5.3 Cooling System Impacts

This section discusses the impacts of the cooling systems associated with operation of STP 3 & 4. The different aspects of cooling system impacts are addressed separately in the following sections:

- Intake system
- Discharge system
- Heat discharge system
- Impacts to members of the public

5.3.1 Intake System

Section 3.4 describes the proposed STP 3 & 4 cooling system and its operation. Subsection 3.4.2.1 provides specifics on the Reservoir Makeup Pumping Facility (RMPF), which includes a screen intake structure with trash racks, a siltation basin, traveling screens, and a 1200 cfs pump station. Subsections 5.3.1 and 5.3.2 describe the impact of the STP 3 & 4 cooling on the aquatic communities of the lower Colorado River. STP 3 & 4 will rely on the existing Main Cooling Reservoir (MCR) for dissipation of waste heat, but it will be necessary to increase the normal operating level of the reservoir by approximately 2 feet (to 49 feet MSL to accommodate STP 3 & 4 [see Sections 3.3 and 3.4]).

5.3.1.1 Hydrodynamic Descriptions and Physical Impacts

The RMPF supplies makeup water to the MCR to replace water lost to evaporation, seepage, and blowdown (should it be necessary). At present, two 240 cfs pumps and two 60 cfs pumps are installed and operational. To support STP 3 & 4 operations, it would be necessary to install four additional pumps, which would approximately double the total pumping capacity of the RMPF.

The makeup pumps at the RMPF operate intermittently, as dictated by weather (patterns of rainfall, both locally and regionally; ambient temperatures), Colorado River flows, and operational considerations. The MCR is expected to lose up to 23,190 gpm (average annual value conservatively based on an assumed 100 percent load factor) to forced evaporation (natural evaporation from the MCR is already accounted for under Units 1 and 2 and thus is not included for units 3 and 4) with STP 3 & 4 operating (see Section 3.3). STPNOC projects that the normalized rate of withdrawal of Colorado River water to replace water losses from the MCR would be 22,799 gpm for normal STP 3 & 4 operations and 47,489 gpm during maximum (peak) use operations (see Section 3.3, Table 3.3-1). The discrepancy between projected river makeup and estimated evaporative losses stems from the fact that there is some groundwater flow into the reservoir through plant processes.

5.3.1.2 Aquatic Ecosystems

The species assemblage at the RMPF at a given time is influenced primarily by river flow, salinity, season, and population dynamics of the individual species. Although it is theoretically possible to predict the presence of a particular species using correlations of abundance with any one of these variables, more often than not these, as well as other, factors interact in complex ways to determine the assemblage of species and life stages at the RMPF.

5.3.1.2.1 Factors Affecting Entrapment, Entrainment, and Impingement

Aquatic organisms can become entrapped, entrained, or impinged when water is drawn into the intakes at a flow greater than what they can escape.

Entrapment can take the form of attracting organisms to a relatively restricted area, such as a long, narrow intake channel, from which they have difficulty escaping due to behavioral responses to environmental cues. If the animals congregate in a channel, and environmental conditions (such as concentration of dissolved oxygen) deteriorate suddenly, the animals may die.

Impingement, in which the organism is physically pressed against the screens, or entrainment, in which smaller organisms travel in the water column through the screens, may also lead to destruction of the organism, depending on other factors. The extent of impingement and entrainment of aquatic organisms at a power plant intake structure depends on several variables, including the (1) species assemblage and densities of organisms at the intake at the time of pumping, (2) velocity of flow into the intake, (3) volume of water withdrawn, and (4) specific design features of the intake structure and pumps.

The seasonal distribution and abundance of various life stages of important aquatic species in the lower Colorado River was discussed in Subsection 2.4.2. By and large, the assemblage of species and densities of organisms found in the vicinity of the RMPF is under the influence of regional climatic events (in particular, patterns of rainfall) that are beyond human control. The other three variables are, to one degree or another, under the control of STPNOC.

<u>Design Features</u>

The location, design, and capacity of power plant intake structures are regulated by EPA under 40 CFR 401.14 and are required to reflect the Best Technology Available (BTA) to minimize adverse environmental impacts. The operation of intake structures at power plants in Texas is permitted and regulated by the Texas Commission on Environmental Quality (TCEQ), which was delegated authority to administer the Texas Pollutant Discharge Elimination System (TPDES) by EPA in 1998 (Reference 5.3-1). STPNOC adhered to principles of BTA in siting and designing the existing RMPF. Entrapment was precluded by the physical location and design of the intake; the STP plant has no intake canal or similar structure that would hold fish. As described in the operation Final Environmental Statement (FES), the intake structure has been installed “flush” to the river bank with no projecting structures that create eddies and countercurrents that would cause entrapment (Reference 5.3-2). Furthermore, the intake area is equipped with an “escape route” that allows fish to swim back to the river.

Impingement and entrainment were minimized by other design features: (1) the intake was oriented in such a way as to reduce attractant flows, (2) the approach velocity at the traveling screens was designed to be 0.5 fps or less, and (3) the RMPF was equipped with a fish “handling and bypass” system. The EPA evaluated the location, design, and operation of the plant and issued an National Pollutant Discharge Elimination System (NPDES) permit in 1985 that explicitly approved the design of the intake structure, characterizing it as BTA (see Part III, number 10 of NPDES Permit No. TX0064947, issued October 18, 1985). As discussed earlier, the RMPF was intended to provide makeup to the MCR for four nuclear units. Thus, the intake for STP 3 & 4 was an integral part of the original design.

The RMPF has a maximum design approach velocity at the traveling screens of 0.5 fps based on a maximum pumping rate of approximately 538,000 gpm, and at the time of construction, this represented the BTA (Reference 5.3-3). It should be noted that in their Final Environmental Statement for Construction of STP 1 & 2, the NRC calculated a slightly higher maximum approach velocity, 0.55 fps (Reference 5.3-4). The pump station was designed to house eight pumps, with a total pumping capacity of 1200 cfs (538,596 gpm) (Reference 5.3-5). However, the site is able to maintain water levels in the MCR using half of the full complement of pumps (two 107,719-gpm pumps and two 26,930-gpm pumps). The current maximum pumping rate, based on Annual Water Use Reports for 2001 through 2006 submitted by STPNOC to the TCEQ, is 600 cfs, (269,298 gpm) (References 5.3-6, 5.3-7, 5.3-8, 5.3-9, 5.3-10, and 5.3-11). To supply sufficient water to the MCR for four operating units, it would be necessary to complete the pump installation with adequately sized pumps, restoring the original design pumping capacity of 1200 cfs (538,596 gpm). The design approach velocity of 0.50 fps was based on this pumping rate and is not expected to change appreciably with four units in operation.

Water will be pumped through a shoreline intake system, passed through trash racks, and through traveling screens with a 3/8-inch (9.5 mm) mesh. The traveling screens will operate intermittently to coincide with the intermittent withdrawal of river water. Fish and debris washed from the traveling screens are carried along a sluice which runs the length of the intake structure. Fish collected on the screens can be returned to the river via the sluice and a fish bypass pipe (Reference 5.3-5). The point of return is at the downstream end of the intake structure, approximately 0.6 meter (2 feet) below normal water elevation, as described in Section 3.4 (Reference 5.3-2).

Operational Features

TPDES Permit No. WQ0001908000 for STP 1 & 2, issued by TCEQ in July 2005, contains no limits on Colorado River water withdrawals. Withdrawal limits are found in Certificate of Adjudication 14-5437, which was issued by the Texas Water Commission (a predecessor agency to the TCEQ) on June 28, 1989, based on water rights granted in 1974. The Certificate of Adjudication authorized Houston Lighting & Power (HL&P) to divert and use up to 102,000 acre-feet of water annually from the Colorado River for industrial purposes (power plant cooling) at a maximum withdrawal rate of 1200 cfs (approximately 540,000 gpm). To the extent feasible, STPNOC has followed internal procedures to withdraw water at times of high river flow, which has the effect of reducing impingement and entrainment of important estuarine and marine species, because high flows push these species downstream. Because evaporative losses and power demand are highest in late summer, some pumping at these times is unavoidable. July, August, and September have historically been periods of low flow in the lower Colorado River, although interannual variability in flow precludes characterizing any given month as “low” or “high” flow with certainty (Reference 5.3-12). The Certificate of Adjudication contains the following Special Condition, which the state of Texas imposed to ensure minimum instream flows in the lower Colorado during periods of low flow:

> “This certificate of adjudication is issued subject to the condition that diversions from the Colorado River shall be limited to 55% of the flows of the Colorado River in excess of 300 cfs at the authorized diversion point on the Colorado River.”

In 1986, the NRC predicted the average annual withdrawal from the river for STP 1 & 2 would be 1.03 × E8 m^3 (83,900 acre-feet) (Reference 5.3-2). In recent years (2001–2006), the annual withdrawal for STP 1 & 2 has averaged approximately 44,423,122 m^3 (37,000 acre-feet), which is approximately 44% of the 83,900 acre-feet the NRC predicted in the FES and 36% of the permitted maximum of 102,000 acre-feet (References 5.3-6, 5.3-7, 5.3-8, 5.3-9, 5.3-10, and 5.3-11). It appears likely that makeup for two additional units will be accommodated by the existing RMPF with all pumps installed, and there would be no need for STPNOC to seek an increase in the current allocation limit of 102,000 acre-feet/year from the Lower Colorado River Authority (LCRA).

The withdrawal of 83,900 acre-feet/year of water for STP 1 & 2 was determined to have minor impacts on aquatic resources (Reference 5.3-12). The withdrawal of up to 102,000 acre-feet/year to maintain levels in the MCR for four units would produce impingement and entrainment rates approximately 22% higher than those evaluated by NRC in the operation FES and deemed less than significant (Reference 5.3-2). However, withdrawal volumes would be substantially lower than 102,000 acre-feet in high rainfall years, and would never be higher, as the withdrawal limit of 102,000 is a condition of the Certificate of Adjudication. In any case, entrapment, impingement, and entrainment impacts would be mitigated by the factors discussed previously in this section and others listed below (from Reference 5.3-2):

- Screens mounted flush with the shoreline to prevent entrapment and lessen the impact of eddy currents on the downstream end of the intake structure
- Free passage of fish between outer trash racks and traveling screens allows fish that enter outer trash racks to swim downstream and exit the intake structure
- Maximizing makeup pumping during periods of high river flow when densities of important estuarine/marine species are low in the intake area

- Generally low densities of fish in the vicinity of the site intake areas compared to downstream areas

Previous Conclusions on Design and Operation Features

Because the design of the RMPF is fixed and operation of the pumps would be bounded by the limits in the permit, impacts of their operation would depend on distribution and abundance of fish and shellfish in the vicinity of the RMPF. The remainder of this section discusses fish and shellfish species that could be affected by operation of STP 3 & 4, emphasizing trends in abundance of important marine/estuarine species over the 1985–2003 period. These species were the focus because they are commercially and recreationally important. During periods of high flow, impingement and entrainment would affect freshwater species such as bluegill, blue catfish, channel catfish, and common carp that are not as highly esteemed by commercial and recreational fishermen and are common-to-ubiquitous in large rivers, ponds, and reservoirs in Texas. The FES for operation of STP 1 & 2 assessed impacts of RMPF operation on marine and estuarine species exclusively (Reference 5.3-2).

5.3.1.2.2 Aquatic Resources Potentially Present at the Makeup Water Intake

Two relevant sources of information on species assemblages near the STP site are available: (1) government data on fish and shellfish abundance in Matagorda Bay collected for general management purposes, and (2) data collected specifically for the construction FES to address potential impacts of STP 1 & 2 on aquatic resources in the lower Colorado River. Each of these is discussed below.

Fish and Shellfish Abundance in Matagorda Bay

The National Oceanographic and Atmospheric Administration's (NOAA's) Estuarine Living Marine Resources (ELMR) program was developed to provide a consistent database of the distribution, abundance, and life history characteristics of important fish and invertebrates in U.S. estuaries (Reference 5.3-13). Four criteria were used to select the 44 species included in the Gulf of Mexico database: (1) commercial value, (2) recreational value, (3) indicator of environmental stress, and (4) ecological value (References 5.3-13, 5.3-14 and 5.3-15). These criteria are similar to those used to identify "important species" in the Environmental Standard Review Plan (NUREG-1555) (Reference 5.3-16).

Various surveys and programs in Texas have focused on different subsets of the species considered important in Reference 5.3-14 and Reference 5.3-15, as shown in Table 5.3-1. Texas Parks and Wildlife Department (TPWD) identified principal fisheries species in Matagorda Bay (Reference 5.3-17). In a recent summary of recreationally important fish, Green and Campbell of TPWD found that three species stand out as prime targets of anglers, as shown in Table 5.3-2 (Reference 5.3-18). The NRC names important species as well (References 5.3-2 and 5.3-4). For this ER, professional judgment based on independently collected data served as the basis for selecting important species potentially affected by plant operations, specifically the RMPF and the discharge from the MCR.

An ELMR report by NOAA presented data on the salinity preferences of various life stages of important fish and shellfish in Matagorda Bay and associated tidal rivers, including the Lower Colorado River (Reference 5.3-14). Salinity is a major factor influencing distribution and abundance of estuarine species, particularly during spawning and early life stages. With the exception of sessile organisms such as oysters, most adult fish and shellfish (nekton) do not stay in Matagorda Bay, but move throughout the estuary in response to salinity gradients. One such example is the movement of estuarine or marine fish upriver during low flow periods when a saltwater wedge penetrates well into the Colorado River. During such time, the salinity differential at the bottom and top of the river can be substantial (Reference 5.3-19, Table 3). Along with the saline wedge come the planktonic larvae of fish and shellfish, which are generally carried passively along in the water column. The result of these hydrodynamic movements is that while the location in space cannot always be predicted for estuarine organisms, the location with respect to salinity gradient is better known (Reference 5.3-14).

The relative abundance of important fish and shellfish in various salinity zones in the Matagorda Bay estuary is summarized in Table 5.3.1.2-2 (Reference 5.3-14). The importance of this profile is that the salinity of the water at the intake of the STP pumps will determine to a large extent the composition and life stages of species present in the area. Regardless of which species or life stages are in the estuary at a given time, high freshwater flows tend to keep many of them from moving up the river as far as the STP site. Conversely, low river flows, and the concomitant saltwater intrusion, allow greater movement of estuarine and marine species upriver, where they may come under the influence of the intake pumps during pumping operations (Reference 5.3-20). Both estuarine and freshwater species are present at the RMPF (Reference 5.3-19).

<u>Previous Studies in Lower Colorado River near STP 1 & 2</u>

Additional information on species that may be affected by plant operations, including freshwater species from upriver, was drawn from References 5.3-2 through 5.3-5, and 5.3-19 through 5.3-21.

HL&P ER 1974: Predictive

In preparing the original ER, HL&P collected phytoplankton, zooplankton, ichthyoplankton, and nekton in the Colorado River near the intake to support estimates of entrainment and impingement.

Salinity and Flow

Although estuarine conditions often prevail at the RMPF, salinities at the intake have at times been essentially zero. In 1973, it was reported that the water was fresh at the bottom as well as at the surface, ranging from 0.2 parts per thousand (ppt) in July to 0.4 ppt in October (Reference 5.3-3).

Entrainment of Phytoplankton and Zooplankton

Phytoplankton and zooplankton are easily entrained due to their small size and inability to swim against the intake flow. The phytoplankton community at the intake was dominated by diatoms and green algae during the preoperational sampling (Reference 5.3-3). It was estimated that 7 x 1013 individual zooplankton would be entrained each year. Studies at a similar plant showed that about 12% of those entrained would die of mechanical damage and the number lost due to intolerance of conditions in the MCR was not estimated. All phytoplankton and zooplankton entrained were assumed lost to the Colorado River (Reference 5.3-3).

Entrainment of Ichthyoplankton

Based on the design of the intake structure in 1974, HL&P concluded that all ichthyoplankton less than 4 inches total length are entrainable (Reference 5.3-3). Larval menhaden and croaker were identified as most likely to be entrained; cyprinids and gobies were considered secondary. Few eggs were collected near the intake, which is consistent with the observation that little spawning occurs in that reach of the river. In 1974, HL&P estimated that 2.6 million fish eggs and larvae may be entrained each year, a number too small to cause any population level effects (Reference 5.3-3).

Impingement

Impingement of organisms on the RMPF traveling screens is directly influenced by the velocity of water moving through the screens. The design of the RMPF at STP 3 & 4 is for a ≤0.5 fps approach velocity at the traveling screens. Estimates of impingement presented in the 1974 construction-phase ER for STP 1 & 2 were based on the assumption that fish and crustaceans were equally distributed in number and weight throughout the water column near the intake (Reference 5.3-3).

HL&P estimated in the construction-phase ER that 6.25 million fish and crustaceans (16,100 pounds) would be impinged per year, representing less than 0.03% of the annual poundage caught in the lower Colorado River and Matagorda Bay. Most of the species that HL&P predicted would be impinged are commercial or forage species: white shrimp, river shrimp, menhaden, anchovy, and croaker. Commercial species impinged accounted for less than 0.1% by weight of landings of fish and shellfish in Texas (Reference 5.3-3). Based on the 1974 ER, the NRC concluded that impingement would not have a significant effect on populations of important species in the lower Colorado River (Reference 5.3-4).

NUS 1976: Year-Long Field Monitoring

In 1975, STPNOC implemented a two-phase monitoring program to identify species that may be entrained by or impinged on the intake system (Reference 5.3-20). Phase 1 (April 75-April 76) included 26 sampling dates and several locations upstream and downstream of the intake, spaced at roughly 14-day intervals. Entrainment predictions based on direct measures of distribution and abundance of important organisms near the RMPF are considered representative of low flow conditions in the lower Colorado River. The NUS monitoring study is summarized in the NRC Operation FES (Reference 5.3-2).

Based on the physical characteristics of the river and the RMPF, NUS concluded that the makeup operation would affect an area of the Colorado River represented by the mid-channel, mid-depth (up to 10 feet) samples and the west bank samples (Reference 5.3-20). Mean densities of plankton and juvenile organisms were used to estimate entrainment. Estimates assumed that populations of organisms were relatively constant for a period of time (unspecified) around the sampling event, and that organisms were continually replenished at the sampling points by tidal and freshwater flow. The number of organisms entrained was calculated by multiplying the standing crop (individuals per cubic foot of river water) by the intake volume for a given time interval. Other assumptions and parameters of the calculations are given in Reference 5.3-20. The entrainment predictions were limited to plant operations during a particular set of low-flow conditions, which prevailed at STP 1 & 2 from August 1975 through March 1976.

Salinity and Flow

The Phase 1 monitoring study was conducted during an unusually dry year when Colorado River flows were low and estuarine conditions extended up to the STP site. All but two of the samples (May 6 and August 5) were collected when salinities at the intake represented estuarine conditions. Throughout the year-long monitoring period, bottom salinity remained high at the RMPF, ranging from 20.9 ppt in November 1975 to 31.0 ppt in August 1975. Surface salinity at the RMPF reached a maximum of 6.3 ppt on October 1, 1975, and by October 24, surface salinity reached an annual low of 0.8 ppt.

Nekton in the Colorado River (Post-larval, Juvenile, and Adult Invertebrates and Fish)

During Phase 1, post-larval, juvenile, or adult white shrimp, menhaden, anchovy, croaker, and mullet were most abundant in samples collected from the Colorado River. These commercially important species were most numerous at stations downriver from STP. All of these species except menhaden decreased in abundance upriver. Brown shrimp and blue crabs were sometimes abundant in samples upriver from the STP site (Reference 5.3-20).

To estimate entrainment at the RMPF, plankton tows were made at various stations upriver and downriver from the STP site to estimate the standing crop of entrainable organisms. Estimates of macroplankton and ichthyoplankton are given below.

Entrainment of Macroplankton

During Phase 1, the most important species in the macroplankton samples were decapod crustaceans, namely blue crab, white shrimp, and brown shrimp. Estimates of entrainment were based on densities of megalops of the commercially valuable blue crab and its congener, the pygmy blue crab, which cannot be distinguished at that stage, as well as first crab and juvenile stages of the blue crab. Estimates of entrainment of the shrimps were based on standing crops of post-larval white and brown shrimp.

Predictions of entrainment during the 8-month low flow period were as follows:

- Blue crab: 1.32×10^6
- White Shrimp: 6.4×10^3
- Brown Shrimp: 4.5×10^3

NUS estimated that in an 8-month period of low river flow, about one million blue and pygmy blue crab megalops, and about a quarter million blue crab individuals at the first crab and juvenile stage would be entrained (Reference 5.3-20). Of these, more than 83% would be entrained during August. Entrainment of white shrimp was predicted to occur exclusively in August, and of brown shrimp, only in March. NUS concluded that expected losses to entrainment were negligible compared with the millions of pounds of these species harvested annually in Texas, and the widespread distribution of the blue crab, white shrimp, and brown shrimp across Gulf of Mexico estuaries (Reference 5.3-20).

Entrainment of Ichthyoplankton

The total estimate of entrainment of ichthyoplankton during the 8-month period was 13,236,233 individuals; more than half of these were expected to be entrained during August 1975 due to an unseasonably high flow period that resulted in greater than normal pumping for that month. Normally, river flows are so low in August that little or no pumping would occur.

The highest densities of ichthyoplankton in samples representing the area of influence of the RMPF were reported in May–October 1975 and March–April 1976. The most abundant ichthyoplankton consistently (for more than 3 of the 8 months) in the area were Gulf menhaden, Atlantic croaker, bay anchovy, and naked goby (*Gobiosoma bosci*, which is the most common goby on oyster reefs [Reference 5.3-22]). On August 5, 1975, high river flows and low salinity prevailed at the RMPF, and freshwater drum and several cyprinids (*Family Cyprinidae*) occurred in the ichthyoplankton in large numbers. Freshwater drum larvae were so plentiful on that day that they made up 48% of the 8-month total of approximately 13 million individuals expected to be entrained. NUS emphasizes that these results reflect anomalous conditions due to extremely high August flows and should not be interpreted as typical entrainment scenarios (Reference 5.3-20).

The Phase 1 entrainment study for STP 1 & 2 estimated that in an 8-month period of low river flow, the following entrainment of important ichthyoplankton would occur:

- Croaker: 3.37×10^6 (more than 90% in December and January)
- Menhaden: 1.35×10^6 (86% in September)
- Anchovy: 5.44×10^5 (70% in March)
- Naked goby: 3.2×10^5 (all months except January and February)

Other infrequently collected ichthyoplankton were reported to be subject to entrainment at low levels, as follows:

- Pinfish (*Lagodon rhomboides*): 4.04×10^4 (February and March)
- Sand sea trout: 1.26×10^4 (February and March)
- Striped anchovy (*Anchoa hepsetus*): 9.78×10^4 (March only)
- Gizzard shad: 3.53×10^4 (March only)
- Black drum: 3.86×10^3 (March only)
- Star drum (*Stellifer lanceolatus*): 9.6×10^3 (August only)

The entrainment estimates made by NUS during low flow months were about 2.5 times those predicted in the HL&P ER, largely because lower flow and higher salinity conditions in the river lead to increases in the density of organisms subject to entrainment at the RMPF (References 5.3-20 and 5.3-3). Estimated losses of crustaceans and fish to entrainment reported in NUS were deemed insignificant by NRC in light of the overall abundance and high reproductive potential of these species in the Gulf of Mexico (References 5.3-20 and 5.3-2).

McAden et al. (1984 and 1985): Phase 2 -Focused Study of Intake Area

The Phase 2 monitoring (July 1983–December 1984) collected both impingement and entrainment samples. Impingement samples were taken at the traveling screens during filling of the MCR from July to September 1983, and again the following September. Each week during the sampling period, samples were taken at two screens for three 30-minute periods over a 24-hour period (roughly every 8 hours).

To document entrainment of organisms, ichthyoplankton samples were collected in the Colorado River in the immediate vicinity of the RMPF (at sampling station 2, established during Phase 1). Samples were collected at three depths using a 0.5 mm mesh conical plankton net, and both stationary sets and oblique tows were used. Methods were the same as used during Phase 1 sampling (References 5.3-19 and 5.3-21). Mid-depth samples from mid-channel locations were used to estimate entrainment, consistent with methods developed during Phase 1 (Reference 5.3-20).

Ichthyoplankton samples were also collected from the sedimentation basin. However, sampling difficulties prevented any collections from mid-depth locations, making comparisons of little value. Sedimentation basin samples are not discussed here.

Salinity and Flow

During the 3-month sampling period, salinity at the mid-depth (about 10 feet) sampling location in the Colorado River ranged from 0.3 ppt in late July to 20.7 ppt in early August. Average Colorado River flow ranged from 492 cfs on July 13, 1983 to 2076 cfs on August 10, 1983.

Nekton (Post-larval, Juvenile, and Adult Invertebrates and Fish)

During the first year of Phase 2 sampling (July 1983 to June 1984), six shrimp species, two crab species, and a crayfish species were collected in seine and trawl samples at Station 2, in the vicinity of the STP RMPF (Reference 5.3-19). During the single sampling event in September 1984, one additional shrimp (*Palaemonetes pugio*) was collected by seine, and another (*Penaeus duorarum*) was collected on the revolving screens of the RMPF, but not by seine or trawl (Reference 5.3-21).

During the first year of Phase 2 sampling (July 1983 to June 1984), 30 species of fish were collected near the RMPF by trawl or seine; the large majority was estuarine or marine. Only four of the 30 fish were freshwater species (Reference 5.3-19). During the single sampling event in September, 1984, no fish or crustaceans were collected by trawl because dissolved oxygen concentrations at the bottom were thought to be too low to support these species. Seine collections yielded 20 species of fish, but only one (*Lepisosteus occulatus*, the spotted gar) lives in freshwater. Seine collections included eight estuarine/marine fish not collected in the previous year.

Entrainment of Macroplankton and Ichthyoplankton

During the Phase 2 study of ichthyoplankton abundance and entrainment, standing stocks of macroplankton and ichthyoplankton were measured using plankton tows, as described in Reference 5.3-14. To maintain consistency with Phase 1 data, entrainment estimates were based on mid-channel, mid-depth samples collected at station 2, near the RMPF. The number of individuals (per 100 cubic meters of Colorado River water) collected over a 24-hour period was multiplied by the volume of water pumped over the same period (Table 5.3-3). The number of macroplankton entrained over 24 hours ranged from about 1 million individuals in late July 1983 to more than 54 million individuals in mid-September 1983. More than 50 species of macroplankton were collected; most common were zoeae of *Callianassa* (ghost shrimp) and *Rhithropanopeus harrisii*. Jellyfish medusae were abundant in some samples and completely absent in others (References 5.3-19 and 5.3-21).

Estimates of ichthyoplankton entrainment also varied across the sampling periods, with a low of about 13,000 in September 1984 and a high of 553,000 in July 1983 (Table 5.3-3). In fact, the same sampling period yielded the lowest estimate of macroplankton entrainment and the highest estimate of ichthyoplankton entrainment (Table 5.3-3). The authors attributed the elevated ichthyoplankton entrainment levels to high densities of the bay anchovy. Bay anchovies were particularly abundant in samples in July 1983, when low salinities were observed from the surface to bottom of the river (Reference 5.3-19). Low salinity (as low as 0.2 ppt) apparently stressed the bay anchovies, making them more vulnerable to capture, and inflated abundance estimates for this species (References 5.3-19 and 5.3-2). Other ichthyoplankton that occurred frequently in the samples were several species of goby (*Gobionellus boleosoma*, *G. hastatus*, and *Gobiosoma bosci*). *Caranx hippos*, *Gobiosoma robustum*, and an unidentified centrarchid occurred in one sample each (References 5.3-19 and 5.3-21).

Impingement of Crustaceans and Fish

Impingement of macroinvertebrates and fish was monitored in 1983–84 during the filling of the MCR and again on a single date in September 1984 (References 5.3-19 and 5.3-21). Impingement was greatest in mid-July, when an estimated 14,976 crustaceans and fish were impinged over a 24-hour period (Table 5.3-4). The September 1984 estimate was the lowest (2880 individuals over a 24-hour period).

The most commonly impinged macroinvertebrate was the blue crab, which was collected during all impingement sampling events (Table 5.3-4). In addition, six shrimp, including four palaemonids and two penaeids, were impinged. Of these, the Ohio shrimp was the most often impinged.

A total of three individual fish were collected in impingement samples during the 1983–1984 monitoring studies. Two were estuarine fish (inland silverside and crevalle jack) and one was a freshwater fish (green sunfish). The September 1984 impingement sampling yielded no fish.

Conclusions of Monitoring

The NRC concluded that losses of important aquatic species due to entrainment at the RMPF for STP 1 & 2 would be “insignificant” for the following reasons:

- Only a small portion of the lower Colorado River population of a species would occur near the intake, and only 10% of those present at the intake would be actually entrained
- The Lower Colorado River tidal reach does not provide unique habitat or services to estuarine or marine organisms, it is one of many similar tidal rivers on the Gulf Coast
- The commonly entrained organisms (anchovy, menhaden, croaker, blue crab) are ubiquitous and abundant along the Gulf of Mexico
- Due to water allocation permit conditions, most withdrawals would occur during high river flows when the assemblage is mostly freshwater (Reference 5.3-2)

The NRC concluded that effects of impingement on lower Colorado River fish and shellfish would be “minor,” based on the following rationale:

- Because absolute densities of organisms are low at the intake, low absolute numbers would be impinged
- The intake design limits impingement, the timing of the pumps would limit impingement of young of the year (assuming low withdrawals from July to September, when young are present), and use of upper strata river water would limit impingement of estuarine organisms in the salt wedge
- The Lower Colorado River is not a unique nursery habitat for any species
- Menhaden, croaker, anchovy, and mullet are ubiquitous and abundant (Reference 5.3-2)

Main Cooling Reservoir

Records of fish caught in the MCR provide a partial list of species that have survived entrainment and are tolerant of the temperature and salinity regimes in the reservoir. In a September 1994 catch and release fishing tournament for employees, the most commonly caught species were redfish (red drum) and catfish (presumably blue catfish, but tournament records did not differentiate among catfish species); other species landed included black drum, common carp, and largemouth bass. One specimen each of gar, croaker, and Southern flounder was reported.

STPNOC is currently undertaking a study to characterize the relative abundance of fish species in the MCR (see Section 6.5). Although intended primarily to gather information on the distribution and abundance of juvenile and adult fish in the reservoir, this study is also expected to yield useful information on survival of fish entrained at the RMPF. The study will not provide a comprehensive list of species entrained, because most estuarine species that are entrained will not survive in the MCR. Some species that could survive in the MCR may be entrained in such low numbers that they are not detected during the survey. However, the presence of a species in the MCR could provide additional insights on differential vulnerability of fish species to entrainment at the RMPF.

Relevance of Previous Entrainment and Impingement Studies to STP 3 & 4

Impacts to aquatic biological resources from STP 1 & 2 were judged to be SMALL and acceptable (Reference 5.3-2). Because no threatened or endangered aquatic species occur in the vicinity, none would be impacted by plant operations (Reference 5.3-2). The RMPF was designed originally to serve four units, so no additional design modifications are required for this project. The intake bays, fish screens, trash racks, and bypass system are already operational for STP 1 & 2. The refurbishment of the RMPF to accommodate STP 3 & 4 will consist primarily of installing new pumps and traveling screens in existing pump bays. Impacts to aquatic species from the operation of STP 3 & 4 will be SMALL.

The RMPF proposed for the new units at STP 3 & 4 will presumably be in compliance with Section 316(b) of the Clean Water Act by virtue of the fact that it has “reduced flow commensurate with (a) closed-cycle re-circulating system” (69 FR 131, July 9, 2004, page 41592). This is one of the “compliance alternatives” a facility may select to demonstrate that it has installed the BTA for minimizing adverse impacts of CWIS (69 FR 131, July 9, 2004). However, the EPA's determination of BTA is one of the provisions of the Phase II regulation that is being challenged in court, which led the EPA to suspend the regulation in March 2007 (Reference 5.3-23). Regardless of the outcome of the legal challenge to the EPA rule, the STP intake system is expected to be in compliance with Section 316(b) because of its closed-cycle design. As stated in the rule, "any facility that reduces its flow to a level commensurate with a closed-cycle, recirculating cooling system meets the performance standards in today's rule because such a reduction in flow is deemed to satisfy any applicable impingement mortality and entrainment performance standards for all water bodies" (69 FR 131, July 9, 2004, page 41601).

In a June 27, 2007 letter, TCEQ stated, "…we have reviewed the information you submitted and based on our best professional judgment, we consider your facility to be a closed-cycle recirculating system (Reference 5.3-45). We also concur that the Main Cooling Reservoir (MCR) at your facility does not meet the definition of water in the state."

5.3.1.2.3 Long-Term Regional Evidence of No Significant Impact

Virtually all available data on fish and invertebrate abundance in Matagorda Bay illustrates that most species show significant variability from year to year, as is typical in estuaries nationwide (Reference 5.3-24). In a complex analysis of the effect of the diversion of the lower Colorado River on epifauna in Matagorda Bay, Wilbur and Bass concluded that "the background level of interannual variability is so great for most species that a substantial and sustained change in abundance would have had to occur to suggest that it resulted from the diversion" (Reference 5.3-17). Variability in species assemblages and abundance is influenced by significant regional conditions such as a major flood in 1992 and a severe drought in 1996 (Reference 5.3-24).

To predict the impact of pumping associated with STP 3 & 4, it is useful to look retrospectively at effects on fish and shellfish populations that may be attributed to pumping for STP 1 & 2. No population data is routinely collected on fish in the lower Colorado River. However, long-term catch data in Matagorda Bay shows that populations of most commercial, recreational, and forage species have either remained stable or increased over the past two decades since STP 1 & 2 became operational. Selected analytical studies are referred to in References 5.3-17, 5.3-24, and 5.3-25.

The U.S. Army Corps of Engineers (USACE) diverted the lower Colorado River into the eastern arm of Matagorda Bay in 1991 to create habitat, increase nutrients, and moderate salinity. The overall goal was to improve fisheries productivity. Wilbur and Bass evaluated several long-term data sets that included fisheries abundance in various parts of the bay before and after the diversion (Reference 5.3-17). The expectation was that the diversion would be shown to have had a significant positive effect on at least some important species, such as white shrimp, brown shrimp, blue crab, croaker, anchovy, or menhaden. However, none of the data sets indicated significant shifts in species abundance, despite substantial habitat changes, such as the growth of a deltaic marsh at the end of the diversion cut. This study points out that, relative to other Gulf of Mexico estuaries, the Colorado River has a small average discharge (76.5 m3/s) compared with the size of Matagorda Bay (1070 km2). In fact, when the flow is less than 14 m3/s (500 cfs), as measured at the Wharton gauge station located upstream of STP, there is no discharge from the Colorado River. The authors noted that there were no diversion-related differences in abundance for any important species monitored by TPWD, and that blue crab and shrimp landings “did not exhibit any unusual deviations from historical interannual variability” (Reference 5.3-17).

If a major diversion and habitat creation project did not elicit a population-level response from key species, it is unlikely that the relatively minor withdrawals of makeup water at the STP site will negatively impact these species.

The TPWD Coastal Fisheries Division samples the nine major bay systems in Texas to monitor the relative abundance of fish and shellfish. Their samples are independent of fisheries pressures, which can skew data away from representing ecologically relevant abundances. Trends in relative abundance of important species in East Matagorda Bay, Matagorda Bay, and the entire Texas coast are presented in Table 5.3-5 for several sample types: (1) gill nets in spring, (2) gill nets in fall, (3) bag seines, and (4) trawls (Reference 5.3 25).

The data clearly shows that populations of fish and shellfish in the Matagorda Bay estuary, and, by extension, the tidal reaches of the lower Colorado River, have either remained stable or increased since 1985 (Reference 5.3-25). This pattern holds even for species that have experienced a decline statewide, such as blue crab and white shrimp. The NRC prediction that the amount of entrainment and impingement that would occur at the STP 1 & 2 intake would be insignificant has been supported (Reference 5.3-2). No evidence of adverse impacts of water withdrawals by STP 3 & is shown.

A cooperative group of several Texas government agencies including LCRA, TPWD, TCEQ, and the Texas Water Development Board (TWDB), prepared an independent analysis of the long-term fisheries-independent data collected by TWPD in Matagorda and East Matagorda Bays (Reference 5.3-24). The study concluded that the current health and productivity of Matagorda Bay is generally good, and gave as evidence the approximately $63 million that Matagorda Bay generates annually in commercial seafood harvests, and the $115 million annually the bay contributes to the sport fishing industry (Reference 5.3-24). The current freshwater inflows have helped maintain the health and productivity of the bay, although the study acknowledges that a host of complex factors that are not yet fully understood interact to affect the overall productivity of the bay.

The LCRA study provides a summary of the economic value of the ecological services provided by Matagorda Bay, with particular reference to its role as habitat for estuarine-dependent fish and shellfish. For example, commercial fishermen in Texas landed an estimated 95.2 million pounds of fish, shrimp, crabs and oysters in 1999. Shrimp are the most valuable resource along the Texas coast, accounting for 81% of the harvest and 88% of the dockside value in 1999 (Reference 5.3-24). Commercial shrimpers in the Matagorda Bay system landed one-fourth of the total shrimp catch from all Texas bays, representing 27% of the dockside value, on average, from 1995 to 1999 (total dockside value was 219 million in 1999 dollars). As reported by LCRA, a Texas A&M University study in 1995 estimated that the Matagorda estuary contributed 1847 jobs and $71.86 million to commercial fishing (gulf and bay). Since the study was published, both landings and economic impact have increased (Reference 5.3-24).

5.3.1.3 Conclusions

NRC assessed impacts of the STP 1 & 2 cooling water intakes in the Final Environmental Statement Related to the Operation of STP 1 & 2 (Reference 5.3-2). NRC concluded that “entrainment impacts appear insignificant when the entire Gulf of Texas coast populations are considered.” With regard to lower Colorado River populations, the NRC observed that “there may be considerable variation in the numbers and kinds of species entrained from year to year” due to annual variation in river flow, salinity, and natural population fluctuations. Having said this, the NRC concluded that “entrainment losses…will not constitute a significant impact to their respective populations” because:

- A relatively small percentage of organisms passing the intake would be potentially affected and an even smaller percentage of the biota of the entire lower Colorado River would be potentially affected
- The lower Colorado River did not appear to be a unique nursery area for estuarine-marine organisms
- The species primarily affected were ubiquitous and abundant along the Texas and Gulf coast
- Most makeup water withdrawal would occur during periods of high river flow when densities of important estuarine-marine organisms are low in the area of the STP 3 & 4 intake

With respect to impingement, the NRC determined that operation of the RMPF “will result in only minor impingement effects on biota in the Colorado River in the vicinity of the intake structure.” The NRC staff based this on the following facts:

- The densities of fish and shellfish near the site are low compared to downstream areas
- The lower Colorado River was not a unique nursery area for estuarine-marine organisms
- Species expected to be most affected (e.g., Gulf menhaden, croaker, bay anchovy, striped mullet) were ubiquitous and abundant along the Texas and Gulf coasts

As discussed previously in this section, the only major change that will be required to the RMPF to support STP 3 & 4 will be the installation of pumps in existing but currently unused pump bays. Because there will be no change in the configuration of the RMPF (other than installing pumps and traveling screens) and there will be no significant change in intake velocity, the major difference with respect to entrainment and impingement will be the total volume of water pumped annually. The NRC's assessment of impacts in 1986 for STP 1 & 2 operations assumed that 83,900 acre-feet would be withdrawn ("diverted") per annum (Reference 5.3-2). With two additional units online, the volume of water pumped annually could approach (but not exceed) 102,000 acre-feet, the permit limit. Although entrainment and impingement losses are likely to be somewhat higher than projected by the NRC in its FES for operation, the NRC's conclusions relative to SMALL impacts of entrainment and impingement appear to remain valid. These conclusions have been substantiated by long-term monitoring studies conducted by the state of Texas that suggest that important populations in Matagorda Bay and the lower Colorado River are stable, if not expanding.

These long-term studies indicate that operation of the RMPF at STP 3 & 4 has had no measurable impact on any important species in the area. The addition of pumps for STP 3 & 4 is not expected to significantly affect the distribution or abundance of populations of important species in the area, or to cause any measurable community-level perturbations. Effects on important aquatic resources will be SMALL.

5.3.2 Discharge Systems

The Final Plant Discharge, which is the existing blowdown facility on the Colorado River, is described in Subsection 3.4.2.1. Designed to reduce total dissolved concentrations in the MCR, it has been used (tested) only once, in 1997. Acceptable water quality has been maintained by selective diversion from the Colorado River during periods of high flow (Reference 5.3-26).

5.3.2.1 Thermal and Physical Impacts

Effluent is discharged from the MCR through Outfall 001 to Segment No. 1401 ("Colorado River Tidal") of the lower Colorado River; the designated uses in Segment No. 1401 are contact recreation and high aquatic life use (Reference 5.3-27). Water quality in high aquatic life use waters is expected to be adequate to support high biotic diversity, high species richness, and a high degree of habitat diversity (Reference 5.3-27).

The current TPDES permit (No. WQ0001908000, issued July 21, 2005) limits the average daily discharge to the Colorado River to 144,000,000 gallons per day. Outfall 001, the only outfall that discharges to the Colorado River, is equipped with a diffuser to enhance dilution at the point of discharge. Potential thermal, physical, and chemical effects of the discharge on aquatic resources are discussed in the sections that follow.

5.3.2.2 Aquatic Ecosystems

5.3.2.2.1 Thermal Effects

Section 3.4 describes the cooling system proposed for STP 3 & 4. As discussed in Section 3.4, blowdown will be directed to the Colorado River via the existing blowdown structure, which includes a 1.1-mile-long discharge line that extends downstream along the west bank of the river and is equipped with seven discharge ports. One or more of the ports may be “valved” open, depending on river flows, to promote rapid mixing of the effluent (Reference 5.3-2).

The original NPDES permit (No. TX0064947) for STP 1 & 2, issued by the EPA in 1985, contained requirements on the number of discharge ports that must be opened, given a range of blowdown flow rates, but these port control requirements were removed from the permit when the state of Texas assumed responsibility for the NPDES program. However, STPNOC procedures direct operators to open two to seven blowdown valves, depending on blowdown rate. STPNOC also prescribes a range (80 to 308 cfs) of allowable blowdown rates.

Based on cooling system design and STP 1 & 2 operating experience, it is anticipated that it will be necessary to discharge from the MCR periodically to reduce levels of dissolved solids in the MCR. Blowdown flows will range from 80 to 308 cfs, depending on flows in the Colorado River. The current TPDES permit for STP 1 & 2 contains limits on daily average (95°F) and daily maximum (97°F) discharge temperatures, limits that are anticipated to be extended to the new units as they are based on state water quality standards. The current TPDES permit also stipulates that the discharge from Outfall 001 shall not exceed 12.5% of the flow of the Colorado River at the discharge point and prohibits discharges from Outfall 001 when flow in the Colorado River adjacent to the plant is less than 800 cfs. Because the blowdown flow will be no more than 12.5% of the Colorado River flow (and under normal circumstances will be an even smaller percentage) the effect on temperature downstream in the Colorado River will be negligible, and limited to an area in the immediate vicinity of the blowdown line. No recirculation of heated effluent is expected.

In 1975 and again in 1986, the NRC concluded that potential thermal impacts to aquatic organisms in the Colorado River from operation of STP 1 & 2 would be limited to the area immediately adjacent to the blowdown diffuser ports (References 5.3-2 and 5.3-4). Assuming STP 3 & 4 are held to the same TPDES permit limits and conditions with regard to blowdown (i.e., blowdown flow no greater than 12.5% of Colorado River flow; two to seven discharge port valves open, depending on blowdown rate), thermal impacts to aquatic biota will continue to be SMALL and will not warrant mitigation (beyond the measures already in place).

5.3.2.2.2 Chemical Effects

TPDES Permit No. WQ0001908000 allows a daily average pH of 6.0, and a daily maximum of 9.0. The permit also allows a daily chlorine limit of up to 0.05 mg/L.

Discharges to the Colorado River will occur only from the MCR. Inputs to the MCR include precipitation, makeup water from the Colorado River, and TPDES permitted discharges from other operations on site (including a mixture of low flow previously monitored effluent, treated sanitary sewage, storm water, and UHS cooling tower blowdown) (Reference 5.3-28). Additional details on the effluent are in Section 3.3.

Dissolved solids make up the majority of the waste discharged into the MCR. Both the construction and operation Environmental Reports for STP 1 & 2 and the NRC construction and operation FESs predicted it would be necessary to periodically blow down the STP 1 & 2 MCR to reduce the buildup of salts and solids (References 5.3-2, 5.3-3, 5.3-5, and 5.3-4). However, it has not been necessary to routinely discharge from the MCR. Acceptable water quality has been maintained by selective diversion from the Colorado River during periods of high flow (Reference 5.3-9). STP 1 & 2 has discharged to the Colorado River from the MCR only once in nearly 20 years of operation, in 1997.

The existing MCR will serve both STP 1 & 2 and STP 3 & 4. The addition of STP 3 & 4 is expected to increase the frequency of blowdown from the MCR to the Colorado River. The FES for operation of STP 1 & 2 assessed impacts of dissolved inorganic chemical substances (measurable as dissolved solids) from the MCR on the water quality of the Colorado River and concluded that the overall effects of reservoir blowdown would not be significant due to dilution by the Colorado River flow (Reference 5.3-2).

This would hold true for STP 3 & 4 as well, because the TPDES requirement that the blowdown flow not exceed 12.5% of the river flow implies a minimum dilution factor of 8 which would continue to be true for operation of four units. Any discharge of dissolved solids will mix quickly with the larger freshwater flow of the Colorado River. Therefore, impacts of dissolved chemical discharges to aquatic communities will be SMALL and will not warrant mitigation.

5.3.2.2.3 Physical Effects

As discussed in the previous sections, TPDES Permit No. WQ0001908000 stipulates that blowdown flow cannot exceed 12.5% of the post-diversion flow of the Colorado River. Once the acceptable blowdown rate has been calculated by subtracting the amount diverted at the RMPF from the flow at Bay City USGS gauging station, an appropriate number of blowdown valves are opened and the blowdown is released. The maximum amount of blowdown that can be released is 308 cfs, which corresponds to a river flow of 2464 cfs.

The FES for construction of STP 1 & 2 assessed blowdown-induced scouring of the seven-port diffuser at blowdown rates of 0 to 308 cfs, and concluded that scouring would be limited to a few feet downstream of each port and would have no significant adverse impacts on lower Colorado River biota (Reference 5.3-4). Assuming STP 3 & 4 are held to the same TPDES permit limits relative to blowdown and adhere to the same guidelines, blowdown-induced scouring should be SMALL and impacts to biota limited to some scouring in the immediate vicinity of the blowdown line (Reference 5.3-4). Physical impacts to aquatic communities will therefore be SMALL and will not warrant mitigation.

5.3.3 Heat Dissipation Systems

This section describes the impacts of the heat dissipation system during operation of STP 3 & 4, including the impacts of heat dissipation on the atmosphere and on terrestrial ecosystems. Consideration is given to potential atmospheric phenomena resulting from operation of this heat-dissipation system and the significance of the potential environmental impacts on terrestrial ecosystems and human activities in the STP site vicinity.

5.3.3.1 Heat Dissipation to the Atmosphere

As described in Section 3.4, a closed-cycle cooling system will be used for STP 3 & 4, using the existing MCR. Additionally, mechanical draft cooling towers will be constructed to assist in heat load dissipation and serve as the UHS. Thermal discharges resulting from plant systems will be to the MCR and to the atmosphere. During normal operating conditions, most of the heat load from STP 3 & 4 will be to the MCR, and each of the towers would operate at one-half capacity. The cooling towers would operate at full capacity during emergency reactor shutdown.

Main Cooling Reservoir

The plume from a cooling pond like the MCR would either exist as a ground level fog over the pond that will evaporate close to the edge of the pond, or lift to become stratus for moderate to calm wind conditions. Elevated plumes and the associated shadowing would not be expected from the operation of the MCR. NUREG-1555 concludes that drift from a cooling pond or lake would not need to be considered. Therefore, only fogging and the associated icing impacts are considered for the operation of the MCR.

Mechanical Draft Cooling Towers

Cooling towers evaporate water to dissipate heat to the atmosphere. The evaporation is followed by partial recondensation which creates a visible mist or plume. The plume creates the potential for shadowing, fogging, icing, localized increases in humidity, and possibly water deposition. In addition to evaporation, small water droplets are blown out of the tops of the cooling towers. The water droplets are referred to as drift and can deposit water and dissolved salts on vegetation and surfaces.

For STP 3 & 4, STPNOC modeled the impacts from fogging, icing, shadowing, and drift deposition using the Electric Power Research Institute's Seasonal/Annual Cooling Tower Impact (SACTI) prediction code. This code incorporates the modeling concepts presented by Policastro et al., which were endorsed by the NRC in NUREG-1555 (References 5.3-29 and 5.3-16). The model provides predictions of seasonal and annual cooling tower impacts from mechanical or natural draft cooling towers. It predicts average plume length, rise, drift deposition, fogging, icing, and shadowing, providing results that have been validated with experimental data (Reference 5.3-29).

Engineering data for the ABWR was used to develop input to the SACTI model for normal operations. The SACTI model simulated two identical cooling towers, each with a maximum heat rejection rate of 30.5 MW and a maximum circulating water flow of 43,101 gallons per minute. The cooling towers are located south of each unit. The cooling tower height would be 119 feet. Three cycles of concentration were assumed for the analysis. The meteorological data was from the STP 1 & 2 meteorological tower for the years 1997, 1999, and 2000, and from the National Climatic Data Center for the same years from the Palacios Municipal Airport (Reference 5.3-30). Additional physical and performance characteristics of the mechanical draft cooling towers during normal operations would be as follows:

Parameter	Value
Number of cooling towers	2
Tower width	52 feet
Tower length	284 feet
Diameter of individual fan outlet	28.3 feet
Number of fans per cooling tower	63
Cooling tower height (above surface elevation)	119 feet
Surface elevation (above MSL)	34 feet
Design duty	30.5 MW
Maximum drift rate (percentage of circulating water flow rate)	0.005%
Circulating water flow rate	43,101 gpm
Cooling range	14.4°F
Approach	9.7°F
Dry bulb temperature	115°F
Wet bulb temperature	85.3°F
Air flow rate per fan	923,200 cubic feet per minute
Cycles of concentration	3
Salt (NaCl) concentration	800 mg/L

5.3.3.1.1 Length and Frequency of Elevated Plumes for Mechanical Draft Cooling Towers

The SACTI code calculated the expected plume lengths by direction for each season for the combined effect of the two mechanical draft cooling towers. The plumes would occur in all compass directions. The average plume length and height was calculated from the frequency of occurrence for each plume based on the distance from the tower. The median plume length and height is the distance where half of all the plumes would be expected to be shorter than that distance.

The average plume length would range from 0.2 miles in the summer season to 4 miles in the winter season. The annual prediction for the average plume length is 3 miles from the cooling towers. The median plume length would be less than two tenths of a mile for each season and annually. The average plume height ranges from 110 feet in the summer season to 720 feet in the winter season. The annual prediction for the average plume height is 180 feet. The median plume height would be 66 feet in every season. The annual prediction for the median plume height would also be 66 feet. The plume would extend beyond the site boundary for a maximum of 30 hours during the winter season to the north of the cooling towers. The annual prediction for the time that the plume extends beyond the site boundary was 43 hours per year in the north-northwest direction.

The plumes from the cooling towers would occur in each direction of the compass and would be spread over a wide area, reducing the time that the plume would be visible from any particular location. The average plume lengths would be short and would not be long enough to reach the site boundary in most directions. Due to the varying directions and short average plume height and length, impacts from elevated plumes would be SMALL and not warrant mitigation.

As modeled, plumes from the mechanical draft cooling towers would be as follows:

	Winter	Spring	Summer	Fall	Annual
Predominant direction	North	North-northwest	North	South	South
Average plume length (miles)	0.44	0.23	0.17	0.37	0.30
Median plume length (miles)	0.12	0.12	0.12	0.12	0.12
Average plume height (feet)	720	140	110	230	180
Median plume height (feet)	66	66	66	66	66
Maximum hours the plume extends beyond the site boundary	30	9	1	11	43
Direction of maximum time plume extends beyond site boundary	North	North-northwest	North-northwest	North-northwest	North-northwest

5.3.3.1.2 Ground-Level Fogging and Icing

Main Cooling Reservoir

The MCR is an approximately 7000 acre cooling pond that was originally designed to serve as the heat removal system for four nuclear power reactors. Only two of the four originally proposed nuclear power reactors were constructed, and these two reactors (STP 1 & 2) use the MCR for cooling. STPNOC has proposed to construct two ABWR reactors at STP. These new reactors (STP 3 & 4) would also use the MCR for heat removal. Although the MCR was designed for four reactors, the additional heat load from the new units would increase the potential for fogging from the MCR.

A fog monitoring program was initiated before the operation of STP 1 & 2 to assess the impact of operation of the MCR on local meteorology. The monitoring program was conducted in two phases. Phase I (pre-operation) began in May 1987 and continued for one year collecting data before the August 1988 commercial operation of STP Unit 1. Phase II (post-operation) began in June 1989 after commercial operation of STP Unit 2 and continued for one year until June 1990. Fog monitoring was accomplished by operation of two visibility meters. One visibility meter was located on FM 521 approximately one mile northwest of STP 1 & 2. The second visibility meter was located approximately 11 miles west-southwest of STP 1 & 2 to serve as a control site. The pre-operational monitoring results totaled 229 hours per year for the FM 521 monitoring station and 163 hours per year for the control monitoring station. The increase in actual hours of fogging was 33 hours for the FM 521 monitoring station and 56 hours per year at the control monitoring station. The control monitoring station resulted in a greater increase in fogging events, indicating an overall increase in natural fog occurrence in the area during the period of the monitoring program. The results of the fog monitoring program do not indicate that the presence of the MCR significantly increases the fog occurrence over the naturally occurring fog for STP 1 & 2.

To determine the increase in fogging potential once STP 3 & 4 becomes operational, the MCR was modeled using the Gaussian Plume Model to determine the downwind plume concentrations of moisture from MCR water evaporation. Inputs for the Gaussian Plume Model include the receptor height, release height, source strength, wind speed, and vertical and lateral plume dispersion parameters. The vertical and lateral plume dispersion parameters were functions of downwind distance and stability class. The MCR was approximated as a square with each side being 5322-meters long, which corresponds to the square root of the pond area. Because of the size of the MCR in relation to the receptor location, the Gaussian Plume model, which is for a point source, was generalized to describe an area source. The generalization was calculated by integrating the point source solution over the pond area.

Daily evaporation rates in inches were provided from the MCR Thermal Calculation. The MCR Thermal Calculation predicts the water consumption from two unit (existing units) and four unit (existing units plus the proposed new units) operation. One of the outputs of this study is the daily evaporation rates. Values of daily evaporation for both the two unit operation and four unit operation at 93% and 100% load factors were provided. The daily evaporation for two and four unit operation at 100% load factor was converted to hourly evaporation rates using the hourly wind speed and relative humidity. Those hourly rates served as the source term in the model. The 100% load factor was assumed for conservatism.

The meteorological data used in the analysis was the same as the data used in other sections of the ER. The data was collected onsite from the STP 1 & 2 meteorological tower for the years 1997, 1999, and 2000. This data included the wind speed, wind direction, and stability class. Additional data was acquired from the National Climatic Data Center for the Palacios Municipal Airport. This data, also for the years 1997, 1999, and 2000, included the dew point temperature and the dry bulb temperature. The relative humidity of the ambient air was calculated from the dry bulb temperature and the dew point temperature.

There were two receptor locations identified, Receptor 1 is 500 meters north of the edge of the MCR on FM 521. Receptor 2 is 1800 meters north of the edge of the MCR along FM 521 where the road arcs around STP 1 & 2. These are expected to be the most sensitive locations to fogging events because of the proximity of these locations to the MCR and because they are in the predominant wind direction. Impacts at these receptor locations would bound any impact at other receptor locations. Because of the size of the MCR, wind blowing from multiple directions could pass over the MCR and reach the receptor locations. For this reason, any wind direction northward from East to West was assumed to pass over the MCR and reach the 500 meter receptor location, and any wind direction northward from Northeast to Northwest was assumed to pass over the MCR and reach the 1800 meter receptor location. The receptor locations were also assumed to be at the ground elevation of STP 1 & 2. The berm around the MCR is approximately 37 feet above the elevation of STP 1 & 2. Therefore, the plume would be released at a higher elevation than the receptor, and this elevation difference is accounted for in the model.

The number of times that the wind was blowing in one of the receptor locations for the entire meteorological period is provided in Table 1. The wind direction is toward Receptor 1 for 64 percent of the year and toward Receptor 2 for 47 percent of the year. This confirms that any impacts observed at these receptor locations would bound other receptor locations. Since the meteorological data was for three years, the total was divided by three to get an average annual number of hours that the wind direction is toward one of the receptors.

Table 1. Number of hours that the wind direction is towards a receptor.

Month	Total number of hours that the wind direction is toward Receptor 1	Annual number of hours that the wind direction is toward Receptor 1	Percentage of time that the wind direction is toward Receptor 1	Total number of hours that the wind direction is toward Receptor 2	Annual number of hours that the wind direction is toward Receptor 2	Percentage of time that the wind direction is toward Receptor 2
January	1240	413	56%	915	305	41%
February	1239	413	61%	908	303	45%
March	1494	498	67%	954	318	43%
April	1430	477	66%	1022	341	47%
May	1700	567	76%	1398	466	63%
June	1820	607	84%	1560	520	72%
July	1922	641	86%	1658	553	74%
August	1730	577	78%	1428	476	64%
September	1200	400	56%	810	270	38%
October	1168	389	52%	625	208	28%
November	937	312	43%	588	196	27%
December	849	283	38%	496	165	22%
All Months	**16729**	**5576**	**64%**	**12362**	**4121**	**47%**

The model simulation then used the inputs described above to determine the number of hours that the relative humidity of the plume from the MCR would be 100 percent when only the heat load from the existing units was applied to the MCR. This value was then divided by three, the number of years in the meteorological period, to determine the average number of hours per year that the plume would have a relative humidity of 100 percent at one of the receptor locations. These would be hours where the potential for fogging would be significantly increased. Table 2 provides this information by month and annually.

Table 2. Number of hours predicted at each receptor location where the Relative Humidity of the plume would be 100 percent for STP 1 & 2.

Month	Hours predicted with 100% Relative Humidity at Receptor 1	Percentage of the time with 100% Relative Humidity[a]	Hours predicted with 100% Relative Humidity at Receptor 2	Percentage of the time with 100% Relative Humidity[a]
January	19	3%	9	1%
February	19	3%	5	1%
March	27	4%	7	1%
April	20	3%	3	0%
May	11	1%	1	0%
June	25	3%	7	1%
July	30	4%	5	1%
August	22	3%	4	0%
September	32	4%	7	1%
October	28	4%	5	1%
November	42	6%	15	2%
December	39	5%	12	2%
Annually	**314**	**4%**	**81**	**1%**

a. Compared to the total number of hours.

The total number of discrete events associated with the above information was also determined. If two or more consecutive hourly outputs resulted in the relative humidity of 100 percent, these were counted as a single discrete event. The total number of hours presented in Table 2 could then be divided by the number of discrete events to determine the average amount of time that each event lasts. Table 3 provides this information by month and annually. It can be seen that the average time for each event is fairly constant throughout the year.

Table 3. Average time that the Plume Relative Humidity is 100 percent at each receptor location for STP 1 & 2.

Month	Number of discrete events where the Relative Humidity is 100% at Receptor 1	Average number of hours that each discrete event lasts at Receptor 1	Number of discrete events where the Relative Humidity is 100% at Receptor 2	Average number of hours that each discrete event lasts at Receptor 2
January	9	2	5	2
February	7	3	3	2
March	9	3	4	2
April	9	2	3	1
May	5	2	1	1
June	10	2	4	2
July	15	2	4	1
August	10	2	2	2
September	13	2	3	2
October	12	2	3	2
November	15	3	6	3
December	11	4	5	2
Annually	**125**	**3**	**42**	**2**

The Gaussian Plume Model described above does not predict when or if fogging may occur. The output of the model is the number of hours that the relative humidity at a receptor location is 100 percent. Fogging is dependent on a number of meteorological factors and is not easily calculated. For this determination, an approximation between the number of hours of high relative humidity and the number of hours of observed fogging was determined. Five years of additional data from the National Climatic Data Center for the Palacios Municipal Airport was acquired. The data was for the years 2002 through 2006 and contained the dry bulb temperature, the dew point temperature, the number of hours of observed fog, and observations of visibility. The number of observations where the relative humidity of this data set was equal to 100 percent (determined by the difference between the dry bulb and dew point temperatures being zero) was determined to be 3,325. Of these observations, the total number of records that also contained observations of fog was determined to be 1,379. Therefore, 41 percent of the time that the Relative Humidity at the Palacios Municipal Airport was equal to 100 percent, there was also fogging. Although this is not an ideal way to determine the relationship between fogging and relative humidity, it should give an approximation that is realistic. Further statistics with this data set were calculated, and it was determined that 87 percent of all fogging observations occurred when the difference between the dry bulb and dew point was less than or equal to 2°F.

The number of events where visibility was impaired, where the visibility was less than 0.3 miles, was also determined from the 2002 through 2006 Palacios Municipal Airport meteorological data. Similar to the observed fogging events determination described above, the number of times that visibility was less than 0.3 miles and the relative humidity was equal to 100 percent was determined to be 214 hours. Therefore, 6 percent of the time that the relative humidity was 100 percent, the visibility was impaired.

Both the percentage of fogging and percentage of time that the visibility was impaired was applied to the number of times that the predicted relative humidity would be 100 percent from the MCR plume at the receptor locations. Table 4 presents the predicted fogging and impaired visibility for the two unit operation.

Table 4. Predicted fogging and impaired visibility at the downwind receptor locations for STP 1 & 2.

Month	Hours of predicted fogging events at Receptor 1	Hours of predicted fogging events where the visibility is less than 0.3 miles at Receptor 1	Hours of predicted fogging events at Receptor 2	Hours of predicted fogging events where the visibility is less than 0.3 miles at Receptor 2
January	8	1	4	1
February	8	1	2	0
March	11	2	3	0
April	8	1	1	0
May	5	1	1	0
June	10	2	3	0
July	12	2	2	0
August	9	1	2	0
September	13	2	3	0
October	12	2	2	0
November	18	3	6	1
December	16	3	5	1
Annually[a]	**130**	**20**	**33**	**5**

[a] Number of annual hours may not equal sum of monthly hours due to roundoff.

Annually, 130 hours of fogging was predicted for locations northward between the East and West and within 500 meters of the edge of the MCR. This would approximate the closest approaches of FM 521. Fogging was predicted to occur for 33 hours annually for locations farther from the MCR, such as along FM 521 north of STP. The receptor location for the fog monitoring program discussed above for STP 1 & 2 is similar to the location of Receptor 2 of this analysis. The results of the fog monitoring program were that 33 additional hours of fogging were observed at that location. Coincidentally, 33 hours of fogging were also predicted at that location using the Gaussian Plume Model described and used in this analysis.

This model was then applied to the MCR with the heat load from STP 1 & 2 and STP 3 & 4. Table 5 presents the same information from Table 2 with the addition of STP 3 & 4. The number of times that the relative humidity at each receptor location is 100 percent increased by nearly a factor of two. This would be expected from an increase in heat load on the MCR by approximately a factor of two. In addition, Table 6 presents the average number of hours that the discrete relative humidity events occur. The number of discrete events increased, but the total average time that the events occur remained similar to the prediction for two unit operation, with 3 hours for Receptor 1 and 2 hours for Receptor 2.

Table 5. Number of hours predicted at each receptor location where the Relative Humidity of the plume would be 100 percent for STP 1 & 2 and STP 3 & 4.

Month	**Hours predicted with 100% Relative Humidity at Receptor 1**	**Percentage of the time with 100% Relative Humidity[a]**	**Hours predicted with 100% Relative Humidity at Receptor 2**	**Percentage of the time with 100% Relative Humidity[a]**
January	32	4%	12	2%
February	31	5%	11	2%
March	45	6%	17	2%
April	31	4%	10	1%
May	33	4%	7	1%
June	45	6%	15	2%
July	60	8%	18	2%
August	61	8%	21	3%
September	70	10%	24	3%
October	43	6%	10	1%
November	56	8%	21	3%
December	49	7%	20	3%
Annually	**554**	**6%**	**185**	**2%**

a. Compared to the total number of hours.

Table 6. Average time that the Relative Humidity of the plume is 100 percent at each receptor location for STP 1 & 2 and STP 3 & 4

Month	Number of discrete events with 100% Relative Humidity at Receptor 1	Average number of hours that each discrete event lasts at Receptor 1	Number of discrete events with 100% Relative Humidity at Receptor 2	Average number of hours that each discrete event lasts at Receptor 2
January	15	2	7	2
February	10	3	6	2
March	15	3	8	2
April	12	3	6	2
May	13	3	5	1
June	17	3	8	2
July	28	2	13	1
August	22	3	10	2
September	22	3	11	2
October	16	3	6	2
November	19	3	7	3
December	15	3	7	3
Annually	**202**	**3**	**94**	**2**

The same methodology described above to predict the number of hours of fogging and impaired visibility was used to determine the impacts from operation of STP 1 & 2 and STP 3 & 4 on the MCR. The ratios of 41 percent fogging and 6 percent impaired visibility were applied to the results of the modeling at each receptor location. Table 7 presents the results. The number of hours of predicted fogging and impaired visibility approximately double for the four unit operation.

Table 7. Predicted fogging and impaired visibility at the downwind receptor locations for STP 1 & 2 and STP 3 & 4.

Month	Hours of predicted fogging events at Receptor 1	Hours of predicted fogging events where the visibility is less than 0.3 miles at Receptor 1	Hours of predicted fogging events at Receptor 2	Hours of predicted fogging events where the visibility is less than 0.3 miles at Receptor 2
January	13	2	5	1
February	13	2	4	1
March	19	3	7	1
April	13	2	4	1
May	14	2	3	0
June	19	3	6	1
July	25	4	8	1
August	25	4	9	1
September	29	4	10	2
October	18	3	4	1
November	23	4	9	1
December	20	3	8	1
Annually	**230**	**36**	**77**	**12**

As described above, the results of the fog monitoring program indicate that the presence of the MCR does not significantly increase the natural fog occurrence for STP 1 & 2 operation. Since the operation of the MCR with STP 1 & 2 does not increase the observable fogging over naturally occurring fogging, this level of fogging could be considered consistent with background levels, or levels without an observable impact. Furthermore, fogging from the MCR with STP 1 & 2 has not created an impact to any onsite or offsite areas. However, any amount of fogging over that level, such as the additional fogging from four-unit operation, could be noticeable and potentially cause an impact. The difference between the predicted fogging for four-unit operation and two-unit operation is 100 hours per year at Receptor 1 and 44 hours per year at Receptor 2. The hours where visibility would be impaired above existing levels would be 16 hours per year at Receptor 1 and 7 hours per year at Receptor 2.

Residents of the area near the MCR and commuters on FM 521 may notice the increase in localized fogging after STP 3 & 4 is operational. The fogging, especially near bodies of water, would often occur in the early morning hours. However, the total number of additional hours of fogging from the MCR would only be a fraction of the number of hours of naturally occurring fogging. The number of hours of impaired visibility from the operation of the MCR would also be small.

Impacts from fogging of the MCR would be SMALL and would not warrant mitigation. Since the climate in the region is typically too warm for frequent and persistent freezing temperatures, impacts from icing would be SMALL and would not warrant mitigation.

Mechanical Draft Cooling Tower

Fogging from the mechanical draft cooling towers occurs when the visible plume intersects with the ground, appearing like fog to an observer. Analysis of results from the SACTI code did not predict fogging to occur from the operation of the cooling towers.

Icing from the mechanical draft cooling towers would be the result of ground-level fogging when ambient temperatures are below freezing. Icing is also not predicted to occur from the operation of the cooling towers since minimal fogging from the operation of the mechanical draft cooling towers is predicted to occur and since the climate of the region is typically too warm for frequent freezing temperatures to occur.

5.3.3.1.3 Salt Deposition

Water droplets blown from the mechanical draft cooling towers would have the same concentration of salts as the water in the cooling tower basin. Groundwater wells would be used for normal makeup water for the cooling towers. This would be supplemented by the MCR in the unlikely event that unanticipated peak site water demands would require additional water sources. Hydrogeochemical data for wells in the vicinity of STP 3 & 4 is provided in Table 2.3.1-20, and includes sodium and chloride concentrations in the groundwater. The maximum concentration of sodium from any of the wells was conservatively used to determine the corresponding maximum concentration of sodium chloride that could potentially be in the makeup water. As the water droplets blown from the towers evaporate, either in the air or on vegetation or equipment, salts are deposited.

The maximum predicted salt deposition is to the north of the cooling towers, less than or equal to 660 feet from the centerline of both of the cooling towers combined. The maximum deposition is 160 pounds per acre per month and occurs during the summer season. The maximum predicted salt deposition during each of the other seasons would also be within 660 feet from the cooling towers. The winter, spring and fall maximum salt deposition would be 81, 120, and 9 pounds per acre per month, respectively. Annually, the maximum salt deposition is 98 pounds per acre per month, also in the north direction and less than or equal to 660 feet from the cooling towers. This is greater than the NUREG-1555 significance level for possible visible effects to vegetation of 8.9 pounds per acre per month. Further discussion of the potential impacts of salt deposition on vegetation is provided in Subsection 5.3.3.2.

The summer season has the maximum deposition rates and the greatest extent of salt deposition. Each of the other seasons and annual salt deposition rates would be bounded by the summer season. As shown in Figure 5.3-1, the rate of salt deposition from the operation of the mechanical draft cooling towers rapidly decreases as the distance from the towers increases. The salt deposition rate falls below the NRC significance limit of 8.9 pounds per acre per month for all locations greater than 1600 feet from the towers. The salt deposition rates are greater than 1 pound per acre per month for some locations as far away from the towers as 4300 feet. The salt deposition rate for all distances greater than 4300 feet would be below 1 pound per acre per month. Salt deposition is only predicted to occur for locations up to two miles from the towers.

The NRC reports that visible damage from salt deposition to terrestrial vegetation at operating nuclear power plants with mechanical draft cooling towers has not been observed (Reference 5.3-32). Therefore, the impacts from the two mechanical draft cooling towers are not expected to be different from the impacts of the currently operating nuclear power plants.

The electrical switchyard for STP 3 & 4 is located approximately 1700 feet to the north of the proposed location of the cooling towers. A maximum predicted salt deposition of 8.8 pound per acre per month would be expected at this location during the summer season and 5.0 pound per acre per month annually. The electrical switchyard for STP 1 & 2 is located approximately 1400 feet to the east of the proposed location of the cooling towers. The salt deposition at this location is 0.65 pound per acre per month in the winter season and 0.43 pound per acre per month annually.

The predicted salt deposition from the operation of the cooling towers at locations away from the immediate vicinity of the mechanical draft cooling towers would be less than the NUREG-1555 significance level where visible effects to vegetation may be observed. Impacts to vegetation from salt deposition are described in Subsection 5.3.3.2. Salt deposition in other potentially sensitive areas, including at the STP 1 & 2 switchyard and STP 3 & 4 switchyard are not expected to impact these facilities. Therefore, the impact from salt deposition from the cooling towers would be SMALL and would not require mitigation.

5.3.3.1.4 Cloud Formation, Cloud Shadowing, and Additional Precipitation

Vapor from cooling towers can create clouds or contribute to existing clouds. The SACTI code predicted the precipitation expected from the two mechanical draft cooling towers. The maximum precipitation would occur during the summer season, with a monthly total of less than an inch of precipitation within 660 feet north of the towers. The precipitation during each of the other seasons would be less than the summer season maximum. Annually, 2.2 inches of rain is predicted to occur, also 660 feet to the north of the cooling towers. This value is very small compared to the average annual rainfall for the South Texas region of 48 inches for the period 1971–2000 (Reference 5.3-33). Impacts from precipitation would be SMALL and would not require mitigation.

The formation of clouds could also prevent sunlight from reaching the ground, or cloud shadowing. This is especially important for agricultural fields or other sensitive areas. As shown in Figure 2.2-2, there are many agricultural areas in the vicinity of the STP site. Shadowing in the vicinity of the cooling towers and in these agricultural areas is predicted to occur for a maximum of 69 hours during the winter season, 64 hours during the fall season, 37 hours during the the spring season and 31 hours during the summer season at any location. The annual prediction was for a maximum of 158 hours of shadowing at any location. Shadowing in areas beyond the site boundaries would occur for less than 18 hours per season and 35 hours annually at any location. This represents a very small percentage of the total hours of each season and per year. Therefore, the impacts from cloud shadowing would be SMALL and would not require mitigation.

5.3.3.1.5 Interaction with Existing Pollution Sources

No other sources of pollution occur within two kilometers of the STP site. Therefore, there would be no interaction with existing pollution sources.

5.3.3.1.6 Ground-Level Humidity Increase

Increases in the absolute and relative humidity could result from the operation of the two mechanical draft cooling towers. The majority of the water evaporated in the cooling tower is buoyant and dissipates into the atmosphere. A small fraction of this evaporated water may not be as buoyant and could increase the ground level humidity. Specific meteorological conditions could also limit the dissipation into the atmosphere, but would be infrequent. The humidity in the region is typically high, and increases in the humidity would not be noticeable. In addition, the ground level increases in humidity would occur in the immediate vicinity of the cooling towers. The impacts from increases in absolute and relative humidity would be SMALL and mitigation would not be warranted.

5.3.3.2 Terrestrial Ecosystems

As discussed in Section 3.4, STP 3 & 4 would use the existing MCR for condenser cooling. Two mechanical draft cooling towers, extending approximately 119.0 feet above grade (El. 153 ft. MSL), would be constructed to serve as the UHS for STP 3 & 4. As planned during MCR construction, inclusion of STP 3 & 4 in the existing cooling reservoir system will lead to an increase in operating water level, potentially impacting existing shoreline vegetation and terrestrial biota using the reservoir. The only important terrestrial species as defined in NUREG-1555 that use the MCR other than the federally listed brown pelican, which is listed as threatened, are the bald eagle and common game species such as ducks (see Subsection 2.4.1) (Reference 5.3-16). The brown pelican nests in other locations of Matagorda County, but currently uses the MCR only for resting, a source of freshwater, and possibly foraging.

Impacts from cooling tower operation on terrestrial biota can result from salt drift, vapor plumes, icing, precipitation modifications, noise, and avian collisions with structures (e.g., cooling towers). Each of these topics is discussed in Subsection 5.3.3.2.2. Overall, there are no important terrestrial habitats as defined in NUREG-1555 in the area encompassed by construction of the two mechanical draft cooling towers.

5.3.3.2.1 Main Cooling Reservoir

The addition of STP 3 & 4 will result in an increase in the normal operating water level of the MCR from 47 feet MSL to 49 feet MSL, which could impact terrestrial biota associated with this impoundment. However, the reservoir side of the berm outlining the MCR is lined with “soil-cement” to prevent erosion and has largely prevented establishment of vegetation on this side (Reference 5.3-34). Recent reconnaissance indicates that shoreline vegetation is extremely sparse and thus the water level increase would have a negligible impact on terrestrial biota.

As stated in Subsection 2.4.1, several species of water birds have nested on the terminal ends of the "Y-dike" in the MCR since the mid-1980s (Figure 2.4-1, Table 2.4-1). These birds tend to nest on the road bed positioned on the crown of the dike and areas immediately adjacent to this road. An increase in water level of 2 feet will not encroach on these nests. Also, most of the 7-mile-long dike system is not being used by these nesting birds and is available as nesting habitat.

Wintering waterfowl and other water birds (recent reconnaissance) use this reservoir for foraging and resting (see Subsection 2.4.1) (Reference 5.3-35). Baker and Greene noted a shift from dabbling to diving ducks as the reservoir was initially filled (Reference 5.3-35). Diving ducks typically feed in waters less than 10 feet (3 meters) deep (References 5.3-36 and 5.3-37). Depending on the depth, some species that forage on benthos may lose a portion of the reservoir floor as foraging habitat due to the increased reservoir depth, but some of this loss should eventually be replaced as mollusks and other invertebrates colonize the newly flooded portions of the reservoir shoreline. Most piscivorous birds, such as eagles, ospreys, pelicans, herons, and gulls, forage on or near the surface of the reservoir and along its banks and will not be affected by a water level increase. These conclusions are based on the assumption that the fish populations are not affected (see Subsection 5.3.2).

5.3.3.2.2 Cooling Towers

Salt Drift

The two mechanical draft cooling towers will be positioned immediately south of Units 3 & 4 in an industrial/developed area. Vegetation adjacent to this area includes relatively open habitats: mowed areas and other areas dominated by bluestem grasses, dewberry, and sea myrtle, all plants common to disturbed or abandoned agricultural land in this region (Reference 5.3-34). Vegetation near the cooling towers could be subjected to salt deposition attributable to drift from the towers. Salt deposition could potentially cause vegetation stress, either directly by deposition of salts onto foliage or indirectly from accumulation of salts in the soil.

To evaluate salt deposition on plants, an order-of-magnitude approach was used since some plant species are more sensitive to salt deposition than others, and tolerance levels of most species are not well known. Deposition of sodium chloride at rates of approximately 1 to 2 pounds per acre per month is typically not damaging to plants, while deposition rates approaching or exceeding 9 pounds per acre per month in any month during the growing season could cause leaf damage in many species (Reference 5.3-16). An alternate approach for evaluating salt deposition is to use 9 to 18 pounds per acre per month of sodium chloride deposited on leaves during the growing season as a general threshold for visible leaf damage (Reference 5.3-16).

As presented in Subsection 5.3.3.1.3, the maximum expected salt deposition rate from the combination of both towers would be 160 pounds per acre per month during the summer. This maximum rate is approximately 18 times greater than the approximately 9 pounds per acre per month rate that is considered a threshold value for leaf damage in many species. However, the distance to the maximum deposition is only 0.12 mile (660 feet) from the center of the towers (Figure 5.3-1). No deposition greater than 8.9 pounds per acre per month would occur beyond 1600 feet (0.3 mile), thus all deposition above 8.9 pounds will occur within the site boundary and most of the deposition will occur on facilities rather than vegetation. As previously discussed, the vegetative cover in the vicinity of the cooling towers is either mowed areas or bluestem/sea myrtle habitat found on previously disturbed agricultural lands, both marginal habitat for most wildlife. Any impacts from salt drift on the local terrestrial ecosystems would therefore be SMALL and would not warrant mitigation. Cumulative impacts are discussed in Section 10.5.

Vapor Plumes and Icing

As discussed in Subsection 5.3.3.1.1, the expected average plume length would range from 0.2 to 0.4 miles and the expected median plume length would be less than 0.2 miles (all seasons). As discussed in Subsection 5.3.3.1.2, ground level fogging as a result of cooling tower operation is not predicted to occur. Similarly, icing resulting from the cooling towers is not predicted to occur. Therefore the impacts of fogging and icing on terrestrial ecosystems would be SMALL and would not warrant mitigation.

Precipitation Modifications

As discussed in Subsection 5.3.3.1.4, the predicted maximum precipitation from the cooling towers would be approximately 2 inches of rain per year at 660 feet north of the towers. This amount is very small compared to the average annual precipitation of approximately 48 inches for the South Texas region over the 1971 to 2000 period (Reference 5.3-33). Thus, additional precipitation resulting from operation of the proposed units on local terrestrial ecosystems would be SMALL and would not warrant mitigation.

Noise

Noise from the operation of each cooling tower would be approximately 65 dBA at 50 feet from the tower, according to vendor-supplied data. This noise level is below 80 to 85 dBA, the sound level at which some birds and small mammals are startled or frightened (Reference 5.3-38). Thus, it is unlikely that noise from each tower would disturb wildlife at distances greater than 50 feet from the tower. The incremental increase in noise resulting from simultaneous operation of the two cooling towers would be insignificant. Given that estimated noise level (51 dBA at 400 feet) associated with the new cooling towers is below the 60-65 dBA the NRC considers of small significance (Reference 5.3-32), noise impacts to terrestrial ecosystems would be SMALL and would not warrant mitigation.

Avian Collisions

As discussed in Subsection 5.3.3.1, the two mechanical draft cooling towers associated with STP 3 & 4 will be 119 feet high. While tall natural draft cooling towers have been associated with bird kills, there have been no reported bird kills on the existing STP 1 & 2 buildings and the relatively lower height of mechanical draft cooling towers pose little risk to migrating birds and cause negligible mortality (Reference 5.3-32). Therefore, impacts to birds from collisions with the cooling towers would be SMALL and would not warrant mitigation.

In summary, there are SMALL impacts to terrestrial ecosystems or biota as a result of operation of the heat dissipation systems.

5.3.4 Impacts to Members of the Public

This section describes the potential health impacts associated with the cooling system for the new units. Specifically, impacts to human health from thermophilic microorganisms and from noise resulting from operation of the cooling system are addressed.

As described in Section 3.4, the existing MCR will be used as a closed-cycle cooling system for STP 3 & 4. Mechanical draft cooling towers will be constructed to assist in heat load dissipation and serve as the UHS. Thermal discharges will result from the following systems:

- Circulating Water System discharge to the MCR
- Turbine Service Water discharge to the MCR
- Mechanical draft cooling tower blowdown to the MCR

5.3.4.1 Thermophilic Microorganism Impacts

Consideration of the impacts of microorganisms on public health are important for facilities using cooling ponds, lakes, canals, or small rivers, because use of such water bodies may significantly increase the presence and numbers of microorganisms. “Microorganisms that are associated with cooling towers and thermal discharges can have negative impacts on human health. The presence and numbers of these organisms can be increased by the addition of heat; thus they are called thermophilic organisms. These microorganisms include the enteric pathogens *Salmonella sp*. and *Shigella sp.* as well as *Pseudomonas aeruginosa* and thermophilic fungi. They also include the bacteria *Legionella sp*., which causes Legionnaires’ disease, and free-living amebae of the genera *Naegleria* and *Acanthamoeba*. Exposure to these microorganisms, or in some cases the endotoxins or exotoxins produced by the organisms, can cause illness or death” (Reference 5.3-39).

These microorganisms are the causative agents of potentially serious human infections, the most serious of which is attributed to *Naegleria fowleri*. *Naegleria fowleri* is a free-living ameba that occurs worldwide. It is present in soil and virtually all natural surface waters such as lakes, ponds, and rivers. *Naegleria fowleri* grows and reproduces well at high temperatures (104º to 113ºF) and has been isolated from waters with temperatures as low as 79.7ºF (Reference 5.3-16). *Naegleria fowleri* thrives in warm, fresh water, particularly if the water is stagnant or slow moving. These protozoa are found in a variety of water bodies, including lakes, ponds, and poorly maintained swimming pools and hot tubs. Since a primary food source for the amebae is coliform bacteria, the presence of significant numbers of coliform bacteria will promote growth of this ameba. Although exposure to this organism is very common, the chance is less than 1 in 100 million that a person exposed to water inhabited by *Naegleria* will become infected. The route of infection is through the nasal passages, then on to the brain and spinal cord. The few cases reported in Texas have occurred in the months of May through September. Symptoms include changes in the ability to taste or smell, rapidly followed by headache, fever, nausea, and vomiting. While the disease is not transmissible from person to person, it is usually fatal (Reference 5.3-40).

On a routine frequency, the Center for Disease Control (CDC) compiles statistical data regarding waterborne disease and outbreaks in the United States. A review of reported data from 1997 through the most recent reporting cycle (2004) indicates that there have been seven reported cases of primary amebic meningoencephalitis associated with recreational waters (References 5.3-40, 5.3-41, 5.3-42, and 5.3-43). In addition, one case was reported by Texas Department of State Health Services (TDSHS) in 2005 (Reference 5.3-44). All cases were from water bodies in the central and northwestern portions of the state. None of the reported cases were in the vicinity of STP 3 & 4.

There are no regulations that could be tied to microorganisms that are associated with cooling towers or thermal discharges. No Occupational Safety and Health Administration (OSHA) or other legal standards for exposure to microorganisms exist at the present time.

Personnel access to the MCR is strictly controlled per administrative controls and security patrols. The MCR is located within the fenced site boundary, precluding access by members of the public. The anticipated usage frequency of the blowdown system has not been experienced during the years of operating STP 1 & 2. A single blowdown system test was performed in 1997. The capability for blowdown is to be retained, as the addition of the heat load from STP 3 & 4 may require this operation (see Subsection 3.4.2.4). All blowdowns will be within limits set in the TPDES wastewater discharge permit. TPDES discharge temperature limits would result in effluent temperatures between 95º–97ºF. Blowdowns would occur during high river flow periods (winter and spring) when river temperatures are significantly lower than the discharge temperature and not conducive to *Naegleria* blooms.

The risk to public health from thermophilic microorganisms associated with the potential discharge of MCR water via blowdown system operation would be SMALL and would not warrant mitigation.

5.3.4.2 Noise Impacts

The principal sources of noise related to cooling system operations are the mechanical draft cooling towers and pumps to supply cooling water. As described in Subsection 4.4.1, there are no applicable state or local noise regulations for unincorporated areas of Matagorda County, where STP is located. As discussed in Subsection 2.2.1.2, the nearest full-time residence is approximately one and a half miles west-southwest from the exclusion area boundary (EAB) or approximately two and a third miles west-southwest from the site of the new units (Figure 2.1-1), and distance and vegetation will attenuate any noise. Relative to the location of the nearest full-time residence, STP 3 & 4 cooling towers would be located approximately 0.6 mile from the site boundary. STPNOC has not received complaints about the noise of the existing units.

The overall cooling tower noise emissions are predicted to be 71 dBA 5 feet from the inlet and 51 dBA 400 feet from the inlet. Although there is no data available on RMPF noise levels, it is anticipated that these levels will not increase above existing STP 1 & 2 levels, which have not presented noise issues. Additionally, the RMPF is oriented to the east, away from the nearest full-time residence. As reported in the Generic Environmental Statement for License Renewal of Nuclear Power Plants (NUREG-1437) and referenced in NUREG-1555, noise levels below 65 dBA are considered of small significance (References 5.3-32 and 5.3-16). The day-night noise levels that are anticipated from the plant's cooling towers and cooling systems are less than 65 dBA at the site boundary, which is considered to be of small significance to the public. Thus, the impacts due to noise would be SMALL and would not warrant mitigation.

5.3.4.3 References

5.3-1 What Is the "Texas Pollutant Discharge Elimination System (TPDES)"? TCEQ 2007. Available at http://www.tceq.state.tx.us/permitting/water_quality/wastewater/pretreatment/tpdes_definition.html.

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Table 5.3-1 General Concurrence on "Important Species" in Lower Colorado River/Matagorda Bay Estuarine System

Species	NOAA ELMR [1]	TPWD "principal fisheries" [2]	TPWD "recreationally important" [3]	NRC [4]	LCRA [5]
American oyster	✓	✓			✓
Brown shrimp	✓			✓	✓
White shrimp	✓	✓		✓	✓
Blue crab					
Gulf menhaden	✓			✓	✓
Bay anchovy	✓			✓	
Sheepshead	✓	✓			
Sand sea trout	✓		✓	✓	
Spotted sea trout	✓		✓	✓	✓
Atlantic croaker	✓			✓	✓
Black drum	✓	✓		✓	✓
Red drum	✓		✓	✓	✓
Striped mullet	✓	✓			✓
Southern flounder	✓	✓		✓	✓

✓ These species are not among the important finfish species listed in Table B.7 of NRC (1975), but receive considerable attention in the impact assessments of both NRC documents.

[1] References 5.3-14 and 5.3-15.

[2] Reference 5.3-17.

[3] Reference 5.3-18.

[4] References 5.3-2 and 5.3-9.

[5] Reference 5.3-24.

Table 5.3-2 Relative Abundance of Important Estuarine Organisms in Matagorda Bay

		Relative Abundance in Salinity Zones		
Species	**Life Stage**	**Tidal Fresh (<0.5 ppt)**	**Mixing (0.5–25 ppt)**	**Seawater (>25 ppt)**
American oyster *Crassostrea virginica*	Adult	Rare	Common	Rare
	Spawning adults	–	Common	–
	Juveniles	Rare	Common	Rare
	Larvae	Rare	Common	Rare
	Eggs	–	Common	–
Brown shrimp *Farfantepenaeus aztecus*	Adult	–	Common	Highly Abundant
	Spawning adults	–	–	–
	Juveniles	Common	Highly Abundant	Common
	Larvae	Common	Highly Abundant	Highly Abundant
	Eggs	–	–	–
White shrimp *Penaeus setiferus*	Adult	Rare	Abundant	Common
	Spawning adults	–	–	–
	Juveniles	Highly Abundant	Abundant	Common
	Larvae	Highly Abundant	Highly Abundant	Highly Abundant
	Eggs	–	–	–
Blue crab *Callinectes sapidus*	Adult	Common	Abundant	Common
	Spawning adults	Common	Rare	
	Juveniles	Common	Abundant	Common
	Larvae	Highly Abundant	Abundant	Common
	Eggs	–	Rare	Common
Gulf menhaden *Brevoortia patronus*	Adult	–	Abundant	Highly Abundant
	Spawning adults	–	–	–
	Juveniles	Highly Abundant	Highly Abundant	Highly Abundant
	Larvae	–	–	–
	Eggs	–	–	–
Bay anchovy *Anchoa mitchelli*	Adult	Abundant	Highly Abundant	Common
	Spawning adults	Common	Highly Abundant	Common
	Juveniles	Abundant	Abundant	Common
	Larvae	Abundant	Common	Common
	Eggs	Common	Common	Common

Table 5.3-2 Relative Abundance of Important Estuarine Organisms in Matagorda Bay (Continued)

		Relative Abundance in Salinity Zones		
Species	**Life Stage**	**Tidal Fresh (<0.5 ppt)**	**Mixing (0.5–25 ppt)**	**Seawater (>25 ppt)**
Sheepshead *Archosargus probatocephalus*	Adult	Common	Abundant	Abundant
	Spawning adults	–	–	–
	Juveniles	Common	Abundant	Common
	Larvae	–	–	–
	Eggs	–	–	–
Sand sea trout *Cynoscion arenarius*	Adult		Common	Common
	Spawning adults	–	–	–
	Juveniles	Common	Common	Common
	Larvae	–	–	–
	Eggs	–	–	–
Spotted sea trout *Cynoscion nebulosus*	Adult	Rare	Common	Common
	Spawning adults	–	Common	Common
	Juveniles	Rare	Common	Common
	Larvae	–	Common	Common
	Eggs	–	Common	Common
Atlantic croaker *Micropogonias undulatus*	Adult	Abundant	Abundant	Abundant
	Spawning adults	–	–	–
	Juveniles	Abundant	Highly Abundant	Abundant
	Larvae	–	–	–
	Eggs	–	–	–
Black drum *Pogonias cromis*	Adult	–	Common	Common
	Spawning adults	–	–	Common
	Juveniles	Common	Common	Common
	Larvae	–	–	Common
	Eggs	–	–	Common
Red drum *Sciaenops ocellatus*	Adult	Rare	Rare	Common
	Spawning adults	–	–	Common
	Juveniles	Common	Common	Common
	Larvae	–	–	Common
	Eggs	–	–	Common

Table 5.3-2 Relative Abundance of Important Estuarine Organisms in Matagorda Bay (Continued)

		Relative Abundance in Salinity Zones		
Species	**Life Stage**	**Tidal Fresh (<0.5 ppt)**	**Mixing (0.5–25 ppt)**	**Seawater (>25 ppt)**
Striped mullet *Mugil cephalus*	Adult	Common	Abundant	Abundant
	Spawning adults	–	–	Abundant
	Juveniles	Abundant	Abundant	Abundant
	Larvae	–	–	Abundant
	Eggs	–	–	Abundant
Southern flounder *Paralichthys lethostigma*	Adult	Common	Abundant	Common
	Spawning adults	–	–	–
	Juveniles	Common	Common	Common
	Larvae	–	–	–
	Eggs	–	–	–

Source: Reference 5.3-14.
Note:
Rare = Present but not frequently encountered.
Common = Frequently encountered but not in large numbers: does not imply a uniform distribution throughout the salinity zone.
Abundant = Often encountered in substantial numbers relative to other species.
Highly Abundant = Numerically dominant relative to other species.
Blank Cell = Absent.

Table 5.3-3 Entrainment of Macroplankton and Ichthyoplankton (1983–1984)

	Start Date (sampling occurred overnight)				
	14-Jul-83	**27-Jul-83**	**9-Aug-83**	**15-Sep-83**	**5-Sep-84**
Mean Number of Macroplankton per 100 m^3 water in Colorado River (mid-depth) [1]	388.15	316.05	2,835.2	8,446.47	726.83
Mean Number of Ichthyoplankton per 100 m^3 water in Colorado River (mid-depth)m^3 [1]	7.4	148.35	6.17	19.42	3.4
Volume of water pumped through the RMPF (m^3) (daily average of 2 sampling days)	358,227	373,393	592,240	644,269	389,887.00
Number of Macroplankton entrained per 24 hours	1,390,458	1,180,109	16,791,188	54,417,988	2,833,816
Number of Ichthyoplankton entrained per 24 hours	26,509	553,929	36,541	125,117	13,256
Other Parameters					
Maximum salinity at screens: surface (ppt)	1.7	0.3	3.4	1.2	4.2
Maximum salinity at screens: bottom (ppt)	2.1	0.3	8	3.3	15.7
Average of 2-day river flow (cfs)	2,086	769	1,356.5	824	692

Sources: Reference 5.3-19.

Data collected in 1984 are from McAden et al (Reference 5.3-21).

[1] Sum of all taxa, averaged over four sampling events during a 24-hour period.

Table 5.3-4 Impingement on RMPF Screens (1983–1984)

	Start Date (sampling occurred overnight)					
Species	**13-Jul-83**	**21-Jul-83**	**27-Jul-83**	**9-Aug-83**	**15-Sep-83**	**5-Sep-84**
Palaemonetes paludosus	1	14	2	1	0	0
Palaemonetes kadiakensis	0	0	1	1	0	0
Palaemonidae sp.	0	0	2	0	0	0
Macrobrachium ohione	21	4	3	4	1	4
Penaeus setiferus	0	0	0	3	13	4
Penaeus duorarum	0	0	0	0	0	1
Callinectes sapidus	55	6	10	44	4	6
Caranx hippos	1	0	0	0	0	0
Menidia beryllina	0	1	0	0	0	0
Lepomis cyanellus	0	1	0	0	0	0
Total number of individuals impinged [1]	78	26	18	53	18	15
Total number of individuals impinged on all screens for 24 hours = (n)(12)(16)	14976	4992	3456	10176	3456	2880
Other Parameters						
Maximum salinity at screens: surface (ppt)	2.7	0.2	0.3	3.4	1.2	4.2
Maximum salinity at screens: bottom (ppt)	3.3	0.2	0.4	8	2.8	15.7
Average of 2-day river flow (cfs)	757	1907.5	769	1356.5	824.5	692
Average of 2 day pumpage (m^3)	210,219	1,048,919	373,392	592,240	644,269	398,887

Sources: Reference 5.3-19.

Reference 5.3-21.

[1] Values in cells = Number impinged on 2 screens for 90 minutes. To get total impingement, multiply by 12 for total screens and by 16 for full day.

Table 5.3-5 Trends in Abundance of Important Estuarine Organisms in Matagorda Bay and Coast-wide 1985–2003

	Gear Type	East Matagorda Bay [2]	Matagorda Bay [1]	Coast-wide [3]
Brown shrimp *Farfantepenaeus aztecus*	Gill net – spring	ND	ND	ND
	Gill net – fall	ND	ND	ND
	Bag seine	+	=	+
	Trawl	=	=	+
White shrimp *Penaeus setiferus*	Gill net – spring	ND	ND	ND
	Gill net – fall	ND	ND	ND
	Bag seine	=	=	–
	Trawl	+	=	–
Blue crab *Callinectes sapidus*	Gill net – spring	=	=	–
	Gill net – fall	=	=	–
	Bag seine	=	–	–
	Trawl	–	=	–
Gulf menhaden *Brevoortia patronus*	Gill net – spring	=	=	ND
	Gill net – fall	=	=	ND
	Bag seine	=	=	ND
	Trawl	=	=	ND
Bay anchovy *Anchoa mitchelli*	Gill net – spring	ND	ND	ND
	Gill net – fall	ND	ND	ND
	Bag seine	ND	ND	ND
	Trawl	ND	ND	ND
Sheepshead *Archosargus probatocephalus*	Gill net – spring	=	+	–
	Gill net – fall	=	=	–
	Bag seine	=	=	ND
	Trawl	=	=	ND
Sand sea trout *Cynoscion arenarius*	Gill net – spring	ND	ND	ND
	Gill net – fall	ND	ND	ND
	Bag seine	=	=	ND
	Trawl	=	=	ND
Spotted sea trout *Cynoscion nebulosus*	Gill net – spring	=	+	+
	Gill net – fall	=	=	+
	Bag seine	=	=	–
	Trawl	=	=	ND
Atlantic croaker *Micropogonias undulatus*	Gill net – spring	=	=	–
	Gill net – fall	=	=	+
	Bag seine	=	–	–
	Trawl	+	=	+

Table 5.3-5 Trends in Abundance of Important Estuarine Organisms in Matagorda Bay and Coast-wide 1985–2003 (Continued)

	Gear Type	East Matagorda Bay [2]	Matagorda Bay [1]	Coast-wide [3]
Black drum *Pogonias cromis*	Gill net – spring	+	+	+
	Gill net – fall	=	+	+
	Bag seine	=	=	+
	Trawl	+	=	ND
Red drum *Sciaenops ocellatus*	Gill net – spring	+	+	+
	Gill net – fall	=	=	+
	Bag seine	=	=	–
	Trawl	=	=	ND
Striped mullet *Mugil cephalus*	Gill net – spring	=	=	ND
	Gill net – fall	=	=	ND
	Bag seine	=	=	ND
	Trawl	=	=	ND
Southern flounder *Paralichthys lethostigma*	Gill net – spring	=	=	–
	Gill net – fall	=	=	–
	Bag seine	=	-	ND
	Trawl	=	=	ND
Total Finfish [3]	Gill net – spring	+	+	+
	Gill net – fall		–	–
	Bag seine	=	=	ND
	Trawl	=	=	ND
American oyster [4] *Crassostrea virginica*	Spat	=	=	+
	Small	+	+	+
	Market size	+	+	+

Source: Martinez-Andrate, Campbell and Fuls (Reference 5.3-25). Trends in Relative Abundance and Size of Selected Finfish and Shellfish along the Texas Coast: November 1975 – December 2003. Texas Parks and Wildlife Management Data Series No. 232.

[1] Trends for East Matagorda Bay and Matagorda Bay were estimated by inspection of annual catch data from 1985 to 2003. No statistical analysis was used or implied.

[2] Coast-wide trends were described in the report based on all data since inception of the study, which varied by gear type and species. The earliest data was collected in 1975.

[3] Total includes some species not represented in this table.

[4] Oyster data was not reported for East Matagorda Bay separately.

Note: Relative Abundance Indicators:

+ Annual catch increased from 1985 to 2003.

– Annual catch decreased from 1985 to 2003.

= Annual catch showed no marked change from 1985 to 2003, either due to relatively steady catches or to large variations with no apparent pattern.

ND = no data.

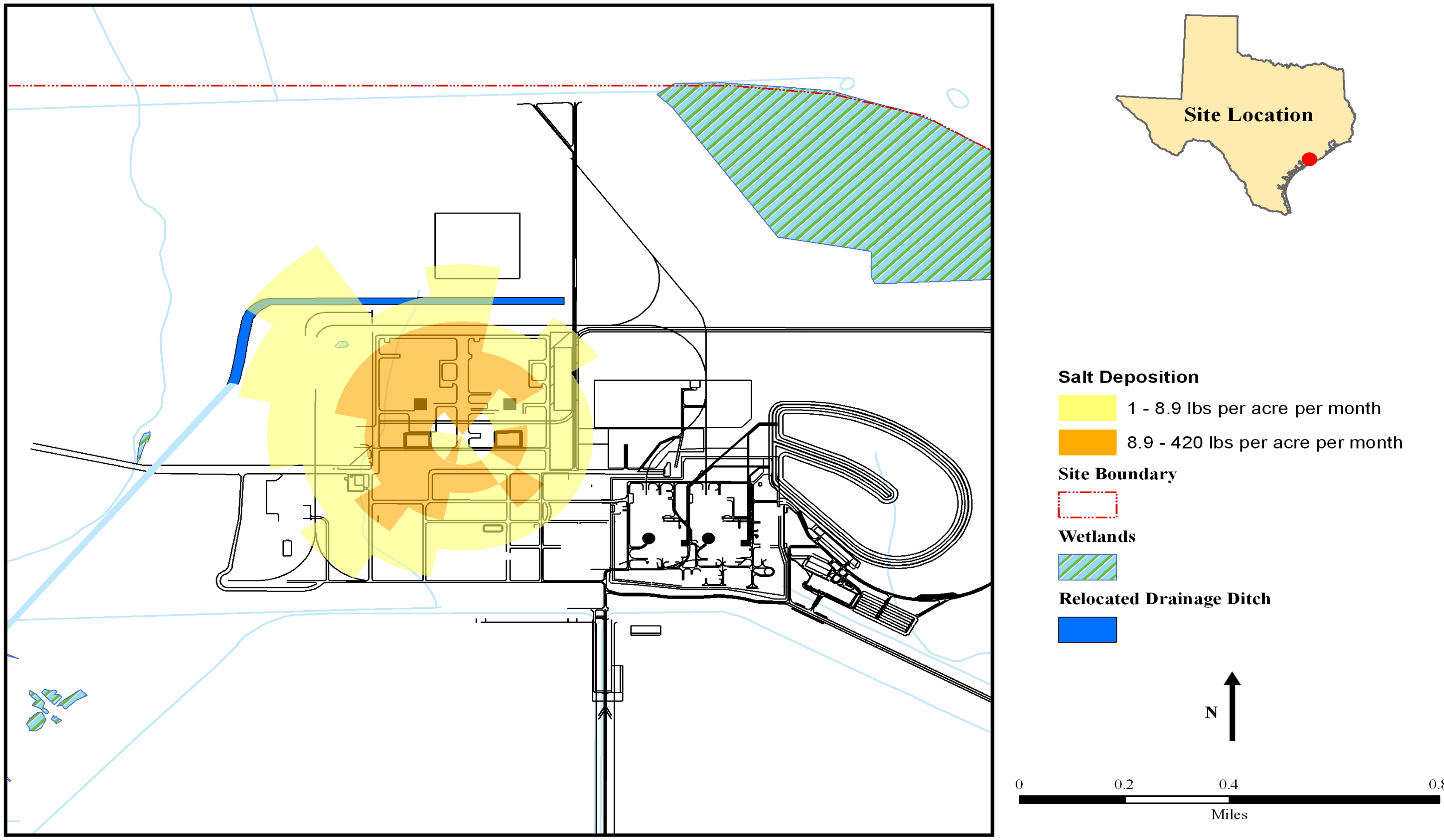

Figure 5.3-1 Summer Salt Deposition