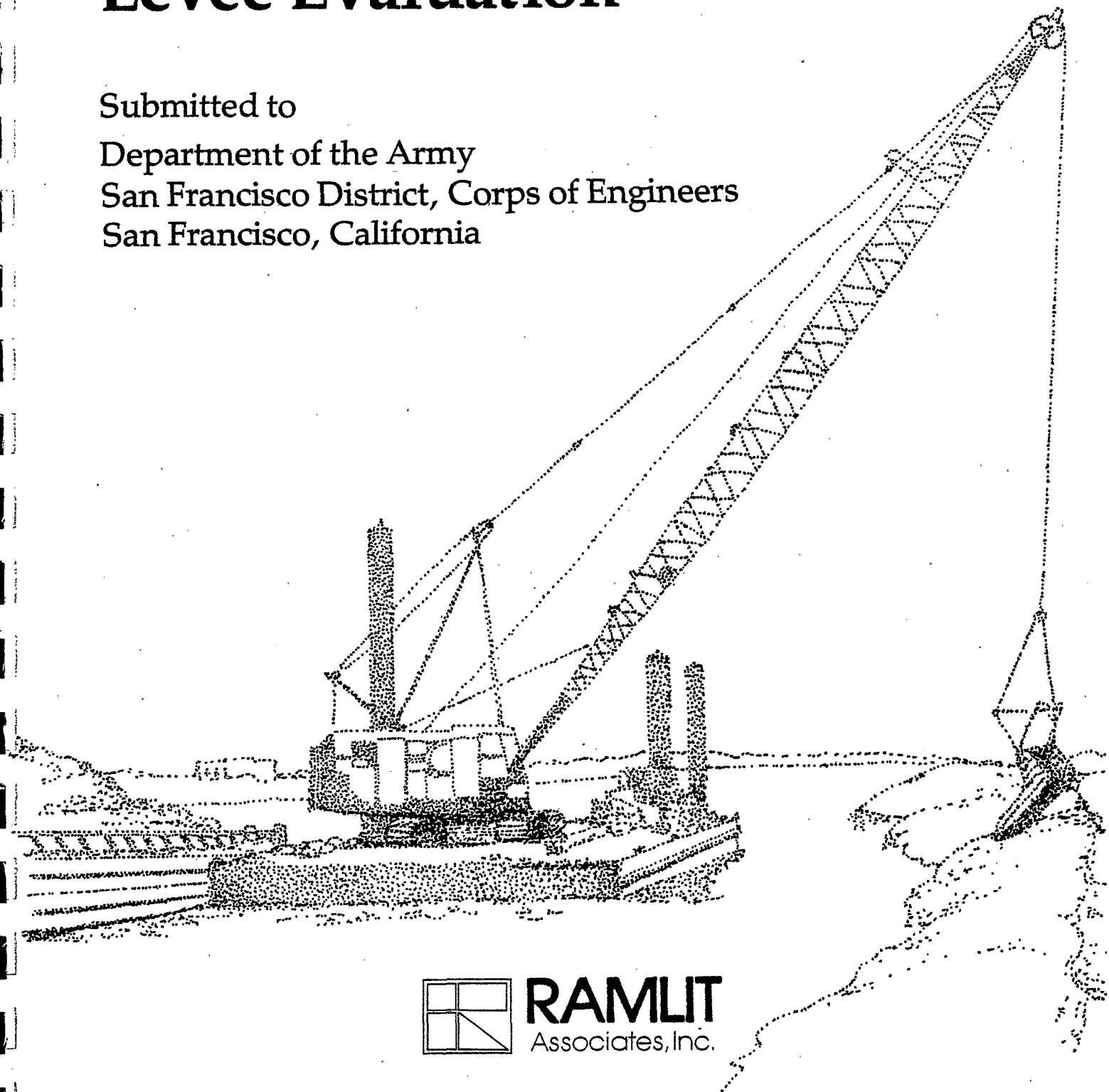
San Francisco Bay Shoreline Study

Suisun Marsh Levee Evaluation

Submitted to

Department of the Army
San Francisco District, Corps of Engineers
San Francisco, California



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DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS
211 MAIN STREET
SAN FRANCISCO, CALIFORNIA 94105

SPNPE-P

1 September 1983

MEMORANDUM FOR RECORD

SUBJECT: Suisun Marsh Levee Evaluation

The subject evaluation was prepared by RAMLIT Associates of Berkeley, California under contract to the U.S. Army Corps of Engineers, San Francisco District. This evaluation was performed as part of the Corps' San Francisco Bay Shoreline Study. The purpose of this study, authorized by Public Law 94-587, the Water Resource Development Act of 1976, is to determine the feasibility of and the Federal interest in providing protection against tidal and fluvial flooding in low-lying areas along the bay shoreline in San Mateo, Santa Clara, Alameda, Napa, Sonoma and Solano counties.

The subject evaluation will be an integral part of the flood control feasibility investigations of the Suisun Marsh portion of the Shoreline Study area in Solano County. However, the results and conclusions noted in the evaluation may or may not reflect the results and conclusions of the Corps' final feasibility investigations. The reason for this is that these investigations will involve further engineering, environmental and economic evaluations contributing to the Corps' final Shoreline Study recommendations.

Edward M. Lee, Jr.

EDWARD M. LEE, JR.
Colonel, Corps of Engineers
District Engineer

D-030806

RAMLIT Associates, Inc.
water resources, environmental and agricultural engineering

February 15, 1983

Department of the Army
San Francisco District
Corps of Engineers
211 Main Street
San Francisco, CA 94105

Attn.: Mr. Raleigh Leef, SPNED-P

Dear Sir:

In accordance with agreement No. DACW08-91-C-0051, we have the pleasure of submitting herewith our report on the rehabilitation needs of the exterior levee system in the Suisun Marsh.

This report summarizes the results of a thorough work effort, consisting of three major demands as follows: (1) development of an assessment methodology; (2) in-house assessment using aerial photos, local familiarity and experience, and other available information; and, (3) field reconnaissance which included spot checks and helicopter overflights of the area by a team of experts. Your comments and suggestions on the interim reports have been carefully incorporated into this final document.

The findings presented in this report reflect levee conditions as of Fall 1982. We wish to point out, however, that the timing of this submittal coincides with new and extensive damage to the exterior levees of the Suisun Marsh caused by the unusually long wet spell of recent weeks.

We wish to thank the San Francisco District of the Corps of Engineers for entrusting us with this project. The adverse effect on the waterfowl management area due to uncontrolled flooding with saline water from Suisun Bay have been a continuing public concern for a prolonged time. We hope that our report will help in formulating public policy in this regard.

Sincerely,

Y. Litwin

Yoram J. Litwin, Ph.D.
President

2437 Durant Avenue • Berkeley, California 94704 • (415) 548-4212

SAN FRANCISCO BAY SHORELINE STUDY

SUISUN MARSH
LEVEE EVALUATION

PREPARED FOR

Department of the Army
San Francisco District, Corps of Engineers
San Francisco, California

PREPARED BY

RAMLIT Associates, Inc.
Berkeley, California

February, 1983

D-030808

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INTRODUCTION

BACKGROUND

Suisun Marsh is located in Solano County and is a principal waterfowl wintering area in California. It is a brackish marsh consisting of approximately 84,000 acres of tidal marsh, managed wetlands, and waterways, and is protected under the Suisun Marsh Protection Plan of 1976. Most of the managed wetlands are separated by exterior levees in various conditions of repair from the tidal water of Suisun Bay and connecting sloughs. Periodic tidal flooding of the managed wetlands causes damages to facilities and interferes with management practices and recreation usage.

PURPOSE AND AUTHORITY

This study was undertaken to inventory and evaluate the condition of the exterior levee system in Suisun Marsh and to estimate the cost of improving the levees to a uniform level of protection. This is part of the San Francisco Bay Shoreline Study which was authorized by Congress in Public Law 94-587: The Water Resources Development Act of 1976 (Section 142).

SCOPE OF WORK

Due to the large extent of the levee system, the study approach was limited to simplified evaluation procedures consisting of the following sequence of tasks:

(1) Identification and definition of the limits of the "exterior levees";

(2) Formulation of a rational levee classification system for categorizing repair and reconstruction needs;

(3) Development of construction cost estimation schedule for upgrading levees to uniform protection standards;

(4) Preliminary in-house assessment of the exterior levees, according to the established classification system, using aerial photos, familiarity, and experience, as well as other available information;

(5) Field reconnaissance, estimation of earthwork needs, and classification of exterior levees by means of low level aerial observation;

(6) On-site inspection and evaluation of examples of each classification to confirm and/or revise the judgments made from in-house and aerial reconnaissance estimation; and

(7) Computation of overall levee modification costs by applying established construction cost schedule to identified reconstruction and repair needs.

SUMMARY OF FINDINGS

The preliminary in-house assessment of levee conditions was conducted in March and April, 1982. The low altitude aerial reconnaissance was made on May 26, June 1 and 2, 1982. Additional on-site field inspections were made in November 1981, prior to in-house assessment, and in July, 1982, following the aerial survey.

Levees were designated according to five general rehabilitation categories (A through E). The extent of levees within each category and the corresponding cost estimates are summarized in Table 1-1. The total cost of rehabilitating the exterior levees to a uniform level of protection was estimated to be $52.7 million (September 1982 Price Level). The estimated annual maintenance cost was computed to be $250,000. The standard design water storage heights by which levees were evaluated was +6' (MSL), plus an additional 2' to 3' of freeboard, depending upon exposure of levees to wind and wave action. This level of protection corresponds roughly to a tidal height exceedence frequency of once in 20 years.

The study approach of conducting a systematic in-house assessment prior to aerial reconnaissance proved to be extremely useful and effective in identifying major problem areas, i.e. major reconstruction needs (Type A and B levees). As expected, the more subtle distinctions between major repair, minor repair, and no repair categories (C, D, and E) differed to a much greater degree between in-house estimates and final aerial survey determinations. This disparity can be attributed to a number of factors related, for example, to: (a) existence of high tide conditions at the time of infrared aerial photography; (b) in-house criteria for rating certain levee conditions from infrared imagery; (c) lag time of two years between aerial photos and the field survey; and, (d) generally conservative nature of uniform design standards in comparison with historical practices in the Marsh.

This study represents the first comprehensive effort to appraise levee conditions and rehabilitation costs in the Suisun Marsh. It involved the development and application of a unique classification and cost estimating system. In the process, several areas were identified for additional investigation that could improve the preliminary findings derived from this study. These are listed for information purposes:

TABLE 1-1

SUMMARY OF LEVEE REHABILIATION NEEDS

Levee Type	Description	Length Of Levee		Estimated Cost	
		Miles	% Of Total	$1000	% Of Total
A	Major Reconstruction Peat & Organic Soils >60%*	41.5	18	$18,954	36
B	Major Reconstruction Clay Soils >60%*	12.8	6	4,277	8
C	Major Repair 20-60%*	129.8	56	26,405	50
D	Minor Repair <20%*	38.7	17	3,061	6
E	Excellent No Repair Need	6.1	3	—	—
TOTAL		**228.8**	**100**	**$52,697**	**100**

* Amount of earthwork to meet design standards.

Aerial Photo Interpretation

The criteria for interpreting infrared aerial photography proved to be fairly accurate in identifying major levee problems. Additional refinement of the rating criteria could be done to improve the photo interpretation of less serious levee repair needs. This could be accomplished through an iterative process, using the field survey results and other information compiled in this study.

Levee Construction Estimates

The construction estimates in this study were made without the benefit of any ground truth surveying. To verify and standardize these estimates, a cross-check could be made of a statistically valid number of levee segments. This would involve surveying and comparing existing levee conditions to design specifications and the MSL reference datum.

Levee Design Standards

This study considered uniform design standards for the entire Marsh, with built-in variations for soil type and wind and wave action. During the course of the study, other factors were noted which might further influence design specifications in certain areas, e.g. the existence of tule berms, water control structures, inner marshland elevation and drainage systems, etc. Further work could be done to refine levee design standards considering some of these factors.

Tide Conditions

Tide conditions shown in aerial photos were found to have a significant effect on the ability to adequately interpret levee conditions. Future efforts to utilize imagery for levee assessment should, for comparison, consider the use of photos showing tidal extremes.

This study dealt specifically with the physical needs and costs of levee rehabilitation. The potential benefits to be derived from such levee improvement work have not been fully quantified. The results of such an analysis would provide additional information for use in evaluating the cost effectiveness of levee rehabilitation for the entire Marsh or any segment. However, there are no further Federal funds available to do any additional studies of the Suisun Marsh under the San Francisco Bay Shoreline Study authority, at this time. The reconnaissance evaluation presented here concludes present Corps activities related to Suisun Marsh under this authority.

CHAPTER II

DESCRIPTION OF THE PROJECT AREA

SUISUN MARSH

Suisun Marsh, shown in Figure 2-1, is located in southern Solano County, south of the cities of Fairfield and Suisun City. The Marsh is bounded on the south by Suisun Bay, Honker Bay, and the confluence of the Sacramento and San Joaquin Rivers. On the west it is bounded by State Highway 21, running from Benecia to Cordelia, on the north by Cordelia Road to the city of Suisun City, around the Potrero Hills to Denverton, and on the east from Denverton along Shiloh Road to Collinsville.

The Marsh consists of approximately 57,000 acres of marshland and 27,000 acres of bays and waterways. Waterways include a network of tidal sloughs, principally tributaries of Suisun and Montezuma Sloughs, together with many drainage sloughs. Major streams carrying runoff from surrounding hills and floodplains include Green Valley, Suisun, Ledgewood, Laurel, McCoy, Union, and Denverton Creeks.

Suisun Marsh is one of the few major marshes remaining in California and furnishes habitat for a variety of plants and animals. It serves as a principal waterfowl wintering area and is also highly valued for fishing and recreation. Despite reclamation improvements in the late 1800's and early 1900's, agricultural development in the Suisun Marsh has been largely unsuccessful due to poor drainage and salt accumulation in the soil. Limited cattle production and dry farming of grain crops occurs today where suitable soils exist. For the most part, however, the marshlands have been converted to private duck clubs and state wildlife management areas. Continued management of the Marsh for waterfowl and recreational activities is threatened by periodic tidal flooding and the problem of maintaining a proper salt balance.

LEVEE SYSTEM

Most of the Suisun Marsh lies at a level at or below mean tide elevation. To protect marshland from uncontrolled tidal inundation and flooding, man-made levees have been added over the years to supplement the natural levees throughout the Marsh. Roughly ninety percent of the marshland is now enclosed by a system of low levees, ranging in height from four to eight feet above ground level. This system of levees is critical to the management of water quality and waterfowl habitat in the Marsh.

FIGURE 2-1

SUISUN MARSH STUDY AREA

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Two types of levees make up the levee system in the Suisun Marsh. Interior levees are the lower levees used to control and spread water or separate ponds within the boundaries of the diked marshland. These levees enable property owners to apply some degree of individual water management within the leveed portions of their property to enhance waterfowl habitat. The exterior levees are the larger levees which protect the marshland against tidal inundation and uncontrolled flooding. The focus of this report is specifically on the condition and rehabilitation needs of the exterior levees.

Levee Construction Practices

The exterior levees have been built up progressively over the years, generally with little effort to design them to any specific engineering standards. They have been constructed along channels, most often using material dredged from adjacent waterways. Dredging is typically done with either a clamshell or dragline dredge, and provides a relatively inexpensive way of obtaining and placing fill material. Other less common construction methods involve the importation of fill material either by truck or barge.

The finished levees vary considerably in their shape, stability, and the degree of protection they provide against tidal action. For example:

- **Sideslopes** - Waterside slopes range from 1.5H:1V to 4H:1V depending upon soil conditions and the severity of currents and wave action. Landward sideslopes are usually flatter, ranging from 2H:1V to 5H:1V.

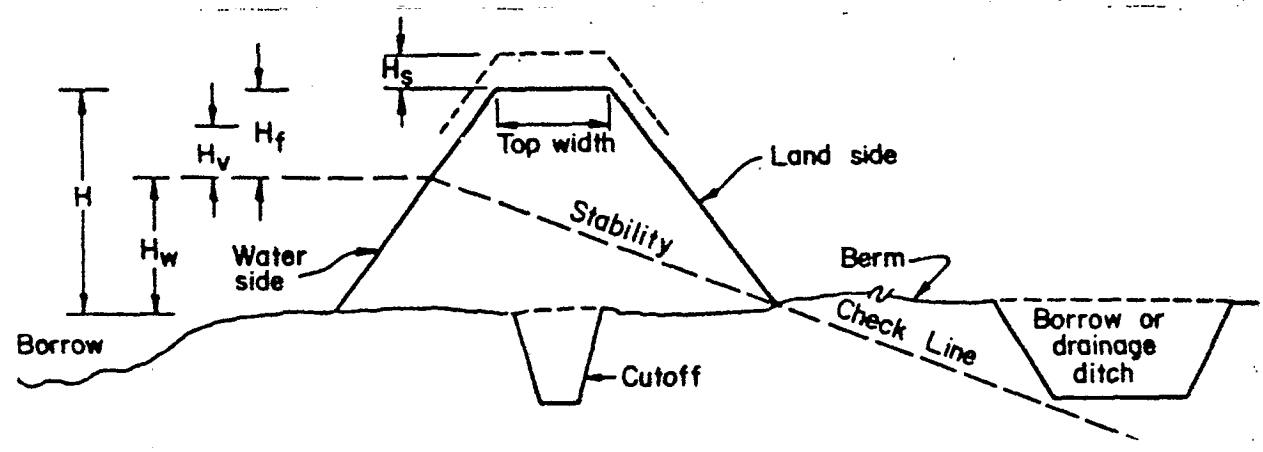
- **Crown** - Many of the levees are constructed to allow vehicle access along the levee crown. Some well-traveled roads are paved while others are unsurfaced and frequently impassable during wet weather. The top width of exterior levees varies from about 12 to 25 feet.

- **Height** - Levee height is usually established to protect against high tide plus additional height for wave action and freeboard. Typical recommended levee height is eight to nine feet above mean sea level.

Figure 2-2 provides a cross-sectional view of typical exterior levee construction. This is obtained from the 1975 Suisun Marsh Management Study which contains levee design and construction recommendations developed by the USDA Soil Conservation Service (SCS). The specific levee design criteria used in this study are presented in Chapter III. They conform to USDA recommendations for the Suisun Marsh.

FIGURE 2-2

TYPICAL EXTERIOR LEVEE CROSS SECTION



The design height of the dike (H) will be the sum of the design high water storage (H_w), the added height (H_v) for wave action, if any, and the freeboard (H_f). The constructed height will include an allowance for settlement (H_s), which will depend on the foundation and material used in construction. The atual design high water stage should be based on the water surface profile.

Levee Problems

The deterioration or outright failure of exterior levees is generally attributable to one or a combination of the following:

- **Consolidation of Soils** - Organic and peat soils, which underlie more than 60% of the exterior levees, undergo significant consolidation with time, due to the added weight of fill placement. Such consolidation is particularly critical in the southeastern part of the Marsh, where settling of levees may sometimes equal the height of the placed fill. Under these conditions, levees need to be raised and widened periodically to maintain adequate height and structural integrity.

- **Erosion** - Wave action and tidal currents are the main erosional forces acting on the exterior levees. Where the levee is inadequately protected, levee sideslopes may be scoured or washed away directly, or collapse as a result of the undermining effect of swift currents. Flatter sideslopes and bank protection with rip-rap and/or vegetation are typical measures used to reduce levee erosion problems.

- **Overtopping** - Overtopping of low-lying levees occurs occasionally during periods of extreme high tides and/or heavy runoff. Not all levee sections in the Marsh have adequate height to protect against overtopping under extreme conditions. Some levee sections are stable enough to withstand periodic overtopping without major damage to the levee. Less stable sections, however, may be completely washed out from the scouring action of overflowing floodwaters.

- **Seepage** - Seepage through rodent holes and cracks in the levee may allow excessive movement of tidal waters through the levee. Eventually this may lead to major piping and erosion problems. Regular maintenance inspections are needed to watch for and correct against such developments. Rodent burrowing problems are most likely to occur where levees are bounded on both sides by water — on the exterior side by tidal sloughs and on the landward side by irrigation ditches or ponds.

Extent of Exterior Levees

The exterior levees are delineated on the attached map of the Suisun Marsh (see pocket insert). The total measured length of exterior levees is 228.8 miles. A complete breakdown of levee lengths for individual waterways is

provided in Table 2-1. Levees are identified according to adjacent waterways and grouped in the following classes:*

- Class I — Nine exterior levees protecting all islands and along primary sloughs (Montezuma, Suisun, and Nurse);
- Class II — Exterior levees along all secondary sloughs (Goodyear, Cordelia, Hill, etc.);
- Class III — Dead end sloughs (Wells, Sheldrake, Boynton, etc.).

The delineation of levees was based on aerial photo interpretation and subsequent confirmation through aerial survey of the Marsh. The levee lengths were determined by measuring directly from USGS topographic maps (1:24,000 scale) using a Wanderer Length Meter. Duplicate measurements were made of each levee for improved accuracy. The figures in Table 2-1 are average readings.

Levee Ownership

Responsibility for levee construction and maintenance rests with owners of the land on which the levees are located. The attached map of the Marsh (see pocket insert) indicates landowners by code number. These code numbers are referenced in the Landowner Roster provided in Appendix A.

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* These classes are not to be confused with the levee rehabilitation categories (Type A through E) which were used in this study to define repair and reconstruction needs. (See Chapter III).

TABLE 2-1

CALCULATED LENGTH OF EXTERIOR LEVEES

Waterway	Bank	Length	
		Feet	Miles
CLASS I			
• Islands	Chipps Island	35,300	6.69
	Snag Island	3,800	.72
	Freeman Island	8,400	1.59
	Rhyer Island	21,900	4.15
	Pt. Buckler	5,400	1.02
Total Islands		74,800	14.17
• Open Bay	Suisun West	26,890	5.09
	Grizzly Bay	53,620	10.16
	Suisun Cutoff	17,010	3.22
	Honker Bay	33,530	6.35
	Spoonbill Creek	8,890	1.68
	Suisun East	13,600	2.58
Total Open Bay		153,540	29.08
• Suisun Slough	West Bank	63,320	11.99
	East Bank	64,590	12.23
Total		127,910	24.22
• Montezuma Slough	Outer Levee	117,780	22.31
	Inner Levee	110,400	20.91
Total		228,180	43.22
• Nurse Slough	Outer Levee	38,660	7.32
	Bradmoor Island	24,290	4.60
Total		62,950	11.92
TOTAL CLASS I		**647,380**	**122.61**
CLASS II			
• Goodyear Slough	West	28,690	5.43
	East	30,290	5.74
Total		58,980	11.17
• Cordelia Slough	West	52,100	9.87
	East	52,320	9.91
Total		104,420	19.78
• Roos Cut		9,000	1.70
• Frank Horan	West	26,310	4.98
	East	27,010	5.12
Total		53,320	10.10
• Chadbourne	North	16,890	3.20
	South	16,410	3.11
Total		33,300	6.31
• Peytonia Slough		20,820	3.94

TABLE 2-1 (Cont.)

CALCULATED LENGTH OF EXTERIOR LEVEES

Waterway	Bank	Length	
		Feet	Miles
CLASS II (Cont.)			
• Hill Slough		18,200	3.45
• Cross Slough		36,000	6.82
• Cutoff Slough		18,830	3.57
• Denverton Slough		13,810	2.62
• Luco Slough		16,020	3.03
TOTAL CLASS II		**382,700**	**72.48**
CLASS III			
• Cordelia # 1		7,990	1.51
• Cordelia # 2		8,800	1.67
• Chadbourne # 3	South	25,400	4.81
	North	13,610	2.58
Total		39,010	7.39
• Boynton Slough		30,300	5.74
• Wells Slough		12,600	2.39
• Sheldrake		11,400	2.16
• Hill # 5		10,020	1.90
• Hill # 4		13,980	2.65
• Tree Slough		18,370	3.48
• Nurse # 6		4,500	.85
• Nurse # 7		2,200	.42
• Nurse # 8		11,300	2.14
• Montezuma # 9		7,590	1.44
TOTAL CLASS III		**178,060**	**33.72**
GRAND TOTAL ALL LEVEES		**1,208,140**	**228.81**

CHAPTER III

PROCEDURES FOR LEVEE CLASSIFICATION AND COST ESTIMATION

LEVEE CLASSIFICATION SYSTEM

Due to the large extent of the exterior levee system, simplified procedures were developed for estimating and classifying levee rehabilitation needs. The objective was to devise and employ a rational system for levee classification which would produce consistent and reproducible results, with minimal field investigation. The basic elements of the classification system included:

- Definition of levee rehabilitation categories;
- In-house classification using aerial photography and other available data;
- Assessment and refinement of initial levee classification, based on personal knowledge and experience of study resource team;
- Low level aerial reconnaissance to verify photo interpretation and estimate earthwork needs;
- On-site inspections to verify and/or revise judgments made from photo interpretation and aerial survey.

Levee Rehabilitation Categories

Based upon experience with levee construction practices in the Marsh, five basic types of levee rehabilitation were defined as follows:

- **Type A** - major reconstruction effort with imported fill material or with local soils using phased construction; more than 60% earthwork required to bring levee to design standards;
- **Type B** - major reconstruction effort with local fill material; phased construction not necessary; more than 60% earthwork required to bring levee to design standards;
- **Type C** - major local repair work; 20-60% earthwork required to bring levee to design standards;

- **Type D** - minor local repair work; less than 20% earthwork required to bring levee to design standards; also includes erosion protection work such as rip-rapping, seeding, etc.;

- **Type E** - no repair needed.

In House Classification

The in-house classification procedures were developed to organize and make maximum use of soils data, aerial photos, personal experience, and other information prior to field reconnaissance. The five factors used in this preliminary in-house classification were as follows:

1. Existing Levee Conditions. IR Photo Interpretation - The photo IR interpretation took into account the following:

   (a) Color interpretation was used for assessing the levee crown and side slopes in regard to soil moisture conditions and vegetation. The guidelines (numerical rating system) used in interpreting the infra-red color information are presented in Table 3-1.

   (b) Image analysis was used for assessing levee conditions based on the visible features. The guidelines (numerical rating system) used in image interpretation are given in Table 3-2.

2. Wind and Wave Action. This is a major consideration in levee classification. Data provided by the Corps of Engineers and levee location in relation to open water were used in assessing levee vulnerability in accordance with the following classification:

   - **Class I** - High wind and wave action - islands, open bays, and major sloughs;

   - **Class II** - Medium wind and wave action - secondary sloughs;

   - **Class III** - Low wind and wave action - small inner sloughs (tertiary).

3. History of Repairs and Problems. Evaluation of past history and repair frequency provided preliminary evidence as to the priorities and needs for future rehabilitation work. This information was obtained from three sources: (1) Annual Maintenance Reports to the Suisun RCD; (2) permits for construction and maintenance along waterways; and, (3) other miscellaneous file information of

TABLE 3-1

GUIDELINES FOR IR COLOR INTERPRETATION

Color	Interpretation	Point Grading System	
		Levee Crown	Side Slopes
White	**Excellent** - dry and unsaturated levee	10	8
Mottled White	**Good** - white with brief interspertion of pink vegetation	7	6
Pink	**Fair** - pink background supporting light vegetation indicating some moisture	4	4
Red	**Poor** - heavy vegetation; suspected overgrowth	2	2
Gray-Green	**Poor** - levee shows heavy moisture saturation	0 or 10*	0 or 10*

* If there is an indication of recent construction and crown and side slopes are both gray

TABLE 3-2

GUIDELINES FOR IR IMAGE INTERPRETATION

Item	Image	Point Grading System
Crown Use		
2 way road	wide clear surface and indication of usea as a main artery	10
1 way road	narrow; less traveled; occasional turnouts	5
no road	no indication of vehicular traffic	0*
Berm Ditch Condition		
good	distinct; clear of vegetation; contains water	2
fair	less distinct; some vegetation; occassional ponds of water	1
poor	indistinct; heavy vegetation no water	0**

* If an island where roads are superfluous, then assign 5 points.
** If an island, assign 1 point.

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the Corps of Engineers. While these records were found to be incomplete and sometimes lacking in reliable repair data, they provided the best source of information on recent levee problems. The relative amount of attention required by various levees were rated based on the reported amount of repair work as follows:

- S (some) - Recent documentation of repair work;
- N (none) - No documented recent repair history.

4. Significance of Protection Provided. In principle, all exterior levees are considered to be of equal importance. In some cases, however, the level of attention required might be affected by considerations such as protection of access roads, the extent of area protected, or presence of special improvement structures (for example, water supply facilities). A "significant" or "insignificant" rating was assigned and on occasion used to shift the levee classification slightly. For example, an "insignificant" rating might have dictated a change from Type D to Type E.

5. Foundation Materials. The type of soils, as identified on published soil maps, served to indicate the levee fill and reconstruction requirements. The main use was to distinguish between Type A and Type B levees. Foundation materials were identified according to the following major soil classifications (Unified System):

- Pt - Peat;
- OH - Organic soils;
- CL - Clay mineral soils.

A complete listing of the types of soils which occur in the Suisun Marsh along the exterior levees is presented in Appendix B. Soil classifications (USDA, Unified, and ASSHO systems) are provided along with a description of selected engineering properties of each soil type.

All levees were divided into segments of approximately 1500-2000 feet in length. Typically, the segments were defined so that their border marks corresponded to visible ground features which could be easily identified during subsequent aerial reconnaissance. For each segment, levee classification was carried out using photo interpretation and a decision tree matrix in the following way:

1. Photo interpretation consisted of the following six steps:

   (a) **Step 1** - General Levee Conditions:

- Distinct Levee - Crown, side slopes, and levee toe are clearly visible. Leave unmarked and proceed to Step 2.
- Indistinct Levee - Distinction between levee crown and side are vague, and the levee toe cannot be differentiated. Indicate by circling in red, temporarily classed as "poor" until field verification.
- Obscured Levee - Levee is hidden by trees, buildings, structures, etc. Indicate by circling in blue for field verification and classification.

(b) **Step 2** - Levee Crown Use - Assign points using Table 3-2.

(c) **Step 3** - Levee Crown Conditions - Assign points using Table 3-1.

(d) **Step 4** - Side Slope Conditions - Assign points using Table 3-1.

(e) **Step 5** - Berm Ditch Conditions - Assign points using Table 3-2.

(f) **Step 6** - Combined Rating:

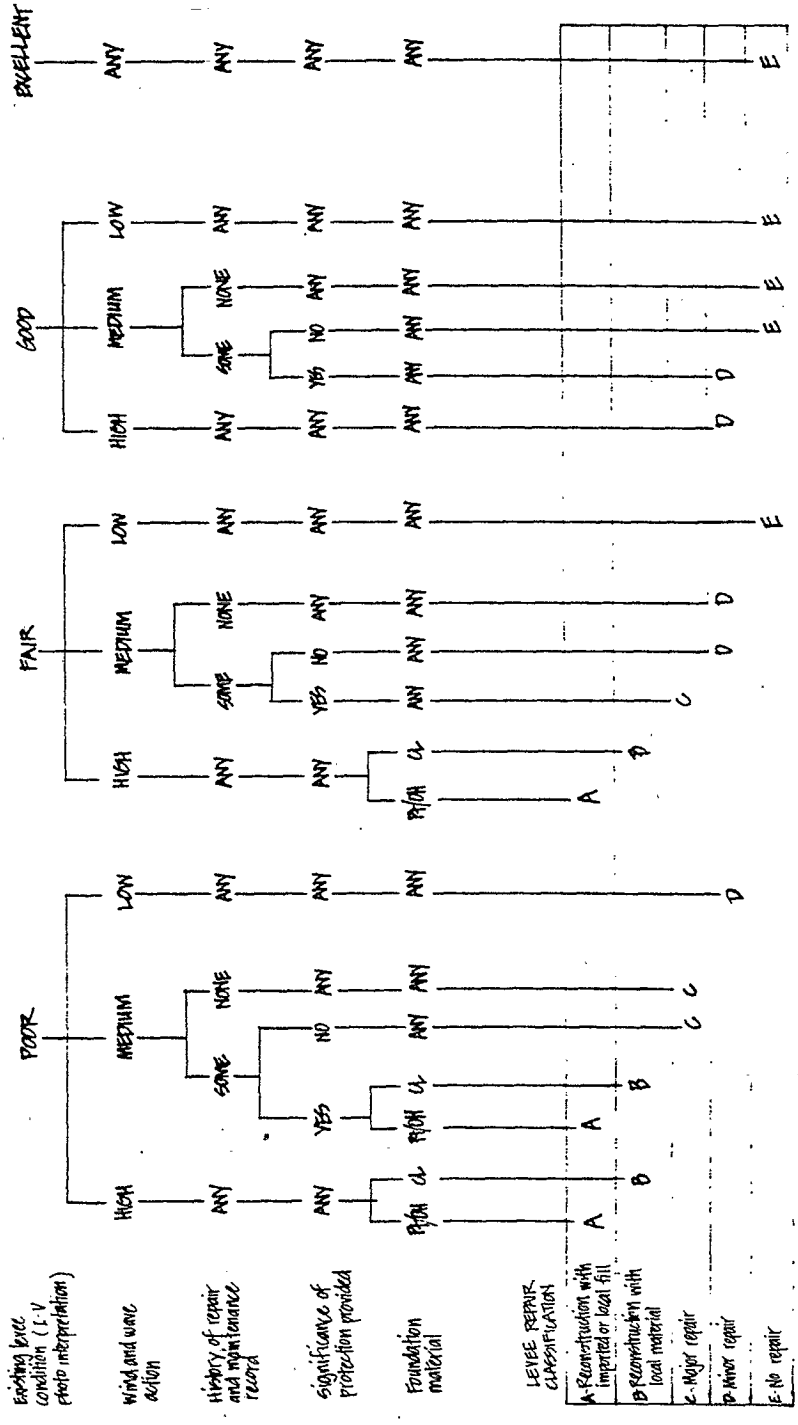
The combined point totals for each levee segment were determined and levee conditions rated according to the following criteria:

Levee Condition	Point Total
Excellent	20+
Good	13-19
Fair	8-12
Poor	0- 7

2. Decision Tree Matrix. The combined rating (Step 6 above) formed the starting point for levee classification using the decision tree shown in Figure 3-1. The other input information for levee segments was compiled separately by the study team and is provided in Supporting Project Documentation. The resulting levee classifications using this system were marked on a working map for field

FIGURE 3-1

DECISION TREE MATRIX FOR IN-HOUSE CLASSIFICATION



reconnaissance. An example is provided in Appendix C to illustrate the application of these procedures.

Input and Refinement by Resource Team

The Study Resource Team* was called upon for initial review and refinement of levee classification prior to field reconnaissance. Specifically, these individuals were asked to provide their assessment of levee conditions and rehabilitation needs, based upon personal knowledge and experience in the Marsh. Their input was in the form of segment-by-segment designation of levee rehabilitation needs according to the following general categories: (A/B) Reconstruction; (C) Major Repair; (D) Minor Repair; and (E) No Repair. This information was recorded on In-house Classification work sheets (See Appendix C, Table C-1).

The Resource Team classifications were used for three purposes:

(1) For comparison with in-house results;

(2) To refine some of the in-house assessment criteria in the aerial photo numerical rating system;

(3) To target historical problem areas and other questionable areas for special attention and photography during field reconnaissance.

Aerial Reconnaissance

The next phase in classifying the levees consisted of low altitude aerial reconnaissance by members of the project team. The aerial inspection was made by helicopter with the option to set-down for ground inspection of certain areas. The team was equipped with the preliminary classification information organized in atlas form according to distinct levee segments. The objectives of the aerial reconnaissance were:

- Assessment of levee conditions to refine in-house classification; and,
- Determination of construction methods, earthwork requirements, and special considerations for bringing levees up to design standards.

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* Study Resource Team included staff members of the Suisun Resource Conservation District, Soil Conservation Service, and Department of Fish and Game who have worked extensively in the Suisun Marsh.

Aerial reconnaissance was carried out on May 26th, June 1st, and on June 2nd, 1982.

1. Assessment of Levee Conditions. The verification of levee conditions was done using the following criteria (based on Suisun Marsh Management Plan, 1975):

   - **Excellent** - Low growing vegetation or rock rip-rap on sides of levees to prevent erosion; top of levee in good condition allowing vehicles to be driven on top and access for inspection; no muskrat burrows or cracks; levee not composed of high organic soils.

   - **Good** - Levees generally in good shape; may have some undersirable vegetation, but minor in extent; can drive on levee; some cracks or muskrat holes, but repairable with minor effort.

   - **Fair** - Numerous areas needing repair due to low spots, cracks, or holes; vegetation overgrowth which prevents easy access for inspection and repair; erosion occurring; some seepage, possibly due to organic content; holes near top, etc.

   - **Poor** - Levee overgrown with vegetation preventing access for inspection or repair; numerous holes, cracks, etc., allowing periods of uncontrolled water flow or potential for uncontrolled flooding without major repair.

   Notes on levee conditions were made using the field data form shown in Table 3-3. Observations were also made of any special conditions not reflected in the in-house classification. These included, for instance:

   - Changes in rating of soil/levee construction material;
   - Evidence of very recent repairs or levee failures;
   - Evidence of levee undercutting or sloughing;
   - Signs of levee overtopping.

   Copies of the actual field estimation forms completed for Chipps Island are provided in Appendix C as an example.

2. Construction Estimation. The identification of construction needs addressed the following:

TABLE 3-3

FIELD ASSESSMENT OF LEVEE CONDITIONS

LEVEE NAME _____
DATE _____
PREPARED BY _____
APPROVED BY _____

LEVEE SEGMENT #	PROBLEM AREAS								COMMENTS	IN-HOUSE ASSESSMENT In-H. Rec-T.			FIELD ASSESSMENT			
	Levee top	Poor access	Over-growth of vegetation	Cracks	Slumping or low spots	Surface erosion	Seepage	Holes					Poor	Fair	Good	Excellent

- Soil type;
- Amount of earthwork to bring levee to design standards;
- Source of material and method of embankment construction;
- Wave action - freeboard requirement; and,
- Erosion protection measures.

These determinations were made segment-by-segment and entered on the data form shown in Table 3-4. Aerial photos of typical levee categories were also taken.

The design standards by which levee earthwork requirements were judged are shown in Figures 3-2 and 3-3. These conform to the general recommendations of the Suisun Resource Conservation District (SRCD). The specified levee breadth (i.e., top width and side-slopes) is slightly greater than the minimum SRCD recommendation; this is based on many years of practical experience with levee construction in this area by the chief construction estimator on the project (Dutra Construction Company).

The standard levee water storage height (H_W), referenced to mean sea level (MSL) is six feet. Added to this is an allowance for freeboard and wave action ($H_F + H_V$) of two feet in general, and three feet where high wind and wave action is indicated. This gives overall levee heights of eight and nine feet above MSL. These design heights correspond to a tidal exceedence frequency of once every twenty years. This was determined on the basis of the tidal frequency data available in the Corps of Engineers' Sacramento-San Joaquin Delta Investigation of July 1976. Corps of Engineers' Investigation used a stage-frequency curve using the following formula for plotting the stage data on probability paper:

$$\frac{1}{P} = \frac{1}{1-0.5^{1/N}}$$

Where: P = the frequency of occurrence

N = the total number of data points

After the hydrological data is plotted on a probability paper, a curve is fitted to the plotted points. The stage-frequency curve developed for the Suisun Marsh is shown in Figure 3-4.

TABLES 3-4

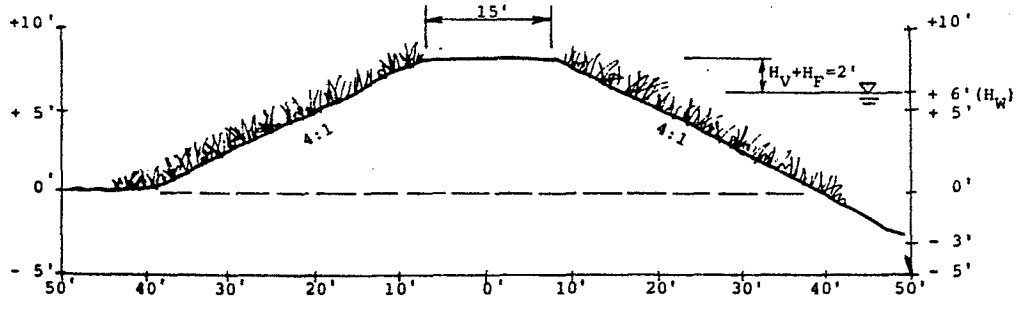
ASSESSMENT OF LEVEE REHABILITATION NEEDS

LEVEE NAME ________________________
DATE ______________________________
PREPARED BY ________________________
APPROVED BY ________________________

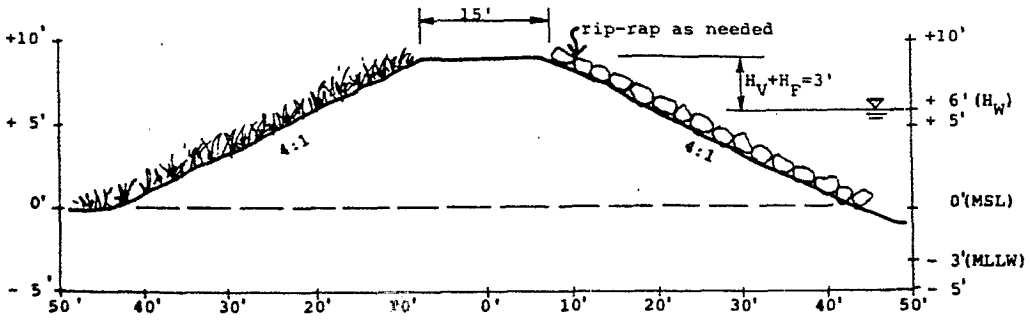
LEVEE SEGMENT #	SOIL TYPE	EARTHWORK TO MEET DESIGN STANDARDS						EMBANKMENT CONSTRUCTION METHOD						EROSION PROTECTION FEATURES			OTHER REMARKS	LEVEE CLASSIFICATION	UNIT COST $/FT
		RECONSTRUCTION (A & B)			REPAIR (C & D)			IMPORT MATERIALS		LOCAL MATERIALS DREDGING									
		100%	80%	60%	40%	20%	0	Barge	Truck	Clamshell	Dragline	Hydraulic	Bulldozer	Rip-rap	Filter fabric	Seeding			

FIGURE 3-2

DESIGN CROSS SECTIONS FOR EXTERIOR LEVEES
PEAT SOILS



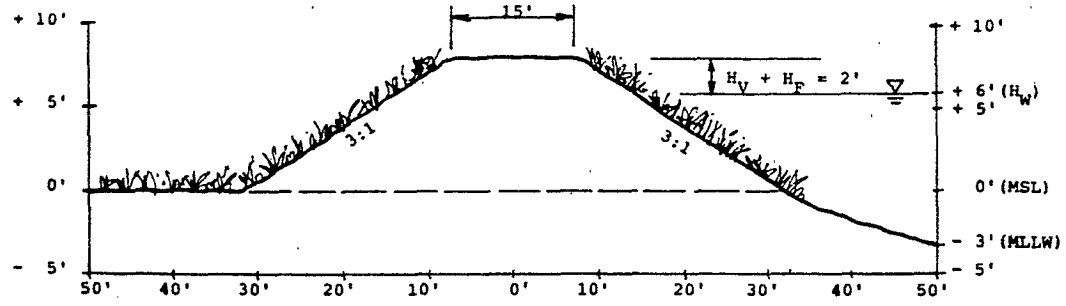
A. Low Wind And Wave Action



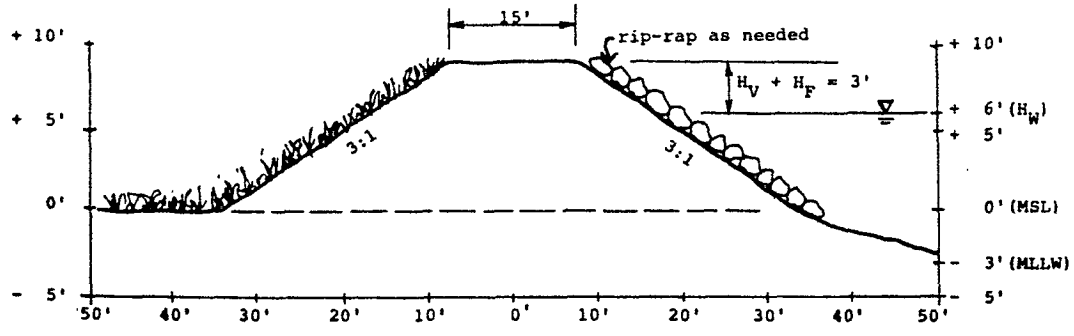
B. High Wind And Wave Action

FIGURE 3-3

DESIGN CROSS SECTIONS FOR EXTERIOR LEVEES ORGANIC AND CLAY/MINERAL SOILS



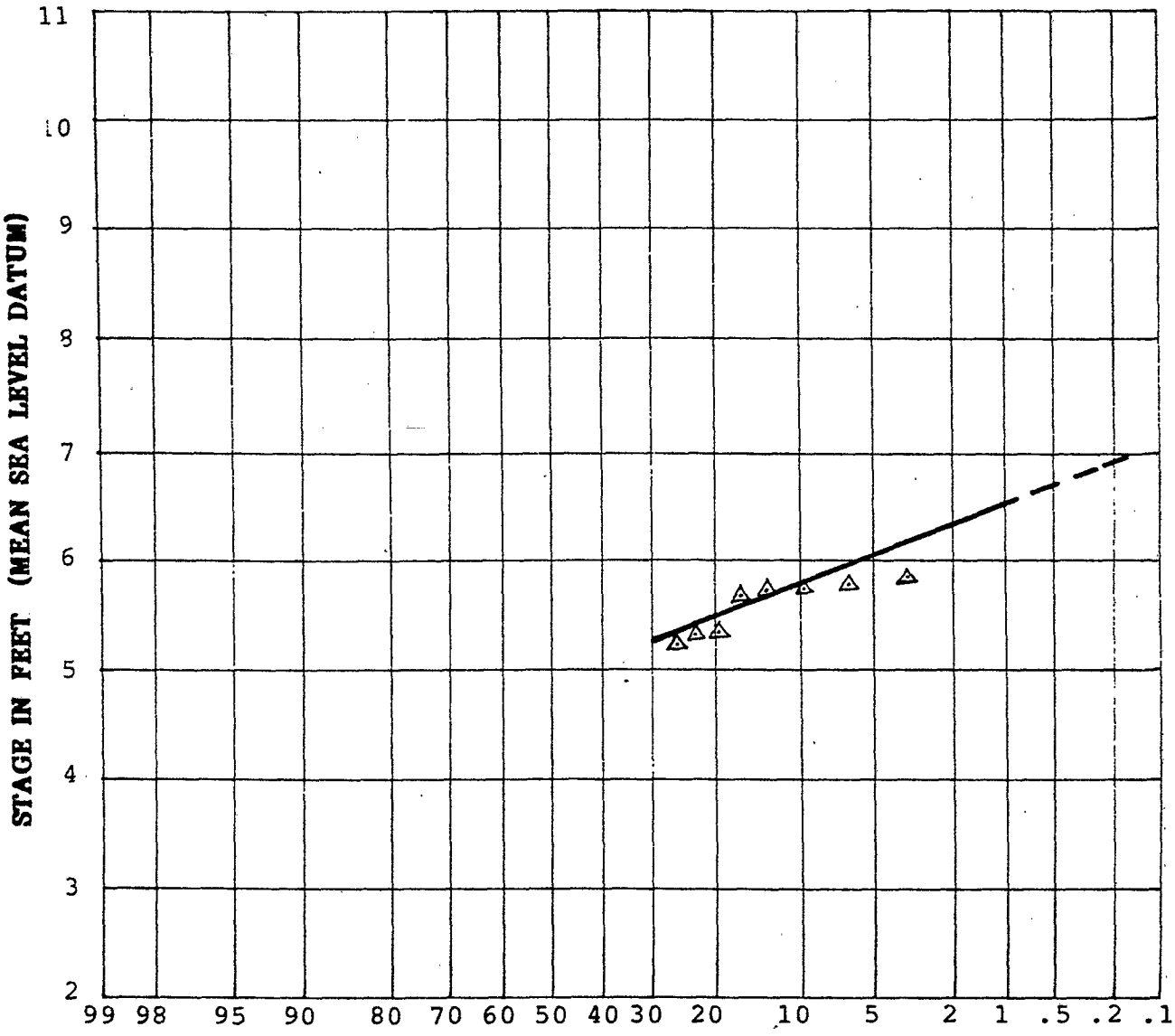
A. Low Wind And Wave Action



B. High Wind And Wave Action

FIGURE 3-4

HIGHER - HIGH STAGE FREQUENCY RELATIONSHIP FOR SUISUN MARSH



[From Corps Of Engineers, Sacramento District's Sacramento - San Joaquin Delta Investigation Of July 1976]

On-Site Field Verification

The final phase of the classifying process consisted of ground truth inspection and verification of levee conditions. This was carried out at selected locations following aerial reconnaissance. The aim of the field inspection was to:

- Examine soil and levee conditions in questionable areas; and,
- Verify prior judgments on levee classification by examining sections representative of each type of levee modification.

Field work included visual inspection of levee conditions, selected measurement, and comparison with in-house and aerial reconnaissance estimates.

COST ESTIMATION SYSTEM

The previously described system for levee classification defined five basic types of levee modification (Types A through E). Within each of these categories a number of different reconstruction and repair options are possible, depending upon construction method, earthwork requirements, etc. The cost estimating system used in this study assigned costs based on the different construction possibilities within each major levee classification.

Construction Factors

The construction factors which combine to produce different levee modification costs are:

- Amount of earthwork to bring levee to design standards;
- Soil type;
- Source of material and method of embankment construction;
- Wave action-freeboard requirement; and,
- Erosion protection measures.

1. Amount of Earthwork. For the purpose of this project, the distinction between reconstruction and repair classifications was based upon the amount of earthwork required to bring levee segments to uniform protection standards. The breakdown used was as follows:

Levee Classification			Amount of Earthwork Required
Type A, Type B	-	Reconstruction	Greater than 60%
Type C	-	Major Repair	20 - 60%
Type D	-	Minor Repair	Less than 20%
Type E	-	No Repair Needed	0

This breakdown was developed in consultation with local dredging contractors, considering the nature of construction work under each major levee classification and the approximate breakpoint for unit costs (i.e., economies of scale).

2. Soil Type. Shrinkage and compaction of soils during levee construction increases earthwork requirements and differs according to: (a) the type of fill material used for embankment construction; and, (b) the type of native soils forming the foundation of the levee. The factors used in this study to adjust for shrinkage and compaction are shown in Table 3-5 according to soil type.

3. Construction Method - Source of Material. Several methods of levee construction are possible in the Suisun Marsh. The most common and economical method is clamshell or dragline dredging from adjacent waterways. Occasionally fill must be imported (by truck or barge) because of equipment access problems, lack of suitable or sufficient local materials, or other circumstances. Recommendation of the most practical construction method was made for each levee segment during aerial reconnaissance to guide the selection of appropriate unit construction costs for earthwork.

4. Freeboard. Recommended freeboard requirements (2' or 3') vary according to the size and exposure of the waterway along which a particular levee is constructed. Added freeboard protection increases earthwork requirements and overall levee costs. The selection of appropriate freeboard design requirements for each levee segment was determined according to the class of waterway (I, II, or III) along which it was located.

5. Erosion Protection. One of the major sources of levee damage is wave action due to winds and boat traffic. Typical measures to protect levee banks from erosion and scour include rip-rap, seeding, or filter fabric. The need for rip-rap was determined segment-by-segment during aerial reconnaissance. Seeding is usually only

TABLE 3-5

LEVEE DESIGN & CONSTRUCTION CRITERIA FOR COST ESTIMATION

Soil Type	Top Width	Height[1]		Side-Slopes[2]	Shrinkage Factor For Native Soil Fill[3]	Shrinkage Factor For Imported Soil Fill[3]
		Areas Of High Wave Action	Areas Of Low Wave Action			
Peat	15'	9'	8'	4:1	60-70%	25%
Organic	15'	9'	8'	3:1	50-60%	15%
Clay-Mineral	15'	9'	8'	3:1	35-50%	0%

1. Above zero tide; includes 6' minimum plus 3' or 2' freeboard.
2. Both sides of levee.
3. Additional fill material required.

D-030842

required when imported fill material is used for levee construction. Filter fabric has been experimented with recently in the Marsh and was identified for only select locations.

Design and Construction Criteria

Cost estimates for levee modification were related to the standards for design and construction normally followed in the Suisun Marsh. These criteria are displayed in Table 3-5. Cross sections are illustrated in Figures 3-2 and 3-3. These design standards are based upon information contained in the Suisun Marsh Management Program and supplementary recommendations provided by the local dredging contractors.

Unit Costs for Construction Items

Unit costs for levee repair and construction work are provided in Table 3-6. The price level is September, 1982.

Linear Unit Costs for Levee Modification

Linear unit costs for different types of levee modification were determined by applying the unit costs in Table 3-6 to various reconstruction and repair options, according to the criteria presented in Table 3-5. This provided a complete array of linear unit costs for different amounts of earthwork in combination with other construction factors. Costs were coded according to the following notation:

Code:	Levee Type	-	Const. Method	-	Soil Type	-	Wave Action	-	% Repair	-	Erosion Measures
Example:	A	-	1	-	Pt	-	H	-	70	-	R

Entries in this notation were as follows:

1. Levee Type: A through E as defined earlier

2. Construction Method:

   1 - Barge
   2 - Truck
   3 - Clamshell

TABLE 3-6

UNIT COSTS FOR LEVEE CONSTRUCTION ITEMS
(September, 1982 Price Level)

Item	Cost ($) Repair	Cost ($) Reconstruction	Units
Clearing and Grubbing	600.00	600.00	ac
Earthwork:			
1. Imported Fill Material			
• Truck	13.50	10.50	ton
• Barge	10.50	8.50	ton
2. Local Fill Material			
• Clamshell Dredging	4.00	3.00	cy
• Dragline Dredging	4.00	3.00	cy
• Hydraulic Dredging	—	2.35	cy
• Bull Dozer	4.00	3.00	cy
Erosion Protection:			
1. Rip-Rap	15.50	12.00	l.f.
2. Filter Fabric	.012	.012	ft^2
3. Seeding	650.00	650.00	ac
Engineering of Design	12%	12%	—
Supervision & Administration	8%	8%	—
Contingencies	20%	20%	—

4 - Dragline
5 - Hydraulic
6 - Bulldozer

3. Soil Type:

Pt - Peat
Or - Organic
Cl - Clay/Mineral

4. Wind/Wave Action:

H - High
M/L - Medium or Low

5. % Repair (Earthwork): 5-100%

6. Erosion Measures:

R - Riprap
F - Filter Fabric
ϕ - No Measures

Summary of the computed linear unit costs is provided in Table 3-7.

Assignment of Costs

Cost codes were assigned for each levee segment on the basis of background data (e.g. soils) and reconstruction estimates made during aerial reconnaissance (see Table 3-4). Total rehabilitation costs for each segment were then obtained by multiplying the assigned unit cost and the estimated cost length of levee segment (measured from U.S.G.S. Maps). The cost code factors, assigned unit cost, levee length, and total segment cost estimates were tabulated as shown, for example, in Appendix C, Table C-5.

Annual Maintenance Costs

Typical annual levee maintenance work may include the following:

- Road resurfacing;

TABLE 3-7

SUMMARY OF LINEAR UNIT COSTS FOR LEVEE REHABILITATION ($/ft)*

Levee Class	Soil Type	Wind & Wave Action	Construction Method				
			Barge	Truck	Clamshell/ Dragline	Hyd. Dredge	Bull-Dozer
Type A	Peat	High	207-360	255-441	72-136	57-111	72-136
		M/L	169-298	209-364	59-114	47- 94	59-114
	Org.	High	157-277	193-338	56-109	44- 90	56-109
		M/L	130-232	160-283	47- 94	37- 93	47- 94
	Clay	High	136-244	168-297	—	—	—
		M/L	113-205	140-249	—	—	—
Type B	Clay	High	—	—	52-102	29- 64	52-102
		M/L	—	—	43- 88	24- 56	43- 88
Type C	Peat	High	113-302	145-380	33-102	**	33-102
		M/L	57-161	72-200	17- 62		17- 62
	Org.	High	88-238	112-300	26- 84	**	26- 84
		M/L	73-202	93-253	22- 74		22- 74
	Clay	High	57-162	73-202	17- 62	**	17- 62
		M/L	47-138	61-171	14- 56		14- 56
Type D	Peat	High	28-107	37-131	9- 47	**	9- 47
		M/L	24- 91	31-111	8- 43		8- 43
	Org.	High	23- 88	29-106	8- 42	**	8- 42
		M/L	19- 77	24- 92	5- 38		5- 38
	Clay	High	21- 83	27-100	7- 40	**	7- 40
		M/L	13- 58	16- 68	5- 33		5- 33

* Cost range reflects differences in amount of fill and erosion control needs.
** Not feasible.

- Repair of tide-gates and other hydraulic structures;
- Mowing of vegetation;
- Discing levee soils;
- Embankment repair;
- Placement (or replacement) of rip-rap.

Annual expenditures for maintenance vary widely, depending, for instance, upon: (a) the condition of the levee; (b) the number and maintainability of hydraulic structures; (c) intensity of vehicle travel on levees; and, (d) erosion damage caused by flooding or wave action. Maintenance requirements do not correspond to the general levee classification used in this study. It is not possible, therefore, to project maintenance costs with the same degree of specificity as is done for construction work.

Based on reported expenditures of various duck clubs in the Suisun Marsh and surveys conducted by the Suisun Resource Conservation District, annual levee maintenance costs are estimated to average $ 0.20 per lineal foot. This figure was used uniformly in this study for development of levee system cost estimates.

CHAPTER IV

STUDY RESULTS

CLASSIFICATION OF LEVEES

As described in the preceding section, classification of levees for rehabilitation work consisted of three phases: (1) in-house aerial photo interpretation; (2) resource team judgment; and, (3) aerial reconnaissance. The determinations made during aerial reconnaissance combined information from the in-house and resource team classifications along with visual inspection. As such, they represent the most reliable and up-to-date judgment of rehabilitation needs. The results are displayed for all levee segments in the attached map of the Suisun Marsh (see pocket insert). Levee segments are coded according to the five major categories of rehabilitation needs defined in this study (types A through E).

Table 4-1 provides a summary of the total linear extent of levees of each rehabilitation class. The preliminary estimates derived from the in-house and resource team classification process are also displayed for comparison. In the final analysis, about 24% of the levees show a need for major reconstruction (A and B), 56% are in need of major repair (C), 17% need minor repair (D), and less than 3% were rated to be in excellent condition with no need for any modification (E).

In general, the final aerial field survey gave a higher estimate of rehabilitation needs than was initially indicated by in-house and resource team evaluations. The best correlation was between the in-house and final estimate of levees needing major reconstruction (Class A and B), which differed only by about 15%. This can be attributed to the fact that very poor levee conditions were readily detected in aerial photos. This confirms the validity and usefulness of using imagery for assessment of major levee problems. The more subtle distinctions between major repair (C), minor repair (D), and no repair (E), by in-house methods did not correspond nearly as well to final field determinations.

The preliminary in-house and resource team evaluations tended to rate levees to be in much better condition than shown from the field estimate. This points out the difficulty in using imagery to gauge minor variations in levee conditions, and also possible disparity between the perceptions of levee conditions and problems. Some of the causes for the differences between in-house, resource team, and aerial survey assessment results are discussed in the last section of this chapter.

TABLE 4-1

EXTENT OF LEVEES BY REHABILITATION CLASSES

LEVEE TYPE	IN-HOUSE SYSTEM				RESOURCE TEAM EVALUATION				FINAL ASSESSMENT FROM AERIAL RECONNAISSANCE			
	Waterway Class				Waterway Class				Waterway Class			
	I	II	III	Total	I	II	III	Total	I	II	III	Total
A	193,993 [36.7]	1,520 [.3]	—	195,513 [37.0]	118,575 [22.5]	18,320 [3.5]	15,790 [3.0]	152,685 [28.9]	199,730 [37.8]	7,700 [1.5]	11,360 [2.2]	218,860 [41.5]
B	46,447 [8.8]	—	—	46,447 [8.8]					62,750 [11.9]	1,850 [0.4]	2,950 [0.6]	67,550 [12.8]
C	35,463 [6.7]	32,182 [6.1]	26,670 [5.1]	94,315 [17.9]	50,223 [9.5]	20,695 [3.9]	—	70,918 [13.4]	279,250 [52.9]	268,170 [50.8]	137,920 [26.0]	685,340 [129.8]
D	238,331 [45.0]	120,757 [22.9]	47,600 [9.0]	406,688 [77.0]	98,270 [18.6]	26,280 [5.0]	19,660 [3.7]	144,210 [27.0]	74,750 [14.2]	103,580 [9.6]	25,830 [4.9]	204,160 [38.7]
E	133,146 [25.2]	228,241 [43.2]	103,790 [19.7]	465,177 [88.1]	295,032 [55.9]	151,260 [28.7]	93,930 [17.8]	540,222 [102.0]	30,900 [5.9]	1,330 [0.3]	—	32,230 [6.1]
U**					85,280 [16.2]	166,145 [31.5]	48,680 [9.2]	300,105 [56.8]				
Total	647,380 [122.6]	382,700 [72.5]	178,060 [33.7]	1,208,140 [228.8]	647,380 [122.6]	382,700 [72.5]	178,060 [33.7]	1,208,140 [228.8]	647,380 [122.6]	382,700 [72.5]	178,060 [33.7]	1,208,140 [228.8]

* feet
[miles]

** U indicates levees with which the Study Resource Team was unfamiliar

COST ESTIMATION

The total cost for rehabilitating levees to a uniform level of protection was estimated to be $52.7 million (all costs are at September 1982 price level). This was determined by compiling the cost estimates for individual segments derived according to the procedures and cost schedule presented in Chapter III. The estimated annual maintenance cost for the exterior levee system was computed to be about $250,000, on the basis of $ .20 per lineal foot of levee.

Table 4-2 provides a breakdown of estimated costs according to the five general levee classifications. The percentage of total rehabilitation costs attributable to each levee classification are as follows: A-36%; B-8%; C-50%; D-6%.

Summary of rehabilitation costs by general waterway classes is given in Table 4-3. Levees along Class I waterways represent the bulk of the total estimated repair cost (71%). Repair costs for levees on Class II and III waterways amount respectively to 18% and 11% of the total.

Table 4-4 provides more detailed itemization of rehabilitation costs according to individual waterways.

FIELD INSPECTIONS

Ground inspections were made and aerial photos taken of numerous levee segments to provide added documentation of existing conditions and to verify assumptions made in deriving repair estimates. Photos were taken during the aerial reconnaissance on June 2, 1982 and are provided with annotations in Supporting Project Documentation. On-site field inspections were made on November 5, 1981, prior to in-house classification, and on July 26, 1982, after aerial survey work.

In general, the field survey work substantiated the in-house and aerial survey estimates. It was evident, however, that many detailed aspects of levee conditions that were observable on the ground could not be seen from the air. These included, for example, rodent holes, cracks, and occasional levee depressions.

DISCUSSION OF RESULTS

The system for exterior levee evaluation in this study sought to combine information and expertise from many sources. Several opportunities were available for comparing and modifying the estimates of levee repair needs. Table 4-1 shows a range of disparity between in-house results, general initial opinion of the Study

TABLE 4-2

ESTIMATED REHABILITATION COSTS
BY LEVEE CLASSIFICATION

Levee Classification	Total Length of Levee (ft)	Average Linear Unit Cost ($/ft)	Estimated Total Rehabilitation Cost ($1000)
A	218,859	87	18,954
B	67,550	64	4,277
C	684,340	39	26,405
D	204,160	15	3,061
E	32,230	—	—
TOTAL	**1,208,140**	**44**	**52,697**

TABLE 4-3

SUMMARY OF ESTIMATED LEVEE REHABILITATION COSTS BY GENERAL WATERWAY CLASSES

Waterway Class	Total Length of Levee (ft)	Average Linear Unit Cost ($/ft)	Estimated Total Rehabilitation Cost ($1000)
Class I	647,380	58	37,512
Class II	382,700	25	9,554
CLASS III	178,060	32	5,631
TOTAL	**1,208,140**	**44**	**52,582**

TABLE 4-4

ITEMIZED BREAKDOWN OF LEVEE CLASSES AND REHABILITATION COSTS ACORDING TO WATERWAYS

Waterway	Length Of Levee By Rehabilitation Class					Total Length (Feet)	Estimated Cost ($1000)
	A	B	C	D	E		
Class I							
• Islands:							
Chipps	27,920		7,370			35,290	3,038
Snag	3,800					3,800	418
Freeman	8,400					8,400	873
Ryer	6,740	5,480	9,690			21,910	1,647
Pt. Buckler	5,400					5,400	596
Total Islands	**52,260**	**5,480**	**17,060**			**74,800**	**6,572**
• Open Bay:							
Suisun West		5,420	15,370	6,100		26,890	1,183
Grizzly Bay	3,500	11,080	21,160	13,770	4,110	53,620	2,275
Suisun Cutoff	12,200	2,960	1,850			17,010	1,263
Honker Bay	20,960	2,720	9,850			33,530	2,422
Spoonbill Creek	7,150		1,740			8,890	703
Suisun Bay East	8,690	1,700	3,210			13,600	1,109
Total Bay	**52,500**	**23,880**	**53,180**	**19,870**	**4,110**	**153,540**	**8,955**
• Suisun Sl (West)	16,570		32,100	14,650		63,320	3,747
(East)	31,630	10,180	10,610	10,400	1,770	64,590	4,394
Total Suisun Sl.	**48,200**	**10,180**	**42,710**	**25,050**	**1,770**	**127,910**	**8,141**
• Montezuma (outer)	28,340	4,190	65,530	16,030	3,690	117,780	6,502
(inner)	16,960	19,020	41,390	11,700	21,330	110,400	4,662
Total Montezuma Sl.	**45,300**	**23,210**	**106,920**	**27,730**	**25,020**	**228,180**	**11,164**
• Nurse (outer)	1,470		35,090	2,100		38,660	1,595
(Brandon Is)			24,290			24,290	1,085
Total Nurse Sl.	**1,470**		**59,380**	**2,100**		**62,950**	**2,680**
Total Class I	**199,730**	**62,750**	**279,250**	**74,750**	**30,900**	**647,380**	**37,512**

TABLE 4-4 (Cont.)

ITEMIZED BREAKDOWN OF LEVEE CLASSES AND REHABILITATION COSTS ACORDING TO WATERWAYS

Waterway	Length Of Levee By Rehabilitation Class A	B	C	D	E	Total Length (Feet)	Estimated Cost ($1000)
Class II							
• Goodyear (West)			13,620	16,670		30,290	513
(East)		1,850	21,740	5,100		28,690	774
Total Goodyear SL		**1,850**	**35,360**	**21,770**		**58,980**	**1,287**
• Cordelia (West)			29,760	22,340		52,100	1,171
(East)			29,200	23,120		52,320	952
Total Cordelia SL			**58,960**	**45,460**		**104,420**	**2,123**
• Frank Horan (West)			22,130	4,180		26,310	601
(East)			25,080	1,930		27,010	623
Total Frank Horan SL			**47,210**	**6,110**		**53,320**	**1,224**
• Chadbourne (West)			16,890			16,890	403
(East)			16,410			16,410	433
Total Chadbourne SL			**33,300**			**33,300**	**836**
• Roos			6,510	2,490		9,000	239
• Cutoff			9,480	9,350		18,830	389
• Hill	7,770		1,550	8,880		18,200	904
• Cross			36,000			36,000	1,020
• Denverton		13,810			13,810	403	
• Luco			16,020			16,020	716
• Peytonia			9,970	9,520	1,330	20,820	413
Total Class II	**7,770**	**1,850**	**268,170**	**103,580**	**1,330**	**382,700**	**9,554**
Class III							
• Cordelia #1				7,990		7,990	334
• Cordelia #2			8,800			8,800	231
• Chadbourne #3			26,840	12,170		39,010	779
• Boynton			30,300			30,300	974
• Wells			12,600			12,600	310
• Sheldrake			11,400			11,400	368
• Hill #5	7,970	2,050				10,020	872
• Hill #4	3,390		7,200	3,390		13,980	493
• Tree		900	16,390	1,080		18,370	517
• Nurse #6			4,500			4,500	142
• Nurse #7			1,000	1,200		2,200	55
• Nurse #8			11,300			11,300	270
• Nurse #9			7,590			7,590	286
Total Class III	**11,360**	**2,950**	**137,920**	**25,830**		**178,060**	**5,631**
GRAND TOTAL	**218,860**	**67,550**	**685,340**	**204,160**	**32,230**	**1,208,140**	**52,697**

Resource Team, and final aerial survey construction estimates.* Some reasons for these differences are discussed below.

Tide Conditions

Aerial photos, used in the in-house classification, showed the Marsh under high tide conditions, obscuring the waterside toe of the levees. Some of the aerial survey work was done under low tide conditions, exposing the full breadth of the levee and often showing very narrow or severely undercut banks that were not visible in the photos. This resulted in higher (worse) final repair estimates.

Levee Distinctness

In-house aerial photo interpretation gave good ratings to levees with distinct features. Field survey work showed some levees to be distinct because of excessively steep or eroded slopes; poorer ratings were given accordingly. Also broad, indistinct levees (rated poor by aerial photo criteria) often were found to be in good condition when viewed in the field.

Vegetation

The aerial photo criteria assigned poor ratings to levees showing heavy vegetation. In the field survey, heavy vegetation did not always correspond to the need for construction repair work. Often it merely showed a need for better maintenance. In such cases, the field appraisal tended to give a better levee rating.

Levee Height

The in-house photo interpretation did not give any direct indication of levee height. Therefore, conformance to standards was generally inferred from such factors as distinctness, existence of roads, etc. During the aerial survey, the dampness of soils from recent high tides and direct visual comparison with water levels gave much clearer indication of levee heights and needs for additional fill.

Soil Type

Recent levee construction and other earthwork along the levees permitted direct exposure of soils. In some instances these differed from the base soil survey maps, and adjustments in levee classification were made accordingly.

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* The final results are generally higher than the preliminary estimates.

Roads

The field survey showed more access roads along levee tops than were indicated on base maps or could be detected from aerial photos.

Inner Drainage Ditches

Levees were rated according to whether or not a drainage ditch was visible on the landward side of the levees. This turned out to be inconsequential in the final field appraisal of levee repair needs. The existence of these ditches is more a function of inner marshland water management than levee conditions or maintenance.

Aerial Photo Lag Time

Aerial photos used in the in-house classification were taken about two years prior to the project. Several recent instances of levee failures and erosion problems were observed during field work and did not show up in the photos. Some failures occurred on recently reconstructed levees (e.g., the north end of Suisun Slough) which were viewed as excellent in the photos. Several failures were actually observed during the course of the field work.

Design Standards

The design standards by which levees were judged conform to recommendations of the Suisun RCD, but provide for more substantial levee construction than has commonly been the practice in many parts of the Suisun Marsh. Some sections of the Marsh seem to have been served adequately with narrower and/or lower levees. The final construction estimate was based on uniform standards and, as such, tended to call for more repair work than would be indicated by the Resource Team's initial in-house judgment.

APPENDIX A

LANDOWNER ROSTER OF SUISUN MARSH EXTERIOR LEVEES

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Landowner Roster of

Suisun Marsh Exterior Levees

Owner-Ship No.	Location: Levee Class	Location: Water Way	Levee Dimensions: Ln. Feet of Levee	Levee Dimensions: Ln Feet of Common Levee (Owner-Ln Feet)	Levee Dimensions: Total Ft Levee	Property Owner - Contact or Lesee: Contact/Owner	Phone	Club Name Comments
104	B	Cordelia Sl.	200		200	I. Pantaleoni Rt. 1, Box 246 Suisun, CA 94585	(707) 864-0870	
105	B	Cordelia Sl.	6,000		6,000	Michael O'Connor 2829 Wright Ave. Pinole, CA 94564	(415) 758-2485(H) (415) 233-9361(O)	Sweetwater Gun Club
108	C		1,600		1,600	Warren's Turf Nursery RFD. Suisun, CA 94585	(707) 864-0779 (707) 422-5100	
109	C		4,200		4,200	Duane Blake, Manager Warren's Turf Nursery P.O. Box 459 Suisun, CA 94585	(707) 422-5100	
110	C		10,800	(120) 3,800	10,800	Roy Sauserman Suisun Marsh Hunting Club P.O. Box 698 Fairfield, CA 94533	(707) 425-4158	
112	B	Peytonia Sl.	2,800		2,800	Timothy J. & D.R. Egan 349 Cordelia Road Suisun, CA 94585	(707) 425-3797	Suisun Farms
113	B	Peytonia Sl.	600		3,800	John E. McNear L.P. McNear Brick Co., Inc. P.O. Box 1380 San Rafael, CA 94902	(415) 454-6811	Tule Farms Club
	B	Peytonia Sl.	3,200					
116	B	Cordelia Sl.	2,200		2,200	I. Pantaleoni & Bill Peoli Rt. 1, Box 246 Suisun, CA 94585	(707) 864-0870	
117	B	Cordelia Sl.	10,000		10,000	M. DeSimoni Channel Lumber Co. 100 West Cutting Blvd. Richmond, CA 94800	(415) 529-2611(O)	Mallard Inn Duck Club

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120	C		5,200	(110)	3,800	5,200	Fred Chadbourne, Jr. P.O. Box 217 Suisun, CA 94585	(707) 446-3682(H) (707) 429-2329(O)	
121	C		2,000			2,000	Roy Sauserman Suisun Marsh Hunting Club P.O. Box 698 Fairfield, CA 94533	(707) 425-4158	
122	C	Boynton Sl.	11,200			11,200	J. Marcus Hardin, Co-owner One Kaiser Plaza Oakland, CA 94610	(415) 444-3131(O) (415) 347-4887(H)	Grey Goose Gun Club
123	A	Suisun Sl.	600			19,600	Walnut Creek Gun Club % Henry Eichner 3902 Leroy Way Lafayette, CA 94549	(415) 284-5477	Walnut Creek Gun Club, Inc.
	B	Peytonia Sl.	7,000	(221)	2,600				
	C	Boynton Sl.	12,000						
124	C	Boynton Sl.	12,200			13,800	Rawson Kelham P.O. Box 2707 Yountville, CA 94599	(707) 944-8063	
	C	Sheldrake Sl.	1,600						
125	B	Cordelia Sl.	13,000			15,200	John Svera 412 Jones Street Martinez, CA 94553	(415) 229-2382	North End Club
							George Howes 4B Admiral Dr. Apt. 434 Emeryville, CA 94608	(415) 547-0472(H) (415) 445-8772(O)	
	C		2,200						
126	B	Cordelia Sl.	600			600	Dick Cole 12 Mara Vista Ct. Tiburon, CA 94920	(415) 421-1676(O) (415) 435-0874(H)	Whistle Gun Club
							Phil Edgar 84 Milthwaith Dr. Martinez, CA 94553	(415) 228-2221	
127	C		2,800			2,800	Albert L. Simmons 240 Bigelow St. Clayton, CA 94517	(415) 781-4211 Ext. 1366(O) (415) 689-3070(H)	Simmons, Mayer Duck Club
							Carl P. Mayer 8621 Farley Way Fair Oaks, CA 95628	(916) 967-2733(H) (916) 440-3471(O)	

128	B	Cordelia Sl.	3,800		9,000	Thomas J. Fogarty,M.D. 770 Welsh Road, Suite 201 Palo Alto, CA 94304	(415) 328-5480	Mrs. Murphy's
	B	Chadbourne Sl.	1,400					
	C		3,800					
129	B	Chadbourne Sl.	5,000		11,200	Harry W. & H.M. Chadbourne Rte. 1, Box 91 Suisun, CA 94585	(707) 425-3874(H)	
	C		6,200					
130	B	Chadbourne Sl.	2,200		3,400	Frederick Tomasini RFD 1, Box 34A Suisun, CA 94585	(707) 425-8825(H)	
	C	Wells Sl.	1,200	(131) (-)200				
131	C	Wells Sl.	(-)200	(130) (-)200	5,000	Edward Cereghino 135 Marino Blvd. San Francisco,CA 94100	(415) 921-0668	Jacksnipe Gun Club
	C		4,800					
132	B	Chadbourne Sl.	600		5,600	John P. Hart 124 Los Robles Dr. Burlingame, CA 94010	(415) 347-2739)	Marsh Lands Duck Club
	C	Wells Sl.	5,000					
133	A	Suisun Sl.	17,800		32,200	Tom Parrish, Keeper	(707) 425-3043	Shelldrake Duck Club
	B	Chadbourne Sl.	3,800					
	C	Wells Sl.	5,200					
	C	Sheldrake Sl.	5,400					
139	A	Suisun Sl.	8,800		15,400	J.V. Development John Van Tress 102 Howard Dr. Tiburon, CA 94920	(415) 435-5414	
	C	Sheldrake Sl.	3,800					
	C	Boynton Sl.	2,800					

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205	B	Hill Sl.	1,800			5,800	Ethel W. Brazelton 2652 Pleasant Valley Rd. Vacaville, CA 95688	(707) 448-2760	
	C		4,000	(223) (225)	1,200 2,800				
206	B	Hill Sl.	4,800			10,600	William L. & John M. Frost Box 696 Fairfield, CA 94533	(707) 422-8728	Hill Slough Club
	C		5,800						
207	B	Hill Sl.	2,000	(214)	1,400	6,400	Robert Dale 1100 Canary Drive Suisun, CA 94585	(707) 429-8671	Black Mallard
	C		4,400						
208	B	Hill Sl.	400	(214)	400	400	Joe DellaZoppa Solano Garbage Company 322 Texas Street Fairfield, CA 94533	(707) 422-4244(O)	
211	A	Suisun Sl.	6,000			13,000	Jim McDowell SPI Group 8707 San Leandro St. Oakland, CA 94621	(415) 846-8116(O) (415) 462-0449(H)	Wings Landing
	B	Peytonia Sl.	7,000						
213	A	Suisun Sl.	5,600			5,600	A.C. Berry Rte. 2, Box 771 Dixon, CA 95620	(916) 678-5757	
214	B	Hill Sl.	1,800	(207)	1,400	1,800	William L. Smith Rte. 1, Box 204S Suisun, CA 94585		
				(208)	400				
219A	A	Suisun Sl.	7,800			7,800	Louis F. Puccinelli 333 Hegenberger Rd., Suite 701 Oakland, CA 94621	(707) 422-4732(H) (415) 639-7733(O)	Old Volanti
219B	A	Suisun Sl.	2,600			4,400	Same As Above	Same As Above	New Volanti
	B	Cutoff Sl.	1,800						

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220	B	Cutoff Sl.	6,200			6,200	Robert Bacon, M.D., P President 490 Post Street San Francisco, CA 94102	(415) 392-4343	Joice Island Mallard Farm
223	B	Hill Sl.	6,000			7,200	State of California 1416-9th Street, Rm. 1206-22 Sacramento, CA 95814		
	C		1,200	(205)	1,200				
224	A	Suisun Sl.	6,000			10,400	Same As Above		
	B	Hill Sl.	4,400						
225	A	Suisun Sl.	3,200			6,400	Same As Above		
	C		3,200	(205)	3,000				
226	C		2,000			2,000	Chuck Arnold, Mgr. 3250 Trifari Place Concord, CA 94518	(415) 881-2232(O) (415) 798-1923(H)	
*	A	Suisun Sl.	3,800			4,400			
	C		600						
302	B	Luco Sl.	1,200			1,200	Gary Von Scyoc 1008 Borrette Lane Napa, CA 94558	(707) 252-4336	S.B.D.C. #64
303	B	Luco Sl.	2,200			2,200	Doyle Reed Box 672 Rio Vista, CA 94571	(707) 374-5335(O) (707) 374-2867(H)	Potrero Duck Club
304	A	Nurse Sl.	2,600			19,200	Joseph Green P.O. Box 428 Courtland, CA 95615	(916) 775-1628 (916) 775-1519	Denverton Land Company
	B	Luco Sl.	5,600						
	B	Denverton Sl.	11,000	(305)	800				
305	B	Denverton Sl.	800	(304)	800	800	David J. Marianno 1119 Coolidge Street Fairfield, CA 94533	(707) 425-6049(H)	
							Michael A. Marianno 1161 Minneapolis St. Fairfield, CA 94533	(707) 425-7478	

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317	B	Luco Sl.	800	(319)	800	800	Leo Braito 2278 Tennessee St. Vallejo, CA 94590	(707) 644-7222(O) (707) 644-4963(H)	Stolte Farms
							Bert Hussey 1720 Broadway Vallejo, CA 94590	(707) 644-0405(O)	
318	B	Luco Sl.	4,400			4,400	Patricia E. Begley 518 Orchard Avenue Vacaville, CA 95688		
319	A	Nurse Sl.	800			4,400	See No. 317		
	B	Luco Sl.	3,600						
320	A	Nurse Sl.	5,800			5,800	C. Earl Kilbert 1900 Green Valley Rd. Suisun, CA 94585	(707) 864-1059	Tulle Meadows Club
321	A	Nurse Sl.	9.600			19,000	Gordon H. Huber P.O. Box 24164 Oakland, CA 94623	(415) 451-3826	Greenhead
	B	Cross Sl.	3,800						
	B	Hastings Sl.	5,600	(526)	1,000				
322	A	Nurse Sl.	16,600			16,600	Dave Maupin Maupin Insurance Co. Holiday Inn Fairfield, CA 94533	(707) 422-7155	Broadmor Island
323	A	Nurse Sl.	3,000			8,200	Gary Tonnessen Scally Rd., Star Rte., Box 38 Suisun, CA 94585	(707) 425-5881(O) (707) 425-4001(H)	Duck & R.
	B	Denverton Sl.	3,200						
	C		2,000	(326)	2,000				
326	A	Nurse Sl.	2,800			8,200	Dave Travis Parson's Automatic Scale 1331 - 8th Street Berkeley, CA 94710	(415) 524-3464(O)	Gunn Ranch Duck Club
	C		4,200	(323)	2,000				
	C		1,200	(604)	1,200				
329	A	Nurse Sl.	8,000			8,000			

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401	C		3,200	(402)	2,400	3,200	Westland Bank 1107 No. Main St. Santa Ana, CA 92700	(800) 432-7060 (800) 432-7208	
402	B	Cordelia Sl.	2,800			15,200	Bruce Ornbaun Ornbaun Kennels Cordelia Road Suisun, CA 94585	(707) 864-0668	
	C		8.200	(403)	3,600				
	C		4,200	(401)	2,400				
403	B	Cordelia Sl.	9,600			13,200	Louis Garibaldi 35 Willotta Drive Suisun, CA 94585	(707) 864-0991(H)	Garibaldi Bros. Duck Club
	C		3,600	(402)	3,600				
404	B	Cordelia Sl.	10,400			18,200	E. Herrick Low 1633 Bayshore Hwy, Su.327 Burlingame, CA 94010	(415) 421-3834(H) (415) 692-1986(O)	Cordelia Gun Club
	B	Chadbourne Sl.	2,200						
	B	Frank Horan Sl.	5,600						
405	B	Chadbourne Sl.	8,200			14,400	Sunrise Duck Club, Inc. % Armond E. Saucci 121 Balceta Cable Car - Robert Kirk, Ltd. San Francisco, CA 94127	(415) 397-4740(O) (415) 731-0149(H)	Sunrise Duck Club
	B	Frank Horan Sl.	6,200						
406	B	Frank Horan Sl.	19,600	(412)	1,000	22,400	Jay Kellette 44 Meadow Hill Dr. Tiburon, CA 94920	(415) 981-4305(O)	Teal Club
	B	Chadbourne Sl.	2,800						
407	B	Cordelia Sl.	6,000			6,000	E.J. Pucinelli 11 View Street Los Altos, CA 94022	(415) 941-4379	Ibis Duck Club
408	B	Cordelia Sl.	2,000			2,200	Richard P. Chicca Franciscan Marshview Duck Club, Inc. 590 Pacific Ave. San Francisco, CA 94133	(415) 781-4455(O) (415) 461-2593(H)	Franciscan/Marshview Duck
	B	Frank Horan Sl.	200						
409	B	Frank Horan Sl.	2,600			2,600	See No. 408		

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410	B	Frank Horan Sl.	12,000			12,200	Luther E. Gibson P.O. Box 3067 544 Maryland St. Vallejo, CA 94590	(707) 643-6104(O)	Gibson Horseshoe Duck Club
	B	Cordelia Sl.	200						
411	B	Cordelia Sl.	3,800			6,600	Robert Covey & Clodd Settles P.O. Box 11 Fairfield, CA 94533	(707) 425-6477(O) (707) 425-9026(H)	Green Lodge Club
	B	Frank Horan Sl.	2,800						
412	B	Frank Horan Sl.	5,600	(406)	1,000	5,600	Fred Hock, Jr. 801 California St. San Francisco, CA 94108	(415) 982-5613	Rousseau Ranch
413	B	Roos Sl.	4,200			4,200	Jack B. Anderson, Pres. Green Valley Assoc. 425 California St., #2150 San Francisco, CA 94104	(415) 391-1155(O)	Sprigateal
414	B	Roos Sl.	3,600			3,600	Albert D. Seeno, Jr. RBM Land Company 4300 Railroad Ave. Pittsburg, CA 94565	(415) 439-1086	Drake Sprig
415	A	Suisun Sl.	11,000			16,600	Joe Mortara Arnold Ranch, Inc. P.O. Box 5297 Vallejo, CA 94590	(707) 643-8476(O) (707) 642-5121(H)	Arnold Ranch Club
	B	Chadbourne Sl.	5,000						
	B	Roos Sl.	600						
416	B	Cordelia Sl.	6,000			6,000	Woodrow Hahn 440 Valle Vista Vallejo, CA 94590	(707) 864-1200	Tule Belle Club
417	B	Cordelia Sl.	6,800			6,800	Same As Above	Same As Above	Tulle Belle Club
418	A	Suisun Sl.	2,000			5,000	George Marcantelli 547 Old Orchard Dr. Danville, CA 94526	(415) 471-9770(O) (415) 837-0793(H)	Cygnus Gun Club
	B	Roos Sl.	1,400						
	B	Cordelia Sl.	1,600						

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419	A	Suisun Sl.	1,400	9,600	Rocky Golden P.O. Box 475 Suisun, CA 94585	(707) 864-0536(H) (707) 425-5761(O)	Mirimonte Duck
	B	Cordelia Sl.	8,200				
	B	Goodyear Sl.	600				
420	A	Suisun Sl.	7,000	7,000	James Murad % Cooper, White & Cooper 44 Montgomery St. San Francisco, CA 94104		The Antioch Golden Eye
422	B	Goodyear Sl.	400	400	Harold Hjelm 625 Olive Avenue Menlo Park, CA 94025 (Alternate Contact Only)	(415) 325-6072	West Family Club
423	B	Goodyear Sl.	6,400	9,400	Don Eaton 60 Singingwood Lane Orinda, CA 94563		The Family Club
	B	Cordelia Sl.	3,000				
424	A	Suisun Sl.	19,400	34,800	Vern Robelado, Caretaker	(707) 864-0959	Joice Island Gun Club
	A	Grizzly Bay	6,400				
	A	Montezuma Sl.	9,000				
425	A	Montezuma Sl.	4,800	4,800	Frank H. Johnson 1000 Hawthorne Dr. Walnut Creek, CA 94596	(415) 933-3100	California Farms
426	A	Montezuma Sl.	4,000	8,400	Warren Detloff, Caretaker	(707) 425-5905	
					Walter Dickie 409-13th Street Oakland, CA 94612	(415) 843-8722(O)	Tip End Gun Club
					Harold E. Petrich 628 Marin Street Vallejo, CA 94590	(707) 552-2151(O)	
427	B	Cordelia Sl.	(-)100	(-)100	See No. 413		
428	B	Cordelia Sl.	(-)100	(-)100	See No. 411		
429	B	Cordelia Sl.	(-)100	(-)100	See No. 418		
430	B	Cordelia Sl.	(-)100	(-)100	See No. 411		
431	B	Cordelia Sl.	(-)100	(-)100	See No. 405		

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432	B	Cordelia Sl.	(-)100			(-)100	See No. 404		
433	B	Cordelia Sl.	(-)100			(-)100	See No. 407		
434	B	Cordelia Sl.	(-)100			(-)100	See No. 418		
435	B	Cordelia Sl.	(-)100			(-)100	See No. 407		
436	B	Cordelia Sl.	(-)100			(-)100	See No. 408		
437	B	Cordelia Sl.	(-)100			(-)100	See No. 408		
439	B	Cordelia Sl.	600			600	See No. 410		
501	A	Montezuma Sl.	1,600			3,200	Anton G. Holter 511 Sir Francis Drake Bl. Suite #202 Greenbrae, CA 94904	(415) 461-2640	Island Club
	A	Grizzly Bay	1,600	(512)	1,600				
502	A	Montezuma Sl.	3,400			3,400	Richard Tesene 2240 Loch Lane Walnut Creek, CA 94598	(415) 647-1142(O) (415) 933-9071(H)	Grizzly Duck Club
503	A	Montezuma Sl.	2,000			2,200	James Telgan, Mgr. 980 Linda Mar Blvd. Pacifica, CA 90440	(415) 355-5000(O) (415) 355-1624(H)	Montezuma Gun Club
	A	Grizzly Bay	200	(512) (513)	100 100				
504	A	Montezuma Sl.	4,800			4,900	Dr. Jerrold Bocci 562 Craig Road Hillsborough, CA 94010	(415) 586-8100 (415) 583-4071 (415) 992-1300	Gum Tree Farm
	A	Grizzly Bay	(-)100	(513)	(-)100				
505	A	Montezuma Sl.	1,000			1,000	James B. Keegen 1559 Foothill Dr. Santa Rosa, CA 95404	(707) 542-0235	Paton Place
506	A	Montezuma Sl.	1,800			1,800	Four Winds % Ronald F. Norman 20302 Cartwright Way Cupertino, CA 95014	(408) 255-9426	Four Winds Duck Club
510	A	Grizzly Bay	3,800	(511)	3,800	3,800	Anthony Grcich 19901 South McHenry Escalon, CA 95320	(209) 577-2178(H) (209) 838-3564(O)	The Honkers Club

511	A	Grizzly Bay	3,900	(510)	3,800	3,800	See No. 510		
512	A	Grizzly Bay	6,000	(501) (503)	720 100	6,000	Harold E. Petrich 628 Marin Street Vallejo, CA 94590	(707) 552-2151(O)	Tip End Gun Club
513	A	Grizzly Bay	16,400	(503) (504)	100 (-)100	16,400	Volney Benson 2997 College Ave. Berkeley, CA 94705	(415) 848-0642(O) (415) 524-2360(H)	Grizzly King Gun Club
514	A	Montezuma Sl.	5,200			9,800	Joe Troy P.O. Box 114 Rheem Valley, CA 94590	(415) 534-0982(O) (415) 254-1633(H)	Tree Slough Farms
	C	Tree Sl.	4,600						
515	C	Tree Sl.	5,600	(516) (534)	600 400	5,600	L.B. Fleishchman P.O. Box 1366 Alameda, CA 94501		Long Point West Club
516	C	Tree Sl.	600	(515)	600	600	Fred B. Bascom 1714 Orleans Court Walnut Creek, CA 94598		Bent Barrell Duck Club
520	A	Montezuma Sl.	3,000			13,000	Raymond E. Lewis 2819 Central Ave. Alameda, CA 94501	(415) 522-7656(O)	
	C	Tree Sl.	10,000	(534)	100				
521	A	Montezuma Sl.	200			200	Richard N. Clayton 55 Harbor Street San Rafael, CA 94901	(415) 454-3634(O) (415) 457-9759(H)	Dik-Dik Ranch
							Richard A. Williams 235 Montgomery St., Su. 450 San Francisco, CA 94104	(415) 433-0285(O)	
522	A	Montezuma Sl.	1,600			1,600	William L. & Joan M. Frost P.O. Box 696 Fairfield, CA 94533	(707) 422-8728(H)	Piedmont Rod & Gun
523	A	Montezuma Sl.	3,200			3,200	Richard A. Weston 2454 Old Sonoma Rd.,#1 Napa, CA 94558	(707) 255-8271(H)	
524	A	Montezuma Sl.	4,200			4,200	See No. 521		
525	A	Montezuma Sl.	1,200			1,200	Richard Gaines, Caretaker 304 Morgan Avenue Suisun, CA 94585	(707) 425-4198	Balboa Farms

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526	A	Montezuma Sl.	6,400	Public Lands		30,800	David D. Bohannon David D. Bahannon Organization 60 Hillsdale Mall San Mateo, CA 94403	(415) 345-8222(O) Can-Can Duck Club
	B	Cross Sl.	19,400					
	B	Hasting Sl.	5,000	(321)	1,200			
527	A	Montezuma Sl.	400			400	Howard Thiel 307 Fruitvale Rd. Vacaville, CA 95688	(707) 446-3982(H) Delta King (707) 425-5333(Club)
533	A	Suisun Sl.	19,400			53,400		
	A	Montezuma Sl.	23,600					
	B	Cutoff Sl.	10,400					
534	C	Tree Sl.	800	(515)	800	800	State of California	
535	A	Grizzly Bay	5,600			36,000	Manual Freitas 160 Seaview San Rafael, CA 94901	(415) 453-6302
	A	Montezuma Sl.	30,400					

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601	A	Montezuma Sl.	4,200	10,200	See No. 526		
	A	Nurse Sl.	2,000				
	B	Cross Sl.	4,000				
604	A	Nurse Sl.	4,800	11,600	James W. & V. Blacklock Star Route 1 Suisun, CA 94585	(707) 425-5037(H)	
	C		1,800				
	C		5,000				
605	A	Nurse Sl.	5,800	11,200	Mildred Wagenet Trust 1880 Jackson St., Apt. 101 Oakland, CA 94612	(415) 832-3648(H)	Wagenet Duck Club
	A	Montezuma Sl.	1,200				
	C		4,200				
606	C		1,600	1,600	John C. & Alice Soares Star Route Suisun, CA 94585	(707) 425-5007(H)	
607	A	Montezuma Sl.	4,400	4,400	Frank F. Borg 4260 Newberry Court Palo Alto, CA 94306	(415) 493-7343(H)	Duck-A-Go-GO
608	A	Montezuma Sl.	4,000	4,000	William J. Olson, M.D. 1900 Pennsylvania Ave. Fairfield, CA 94533	(707) 425-1056	Shurshot Gun Club
609	A	Montezuma Sl.	400	400	Kenneth H. Hofman P.O. Box 907 Concord, CA 94522	(415) 682-4830(O)	Black Dog Gun Club
610	A	Montezuma Sl.	4,000	4,000	Joe Bulloch 3611 Haven Avenue Menlo Park, CA 94025	(415) 364-3377(O)	Westwind Duck
612	A	Montezuma Sl.	3,200	3,200	Robert S. Cooper 940 E. Meadow Drive Palo Alto, CA 94303	(415) 494-7555(O) (415) 854-3879(H)	Hidden Cove Gun Club
613	A	Montezuma Sl.	8,600	13,600	Richard Emigh R. Emigh Livestock 98 Bruning Rio Vista, CA 94571		Kirby Hill Club

	C	Montezuma Sl.	5,000	(626) (627)	2,000 1,600				
618	A	Montezuma Sl.	3,200	(625)	200	3,200	Everett Dawson, Treas. 3985 Woodside Road Woodside, CA 94062	(415) 851-7339(O) (415) 851-7344(H)	Meridian Gun Club
625	A	Montezuma Sl.	8,000	(618)	200	8,000	Jack Keeler, Treas. 1327 Texas Street Fairfield, CA 94533		Pintail Ranch #6
627	A	Montezuma Sl.	2,600			4,800	Art Honegger Rte. 1 Oakley, CA 94561	(415) 625-2404	
	C		2,200	(613)	1,600				
631	A	Montezuma Sl.	15,400			15,400	Christopher Clegg 369 Pine St., Su. 320 San Francisco, CA 94104	(415) 781-5787(O)	Meins Landing Duck Club
701	B	Goodyear Sl.	7,200	(702)	2,600	7,200	Ed Parish Box 6 Benicia, CA 94510	(707) 745-1066(O) (916) 885-4794(H)	Good Year Club
702	A		6,600			20,000	John L. Winther 12 El Sereno Rd. Orinda, CA 94563	(415) 461-3734(O) (415) 254-7731(H)	Happy Eight Club
	B	Goodyear Sl.	13,400	(701)	2,600				
704	A	Suisun Sl.	2,400			6,400	Stone Enterprises P.O. Box 5194 Walnut Creek, CA 94596	(415) 935-6611(O) (415) 254-2596(H)	
	A	Suisun Bay	4,000						
705	B	Goodyear Sl.	1,800	Public Lands	1,800	1,800	Tom Bensinger 106 Brookfield Moraga, CA 94556	(415) 376-6930	Mulberry Land Company
706	B	Goodyear Sl.	4,000	(701)	400	4,000	Leslie S. Mayne 426 Dorchester Road Box 522 San Mateo, CA 94402	(415) 344-3860(O) (415) 344-5106(H)	Mayne Duck Club
707	A	Suisun Bay	3,400			8,200	James F. Eggert 4055 Los Arabis Dr. Lafayette, CA 94549	(415) 254-1932(O) (415) 893-4318(H)	Goodyear Land Development Co.

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	B	Goodyear Sl.	4,800	(715)	400				
708	B	Goodyear Sl.	800			800	Jerry Perris 923 Mareno Drive Napa, CA 94558		
714	B	Goodyear Sl.	8,000	(715)	2,600	8,000	Charles Broadway % Wells Fargo Bank 464 California St. San Francisco, CA 94104	(415) 396-3695	Sprig Haven Duck Club
715	A	Suisun Bay	10,200	Public Lands	10,200	19,600	John G. & Bonnie Pahl Box 8485 Stockton, CA 95208	(209) 464-8381(O)	Pahl Duck Club
	B	Goodyear Sl.	9,400	(707) (714) (715) (717)	400 2,600 3,000 1,200				
717	A	Suisun Bay	7,200	Public Lands	7,200	10,000	Stone Enterprises P.O. Box 5194 Walnut Creek, CA 94596	(415) 935-6612(O) (415) 254-2597(H)	Bowman Club
	B	Goodyear Sl.	2,800	(715)	1,200				
718	B	Goodyear Sl.	1,400			1,400	Gennaro A. Felice, Jr. 405 Miner Road Orinda, CA 94563	(415) 254-8184 (415) 376-2440	Family Gun Club
720	B	Goodyear Sl.	6,200	(715)	3,000	6,200	Angelo Biagi 26 Hayward Avenue San Mateo, CA 94401	(415) 552-2311	6 Gun Club

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801	A	Buckler Island	4,400			4,400	James Taylor 700 Parker Avenue Rodeo, CA 94572	(415) 758-2100(O) (415) 932-8915(H)	Annie Mason Point Bluc
802	A	Grizzly Bay	7,000			17,400	Robert Henderson, Treas. Rich Island Gun Club 220 Montgomery St.,#1039 San Francisco, CA 94104	(415) 981-5928(O) (415) 342-3976(H)	Rich Island Gun Club
	A	Suisun Bay	10,400						
803	A	Grizzly Bay	3,600			5,200	Armando Flocchini, Sec/ Treas. 160 Sunol Street San Jose, CA 95159	(408) 298-6404(O) (415) 357-3092(H)	St. Germain Duck Club
	A	Suisun Bay	1,600						
804	A	Grizzly Bay	200			200	Bill Armstrong 329-15th Street Oakland, CA 94612	(415) 451-6327(O)	Sprigfarm Duck Club
805	A	Suisun Bay	3,600			3,600	Mike Grace Canvasback Farms P.O. Box 7138 Berkeley, CA 94707	(415) 524-2696	Canvasback Farm
807	A	Grizzly Bay	9,800	(901)	1,000	9,800	William E. Ready 990 Moraga Road Lafayette, CA 94540	(415) 284-5511(O)	Wheeler Island
							Berger Benson 847 La Mesa Drive Portola Valley, CA 94025	(415) 342-4445(O)	
809	A	Fyer Island	22,600			22,600	Bill McDermott 134 East 10th Street Pittsburg, CA 94565	(415) 432-6431	Long Point Isl. Protective Assn.
810	A	Freeman Island	8,400			8,400	U.S.A.		
811	A	Snag Island	3,200			3,200	See No. 807		

901	A	Honker Bay	6,200	(807)	800	6,200	Leo DeMarco #8 Hill Street Pittsburg, CA 94569	(415) 458-2704(H)	San Souci Land
902	A	Honker Bay	2,000			2,000	Donald Q. Billings, Treasurer 4095 Pacheco Blvd. Martinez, CA 94553	(415) 676-4151(O)	Fantasy Island Duck Club
903	A	Honker Bay	800			800	William K. Walter 3110 Diablo View Rd. Lafayette, CA 94549	(415) 834-3200(O) (415) 935-6422(H)	Blue Bird Club
904	A	Honker Bay	2,200			2,200	Lester C. Bedient Crowley Maritime Corp. 1 Market Plaza, Su. 3200 San Francisco, CA 94105		Roaring River Club
905	A	Honker Bay	3,600			3,600	David M. Cavanaugh 1700 Park Street Alameda, CA 94501	(415) 523-5246	Mallard Farms
907	A	Honker Bay	4,000	(942)	4,000	4,000	J.B. McIntosh 100 Bush Street.,Su. 326 San Francisco, CA 94104 James Flood, Vice Pres. Wells Fargo Bank 3742 Washington St. San Francisco, CA 94118	(415) 398-5757	The Island Farm
908	A	Montezuma Sl.	4,000			4,000	Robert Nave 5800 Redwood Highway Novato, CA 94947	(415) 454-4700	Montezuma Ranch
910	A	Chipps Island	16,400			16,400	Ownership Unknown		
912	A	Honker Bay	2,40	(942)	+	2,400	Honker Farms % Andy Landerman 234 Bonito Road Portola Valley, CA 94025	(408) 257-9111(O) (415) 851-2207(H)	Honker Duck
913	A	Montezuma Sl.	2,600			2,600	Fred Fisher, Secy Nine Land Company 1291 Hillcrest Blvd. Millbrae, CA 94030	(415) 697-8640	Nine Land Club
914	A	Chipps Island	11,600			11,600	Henry Cesa Antioch Building Material P.O. Box 870 Antioch, CA 94509	(415) 432-3828	Cesa Farms
915	A	Chipps Island	5,600			5,600	Steve Andrus 1925 Oak Avenue Menlo Park, CA 94025	(415) 366-3833(O) (415) 322-1271(H)	Fin & Feathers

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916	A	Spoonbill Creek	3,000			3,000	John Brogan 607 Rheem Moraga, CA 94556	(415) 376-4623	A & B Duck Club
919	A	Spoonbill Creek	(-)200			(-)200	Ruby Violet Pozzan 10979 San Pablo Ave. El Cerrito, CA 94530	(415) 232-9869(O) (415) 232-0829(H)	Island Gun Club
923	A	Spoonbill Creek	800			800	James L. Ferry, Jr. 6749 Stanley Avenue Carmichael, CA 95608		
926	A	Spoonbill Creek	3,200			3,200	Emil Vaini 56 Rico Way San Francisco, CA 94123	(415) 921-3005	Webfoot
930	A	Suisun Bay	2,000			2,000	Emma Ricci 157 Bayview Drive San Rafael, CA 94901	(415) 453-1812	Hit & Miss Club
931	A	Suisun Bay	4,000			4,000	Frank Salamid, Jr. 1441 Franklin Street Oakland, CA 94612	(415) 444-5753(O) (415) 547-2267(H)	Delta Farms
932	A	Suisun Bay	3,800	(Bay)	2,800	5,200	Irv Kraemer, Sec/Treas. Concord Farms, Inc. 554 Golf Club Road Pleasant Hill, CA 94523	(415) 689-6684(H)	Concord Farms
	A	Montezuma Sl.	1,400						
934	A	Montezuma Sl.	1,200			1,200	John M. & Wynoma L. Vesco 425 Estudillo San Leandro, CA 94577		
935	A	Montezuma Sl.	1,200			1,200	Oleroy D. Hytholt 4931 Pacheco Blvd. Pacheco, CA 94520	(415) 229-0199	
936	A	Montezuma Sl.	1,200			1,200	Jan D. Gladstein Box 2512, Airport Station Oakland, CA 94614		
937	A	Montezuma Sl.	1,200			1,200	Charles W. & M.L. Conger 4237 Brentwood Circle Concord, CA 94521		
938	A	Montezuma Sl.	1,200			1,200	See No. 935		
939	A	Montezuma Sl.	1,200			1,200	Douglas R. & Marilyn Trost 4940 Morgan Territory Rd. Clayton, CA 94517	(415) 439-9461	

940	A	Suisun Bay	1,200		1,200	Frank B. Malfitano 3891 Brookside Drive Pittsburg, CA 94565	(415) 432-4497 (415) 754-4020	Frandora's Island
941	A	Chipps Island	1,200		1,200	Volney Benson 2997 College Avenue Berkeley, CA 94705	(415) 848-0642(0) (415) 524-2360	
942	A	Honker Bay	2,800		2,800			

(807)	1,800
(901)	1,200
(902)	1,800
(903)	1,600
(904)	800
(907)	4,600

NOTES

1. Suisun Slough. 3,800 linear feet beyond Suisun RCD ownership map boundaries. Class A levee.
2. Secondary Levee north of Hill Slough. Class C levee extending 600 linear feet beyond Suisun RCD ownership map boundaries.
3. Approximately 200 feet of levee appears to be on public land in Frost Slough between ownership parcels 527 and 609.
4. 29,200 linear feet of Class A levee lies beyond the Suisun RCD ownership map along the East side of the Montezuma Slough.

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APPENDIX B

DESCRIPTION OF SUISUN MARSH SOILS

D-030877

TABLE B-1. ESTIMATED SOIL PROPERTIES ALONG THE EXTERIOR LEVEES

Soil Symbol	Description	Unified Class	AASHO Class	Hydrologic Soil Group	Selected Engineering Properties
Va	Valdez silt loam	CL	A-4	C	Moderate shrink-swell potential, medium to low sheer strength, medium compressibility, medium to high piping hazard, medium to low permeability when compacted
Vc	Valdez silty clay loam	CL	A-6	C	Medium to low sheer strength, medium compressibility, medium to high piping hazard, medium to low permeability when compacted, moderate shrink-swell potential
Vd	Valdez silty clay loam, wet	CL	A-6	D	Similar to Vc, except is more strongly saline. Formed in dredged material pumped from saline bodies of water
Ve	Valdez silty clay loam with clay substratum	CL	A-6	C	Low sheer strength, high compressibility, low piping hazard, low permeability when compacted
An	Alviso silty clay loam	CL	A-6	D	High shrink-swell potential, low to medium sheer strength, medium compressibility, low to medium piping hazard, low permeability when compacted
St	Sycamore silty clay loam, saline	CL	A-6	C	Moderate shrink-swell potential, medium sheer strength, medium compressibility, low to medium piping hazard, low permeability when compacted

Soil Symbol	Description	Unified Class	AASHO Class	Hydrologic Soil Group	Selected Engineering Properties
SeB	San Ysidro sandy loam	CL	A-6	D	High shrink-swell potential, medium to low sheer strength, medium compressibility, medium piping hazard, medium to low permeability when compacted
Sm	Solano loam, dark surface variant	CL	A-6	D	Layer of clay loam underneath the loam followed by loamy sand. Moderate shrink-swell potential, medium to low sheer strength, medium compressibility, medium to high piping hazard, medium to low permeability when compacted
Re	Reyes silty clay	CL	A-7	D	High shrink-swell potential. Often stratified with organic matter. High organic matter content necessitates on-site evaluation for use in any water retention structure, slow permeability
AoA	Antioch-San Ysidro loam and sandy loam	CL	A-7	D	Loam over clay at depth of 15-30 in. High shrink-swell potential, low sheer strength, high compressibility, low piping hazard, low permeability when compacted
AsC	Antioch-San Ysidro loam and sandy loam	CL	A-7	D	Similar to AoA except higher content of sandy loam
Pc	Pascardero clay loam	CL	A-7	C	High shrink-swell potential, low sheer strength, high compressibility, low permeability when compacted

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Soil Symbol	Description	Unified Class	AASHO Class	Hydrologic Soil Group	Selected Engineering Properties
Ta	Tamba mucky clay	OH	A-8	D	High shrink, low swell, high organic matter necessitates on-site evaluation for use in any water retention structures
Td	Tidal marsh	OH	A-8	D	Highly variable soil located between constructed levees and water bodies
Ja	Joice clayey muck	Pt	A-8	D	High shrink, low swell, highly organic, not suitable for embankment
Jb	Joice variant with clay substratum	Pt	A-8	D	High shrink, low swell, highly organic material over clay, not suitable for embankments
Sp	Suisun peaty muck	Pt	A-8	D	High shrink, low swell, highly organic, not suitable for embankments

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APPENDIX C

EXAMPLE OF CLASSIFICATION, FIELD SURVEY, AND COST COMPUTATION FOR CHIPPS ISLAND

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EXAMPLE OF LEVEE CLASSIFICATION

An example application of the classification system is presenteed here for the exterior levees of Chipps Island (total length 6.63 miles). The following illustrates the procedure:

IN-HOUSE

- o **Figure C-1** - Identification of exterior levees - shows the extent of exterior levees, the aerial photography coverage (three photos , #24-8, #24-9, and #25-8);
- o **Figure C-2** - Soil classification and repair history - shows the ownership code and boundaries, segment designation, soil classification, and repair history;
- o **Table C-1** - Presents analytical work leading to levee classification;
- o **Figure C-3** - Levee classification based on results of photo interpretation;
- o **Figure C-4** - In-house levee classification shows the final classification system used.
- o **Table C-2** - Presents the analytial work leading to the in-house levee classification;
- o **Table C-3** - Presents an example of field assessment of levee structural conditions;
- o **Table C-4** - Presents an example of field assessment of levee maintenance conditions;
- o **Table C-5** - Presents an example of field assessment of levee rehabilitation needs;
- o **Table C-6** - Presents an example of cost calculations for levee repair;

CHIPPS ISLAND

FIGURE C-1
IDENTIFICATION OF EXTERIOR LEVEES

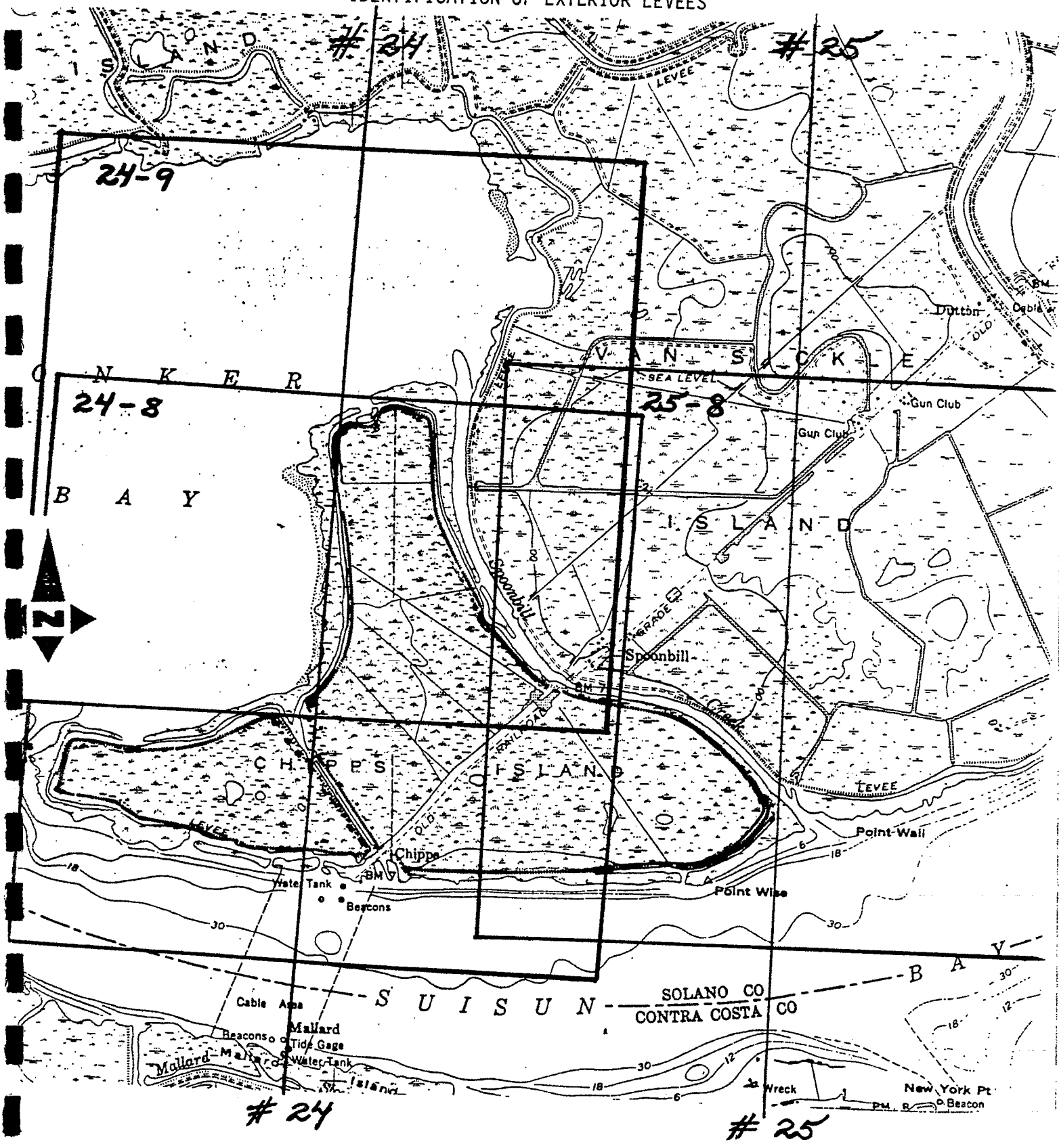

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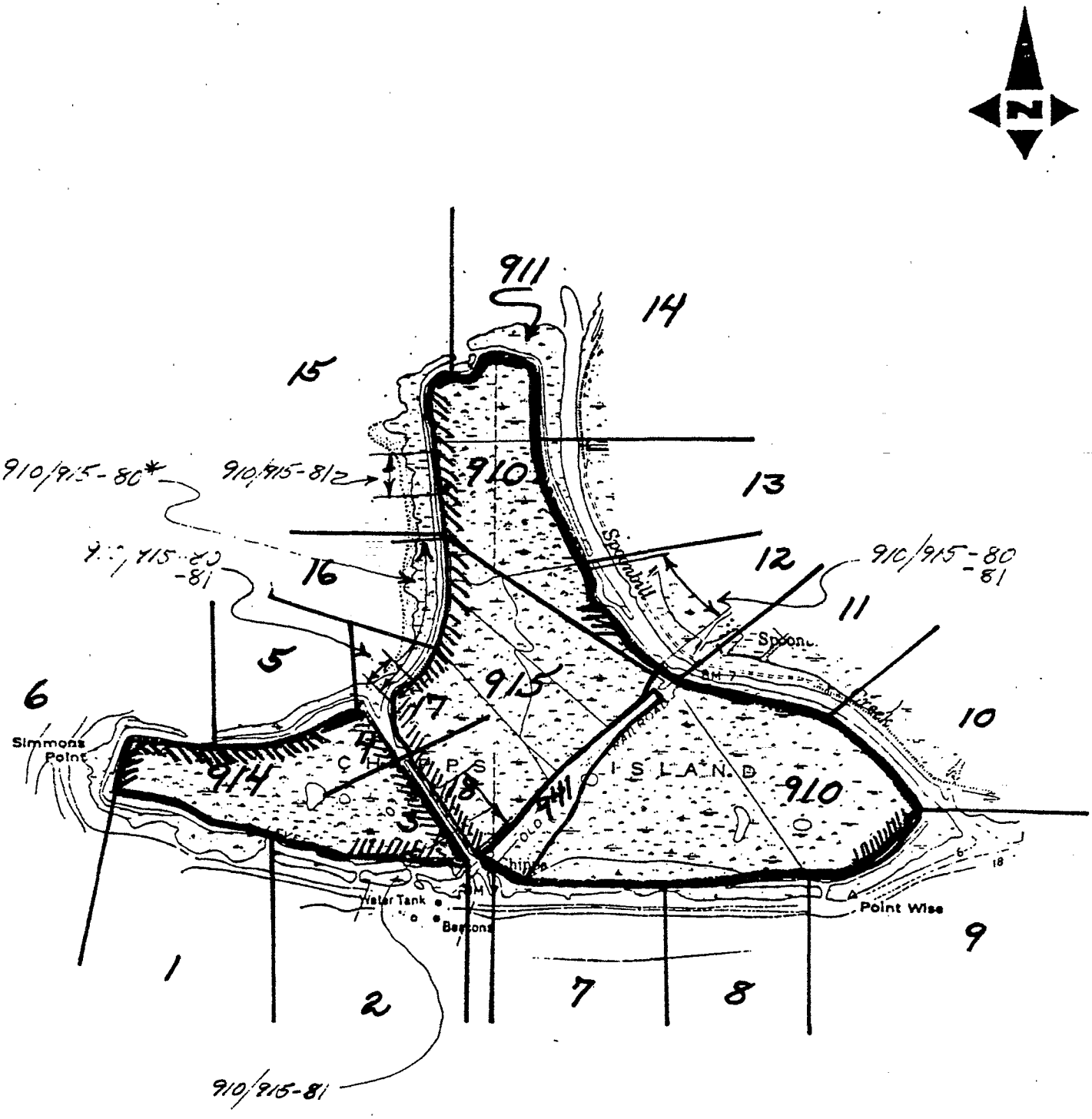
FIGURE C-2

SOIL CLASSIFICATION AND REPAIR HISTORY



Soils

Pt

OH

Ownership Code 915

Segment Number 14

Repair Record (See Repair Index in Checkpoint B-2) 910/915 - 80

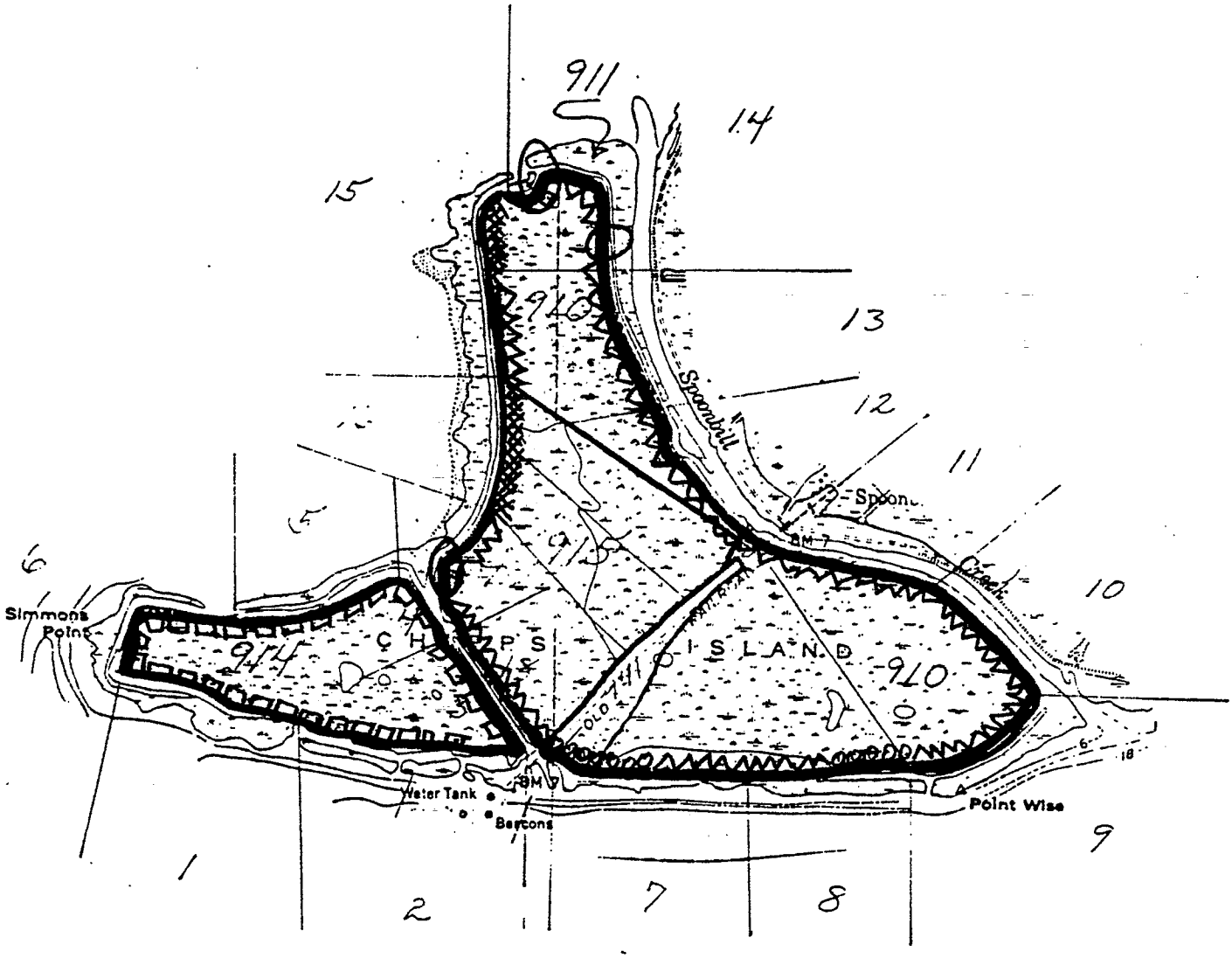
Table C-1 In house levee classification system

Levee name: Chipps Island
Date: February 4, 1982
Prepared by: Carolin Grieg
Approved by: Joseph Smiell

Segments	I-R photo interpretation						Decision tree matrix					Levee classification		
	1	2	3	4	5	6	Existing levee condition	Wind and wave action	Repair history	Significance of protection	Foundation material	In-house class.	Resource team class.	Ground verification
1	I						P	H	N	N	Pt/OR	A	A/B	
2	I						P	H	N	N	Pt/OR	A	A/B	
3	I						P	H	N	N	Pt/OR	A	A/B	
4	I						P	H	N	N	Pt/OR	A	A/B	
5	I						P	H	N	N	Pt/OR	A	A/B	
6	I						P	H	N	N	Pt/OR	A	A/B	
7	I/D	5/5	4/7	2/4	1/1	12/17	F/G	H	N	N	Pt/OR	A/D	A/E	
8	D	5/5	7/4	1/1	1/1	14/11	G/F	H	N	N	Pt/OR	D/A	E	
9	D	5	4	3	1	13	G	H	N	N	Pt/OR	D	A/B/E	
10	D	5	6	2	1	14	G	H	N	N	Pt/OR	D	E	
11	D	5	7	3	1	16	G	H	N	N	Pt/OR	D	E	
12	D	5	7	4	1	17	G	H	S	N	Pt/OR	D	E	
13	D	5/5	7/10	4/2	1/1	17/18	G	H	N	N	Pt/OR	D	E	
14	D(I)	5	10	2	1	18	G	H	N	N	Pt/OR	D	E	X
15	D	5/5	10/7	10/4	1/1	26/17	E/G	H	S	N	Pt/OR	E/D	E	
16	D	5	10	10	1	26	E	H	S	N	Pt/OR	E	E	
17	D(I)	5	10	2	1	18	G	H	S	N	Pt/OR	D	E	X
18	D	5	8	3	1	17	G	H	S	N	Pt/OR	D	E	

FIGURE C-3

LEVEE CLASSIFICATION BASSED ON RESULTS OF PHOTO INTERPRETATION



Excellent

Good

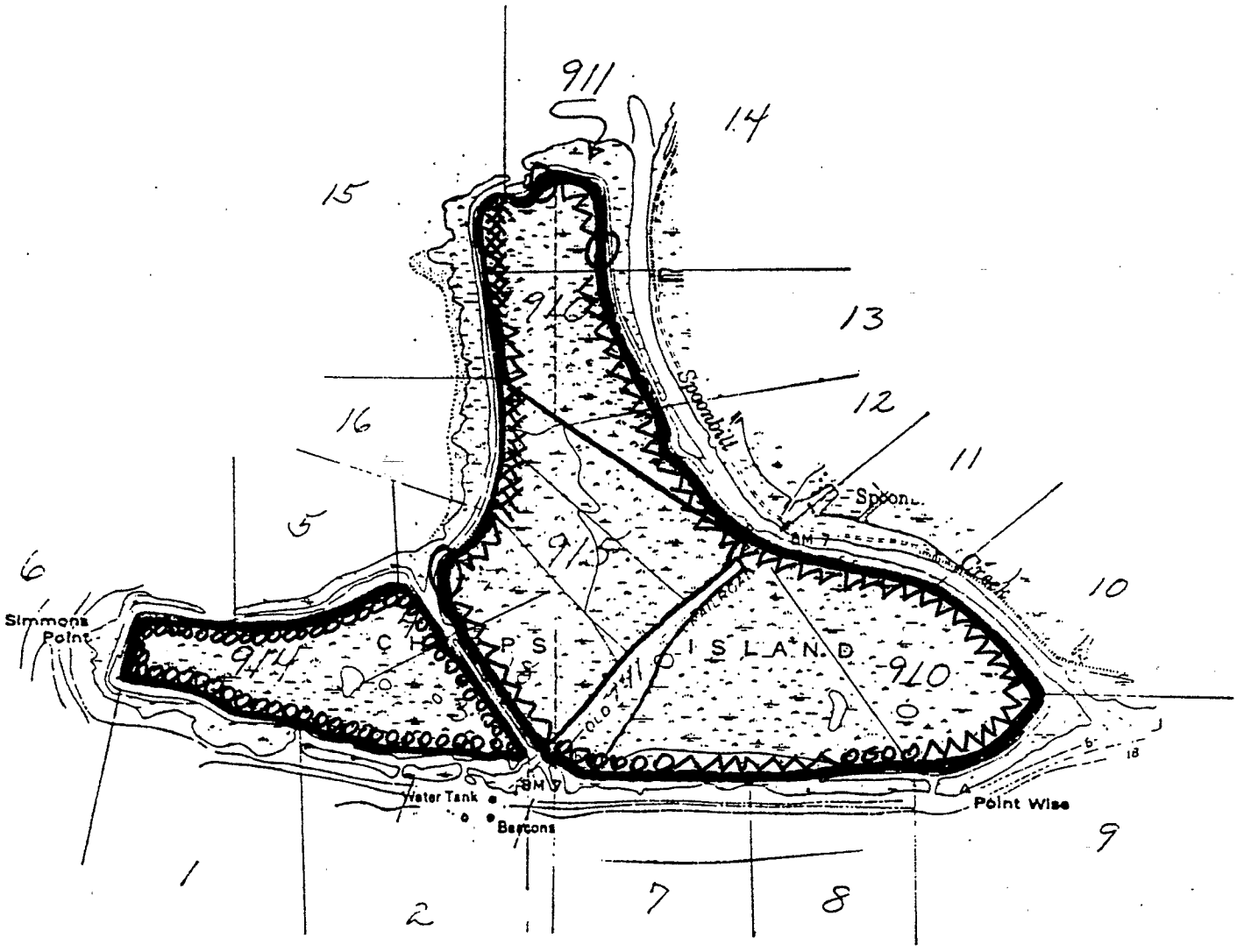
Fair

Poor

Indistinct (Field Check)

FIGURE C-4

IN-HOUSE LEVEE CLASSIFICATION



Type A

Type B

Type C

Type D

Type E

Field Check

Table C-2 In house levee classification system

Levee name Chipps Island
Date 3-22-82
Prepared by Joseph E Smiell
Approved by JKN

Segments	I-R photo interpretation						Decision tree matrix					Levee classification		
	1	2	3	4	5	6	Existing levee condition	Wind and wave action	Repair history	Significance of protection	Foundation material	In-house class.	Resource team class.	Ground verification
1	(I)						P	H	N	N	PT/OR	A	A-B	(✓)
2	I						P	H	N	N	PT/OR	A	A-E	✓
3	I						P	H	N	N	PT/OR	A	A-E	✓
4	I						P	H	N	N	PT/OR	A	A-E	✓
5	I						P	H	N	N	PT/OR	A	A-E	✓
6	I						P	H	N	N	PT/OR	A	A-E	✓
7		3	4/7	2/4	1	10/15	F/G	H	N	N	PT/OR	A/D	A-B, E	
8		3	7/4	1/1	1	12/9	F	H	N	N	PT/OR	A	"	
9		3	4	3	1	11	F	H	N	N	PT/OR	A	"	
10	( )	3	6	2	1	12	F	H	N	N	PT/OR	A	E	(✓)
11		3	7	3	1	14	G	H	N	N	PT/OR	D	E	
12		3	7	4	1	15	G	H	S	N	PT/OR	D	E	
13		3	7/10	4/2	1	15/16	G	H	N	N	PT/OR	D	E	
14	✓✓	3	10	2	1	16	G	H	N	N	PT/OR	D	E	✓
15		3	10/7	10/4	1	24/15	E/G	H	S	N	PT/OR	E/D	E	
16		3	10	10	1	24	E	H	S	N	PT/OR	E	E	
17	✓	3	10	2	1	16	G	H	S	N	PT/OR	D	E	✓
18		3	8	3	1	15	G	H	S	N	PT/OR	D	E	

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Table C-3 **Field assessment of levee conditions**

Levee name Chipps Island
Date
Prepared by Mike Lewis
Approved by

Levee segment #	Problem areas: Levee top	Poor access	Overgrowth of vegetation	Cracks	Slumping or low spots	Surface erosion	Seepage	Holes	Comments	In-house assessment: IN-H.	Res.-T.	Field assessment: Poor	Fair	Good	Excellent
1 (V)									gone	A	A-B	✓			
2 V									gone	A	A-B	✓			
3 V									"	A	A-B	✓			
4 V									"	A	A-B	✓			
5 V									"	A	A-B	✓			
6 V									"	A	A-B	✓			

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Table C-4 **Field assessment of levee conditions**

Levee name Chipps Island
Date
Prepared by Mike Lewis
Approved by

Levee segment #	Problem areas: Levee top	Poor access	Overgrowth of vegetation	Cracks	Slumping or low spots	Surface erosion	Seepage	Holes	Comments	In-house assessment: IN-H.	Res.-T.	Field assessment: Poor	Fair	Good	Excellent
7		✓		✓		✓	✓		recent work	A/O	A-B/E	✓			
8									↓	A	A-B/E		✓		
9									↓	A	A-B/E		✓		
10 (✓)									↓	A	E		✓		
11									↓	D	E		✓		
12									low	D	E	✓			
13										D	E		✓		
14 ✓										D	E		✓		
15			✓							E/D	E		✓		
16									low	E	E		✓		
17 ✓										D	E		✓		
18										D	E		✓		

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D—030890

Table C-5 **Assessment of levee rehabilitation needs**

Levee name Chipps Island
Date
Prepared by Norm Hantzsche
Approved by

#1-#6

Note: Exterior levee Abandoned. Owner maintains interior levee.

Levee segment #		Soil type	Earthwork to meet design standards: Reconstruction (A&B) 100%	80%	60%	Repair (C&D) 40%	20%	0	Embankment construction method: Import materials: Barge	Truck	Local materials Dredging: Clamshell	Dragline	Hydraulic	Bulldozer	Erosion protection features: Rip-rap	Filter fabric	Seeding	Other remarks	Levee classification	Unit cost ($/lin.ft.)
1	✓ A	A/Ob	✓								✓	(✓) some			✓					
2	✓ A		✓								✓				✓					
3	✓ A		✓								✓									
4	✓ A		✓								✓									
5	✓ A		✓								✓									
6	✓ A		✓								✓				✓					
7	A/O		✓	✓							✓				✓			Sandy clay soils	Dredged Spoils	
8	A			✓							✓				✓					
9	A			✓	✓						✓									
10	✓ A				✓						✓	✓								
11	O				✓	✓						✓								
12	O			✓	✓	✓						✓								
13	O				✓							✓								
14	✓ D					✓					✓									
15	E/O					✓					✓									
16	E				✓						✓									
17	✓ D			✓	✓						✓									
18	O	↓			✓						✓									

D-030891

D—030891

ACOE - NAMC Chippewa Island

Class A

TABLE C-6 Cost Calculations

#86.11 35,290 #3,038,627.60

Segment		Repair Classification: Gen'l. Type	Soil	Wind + Wave	% Constr.	Erosion Protec.		Cost Estimate: Cost $/LF	Approx Length	Est. Cost		Comments: In-House Class	Resource Team
1		A3	PT/OR	H	100	R	*	122.67	1990	243,914	3	A	A/B
2		A3	PT/OR	H	100	R	*	122.57	2580	317,456	3	A	A/B
3		A3	PT/OR	H	100	ϕ	*	105.77	1800	190,386		A	A/B
4		A3	PT/OR	H	100	ϕ	*	105.77	1200	126,924		A	A/B
5		A3	PT/OR	H	100	ϕ	*	105.77	1990	210,482	3	A	A/B
6		A3	PT/OR	H	100	R	*	122.67	1990	243,914	3	A	A/B
7		A3	PT/OR	H	90*	R	*	112.14	1990	223,158	6	A/D	A/B/E
8		A3	PT/OR	H	80	R	*	101.70	1990	202,383		A	A/B/E
9		A3	PT/OR	H	70*	R	*	74.46	1800	134,028		A	A/B/E
10		A3/4	PT/OR	H	60	ϕ	*	64.02	1800	115,236		A	E
11		C4	"	H	50	ϕ	*	71.12	2190	155,752	8	D	E
12		A4	"	H	60*	ϕ	*	64.02	1990	127,399	8	D	E
13		A4	"	H	60	ϕ	*	64.02	1600	102,432		D	E
14		C3	"	H	40	ϕ	*	57.18	2390	136,660	2	D	E
15		C3	"	H	40	ϕ	*	57.18	2790	159,532	2	E/D	E
16		A3	"	H	60	ϕ	*	64.02	1600	102,432		E	E
17		A3	"	H	70	ϕ	*	74.46	1600	119,136		D	E
18		A3	"	H	60	ϕ	*	64.02	1990	127,399	8	D	E

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