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SUBJECT TO REVISION

Environmental Impacts Associated with Construction and Operation of Evaporation Ponds to Control Salinity of the Salton Sea

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Introduction

The Bureau of Reclamation is evaluating the feasibility of constructing two evaporation ponds having a total surface area of 34.3 square miles at the southwest shore of the Salton Sea. The total capacity of the pond complex would be 245,226 acre feet. Water would be pumped from the Salton Sea into the ponds where it would evaporate, concentrating the salts. Inflow to the Sea is less saline and would replace water pumped to the ponds creating a net loss of salt from the Sea. Earlier variations of this alternative appeared in Bureau of Reclamation (1997, 1998) and involved construction of in-lake dikes isolating areas ranging from 30 to 127 square miles. Due to seismic activity in the area, dikes required to partition large sections of the Sea would have to be built using coffer dams that would need a seismic stability of Richter 5?? Dikes for shallow and smaller ponds could be constructed without coffer dams.

Description of the ponds

A south pond with an approximate area of 20? square miles would be constructed north of the inflow of the New River to a point immediately south of San Felipe Creek. A west pond with an area of 15 square miles would be constructed about 3 miles north of San Felipe Creek to Salton City (figure 1). The mouth of San Felipe Creek would not be obstructed to allow Desert pupfish access to the backwater areas. Earthen dikes for both ponds would be constructed along the –250 foot contour of the Sea. Operating elevation of the ponds would be –227 foot, and maximum water depth at the dike would be about 23 feet. The pond bottom would slope shoreward and water depth would be only several inches at the shoreward extreme. The ponds would be unlined.

Construction of the dikes

Organic-rich sediment covers about 750 acres of the Sea bottom where the dike footing would be placed. The material is not structurally stable and would be removed to a depth of 5 feet using a suction dredge. Approximately 7 million cubic yards of sediment would be removed. The material would be returned to the Sea between parallel silt curtains suspended by floats from the water surface. The silt curtain would allow water to pass but would contain the solids in a path of unknown width on the Sea bottom. The base area for the dike would be compacted and fill added to bring the dike top elevation to –220 feet. The outer (seaward) bank of the dike would be armored with stone riprap. The top surface of the dike (30 feet wide) would be graded to create a road for access and maintenance. The base of the dike would be 300 feet wide with a finished side slope of 3.5:1. Dikes would be constructed from the shore outward, so coffer dams would not be required.

An estimated 21 million cubic yards of fill and 440,000 cubic yards of riprap would be obtained from an area located west of Salton Sea Beach within the Torres-Martinez Indian Reservation. The Tribe owns mineral rights in the area and is desirous of selling the material. A haul road would be constructed to facilitate movement to the construction site. Due to the massive amounts of fill and riprap required, construction of the ponds would require about 4 years.

Operation of the Ponds

Spreadsheets simulating pond operation prepared by Paul Weghorst (Bureau of Reclamation, Denver) assume reduction of current inflows to the Salton Sea to 1.06 million acre feet annually and increases in salinity of the Sea to 50,000 ppm by the time the ponds are ready for operation (table 1). Under these conditions, the ponds would initially contain 16,671,500 tons of salt. Between 97,150 and 115,700 acre feet of water would be pumped annually from the Sea into the ponds to replace water lost through evaporation. Annual salt removal by the ponds would be about 6.9 to 8.0 million tons. Annual inflow of salt to the Salton Sea would be about 4.03 million tons. The concentration of salt in the ponds would reach 200,000 ppm within 7 years and would stabilize at that value (fig. 2). Salinity of the Salton Sea would remain below 51,000 ppm for about 5 years and would then slowly increase. After an arbitrary period of 30 years, chosen as a likely period of stability to earthquakes, pumping would discontinue and the ponds would be allowed to dry. The dikes would be reinforced and the ponds abandoned. Current plans do no call for capping to isolate the salt block in the ponds.

Potential Environmental Impacts

Impacts identified during a workshop held at San Diego State University on June 17 are identified as bullet items below. A list of participants appears at the end of this document.

Borrow pit and haul road

- Presence of sensitive or T and E species in area

Development of a borrow area to provide 21 million cubic yards of fill would require literature search for the presence of sensitive species and threatened or endangered species in the area. This has been done by Tetra Tech using a computerized database maintained by the California Department of Game and Fish. If threatened or endangered species were present, Section 7 consultation with the US Fish and Wildlife Service may be required in the planning stage.

- Presence of cultural resources in the area

A survey should be done of cultural resources that may be located in the area of the borrow pit and haul road. Since the potential site for the pit is located on land owned by the Torres-Martinez Tribe, this may have already been done. Tetra Tech indicated they would pursue this information.

- <u>Presence of wetlands or permanent streams</u>

  The presence of any wetlands or permanent streams in the area should be determined and mitigation may be required if damage done to these resources. A potential problem of pit construction is inflow of surface water or ground water that may inhibit removal of material and could attract waterbirdsl to the pit site.

- <u>Use of 100 yd^3 trucks on private road vs conventional trucks on highway</u>

  Use of special 100 yd^3 trucks would require 273,000 truck trips to move the 21 million yd^3 of fill (This assumes 30% more material required to all for compaction when placed). Movement of the 440,000 yds^3 of riprap would require 4,400 truck trips. Assuming a three year active hauling period, about 250 truck trips per day would be required. As trucks of this capacity are not permitted on public highways, a separate haul road would be required for the 3 year period of movement of material. Use of conventional (10 yd^3) trucks would require 10 times as many truck trips.

- <u>Presence of contaminants in borrow fill material used for dikes</u>

  The tribal land under consideration as a source of dike fill and riprap has been surveyed for geologic potential, particularly for precious metal production (Toby Mancuso, Mancuso Resource Development Services, oral commun. June 1999). While there may be gold present in part of the deposit, the fill material and riprap could be removed without affecting the metal deposits. The riprap would be removed from a Jurassic deposit of quartz monzonite. Most of the fill material is derived from weathering of the monzonite and is of recent origin (Quaternary). Concentrations of leachable trace metals and metaloids such as selenium are expected to be quite small. Detailed geochemistry of the ore deposit is believed available from the Bureau of Indian Affairs in Denver.

- <u>Compaction of haul road and need for restoration</u>

  This is being addressed by Tetra Tech.

Construction Impacts- Pond construction

- <u>Return of 7 million yds^3 of dredged sediment to the Salton Sea- turbidity, nutrient or trace element release, blanket of fish habitat, dissolved oxygen demand or hydrogen sulfide release</u>

  The most comprehensive inventory of the quality of bottom sediment in the Salton Sea was done by Levine-Fricke Recon (LFR) in 1999. Surficial sediment samples taken with a box corer were collected from several sites within the proposed area of the evaporation ponds: sites 37-40 and 43-46. Three cores (8 to 10 feet depth) were taken southwest of the New River delta. Concentrations of trace elements in these samples did not exceed the lower effect range given in Long et al. (1995) except for selenium at one site. The sample from site 45, several miles east of the San Felipe alluvial area contained a selenium concentration of 0.9 mg/kg, 0.2 mg/kg greater than the lowest effect level given in Long et al. (1995). Elevated levels of avian teratogenesis have been associated with sediment selenium concentrations as low as 0.9 mg/kg in ponds near Tulare, California (Skorupa, 1998).

As the sediment may be aerated during dredging, there is some potential that reduced forms of selenium such as selenides may be oxidized and could become mobile in water when sediment is released back to the Salton Sea. Concentrations of all other trace elements in bottom sediment analyzed by LFR did not appear to be problematic if the material were redeposited in the Sea.

The high organic material content of the sediment and its reduced state, as evidenced by hydrogen sulfide odor, indicate there will be considerable oxygen demand as the material is released back to the Sea. This will cause localized oxygen depletion with potentially adverse effects on biota. The amount of hydrogen sulfide released from the sediment is not known, but it may cause localized odor problems and can be toxic to biota.

- 750 acres of sea bottom + 140 acres shoreline disrupted- effects on habitat or wetlands

Polychaetes (*Neanthes succinea*) are the principle food item for many fish and shorebirds in the Salton Sea and densities average 1,000 individuals/m^2 throughout much of the Sea (Dexter et al.,1999). Walker et al. (1961) estimated the spring standing crop of Neanthes at 300 pounds/acre. Replacement of soft bottom material with dike fill could result in loss of about 3 billion polychaetes in the footprint of the dikes. It is not known if polycheates would colonize the seaward side of the dike surface as it would be covered with riprap. An additional 34.3 square miles of Sea bottom converted to hypersaline pond would also be devoid of polychaetes. This would constitute a loss of about 8.8×10^{10} polychaetes.

- Vehicle traffic and dust generation- effects on humans

This will be addressed by Tetra Tech as it is common to all constructed alternatives.

- Desert pupfish in San Felipe Creek and local drains

Pupfish use of 45.5% and 72% of Imperial Valley drains has been documented in two studies (Remington and Hess, 1993; Lau and Boehm, 1991, both cited in Hurlbert, 1997). Pupfish have been trapped by personnel of the California Department of Fish and Game in 16 irrigation drains and 4 shoreline pools in the planned location for the evaporation ponds (Glenn Black, written commun., July 6, 1999). Pupfish are believed to live in San Felipe Creek where high flows periodically move them to the Salton Sea and they return to the creek when flows subside (Black, 1980; Lau and boehm, 1991). Investigative studies of Desert pupfish are currently underway by Ron Sutton of the Bureau of Reclamation.

- Bird use of existing area, specifically near mouth of San Felipe Cr. and New River

Studies underway by Point Reyes Bird Observatory (1999), indicate the majority of nesting colonies of birds are concentrated near the river deltas such as the New and Alamo Rivers at the southern end of the sea. The only systematic study of black rail distribution (a bird listed by California as Threatened) reported 13 of the 23 birds were observed at the mouth of the New River (Point Reyes Bird Observatory,1999).

Tetra Tech is pursuing acquisition of additional information from the Redlands database and directly from Point Reyes Bird Observatory.

- <u>Noise and activity effects on bird populations using the area</u>
  Construction of a haul road and activities associated with pond construction will generate noise and human presence. These activities may result in loss of habitat, habitat fragmentation, and isolation of some biota. Several studies indicate that species richness and density of individual species decrease with increasing proximity to roads and construction (Van der Zande, 1980; Reijnen and Foppen, 1994). Noise appears to be a major factor in reduced populations of birds near roads. Van der Zande et al. (1980) reported that species density losses for some species of up to 56% were found within a 1.24 mile disturbance zone adjacent to major highways and up to 34% for lightly traveled dirt roads.

Birds and other animals utilizing areas that may be disturbed may voluntarily relocate to nearby areas of suitable habitat such as the Alamo River during the construction phase. If this occurs it could result in competition for nesting sites and short term reduction in available habitat.

Pond Operation

- <u>Effectiveness of fish screen on inflow</u> –
  The issue of entrainment of small fish and fish larvae is being addressed by Tetra Tech as water intakes are part of several alternatives under consideration.

- <u>Seismic stability during operation and after closure</u>
  This issue is being addressed by Tetra Tech as seismic concerns are part of several alternatives under consideration.

- <u>Loss of waterbird and fish habitat along shoreline and at river/stream deltas</u>-

Fresh water and brackish water areas of the New and Alamo Rivers are classified as two of the most important fish habitats of the Salton Sea especially for larval stages of orangemouth corvina and sargo (Costa-Pierce, 1999) and the mouth of the New River is part of Unit 1 of the Sonny Bono National Wildlife Refuge. The Trifolium 2 drain enters the Sea immediately west of the mouth of the New River and 62 species of birds including several sensitive-status species have been documented using this water source (Hurlbert, 1997). Burrowing owls were quite numerous (83 counted) along the banks of this drain and the drain ranked in the top three for bird use of all drains surveyed (Hurlbert, 1997).

- <u>Pond salinity will reach 200,000 ppm having adverse effects on feeding and nesting waterbirds</u>
  This may be addressed by posing several questions:
  <u>(1)Are waterbirds attracted to hypersaline ponds if less saline water is available?</u>

Investigations of bird use of evaporation ponds in the San Joaquin Valley have shown considerable attraction to the ponds for feeding, roosting, cover or escape from predators. Personal communications from the San Francisco Bay National Wildlife Refuge (Bradford et al., 1989) indicated the highest diversity of food items was found in ponds with salinities close to that of sea water. At salinities greater than 200,000 ppm, productivity decreased and brine shrimp levels declined. However, these extremely saline ponds were still used by birds for roosting, especially during high tide when feeding areas were inundated.

Use of even highly concentrated saline ponds in Hawaii was reported in a study of bird use at increasing salinities. Black necked stilts and phalaropes were found in ponds having salinities up to 240,000 ppm. Generally, the only sites that birds did not use were crystallization ponds (>300,000 ppm) and bittern ponds (concentrated magnesium and potassium salts after removal of sodium chloride) (Harvey, 1989). The western snowy plover also has been reported to be attracted to evaporation ponds in the San Joaquin Valley (Ivy, 1984). As the Salton Sea supports the largest population of wintering snowy plovers in western North America (Shuford et al., 1995 as cited in Point Reyes Bird Observatory, 1999), it is reasonable to expect seasonally large numbers of these birds near the evaporation ponds.

(2) What dietary items may be present in evaporation ponds?

Feeding activities of water birds in saline ponds in prairie wetlands was found to vary with the succession of organisms as salinity increased. Breeding dabbling ducks were observed to concentrate and feed in saline lakes of high salt content. Blue-winged teal shifted from a diet dominated by amphipods, gastropods, and insects on lakes where specific conductance averaged 1,234 μS (about 950 ppm) to a diet dominated by Anostraca crustaceans (primarily Brachinecta and Artemia) on lakes averaging 32,583 μS (about 24,500 ppm) (Swanson et al., 1988).

Organisms potentially useable for food by water birds undergo succession of species as the salinity increases and some species will be more attractive than others as food items (see fig. 2). At a Salton Sea salinity of about 46 g/L several species of zooplankton reported by Carpelan (in Walker,1961-salinity of 34 g/L) still are present (Dexter et al., 1999) and would likely survive the initial evaporation stages in ponds. The rotifer, *Brachionus plicatilis* is reported to be tolerant of salinities up to 90,000 ppm (Hammer, 1986), and was dominant zooplankter in the Sea in summer of 1997. Winter populations of rotifers may be dominated by *Synchaeta* sp. The copepod, *Apocyclops dengizicus* is present primarily during summer and it and a harpacticoid copepod (*Cletocamptus deitersi*) may be predaceous on rotifers and artemia nauplii (Dexter, 1993). It is unlikely that the polychaete, *Neanthes succinea*, currently the major invertebrate utilized by birds in the Salton Sea, would be present in the evaporation ponds as reproduction is inhibited at salinities exceeding 50,000 ppm (Kuhl and Oglesby, 1979).

Brine shrimp (*Artemia franciscana*, the species that occurs in Salton Sea) are present in saline water from about 30,000 ppm to near saturation (Hammer, 1986). However, shrimp cysts lose buoyancy and populations decline at salinities less than about 60,000 ppm in Great Salt Lake (Stephens, 1990 and 1998) and Conte et al. (1972, 1973) found nauplii did poorly at salinities greater than 175 g/L. Artemia have been reported as dominant food items in prairie ponds where the specific conductance was 35,000 μS (salinity about 26,000 ppm) (Swanson et al., 1988). They are capable of adapting to water in which sodium sulfate is precipitating as long as sodium chloride is the dominant salt (Croghan, 1958). However, artemia are not tolerant of high concentrations of potassium salts (Hammer and Parker, 1984) and toxicity is dependent on molar ratios of sodium to potassium being less than about 12 (Bowen and Carl, 1992). Microcosm experiments using Salton Sea water done at San Diego State University (Dexter et al., 1999) showed that at a salinity of 65 g/L, artemia were present at high densities and were accompanied by brinefly larvae (*Ephydra riparia*) and some surface-dwelling insects (*Trichocorixa reticulata*). Some of the ephydra are very tolerant of high salinity. Ephydra occur and reproduce in the north arm of Great Salt Lake at a salinity of 330,000 g/L but numbers are fewer than in the less saline south arm of the lake (Post, 1977). Hammer (1986) believed Ephydra were important in lakes where the salinity was greater than 100,000 ppm. Water birds are known to feed heavily on artemia and ephydra in Great Salt Lake (commun. D. Paul, Utah Div. of Wildlife Resources). Artemia also are a highly preferred food for eared grebes in saline environments (Jehl, 1988).

(3) What are the effects of salinity on water birds feeding in evaporation ponds?

Birds contain a supraorbital salt gland that actively removes salt obtained through diet or drinking water (Schmidt-Nielsen and Kim, 1964). Ducklings do not have functional salt glands until they are 6 days old and must have ready access to fresh water in order to survive (Swanson et al., 1988). Mitcham and Wobeser (1988) found that mallard ducklings given water with a specific conductivity of 35,000 µS died within 60 hours. Assuming salinity for water high in sodium sulfate is 75% of the value for conductivity (Hem, 1985) this would be equivalent to a salinity of 26,250 ppm. Clearly, ducklings raised on Salton Sea need access to fresh water during their development.

Salt encrustation of the feathers may prevent birds from flying from ponds when water is nearing saturation with respect to salt (primarily this is sodium chloride or sodium sulfate). Accompanying the encrustation is sodium toxicity as birds attempt to groom their feathers. Mortality due to salt encrustation on waterbirds has been reported at specific conductances of 77,000 to 90,000 (salinities of 58,000 to 68,000 ppm) in a small sodium-sulfate lake in Canada (Wobeser and Howard, 1987). Sodium toxicity to waterbirds has been associated with ingestion of water containing 17,000 mg/L of sodium in North Dakota (Windingstad et al., 1987) and in playa lakes containing total solids concentrations of 200,000-300,000 ppm in New Mexico (Meteyer et al., 1997).

- Variable salinity and ionic composition in the ponds depending on stage of evaporation.

The amount and types of salts in solution and precipitation depends on composition of salts in the water, average pond temperature, daytime and nighttime pond temperatures, evaporation rate, and depth of pond (Butts, 1980).

Mineral composition of water from Great Salt Lake at various stages of evaporation

% of Water Evap.	Salt Precipitate	Composition
75	Halite	NaCl
70	Mirabilite	Na^2SO^4-10 $H^2$0
>65	Epsomite	$MgSO^4$-7 H2O
80	Schoenite	K^2SO^4-$MgSO^4$-6 H^2O
83	Hexahydrite	$MgSO^4$-6 H^2O
87	Kainite	KCl-$MgSO^4$-2.75 H^2O
90	Carnallite	KCl-$MgCl^2$-6 H^2O

Invertebrates such as artemia that are intolerant of high potassium concentrations, particularly in low sodium waters tend to disappear as halite begins precipitating and the ratio of sodium to potassium declines.

- Use of dikes for bird nesting

Colonial nesting birds such as gulls, terns, and skimmers utilize a variety of island-like (surrounded by water) features: earthen levee remnants, low-lying boulder and barnacle bars, and clumps of vegetation. Similarly, cormorants and pelicans may nest on rocky ledges (Point Reyes Bird Observatory, 1999). The long dikes surrounding the evaporation ponds may appear to be islands and may draw nesting birds; and the exposed riprap may attract pelicans. As the dikes have land access and may have human usage, nesting areas on the dikes would place birds at risk if access were not controlled. Management of the dikes for bird production should be considered as an enhancement of their construction. Increased access to fresh water may be needed to mitigate the high salinity in water and food from the ponds.

- Evaporative concentration of trace elements in the ponds.

There could be a 6 or 7 fold concentration of dissolved elements present in Salton Sea water as it evaporates in the ponds. Dissolved elements and compounds present in the dissolved phase in biologically acceptable concentrations could increase to the concentration at which they may represent a health risk to wildlife. While some elements may complex with the salts and not be readily available, others may remain in solution and be potentially toxic to organisms using the ponds, and some metals may precipitate. Stiller and Sigg (1990) found that when the salinity of the Dead Sea reached 340 g/L, precipitation of halite occurred which co-precipitated many heavy metals from the water. Most of the cadmium, much of the lead, and varying amounts of zinc and copper were removed primarily as salts of chloride.

- Desert pupfish access and mobility near San Felipe Cr.

Little is known about the movements of pupfish in San Felipe Creek. An unobstructed access to the creek from the sea likely would be required, as the fish prefer shallow backwaters areas where predators are fewer. They are reportedly quite tolerant of salinities as high as twice that of sea water (70,000 ppm) (Walker et al., 1961, p.80) and could possibly live and spawn in early stage evaporation ponds. They are tolerant of temperature extremes that might occur in shallow evaporation ponds.

- Circulation changes in delta of New River

This will be addressed by Tetra Tech as part of the modeling effort using the Orlob model for circulation patterns in the Salton Sea.

- Location of pump intakes

This will be addressed by Tetra Tech as part of the design of the fish screens.

- Stability of dikes and ability to pump water if sea elevation drops below –227

This will be addressed by Tetra Tech.

- Abandonment of ponds with no cap: creation of hypersaline habitat during wet weather

  Heavy rainfall on the uncovered surface of the salt block could solubilize the salt and create a hypersaline pond that may attract water birds and wildlife.
- Creation of deeper water habitat at toe of dikes and barnacle colonization of riprap.

The seaward extent of the dikes will create water with a depth of about 23 feet, covering much of the riprap facing. Barnacles (*Balanus amphitrite*) in the Sea form dense colonies on rock substrates reaching densities of 33,000 organisms per m^2 (D. Dexter, personal commun. June 1999). While the barnacles avoid mud and clay substrate, they appear to be substrate limited in the Sea and will quickly colonize most other substrates. The appearance of large numbers of barnacles may provide cypris stage larvae utilized as food by croaker (*Bairdiella icistius*) (J.C. Quast in Walker, 1961). Walker (1961) indicted only the mudsucker consumed adult barnacles, however.

Positive Environmental Impacts of Evaporation Pond Construction

- Reduction or stabilization of salinity in Salton Sea

  Annual removal of 6.9 to 8 million tons of salt for each of the first five years stabilizes Salton salinity below 51 ppm, and would continue to remove salt for its 30 year useful life span. This would allow the established ecosystem in the Salton to continue functioning but not at the target salinity of 37.5 ppm.

- Creation of hypersaline environments in the ponds could promote high primary productivity of the phytoplankton accompanied by high secondary production of invertebrates such as brine flies and brine shrimp. These organism serve as protein sources for many waterbirds.

- The riprap dikes, if managed correctly, could provide additional habitat for nesting waterbirds, and recreational access for fishing.

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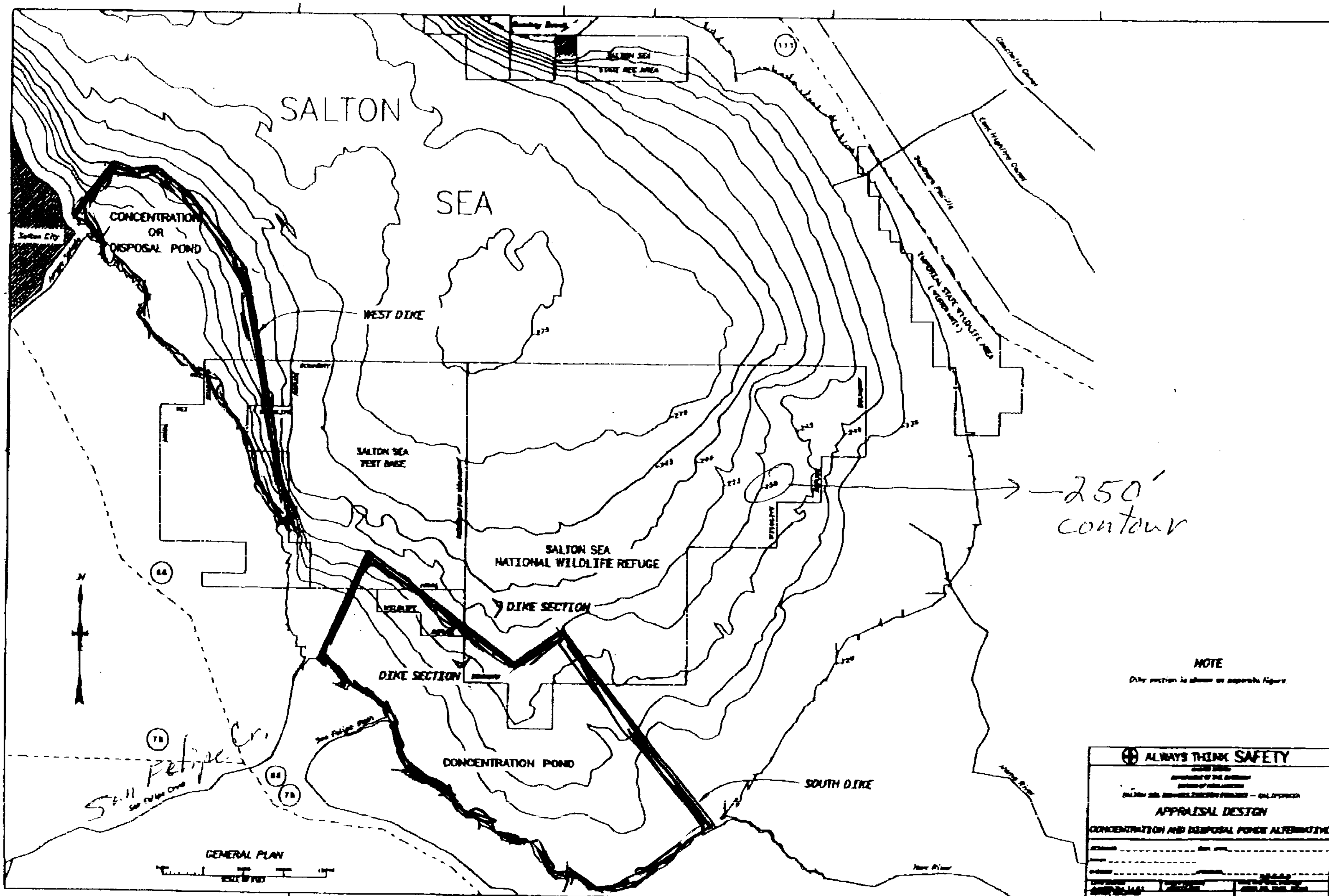
SALTON
SEA
CONCENTRATION
OR
DISPOSAL POND
WEST DIKE
SALTON SEA
TEST BASE
SALTON SEA
NATIONAL WILDLIFE REFUGE
DIKE SECTION
DIKE SECTION
CONCENTRATION POND
SOUTH DIKE
250'
contour
Salton City
SALTON SEA
STATE REC AREA
Southern Pacific
East Highline Canal
Coachella Canal
IMPERIAL STATE WILDLIFE AREA
New River
GENERAL PLAN
NOTE
ALWAYS THINK SAFETY
APPRAISAL DESIGN
CONCENTRATION AND DISPOSAL PONDS ALTERNATIVE
San Felipe Cr.
San Felipe Creek
N

Figure 1

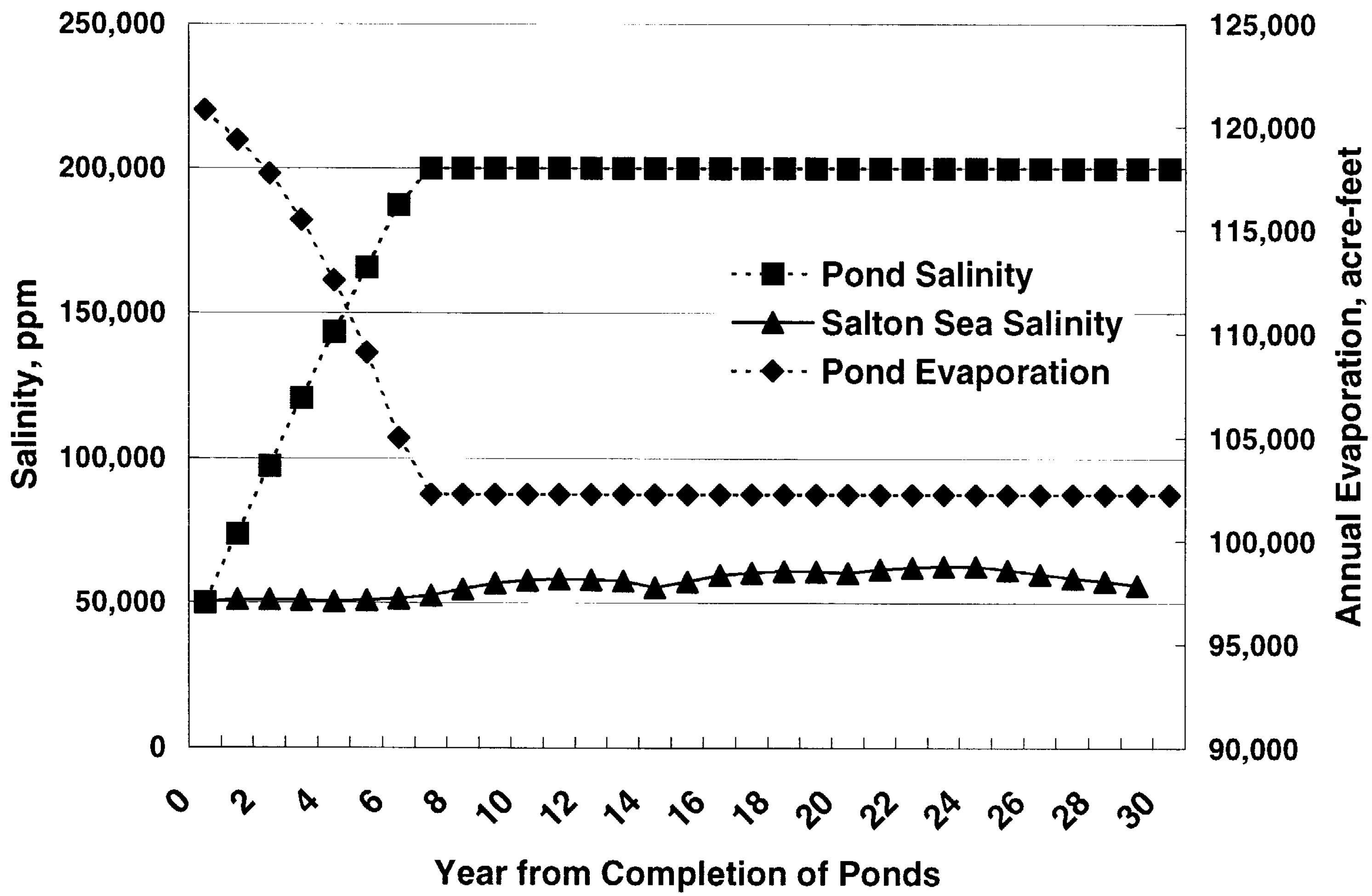

Figure 2.- Salinity of evaporation pond water and inflow water from the Salton Sea.

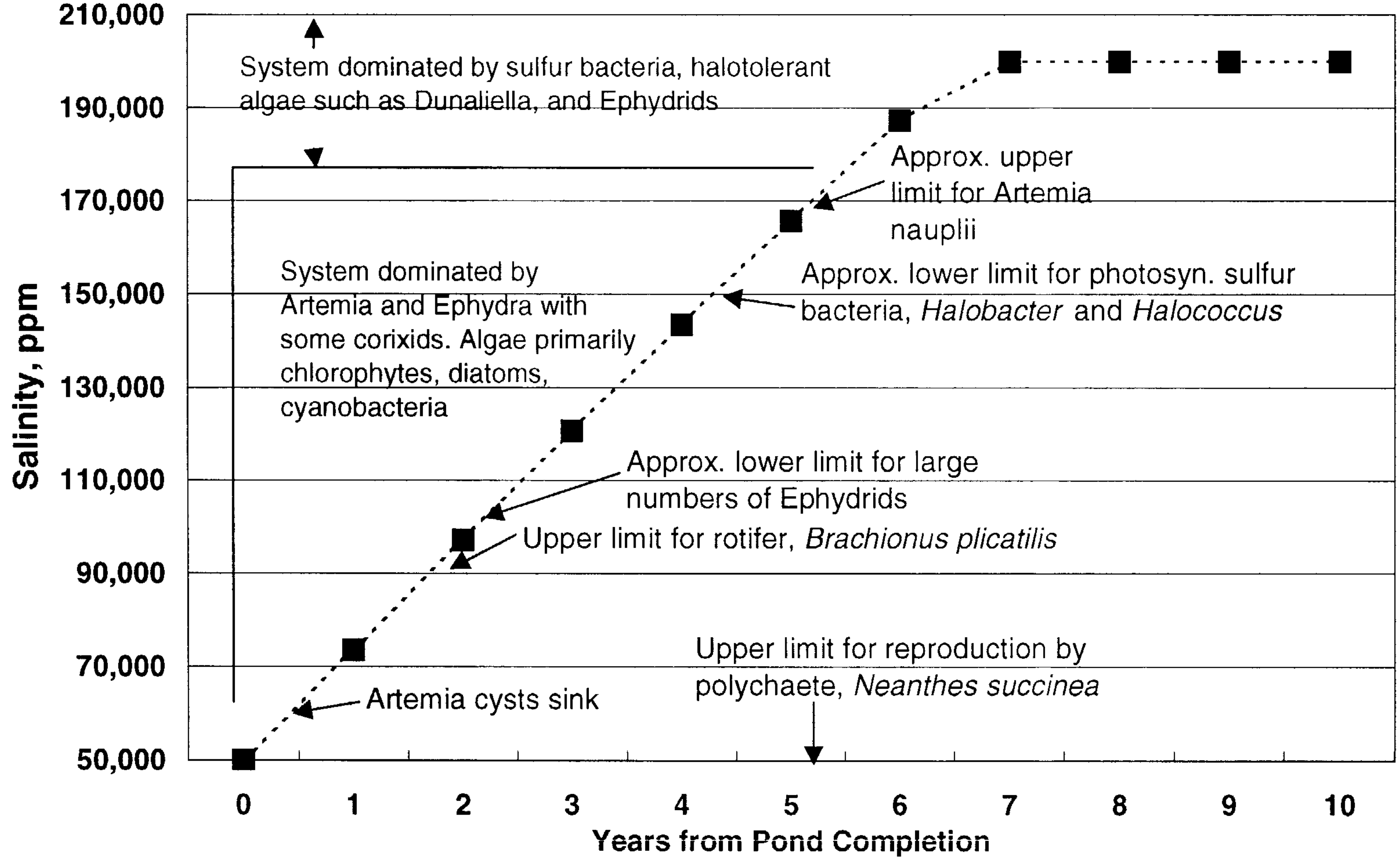

Figure 3.-Hypothesized changes in aquatic ecosystem in Salton Sea evaporation ponds