effort at Sites 1 and 49 varied across months. On May 11, 1994 CPUE was greater for all species captured in the diversion than in the channel (Table 13). On the other three days, CPUE was

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generally higher for fish captured in the channel.

There was little overlap in body length between fish captured in the channel (Site 49) by midwater trawl and those caught at diversion Site 1 (Figures 9-12). Fish caught in the diversion tended to be smaller. This is, however, most likely a consequence of the small mesh size used in the diversion.

On two days, measurements of fish caught in the channel were mistakenly recorded in fork length (Figures 9 and 12) indicating that the size overlap would have been less had total length been measured. Of the larger fish observed in the channel, four were chinook salmon, two were striped bass and one a carp. The larger fish observed in the diversion included one largemouth and three striped bass. One delta smelt (23 mm TL) was caught at Site 1 during simultaneous sampling on May 11, 1994 (Figure 9).

Day and Night Fish Density Comparisons

Catches of entrained early-life stage fish were not significantly different between day and night samples collected at Site 2 in 1994 and 1995 ($p \geq 0.05$) (Table 14). An insufficient number of paired samples ($n \leq 2$) from Site 1 in 1993 and 1994 precluded diurnal comparison of entrainment densities of early-life stage fish at that site.

In contrast, sampled densities of later-life stage fish were significantly greater at night than during the day at Site 2 in 1993 and 1995 ($p \leq 0.05$), and at Site 1 in 1994 ($p \leq 0.01$) (Table 14). Note however that under an assumption of high potential gear efficiency variability, these results could differ.

Seasonal Entrainment

Total species numbers were largest from May through August, when the vast majority of sampling effort occurred (Table 15). Sampling intensity was, however, also proportionately greater in those months. No sampling was conducted from February through March in any year. The period between November and January was only sampled from November 1993 through January 1994.

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Discussion

Quantitative estimates of site specific fish entrainment were not accomplished largely because of insufficient sampling over the irrigation period, a result of staff and equipment limitations and lack of cooperation from diversion operators. In addition, most sampling occurred during daylight hours though diversions were continuously active for several days at a time. While generally higher fish densities collected at night from Sacramento-San Joaquin delta diversions have been observed elsewhere (e.g., Pickard et al. 1982), the small amount of nighttime sampling in this study precluded conclusions about daytime versus nighttime entrainment. Because of this, no point estimates of daily entrainment were obtained either.

The results of this study do, however, suggest that small-scale diversions within the Sacramento-San Joaquin delta can entrain a large diversity of fish species, at least from May through August, when young-of-year (YOY) of many species are present. Furthermore, the actual number of entrained fish can be large. Because the period of high YOY abundance overlaps with the principal agricultural season, substantial numbers of fish may be lost to irrigation operations each year.

The results also tend to suggest that small, unscreened diversions may entrain a greater number of smaller than larger fish. Similar results were also reported from this program's pilot study (Spaar 1994). Speculatively, fish in early-life stages may become entrained in higher densities than later-life stage fish for several reasons. Larval fish can potentially be more abundant in adjacent channels than older fish in areas of high spawning success. Additionally, the seasonal timing of active diversions often coincides with periods of high abundance of eggs and larvae in adjacent channels (Miller pers. comm.)

Early-life stage fish may also be more vulnerable to entrainment because of under developed swimming ability. For example, because young striped bass under 17 mm standard length are poor swimmers, they are likely entrained more often than larger striped bass (Allen 1975). Note, however, that because the sampling methods used in this study to collect larger fish were not entirely efficient, comparisons of the relative numbers of larger and smaller numbers of fish are not valid.

Catch Per Unit Effort calculations derived from this study tend to suggest that relatively higher numbers of bottom oriented fish and relatively lower densities of special status species like chinook salmon and delta smelt were entrained. The larger numbers of bottom oriented species observed in this study may reflect increased vulnerability during epibenthic foraging (Urquhart pers. comm.). The sampling regime of this study, however, was not sufficiently consistent to confidently identify relative densities of fish species entrained.

Because actual channel densities of fish are not known, it is impossible to separate density effects from behavioral and life stage effects contributing to entrainment vulnerability. The large numbers of threadfin shad entrained at times demonstrate the potential for entrainment of surface oriented species. Failure to observe many individuals of species such as salmon and delta smelt may therefore have been a consequence of small sample sizes, species distribution patterns during the sampling period, and/or species specific behavior.

The virtual lack of overlap in species observed between the channels and diversions from simultaneous sampling efforts suggest that results from midchannel sampling cannot be used to predict those species most likely to be entrained or the total number of fish lost to entrainment. This is

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most likely because habitats, and therefore species compositions, vary between mid channel and near shore locations. Mid-channel species and life-stages may therefore not be expected to occur as often in diversions. For example, American shad, a midchannel species, was regularly collected from the channels, but rarely from the diversions. The substantial differences in gear types and net mesh sizes used, however, could also account for part of the variation in species observed between channel and diversion sites.

It is not presently possible to identify the proportional effect of the impacts agricultural diversions have on resident and migratory delta fish. This is due mainly to our inability to quantify population sizes and demographics in an open and highly variable system like the Sacramento-San Joaquin delta. Because we lack this information, we cannot relate data from fish captured in diversions to population level effects on species in the system. Furthermore, because environmental variables, such as outflow and water quality, which affect fish distributions, change over time, and because fish behaviors are complex and variable, the ability to predict future impacts does not exist.

Near shore sampling with the goal of determining species presence could potentially be accomplished. Such efforts, however, should not occur simultaneously with diversion sampling as this could effect behavior of the fish and thereby entrainment. Because channel sampling is generally characterized by low and highly variable efficiencies (Rozas and Minello 1997), fish density comparisons between channels and diversions, as well as entrainment density estimation, based on channel sample observations, will be a challenge for future studies.

Through this study we have gained a broader understanding of the difficulties involved with assessing fish entrainment in agriculture diversions. A combination of variable study design and sampling methodology, and small sample sizes, brought about, in part, by uncontrollable confounding events, precluded achievement of one of this study's objectives - to evaluate entrainment losses of resident and migratory fish species at several agricultural diversion sites.

The difficulties associated with accomplishing the study's other objectives - to develop reliable means of estimating fish entrainment, and to determine the susceptibility of fish species to entrainment relative to their abundance and life stages in adjacent Delta channels - are also now better understood. Because channel habitat varies over time and space throughout the Delta, high spacio-temporal variability of channel species composition and densities must be assumed. The data in Appendix C indicates such variability within the channel sites included in this study. As a result, reliable extrapolation of entrainment measures from a sampled diversion to another site separated by time or location is not possible.

Fortunately, some of the difficulties encountered during this study can be reduced in future ones. To do so, a concise, detailed set of objectives must be prepared along with a thorough analysis of their attainability, followed by careful planning and implementation.

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Recommendations

A sufficient body of information, required for the development of management plans for small agricultural diversions in the delta, was not produced by this study. Further procedures and evaluations are suggested which should provide the basis for better decision making. Recommendations include altering study objectives to produce a higher expectation of accomplishment, continuing discussion between knowledgeable persons, and creating well planned studies to address specific questions. Recommendations are as follows.

- Omit the goal of extrapolating species likely to be entrained, and total entrainment estimates of fish, from sampled to unsampled diversions unless studies involve statistically determined adequate sample sizes of diversions across all water year types. This would be a lengthy project, involving many years and considerable expense.
- Conduct a thorough literature review including studies from other geographic regions.
- Plan a forum for discussion within a Project Work Team or a special colloquium about:
  - (1) relationships of sampling results between channels and diversions.
  - (2) methods for sampling channels and diversions that would increase data reliability.
  - (3) methods for simultaneously sampling channels and diversions.
  - (4) possible means of modeling entrainment losses at unsampled diversions based on results from sampled diversions separated by space and/or time.
- Continue studies to assess the relative magnitudes of entrainment at unscreened agricultural diversions and the patterns of daily, seasonal, and annual loss of fish.
  - (1) Identify clear obtainable study objectives and focus, define and outline questions in scientific form.
  - (2) Define adequate study designs and methodology prior to initiating field investigations. Data should be subjected to statistical analysis.
  - (3) Previous studies within the Sacramento-San Joaquin delta (e.g., Spaar 1994, Wadsworth 1998), designed to evaluate fish entrainment in agricultural diversions have been conducted on limited geographical scales. Consequently the present body of information is inadequate for planning and management purposes. Studies should be conducted over a broader geographical region. This would provide more reliable data about species vulnerability to entrainment overall and better identify factors associated with entrainment. Study sites should be chosen where factors limiting appropriate study design and methodology are minimized.
    - Locate study sites where diversions have operational frequency sufficient to enable at least eight sampling days per month from April through August.
    - Ensure that communication and cooperation with site managers is established and maintained, permitting ready site access and notice of diversion operation.
    - Ensure adequate staff and equipment allocation to meet sampling protocol including minimum sample size requirements.
- Design and conduct additional studies that would qualitatively assess potential differences in the magnitude of entrainment of total numbers, life stages and species between screened and unscreened diversions. Studies should include delta

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diversions where side by side intakes serve as experimental and control treatments. Data from both screened and unscreened intakes allow numerical estimation of the types, sizes and abundances of fish excluded from diversions by screens and how these differ across seasons. See Appendix E for results of an earlier study of fish entrained by a screened versus an unscreened agricultural diversion. Such studies also serve as further means of evaluating the effectiveness of screens installed on intakes for mitigation purposes. Limitations would still include the inability to extrapolate results between years or across sites. Calculated estimates could, however, indicate trends in annual entrainment and identify specific sites where mitigation efforts to reduce or avoid entrainment would be most beneficial. Features of such a study should include the following:

(1) Site locations should be chosen where the occurrence and relative abundance of fish in adjacent channels in known to be great. This is important because fish entrainment, theoretically, is, at least in part, a function of channel density.

(2) Residence times of species of concern should coincide with the primary irrigation season.

(3) Diversions should have high operation frequency.

(4) Diversions should be active throughout the primary irrigation season.

(5) Sites should have at least two side by side diversions.

(6) Sites must be accessible for sampling.

(7) Sites must have a source of power on site or the installation of power must be possible.

(8) Intake screening should be feasible.

(9) At least one diversion at a site should be screened and at least one left unscreened.

(10) Sampling should be conducted at least twice per week, if not more often.

(11) Sampling should include equally weighted random sampling during day, night and crepuscular periods.

(12) Sampling methods should ensure that 100 percent of the diversion outfall is strained during each sampling period.

(13) Samples should be collected at each site during those months in which agricultural diversions are potentially operating.

(14) Sampling should be conducted over at least a three-year period at each site.

(15) Data from existing delta channel surveys (e.g., DFG's Global Positioning System data (related to the delta agricultural diversion inventory), resident fishes survey, midwater trawl survey, townet survey, and egg and larval survey, USFWS's salmon trawling and beach seine survey, and DWR's egg and larval survey) can be used to determine fish occurrence to the extent that the data is useful.

- A companion laboratory study should be designed to compliment field work by addressing questions difficult to investigate in the field. Such a laboratory study should examine:

(1) density effects on entrainment.

(2) species and life-stages most vulnerable to loss through impingement on diversion screens.

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Tables 1-15

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Table 1. Potential Factors Influencing the Rate and Magnitude of Fish Entrained in Unscreened Agricultural Diversions

Biological Factors

Life stage of the fish
Seasonal occurrence of fish in the source channel
Abundance of fish within the source channel
Distribution of fish within the source channel
Feeding behavior of the different fish species
Spawning behavior of the different fish species

Diversion Specific Factors

Seasonal timing of diversion operations
Frequency of diversion operations
Duration of diversion operations
Flow rate through diversion
Total volume of water diverted
Orientation of diversion in the channel
Depth of diversion in the channel

Environmental Factors

Time of day
Tidal change and current velocity
Turbulence
Channel bottom configuration
Turbidity
Type of local aquatic habitat (e.g. vegetated or unvegetated)

Adapted from Spaar 1994

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Table 2. Summary of Diversion Sampling for Early-life Stage Fish Using an Egg and Larval Net, 1993-1995

	Site 1 Twitchell Island	Site 2B Bacon Island, 14" siphon	Site 2 Bacon Island, 16" siphon	Site 4 Naglee Burk
1993				
Sampling period	6/28 - 7/14	7/13 - 7/27	5/4 - 7/9	5/24 - 6/23
Number of days sampled	2	2	22	6
Total number of samples	2	7	100	9
Acre-feet sampled	0.019	0.043	1.045	0.232
1994				
Sampling period	1/19 - 5/12	N/A	4/26 - 7/8	N/A
Number of days sampled	5		21	
Total number of samples	6		78	
Acre-feet sampled	0.072		1.121	
1995				
Sampling period	N/A	N/A	5/30 - 7/11	N/A
Number of days sampled			11	
Total number of samples			20	
Acre-feet sampled			0.040	

N/A = site not sampled.

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Table 3. Summary of Diversion Sampling Using a Fyke Net, 1993-1995

	Site 1 Twitchell Island	Site 2 Bacon Island, 16" siphon	Site 4 Naglee Burk
1993			
Sampling period	6/11/93 - 1/19/94	4/28 - 10/14	5/24 - 8/31
Number of days sampled	28	47	11
Total number of samples	122	228	38
Acre-feet sampled	143.16	257.30	191.10
1994			
Sampling period	4/27 - 10/17	4/26 - 8/2	6/1 - 8/30
Number of days sampled	28	31	11
Total number of samples	130	191	36
Acre-feet sampled	136.79	167.02	171.07
1995			
Sampling period	6/5 - 8/31	5/30 - 8/29	8/2 - 8/29
Number of days sampled	21	25	8
Total number of samples	44	51	12
Acre-feet sampled	202.53	199.81	130.22

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Table 4. Summary of Simultaneous Diversion and Channel Sampling, 1994

Channel Gear/ Diversion Gear Channel Site/ Diversion Site	Sample Date	Sample Time	No. Channel Samples	No. Diversion Samples	Volume Sampled Channel (AF)	Volume Sampled Diversions (AF)
Egg and Larva Net/Egg and Larval Net						
Site 932 -Middle River/ Site 2 - Bacon Island	5/5	0500-1030	12	12	2.07	2.57
Townet/ Fyke Net						
Site 49 – San Joaquin River/ Site 1 - Twitchell Island	7/11	1630-2230	7	7	4.17	7.06
Site 932 - Middle River/ Site 2 - Bacon Island	7/7	1845-2345	9	9	5.36	7.27
Midwater Trawl/Fyke Net						
Site 49 - San Joaquin River/ Site 1 - Twitchell Island	5/11	1630-2230	8	8	42.61	3.77
Site 49 - San Joaquin River/ Site 1 - Twitchell Island	9/29	1504-2204	8	7	60.75	5.78
Site 49 - San Joaquin River/ Site 1 - Twitchell Island	10/5	0305-0805	6	6	52.36	6.03
Site 49 - San Joaquin River/ Site 1 - Twitchell Island	10/17	1417-2003	7	7	54.28	6.74

AF = acre-feet

C-115713

C-115713

Table 5. Catch and Catch Per Unit Effort of Early-life Stage Fish at Diversion Site 2 (Bacon Island 16-inch Siphon) Using an Egg and Larval Net,1993

Species	Catch	CPUE
Delta smelt	5	5.0
Threadfin shad	479	458.4
Bigscale logperch	220	210.5
Shimofuri goby	38	36.4
Striped bass	54	51.7
Prickly sculpin	14	13.4
Centrarchidae	19	18.2
Cyprinidae	3	2.9
Total	832	796.5

CPUE = catch per unit effort = catch per acre-foot of water sampled.

C-115714

C-115714

Table 6 . Catch and Catch Per Unit Effort of Early-life Stage fish at Diversion Site 2 (Bacon Island 16-inch Siphon) Using an Egg and Larval Net, 1994

Species	Catch	CPUE
Striped bass	9	8.0
Yellowfin goby	0	0
Bigscale logperch	13	11.6
Prickly sculpin	78	69.6
Threadfin shad	19	17.0
Shimofuri goby	35	31.2
Centrarchidae	6	5.4
Cyprinidae	2	1.8
Total	162	144.6

CPUE = catch per unit effort = catch per acre-foot of water sampled.

C—115715

C-115715

Table 7. Catch and Catch Per Unit Effort of Early-life Stage Fish at Diversion Site 2 (Bacon Island 16-inch Siphon) Using an Egg and Larval Net, 1995

Species	Catch	CPUE
Threadfin shad	12	300.0
Bigscale logperch	1	25.0
Centrarchidae	7	175.0
Cyprinidae	1	25.0
Ictaluridae	1	25.0
Total	22	550.0

CPUE = catch per unit effort = catch per acre-foot of water sampled.

C-115716

C-115716

Table 8. Catch and Catch Per Unit Effort of Fish Captured in Diversions Using a Fyke Net, 1993

	Site 1 Twitchell Island				Site 2 Bacon Island				Site 4 Naglee Burk			
	Early-life Stage Fish		Later-life Stage Fish		Early-life Stage Fish		Later-life Stage Fish		Early-life Stage Fish		Later-life Stage Fish	
Species	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
Delta smelt	1	0.01	0	0.00	3	0.01	2	0.01	0	0.00	0	0.00
Striped bass	70	0.49	3	0.02	1787	6.94	0	0.00	1	0.01	1	0.01
American shad	0	0.00	3	0.02	0	0.00	0	0.00	0	0.00	0	0.00
Threadfin shad	331	2.31	7	0.05	1262	4.90	0	0.00	3842	20.10	60	0.31
Inland silverside	115	0.80	11	0.08	0	0.00	0	0.00	1	0.01	0	0.00
Prickly sculpin	0	0.00	2	0.01	76	0.30	0	0.00	0	0.00	0	0.00
Bigscale logperch	1	0.01	5	0.03	114	0.44	0	0.00	0	0.00	0	0.00
Yellowfin goby	4	0.03	8	0.06	465	1.81	19	0.07	3	0.02	0	0.00
Shimofuri goby	6	0.04	6	0.04	436	1.69	2	0.01	6	0.03	0	0.00
Carp	1	0.01	1	0.01	3	0.01	0	0.00	0	0.00	0	0.00
Golden shiner	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
Largemouth bass	3	0.02	3	0.00	8	0.03	1	0.01	0	0.00	0	0.00
Blue gill	2	0.01	1	0.00	3	0.01	4	0.02	14	0.07	0	0.00
Black crappie	0	0.00	2	0.00	2	0.01	0	0.00	1	0.01	0	0.00
unk centrarchids	3	0.02	0	0.00	7	0.03	0	0.00	0	0.00	0	0.00
White catfish	0	0.00	0	0.00	0	0.00	7	0.03	3	0.02	33	0.17
Channel catfish	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00
Brown bullhead	0	0.00	0	0.00	6	0.02	0	0.00	0	0.00	0	0.00
unk ictalurids	0	0.00	0	0.00	6	0.02	0	0.00	3	0.02	2	0.01
Mosquitofish	7	0.05	21	0.15	0	0.00	0	0.00	5	0.03	2	0.01
Threespine stcklbck	0	0.00	1	0.10	0	0.00	0	0.00	0	0.00	0	0.00
unidentified fish	0	0.00	0	0.00	7	0.03	1	0.01	1	0.01	0	0.00
Total	544	3.80	75	0.58	4186	16.27	36	0.14	3880	20.30	98	0.51

C—115717

C-115717

Table 9. Catch and Catch Per Unit Effort of Fish Captured in Diversions Using a Fyke Net, 1994

	Site 1 Twitchell Island				Site 2 Bacon Island				Site 4 Naglee Burk			
	Early-life Stage Fish		Later-life Stage Fish		Early-life Stage Fish		Later-life Stage Fish		Early-life Stage Fish		Later-life Stage Fish	
Species	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
Chinook salmon	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
Delta smelt	14	0.10	4	0.03	0	0.00	0	0.00	0	0.00	0	0.00
Striped bass	778	5.69	5	0.04	159	0.95	0	0.00	2	0.01	0	0.00
Threadfin shad	46	0.34	7	0.05	84	0.50	0	0.00	48	0.28	0	0.00
Inland silverside	0	0.00	3	0.02	0	0.00	0	0.00	0	0.00	0	0.00
Prickly sculpin	34	0.25	12	0.09	29	0.17	4	0.02	1	0.01	4	0.02
Bigscale logperch	15	0.11	2	0.01	7	0.04	0	0.00	0	0.00	0	0.00
Yellowfin goby	186	1.36	20	0.15	16	0.10	1	0.01	0	0.00	0	0.00
Shimofuri goby	17	0.12	16	0.12	184	1.10	6	0.04	6	0.04	2	0.01
Carp	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00
Largemouth bass	3	0.02	3	0.02	3	0.02	0	0.00	0	0.00	0	0.00
Blue gill	0	0.00	0	0.00	10	0.06	3	0.02	0	0.00	1	0.01
Black crappie	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00
unk centrarchids	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	0	0.00
White catfish	0	0.00	1	0.01	0	0.00	6	0.04	0	0.00	4	0.02
Channel catfish	0	0.00	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00
Brown bullhead	1	0.01	1	0.01	5	0.03	1	0.01	0	0.00	0	0.00
unk ictalurids	1	0.01	0	0.00	4	0.02	1	0.01	9	0.05	0	0.00
Mosquitofish	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00
Threespine stcklbck	0	0.00	7	0.05	0	0.00	0	0.00	0	0.00	0	0.00
Wakasagi	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
Staghorn sculpin	0	0.00	0	0.00	1	0.01	2	0.01	0	0.00	1	0.01
Tule perch	5	0.04	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
unidentified fish	1	0.01	0	0.00	5	0.03	0	0.00	1	0.01	0	0.00
Total	1101	8.05	84	0.61	510	3.05	25	0.15	68	0.40	12	0.07

C-115718

Table 10. Catch and Catch Per Unit Effort of Fish Captured in Diversions Using a Fyke Net, 1995

	Site 1 Twitchell Island				Site 2 Bacon Island				Site 4 Naglee Burk			
	Early-life Stage Fish		Later-life Stage Fish		Early-life Stage Fish		Later-life Stage Fish		Early-life Stage Fish		Later-life Stage Fish	
Species	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE	Catch	CPUE
Chinook salmon	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
Striped bass	62	0.31	5	0.02	4	0.02	2	0.01	0	0.00	0	0.00
Splittail	0	0.00	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00
Sacramento sucker	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
American shad	0	0.00	3	0.01	0	0.00	0	0.00	0	0.00	0	0.00
Threadfin shad	1345	6.64	18	0.09	62	0.31	0	0.00	0	0.00	0	0.00
Inland silverside	13	0.06	6	0.03	0	0.00	0	0.00	0	0.00	0	0.00
Prickly sculpin	2	0.01	4	0.02	0	0.00	0	0.00	0	0.00	1	0.01
Bigscale logperch	6	0.03	8	0.04	1	0.01	0	0.00	0	0.00	0	0.00
Yellowfin goby	21	0.10	15	0.07	3	0.01	0	0.00	0	0.00	0	0.00
Shimofuri goby	9	0.04	6	0.03	0	0.00	0	0.00	0	0.00	1	0.01
Largemouth bass	0	0.00	9	0.04	4	0.02	6	0.03	0	0.00	0	0.00
Blue gill	21	0.10	2	0.01	25	0.12	10	0.05	2	0.02	2	0.01
Black crappie	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Red sunfish	0	0.00	1	0.01	0	0.00	1	0.01	0	0.00	0	0.00
unk centrarchids	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00
White catfish	58	0.29	2	0.01	51	0.26	5	0.02	14	0.11	22	0.17
Channel catfish	2	0.01	0	0.00	0	0.00	0	0.00	7	0.05	7	0.05
Brown bullhead	0	0.00	0	0.00	83	0.42	0	0.00	1	0.01	1	0.01
unk ictalurids	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Mosquitofish	23	0.11	0	0.00	1	0.01	1	0.01	0	0.00	0	0.00
Riffle sculpin	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
Threespine stcklbck	3	0.01	14	0.07	0	0.00	0	0.00	0	0.00	0	0.00
Wakasagi	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Staghorn sculpin	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Tule perch	1	0.01	1	0.01	0	0.00	1	0.01	0	0.00	0	0.00
Pac brook lamprey	1	0.01	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
unidentified fish	1	0.01	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
Total	1568	7.74	99	0.49	235	1.18	27	0.14	24	0.18	34	0.26

C-115719

C-115719

Table 11. Summary of Catch and Catch Per Unit Effort during Simultaneous Channel and Diversion Sampling for Early-life Stage Fish at Channel Site 932 (Middle River) and Diversion Site 2 (Bacon Island), 1994

		Channel Site 932 Middle River		Diversion Site 2 Bacon Island	
Date/Gear	Species	Catch	CPUE	Catch	CPUE
5/5/94	Shimofuri goby	135	65.2	0	0.0
Egg and Net	Delta smelt	2	1.0	0	0.0
Larval Net	Bigscale logperch	2	1.0	2	12.0
	Prickly sculpin	139	67.1	2	12.0
	Threadfin shad	2	1.0	0	0.0
	Striped bass	58	28.0	0	0.0
	Centrarchidae	2	1.0	0	0.0

CPUE = catch per unit effort = catch per acre-foot of water sampled.

C—115720

C-115720

Table 12. Summary of Catch and Catch Per Unit Effort during Simultaneous Channel and Diversion Sampling Using a Townet and Fyke Net at Channel Site 932 (Middle River) and Diversion Site 2 (Bacon Island), 1994

		Channel Site 932 Middle River (Townet)		Diversion Site 2 Bacon Island (Fyke Net)	
Date	Species	Catch	CPUE	Catch	CPUE
7/7/94	Centrarchidae	0	N/A	3	0.4
	American shad	16	N/A	0	0
	Threadfin shad	5	N/A	18	2.5
	Striped bass	114	N/A	0	0
	Yellowfin goby	19	N/A	0	0
	Inland silverside	16	N/A	0	0
	Ictaluridae	46	N/A	3	0.4
	Shimofuri goby	0	N/A	10	1.4

CPUE = catch per unit effort = catch per acre-foot of water sampled.

N/A = Not Available.

Ictalurid species = channel catfish and white catfish.

C—115721

C-115721

Table 13. Summary of Catch during Simultaneous Channel and Diversion Sampling Using a Townet, Midwater Trawl, and Fyke Net at Channel Site 49 (San Joaquin River) and Diversion Site 1 (Twitchell Island) between May and October, 1994

		Channel Site 49		Diversion Site 1	
Date/Gear	Species	Catch	CPUE	Catch	CPUE
7/11/94	American shad	2	N/A	0	0
Townet (Channel)	Striped bass	7	N/A	3	0.422
Fyke Net (Diversion)	Splittail	1	N/A	0	0
	Yellowfin goby	1	N/A	1	0.14
	Inland silverside	6	N/A	1	0.14
	Threadfin shad	0	N/A	12	1.70
5/11/94	Striped bass	2	0.05	5	1.33
Midwater	Chinook salmon	2	0.05	0	0
Trawl (Channel)	Ictaluridae	3	0.07	0	0
Fyke Net (Diversion)	Cyprinidae	1	0.02	0	0
	Delta smelt	0	0	1	0.26
	Prickly sculpin	0	0	6	1.59
	Yellowfin goby	0	0	6	1.59
9/29/94	American shad	114	1.88	0	0
Midwater	Threadfin shad	70	1.15	1	0.13
Trawl (Channel)	Inland silverside	1	0.02	0	0
Fyke Net (Diversion)	Striped bass	7	0.12	0	0
	Centrarchidae	0	0	1	0.13
	Shimofuri goby	0	0	6	0.78
10/5/94	American shad	67	1.28	0	0
Midwater	Threadfin shad	80	1.53	1	0.17
Trawl (Channel)	Striped bass	19	0.36	0	0
Fyke Net (Diversion)	Chinook salmon	2	0.04	0	0
	Threespine stickleback	0	0	3	0.50
	Shimofuri goby	0	0	4	0.66
10/17/94	American shad	61	1.12	0	0
Midwater	Threadfin shad	38	0.70	0	0
Trawl (Channel)	Shimofuri goby	0	0	5	0.74
Fyke Net (Diversion)	Striped bass	0	0	4	0.59
	Inland silverside	0	0	1	0.15
	Cyprinidae	0	0	1	0.15

CPUE = catch per unit effort = catch per acre-foot of water sampled.
N/A = Not Available.

Table 14. Paired Comparisons of Fish Catch Per Unit Effort from Diversions, Day versus Night, 1993, 1994, 1995

	1993		1994		1995	
Early-Life Stage Fish	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**
Site 2 Bacon Island, 16"	N/A		110.58 (7)	187.18 (7)	242.09 (9)	203.45 (9)
Site 1 Twitchell Island	—	—	N/A			
Later-Life Stage Fish	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**
Site 2 Bacon Island, 16"	10.53 (21)*	29.38 (21)*	3.19 (11)	5.96 (11)	0.41 (12)*	1.91 (12)*
Site 1 Twitchell Island	2.28 (10)	14.22 (10)	5.16 (27)**	12.68 (27)**	6.17 (9)	10.07 (9)

Values shown are the mean catch per unit effort for all species combined used in the t test for dependent samples of day vs. night catch. Catch per unit effort is the total number of fish captured per acre foot of water sampled. The figure in parentheses equals the number of paired samples. Results considered significant at $p \leq 0.05$.

no asterisk	$p > 0.05$
*	$p \leq 0.05$
**	$p \geq 0.01$

N/A = site not sampled or all samples were collected during the day.

– = insufficient number of paired samples ($n \leq 2$).

C—1 1 5 7 2 3

C-115723

Table 15. Annual Entrainment of Fish by Species in Agricultural Diversions, 1993, 1994, and 1995

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook salmon					4	5						
Delta smelt				4	3,4	3,4						
Wakasagi					4							
Splittail						5						
Striped bass					3,4	3,4,5	3,4,5	3,4,5		4		
Cyprinidae					3,4	3,4,5	3			3		
Sacramento sucker							5					
Centrarchidae	4			4	3,4	3,4,5	3,5	3,5	3,4	3		
Tule perch					4	4		5				
Bigscale logperch				4	3,4	3,4,5	3,5	3,5	4			
Pacific lamprey						5						
Prickly sculpin					3	3,5	3	3,5				
Pacific staghorn sculpin				4	4	4						
Riffle sculpin						5						
Threespine stickleback						4,5	5	4,5		3,4		
Yellowfin goby					3,4	3,4,5	3,4,5	3,5	3	3	3	
Shimofuri goby	4				3,4	3,4	3,4,5	3,5	3			3
Chameleon goby					4			4	4	4		
Ictaluridae					3,4,5	3,4,5	3,4,5	3,4,5	3,4			
American shad							3,5		3			
Threadfin shad					3,4	3,4,5	3,4,5	3,4,5	4	3,4	3	
Inland silverside							3,4,5	3,4,5		4		
Mosquitofish						5	3,5	3,5		3	3	3
Starry flounder							5	5				

3 = 1993, 4 = 1994, 5 = 1995

Number of days per month that sampling was conducted

Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1993	0	0	0	3	14	11	12	9	4	3	3	3
1994	1	0	0	3	15	11	3	7	2	2	0	0
1995	0	0	0	0	2	11	17	19	0	0	0	0

C-115724

C-115724

C—115725

C-115725

Figures 1-12

C—115727

C-115727

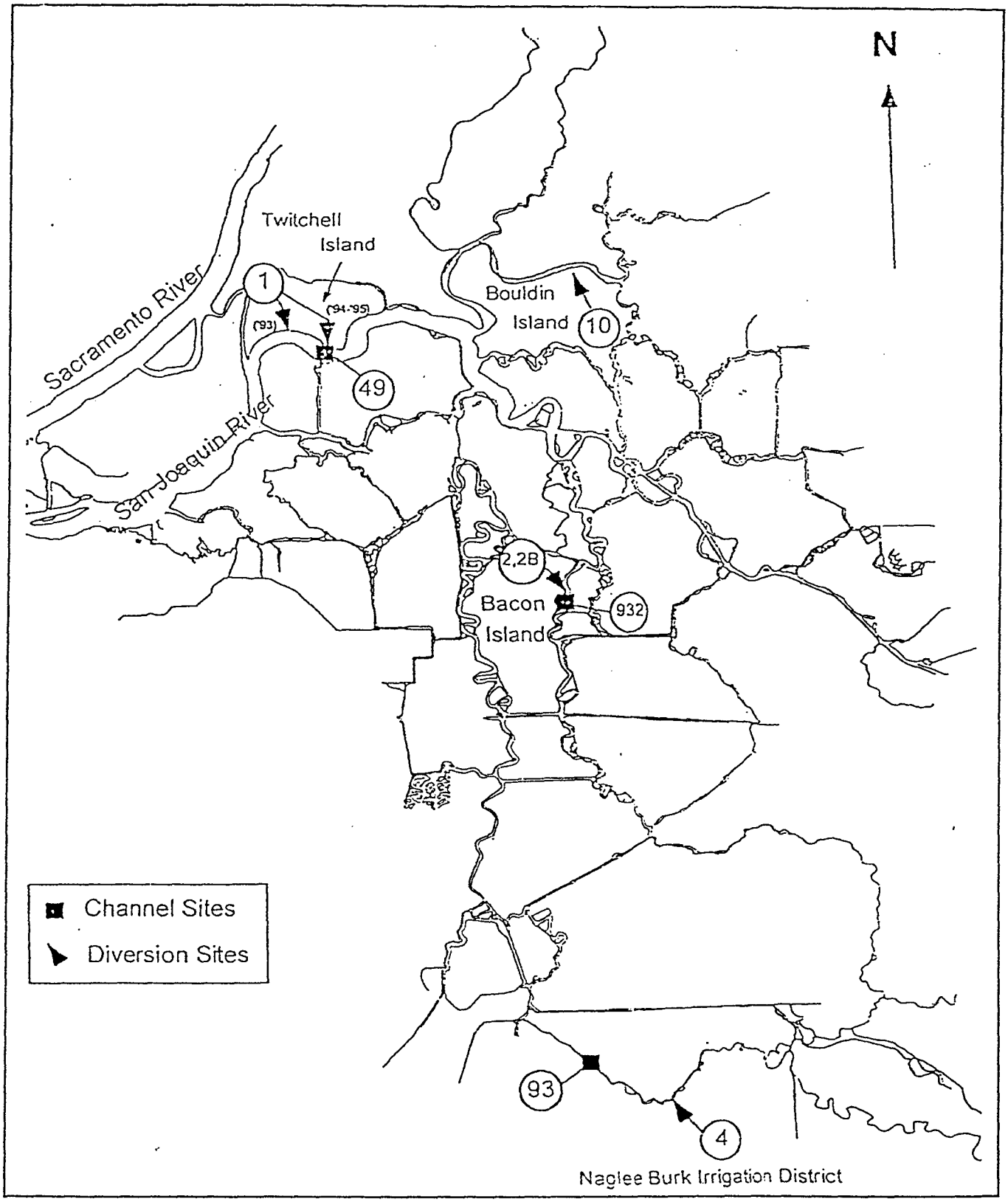

Figure 1
Channel and Diversion Sampling Sites, 1993-1995

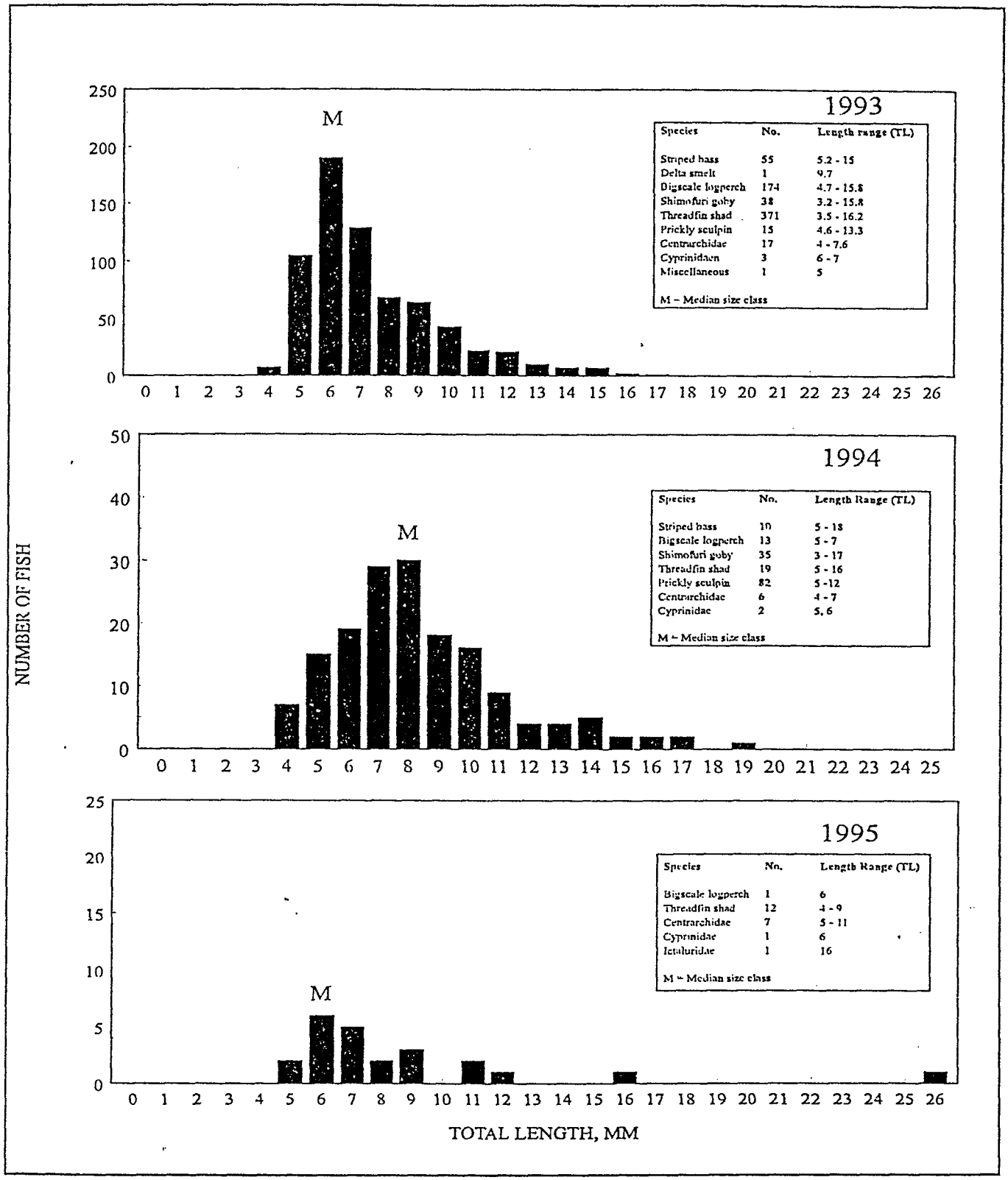

Figure 2
Length-Frequency Distributions of Early-life Stage Fish Collected at Diversion Site 2 (Bacon Island) Using an Egg and Larval Net, 1993-1995

C-115729

C-115729

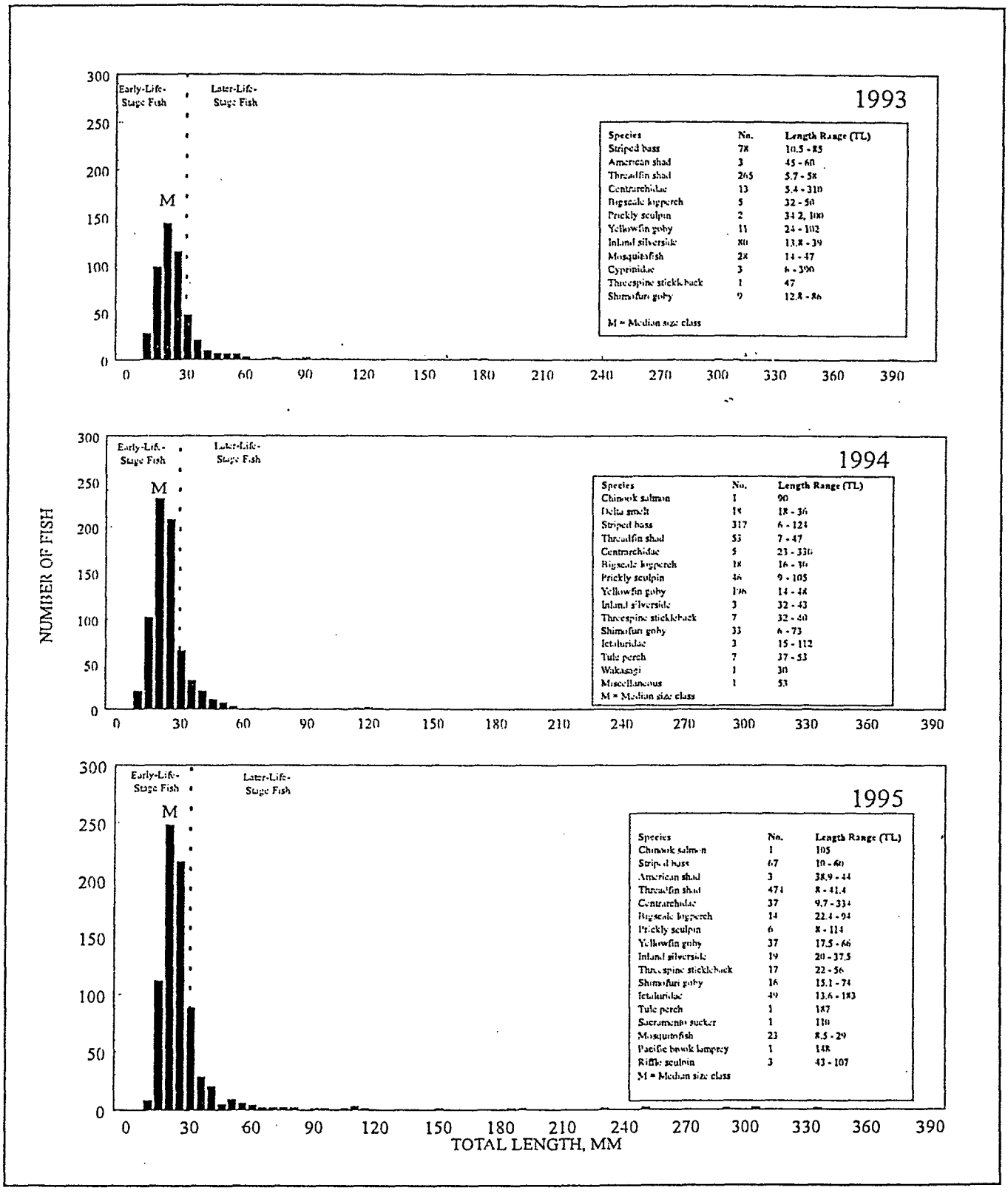

Figure 3
Length-Frequency Distributions of Fish Collected at Diversion Site 1 (Twitchell Island) Using a Fyke Net, 1993-1995

C-115730

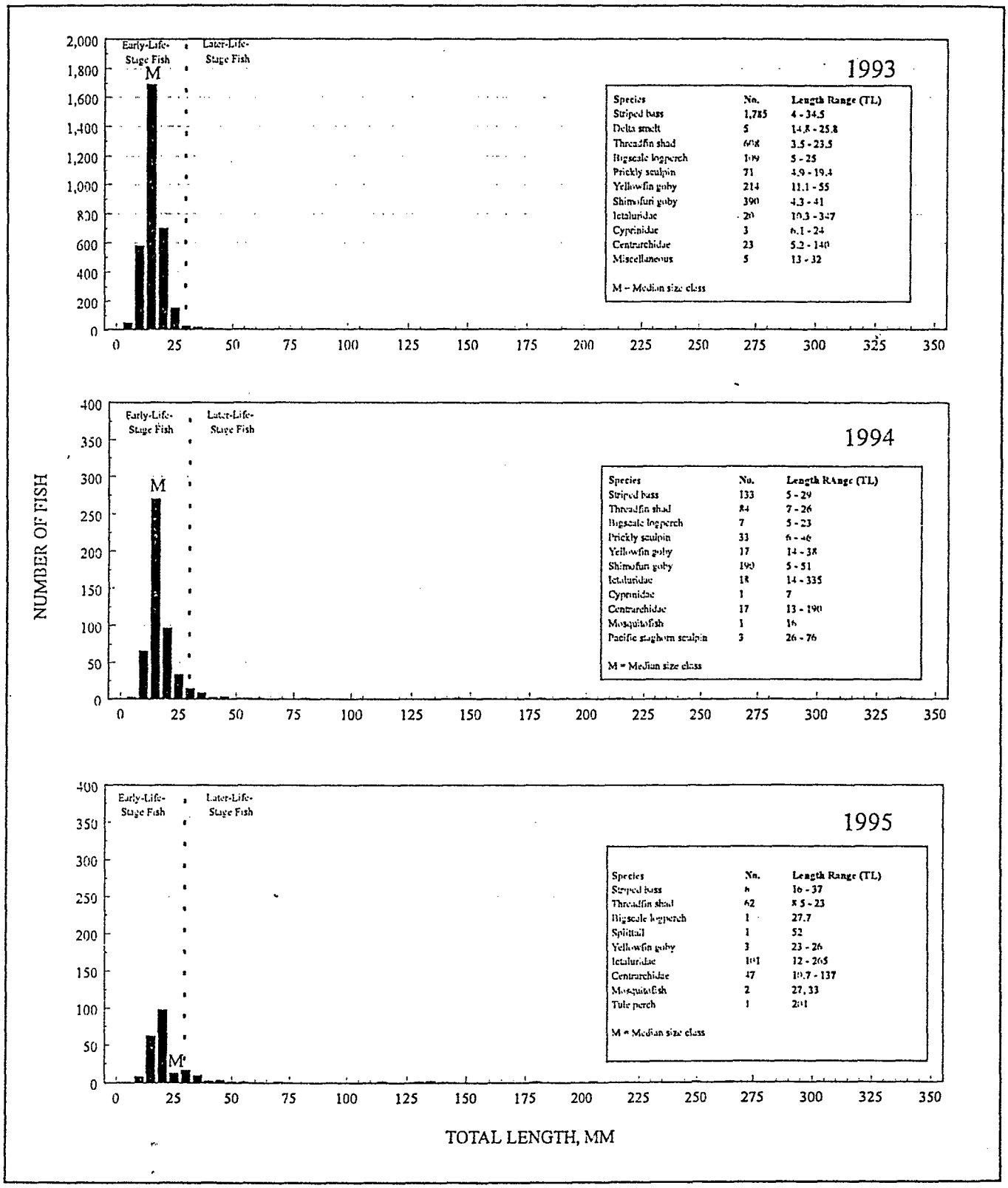

Figure 4
Length-Frequency Distributions of Fish Collected at Diversion Site 2 (Bacon Island) Using a Fyke Net, 1993-1995

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C-115731

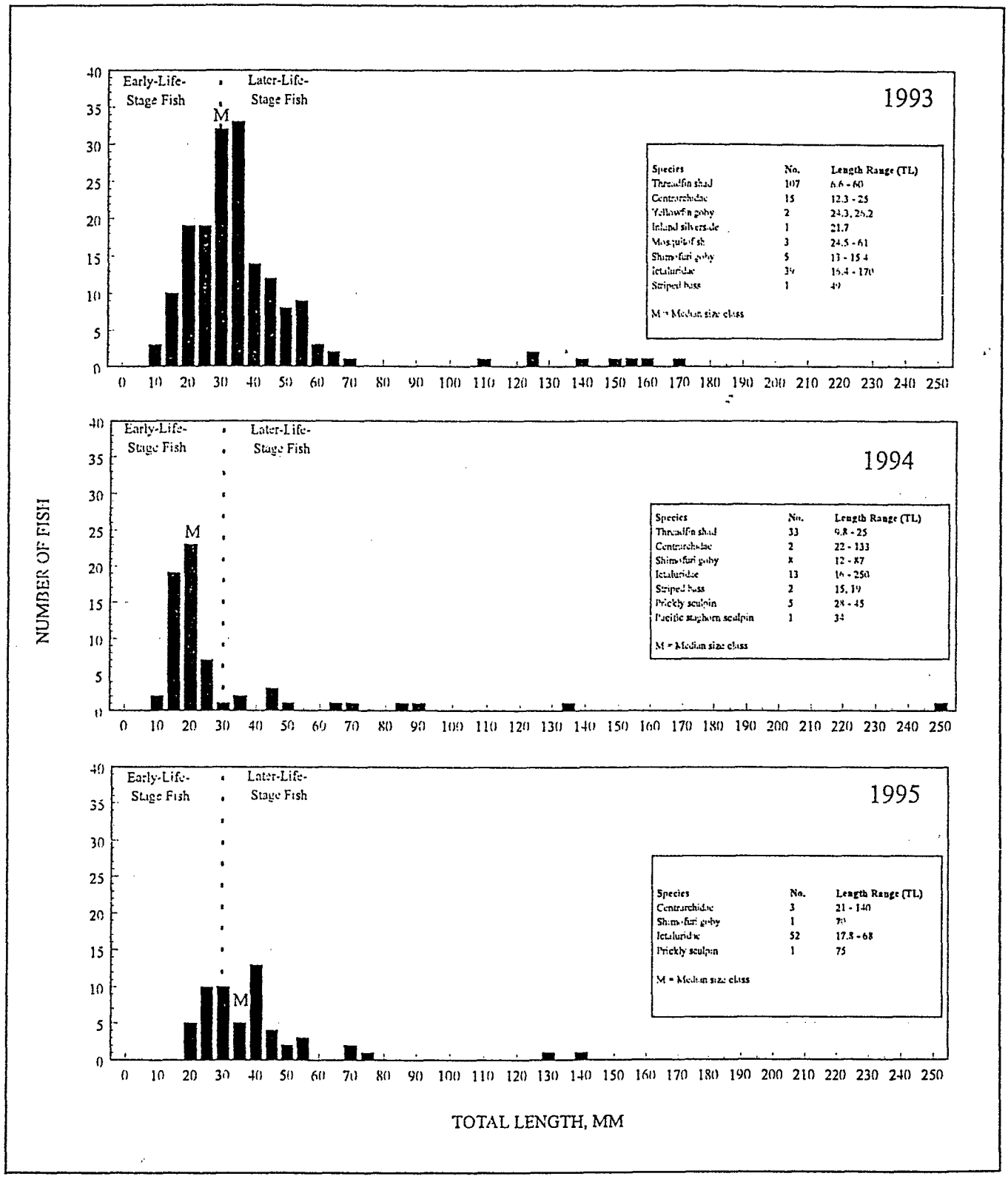

Figure 5
Length-Frequency Distribution of Fish Collected at Diversion Site 4 (Naglee Burk) Using a Fyke Net, 1993-1995

C-115732

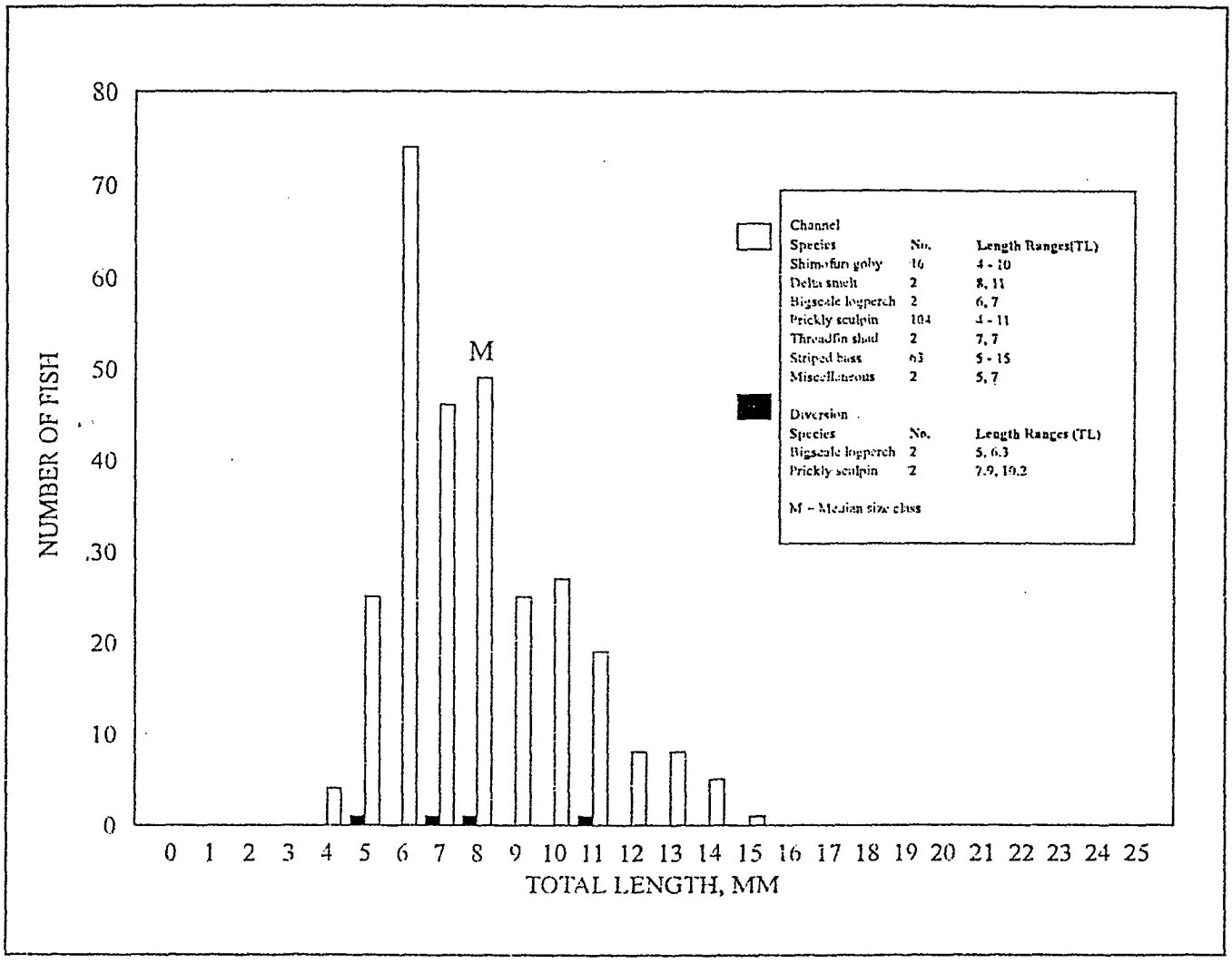

Figure 6
Length-Frequency Distributions of Early-life Stage Fish Collected during Simultaneous Sampling at Diversion Site 2 (Bacon Island) and Channel Site 932 (Middle River), May 5, 1994

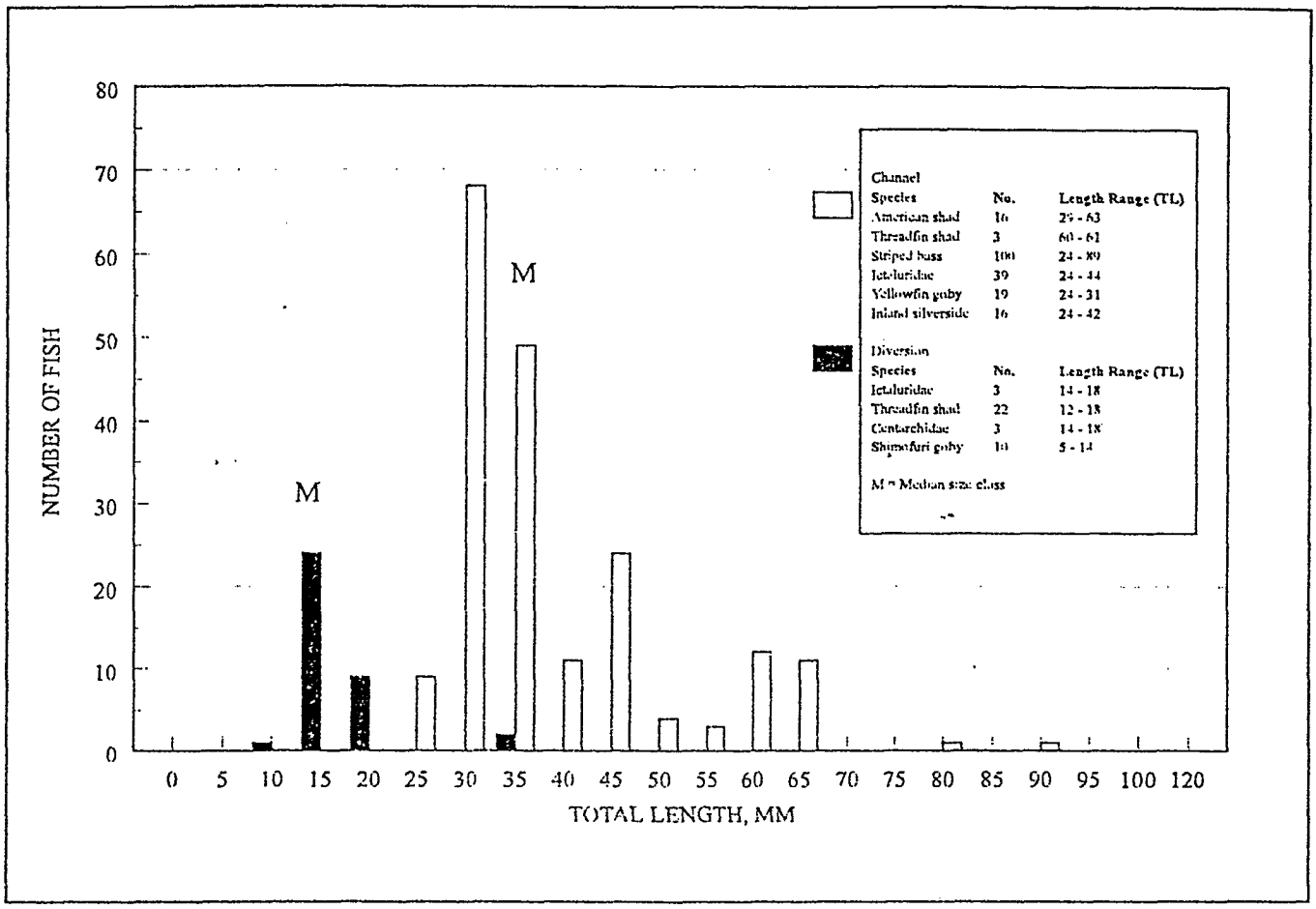

Figure 7
Length-Frequency Distributions of Fish Collected during Simultaneous Sampling at Diversion Site 2 (Bacon Island) and Channel Site 932 (Middle River) Using a Fyke Net, July 7, 1994

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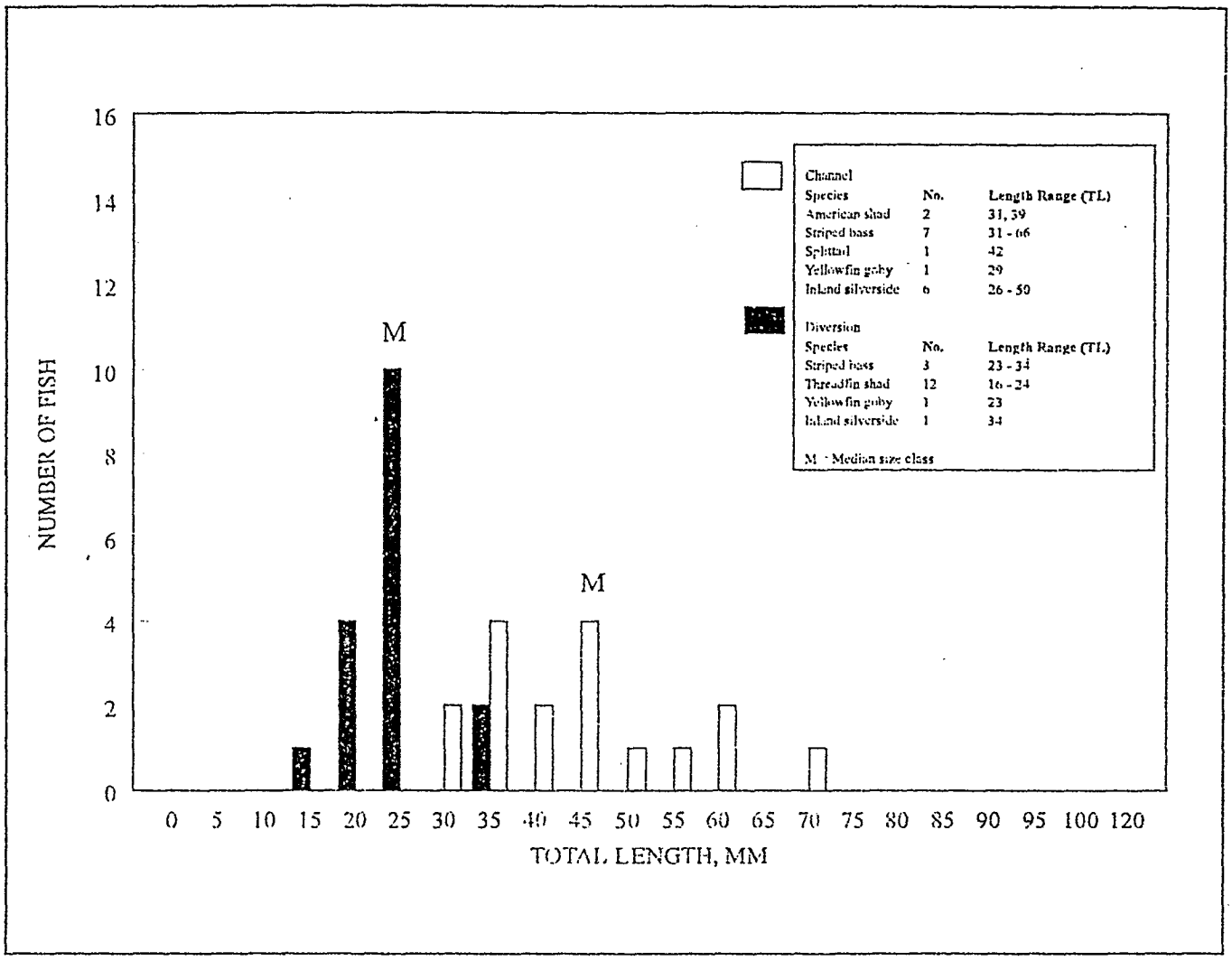

Figure 8
Length-Frequency Distributions of Fish Collected during Simultaneous Sampling at Diversion Site 1 (Twitchell Island) and Channel Site 49 (San Joaquin River at Oulton Point) Using a Fyke Net, July 11, 1994

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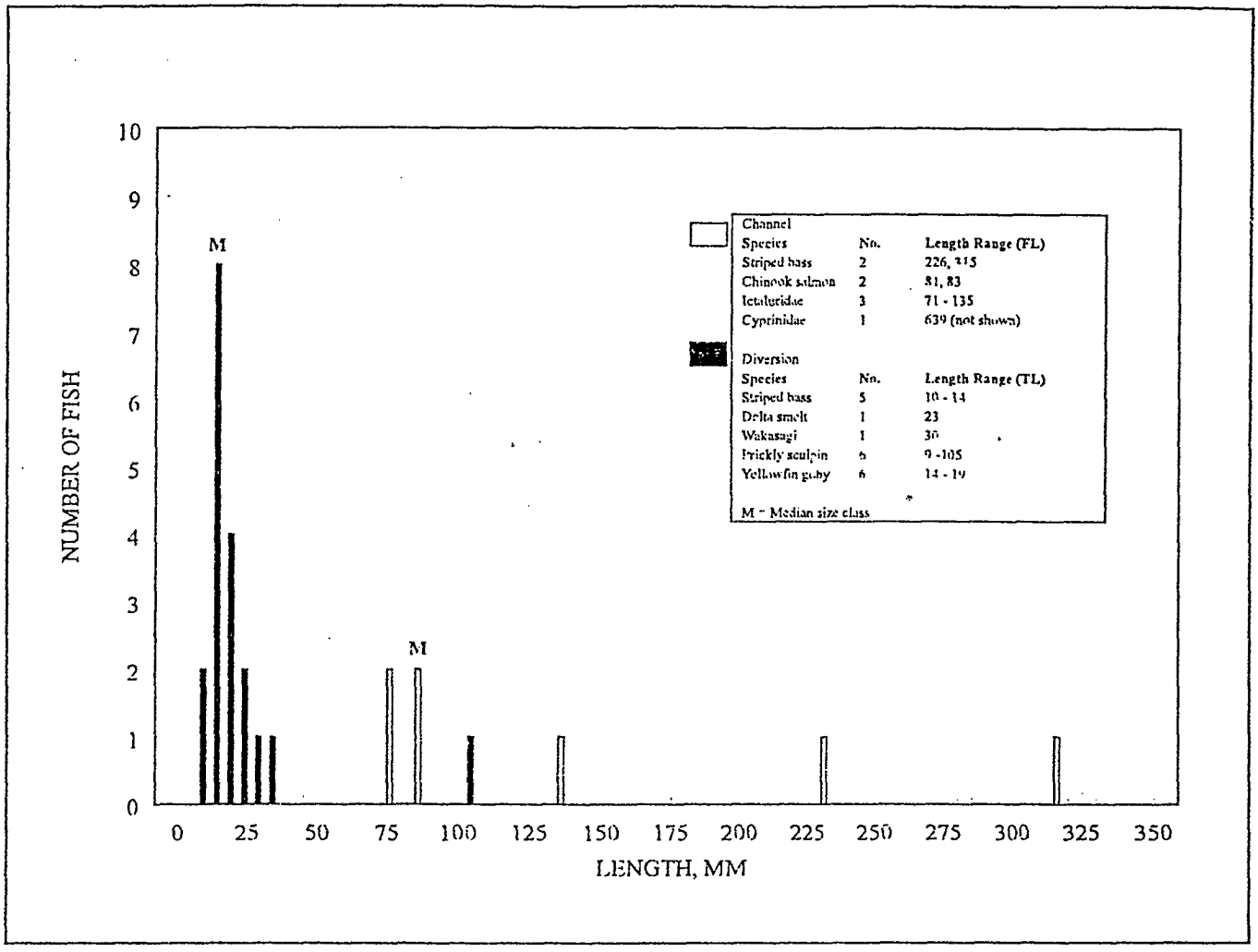

Figure 9
Length-Frequency Distributions of Fish Collected during Simultaneous Samping at Diversion Site 1 (Twitchell Island) and Channel 49 (San Joaquin River at Oulton Point) Using a Fyke Net, May 11, 1994

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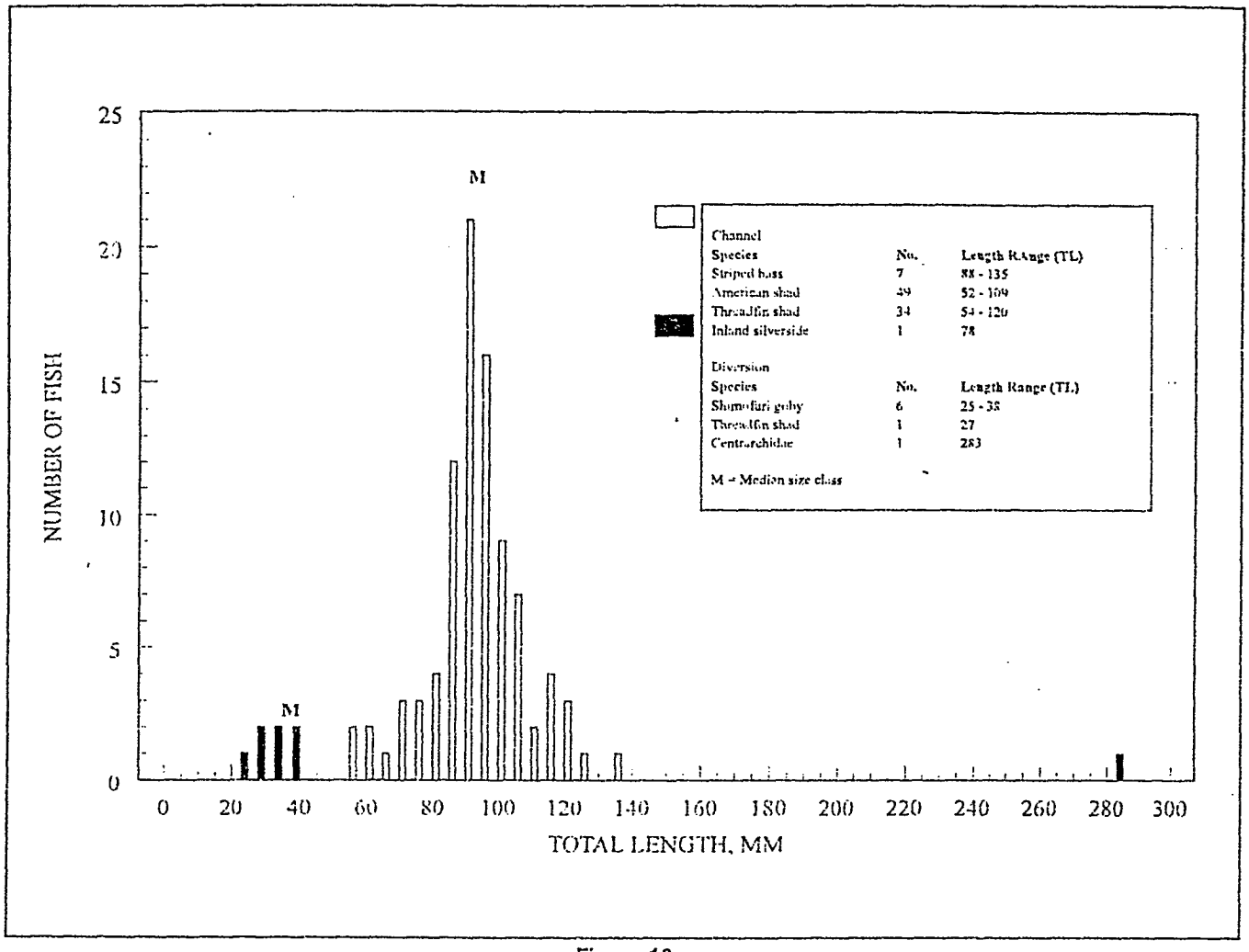

Figure 10
Length-Frequency Distributions of Fish Collected during Simultaneous Sampling at Diversion Site 1 (Twitchell Island)

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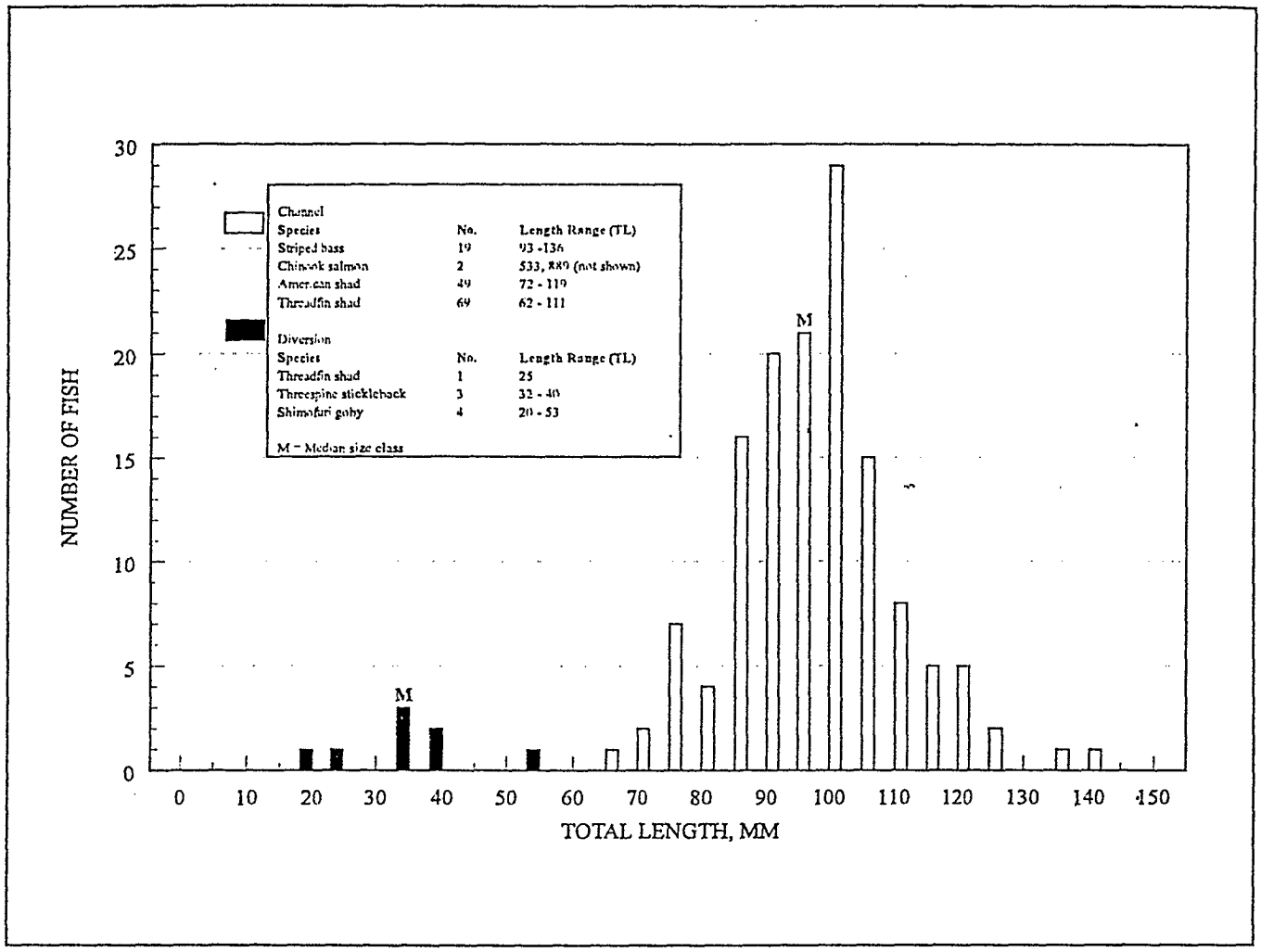

Figure 11
Length-Frequency Distributions of Fish Collected during Simultaneous Sampling at Diversion Site 1 (Twitchell Island) and Channel Site 49 (San Joaquin River at Oulton Point) Using a Fyke Net, October 5, 1994

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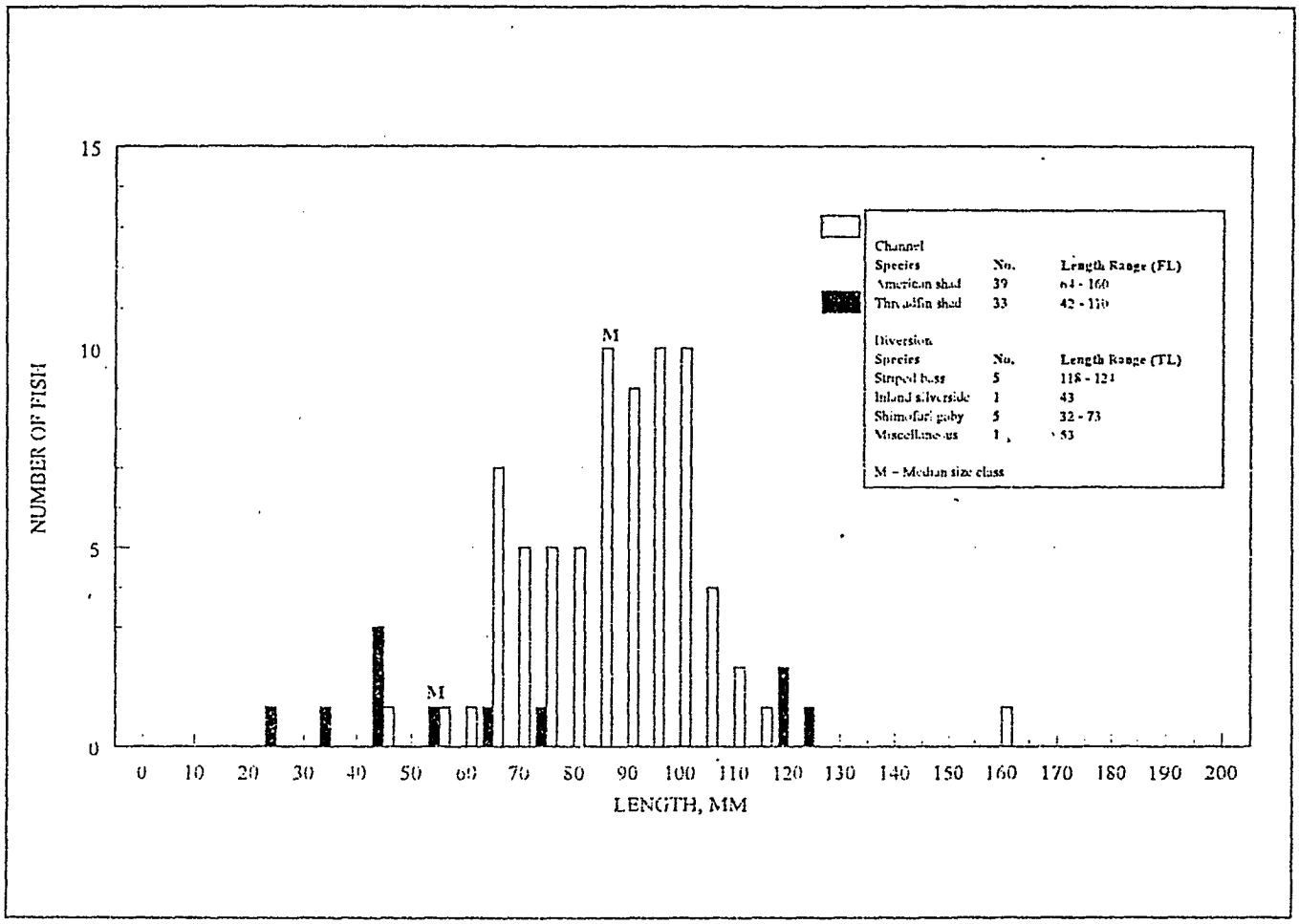

Figure 12
Length-Frequency Distributions of Fish Collected during Simultaneous Sampling at Diversion Site 1 (Twitchell Island) and Channel Site 49 (San Joaquin River at Oulton Point) Using a Fyke Net, October 17, 1994

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Appendices A-E

C-115740

C-115740

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APPENDIX A

Data about fish collected at the agricultural diversion on Bouldin Island (Site 10) by Department of Water Resources staff on 6 days between June 21 and August 20, 1993. Site 10 was a data collection site of the California Department of Fish and Game and the resulting data is presented in the Striped Bass Stamp Fund Agricultural Diversions Quarterly Report (DeLeon 1994) and in Monitoring of an Unscreened Agricultural Diversion on the San Joaquin River at McMullin Tract (Griffin 1993). Department of Water Resources personnel sampled the site to enable comparison of species composition and abundance with the sites included as part of the Interagency Ecological Program's Delta Agricultural Diversion Evaluation but were unable to sample frequently enough to collect a sufficient data set.

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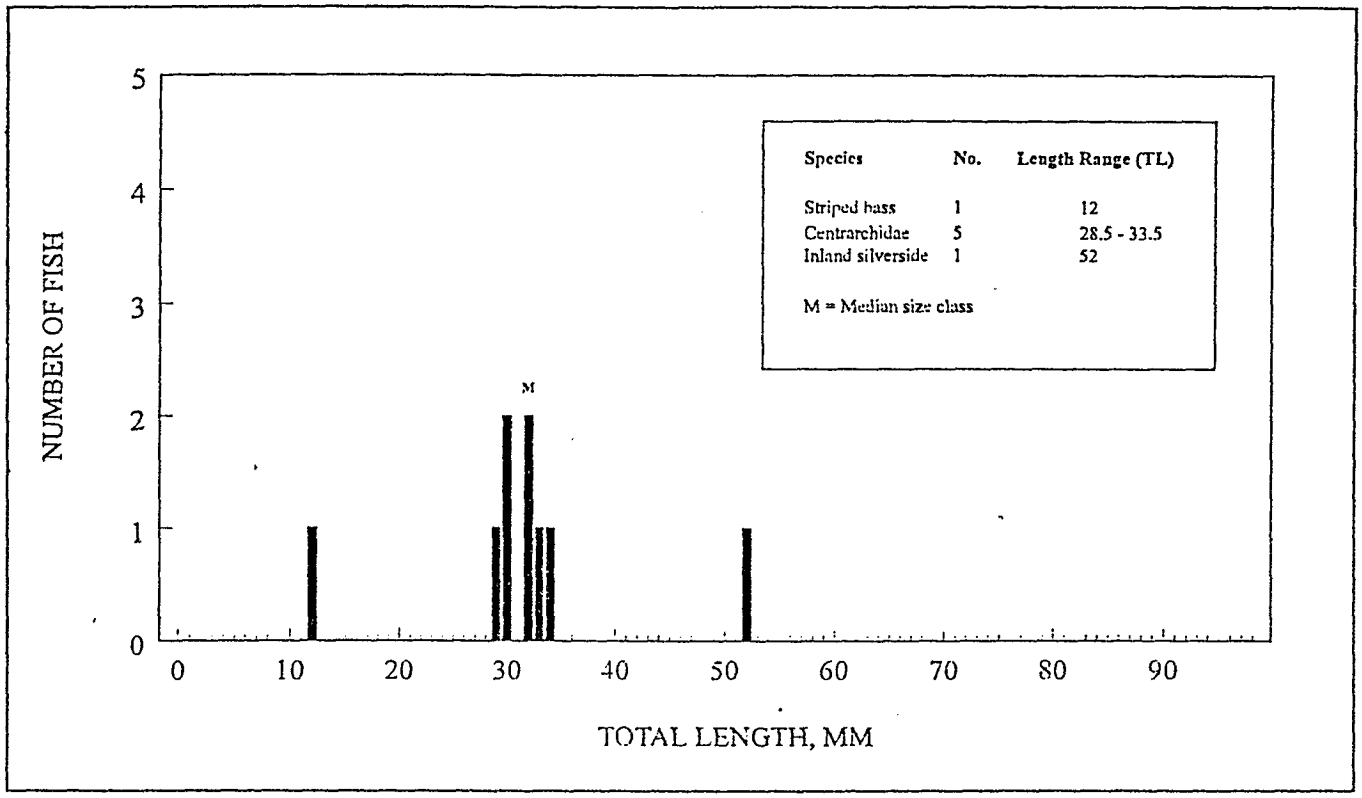

Figure A-1
Length-Frequency Distributions of All Fish Collected at Diversion Site 10 (Bouldin Island), June 21 through August 20, 1993

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APPENDIX B

Data about early-life stage fish captured in 505-micron mesh egg and larval nets in the years 1993 through 1995 at channel sites 49, 93, and 932 (near study Sites 1 (Twitchell Island), 4 (Naglee Burk) and 2 (Bacon Island's 16 inch siphon)), respectively. Data is included to provide additional qualitative information about relative numbers and total catches of species and how these may vary across time and space.

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Table B - 1. Summary of Channel Sampling for Early-life Stage Fish Using a 505 Micron Mesh Egg and Larval Fish Net, 1993-1995

	1993	1994	1995
Site 49 - San Joaquin River at Oulton Point			
Sampling period	June 1 - July 15	February 11 - July 5	February 15 - July 10
Number of days sampled	20	42	20
Total Number of samples	20	42	20
Number of acre-feet sampled	1.35	5.35	3.82
Site 93 - Old River, downstream of Naglee Burk			
Sampling period	February 27 - July 5	February 11 - July 5	February 15 - June 1
Number of days sampled	33	46	22
Total Number of samples	33	46	22
Number of acre-feet sampled	4.26	7.52	4.36
Site 932 - Middle River at Bacon Island			
Sampling period	February 27 - July 15	February 11 - July 5	February 15 - June 1
Number of days sampled	35	43	17
Total Number of samples	35	43	17
Number of acre-feet sampled	3.69	6.54	3.44

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Table B - 2. Catch of Striped Bass Eggs and Early-life Stage Fish at Site 49 (San Joaquin River at Oulton Point) Using a 505 Micron Mesh Egg and Larval Fish Net, 1993 - 1995

	1993		1994		1995	
Striped Bass Eggs	Catch	CPUE	Catch	CPUE	Catch	CPUE
Morula	10	7.4	189	35.3	5	1.3
Early embryo	8	5.9	64	12.0	0	0
Late embryo	0	0	71	13.3	5	1.3
Dead	1	0.7	17	3.2	30	7.8
TOTAL	19	14.0	341	63.8	40	10.4

	1993		1994		1995	
Early-Life Stage Fish (Species)	Catch	CPUE	Catch	CPUE	Catch	CPUE
Striped bass	125	92.6	135	25.2	147	38.5
Longfin smelt	0	0	10	1.9	0	0
Delta smelt	2	1.5	102	19.1	6	1.6
Splittail	0	0	0	0	4	1.0
Yellowfin goby	0	0	1	0.2	0	0
Shimofuri goby	4	3.0	190	35.5	0	0
Threadfin shad	70	51.8	19	3.6	33	8.6
Prickly sculpin	8	5.9	992	185.4	962	251.8
Sacramento sucker	1	0.7	0	0	1	0.3
Bigscale logperch	0	0	7	1.3	35	9.2
Centrarchidae	0	0	11	2.1	30	7.8
Other	3	2.2	0	0	15	3.9
TOTAL	213	157.7	1,467	274.3	1,233	322.7

CPUE = catch per unit effort = catch per acre-foot of water sampled.

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Table B - 3. Catch of Striped Bass Eggs and Early-life Stage Fish at Site 93 (Old River Downstream of Naglee Burk) Using a 505 Micron Mesh Egg and Larval Fish Net, 1993 - 1995

	1993		1994		1995	
Striped Bass Eggs	Catch	CPUE	Catch	CPUE	Catch	CPUE
Morula	0	0	115	15.3	0	0
Early embryo	0	0	1	0.1	0	0
Late embryo	0	0	2	0.3	0	0
Dead	0	0	20	2.7	0	0
TOTAL	0	0	138	18.4	0	0

	1993		1994		1995	
Early-Life Stage Fish (Species)	Catch	CPUE	Catch	CPUE	Catch	CPUE
Chinook salmon	0	0	0	0	1	0.2
Striped bass	80	18.8	23	3.1	0	0
Longfin smelt	0	0	1	0.1	0	0
Delta smelt	0	0	4	0.5	1	0.2
Splittail	1	0.2	0	0	24	5.5
Shimofuri goby	696	163.4	3,770	501.3	0	0
Threadfin shad	664	155.9	161	21.4	39	8.9
Prickly sculpin	920	216.0	1,876	249.5	185	42.4
Sacramento sucker	1	0.2	1	0.1	2	0.5
Bigscale logperch	28	6.6	11	1.5	7	1.6
Cyprinidae	0	0	6	0.8	0	0
Centrarchidae	30	7.0	3	0.4	82	18.8
Other	14	3.3	2	0.3	321	73.6
TOTAL	2,434	571.4	5,858	779.0	662	151.7

CPUE = catch per unit effort = catch per acre-foot of water sampled.

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Table B - 4. Catch of Early-life Stage Fish at Site 932 (Middle River at Bacon Island) Using a 505 Micron Mesh Egg and Larval Fish Net, 1993 - 1995

	1993		1994		1995	
Early-Life Stage Fish (Species)	Catch	CPUE	Catch	CPUE	Catch	CPUE
Striped bass	97	26.3	108	16.5	0	0
Longfin smelt	0	0	4	0.6	2	0.6
Delta smelt	4	1.1	12	1.8	0	0
Splittail	0	0	0	0	2	0.6
Yellowfin goby	0	0	1	0.2	0	0
Shimofuri goby	166	45.0	958	146.5	0	0
Threadfin shad	78	21.1	179	27.4	11	3.2
Prickly sculpin	1,752	474.8	2,898	443.1	494	143.6
Sacramento sucker	0	0	0	0	0	0
Bigscale logperch	25	6.8	12	1.8	16	4.6
Centrarchidae	22	6.0	29	4.4	23	6.7
Other	3	0.8	2	0.3	53	15.4
TOTAL	2,147	581.9	4,203	642.6	601	174.7

CPUE = catch per unit effort = catch per acre-foot of water sampled.

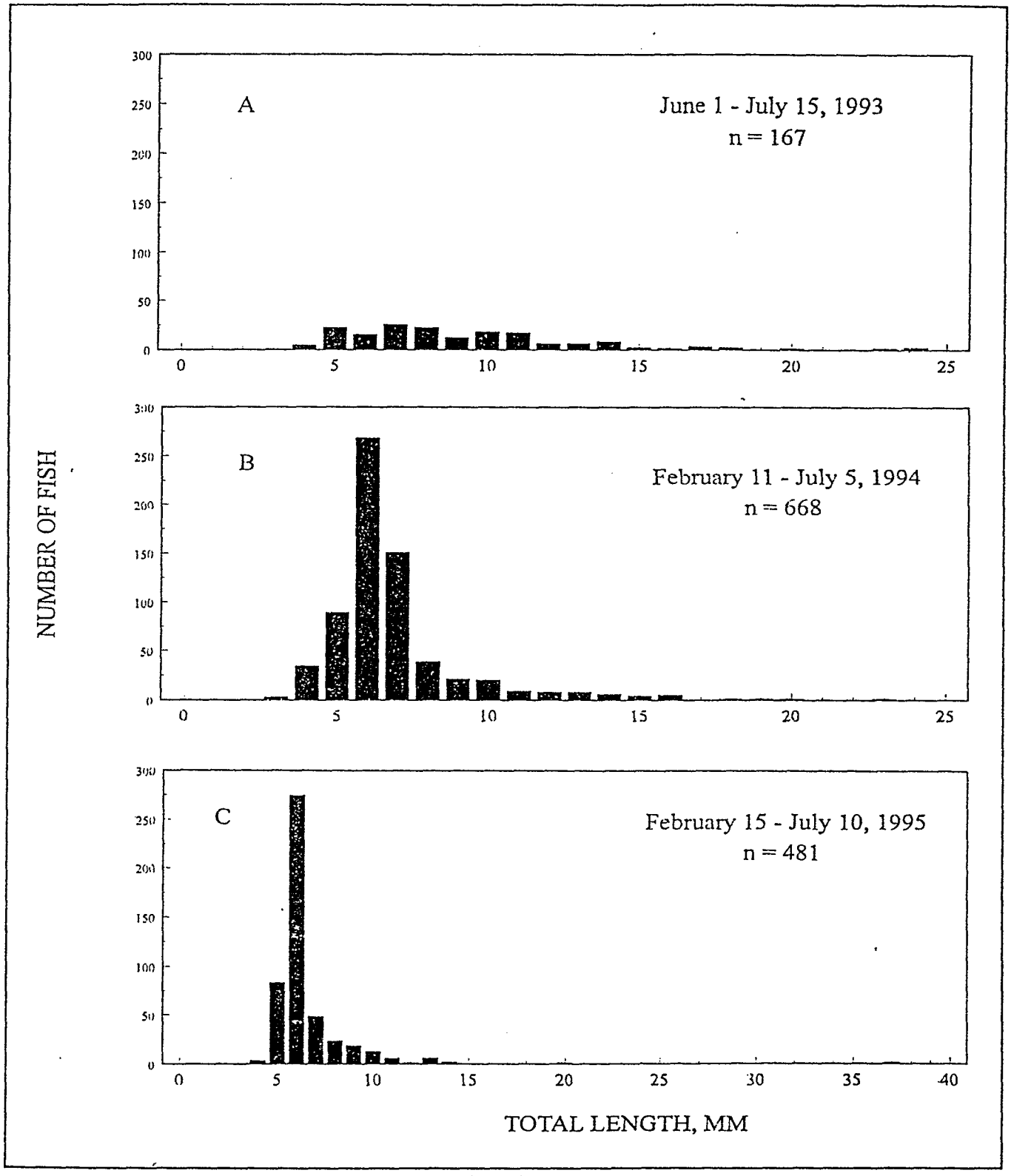

Figure B-1
Length-Frequency Distributions of Early-life Stage Fish Collected at Channel 49 (San Joaquin River) Using a 505 Micron Mesh Egg and Larval Fish Net, 1993-1995

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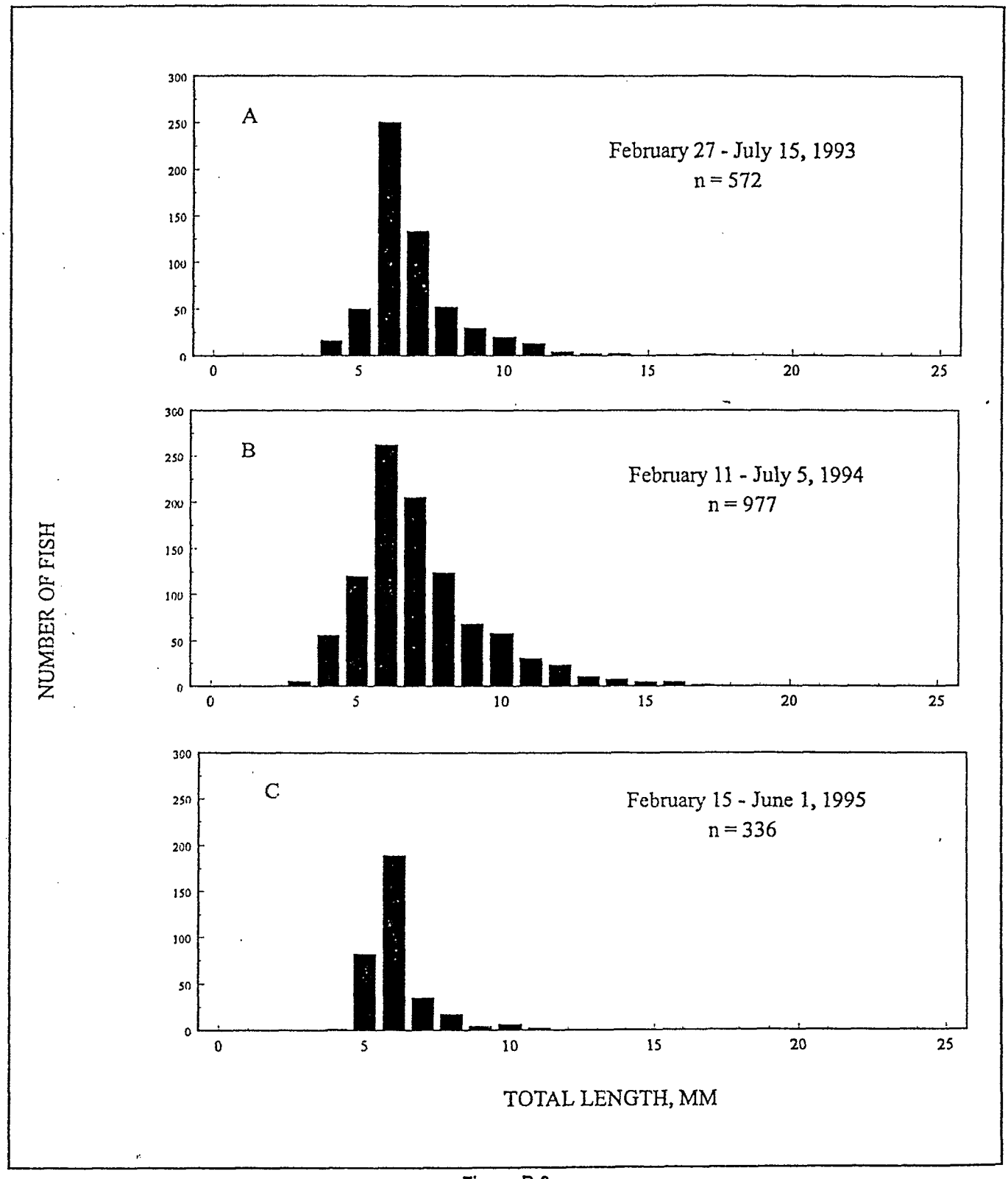

Figure B-2
Length-Frequency Distributions of Early-life Stage Fish Collected at Channel Site 932 (Middle River) Using a 505 Micron Mesh Egg and Larval Fish Net, 1993-1995

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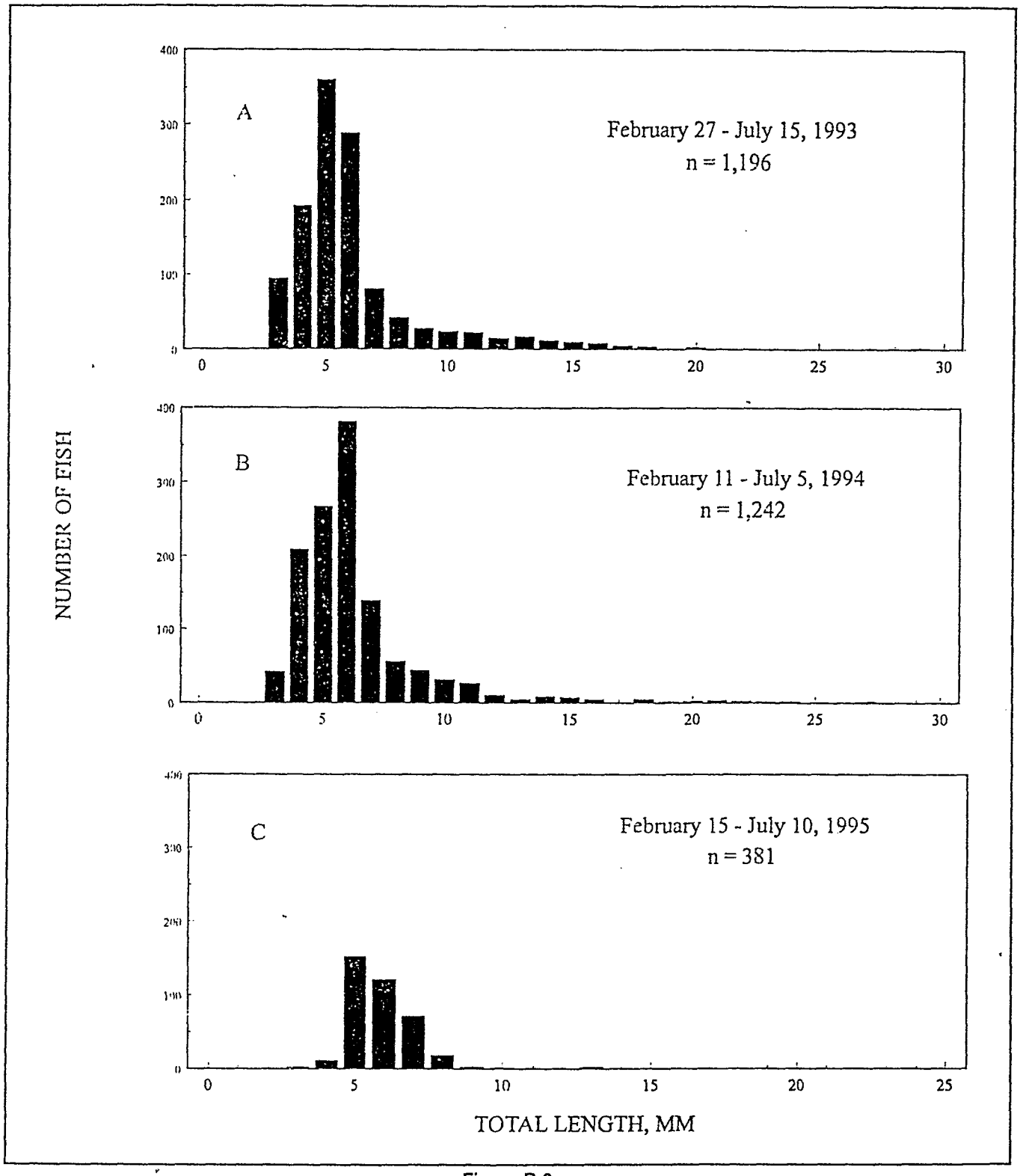

Figure B-3
Length-Frequency Distributions of Early-life Stage Fish Collected at Channel Site 93 (Old River) Using a 505 Micron Mesh Egg and Larval Fish Net, 1993-1995

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APPENDIX C

Data about later-life stage fish captured in channels in 1993 at Sites 49 and 932 near diversion Sites 1 and 2, respectively. Sampling was conducted using midwater trawls, townets and otter trawls. Sampling effort was limited but the data are included to provide additional qualitative information about the relative number and total catch of species and how they may vary across sites. Gear efficiencies in channels can be low and highly variable. Gear type may also account for a portion of the variance between catches using different gear.

Table C - 1. Catch and Catch Per Unit Effort of Later-life Stage Fish (≥ 30 MM TL) at Channel Sites 49 (San Joaquin River At Oulton Point) and 932 (Middle River At Bacon Island) Using a Midwater Trawl, 1993

Summary of Sampling

	Site 49 San Joaquin River at Oulton Point	Site 932 Middle River at Bacon Island
Sampling period	August 23 & September 27	August 24 & September 28
Number of days sampled	2	2
Total number of trawls	26	20
Total number of acre-feet sampled	166.28	129.54

Later-life Stage Fish Collected

Species	Catch	CPUE	Catch	CPUE
Striped bass	175	1.05	106	0.82
Delta smelt	1	0.01	0	0.0
American shad	279	1.68	209	1.61
Threadfin shad	89	0.53	223	1.72
Inland silverside	8	0.05	1	0.01
Yellowfin goby	1	0.01	0	0.0
Cyprinidae	0	0.0	1	0.01
Ictaluridae	0	0.0	31	0.24
Bigscale Logperch	0	0.0	5	0.04
Shimofuri goby	0	0.0	3	0.02
Cetrarchidae	0	0.0	28	0.22
TOTAL	553	3.3	607	4.7

CPUE = catch per unit effort = catch per acre-foot of water sampled.

Table C - 2. Catch and Catch Per Unit Effort of Later-life Stage Fish (≥ 30 MM TL) at Channel Sites 49 (San Joaquin River at Oulton Point) and 932 (Middle River At Bacon Island) Using a Townet, 1993

Summary of Sampling

	Site 49 San Joaquin River at Oulton Point	Site 932 Middle River at Bacon Island
Sampling period	June 2 - July 8	May 25 - July 8
Number of days sampled	7	7
Total number of tows	7	7
Total number of acre-feet sampled	N/A	N/A

Later-life Stage Fish Collected

Species	Catch	CPUE	Catch	CPUE
Striped bass	2	N/A	16	N/A

N/A = Not enough information available to calculate the volume sampled.

CPUE = catch per unit effort = catch per volume of water sampled.

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APPENDIX D

Catch and length frequency data for early-life stage fish captured at Sites 1 (Twitchell Island), 2B (Bacon Island's 14-inch simphon), and 4 (Naglee burk) in 1993 and 1994 as part of the Interagency Ecological Program's Delta Agricultural Diversion Evaluation.

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Table D-1. Catch and Catch Per Unit Effort of Early-life-Stage Fish at Site 1 (Twitchell Island), Site 2B (Bacon Island 14-Inch Siphon) and Site 4 (Naglee Burk) Using an Egg and Larval Net, 1993

	Site 1 Twitchell Island		Site 2B Bacon Island, 14" siphon		Site 4 Naglee Burk	
Species	Catch	CPUE	Catch	CPUE	Catch	CPUE
Delta smelt	0	0	0	0	0	0
Threadfin shad	7	368.4	12	279.1	114	491.4
Bigscale logperch	1	52.6	1	23.2	0	0
Shimofuri goby	0	0	1	23.2	60	258.6
Striped bass	0	0	1	23.2	1	4.3
Prickly sculpin	0	0	0	0	0	0
Centrarchidae	0	0	0	0	8	34.5
Cyprinidae	0	0	0	0	2	8.6
TOTAL	8	421.0	15	348.7	185	797.4

CPUE = catch per unit effort = catch per acre-foot of water sampled.

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Table D-2. Catch and Catch Per Unit Effort of Striped Bass Eggs and Early-life Stage Fish at Site 1 (Twitchell Island) Using an Egg and Larval Net, 1994

Striped Bass Eggs	Catch	CPUE
Morula	3	41.7
Early embryo	4	55.6
Late embryo	5	69.4
Dead	1	13.9
TOTAL	13	180.6

Early-Life-Stage Fish (Species)		
Striped bass	5	69.4
Yellowfin goby	2	27.8
Bigscale logperch	1	13.9
Prickly sculpin	8	111.1
Threadfin shad	0	0
Shimofuri goby	0	0
Centrarchidae	1	13.9
Cyprinidae	0	0
TOTAL	17	236.1

CPUE = catch per unit effort = catch per acre-foot of water sampled.

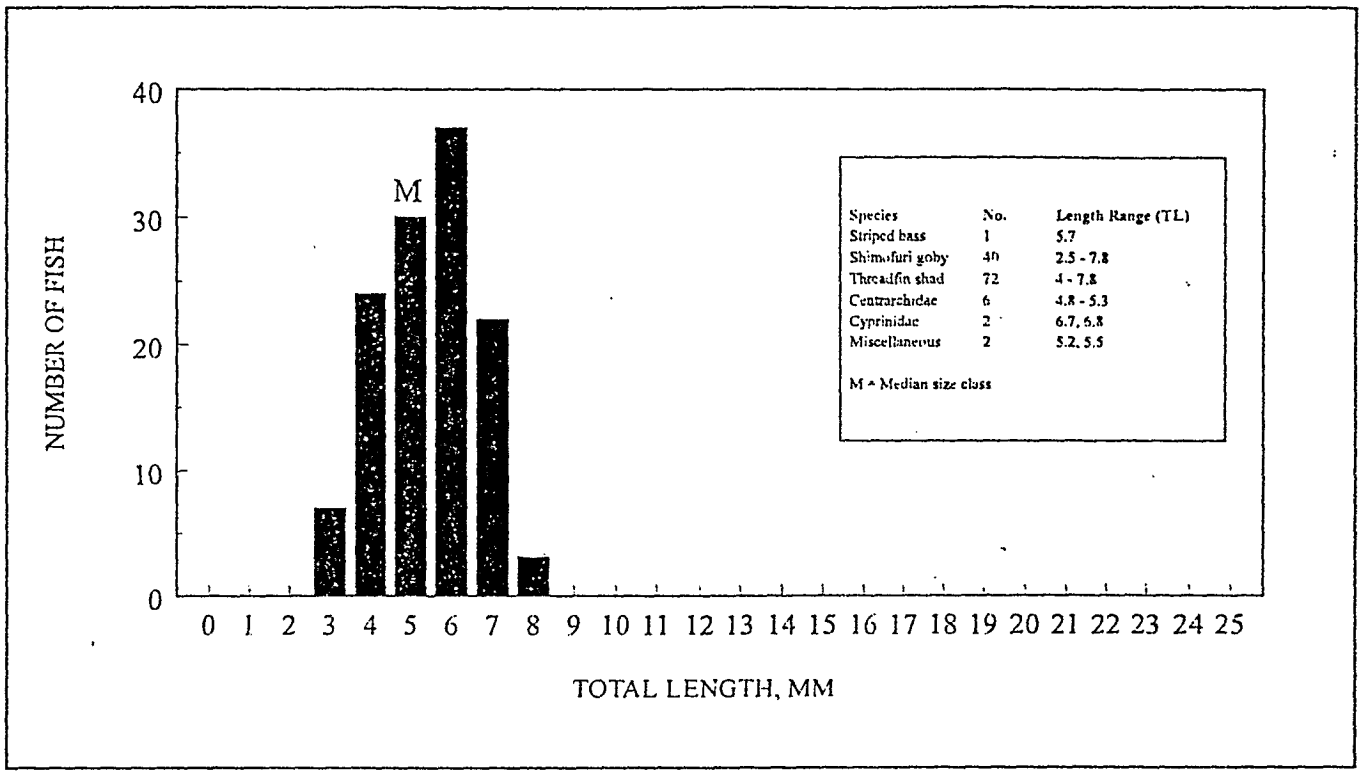

Figure D-3
Length-Frequency Distributions of Early-life Stage Fish Collected at Naglee Burk Using an Egg and Larval Net, 1993

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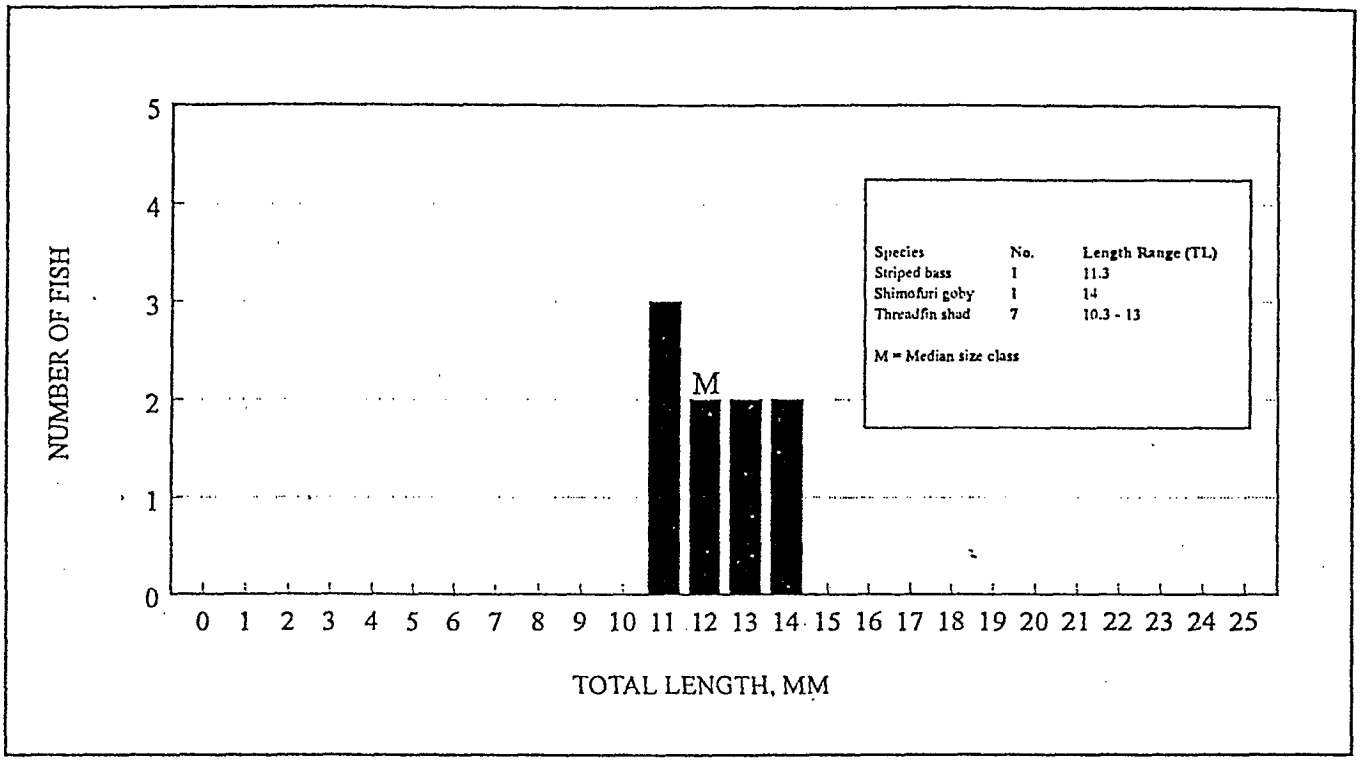

Figure D-2
Length-Frequency Distributions of Early-Life Stage Fish Collected at Site 2B (Bacon Island 14-inch Siphon) Using an Egg and Larval Net, 1993

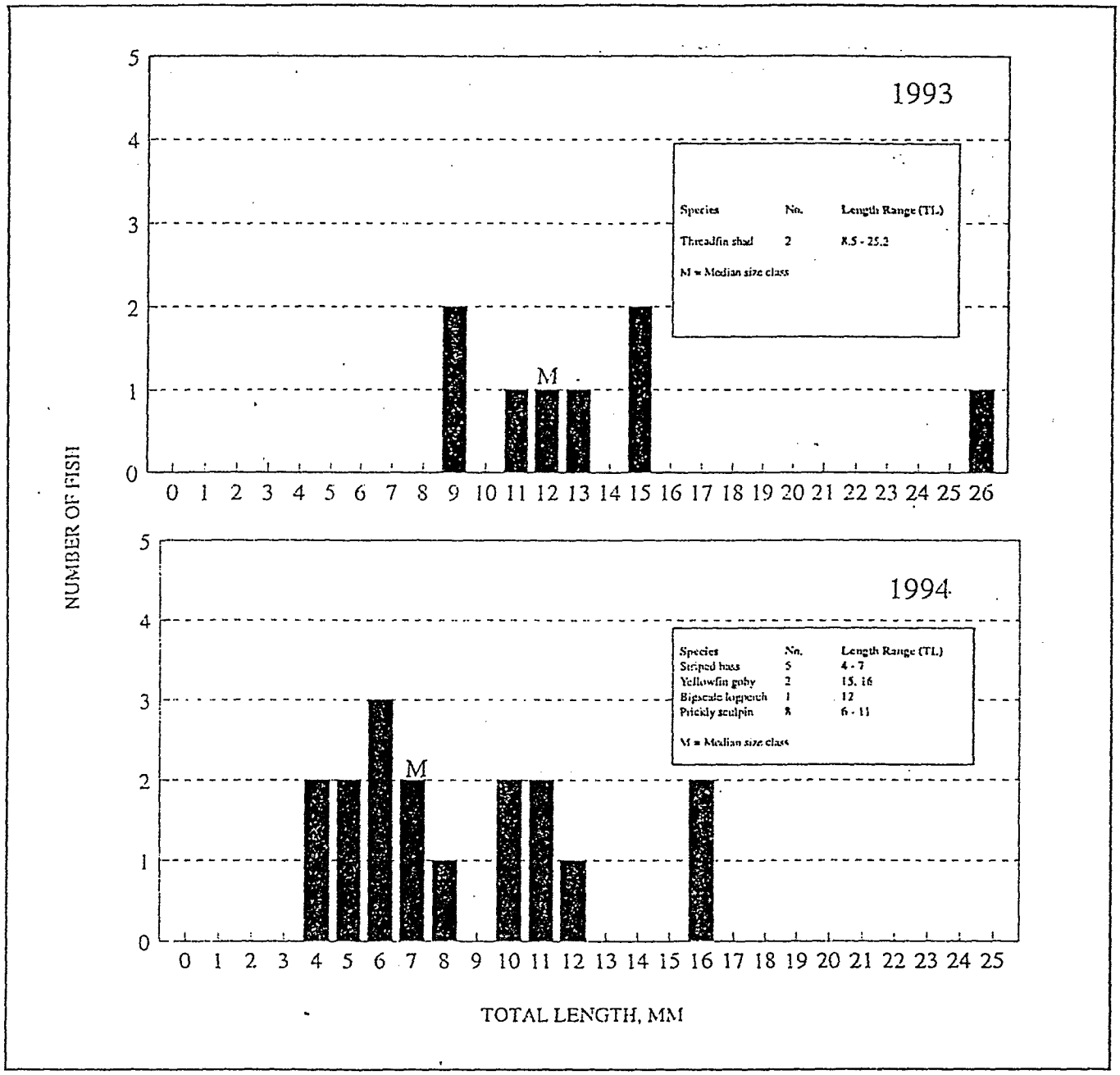

Figure D-1
Length-Frequency Distributions of Early-life Stage Fish Collected at Site 1 (Twitchell Island) Using an Egg and Larval Net, 1993-1994

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APPENDIX E

1993 and 1994 Lakos Screen Evaluation

A Lakos-Plum Creek self cleaning, rotating, cylindrical fish screen was tested for its effectiveness at reducing fish entrainment in an agricultural diversion during 1993 and 1994. The diversion was located on Bacon Island adjacent to Middle River in the southern Sacramento-San Joaquin Delta. Overall study results showed:

- In 1993 and 1994, the density of fish collected under screened conditions was significantly less than the density of fish collected under unscreened conditions, with P.05 (n=30) and P.05 (n=54), respectively.
- Screen efficiency varied depending on the species of fish and life stage. In general, from spring through summer as fish grew in length, screen efficiency improved, as indicated by a decrease in entrainment.
- The self-cleaning Lakos-Plum Creek screen (2.3 mm square mesh, 0.045 mm wire diameter, 68.72 percent open area) was highly effective at reducing entrainment of fish over 20 mm TL.
- For the Lakos screen to be considered effective, it has to reduce fish loss and provide reliable operation. The screen significantly reduced entrainment; however, operational problems occurred with the siphon and spray bar system. Mortality resulting from impingement was not measured.

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1993 AND 1994 LAKOS SCREEN EVALUATION

Katie Wadsworth

Department of Water Resources

May 1996

Introduction

In 1992, the Department of Water Resources (DWR) and Department of Fish and Game (DFG) implemented the Delta Agricultural Diversion Evaluation to develop reliable estimates of fish entrainment to agricultural diversions in the delta during the irrigation season, April through August. One component of the study was to test the effectiveness of a Lakos-Plum Creek self-cleaning fish screen on a 16-inch siphon at Bacon Island.

The 1993 and 1994 agricultural diversion screen tests took place in the central delta on the eastern side of Bacon Island, adjacent to Middle River (Figure 1). The Lakos-Plum Creek design (Model No. 3424-95512) had four self-cleaning, rotating, cylindrical screens constructed of 0.045 mm diameter phosphor bronze wire with 2.3 mm square mesh and 68.72 percent open area. The study was designed to determine the overall effectiveness of the Lakos screen design at reducing entrainment of fish into a small (less than 20 cfs) agricultural diversion. Another purpose of the study was to determine the feasibility of screening other similar agricultural diversions in the delta with the Lakos screen design.

Site Preparation

Before the screen could be installed and operated on Bacon Island, permission was obtained from the land owner. Electrical power was brought to the site and extensions and other special adjustments were made to the siphon. The screen backwash pump and electricity outlet box were enclosed with a chain link fence for safety and security reasons. The final cost of the Lakos fish screen at Bacon Island was $30,176.26, or approximately $2,011.75 per cfs when the siphon was operated at maximum capacity of 15 cfs.

Sampling Procedures

Sampling for juvenile and adult fish was conducted with and without the screen operating approximately once a week from June 3 through September 1, 1993, and April 26 through August 2, 1994. Sampling without the screen in place was achieved by raising the screen with the hand-winch until it was out of the water, and away from the diversion intake, and turning off the backwash pump. Conversely, screening the diversion was achieved by manually lowering the cylindrical drums with a hand-winch until the screen was in place over the intake, and then turning on the backwash pump for self-cleaning.

The screen test consisted of a paired sample of one hour under screened conditions and one hour under unscreened conditions. The order of screened to unscreened or unscreened to screened conditions was determined randomly. Most sampling was conducted during daylight hours for periods of four to eight hours. Night samples were collected through the tidal cycle over 24-hour sample periods one time during each of the sampling seasons. A total of 35 paired samples were collected in 1993 and a total of 54 paired samples were collected in 1994.

A fyke-type net constructed of one-eighth-inch mesh with live-box attached to the cod end was placed directly over the diversion outfall to sample one hundred percent of the diverted water during each test. Fish were identified to species, counted, and total length measured to the

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nearest mm. A flow meter (propeller type, Ketma McCrometer model MO300) installed in the diversion pipe measured diversion flow in cubic feet per second and total water volume diverted in acre-feet. Flowmeter readings were used to compute water volume sampled and fish densities entrained during each sample period.

Statistical evaluation of the data included the Wilcoxon signed ranks test, a nonparametric test based on the differences in paired observations, to determine the probability of a significant difference at the 0.05 level or 95 percent confidence (P=0.05) between the density of fish collected under screened and unscreened conditions. The Wilcoxon signed ranks test was also applied to individual species to determine if screening efficiency varied with species.

1993 Results Of Lakos Screen Study

Twelve species representing eight families were collected during screened and unscreened diversion sampling. All fish observed were introduced species. Striped bass were the most numerous, followed by threadfin shad, shimofuri goby, and yellowfin goby. No threatened or endangered species or species of special concern such as, delta smelt, winter-run chinook salmon, longfin smelt, or splittail, were collected during the 1993 screen test.

A total of 1,559 fish representing the twelve species was entrained in the diversion during the 15 days of 1993 screen testing. Of the 1,559 fish, 140 fish were collected with the screen in operation and 1,419 fish were collected without the screen in operation. For all species combined, the average number of fish entrained per acre-foot using the screen was 3.2, ranging between 0.0 and 20.6, while the average number of fish entrained per acre-foot without using the screen was 26.1, ranging from 0.0 to 184.8. Fish collected under screened conditions ranged in size from 4.5 - 51.0 mm total length (TL) (mean size 11.7 mm TL), while fish caught without the screen ranged in size from 3.5 - 347.0 mm TL (mean size 14.9 mm TL). Testing the two population means showed that the mean length of fish collected with the screen was significantly less (P.05) than the mean length of fish collected without the screen.

Results of the Wilcoxon signed ranks test indicate that the density of fish collected under screened conditions was significantly less (P.05, n=30) than the density of fish collected under unscreened conditions, with P-level equal to 0.001 (Table 1). In other words, the Lakos screen effectively reduced entrainment with greater than 95 percent certainty.

Separating out densities by species and applying the Wilcoxon signed ranks test showed that the Lakos screen significantly reduced entrainment of striped bass (mean length 15 mm TL), shimofuri goby (mean length 12 mm TL), bigscale logperch mean length 14 mm TL), and threadfin shad (mean length 11 mm TL)(Table 1). The screen did not significantly (P0.05) reduce entrainment of prickly sculpin (mean length 11 mm TL) and yellowfin goby (22 mm TL)(Table 1). An insufficient number of paired samples (n) to test with nonzero differences occurred for the following species: largemouth bass, white catfish, brown bullhead, fathead minnow, carp, and bluegill (Table 1).

While sampling with the screen, the average diversion flow rate was 11.6 cfs (range 8.2 to 13.3 cfs). Without the screen in operation, the average sampling diversion flow rate was 12.7 cfs (range 8.2 to 14.8 cfs). The average reduction in diversion flow was 8 percent with the screen in place relative to the average non-screen diversion flow.

1994 Results Of Lakos Screen Study

Similar to 1993, twelve species were entrained in the diversion during the 17 days of 1994 screen testing, with ten of the species remaining consistent between years. Staghorn sculpin and black crap-

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pie, entrained in 1994, were not seen in 1993.

Of the 357 fish collected in 1994, 68 fish were collected with the screen operating and 289 fish were collected without the screen. Striped bass were the most numerous, followed by shimofuri goby, threadfin shad, and prickly sculpin. No threatened or endangered or species of concern were collected during the 1994 screen test.

For all species combined, the average number of fish entrained per acre-foot with the screen was 0.10, with a range from 0.0 to 21.95, while the average number of fish entrained per acre-foot without the screen was 4.68, with a range from 0.0 to 35.11. Fish collected under screened conditions ranged in size from 7.5 - 29.0 mm TL (mean size 13.7 mm TL) while fish collected without the screen ranged in size from 4.7 - 335.0 mm TL (mean size 18.1 mm TL). The mean length of fish collected with the screen was significantly less (P.05) than the mean length of fish caught without the screen.

Wilcoxon signed ranks test results show that the density of fish collected under screened conditions was significantly less (P.05, n=37) than the density of fish collected under unscreened conditions (Table 1). Separating out densities by species and applying the Wilcoxon signed ranks test showed that the Lakos screen significantly reduced (P.05) entrainment of shimofuri goby (mean length 14 mm TL) and striped bass (mean length 14 mm TL) (Table 1). The screen did not significantly reduce (P0.05) entrainment of prickly sculpin (mean length 12 mm TL) and threadfin shad (mean length 14 mm TL) (Table 1). An insufficient number of paired samples (n) to test with nonzero differences occurred for the following species: bigscale logperch, yellowfin goby, staghorn sculpin, black crappie, carp, largemouth bass, white catfish, and bluegill (Table 1).

While sampling with the screen, the average diversion flow rate was 9.7 cfs (range 3.5 to 12.4 cfs). Without the screen in operation, the average diversion sampling flow rate was 10.5 cfs (range 3.1 to 13.7 cfs). The average reduction in diversion flow was 7 percent with the screen in place relative to the average non-screen diversion flow.

Discussion

The Lakos-Plum Creek Self-Cleaning Fish Screen reduced entrainment of fish into the 16-inch diversion on Bacon Island. However, screen efficiency varied depending on the species of fish and life stage. In general, from spring through summer in 1993 and 1994, screen efficiency improved and entrainment decreased as fish grew in length.

In 1993, the 140 fish collected under screened conditions were less than or equal to 20.0 mm TL, except for one yellowfin goby that measured 51.0 mm TL (Figure 2). Most likely, the larger yellowfin goby was entrained before the screen was lowered into place, and became stuck in the siphon or net, then later appeared in the live-box. In 1994, the 68 fish collected under screened conditions were 29.0 mm TL and smaller (Figure 3). Overall, the Lakos screen was highly effective at reducing entrainment of fish over 20.0 mm TL (Figure 2 and 3).

Although impingement mortality was not measured, past studies have indicated that approach velocities of 0.2 feet per second or lower, and sweeping velocities no greater than 0.37 feet per second, are required to prevent impingement and increased mortality of more sensitive species and life stages. Past test results were based on the swimming ability and impingement of larval and juvenile American shad and striped bass.

Average velocity through the Lakos screen was estimated to be 0.21 feet per second at the maximum diversion flow of 15 cfs. However, the diversion flow was generally less than 15 cfs during the 1993 and 1994 screen test, which would reduce the screen velocity. No measurements were taken of channel velocities sweeping

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past the test screen during 1993 and 1994 testing.

If fish avoid entrainment, the assumption is that fish survive. However, the possibility of impingement exists, along with the potential impacts of the backwash spray. If the backwash system results in physical injury to the fish, acute or delayed mortality may occur due to injuries or increased vulnerability to predation. Vulnerability to predation could also increase if the fish becomes too disoriented to escape or evade predators.

Flow alterations were noted by the farmer. Flow rate declined by as much as 1.5 cfs when the screen was in position on the end of the diversion pipe. Although the increase and decrease in flow due to operation of the screen did not appear to impact production or growth of potatoes, corn, and sunflowers grown on the island, it is important to note that the screen operation does impact diversion flow.

Operational problems occurred when the siphon lost prime several times from a leak in the backwash system, resulting in no screen sampling during July 1994. Also, fresh water sponge growths periodically blocked the spray jets so that the self-cleaning backwash system did not work properly. The jets needed to be unplugged manually two separate times in 1994. These features of the siphon and screen, in particular, would need to be addressed for maintenance criteria and reliability before the screen could be used on a widespread basis in the Delta.

Recommendations And Conclusions

The feasibility of test screening other small diversions in the Delta is questionable. Accessibility to properties and diversions, as well as obtaining permission from individual land owners to install and monitor screens is necessary. After electricity is brought to the site for operation of the screen, appropriate safety and security measures are also required. Finally, due to the problems that arose during the testing of the screen, a routine maintenance program is needed to ensure that a screen is working properly and meets current screen approach velocity criteria.

Table E-1. Paired Comparisons of Fish Densities Collected under Screened and Unscreened Conditions

Species	1993 Screen Test	1994 Screen Test
Striped Bass	P=0.000, n=24	P=0.005, n=22
Shimofuri Goby	P=0.000, n=24	P=0.000, n=33
Yellowfin Goby	P=0.463, n=6	* n=3
Prickly Sculpin	P=0.075, n=6	P=0.207, n=8
Bigscale Logperch	P=0.012, n=8	* n=3
Threadfin Shad	P=0.002, n=24	P=0.328, n=11
Largemouth Bass	* n=3	* n=2
White Catfish	* n=2	* n=3
Brown Bullhead	* n=3	* n=0
Fathead Minnow	* n=1	* n=0
Carp	* n=1	* n=1
Staghorn Sculpin	* n=0	* n=3
Black Crappie	* n=0	* n=1
Bluegill	* n=2	* n=1
All Species Combined	P=0.001, n=30	P=0.001, n=37

Values shown are the significance levels from the Wilcoxon Signed Ranks Test. An asterisk indicates zero catch during paired sampling or an insufficient number of paired samples (n) to test with nonzero differences.

Ho: The density of fish collected under screened conditions is not significantly less than the density of fish collected under unscreened conditions.

Ha: The density of fish collected under screened conditions is significantly less than the density of fish collected under unscreened conditions at a confidence level of 95% (P.05).

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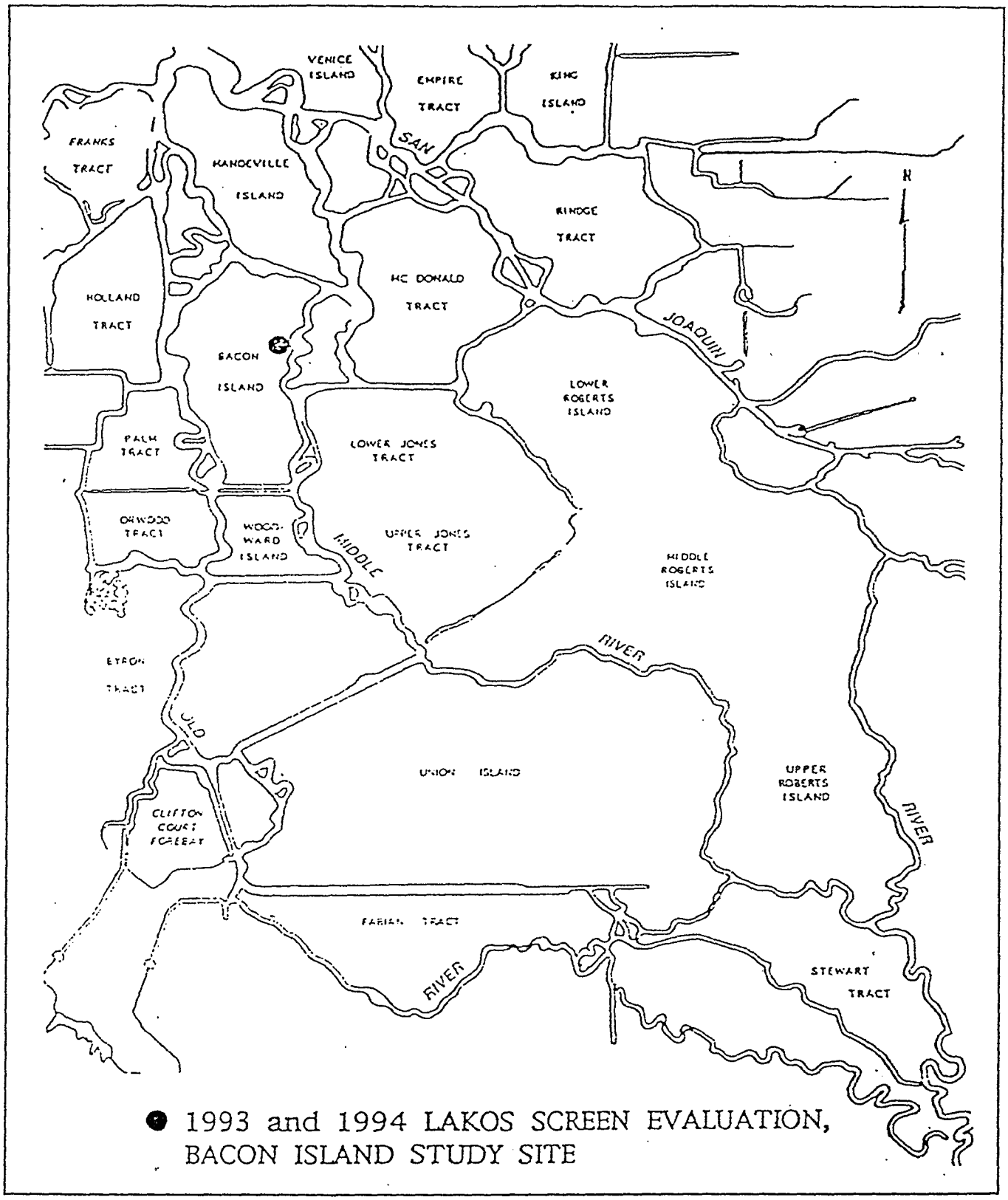

Figure E-1
Location of the 1993 and 1994 Lakos Screen Study Site, Bacon Island

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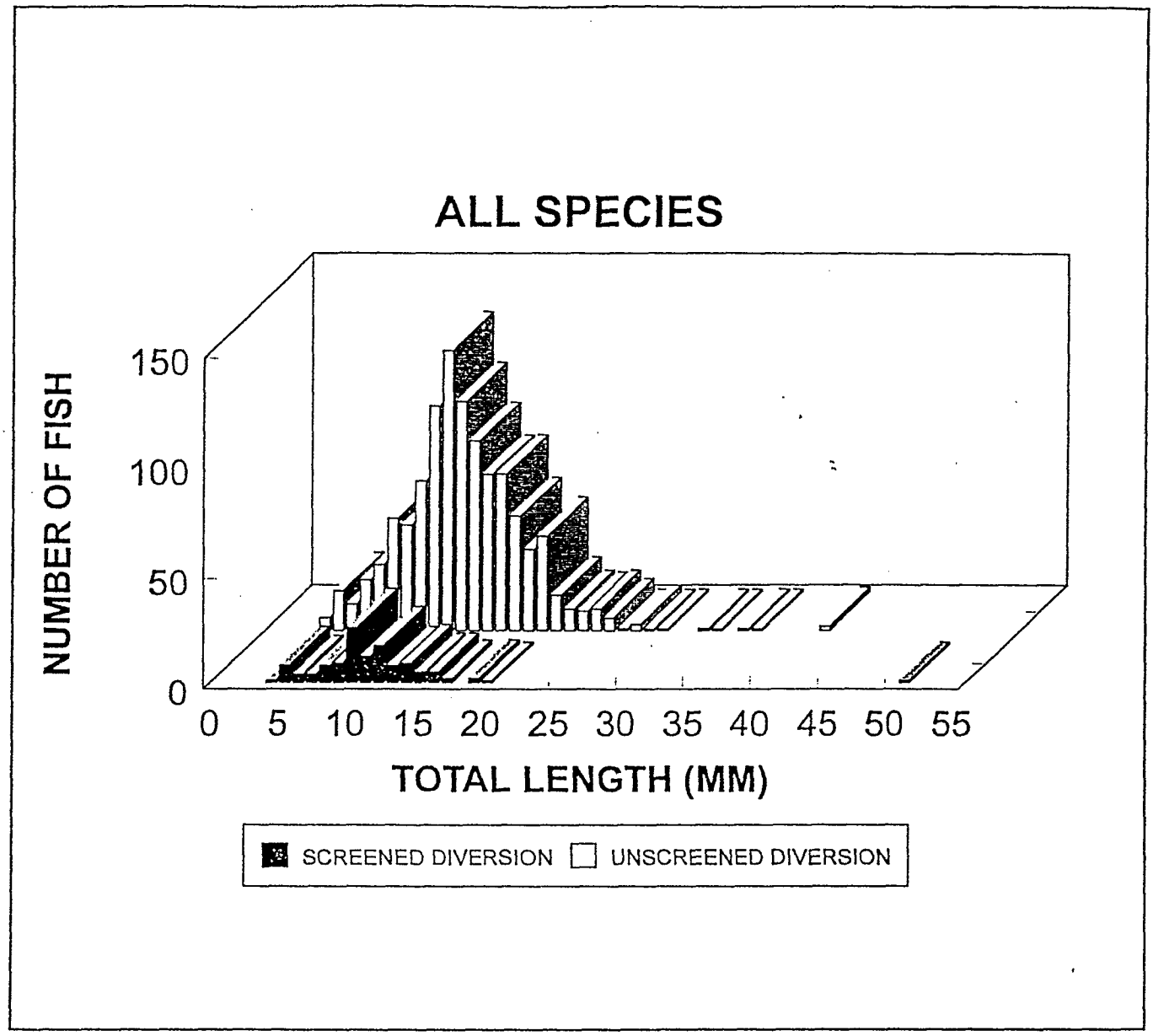

Figure E-2
Length-Frequency Distribution of 5-55 mm TL Fish under Screened and Unscreened Conditions at Bacon Island Study Site, 1993

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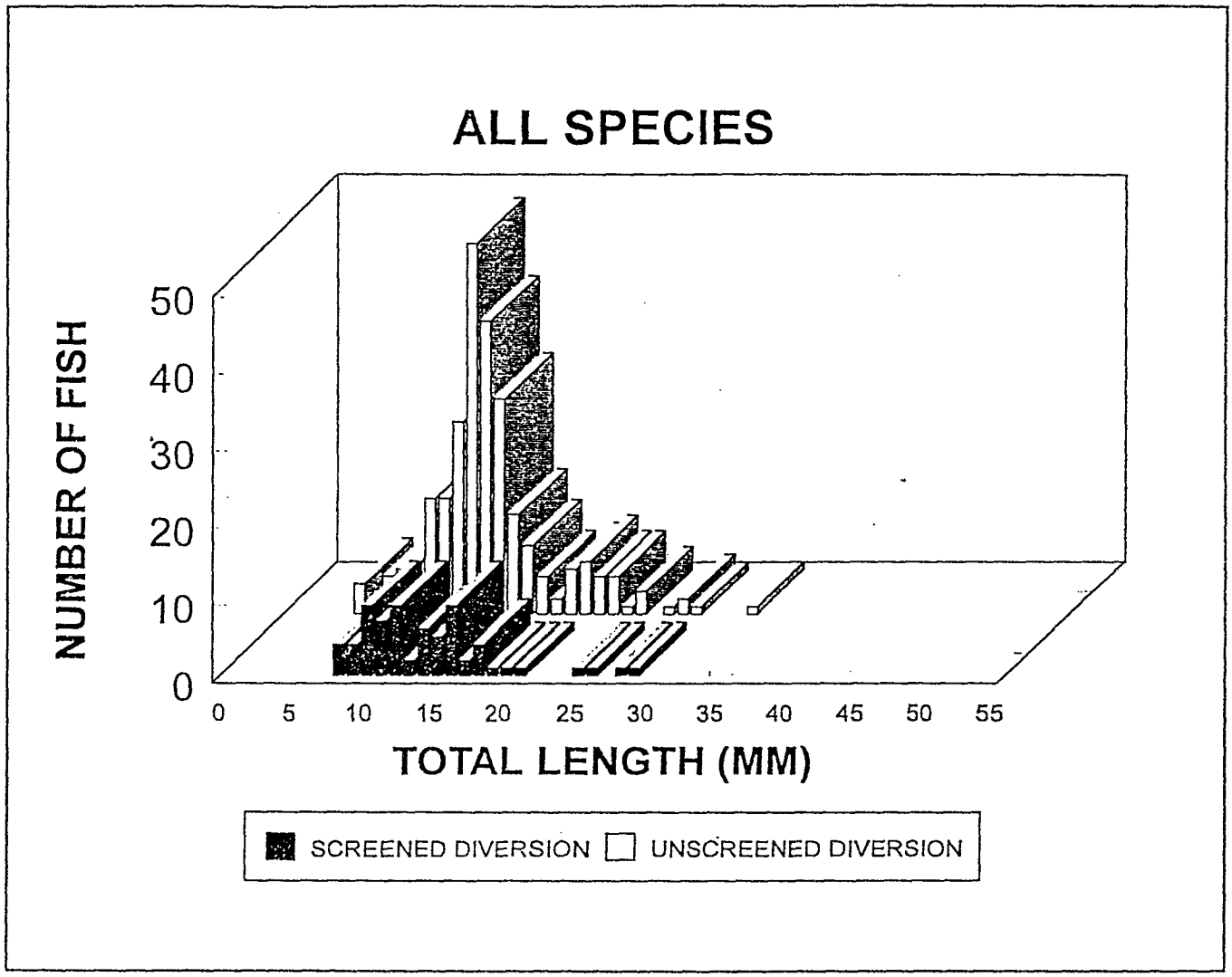

Figure E-3
Length-Frequency Distribution of 5-55 mm TL Fish under Screened and Unscreened Conditions at the Bacon Island Study Site, 1994

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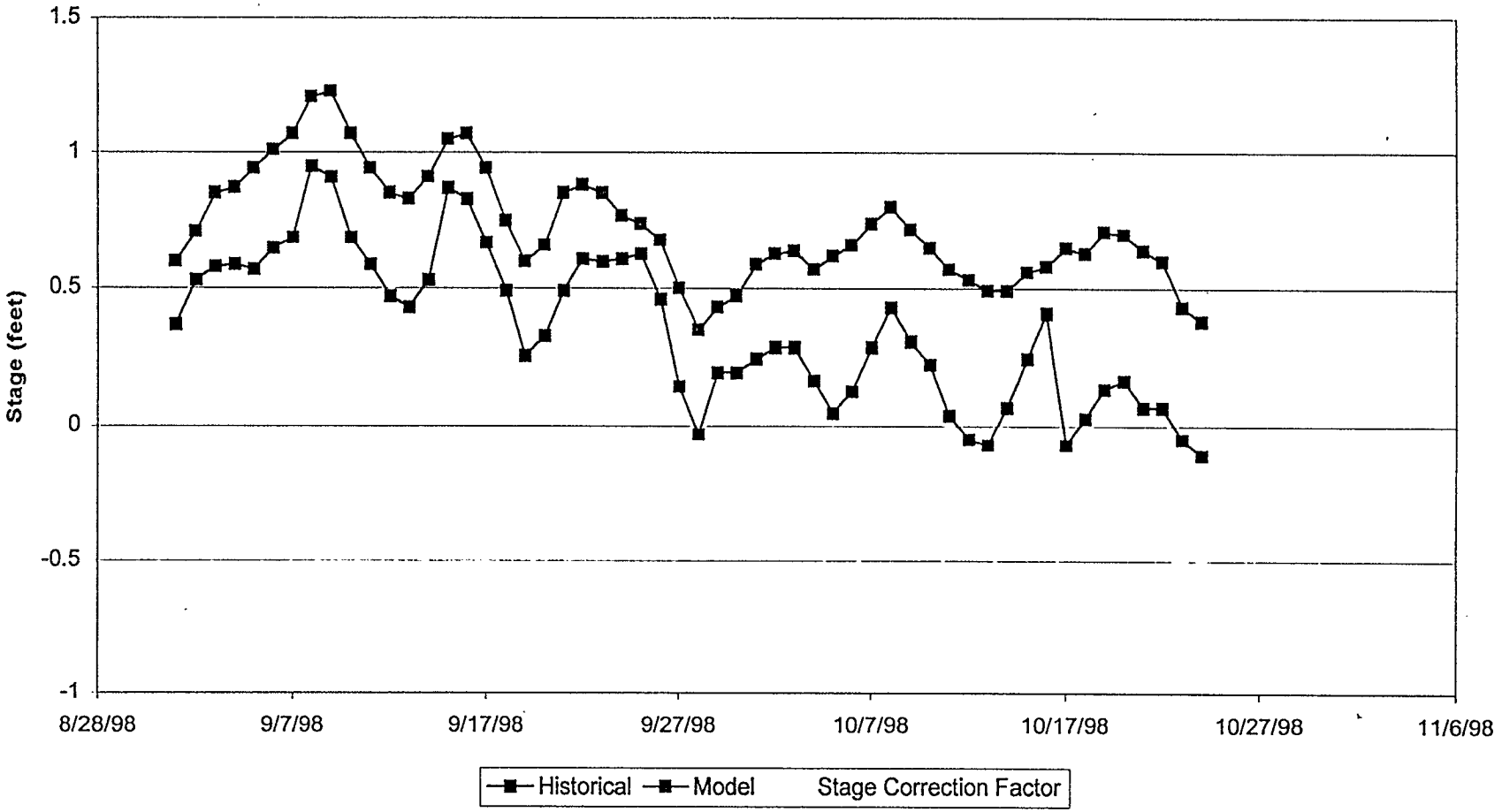
Model Tide, Historical Tide, Historical - Model Tide Stage
Low Low Tides
Grant Line Canal
September 1 - October 24 1998
BOTH BANKS (SWP) AND TRACY (CVP) PUMPING



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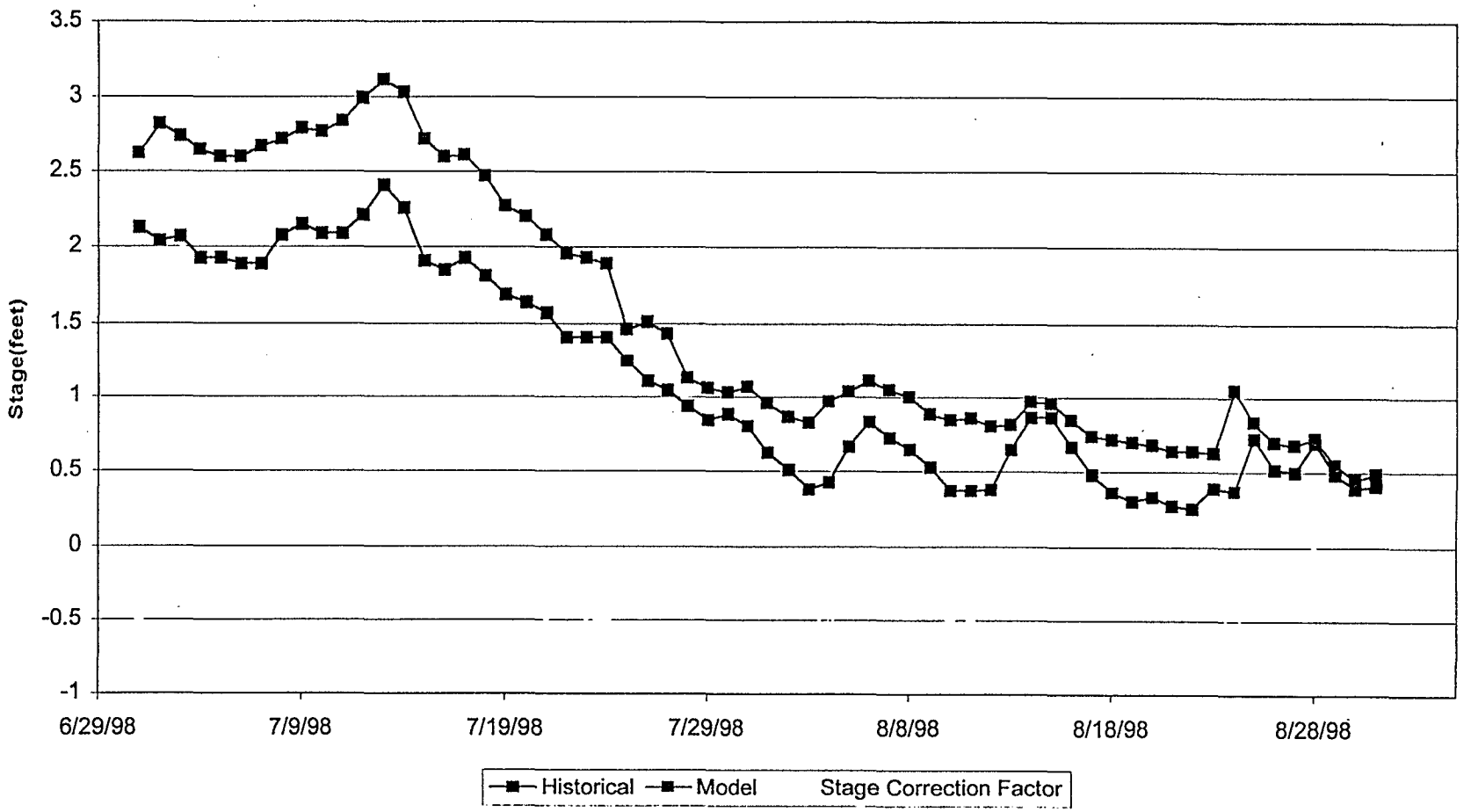
Model Tide, Historical Tide, Historical - Model Tide Stage
Low Low Tides
Grant Line Canal
July 1 - August 31 1998
BOTH BANKS (SWP) AND TRACY (CVP) PUMPING



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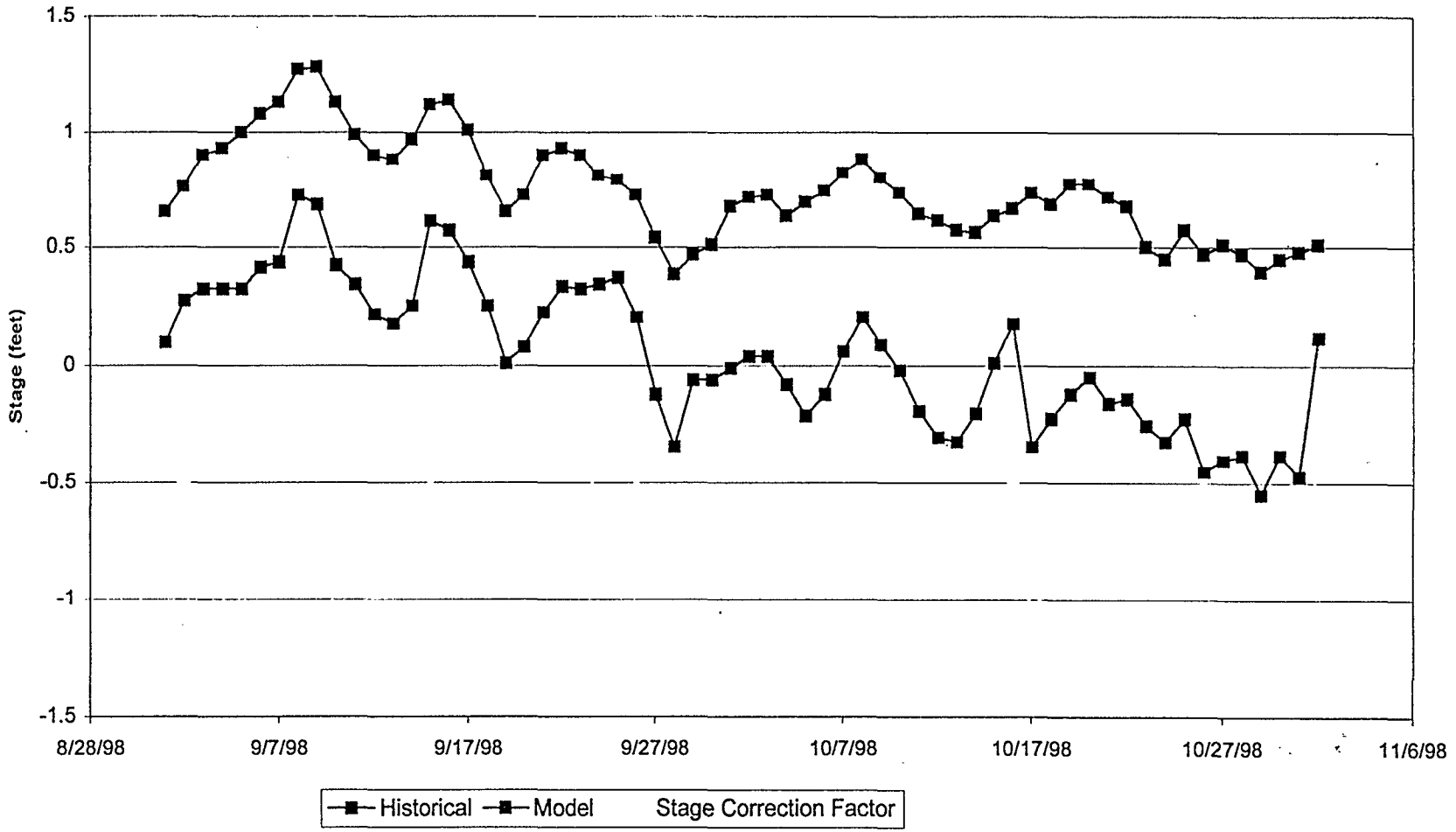
Model Tide, Historical Tide, Historical - Model Tide Stage
Low Low Tides
Old River at Tracy
September 1 - October 31, 1998
BOTH BANKS (SWP) AND TRACY (CVP) PUMPING



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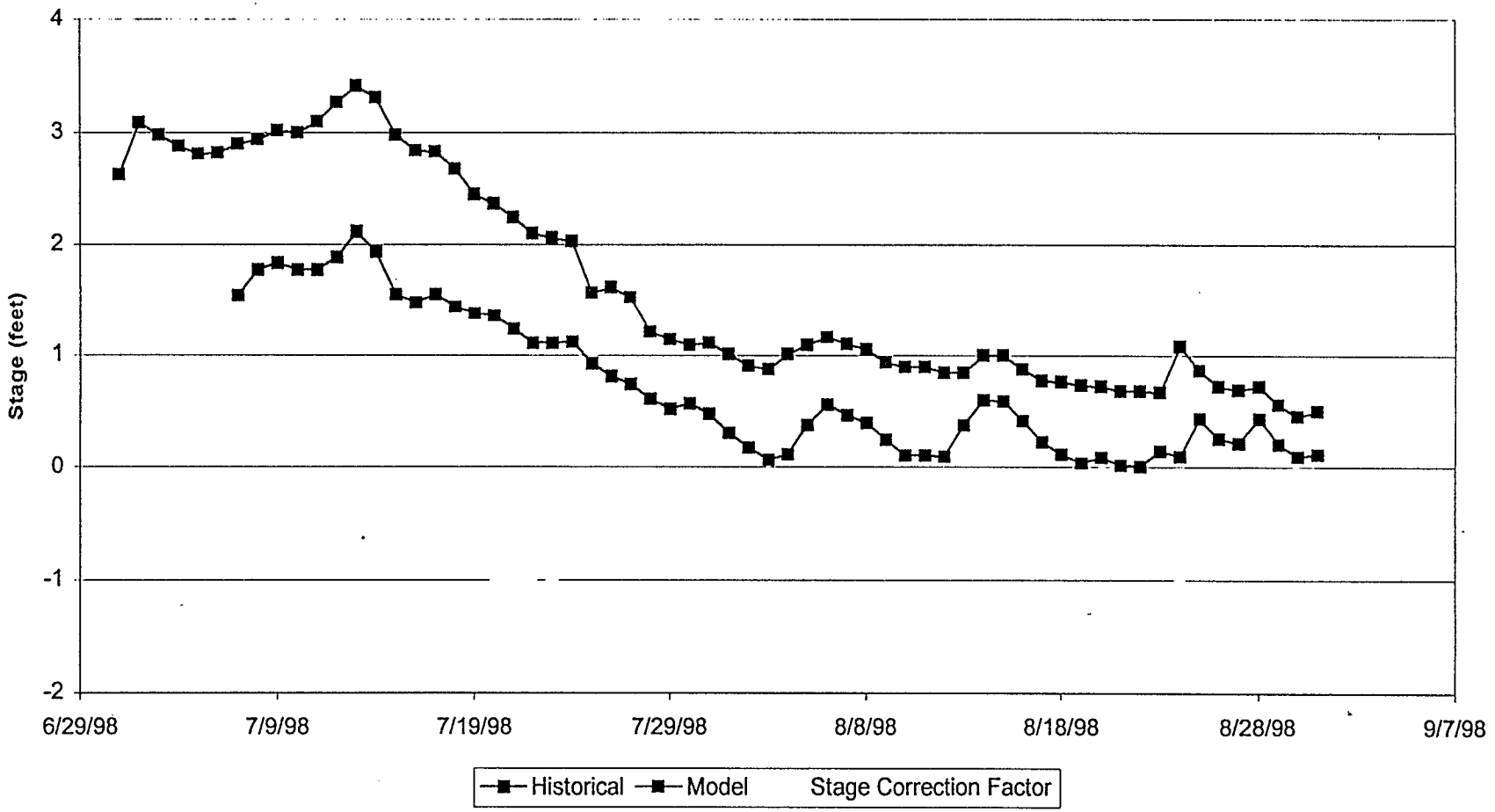
Model Tide, Historical Tide, Historical-Model Tide Stage
Low Low Tides
Old River at Tracy
July 1 - August 31 1998
BOTH BANKS (SWP) AND TRACY (CVP) PUMPING



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TESTIMONY OF ALEX HILDEBRAND IN SUPPORT OF SOUTH DELTA WATER AGENCY'S PHASE 2A CASE IN CHIEF

Phase 2A seeks to evaluate and compare all of the Alternatives in the Draft EIR for Implementation of the 1995 Water Quality Control Plan, especially comparing the alternatives with Alternative 8, the SJRA proposal. SDWA would like to first propose a method of implementing one of the Alternatives and then compare it with the other Alternatives including the SJRA. It is my understanding that the Central Delta Water Agency will be joining in on portions of the proposals herein.

SDWA offers the following comprehensive water management plan for the San Joaquin River watershed ("Comprehensive Plan") as a method of implementing the 1995 Water Quality Control Plan and meeting all of the Objectives therein with the minimum amount of impact to any water user.

This proposal is generally Flow Alternative No. 2 (USBR and DWR being responsible for the 95 Plan Obligations) but with certain significant changes and restrictions so that discretionary decisions by the USBR are limited in order to avoid adverse impacts to other interests. Alternative 2 is appropriate and consistent with SDWA's previous position that before any other interest be charged with obligations to improve fisheries and water quality, the Bureau must first mitigate its adverse impacts thereon.

The 1980 Report on the Effects of the CVP Upon the Southern Delta Water Supply (SDWA No. 48) clearly describes the Bureau's adverse impacts on both quality and flow in the San Joaquin River. The Bureau and the State's impacts on fisheries are clearly evidenced by the large numbers of fish entrained and killed at the pumps (see DFG and USF&WS websites). The projects in fact operate under biological opinions that require decreases or actual cessation of export pumps after certain numbers of endangered or threatened species are killed.

SDWA's Comprehensive Plan includes the following objectives:

1) Provide the full proposed VAMP flows at Vernalis in all years with the April/May 31-day pulse flow never below 3,200 cfs.

2) Meet the Vernalis salinity standard at all times in all years.

3) Provide substantial protection for downstream salmon smolt migration throughout the migration period and not just for 31 days. (35% of the migration was alleged in expert testimony before the SWRCB to occur before and after the 31-day Vernalis pulse flow).

4) Provide improved flow and lowered selenium and salinity concentrations in the San Joaquin mainstem from Mud Slough to the mouth of the Tuolumne in order to benefit fisheries and protect those parties who divert from this reach of the river. (Phase 2 testimony by

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biologists and fishery experts revealed that there has been no analysis of the effect of these high concentrations in the river on salmon smolts).

5) Maintain adequate Vernalis flow, particularly in the summer, to meet channel depletion needs in the South Delta (riparian and public trust needs).

6) Reduce the salinity in the Delta Mendota Canal (DMC) in order to reduce the salt load delivered to the Westside Service Area and to reduce the drainage salt load that then reaches the San Joaquin River, thereby reducing the need for dilution water to meet the Vernalis salinity standard.

7) Minimize both the dollar and water cost of providing the desired Vernalis April/May pulsed flow.

8) Avoid water acquisitions that impact water users downstream of the sellers and/or export water users other than water sellers.

9) Facilitate a quick transition from salmon and export protection to endangered species protection whenever an export "take limit" would otherwise be exceeded.

Description of Comprehensive Plan

SDWA's Comprehensive Plan seeks to provide the necessary flows for fishery and water quality from three potential sources: (1) recirculation and/or (2) purchases from export users and/or (3) water currently being provided outside of the Bureau's permitted areas of use. The water will be provided at times and in a manner to maximize multiple beneficial uses and thereby use water efficiently.

SDWA's Comprehensive Plan also includes the coordination of the initial spring-time drainage from the west side of the San Joaquin Valley (areas served by export water) in order to take advantage of the dilution capacity of the San Joaquin River during the pulse flow. SDWA's Comprehensive Plan also requires the operation of the three South Delta tidal barriers in conjunction with export pumping (in order to fully protect superior water rights in the Delta on a real time basis). Furthermore, it benefits out-migrating smolts in times other than the 31-day pulse period, decreases exportation of salt, and improves South Delta channel circulation.

SDWA's Comprehensive Plan also insures the Vernalis Water Quality Standard is met at all times as well as providing channel depletion flows which include public trust needs.

SDWA's Comprehensive Plan limits the USBR and DWR operations by placing restrictions on their relevant permits such that those entities would have to show ahead of time how and where they would provide the water. If they could not show this ahead of time or did not meet any Objective in the 1995 WQCP, then their ability to store or export water would be curtailed.

Sources of Water

The Board currently has two proposals before it regarding what the flow Objectives for fish and wildlife should be. The first choice is to implement an Alternative or Alternatives that will provide the full amount of water as set forth in the 1995 Water Quality Control Plan (Table No. 3 therein).

The second choice is to adopt new flow Objectives for fish and wildlife as part of the Board's triennial review of the water quality control plan. SDWA believes this is the required step if the Board is considering the adoption of flows consistent with SJRA which are lower than those in the 1995 WQCP. SJRA seeks to provide flows that are less than the 1995 Plan based upon the expert testimony given in Phase 2. That testimony clearly stated that the Department of Fish and Game and the Fish and Wildlife Service believe there is currently no discernable relationship between flows at Vernalis and smolt survivability. There may be a correlation between flows past Stockton when the HOR barrier is in place; however, that relationship and any other relationships would be determined based upon data developed under the VAMP study.

Based on this testimony, the Board as part of this process can "re-evaluate" and change the flow Objectives. The legal issues involved in this will be part of the SDWA's closing brief.

SDWA takes no position on which set of flows the Board should require. However, in light of the lack of any excess water on the San Joaquin River system, it would seem to be an unreasonable use of water to require the higher flows if the fishery agencies do not believe there is any correlation between flows at Vernalis and smolt survivability. For purposes of this presentation, I will assume the Board is requiring the VAMP (not the lesser SJRA) flows and that export rates are also limited by the VAMP recommendations.

According to the testimony in Phase 2 by Daniel Steiner, providing the supplemental flows for VAMP (the amount above the existing flows) varies from year to year and requires from zero to 150,000 acre-feet of water annually. This water should be provided from one of three sources:

Recirculation. This method is the primary source proposed in SDWA's Comprehensive Plan. It anticipates the release of water (at a point no lower on the San Joaquin River than the Newman Wasteway) where it will add to the flow of the San Joaquin River during the 31-day pulse flow. This proposal is more specifically described in SDWA Exhibit Nos. 13 and 27 and partially described in Alternative No. 6 of the DEIR. The proposal requires the use of available export pump capacity in order to re-pump the additional pulse flow water and a "priming" of the system to allow the 31-day pulse to occur as desired.

Effects of Recirculation. The proposed recirculation of DMC releases would be superimposed on the base conditions. The recirculation could provide up to about one-third of the VAMP flow at Vernalis. Recapture of this component of flow would increase export pumping during the pulse flow as compared to furnishing the flow by reallocation of water from users of tributary flows or from export water users. The question is whether this higher pump

rate is significantly adverse to fisheries and if so are there offsetting fishery benefits from the proposal? The increased pumping will not draw Sacramento water across the Delta as the additional water is coming from the San Joaquin. However, the concern that has been expressed is that when the recirculated water is conveyed to the Central Delta and an equivalent amount is then drawn to the export pumps from the Central Delta, it will draw with it both resident fish and San Joaquin smolts. Testimony by fishery experts before the SWRCB during Phase 2 indicated that when dye and tagged smolts are released at Mossdale, the fish soon arrive in the western Delta even though most of the dye does not. This and other testimony such as the movement of Delta smelt seems to indicate that although small fish largely move with net river flow upstream of the Delta, they cease to do so in the Central Delta where the net cross flow is very small compared to tidal flows. This net cross flow should be small during the pulsed flow. In any event, fishery benefits for the plan should also be considered. The plan will decrease the need for New Melones releases to meet the Vernalis salinity standard. This makes more water available for other uses including fishery flows.

The actual effect this additional pumping will have on Delta smelt is currently unknown. Although the smelt Biological Opinion suggests that it may be a problem, my conversations with DFG and USF&WS personnel suggest that the factors governing the location and movement of smelt are simply unknown. Regardless, the questions arise as to whether recirculation pumping can be accomplished in compliance with the current Biological Opinion for that species. The answers to these questions is yes.

Taking the later first, the Biological Opinion (page 19 therein) requires the USBR to seek additional flows above the Vernalis Objective in order that the actual Vernalis flow totals export pumping plus one-half of the Vernalis pulse flow Objective. Since USBR and DWR always attempt to maximize exports, the net effect is that most people interpret the Biological Opinion to require a 2:1 ratio of San Joaquin River flows to exports.

My analysis of this reveals that at the lower end of the Vernalis pulse flows and depending upon the base flow in the River, there are times when the additional export pumping of recirculated water simply continues to "ratchet up" the amount of Vernalis flow necessary under the Biological Opinion. However, I conclude that as the required Vernalis pulse flow amount increases, you can generally provide all or at least most of the additional water needed to meet the Objective through recirculation without violating the Biological Opinion. The following is a good example: Base flow 5,000 cfs; Vernalis pulse flow Objective 7,000 cfs; Base export rate 1,500 cfs.

In this example, you would need to recirculate and thus increase export pumping by 2,000 cfs in order to meet the Objective. That makes the total export rate 3,500 cfs. The Biological Opinion requires the maximum flow in this instance to be: 3,500 cfs (total export pumping) plus 3,500 cfs (one half the 7,000 cfs objective) or, 7,000 cfs.

As you can see, in this example all of the flow necessary to bring the base flow up to the Vernalis pulse flow Objective can be recirculated and still comply with the Biological Opinion.

Clearly as the base flow approaches the Objectives, there is an increasing likelihood that all of the necessary flow can be provided through recirculation.

With regard to the second question I pose, if export pumping in combination with tidal barrier operations and/or a pulse flow and/or recirculation result in unacceptable takes of smelt, then export pumping would have to be decreased. Export pumping cannot and does not take priority over endangered or threatened species or over superior water rights.

At any time that exports must be curtailed and thus recirculation opportunities decrease, other alternatives can take over.

The relevant San Luis Reservoir storage permits could be adjusted to allow a borrowing of export water in order to control export levels during the pulse period. This borrowed water could be replaced at other times just as the joint point proposal contemplates. Such a borrowing method could strive for a "no-net loss" goal as contained in the current joint point operations under WR 96-5. However, this principal cannot be used to override existing water right priorities and must be considered only a goal.

Finally, the other methods of providing the pulse flow water (described below) could take up the slack occasioned by decreased recirculation.

Benefits. The benefits from the recirculation method are tremendous. Any amount of flow contributed towards the pulse period up to the full 1995 Water Quality Control Plan amounts can be provided without a loss to any water user. It also makes it unnecessary to purchase water on the San Joaquin River tributaries which can harm users other than the seller as described in SDWA 7 and 34. This method can also be used in conjunction with the other methods in order to determine the most efficient and beneficial method of providing fishery flows and holding exports at certain levels.

Finally, by providing a portion of the pulse flow above the mouth of the Merced, other benefits are realized. Increased flows in that stretch of the San Joaquin River assist in transporting and protecting Tuolumne and Merced River smolts. It also helps dilute the salinity and selenium in the river.

I believe it is important to note that this and any other proposal may require further consultation under ESA. The existing Biological Opinions were based on pre-barrier data and so should be re-examined. SDWA's Comprehensive Plan described herein provides numerous and flexible options for protecting fish which should be included in the Biological Opinion. Such changes should inure to the benefit of all users as well.

Purchases from Exports. The second method for providing flow Objective water is through purchases from export users. Purchases can be made from the export contractors of the CVP and SWP including Friant. In recent years we have seen that export or out-of-basin interests have water to sell. One example is the USBR's Draft FONSI and Environmental Assessment dated March 1997 which shows that the Arvin-Edison Water Storage District seeks

to sell 350,000 acre-feet over 25 years (see Exhibit "A"). Another example is the Diablo Grande Project. Two of its possible sources of water are from Kern County; the Berenda Mesa Water District (offering to sell 75,000 acre-feet), and Bravo Management Company (offering to sell 2,000 acre-feet) (see Exhibit "B"). All of these sources of water can either be directly delivered to the San Joaquin River System or through exchanges can result in a corresponding amount of water being directly delivered to the San Joaquin River.

Effects. Purchases from export interests appear to generate benefits while causing no meaningful harm. By adding water to the San Joaquin River system that was previously not present, we avoid the adverse effects that accompany in-basin transfers. That is to say, return flows and the beneficial uses thereof are not affected. These purchases also free up other water in New Melones which has the potential of increasing allocations for other purposes thus benefitting those beneficial uses including area of origin parties.

Water Currently Exported in Violation of Permits. The third source of water to meet the 1995 Water Quality Control Plan Objectives is from water that is currently exported by the CVP in violation of its permits. As part of this same water right proceedings, there is before the Board the CVP's request that it conform and consolidate the places of use in its existing permits. Pursuant to that request, the CVP has admitted that it is currently exporting water to places outside of its permitted places of use. A review of the documents submitted in support of the request to conform and consolidate the places of use in the Bureau's permits suggests that the amount of unpermitted exports is substantial. It is our position that such a significant and admitted permit violation cannot simply be ignored. There must be a sanction for such actions. We suggest that the CVP's permits be changed to decrease its total export for deliveries to contractors by this same amount, and then allow part or all of this amount to be exported (and perhaps stored in San Luis) in order to provide pulse flow water to the San Joaquin River.

Benefits. By using this source of water, the Board insures compliance with the Objectives without any increased exports of water or increased export rates. In addition, by not delivering DMC water to an agricultural user, there is a small improvement in the San Joaquin Valley salt problem in that the total salt imported to the area is decreased. [The Board will remember from my earlier testimonies that there is currently a large net salt load increase in the San Joaquin Valley due to CVP deliveries.]

Controlling Drainage. SDWA's Comprehensive Plan also recommends that the Board control the release of drainage water to the San Joaquin River via Salt and Mud Sloughs so that about 50 percent of the drainage is withheld from March 1 to April 15. This withheld drainage is then released during the pulse flow period when substantial dilution is available. The dilution must be available near Mud Slough in order to protect the downstream reach that could be effected by the delayed drainage. This greatly reduces water quality problems in the mainstem of the river and the need for New Melones releases prior to April 15. This disposes of salt during the April-May pulse flow when it can be diluted where it reaches the river instead of having to flow down to the Tuolumne and Stanislaus inflows before full dilution is available. The Board should note that the smelt Biological Opinion recognizes that upstream poor quality drainage "likely adversely affects Delta smelt and its food organisms." Until the Board or the Regional

Board takes action to address this problem, mixing part of the drainage with the pulse flow should benefit smelt.

As I have stated before, many of these contractors whose drainage reaches the San Joaquin River are attempting to voluntarily cooperate and implement this program. I would like to insure that their efforts are recognized and encouraged by the Board. It is my understanding that some of these entities are actually working towards a "no drainage" goal. Although this helps to keep salt out of the San Joaquin River, it means that the salt is being kept in the Valley and will therefore exacerbate the long-term salt build up problem I have mentioned.

I recommend the Bureau's permits to export and deliver water to the San Joaquin Valley be conditioned upon the CVP requiring their users to implement this coordinated drainage program with certain reasonable goals of increasing percentages mandated over time. In the alternative, an agreement might be worked out among those parties and thereafter recognized by the Board as part of its implementation of the 1995 Plan.

Tidal Barriers. Our proposed Comprehensive Plan also requires the operation of the three tidal South Delta barriers except when "take limits" reduce export pumping. These barriers (a) mitigate the impact of the Head of Old River barrier on downstream water supply during the April/May pulse; (b) create a hydraulic barrier to keep downstream smolt migrants from being drawn to the export pumps before and after the 31-day pulse; (c) protect South Delta diverters from the loss of adequate water depth caused by export pumping; (d) restore the circulation in some South Delta channels that is needed to avoid stagnant channel reaches and to control water quality; and (e) avoid re-exporting most of the westside drainage salt load that reaches the Delta via the San Joaquin River. The conceptual operation of the four South Delta barriers is discussed in SDWA Exhibit No. 13 which is the memo by myself and Mr. Bill Loudermilk of Department of Fish and Game.

I would like to re-emphasize that the operation of the tidal barriers must be linked to export operations. Although DWR and USBR choose not to admit it in public, the barriers are the best and only practical method of mitigating the adverse effects of the export pumps on the South Delta. Because of this, the operation of the pumps must be linked to barrier operations. At any time exports cause lowered levels, reverse flows, and quality problems such that other beneficial users are impaired, the barriers must be operating if export pumping is to be continued. Should the pumping and barrier operations result in an unacceptable situation such as an increased take of Delta smelt, then barrier operations should only cease if export operations are decreased to the point that the adverse effects on the other beneficial uses have been cured. It makes no sense to inhibit or prohibit barrier operations in order to maintain exports as the CALFED OPS Group decided in 1997.

The enforcement of this proposal is more complicated but not impossible. We suggest the Board require that the existing permits of the USBR and DWR be amended to require that export operations be conditioned upon the operation of the tidal barriers or some other actions that similarly mitigate the effects of the pumps on water levels and water quality in South Delta channels. We realize that the Interim South Delta Program and the permits for the barriers are

contingent upon "approvals" by USF&WS, COE, and DFG. However, the results of that process do not change the fact that the South Delta beneficial users are entitled under their existing water rights to be free of harm caused by export pumping.

As you know, the Head of Old River Fish Barrier is part of the ISDP. The memorandum I authored with Bill Loudermilk (SDWA 13) describes how the HOR barrier can and should allow for some water to "leak" or pass through as needed for downstream rights and uses. The needed amount of pass through can be minimized by coordinated management of the tidal barriers.

We have suggested the addition of culverts in the temporary HOR barriers. These culverts can be screened (as practicable). This practice can also provide further opportunity for flexibly operating the systems. Water flowing through the culverts can provide more "fish-free" water reaching the export pumps. When there is a smelt problem, this would/could help avoid smelt take problems by decreasing the amount of water flowing from the Central Delta. If there is a Delta smelt problem, this would also help provide additional recirculation water with similar smelt benefits.

Meeting the Vernalis Water Quality Standard. We believe that any plan that assumes the Vernalis standard will not be met is unacceptable if not illegal. The Board is clearly not protecting beneficial uses or water quality if it adopts an implementation of the 1995 Plan that anticipates not meeting Objectives of that Plan.

In order to accomplish this, we suggest the Board require the Bureau to budget a sufficient amount of water in New Melones to meet the Vernalis standard. Since the other parts of this Plan allow for the fishery pulse flows to be supplied through sources other than New Melones, the Bureau could increase its New Melones budget for water quality. Subsequent to the passage of CVPIA, the Bureau changed its New Melones operations to emphasize fishery flows. This adversely affects the ability to meet water quality obligations as well as the area of origin contractors of New Melones water. We believe this change in emphasis, formally instituted through the Interim Operation Plan, is in violation of paragraph 27 of the Bureau's New Melones permits. That paragraph states:

> Before making any change in the project determined by the State Water Resources Control Board to be substantial, Permittee shall submit such change to the Board for its approval in compliance with Water Code § 10504.5(A).

In order to cure this problem and to add the necessary incentive to get the Bureau to follow through with the above-mentioned methods of providing fish flow water, there need to be simple changes made to the Bureau's New Melones permits. The original permits recognize the obligation to make fishery releases and water quality releases. However, the mechanism to insure compliance only applied to fishery releases. Paragraph 18 of the New Melones permits state:

> Permittee shall file with the Board a reservoir operation study showing the water level elevations required to provide the yield specified in paragraph 17. A reservoir operation schedule shall be submitted by the Permittee which shall be subject to approval of the Board. The study shall be updated at least once every five years until further order of the Board.

Unfortunately, this only applied to the fish release obligation which was in paragraph 17. We recommend the Board make this provision also apply to the water quality obligation which appears in paragraph 19 and the required report be produced every year or two. The Bureau's operation of New Melones must result in compliance with the water quality standard at Vernalis. If the Bureau cannot budget sufficient amounts for water quality, then the Board should require automatic decreases in exports. It is patently unfair to allow the Bureau to continue exports (the benefits of the system) when it chooses or fails to meet its permit obligations (the responsibilities of the system). Such a new incentive will also force the Bureau to take action on the Valley salt problem caused by the CVP.

Maintaining Adequate Flow for Riparian and Public Trust Needs. As we have shown, the operation of the CVP (prior to New Melones) resulted in an average annual decrease of flows at Vernalis of 553,000 acre-feet with 345,000 acre-feet of this decrease occurring between April and September. The draft EIR for these hearings incorporates the SDWA's proposal for the minimum amounts of flow at Vernalis required to provide adequate channel depletion needs. As I stated before in earlier testimony, these numbers were developed using the information contained in the Draft Contract and supporting documents produced by DWR, USBR, and our Agency in the development of the South Delta Barrier Program.

We suggest that the Bureau's export and New Melones permits be amended to include a requirement that it maintain these channel depletion needs. This does not create a significant burden on the Bureau as might first appear. The methods of providing fishery flows listed above can also be used to provide channel depletion water, again, in most instances at no water cost to other interests. In addition, those flows decrease the obligations on New Melones thus freeing up water, and could further decrease those New Melones obligations if they are used to provide water quality flows and not just fishery flows.

An alternative method would be to adopt an amended Flow Alternative 5 if the Board decides that downstream channel depletion needs should be a responsibility of all tributaries. My analysis though suggests that the decrease in San Joaquin River flows caused by the Friant project are greatly in excess of any decreases caused by the other tributary projects since Friant removes water from the system and generates no return flow. I therefore conclude and recommend that the obligation rest squarely on the Bureau.

Comparison of Alternatives.

I will now attempt to compare this Comprehensive Plan with the other Alternatives and the SJRA.

Flow Alternative No. 1 is the no project scenario. Under this Alternative, D 1485 and D 1422 conditions prevail. Given the testimony of the Bureau, it will continue to operate New Melones under its Interim Operation Plan under this scenario. This means that the Vernalis water quality Objective will not be met in 40 percent of year types. If the Bureau continues to make purchases on the tributaries under its other obligations (e.g., CVPIA), the Vernalis standard violations will actually further increase. In addition, one must assume the Biological Opinions will continue posing certain limitations on exports.

The Comprehensive Plan SDWA has proposed is obviously better than this Alternative as it allows for a meeting of all Objectives (including either the 1995 Plan or the VAMP flows with a minimum of adverse effects on other users.) Both Alternative 1 and SDWA's Comprehensive Plan could result in decreased exports pursuant to Biological Opinions. SDWA's Comprehensive Plan however provides flexibility in order to avoid this problem. The SJRA provides little benefit over Alternative No. 1 as it actually locks in water quality violations and does not affect the operation of New Melones which is anticipated to provide a substantial portion of the pulse flow waters in part by violating the salinity standard and by reducing summer flows.

Flow Alternative No. 2 assigned the responsibility of meeting 1995 Plan Objectives to the USBR and DWR with Vernalis flow Objectives being met from New Melones releases. This is a bizarre proposition since New Melones does not generate sufficient yield to meet all of the flow Objectives and thus does not meet the purpose of the project. This Alternative also necessarily assumes obligations will be violated.

SDWA's Comprehensive Plan is clearly superior to this Alternative as it allows for the Objectives to be met in all years. The SJRA is only marginally better than Alternative 2 as it allows a "relaxation" of its contributions to flows in some years. In the case of such relaxations, the Bureau/New Melones become solely responsible for the Objectives. We know that New Melones cannot meet those Objectives on its own and the USBR testified that it had no plan for providing the "backup" stipulated in the SJRA.

Flow Alternative No. 3 assigns responsibility for meeting the objectives to various San Joaquin watershed right holders based upon priority but makes the CVP and SWP responsible for insuring such compliance. Through an involved calculation, project releases would incrementally require the right holders to cease diversions unless the Objectives are met.

Although this method would result in compliance with the Objectives, it is deficient in requiring senior right holders to mitigate the adverse effects of the projects. It is beyond dispute that the CVP is the cause of the San Joaquin River salinity problem. To require some diverter on a tributary to the San Joaquin to cut his diversions in order to meet the Vernalis salinity Objectives is patently unfair (and probably illegal).

SDWA's Comprehensive Plan is also better in that it only has potentially significant impacts to exports (which can be minimized if not avoided) while Alternative No. 3 would cause

area-wide significant impacts each time categories of water right holders must decrease diversions.

SJRA is worse than Alternative No. 3 by not providing the full 1995 Plan amounts, by insuring water quality violations will occur, by not providing VAMP flows in all years, and by not having an immediate or viable backup provision. The SJRA is in some respects better than Alternative No. 3, for example with regard to transferred impacts.

Flow Alternative No. 4 is the same as Alternative No. 3 except the Friant-Kern component of the CVP is considered an export facility. The DEIR goes on to state that New Melones, as an in-basin project, has no obligations to make releases for Delta flow Objectives unless junior right holders cease diversions. In addition, Friant obligations are assumed to come from New Melones. I will let SDWA's counsel address this unnatural construct in his closing brief.

Notwithstanding the specifics of this Alternative, a comparison results in the same situation as Alternative 2 or 3. Either innocent parties bear the burden of mitigating the Projects' effects and/or New Melones is drained of every possible acre foot of water. Our Comprehensive Plan is superior in that it meets the Objectives without wide-spread harm. Again, SJRA would interfere with fewer diverters but insure water quality violations and provide lower fish flows and lower summer flows.

Flow Alternative No. 5 assigns responsibility by watershed/tributary. After the projects have mitigated their impacts to fisheries and water quality, the Alternative has appeal if further flows are needed. However, since additional flows are not needed if the Projects mitigate their effects, the Alternative also needlessly harms innocent water users. Again, when compared to SJRA, Alternative 5 provides for the meeting of the Objectives while SJRA does not.

Flow Alternative No. 6 is the Board's limited analysis of our recirculation idea. As described, it is difficult to compare to the other alternatives as it includes the Joint Point Principle to maximize exports.

The better analysis and comparison is done by examining the SJRIO study (SDWA Exhibit No. 12) along with Exhibit No. 13, the Hildebrand/Loudermilk memo. We believe the recirculation proposal as part of an overall program is clearly better than the other proposals as I have and am describing herein.

Flow Alternative No. 7 I understand to be the original VAMP proposal. However, the SJRGA is now proposing the SJRA which is Flow Alternative No. 8, and so I will compare our Comprehensive Plan to that.

The SJRA does not guarantee the minimum 3,200 cfs flows set forth in VAMP whereas SDWA's Comprehensive Plan does. The SJRA biologists stated in Phase 2 that they believe the lower end flows of VAMP are more important than the higher end flows because the fisheries are more stressed at the lower flows. They concluded they would not "trade" extra flows at the high

end for flows at the lower end. However, this is exactly what the SJRA does in that it contains a double step during higher flow times while relaxing or removing the minimum VAMP flows under drought times. SDWA's Comprehensive Plan on the other hand can and will provide the VAMP flows in their full amounts.

The SJRA has a double step but no explanation as to why providing a double step VAMP data point is more helpful than the "regular" VAMP data point for that year. SDWA's Comprehensive Plan as stated above provides the means of gathering all desired data points as per the VAMP program.

The SJRA guarantees that the water quality obligations will be violated. SDWA's Comprehensive Plan guarantees the water quality obligations will be met.

The SJRA will exacerbate those times when the San Joaquin River provides insufficient channel depletion flows. SDWA's Comprehensive Plan insures that these flows will be available thus protecting beneficial users.

The SJRA costs $4,000,000 per year and sometimes provides no water. SDWA's Comprehensive Plan's cost is undetermined as of yet, but its flexibility allows for a least cost approach. The incremental cost of recirculation is far less per acre foot than water purchases and it would only pay for purchases as needed.

The SJRA gets flows from some SJRGA parties. Those parties will make that water available either by decreasing return flows or shifting the time of use of the water. These actions decrease downstream flows and cause harm to downstream water quality, beneficial users, and public trust needs. SDWA's Comprehensive Plan only contemplates purchases that add to the overall net flow of the San Joaquin River and thus not only avoids these problems but actually helps to mitigate the existing problems.

The SJRA "requires" the Head of Old River Barrier and the tidal barriers as may be necessary. SDWA's Comprehensive Plan sets forth the details of the need and operation of all barriers in a manner to maximize the most efficient and reasonable use of water for all beneficial uses.

The SJRA protects only those salmon smolts which happen to out migrate during the 31-day pulse period. SDWA's Comprehensive Plan protects a much larger percentage of the smolts with the corresponding enhancement of the fishery.

The SJRA allows the Bureau to make unilateral operational decisions which resulted in harm to water quality, downstream interests, and area of origin parties. SDWA's Comprehensive Plan specifically forces the Bureau to act in a reasonable manner and in recognition of California water law.

Based on the above, it is clear that SDWA's Comprehensive Plan is proposing is superior to all other alternatives and in every respect to the SJRA.

CONCLUSION

The responsibility for meeting the 1995 Plan Objectives (or revised Objectives) should rest with the entities/parties who have adversely impacted the various beneficial uses especially fisheries and water quality. I believe it is clear that the State and Federal Projects are those parties. However, in charging them with the obligation to meet the 1995 Plan Objectives, the Board must insure that the methods of providing the necessary flows or actions must be done in a manner that does not shift the harm or burden to third parties. We have seen this very shift in harm in the Bureau's operations under WR 95-6.

The best method of meeting the Objectives of the 1995 Plan is SDWA's Comprehensive Plan I have described above. It is the only alternative that can fairly and actually meet all of the Objectives. This Plan enables the State and Federal Projects to provide the necessary mitigation at a minimum cost to themselves. It is clearly not reasonable to adopt an alternative such as the SJRA which favors some Objectives over others and locks in water quality violations.

Dated: September 14, 1998

Alexander Hildebrand

ALEXANDER HILDEBRAND

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

FINDING OF NO SIGNIFICANT IMPACT

PROPOSED WATER TRANSFER BETWEEN THE ARVIN-EDISON WATER STORAGE DISTRICT AND THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

In accordance with the National Environmental Policy Act of 1969, as amended, the Bureau of Reclamation (Reclamation) has determined that the temporary transfer of water from the Arvin-Edison Water Storage District (Arvin-Edison) to the Metropolitan Water District of Southern California (Metropolitan) would not result in significant environmental impacts. An Environmental Impact Statement is therefore not required for this transfer.

The purpose of the transfer is to provide a mechanism for Arvin-Edison and Metropolitan to reduce the year to year variability in surface water supplies available to their service areas. Historically, to regulate its water supply, Arvin-Edison has either banked a portion of its supply of Central Valley Project (CVP) water in the groundwater basin for later use or exchanged a portion with other water agencies located on the east side of the San Joaquin Valley for water available from the California Aqueduct. Due to changes in supply reliability and cost increases, certain historic exchanges are no longer feasible. Metropolitan also seeks to regulate its water supplies to ensure that adequate water supplies will be available during dry years or periods of insufficient supply from existing sources.

The transfer will cover a 25 year period during which Arvin-Edison, at its discretion, will transfer up to 350,000 acre-feet of non-firm Class 2 CVP water to Metropolitan. The water will be transferred on a "when available" basis, and the point of transfer will be the terminus of the Friant-Kern Canal. Metropolitan will either bank the transferred water in the Arvin-Edison groundwater aquifer for later retrieval or convey the water directly through the Arvin-Edison system to the California Aqueduct.

To ensure that the program will not have any effect on other Friant Division contractors or the San Joaquin River, the water to be transferred and banked under this program is the result of water conservation measures that will undertaken by Arvin-Edison to reduce consumptive use.

EXHIBIT "A"

The measures include: (1) conversion of farmland to water spreading ponds; (2) savings in losses from exchange programs; and (3) tiered water pricing and other policy revisions that will reduce the consumptive use of water by Arvin-Edison's farmers.

This Finding of No Significant Impact is based n the following:

1. The transfer program would not effect CVP operations because the volume and timing of water deliveries from the CVP to Arvin-Edison would remain unchanged.

2. The transfer program would not change existing conditions of the biological, physical, and socio-economic environment because existing CVP facilities would be used.

Note: Environmental documentation under the California Environmental Quality Act has been completed for the construction of new facilities within Arvin-Edison to store and convey the transferred water.

Approved:

Regional Director, Mid-Pacific Region Date
Bureau of Reclamation

Revised: March 12, 1997

ENVIRONMENTAL ASSESSMENT

PROPOSED WATER TRANSFER BETWEEN THE ARVIN-EDISON WATER STORAGE DISTRICT AND THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

INTRODUCTION

The Arvin-Edison Water Storage District (Arvin-Edison) has requested approval from the US Secretary of the Interior to transfer of a portion of its Central Valley Project (CVP) water to The Metropolitan Water District of Southern California (Metropolitan). The Proposed Action would provide for the transfer of up to 350,000 acre-feet of Arvin-Edison's CVP Friant-Kern Class 2 water, when available, to Metropolitan over a 25-year period beginning in 1997. This water will be transferred from Arvin-Edison to Metropolitan at the terminus of the Friant-Kern Canal.

After receipt of the water at the terminus of the Friant-Kern Canal, Metropolitan will either bank the water in the Arvin-Edison groundwater aquifer for later retrieval, transmit the water directly through the Arvin-Edison system to the California Aqueduct, or convey the water to the California Aqueduct through existing non-federal intertie facilities between the Friant-Kern Canal and the California Aqueduct.

BACKGROUND

Arvin-Edison Water Storage District

The Arvin-Edison Water Storage District (Arvin-Edison) was established in 1942 for the purpose of supplying supplemental water within its service area boundaries. Arvin-Edison's service area covers approximately 130,000 acres of highly productive farmland of which 52,000 acres are supplied directly by CVP water. Arvin-Edison's service area is located in the southeastern portion of the San Joaquin Valley in Kern County (Figure 1). Arvin-Edison lies approximately 12 miles to the south and east of the city of Bakersfield and approximately 15 miles to the north of the Tehachapi Mountains.

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To meet the water needs within its service area, Arvin-Edison provides water to its customers either by direct delivery of surface water or through extraction of water previously stored in the underlying groundwater basin. Arvin-Edison has under contract, and has historically received when available (less some flood control releases), up to approximately 350,000 acre-feet of water annually via the Friant-Kern Canal. This water consists of 40,000 acre-feet of firm (Class 1) water and 311,675 acre-feet of non-firm (Class 2) water. Arvin-Edison utilizes its water under contract with the US Bureau Reclamation (Reclamation) in three ways: (1) providing the water directly to its customers, (2) placing the water into groundwater storage for later use, and (3) exchanging water with other San Joaquin Valley water districts.

Arvin-Edison has operated a conjunctive-use project since 1967, whereby a portion of its Class 2 water, when available, is stored in the groundwater basin beneath Arvin-Edison and withdrawn during periods of insufficient surface water supplies. Historically, Arvin-Edison has also exchanged water with other San Joaquin Valley water districts. This Proposed Action provides a way for both Arvin-Edison and Metropolitan to optimize the regulation of water available to Arvin-Edison.

The Metropolitan Water District of Southern California

Metropolitan is a public agency formed under the Metropolitan Water District Act of 1927. Metropolitan provides imported water to 27 member public agencies to supplement local municipal water supplies within its six county service area located in Southern California's coastal plain. Metropolitan obtains its water supplies from the Colorado Aqueduct, the State Water Project, and other sources. Metropolitan seeks to augment its water supplies by arranging for intermittent water supplies to be transferred and regulated to firm supplies by placement in storage until required during periods of insufficient supply.

Central Valley Project Improvement Act of 1992

The CVP Improvement Act of 1992 (Title XXXIV of Public Law 102-575) (CVPIA), contains provisions that increase the opportunities to transfer CVP water:

> *"In order to assist California urban areas, agricultural water users, and others in meeting their future water needs, subject to the conditions and requirements of this subsection, all individuals or districts who receive Central Valley Project water under water service or repayment contracts, water rights settlement contracts or exchange contracts entered into prior to or after the date of enactment of this title are authorized to transfer all or a portion of the water subject to such contract to any other California water user or agency, State or Federal agency, Indian tribe, or private nonprofit organization for project purposes or any purpose recognized as beneficial under*

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WATER RESOURCES PLAN FOR DIABLO GRANDE

PREPARED FOR

WESTERN HILLS WATER DISTRICT
MODESTO, CALIFORNIA

PREPARED BY

BOOKMAN-EDMONSTON ENGINEERING
A DIVISION OF RESOURCE MANAGEMENT INTERNATIONAL, INC.

Unpublished Work © February 1997

EXHIBIT "B"

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2 Existing Water Supply Facilities for Diablo Grande
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7 Locations of Alternative Water Sources in Kern County

in county roadways. Pipeline facilities for water extracted from the west side of the San Joaquin River would be similar, although it would not be necessary to cross the San Joaquin River.

Approvals required to deliver this groundwater to WHWD would include:

- Approval of the sale and construction of wells, pumps, and pipelines by the affected irrigation and/or water district.
- WHWD approval of sale and construction of pumps and pipelines.
- County of Stanislaus affirmation of long-term supply.
- Approval of a water treatment plant and quality of water by the Department of Health Services.

BERRENDA MESA WATER DISTRICT (No. 5)

Berrenda Mesa Water District (BMWD) is a California water district located in northwestern Kern County, largely north of State Highway 46 and on both sides of State Highway 33 (see Figure No. 7). All lands are west of and higher than the California Aqueduct.

BMWD is a member unit of the Kern County Water Agency (KCWA), which has a contract with DWR for over 1 million acre-feet annually from the SWP. BMWD has a contract with KCWA for approximately 155,000 acre-feet of which it is attempting to sell approximately 75,000 acre-feet. In 1995, KCWA and DWR agreed in the Monterey Principles that KCWA would transfer up to 130,000 acre-feet of its agricultural water entitlement to non-SWP contractors, subject to the right of first refusal by other member units of KCWA and other SWP contractors. (The EIR for the Monterey Principles was challenged in court and in the fall of 1996, the court agreed the process was flawed, but the EIR was adequate.) Sale of BMWD's entitlement is within the KCWA sale commitment.

Acquisition of water by WHWD from BMWD would require assumption of the obligations and conditions of KCWA/BMWD to the DWR for SWP water. The obligations would include financial obligations to assure repayment of SWP bonds and operating costs and operation conditions. WHWD would probably not become a contractor for SWP water with the DWR because it does not now have sufficient taxable assets to meet bond requirements.

If WHWD acquires some of BMWD's contract entitlement, the water could be delivered to the Diablo Grande main supply line at its crossing of the California Aqueduct. (Except for a turnout, no new facilities would be needed.) At this time, the DWR cannot provide all of its delivery commitments to all contractors in many years because of lack of storage and restraints on pumping from the Sacramento-San Joaquin Delta for the California Aqueduct.

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There would be significant shortages in many years. DWR currently can supply an average of only about 50 percent of the current demand. To provide for the full needs of Diablo Grande it would be necessary to (1) have an entitlement twice or more than the demands, (2) store a portion of the BMWD supply in wet years for use in dry years, or (3) have alternative backup supplies. Extra wet year water could be stored in Kern County and exchanged in dry years for KCWA SWP entitlement water, which would otherwise be delivered through the California Aqueduct.

WHWD would need to secure approval of the DWR to construct a turnout from the California Aqueduct. Such approval would be a condition in the water purchase agreement between WHWD and DWR-KCWA-BMWD.

The DWR would need to apply to the SWRCB to add Diablo Grande to its place of use in its water rights for the SWP.

Approvals required to deliver BMWD's state water entitlement supply to WHWD include:

- BMWD approval of sale.
- KCWA approval of sale and water transfer and a new turnout from the California Aqueduct.
- The DWR would need to approve the transfer because it manages the SWP.
- WHWD approval of purchase and construction of needed facilities.
- County of Stanislaus affirmation of long-term supply.
- Approval of water treatment plant by Department of Health Services.
- Approval by SWRCB of change in place of use.

MERCY SPRINGS WATER DISTRICT (No. 6)

Mercy Springs Water District (MSWD) is a California water district located in northwestern Fresno County consisting of about 3,390 acres (see Figure 1). MSWD has an annual allocation of 13,300 acre-feet of CVP water from the D-MC by contract with the USBR. MSWD lands have drainage limitations and drain water is quite saline. Landowners have offered to sell their water contract entitlements with or without the land.

WHWD could purchase all or a portion of the water and/or land in MSWD. USBR administrative procedures provide for transfer of the MSWD contract to WHWD. MSWD contract provides for use of the water for municipal and industrial (M&I) purposes as well

- Approval by SWRCB of change in place of use.

OAKWOOD LAKE WATER DISTRICT (No. 7)

Oakwood Lake Water District (OLWD) is a California water district located in southwestern San Joaquin County as shown on Figure 1. OLWD provides groundwater to its primary property owner in the district, the Manteca Water Slides, a public water recreation park (Park).

The Park currently pumps an average of 6,000 acre-feet per year of water into the San Joaquin River. The SWRCB has concurred in findings of studies of the OLWD that most of the water is groundwater and, therefore, is not under SWRCB jurisdiction. The SWRCB has agreed that 95 percent of the water discharged to the San Joaquin River can be classified as groundwater. The balance is classified as underflow from the river.

The discharged groundwater could be sold to WHWD and transported to Diablo Grande by pumping at the Banks Pumping Plant and wheeling the water in the California Aqueduct to a new turnout at the Oak Flat Road. Because the water is pumped into the San Joaquin River within the Delta, DWR would not normally assess any channel losses. Because the discharge is into the southern Delta, a carriage water assessment for water quality in the Delta would not be made as for a transfer from north of the Delta. The water supply could be produced throughout the year, but wheeling in the California Aqueduct would be limited by other priority uses and pumping restrictions because of endangered fish in the Delta. Seasonal regulation in San Luis Reservoir could be provided by DWR. With regulation, up to 5,700 acre-feet could be supplied to WHWD.

Approvals required to deliver OLWD water to Diablo Grande include:

- OLWD approval of sale of water.
- WHWD approval of purchase water and wheeling agreements.
- DWR approval of agreement to wheel water in the California Aqueduct and a new turnout.
- County of Stanislaus affirmation of long-term water supply.

BRAVO MANAGEMENT COMPANY, INC. (BMC) (No. 8)

BMC is a private company with land and water rights in Kern County. BMC lands include developments adjacent to the Kern River east of the City of Bakersfield. Water rights on the Kern River date back to 1888 and have been adjudicated. Kern River water is managed by a watermaster.

BMC has offered to sell 2,000 acre-feet per year for use by Diablo Grande. The sale/exchange would involve KCWA. BMC would provide water to Improvement District #4 (ID-4), a member unit of KCWA which incudes and supplies water to the City of Bakersfield, and KCWA would release a portion of its SWP entitlement water destined to ID-4 to WHWD in the California Aqueduct at Oak Flat Road. BMC would provide water to ID-4 from a portion of its supply already banked in groundwater storage available to ID-4 and by pumping groundwater from a basin east of the City of Bakersfield in which BMC has a 99 percent interest.

Approvals required to deliver BMC water to WHWD include:

- Agreement by WHWD to purchase water.
- Agreement by BMC to sell water.
- Agreement by ID-4 to exchange water.
- Agreement by DWR to wheel water in the California Aqueduct and to provide a new turnout.
- Agreement by DWR and the SWRCB that a change in place of use for SWP water is not required because it is equivalent to groundwater.
- If DWR and/or SWRCB do not agree that the water delivered to WHWD is equivalent to groundwater, DWR would need to petition SWRCB for a change in place of use.

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Testimony of Alex Hildebrand for Phase 5
Responsibilities for Meeting the Dissolved Oxygen and
Southern Delta Salinity Objectives

Introduction

In addressing the salinity problem on the San Joaquin River and in the Delta, the Board should first take note of the statutory directives which bind it and other parties to these proceedings. Water Code § 12202 states that the SWP and CVP have as one of their functions "the provision of salinity control and an adequate water supply for the users of water in the Sacramento-San Joaquin Delta." It is, therefore, appropriate that the permit conditions of the projects require they abide by their statutory obligations. The causes of inadequate dissolved oxygen, high salinity, and deficient flow problems are interrelated, and the measures that can mitigate those problems are also interrelated. Let us first examine these causes and interrelations.

Causes of High Salinity

The root cause of the salinity problem is almost entirely the operations of the CVP. In the absence of the CVP we did not have and would not now have a salinity problem. Our testimony has shown that the salt load which enters the San Joaquin River from the CVP's westside service area is the cause of high salinity in the river whenever flows from eastside tributaries are insufficient to dilute that salt load. We have shown that the salt load in the river during low flows derives primarily from the import of salt from the Delta via the Delta Mendota Canal. The substantial natural salt load which derives from the weathering of soils enters the river largely at times of high flow so that it does not cause a salinity problem. Other sources of salt load, including cities, would be unlikely at this time to exceed the dilution capacity of flows from the eastside tributaries in the absence of CVP operations. Our testimony has also shown that the CVP exports from Friant cause a major reduction in the Vernalis flow which would otherwise be available to dilute salt, particularly in the spring and summer months of greatest concern. Exports to the Bay Area from the Tuolumne, and some CVP exports from the Stanislaus watershed also contribute to the decline in available dilution water. Furthermore, the consumptive use of tributary water has substantially increased.

These specified causes of the salinity problem are not in doubt. SDWA has provided the relevant information documenting this causal relationship many times. In Phase 1 of these proceedings, we introduced SDWA Exhibit Nos. 14, 17, 18, 19, and 20. These exhibits show how the CVP imports salts into the basin and how those salts make their way to the San Joaquin River. They also show that the CVP Friant operations have resulted in the net annual decrease of San Joaquin River flows in the amount of 553,000 acre-feet with 345,000 acre-feet of that decrease occurring between April and September.

SDWA 39

This same information was introduced in the hearings that led to the development of the 1995 Water Quality Control Plan as well as WR 95-6.

Similarly, SDWA has introduced in previous hearings the 1980 "Report on the Effects of the CVP upon the Southern Delta Water Supply Sacramento-San Joaquin River Delta, California". As that document is an official federal government publication, and as copies are in the Board's records, SDWA will request it be made part of the evidentiary record of these proceedings.

The availability of water to dilute the CVP salt load to meet salinity objectives is further reduced when the Department of Interior pays tributary water managers to shift releases from other months to spring and fall fish flows. Before, and to a larger extent after the adoption of CVPIA, the USBR seeks to make purchase of water on the tributaries of the San Joaquin River. Indeed, the testimony in Phase 2 confirmed that the Bureau will continue to seek these purchases. The purposes of these purchases is to secure additional water to improve instream fishery flows at Vernalis and on the tributaries. This is so in spite of the testimony of the biologists in Phase 2 that little if any correlation exists between flows and salmon smolts survival.

The problem with these purchases is that they rob Peter to pay Paul. Absent a decrease in consumptive use by the seller, the sale water is merely a reoperation. Put another way, the seller changes the time of use of the water so that it adds to spring (or October) flows. As SDWA has stated numerous times, this necessarily results in a decrease at other times. That decrease is generally during times when quantity and quality are most often at risk in the Southern Delta. Therefore, the actions to increase fishery flows cause a corresponding harm to water quality and channel depletion needs. SDWA believes that existing legal principles require that the Bureau mitigate these adverse impacts caused by its purchases of water.

Harm

I believe it is important to restate why we have these water quality objectives/ standards: to protect beneficial uses. Nearly 20 years ago, the Board developed and implemented a Water Quality Plan through D 1485. At those hearings, witnesses on behalf of SDWA presented evidence on the harm caused by high salinity in the San Joaquin River. Although SDWA argued for standards lower than those currently in place, particularly in March and September, the evidence clearly showed that salinity concentrations above the current April through August standard (455 TDS or .7 EC) had a detrimental effect on crop production and contributed to an increased salt buildup in Delta soils. That testimony also indicated that as salinity increased, there was a corresponding increase in harm to agriculture. In light of this evidence, the Board

implemented water quality objectives for agricultural uses by setting a salinity standard at Vernalis and identifying salinity standard measuring points in the Southern Delta. For reference, SDWA identifies these documents produced for D 1485 as follows: SDWA's 1976 Phase I Exhibits Nos. II and IV-E; Transcripts of Testimony: Vol. XIV dated Tuesday, December 7, 1976, pgs. 2:16-47:18, 86:4-87:18, 98:5-17, and 155:17-156:15; Vol. XXVIII dated Wednesday June 22, 1977, pgs. 122:6-123:11, 127:7-128:2, and 132:4-140:11; Transcript dated Tuesday May 30, 1978 (no volume number) pgs. 114:2-119:21; University of California's 1976 Phase I Exhibits Nos. UC II, UC II-A, and UC VII. In addition, during the 1981 triennial review of that Water Quality Control Plan SDWA submitted as Exhibit No. SDWA 23 the document entitled Water Quality Considerations for the South Delta Water Agency.

These documents and testimony were previously introduced and are part of the Board's files, SDWA will request they become part of the evidentiary record of these proceedings.

To address salinity considerations, the CVP can take advantage of the tributary flows released for other purposes to dilute the CVP salt load, but they diminish this available dilution when they pay tributary managers to shift releases to times when dilution is not needed. The CVP is almost entirely responsible for the drainage salt loads in the river that are not indigenous salts and that enter the river at concentrations above the salinity objectives.

Causes of Inadequate Dissolved Oxygen

The causes of inadequate dissolved oxygen are less defined. Low dissolved oxygen can result from a combination of high temperature, low flow, and algae and other aquatic vegetation stimulated by nutrients and sewage outfalls.

There is not much potential for controlling average temperatures in southern Delta channels. However, low Vernalis flows combine with the drawdown of water levels caused by export pumping (explained below) to cause stagnant channel reaches and very shallow water depths which contribute to high local temperatures.

The drawdown of water levels and low Vernalis flows often cause a reverse flow in the river from the Stockton ship channel up to Old River. This reversal is a major contributor to low DO in that reach.

The other area of DO concern is in the vicinity of the Tracy sewer outfall. DO in this area is also influenced by the shallow water depth and low flows which occur in that area. Nutrient loads derive from numerous sources, most of which are now being

addressed per the Clean Water Act. The Board should note that there are currently proposed additional discharges into Old River upstream of the tidal barrier location. Those additional discharges include the Mountain House development's sewer and storm drainage outflows as well as additional sewage and storm drainage outflow from Tracy.

Tidal Barriers

I would now like to explain how South Delta water levels and circulation are affected by the projects and how the tidal barriers can act to mitigate those effects.

The South Delta channels, like any other water system, react to hydrological pressure and gravity. Without getting too basic, water flows downhill, and towards a lower water level. In the absence of water diversions in the South Delta, the inflow of the San Joaquin River flows downstream in all channels. Into this system the State and Federal Governments introduced their respective export pumps. When operating, these pumps draw water towards them causing lowered water levels as well as reversing flows in some channels. These flows reverse because the pull of the pumps cause water levels lower than exists in the normal downstream channel.

As a means of mitigating these changes, the tidal barriers take advantage of the tremendous tidal flows experienced twice daily in the Delta. As the tidal flow moves upstream, it fills the channels and raises the water levels. The barriers then trap these flows to hold the high levels so that local diversions can be satisfied during low tides. By manipulating when and how the barriers operate, flow directions can be controlled to avoid stagnant reaches, flush areas of low DO, and redirect out-migrating smolts.

The HOR barrier only functions to redirect fish. Its largest shortcoming is the fact that it harms downstream diverters by cutting off flow. Therefore, the HOR barrier cannot be operated without the other three tidal barriers or serious harm results to downstream beneficial uses.

As the Board knows, the Bureau is supposed to make releases from New Melones sufficient to maintain the Vernalis salinity standard. That obligation was not only a condition of the project's authorization, it is a condition in each of its permits. Exhibit SDWA 40 are the correspondence in the Board's own files since 1990 evidencing the Bureau's failure to abide by its permit conditions and therefore violations of the Vernalis water quality standard. [You will note from the handwritten portion on the July 19, 1994 letter that the Board decided it need not even respond to the Notice of Permit Violations.]

Under its current and proposed operations, the Bureau estimates that it will continue to violate the Vernalis Water Quality Standard in approximately 40 percent of

historic year types (see SDWA 23). This frequency of violation will be further increased by water purchases that shift summer flow to spring flow.

Some parties have argued that making releases from New Melones to dilute San Joaquin River salinity is an unreasonable use of water. This cannot be true. The Board will recall that the CVP has decreased San Joaquin River flows annually approximately 345,000 acre-feet per year during April through September. The Board could have (or can now) allow less diversion to storage at Friant in order to maintain sufficient San Joaquin River flow. Such a decision is not an unreasonable use of water, it is merely a recognition of whether or not there is sufficient water surplus to the needs of higher priority beneficial uses. Put another way, the decision of how much water to allow to flow downstream depends on the satisfaction of various beneficial uses. Therefore, using an alternate supply for this same flow cannot be considered unreasonable.

A different question is whether area of origin rights determine where such flows should and should not arise. SDWA has and continues to believe that solving the San Joaquin River salinity problem should be accomplished in a manner that will free up more tributary water supplies for tributary needs. However, pending that "cure," the Bureau's obligations to mitigate its harm must continue.

Responsibilities for Meeting Objectives

The CVP should bear the entire responsibility for meeting the Vernalis salinity objective. It causes the salinity problem, it has inferior water rights, and it has pursued measures which exacerbate rather than mitigate the problem. When it complies with the Vernalis salinity objective it is still not fully restoring the water quality that existed pre-CVP and which would now exist in the absence, of the CVP. The CVP failed to build the authorized valley drain. It has done nothing to restore dilution water except for inconsistent "water quality" releases from New Melones. It has exercised little leadership toward managing the salt load in westside drainage waters to optimize the use at dilution water available from flows released for other purposes. It has been unwilling to provide dilution by recirculating DMC water when excess pump and conveyance capacity is available. It has made water purchases that reduce the availability of water when it is needed for dilution. It has not made purchases from export water users to restore river flow. It is aware that the salt load imported by the DMC could be significantly reduced by operation of the three tidal South Delta barriers, yet the Department of Interior has been a major obstacle to obtaining permission to install and operate those barriers on an as needed basis.

The salinity objectives in the southern Delta downstream of Vernalis on the San Joaquin River cannot be met unless the Vernalis standard is also met with some margin,

and an adequate flow provided. Diverters downstream of Vernalis do not add a significant salt load. They must be able to divert the CVP salt load that is in their diversions from the river and then return that salt into the river without causing a violation of the downstream objective. Meeting this objective is, therefore, also a CVP responsibility.

If the three tidal South Delta barriers were operated on an as-needed basis there would be no problem in meeting the interior salinity objectives in Middle River, Old River, and Grantline Canal.. In the absence of the barriers these objectives cannot be met. The salinity standard at the Old Brandt Bridge location cannot be met with the barriers in operation unless the Vernalis standard is more than met and Vernalis flow exceeds local channel depletion. In the absence of the barriers this objective could sometimes be met due to reverse flows in the Stockton to Old River reach. However, the salinity in the other channels cannot be controlled without barriers unless exports are greatly curtailed.

Measures and responsibilities for meeting the internal South Delta salinity objectives, for meeting the DO objectives, and for meeting the flow dependent objectives are all interrelated, particularly if the three South Delta tidal barriers are not available for operation on an "as needed" basis. Absent functioning barriers, the reverse flow between Old River and Stockton is not caused by the City of Stockton. The City should, therefore, not be required to mitigate the consequences of that reverse flow on DO by, for example, expensive sewage treatment beyond current practices. The reversal is caused by Vernalis flow depletion combined with drawdown by export pumping. The projects must, therefore, correct this DO problem in so far as it results from reverse flow.

The DO problem near the junction of Old River and Grantline Canal, aside from any appropriate control of nutrients, is again a flow problem. The problem will increase as new cities and sewer expansions are allowed to discharge in or near Old River. The flows and in-channel water volumes needed to dispense sewage and other discharges affecting DO are affected by Vernalis flow, by export pumping, by the schedule of pumping in relation to tides and seasons, by joint point pumping, and by the effect of ambient temperature on channel water temperature. Operable barriers could be manipulated to provide this dispersal, but in the absence of barriers it will not always be possible to achieve dispersal without substantial export curtailment and Vernalis flow restoration.

Until flow responsibilities are determined in Phase 8, it will not be possible to determine in detail the responsibilities and measures needed to meet internal South Delta salinity and DO objectives. If the flow-dependent objectives are allowed to be met with water taken from other months, compliance with salinity and DO objectives will be much more difficult and violations will occur. If, on the other hand, the spring and fall flow objectives are required to be met without any impact on the flow and water quality that

would otherwise occur in other months, and, if the downstream superior water rights are required to be met at all times, then responsibility and measures for compliance with salinity and DO objectives can be determined from a better defined base. Furthermore, it will be necessary to define what protective measures must be taken either with or without the three tidal barriers and the Head of Old River fish barrier since no permanent or adequate permits have yet been issued for any of these barriers.

Recommendations

As part of the Board's decision implementing the 1995 Water Quality Control Plan, SDWA recommends the USBR's export permits be amended to include the following conditions:

> USBR's ability to export water from the Tracy Pumping Plant or from the SWP's Banks Pumping Plant is conditioned upon (i) the existence of sufficient water depth in South Delta channels to support local diversions; (ii) the existence of sufficient water quantity in South Delta channels to support local diversions and channel depletions. In the absence of either of these conditions, USBR exports shall decrease until the condition or conditions are met. If the conditions are not met, there is no surplus water available for export as per Water Code §§ 12200 et seq.

A similar conditions should be in the SWP's permits.

USBR's New Melones permits as well as its export permits should be amended to include the following conditions:

> USBR's ability to store water in or directly divert water from New Melones, and its ability to export water from the Tracy Pumping Plant or from the SWP's Banks Pumping Plant are conditioned on the maintenance of the 1995 Water Quality Control Plan Water Quality Objectives for Agricultural Beneficial Uses in the Southern Delta. If the CVP's operational projections anticipate violations of the Objectives, the CVP shall cease diverting water to storage and/or decrease exports until such projections include compliance. At any time violations of the Objectives occur, export operations shall

> cease, and all of the natural flow of the Stanislaus River shall be passed through New Melones.

All projects which divert water to storage upstream of Vernalis on the San Joaquin River and its tributaries shall be amended to include the following condition:

> At any time the flow at Vernalis is less than the channel depletion requirements of the South Delta, all natural flow shall be passed through or by the permittee.

SDWA believes these permit conditions are clearly required by existing law and will result in adequate incentive for the Projects to fully comply with the 1995 WQCP Objectives and to address the San Joaquin River salinity problems.

In Phase 8 SDWA will propose an alternative that will address watershed measures that will result in compliance with all Control Plan Objectives in the San Joaquin watershed including the South Delta. The proposal will comply with existing laws, will minimize impacts on any party, will minimize the cost of compliance, and make the most efficient and hence the most reasonable use of water.

Dated: August 4, 1998

ALEXANDER HILDEBRAND

Testimony

Gerald T. Orlob
for the
South Delta Water Agency

State Water Resources Control Board Hearings

Implementing 1995 Water Quality Control Plan

I. General Concerns

The adequacy of the water supply of the SDWA for its entitled beneficial use is dependent upon maintenance of sufficient flow in the San Joaquin River at Vernalis to meet net channel depletion requirements within the SDWA at levels of quality that will assure continued agricultural productivity. The Agency asserts that the water resources of the San Joaquin Basin above Vernalis have been over-developed to a degree that makes it increasingly difficult to maintain necessary flows and water quality, even under present conditions of operation of upstream projects. Moreover, changes in operation procedures and reallocation of available water in storage as proposed under the Water Quality Control Plan and the San Joaquin River Agreement, if adopted, will further jeopardize the entitlements of the SDWA. The SDWA believes that any action taken to transfer water out of the basin or to reallocate present resources geographically or temporally will increase the frequency and severity of violations of water quality and flow objectives already in place.

II. Specific Concerns

The SDWA wishes to present factual evidence to the State Water Resources Control Board addressing the following specific concerns:

1. <u>Historic development of water resources in the San Joaquin Basin has resulted in over-exploitation of the limited available surface water resource with a resultant diminution of net outflow at Vernalis.</u>

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During the period from the early 1940s to the late 1980s when New Melones Reservoir was placed in operation the total installed storage capacity of project implemented in the San Joaquin Basin increased more than four-fold. (See Figure 1) Construction of Friant Dam on the Upper San Joaquin and creation of Millerton Lake was followed by major projects on each of the other major tributaries to the main stem of the river, the Stanislaus, Tuolumne, and Merced Rivers. A result was a combined capability of project reservoirs to capture the major portion of natural runoff of these streams, retain it in storage, and divert it to use, largely for agriculture in the valleys below the dams. Accordingly, irrigated areas expanded, diversions for irrigation increased (See Figure 2), consumptive use by crops increased and, in response to the season pattern of regulated flows, tail waters conveyed residual salt loads downstream during the irrigation season.

2. Historic expansion of consumptive water using activities in the basin, beyond the capacity of surface supplies to meet the demand, resulted in a steady increase in the use of lower quality ground water throughout the basin.

Because the storage capacity of projects was sufficient to capture a major part of surface runoff, and to allow expansion of irrigated areas, there was an increasing incidence of failure of stored surface water to meet the demand of agriculture in place. For example during the 1976-1977 drought surface water supplies were reduced to about one quarter of the normal demand. (See Figure 2) To make up for this supply deficiency farmers increased pumping of ground waters. During the 1976-1977 drought, for example, the rate of ground water usage nearly doubled over the normal historic trend. Conjunctive use of surface and ground waters to meet agricultural requirements is evident in the chronologies of the two sources of supply as depicted in Figures 2 and 3. Although the quality of surface water from eastside streams is generally high, tailwaters from irrigated areas carry virtually the same loads as applied water, but at increased concentrations depending on irrigation efficiency. These are delivered to the main stem of the river, either through ground waters or surface channels of tributary streams, thereby contributing to its overall degradation in flow and quality.

3. Salt loads carried by the San Joaquin River system have steadily increased over the period of water resource development such that the quality of the basin outflow has deteriorated beyond reasonable target levels for unimpaired agricultural use on the lands of the SDWA.

Expansion of irrigated agriculture, development of marginally productive saline lands, increased consumptive use of water, exportation of high quality water out of the basin and importation of waters of lesser quality have contributed to a salt imbalance in the San Joaquin basin. More salt is now being added to the basin than is exported through it only natural outlet at Vernalis. The salt load delivered by the system varies with hydrologic conditions from year to year, but on average over the period since the early 1950s the load has increased about 25 percent. (See Figure 4) During the pre-Central Valley Project period 1930-1950 the average salt load at Vernalis was about 750,000 tons per year. Over the period 1951-1997 the load has averaged more than 950,000 tons per year. Peak loads have exceeded 1,500,000 tons per year following extended droughts. Salinities have risen accordingly, especially in drier-than-normal years when flows at Vernalis are generally lowest.

4. Any allocation of water resources that will result in increased consumptive use, e.g., evaporation and evapo-transpiration, at upstream locations within the basin will also degrade water quality and increase the difficulty in achieving water quality control.

Consumptive use of water by vegetation, or by evaporation from water or soil surfaces, leaves a residual salt load which when diluted in the remaining drainage results in an increased concentration. In normal agricultural use the concentration of salts in soil moisture in the plant root zone or drainage water below the root zone is a function of irrigation efficiency: the ratio of the volume of water used consumptively by plants to the volume of applied water. Generally, the higher the irrigation efficiency the lower will be the volume of drainage and the higher the concentration of total dissolved salts contained in the drainage.. Irrigation efficiencies customarily range between 50 and 80 percent depending on irrigation practice, soil properties and crops grown. Accordingly, concentration factors (ratio of salinities in drainage and applied water) may range from 2 to 5.

5. Use of ground water to augment surface water deliveries during dry or critical runoff periods increases salt loads carried in return flows during these periods, further degrading the quality of receiving waters downstream.

Over the period of water resource development in the Valley farmers have supplemented their supplies by exploiting ground waters underlying irrigated lands. Literally hundreds of wells have been installed, penetrating aquifers both above and below the Corcoran Clay layer that extends throughout much of the valley's subsurface (See Figure 5). The quality of ground water is generally inferior to that of the overlying surface waters. (See Figure 6) Along the east side of the Valley the average specific conductance (EC) of water pumped from wells perforated both above and below the Corcoran Clay ranges from 250 to 1000 microSiemens (about 160 to 640 mg/l TDS). On the west side of the Valley between the river and the route of the California Aqueduct the quality ranges from 1000 to 2500 microSiemens. Ground waters with concentrations in excess of 3000 microSiemens are evident in some local areas along the west side of the San Joaquin River

6. The burden of controlling quality at Vernalis has been shifted downstream to the New Melones Project, which in dry or critical years may not be able to release sufficient high quality water from storage to reduce salt concentrations at Vernalis to required levels.

Under present conditions releases from New Melones Reservoir are diverted at Goodwin Dam to agricultural use by the South San Joaquin and Oakdale irrigation districts (SSID and OID), the residual flows passing downstream in the Stanislaus River to meet local demands and project obligations to control water quality in the San Joaquin River at Vernalis. (See Figure 7) In periods of lower than normal runoff, such as prevailed from 1989 to 1992, (See Figure 8) project releases may not be sufficient to meet nominal quality targets, thereby requiring additional releases above the 70,000 acre feet reserved in the project for quality control. (Note: Figures 7 and 8 are derived from a memorandum report to Mr. Alex Hildebrand of the South Delta Water Agency dated September 9, 1997.)

7. Exportation of New Melones water to locations outside of the hydrologic basin would further exacerbate an already critical situation, evidenced by conditions during historic periods of low natural inflow to upstream reservoirs.

Proposals to divert water to locations outside of the hydrologic basin will further reduce the capability of the project to allocate sufficient water for downstream quality control. If the proposed increased diversions are made by reducing allocations to SSID and OID and these are not replaced by corresponding releases from storage to quality control in the lower river the result will likely be greatly elevated salinity in the San Joaquin River as it enters channels within the SDWA. (See Figure 9). (Note: Figure 9 is derived from a memorandum report to A. Hildebrand dated September 9, 1997.)

8. Modifying the temporal patterns of releases from storage to accommodate other flow requirements, e.g., springtime pulse flows, may deplete storage that otherwise would be available during critical water quality control periods.

The critical period for quality control for agricultural use in the South Delta spans the late spring and summer period of maximum demand for crops, May through September. The most critical months are July, August and September when flows are usually the lowest in the San Joaquin and in the tributaries below project dams. This is also the period when drainage returns with highest salt loads and salinities are delivered to the San Joaquin River, making the river essentially an agricultural drain. Consequently, any reallocation of high quality water from the critical summer months to months when quality is not the major concern would place additional stress on the capability of the projects to control water quality at Vernalis. It would inevitably result in degradation of water quality at other locations along the river, such as within the reach just below the mouth of the Tuolumne River where salinity often far exceeds the desired levels for productive agriculture. Pulse flows, as may be provided in April and May for the benefit of fisheries, would be of little value to agricultural users since such flows would only enhance water quality when it is normally not required. Moreover, such allocations have the potential to preclude adequate water quality control releases later in the irrigation season in situations where releases from storage are limited.

III. Conclusions

The South Delta Water Agency believes that the San Joaquin Basin's water resources are already over-developed, to a degree that threatens the ability of existing projects to control water quality in the main stem of the San Joaquin River, especially in the lower reach and at Vernalis. Any reallocation of existing resources that would diminish flows at Vernalis below the net channel depletion requirements of the Agency, or would increase the salt load and salinity of the flow above the targets set to assure productive agriculture is contrary to the interests of the Agency. Water quality control measures need to be devised that will ensure the integrity of Delta agriculture.

5/31/98

IV. References

U.S. Geological Survey, 1971, "Geology, Hydrology and Water Quality of the Tracy-Dos Palos Area, San Joaquin Valley, California," Open File Report, 6433-02, 107 pp.

U. S. Geological Survey, 1982, "Compilation of Selected Ground-Water-Quality Data from the San Joaquin Valley, California," Open File Report, 82-335, 6400-03, 276 pp.

J. M. Montgomery and Boyle Engineering Corporation, 1990, "Central Valley Ground-Surface Water Model, Central Valley, California," Report to U.S. Bureau of Reclamation, California Department of Water Resources, California State Water Resources Control Board, and Contra Costa Water District, California, 38 pp. w/ tables and figures

Orlob, G. T., "New Melones Interim Water Acquisition Program, Potential Effects on Flow and Water Quality in the San Joaquin River near Vernalis," Memorandum report to A. Hildebrand of the South Delta Water Agency, Sept. 9, 1997, 3 pp., 11 figures

Orlob, G. T., "Assessment of Potential Effects of Deliveries to Stockton East Water District from Stanislaus River Basin," Memorandum report to A. Hildebrand and J. Herrick of the South Delta Water Agency, October 18, 1997, 3 pp., 1 table

List of Exhibits

Testimony of G. T. Orlob
for the
South Delta Water Agency

Exhibit No.	Figure
SDWA 01	1. Total Installed Storage Capacity, San Joaquin Valley, 1900 - 1989
SDWA 02	2. Irrigation Diversions from Four Subbasins, San Joaquin River System, 1901 - 1993
SDWA 03	3. Ground Water Pumping, Eastern San Joaquin Valley, 1922 - 1980
SDWA 04	4. Annual Salt Load, San Joaquin River near Vernalis, 1930 - 1996
SDWA 05	5. San Joaquin Valley Wells
SDWA 06	6. San Joaquin Valley Ground Water Quality
SDWA 07	7. Schematic of Stanislaus River Water Allocation Options
SDWA 08	8. Monthly Runoff, Mean TDS and Salt Load, San Joaquin River near Vernalis, 1990 - 1997
SDWA 09	9. Change in Water Quality Due to Water Transfer from Stanislaus Basin, San Joaquin River near Vernalis, 1990 - 1995

Testimony by Alex Hildebrand for SDWA in 7/98, Phase I and Phase II Hearings by SWRCB

PHASE I Interim Extension of WR 95-6

Introduction

WR 95-6 should not be extended. The Board has not determined what entities and water sources are responsible for complying with the 1995 flow and quality standards in the San Joaquin River System and South Delta. There is not yet a scrutinized EIR to assure that those standards are met in the most water efficient and reasonable manner. There is no analysis to assure that the 1995 Vernalis spring fish flow standards will not be met by reallocating water needed to avoid violating water quality standards and riparian and public trust needs at other times. The Board can not delegate or disregard its responsibility for these determinations and assurances.

In most years there is no surplus water in the San Joaquin River System. It is all being beneficially used at some point in time except for flood releases. Increased stream flow taken from the system at one point in time, therefore, results in a decrease, at some other time, of the water needed to maintain water quality, protect riparian water users, and provide for public trust needs. This issue was explained in greater detail in our testimony to you on April 21, 1998.

There is a potential for more efficient use of the limited supply by better multiple use and reuse of water. It is also possible, without depriving downstream needs, to purchase water that derives from increases in water yield by new surface or subsurface storage, or from decreases in consumptive use of water by sellers. However, these measures have not and will not happen under WR 95-6

Overcommitment of the San Joaquin River System

Prior to 1950 when Friant Dam and the Delta Mendota Canal went into operation, water quality in the river down past Mossdale was always very good and flows were ample with very rare exceptions. As you know from previous testimony, these features of the CVP caused an average annual decrease in San Joaquin River flow of 553,000 acre feet, of which 345,000 acre feet is a reduction in summer flow. (SDWA 14). Increases in exports from the Tuolumne, and increases in consumptive use of water from the tributaries have further reduced the inflow of the river to the South Delta. For reference, I am also including other exhibits (now SDWA 15-21) from our testimony in the hearings that lead to WR 95-6.

The Department of Water Resources, the Bureau of Reclamation, and the South Delta Water Agency have an agreed quantification of the channel depletion (riparian diversions, consumptive public trust needs, etc.) in the South Delta. (SDWA 22). This was developed in the course of negotiating a settlement of SDWA's 1982 lawsuit. WR 95-6 provides no assurance that these superior downstream rights will be protected.

New Melones and Water Quality

When New Melones was built, it was expected to provide a new water yield of about 250,000 acre feet. The State permit required that the project must release dilution water to meet a 500 ppm salinity standard at Vernalis. The need for the dilution is to partially redress the salinity damage caused by very salty drainage which enters the river from the CVP westside service area. In forecasting the yield of New Melones The Bureau estimated an average annual dilution requirement of about 35,000 acre feet with a maximum of 70,000 in any year. This was a gross underestimate. The requirement has been as high as 220,000 acre feet in a single year! This, then, substantially reduces the reservoir yield available for other commitments. The Bureau has not reduced this New Melones dilution requirement by controlling drainage or providing other dilution, and it has refused to carry over wet year water to provide quality control in below normal years even when there is reservoir space available for that purpose. They, therefore, do not consistently meet the standard and do not expect to do so. We previously submitted their analysis of their interim plan. (SDWA 23). It shows that they expect to violate the salinity standard in about 40% of the water years. This analysis did not even include their plan to make water purchases. Those purchases increase stream flows for fish by reducing flows at other times when they are needed to contribute to quality control. This will therefore further increase the frequency of violation of the standard. This underestimate of the dilution requirement reduces the beneficial project yield substantially. Extension of WR 95-6 would, in effect, condone these violations of the salinity standard.

In your hearing for D1485 we submitted extensive testimony on the loss of South Delta crop yields when the in-channel water salinity rises above about 450 ppm. We request that testimony be incorporated into this Record, and can supply it if necessary. There are about 80 different soil types in the South Delta with a wide range of permeability. The loss is greatest for the substantial areas that have high fertility, but low permeability, and hence a low ability to leach the river salt load that comes down the river from the CVP service area.

The effective yield of New Melones for purposes other than fish flows was further reduced by underestimating the flow required to meet an agreement with the Department of Fish and Game. The Bureau only forecast a requirement of 65,000 acre feet in dry

years and 98,300 acre feet in other years. In 1987 this was changed to a low of 98,300 in dry years and up to more than 300,000 acre feet depending on year type. They also had made a 49,000 acre feet "firm yield" contract commitment to the eastern part of San Joaquin County which they have since only honored in wet years.

A further overcommitment resulted from their contract with the Oakdale and South San Joaquin Irrigation Districts. Those districts had pre-1914 diversion rights to the amount of their pre-1914 diversions for agricultural use within their boundaries. They also had permitted/licensed rights for storage of water. However, both of those rights are limited by the actual amount they beneficially use. They were given a contractual right from the Bureau to more water than their historic diversions. The Bureau then, at times, uses taxpayer money to buy back part of the contract water that is in excess of the districts' needs. When this buyback water is used to further augment fish flows there is a further depletion of water available in the watershed to meet water quality and downstream water rights at other times of the year. In the absence of the sale, that water would eventually come downstream or generate return flow.

An extension of WR 95-6 would continue to delegate to the overcommitted Bureau the discretion as to which obligations it chooses to meet. It also permits it to procrastinate any effort to reduce the burden on New Melones for mitigating the high salinity and low river flows that have been caused by the CVP.

Better Multiple Use and Reuse of Water

Instead of extending WR95-6, the overall management of water in the watershed should be such that water provided for fish flows will serve also for water quality control, and the supplemental flows needed for Vernalis spring fish flows should be provided in large part by reusing water instead of depleting the supply of high quality tributary water that now serves other needs.

The proposal that SDWA presented to you on April 21, 1998 has been reviewed with numerous stakeholders and agencies and has been modeled by DWR personnel with input and oversight by technical experts from DWR, USBR, SDWA, the Regional Water Quality Control Board, and, less extensively, from the Contra Costa Water District and the San Luis and Delta Mendota Water Authority. The proposal is consistent with both the 1994 Accord and the 1995 Control Plan. Refer to our March 6, 1998 letter to Walter Pettit and others and to the January Draft Report by DWR entitled SJRIO Studies of San Joaquin Recirculation and Reoperation of Wetland Discharge and Tile Drainage (SDWA 12).

The proposal could be fine tuned to be even better. However, we have modeled a proposal that is fairly simple. Basically we define a base case which involves no water purchases or reduction in diversion rights, but includes FERC flows in the Tuolumne, Davis Grunsky flows in the Merced, and fish flows in the Stanislaus per the 1987 USBR-Fish and Game agreement. This base case, however, requires substantial releases of New Melones water to meet the Vernalis salinity standard, and it falls far short of providing the 31 day spring fish flow at Vernalis required by the Control Plan.

The supplemental flow needed to meet the Vernalis spring fish flow in the control Plan is then provided by releasing water from the Delta Mendota Canal through the Newman Wasteway. DMC water will not degrade and will somewhat enhance water quality in the river. Water equivalent in quantity to the DMC releases is recaptured by the export pumps and re-exported. This recirculation of canal water is superimposed on the stream and canal flows and the pumping that would occur in the base case.

The third step is to control the time of entry to the river of some of the agricultural drainage that now reaches the San Joaquin River via Salt and Mud Sloughs. For the purpose of the analysis it is assumed that at least 50%of the agricultural drainage can be held back for six weeks prior to the spring fish flow and that the retained drainage would then be released during the 31 day fish flow in order to dilute that drainage with the fish flows from the tributaries instead of diluting it with "water quality" releases from New Melones. The drainers have indicated an ability and willingness to do this.

The plan also takes advantage of the reduction in salinity in the Delta Mendota Canal that results from using South Delta barriers to avoid the capture and re-export of the salt load in the San Joaquin River. We have a conceptual operating plan for these barriers that we believe will optimize protections of fish while protecting downstream diverters. (SDWA 11, & 13). Furthermore, a benefit of the plan is to substantially improve streamflow in the San Joaquin River downstream of the Merced River during the pulse flow period.

A substantial overall savings in water and costs, and a better distribution of streamflow and in-stream water quality would result from the proposal. The benefits derive from providing the supplemental water for fish flow and the water needed for the dilution of drainage salts by this proposed method as compared to meeting those needs by reducing diversion rights, or by water purchases on the tributaries.

We believe that this proposal is a much more water-efficient way to implement the Control Plan as compared to other proposals. To implement the Control Plan by other means would therefore be an unreasonable use of water which would be damaging to

water users in the watershed including the South Delta. Extending WR 95-6 would not result in this more reasonable use of water.

Barriers

WR 95-6 does not address the fact that the three South Delta tidal barriers are needed to mitigate the water level and water quality problems that result from operation of the export pumps. The export pumping and the barriers needed to mitigate the impact of that pumping should be viewed as a package. When the tidal barriers are functioning the water level and quality impacts are avoided. If the pumping is stopped by a "take limit", the barriers are not needed. When the barriers are not functioning on an as needed basis, the export pumps must be curtailed as necessary to avoid both the water level and quality problems, and any exceedence of the "take limit".

This linkage requires that there be a system of monitoring and forecasting water levels and in channel water quality (including salinity and dissolved oxygen) such that inadequate water levels and violations of South Delta water quality standards do not occur. A plan for doing this is being developed with DWR. Extending WR 95-6 would not accomplish this.

The CALFED Operations Group has become receptive and responsive to SDWA comments on the effect of its operating decisions. However, final decisions are made by the agencies and project operators. The SDWA is not, therefore, reliably protected by the process. Under WR 95-6, the CALFED Ops Group is allowed to make decisions regarding export and related operations in order to protect fisheries and make up lost export pumping. Last year, that group delegated some of its authority to a subgroup which decided to prevent the operation of South Delta barriers while allowing exports to "ramp up" during the period that the spring fishery flow was being decreased. These actions were taken without consultation or notice to SDWA. Given that the barriers are the mitigation for the adverse effects of the export pumps, it is inexcusable that someone would decide to increase export pumping while at the same time halting the operation of the mitigation measures. Even if SDWA had notice of this potential action, our Agency has no voting power on such a decision, and the same results could have occurred. The SWRCB should not allow any group to make decisions that exacerbate the adverse effects of the export pumps.

PHASE II San Joaquin River Agreement (VAMP)

The San Joaquin River Agreement should not be adopted as now proposed. SDWA is not opposed to the fishery objectives of the plan. However, we oppose the flow implementation proposals in the plan.

Our Phase I testimony explained that the overall yield of the river system is seriously overcommitted, and we discussed the causes of this overcommitment. The proposal incorporates the Bureau's interim operating plan for New Melones which would include frequent violation of the Vernalis salinity standard, as previously explained. It also proposes to augment Vernalis flows by water purchases which are not provided by any quantified, monitored, and assured reductions in consumptive use or increased yield by the sellers. As explained in our Phase I testimony this would inevitably reduce the stream flows at other times that now contribute to water quality control and to maintaining the flows needed for superior downstream diversion rights and public trust needs.

We also explained that it would be much more water efficient and less costly to provide the desired supplemental Vernalis spring fish flow by recirculating water from the Delta Mendota Canal. Furthermore, this alternative improves stream flow and water quality in the river downstream of the Newman Wasteway, and in some degree reduces the need for water quality control releases from the overcommitted New Melones Reservoir.

We explained that, in the absence of land fallowing or new yield, a reallocation of purpose of use of tributary supplies will inevitably cause downstream water quality and supply impacts when the overall watershed yield is already all being beneficially used. If a pumper in an over drafted groundwater basin can pump and sell water in excess of his needs, he obviously impacts other users of that groundwater basin. The same is true of a tributary diverter if he captures and sells water in excess of his needs. He inevitably impacts the beneficial use of water by downstream interests at some point in time.

For all these reasons, the VAMP implementation plan would be an inefficient and, therefore, unreasonable use of water in an overcommitted watershed, and would impact existing beneficial uses of water by downstream parties, most of whom have superior water rights. These inefficiencies and impacts could be avoided if the supplemental flow were provided by recirculation of canal flow combined with coordinated operation of the four South Delta barriers, and if full compliance with the Vernalis salinity standard were enforced. However, this is not what is proposed. It would, therefore, be unreasonable to adopt the VAMP implementation plan as now proposed.

Dated: June 1, 1998

Alex Hildebrand

ALEX HILDEBRAND

c:\SDWA\comments\Hildebrand, Alex testimony

TESTIMONY OF ALEX HILDEBRAND FOR PHASE 2B OF BAY-DELTA WATER RIGHT HEARINGS

My name is Alex Hildebrand. I am the Secretary of the South Delta Water Agency, the President of the Delta Water Users Association, a member of the BDAC , and a farmer in the South Delta. I have previously given testimony in these hearings, and my qualifications and background have been previously submitted and accepted into evidence as SDWA 28.

The statutes authorizing the South Delta Water Agency provide that Agency has the power:

> To do any and every lawful act necessary in order that a sufficient in-channel water supply may be available for any present or future beneficial use or uses of the lands within the agency.

Based on these statutory provisions it is my belief and the position of the South Delta Water Agency that they have sufficient standing and right to be able to appear on behalf of the water right holders within the South Delta Water Agency's boundaries.

I currently reside at 23443 South Hays Road in Manteca, California. This property abuts the San Joaquin River (see SDWA 60A). At the time of my purchase of this property and pursuant to my investigations thereafter, my land has always been contiguous to the river and so is considered riparian under California law.

In addition to my riparian rights, I applied for and now have two licenses to divert water, License Nos. 7143 and 7144. These licenses are on file and of record with the SWRCB. I have regularly reported to DWR my water use, three such reports are included as SDWA 61. My water use began in the year I purchased the property, which was 1945.

As an additional example of a south Delta diverter, I have included one of the parcels of land owned by the President of the South Delta Water Agency, Jerry Robinson who testified in Phase 1 of these proceedings. Some of his land borders Middle River as you can see from SDWA 60B which is a map of that area. Pursuant to our investigation, it too has always been contiguous to the river and is therefore riparian. Also, the State has previously taken the position that all lands within the Delta are riparian due to the lands' subsurface connection with the numerous waterways of the Delta . Mr. Robinson's farming operation has regularly reported its water use to DWR, and copies of

60C

some of those reports are included herewith as SDWA 62. Mr. Robinson's family began using water well over forty years ago.

My operations do not include a metering system for the water I use. However, I irrigate in almost every April through September time frame, often in March, and October, and more infrequently in February and November. The same can be said for Mr. Robinson, although he has irrigated in every month of the year in the past as conditions warrant. The DWR and the U.C. Extension Service have extensive data on the consumptive use of water by various crops. Unconsumed water that we apply to crops serves to avoid the accumulation in our soils of the salt in the irrigation water. It then accretes back to the channels.

The place of use of the water I divert from the San Joaquin River is the property on which I live and farm as shown on SDWA 60A. The purpose is for my domestic use and the agricultural use on that same land. These limitations are also set forth in my licenses. On Mr. Robinson's land, the place of use is also the land that is contiguous to the river, and it is used mainly for agricultural use with no domestic use.

I believe the evidence presented to date in these hearings clearly shows that granting the Petitions for changes to the permits/licenses will adversely affect me, Mr. Robinson, and other South Delta diverters.

SDWA's and my interpretation of Water Code § 1707 is based upon the plain meaning of the statute's language. Section 1707(b)(2) limits any change to situations where it "will not unreasonably affect any legal user of water."

This is clearly a broad protection and is not limited to only those legal users of *the* water as set forth in Section 1702. The statute clearly anticipates that the Board should not allow changes to permits if those changes unreasonably interfere with the people who rely on the interconnected water system in California. The statute is not just a protection of a small group of water right holders with rights to the Petitioner's water, it is a broad protection of all legal users. I believe the Board's Staff's previous interpretation of "legal users" is incorrect.

In previous hearings wherein SDWA or other users argued that changes to permits would adversely affect downstream users, the Board incorrectly described SDWA's opposition arguments as being that SDWA was seeking to force an upstream diverter to release stored water for SDWA's benefit and at times demanded by SDWA. This is and was never the case. As SDWA has said numerous times, it is not attempting to force those upstream diverters to make releases. Rather, it is asking the Board to not approve changes which will result in changed operations by permit holder. Again, as we have stated numerous times, if a diverter wishes to change its operations *within* its existing

permit terms and conditions, it may do so. However, the statute clearly anticipates that changes in operations that will result from permit changes must not have unreasonable effects on downstream users.

I conclude that if the Petitions are granted, they will adversely and unreasonably affect me and other Delta agricultural diverters. I have previously explained that in most years there is no surplus water on the San Joaquin River system. Therefore, in those years, any reallocation of water to improve an April-May pulse flow (as sought by the Petitioners) necessarily decreases flows at other times either in the current year or subsequent years. Since the USBR has not in the past, and is currently not operating to consistently meet the Vernalis Water Quality Standard, the shift in flow that will result from the Petitions will result in a significant increase in water quality violations.

To evidence this, I will compare the data provided by the SJRGA and DOI in the ongoing hearings. This examination includes the effects of the New Melones Interim Operation Plan, on which the SJRA relies, as well as other data currently before the Board. The Board should recognize that the Petitions cannot be considered in a vacuum. The requested changes are only being sought as a means of implementing the SJRA.

Before we examine the data, I will clarify that I am primarily looking at critical, dry, and below normal years. These are the years of concern and greatest risk to the water quality standard at Vernalis. Since there are rarely if ever any violations of that standard in above normal and wet years, the effect of the Petitions on those years is less important to the examination of whether or not they cause unreasonable effects or harm.

Pursuant to data previously submitted (SDWA 41 - 47), changes in salinity are known to adversely affect the crop yield at given soil permeabilities. In normal farming operations, there is no way to compare any particular year's yield with any other year's yield and then calculate the effects caused by salinity differences in the applied water. This is because there are many other variables and the effect of each cannot be separately determined in field conditions. Each year, differences such as temperature, time of planting, leach ratios, chemical and fertilizer use, and a myriad of other things affect yield. Since we cannot measure, quantify, and then relate each variable to crop yield, we rely on previous scientific studies which did hold variables constant and made findings as to how changes in salinity affect yield. Those studies, evidenced by SDWA 42 and 47, allows us to estimate the effect a salinity change has on any particular crop. Depending on the crop and the soil permeability which controls the ability to leach salts, once a certain threshold is reached, there is a linear relationship between increases in the salinity of the applied water and decreases of the yield. It is important to note that depending on the slope of the line describing that linear relationship, the yield decreases can be dramatic.

Mr. Daniel Steiner presented testimony and modeling results on behalf of the SJRGA. His modeling indicated that with the SJRA in place, in the months of June through September there are 52 months in which the water quality at Vernalis is made worse by that program (see SJRGA 11, Table 3 Page 3 of 8) when the pulse modeled in April (and 51 times when the pulse is modeled in May).

Ms. Peggy Manza of DOI provided additional information on these differences. Her data looked at contract years and water years. Under contract years, the average July exceedences of the standard under the base case are 179 ppm TDS, while under the SJRA they are 198 ppm TDS. The numbers for June are 27 ppm TDS for the base case and 62 ppm TDS for the SJRA. For August, they are 180 TDS and 180 TDS. It is important to note that the April - August standard is 455 ppm TDS which means that the violations average at or greater than 40% of the standard.

For water years, Ms. Manza's data showed similar results. July average exceedences of the standard rise from 179 to 178 ppm, the June exceedences rise from 27 to 62, and the August stay at 180.

This data clearly indicates that the effects of the SJRA are significant. The proponents of that plan and the Petitioners herein attempt to combine all the data to present dampened results. However, the increased number and magnitude of violations in the summer months is necessarily a significant adverse and unreasonable effect on agriculture. These effects would result from the Petition being granted. The Petitioners point to the fact that the SJRA results in fewer violations in October. An improvement in water quality in October does not somehow offset worse water quality in the summer. October is a less critical time for agriculture. There is less irrigation than in the summer. The crops are less vulnerable to salinity at this stage of development.

It is important to remember that the above data is comparing the SJRA to a base case which includes the New Melones Interim Operation Plan. That plan itself results in water quality violations in 52.1 percent of the years (see DOI 105). In critical years, the Interim Operations Plan results in violations in two or more summer months in 15 of the 15 critical years. In dry years there are violations in at least two summer months in 9 of the 10 dry years (see DOI 105a). Ms. Manza admitted that if we exclude the wetter years in which there are rarely water quality problems, the IOP results in violations in 69.8 per cent of the years (RT 10600:24-10602:18).

All of these projected violations are much worse than the historic violations (which are part of the SWRCB's records). Hence, we see that the SJRA has as its basis a program that causes extreme harm to those that depend on the Vernalis standard, and then causes additional harm during peak irrigation months.

With regard to the quantity of water available to downstream riparians, the effects are similar. SDWA previously submitted Exhibit 22 which sets forth the amount of Vernalis flow necessary to supply channel depletion needs in the souther Delta.

Mr. Steiner's testimony (SJRGA Exhibit 11, Figure 3, page 1 of 5) shows that under both the SJRA and the New Melones Interim Operation Plan, in critical years the average Vernalis flow in July, August, and September is insufficient to meet the channel depletion needs of the SDWA. The range of flows from which the averages are determined are set forth in the data attached to Mr. Steiner's testimony.

If the Bureau were operating New Melones in compliance with its permits, it would be releasing additional water to meet the Vernalis standard in critical years in the months of July, August and September. Hence, as the SJRA worsens the water quality in the summer, it also exacerbates the insufficiency of the quantity of water needed by making the already insufficient amount less useable. I conclude therefore that the Petition would result in additional unreasonable harm to South Delta riparians.

Finally, the above-referenced data understates the problem. SDWA showed that under the Petitioner's plan, they will reallocate 15,000 acre-feet of OID water to USBR storage. Rather than this reallocation helping to improve Vernalis water quality as alleged by Mr. Steiner (SJRA 11), SDWA showed that the reallocation actually results in less water in the channel. This then exacerbates the quality and quantity problems in years of need.

The Board should also remember that Mr. Steiner's analysis did not examine the impacts to future flows that result when the Petitioners refill their reservoir storage space vacated by the increased fishery releases. It is beyond dispute that without surplus flood flows, such a recovery of lost reservoir storage will decrease downstream flows during the time of recovery. Other users depend on those non-flood flows to supply their beneficial uses. Similarly, Mr. Steiner admitted that for the purpose of his modeling, it was assumed that OID/SSJID in the absence of the SJRA would take and apply within their districts their full 600TAF contractual amount. We have already seen that is not the case. Each of these two false assumptions by Mr. Steiner result in an understatement of the adverse effects of the SJRA (or the granting of the Petition) on downstream flows and water quality.

In addition, Mr. Steiner admitted that additional purchases on the tributaries would exacerbate the problem of water quality and quantity (R.T. 1460:10-15). This year alone, the USBR has sought additional tributary purchases of 47,000 acre-feet and 50,000 acre-feet, and that OID/SSJID are seeking to sell 30,000 acre-feet to SEWD (SDWA 63). Such shifts in flow patterns exacerbate the situation by further decreasing summer flows and worsening water quality as explained by Mr. Orlob (see SDWA 34A).

These changes can also adversely affect fish and wildlife. As per prior testimony by the panel of biologists presented by the SJRGA, 35 percent of out-migrating salmon smolts come down the river at times other than during the pulse flow. By reallocating water to the pulse flow, those smolts are at greater risk by now having less sufficient transport flows to get them past the export pumps. [Those smolts travel mostly at times when exports are maximized and the tidal barriers are not permitted to operate.] In addition, we heard testimony from SAVE the BAY's witness that the San Joaquin River water temperature needed to be kept at or below 57 degrees Fahrenheit in summer months in order to protect Steelhead trout, a federally listed threatened species. The reallocation of water to the pulse flow period depletes the upstream cold water necessary to protect that species.

Section 1707(b)(1) Requires the Board to Examine Whether or Not the Petitioners will Increase the Amount of Water They Use. In this instance, the evidence is clear. All of the testimony to date shows that the Petitioners *might* institute water conservation measures. However, these measures are neither quantified or assured. No proposed activities by them reduce their consumptive use, and therefore, they are simply reallocating the water they do not consume. Put another way, they will be continuing their current consumptive uses, and also making additional releases of water in April and May for fishery purposes.

If the release of water for fishery purposes during the pulse is made from storage, then the amount of water diverted to storage at a later time to make up for those releases is greater than if the fishery release water had remained in the reservoir. Hence, the Petitioner will be storing more water in years of refill than was their previous practice. If they use ground water instead of storage, and continue to store the same amount, again they are still consuming the same amount of water but changing when the water they don't use comes down the river. **In fact, what the Petitioners are telling the Board is that they have the ability to store water in excess of the needs of their service areas.** It is my understanding that under California law, all permits and licenses to appropriate water are limited to the amount of water that is actually beneficially used by the permit or license holder. They should have no right to water in excess of their beneficial needs.

Absent a decrease in consumptive use, the Petitioners are seeking the ability to provide water for an additional use outside their districts without decreasing their current use.

I do not believe you can condition the approval of the Petitions to mitigate the predicted harm without requiring the USBR or the Petitioners to add water to the San Joaquin River system. Anything less than this will simply cause another reallocation of water which will further deplete flows at some other time and exacerbate the problems discussed above.

However, that is not to say that these proceedings should not result in new permit terms and conditions. As we have stated before, all upstream dam operators should be required to pass through the natural flow at any time the South Delta channel depletion needs are not being met. This would also assist in meeting the water quality standard.

In addition, the Board should require the USBR to comply with its permit conditions to meet water quality as well as its agreement with Department of Fish and Game (implemented by its permits). *That agreement* (SDWA 64) *only allows the Bureau to make fishery releases in excess of 98,000 acre-feet after it meets the water quality standard at Vernalis*. The Bureau's previous statements that additional releases from New Melones are mandated by CVPIA are incorrect. That statute requires the Bureau to first meet water quality obligations before budgeting (b)(2) water (Section 3406(b) and (b)(2)).

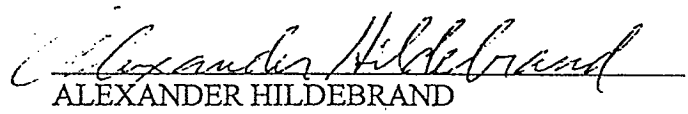
Lastly, the Board needs to be made aware of other activities that may exacerbate or intensify the adverse effects that will result from granting the Petition. The Board is well versed in the activities of the CALFED process. Board staff regularly attends CALFED meetings and the negotiations among parties thereto. Recently CALFED under took to examine the proposed South Delta tidal barrier program. After less than three months of analysis and input from USF&WS, a CALFED group concluded that it is undesirable to have three tidal barriers, rather there should only be two barriers and some unspecified dredging in and about Grantline Canal. Furthermore, they proposed to extend the operation of the fish barrier at times when the tidal barriers would not be allowed to mitigate the impacts of the fish barrier. You will recall that the three tidal barrier program was the result of fifteen years of litigation, negotiation, and analysis. I attempted to give input in that process, but was excluded from participating and none of my comments or requests for modeling had any effect on the CALFED personnel. In my opinion, the two barrier/ dredging proposal will *not* protect South Delta diverters and will probably *worsen* the harm they currently endure. This worsening will be substantially exacerbated by the intent to take water into Clifton Court during low tides. The CALFED Policy Group recently adopted this proposal. If the Board believes that Delta diverters are/will be protected by the barrier program, that belief is now without foundation.

The Board should also know that in a recent No-Name Group teleconference, the modeling to which DWR, USBR, and SDWA agreed under the Response Plan (for joint point pumping), indicated that export pumping after this year's pulse flow would cause lowered water levels to the point where local diversions would be impaired. The Bureau informed SDWA it would take no action to avoid or mitigate this.

Finally, the DAT Group has recently proposed to once again tie the tidal barriers open in order to protect smelt while at the same time allowing exports to increase. It is

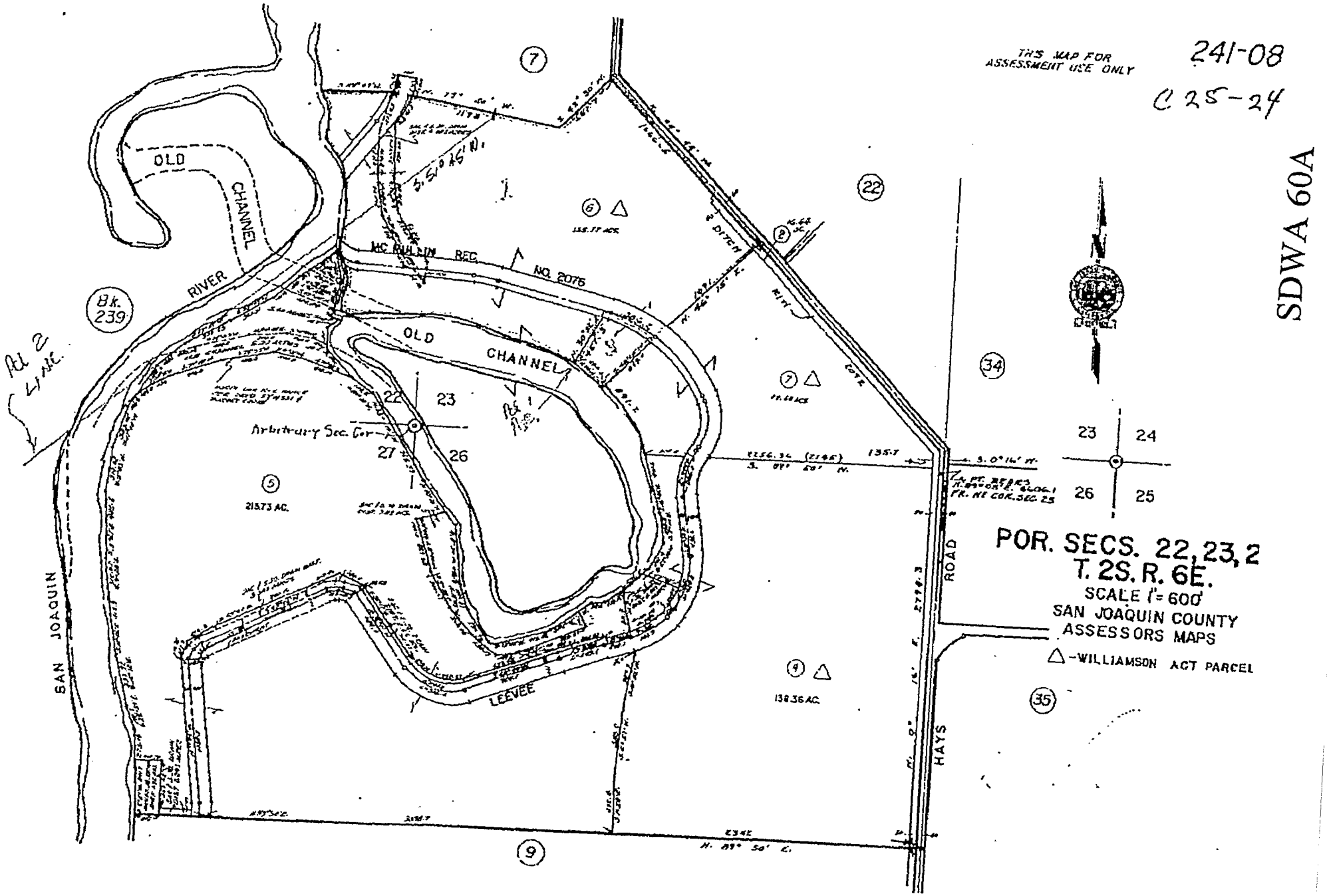
clear that non-governmental interests have little or no say in Delta activities that adversely affect them. It is time for the Board to protect us.

Dated: May 24, 1999



ALEXANDER HILDEBRAND

C:\SDWA\Comments\Testimony by AH re Phase 2B


THIS MAP FOR ASSESSMENT USE ONLY
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C 25-24
SDWA 60A
C-115826
OLD
CHANNEL
RIVER
Bk. 239
Alt 2 Line
MC BULLIN REC. NO. 2076
OLD CHANNEL
Arbitrary Sec. Cor.
21.73 AC.
LEEVEE
SAN JOAQUIN
HAYS ROAD
138.36 AC.
23 24
26 25
POR. SECS. 22, 23, 2
T. 2S. R. 6E.
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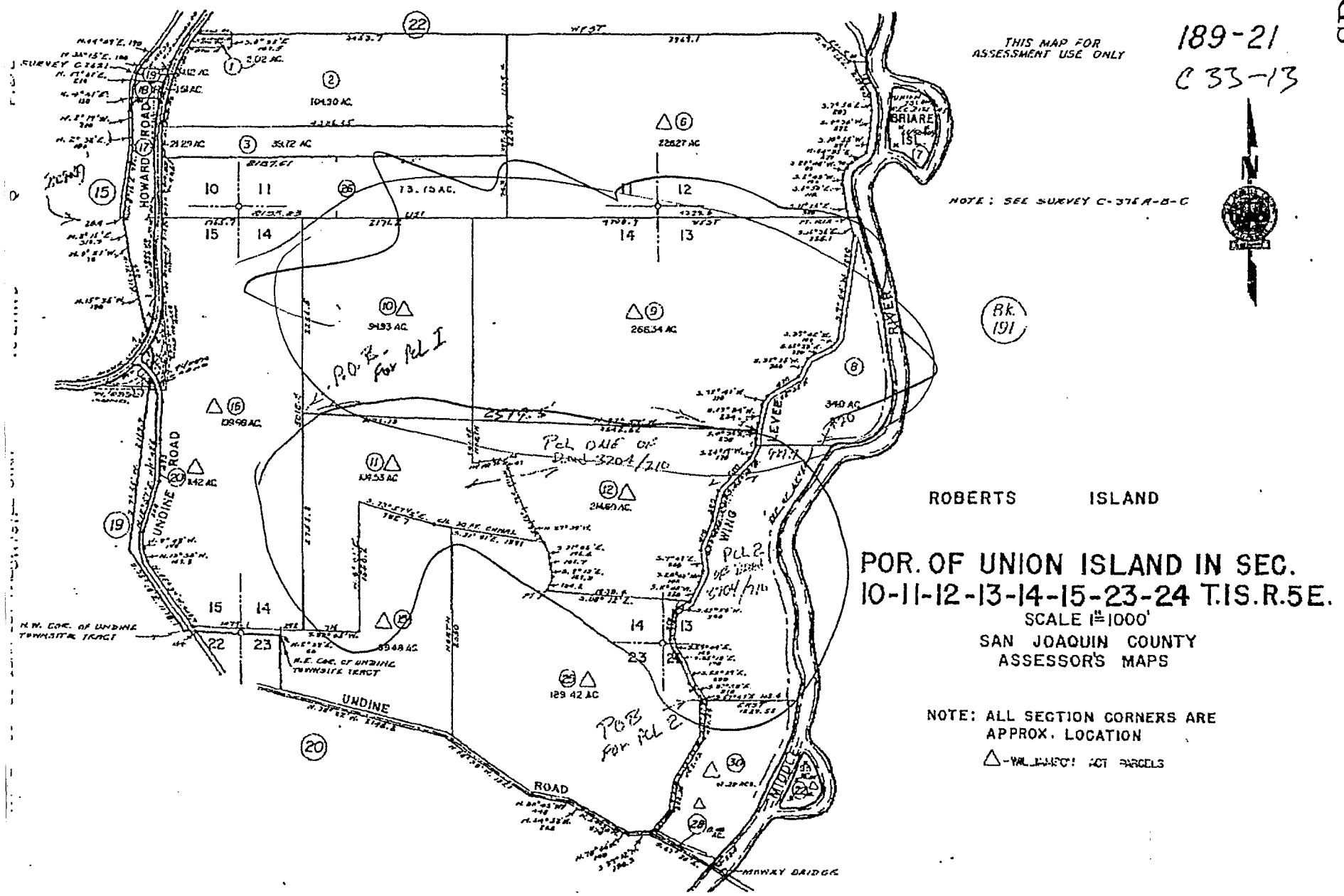
SAN JOAQUIN COUNTY
ASSESSORS MAPS
△-WILLIAMSON ACT PARCEL

C-115826

SDWA 60B

C-115827



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State Water Resources Control Board
DIVISION OF WATER RIGHTS
P.O. Box 2000 SACRAMENTO, CA 95812-2000
901 P STREET, SACRAMENTO, CA
(916) 657-1364 FAX: (916) 657-1485

A 0 1 9 1 9 4

REPORT OF LICENSEE FOR

1994, 1995, 1996

OWNER OF RECORD: BARBARA F HILDEBRAND, ALEXANDER HILDEBRAND

APPLICATION: A019194

LICENSE: 007144

ALEXANDER HILDEBRAND
23443 SOUTH HAYS ROAD
MANTECA, CA 95336

TELEPHONE NUMBER:
(209) 823-4165

IF OWNER'S NAME/ADDRESS/PHONE NO. IS WRONG OR MISSING, PLEASE CORRECT.

SOURCE:		COUNTY:
SAN JOAQUIN RIVER		SAN JOAQUIN
PURPOSE:	DIVERSION/STORAGE SEASON:	ACRES/HP:
IRRIGATION	MAY 01 TO NOV 01 /	40 AC
STOCKWATERING	MAY 01 TO NOV 01 /	0 AC

AMOUNT: 0.5 CFS 0 AC-FT

THIS REPORT IS REQUIRED BY THE TERMS AND CONDITIONS OF YOUR LICENSE

IMPORTANT! EVERY license is subject to the conditions herein. I have currently reviewed my license: YES [✓] NO [ ]. I am complying with the conditions of my license: YES [✓] NO [ ]. Identify any noncompliance by license term number under "Remarks" on reverse side. This report is important in providing the record of use needed in maintaining your water right. It should be filed out carefully and returned promptly to the above-listed address.

THE PROJECT HAS BEEN ABANDONED, AND I REQUEST REVOCATION OF THE LICENSE: YES [ ].

COMPLETE FOR DIRECT DIVERSION PROJECTS

1. Have you used the full licensed amount of water each year? YES [✓] NO [ ]
2. State the quantity of water used each month in gallons or acre-feet (if not known, check months water was used).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Annual
1994			✓	✓	✓	✓	✓	✓	✓	✓			
1995			✓	✓	✓	✓	✓	✓	✓	✓			
1996													

COMPLETE FOR STORAGE PROJECTS

	1994	1995	1996
3. Did your reservoir spill this year?			
4. If not, how many feet below spillway vertically was the water level at maximum storage?			
5. Have you emptied the reservoir?			
6. How many feet below spillway vertically was it drawn down at end of season?			

(Continued on reverse side)

1996

SDWA 61

State Water Resources Control Board
DIVISION OF WATER RIGHTS
P.O. Box 2000 SACRAMENTO, CA 95812-2000
901 P STREET, SACRAMENTO CA
(916) 657-1364 FAX (916) 657-1485

A 0 1 7 9 5 0

REPORT OF LICENSEE FOR

1994, 1995, 1996

OWNER OF RECORD: BARBARA F HILDEBRAND, ALEXANDER HILDEBRAND

APPLICATION: A017950

LICENSE: 007143

ALEXANDER HILDEBRAND
23463 SOUTH HAYS ROAD
MANTECA, CA 95336

TELEPHONE NUMBER:
(209) 823-4166

IF OWNER'S NAME/ADDRESS/PHONE NO. IS WRONG OR MISSING, PLEASE CORRECT.

SOURCE: SAN JOAQUIN RIVER

COUNTY: SAN JOAQUIN

PURPOSE:	DIVERSION/STORAGE SEASON:	ACRES/HP:
STOCKWATERING	APR 01 TO NOV 01 /	0 AC
IRRIGATION	APR 01 TO NOV 01 /	24 AC

AMOUNT: 0.3 CFS 0 AC-FT

THIS REPORT IS REQUIRED BY THE TERMS AND CONDITIONS OF YOUR LICENSE

IMPORTANT! EVERY license is subject to the conditions therein. I have currently reviewed my license. YES [ ] NO [ ]. I am complying with the conditions of my license: YES [ ] NO [ ]. Identify any noncompliance by license term number under "Remarks" on reverse side. This report is important in providing the record of use needed in maintaining your water right. It should be filled out carefully and returned promptly to the above-listed address.

THE PROJECT HAS BEEN ABANDONED, AND I REQUEST REVOCATION OF THE LICENSE: YES [ ]

COMPLETE FOR DIRECT DIVERSION PROJECTS

1. Have you used the full licensed amount of water each year? YES [✓] NO [ ]
2. State the quantity of water used each month in gallons or acre-feet (if not known, check months water was used)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Annual
1994			✓	✓	✓	✓	✓	✓	✓	✓			
1995			✓	✓	✓	✓	✓	✓	✓				
1996				✓	✓	✓	✓	✓	✓				

COMPLETE FOR STORAGE PROJECTS

	1994	1995	1996
3. Did your reservoir spill this year?			
4. If not, how many feet below spillway vertically was the water level at maximum storage?			
5. Have you emptied the reservoir?			
6. How many feet below spillway vertically was it drawn down at end of season?			

(Continue on reverse side)

1996

C-115829

1416 - 9th St.
Sac. 95814

STATE OF CALIFORNIA—THE RESOURCES AGENCY

STATE WATER RESOURCES CONTROL BOARD

DIVISION OF WATER RIGHTS

REPORT OF LICENSEE FOR 1970, 1971, 1972

OWNER OF RECORD: APPLICATION 17950

ALEXANDER & BARBARA FITCH HILDEBRAND
23443 SOUTH HAYS ROAD,
MANTECA, CALIF 95336

(209) 823-4166
TELEPHONE NUMBER

If the information shown above is wrong, please correct

SOURCE: SAN JOAQUIN RIVER

AMOUNT: 0.3 CU FT/SEC
PURPOSE: IRRIGATION & STOCKWATERING

LICENSE 7143 IRRIGATION OF: 24 ACRES

THIS REPORT IS REQUIRED BY THE TERMS AND CONDITIONS OF YOUR LICENSE

Please fill out carefully and return promptly to the State Water Resources Control Board, Division of Water Rights, Room 1016, Resources Building, 1416 Ninth Street, Sacramento, California 95814.

The project has been abandoned, and I request revocation of the license. ☐ Yes ☒ No

DIRECT DIVERSION

1. Have you used the full licensed amount of water each year? ☑ Yes ☐ No
2. State the quantity of water used each month in gallons or acre-feet. (If not known check months water was used.)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Annual
1970			✓	✓	✓	✓	✓	✓	✓	✓			
1971			✓	✓	✓	✓	✓	✓	✓	✓			
1972		✓	✓	✓	✓	✓	✓	✓	✓	✓			

STORAGE

	1970	1971	1972
1. Did your reservoir spill this year?			
2. How many feet below spillway vertically was the water level at maximum storage?			
3. Have you emptied the reservoir?			
4. How many feet below spillway vertically was it drawn down at end of season?			

STATE W. R RESOURCES CONTROL BOARD, DIVISION OF W. ER RIGHTS
P.O. BOX 2000, SACRAMENTO, CA 95812-2000
(916) 657-2170

SUPPLEMENTAL STATEMENT OF WATER DIVERSION AND USE

If the information below is inaccurate, please line it out in red and provide current information.
Notify this office if ownership or address changes occur during the coming year.

PLEASE COMPLETE AND RETURN THIS FORM BY JULY 1, 1997

OWNER OF RECORD: NEWT ROBINSON

NEWT ROBINSON
7000 S INLAND DRIVE
STOCKTON, CA 95206

STATEMENT NO: S009023

S 0 0 9 0 2 3

SOURCE: MIDDLE RIVER
TRIBUTARY TO: SAN JOAQUIN RIVER DELTA CHANNELS
COUNTY: SAN JOAQUIN
DIVERSION
WITHIN: ¼ OF ¼ SECTION 35, T1N, R5E, MB&M.

TELEPHONE NUMBER:
( ) -
YEAR OF FIRST USE: 1927
PARCEL NO:

A. Water is used under: Riparian claim X ; Pre 1914 right _____; Other (explain): _____

B. Year of first use (Please provide if missing above) _____.

C. Amount of Use - Enter the amount of water used each month. If monthly and annual use are not known, check the months in which water was used.

Amounts below are: ☐ Gallons ☐ Acre-feet ☐ (other) _____

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Annual
1994			X	X	X	X	X	X	X				
1995			X	X	X	X	X	X	X				
1996			X	X	X	X	X	X	X				

D. Purpose of Use - Specify number of acres irrigated, stock watered, persons served, etc.

Irrigation 33.5 acres; Stockwatering _____; Domestic _____

Other (specify) _____

E. Changes in Method of Diversion - Describe any changes in your project since your previous statement was filed. (New pump, enlarged diversion dam, location of diversion, etc.)

None

F. If part of the water listed in Part C consists of reclaimed or polluted water, please indicate the annual amounts of reclaimed or polluted water in the space below.

None

I declare under penalty of perjury that the information in this report is true to the best of my knowledge and belief.

DATED: _____, 19 ____ at _____, California

SIGNATURE: I. N. Robinson Jr.

PRINTED NAME: I.N. Robinson Jr.
(FIRST NAME) (MIDDLE INIT.) (LAST NAME)

COMPANY NAME: _____

See back of page for General Information. If there is insufficient space for your answers, please number them in the space provided on the back of this form.

WR 40-1

SDWA 62

C-115831

C-115831

ITEM CONTINUATION

GENERAL INFORMATION PERTAINING TO WATER RIGHTS IN CALIFORNIA

There are two principal types of surface water rights in California. They are riparian and appropriative rights.

A riparian right enables an owner of land bordering a natural lake or stream to take and use water on his riparian land. Riparian land must be in the same water shed as the water source and must never have been severed from the sources of supply by an intervening parcel without reservation of the riparian right to the severed parcel. Generally, a riparian water user must share the water supply with other riparian users. Riparian rights may be used to divert the natural flow of a stream but may not be used to store water for later use or to divert water which originates in a different watershed, or return flows from use of groundwater.

An appropriative right is required for use of water on nonriparian land and for storage of water. Generally, appropriative rights may be exercised only when there is a surplus not needed by riparian water users. Since 1914 new appropriators have been required to obtain a permit and license from the State.

Statements of Water Diversion and Use must be filed by a riparian and pre-1914 appropriative water users. The filing of a statement (1) provides a record of water use, (2) enables the State to notify such users if someone proposes a new appropriation upstream from their diversion, and (3) assists the State to determine if additional water is available for future appropriators.

The above discussion is provided for general information. For more specific information concerning water rights, please contact an attorney or write to this office. We have several pamphlets available. They include.

"Statements of Water Diversion and Use"
"Information Pertaining to Water Rights in California"
"Water Rights for Stockponds Constructed Prior to 1969"
"Appropriation of Water in California"

WR 40-1 (4/97)

STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER RIGHTS

P.O. BOX 2000 SACRAMENTO, CA 95812-2000
(916) 657-1875

SUPPLEMENTAL STATEMENT OF WATER DIVERSION AND USE

DIVERTER OF RECORD: STATEMENT NO: 009023

NEWT ROBINSON
7900 S INLAND DRIVE
STOCKTON, CA 95206

TELEPHONE NUMBER:
( ) - -

IF NAME/ADDRESS/PHONE NO. IS WRONG OR MISSING, PLEASE CORRECT.

SOURCE: MIDDLE RIVER

TRIBUTARY TO: SAN JOAQUIN RIVER DELTA CHANNELS

COUNTY: SAN JOAQUIN YEAR OF FIRST USE: 1927

DIVERSION
WITHIN: 1/4 OF 1/4 SECTION 35, T01N, R05E, MDB&M.

COMPLETE AND RETURN THIS FORM BY JULY 1, 1994.

A. Water is used under: Riparian claim YES; Pre 1914 right _____; Other (explain) _____

B. Year of first use (Please provide if missing above) _____

C. Amount of Use - Enter the amount of water used each month. If monthly and annual use are not known, check the months in which water was used.

Amounts below are: ☐ Gallons ☐ Acre-feet ☐ (other) _____

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL ANNUAL
1991		MY PREVIOUS REPORTS							AVERAGE EQUAL EACH				YEAR
1992			X	X	X	X	X	X	X				
1993			X	X	X	X	X	X	X				

D. Purpose of Use - Specify number of acres irrigated, stock watered, persons served, etc.
Irrigation 33.5 acres; Stockwatering NONE; Domestic _____
Other (specify) _____

E. Changes in Method of Diversion - Describe any changes in your project since your previous statement was filed. (New pump, enlarged diversion dam, location of diversion, etc.)

NONE

F. If part of the water listed in Part C consists of reclaimed or polluted water, please indicate the annual amounts of reclaimed or polluted water in the space below.

NONE

I declare under penalty of perjury that the information in this report is true to the best of my knowledge and belief.

DATED: JUNE 29, 19 94, at STOCKTON, California

Signature: [signature]

WR 40-1 (1/94)
FOR0127R2

STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER RIGHTS
SACRAMENTO
1994 JUN 30 PM 3

C-115833

DIVISION OF WATER RIGHTS
P.O. Box 2000 SACRAMENTO, C 5812-2000
901 P STREET, SACRAM. , CA
(916) 657-1364 FAX: (916) 657-1485

A 0 1 1 6 9 4

REPORT OF LICENSEE FOR 1994, 1995, 1996

OWNER OF RECORD: I S ROBINSON, I NEWTON ROBINSON

APPLICATION: A011694

LICENSE: 003677

I NEWTON ROBINSON
7000 S INLAND DR
STOCKTON, CA 95206

TELEPHONE NUMBER:
(209) 466-7915

IF OWNER'S NAME/ADDRESS/PHONE NO. IS WRONG OR MISSING, PLEASE CORRECT.

SOURCE: MIDDLE RIVER

COUNTY: SAN JOAQUIN

PURPOSE:	DIVERSION/STORAGE SEASON:	ACRES/HP:
STOCKWATERING	JAN 01 TO DEC 31 /	0 AC
IRRIGATION	JAN 01 TO DEC 31 /	427.6 AC

AMOUNT: 4.5 CFS 0 AC-FT

THIS REPORT IS REQUIRED BY THE TERMS AND CONDITIONS OF YOUR LICENSE

IMPORTANT! EVERY license is subject to the conditions therein. I have currently reviewed my license: YES [X] NO [ ]. I am complying with the conditions of my license: YES [X] NO [ ]. Identify any noncompliance by license term number under "Remarks" on reverse side. This report is important in providing the record of use needed in maintaining your water right. It should be filled out carefully and returned promptly to the above-listed address.

THE PROJECT HAS BEEN ABANDONED, AND I REQUEST REVOCATION OF THE LICENSE: YES [ ].

COMPLETE FOR DIRECT DIVERSION PROJECTS

1. Have you used the full licensed amount of water each year? YES [ ] NO [X]. Sufficient rainfall.
2. State the quantity of water used each month in gallons or acre-feet (if not known, check months water was used).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Annual
1994			X	X	X	X	X	X	X	X	X		
1995			X	X	X	X	X	X	X	X	X		
1996			X	X	X	X	X	X	X	X	X		

COMPLETE FOR STORAGE PROJECTS

3. Did your reservoir spill this year?	1994	1995	1996
4. If not, how many feet below spillway vertically was the water level at maximum storage?			
5. Have you emptied the reservoir?			
6. How many feet below spillway vertically was it drawn down at end of season?			

(Continues on reverse side)

1996

C-115834

USE (COMPLETE FOR ALL PROJECTS) (see page 1 for year of use)

7. Acreage irrigated	427.6	427.6	427.6
8. Stockwatering - number of stock			
9. Domestic - number of persons			
garden area, etc.			
10. Recreational - nature of use			
11. Industrial - nature of use			
12. Municipal - approximate population			
13. Power generation - K.W.			
14. Other			

15. If no water was used in one or more years, briefly state the reason under "Remarks".

16. If the location of the point of diversion or place of use or type of use(s) has been changed and the permission of this Board has not yet been obtained, please describe nature of changes under "Remarks".

PLEASE ANSWER ONLY THOSE QUESTIONS BELOW WHICH ARE APPLICABLE TO YOUR PROJECT.

CONSERVATION OF WATER

17. Describe any water conservation efforts you may have started: _____

18. If credit toward beneficial use of water under this license for water not used due to a conservation effort is claimed under Section 1011 of the Water Code, please show the amounts of water conserved:
19___ _____(af/mg) 19___ _____(af/mg) 19___ _____(af/mg)

WATER QUALITY AND WASTEWATER RECLAMATION

19. Are you now or have you been using reclaimed water from a wastewater treatment facility, desalination facility or water polluted by waste to a degree which unreasonably affects such water for other beneficial uses? YES [ ] NO [X].

20. If credit toward use under this license through substitution of reclaimed water, desalinated water or polluted water in lieu of appropriated water is claimed under Section 1010 of the Water Code, please show amounts of reduced diversion and amounts of reclaimed water used: 19___ _____(af/mg) 19___ _____(af/mg) 19___ _____(af/mg)

CONJUNCTIVE USE OF SURFACE WATER AND GROUNDWATER

21. Are you now using groundwater in lieu of surface water? YES [ ] NO [X]

22. If credit toward use under this license through substitution of groundwater in lieu of appropriated water is claimed under Section 1011.5 of the Water Code, please show the amounts of groundwater used:
19___ _____(af/mg) 19___ _____(af/mg) 19___ _____(af/mg)

REMARKS: (Identify the item you are explaining. Additional pages may be attached.)

I declare under penalty of perjury that the information in this report is true to the best of my knowledge and belief:

Date:_____ Sign Here: J. M. Robinson
LICENSEE (OR AGENT OR DESIGNEE)

STATE OF CALIFORNIA
THE RESOURCES AGENCY
STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER RIGHTS

ORDER

APPLICATION 11694 PERMIT 6790 LICENSE 3677

ORDER ALLOWING CHANGE IN PLACE OF USE

WHEREAS License 3677 was issued to Abigail Meyer and Estate of Leland Meyer and was filed with the County Recorder of San Joaquin County on February 25, 1953, and

WHEREAS said license was subsequently assigned to I. N. Robinson, Jr., Isabelle Smith Robinson and the Rio Blanco Corporation, and

WHEREAS the State Water Resources Control Board has found that the change in place of use under said license for which petition was submitted on December 5, 1967, will not operate to the injury of any other legal user of water, and

WHEREAS the Board has approved and allowed said change and has directed that an order be issued to describe said place of use in accordance with said petition;

NOW THEREFORE IT IS ORDERED that permission be and the same is hereby granted to change the place of use under said License 3677 to place of use described as follows, to wit:

IRRIGATION OF A NET AREA OF 427.6 ACRES WITHIN A GROSS AREA OF 507.0 ACRES CONSISTING OF 79.4 ACRES WITHIN E½ OF SE¼ OF SECTION 7, 73.8 ACRES WITHIN W½ OF W½ OF SECTION 17 AND 353.8 ACRES WITHIN S½ OF SECTION 18, ALL WITHIN T1S, R6E, MDB&M, AS SHOWN ON MAP FILED WITH THE STATE WATER RESOURCES CONTROL BOARD.

Dated: MAR 2 2 1968

K. L. Woodward
K. L. Woodward, Chief
Division of Water Rights

3

WRCB
133 (12-67)

16283-957 11-67 2M OSP

C—115836

C-115836

STATE OF CALIFORNIA—DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
STATE ENGINEER

License for Diversion and Use of Water

APPLICATION 11694 PERMIT 6790 LICENSE 3677

THIS IS TO CERTIFY, *That* Abigail Meyer and Estate of Leland Meyer
c/o Robert Meyer
Route 6, Box 662
Stockton, California
have made proof as of May 20, 1952
(the date of inspection) to the satisfaction of the State Engineer of California of a right to the use of the water of Middle River in San Joaquin County
tributary to San Joaquin River
for the purpose of irrigation and stock-watering uses
under Permit 6790 *of the Department of Public Works and that said right to the use of said water has been perfected in accordance with the laws of California, the Rules and Regulations of the Department of Public Works and the terms of the said permit; that the priority of the right herein confirmed dates from* January 13, 1947; *and that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to the amount actually beneficially used for said purposes and shall not exceed* four and five tenths (4.5) cubic feet per second to be diverted from January 1 to December 31 of each year.

The equivalent of such continuous flow allowance for any thirty day period may be diverted in a shorter time if there be no interference with other vested rights.

The point of diversion of such water is *located* north seventy-one degrees five minutes west (N71°05'W) three thousand nine hundred four (3904) feet from SW corner of Section 18, T 1 S, R 6 E, MDB&M, being within SE¼ of SW¼ of Section 13, T 1 S, R 5 E, MDB&M.

A description of the lands or the place where such water is put to beneficial use is as follows: 427.6 acres in S½ of Section 18 and W½ of W½ of Section 17, T 1 S, R 6 E, MDB&M, as shown on map filed with State Engineer.

All rights and privileges under this license including method of diversion, method of use and quantity of water diverted are subject to the continuing authority of the Department acting through the State Engineer in accordance with law and in the interest of the public welfare to prevent waste, unreasonable use, unreasonable method of use or unreasonable method of diversion of said water.

Reports shall be filed promptly by licensee on appropriate forms which will be provided for the purpose from time to time by the State Engineer.

The right hereby confirmed to the diversion and use of water is restricted to the point or points of diversion herein specified and to the lands or place of use herein described.

1

FORM 64

C—115837

This license is granted and licensee accepts all rights herein confirmed subject to the following provisions of the Water Code:

Section 1625. Each license shall be in such form and contain such terms as may be prescribed by the Department.

Section 1626. All licenses shall be under the terms and conditions of this division (of the Water Code).

Section 1627. A license shall be effective for such time as the water actually appropriated under it is used for a useful and beneficial purpose in conformity with this division (of the Water Code) but no longer.

Section 1628. Every license shall include the enumeration of conditions therein which in substance shall include all of the provisions of this article and the statement that any appropriator of water to whom a license is issued takes the license subject to the conditions therein expressed.

Section 1629. Every licensee, if he accepts a license does so under the conditions precedent that no value whatsoever in excess of the actual amount paid to the State therefor shall at any time be assigned to or claimed for any license granted or issued under the provisions of this division (of the Water Code), or for any rights granted or acquired under the provisions of this division (of the Water Code), in respect to the regulation by any competent public authority of the services or the price of the services to be rendered by any licensee or by the holder of any rights granted or acquired under the provisions of this division (of the Water Code) or in respect to any valuation for purposes of sale to or purchase, whether through condemnation proceedings or otherwise, by the State or any city, city and county, municipal water district, irrigation district, lighting district, or any political subdivision of the State, of the rights and property of any licensee, or the possessor of any rights granted, issued, or acquired under the provisions of this division (of the Water Code).

Section 1630. At any time after the expiration of twenty years after the granting of a licenie, the State or any city, city and county, municipal water district, irrigation district, lighting district, or any political subdivision of the State shall have the right to purchase the works and property occupied and used under the license and the works built or constructed for the enjoyment of the rights granted under the license.

Section 1631. In the event that the State, or any city, city and county, municipal water district, irrigation district, lighting district, or political subdivision of the State so desiring to purchase and the owner of the works and property can not agree upon the purchase price, the price shall be determined in such manner as is now or may hereafter be provided by law for determining the value of property taken in eminent domain proceedings.

Witness my hand and the seal of the Department of Public Works of the State of California, this 24th *day of* February, 1953

A. D. EDMONSTON, *State Engineer*

11-21-66 D. M. Robinson Jr.
& Isabelle Smith Robinson
The Rio Blanco Corporation

6/20/72 WRONG NOTICE OF ASSIGNMENT TO D. M. Robinson Jr. & Isabelle Smith Robinson

LICENSE 3677

STATE OF CALIFORNIA—DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
STATE ENGINEER

LICENSE
TO APPROPRIATE WATER

ISSUED TO Abigail Meyer and Estate of Leland Meyer

DATED

46907 7-51 3M STATE PRINTING OFFICE

2

C—115838

C-115838

13386.02.2150

DRAFT

Additional Water Acquisition for Meeting VAMP Flow Objectives 1999

Environmental Assessment and Initial Study

Prepared for

U.S. Department of the Interior
Bureau of Reclamation
Sacramento, California

and

San Joaquin River Group Authority
Modesto, California

Prepared by

EA Engineering, Science, and Technology
Lafayette, California

March 30, 1999

SDWA 63

C-115839

C-115839

EXECUTIVE SUMMARY

PROPOSED ACTION: The Bureau of Reclamation (Reclamation) proposes a one-year purchase of up to a maximum of 47,000 acre-feet of water from water users on the San Joaquin River and its tributaries in 1999 (separate from other existing agreements/contracts) for the following purpose:

> San Joaquin River System. Up to 47,000 acre-feet may be acquired from the San Joaquin River Group Authority in order to provide additional stream flows for anadromous fish in the San Joaquin River at Vernalis and its tributaries for the 31-day spring pulse flow in 1999. The project objective is to provide up to 47,000 acre-feet of additional water for the pulse flow in April-May 1999, under the San Joaquin River Agreement. This additional water is needed to support the Vernalis Adaptive Management Plan (VAMP) and to provide protective measures for fall-run chinook salmon in the San Joaquin River.

Due to uncertain hydrologic conditions that may occur during April and May, Reclamation may actually purchase less water, but the analyses in the EA/IS were made to analyze the potential range of purchases that may occur for 1999. Hydrologic conditions in 1999 when combined with the wet year in 1998 could mean that additional water above the 110,000 acre-feet that is provided for under the San Joaquin River Agreement (SJRA) may be required to meet the VAMP flow target.

ENVIRONMENTAL IMPACT REVIEW PROCESS

The Bureau of Reclamation (Reclamation, Lead Agency under NEPA) and the San Joaquin River Group Authority (Authority, Lead Agency under CEQA) will seek public comments on the Draft EA/IS. Following public review and consideration of public comments that will be incorporated into a Final EA/IS, and assuming that no significant effects are determined to occur for the one-year project, Reclamation may acquire the additional water.

DECISION TO BE MADE: The Bureau of Reclamation and the San Joaquin River Group Authority expect to approve a Finding of No Significant Impact and a Negative Declaration on the proposed action.

SUMMARY OF ENVIRONMENTAL CONSEQUENCES: The proposed action potentially affects a variety of resources and concerns. Table ES-1 summarizes the environmental effects of the water acquisitions for each component. For each resource and concern, there are either no impacts or impacts are less than significant.

STATE WATER CONTRACTORS
MEMO

April 28, 1999

TO: Ag/Urban Policy Group

FROM: Steve Macaulay, General Manager

SUBJECT: Update, 1999 Operations Plan

At the April 26 Policy Group meeting I was asked to keep the Policy Group informed regarding developments over the 1999 Delta operations plan. Late yesterday I got a progress report on yesterday's CALFED "Small Group" meeting – participants are at the deputy director level of CALFED agencies. I was told the following:

1. The group supports putting the funding of water purchases in CALFED's lap from a funding standpoint, but there is recognition this is for funding convenience and not intended to imply this is a CALFED responsibility.

2. USBR is proceeding with two water purchases – one with Yuba County Water Agency and one with water users on the Stanislaus (apparently will not run into the "real water" concern that caused the SWRCB to turn down a Stanislaus River transfer several weeks ago). Anticipated total purchase of 120,000 acre-feet (60K each).

3. Full speed ahead on "joint point."

4. It is not clear whether a modification of the export / inflow ratio standard will be pursued (not clear if necessary either, if water purchases meet the full need). In June the striped bass Delta outflow standard will control, but flexing the E/I could be used to move water from Oroville to San Luis. There is also the complicating factor of potential smelt and splittail "take" in May and flexing the E/I could help make up for additional export reductions associated with these species.

The next meeting of the "Small Group" is Tuesday, May 4. DWR will continue to cooperate with the export limitation with the understanding that the federal government will strongly pursue the payback measures, and with the expectation that this will be documented in the near future.

455 Capitol Mall, Suite 220 • Sacramento, California 95814 • (916) 447-7357 • FAX (916) 447-2734
car: (916) 761-3728 email: macaulay@calweb.com

COPY

STATE WATER RESOURCES CONTROL BOARD

PUBLIC HEARING

1998 BAY-DELTA WATER RIGHTS HEARING

HELD AT:

BONDERSON BUILDING
901 NINTH STREET
SACRAMENTO, CALIFORNIA

THURSDAY, JULY 30, 1998
9:00 A.M.

Reported by: ESTHER F. WIATRE
CSR NO. 1564

APPEARANCES

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---oOo---

1 Go ahead.

2 C.O. CAFFREY: But we appreciate it. Go ahead.

3 MR. HERRICK: Do you have an understanding to whether
4 or not Mr. Steiner's modeling included any potential
5 purchases under any other --

6 MR. PLOSS: I am not aware of that.

7 MR. HERRICK: The San Joaquin River Agreement provides
8 certain conditions or relaxations of conditions. Does the
9 Bureau have any plans at this time for -- has the Bureau
10 identified sources of water it may purchase in order to make
11 up for any relaxation of a VAMP flow?

12 MR. PLOSS: No we have not.

13 MR. HERRICK: So, the Bureau has not identified any
14 sources of water that may be purchased to make up in a year
15 that the objective is relaxed?

16 MR. PLOSS: The San Joaquin River Agreement provides
17 for water purchases from willing sellers in those
18 conditions, but does not identify who those parties will
19 be.

20 MR. HERRICK: Mr. Ploss, the word "backstop" has been
21 used in the San Joaquin River Agreement discussions. I
22 understand that to mean that, if for some reason the
23 agreement is terminated or interrupted for some reason, that
24 the Bureau and DWR are offering to backstop the obligations.
25 Is that correct?

MR. PLOSS: We are assuming to take on the responsibility of complying with the 1995 Water Quality Control Plan in that circumstance.

MR. HERRICK: When you say "comply with the Water Quality Control Plan," you are talking about the 1995 Water Quality Control Plan objectives?

MR. PLOSS: Yes.

MR. HERRICK: You are not talking about San Joaquin River objectives?

MR. PLOSS: No. 1995 Water Quality Control Plan.

MR. HERRICK: Would you agree that your agency's modeling of the operations of New Melones show that there is insufficient water from New Melones to meet all of the 1995 Water Quality Control Plan objectives?

MR. PLOSS: Yes. As well as many other purposes of water out off New Melones.

MR. HERRICK: Has your agency then done any calculation or determination of how you might backstop the San Joaquin River Agreement?

MR. PLOSS: No, we have not.

MR. HERRICK: The San Joaquin River Agreement allows for the operations plan, I will say, to be disputed by any party as it is being developed. Fair assumption?

MR. PLOSS: That's fair.

MR. HERRICK: In that event, the parties are supposed

Oakdale Irrigation District/
South San Joaquin Irrigation District

Water Transfer Project
Draft Environmental Impact Report

PREPARED FOR THE

OID
OAKDALE IRRIGATION DISTRICT

SSJID
SOUTH
SAN JOAQUIN
IRRIGATION DISTRICT

PREPARED BY

EIP
ASSOCIATES

March 1999

C-115846

C-115846

2. *SUMMARY OF IMPACTS AND MITIGATION MEASURES*

PROJECT UNDER REVIEW

The OID/SSJID proposes to transfer up to 30,000 acre feet (AF) of surface water annually over a 10-year period from OID and SSJID through existing conveyance facilities to the Stockton East Water District (SEWD) and its customers, the City of Stockton, and the Lincoln Village and Colonial Heights Maintenance Districts. The transferred water would be used by SEWD and its customers primarily for direct municipal and industrial use by the City of Stockton, California Water Service Company and the Lincoln Village and Colonial Heights Maintenance Districts in order to reduce groundwater pumping and enhance recovery of the Eastern San Joaquin Groundwater Basin. Although it is likely that SEWD would maximize the use of purchased water to conserve other available supplies, it is unlikely the entire allocated amount would be fully utilized during the ten-year period. For a complete description of the proposed project, please see Chapter 3, Project Description.

SUMMARY OF IMPACTS

This summary provides an overview of the analysis contained in Chapter 4, Environmental Setting, Impacts and Mitigation Measures. The following issues are addressed in Chapter 4: water resources, and fisheries.

Levels of Significance

An EIR uses a variety of terms to describe the level of significance of adverse impacts identified during the course of the environmental analysis, as defined below.

- Significant and Unavoidable Impact - Impact that exceeds the defined standards of significance and which cannot be eliminated or reduced to a less-than-significant level through the implementation of feasible mitigation measures. No significant and unavoidable impacts were identified for the proposed project.

- Significant Impact - Impact that exceeds the defined standards of significance and which can be eliminated or reduced to a less-than-significant level through the implementation of feasible mitigation measures. No significant impacts were identified for the proposed project.

- Less-Than-Significant Impact - Impact that does not exceed the defined standards of significance.

Significant Impacts

Under CEQA, a significant effect on the environment is defined as a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project, including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance.

Implementation of the proposed project would not result in any significant impacts and therefore, no mitigation measures are proposed.

Effects Found Not to Be Significant

The analysis identified less-than-significant impacts for reductions in surface water levels in the Stanislaus and San Joaquin Rivers. Associated decreases in water quality and the potential to adversely affect fisheries habitat is also considered less than significant. In addition, the proposed project would result in less-than-significant impacts as a result of increased groundwater pumping within OID and SSJID and associated reductions in groundwater quality.

Statutorily Required Impact Sections

Chapter 5 of this EIR includes discussions of Cumulative Impacts (5.1), Growth-Inducing Impacts (5.2), Irreversible Changes to the Environment (5.3), and Significant and Unavoidable Impacts (5.4).

Cumulative Impacts

Cumulative impacts of the proposed project are described in Chapter 4 and summarized in Section 5.1, Cumulative Impacts. For the purposes of the cumulative impact analysis for this EIR, the "cumulative context" for the proposed project is defined as existing and reasonably foreseeable future projects within a geographic area that would contribute to the particular cumulative impact. The cumulative analysis focuses on implementation of the proposed project in conjunction with other water transfers from the Stanislaus River and additional groundwater pumping of the Eastern San Joaquin County and Modesto Groundwater Basins associated with other water transfer projects.

Growth-Inducing Impacts

Growth-inducing impacts are discussed in Section 5.2. The proposed project is the interdistrict transfer of surface water through an existing water conveyance system. No new infrastructure would be constructed. The proposed project would provide additional surface water to SEWD and its customers to enable users in the District to decrease groundwater pumping to provide for urban water uses.

The proposed project does not anticipate a net change water availability because it would substitute sources of supply without affecting the quantity of water used. However, it is possible

that the City could continue to pump groundwater to meet urban demand. However, any increase in demand and associated growth would not be over that evaluated and approved as part of the City of Stockton's General Plan Revision and Infrastructure/Public Facilities Master Plan Environmental Impact Report and Findings, Statement of Overriding Considerations. Therefore, the proposed project would not induce growth or support population increases over that projected and previously evaluated and approved. If growth beyond that approved in the City of Stockton General Plan occurs, and an additional supply source is required beyond that which currently exists (including the proposed transferred water), then additional environmental documentation would be required to evaluate the potential impacts (including growth-inducement) of developing and distributing that new supply source.

Irreversible Changes to the Environment

Significant irreversible changes identified as a result of project implementation are discussed in Section 5.3. Because the proposed project would not involve new construction, it would not involve a commitment of nonrenewable resources, it would not involve uses in which irreversible damage could result from potential environmental accidents, and it does not include consumption of resources that is not justified. Furthermore, one short-term transfer would not result in a change in net water availability. Therefore, the proposed project would not result in any significant irreversible impacts.

Unavoidable Significant Impacts

Implementation of the proposed project would not result in any significant and unavoidable impacts.

SUMMARY TABLE

Table 2-1, Summary of Impacts and Mitigation, located at the end of this chapter, has been organized to correspond with the environmental issues discussed in Chapter 4. The summary table is arranged in four columns: 1) Impacts 2) Level of Significance Prior to Mitigation; 3) Mitigation Measures; and 4) Level of Significance after Mitigation. Two alternatives were considered as part of this environmental review, the No Project Alternative and the Proposed Project.

ALTERNATIVES ANALYSIS

In accordance with Section 15126 of the CEQA Guidelines, an DEIR must describe a reasonable range of alternatives to the proposed project that could feasibly attain the objectives of the project. The comparative merits of these alternatives must be described and evaluated. The CEQA Guidelines require that the No Project Alternative and its impacts be evaluated and that an environmentally superior alternative be designated. The alternatives analysis also includes a discussion of an alternative that was considered but was rejected from further analysis. The City of Stockton considered use of water from the Delta. However, this alternative was rejected from further consideration because it would not be implementable during the 10-year water transfer

period, the outcome is uncertain regarding the City's water rights application, the water would require substantial treatment, and implementation of this alternative would result in substantially more significant impacts when compared to the project.

The alternatives are evaluated in Chapter 6 (Alternatives) in this DEIR.

AGREEMENT

NOW THEREFORE, the Parties agree as follows:

I. The Parties agree to implement the following program of fishery instream flow releases from New Melones Dam to provide (1) flows acceptable and reasonable for upstream migration, spawning, incubation, rearing and downstream migration of chinook salmon and (2) the basis for expedient completion of biological studies to identify long-term instream flow needs of the Stanislaus River below Goodwin Dam.

II. Each year the Bureau shall compute the supply available for annual fishery instream flow releases using the procedure described in Exhibit C. For the purposes of this AGREEMENT a year shall begin on March 1 and end on the last day of February of the succeeding calendar year.

An initial appraisal of the supply available for annual fishery instream flow releases will be computed and furnished to Fish and Game on February 1st of each year or as soon as practicable but no later than February 15th. This initial appraisal will be used by Fish and Game to produce a fishery instream flow release schedule for the first 15 days of March. This schedule shall be provided to the Bureau as soon as practicable, but no later than February 20th.

A second estimate of the supply available for annual fishery instream flow releases will be computed and furnished to Fish and Game on March 1st of each year or as soon as practicable but no later than March 10th. A preliminary 12 month fishery instream flow release schedule shall be provided to the Bureau as soon as practicable, but no later than March 15th. The final determination of the supply available will be computed and furnished to Fish and Game on April 1st of each year or as soon as practicable but no later than April 10th. The final fishery instream flow release schedule for the April through February period shall be provided to the Bureau no later than April 15th. Instream flow releases shall be provided by the Bureau in accordance with schedules furnished by Fish and Game.

A. The maximum annual supply available for fishery instream flow releases shall be 302,100 acre-feet and the minimum supply shall be 98,300 acre-feet.

B. Fish and Game agrees that fishery instream flow releases which may be requested, either for the purpose of study, or based upon the results of studies as herein provided, shall not exceed 1,250 cubic feet per second, except at the discretion of the Bureau for compliance with existing guidelines for flood control, water quality requirements, nondamaging flow levels, implementation of the Plan of Study (Exhibit A) and

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other downstream considerations.

C. Both parties recognize that the determination of target storage as defined in Exhibit C is dependent on the amount of water being consumed by uses upstream of New Melones Reservoir, and by Oakdale Irrigation District and South San Joaquin Irrigation District.

(1.) The annual use of Oakdale and South San Joaquin Irrigation Districts shall be monitored and as the three year average water use increases to the maximum allowed by the 1972 Stipulation and Agreement between the Bureau and the Districts, the target storage specified in Exhibit C shall be modified in accordance with the schedule shown in Figure C-1, to protect authorized inbasin uses. Only those years in which the New Melones inflow equals or exceeds 654,000 acre-feet for the period from November 1 through October 31 of the following calendar year will be used to compute the three year average water use.

(2.) The consumptive use of water in the basin above New Melones shall be monitored on an annual basis. If the use of water under existing or new permits increases by 10,000 acre-feet per year over the present level, the provisions for fishery releases in excess of 98,300 acre-feet per year shall be renegotiated to accommodate the increased upstream use. Dry and critical year shortage criteria may also be considered during these negotiations. The present level of use of water above New Melones Reservoir is estimated to be 36,800 acre-feet per year.

D. Said fishery instream flow releases shall be made in a manner allowing for the implementation of the Plan of Study described in Exhibit A.

III. The fishery instream flow releases provided for in this AGREEMENT shall be made by the Bureau until long-term salmon protection standards are agreed to or adopted by the Board. At the time of completion of the studies described in Exhibit A, the results, along with other pertinent information shall be considered by the Parties in identifying an acceptable instream flow program. A Final Agreement is anticipated, which would contain mutual recommendations to afford long-term fishery resource protection. Said recommendations would be provided to the Board, together with a mutual request that they be implemented as a condition of any Permit or License issued pursuant to Applications No. 14858, 27319, 27320, and 27321. In the event said Final Agreement cannot be made, within a period of two years following concurrence of the Parties that the Plan of Study is completed, or six years following the last release of coded-wire-tagged salmon as described in Exhibit A, the Parties agree that either Party may submit its independent recommendations and request to said Board.

IV. Fish and Game agrees to dismiss its Protest to the Bureau's Applications No. 14858, 27319, 27320, and 27321, as filed before the Board provided any Permit issued pursuant to said Applications contains provisions sufficient to permit the implementation of paragraph III above.

V. The Parties agree that they will work with other water agencies in an attempt to implement a conjunctive use program that would augment river flows so as to improve habitat conditions for chinook salmon and other fishery resources. In that event, this AGREEMENT will be amended, as appropriate.

VI. Nothing herein shall be construed to require any action which would, of itself, constitute any infraction or violation of either the Constitution of the United States of America or the State of California, or of any Federal or State statute.

VII. It is the intent of the Parties to implement the Plan of Studies as described in Exhibit A. The Parties agree to diligently pursue approval for funding of the Plan of Studies (Exhibit A). It is recognized that said funding is contingent upon approval of the budgets of Fish and Game, the Bureau and Fish and Wildlife Service, by the State Legislature and United States Congress, as applicable.

VIII. This AGREEMENT may be modified, based upon written concurrence of both Parties, except that in the event this AGREEMENT becomes an instrument of either law or permit, concurrence of all concerned legal and/or permit agencies shall also be required.

6-2-87
(Date)

Pete Bontadelli
Jack C. Parnell, Director
California Department of Fish and Game

6-5-87
(Date)

David G. Houston, Regional Director
U. S. Bureau of Reclamation

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Exhibit C

Purpose

1. This exhibit defines the equation used to compute the supply available for annual instream flow releases.

Variables

2. When used in this exhibit, the following variable representations shall be applied:

(a) "M" is the variable label that represents the calendar year month number of the current month of calculation. For example, when the calculation is performed in March, M is equal to 3.

(b) "SAAIF(M)" is the variable label that represents the supply available, computed in month "M", for annual instream flow releases in acre-feet.

(c) "AIF" is the variable label that represents the amount of instream flow in acre-feet released since March 1 of the current year.

(d) "EOMS(M-1)" is the variable label that represents the New Melones end-of-month storage in acre-feet for the previous month.

(e) "PI(M)" is the variable label that represents the projected inflow to New Melones reservoir, in acre-feet, for the current month through September of the current year.

(f) "POSWD(M)" is the variable label that represents the projected water demands, in acre-feet, for the Oakdale and South San Joaquin Water Districts from the current month through September of the current year.

(g) "PCWD(M)" is the variable label that represents the projected contracted CVP Stanislaus River water demands in acre-feet for the current month through September of the current year.

(h) "PWQWD(M)" is the variable label that represents the projected water demands in acre-feet associated with supporting downstream water quality and minimum flow committments for the current month through September of the current year. These flow requirements are those contained in SWRCB D-1422 and the Agreement with the South Delta Water Agency.

(i) "EVAP(M)" is the variable label that represents the estimated evaporation from New Melones reservoir in acre-feet from the current month through September of the current year. The evaporation rates applied in projecting New Melones reservoir evaporation in acre-feet per acre are:

MAR	APR	MAY	JUN	JUL	AUG	SEP
.199	.386	.507	.581	.764	.711	.595

(J) "TS" is the variable label that represents the September end-of-month target storage in acre-feet. This value is influenced by the level of upstream and downstream demands for water from New Melones reservoir. Given the assessment of current conditions related to water demands on New Melones a target storage of 1,700,000 acre-feet shall be used. This value can be changed by mutual agreement of the parties as reassessment of these conditions indicate the need for change.

Equation

3. The following equation shall be used to compute the supply available for annual instream flow releases on the Stanislaus River at Goodwin Dam:

$$SAAIF(M) = AIF + EOMS(M-1) + PI(M) - POSWD(M) - PCWD(M) - PWQWD(M) - EVAP(M) - TS$$

Figure C-1

TARGET STORAGE TABLE
(Thousands of Acre-feet)

Oakdale I. D. and South San Joaquin I. D. Demand	-	600	620	640	650	654
Required Target Storage for New Melones Reservoir	-	1700	1700	1700	1750	1750

AGREEMENT BETWEEN
CALIFORNIA DEPARTMENT OF FISH AND G E
AND
THE UNITED STATES DEPARTMENT OF THE IN RIOR
BUREAU OF RECLAMATION
REGARDING
INTERIM INSTREAM FLOWS AND FISHERY S IES
IN THE STANISLAUS RIVER BELOW NEW MELONES SERVOIR

This AGREEMENT is made by and between the Stat of California, as represented by the Department of Fish and Game, her after referred to as "Fish and Game", and the United States Departmen of the Interior, Bureau of Reclamation, hereinafter referred to as " eau", and both hereinafter collectively referred to as "Parties", r the combined purposes of (1) providing appropriate Stanislaus Ri r instream flows as needed to maintain or enhance the fishery resource ring an interim period in which habitat requirements are better def ed, and (2) completing studies of the chinook salmon fisheries the Stanislaus River.

RECITALS

THE PARTIES RECOGNIZE:

A. Chinook salmon stocks of the San Joaquin ver and its tributaries represent important fishery resources the State of California. These include salmon which annually lize the Stanislaus River, downstream from Goodwin Dam, for the purpo of spawning, incubation, juvenile rearing and migration. All Joaquin River system salmon stocks have been reduced in recent rs, resulting from numerous factors affecting their habitat and redu g their survival, particularly during juvenile stages.

B. Through its operation, the Bureau's New lones Reservoir can materially affect the amount and timing of instre flows available below (downstream) of Goodwin Dam, thereby affecting th welfare and success of salmon stocks and other fishery resources of the anislaus River and of the San Joaquin River in the reach between the St islaus River confluence and the San Joaquin-Sacramento River Delta. It is recognized, however, that the adequacy of instream flows in e San Joaquin River and Delta reaches is dependent upon conditions and i tream flow releases from other upstream tributaries, in addition to e Stanislaus River.

C. During 1984, the Bureau filed Applicatio No. 14858, 27319, 27320, and 27321, before the California State W r Resources Control Board (Board), which in part sought permits to ectly divert water for beneficial use at New Melones Dam and other poi s, as described in those applications. Fish and Game, acting on behalf the people of the State of California, filed a protest to the Bureau's plications on the basis

TUOLUMNE UT LITIES DISTRICT EXHIBIT NO.

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that, lacking appropriately scheduled instream flows, : proposed direct diversions could adversely affect salmon and other resc ces of the Stanislaus River and the reach of the San Joaquin Riwe: described in Recital B above.

D. In its protest, Fish and Game identified the : ed to perform detailed studies of the Stanislaus River salmon fisher for the purpose of prescribing an appropriate instream flow sc dule. The need for such studies had earlier been identified Decision D-1422 of the Board. The Parties, in coordination wit the United States Department of the Interior Fish and Wildlife Se ice (the Service), have already cooperated, to some extent, in e design, partial funding and partial conduct of said studies, p or to execution of this AGREEMENT. As yet, insufficient study results re available, however to make the intended instream flow prescriptio .

The cooperative studies as agreed to by the Parties ar the Service are outlined in the Plan of Study, a copy of which is atta ed hereto as Exhibit A of this AGREEMENT. The funding responsibili es and budget for the studies are provided for in the document attac d hereto as Exhibit B.

E. The purposes of this AGREEMENT are:

1. To commit the Parties, within constraints impose y Legislative approvals of their budgets, to the completion of a prc am of studies intended to identify the long-term instream fl and other physical needs of Stanislaus River chinook salmon.

2. To implement an interim instream flow schedule wh h will (1) protect the chinook salmon stock of the Stanislaus River ring completion of said studies, and (2) provide for experimentation the amount and timing of instream flows to ascertain if acceptab criteria for protection of salmon can be provided conjunctively wi other beneficial water uses.

F. This AGREEMENT shall pertain only to fishery esources and habitat within the Stanislaus River and San Joaquin R er as described in Recital B above. The Parties further recognize th there are other downstream activities which also materially affect th survival of downstream migrant chinook salmon from the Stanislaus iver, and that said downstream aspects need to be addressed in the fi ure. The parties acknowledge that despite the adequacy of instream flo which are provided for the Stanislaus River below Goodwin Dam, covery of the fishery may be hampered, pending correction of existi problems associated with downstream diversions, Delta diversio and fish passage through the Delta.

G. It is the intention of Fish and Game that th AGREEMENT shall become the instrument through which it will provision ly dismiss its protest against the Bureau's applications, as describ in Recital C.

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