CALFED
BAY-DELTA
PROGRAM

PRELIMINARY WORKING DRAFT

CALFED BAY-DELTA PROGRAM ECOSYSTEM RESTORATION PROGRAM PLAN

IMPLEMENTATION OBJECTIVES AND TARGETS

NOVEMBER 15, 1996

D-026694

Table 2. ERPP Ecosystem Elements

A. Primary Physical Processes

1. Hydrograph
2. Hydraulic regime
3. Sediment supply
4. Geomorphology
5. Tides
6. Fire

B. Secondary Ecosystem Processes and Functions

1. Stream meander belts
2. Gravel recruitment
3. Gravel transport and cleansing
4. Estuarine mixing
5. Water temperature
6. Current velocities
7. Floodwater and sediment detention and retention
8 Vegetation succession, overbank flooding, and floodplain inundation
9. Nutrient inputs
10. Primary production
11. Secondary production
12. Nutrient cycling

C. Stressors

1. Levees, bridges, and bank protection
2. Dredging
3. Land use
4. Wildfire
5. Exotic species
6 Dams, reservoirs, and other human-made structures
7. Water management
8. Gravel mining
9. Contaminants
10. Human disturbance
11. Harvest of fish and wildlife
12. Predation and competition
13. Artificial production of fish

D. Habitats

1. Tidal perennial aquatic
2. Nontidal perennial aquatic
3. Dead-end sloughs
4. Open-ended sloughs
5. Seasonal wetland and aquatic
6. Shaded riverine aquatic
7. Saline emergent wetland
8. Fresh emergent wetland
9. Midchannel islands and shoals
10. Riparian scrub, woodland, and forest
11. Coastal scrub
12. Valley-oak woodland
13. Perennial grassland
14. Agricultural wetland
15. Agricultural upland

E. Species and Species Groups

Fishes

1. Delta smelt
2. Sacramento splittail
3. Longfin smelt
4. Green sturgeon
5. Sacramento fall-run chinook salmon
6. Sacramento winter-run chinook salmon
7. Sacramento spring-run chinook salmon
8. Sacramento late-fall-run chinook salmon
9. San Joaquin fall-run chinook salmon
10. Steelhead trout
11. Striped bass
12. White sturgeon
13. American shad
14. Largemouth bass

Fish Species Groups

15. Other native resident fishes
16. Other non-native resident fishes
17. Marine fishes

Amphibians and Reptiles

18. California red-legged frog
19. Giant garter snake
20. Western pond turtle
21. Other native amphibians and reptiles

Birds

22. Swainson's hawk
23. California clapper rail
24. California black rail
25. Greater sandhill crane
26. Western yellow-billed cuckoo
27. Suisun song sparrow

Mammals

28. Salt marsh harvest mouse
29. Riparian brush rabbit

Wildlife Habitat Guilds

30. Deepwater wildlife guild
31. Shallow-water and mudflat wildlife guild
32. Saline emergent wetland wildlife guild
33. Fresh emergent wetland wildlife guild
34. Riparian wildlife guild
35. Valley-oak woodland wildlife guild
36. Agricultural wetland wildlife guild
37. Agricultural upland wildlife guild

Wildlife Species Guilds

38. Shorebird and wading bird guild
39. Upland game guild
40. Waterfowl guild
41. Neotropical migratory bird guild

Other Groups

42. Estuarine foodweb organisms
43. Terrestrial invertebrates

Plants

44. Delta button-celery

Plant Species Associations

45. Saline emergent wetland plant association
46. Fresh emergent wetland plant association
47. Coastal scrub plant association

Table 3. Basis for Selection of Primary Physical Process Ecosystem Elements

Primary Physical Process	Basis for Selection as an Ecosystem Element
Hydrograph	Hydrograph refers to the total amount and seasonal distribution of water entering the ecosystem, including surface and groundwater, and includes episodic events such as floodflows and drought cycles. The total volume and distribution in time and location of water supports important ecological processes and functions that sustain habitats and many species of the Bay-Delta, the Sacramento and San Joaquin rivers, and their tributaries. Human activities have had a large influence on the natural hydrograph of the Bay-Delta and the Sacramento-San Joaquin basin. There are opportunities to restore or simulate, where appropriate, a more natural hydrograph that sustains ecological functions and meets the life requirements of plants and animals.
Hydraulic regime	Hydraulic regime refers to the direction and velocity of flows in the Bay-Delta channels on a temporal, tidal, and seasonal basis for a given hydrologic condition. The direction and velocity of flows and their distribution in time and location support important ecological processes and functions in the Bay-Delta that sustain the foodweb, influence the spawning, rearing, and feeding of estuarine and anadromous fish, and support migration of adult and juvenile fish. Human activities have had a large influence on the natural hydraulic regime of the Bay-Delta. There are opportunities to restore or simulate, where and when appropriate, a more natural hydraulic regime that sustains ecological functions and meets the life requirements of fish and wildlife in or dependent on the Bay-Delta.
Natural sediment supply	The natural sediment supply is composed of mineral and organic fines, sands, gravel, cobble, and woody debris that naturally enter, deposit, erode, and transport through the Sacramento-San Joaquin basin. Sediment, like water, is one of the natural building blocks of the ecosystem on which many other ecological processes, functions, habitats, and species depend. Gravel, for example, is important for maintaining spawning habitat of salmon and supports the many invertebrates on which young salmon prey. Finer sediments and fluvial processes create the conditions necessary to establish new riparian forests and wetlands. Human activities have had a large effect on natural sediment processes in the watershed. There are opportunities to restore natural sediment processes or to compensate for the loss of sediment supply from building levees, dams, and reservoirs to meet the life requirements of plants and animals.

Table 3. Continued

Primary Physical Process	Basis for Selection as an Ecosystem Element
Geomorphology	Geomorphology refers to the ecosystem's natural landscape form that serves to influence the direct effects of water, sediment, and plants on the Sacramento-San Joaquin basin. Geomorphology, like water and sediment, is a key structural component of the ecosystem. Natural barriers, channel morphometry, basin configuration, watershed and channel erosion, and other geological features determine the landscape of the ecosystem. There are opportunities to restore or manipulate geomorphology to benefit ecosystem health.
Tides	Tides are daily and seasonal water-level changes exerted by the moon's gravitational effect on the earth. Daily, monthly, and seasonal (neap and spring tides) tides exert important influences on estuarine processes in the Bay-Delta. Human activities have altered the effects of tides primarily as a result of changing geomorphology and sediment and hydrological processes. More natural tidal force can be restored through manipulations of other physical processes to change tidal effects and produce secondary effects on sediments and nutrient supply, vegetation, currents, and water levels.
Fire	Natural fire events are important determinants of watershed processes by maintaining grassland, woodland, and forest health through fuels reduction and plant succession and reproduction. By suppressing fires, modern human activities have had a large effect on the ecological role of natural fires in grasslands, woodlands, and forests. There are potential opportunities to expand the use of prescribed fires for restoring and maintaining grassland, woodland, and forest health in the upper watersheds of the Sacramento-San Joaquin basin.

Table 4. Basis for Selection of Secondary Ecosystem Process and Function Ecosystem Elements

Secondary Ecosystem Processes and Functions	Basis for Selection as an Ecosystem Element
Stream meander belts	Stream meander belts are the area in which natural bank erosion and floodplain and sediment bar accretion occur along streamcourses. Natural stream meander belts in alluvial systems function dynamically to transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish, as well as surfaces that are colonized by natural vegetation that support wildlife.
Gravel recruitment	Gravel recruitment is the process of gravel entering into the fluvial systems of the Sacramento-San Joaquin basin. Gravel deposits in streams and rivers are essential to maintain spawning and rearing habitats of salmon and steelhead and other native fishes. Gravel deposits have been greatly altered by human activities. Opportunities to maintain and restore gravel recruitment are possible through manipulation of natural processes (e.g., the natural hydrograph and sediment supply) and control or management of environmental stressors that adversely affect gravel recruitment (e.g., instream gravel mining and riprapped banks).
Gravel transport and cleansing	Gravel transport is the process whereby flows carry away finer sediments that fill gravel interstices, and gravel cleansing is the process whereby flows transport, grade, and scour gravel. Gravel transport and cleansing through flushing the majority of fines and movement of bedload is important to maintain the amount and distribution of spawning habitat in the Sacramento-San Joaquin basin. Human activities have greatly reduced or altered these processes. Opportunities for maintenance and restoration are possible by changing waterflow, sediment supplies, geomorphology of the basin, removing stressors, or directly manipulating channel features and stream vegetation.
Estuarine mixing	Estuarine mixing controls the salinity gradient, vertical and horizontal stratification of the water column, the position of entrapment and null zones, and the X2 water quality standard in the Bay-Delta estuary. The estuarine mixing process is controlled by geomorphology, tides, and freshwater inflow. Freshwater flow contributes to estuarine mixing and its associated processes, and creates freshwater and low-salinity aquatic habitat essential to many estuarine fishes. The entrapment and null zones collect nutrients and many types of organisms, and thus are essential in the foodweb of many estuarine organisms.

Secondary Ecosystem Processes and Functions	Basis for Selection as an Ecosystem Element
Water temperature	Water temperature is determined by the natural heating and cooling process of water bodies and flows in the Sacramento-San Joaquin basin. Water temperature in the Sacramento-San Joaquin basin is controlled by water source (i.e., dam releases; runoff; and agricultural, municipal, and industrial discharges); surface and groundwater flow; geomorphology; tides; riparian shading; and, most often, by air temperature. Water temperature is a key factor in habitat suitability for aquatic organisms. Unnaturally high water temperatures can become stressors to many aquatic organisms.
Current velocities	Current velocities are the speed at which water flows through the watercourses of the Sacramento-San Joaquin basin. Tidal and nontidal freshwater current velocities are important in the vertical, lateral, and longitudinal transport of materials and organisms in the Bay-Delta and rivers. Human activities that have altered channel configurations or flow rates have altered current velocities throughout the Sacramento-San Joaquin basin. Opportunities to restore more natural current velocities to channels are possible primarily through manipulation of channel cross sections, floodplain topography, and secondarily through changes in flow rates downstream of reservoirs.
Floodwater and sediment detention and retention	Floodwater and sediment detention and retention is the process whereby flows and sediment are retained within floodplains of the Sacramento-San Joaquin basin. Retention and detention of water and sediment within basin floodplains are a secondary process controlled primarily by flow patterns and channel geomorphology, and secondarily by soils and plant communities. Floodwater storage and retention reduces flood effects, soil erosion, peat oxidation, and nutrient loss. The process stores water and sediment either permanently or temporarily, reducing the peak loads of both downstream systems.

Secondary Ecosystem Processes and Functions	Basis for Selection as an Ecosystem Element
Vegetation succession, overbank flooding, and floodplain inundation	Vegetation succession, overbank flooding, and floodplain inundation refers to seasonal flooding of floodplain habitats and the response of vegetation to the flood cycles. Overbank flooding is a secondary process to water and sediment flow through the Sacramento-San Joaquin basin in combination with geomorphology. Flooding of lands provides important seasonal habitat for fish and wildlife and provides sediment and nutrients to both the flooded lands and aquatic habitats that receive the returning or abating floodwaters. The flooding also shapes the plant and animal communities in the riparian, wetland, and uplands habitat subject to flooding. Opportunities to restore or enhance this process are possible by changing landscape features, geomorphology, and seasonal distribution of flow volume through the system.
Nutrient inputs	Nutrient inputs refer to the creation of, input to, flow through, and storage within the Sacramento-San Joaquin basin of carbon, nitrogen, phosphorous, and other inorganic elements, as well as organic compounds, in the Bay-Delta ecosystem. Nutrients important to plant and animal communities in the basin are derived through many of the primary and secondary processes influencing the Bay-Delta ecosystem. Human activities have greatly altered the input, residence time, and flow of nutrients into the ecosystem.
Primary production	Primary production refers to the energy produced by algae and other plants through photosynthesis. Primary production of plants in the Sacramento-San Joaquin basin is the basic process that supports the biological system. Nearly all primary and secondary processes have some effect on primary production in the basin. Human activities have altered production in many ways and opportunities to enhance this process exist by manipulating waterflow, nutrients, and geomorphology, and alleviating environmental stressors such as the introduction of salts, herbicides, and other toxins in watercourses.
Secondary production	Secondary production refers to the production of energy not directly related to photosynthesis. Secondary production in the Sacramento-San Joaquin basin occurs primarily through the breakdown of plant materials by microorganisms, such as bacteria, fungi, protozoans, and zooplankton, and large-animal grazing. Organic carbon forms, including the microorganisms and the byproducts of their work, are the base of the aquatic foodweb of the Bay-Delta ecosystem.

Table 4. Continued

Secondary Ecosystem Processes and Functions	Basis for Selection as an Ecosystem Element
Nutrient cycling	Nutrient cycling is the process of basic nutrients, such as nitrogen, phosphorous, and carbon, moving through the ecosystem and being repeatedly used and made available through physical, chemical, and biological processes. Many of the physical, chemical, and biological processes operating in the Sacramento-San Joaquin basin affect the cycling of nutrients through the ecosystem temporally and spatially. The reuse or recycling of nutrients is important to overall primary and secondary productivity of the Bay-Delta ecosystem.

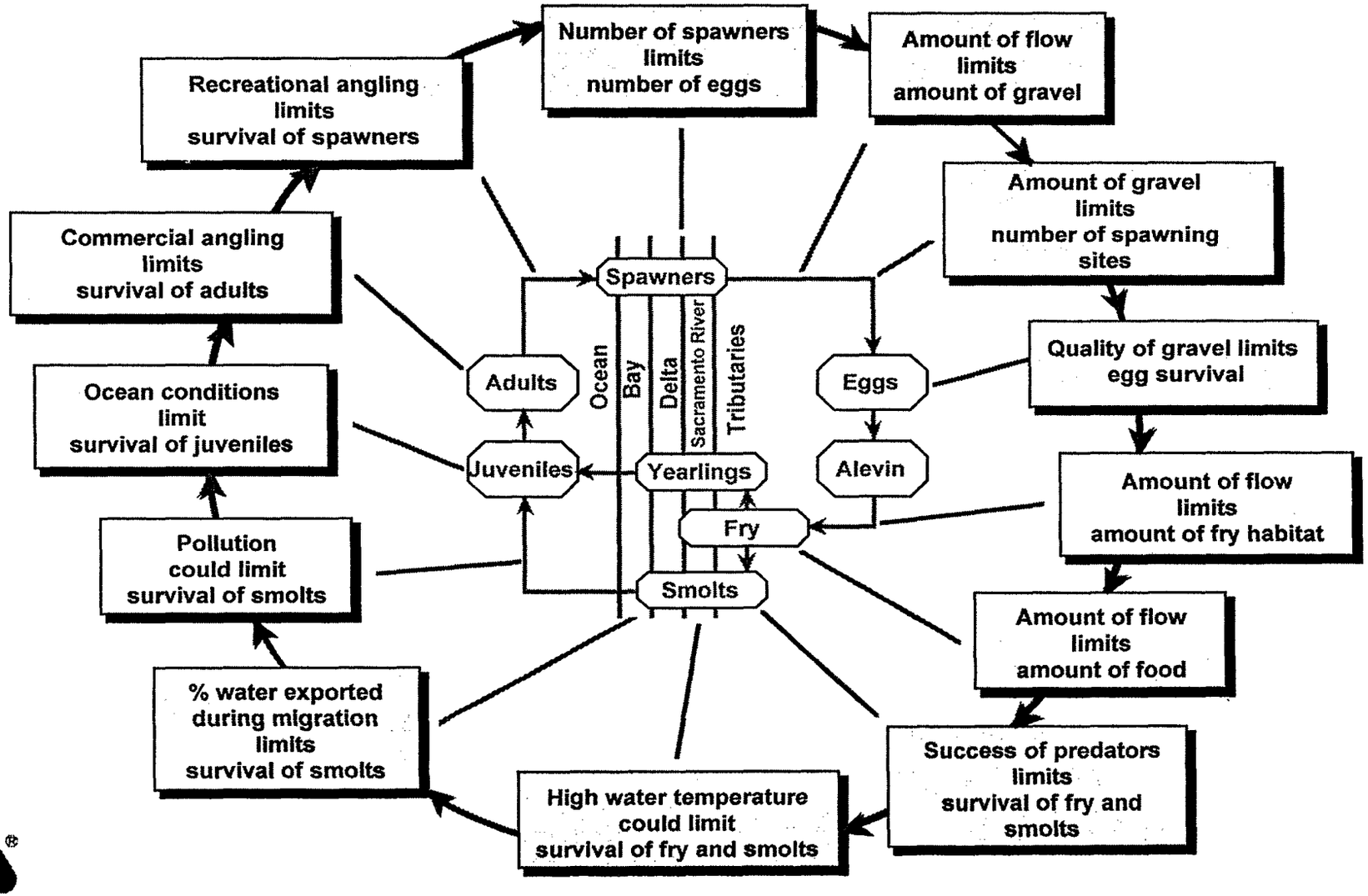
Table 5. Basis for Selection of Stressor Ecosystem Elements

Stressor	Basis for Selection as an Ecosystem Element
Levees, bridges, and bank protection	Levees, bridges, and bank-protection structures inhibit overland flow and erosion and depositional processes that develop and maintain floodplains, and allow stream channels to meander. Levees prevent floodflows from entering historic floodplains behind levees, stopping evolution of floodplain geomorphology, and eliminate or alter the character of floodplain habitats dependent on overbank flows. Confinement of floodflows to channels by levees and bank protection structures also increases the fluvial energy of flows that scour or incise channel beds and reduces or halts the rate of channel meander and oxbow formation. Bridges have a similar, though generally more localized effect, on channel morphology and sediment transport.
Dredging	Dredging in Bay-Delta waters may damage aquatic habitat, increase turbidity and sediment suspension above ambient levels, release toxic-laden sediments into the water column, or harm aquatic animals and plants. Channel dredging also contributes to levee instability by deepening channels, and steepens channelbanks causing progressive erosion of shoreline habitats.
Land use	Land use in the Bay-Delta watershed may stress ecosystem processes, functions, habitats, and aquatic and terrestrial organisms. Land use activities that may be harmful include urban and industrial development, land reclamation, water conveyance infrastructure, livestock grazing, and agricultural practices.
Wildfire	Wildfires caused from unnaturally high fuel levels in tributary watersheds of the Bay-Delta threaten water supply and fish and wildlife habitat through deforestation and resulting high levels of erosion and increased rates of surface runoff.
Non-native species	Introductions of non-native plants, wildlife, fish, and clams and other aquatic invertebrates have greatly altered ecosystem processes, functions, habitats, species diversity, and abundance of native plants, fish, and wildlife. The number of introduced non-native species in the ERPP focus area continues to increase.
Dams, reservoirs, and other human-made structures	Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Other human-made structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern.

Table 5. Continued

Stressor	Basis for Selection as an Ecosystem Element
Water management	Diversion, storage, and release of water in Bay-Delta watershed directly affects fish, aquatic organisms, and nutrient levels in the system, and indirectly affects habitat, foodweb production, and species abundance and distribution. Diversions cause consumptive loss of water, nutrients, sediment, and organisms (entrainment). Seasonal and daily patterns of water released from storage may affect habitat, water quality, and aquatic organism survival (e.g., stranding). Flood control releases into bypasses also cause stranding of adult and juvenile fish. The transfer of water across the Delta through existing channels may also steer upstream migrating adult salmon and downstream migrating juvenile salmon from their primary migration routes. The rate of diversion from the Delta also contributes to reduced residence time of water, reducing primary and secondary production and standing biomass.
Gravel mining	Mining gravels from rivers and floodplains may affect gravel recruitment, fish and wildlife habitat, abundance of aquatic predators, water quality (primarily water temperature), and fish and wildlife populations. Instream mining removes riparian and marsh vegetation, alters channel sediment transport, and causes channel widening and incisions. Excessive instability of the riparian corridor could result.
Contaminants	Contaminants from point and nonpoint sources affect water quality and survival of fish, waterfowl, and the aquatic foodweb. Contaminant sources may cause severe toxicity and organism mortality or chronic low-level toxicity that affects species' health and reproduction.
Human disturbance	Human activities, including boating, habitat disturbance, and other activities, may affect wildlife habitat and species abundance and distributions.
Harvest of fish and wildlife	Legal and illegal harvest of fish and wildlife may affect abundance of species or viability of local populations.
Predation and competition	Unnatural levels of predation and competition may adversely affect populations of fish and wildlife.
Artificial production of fish	Fish hatcheries and other artificial rearing programs (e.g., pen-rearing salvaged striped bass) may adversely affect populations of "wild" fish. Direct effects might be predation on wild fish or competition from artificially reared fish. Indirect effects may occur from adverse changes in wild population genetics from interbreeding with hatchery fish. Disease may also be transferred from hatchery fish to wild fish.

Simulation Model for a Salmon Population



To: Sacramento River and Tributaries Technical Team Participants.
From: Cindy Darling, Kate Hansel, and Scott Wilcox

The following matrix has been prepared to assist in identification and prioritization of stressors in the Sacramento River system. Within each stressor group, please insert your ideas of individual stressors within the Sacramento River system, and check off the habitats and species or runs to which you feel they apply. Examples of stressors listed by the San Joaquin Technical Team are provided in parentheses as a reference.

	Habitats		Species/Run					
ERPP Stressor Group (Individual stressor examples from the San Joaquin system)	Seasonal wetland and aquatic (floodplain)	Shaded riverine aquatic	Winter Run Chinook	Spring Run Chinook	Steelhead	Green sturgeon	Sacramento splittail	Striped bass
Levees, bridges, and bank protection (Riparian vegetation loss)								
Dredging								
(Lack of shallow water rearing habitat)								
Land use								
(Lack of floodplain)								
Wildfire								
Exotic species								
(Smallmouth bass)								
Dams, reservoirs, and other human made structures (Barriers to migration)								
(Migration delays)								
(Entrainment)								

ERPP Stressor Group (Individual stressor examples from the San Joaquin system)	Habitats		Species/Run					
	Seasonal wetland and aquatic (floodplain)	Shaded riverine aquatic	Winter Run Chinook	Spring Run Chinook	Steelhead	Green sturgeon	Sacramento splittail	Striped bass
Water management								
(Inadequate instream flows: for attracting adults, flushing flows for bed maintenance)								
(Water temperature)								
Gravel mining								
(Sedimentation of spawning reach)								
(Gravel deficit)								
Contaminants								
(Water quality/pollutants)								
Human disturbance								
(Large woody debris losses)								
Fish and wildlife harvest								
(Harvest: Ocean and freshwater)								
Predation and competition								
(Predation: introduced species and others)								
Artificial production of fish								
(Hatchery management: genetics)								
Other								
(Diseases)								
(Lack of food supply)								

Conceptual Program or Project Description

For Sacramento River and Tributaries Technical Meeting

Title:

Location:

Problem Addressed:

Benefits:

Conceptual Program/Project Description:

Estimated Costs: (if available)

Current Status of Implementation:

D-026708