2.4S.12 Groundwater

The following site-specific supplement addresses COL License Information Item 2.32.

This section describes the hydrogeologic conditions present at, and in the vicinity of, the STP 3 & 4 site. Regional and local groundwater resources that could be affected by the construction and operation of STP 3 & 4 are discussed. The regional and site-specific data on the physical and hydrologic characteristics of these groundwater resources are summarized in order to provide the basic data for an evaluation of impacts on the aquifers of the area.

The STP site covers an area of approximately 12,220 acres and is located on the coastal plain of southeastern Texas in Matagorda County. The power station lies approximately 10 mi north of Matagorda Bay. Nearby communities include Palacios, approximately 10 mi to the southwest and Bay City, approximately 12 mi to the northeast (Figure 2.4S.12-1). The closest major metropolitan center is Houston, approximately 90 mi to the northeast.

The 7000-acre Main Cooling Reservoir (MCR) is the predominant feature at the STP site, as shown in Figure 2.4S.12-2. The reservoir is fully enclosed with a compacted earth embankment, and it encompasses the majority of the southern and central portion of the site. The existing STP 1 & 2 facilities are located just outside of the MCR northern embankment. STP 3 & 4 is located further north of the embankment and to the northwest of STP 1 & 2.

The STP site, in general, has less than 15 ft of natural relief in the 4.5 mi distance from the northern to southern boundary. The northern section is at an elevation of approximately 30 ft above mean sea level (MSL). The southeastern section is at an elevation of approximately 15 ft above MSL. The Colorado River flows along the southeastern site boundary. There are also several unnamed drainages within the site boundaries, one of which feeds Kelly Lake.

Regional and local surface water features are described in Subsection 2.4S.1 and a geologic overview is presented in Subsection 2.5S.1.

2.4S.12.1 Description and Onsite Use

This section describes the regional and local groundwater aquifers and associated geologic formations, groundwater sources and sinks, and onsite use of groundwater.

2.4S.12.1.1 Regional Hydrogeologic Setting

The STP site is located in Matagorda County and lies in the Gulf Coastal Plains physiographic province within the Coastal Prairies sub-province, which extends as a broad band parallel to the Texas Gulf Coast (Figure 2.4S.12-3). The Coastal Prairies sub-province is characterized by relatively flat topography with land elevation ranging from sea level along the coast to 300 ft above sea level along the western boundary. The geologic materials underlying the Coastal Prairies sub-province consist of deltaic sands and muds (Reference 2.4S.12-1).

The STP site is underlain by a thick wedge of southeasterly dipping sedimentary deposits of Holocene age through Oligocene age. The site overlies what has been referred to as the "Coastal Lowland Aquifer System" (Figure 2.4S.12-4). This aquifer system contains numerous local aquifers in a thick sequence of mostly unconsolidated Coastal Plain sediments of alternating and interfingering beds of clay, silt, sand, and gravel. The sediments reach thicknesses of thousands of feet and contain groundwater that ranges from fresh to saline. Large amounts of groundwater are withdrawn from the aquifer system for municipal, industrial, and irrigation needs (Reference 2.4S.12-2).

The lithology of the aquifer system is generally sand, silt, and clay and reflects three depositional environments: continental (alluvial plain), transitional (delta, lagoon, and beach), and marine (continental shelf). The depositional basin thickens towards the Gulf of Mexico, resulting in a wedge-shaped configuration of hydrogeologic units. Numerous oscillations of ancient shorelines resulted in a complex, overlapping mixture of sand, silt, and clay (Reference 2.4S.12-2).

As part of the United States Geological Survey's (USGS) Regional Aquifer-System Analysis (RASA) program, the aquifer system was subdivided into five permeable zones and two confining units. The term "Gulf Coast Aquifer" is generally used in Texas to describe the composite of the sands, silts, and clays of the Coastal Lowland Aquifer System. Comparison of the USGS aquifer system nomenclature to that used in Texas is shown in Figure 2.4S.12-5. A cross-sectional representation is shown in Figure 2.4S.12-6 (Reference 2.4S.12-2).

The Texas nomenclature is used to describe the Gulf Coast Aquifer beneath the site. The hydrogeologic units commonly used to describe the aquifer system (from shallow to deep) are as follows (Figure 2.4S.12-5).

- Chicot Aquifer
- Evangeline Aquifer
- Burkeville Confining Unit
- Jasper Aquifer
- Catahoula Confining Unit (restricted to where present in the Jasper Aquifer)
- Vicksburg-Jackson Confining Unit

The base of the Gulf Coast Aquifer is identified as either its contact with the top of the Vicksburg-Jackson Confining Unit or the approximate depth where groundwater has a total dissolved solids concentration of more than 10,000 milligrams per liter (mg/L). The aquifer system is recharged by the infiltration of precipitation that falls on aquifer outcrop areas in the northern and western portion of the province. Discharge occurs by evapotranspiration, loss of water to streams and rivers as base flow, upward leakage to shallow aquifers in low lying coastal areas or in the Gulf of Mexico, and pumping.

In the shallow zones, the specific yield for sandy deposits generally ranges from between 10 percent and 30 percent. For the confined aquifer, the storage coefficient is estimated to range between 1×10^{-4} and 1×10^{-3}. The productivity of the aquifer system is directly related to the thickness of the sands in the aquifer system that contain freshwater. The aggregated sand thickness ranges from 0 ft at the up dip limit of the aquifer system to as much as 2000 ft in the east. Estimated values of transmissivity are reported to range from 5000 ft^2/day to nearly 35,000 ft^2/day (Reference 2.4S.12-2).

2.4S.12.1.2 Regional Groundwater Aquifers

The STP site is located over the Gulf Coast Aquifer System as shown on Figure 2.4S.12-7 (Reference 2.4S.12-3). The Gulf Coast Aquifer has not been declared a Sole Source Aquifer (SSA) by the United States Environmental Protection Agency (EPA) (Reference 2.4S.12-4). A SSA is the sole or principal source of drinking water for an area that supplies 50 percent or more of drinking water with no reasonably available alternative source should the aquifer become contaminated. Figure 2.4S.12-8 shows the location of SSAs in EPA Region VI, which includes Texas. The nearest Texas SSA is the Edwards I and II Aquifer System, which is located approximately 150 mi northwest of STP. Based on a southeasterly groundwater flow beneath Matagorda County, toward the Gulf of Mexico, and the distances to the identified SSAs, STP 3 & 4 will not adversely impact the SSAs in EPA Region VI. The identified SSAs are beyond the boundaries of the local and regional hydrogeologic systems associated with the STP site.

The principal aquifer used in Matagorda County is the Chicot Aquifer, which extends to a depth of greater than 1000 ft in the vicinity of the STP site, as shown on Figure 2.4S.12-9. The Chicot Aquifer is comprised of Holocene alluvium in river valleys and the Pleistocene age Beaumont, Montgomery, and Bentley Formations, and the Willis Sand (Reference 2.4S.12-5). Groundwater flow is, in general, southeasterly from the recharge areas north and west of the county to the Gulf of Mexico. Numerous river systems and creeks flow south and southeasterly through Matagorda County. River channel incisions can act as localized areas of recharge and discharge to the underlying aquifer system, resulting in localized hydraulic sources and sinks.

The Chicot Aquifer geologic units used for groundwater supply in the STP site area are the Beaumont Formation and the Holocene alluvium in the Colorado River floodplain. The following sections describe the pertinent details of these units.

2.4S.12.1.2.1 Beaumont Formation

The Beaumont Formation consists of fine-grained mixtures of sand, silt, and clay deposited in alluvial and deltaic environments. In the upper portion of the Beaumont Formation, sands occur as sinuous bodies, representing laterally discontinuous channel deposits, while the clays and silts tend to be more laterally continuous, representing their deposition as natural levees and flood deposits. The deeper portion of the unit, the Deep Aquifer, is greater than about 250 ft below ground surface in the vicinity of the site and has thicker and more continuous sands. This portion of the Beaumont Formation is the primary groundwater production zone for most of Matagorda County. Well yields in this interval are typically between 500 gallons per minute (gpm) and 1500 gpm with yields of up to 3500 gpm reported (Reference 2.4S.12-6). Groundwater occurs in this zone under confined conditions.

2.4S.12.1.2.2 Holocene Alluvium

Holocene alluvium of the Colorado River floodplain occurs in a relatively narrow band surrounding the river. The alluvial deposits are typically coarser-grained than the materials found in the Beaumont Formation. The alluvium consists of silt, clay, fine- to coarse-grained sand, and gravel, along with wood debris and logs (Reference 2.4S.12-6). In the immediate site area, the alluvium is too thin to be a significant source of groundwater. Since the alluvial materials are deposited in a channel incised into the Beaumont Formation, it is likely that the alluvium is in contact with the shallow aquifer units in the Beaumont Formation.

2.4S.12.1.3 Local Hydrogeology

The local hydrogeologic system is identified in the STP site area and it includes areas of groundwater - surface water interactions within a few miles of the site. The Beaumont Formation within the Chicot Aquifer (and to a lesser, extent, the Holocene alluvium associated with the Colorado River floodplain) is the principal water-bearing unit used for groundwater supply in the vicinity of STP. Within this area, the Chicot Aquifer is divided into two aquifer units, the Shallow Aquifer and the Deep Aquifer. The base of the Shallow Aquifer is 90 ft to 150 ft deep in the site area. The Shallow Aquifer has limited production capability and is used for livestock watering and occasional domestic use. Potentiometric heads are generally within 15 ft of ground surface (Reference 2.4S.12-6). The Deep Aquifer is the primary groundwater production zone and lies below depths of 250 ft to 300 ft. An overlying zone of predominately clay materials, usually greater than 150 ft thick, separates the Shallow and Deep Aquifers.

Recharge to the Shallow Aquifer is considered to be a few miles north of the site. Discharge is to the Colorado River alluvial material east of the site. Recharge to the Deep Aquifer is further north in Wharton County where the aquifer outcrops. Discharge from the Deep Aquifer is to Matagorda Bay, groundwater production wells, and the Colorado River estuary, approximately 5 mi southeast of the site. Shallow Aquifer groundwater quality is generally inferior to that of the Deep Aquifer (Reference 2.4S.12-6).

The Shallow Aquifer has been subdivided into upper and lower zones over the site area. Both zones respond to pumping as confined or semi-confined aquifers with somewhat different potentiometric heads. The Upper Shallow Aquifer is comprised of interbedded sand layers to depths of approximately 50 ft below ground surface. The Lower Shallow Aquifer consists of the sand layers between depths of approximately 50 ft to 150 ft below ground surface.

Aquifer pumping tests performed at the site in support of STP 1 & 2 indicate well yields from 10 gpm to 300 gpm in the Shallow Aquifer. These tests also indicate a variable degree of hydraulic connection between the Upper and Lower Shallow Aquifer zones (Reference 2.4S.12-7). Analysis of the aquifer pumping tests indicates that groundwater occurs under confined conditions at the four test sites. A pumping test conducted at STP Production Well 5 confirmed confined conditions in the Deep Aquifer (Reference 2.4S.12-8).

2.4S.12.1.4 Site Specific Hydrogeology

A geotechnical and hydrogeological investigation was performed to provide information on the STP 3 & 4 site to depths of 600 ft below ground surface. Subsurface information was collected from over 150 geotechnical borings and cone penetrometer tests (CPTs). A detailed description of the geotechnical subsurface investigation, including the locations of these borings and CPTs, boring logs, and soil testing data is provided in Subsection 2.5S.4.

Twenty-eight (28) groundwater observation wells were installed in the vicinity of the STP 3 & 4 site. The wells were completed in the Upper and Lower Shallow Aquifer. The wells were located to a) supplement the existing STP piezometer network in order to provide an adequate distribution for determining groundwater flow directions and b) provide additional information on the hydraulic gradients beneath the site. Well pairs were installed at selected locations to determine vertical gradients. Figure 2.4S.12-10 shows the locations of observations wells and piezometers at the STP site. Table 2.4S.12-1 presents the installation information for the newly installed observation wells. Field hydraulic conductivity tests (slug tests) were conducted in each observation well. Monthly water level measurements from these groundwater observation wells began in December 2006.

The subsurface data collected in late 2006 and early 2007 as part of the STP 3 & 4 site subsurface investigation confirmed the aquifer conditions described for STP 1 & 2. The top of the uppermost sand layer within the Upper Shallow Aquifer is encountered at a depth of about 15 ft to 30 ft below ground surface at STP 3 & 4. The groundwater level is about 5 ft to 10 ft below ground surface. The unit is comprised of sand and silty sand, approximately 15 ft to 20 ft thick. Multiple sandy units that are separated by silts and clays define the Lower Shallow Aquifer. The groundwater level in these sand intervals is about 10 ft to 15 ft below ground surface beneath the STP 3 & 4 facility area.

2.4S.12.1.5 Groundwater Sources and Sinks

The natural regional flow pattern in the Beaumont Formation is from recharge areas, where the sand layers outcrop at the surface, to discharge areas, which are either at the Gulf of Mexico or the Colorado River Valley alluvium. The outcrop areas for the Beaumont Formation sands are in northern Matagorda County (Shallow Aquifer) and Wharton County (Deep Aquifer), to the north of Matagorda County. In the outcrop areas, precipitation falling on the ground surface can infiltrate directly into the sands and recharge the aquifer. Superimposed on this simplistic flow pattern is the influence of heavy pumping within the aquifer. Concentrated pumping areas can alter or reverse the regional flow pattern. Further discussion of regional groundwater use and flow patterns is presented in Subsection 2.4S.12.2.

The Holocene alluvium receives recharge from infiltration of precipitation and groundwater flow from the Shallow Aquifer in the Beaumont Formation. In the site area, flow paths in the alluvium are short due to the limited surface area. Discharge from the Holocene alluvium contributes to the base flow of the Colorado River. The Colorado River is dammed to the south of Bay City to supply irrigation water canals. During certain times of the year the only sources of water to the Colorado River below the dam are irrigation tail water releases and base flow created by seepage from the Holocene alluvium. Because there are no flow-gaging stations downstream of the dam, the amount of base flow contributed by seepage is not known (Reference 2.4S.12-6).

The MCR is unlined and may act as a local recharge source to the Shallow Aquifer at the STP site. The historical, normal maximum operating level of the 7000-acre MCR is at an elevation of 49 ft above mean sea level, imposing a head of up to 20 ft above ground surface. The capacity of the reservoir at this elevation is 202,700 acre-ft. The reservoir embankment dike is designed to lower the hydraulic gradient across the embankment to the extent that the potentiometric levels of the soil layers in the plant area stay below the ground surface. This is accomplished through the use of low permeability clay (compacted fill), relief wells, and sand drainage blankets. Discharge to the environment from the MCR occurs from seepage through the reservoir floor to the groundwater. Groundwater flow from the reservoir is intercepted, in part, by the relief well system around the perimeter of the MCR, which is collected in toe and drainage ditches around the periphery of the reservoir embankment and then discharges to surface water features at various locations. Seepage discharge from the reservoir is composed of two parts: (a) seepage that is collected and discharged through about 700 relief wells that have been installed in the embankment around the reservoir to relieve excess hydrostatic pressure, and (b) seepage through the Upper Shallow Aquifer that bypasses the relief wells and continues down gradient. During the design stage, total seepage of the MCR was estimated to be 3530 gpm or approximately 5700 acre-ft/yr. Of this value, approximately 68 percent or 3850 acre-ft/yr would be discharged through the relief wells (Reference 2.4S.12-9).

2.4S.12.1.6 Plant Groundwater Use

Groundwater is currently used on the site to support STP 1 & 2 plant operations. The water is pumped from the Deep Aquifer using five production wells (Production Wells 5 through 8 and the Nuclear Training Facility [NTF] well). The production well depths are between 600 and 700 ft below ground surface with well capacities between 200 and 500 gpm as shown on Table 2.4S.12-2.

Figure 2.4S.12-10 shows the location of the existing site production wells. No sustained pumping is permitted within 4000 ft of the STP 1 & 2 plant area in order to minimize the potential for subsidence resulting from lowering of the Deep Aquifer zone potentiometric head. The exception is the NTF well, which was installed to provide water to the Nuclear Training Facility. (The NTF well only provides fire protection water to the NTF. Potable water for the NTF is supplied by Production Well 8.)

Groundwater use from these wells includes a makeup water source for the Essential Cooling Pond (ECP), makeup of demineralized water, the potable and sanitary water system, and the plant fire protection system (Reference 2.4S.12-9). Table 2.4S.12-3 presents the combined monthly groundwater withdrawals from the five production wells between 1995 and 2006. The table indicates that an annual groundwater usage of between 1200 and 1300 acre-ft is typical.

Groundwater is projected to be the main source of water for STP 3 & 4 plant operations. Operation of STP 3 & 4 is predicted to require a typical groundwater consumption of 1077 gpm or 1738 acre-ft per year. The peak groundwater consumption (i.e., plant outage) for STP 3 & 4 is expected to be as great as 3935 gpm. The projected combined STP plant typical groundwater consumption for STP 1 & 2 and STP 3 & 4 is expected to be between 2938 acre-ft and 3038 acre-ft per year. The impacts to the local groundwater aquifer system are discussed in Subsection 2.4S.12.3.3.

The groundwater supply wells to be used for STP 3 & 4 are not a safety-related water source because the Ultimate Heat Sink (UHS) has a 30-day supply of water, which is sufficient to allow plant shutdown without additional water supply.

2.4S.12.2 Groundwater Sources

This section describes historical and projected groundwater use, groundwater flow directions, groundwater hydraulic gradients, temporal groundwater trends, aquifer properties, and hydrogeochemical characteristics. STP site groundwater information is based on groundwater observation wells installed at the site, as shown on Figure 2.4S.12-10.

2.4S.12.2.1 Historical and Projected Groundwater Use

Groundwater pumpage in the Gulf Coast Aquifer system was relatively small and constant from 1900 until the late 1930s. Pumping rates increased sharply between 1940 and 1960 and then increased relatively slowly through the mid 1980s. By the mid 1980s withdrawals were primarily from the east and central area of the aquifer system. This included the Houston area but some of the greatest pumpage was associated with rice irrigation centered in Jackson, Wharton, and portions of adjacent counties including Matagorda. The highest water demand was from the upper portion of the Deep Aquifer (Reference 2.4S.12-2).

Problems associated with groundwater pumpage, such as land subsidence, saltwater encroachment, stream base-flow depletion, and larger pumping lifts have caused pumpage to be curtailed in some areas. By the mid 1980s, the Texas Water Development Board (TWDB) had made projections of groundwater use to 2030. For the 10 counties that withdrew the largest amount of water from the Gulf Coast aquifer system during 1985, state officials projected a large decline in pumping from six counties, which included Matagorda County. The county was expected to experience a net decrease of 48 percent or 15 million gallons per day (mgd), with pumping rates decreasing from 31 mgd to approximately 16 mgd (Reference 2.4S.12-2). The water use projections undergo revisions and updating as technical and socioeconomic factors change. These factors are discussed later in this section.

The EPA monitors drinking water supply systems throughout the country and displays the results on their Safe Drinking Water Information System (SDWIS) website (Reference 2.4S.12-10). Table 2.4S.12-4 presents a listing of SDWIS water supply systems in Matagorda County as of March 2007. Figure 2.4S.12-11 shows the locations of these water supply systems. A total of 40 systems are identified in Matagorda County by SDWIS with seven systems serving greater than 1000 people, 18 systems serving greater than 100 to less than 1000 people, and 15 systems serving less than or equal to 100 people. The closest SDWIS water supply systems are the onsite water supply (Water system ID TX1610051) and the Nuclear Training Facility water supply (Water system ID TX1610103). The nearest nonsite related SDWIS water supply system is the Selkirk Water System, which is located across the Colorado River from the STP, approximately 4 mi to the southeast (Water system ID TX1610027).

Groundwater use in the site area is controlled by the TWDB and locally (Matagorda County) by the Coastal Plains Groundwater Conservation District. The TWDB maintains a statewide database of wells called the Water Information Integration and Dissemination (WIID) system. This database includes water wells and petroleum production wells (Reference 2.4S.12-11). The Coastal Plains Groundwater Conservation District, in conjunction with the Coastal Bend Groundwater Conservation District (Wharton County), also maintains a database of water wells (Reference 2.4S.12-12).

Information from the TWDB database was used to prepare Figure 2.4S.12-12, which shows well locations near the STP site as of March 2007. Plate I in Appendix 2.4S.12-A shows known well locations in Matagorda County. This database includes water wells, driller's logs and petroleum wells, as designated on the figure and plate legends. Information for water wells contained in the database for Matagorda County is presented in tabular form in Appendices 2.4S.12-A1 and 2.4S.12-A2. The search area for wells was limited to Matagorda County because pumping effects in the Deep Aquifer and flow information in the Shallow Aquifer suggest that groundwater impacts from groundwater use or accidents at STP would be limited to this area. The tables show a total of 838 water wells in Matagorda County. It should be noted that Appendix 2.4S.12-A2 (Driller's Report database) includes 18 wells identified as being in other counties, but the well coordinates plot within Matagorda County. It is not known if these entries have erroneous county names or location coordinates.

Figure 2.4S.12-13 presents the water well information from the Coastal Plains Groundwater Conservation District in the STP area as of March 2007. Plate II in Appendix 2.4S.12-A and Appendix 2.4S.12-A3 present the data for Matagorda County. The database includes 1989 water wells in Matagorda County and water use values for a portion of the wells. The larger number of wells in this database is primarily a result of including single-family domestic wells.

The TWDB conducts water use surveys throughout the state. The surveys are based on water user submitted information and may include estimated values. These surveys do not include single-family, domestic well groundwater use. The results of these surveys are divided up into use categories and water supply media (groundwater or surface water). Table 2.4S.12-5 presents regional historical groundwater and surface water use data for Matagorda County (Reference 2.4S.12-13). The table indicates that irrigation is the greatest groundwater user, followed by manufacturing, steam electric power generation, and municipal supply.

The TWDB also prepares estimates of future water use as part of water supply planning. These estimates have uncertainties associated with population growth projections, assumptions about climatic conditions (drought or wet years), and schedules for implementation of water conservation measures. The estimates of future water use for steam electric power generation include increased demand based on higher generation capacity and increased reservoir blowdown to maintain water quality. Table 2.4S.12-6 presents projected water use through the year 2060 (Reference 2.4S.12-14). This information was combined with historical water use to prepare the graphical representation of water use, as shown on Figure 2.4S.12-14. The relative percentages of water use categories are projected to remain the same as the historical data.

2.4S.12.2.2 Groundwater Flow Directions

A regional potentiometric surface map for the Deep Aquifer in Matagorda County in 1967 is presented on Figure 2.4S.12-15 (Reference 2.4S.12-6). Figure 2.4S.12-16 presents a potentiometric surface map for the Gulf Coast Aquifer from data collected between 2001 and 2005 (Reference 2.4S.12-15). Comparison of the figures suggests the regional flow direction of northwest to southeast is represented on both figures with localized flow disturbances caused by pumping. Comparison of the figures also suggests that groundwater elevations have increased in some parts of Matagorda County. In 1967, groundwater elevations above mean sea level were primarily located in the northern portion of the county. In the 2001-2005 potentiometric surface map, groundwater elevations in the northern and central portions of the county were above mean sea level. The hydraulic gradient in the STP site area for the 1967 potentiometric surface map is approximately 0.0006 ft/ft and for the 2001 to 2005 map is approximately 0.0002 ft/ft. Regional potentiometric surface maps are not available for the Shallow Aquifer due primarily to its limited regional use.

Using available information from the existing STP site piezometers, site-specific groundwater level measurements from November 1, 2005 and May 1, 2006 were used to develop potentiometric surface maps for the Upper and Lower Shallow Aquifer (Figure 2.4S.12-17) and the Deep Aquifer (Figure 2.4S.12-18). The Upper Shallow Aquifer groundwater flow direction in the vicinity of STP 3 & 4 is generally toward the southeast. There is also an apparent southerly flow direction along the west side of the MCR. This southerly flow direction may be influenced by controlled leakage from the MCR or by the operation of the relief wells adjacent to the MCR dike. The groundwater flow direction in the vicinity of STP 3 & 4 in the Lower Shallow Aquifer is generally easterly. The Lower Shallow Aquifer flow direction turns southeasterly near the eastern edge of the site. Both the Upper and Lower Shallow Aquifer flow directions are consistent with flow toward the Holocene alluvium in the Colorado River floodplain. The potentiometric maps for the Deep Aquifer show the influence of onsite groundwater production, with a majority of the onsite groundwater flow toward the production wells. The onsite Deep Aquifer potentiometric surface suggests a reversal of the regional flow direction in the southern portion of the map, where flow is north towards the pumping wells, rather than toward the southeast.

The potentiometric surface maps were used to estimate hydraulic gradients at the site. For each map, a flow line originating in the area of STP 3 & 4 was drawn. The hydraulic gradient along these flow lines is estimated by dividing the head change along the flow line by the length of the flow line. The Upper Shallow Aquifer potentiometric surfaces indicate a hydraulic gradient of approximately 0.001 ft/ft. The Lower Shallow Aquifer maps indicate a hydraulic gradient of approximately 0.0004 ft/ft. The Deep Aquifer has a hydraulic gradient between approximately 0.0008 ft/ft and 0.002 ft/ft. The hydraulic gradient in the Deep Aquifer adjacent to STP 3 & 4 appears to be influenced primarily by changes in pumping at Production Well 6.

Monthly groundwater level measurements have been collected from the newly installed Shallow Aquifer observation wells for the STP 3 & 4 subsurface investigation. The measurements are presented on Table 2.4S.12-7. Well construction information is provided in Table 2.4S.12-1. The measurements were used to prepare the potentiometric surface maps shown on Figure 2.4S.12-19 for February and April of 2007. These maps indicate flow directions toward the southeast and southwest. The Upper Shallow Aquifer potentiometric surface map also shows seepage influence from the MCR and the duck pond/marsh located to the north of observation well pair OW-929U/L. The potentiometric surface maps indicate hydraulic gradients of approximately 0.001 ft/ft to 0.002 ft/ft for the southeast flow component in the Upper Shallow Aquifer and between approximately 0.0007 ft/ft and 0.0008 ft/ft for the southwest flow component. The Lower Shallow Aquifer hydraulic gradient is approximately 0.0004 ft/ft.

As part of the subsurface investigation program, well pairs screened in the Upper and Lower zones of the Shallow Aquifer were installed. These well pairs were used to estimate the vertical hydraulic gradient in the Shallow Aquifer. The vertical flow path length is assumed to be from the midpoint elevation of the Upper zone observation well screen to the midpoint elevation of the Lower zone observation well screen. Figure 2.4S.12-20 shows a generalized hydrogeologic section through the STP 3 & 4 area. This section shows the relationship between the Upper and Lower Shallow Aquifer zones and the interconnection of sand layers in the Lower Shallow Aquifer. The head difference over the vertical flow path is the difference in water level elevations between the two paired wells. The hydraulic gradient is estimated by dividing the head difference by the length of the flow path. Table 2.4S.12-8 presents the estimated vertical hydraulic gradients. All well pairs indicate a downward flow potential between the Upper and

Lower zones in the Shallow Aquifer. The estimated vertical hydraulic gradients range from approximately 0.06 ft/ft to 0.29 ft/ft in a downward direction. Additional geologic and geotechnical cross-sections are provided in Section 2.5S.

A specific concern with respect to the groundwater flow direction in the Shallow Aquifer is the impact of the MCR on the groundwater system. Figure 2.4S.12-21 presents a conceptual hydrogeologic section extending from the MCR to the STP 3 & 4 area. This section suggests that the influence of the MCR is restricted to the area immediately downgradient (outside) of the reservoir dike. The combined effects of the relief wells and the toe drain act to reduce the head applied by the reservoir. Further evidence of the effectiveness of this drainage system is the absence of significant water ponding on the downgradient side of the MCR dike.

2.4S.12.2.3 Temporal Groundwater Trends

The TWDB has collected groundwater level data in Matagorda County since the 1930s (Reference 2.4S.12-16). Two observation wells near the STP were selected to prepare the regional hydrographs shown on Figure 2.4S.12-22. These wells monitor two different intervals in the Deep Aquifer. Well 8015402 monitors the heavy pumping interval at about 300 ft below ground surface. This well indicates that between 1957 and the early 1990s, a significant drop in groundwater level occurred. Since the early 1990s, the groundwater level has been recovering and has nearly returned to the 1957 level. The second well, 8015301, monitors the deeper zone of the Deep Aquifer, corresponding to the production zone in the STP onsite wells (well depths from 600 ft to 700 ft below ground surface). This well shows generally stable water levels over the period of record for the well. Due to the limited groundwater development potential in the Shallow Aquifer, regional temporal measurements of water levels have not been collected.

Groundwater levels are monitored in site observation wells as part of STP 1 & 2 operations. Selected observation wells in proximity to STP 3 & 4 were used to prepare hydrographs of the Shallow and Deep Aquifers, as shown on Figure 2.4S.12-23. The monitoring data set selected extends from March 1995 through May 2006. Upper Shallow Aquifer Wells 603B and 601 are located to the west and east, respectively, of STP 3 & 4 and well 602A, which is located immediately north of the STP 3 area. Well 603B shows some seasonal variability on the order of 1 ft to 2 ft, while Well 601 shows little seasonal variability. Well 602A shows some seasonal variability, with a peak groundwater elevation over the period of record of 25.8 ft MSL and with a long term variability of approximately 4 ft. Lower Shallow Aquifer wells 603A and 601A are located to the west and east, respectively, of STP 3 & 4. These wells show some seasonal variability with an overall decreasing trend in groundwater elevation. The elevation difference between the two wells suggests that they may be screened in different sand units within the Lower zone. Deep Aquifer observation wells 613 and 605 are located to the southwest and north, respectively, of STP 3 & 4. These wells show a notable increase in water level elevation between 1996 and 1998. Water levels in Well 613 show a slight declining trend between 2004 and 2006. Well 613 is located within the influence of STP Production Well 6, which may be the cause of the slight decrease in groundwater levels.

Shallow Aquifer observation wells installed as part of the STP 3 & 4 subsurface investigation program have been used for monthly water level measurements since December of 2006. Monthly groundwater levels will be collected through December 2007 from the STP 3 & 4 observation wells. Confirmatory information, based on the additional water level measurements, will be provided in a future COLA update in accordance with 10CFR50.71(e) (COM 2.4S-2). Three well series designations represent the following location areas.

- OW-300 series wells are located in the proposed STP 3 facility area.
- OW-400 series wells are located in the proposed STP 4 facility area.
- OW-900 series wells include all of the wells located outside of the power block areas.

An "L" suffix on the well number indicates a Lower Shallow Aquifer well and a "U" suffix indicates an Upper Shallow Aquifer well.

Figure 2.4S.12-24 presents the hydrographs for these wells. These hydrographs suggest short-term temporal variations in the Upper Shallow Aquifer on the order of 1 ft to 2 ft. The Upper Shallow Aquifer wells show consistently higher groundwater elevations than the adjacent Lower Shallow Aquifer wells. Within the STP 3 & 4 power block area, depth to groundwater is approximately 5 ft below ground surface.

Based on the water level elevations collected to date, the groundwater depth in both power block areas is below the maximum groundwater level of 61 cm (2 ft) below ground surface as specified in DCD/Tier 2 Table 2.0-1 for the ABWR. The plant ground floor grade elevation for safety-related structures is anticipated to be 35 ft MSL. Based on this observation, a permanent dewatering system will not be needed at STP 3 & 4.

2.4S.12.2.4 Aquifer Properties

Between 1951 and 1980 the average annual precipitation in the general area of STP was about 42 inches, and the corresponding average annual runoff is estimated as about 12 inches (Reference 2.4S.12-2). The difference of approximately 30 inches is either evaporated, consumed by plants, or percolates into the vadose zone to recharge the shallow aquifers. Much of the water is returned to the atmosphere by evapotranspiration (Reference 2.4S.12-2).

The vadose zone is considered to be relatively thin and limited at the site. The first saturated sand zone is encountered at a general depth of approximately 20 ft below ground surface, and it is classified as part of the Upper Shallow Aquifer. The aquifer zone exhibits semi-confined to confined conditions. The potentiometric head is under pressure, rising to within 5 ft to 10 ft of ground surface as measured in the onsite observation wells. The soils overlying the sand are generally described as clay (CL to CH, USCS Groups). From the geotechnical data listed in Subsection 2.5S.4, measured natural moisture contents from samples collected to a depth of 20 ft ranged from approximately 5 percent to 29 percent. The majority of the values ranged between 15 percent and 25 percent. Dry unit weights for the materials sampled ranged from approximately 92 pounds per cubic foot (pcf) to 115 pcf. Wet densities, when measured, ranged from approximately 97 pcf to 133 pcf.

The properties of the aquifer materials at the STP site are divided into hydrogeological and geotechnical derived parameters. The hydrogeological parameters include transmissivity and storage coefficient measurements from aquifer pumping tests and hydraulic conductivity values determined from historical aquifer pumping tests and the slug tests performed in December

2006 as part of the STP 3 & 4 site subsurface investigation. The geotechnical parameters derived from laboratory testing include bulk density (or dry unit weight), porosity, effective porosity, and permeability from grain size.

The following are definitions of hydrogeological parameters adapted from Reference 2.4S.12-17:

- Transmissivity - The rate at which a fluid of a specified density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient and is a function of the properties of the fluid, the porous medium, and the thickness of the porous medium.
- Storativity (Storage Coefficient) - The volume of water released from or taken into storage per unit surface area of the aquifer per unit change in head.
- Hydraulic Conductivity (permeability) - A coefficient of proportionality describing flow per unit time under a unit hydraulic gradient through a unit area of a porous medium and is a function of the properties of the fluid and the porous medium.

2.4S.12.2.4.1 Hydrogeological Parameters

Regional aquifer properties have been collected by the TWDB (Reference 2.4S.12-6). Data for the area in proximity to the STP site is presented in Table 2.4S.12-9. Deep Aquifer transmissivity ranges from 10,500 gpd/ft to 195,300 gpd/ft and storage coefficient ranges from 4.6×10^{-5} to 1.4×10^{-3}. Although several of the wells in the table have screened intervals that encompass the depth interval associated with the Shallow Aquifer at the STP site, the screened intervals also extend into the Deep Aquifer, thus the test results cannot be applied to the Shallow Aquifer. Aquifer pumping tests have been performed on the STP site (Reference 2.4S.12-7 and Reference 2.4S.12-8) at three of the Deep Aquifer production wells and four test wells in the Shallow Aquifer in support of STP 1 & 2. The results of these tests are summarized in Table 2.4S.12-10. Transmissivity ranges from 1100 gpd/ft to 50,000 gpd/ft and the storage coefficient ranges from 2.2×10^{-4} to 1.7×10^{-3}.

Figure 2.4S.12-25 presents a graphical comparison of regional and site-specific measurements using box and whisker plots. The box and whisker plot, also known as a boxplot, is a graphical representation of the data based on dividing the data set into quartiles. The data range of the solid portion of the box encompasses 50 percent of the data and the data range of each whisker contains 25 percent of the data. The ends of the whiskers represent the minimum and maximum values in the data set. Examination of the transmissivity plot indicates that the regional and STP deep values fall within the same data range, while the STP Shallow Aquifer data range falls below the regional range. This is caused by two Upper Shallow Aquifer tests that have transmissivity values of 1100 gpd/ft and 12,500 gpd/ft. The plot for storage coefficient indicates that the regional, STP Deep Aquifer, and STP Shallow Aquifer all fall within the same data range. The Shallow Aquifer values fall within the upper portion of the regional range of data. This may be a result of aquitard leakage influencing the Shallow Aquifer tests.

Hydraulic conductivity can be determined from aquifer pumping tests by dividing the transmissivity by the saturated thickness. There is uncertainty associated with this method, because assumptions are made regarding the amount of permeable material present within the screened interval of the test well. The pumping wells have screened intervals ranging from 16 ft to 819 ft in length, and the saturated thickness is apportioned across this screened interval (possibly underestimating the hydraulic conductivity for the more permeable sand units crossed by the well screen intervals). Hydraulic conductivity values from the aquifer pumping tests are included in Table 2.4S.12-9 and Table 2.4S.12-10.

Hydraulic conductivity can also be determined by the slug test method. This method measures the water level response in the test well to an instantaneous change in water level in the well. A disadvantage of this method is that it measures hydraulic conductivity only in the immediate vicinity of the test well. However, because the slug test requires minimal equipment and can be performed rapidly, slug tests can be performed in many wells, allowing a determination of spatial variability in hydraulic conductivity. Table 2.4S.12-11 presents a summary of slug tests performed in observation wells installed as part of the STP 3 & 4 subsurface investigation program. The test results indicate a range of hydraulic conductivity from 9 gpd/ft^2 to 561 gpd/ft^2. The slug test results for the Upper and Lower zones of the Shallow Aquifer were contoured, as shown on Figure 2.4S.12-26 to delineate spatial trends. The Upper Shallow Aquifer contour map indicates areas of higher hydraulic conductivity in the vicinity of STP 3 and to the northwest of STP 4. The surrounding measurements suggest these areas are localized. The Lower Shallow Aquifer map indicates an area of higher hydraulic conductivity between STP 3 & 4 and extending to the south of the units. This area corresponds to the area of higher groundwater elevation identified on the February 22, 2007 potentiometric surface map for the Lower Shallow Aquifer shown on Figure 2.4S.12-19. The correspondence between a higher hydraulic conductivity area and higher potentiometric elevation suggests the presence of a flow pathway, such as a paleochannel, from the MCR toward STP 3 & 4.

Box and whisker plots comparing hydraulic conductivity from regional aquifer pumping tests, STP site aquifer pumping tests, STP site slug tests, and grain size data are shown on Figure 2.4S.12-27. The grain size derived hydraulic conductivity is discussed in Subsection 2.4S.12.2.4.2. The plots indicate that the slug tests have the greatest range of hydraulic conductivity. However, the geometric means for the aquifer pumping test derived hydraulic conductivity values and the slug test results are not significantly different (337 gpd/ft^2 versus 205 gpd/ft^2).

2.4S.12.2.4.2 Geotechnical Parameters

The geotechnical investigation component of the STP 3 & 4 subsurface investigation program included the collection of soil samples for laboratory determination of soil properties. These tests are discussed in Section 2.5S.4. A summary of the test results is presented in Table 2.4S.12-12. The results have been arranged to reflect the properties of the various hydrogeologic units present at the site. Basic soil properties are used to estimate the hydrogeologic properties of the materials such as porosity, effective porosity (specific yield), and permeability. Bulk density values were measured by the laboratory thus no further processing of the data was necessary.

Porosity is determined from a conversion of the void ratio to porosity. The effective porosity (or specific yield) is some fraction of porosity. In general terms, the effective porosity of sands or gravels approximates porosity, while the effective porosity of silts and clays is much less than their porosity. Figure 2.4S.12-28 (from Reference 2.4S.12-18) is a graph that shows the relationship between porosity, specific yield, and specific retention for various median grain sizes and sorting conditions. Interpolating from this graph for median grain sizes in the Shallow Aquifer and using the curve for average material, suggests that the specific yield is approximately 80 percent of the porosity of the Shallow Aquifer.

Permeability or hydraulic conductivity of sands with a D_{10} grain size between 0.1 and 3.0 mm can be estimated using the Hazen approximation (Reference 2.4S.12-18). This formula was based on empirical studies for the design of sand filters for drinking water. The formula was developed for use in well-sorted sand and application to poorer-sorted materials would result in over-prediction of permeability. Figure 2.4S.12-27 includes the grain size derived hydraulic conductivity with aquifer pumping test and slug test derived hydraulic conductivity. Comparison of the boxplots suggests that the grain size derived hydraulic conductivity is within the range of regional hydraulic conductivity values and the STP aquifer test ranges. Comparison of geometric means indicates the grain size derived hydraulic conductivity is similar to the STP aquifer test results.

The hydraulic conductivity of the clay materials was measured in the STP 1 & 2 subsurface investigation (Reference 2.4S.12-9). Table 2.4S.12-13 summarizes the results of these tests. The geometric mean hydraulic conductivity of the clay samples is 0.004 gpd/ft^2 (1.72 x 10^{-7} cm/sec). The clay samples were collected to a maximum depth of 39 ft below ground surface. The uniform depositional history and effects of consolidation and loading on clay hydraulic conductivity suggest that it would be a conservative assumption to apply these hydraulic conductivity values to deeper clays at the site.

2.4S.12.2.4.3 Representative Properties of Hydrogeologic Units

A simplified conceptual model of the STP site was developed to apply site parameters to the estimation of groundwater flow and contaminant transport. Figure 2.4S.12-29 presents a simplified hydrostratigraphic section of the site. The units presented on the section were used as a framework to relate measured or estimated properties to the groundwater system. A summary of important properties related to groundwater flow and contaminant transport is presented in Table 2.4S.12-14. The values for bulk density, total porosity, and effective porosity for the Deep Aquifer were taken from tests performed in the Lower Shallow Aquifer. The similarity of depositional environments and the observed grain size distributions suggest that an assumption of equivalence between the units is reasonable.

To assign representative values, the properties were divided into spatially and temporally variable data. Spatially variable data includes unit thickness, hydraulic conductivity, bulk density, porosity, and effective porosity. Representative values for the spatially variable data were assigned either an arithmetic mean (unit thickness, bulk density, porosity, and effective porosity) or a geometric mean (hydraulic conductivity) of the referenced data set. Temporally variable data are the hydraulic gradient measurements; the maximum value from each data set is assigned as the representative value.

2.4S.12.2.5 Hydrogeochemical Characteristics

Regional hydrogeochemical data were obtained from Reference 2.4S.12-6 and are presented in Table 2.4S.12-15. The data set includes ten wells in the Deep Aquifer and seven wells in the Shallow Aquifer. The analytical data was compared to EPA Primary and Secondary Drinking

Water Standards (Reference 2.4S.12-19) and exceedances are identified on the table. The principal exceedances were for total dissolved solids and chloride (Secondary Drinking Water Standards). Examination of data suggests that the highest concentrations of total dissolved solids and chlorides are present in the Shallow Aquifer.

STP site-specific hydrogeochemical data are presented in Table 2.4S.12-16, which includes seven samples from the Deep Aquifer and 23 samples from the Shallow Aquifer. The analytical data were compared to EPA Primary and Secondary Drinking Water Standards and the exceedances are identified in the table. The principal exceedances were for total dissolved solids and chloride. The data indicate that the highest concentrations of total dissolved solids and chloride are present in the Shallow Aquifer.

The hydrogeochemical data can also be used as an indicator of flow patterns in the groundwater system. Variations in chemical composition can be used to define hydrochemical facies in the groundwater system. The hydrochemical facies are classified by the dominant cations and anions in the groundwater sample. These facies may be shown graphically on a trilinear diagram (Reference 2.4S.12-20). A trilinear diagram showing the regional and STP site-specific data is presented on Figure 2.4S.12-30. The predominant groundwater type for the Deep Aquifer regional groundwater data is sodium-bicarbonate, while for the Shallow Aquifer regional data the groundwater type varies from sodium-bicarbonate to sodium-chloride. The predominant STP site-specific groundwater type is sodium-bicarbonate in the Deep Aquifer, sodium-chloride in the Upper Shallow Aquifer, and sodium-bicarbonate in the Lower Shallow Aquifer. An exception to the Lower Shallow Aquifer hydrochemical facies pattern is observed at observation wells OW-332L and OW-930L, where the water type is sodium-chloride. This facies change may indicate the proximity of a zone of vertical interconnection between the Upper and Lower Shallow Aquifers. This observation would be consistent with the findings of aquifer pumping test WW-4 (Reference 2.4S.12-7), which indicates a localized hydraulic connection between the Upper and Lower Shallow Aquifers. The conclusion that this is a localized connection is based on the absence of a hydraulic connection at the other three aquifer pumping test sites. The source of this interconnection may be either a natural feature, such as an incised channel or scour feature, or a man-made feature such as an excavation backfilled with pervious material or a leaking well seal. The manmade sources of interconnection are less probable, since the depth to the Lower Shallow Aquifer is on the order of 60 ft below ground surface, which would be below most site excavations, and leaky well seals also typically exhibit elevated pH associated with the impacts of cement grout, which is not observed at either of the wells.

Comparison of historical and more recent hydrogeochemical data indicates a general temporal consistency in groundwater chemistry for the individual aquifers present in the site area. This suggests that there are no long-term variations in groundwater chemistry occurring the site area.

2.4S.12.3 Subsurface Pathways

This section presents an evaluation of subsurface pathways for offsite exposure resulting from a liquid effluent release at STP 3 & 4. The section focuses on advective groundwater flow. Discussion of sorption and radioactive decay effects on offsite exposure is presented in Subsection 2.4S.13.

2.4S.12.3.1 Exposure Point and Pathway Evaluation

Figure 2.4S.12-31 presents the Blessing SE U.S. Geological Survey 7.5 minute quadrangle map of the site area (Reference 2.4S.12-21). This map shows onsite and offsite surface features considered in the evaluation. Review of regional groundwater use data presented in Subsection 2.4S.12.2.1 indicates that there is a credible Shallow Aquifer groundwater user exposure point in the vicinity of the STP site at Well 2004120846. This would be the most likely exposure point for the Shallow Aquifer groundwater. A second exposure pathway is via surface water, where the Shallow Aquifer discharges to local creeks or the Colorado River. The most likely exposure point for the Deep Aquifer would be the onsite groundwater production wells.

Off-site migration pathways were evaluated for the following hydrogeologic units:

- Upper Shallow Aquifer
- Lower Shallow Aquifer
- Deep Aquifer

The Upper Shallow Aquifer is the most likely hydrogeologic unit to be impacted by an accidental liquid effluent release onsite. Due to the shallow depth of this unit, a conservative release scenario would be a direct injection of liquid effluent into the Upper and Lower Shallow Aquifer. The Upper Shallow Aquifer has a flow direction toward the southeast, as discussed in Subsection 2.4S.12.2.2. Examination of Figure 2.4S.12-31 indicates that a potential Upper Shallow Aquifer groundwater discharge area would be the unnamed tributary, located to the east of the STP 1 & 2 Essential Cooling Pond (ECP), which flows into Kelly Lake, approximately 7300 ft from STP 3. A second possible discharge area for both the Upper and Lower Shallow Aquifer is at Well 2004120846, which is an 80 ft deep livestock well, located east of the site boundary approximately 9000 ft from STP 3. This pathway assumes the well discharges to stock watering containers and that the groundwater is consumed by livestock, which would be an indirect human exposure pathway. Information from Appendix 2.4S.12-A3 indicates this well is estimated to produce 200,000 gallons per year or approximately 0.4 gpm. A third possible discharge area for both Shallow Aquifer units would be the Colorado River, approximately 17,800 ft from STP 3.

The Lower Shallow Aquifer is isolated over much of the site by the Lower Shallow Aquifer Confining Layer. However, aquifer pumping test data (Subsection 2.4S.12.2.4.1) and hydrogeochemical data (Subsection 2.4S.12.2.5) suggest that leakage through the less permeable confining layer is occurring. Additionally, excavations for the foundations of some of the deeper structures are projected to enter the Lower Shallow Aquifer. Subsection 2.4S.12.2.2 indicates that a consistent downward vertical hydraulic gradient exists between the Upper and Lower Shallow Aquifer, which would provide the driving force for movement of groundwater from the Upper to the Lower Shallow Aquifer in the leakage areas. A conservative effluent release scenario would be a direct effluent release into the Lower Shallow Aquifer. Subsection 2.4S.12.2.2 indicates the Lower Shallow Aquifer has an east to southeast flow direction. Due to the depth to the top of the aquifer and the downward vertical hydraulic gradient in the Lower Shallow Aquifer, it is unlikely that discharge would occur into the unnamed tributary to the east of the STP 1 & 2 ECP. Likely discharge points are Well

2004120846, as discussed above, or the Colorado River alluvium, where the river channel has incised into the Lower Shallow Aquifer, approximately 17,800 ft from STP 3 & 4.

The Deep Aquifer is the least likely hydrogeologic unit to be impacted by an accidental liquid effluent release. The Deep Aquifer is separated from the Shallow Aquifer by a 100 ft to 150 ft thick clay and silt layer. Recent potentiometric surface maps for the Deep Aquifer (Subsection 2.4S.12.2.2) indicate that groundwater flow in the plant area is moving toward the production wells at the site, thus precluding the potential for offsite migration should the effluent pass through the clay layer. The additional groundwater needs for operation of STP 3 & 4 will further depress the potentiometric surface in the Deep Aquifer. The combined effects of horizontal flushing by flow in the Shallow Aquifer, radionuclide sorption as the effluent passes through the 100+ ft thick clay layer, and groundwater capture by the site production wells suggest that there is no credible offsite release pathway for the Deep Aquifer.

2.4S.12.3.2 Advective Transport

Advective transport assumes that a accidental liquid effluent release travels at the same velocity as groundwater flow. The groundwater flow velocity or average linear velocity is estimated from the following equation (Reference 2.4S.12-17):

$$v = \frac{Ki}{n_e}$$

where:

v = average linear velocity (ft/day)

K = hydraulic conductivity (ft/day)

i = hydraulic gradient (ft/ft)

n_e = effective porosity (decimal)

The travel time from the effluent source to the receptor would be:

$$T = \frac{D}{v}$$

where:

T = travel time (day)

D = distance from source to receptor (ft)

v = average linear groundwater velocity (ft/day)

Table 2.4S.12-17 presents average linear velocity and travel time estimates for the Upper Shallow Aquifer using information from Table 2.4S.12-14. The table includes ranges of groundwater velocities and travel times for the extremes (high and low) of the data set. The average linear velocity in the Upper Shallow Aquifer is estimated to be 0.2 ft/d and in the Lower Shallow Aquifer to be 0.09 ft/d. In the Upper Shallow Aquifer, travel time to the unnamed tributary east of the ECP would be 100 years, to Well 2004120846 it would be 123 years, and to the Colorado River it would be 244 years. In the Lower Shallow Aquifer, travel time to Well 2004120846 would be 274 years and to the Colorado River it is estimated to be 541 years.

2.4S.12.3.3 Plant Groundwater Use and Effects

Groundwater is projected to be the main source of water for STP 3 & 4 plant construction and operation. During construction, groundwater use requirements will vary and will be used for the following activities: onsite personnel consumption and use; manufacturing of concrete, concrete curing, and clean-up; dust control; addition of moisture and placement of engineered backfill; and piping hydro tests and flushing. Preliminary estimates indicate that up to 1200 gpm of groundwater will be required during construction.

STP is currently permitted to use up to 3000 acre-ft per year of groundwater from their existing production wells. STP currently uses about 1300 acre-ft per year for plant operations. Therefore, approximately 1700 acre-ft per year (1050 gpm) of groundwater could be available for construction use. Water demand could be met by increasing the yield of the existing wells or by installing new wells with the objective that total STP use would not exceed the 3000 acre-ft per year permitted amount. A detailed evaluation of groundwater availability and estimates of aquifer drawdown, requirements for permitting of new wells and yields, water conservation measures, and the identification of alternative sources, if practicable, will be addressed as part of the detailed engineering for STP 3 & 4.

Operation of STP 3 & 4 is predicted to require a typical groundwater consumption of 1077 gpm or 1738 acre-ft per year, whereas the peak groundwater consumption for STP 3 & 4 is expected to be as great as 3935 gpm, when required (i.e., outages). The projected combined STP plant normal groundwater consumption for STP 1 & 2 and STP 3 & 4 is expected to be between 2938 and 3038 acre-ft per year, which is approximately equal to the current STP permitted use of 3000 acre-ft per year. Peak demand for outages could be met by increasing the permitted groundwater allotment for short-term uses or by obtaining water from other sources such as the MCR or the Colorado River.

Based on these estimates, additional groundwater wells will be required to satisfy site demands. As with STP 1 & 2, it is expected that no sustained pumping will be permitted within 4000 ft of the plant safety-related facility areas in order to minimize the potential for regional subsidence resulting from lowering of the Deep Aquifer zone potentiometric head. Based on this requirement, the location of the additional groundwater wells required for expanded plant operations would most likely be located in the northwestern and northeastern sections of the STP site and/or in the southeastern and southwestern site areas adjacent to the MCR.

As stated in Subsection 2.4S.12.2.2, comparison of a regional potentiometric surface map for the Deep Aquifer in Matagorda County in 1967 (Figure 2.4S.12-15) and that of a potentiometric surface map for the Gulf Coast Aquifer from data collected between 2001 and 2005 (Figure 2.4S.12-16) suggests that groundwater elevations have increased in some parts of Matagorda County. In 1967, groundwater elevations above mean sea level were primarily located in the northern portion of the county. In the 2001-2005 potentiometric surface map, groundwater elevations in the northern and central portions of the county were above mean sea level. Therefore, the regional impacts of groundwater production on the aquifer groundwater levels appear to be decreasing, thus minimizing impact to the regional aquifer as the result of STP plant expansion with the construction and operation of STP 3 & 4. Some additional aquifer drawdown would be expected near the STP site boundaries as the result of installing and operating new groundwater wells. Based on Figure 2.4S.12-18, it can be expected that the lowering of the potentiometric head in the Deep Aquifer at the existing STP production would expand over most of the northern portion of the site due to the installation of the new site production wells. The decrease in head would be expected to extend beyond the site boundaries but the impact would be less than that beneath the site.

As part of the detailed engineering for the STP 3 & 4, the impact of the groundwater pumping in the Deep Aquifer will be evaluated to the current site conditions and that of nearby, offsite groundwater users (Figure 2.4S.12-13). Permitting of new wells and yields, plant water conservation methods, and the identification of alternative sources or recycling, if practicable, will be addressed as part of the detailed engineering for STP 3 & 4.

2.4S.12.4 Monitoring or Safeguard Requirements

Groundwater level monitoring in the STP 3 & 4 area is currently being implemented through the use of the groundwater observation wells installed in 2006 for the site subsurface investigation and through the periodic review of water levels from selected wells in the vicinity of the site.

Some of the existing STP 3 & 4 area observation wells will be taken out of service prior to construction activities due to anticipated earth moving and construction requirements. Prior to construction activities, the observation well monitoring network will be evaluated in the detailed design to determine groundwater data gaps and needs created by the abandonment of existing wells.

As part of the detailed design for STP 3 & 4, the current STP groundwater monitoring programs will be evaluated with respect to the addition of STP 3 & 4 to determine if any modification of the existing programs is required to adequately monitor plant effects on the groundwater. Considerations to revise the site groundwater monitoring program will include the following components:

- Deep Aquifer - Periodic water level measurements in deep observation wells and geochemical sampling and analysis of production wells would detect changes in the Deep Aquifer that may impact groundwater supply availability or the accident release analysis.
- Shallow Aquifer - Periodic water level measurements in the Upper and Lower zone observation wells and collection of geochemical samples and analysis will be performed in selected observation wells. The water level monitoring program objective is to detect changes in flow patterns in the Shallow Aquifer that might impact accident analysis and would track temporal trends in groundwater levels that might impact structural stability. The geochemical monitoring would detect changes in groundwater geochemistry that would be deleterious to plant structures and subsurface components.

- Subsidence Monitoring - The current plant subsidence monitoring program will be expanded to include STP 3 & 4.
- Operational Accident Monitoring - In the unlikely event of an operational accident, site observation wells in the Shallow and Deep Aquifers and onsite groundwater production wells in the Deep Aquifer would be sampled for radionuclides associated with the plant. Additional monitoring locations may be added if onsite monitoring indicates the potential for offsite exposure.

Groundwater level measurements in the Deep and Shallow Aquifers would be collected starting during construction and after plant startup Selection of observation wells to be included in the program will be made prior to the start of operation based on well condition, position relative to plant site and other observation wells (provide optimal spatial distribution for potentiometric map preparation and vertical hydraulic gradient assessment), and long-term viability of the observation well (likelihood well will survive construction).

Geochemical sampling and analysis in the Deep and Shallow Aquifers would be performed during construction and after startup. Analysis will include field parameters (pH, temperature, specific conductance, oxidation-reduction potential, and dissolved oxygen), major cations, major anions, total dissolved solids, and silica. Sampling would be performed in site production wells, any new production wells installed to support STP 3 & 4 operation, and selected observation wells in the Shallow Aquifer. Observation wells would be selected during detailed design.

Additional near-surface subsidence monuments would be installed around STP 3 & 4 structures. The onsite subsidence monitoring frequency would increase during construction and after startup.

Operational accident monitoring would be triggered in the unlikely event of a release of liquid effluent from the plant. Quarterly groundwater samples would be collected from site production wells and downgradient Shallow Aquifer observation wells. Selection of downgradient observation wells would be based on flow directions determined from the most recent groundwater level measurements.

Safeguards will be used to minimize the potential of adverse impacts to the groundwater by construction and operation of the new units. These safeguards would include the use of lined containment structures around storage tanks (where appropriate), hazardous materials storage areas, emergency cleanup procedures to capture and remove surface contaminants, and other measures deemed necessary to prevent or minimize adverse impacts to the groundwater beneath the STP 3 & 4 site.

2.4S.12.5 Site Characteristics for Subsurface Hydrostatic Loading

Subsurface hydrostatic loading estimates for structures at STP 3 & 4 were evaluated using two approaches. First, by conservatively assuming the maximum groundwater level of 61 cm (2 ft) below ground surface as specified in DCD Table 2.0-1 for the ABWR. The existing plant grade at the site is approximately 30 ft MSL and the finished plant grade in the Power Block area is anticipated to be between approximately 32 and 36.5 ft MSL, thus a grade elevation of 35 ft MSL would result in a maximum groundwater elevation of 33 ft MSL. The second approach uses the maximum observed groundwater level elevation (December 2006 - June 2007), within the STP 3 & 4 power block area; elevation 25.85 ft MSL from observation well OW-332U on April 27, 2007. The maximum hydrostatic loading is estimated using the following formula:

$$\rho_w = z_w \times \gamma_w$$

where:

ρ_w = hydrostatic pressure (psf)

z_w = depth below groundwater level (ft)

γ_w = unit weight of water (62.4 pcf)

Figure 2.4S.12-32 presents a graph of building elevation versus hydrostatic pressure. Two lines are provided on the graph, one representing the upper bound condition using the DCD maximum groundwater level and the second using the maximum observed groundwater level in the power block area.

Excavations for the construction of STP 3 & 4 are preliminarily planned to depths of about 90 ft below existing grade. The reactor building mat is expected to be placed at a depth of approximately 85 ft with the control building at a depth of approximately 75 ft, the UHS at a depth of approximately 40 ft, and the turbine building at a depth of approximately 30 ft. Perimeter dewatering will be required to a depth of at least 35 ft with deeper excavation dewatering to a depth of at least 100 ft. To minimize excess dewatering, the UHS would utilize a separate perimeter dewatering system. The excavation design may require the use of slope stability structures. The actual excavation design will be refined as part of the detailed design.

During excavation and construction of STP 3 & 4, the hydrostatic loading on the excavation and structures will be controlled by a temporary construction dewatering system. Typical dewatering systems for this type of cut and fill excavation would consist of a combination of perimeter dewatering wells and open pumping from sumps within the excavation. The perimeter dewatering wells would control lateral inflow and assist in removing water stored within the excavation. The open pumping system would control precipitation run-off, assist in water storage removal, and removal of any inflow to the excavation.

To prevent uplift of foundation soils, groundwater levels will be maintained a minimum of 5 ft below the bottom of the deepest excavation. The STP 3 & 4 excavation is deeper than the excavation for STP 1 & 2 (Reference 2.4S.12-9). The hydrogeologic conditions encountered beneath the proposed STP 3 & 4 are, in general, similar to that beneath STP 1 & 2. A long-term, steady state dewatering flow rate is estimated to be between 1800 and 4200 gpm. The range in pumping rates is dependent on the hydraulic conductivity used in the analysis (low range or geometric mean of the pumping test hydraulic conductivity values) and on the excavation plan. Because the excavation required for the construction of STP 3 & 4 is estimated to be deeper than that for STP 1 & 2, the flow rates estimated for STP 3 & 4 are considered to be within reason in comparison to actual flow rates measured at STP 1 & 2 (between 1300 gpm to 2900 gpm). Alternatives that could reduce the amount of water to be removed include various types of cut-off walls. The cut-off walls could include a slurry wall, grout curtain, or freeze-wall. The slurry wall and grout curtain are permanent features, while the freezewall can be temporary. Some dewatering would still have to be performed to remove storage, precipitation run-off, and vertical inflow. Methods to mitigate the subsidence beneath existing structures include cut-off walls, injection wells, and infiltration trenches. The dewatering system design will be refined as part of the detailed design.

Another concern is rewatering after completion of excavation and backfill around structures. Groundwater levels will be raised in a controlled manner to prevent rapid hydrostatic pressure build-up or damage to the subsurface backfill materials. Prior to the start of excavation, a dewatering and rewatering plan will be prepared to document the construction dewatering system design and groundwater control criteria.

In summary, based on the water level elevations collected to date, the groundwater depth in both power block areas is below the maximum groundwater level of 61 cm (2 ft) below ground surface as specified in DCD Table 2.0-1 for the ABWR. Based on this observation, a permanent dewatering system is not anticipated to be a design feature for the STP 3 & 4 facility. Post-construction groundwater conditions are anticipated to have some localized changes resulting from excavation and backfilling, however, based on observations of STP 1 & 2 post-construction groundwater conditions, the effects would be minimal and may include localized communication between the Upper and Lower Shallow Aquifers and an increased cone of depression in the Deep Aquifer resulting from increased groundwater use for STP 3 & 4. The groundwater supply wells to be installed for STP 3 & 4 are not a safety-related source of water because the UHS has a 30-day supply of water, which is sufficient for plant shutdown without a supplementary water source.

2.4S.12.6 References

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Table 2.4S.12-1 Observation Well Construction Details

Well Number[2]	Northing (ft) [3]	Easting (ft) [3]	Well Pad Elevation (ft MSL) [3]	Reference Elevation (ft MSL) [3]	Borehole Diameter (in)	Well Depth (ft bgs)	Screen Interval Depth [4]		Screen Interval Elevation [4]		
							Top (ft bgs)	Bottom (ft bgs)	Top (ft MSL)	Bottom (ft MSL)	To
OW-308L	363196.43	2943374.36	29.87	31.78	8	97.1	86	96	-56.13	-66.13	
OW-308U	363195.64	2943354.04	29.86	31.80	8	47.1	36	46	-6.12	-16.12	
OW-332L[1]	363739.87	2943610.91	30.24	31.85	8	103.2	92.1	102.1	-61.86	-71.86	
OW-332L(R)	363729.36	2943608.74	30.01	32.08	8	103.1	92	102	-61.99	-71.99	
OW-332U	363739.21	2943591.02	30.24	32.10	8	46.1	35	45	-4.76	-14.76	
OW-348L	362685.92	2943014.48	30.08	31.86	8	79.1	68.2	78.2	-38.12	-48.12	
OW-348U	362685.23	2942994.44	30.51	32.28	8	39.1	28	38	2.51	-7.49	
OW-349L	362901.84	2943602.97	29.41	31.03	8	81.1	70	80	-40.59	-50.59	
OW-349U	362902.40	2943582.28	29.40	31.29	8	46.1	35	45	-5.60	-15.60	
OW-408L	363196.18	2942472.54	31.73	33.76	8	81.3	70.2	80.2	-38.47	-48.47	
OW-408U	363194.01	2942456.01	31.50	33.57	8	43.1	32	42	-0.50	-10.50	
OW-420U	362902.15	2942018.94	32.25	33.79	8	49.1	38	48	-5.75	-15.75	
OW-438L	363790.77	2942045.09	30.11	31.57	8	104.1	93	103	-62.89	-72.89	
OW-438U	363792.04	2942025.17	30.53	32.18	8	41.0	30	40	0.53	-9.47	
OW-910L	363363.45	2941266.45	30.75	32.48	8	92.1	81	91	-50.25	-60.25	
OW-910U	363362.02	2941246.57	30.69	32.32	8	36.1	25	35	5.69	-4.31	
OW-928L	364932.30	2940376.21	29.81	31.56	8	121.1	110	120	-80.19	-90.19	
OW-928U	364933.86	2940356.48	30.02	31.69	8	39.6	28.5	38.5	1.52	-8.48	
OW-929L	364671.50	2945497.78	36.93	38.63	8	98.1	87	97	-50.07	-60.07	
OW-929U	364672.34	2945477.58	36.91	38.71	8	60.1	49	59	-12.09	-22.09	
OW-930L	360214.45	2949525.96	26.21	27.98	8	106.5	95	105	-68.79	-78.79	
OW-930U	360209.72	2949506.58	25.62	27.33	8	36.1	25	35	0.62	-9.38	
OW-931U	361979.42	2939520.36	30.53	32.10	7	36.0	25	35	5.53	-4.47	
OW-932L	361899.37	2942115.90	31.09	32.79	8	79.6	68.5	78.5	-37.41	-47.41	
OW-932U	361898.53	2942097.29	31.35	32.83	8	39.6	28.5	38.5	2.85	-7.15	
OW-933L	361898.05	2943515.01	28.74	30.45	8	87.1	76	86	-47.26	-57.26	
OW-933U	361897.65	2943494.86	28.87	30.62	8	37.1	26	36	2.87	-7.13	
OW-934L	362082.08	2948254.12	29.04	30.94	7	100.0	89	99	-59.96	-69.96	
OW-934U	362079.87	2948234.20	28.54	30.39	8	41.1	30	40	-1.46	-11.46	

[1] Well was found to be collapsed. Drilled and installed replacement well OW-332L(R)

[2] “L” suffix wells installed in Lower Shallow Aquifer and “U” suffix wells installed in Upper Shallow Aquifer

[3] Coordinates based on the North American Datum of 1927 (NAD27) and elevations based on National Geodetic Vertical Datum of 1929 (NGVD29)

[4] Observation well screens are 2 in diameter, 0.020 in slot width, 10 ft in length

Abbreviations: ft MSL = feet mean sea level, ft bgs = feet below ground surface, and in = inches

Table 2.4S.12-2 STP Production Well Information

Well No.	Year Drilled	Depth (ft)	Capacity (gpm)	Potable Water Source (Yes/No)	Casing Diameter (in)	Discharge Diameter (in)	La
5	1975	700	500	Yes	10.02	6.065	28° 4
6	1977	700	500	Yes	10.02	6.065	28° 4
7	1977	700	500	Yes	10.02	6.065	28°
8	1991	600	250	Yes	10.75	4	28°
Nuclear Training Facility	1985	600	200	No	8	3	28

Table 2.4S.12-3 STP Groundwater Withdrawals 1995-2006

Month	1995 (gallons)	1996 (gallons)	1997 (gallons)	1998 (gallons)	1999 (gallons)	2000 (gallons)	2001 (gallons)	2002 (gallons)	2003 (gallons)
January	7,765,025	41,812,919	39,525,831	36,128,090	34,041,991	35,446,250	44,476,292	31,115,804	36,279,188
February	12,521,357	37,551,891	36,180,612	29,461,480	32,117,186	30,568,014	42,574,575	36,198,000	31,944,711
March	22,598,920	41,169,835	38,532,459	36,223,601	29,792,357	32,643,753	48,053,000	33,244,000	28,020,000
April	24,601,783	43,177,241	35,683,774	33,649,929	27,093,385	35,652,764	40,828,467	29,628,405	28,524,378
May	25,618,936	45,752,274	38,428,753	38,956,861	35,593,523	36,847,100	35,327,680	37,118,205	43,365,000
June	19,654,117	41,995,128	35,811,044	42,057,320	31,347,265	40,259,759	35,534,592	36,604,000	29,816,000
July	31,055,407	35,369,911	43,862,008	41,054,570	37,595,060	43,141,872	35,660,218	30,254,000	36,912,782
August	33,187,388	32,728,731	42,628,395	36,127,366	36,092,764	43,008,513	38,193,859	29,863,036	45,828,000
Sept.	24,719,646	33,787,725	37,324,840	34,910,719	36,325,308	40,309,148	31,716,791	33,151,000	39,865,019
October	25,744,319	42,742,696	34,426,989	38,050,780	30,770,476	38,460,958	37,052,232	25,675,791	37,863,296
November	22,606,096	38,944,140	35,413,702	32,764,920	36,391,863	31,657,842	30,886,310	33,875,759	37,353,000
December	21,338,258	39,694,275	33,674,338	34,950,153	36,841,789	29,493,213	33,436,651	34,751,855	30,409,159
Total (gallons)	271,411,252	474,726,766	451,492,745	434,335,789	404,002,967	437,489,186	453,740,667	391,479,855	426,180,533
Total (acre-feet)	833	1,457	1,386	1,333	1,240	1,343	1,392	1,201	1,308

Table 2.4S.12-4 Listing of U.S. Environmental Protection Agency (EPA) Safe Drinking Water Information System (SDWIS) Community and Non-Community Groundwater Systems in Matagorda County, Texas

Community Water Systems: Water Systems that serve the same people year-round (e.g. in homes or businesses)

Water System Name	County(s) Served	Population Served	Primary Water Source Type	System Status	Water System ID
Camelot Forest Water System	Matagorda	309	Groundwater	Active	TX1610058
Caney Creek Haven Club Water System	Matagorda	348	Groundwater	Active	TX1610049
Caney Creek Mud of Matagorda County	Matagorda	3000	Groundwater	Active	TX1610087
City Of Bay City	Matagorda	19000	Groundwater	Active	TX1610001
City Of Palacios	Matagorda	5100	Groundwater	Active	TX1610004
Eldorado Water Co	Matagorda	270	Groundwater	Active	TX1610024
Frost Mobile Home Park	Matagorda	90	Groundwater	Active	TX1610097
Hubert Watson Subdivision Water System I	Matagorda	90	Groundwater	Active	TX1610114
LCRA Matagorda Dunes Subdivision	Matagorda	381	Groundwater	Active	TX1610052
Live Oak Bend WSC	Matagorda	369	Groundwater	Active	TX1610012
Markham Mud	Matagorda	1200	Groundwater	Active	TX1610006
Matagorda County WCID 2	Matagorda	50	Groundwater	Active	TX1610016
Matagorda County WCID 5	Matagorda	990	Groundwater	Active	TX1610002
Matagorda County WCID 6	Matagorda	1173	Groundwater	Active	TX1610007
Matagorda WSC	Matagorda	975	Groundwater	Active	TX1610013

Table 2.4S.12-4 Listing of U.S. Environmental Protection Agency (EPA) Safe Drinking Water Information System (SDWIS) Community and Non-Community Groundwater Systems in Matagorda County, Texas (Continued)

Water System Name	County(s) Served	Population Served	Primary Water Source Type	System Status	Water System ID
Community Water Systems: Water Systems that serve the same people year-round (e.g. in homes or businesses)					
Midfield WSC	Matagorda	300	Groundwater	Active	TX1610086
Oak Hollow Subdivision	Matagorda	63	Groundwater	Active	TX1610031
Pecan Shadows Water Supply Company	Matagorda	100	Groundwater	Active	TX1610014
River Oaks WSC	Matagorda	384	Groundwater	Active	TX1610018
Selkirk Water	Matagorda	540	Groundwater	Active	TX1610027
Tidewater Oaks Subdivision	Matagorda	165	Groundwater	Active	TX1610033
Tres Palacios Oaks Subdivision	Matagorda	426	Groundwater	Active	TX1610017
Wadsworth WSC	Matagorda	450	Groundwater	Active	TX1610015
Non-Transient Non-Community Water Systems: Water Systems that serve the same people, but not year-round (e.g. schools that have their own water system)					
Water System Name	**County(s) Served**	**Population Served**	**Primary Water Source Type**	**System Status**	**Water System ID**
Celanese Ltd Bay City Plant	Matagorda	200	Groundwater	Active	TX1610055
Equistar Chemical LP	Matagorda	254	Groundwater	Active	TX1610089
Main Potable Water System	Matagorda	1300	Groundwater	Active	TX1610051
NSC NTF Potable Water System	Matagorda	1300	Groundwater	Active	TX1610103
Tidehaven High School TISD	Matagorda	291	Groundwater	Active	TX1610056
Tidehaven Intermediate School TISD	Matagorda	221	Groundwater	Active	TX1610057

Table 2.4S.12-4 Listing of U.S. Environmental Protection Agency (EPA) Safe Drinking Water Information System (SDWIS) Community and Non-Community Groundwater Systems in Matagorda County, Texas (Continued)

Transient Non-Community Water Systems: Water Systems that do not consistently serve the same people (e.g. rest stops, campgrounds, gas stations)					
Water System Name	**County(s) Served**	**Population Served**	**Primary Water Source Type**	**System Status**	**Water System ID**
Berts RV Park	Matagorda	50	Groundwater	Active	TX1610065
City of Letulle Park Bay City	Matagorda	75	Groundwater	Active	TX1610047
Letulle Estates Chinquapin 1	Matagorda	52	Groundwater	Active	TX1610005
Matagorda County Nature Center Inc	Matagorda	50	Groundwater	Active	TX1610124
Pier 57	Matagorda	25	Groundwater	Active	TX1610042
Rio Colorado Golf Course	Matagorda	35	Groundwater	Active	TX1610119
Riverside Park Water Bay City	Matagorda	200	Groundwater	Active	TX1610118
T W E Enterprises Inc	Matagorda	25	Groundwater	Active	TX1610125
Texas Aquaculture	Matagorda	25	Groundwater	Active	TX1610127
Texas State Marine Education Center	Matagorda	50	Groundwater	Active	TX1610117
VFW Post 2438	Matagorda	100	Groundwater	Active	TX1610081

Source: Reference 2.4S.12-10

Table 2.4S.12-5 Matagorda County Historical Water Use

Historical Water Use Summary by Groundwater (GW) and Surface Water (SW) Unit: Acre Feet								
Year	**Source**	**Municipal**	**Manufacturing**	**Steam Electric**	**Irrigation**	**Mining**	**Livestock**	**Total**
1974	GW	3,818	280	0	36,615	288	158	41,159
1974	SW	0	5,568	0	172,244	0	1,373	179,185
	Total	3,818	5,848	0	208,859	288	1,531	220,344
1980	GW	5,912	1,688	0	29,997	357	600	38,554
1980	SW	0	4,238	0	269,616	0	400	274,254
	Total	5,912	5,926	0	299,613	357	1,000	312,808
1984	GW	5,887	2,025	0	30,639	172	833	39,556
1984	SW	0	2,509	0	237,151	77	554	240,291
	Total	5,887	4,534	0	267,790	249	1,387	279,847
1985	GW	5,729	2,367	0	24,666	119	823	33,704
1985	SW	0	2,958	0	195,594	68	547	199,167
	Total	5,729	5,325	0	220,260	187	1,370	232,871
1986	GW	5,593	2,213	1,351	25,127	235	550	35,069
1986	SW	0	3,435	3,989	186,122	71	367	193,984
	Total	5,593	5,648	5,340	211,249	306	917	229,053
1987	GW	5,830	974	1,296	21,934	266	611	30,911
1987	SW	0	3,012	0	162,468	65	406	165,951
	Total	5,830	3,986	1,296	184,402	331	1,017	196,862
1988	GW	5,381	1,975	1,451	34,054	185	652	43,698
1988	SW	0	2,758	30,613	252,246	69	434	286,120
	Total	5,381	4,733	32,064	286,300	254	1,086	329,818
1989	GW	5,172	2,966	1,462	8,901	250	683	19,434
1989	SW	0	3,581	32,349	204,859	0	454	241,243
	Total	5,172	6,547	33,811	213,760	250	1,137	260,677
1990	GW	5,225	3,514	1,158	26,717	250	673	37,537
1990	SW	0	3,293	34,757	168,825	0	447	207,322
	Total	5,225	6,807	35,915	195,542	250	1,120	244,859
1991	GW	4,906	4,028	879	26,172	295	687	36,967
1991	SW	0	2,686	13,031	166,168	0	458	182,343
	Total	4,906	6,714	13,910	192,340	295	1,145	219,310
1992	GW	4,982	4,037	1,036	18,086	266	614	29,021
1992	SW	0	4,882	28,380	162,680	0	409	196,351
	Total	4,982	8,919	29,416	180,766	266	1,023	225,372
1993	GW	5,190	4,834	776	16,827	266	634	28,527
1993	SW	0	4,346	6,918	195,879	0	423	207,566
	Total	5,190	9,180	7,694	212,706	266	1,057	236,093

Table 2.4S.12-5 Matagorda County Historical Water Use (Continued)

Historical Water Use Summary by Groundwater (GW) and Surface Water (SW) Unit: Acre Feet								
Year	Source	Municipal	Manufacturing	Steam Electric	Irrigation	Mining	Livestock	Total
1994	GW	4,902	6,560	833	12,382	273	694	25,644
1994	SW	0	3,360	23,330	241,826	0	463	268,979
	Total	4,902	9,920	24,163	254,208	273	1,157	294,623
1995	GW	4,977	6,579	1,201	22,481	277	604	36,119
1995	SW	0	5,991	37,392	261,684	0	402	305,469
	Total	4,977	12,570	38,593	284,165	277	1,006	341,588
1996	GW	5,460	7,534	1,457	21,781	277	1,048	37,557
1996	SW	0	3,002	38,905	253,533	0	698	296,138
	Total	5,460	10,536	40,362	275,314	277	1,746	333,695
1997	GW	4,867	5,764	1,386	1,581	251	564	14,413
1997	SW	0	2,846	12,156	122,924	0	376	138,302
	Total	4,867	8,610	13,542	124,505	251	940	152,715
1998	GW	5,137	4,733	1,333	2,249	196	676	14,324
1998	SW	0	2,933	20,924	174,951	0	452	199,260
	Total	5,137	7,666	22,257	177,200	196	1,128	213,584
1999	GW	5,170	4,686	1,240	3,119	196	676	15,087
1999	SW	0	3,656	25,217	242,648	0	452	271,973
	Total	5,170	8,342	26,457	245,767	196	1,128	287,060
2000	GW	5,502	2,649	1,313	17,283	481	943	28,171
2000	SW	0	7,706	59,712	140,603	0	628	208,649
	Total	5,502	10,355	61,025	157,886	481	1,571	236,820
2001	GW	2,499	3,210	4,965	13,794	131	710	25,309
2001	SW	0	6,019	43,547	177,159	0	474	227,199
	Total	2,499	9,229	48,512	190,953	131	1,184	252,508
2002	GW	2,290	3,488	4,439	13,751	131	690	24,789
2002	SW	0	6,541	38,930	111,261	0	459	157,191
	Total	2,290	10,029	43,369	125,012	131	1,149	181,980
2003	GW	3,160	3,490	4,439	41,954	131	912	54,086
2003	SW	0	6,545	38,930	151,200	0	490	197,165
	Total	3,160	10,035	43,369	193,154	131	1,402	251,251
2004	GW	2,753	4,979	4,656	32,196	131	978	45,693
2004	SW	0	9,335	40,836	154,625	0	526	205,322
	Total	2,753	14,314	45,492	186,821	131	1,504	251,015

Source: Reference 2.4S.12-13

Table 2.4S.12-6 Matagorda County Projected Water Use

Category	Acre-Feet					
	2010	2020	2030	2040	2050	2060
Municipal	5590	5830	5906	5883	5815	5762
Manufacturing	12180	13253	13991	14686	15259	16267
Steam Electric	80000	80000	102000	102000	102000	102000
Irrigation	193048	186072	179353	172916	166722	160750
Mining	177	172	169	167	165	163
Livestock	1151	1151	1151	1151	1151	1151
Total	**292146**	**286478**	**302570**	**296803**	**291112**	**286093**

Source: Source 2.4S.12-14

Table 2.4S.12-7 STP 3 & 4 Area Monthly Groundwater Levels

WELL ID	WELL DEPTH (ft bgs)	BOTTOM OF SCREEN (ft bgs)	REFERENCE POINT ELEVATION (ft MSL)	December 28, 2006		January 30, 2007		February 22, 2007		March 29, 2007		April 27, 2007		May 25, 200	
				Depth to Water (ft)	Elevation (ft MSL)	Depth to Water (ft)	Elevation (ft MSL)	Depth to Water (ft)	Elevation (ft MSL)	Depth to Water (ft)	Elevation (ft MSL)	Depth to Water (ft)	Elevation (ftMSL)	Depth to Water (ft)	E (
Shallow Aquifer - Upper Zone															
OW-308 U	47.1	48	31.80	7.78	24.02	6.46	25.34	7.46	24.34	7.41	24.39	7.17	24.63	7.07	
OW-332 U	46.1	45	32.10	8.01	24.09	6.57	25.53	7.46	24.64	7.39	24.71	6.25	25.85	7.09	
OW-348 U	39.1	38	32.28	8.09	24.19	6.52	25.76	7.71	24.57	7.66	24.62	7.34	24.94	7.25	
OW-349 U	46.1	45	31.29	7.28	24.01	5.82	25.47	6.97	24.32	6.91	24.38	6.56	24.73	6.50	
OW-408 U	43.1	42	33.57	9.71	23.86	8.30	25.27	9.13	24.44	9.08	24.49	8.95	24.62	8.94	
OW-420 U	49.1	48	33.79	9.98	23.81	8.42	25.37	9.32	24.47	9.26	24.53	9.08	24.71	8.99	
OW-438 U	41	40	32.18	8.45	23.73	6.55	25.63	7.21	24.97	7.14	25.04	7.17	25.01	7.00	
OW-910 U	36.1	35	32.32	9.11	23.21	7.57	24.75	8.30	24.02	8.23	24.09	8.10	24.22	8.00	
OW-928 U	39.6	38.5	31.69	8.18	23.51	6.21	25.48	6.85	24.84	6.72	24.97	6.69	25.00	6.59	
OW-929 U	60.1	59	38.71	12.92	25.79	11.33	27.38	11.68	27.03	11.75	26.96	11.77	26.94	11.81	
OW-930 U	36.1	35	27.33	7.92	19.41	5.79	21.54	7.05	20.28	6.98	20.35	6.45	20.88	7.31	
OW-931 U	38	35	32.10	9.82	22.28	8.81	23.29	9.43	22.67	9.34	22.76	9.19	22.91	9.25	
OW-932 U	39.6	38.5	32.83	8.52	24.31	7.03	25.80	8.04	24.79	7.96	24.87	7.77	25.06	7.68	
OW-933 U	37.1	38	30.62	8.44	24.18	4.97	25.65	5.95	24.67	5.91	24.71	5.57	25.05	5.50	
OW-934 U	41.1	40	30.39	10.22	20.17	9.54	20.85	10.04	20.35	10.08	20.31	9.91	20.48	10.00	
Shallow Aquifer - Lower Zone															
OW-308 L	97.1	96	31.78	16.08	15.70	15.08	16.70	14.91	16.87	14.67	17.11	14.21	17.57	14.32	
OW-332 L [1]	103.2	102.1	31.85	15.22	16.63	-	-	-	-	-	-	-	-	-	
OW-332 L(R) [1]	103.1	102	32.08	-	-	-	-	15.29	16.79	15.05	17.03	14.59	17.49	14.71	
OW-348 L	79.1	78.2	31.86	16.16	15.70	15.08	16.78	14.94	16.92	14.71	17.15	14.29	17.57	14.40	
OW-349 L	81.1	60	31.03	15.22	15.81	14.19	16.84	14.02	17.01	13.80	17.23	13.35	17.68	13.48	
OW-408 L	81.3	80.2	33.76	18.05	15.71	17.05	16.71	18.86	16.90	16.64	17.12	16.20	17.56	16.32	
OW-438 L	104.1	103	31.57	15.85	15.72	14.96	16.61	14.75	16.82	14.49	17.08	14.02	17.55	14.12	
OW-910 L	92.1	91	32.48	16.62	15.86	18.22	16.26	15.77	16.71	15.59	16.89	15.27	17.21	15.22	
OW-928 L	121.1	120	31.56	15.75	15.81	15.00	16.56	14.75	16.81	14.50	17.06	14.03	17.53	14.13	
OW-929 L	96.1	97	38.63	23.47	15.16	22.41	16.22	22.26	16.37	22.00	16.63	21.51	17.12	21.70	
OW-930 L	106.5	105	27.98	14.90	13.08	13.41	14.57	13.35	14.63	13.21	14.77	12.81	15.17	13.09	
OW-932 L	79.6	78.5	32.79	17.23	15.56	16.01	16.78	15.90	16.89	15.73	17.06	15.35	17.44	15.48	
OW-933 L	87.1	86	30.45	14.60	15.85	13.37	17.08	13.29	17.16	13.11	17.34	12.71	17.74	12.84	
OW-934 L	100	99	30.94	17.07	13.87	15.83	15.11	15.73	15.21	15.51	15.43	15.09	15.85	15.33	

[1] Observation well OW-322L was damaged in January of 2007, a replacement well. OW-332L(R) was installed and developed in February of 2007 prior to the February monthly water level measurements

Table 2.4S.12-8 Estimated Vertical Hydraulic Gradients in the STP 3 & 4 Area

		Upper Well Screen [1]					Lower Well Screen [1]						Groundwater [2]			
Date	Well Pair	Ground Elevation (ft MSL)	Top (ft bgs)	Bottom (ft bgs)	Midpoint (ft bgs)	Elevation (ft MSL)	Ground Elevation (ft MSL)	Top (ft bgs)	Bottom (ft bgs)	Midpoint (ft bgs)	Elevation (ft MSL)	dx (ft)	Upper (ft MSL)	Lower (ft MSL)	dh (ft)	(f
12/28/2006	OW-308 U/L	29.88	36	46	41	-11.12	29.87	86	96	91	-61.13	50.0	24.02	15.70	8.32	0.
1/30/2007	OW-308 U/L	29.88	36	46	41	-11.12	29.87	86	96	91	-61.13	50.0	25.34	16.70	8.64	0.
2/22/2007	OW-308 U/L	29.88	36	46	41	-11.12	29.87	86	96	91	-61.13	50.0	24.34	16.87	7.47	0.
3/29/2007	OW-308 U/L	29.88	36	46	41	-11.12	29.87	86	96	91	-61.13	50.0	24.39	17.11	7.28	0.
4/27/2007	OW-308 U/L	29.88	36	46	41	-11.12	29.87	86	96	91	-61.13	50.0	24.63	17.57	7.06	0.
5/25/2007	OW-308 U/L	29.88	36	46	41	-11.12	29.87	86	96	91	-61.13	50.0	24.73	17.46	7.27	0.
6/27/2007	OW-308 U/L	29.88	36	46	41	-11.12	29.87	86	96	91	-61.13	50.0	24.08	17.48	6.60	0.
12/28/2006 [3]	OW-332 U/L	30.24	35	45	40	-9.76	30.24	92.1	102.1	97.1	-66.86	57.1	24.09	16.63	7.46	0.
2/22/2007 [3]	OW-332 U/L(R)	30.24	35	45	40	-9.76	30.01	92	102	97	-66.99	57.2	24.64	16.79	7.85	0.
3/29/2007 [3]	OW-332 U/L(R)	30.24	35	45	40	-9.76	30.01	92	102	97	-66.99	57.2	24.71	17.03	7.68	0.
4/27/2007 [3]	OW-332 U/L(R)	30.24	35	45	40	-9.76	30.01	92	102	97	-66.99	57.2	25.85	17.49	8.36	0.
5/25/2007 [3]	OW-332 U/L(R)	30.24	35	45	40	-9.76	30.01	92	102	97	-66.99	57.2	25.01	17.37	7.64	0.
6/27/2007 [3]	OW-332 U/L(R)	30.24	35	45	40	-9.76	30.01	92	102	97	-66.99	57.2	24.05	17.40	6.65	0.
12/28/2006	OW-348 U/L	30.51	28	38	33	-2.49	30.08	68.2	78.2	73.2	-43.12	40.6	24.19	15.70	8.49	0.
1/30/2007	OW-348 U/L	30.51	28	38	33	-2.49	30.08	68.2	78.2	73.2	-43.12	40.6	25.76	16.78	8.98	0.
2/22/2007	OW-348 U/L	30.51	28	38	33	-2.49	30.08	68.2	78.2	73.2	-43.12	40.6	24.57	16.92	7.65	0.
3/29/2007	OW-348 U/L	30.51	28	38	33	-2.49	30.08	68.2	78.2	73.2	-43.12	40.6	24.62	17.15	7.47	0.
4/27/2007	OW-348 U/L	30.51	28	38	33	-2.49	30.08	68.2	78.2	73.2	-43.12	40.6	24.94	17.57	7.37	0.
5/25/2007	OW-348 U/L	30.51	28	38	33	-2.49	30.08	68.2	78.2	73.2	-43.12	40.6	25.03	17.46	7.57	0.
6/27/2007	OW-348 U/L	30.51	28	38	33	-2.49	30.08	68.2	78.2	73.2	-43.12	40.6	24.33	17.50	6.83	0.
12/28/2006	OW-349 U/L	29.40	35	45	40	-10.6	29.41	70	80	75	-45.59	35.0	24.01	15.81	8.20	0.
1/30/2007	OW-349 U/L	29.40	35	45	40	-10.6	29.41	70	80	75	-45.59	35.0	25.47	16.84	8.63	0.
2/22/2007	OW-349 U/L	29.40	35	45	40	-10.6	29.41	70	80	75	-45.59	35.0	24.32	17.01	7.31	0.
3/29/2007	OW-349 U/L	29.40	35	45	40	-10.6	29.41	70	80	75	-45.59	35.0	24.38	17.23	7.15	0.
4/27/2007	OW-349 U/L	29.40	35	45	40	-10.6	29.41	70	80	75	-45.59	35.0	24.73	17.68	7.05	0.
5/25/2007	OW-349 U/L	29.40	35	45	40	-10.6	29.41	70	80	75	-45.59	35.0	24.79	17.55	7.24	0.
6/27/2007	OW-349 U/L	29.40	35	45	40	-10.6	29.41	70	80	75	-45.59	35.0	24.10	17.61	6.49	0.
12/28/2006	OW-408 U/L	31.50	32	42	37	-5.5	31.73	70.2	80.2	75.2	-43.47	38.0	23.86	15.71	8.15	0.
1/30/2007	OW-408 U/L	31.50	32	42	37	-5.5	31.73	70.2	80.2	75.2	-43.47	38.0	25.27	16.71	8.56	0.
2/22/2007	OW-408 U/L	31.50	32	42	37	-5.5	31.73	70.2	80.2	75.2	-43.47	38.0	24.44	16.90	7.54	0.
3/29/2007	OW-408 U/L	31.50	32	42	37	-5.5	31.73	70.2	80.2	75.2	-43.47	38.0	24.49	17.12	7.37	0.
4/27/2007	OW-408 U/L	31.50	32	42	37	-5.5	31.73	70.2	80.2	75.2	-43.47	38.0	24.62	17.56	7.06	0.

Table 2.4S.12-8 Estimated Vertical Hydraulic Gradients in the STP 3 & 4 Area (Continued)

		Upper Well Screen [1]					Lower Well Screen [1]						Groundwater [2]			
Date	Well Pair	Ground Elevation (ft MSL)	Top (ft bgs)	Bottom (ft bgs)	Midpoint (ft bgs)	Elevation (ft MSL)	Ground Elevation (ft MSL)	Top (ft bgs)	Bottom (ft bgs)	Midpoint (ft bgs)	Elevation (ft MSL)	dx (ft)	Upper (ft MSL)	Lower (ft MSL)	dh (ft)	(
5/25/2007	OW-408 U/L	31.50	32	42	37	-5.5	31.73	70.2	80.2	75.2	-43.47	38.0	24.63	17.44	7.19	0.18
6/27/2007	OW-408 U/L	31.50	32	42	37	-5.5	31.73	70.2	80.2	75.2	-43.47	38.0	24.10	17.48	6.62	0.17
12/28/2006	OW-438 U/L	30.53	30	40	35	-4.47	30.11	93	103	98	-67.89	63.4	23.73	15.72	8.01	0.12
1/30/2007	OW-438 U/L	30.53	30	40	35	-4.47	30.11	93	103	98	-67.89	63.4	25.63	16.61	9.02	0.14
2/22/2007	OW-438 U/L	30.53	30	40	35	-4.47	30.11	93	103	98	-67.89	63.4	24.97	16.82	8.15	0.12
3/29/2007	OW-438 U/L	30.53	30	40	35	-4.47	30.11	93	103	98	-67.89	63.4	25.04	17.08	7.96	0.12
4/27/2007	OW-438 U/L	30.53	30	40	35	-4.47	30.11	93	103	98	-67.89	63.4	25.01	17.55	7.46	0.11
5/25/2007	OW-438 U/L	30.53	30	40	35	-4.47	30.11	93	103	98	-67.89	63.4	25.18	17.45	7.73	0.12
6/27/2007	OW-438 U/L	30.53	30	40	35	-4.47	30.11	93	103	98	-67.89	63.4	24.21	17.47	6.74	0.10
12/28/2006	OW-910 U/L	30.69	25	35	30	0.69	30.75	81	91	86	-55.25	55.9	23.21	15.86	7.35	0.13
1/30/2007	OW-910 U/L	30.69	25	35	30	0.69	30.75	81	91	86	-55.25	55.9	24.75	16.26	8.49	0.15
2/22/2007	OW-910 U/L	30.69	25	35	30	0.69	30.75	81	91	86	-55.25	55.9	24.02	16.71	7.31	0.13
3/29/2007	OW-910 U/L	30.69	25	35	30	0.69	30.75	81	91	86	-55.25	55.9	24.09	16.89	7.20	0.12
4/27/2007	OW-910 U/L	30.69	25	35	30	0.69	30.75	81	91	86	-55.25	55.9	24.22	17.21	7.01	0.12
5/25/2007	OW-910 U/L	30.69	25	35	30	0.69	30.75	81	91	86	-55.25	55.9	24.32	17.26	7.06	0.12
6/27/2007	OW-910 U/L	30.69	25	35	30	0.69	30.75	81	91	86	-55.25	55.9	23.83	17.35	6.48	0.11
12/28/2006	OW-928 U/L	30.02	28.5	38.5	33.5	-3.48	29.81	110	120	115	-85.19	81.7	23.51	15.81	7.70	0.09
1/30/2007	OW-928 U/L	30.02	28.5	38.5	33.5	-3.48	29.81	110	120	115	-85.19	81.7	25.48	16.56	8.92	0.10
2/22/2007	OW-928 U/L	30.02	28.5	38.5	33.5	-3.48	29.81	110	120	115	-85.19	81.7	24.84	16.81	8.03	0.09
3/29/2007	OW-928 U/L	30.02	28.5	38.5	33.5	-3.48	29.81	110	120	115	-85.19	81.7	24.97	17.06	7.91	0.09
4/27/2007	OW-928 U/L	30.02	28.5	38.5	33.5	-3.48	29.81	110	120	115	-85.19	81.7	25.00	17.53	7.47	0.09
5/25/2007	OW-928 U/L	30.02	28.5	38.5	33.5	-3.48	29.81	110	120	115	-85.19	81.7	25.10	17.43	7.67	0.09
6/27/2007	OW-928 U/L	30.02	28.5	38.5	33.5	-3.48	29.81	110	120	115	-85.19	81.7	24.36	17.50	6.86	0.08
12/28/2006	OW-929 U/L	36.91	49	59	54	-17.09	36.93	87	97	92	-55.07	38.0	25.79	15.16	10.63	0.28
1/30/2007	OW-929 U/L	36.91	49	59	54	-17.09	36.93	87	97	92	-55.07	38.0	27.38	16.22	11.16	0.29
2/22/2007	OW-929 U/L	36.91	49	59	54	-17.09	36.93	87	97	92	-55.07	38.0	27.03	16.37	10.66	0.28
3/29/2007	OW-929 U/L	36.91	49	59	54	-17.09	36.93	87	97	92	-55.07	38.0	26.96	16.63	10.33	0.27
4/27/2007	OW-929 U/L	36.91	49	59	54	-17.09	36.93	87	97	92	-55.07	38.0	26.94	17.12	9.82	0.25
5/25/2007	OW-929 U/L	36.91	49	59	54	-17.09	36.93	87	97	92	-55.07	38.0	26.90	16.93	9.97	0.26
6/27/2007	OW-929 U/L	36.91	49	59	54	-17.09	36.93	87	97	92	-55.07	38.0	25.54	16.96	8.58	0.22
12/28/2006	OW-930 U/L	25.62	25	35	30	-4.38	26.21	95	105	100	-73.79	69.4	19.41	13.08	6.33	0.09
1/30/2007	OW-930 U/L	25.62	25	35	30	-4.38	26.21	95	105	100	-73.79	69.4	21.54	14.57	6.97	0.10

Table 2.4S.12-8 Estimated Vertical Hydraulic Gradients in the STP 3 & 4 Area (Continued)

Date	Well Pair	Upper Well Screen [1]					Lower Well Screen [1]					dx (ft)	Groundwater [2]	
		Ground Elevation (ft MSL)	Top (ft bgs)	Bottom (ft bgs)	Midpoint (ft bgs)	Elevation (ft MSL)	Ground Elevation (ft MSL)	Top (ft bgs)	Bottom (ft bgs)	Midpoint (ft bgs)	Elevation (ft MSL)		Upper (ft MSL)	Lower (ft MSL)
2/22/2007	OW-930 U/L	25.62	25	35	30	-4.38	26.21	95	105	100	-73.79	69.4	20.28	14.63
3/29/2007	OW-930 U/L	25.62	25	35	30	-4.38	26.21	95	105	100	-73.79	69.4	20.35	14.77
4/27/2007	OW-930 U/L	25.62	25	35	30	-4.38	26.21	95	105	100	-73.79	69.4	20.88	15.17
5/25/2007	OW-930 U/L	25.62	25	35	30	-4.38	26.21	95	105	100	-73.79	69.4	20.02	14.89
6/27/2007	OW-930 U/L	25.62	25	35	30	-4.38	26.21	95	105	100	-73.79	69.4	19.36	14.99
12/28/2006	OW-932 U/L	31.35	28.5	38.5	33.5	-2.15	31.09	68.5	78.5	73.5	-42.41	40.3	24.31	15.56
1/30/2007	OW-932 U/L	31.35	28.5	38.5	33.5	-2.15	31.09	68.5	78.5	73.5	-42.41	40.3	25.80	16.78
2/22/2007	OW-932 U/L	31.35	28.5	38.5	33.5	-2.15	31.09	68.5	78.5	73.5	-42.41	40.3	24.79	16.89
3/29/2007	OW-932 U/L	31.35	28.5	38.5	33.5	-2.15	31.09	68.5	78.5	73.5	-42.41	40.3	24.87	17.06
4/27/2007	OW-932 U/L	31.35	28.5	38.5	33.5	-2.15	31.09	68.5	78.5	73.5	-42.41	40.3	25.06	17.44
5/25/2007	OW-932 U/L	31.35	28.5	38.5	33.5	-2.15	31.09	68.5	78.5	73.5	-42.41	40.3	25.15	17.31
6/27/2007	OW-932 U/L	31.35	28.5	38.5	33.5	-2.15	31.09	68.5	78.5	73.5	-42.41	40.3	24.56	17.41
12/28/2006	OW-933 U/L	28.87	26	36	31	-2.13	28.74	76	86	81	-52.26	50.1	24.18	15.85
1/30/2007	OW-933 U/L	28.87	26	36	31	-2.13	28.74	76	86	81	-52.26	50.1	25.65	17.08
2/22/2007	OW-933 U/L	28.87	26	36	31	-2.13	28.74	76	86	81	-52.26	50.1	24.67	17.16
3/29/2007	OW-933 U/L	28.87	26	36	31	-2.13	28.74	76	86	81	-52.26	50.1	24.71	17.34
4/27/2007	OW-933 U/L	28.87	26	36	31	-2.13	28.74	76	86	81	-52.26	50.1	25.05	17.74
5/25/2007	OW-933 U/L	28.87	26	36	31	-2.13	28.74	76	86	81	-52.26	50.1	25.12	17.61
6/27/2007	OW-933 U/L	28.87	26	36	31	-2.13	28.74	76	86	81	-52.26	50.1	24.75	17.73
12/28/2006	OW-934 U/L	28.54	30	40	35	-6.46	29.04	89	99	94	-64.96	58.5	20.17	13.87
1/30/2007	OW-934 U/L	28.54	30	40	35	-6.46	29.04	89	99	94	-64.96	58.5	20.85	15.11
2/22/2007	OW-934 U/L	28.54	30	40	35	-6.46	29.04	89	99	94	-64.96	58.5	20.35	15.21
3/29/2007	OW-934 U/L	28.54	30	40	35	-6.46	29.04	89	99	94	-64.96	58.5	20.31	15.43
4/27/2007	OW-934 U/L	28.54	30	40	35	-6.46	29.04	89	99	94	-64.96	58.5	20.48	15.85
5/25/2007	OW-934 U/L	28.54	30	40	35	-6.46	29.04	89	99	94	-64.96	58.5	20.39	15.61
6/27/2007	OW-934 U/L	28.54	30	40	35	-6.46	29.04	89	99	94	-64.96	58.5	20.03	15.71

[1] From Table 2.4S.12-1

[2] From Table 2.4S.12-7

[3] Observation well OW-322L was damaged in January of 2007, a replacement well. OW-332L(R) was installed and developed in February of 2007 prior to the February monthly water level measurements

ft MSL = feet mean sea level

ft bgs = feet below ground surface

Table 2.4S.12-9 Regional Aquifer Properties from Aquifer Pumping Tests

Well Number	Test Date	Screened Interval (ft bgs)	Hydraulic Conductivity (gpd/ft^2)	Transmissivity (gpd/ft)	Storage Coefficient (unitless)	Yield (gpm)	Drawdown or Recovery (ft)	1-Hour Specific Capacity (gpm/ft)	Test Type
TA-65-49-901	3/8/1966	300-355	658	26,300	ND	91.5	10.1	9	Recovery
TA-65-57-702	3/14/1966	331-553	512	25,600	ND	252	36.1	7	Drawdown
TA-65-57-801	7/28/1955	150-530	812	160,000	ND	2,530	ND	ND	Recovery
TA-65-58-107	10/4/1966	75-202	ND	176,000	1.1×10^{-3}	NA	NA	NA	Observation well for TA-65-58-108 drawdown test
TA-65-58-108	10/4/1966	150-275	693	86,600	ND	2,378	40.7	58	Drawdown
TA-65-58-803	7/1/1966	91-215	3,950	399,000	ND	1,354	34.2	40	Drawdown
TA-66-63-802	5/25/1966	240-760	582	154,100	ND	2,692	55.9	48	Drawdown
TA-66-63-902	5/26/1966	unknown	753	82,800	9.1×10^{-4}	NA	NA	NA	Observation well for TA-66-63-903 drawdown test
TA-66-63-903	5/26/1966	63-240	ND	ND	ND	1,020	ND	ND	Unknown
TA-66-64-401	5/18/1966	317-1,042	386	162,000	ND	3,417	61.6	55	Drawdown
TA-66-64-702	3/14/1966	unknown	223	64,600	ND	2,005	114	18	Recovery
TA-80-07-501	7/13/1955	220-820	403	120,000	ND	1,760	21.3	83	Recovery
TA-80-08-302	10/28/1966	530-630	355	35,500	ND	413	85	5	Recovery
TA-80-08-701	9/23/1966	300-600	212	19,700	ND	805	51.8	16	Recovery
TA-80-15-102	3/9/1967	506-634	458	45,800	ND	408	47.4	9	Recovery
TA-80-15-201	5/15/1955	353-878	420	107,000	ND	2,630	53	50	Drawdown, specific capacity calculated from recovery test
TA-80-15-301	6/10/1966	unknown	413	67,700	ND	1,026	49.3	21	Drawdown
TA-80-15-401	7/13/1955	225-1,044	177	63,000	ND	2,000	47.4	42	Recovery
TA-80-15-502	9/19/1966	244-776	103	31,300	ND	2,020	ND	ND	Recovery
TA-80-16-301	3/10/1967	615-800	505	40,400	ND	158.4	31.6	5	Recovery
TA-80-23-101	7/19/1955	190-776	344	82,500	ND	1,560	34.1	46	Recovery
TA-80-23-301	7/19/1955	200-770	139	51,500	ND	1,535	50.5	30	Recovery
TA-80-23-402	3/17/1967	544-586	ND	44,800	ND	388.5	ND	ND	Recovery
TA-80-23-403	3/17/1967	542-578	ND	42,500	4.6×10^{-5}	NA	NA	NA	Observation well for TA-80-23-402 recovery test
TA-81-01-101	10/13/1955	565-760	489	68,500	ND	1,000	NA	NA	Recovery
TA-81-01-102	10/13/1955	777-1,020	214	30,000	ND	915	50	18	Recovery
TA-81-01-601	3/13/1967	218-660	379	42,800	ND	1,290	45.8	28	Recovery

Table 2.4S.12-9 Regional Aquifer Properties from Aquifer Pumping Tests (Continued)

Well Number	Test Date	Screened Interval (ft bgs)	Hydraulic Conductivity (gpd/ft^2)	Transmissivity (gpd/ft)	Storage Coefficient (unitless)	Yield (gpm)	Drawdown or Recovery (ft)	1-Hour Specific Capacity (gpm/ft)	Test
TA-81-01-802	7/18/1955	150-250	269	35,000	ND	1,075	73.2	15	Rec
TA-81-09-401	3/24/1966	unknown	250	44,300	ND	1,182	83.3	14	Specific capaci drawdown, p transmissivity
TA-81-09-504	7/19/1955	150-721	306	53,000	ND	2,000	52.4	38	Rec
TA-81-09-904	3/16/1967	361-482	717	43,000	1.27×10^{-3}	NA	NA	NA	Observation wel recov
TA-81-09-905	3/16/1967	364-491	454	29,500	ND	338	27.3	12	Rec
TA-81-10-901	4/28/1966	280-296	ND	ND	ND	6.4	ND	ND	Unk
TA-81-10-902	4/28/1966	unknown	ND	10,500	1.36×10^{-4}	NA	NA	NA	Observation wel drawd
PP-80-06-101	7/8/1955	85-550	727	189,000	ND	1,485	ND	NA	Rec
PP-80-06-102	9/9/1963	104-364	790	124,000	ND	1,690	29.9	57	Drav
PP-80-06-104	9/9/1963	50-215	ND	119,000	1.4×10^{-3}	NA	NA	NA	Observation wel drawd
PP-80-06-703	7/8/1955	154-590	359	79,000	ND	1,450	36.1	40	Rec
PP-80-06-704	8/21/1963	146-430	616	104,800	ND	1,500	19.6	77	Rec
PP-80-22-501	9/5/1963	288-370	361	20,600	ND	540	33.2	16	Rec
ZA-66-62-904	7/18/1955	162-573	382	102,000	ND	1,430	21	68	Rec
ZA-66-63-504	3/15/1967	167-682	475	195,300	ND	2,508	37.7	67	Rec
		Geometric Mean	420	63,640	4.7×10^{-4}	-	-	-	

Source: Reference 2.4.12-6

Well County Codes:

TA = Matagorda County

PP = Jackson County

ZA = Wharton County

NA = Not applicable to test performed

ND = Not Determined

gpd/ft2 = gallons per day/square foot

ft bgs = feet below ground surface

gpm = gallons per minute

gpm/ft = gallons per minute/foot

Table 2.4S.12-10 STP Aquifer Pumping Test Results Summary

Well	Screened Interval (ft bgs)	Aquifer	Test Start Date	Pumping Rate (gpm)	Pumping Duration (hrs)	Hydraulic Conductivity (gpd/ft^2)	Transmissivity (gpd/ft)
Production Well 5	290-670	Deep	1/27/1975	300/600	8/72	ND	50,000
Production Well 6	340-685	Deep	10/31/1977	320/614	8/72	ND	24,201
Production Well 7	302-702	Deep	1/13/1978	316/614	8/72	ND	25,533
WW-1	60-140	Lower Shallow	unknown	200/300	67/24	410	33,150
WW-2	59-83	Lower Shallow	11/21/1973	140	120	600	13,000
WW-2 Long Term	59-83	Lower Shallow	12/14/1973	140	288	651	14,000
WW-3	20-43	Upper Shallow	11/28/1973	10	48	65	1,100
WW-4	30-45	Upper Shallow	1/4/1974	50	46	420	12,500
					Geometric Mean All Tests	337	15,000
					Geometric Mean Lower Shallow Aquifer	543	18,209
					Geometric Mean Upper Shallow Aquifer	165	3,708
					Geometric Mean Deep Aquifer	ND	31,379

Data Source:

1- Reference 2.4S.12-8

2- pumping test data interpretation

3- Reference 2.4S.12-7

ND = Not Determined

Table 2.4S.12-11 STP Slug Test Results

Well	Test Type						Arithmetic Mean of Tests		
	Rising Head Test Method			Falling Head Test Method			ft/d	gpd/ft^2	cm/s
	Butler	KGS	B-R	Butler	KGS	B-R			
OW-308L	64	67	65	72	73	56	66	495	2.33E-02
OW-308U	70	64	63	64	62	68	65	488	2.30E-02
OW-332L	53	54	P	49	49	55	52	389	1.83E-02
OW-332U	37	36	27	19	18	11	25	184	8.70E-03
OW-348L	58	46	44	76	61	39	54	404	1.90E-02
OW-348U	P	83	88	68	71	65	75	561	2.65E-02
OW-349L	63	51	35	43	40	52	47	354	1.67E-02
OW-349U	P	P	43	P	P	53	48	359	1.69E-02
OW-408L	P	72	P	70	68	50	65	486	2.29E-02
OW-408U	17	11	11	22	32	28	20	151	7.11E-03
OW-420U	P	33	45	ND	ND	ND	39	292	1.38E-02
OW-438L	17	27	10	15	28	14	18	138	6.53E-03
OW-438U	38	39	26	P	P	24	32	238	1.12E-02
OW-910L	3	0.3	0.6	2	0.9	0.5	1	9	4.29E-04
OW-910U	26	29	21	P	P	P	25	190	8.94E-03
OW-928L	19	11	7	P	24	21	16	123	5.79E-03
OW-928U	19	P	8	19	16	16	16	117	5.50E-03
OW-929L	56	54	29	59	P	59	51	384	1.81E-02
OW-929U	P	3	4	P	12	2	5	39	1.85E-03
OW-930L	40	37	27	24	15	19	27	202	9.52E-03
OW-930U	P	23	32	P	47	48	38	280	1.32E-02
OW-931U	34	23	20	P	P	49	32	236	1.11E-02
OW-932L	24	23	18	22	22	25	22	167	7.88E-03
OW-932U	21	13	14	P	16	22	17	129	6.07E-03
OW-933L	P	51	63	P	P	64	59	444	2.09E-02
OW-933U	P	10	3	8	5	3	6	43	2.05E-03
OW-934L	P	P	35	P	P	32	34	251	1.18E-02
OW-934U	P	32	33	49	P	40	38	288	1.36E-02
Geometric Mean all tests							27	205	9.66E-03
Geometric Mean Upper Shallow Aquifer							26	192	9.04E-03
Geometric Mean Lower Shallow Aquifer							30	221	1.04E-02

P = Poor curve match or questionable data

Test Methods:

KGS = Kansas Geological Survey

B-R = Bouwer and Rice

ND = No data - data not recovered from data logger

Table 2.4S.12-12 Summary of STP Aquifer Properties from Laboratory Analyses

Hydrogeologic Unit	Parameter	Bulk Density	Porosity	Effective Porosity or Specific Yield	G Pe
Upper Shallow Aquifer Confining Layer	Number of Tests	11	11	NA	
	Mean or Geometric mean	101 pcf	40%	NA	
	Range	96.4 – 114.9 pcf	31.8 – 42.8%	NA	
Upper Shallow Aquifer	Number of Tests	4	4	4	
	Mean or Geometric mean	99 pcf	41%	33%	
	Range	97.2 – 100.2 pcf	39.5 – 41.7%	31.6 – 33.4%	4.11
Lower Shallow Aquifer Confining Layer	Number of Tests	9	11	NA	
	Mean or Geometric mean	99 pcf	42%	NA	
	Range	87.3 – 107.7 pcf	36.1 – 47.2%	NA	
Lower Shallow Aquifer	Number of Tests	8	9	9	
	Mean or Geometric mean	102 pcf	39%	31%	6.0
	Range	94.5 – 120.0 pcf	28.8 – 43.9%	23.0 – 35.1%	4. 1.02
Deep Aquifer Confining Layer	Number of Tests	22	23	NA	
	Mean or Geometric mean	101 pcf	41%	NA	
	Range	82.1 – 111.4 pcf	33.4 – 51.8%	NA	
Deep Aquifer	Number of Tests	1	1	1	
	Mean or Geometric Mean	NA	NA	NA	
	Range	103.1	38.8%	31.0%	

NA- parameter not applicable or insufficient data to compute statistic

Table 2.4S.12-13 Hydraulic Conductivity of Clay

Soil Boring/Sample	Depth (ft)	Hydraulic Conductivity (cm/s)	Hydraulic Conductivity (gpd/ft^2)
B-601 S2	3	3.6×10^{-7}	0.0076
B-241 T3	9	2.4×10^{-6}	0.051
B-242 T3	9	1.2×10^{-6}	0.025
B-601 T5	9	2.4×10^{-8}	0.00051
B-601 T9	29	2.6×10^{-8}	0.00055
B-400 T11	39	4.0×10^{-8}	0.00085
	Geometric Mean	1.72×10^{-7}	0.0036

Source: Reference 2.4S.12-9, Section 2.5.4.2.6.1

Table 2.4S.12-14 Representative Properties of Hydrogeologic Units

Hydrogeologic Unit	Property	Units	Representative Value	Range	Source
Upper Shallow Aquifer Confining Layer	Thickness	ft	20	10-30	Figure 2.4S.12-20
	Vertical Hydraulic Conductivity	gpd/ft^2	0.004	0.05-0.0005	Table 2.4S.12-13
	Bulk (dry) Density	pcf	101	96.4 - 114.9	Table 2.4S.12-12
	Total Porosity	%	40	31.8-42.8	Table 2.4S.12-12
Upper Shallow Aquifer	Thickness	ft	25	20-30	Figure 2.4S.12-20
	Horizontal Hydraulic Conductivity	gpd/ft^2	192	39-561	Table 2.4S.12-11
	Hydraulic Gradient	ft/ft	0.002	0.001-0.002	Section 2.4S.12.2.2
	Bulk (dry) Density	pcf	99	97.2 - 100.2	Table 2.4S.12-12
	Total Porosity	%	41	39.5-41.7	Table 2.4S.12-12
	Effective Porosity	%	33	31.6-33.4	Table 2.4S.12-12
Lower Shallow Aquifer Confining Layer	Thickness	ft	20	15-25	Figure 2.4S.12-20
	Vertical Hydraulic Gradient	ft/ft	0.29	0.079-0.29	Table 2.4S.12-8
	Vertical Hydraulic Conductivity	gpd/ft^2	0.004	0.05-0.0005	Table 2.4S.12-13
	Bulk (dry) Density	pcf	99	87.3 - 107.7	Table 2.4S.12-12
	Total Porosity	%	42	36.1-47.2	Table 2.4S.12-12
Lower Shallow Aquifer	Thickness	ft	40	25-50	Figure 2.4S.12-20
	Horizontal Hydraulic Conductivity	gpd/ft^2	543	410-651	Table 2.4S.12-10
	Hydraulic Gradient	ft/ft	0.0004	0.0004	Section 2.4S.12.2.2
	Bulk (dry) Density	pcf	102	94.5 - 120.0	Table 2.4S.12-12
	Total Porosity	%	39	28.8-43.9	Table 2.4S.12-12
	Effective Porosity	%	31	23.0-35.1	Table 2.4S.12-12
Deep Aquifer Confining Layer	Thickness	ft	100	100-150	Section 2.4S.12.3.1
	Vertical Hydraulic Conductivity	gpd/ft^2	0.004	0.05-0.0005	Table 2.4S.12-13
	Bulk (dry) Density	pcf	101	82.1 - 111.4	Table 2.4S.12-12
	Total Porosity	%	41	33.4 - 51.8	Table 2.4S.12-12
Deep Aquifer	Horizontal Hydraulic Conductivity	gpd/ft^2	420	103-3,950	Table 2.4S.12-9
	Horizontal Hydraulic Gradient	ft/ft	0.002	0.0006-0.002	Section 2.4S.12.2.2
	Bulk (dry) Density	pcf	102	94.5 - 120.0	Lower Shallow Aquifer
	Total Porosity	%	39	28.8-43.9	Lower Shallow Aquifer
	Effective Porosity	%	31	23.0-35.1	Lower Shallow Aquifer

Table 2.4S.12-15 Regional Hydrogeochemical Data

ple ıth gs)	pH (standard units)	Specific Conductance (µmhos/cm)	Total Dissolved Solids (mg/L)	Total Hardness (mg/L as CaCO3)	Silica (mg/L)	Cations				Anions				
						Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)
0	7.7	1,550	880	348	22	82	35	195	3	382	302	47	0.7	BDL
6	7.9	732	430	77	18	17	8	143	BDL	306	79	14	0.6	BDL
3	7.7	1,840	1,060	314	24	60	40	285	8	520	333	66	0.8	BDL
)	7.4	884	530	403	28	98	39	33	BDL	411	54	9	0.8	70
3	8.1	1,200	710	295	25	65	32	160	3	489	153	33	0.8	BDL
0	7.6	746	437	216	20	53	20	87	BDL	349	73	11	0.7	BDL
3	8.0	720	570	46	10	11	5	150	ND	309	74	14	ND	ND
5	7.9	676	554	47	9	12	4	143	ND	312	62	14	ND	ND
3	7.8	1,051	620	353	20	79	38	110	ND	530	111	3	0.6	BDL
0	7.5	1,760	1,000	355	22	73	42	245	ND	453	341	52	0.7	BDL
0	8.3	846	488	42	17	9.9	4.3	177	ND	344	94	11	ND	BDL
1	8.0	674	403	55	15	14	5	141	ND	334	51	12	0.7	BDL
3	7.5	2,800	1,570	730	25	191	62	297	6	375	760	41	0.4	BDL
1	8.0	811	475	36	10	7	5	182	2	367	79	9	1	BDL
0	7.8	1,290	730	361	25	79	39	138	3	368	240	25	0.5	BDL
1	8.0	849	498	128	21	37	8.8	143	ND	366	90	11	ND	0.2
8	8.3	1,600	910	18	15	5	1	367	BDL	550	253	BDL	3.1	BDL

BDL = Below analytical detection limit

ND = Not Determined

National Secondary Drinking Water Standard Exceeded

National Primary Drinking Water Standard Exceeded

Source: Reference 2.4S.12-6

Table 2.4S.12-16 STP Hydrogeochemical Data

Well	Sample Date	Sample Depth (ft bgs)	pH (standard units)	Specific Conductance (µmhos/cm)	Temperature (°C)	Total Dissolved Solids (mg/L)	Total Alkalinity (mg/L as CaCO3)	Total Hardness (mg/L as CaCO3)	Silica (mg/L)	Cations: Calcium (mg/L)	Cations: Magnesium (mg/L)	Cations: Sodium (mg/L)	Cations: Potassium (mg/L)	Cations: Iron (mg/L)	Cations: Manganese (mg/L)	Anions: Bicarbonate (mg/L)	Anions: Chloride (mg/L)	Anions: Sulfate (mg/L)
Shallow Aquifer at Prod. Well 5	12/17/1974	105	7.84	1,480	ND	1,095	390	324	18	74	34	211	ND	BDL	0.2	476	245	42
Prod. Well 5	1/29/1975	290-670	7.95	863	ND	642	284	37	14	10	3	176	1.3	BDL	BDL	346	87	11
Prod. Well 5	1/30/1975	290-670	8.25	863	ND	623	286	38	13	10	3	177	1.3	BDL	BDL	320	87	12
Prod. Well 5	1/31/1975	290-670	8.25	863	ND	626	284	37	13	10	3	176	1.3	BDL	BDL	317	87	11
Prod. Well 5	12/16/1982	290-670	7.90	818	ND	648	289	42	14	10	4	ND	ND	BDL	0.13	353	79	10
Prod. Well 6	12/7/1982	330-670	7.65	809	ND	635	298	49	15	12	5	ND	ND	BDL	BDL	364	69	14
Prod. Well 7	2/9/1983	302-682	7.83	831	ND	628	288	38	13	10	3	168	1.4	BDL	BDL	351	74	8
Prod. Well 8	5/15/1991	449-552	8.20	ND	ND	256	197	89	ND	28.2	4.28	70.8	ND	0.06	BDL	216	33	12
WW-2	12/20/1973	59-83	7.7	1,490	ND	1,044	ND	320	ND	65	38	192	ND	ND	ND	464	242	42
WW-3	11/30/1973	20-43	ND	4,750	ND	2,618	ND	672	ND	125	88	680	ND	ND	ND	458	1180	86
WW-4	11/4/1974	30-45	ND	1,610	ND	1,103	ND	430	ND	118	33	191	ND	ND	ND	421	304	36
Piezometer 115-A	12/21/1973	79	7.6	6,100	ND	3,316	ND	712	ND	130	95	920	ND	ND	ND	427	1610	134
Piezometer 115-B	12/21/1973	40	7.5	4,020	ND	2,326	ND	688	ND	128	90	548	ND	ND	ND	458	1010	91
Piezometer 415	12/14/1973	40	7.8	2,050	ND	1,315	ND	435	ND	93	49	265	ND	ND	ND	415	452	41
Piezometer 417	12/14/1973	100	7.7	1,930	ND	1,257	ND	445	ND	104	45	238	ND	ND	ND	396	436	38
OW-308L	12/30/2006	97.8	7.11	1,240	23.1	661	347	ND	ND	62.7	34.2	149	5.47	ND	ND	423	199	24.4
OW-308U	12/30/2006	48.9	6.93	2,348	23.7	1,240	367	ND	ND	97.1	55.6	298	2.53	ND	ND	447	558	76.6
OW-332L	12/29/2006	104.6	7.07	1,298	22.9	1,020	351	ND	ND	98.3	53.5	208	2.98	ND	ND	428	439	43.9
OW-332U	12/29/2006	47.6	7.03	1,582	22.7	870	383	ND	ND	70.2	35.9	213	BDL	ND	ND	467	240	104
OW-408L	12/30/2006	83.2	7.07	1,242	23.4	650	349	ND	ND	66	32.5	145	1.97	ND	ND	426	195	21.6
OW-408U	12/30/2006	44.3	6.99	1,764	23.4	913	385	ND	ND	74.5	38.6	240	1.64	ND	ND	469	344	29.5
OW-420U	12/30/2006	50.5	6.94	2,114	22.9	1,120	320	ND	ND	101	46.8	259	1.79	ND	ND	390	505	44.9
OW-928L	12/29/2006	124	6.99	1,168	22.5	643	284	ND	ND	74	36.2	110	2.37	ND	ND	346	197	17.1
OW-928U	12/29/2006	41.1	6.82	2,885	22.3	1,560	296	ND	ND	156	51.6	315	2.03	ND	ND	361	815	132
OW-930L	12/28/2006	104.6	7.06	1,506	22.3	726	360	ND	ND	65.5	34.7	200	2.66	ND	ND	439	280	28.2
OW-930U	12/28/2006	34.7	6.87	1,152	22.4	623	358	ND	ND	95.6	31.5	89.7	BDL	ND	ND	436	175	16.8
OW-933L	12/29/2006	88.8	6.93	1,936	23.5	713	392	ND	ND	63.4	33.6	149	2.93	ND	ND	478	197	25.6
OW-933U	12/29/2006	38.8	7.28	1,658	24.2	908	367	ND	ND	39.2	25.8	273	1.9	ND	ND	447	294	70.9
OW-934L	12/31/2006	100.3	7.10	1,359	22.6	731	380	ND	ND	62	35.4	185	2.3	ND	ND	463	189	24.5
OW-934U	12/31/2006	42.4	6.91	1,891	22.7	1,020	378	ND	ND	87.8	56.2	218	BDL	ND	ND	461	412	47.3

BDL = Below analytical detection limit

ND = Not Determined

National Secondary Drinking Water Standard Exceeded

Table 2.4S.12-17 Estimated Average Linear Velocity and Travel Time

Property		Hydrogeologic Unit/Pathway: Upper Shallow Aquifer Discharge at tributary east of Plant	Upper Shallow Aquifer at Well 2004120846	Lower Shallow Aquifer at Well 2004120846	Upper Shallow Aquifer Discharge at Colorado River	Lower Shallow Aquifer Discharge at Colorado River
Hydraulic Conductivity	Representative Value (gpd/ft^2)	192	192	543	192	543
	Range (gpd/ft^2)	39 - 561	39 - 561	410 - 651	39 - 561	410 - 651
	Representative Value (ft/day)	26	26	72	26	72
	Range (ft/day)	5 - 75	5 - 75	55 - 87	5 - 75	55 - 87
Hydraulic Gradient	Representative Value (ft/ft)	0.002	0.002	0.0004	0.002	0.0004
	Range (ft/ft)	0.001 - 0.002	0.001 - 0.002	0.0004	0.001 - 0.002	0.0004
Effective Porosity	Representative Value (decimal)	0.33	0.33	0.31	0.33	0.31
	Range (decimal)	0.316 - 0.334	0.316 - 0.334	0.23 - 0.351	0.316 - 0.334	0.23 - 0.351
Average Linear Velocity	Representative Value (ft/day)	0.2	0.2	0.09	0.2	0.09
	Range (ft/day)	0.03 – 0.5	0.03 – 0.5	0.06 - 0.2	0.03 – 0.5	0.06 - 0.2
Distance	Distance to Receptor (ft)	7,300	9,000	9,000	17,800	17,800
Travel Time	Representative Value (day)	36,500	45,000	100,000	89,000	197,800
	Range (day)	14,600 – 243,300	18,000 – 300,000	45,000 – 150,000	35,600 – 593,300	89,000 – 296,700

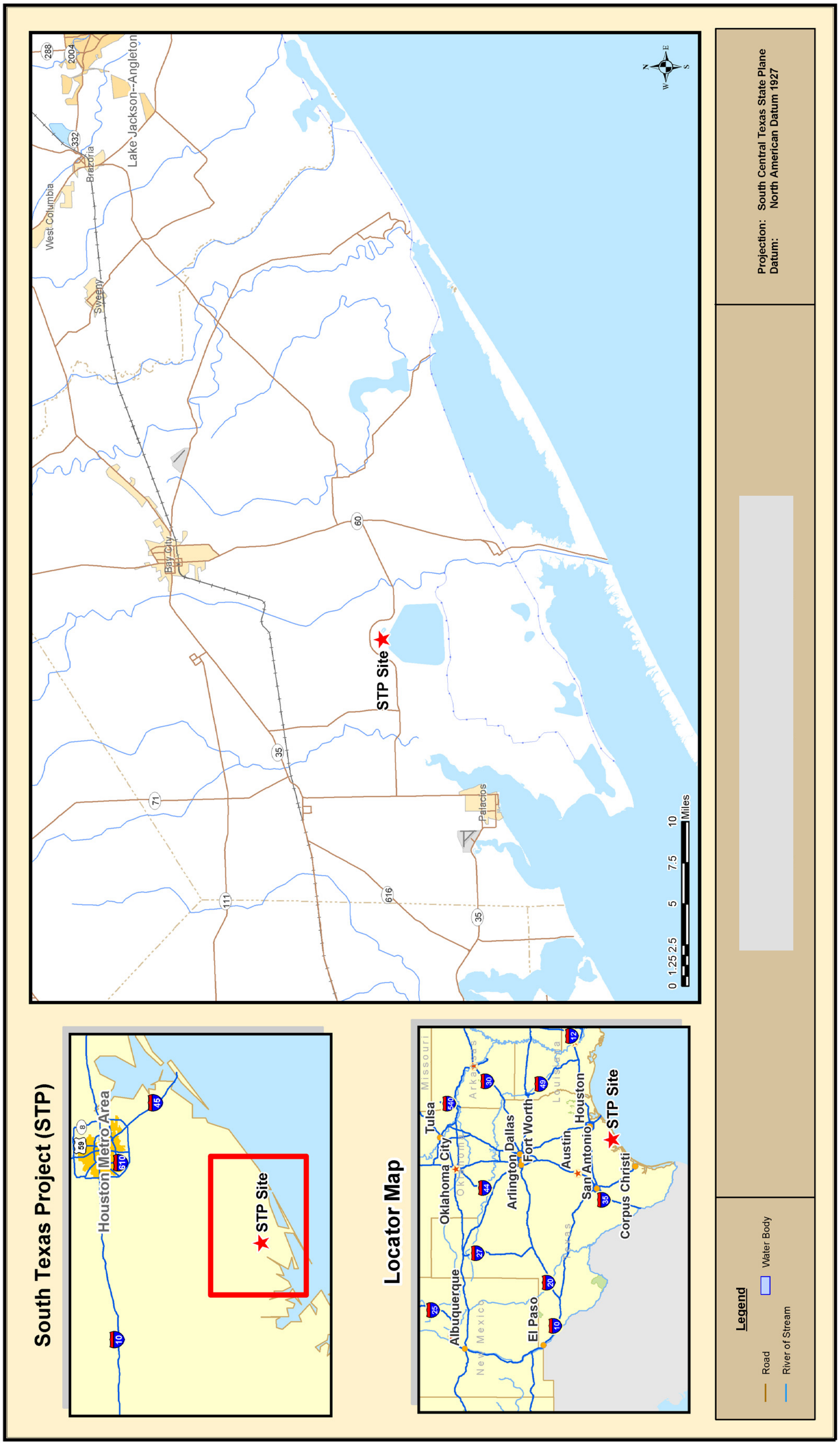


Figure 2.4S.12-1 Matagorda County Location Map

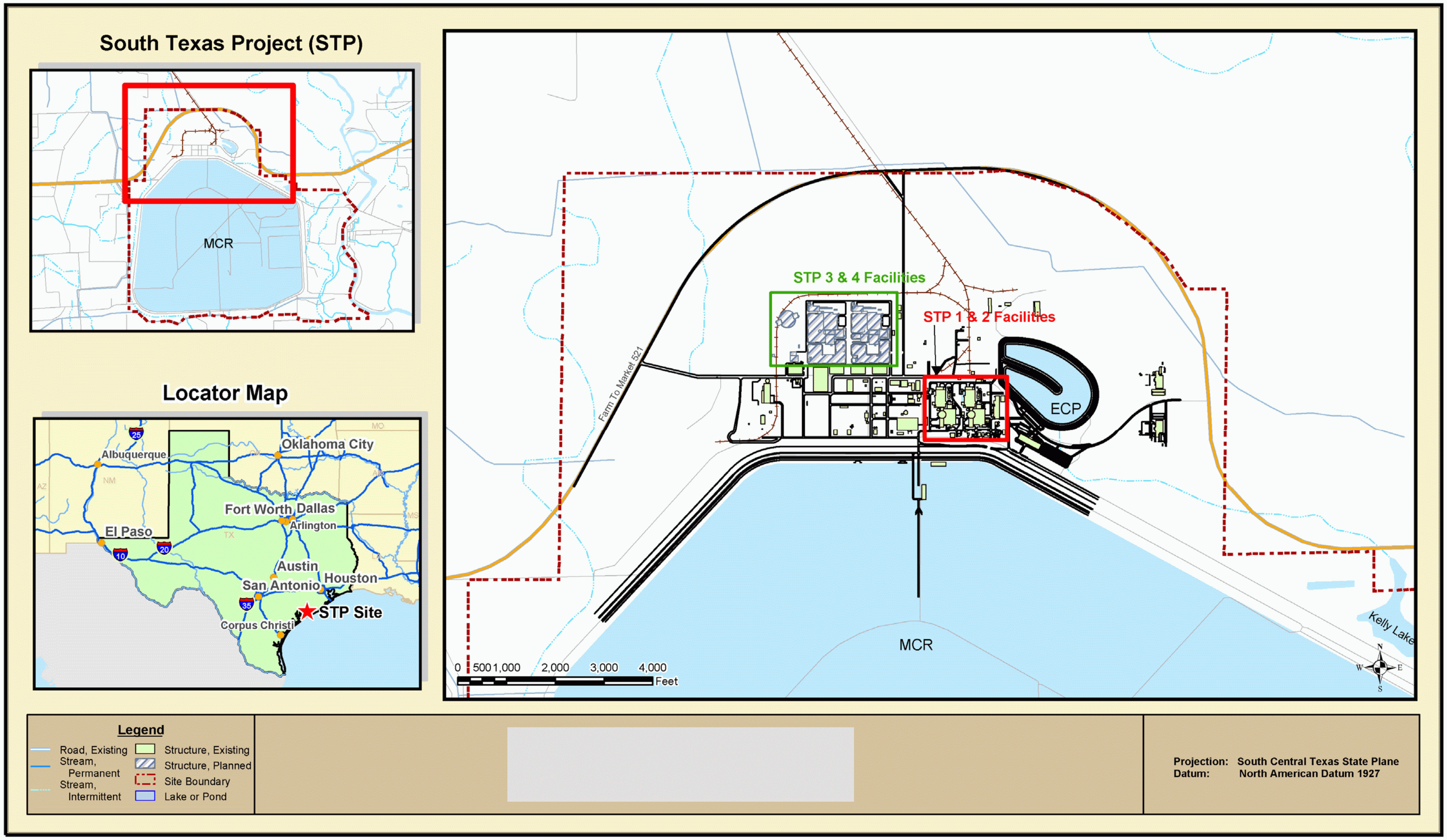
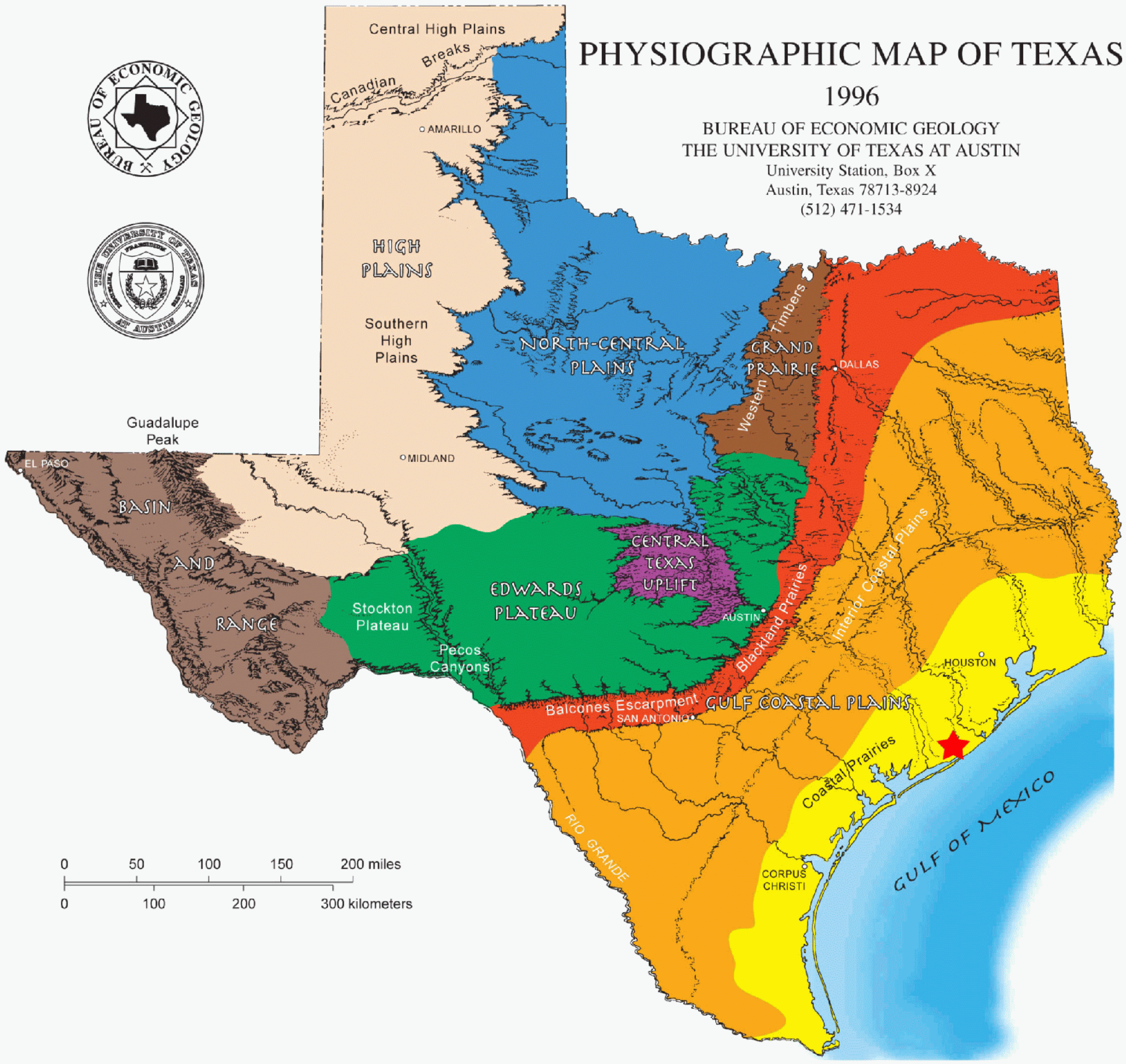


Figure 2.4S.12-2 STP Facility Location Map



PROVINCE	MAX. ELEV. (ft)	MIN. ELEV. (ft)	TOPOGRAPHY	GEOLOGIC STRUCTURE	BEDROCK TYPES
Gulf Coastal Plains					
Coastal Prairies	300	0	Nearly flat prairie, <1 ft/mi to Gulf	Nearly flat strata	Deltaic sands and muds
Interior Coastal Plains	800	300	Parallel ridges (questas) and valleys	Beds tilted toward Gulf	Unconsolidated sands and muds
Blackland Prairies	1000	450	Low rolling terrain	Beds tilted south and east	Chalks and marls
Grand Prairie	1250	450	Low stairstep hills west; plains east	Strata dip east	Calcareous east; sandy west
Edwards Plateau					
Principal	3000	450	Flat upper surface with box canyons	Beds dip south; normal faulted	Limestones and dolomites
Pecos Canyons	2000	1200	Steep-walled canyons		Limestones and dolomites
Stockton Plateau	4200	1700	Mesa-formed terrain; highs to west	Unfaulted, near-horizontal beds	Carbonates and alluvial sediments
Central Texas Uplift	2000	800	Knobby plain; surrounded by questas	Centripetal dips, strongly faulted	Granites; metamorphics; sediments
North-Central Plains	3000	900	Low north-south ridges (questas)	West dip; minor faults	Limestones; sandstones; shales
High Plains					
Central	4750	2900	Flat prairies slope east and south	Slight dips east and south	Eolian silts and fine sands
Canadian Breaks	3800	2350	Highly dissected; local solution valleys		
Southern	3800	2200	Flat; many playas; local dune fields		
Basin and Range	8750	1700	North-south mountains and basins	Some complex folding and faulting	Igneous; metamorphics; sediments

Figure 2.4S.12-3 Physiographic Map of Texas (modified from Reference 2.4S.12-1)

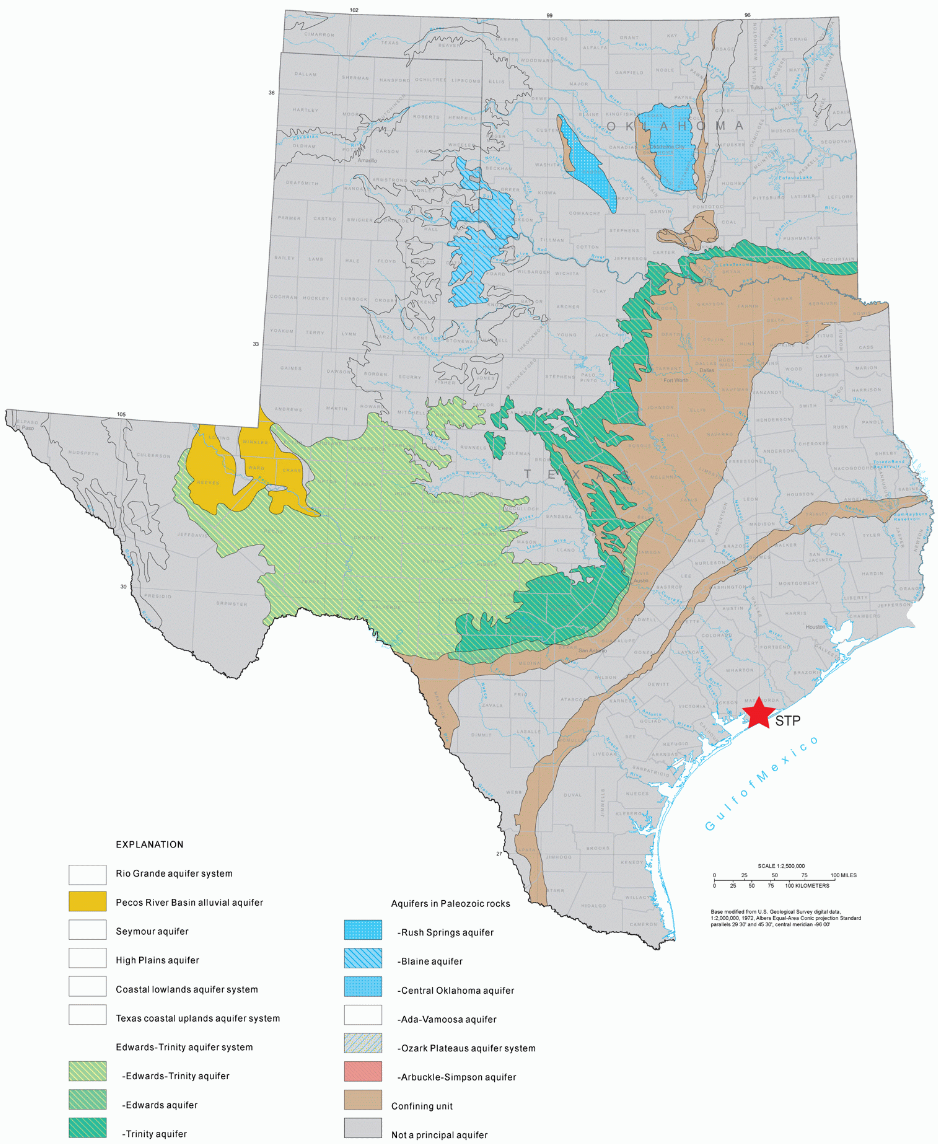
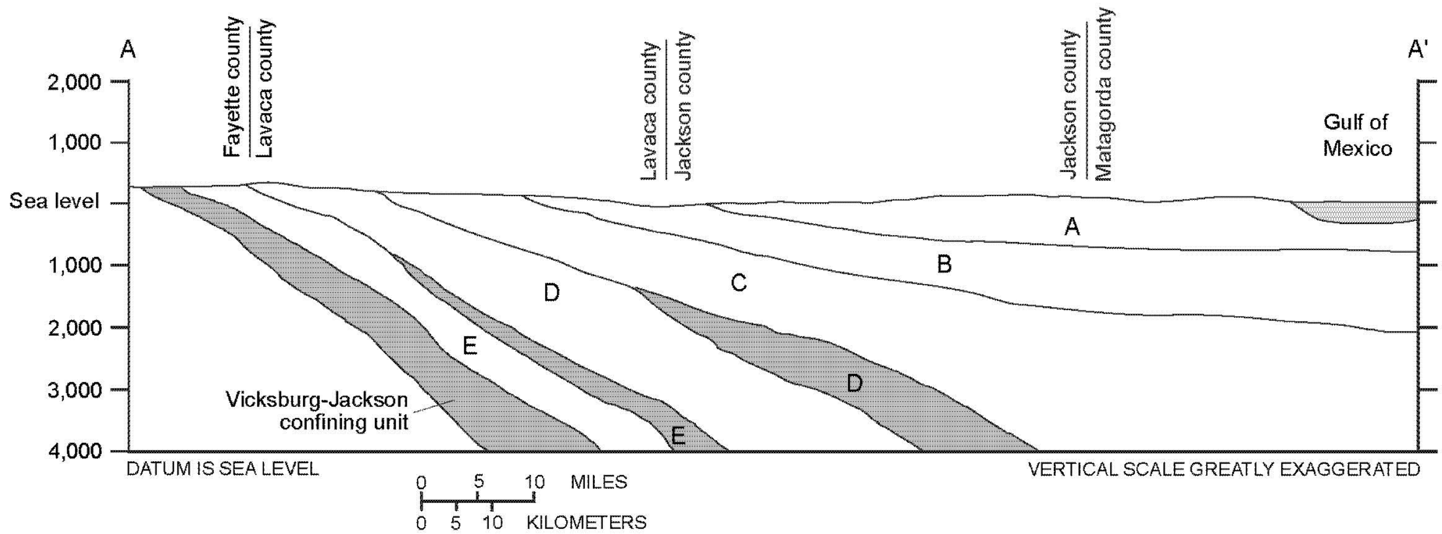


Figure 2.4S.12-4 Aquifers of Texas (modified from Reference 2.4S.12-2)

Era	System	Series	Stratigraphic unit (Modified from Baker, 1979)	Lithology	Hydrogeologic unit commonly used in Texas (Modified from Baker, 1979)	Hydrogeologic nomenclature used in this report (Modified from Weiss, 1992)	
Cenozoic	Quaternary	Holocene	Alluvium	Sand, silt, and clay	Chicot aquifer	Permeable zone A	Coastal lowlands aquifer system
		Pleistocene	Beaumont Formation Montgomery Formation Bentley Formation Willis Sand	Sand, silt, and clay		Permeable zone B	
	Tertiary	Pliocene	Goliad Sand	Sand, silt, and clay	Evangeline aquifer	Permeable zone C	
		Miocene	Fleming Formation	Clay, silt and sand	Burkeville confining unit	Zone D confining unit [1]	
			Oakville Sandstone	Sand, silt, and clay	Jasper aquifer	Permeable zone D	
			Catahoula Sandstone or Tuff [2]		Catahoula confining unit (restricted)		
			Anahuac Formation [1]	Clay, silt and sand		Zone E confining unit [1]	
		Oligocene	Frio Formation [1]	Sand, silt, and clay		Permeable zone E	
			Frio Clay [3] / Vicksburg Formation [1]	Clay and silt	Vicksburg-Jackson confining unit	Vicksburg-Jackson confining unit	
		Eocene	Jackson Group: Whitsett Formation Manning Clay Wellborn Sandstone Caddell Formation				

[1] Present only in the subsurface
[2] Called Catahoula Tuff west of Lavaca County
[3] Not recognized at surface east of Live Oak County

Figure 2.4S.12-5 Correlation of USGS and Texas Nomenclature (modified from Reference 2.4S.12-2)



Notes:

Coastal lowlands aquifer system—Dot patterned area indicates freshwater

Texas coastal uplands aquifer system

Confining unit

D Hydrogeologic unit—See figure 2.4S.12-5

Figure 2.4S.12-6 Generalized Cross Section through the Coastal Lowlands/Coastal Uplands Aquifer Systems (modified from Reference 2.4S.12-2)

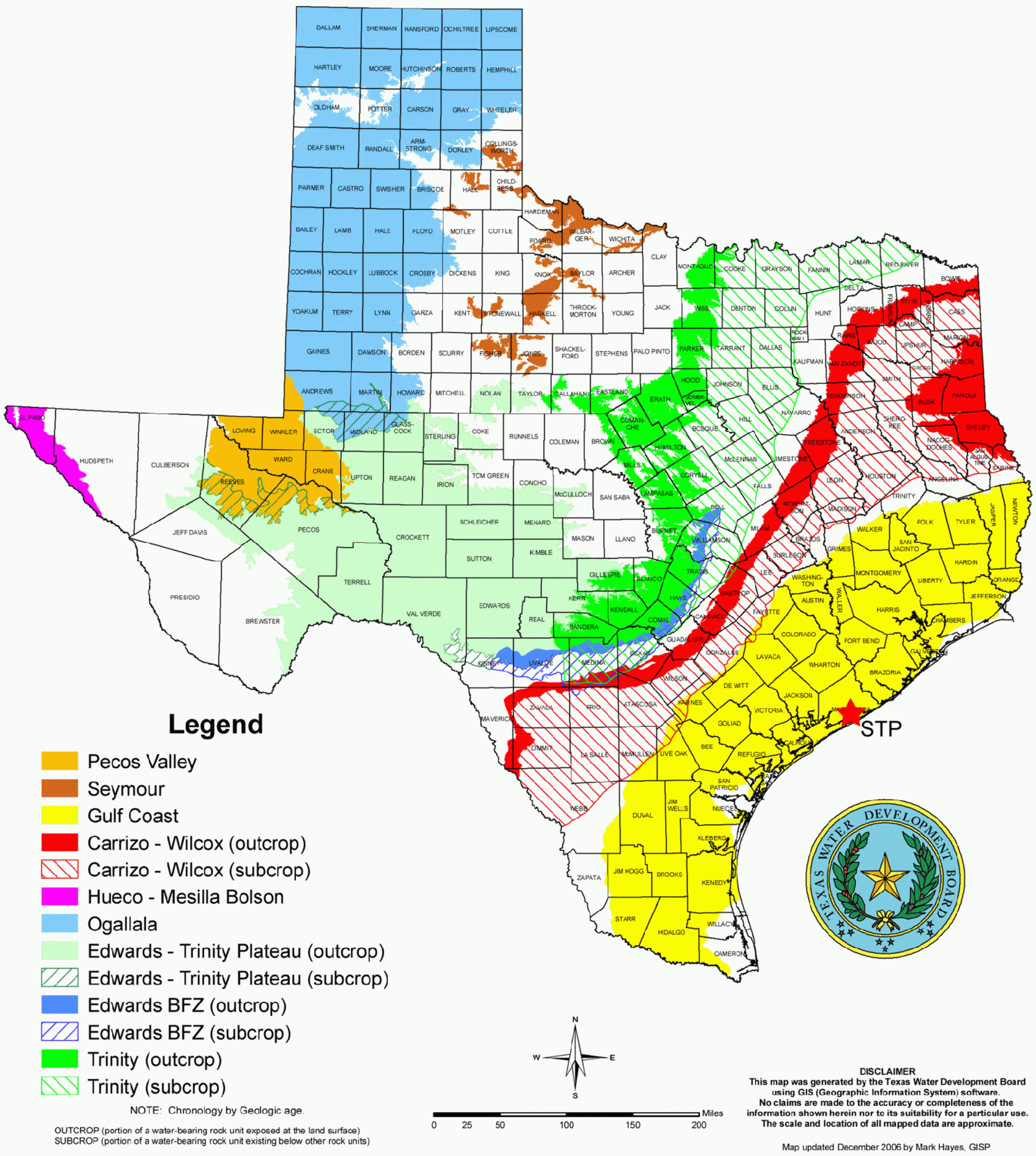


Figure 2.4S.12-7 Major Aquifers of Texas (Reference 2.4S.12-3)

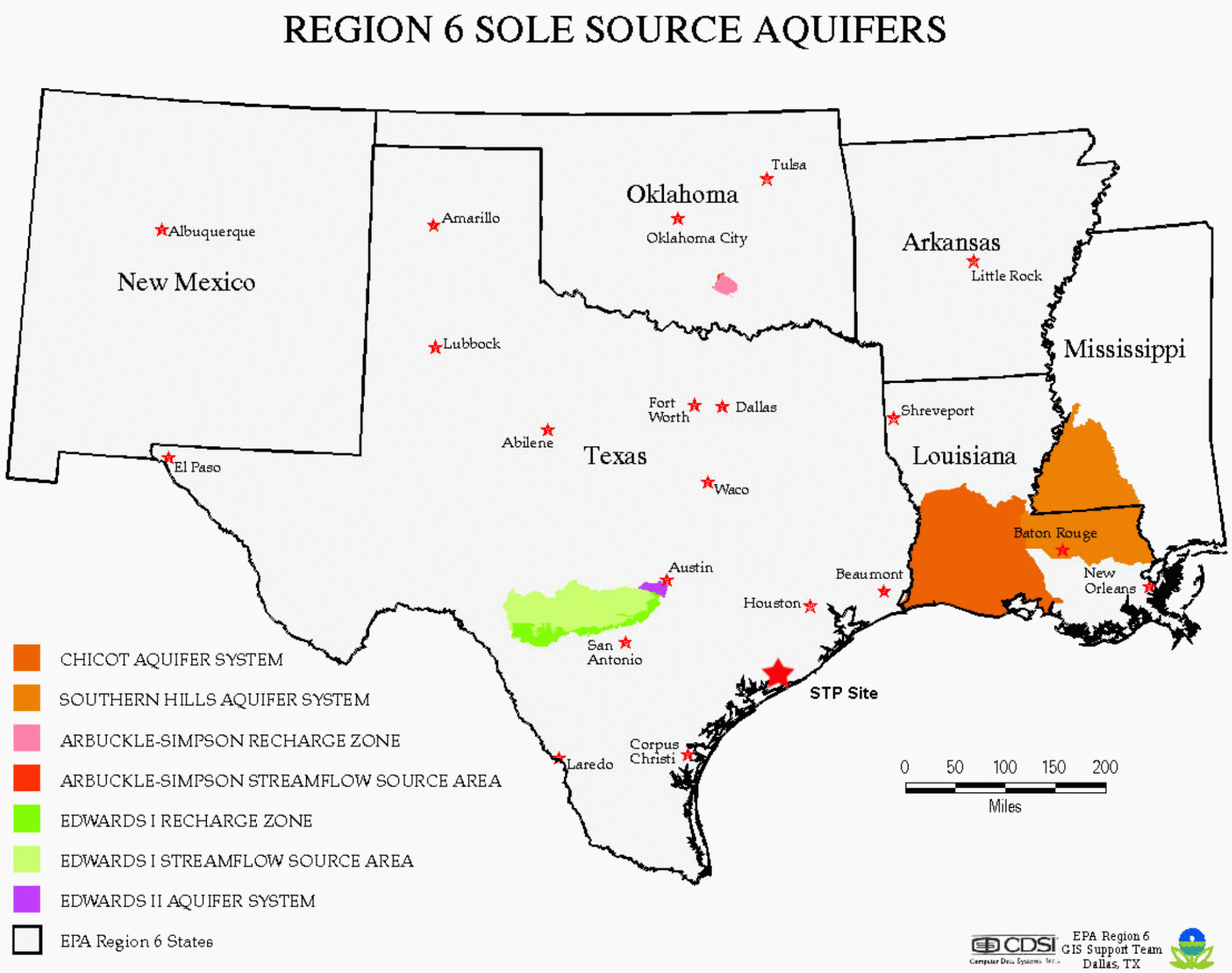


Figure 2.4S.12-8 Sole Source Aquifers in EPA Region VI (Reference 2.4S.12-4)

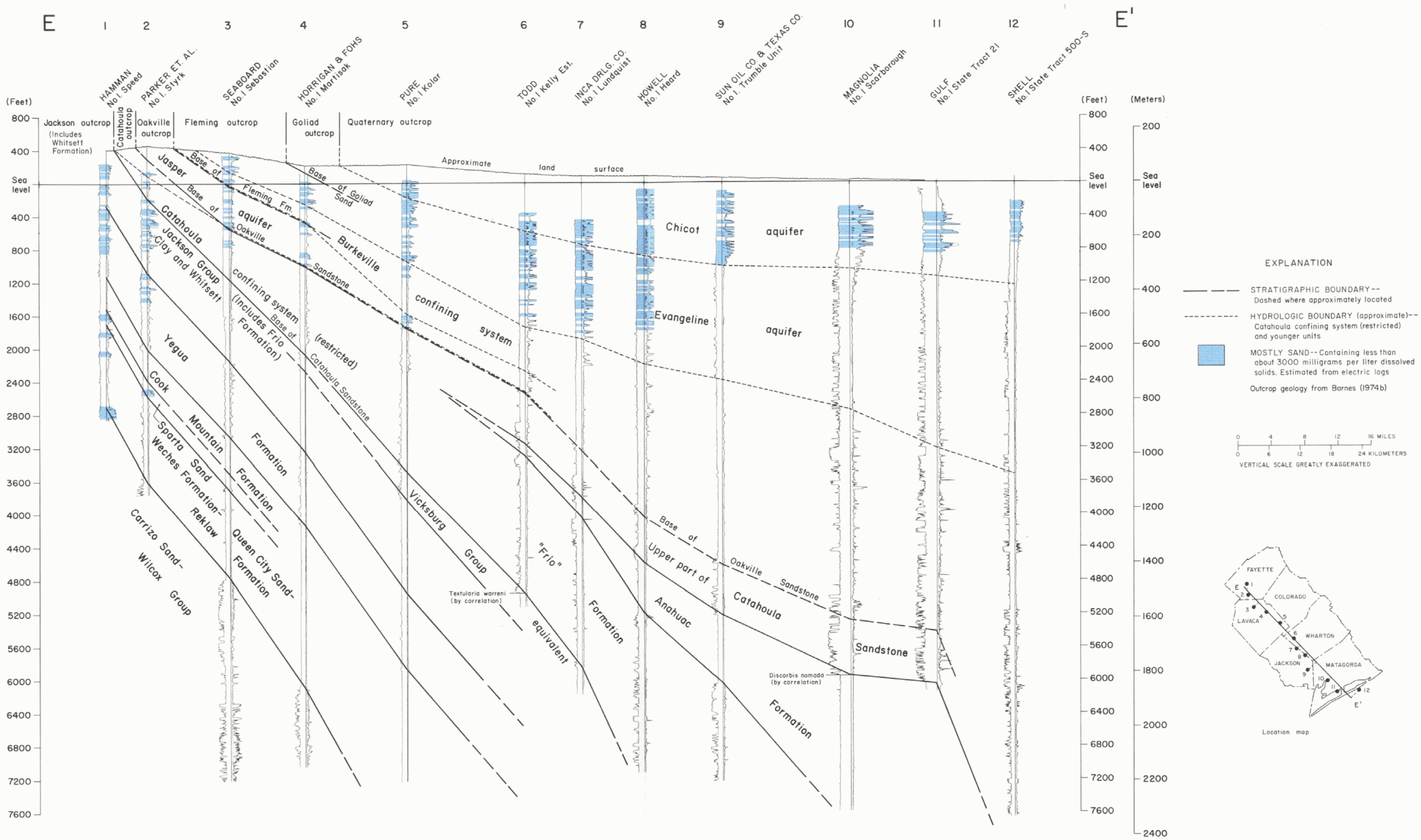


Figure 2.4S.12-9 Regional Hydrogeologic Cross Section through the Gulf Coast Aquifer System (Reference 2.4S.12-5)

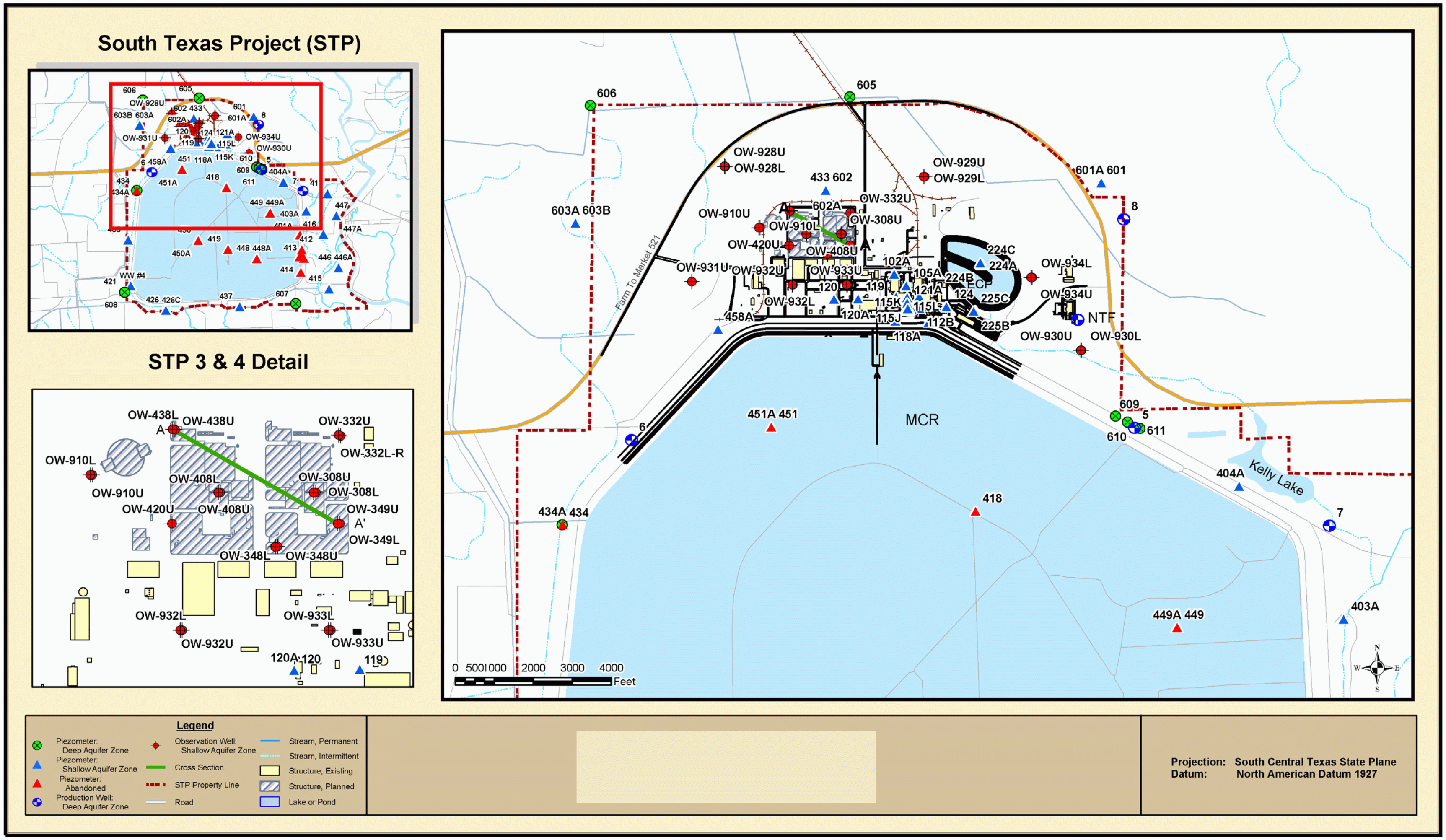


Figure 2.4S.12-10 STP Site Well Locations

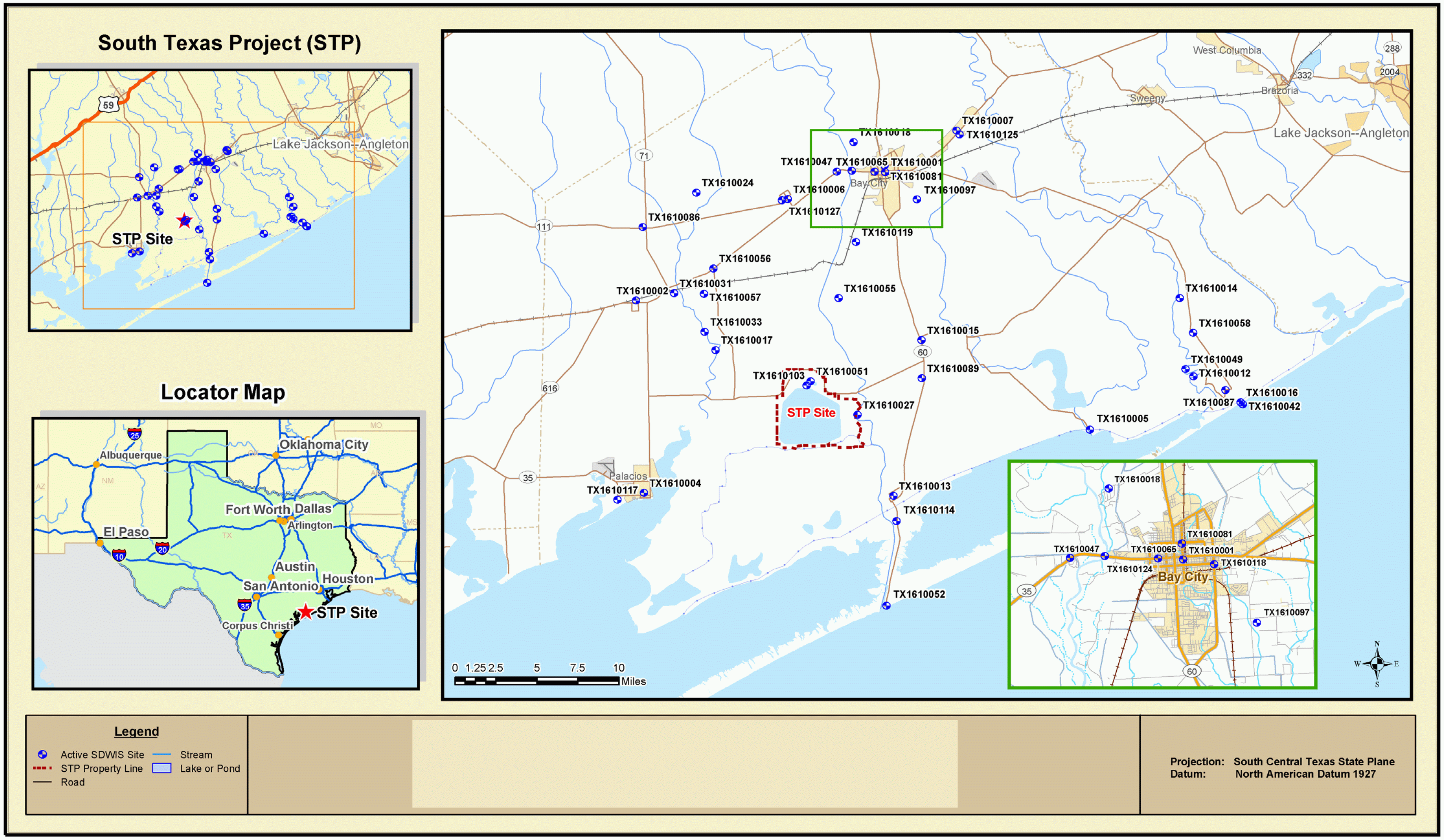


Figure 2.4S.12-11 Safe Drinking Water Information System (SDWIS) Water Supply Systems in Matagorda County

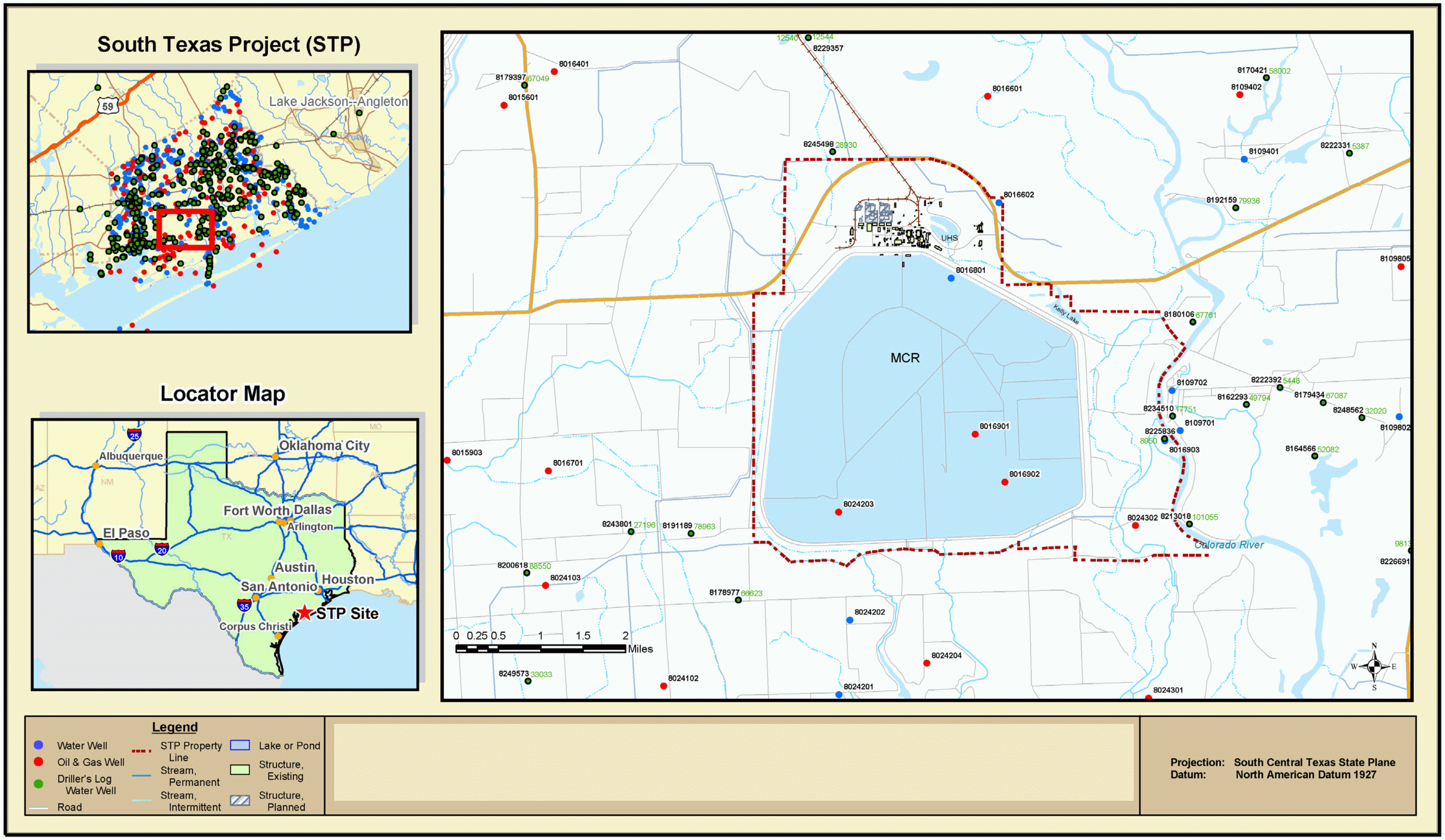


Figure 2.4S.12-12 Well Locations in Matagorda County and Adjacent areas from the TWDB Database (See Plate I of Appendix 2.4S.12-A for clarity)

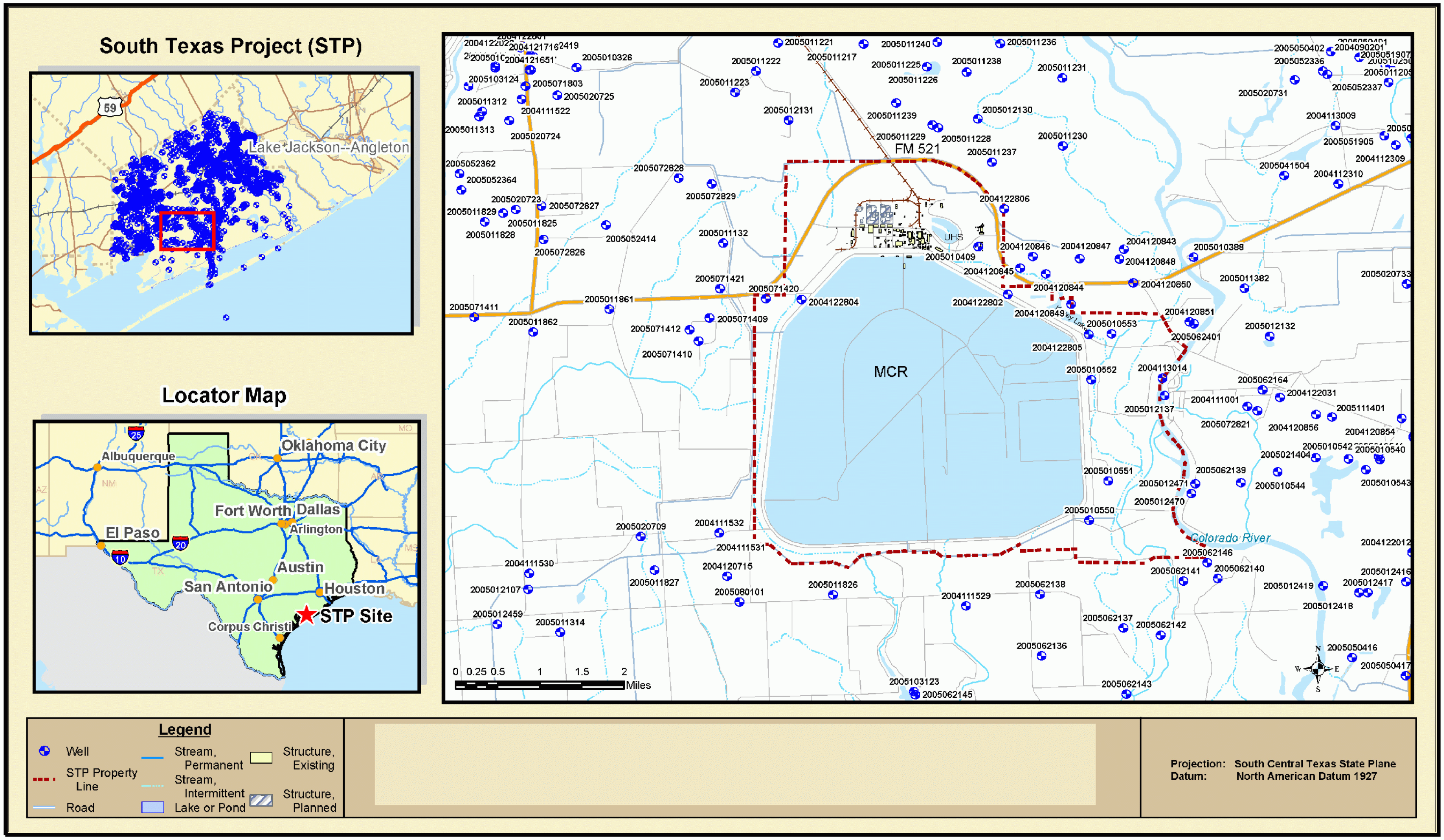


Figure 2.4S.12-13 Coastal Plains Groundwater Conservation District Well Locations (See Plate II of Appendix 2.4S.12-A for clarity)

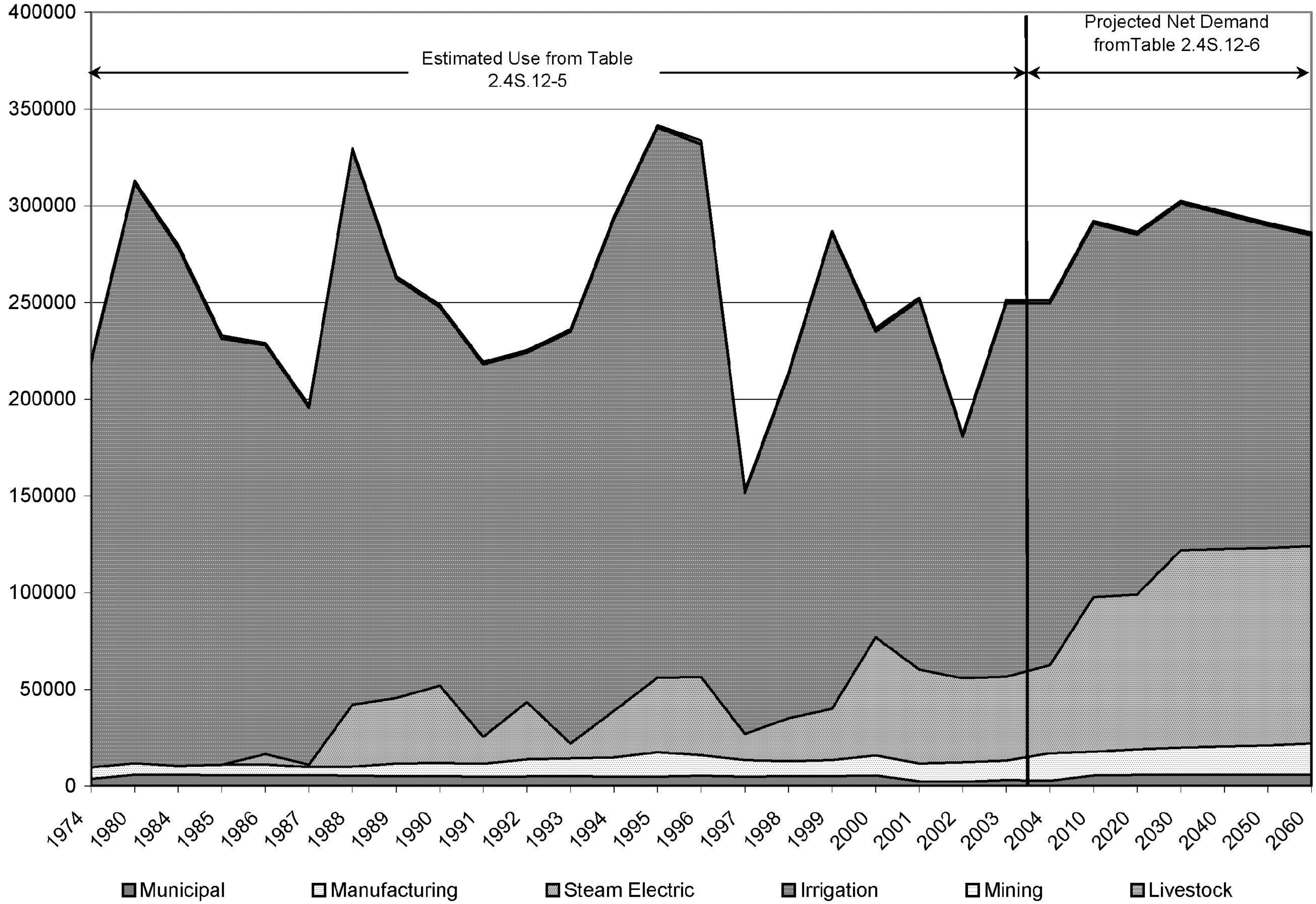


Figure 2.4S.12-14 Water Use Estimates

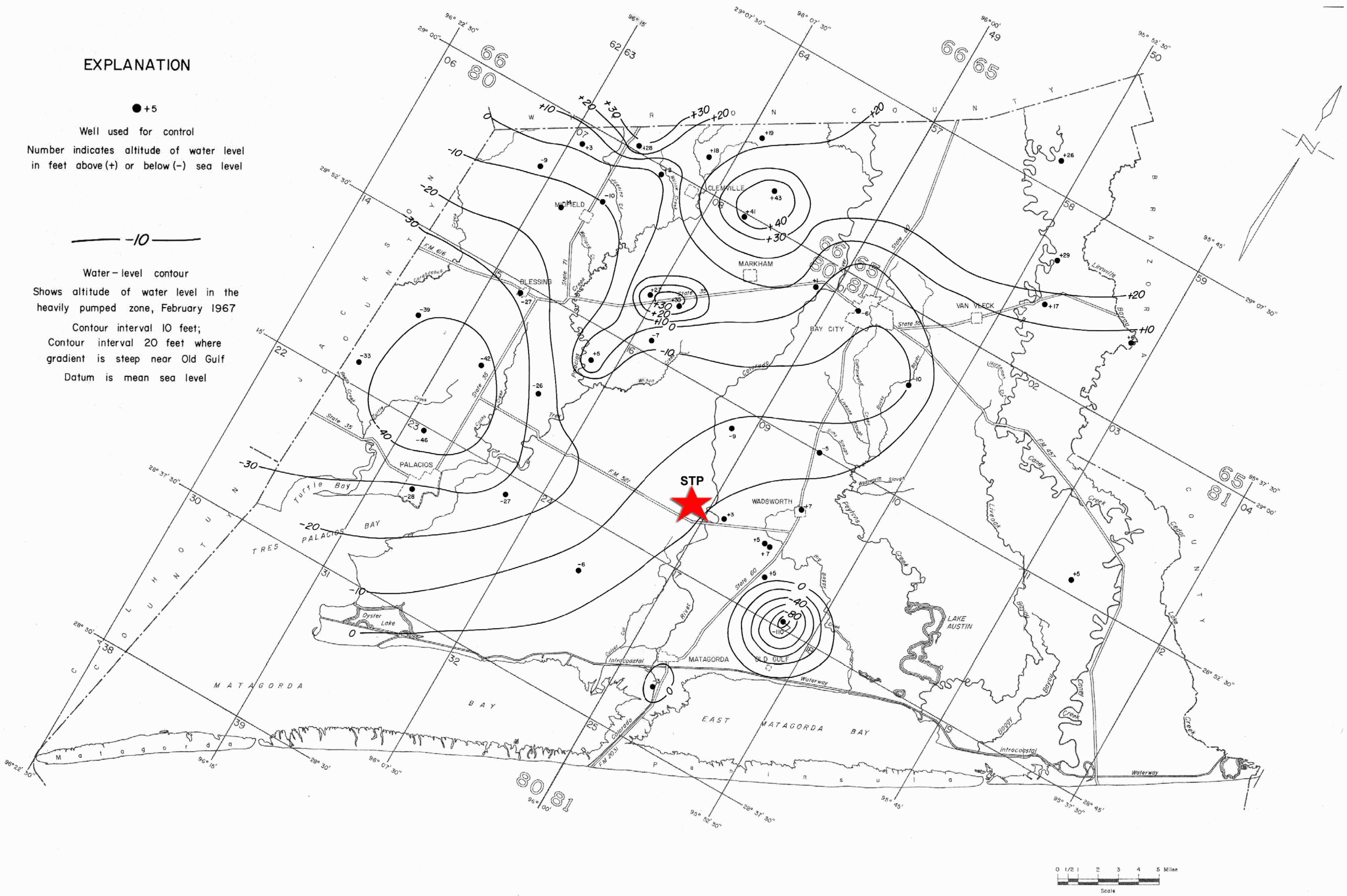


Figure 2.4S.12-15 Potentiometric Surface in the Deep Aquifer in Matagorda County in 1967 (modified from Reference 2.4S.12-6)

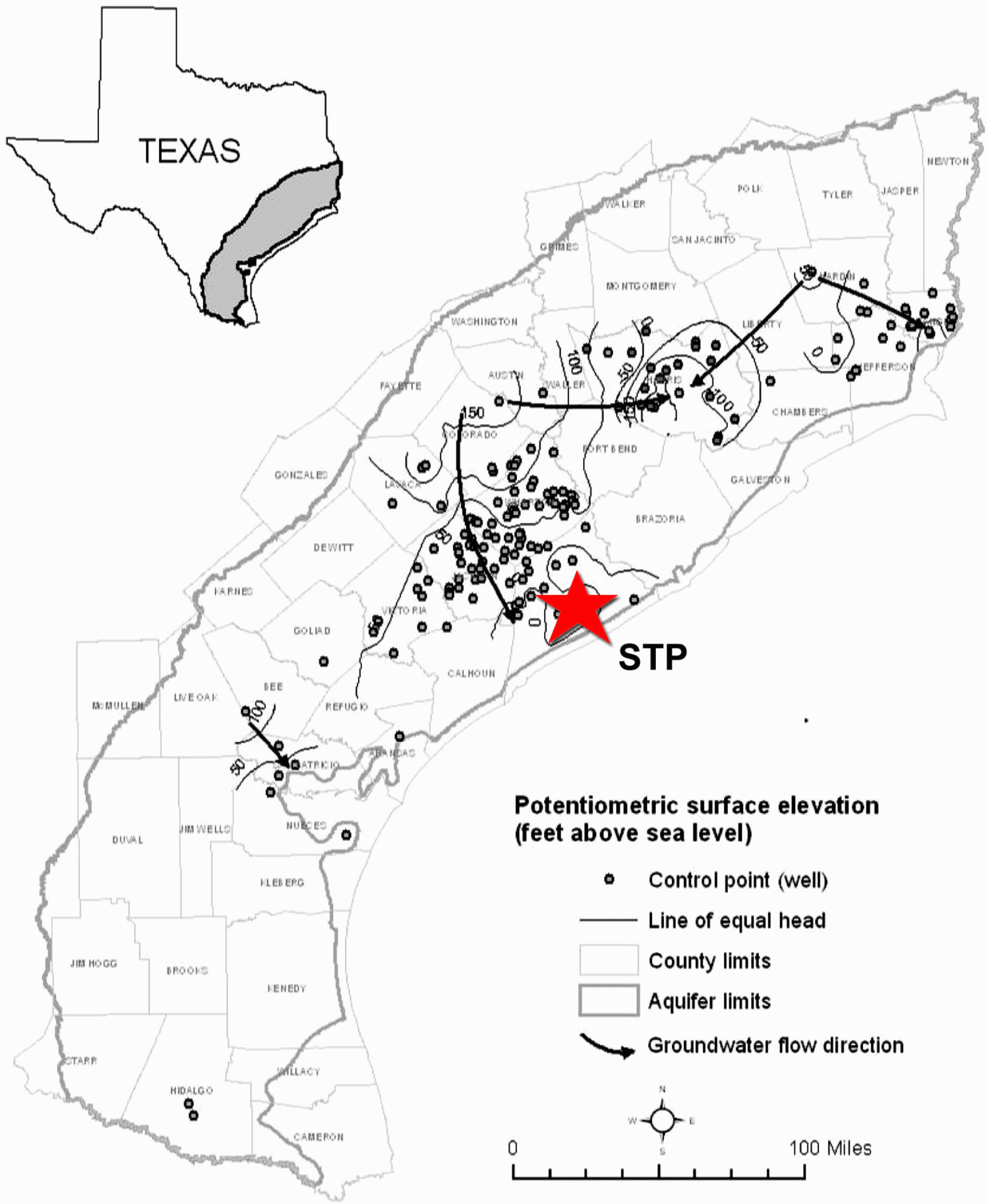


Figure 2.4S.12-16 Regional Potentiometric Surface Map including water level measurements from 2001 to 2005 (Reference 2.4S.12-15)

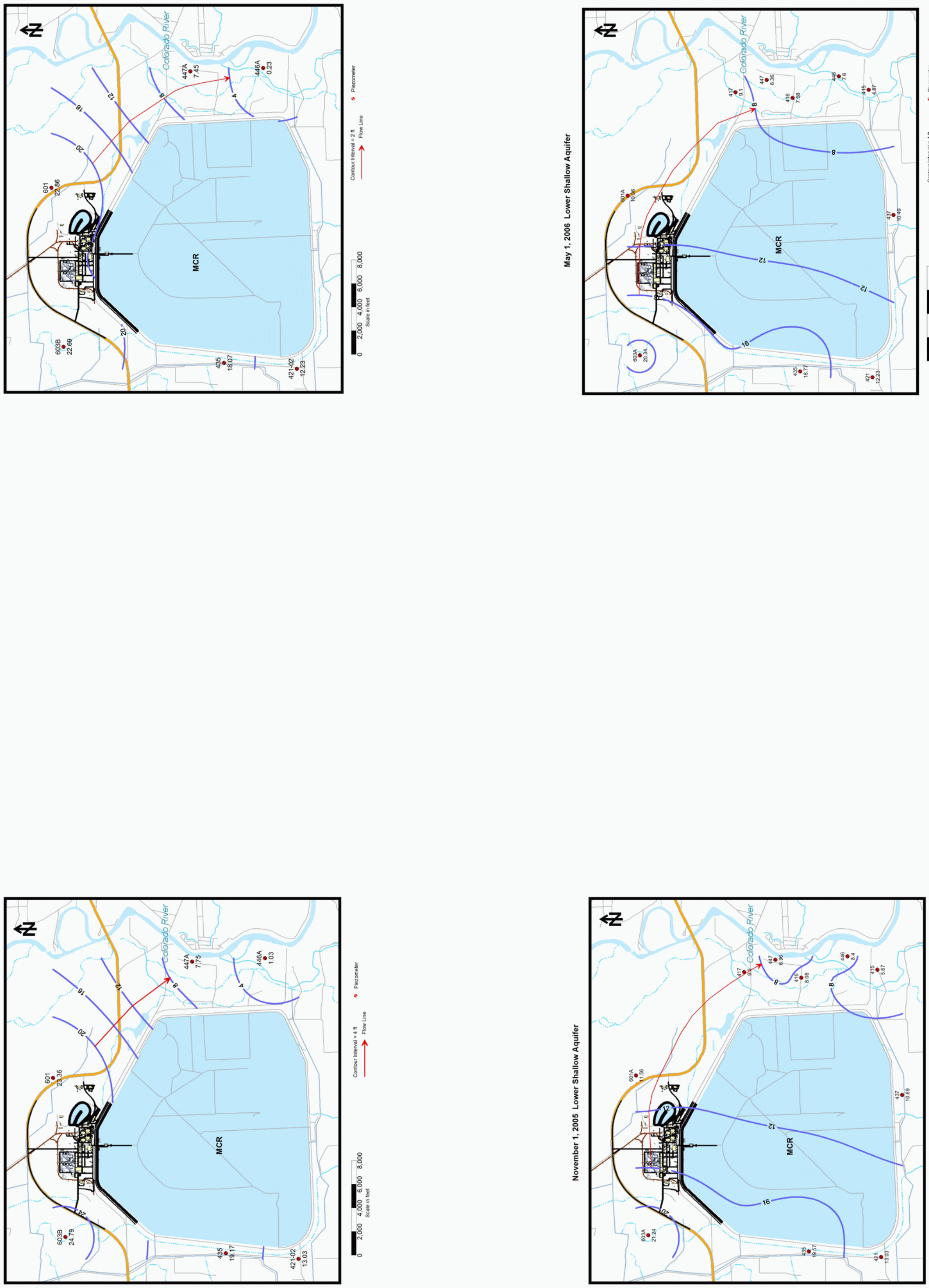


Figure 2.4S.12-17 Shallow Aquifer Potentiometric Surface Maps

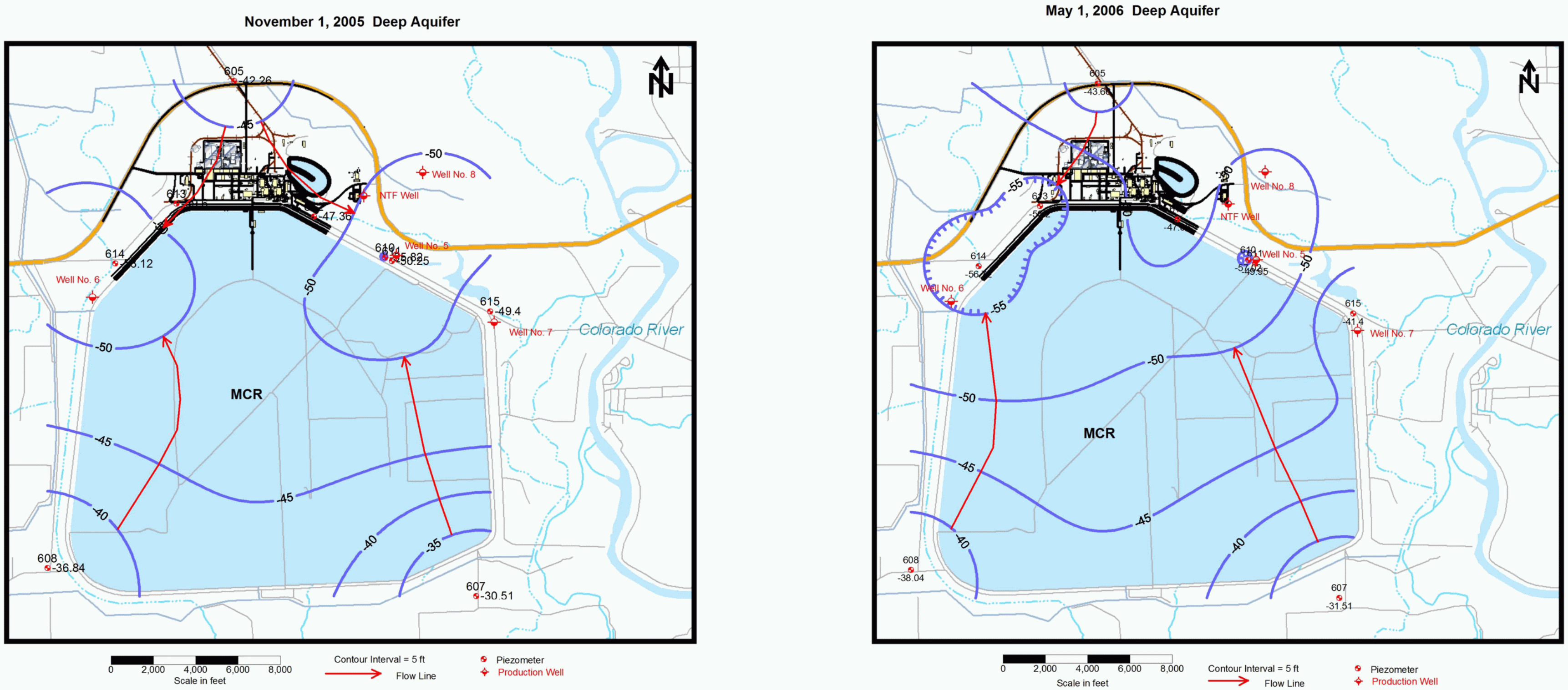


Figure 2.4S.12-18 Deep Aquifer Potentiometric Surface Maps

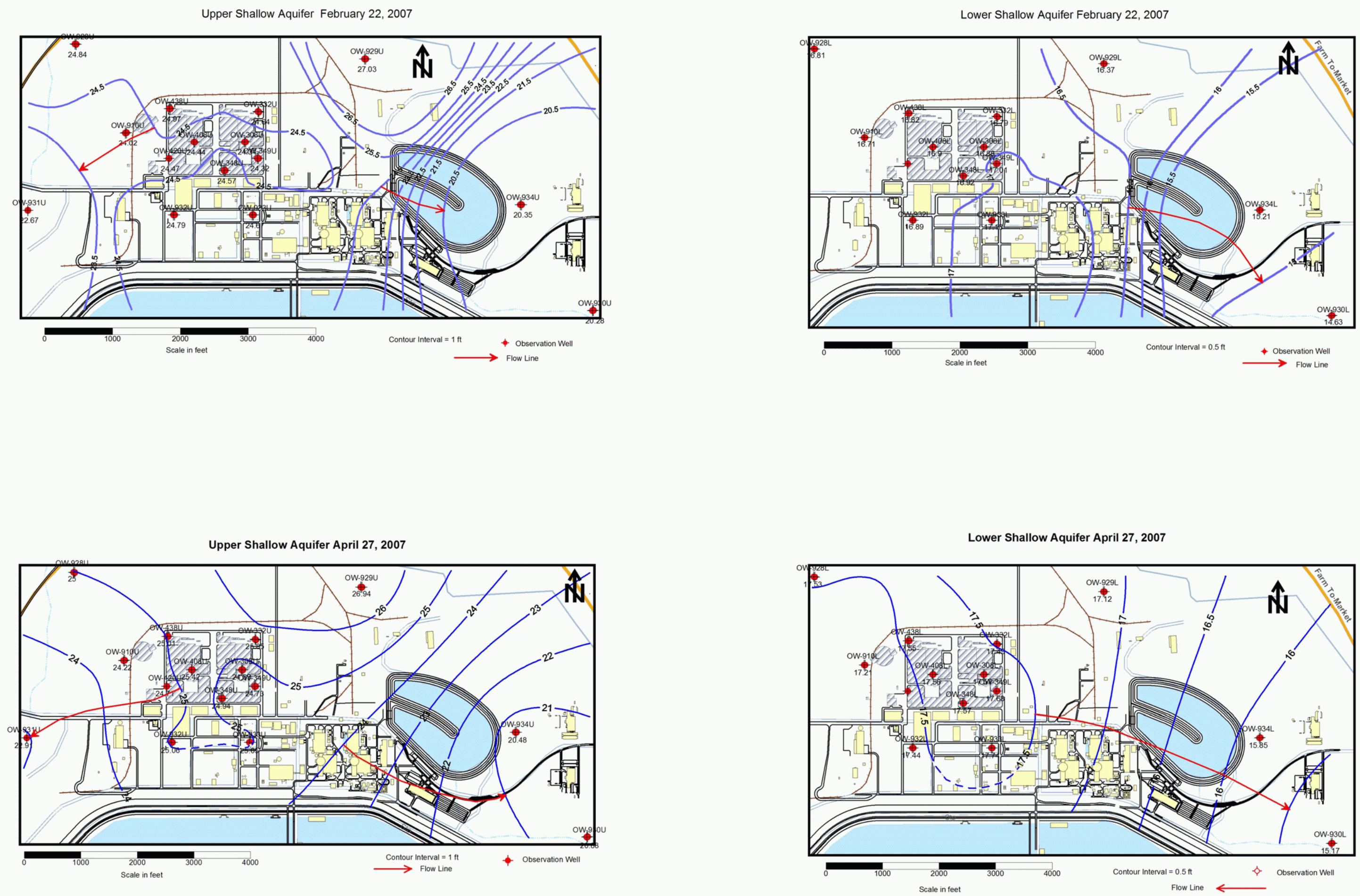


Figure 2.4S.12-19 Quarterly Potentiometric Surface Maps in the STP 3 & 4 Areas

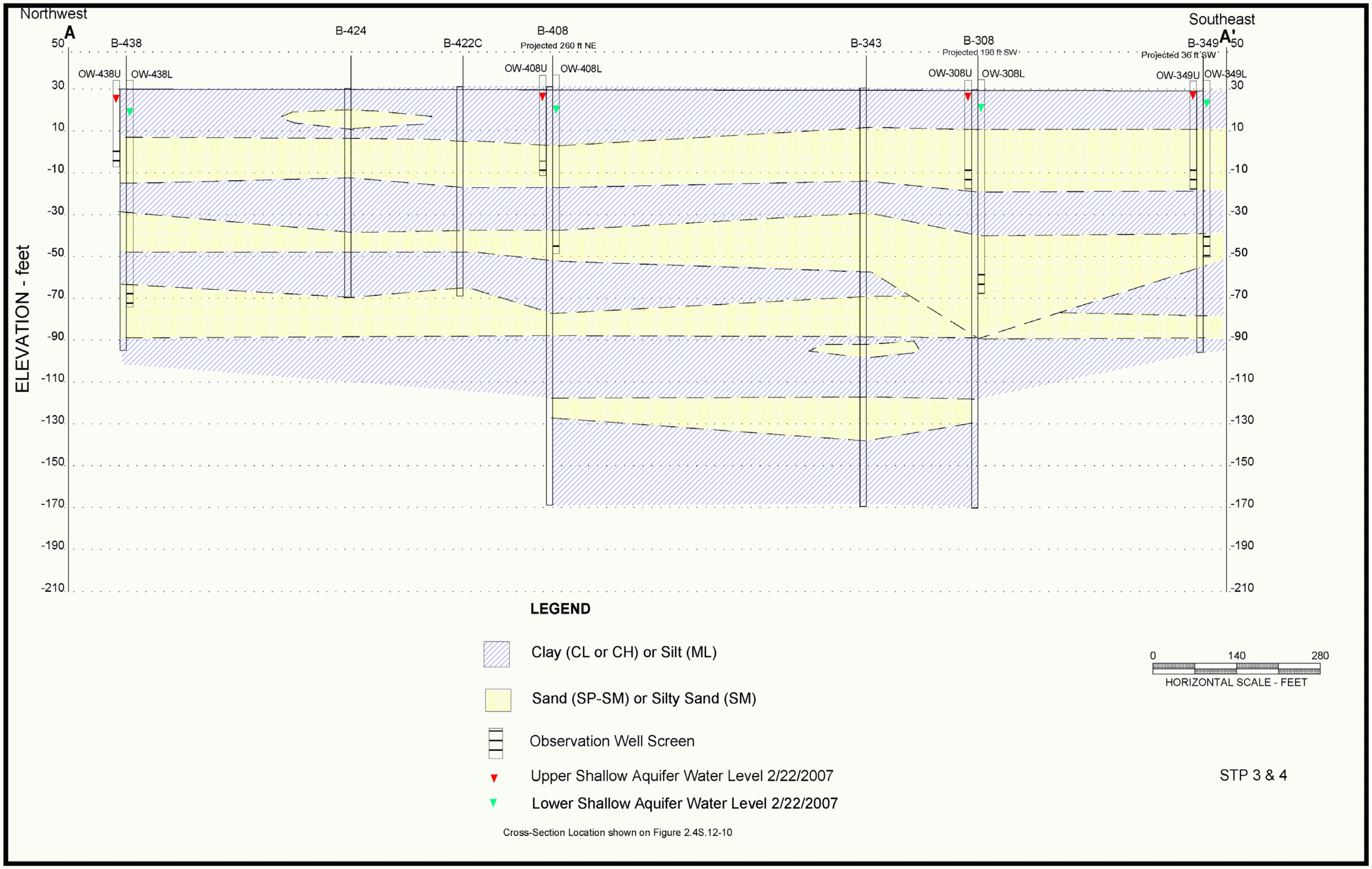


Figure 2.4S.12-20 Hydrogeologic Cross-Section A-A'

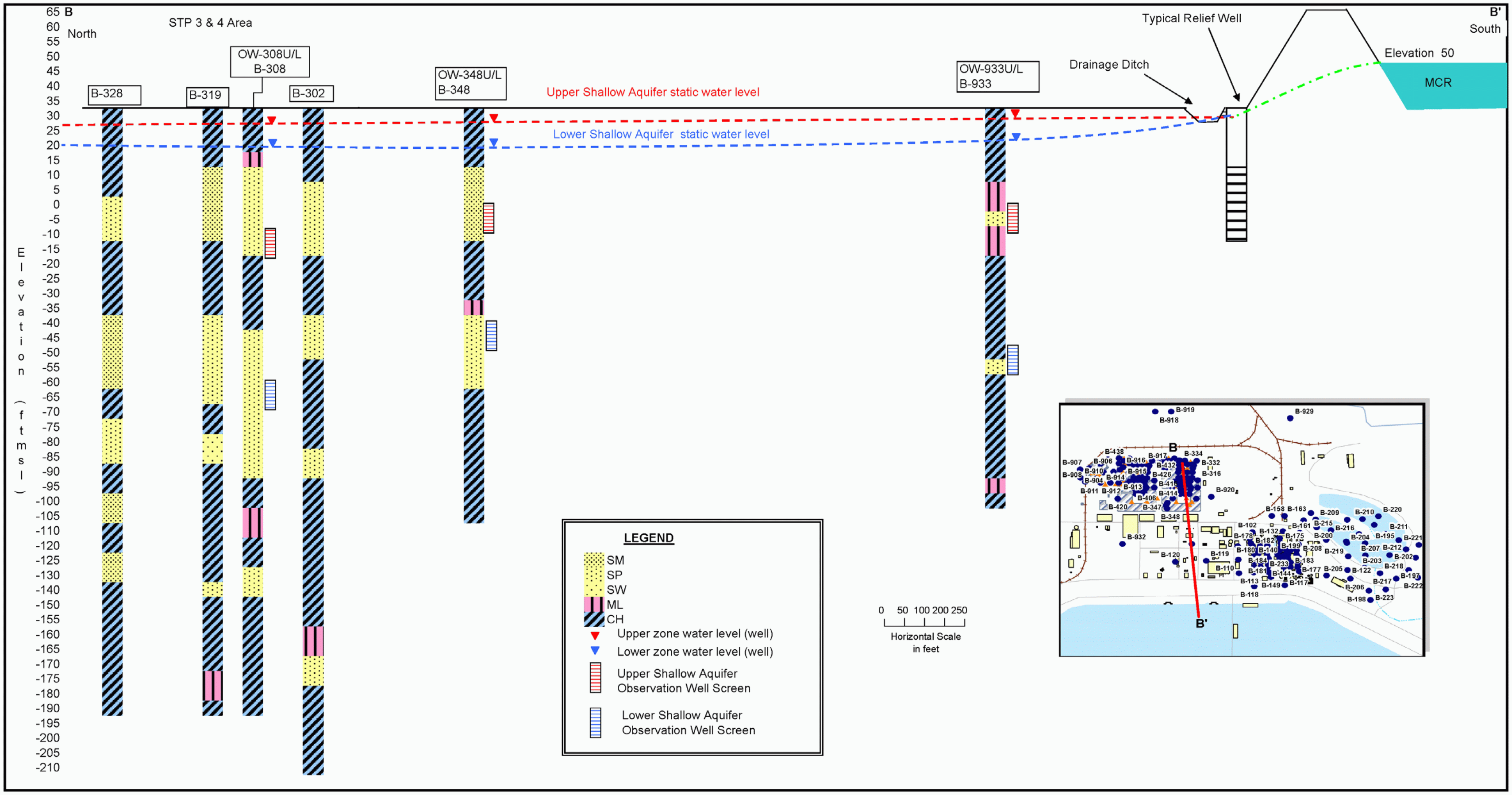


Figure 2.4S.12-21 Conceptual Hydrogeologic Cross-Section B-B'

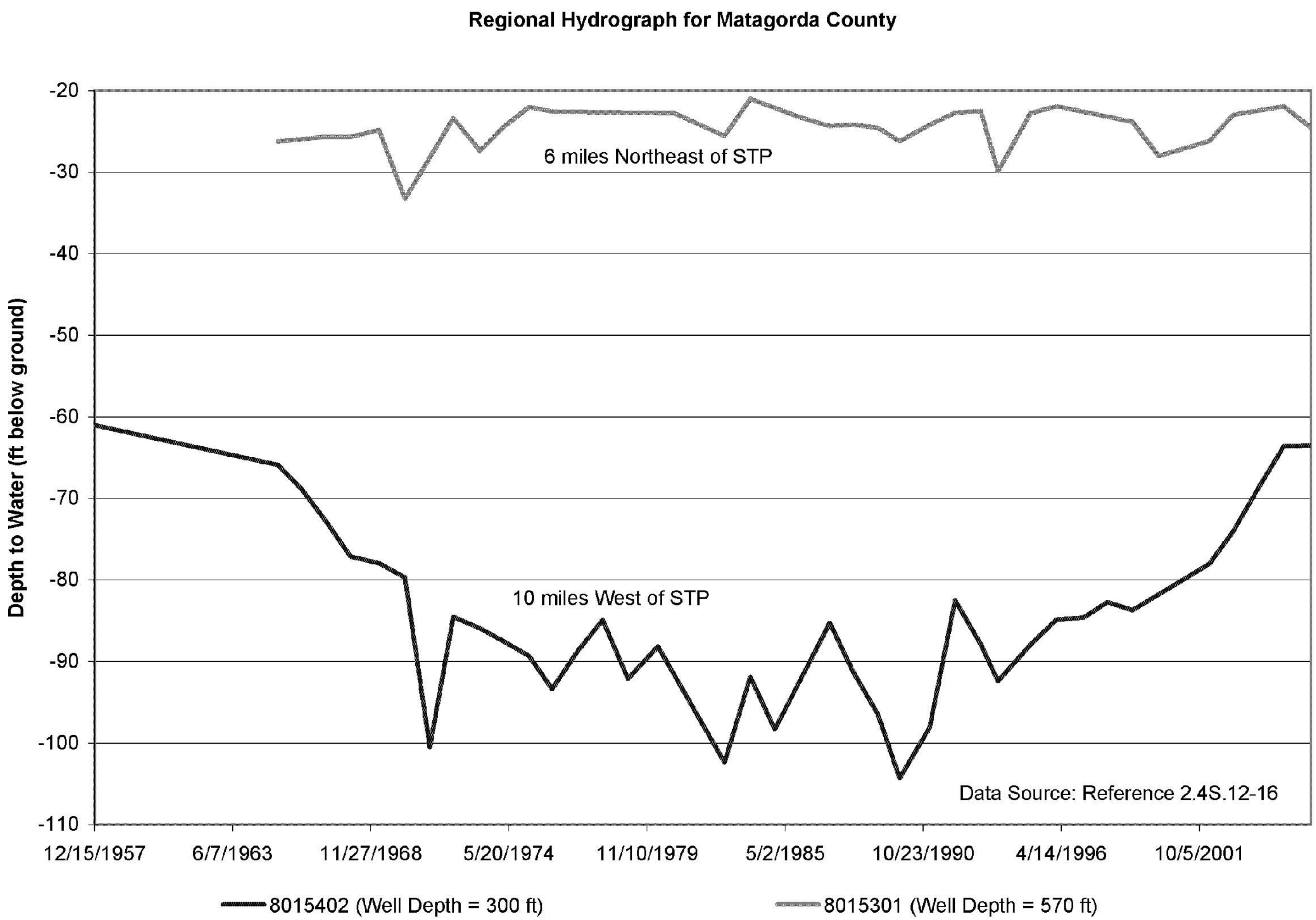


Figure 2.4S.12-22 Regional Hydrographs for Deep Aquifer

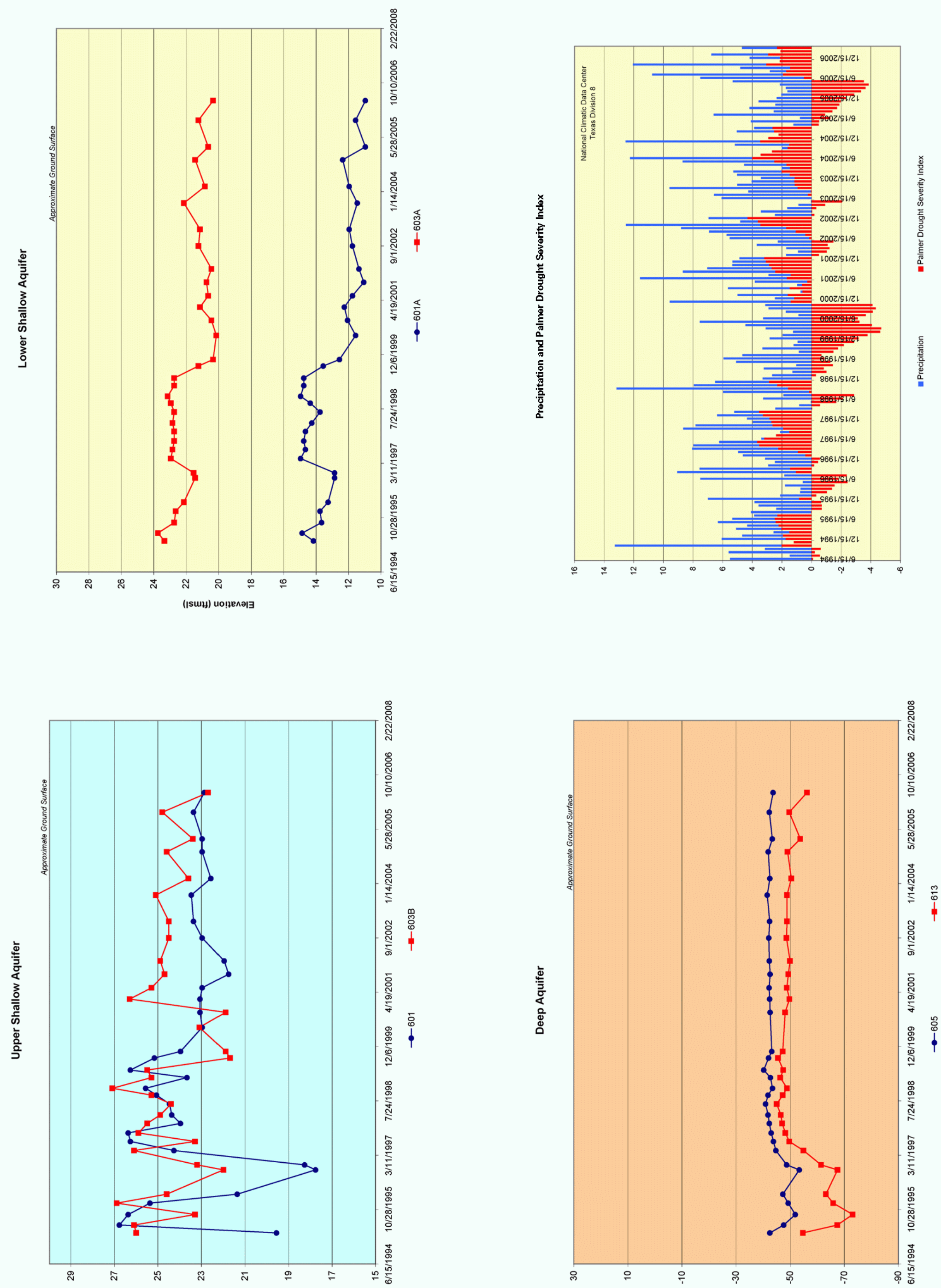


Figure 2.4S.12-23 Hydrographs of Selected Wells at the STP Site

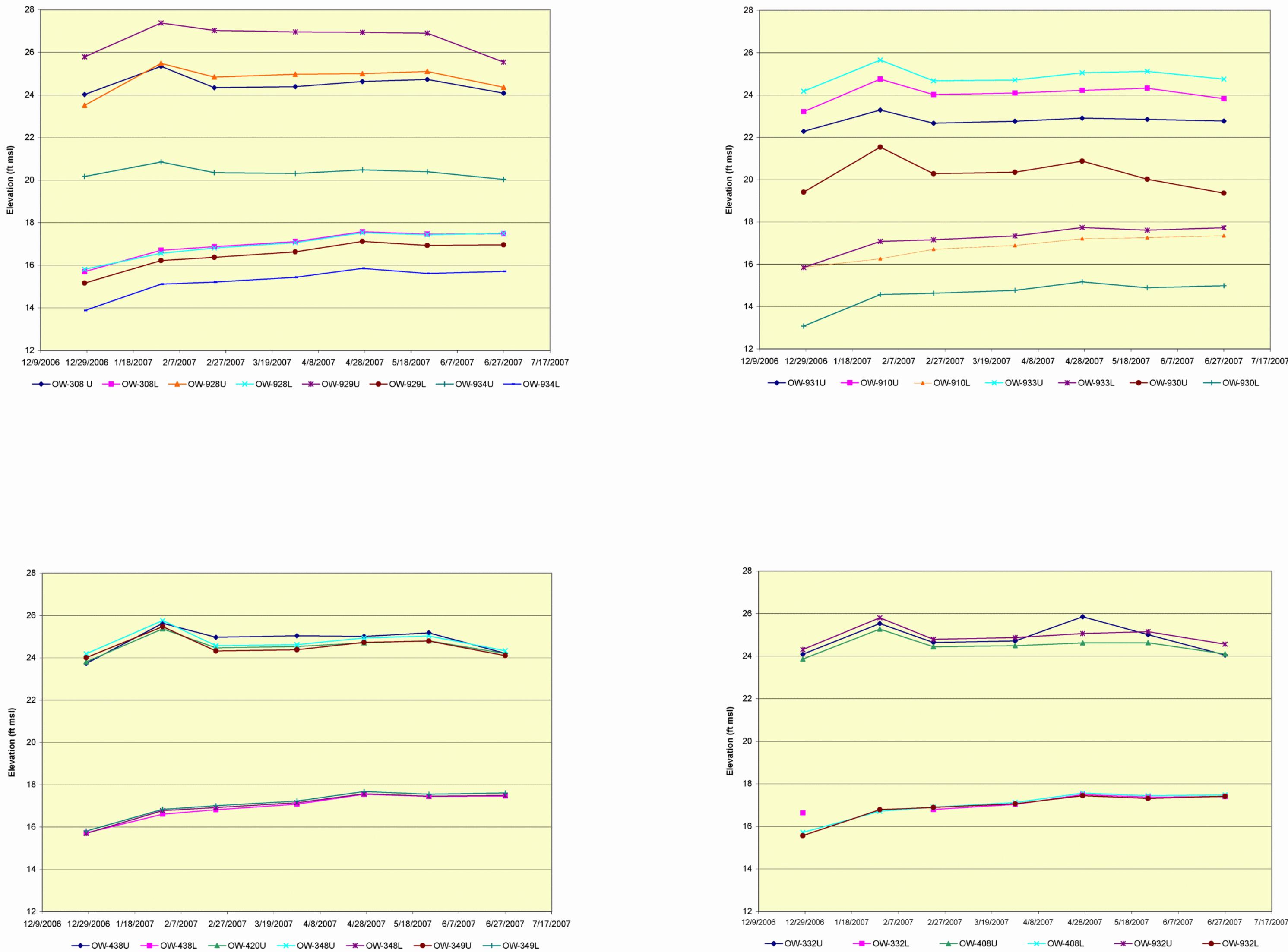


Figure 2.4S.12-24 Hydrographs of Wells in the STP 3 & 4 Area

Parameter	Regional Transmissivity (gpd/ft)	STP Deep Aquifer Transmissivity (gpd/ft)	STP Shallow Aquifer Transmissivity (gpd/ft)	Regional Storage Coefficient (unitless)	STP Deep Aquifer Storage Coefficient (unitless)	STP Shallow Aquifer Storage Coefficient (unitless)
Sample Size (N)	40	3	5	6	2	4
Standard Deviation	71,936	14,526	11,620	0.0006	0.0004	0.0006
Mean	84,500	33,245	14,320	0.0008	0.0005	0.0009
Geometric Mean	63,725	31,379	9,295	0.0005	0.0004	0.0008
Median	63,800	25,533	13,000	0.0010	0.0005	0.0007

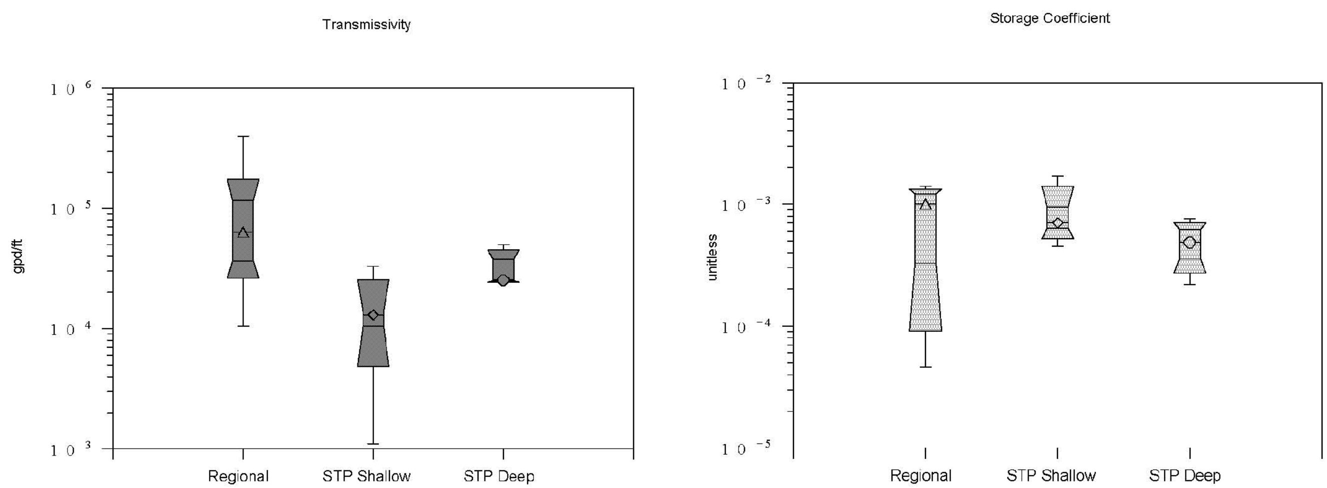


Figure 2.4S.12-25 Summary of Aquifer Transmissivity and Storage Coefficient Data from Aquifer Pumping Tests

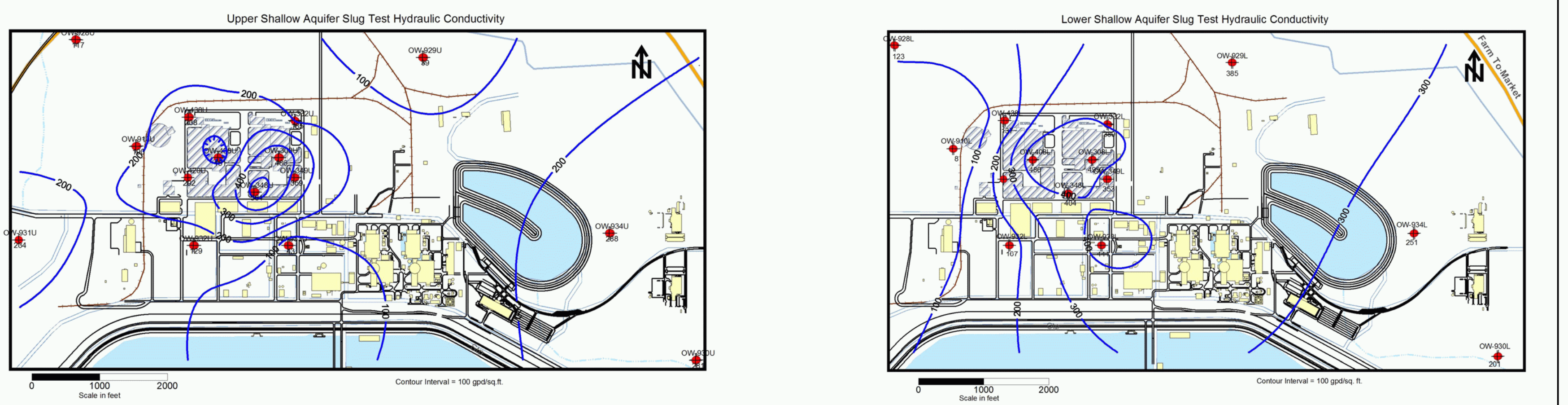


Figure 2.4S.12-26 Contour Maps of Hydraulic Conductivity from Slug Tests in the Shallow Aquifer

Parameter	Regional Hydraulic Conductivity (gpd/ft^2)	STP Aquifer Pumping Test Hydraulic Conductivity (gpd/ft^2)	STP Slug Test Hydraulic Conductivity (gpd/ft^2)	STP Grain Size Hydraulic Conductivity (gpd/ft^2)
Sample Size (N)	35	5	28	12
Standard Deviation	623	230	152	40
Mean	540	429	266	125
Geometric Mean	420	337	205	120
Median	413	420	244	108

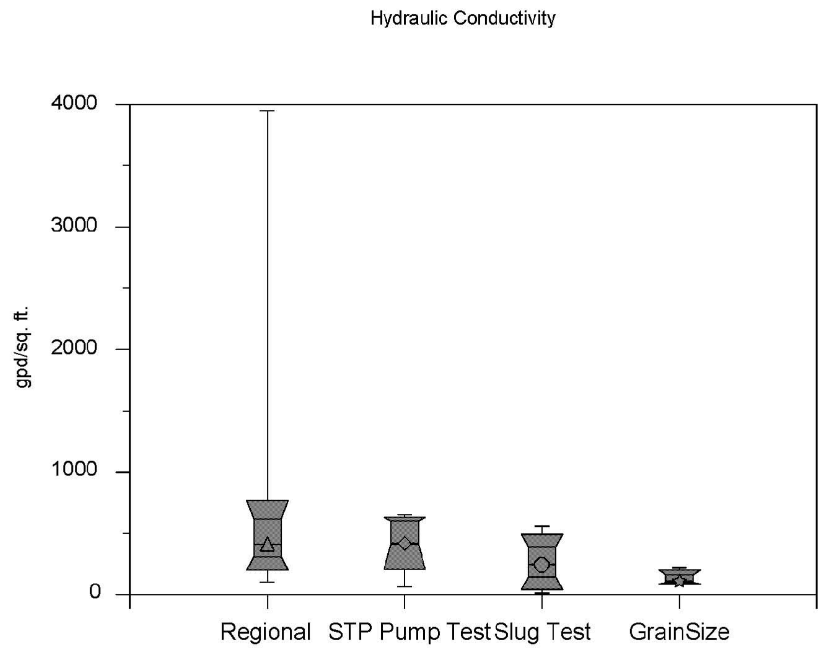


Figure 2.4S.12-27 Summary of Hydraulic Conductivity from Aquifer Pumping Tests, Slug Tests, and Grain Size

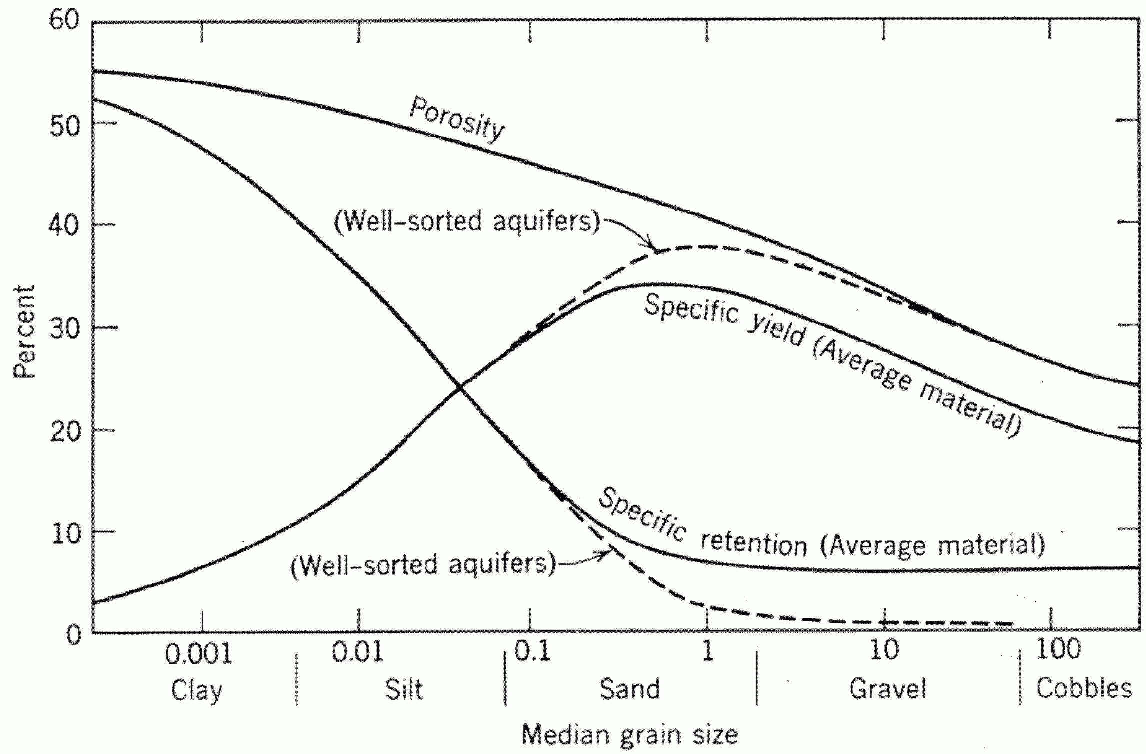


Figure 2.4S.12-28 Relationship of Porosity, Specific Yield, and Specific Retention (Reference 2.4S.12-18)

Unit	Hydrogeologic Zone	Ground Surface	Thickness	Geologic Materials
Shallow Aquifer	Upper Shallow Aquifer Confining Layer		10 - 30 ft	Clay and Silt
	Upper Shallow Aquifer		20 -30 ft	Silty Sand and Poorly Graded Sand
	Lower Shallow Aquifer Confining Layer		15 - 25 ft	Clay and Silt
	Lower Shallow Aquifer		25 - 50 ft	Silty Sand and Poorly Graded Sand with thin Clay and Silt Layers
Deep Aquifer Confining Layer			100 - 150 ft	Silty Clay and Silt with thin Sand Layers
Deep Aquifer			>500 ft	Sand with thin Clay and Silt Layers

Figure 2.4S.12-29 Simplified Hydrostratigraphic Section

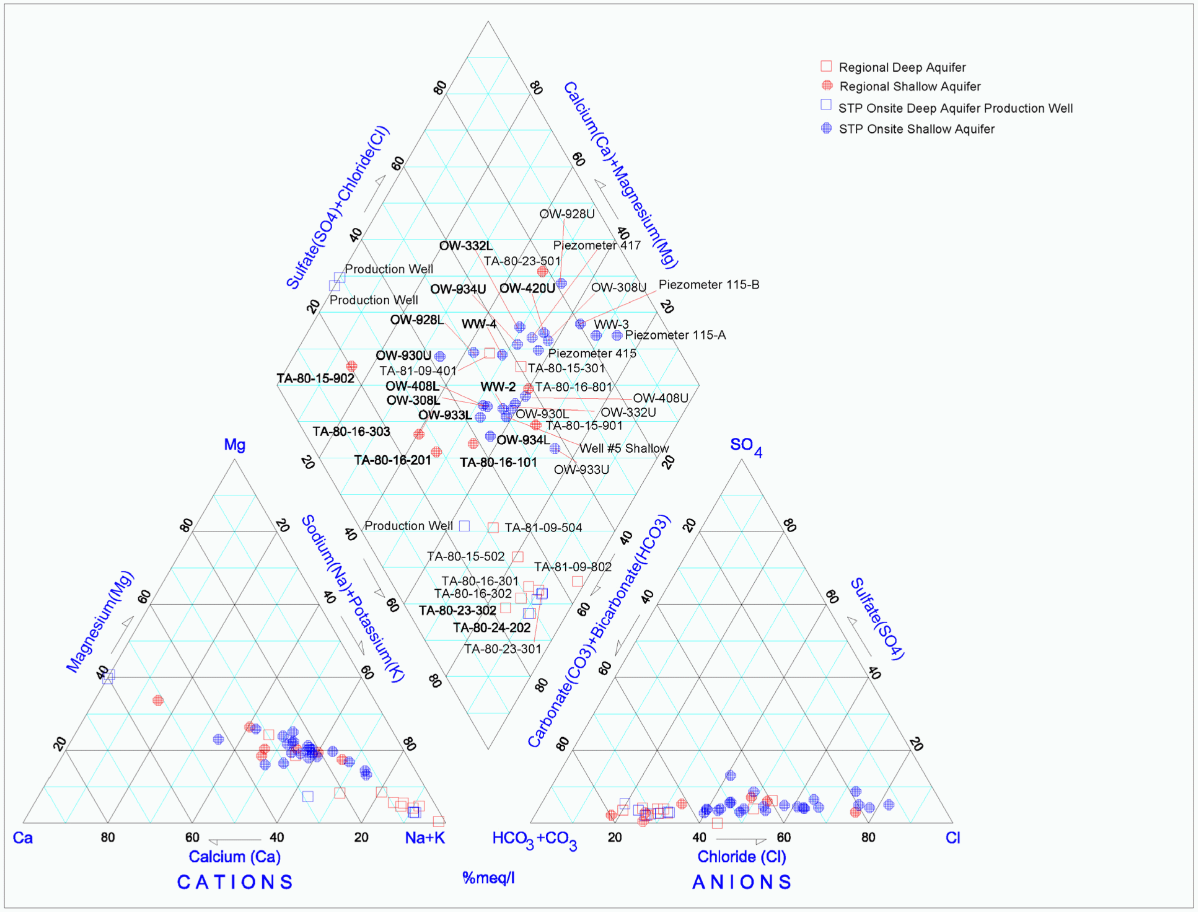


Figure 2.4S.12-30 Trilinear Diagram of Hydrogeochemical Data

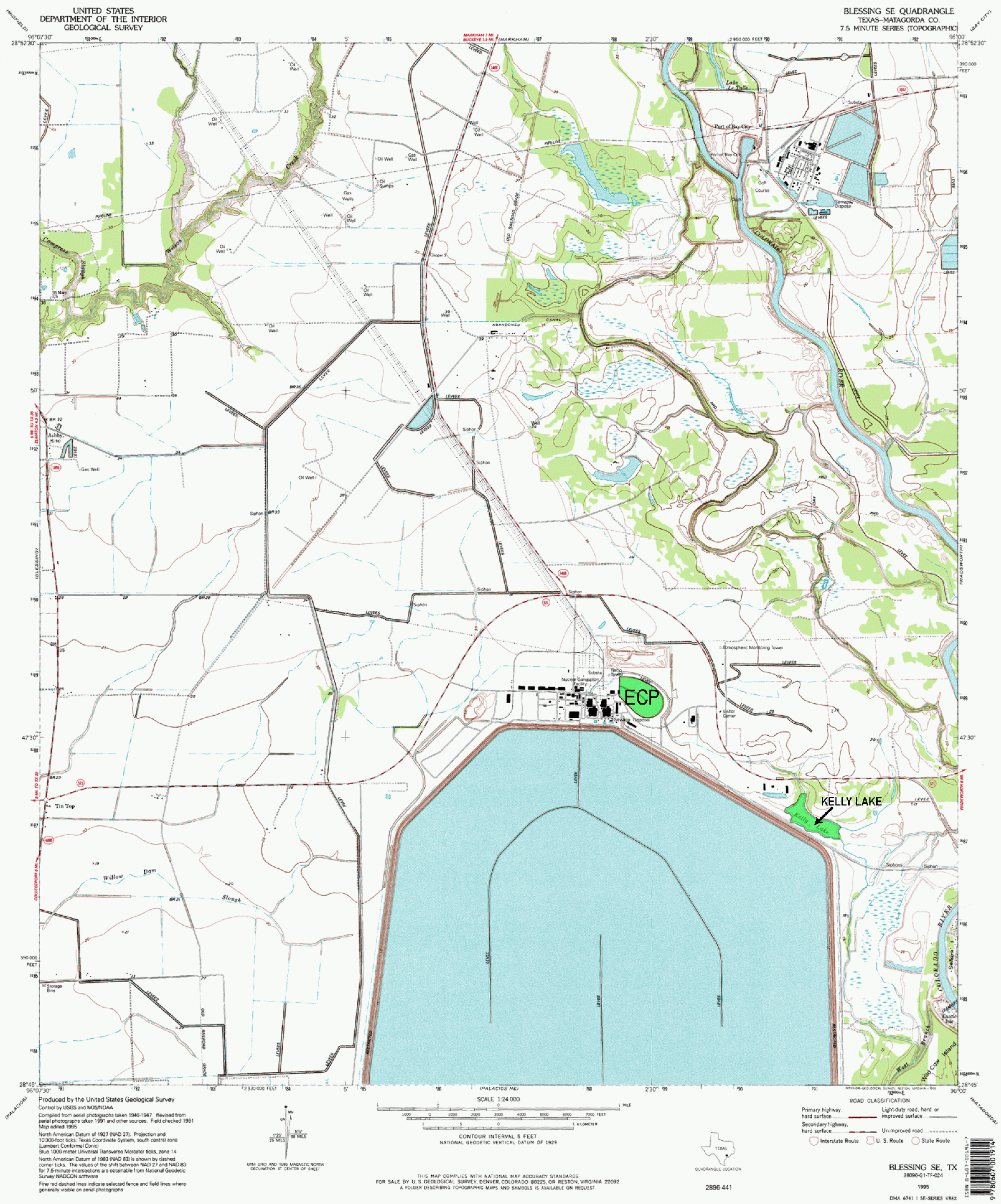


Figure 2.4S.12-31 Blessing SE 7.5 minute Topographic Map (modified from Reference 2.4S.12-21)

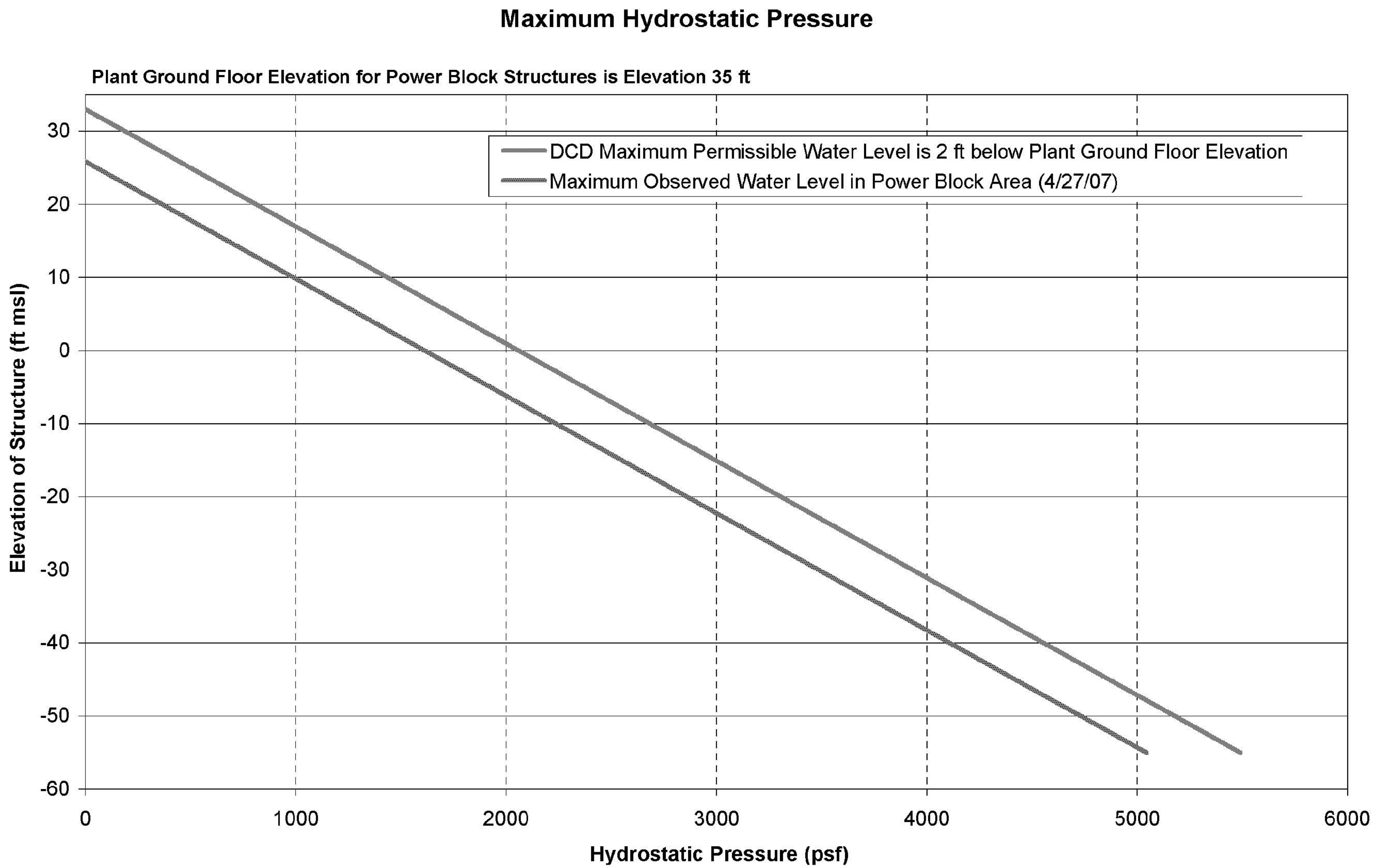


Figure 2.4S.12-32 Subsurface Hydrostatic Loading