G-160 and Loxahatchee Slough Groundwater – Surface Water Interaction Study Technical Report

Technical Publication WS-40

May 2016

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EXECUTIVE SUMMARY

This technical report documents the results of a study conducted to assess surface water and groundwater conditions within and adjacent to the eastern portion of the Loxahatchee Slough in northern Palm Beach County, Florida since the installation and operation of the G-160 structure on the C-18 Canal, particularly after the structure's headwater stage was increased in June 2009. The study involved the analysis of monitoring data collected between November 2005 and mid-March 2013 from groundwater monitor wells installed in 2004 and 2010 as well as from several local stage and rainfall stations.

The north-south trending C-18 Canal, which bisects the Loxahatchee Slough, is a component of the Central and South Florida Flood Control Project (C&SFFCP) and was originally constructed in the late 1950s by the U.S. Army Corps of Engineers (USACE), and currently is operated by the South Florida Water Management District (SFWMD). The G-160 structure, which was constructed in 2003 and began operating in January 2004, is a key component of the C-18 Canal. The structure initially was identified in the Northern Palm Beach County Comprehensive Water Management Plan and subsequently incorporated into the Comprehensive Everglades Restoration Plan's (CERP's) Loxahatchee River Watershed Restoration Project (LRWRP) Part 1 (formerly North Palm Beach County – Part 1). The purpose of the structure is to 1) serve as an engineering solution to maintain the existing level of service for flood protection, 2) aid in meeting environmental water supply demands by enhancing delivery of freshwater flows to the Northwest Fork of the Loxahatchee River, and 3) improve the sensitive wetlands environment in the C-18 Basin, including the Loxahatchee Slough.

The initial operational schedule called for maintaining the headwater stage at 15.5 feet NGVD during the dry season and 15.0 feet NGVD during the wet season. Since June 1, 2009, at the direction of the Florida Department of Environmental Protection (FDEP) and according to the FDEP operating permit issued in 2003, the SFWMD has been maintaining the headwater stage between 16.3 and 16.7 feet NGVD, provided water has been available.

After construction and initial operation of the G-160 structure in early 2004 as well as after considering the operational schedule changes proposed in the 2003 FDEP permit, several questions and concerns were raised by local and regional stakeholders, prompting the SFWMD to enact initiatives to address the issues. Several months after the G-160 structure began operating, the Florida Department of Transportation (FDOT) conveyed concerns about the cause of occasional flooding along PGA Boulevard near the C-18 Canal. In early 2004, the SFWMD installed seven groundwater monitor wells at five sites (PGAW01 to PGAW05) located along the northern side of PGA Boulevard in the vicinity of the C-18 Canal. Water levels from these wells have been collected since November 2005.

In response to other concerns, the SFWMD entered into a four-party agreement with the Northern Palm Beach County Improvement District (NPBCID), South Indian River Water Control District (SIRWCD) and the City of Palm Beach Gardens in August 2005, whereby the SFWMD agreed to maintain the G-160 structure headwater stage at 15.0 feet NGVD in the wet season and 15.5 feet NGVD in the dry season for a period of 5 years. However, FDEP later ruled that the operating permit issued in 2003 superseded this agreement and directed the SFWMD to follow the operating schedule stipulated in the permit, which resulted in the headwater stage being raised to 16.5 feet starting on June 1, 2009. In early 2010, to mitigate the continuing concerns of the local stakeholders, the SFWMD agreed to install and monitor 14 additional surficial aquifer wells at 8 sites east of the C-18 Canal and adjacent to the residential developments north and south of PGA Boulevard for a period of at least 2 years following the increase in stage. Data collection from the wells began in April 2010 and continued to mid-March 2013.

The lithology of the upper surficial aquifer system (SAS) in the study area consists of unconsolidated Holocene-aged sands and shells that range in thickness from 20 to 70 feet below land surface (bls). The

strata below this, from 40 to >70 feet bls, are the Pleistocene-aged Anastasia Formation (coquina, shell, quartz sand, sandstone, and limestone), Caloosahatchee Marl (sandy marl, clay, quartz sand, and silt), and Fort Thompson Formation (marine limestone, quartz sandstone, and grey limestone), which also are part of the SAS and contain a localized cavity-riddled zone of high porosity and secondary permeability sometimes referred to as the "Turnpike Aquifer".

A Water Year (WY) in South Florida runs from May 1 to April 30 and is designated by the later year. WY2011 and WY2012 experienced below average rainfall and above average potential evapotranspiration (ETp), with the WY2011 dry season being one of the driest on record. However, in WY2013, Palm Beach County experienced above average rainfall with extreme wet and flooding conditions from Tropical Storm Isaac in August 2012.

From November 2005 through mid-March 2013, groundwater level data were collected and analyzed from the wells (PGAW01 to PGAW05) along PGA Boulevard east and west of the C-18 Canal; G-160 headwater and tailwater stages as well as rainfall data were collected also. Results showed relatively little change or no increase in the groundwater elevations in the wells throughout the 6- to 7-year time period even after raising the G-160 headwater stage in June 2009. From April 2010 to March 2013, the groundwater elevations in five wells located in the northern and southern portions of the study area tended to fall below the G-160 headwater stage and above the tailwater stage during periods of high rainfall. However, in the three wells located in the central portion of the study area west of two regional wellfields, groundwater elevations consistently were above the G-160 headwater stage and generally higher than those to the north and south, suggesting that the latter two areas might be subjected to more drawdown from the regional wellfield activity.

In the northern part of the study area as well as the area south of the Old Marsh development, horizontal hydraulic gradients trended from east to west due to the possible influence of surface water management practices along the SIRWCD's Canal E located at the northern boundary of the study area and the C-18 Canal to the west. Between the two areas, groundwater flow appeared to be toward the northeast in the direction of historic flow and possibly in response to pumpage from the adjacent Town of Jupiter wellfield.

Vertical gradients were primarily downward, from shallow to deep portions of the aquifer, throughout the study area due to the effects of rainfall recharging the aquifers. Exceptions to this were found at the NEB well cluster where there has been a consistent upward vertical gradient (from deep to shallow), possibly due to its close proximity to the Town of Jupiter wellfield and the SIRWCD Canal E, and at the C18P well cluster where upward gradients were prominent during prolonged dry periods when groundwater tended to discharge into the nearby C-18 Canal.

Groundwater levels in the study area are influenced by a combination of local rainfall, surface water management practices, and wellfield pumpage. Based on the data analyzed for this study, the increase in the operating stage at the G-160 structure has not had a significant impact on groundwater levels or resulted in adverse conditions.

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ACRONYMS AND ABBREVIATIONS

bls	below land surface
C&SFFCP	Central and South Florida Flood Control Project
CERP	Comprehensive Everglades Restoration Plan
District	South Florida Water Management District
ETp	potential evapotranspiration
FDEP	Florida Department of Environmental Protection
LRWRP	Loxahatchee River Watershed Restoration Project
MFL	minimum flow and level
NGVD	National Geodetic Vertical Datum
NPBCID	Northern Palm Beach County Improvement District
SAS	surficial aquifer system
SFWMD	South Florida Water Management District
SIRWCD	South Indian River Water Control District
USACE	U.S. Army Corps of Engineers
WY	Water Year

INTRODUCTION

This technical report presents the findings of a study conducted to assess surface water and groundwater conditions within and adjacent to the eastern portion of the Loxahatchee Slough that resulted from the installation and operation of the G-160 structure located just south of the confluence of the C-18 and C-18 West (C-18W) canals in northern Palm Beach County, Florida. The study area (**Figure 1**) primarily lies between the C-18 Canal on the west and the municipalities of Palm Beach Gardens and Jupiter to the east. The investigation involved the analysis of data collected between November 2005 and mid-March 2013 from the stage, rainfall, and groundwater monitoring stations depicted in **Figure 1**.

Project Background

The C-18 Canal and its levees were constructed in the late 1950s by the U.S. Army Corps of Engineers (USACE) as part of the Central and South Florida Flood Control Project (C&SFFCP), which the South Florida Water Management District (SFWMD or District), then the South Florida Flood Control District, was the non-federal sponsor.

The G-160 structure, which was constructed in 2003 and began operating in January 2004, is a key component of the C-18 Canal. The structure is constructed of reinforced concrete and has a gated spillway controlled by two stem-operated vertical lift gates (**Figure 2**).

The structure was initially identified in the Northern Palm Beach County Comprehensive Water Management Plan, and was subsequently incorporated into the Comprehensive Everglades Restoration Plan's (CERP's) Loxahatchee River Watershed Restoration Project (LRWRP) Part 1 (formerly North Palm Beach County – Part 1). The purpose of the structure is to 1) serve as an engineering solution to maintain the existing level of service for flood protection, 2) aid in meeting environmental water supply demands by enhancing delivery of freshwater flows to the Northwest Fork of the Loxahatchee River, and 3) improve the sensitive wetlands environment in the C-18 Basin, including the Loxahatchee Slough, which is an historic tributary component to the Loxahatchee River that provides important base and wet season flows. The G-160 structure allows stages in the C-18 Canal to be increased in accordance with specific hydraulic conditions and zones to meet recommended target stages (**Figure 3**) within the Loxahatchee Slough that are necessary to maintain the ecological integrity of the slough vegetative communities. When a supplemental water source is identified through the LRWRP, the G-160 structure will allow a permanent water pool between 15.5 to 17.5 feet National Geodetic Vertical Datum (NGVD) to be maintained in the Loxahatchee Slough with maximum water levels up to 18.2 feet NGVD for rainfall driven conditions. The structure can maintain optimum water control stages upstream in the C-18 Canal and pass flood water from the upstream portions of the drainage basin in a manner that restricts downstream flood stages without exceeding the upstream flood design stage.

Initially, the operational schedule for the G-160 headwater stage was maintained by the SFWMD at 15.5 feet NGVD during the dry season and 15.0 feet NGVD during the wet season. Since June 1, 2009, the SFWMD has been maintaining the G-160 head water stage between 16.3 and 16.7 feet NGVD, provided water has been available, as directed by the Florida Department of Environmental Protection (FDEP) Environmental Resource Permit EI 50-0128848-004 issued in 2003 (**Appendix A**). When sufficient water has not been available, the District has operated the G-160 structure according to the goals established to enhance delivery of the minimum flow and level (MFL) to the Northwest Fork of the Loxahatchee River. For flood protection purposes, the SFWMD has, at its discretion, partially or fully opened the gates of the G-160 structure during and after rainfall events to lower the water levels in the C-18 Canal.

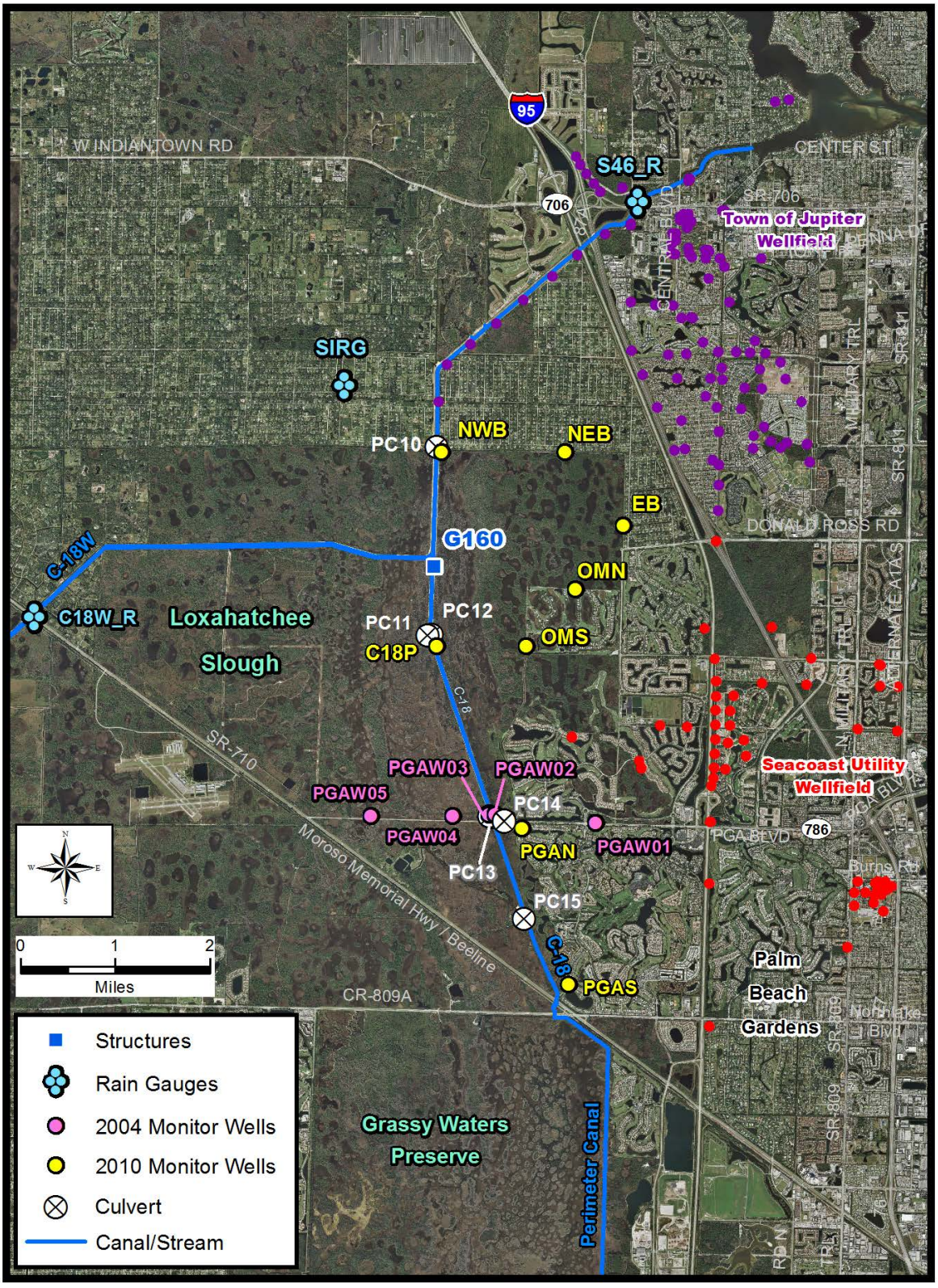

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Figure 1. Map of the study area showing the locations of the G-160 structure, C-18 and C-18W canals, and other key features, including monitoring locations and nearby wellfields.

Figure 2. G-160 water control structure in the C-18 Canal.

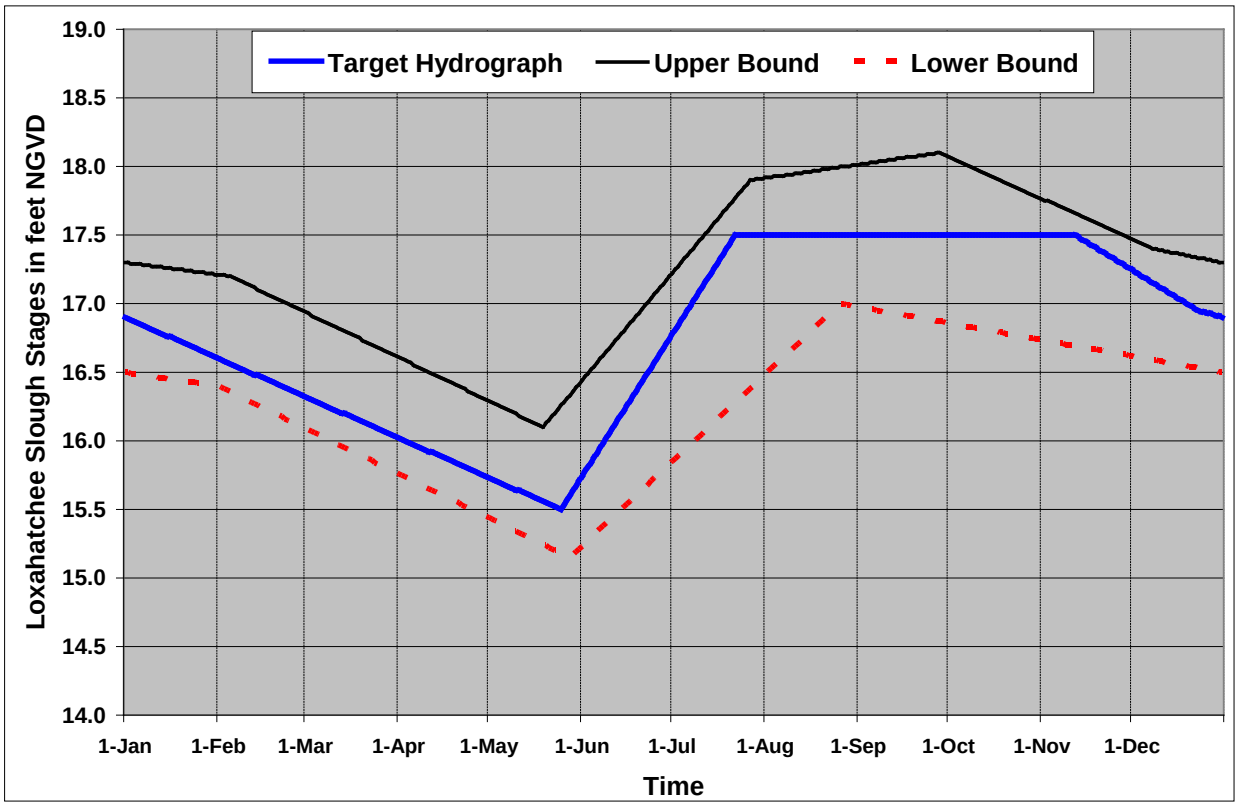

Figure 3. Loxahatchee Slough target hydroperiod.

In addition to the G-160 structure, there are several project culverts shown on **Figure 1** that pass through the levees along the east and west side of the C-18 Canal through which rainfall runoff enters the canal. The three culverts along the eastern levee are PC-10, PC-12, and PC-14; those along the western levee are PC-11, PC-13, and PC-15. From 2002 through 2011, the SFWMD replaced the project culverts because they had reached the end of their useful life. When the culverts were rebuilt, the flashboard control elevations were set at 16.9 feet NGVD as recommended in the Feasibility Report and Environmental Assessment of the C18 Basin and Loxahatchee Slough (USACE 1984). However, the riser boards can be removed to lower levels within the slough if rainfall conditions and slough elevations warrant.

Previous Work

In 2004, Taylor Engineering, under contract with the SFWMD, completed a modeling study to evaluate the potential impacts of G-160 operation on existing resources in the C-18 Basin. The study simulated a combination of event-based and hydroperiod conditions to assess the capability of the C-18 Canal and associated basins to maintain flood control and long-term hydroperiod target elevations under several project scenarios as well as existing conditions for 10-, 25-, and 100-year storm events. The modeling scenarios included operational schedules where the G-160 gates were fully opened during rainfall events (Schedule A) or operated such that they open when the upstream stage exceeds 16.2 feet NGVD and closed at 15.5 feet NGVD (Schedule B). The model results showed that operation of the structure to maintain slough stages while simultaneously opening the project culvert connections (removing the flashboard controls, thus increasing connectivity between the sub-basins and the canal) will allow an improved hydroperiod in the eastern Loxahatchee Slough without adversely impacting other sub-basins, nearby roadways (including PGA Boulevard), and developments.

Stakeholder Issues

After construction and initial operation of the G-160 structure in early 2004 as well as after considering the operational schedule changes proposed in the 2003 FDEP permit, several questions and concerns were raised by local and regional stakeholders, prompting the SFWMD to enact initiatives to address the issues. Several months after the G-160 structure began operating, the Florida Department of Transportation (FDOT) conveyed concerns about the cause of occasional flooding along PGA Boulevard near the C-18 Canal. In early 2004, the SFWMD installed seven groundwater monitor wells at five sites (PGAW01 to PGAW05) located along the northern side of PGA Boulevard in the vicinity of the C-18 Canal (indicated by the pink dots in **Figure 1**). Although monitoring data has been collected from these wells since November 2005, it was never formally evaluated or documented in a separate report; however, these data have been analyzed and incorporated as part of this report.

Subsequently, the City of Palm Beach Gardens along with the Northern Palm Beach County Improvement District (NPBCID) and the South Indian River Water Control District (SIRWCD) weighed in on the structure and its operational schedule. **Figure 4** shows the location of the two local Chapter 298 Districts that provide stormwater management and other necessary public services to the surrounding communities. The NPBCID to the east serves the residential developments of Old Marsh, East Point, Mirasol, and PGA National, while the SIRWCD to the north serves Palm Beach Country Estates.

Although the results of the Taylor Engineering modeling effort were generally accepted, the NPBCID, SIRWCD, and City of Palm Beach Gardens expressed concerns with the proposed operational schedule for the structure, specifically what additional seepage might be expected with the elevated stages in the C-18 Canal and Loxahatchee Slough, and what effect the seepage might have on nearby developments. There also were concerns regarding whether increased seepage would occur through the northern and eastern SIRWCD berms that separate the Loxahatchee Slough from the Palm Beach Country Estates subdivision, potentially leading to a need to increase the discharge capability of the SIRWCD control structure.

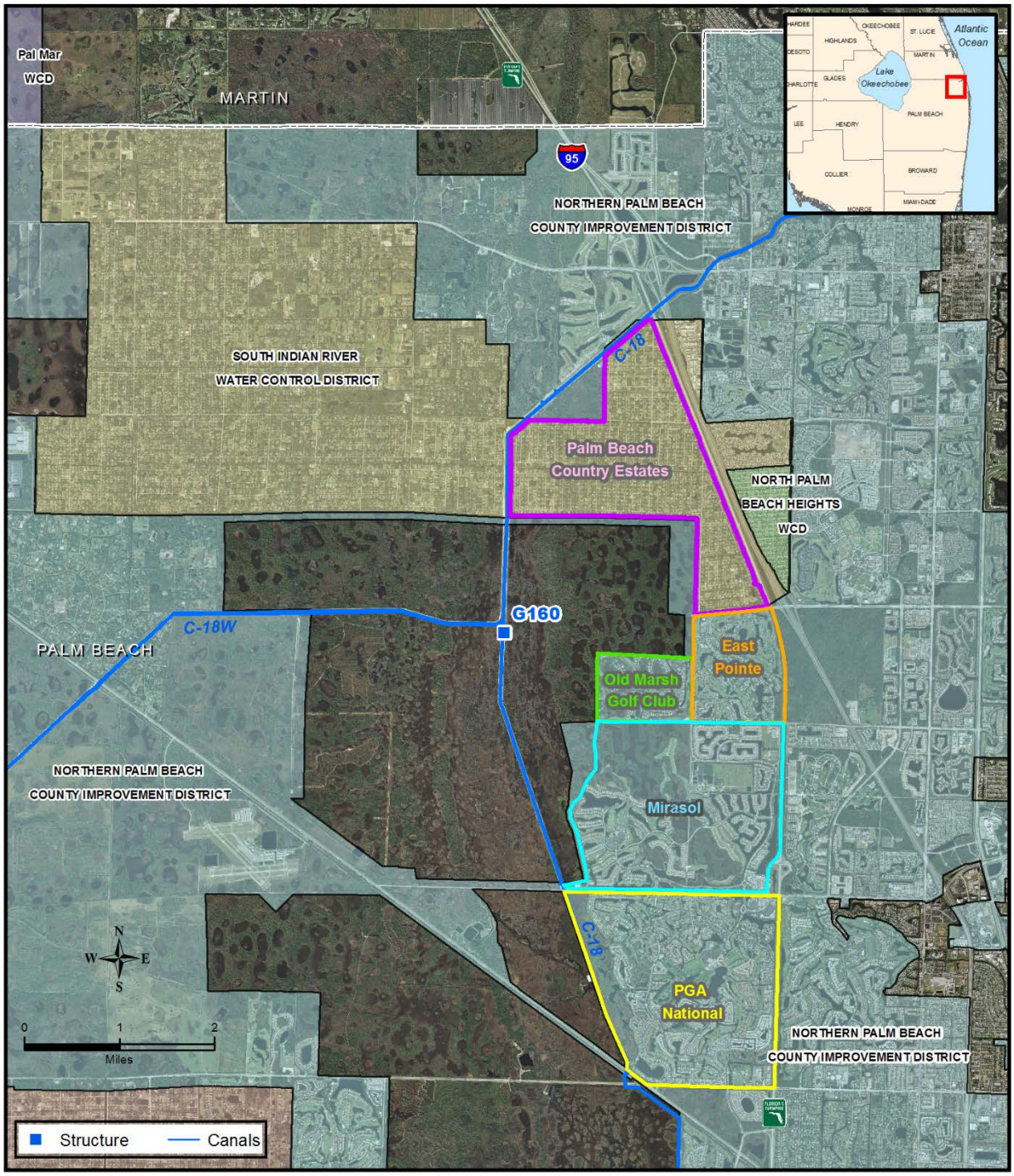

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Figure 4. Chapter 298 drainage districts and surrounding communities in the area of the G-160 structure.

In response to these stakeholder concerns, the SFWMD entered into a four-party agreement with the SIRWCD, NPBCID, and City of Palm Beach Gardens in August 2005 (**Appendix B**), whereby the SFWMD agreed to maintain the G-160 stage at 15.0 feet NGVD in the wet season and 15.5 feet NGVD in the dry season for a period of 5 years. At the same time, a second 1-year agreement with the NPBCID was executed to assess the issues of concern and determine if specific mitigation measures were necessary to offset seepage-related impacts. With this second agreement, survey and geotechnical data related to roadways, berms, and facilities within the communities were collected. No specific conclusions were verified from the information collected prior to the expiration of the agreement, and the SFWMD opted to not modify the scope of the agreement or extend the agreement.

In a February 2009 letter, the FDEP stated that the 2003 permit superseded the four-party agreement and directed the SFWMD to begin incrementally raising the headwater stage of the G-160 structure in compliance with the interim operating plan that was stipulated by the permit. The SFWMD indicated that G-160 headwater would be increased to 16.5 feet NGVD with the beginning of the 2009 wet season on June 1. Concerns were raised again by the two flood control districts and the City of Palm Beach Gardens regarding the possibility that the change in G-160 structure operations might result in adverse groundwater conditions that could impact nearby residential properties and municipal features. In response, the SFWMD agreed to install and monitor seepage wells adjacent to the communities for a period of at least 2 years following the increase in stage to determine if the concerns were valid. The representative agencies (SFWMD, NPBCID, SIRWCD, and City of Palm Beach Gardens) met over several months in late 2009 to determine the location and number of wells to be installed. As a result, 14 wells (yellow dots in **Figure 1**) were installed (six shallow/deep pairs at strategic locations near community boundaries north of PGA Boulevard, and two individual shallow wells in PGA National adjacent to the Loxahatchee Slough) by the SFWMD between January and March 2010. Data collection from the wells began in April 2010 and continued to mid-March 2013. This report documents the data collected as well as the analyses of shallow and deep groundwater gradients and their effects on the horizontal and vertical flow of groundwater.

DESCRIPTION OF STUDY AREA

Geographical

The study area is located in northeastern Palm Beach County within the low-lying “sandy flatlands” physiographic province, which includes the Loxahatchee Slough north and south of PGA Boulevard and bisected by the C-18 Canal (**Figure 1)**. The five stakeholder residential communities previously mentioned surround the area to the north and east while the Grassy Waters Preserve (formerly known as the West Palm Beach Water Catchment Area) is located to the south.

Environmental

The Loxahatchee Slough is a wide shallow channel of water that flows approximately 250 days per year. It provides drainage through historical strand swamp and peat soil swale systems. The Loxahatchee Slough is a regionally significant wetland, and along with the Grassy Waters Preserve and Hungryland Slough, forms the historic headwaters of the Loxahatchee National Wild and Scenic River. It is a mosaic of high-quality freshwater wetlands such as cypress swamps, marshes, and wet prairies, interspersed with pine flatwoods and hammocks (Foote 2014).

Hydrogeology

The study area is covered by unconsolidated Holocene-aged surficial sands and shells that compose the upper portion of the surficial aquifer system (SAS) and range in thickness from 20 to 70 feet below land surface (bls). The areal extent of the sediments can be highly variable as a result of rapid shifts in depositional patterns vertically and horizontally. Locally, these surficial sediments can contain layers of clay, marl, and silt, which act as semi-confining intervals to downward flow of water from the unconfined water table toward deeper strata.

Underlying the surficial sandy sediments are the Pleistocene-aged Anastasia Formation (coquina, shell, quartz sand, sandstone, and limestone), Caloosahatchee Marl (sandy marl, clay, quartz sand, and silt), and the Fort Thompson Formation (marine limestone, quartz sandstone, and grey limestone), which are also part of the SAS. These strata extend from 40 to 160 feet bls and contain a localized cavity-riddled limestone zone of high porosity and secondary permeability. This feature is somewhat persistent in the area of Florida's Turnpike (SR 91) and has been referred to as the "Turnpike Aquifer" (Miller 1988). Several water utilities in the study area have installed water supply wellfields in this locally productive interval.

Figure 5 shows test wells, lithologic cross-section lines, and the estimated zone of higher secondary permeability in eastern Palm Beach County. The A-A' line runs along PGA Boulevard with wells PB-1085, PB-1084, and PB-1086 being of significant interest due to their proximity to the study area. **Figure 6** shows the lithologic cross-section of A-A', displaying the degree of variability that exists from west to east and the thickness of the zone of secondary permeability.

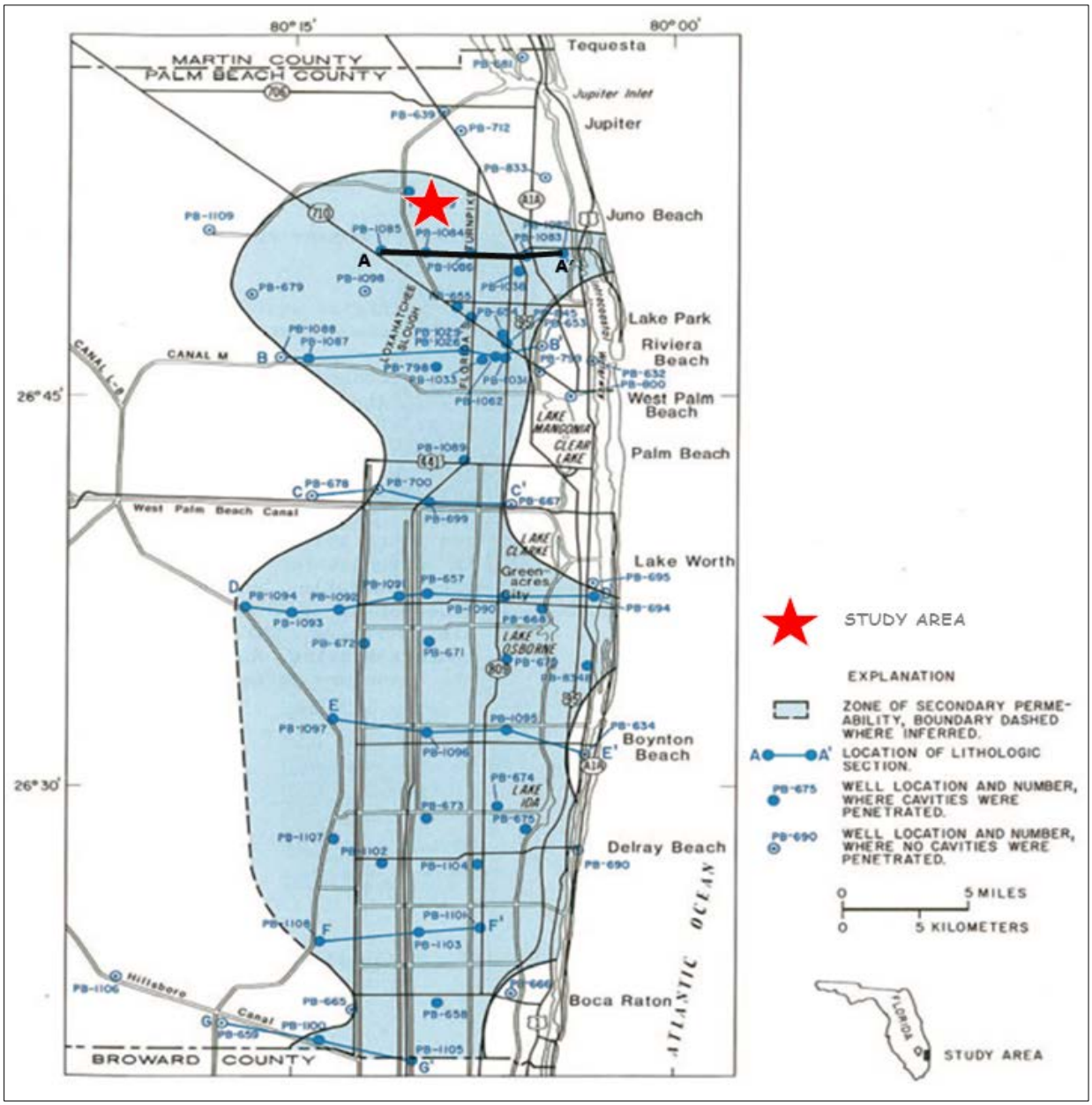


Figure 5. Map of eastern Palm Beach County showing locations of geologic test wells, lithologic cross-section lines, and estimated areal extent of the zone of higher secondary permeability (From: Swayze and Miller 1984).

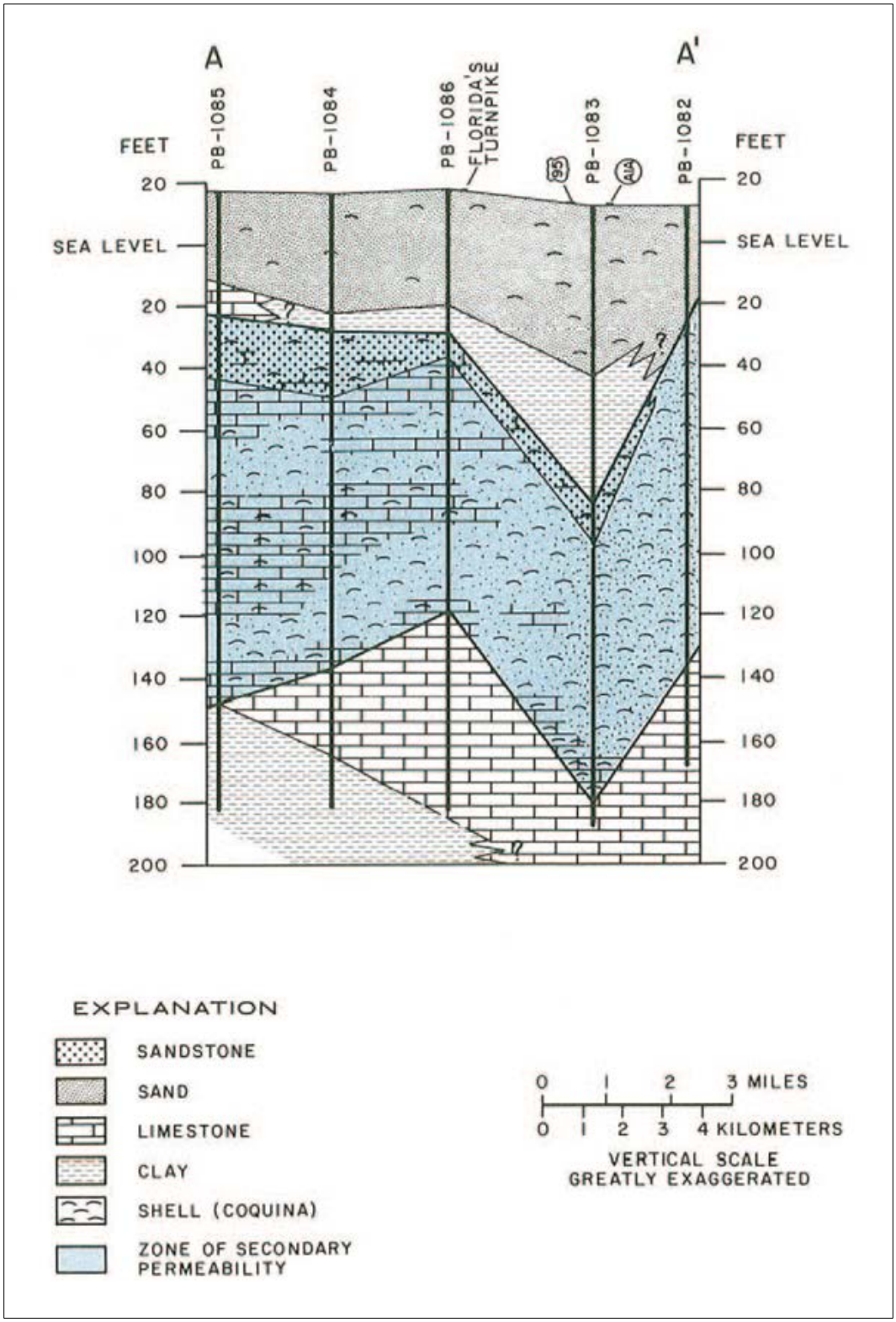


Figure 6. Lithologic cross-section A-A' through northern Palm Beach County from west to east along PGA Boulevard with PB-1085, PB-1084, and PB-1086 being key wells in the study area (From: Swayze and Miller 1984).

Rainfall and Evapotranspiration

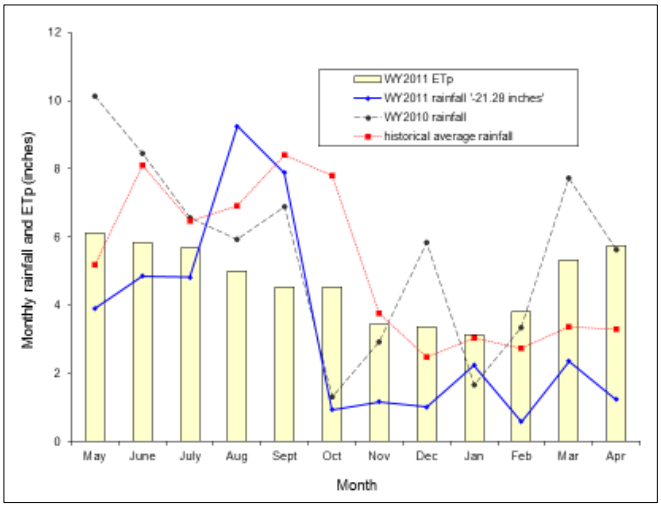
Descriptions and the graphics in **Figure 7** of the regional rainfall and potential evapotranspiration (ETp) patterns for the main time period covered in this report (April 2010 to mid-March 2013) were extracted from the 2012 through 2014 editions of the South Florida Environmental Conditions Report. Local rainfall data for the three rain gauges in the study area (blue symbols in **Figure 1**) were obtained from DBHYDRO, which is the SFWMD's environmental database. DBHYDRO stores current and historical hydrologic, meteorologic, hydrogeologic, and water quality data.

During Water Year 2011 (WY2011), rainfall was below average throughout the District, the driest being Palm Beach County with a 21.28-inch rainfall deficit (**Figure 7a**). The WY2011 dry season (November 1, 2010 to April 30, 2011) was considered one of the driest on record. Northeastern Palm Beach County experienced below average rainfall (9.33, 9.47, and 9.62 inches) at the three rainfall recorders in the area (SIRG_R, C-18W_R, and S46_R, respectively). At this time, the period of record rainfall average for these three sites for the dry season was 16.01 inches. Monthly rainfall deficits between October 2010 and May 2011 averaged 2.4 inches, with a maximum deficit of 4.73 inches occurring in October 2010. During that dry period, ETp far exceeded rainfall in Palm Beach County, as shown in **Figure 7a**.

In the WY2012 wet season, rainfall did not increase until late June 2011 but remained high through October 2011, which was unusually wet. However, during the WY2012 dry season (November 1, 2011 to April 30, 2012), Palm Beach County was the driest for the second year in a row compared to other areas in the SFWMD (**Figure 7b**) although not as extreme. The study area experienced below average rainfall (1.95, 8.74, and 13.82 inches) at each of the three rainfall recorders. The dry season period of record rainfall average for the three sites was calculated at 14.66 inches. Regionally, ETp was higher than rainfall by 5.46 inches, but much lower than it was in WY2011 (15.28 inches).

In WY2013, following the two below-average rainfall years, hydrologic conditions in South Florida improved. Palm Beach County experienced above average rainfall and was subjected to extreme wet and flooding conditions from Tropical Storm Isaac in August 2012, which is reflected the WY2013 rainfall and ETp graph in **Figure 7c**. During the WY2013 dry season (November 1, 2012 to April 30, 2013), the study area experienced above average rainfall (24.2, 22.52, and 23.59 inches) at each of the rainfall recorders in the area. The dry season period of record rainfall average for these three sites at this time was 18.99 inches. ETp was slightly lower than rainfall by 0.42 inches, reflecting wetter conditions during this period.

a)



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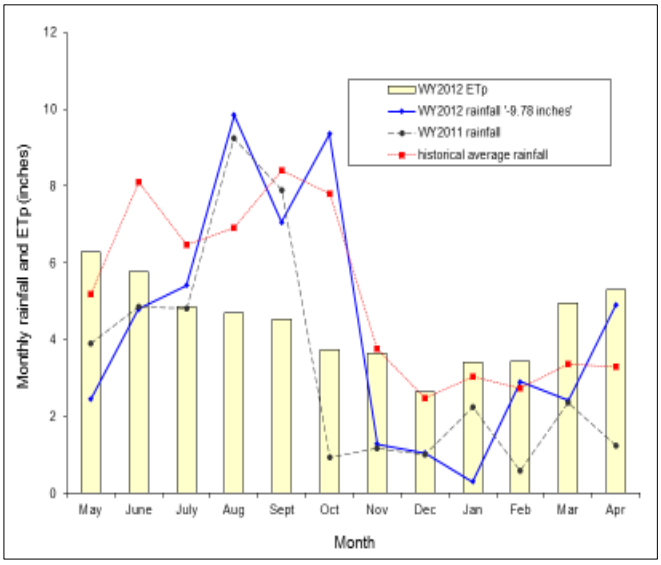

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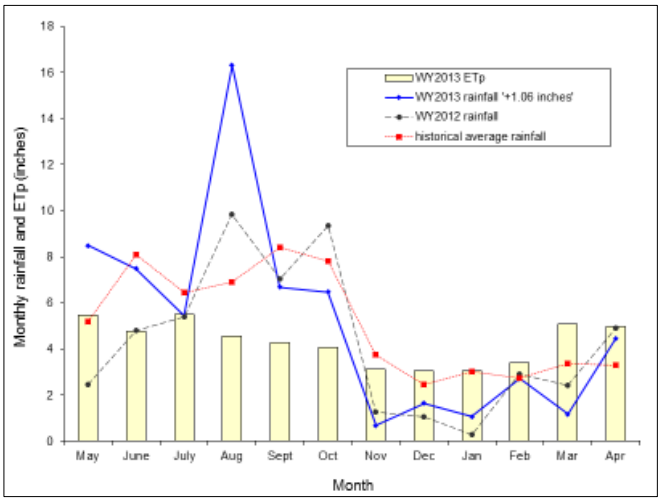

Figure 7. Monthly rainfall and potential evapotranspiration (ETp) for Palm Beach County for WY2011, WY2012, and WY2013 (From: Abtew and Ciuca 2012, 2013, 2014).

MONITOR WELL CONSTRUCTION

The SFWMD's initial groundwater water investigation that started in early 2004 included the construction of seven groundwater monitor wells placed at five sites located parallel to PGA Boulevard. As mentioned previously, these wells were installed to monitor groundwater levels in response to concerns about the possible flooding of PGA Boulevard due to the G-160 structure coming online and are indicated on the map as pink dots in **Figure 1**. According to information obtained from DBHYDRO, the hollow stem auger drilling method was used to complete the boreholes for all seven wells. Additionally, all sites (PGA01W to PGA05W) have single wells constructed of 2-inch diameter polyvinyl chloride (PVC) to a total depth of 15 feet and were screened from 13 to 15 feet. Two of the sites (PGA02W and PGA03W) have an additional well constructed of 2-inch PVC to a total depth of 45 feet and screened from 40 to 45 feet. Each well site was equipped with a data logger and pressure transducer connected to the District's SCADA telemetry system, which provides real-time data that undergo quality assurance and quality control (QA/QC) by SFWMD staff and are uploaded to DBHYDRO. Monitoring information from the wells was used to document the change in groundwater elevations before and after the June 1, 2009 change in the G-160 operations schedule.

During March 2010, the District contracted with Earth Tech Drilling, Inc. to install 14 monitor wells at 8 sites located east of the C-18 Canal as well as north and south of the G-160 structure (yellow dots in **Figure 1**). The wells were installed in the communities of PGA National and Old Marsh, along the SIRWCD canal berms south of Palm Beach Country Estates, and at one site along the C-18 Canal on the SFWMD right-of-way. Two of the eight sites (PGAN and PGAS) are single shallow wells, completed to a depth of 20 feet bls in the surficial sediments while the remaining six sites (NWB, NEB, EB, OMN, OMS, and C18P) consist of paired monitor wells, with one shallow well installed to 20 feet bls and a deeper well completed to 70 feet bls within the zone of secondary permeability. **Table 1** provides the well names and general locations.

Table 1. Well names and locations

Well Name	Number and Depth of Wells at Each Site	Location	Site Owner	Drainage District
PGAS	1-20'	PGA	PGA	NPBCID
PGAN	1-20'	PGA	PGA	NPBCID
OMS-S OMS-D	1-20' 1-70'	Old Marsh	Old Marsh	NPBCID
OMN-S OMN-D	1-20' 1-70'	Old Marsh	Old Marsh	NPBCID
EB-S EB-D	1-20' 1-70'	Berm	SIRWCD	SIRWCD
NEB-S NEB-D	1-20' 1-70'	Berm	SIRWCD	SIRWCD
NWB-S NWB-D	1-20' 1-70'	Berm	SIRWCD	SIRWCD
C18P-S C18P-D	1-20' 1-70'	SFWMD ROW	SFWMD	N/A

N/A = not applicable – no drainage district covers the area.

The shallow wells were installed using hollow stem auger, and the deep wells were installed with a combination of hollow stem auger and mud-rotary methods according to ASTM standard practice D5092. Geologic samples were continuously collected at 2-foot intervals via a 2-foot split spoon for each deep borehole as it was drilled. Standard penetration rates were collected along with the split spoon samples.

Logs with the lithologic descriptions are provided in **Appendix C**. After attaining the desired depth, the well screen and casing were installed inside the drill pipe.

The wells were constructed with Schedule 40 PVC Tri-Loc riser pipe and screens. The shallow well screens consisted of 2-foot sections of 0.010-inch machine-slotted PVC screen. The deep well screens consisted of 10-foot sections of 0.010-inch machine-slotted PVC screen. The wells were completed above the screens with solid Schedule 40 PVC riser pipe. All well casings and screen joints were connected with threaded connections and manufacturer-supplied "O" rings, cleaned, and sealed in plastic at the factory.

A filter pack of 6/20 silica sand was emplaced in the annual space around the well screen of each well using the tremie method. This silica sand was appropriate for the well slot size selected for the wells and also for the surrounding formation. The filter pack extended 3 feet above the top of the screen after well development. In the deep wells, the filter pack extended from 57 to 70 feet bls. In the shallow wells, the filter pack extended from 15 to 20 feet bls. Two feet of bentonite pellets were placed above the filter pack in each well and hydrated to provide a seal between the filter pack and the cement grout. The remaining annular space in each well was filled with neat cement to land surface. Construction diagrams of each of the wells are in **Appendix D**, and a well construction table that includes horizontal and vertical nomographs as well as survey information is provided in **Appendix E**.

Each monitor well was purged for a period of 30 to 45 minutes with a centrifugal pump to stabilize the water quality parameters and remove all visible particulate matter from the formation waters. Development water from each well was discharged onto the ground in the vicinity of the wells.

All wells were recessed below the grade of the surrounding land and enclosed in a "meter"-type protective boxes with bolt-down lids. The boxes were made of cast iron, dipped in primer, and painted with Rustoleum before installation to prevent corrosion. The well recesses have two 0.5-inch diameter drain holes, placed 180° apart, to prevent the accumulation of excess water. Each well was completed and sealed at the surface with a 30 × 30 × 6-inch rebar-reinforced "flush-mounted" cement pad that slopes slightly away from the well. Each of the wells was surveyed for spatial coordinates along with ground surface and top-of-casing elevations relative to 1929 NGVD and 1988 NAVD (**Appendix E**). Because the monitoring was to be short in duration, the wells were instrumented with temporary data loggers and pressure transducers that could collect groundwater data and be downloaded manually on a monthly basis instead of having permanently installed equipment connected to the SCADA telemetry system. In the event any of the well are designated to connect to SCADA in the future, each well station contains a 1-inch 90° elbow of gray electrical conduit that extends 1 inch above the concrete and several inches below and beyond the side of the concrete to accommodate necessary cabling.

GROUNDWATER ELEVATION RESPONSES TO CHANGES IN G-160 STRUCTURE OPERATIONS

From August 2005 through May 2009, the SFWMD maintained the G-160 stage at 15.0 and 15.5 feet NGVD (wet and dry season levels, respectively) according to the four-party agreement. However, on June 1, 2009, the G-160 structure headwater stage was raised to 16.5 feet NGVD and, provided enough water was available, has been maintained at that level since, as envisioned in the design of the structure and according to the 2003 FDEP permit requirements.

The wells (PGAW01 to PGAW05) that were constructed along PGA Boulevard east and west of the C-18 Canal and upstream of the G-160 structure in 2004, were instrumented with continuous real-time recorders in November 2005 allowing groundwater level data to be captured prior to and after the change in the operating schedule. **Figure 8** is a composite hydrograph showing groundwater elevations in the PGA Boulevard wells compared to the G-160 headwater and tailwater stages, along with rainfall before and after

the change to the higher operating stage in June 2009. Daily averages of groundwater levels, stages, and rainfall were used for analyses. It can be seen that throughout the time period from November 2005 to March 2013 (with the exception of August 2013 during and immediately following Tropical Storm Isaac), there was little change in groundwater elevations at PGAW04 and PGAW05, even after raising the G-160 headwater stage in June 2009. Maximum elevations in PGAW02 and PGAW03 increased less than a foot following the change in operations but tended to converge with PGAW04 and PGW05 elevations and closely track the G-160 headwater stage, never exceeding maximum historical water levels. Before the schedule change there was considerably more variation in the water levels of these four wells. It was also observed that groundwater levels in PGAW01, located approximately 1 mile east of the C-18 Canal and within the residential areas, generally were above the G-160 headwater stage prior to June 2009 but mostly have been below the headwater stage during the wet seasons and above it during the dry seasons since that time. Overall, the levels at PGAW01 do not appear to have significantly increased over the 6- to 7-year time period.

Groundwater elevation data collected from the 14 new wells installed as part of this study between January and March 2010 are only available after the June 2009 operational schedule change. The data were collected from each of the wells and graphed in daily averages along with G-160 headwater and tailwater stage and rainfall data for the period April 6, 2010 to March 14, 2013, resulting in the composite hydrographs provided in **Figures 9** and **10**. Both hydrographs show the response of groundwater elevations to the extended period of below-normal rainfall (drought) from October 2010 to June 2011, and to the above-normal rainfall due to the Tropical Storm Isaac event in August 2012. **Figure 9** shows the groundwater elevations of wells EB, NEB, NWB, PGAN, and PGAS, which tended to fall below the G-160 headwater stage and above the tailwater stage during periods of high rainfall. Well clusters EB, NEB, and NWB are located in the northern portion of the study area; the PGAS and PGAN wells are found in southern portion (**Figure 1**). During this timeframe, groundwater levels in the PGAS and PGAN wells generally were higher than those of the EB, NEB, and NWB wells except at times of higher than normal rainfall events when well cluster EB levels occasionally spiked above the headwater stage elevation. Well cluster EB is close to the central portion of the study area where groundwater levels behaved differently than in the northern and southern portions.

The hydrograph in **Figure 10** includes groundwater elevation data for wells OMN, OMS, and C18P, all of which are located in the central portion of the study area and west of, but between, the two regional wellfields (**Figure 1**). In these three well clusters, with a few minor exceptions, groundwater elevations consistently were above the G-160 headwater stage and tracked each other closely. OMN and OMS elevations, which may have been impacted by water pumping off the Old Marsh development by local permittees, displayed a more erratic pattern during higher rainfall events than those in the C18P wells located near the C-18 Canal. Overall, groundwater levels in the central portion of the study area seem to have been higher than those in the northern and southern portions, suggesting that the latter two areas might have been subjected to more drawdown from regional wellfield activity.

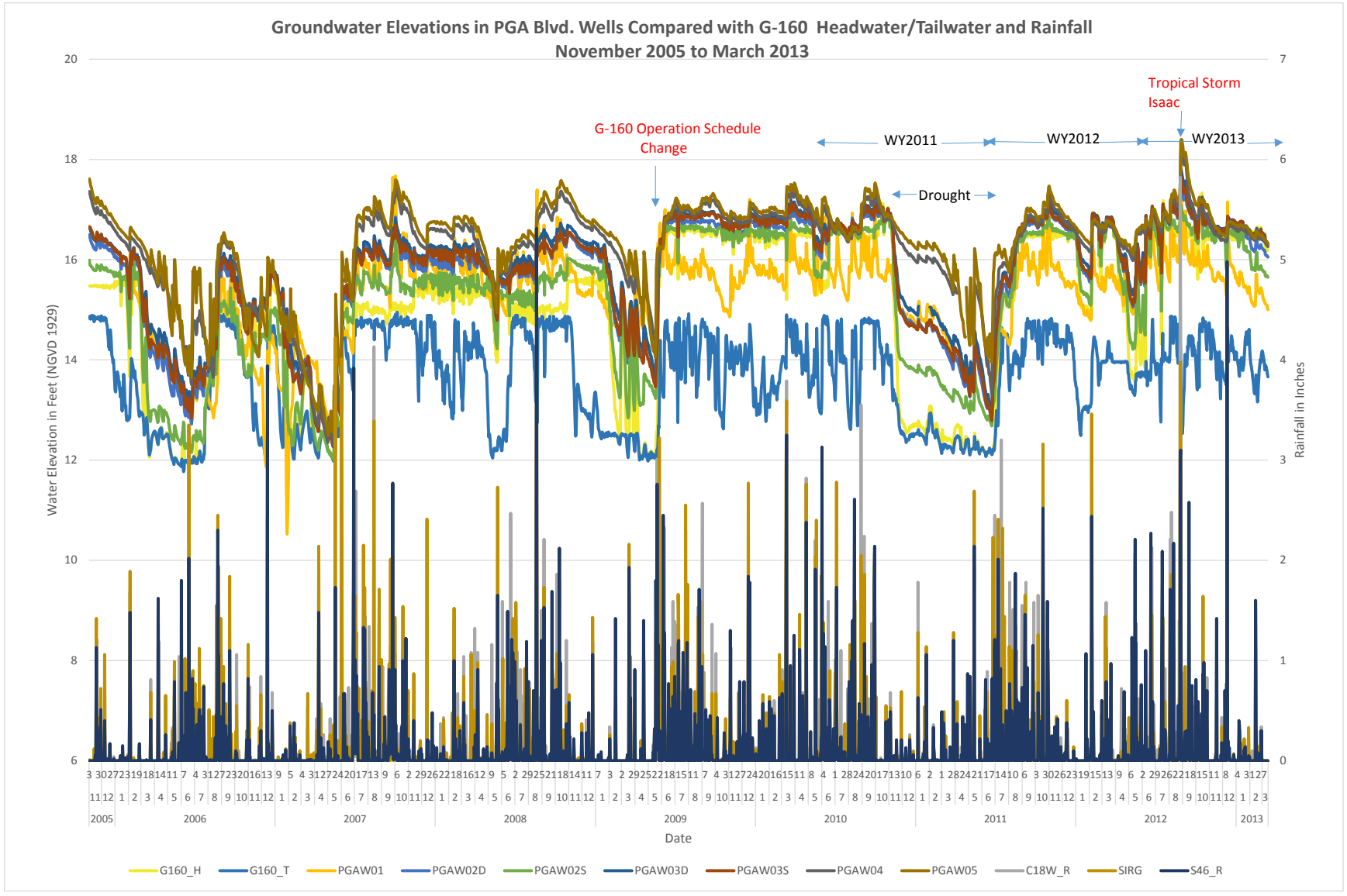

Figure 8. Changes in groundwater elevations of PGA Boulevard wells compared to changes in G-160 headwater and tailwater stages before and after June 2009 (November 2005 to March 2013).

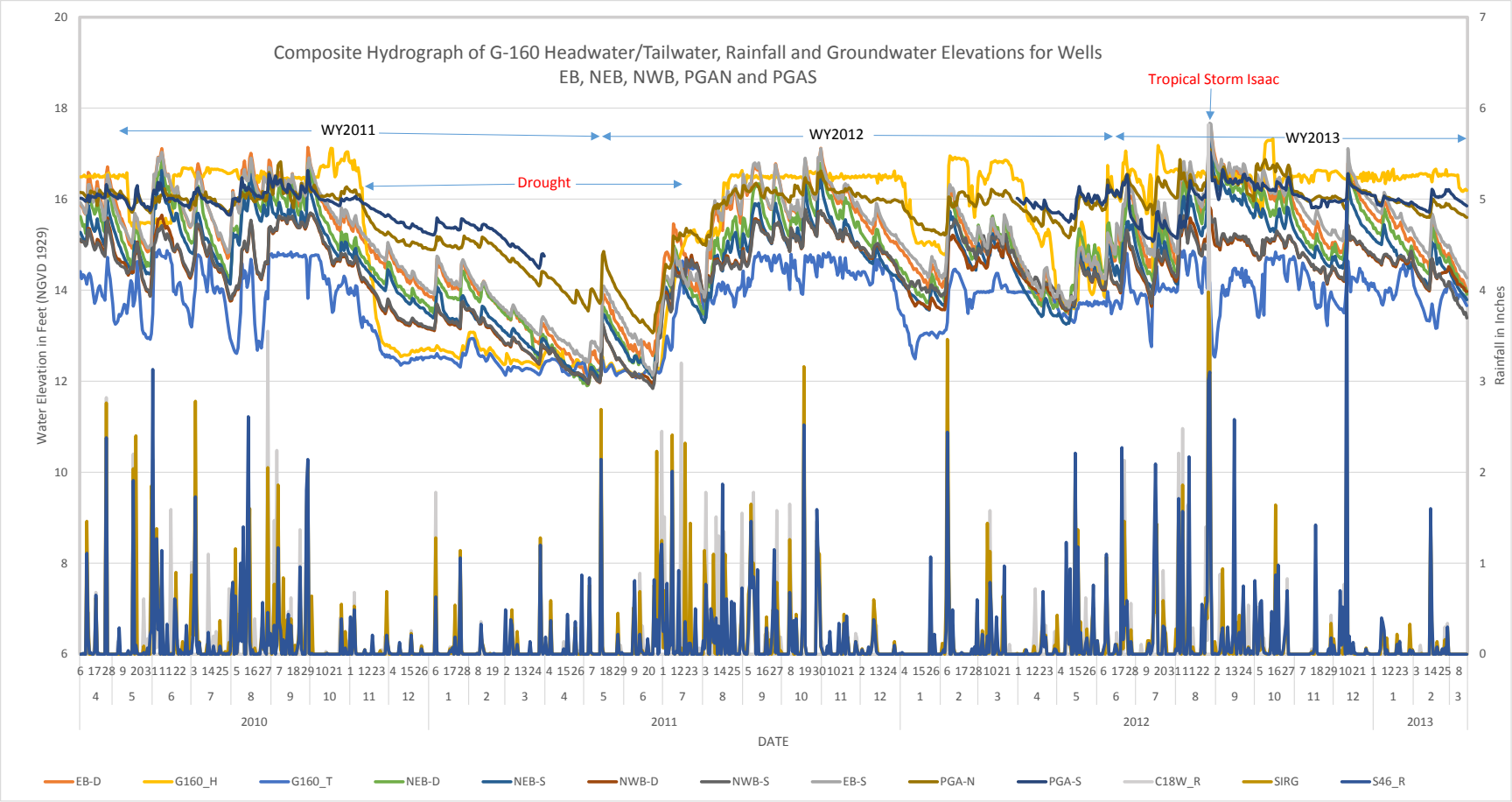

Figure 9. Composite hydrograph comparing G-160 headwater/tailwater, rainfall, and groundwater elevations for wells EB, NEB, NWB, PGAN, and PGAS. Groundwater elevations for these wells generally fall between G-160 headwater and tailwater elevations.

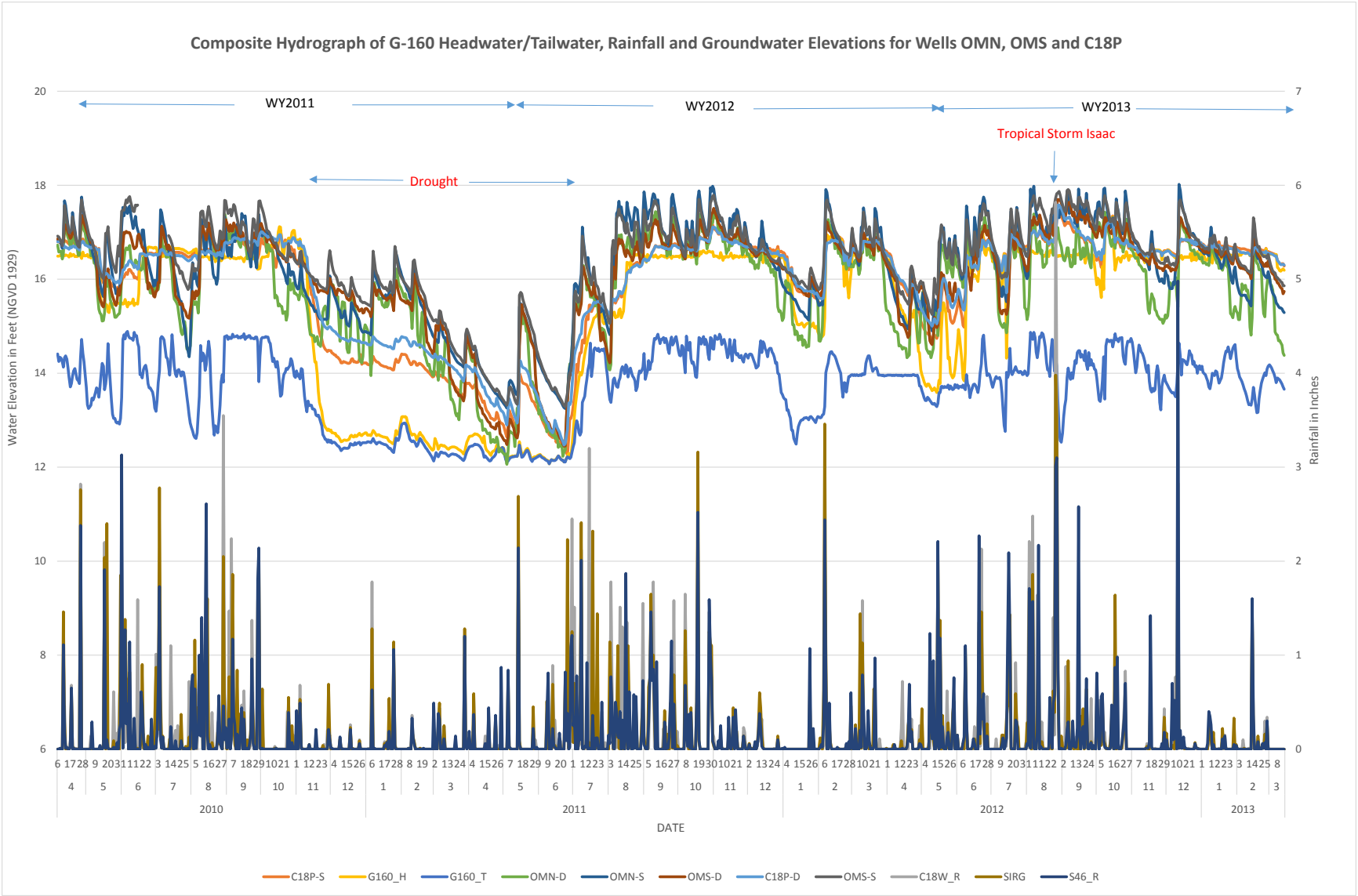

Figure 10. Composite hydrograph of G-160 headwater/tailwater, rainfall, and groundwater elevations for wells OMN, OMS, and C18P. Groundwater elevations in these wells generally fall above the G-160 headwater elevation.

HORIZONTAL AND VERTICAL HYDRAULIC GRADIENTS

Groundwater level data from the six well clusters shown in **Figure 11** were analyzed and graphed to determine horizontal and vertical hydraulic gradients, which are the driving force for groundwater flow and vary spatially and temporally in groundwater systems. The gradient direction indicates the potential for groundwater to flow in that direction. The horizontal gradients were compared to average monthly rainfall to determine if extreme weather events or surface water management operations have affected groundwater levels and flow. The provided equations are standard methodologies used for computing horizontal and vertical hydraulic gradients when analyzing groundwater (Todd 1980).

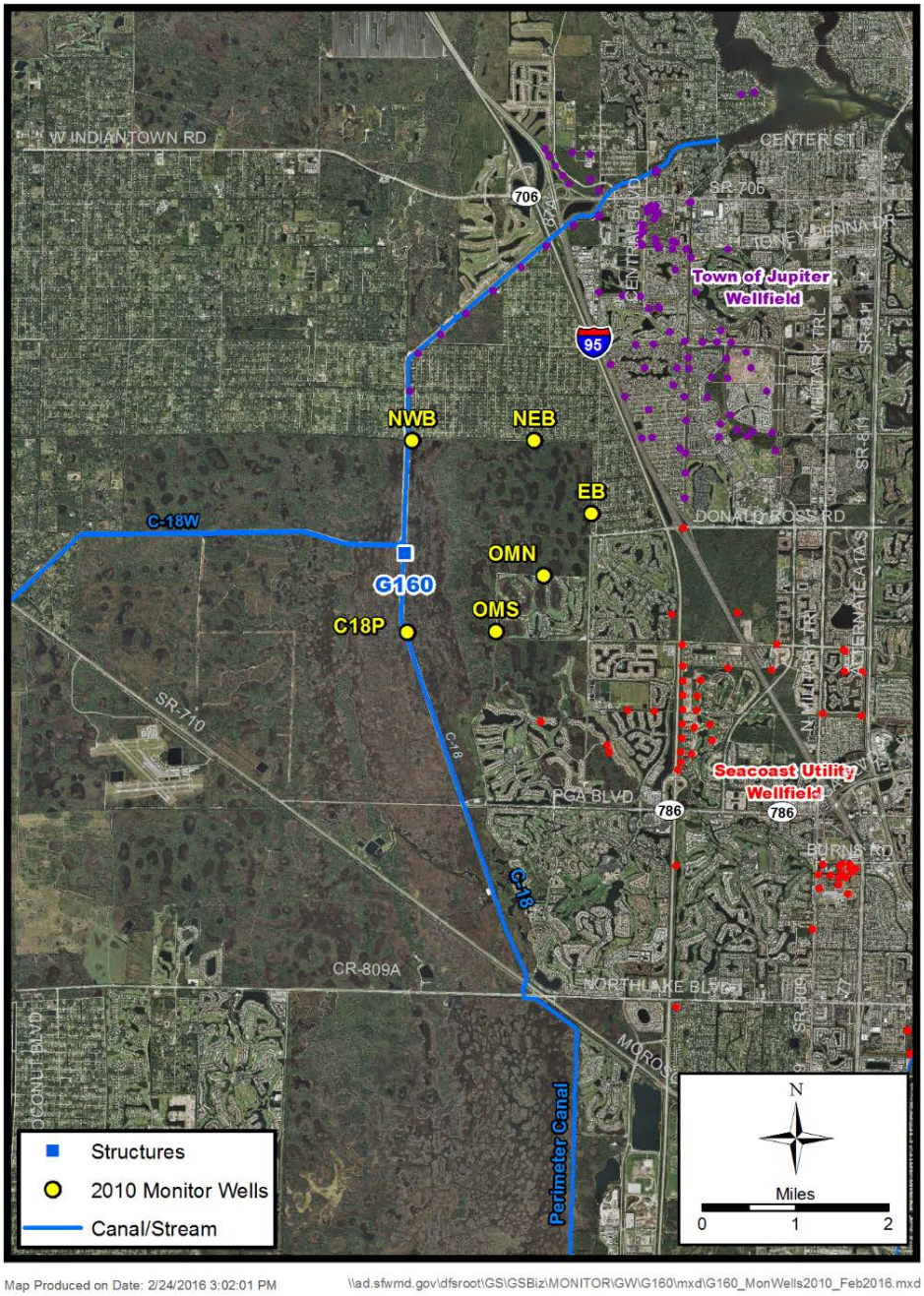

Figure 11. Location of 2010 monitor well clusters used to analyze horizontal and vertical gradients.

Horizontal Groundwater Flow

In order to determine the relative horizontal flow of groundwater in the study area, gradients were calculated between four different pairs of well clusters. Shallow wells were compared to shallow wells and deep wells were compared to deep wells using the following equation:

$$i_{(horizontal)} = \left(\frac{(h1 - h2)}{\Delta l}\right)$$

Where: $i_{(horizontal)}$ = horizontal hydraulic gradient (unitless)

h_1 = hydraulic head at well one (feet NGVD)

h_2 = hydraulic head at well two (feet NGVD)

Δl = horizontal distance between the two wells (feet)

A positive value for $i_{(horizontal)}$ indicates flow from well one towards well two. The well pairs used in analyzing horizontal flow direction are listed in **Table 2**. Graphs of the water levels and gradients at shallow and deep monitor zones are provided in **Appendix F**.

Table 2. Well pairs used for analyzing horizontal hydraulic gradient.

Well One	Well Two	Distance Between Wells (ft)	Predominant Flow Direction
NWB-S	NEB-S	6,923	West
NWB-D	NEB-D	6,934	West
C18P-S	EB-S	12,424	Northeast
C18P-D	EB-D	12,429	Northeast
NEB-S	OMS-S	11,023	North
NEB-D	OMS-D	11,023	North
C18P-S	OMS-S	5,018	West
C18P-D	OMS-D	5,021	West

D = deep well; S = shallow well.

The horizontal hydraulic gradient between the NWB and NEB well clusters was from east to west according to the hydrographs for the shallow and deep flow regimes. For the C-18P and EB well clusters, the gradient pattern was more complex. While flow was predominantly from southwest to northeast, there were brief reversals in flow direction between the two stations at shallow and deep levels, with the effect more pronounced in the shallow flow zone. The horizontal hydraulic gradient between the OMS and NEB well clusters in both flow zones was distinctly from south to north during the wet and dry seasons. Between the C18P and OMS well clusters, the horizontal hydraulic gradient was predominantly from east to west toward the C-18 Canal, possibly due to surface water operations. There were brief occasions in the shallow and deep zones when the gradient was reversed, particularly during drier periods, which suggests some periodic influence from the nearby wellfields.

Because the horizontal gradients were calculated using only two wells at a time, flow directions are considered approximate. Overall, a horizontal groundwater flow gradient from east to west was measured in the northern portion of the study area, possibly influenced by the SIRWCD Canal E bordering the study area on the north, as well as in the area just south of the Old Marsh development where surface water management practices may have facilitated groundwater flow to the west toward the C-18 Canal. A south to north/northeast flow was observed in the interior portion of the study area. The northerly flow between

the OMS and NEB well clusters as well as the northeasterly flow between the C18P and EB well clusters could have been influenced by the proximity of the Town of Jupiter's public water supply wellfield; however, the flow direction also is consistent with historical flow from the Loxahatchee Slough to the headwaters of the Loxahatchee River.

Vertical Groundwater Flow

The vertical groundwater flow within five well clusters were analyzed using the following equation:

$$i_{(vertical)} = \left(\frac{(hs-hd}{zs-zd}\right)$$

Where: $i_{(vertical)}$ = vertical hydraulic gradient (unitless)

h_s = hydraulic head at the shallower well (feet NGVD)

h_d = hydraulic head at the deeper well (feet NGVD)

z_s = vertical elevation of the top of the shallower well screen (feet NGVD)

z_d = vertical elevation of the top of the deeper well screen (feet NGVD)

A positive value for $i_{(vertical)}$ indicates that the flow of water is downward, from shallow to deep, which typically is characteristic of recharge areas; a negative value indicates groundwater flow is upward, characteristic of discharge areas. The groundwater level data, along with the vertical separation between the two screen depths, from the five well pairs listed in **Table 3** were used to calculate the vertical hydraulic gradient at each site. Graphs of the results are provided in **Appendix F**.

Table 3. Wells used for vertical gradient calculations and their corresponding screen distances.

Shallow Well	Deep Well	Vertical Distance Between Top of Screens (ft)	Predominant Flow Direction
OMS-S	OMS-D	40.84	Down
EB-S	EB-D	41.44	Down
NEB-S	NEB-D	42.38	Up
NWB-S	NWB-D	42.03	Down
C18P-S	C18P-D	39.72	Up

At station OMS, the vertical gradient was consistently downward, with increasing positive gradients during the wet season periods. The vertical gradient in the EB well cluster oscillated between upward flow and downward flow from April through September 2010, but was primarily downward from October 2010 through March 2013 except for an unusually prominent upward gradient during a high rainfall period from mid-June to mid-July 2011. The vertical gradient at the NEB well cluster was primarily upward, suggesting strong influence from the nearby Town of Jupiter wellfield and possibly surface water management operations on the adjacent SIRWCD Canal E; however, from early April through June 2011, the gradient reversed and flow was slightly downward.

The NWB well cluster gradient appears to have been mostly flat and moderately downward throughout the study period except during portions of the three wet seasons (e.g., the end of August 2012 during Tropical Storm Isaac) when upward gradients were observed as a possible result of surface water operations for

flood control. There was a period of more prominent downward vertical gradient during the dry season from January through mid-May 2012 and on August 31, 2012 following Tropical Storm Isaac.

At C18P, the vertical gradient was primarily upward, most prominently during the extended drought period from October 2010 through June 2011 as well as during the following dry season from January to mid-June 2012. The upward gradients correspond to the lower headwater stage elevations recorded for the G-160 structure, which promoted groundwater discharge to the canal. As subsequent rainy seasons took hold, the flow fluctuated moderately between upward and downward gradients, with rising canal stages periodically recharging the nearby groundwater.

Overall, throughout most of the study area, groundwater moved downward from shallow to deep portions of the aquifer during both wet and dry periods. The exceptions to this were seen in the well clusters at C18P and NEB, where upward groundwater flow seemed to be prevalent. This may have been hydraulically influenced by the rising and falling stage levels in the adjacent C-18 and SIRWCD E canals, and in the case of NEB, by pumpage from the Town of Jupiter wellfield. Additionally, vertical gradients tended to be steeper and more variable than horizontal gradients by one to two orders of magnitude, indicating that groundwater levels and flows in the study area are influenced primarily by a combination of rainfall, surface water management operations, and wellfield withdrawals.

Average Monthly Rainfall and Horizontal Gradients

Appendix F includes graphs of average monthly rainfall compared to the horizontal gradients of the same four well cluster pairs listed in **Table 2**. The horizontal gradients for the first three well pairs (NWB and NEB; C18P and EB; and OMS and NEB) for the shallow and deep zones tended to be relatively flat in magnitude (whether negative or positive) over the course of the study period and showed relatively little change between the wet and dry seasons. This indicates that overall groundwater levels have remained steady and have not been significantly impacted by extreme rainfall events, which were possibly moderated by surface water management operations and pumpage from the Town of Jupiter wellfield to the east. The shallow and deep hydraulic gradients that appeared between well pairs C18P/EB and OMS/NEB were more variable and fluctuated more widely in magnitude between wet and dry periods. The gradient between the two well clusters was more prominent during the prolonged drought period that occurred from October 2010 through June 2011 than those for the other three well pairs. The erratic pattern may have been the result of surface water pumping by individual permittees during heavy rainfall events in order to move water off the Old Marsh property.

SUMMARY

Despite concerns raised by stakeholders that the installation of the G-160 structure and its subsequent operations would impact the area's groundwater levels, the data collected and analyzed for this study demonstrated that groundwater conditions have been unaffected and have not increased to adverse levels.

Data obtained from the PGA Boulevard wells (PGAW01 to PGAW05) from November 2005 to March 2013 showed that groundwater elevations changed very little, even after the G-160 headwater stage was raised in June 2009, and never exceeded maximum historical water levels over this 6- to 7-year time period. Starting in April 2010, the groundwater elevations recorded from the well clusters EB, NEB, and NWB in the northern portion of the study area and wells PGAN and PGAS in the southern portion, tended to remain below the G-160 headwater stage but above the tailwater stage during periods of high rainfall. However, data from the three well clusters located in the more central portion of the study area (OMN, OMS and C18P) show that groundwater elevations consistently were above the G-160 headwater stage during the wet and dry seasons. The groundwater levels in this area generally were higher than those in the northern and

southern portions suggesting that the latter two areas were subjected to more drawdown from the regional wellfield activity to the east.

Overall, the observed horizontal groundwater flow direction was from east to west in the northernmost portion of the study area, possibly influenced by the east-west trending SIRWCD's Canal E, as well as in the area just south of the Old Marsh development where surface water management practices appear to have facilitated groundwater flow to the west toward the C-18 Canal – away from the residential areas to the east. A south to north/northeast flow was observed in the wells located in interior portion of the study area, which may have been influenced by the proximity of the Town of Jupiter's public water supply wellfield or consistent with the historical flow from the Loxahatchee Slough to the headwaters of the Loxahatchee River.

Throughout most of the study area, groundwater has moved predominantly downward from the shallow to deep portions of the aquifer during both wet and dry periods. The exceptions to this were observed in the well clusters at C18P and NEB, where upward groundwater flow tended to be prevalent. This may have been influenced hydraulically by the rising and falling stage levels in the adjacent C-18 and SIRWCD E canals, respectively, and in the case of NEB, by pumpage from the Town of Jupiter wellfield. Because of strong influences from rainfall, surface water management practices, and wellfield pumpage, vertical groundwater gradients have tended to be steeper and more variable over time compared to horizontal groundwater gradients.

Future analyses could include continuing to review the data being generated from the active PGA Boulevard well series which are on the SCADA system to further monitor the influence of G-160 operations, rainfall, and wellfield effects on the local groundwater flow regime. Public water supply pumpage data also could be examined to determine how much influence wellfield withdrawals are having on groundwater levels in the area.

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APPENDICES

APPENDIX A

Florida Department of Environmental Protection
Environmental Resource Permit EI 50-0128848-004

Department of
Environmental Protection

Jeb Bush
Governor

Southeast District
P.O. Box 15425
West Palm Beach, Florida 33416

David B. Struhs
Secretary

ELECTRONIC CORRESPONDENCE March 7, 2003

ENVIRONMENTAL RESOURCE PERMIT

PERMITTEES:
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406
Attn.: Mr. Victor A. Powell, PE
Director of Project Implementation

Palm Beach County Department of
Environmental Resource Management
3323 Belevedere Road, Building 502
West Palm Beach, FL 33406
Attn.: Mr. Richard Walesky

Director

Permit Number: **EI 50-0128848-004**

Date of Issue: **3/7/2003**
Expiration Date of
Construction Phase: **3/6/2008**

County: Palm Beach County
Project: C-18 Canal Control Structure (G160)

This permit is issued under the authority of Part IV of Chapter 373, F.S., and Title 62, Florida Administrative Code (F.A.C.). The activity is not exempt from the requirement to obtain an Environmental Resource Permit. Pursuant to Operating Agreements executed between the Department and the water management districts, as referenced in Chapter 62-113, F.A.C., the Department is responsible for reviewing and taking final agency action on this activity.

ACTIVITY DESCRIPTION: This project involves construction and operation of a water control structure (G-160) which includes dredging and filling 0.21 acres of Class I Surface Waters in the C-18 Canal to allow for installation of a dual-bay spillway with a combined sectional flow length of 50 feet. The purpose of this structure is to provide for restoration of a more natural hydroperiod for wetland areas located upstream of the proposed structure, while maintaining flood protection for adjacent developed areas and providing base flow augmentation to help restore freshwater flows in the Northwest Fork of the Loxahatchee River. The structure will be installed in the east leg of the C-18 canal, immediately upstream (south) of the C-18 Canal's confluence with the west leg. The G-160 Structure is a major component of the North Palm Beach County Comprehensive Water Management Plan, the Comprehensive Everglades Restoration Plan (CERP), and the associated restoration efforts planned for Loxahatchee Slough and the NW Fork of the Loxahatchee River.

ACTIVITY LOCATION: The project is located in the C-18 Canal, Class I waters, just upstream of the junction of the C-18W Canal, in Palm Beach County (Sections 29 and 30, Township 41 South, Range 42 East).

Permittee: South Florida Water Management District & Palm Beach County Department of Environmental Resource Management
Project: C-18 Canal Control Structure (G160)
File No.: EI 50-0128848-004

This permit also constitutes a finding of consistency with Florida's Coastal Zone Management Program, as required by Section 307 of the Coastal Management Act, and constitutes certification of compliance with water quality standards under Section 401 of the Clean Water Act, 33 U.S.C. 1341.

A copy of this authorization also has been sent to the U.S. Army Corps of Engineers (USACOE) for review. The USACOE may require a separate permit. Failure to obtain this authorization prior to construction could subject you to enforcement action by that agency. You are hereby advised that authorizations also may be required by other federal, state, and local entities. This authorization does not relieve you from the requirements to obtain all other required permits and authorizations.

The above named permittee is hereby authorized to construct the work shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with the Department and made a part hereof. **This permit is subject to the limits, conditions, and locations of work shown in the attached drawings, and is also subject to the attached 19 General Conditions and 12 Specific Conditions, which are a binding part of this permit.** You are advised to read and understand these drawings and conditions prior to commencing the authorized activities, and to ensure the work is conducted in conformance with all the terms, conditions, and drawings. If you are utilizing a contractor, the contractor also should read and understand these drawings and conditions prior to commencing the authorized activities. Failure to comply with all drawings and conditions shall constitute grounds for revocation of the permit and appropriate enforcement action.

Operation of the facility is not authorized except when determined to be in conformance with all applicable rules and with the general and specific conditions of this permit.

GENERAL CONDITIONS:

1. All activities authorized by this permit shall be implemented as set forth in the plans, specifications and performance criteria as approved by this permit. Any deviation from the permitted activity and the conditions for undertaking that activity shall constitute a violation of this permit and Part IV, Chapter 373, F.S.
2. This permit or a copy thereof, complete with all conditions, attachments, exhibits, and modifications shall be kept at the work site of the permitted activity. The complete permit shall be available for review at the work site upon request by the Department staff. The permittee shall require the contractor to review the complete permit prior to commencement of the activity authorized by this permit.
3. Activities approved by this permit shall be conducted in a manner which does not cause violations of state water quality standards. The permittee shall implement best management practices for erosion and pollution control to prevent violation of state water quality standards. Temporary erosion control shall be implemented prior to and during construction, and permanent control measures shall be completed within 7 days of any construction activity. Turbidity barriers shall be installed and maintained at all locations where the possibility of transferring suspended solids into the receiving waterbody exists due to the permitted work. Turbidity barriers shall remain in place at all locations until construction is completed and soils are stabilized and vegetation has been established. All practices shall be in accordance with the guidelines and specifications described in Chapter 6 of the Florida Land Development Manual; A Guide to

Sound Land and Water Management (Department of Environmental Regulation, 1988), unless a project-specific erosion and sediment control plan is approved as part of the permit. Thereafter the permittee shall be responsible for the removal of the barriers. The permittee shall correct any erosion or shoaling that causes adverse impacts to the water resources.

4. The permittee shall notify the Department of the anticipated construction start date within 30 days of the date that this permit is issued. **At least 48 hours prior to commencement** of activity authorized by this permit, the permittee shall submit to the Department an "Environmental Resource Permit Construction Commencement" notice (Form No. 62-343.900(3), F.A.C.) indicating the actual start date and the expected completion date.
5. When the duration of construction will exceed one year, the permittee shall submit construction status reports to the Department on an annual basis utilizing an "Annual Status Report Form" (Form No. 62-343.900(4), F.A.C.). Status Report Forms shall be submitted the following June of each year.
6. **Within 30 days after completion of construction** of the permitted activity, the permittee shall submit a written statement of completion and certification by a registered professional engineer or other appropriate individual as authorized by law, utilizing the supplied "Environmental Resource Permit As-Built Certification by a Registered Professional" (Form No. 62-343.900(5), F.A.C.). The statement of completion and certification shall be based on on-site observation of construction or review of as-built drawings for the purpose of determining if the work was completed in compliance with permitted plans and specifications. This submittal shall serve to notify the Department that the system is ready for inspection. Additionally, if deviation from the approved drawings are discovered during the certification process, the certification must be accompanied by a copy of the approved permit drawings with deviations noted. Both the original and revised specifications must be clearly shown. The plans must be clearly labeled as "as-built" or "record" drawings. All surveyed dimensions and elevations shall be certified by a registered surveyor.
7. The operation phase of this permit shall not become effective: until the permittee has complied with the requirements of condition (6) above, has **submitted a "Request for Transfer of Environmental Resource Permit Construction Phase to Operation Phase" (Form No. 62-343.900(7), F.A.C.)**; the Department determines the system to be in compliance with the permitted plans and specifications; and the entity approved by the Department in accordance with Sections 9.0 and 10.0 of the Basis of Review for Environmental Resource Permit Applications Within the South Florida Water Management District - August 1995, accepts responsibility for operation and maintenance of the system. The permit shall not be transferred to such approved operation and maintenance entity until the operation phase of the permit becomes effective. Following inspection and approval of the permitted system by the Department, the permittee shall initiate transfer of the permit to the approved responsible operating entity if different from the permittee. Until the permit is transferred pursuant to Section 62-343.110(1)(d), F.A.C., the permittee shall be liable for compliance with the terms of the permit.
8. Each phase or independent portion of the permitted system must be completed in accordance with the permitted plans and permit conditions prior to the initiation of the permitted use of site infrastructure located within the area served by that portion or phase of the system. Each phase or independent portion of the system must be completed in accordance with the permitted plans and permit conditions prior to transfer of responsibility for operation and maintenance of the phase or portion of the system to a local government or other responsible entity.

9. For those systems that will be operated or maintained by an entity that will require an easement or deed restriction in order to enable that entity to operate or maintain the system in conformance with this permit, such easement or deed restriction must be recorded in the public records and submitted to the Department along with any other final operation and maintenance documents required by sections 9.0 and 10.0 of the Basis of Review for Environmental Resource Permit Applications Within the South Florida Water Management District - August 1995, prior to lot or unit sales or prior to the completion of the system, whichever occurs first. Other documents concerning the establishment and authority of the operating entity must be filed with the Secretary of State where appropriate. For those systems which are proposed to be maintained by the county or municipal entities, final operation and maintenance documents must be received by the Department when maintenance and operation of the system is accepted by the local government entity. Failure to submit the appropriate final documents will result in the permittee remaining liable for carrying out maintenance and operation of the permitted system and any other permit conditions.
10. Should any other regulatory agency require changes to the permitted system, the permittee shall notify the Department in writing of the changes prior to implementation so that a determination can be made whether a permit modification is required.
11. This permit does not eliminate the necessity to obtain any required federal, state, local and special district authorizations prior to the start of any activity approved by this permit. This permit does not convey to the permittee or create in the permittee any property right, or any interest in real property, nor does it authorize any entrance upon or activities on property which is not owned or controlled by the permittee, or convey any rights or privileges other than those specified in the permit and Chapter 40E-4 or Chapter 40E-40, F.A.C.
12. The permittee is hereby advised that Section 253.77, F.S. states that a person may not commence any excavation, construction, or other activity involving the use of sovereign or other lands of the state, the title to which is vested in the Board of Trustees of the Internal Improvement Trust Fund without obtaining the required lease, license, easement, or other form of consent authorizing the proposed use. Therefore, the permittee is responsible for obtaining any necessary authorizations from the Board of Trustees prior to commencing activity on sovereignty lands or other state-owned lands.
13. The permittee is advised that the rules of the South Florida Water Management District require the permittee to obtain a water use permit from the South Florida Water Management District prior to construction dewatering, unless the work qualifies for a general permit pursuant to subsection 40E-20.302(4), F.A.C., also known as the "No Notice" rule.
14. The permittee shall hold and save the Department harmless from any and all damages, claims, or liabilities which may arise by reason of the construction, alteration, operation, maintenance, removal, abandonment or use of any system authorized by the permit.
15. Any delineation of the extent of a wetland or other surface water submitted as part of the permit application, including plans or other supporting documentation, shall not be considered binding unless a specific condition of this permit or a formal determination under section 373.421(2), F.S., provides otherwise.
16. The permittee shall notify the Department in writing within 30 days of any sale, conveyance, or other transfer of ownership or control of a permitted system or the real property on which the permitted system is located. All transfers of ownership or transfers of a permit are subject to the requirements of section 62-343.130, F.A.C. The permittee transferring the permit shall remain

liable for corrective actions that may be required as a result of any violations prior to the sale, conveyance or other transfer of the system.

17. Upon reasonable notice to the permittee, Department authorized staff with proper identification shall have permission to enter, inspect, sample and test the system to insure conformity with the plans and specifications approved by the permit.

18. If historical or archaeological artifacts are discovered at any time on the project site, the permittee shall immediately notify the appropriate Department office.

19. The permittee shall immediately notify the Department in writing of any previously submitted information that is later discovered to be inaccurate.

SPECIFIC CONDITIONS:

1. **Authorized Construction:** The construction of the G160 Gated Spillway (Structure) and associated works is authorized under this permit in accordance with the following. The G160 structure shall be a fully automated double gated spillway, consisting of two 25 feet wide upward opening slide gates with a still elevation at 3.0 feet NGVD. Maximum discharge capacity is 1890 csf. Associated works include an operation control building and associated paving and grading.

2. **Interim Operation:** The permit authorizes construction and interim operation of the G-160 Structure. An interim operation period is required to develop and optimize a long term operation plan as part of restoring the hydroperiod in Loxahatchee Slough, enhancing freshwater flows to protect and restore the water resources and ecology of the Northwest Fork of the Loxahatchee River, while providing exiting level of flood protection for adjacent privately owned lands. During the interim operation period the South Florida Water Management District shall perform additional data collection and analysis to better assess potential impacts of the installation and operation of the G-160 structure and water elevations in the Loxahachee Slough. The interim operation period shall be time limited to not extend beyond the required data collection and optimization phase of this project. A final operation plan shall be developed and submitted to the Department for Permit approval by 2004. As part of implementing the final operation plan the South Florida Water Management District shall reserve from allocation the water made available from this project in accordance with Special Condition No. 8.

3. **Control Elevations.** The proposed G-160 structure shall be operated in accordance with attached Interim Operation Schedule for the G-160 (Exhibit 1) to optimize water deliveries by providing 50 cfs or more to the Northwest Fork of the Loxahatchee River when water is available while achieving the desired Target Hydroperiod for the Loxahatchee Slough (Exhibit 2). G-160 discharge shall be maintained to meet the Minimum Flows and Levels as established by District Rule 40-E8.221, F.A.C. during periods when Slough water Levels are below targets (Target Hydroperiod). Optimum design stage of 16.0 to 17.5 feet NGVD shall be maintained just upstream of the structure, with a maximum stage of 17.8 feet NGVD during extreme rainfall/runoff conditions. Interim operation allows lowering the control elevations of the existing boards on project culverts PC-13 and PC-15 (discharging from the Slough to the C-18 Canal) from 16.9 feet NGVD to 15.0 feet NGVD while operating the G-160 structure in accordance with the above.

4. **Stage Monitoring:** Continuous monitoring of water levels during the interim operation is required for:

   - RM_4.73: Location of the G-160 structure
   - RM_0.00: Intersection Beeline Highway and C-18 East Canal
   - Loxahatchee Slough West: Unit 18
   - Loxahatchee Slough East: Unit 27

Rob plan now, change order monitoring

Stage monitoring is required to help optimize operation during the interim period, the permittee shall install stage gages which records stage levels in feet NGVD in the C-18 Canal immediately upstream and downstream of the proposed structure. Stage gauges shall also be established in the Slough at project Culver PC –13 and PC-15, and at the Intersection Beeline Highway and C-18 East Canal. In addition, stage-monitoring stations within the interior slough shall be established to better asses the effect of water level changes on the vegetation communities in accordance with specific condition 5 below.

5. **Vegetation Monitoring for Loxahatchee Slough:** To ensure that the Loxahatchee Slough wetland restoration portion of this project is successful, both hydrological and vegetation monitoring is required. Loxahatchee Slough monitoring shall be implemented in accordance with the attached G160 Monitoring Plan Agreement (Attached Exhibit 3). The purpose of this proposed monitoring plan is to conduct baseline (current) and post-construction/operation (G-160 Structure) vegetation and hydrological monitoring within the Loxahatchee Slough, to help optimize the long-term operation and restoration efforts.

6. **Operational Monitoring of S-46:** The District shall develop an annual operational evaluation report to determine potential impacts of discharges through the S-46 to the Loxahatchee Estuary resulting from the construction and operation of the G-160 structure. The operational evaluation reports shall analyze flows at the S-46, and compare the flow data (rates, volumes and duration) for post project conditions with pre-project discharges for both average annual flows and peak events. If it is determined that the operation of the G-160 affects discharges through the S-46 by significantly increasing duration or flow rates of peak discharge events, the district shall expand the operational evaluation to include monitoring of the downstream Loxahachee Estuary. This report is to be submitted to the Department no latter than 45 days following the end of each year of operation.

7. **Annual Monitoring Reports.** As part of the monitoring and reporting requirements for this permit, for each Year of operation, the District shall submit to the Department an annual report that summarizes the data collection, including environmental monitoring, hydrological monitoring, and operational details. The annual report shall be used as a tool to further refine and optimize the operation schedule and shall include analyses and recommendations on possible modifications to the interim operation plan. This report is to be submitted to the Department no latter than 45 days following the end of each year of operation.

8. **Water Reservation/Allocation:** This project is part of the strategy to help restore fresh water flows to the Northwest Fork of the Loxahatchee River. Pursuant to Rule 40E-8.421(7)(f), F.A.C., the South Florida Water Management District "intends to adopt reservations for the Loxahatchee River, pursuant to Section 373.223(4), F.S., on a project by project basis ..... These water reservations are intended to prevent the future allocation to consumptive uses the fresh water intended for the restoration of the Loxahatchee River". Implementation of water reservations for this project shall be consistent with the reservations being developed for restoration of the Everglades under CERP. Specifically, the water reservation shall be consistent with the amount of water identified for the natural system in the Project Implementation Report(s) for CERP projects that delivers flows either directly or indirectly to the Loxahachee River.

9. **Construction Best Management Practices.** At all times during the construction, the permittee shall use best management techniques for erosion and sedimentation control. Silt screens, straw bales, turbidity curtains or other sediment control measures shall be used during construction. All graded areas shall be stabilized and vegetated immediately after construction to prevent erosion. Effective means of turbidity control, such as, but not limited to, turbidity curtains shall be employed during all operations that may create turbidity so that it shall not exceed 29 NTU's above background in the C-18 Canal, nor degrade downstream waters (Outstanding Florida Waters). Turbidity screens shall be placed and maintained around the work area to confine turbidity generated by construction activities. All screens, sheet-piles, and other turbidity control devices shall remain in place until all turbidity has subsided and meets state standards. Turbidity control and turbidity monitoring shall be implemented in accordance with attached Exhibit 4.

10. **Drawings and Attachments.** Drawing exhibits 5 through 10, and DEP forms: 62-343.900(3), (4), (5), (7), and (8) F.A.C., are hereby attached to and become part of this permit.

11. **Compliance with Specific Conditions.** If the approved permit drawings and/or attached exhibits conflict with the specific conditions, then the specific conditions shall prevail.

12. **Compliance with General Conditions.** The permittee shall be aware of and operate under the attached general limiting conditions. General conditions are binding upon the permittee and enforceable pursuant to Chapters 403 and 373 of the Florida Statutes.

RIGHTS OF AFFECTED PARTIES

This permit is hereby granted. This action is final and effective on the date filed with the Clerk of the Department unless a sufficient petition for an administrative hearing is timely filed under sections 120.569 and 120.57 of the Florida Statutes as provided below. If a sufficient petition for an administrative hearing is timely filed, this action automatically becomes only proposed agency action on the application, subject to the result of the administrative review process. Therefore, on the filing of a timely and sufficient petition, this action will not be final and effective until further order of the Department. Because an administrative hearing may result in the reversal or substantial modification of this action, the applicant is advised not to commence construction or other activities until the deadlines

Permittee: South Florida Water Management District & Palm Beach County Department of Environmental Resource Management
Project: C-18 Canal Control Structure (G160)
File No.: EI 50-0128848-004

noted below for filing a petition for an administrative hearing or request for an extension of time have expired.

Mediation is not available.

A person whose substantial interests are affected by the Department's action may petition for an administrative proceeding (hearing) under sections 120.569 and 120.57 of the Florida Statutes. The petition must contain the information set forth below and must be filed (received by the clerk) in the Office of General Counsel of the Department at 3900 Commonwealth Boulevard, Mail Station 35, Tallahassee, Florida 32399-3000.

Under rule 62-110.106(4) of the Florida Administrative Code, a person whose substantial interests are affected by the Department's action may also request an extension of time to file a petition for an administrative hearing. The Department may, for good cause shown, grant the request for an extension of time. Requests for extension of time must be filed with the Office of General Counsel of the Department at 3900 Commonwealth Boulevard, Mail Station 35, Tallahassee, Florida 32399-3000, before the applicable deadline. A timely request for extension of time shall toll the running of the time period for filing a petition until the request is acted upon. If a request is filed late, the Department may still grant it upon a motion by the requesting party showing that the failure to file a request for an extension of time before the deadline was the result of excusable neglect.

If a timely and sufficient petition for an administrative hearing is filed, other persons whose substantial interests will be affected by the outcome of the administrative process have the right to petition to intervene in the proceeding. Intervention will be permitted only at the discretion of the presiding officer upon the filing of a motion in compliance with rule 28-106.205 of the Florida Administrative Code.

In accordance with rules 28-106.111(2) and 62-110.106(3)(a)(4), petitions for an administrative hearing by the applicant must be filed within 21 days of receipt of this written notice. Petitions filed by any persons other than the applicant, and other than those entitled to written notice under section 120.60(3) of the Florida Statutes must be filed within 21 days of publication of the notice or within 21 days of receipt of the written notice, whichever occurs first. Under section 120.60(3) of the Florida Statutes, however, any person who has asked the Department for notice of agency action may file a petition within 21 days of receipt of such notice, regardless of the date of publication.

The petitioner shall mail a copy of the petition to the applicant at the address indicated above at the time of filing. The failure of any person to file a petition for an administrative hearing within the appropriate time period shall constitute a waiver of that person's right to request an administrative determination (hearing) under sections 120.569 and 120.57 of the Florida Statutes.

A petition that disputes the material facts on which the Department's action is based must contain the following information:

(a) The name and address of each agency affected and each agency's file or identification number, if known;
(b) The name, address, and telephone number of the petitioner; the name, address, and telephone number of the petitioner's representative, if any, which shall be the address for service purposes

during the course of the proceeding; and an explanation of how the petitioner's substantial interests are or will be affected by the agency determination;

(c) A statement of when and how the petitioner received notice of the agency decision;
(d) A statement of all disputed issues of material fact. If there are none, the petition must so indicate;
(e) A concise statement of the ultimate facts alleged, including the specific facts that the petitioner contends warrant reversal or modification of the agency's proposed action;
(f) A statement of the specific rules or statutes that the petitioner contends require reversal or modification of the agency's proposed action; and
(g) A statement of the relief sought by the petitioner, stating precisely the action that the petitioner wishes the agency to take with respect to the agency's proposed action.

A petition that does not dispute the material facts on which the Department's action is based shall state that no such facts are in dispute and otherwise shall contain the same information as set forth above, as required by rule 28-106.301.

Under sections 120.569(2)(c) and (d) of the Florida Statutes, a petition for administrative hearing must be dismissed by the agency if the petition does not substantially comply with the above requirements or is untimely filed.

This permit constitutes an order of the Department. Subject to the provisions of paragraph 120.68(7)(a) of the Florida Statutes, which may require a remand for an administrative hearing, the applicant has the right to seek judicial review of the order under section 120.68 of the Florida Statutes, by the filing of a notice of appeal under rule 9.110 of the Florida Rules of Appellate Procedure with the Clerk of the Department in the Office of General Counsel, 3900 Commonwealth Boulevard, Mail Station 35, Tallahassee, Florida, 32399-3000; and by filing a copy of the notice of appeal accompanied by the applicable filing fees with the appropriate district court of appeal. The notice of appeal must be filed within 30 days from the date when the order is filed with the Clerk of the Department.

Executed in West Palm Beach, Florida.

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL PROTECTION

John F. Moulton, III 3/7/03

John F. Moulton, III Date
Assistant District Director
Southeast District Office

JFM/JC/ih

e-mail: **SFWMD's** Kimberley M. Koptak [kkoptak@sfwmd.gov]; Ashie Akpoji [aakpoji@sfwmd.gov]; Pat Walker [pwalker@sfwmd.gov]; Matthew Morrison [mjmorris@sfwmd.gov]; John G. Zahina [jzahina@sfwmd.gov]; Michael Voich [mvoich@sfwmd.gov]; Ken Ammon [kammon@sfwmd.gov]; Chip Merriam [cmerria@sfwmd.gov]
Rich Walesky [rwalesky@co.palm-beach.fl.us]; Ken Todd [ktodd@co.palm-beach.fl.us]

Permittee: South Florida Water Management District & Palm Beach County Department of Environmental Resource Management
Project: C-18 Canal Control Structure (G160)
File No.: EI 50-0128848-004

Lisa B. Interlandi [lisa@smallgrey.com]
Patrick J. Hayes [hayespatj@aol.com]
John C. Bills [john@jcbills.com]
Dan Shalloway [shalloway@sfrninc.com]
DEP's Llewellyn, Janet; Barnett, Ernie; Moulton, John; McVety, Pam; Greenwood, Kathleen; Zebuth, Herbert H.; Roberts, Richard; Calas, Jose J; Hansen, Inger; Outland, John; Morgan, Temperince; Rach, Timothy; Borkowski, Winston
L-8 Partners: 'lreilly@sfwmd.gov'; 'acadogan@sfwmd.gov'; 'shunter@ci.west-palm-beach.fl.us'; 'jbonde@indiantrail.com'; 'lamb@mfl-inc.com'; 'ktodd@co.palm-beach.fl.us'; 'krearden@ci.west-palm-beach.fl.us'; 'darla_fousek@fws.gov'; 'teel.susan@epa.gov'; 'office@indiantrail.com'; 'pwalker@sfwmd.gov'; 'kevina@detwpb.org'; Karen-B@lbfh.com

Prepared by: Inger Hansen, Engineer IV

ATTACHMENTS

Permit No. EI 50-0128848-004 - EXHIBIT 3
Attached G160 Monitoring Plan Agreement (attached separately)

Permit No. EI 50-0128848-004 - EXHIBIT 4
Attached Section 02435 Turbidity Control and Monitoring (attached separately)

Permit No. EI 50-0128848-004 - EXHIBIT 1 Operation Schedule of the G-160 Structure

The G-160 will be operated in two primary modes: the dry season mode and the wet season mode. The interim operational plan for the G-160 structure is presented in Table 21. The wet season mode can be further divided into two sub-modes: the major storm mode, and the normal release mode. Zones A-D in Table 21 correspond to zones in Figure 8. These zones take into account the needs of plant communities in the slough.

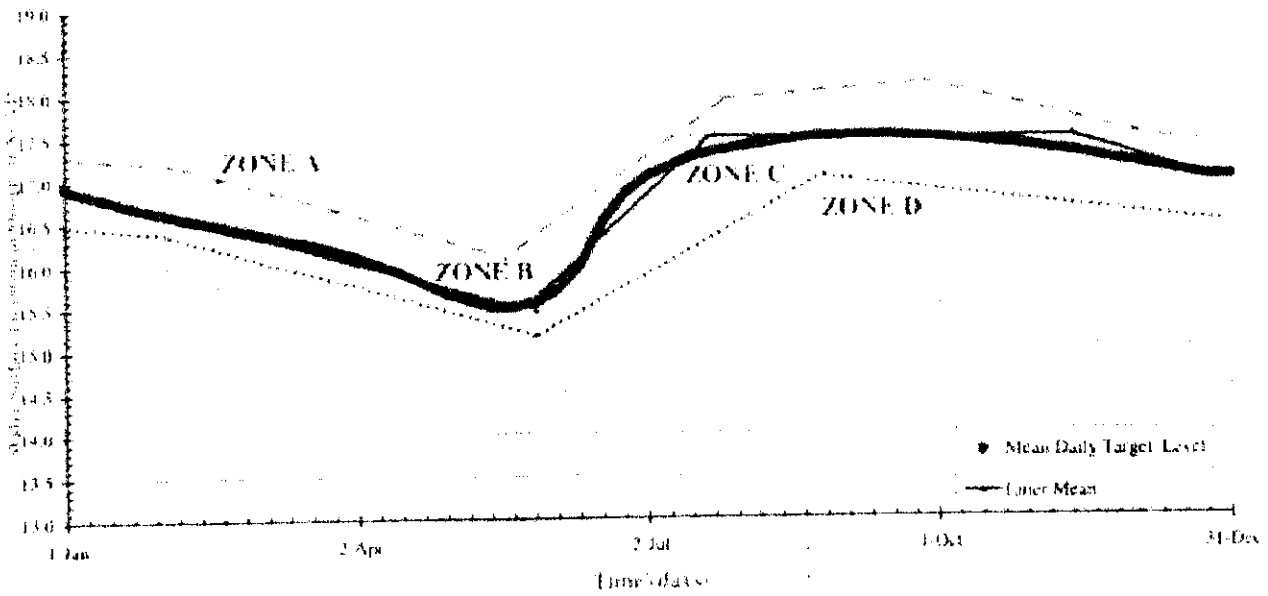
Table 21: Interim Operational Schedule for the G-160 Structure

Subject to revision when the Loxahatchee River water management plan is established

Zone defined by Slough Water Levels	Hydraulic Condition	Action
A	Slough water level is in storm condition and is Zone A	G-160 will be opened as long as the C-18 Canal has the capacity to receive water from G-160 and G-92. Route water from G-160 through G-92 structure as much as possible rather than discharge to tide through S-46.
B	Slough water level is *above* target, but not in a storm condition. There is storage in the slough.	Control G-160 and G-92 structures as needed to release water to the Northwest Fork of the Loxahatchee River to meet MFL and restoration requirements, subject to meteorological forecasts and vegetal community needs.
C	Slough water level is *below* target, but not in a drought condition.	*Wet season schedule (June 1 – October 31)* Control releases at G-160 and G-92 structures as needed to augment flow to the Northwest Fork of the Loxahatchee River to meet MFL requirements, subject to meteorological forecasts and vegetal community needs. *Dry season schedule (November 1 – May 31)* G-160 should remain closed, except extreme hydrologic conditions occur, or rule making requires release of water to meet MFL requirements.
D	Slough water level is in drought condition and is in Zone D	Close G-160.

Permit No. EI 50-0128848-004 - EXHIBIT 2

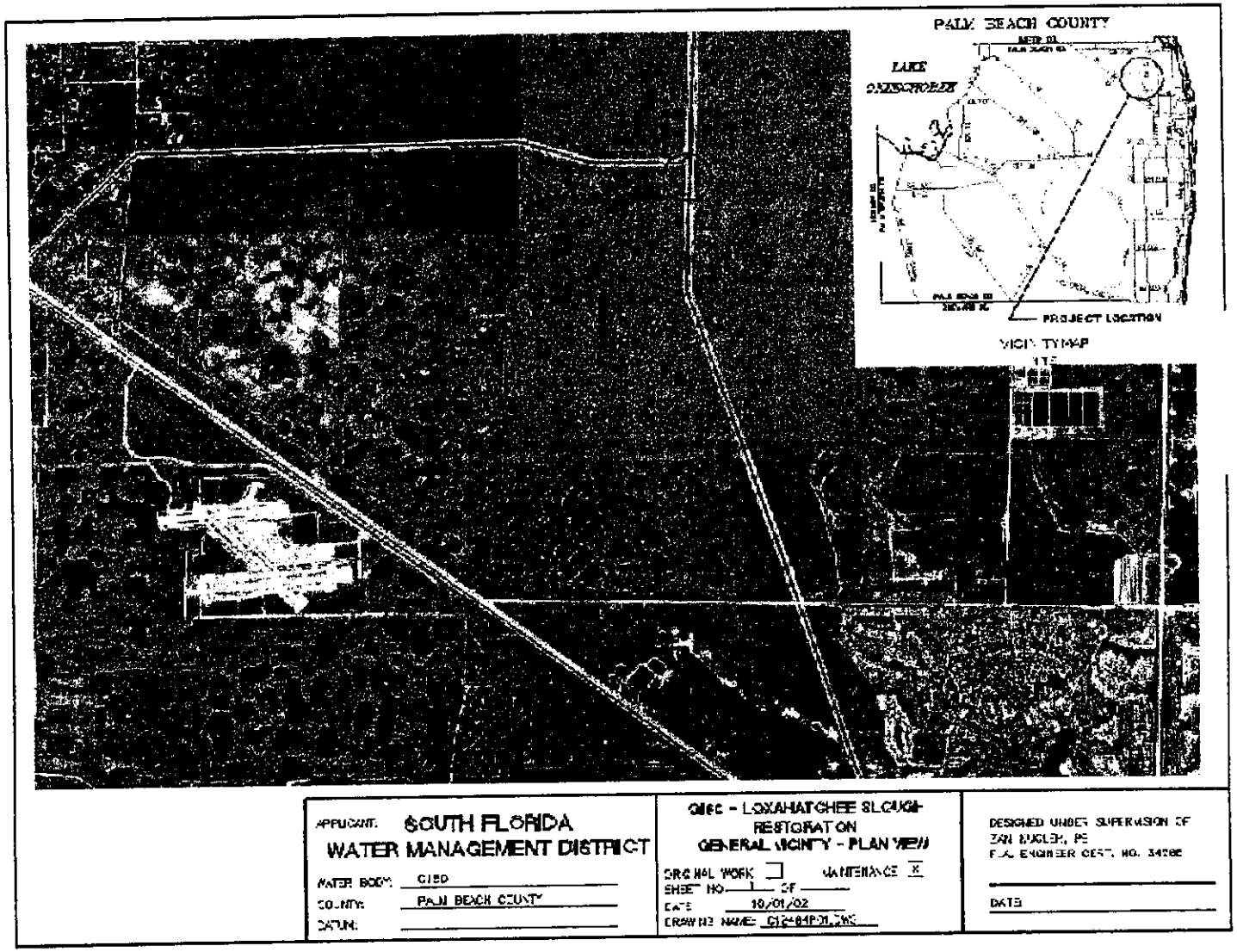
Figure 8. Annual Target Hydroperiod at the Loxahatchee Slough



Levels for Loxahatchee Slough

Loxahatchee Slough Water Budget Model
City of West Palm Beach and SFWMD

Permit No. EI 50-0128848-004 - EXHIBIT 5



APPLICANT: SOUTH FLORIDA WATER MANAGEMENT DISTRICT

WATER BODY: C18D

COUNTY: PALM BEACH COUNTY

DATUM:

C18C - LOXAHATCHEE SLOUGH RESTORATION
GENERAL VICINITY - PLAN VIEW

ORIGINAL WORK [ ] MAINTENANCE [X]

SHEET NO. 1 OF

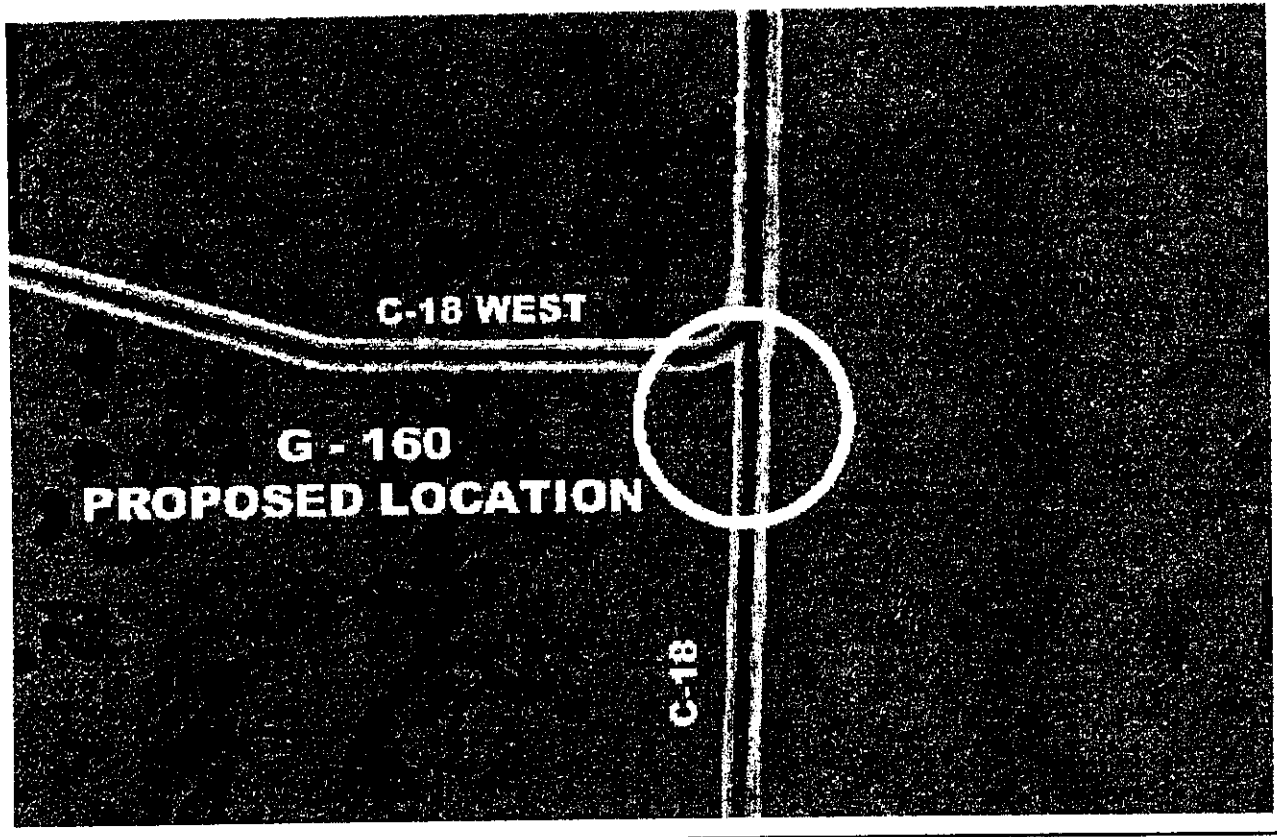
DATE 10/01/02

DRAWING NAME: C18-84P01.DWG

DESIGNED UNDER SUPERVISION OF
JAN BUGLER, PE
FLA. ENGINEER REG'T. NO. 34286

DATE

Permit No. EI 50-0128848-004 - EXHIBIT 6



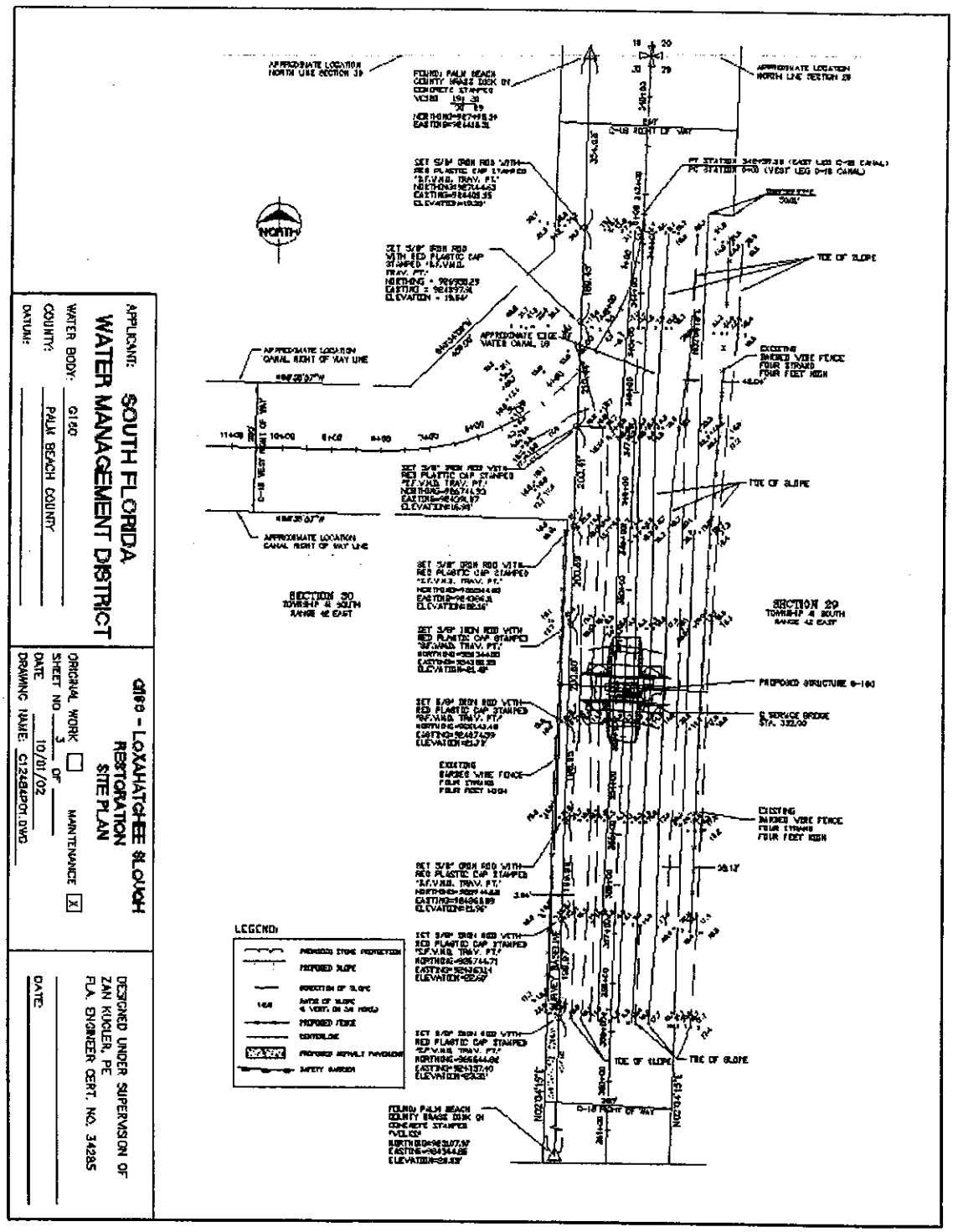
APPLICANT: SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WATER BODY: 3165
COUNTY: PALM BEACH COUNTY
DATUM:

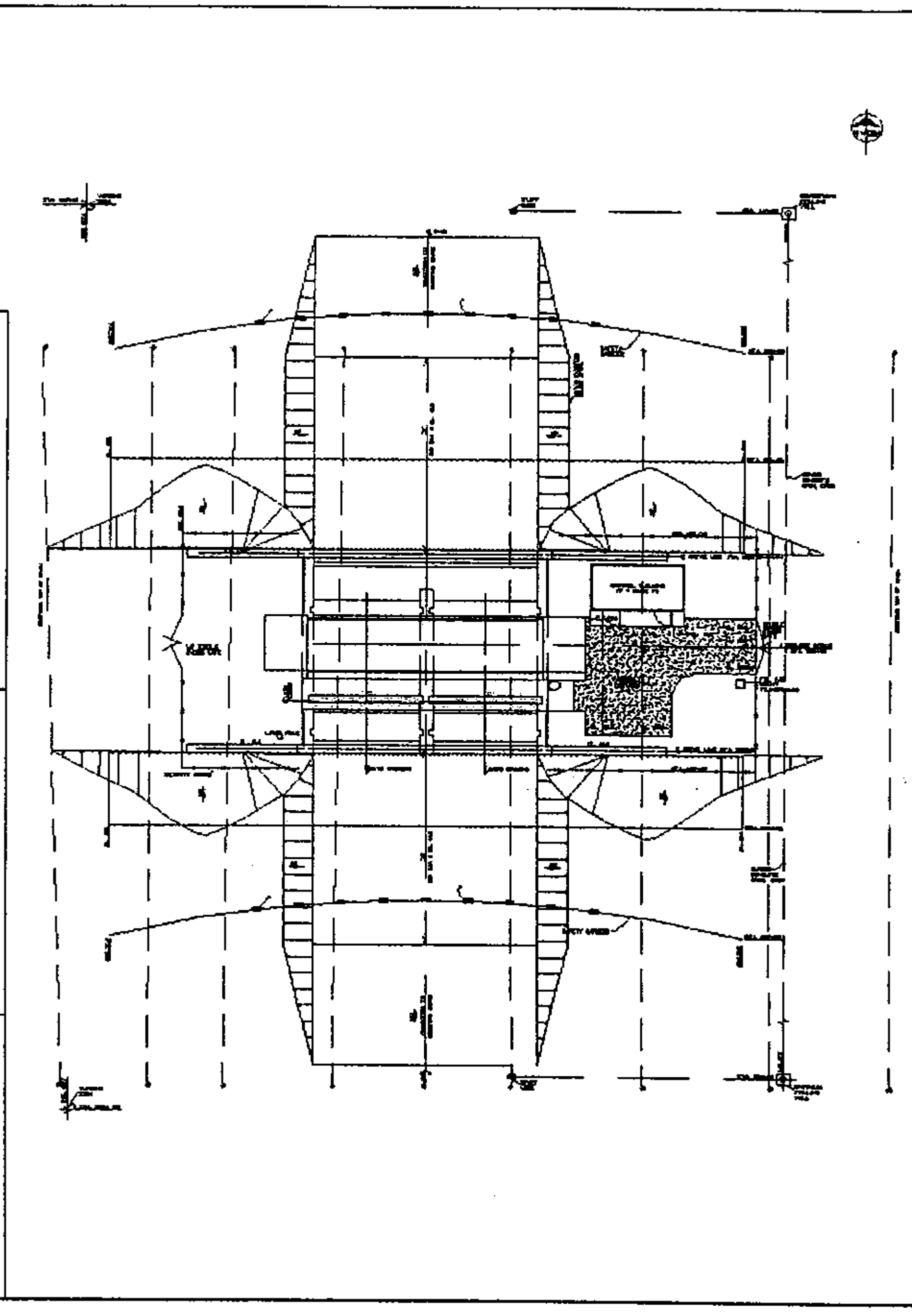
G160 - LOXAHATCHEE SLOUGH RESTORATION PLAN VIEW
ORIGINAL WORK ☐ MAINTENANCE ☒
SHEET NO 2 OF
DATE 10/01/03
DRAWING NAME G1246-E01.DWG

DESIGNED UNDER SUPERVISION OF
IAN FULLER, PE
FLA. ENGINEER DEPT. NO. 31265

DATE

Permit No. EI 50-0128848-004 - EXHIBIT 7





APPLICANT: **SOUTH FLORIDA WATER MANAGEMENT DISTRICT**

WATER BODY: G160

COUNTY: PALM BEACH COUNTY

DATUM:

G160 - LOXAHATCHEE SLOUGH RESTORATION SITE PLAN

ORIGINAL WORK ☐ MAINTENANCE ☒

SHEET NO 4 OF

DATE 10/01/02

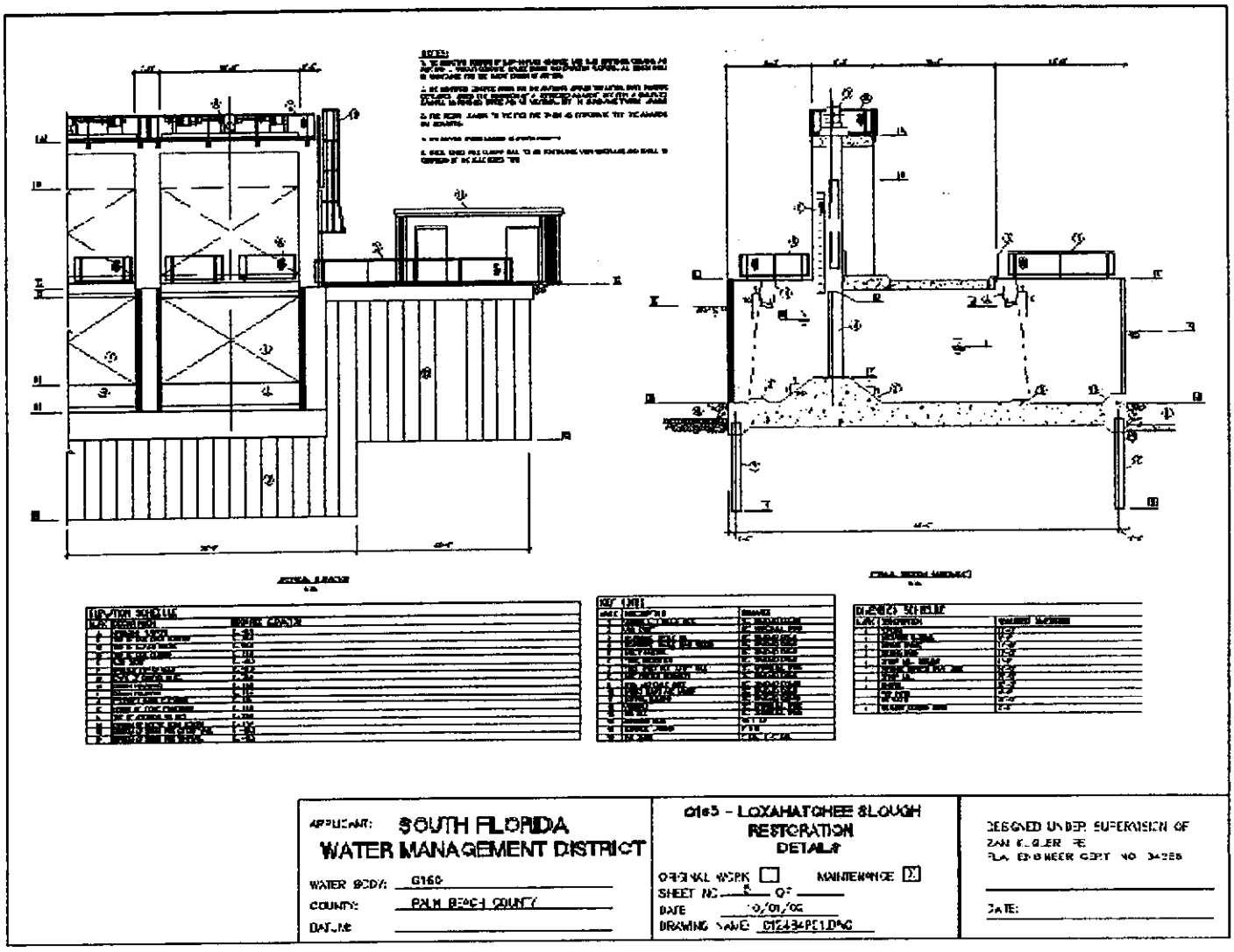
DRAWING NAME: C1248P01.DWG

DESIGNED UNDER SUPERVISION OF
ZAN KUGLER, PE
FLA. ENGINEER CERT. NO. 34285

DATE:

Permit No. EI 50-0128848-004 - EXHIBIT 8

Permit No. EI 50-0128848-004 - EXHIBIT 9



APPLICANT: SOUTH FLORIDA WATER MANAGEMENT DISTRICT

WATER BODY: G160

COUNTY: PALM BEACH COUNTY

DATUM:

G165 - LOXAHATCHEE SLOUGH RESTORATION DETAILS

ORIGINAL WORK ☐ MAINTENANCE ☒

SHEET NO. 5 OF

DATE 2/01/06

DRAWING NAME: G1234PE1.DWG

DESIGNED UNDER SUPERVISION OF

ZAN KLEIER PE

FLA. ENGINEER LIC. NO. 34286

DATE:

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
3301 Gun Club Road, West Palm Beach, Florida 33406 • (561) 686-8800 • FL WATS 1-800-432-2045 • TDD (561) 697-2574
Mailing Address: P.O. Box 24680, West Palm Beach, FL 33416-4680 • www.sfwmd.gov

May 23, 2002

Richard E. Walesky, Director
Environmental Resources Management
Palm Beach County Dept. of Environmental Resources Management
3323 Belvedere Rd., Building 502
West Palm Beach, FL 33406-1548

SUBJECT: MONITORING OF THE LOXAHATCHEE SLOUGH

Dear Richard,

We have received your letter of assurance dated May 3, 2002 (attached), regarding PBC DERM's agreement and commitment to assist in executing the Loxahatchee Slough Restoration and G-160 Monitoring Plan. With this pledge we are preparing to begin work on this effort immediately. Our first step will be to complete a survey of the vegetation monitoring sites and install staff gages, which will be completed before the August 2002 vegetation survey.

Thank you for your commitment to this effort, we look forward to your continued cooperation on this monitoring plan.

Sincerely,

Matthew J. Morrison
Director
Planning and Development Division
Water Supply Department

MJM/nk

Attachment

Department of Environmental Resources Management
3323 Belvedere Road, Building 502
West Palm Beach, FL 33406-1548
(561) 233-2400
Fax (561) 233-2414
www.pbcgov.com

May 3, 2002

Matt Morrison
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33416

Dear Morrison:

SUBJECT: MONITORING OF THE LOXAHATCHEE SLOUGH

Palm Beach County Department of Environmental Resources Management (ERM) has received your Loxahatchee Slough Restoration and G-160 Monitoring Plan (Exhibit C), and will be happy to assist the South Florida Water Management District in this effort. ERM will make the commitment to provide the staff, and perform the work assigned to us in the attached plan.

We look forward to working with you and your staff on this project. If you have any questions or need any additional information, please contact me at 233-2424 or Frank Griffiths at 233-2486.

Sincerely,

Richard E. Walesky, Director
Environmental Resources Management

REW:FG:ea
attachment

EXHIBIT "C"
STATEMENT OF WORK
Loxahatchee Slough Restoration and G-160 Monitoring Plan

1.0 INTRODUCTION

A mutually agreeable arrangement is proposed by Palm Beach County (COUNTY) and the South Florida Water Management District (DISTRICT) with regard to conducting a monitoring program for the Loxahatchee Slough and G-160 structure. This property, which is owned by the COUNTY, is located within Sections 29, 30, 31 and 32, Township 41S, Range 42E and Sections 5, 6, and 8, Township 42S, Range 42E.

The primary consideration upon which this agreement is based involves increasing water control in the C-18 canal immediately south of its intersection of C-18W as well as improving the availability and operational flexibility to better manage the Loxahatchee Slough for the purposes of water supply and environmental quality. This includes, but is not limited to, restoring and maintaining the hydrologic restoration of the Loxahatchee Slough and providing water to meet the base flow requirements for the Northwest Fork of the Loxahatchee River.

2.0 OBJECTIVE

The purpose of this monitoring plan is to conduct baseline (current) and post-construction/operation (G-160 Structure) vegetation and hydrological monitoring within the Loxahatchee Slough. This plan is designed to determine the effectiveness of the first tier improvements completed under the North Palm Beach County Comprehensive Water Management Plan. The results are expected to provide the South Florida Water Management District (DISTRICT) with beneficial information that will allow adjustments to the operation of the G-160 Structure which is a sub-regional part of the Lower East Coast Regional Water Supply Plan and an integral component for storage of water on a regional level to satisfy flood protection, water supply and environmental benefits to most effectively meet the Plan's objectives.

3.0 SCOPE OF WORK

The COUNTY and the DISTRICT mutually agree that a monitoring program is necessary to determine the effectiveness and provide important information to allow for adjustments to the operation of the G-160 structure to meet the plan's objectives.

In accordance with this Agreement, the plan is divided into two components that encompass two approaches to monitoring vegetation: a field-based site-specific component which will be monitored and managed by the COUNTY and a Geographical

Information System (GIS) based landscape-level analysis will be provided by the DISTRICT.

FIELD-BASED MONITORING COMPONENT – COUNTY ACTIVITIES

>Establishment of Monitoring Sites
>Installation of Staff Gauges
>Establishment of Vegetation Monitoring Plots
>Baseline (pre-construction/operation) Vegetation Survey
>Semi-Annual Vegetation Monitoring
>Vegetation Plot Photography
>Annual Report

LANDSCAPE LEVEL MONITORING COMPONENT – DISTRICT ACTIVITIES

>GIS analysis of Long-Term Vegetation Changes
>Report Analysis

4.0 WORK BREAKDOWN STRUCTURE:

In consideration of the benefits flowing from each to the other, the COUNTY and the DISTRICT agree to the following tasks for this project site for water control which is located in the C-18 canal immediately south of its intersection of C-18W. The monitoring activities will allow for increased water levels in the Loxahatchee Slough.

- The COUNTY will be responsible for establishing a field based monitoring program in the Loxahatchee slough as well as being responsible for all field based monitoring and reporting as designed in the Field-based monitoring component for a period of six (6) years.

- The DISTRICT will be responsible for conducting landscape level monitoring as outlined in the Landscape-level Monitoring component. In addition, the DISTRICT will be responsible for providing survey benchmarks within a reasonable distance of vegetation plots and to install staff gauges for the five (5) designated sites within the slough.

The activities for both entities are listed below and commence with the COUNTY's responsibilities.

4.1 COUNTY RESPONSIBILITIES
COMPONENT: FIELD-BASED MONITORING ACTIVITY

Field-based monitoring will be conducted in fifteen vegetation survey plots at five (5) sites within the Loxahatchee Slough (Figure 1). Sites will be chosen within representative (dominant) communities currently found within the Slough (i.e. bald cypress strand, wet prairie). Within each site, three plots will be established to monitor vegetation community change through time. Field data will be collected twice annually over a period of six years and will commence in August – September 2002. In addition,

the COUNTY agrees to monitor and maintain each site for a period of six years after signing this Agreement.

Task 1. Establishment of Monitoring Sites

The COUNTY will establish vegetation monitoring sites at the five (5) mutually agreed upon locations indicated on Figure 1. Each site will be surveyed and permanently marked prior to initiating the August – September 2002 vegetation survey as described in Task 4. The average ground elevation per the National Geodetic Vertical Datum (NGVD) within each site shall be delineated.

Task 2. Installation of Staff Gauges

Staff gauges will be installed measure water depth at each site prior to the initiating the August – September 2002 vegetation survey as described in Task 4. The COUNTY's monitoring crew will record the date, time, and water depth during each field-monitoring event. Water elevation at the C-18 canal staff gauge will also be recorded.

Task 3. Establishment of Vegetation Monitoring Plots

Three 3m by 3m plots will be established at each site. Plots will contain a representative plant community for that site and shall be dominated by non-tree species. Each monitoring plot will be permanently marked prior to initiating the August – September 2002 vegetation survey as referenced in Task 4.

Task 4. Baseline (pre-construction/operation) Vegetation Survey

The COUNTY's monitoring crew will begin a baseline vegetation survey within the established plots as described in Task 3) in the fall of 2002. The vegetation survey will include water depth in the plot, a characterization of the macrophyte species that are present and their relative abundance using actual counts or a standard comparative index (whichever is appropriate to that species). This baseline monitoring shall be conducted once during the wet season (between August 1 and September 15) in 2002 and once during the dry season (between February 1 and March 15) in 2003.

Task 5. Semi-Annual Vegetation Monitoring

The COUNTY's monitoring crew will conduct a vegetation and hydrological monitoring survey twice per year, once during the dry season (between February 1 and March 15) and once during the wet season (between August 1 and September 15). This monitoring is to begin after the completion of the baseline vegetation survey in the spring of 2003 as described in Task 4, and will be carried out four (4) years thereafter. The vegetation survey will include water depth in the plot, a characterization of the macrophyte species that are present and their relative abundance, using actual counts or a standard comparative index (whichever is appropriate to that species).

Task 6. Vegetation Plot Photography

The COUNTY's monitoring crew will photograph each monitoring plot during each survey event. These photographs are to be taken during each sampling event from the same angle, location, and perspective.

Task 7. Annual Report.

A report of the findings from the vegetation surveys will be compiled and distributed to each participating Agency (Palm Beach County ERM and DISTRICT) each year. The final version of the annual report will be completed and distributed to the participating agencies each year (2002-2007) before January 1st following completion of the August – September monitoring event, with the first report due before January 1, 2003. This annual report will contain an executive summary, introduction, methods section, summary of data, and discussion of findings. Field data will be included in an appendix within the report, and will be subject to the review processes of the COUNTY and the DISTRICT before being released for public distribution. This report will be combined with the summary report prepared by the DISTRICT.

4.2 DISTRICT RESPONSIBILITIES
LANDSCAPE LEVEL MONITORING COMPONENT

Landscape-level analysis of the changes to Slough vegetation through time will be conducted using aerial photography from Digital Orthographic Quad (DOQ) photos, purchased every five (5) years by the DISTRICT. A comparison of changes in the extent of vegetation communities will be documented using GIS analysis.

Task 1. GIS Analysis of Long-Term Vegetation Changes

District staff will conduct a GIS-based analysis of the extent (acres) of major vegetation communities within the Loxahatchee Slough (e.g. bald cypress swamp, wet prairie, sloughs, etc.). Digital Orthophoto Quad (DOQ) aerial photography from the U.S. Geological Survey, which is available every five (5) years, will be used as the base coverage. The 1995 and 2000 DOQs will be analyzed for the extent of existing vegetation communities in 2002. The 2005 and 2010 DOQs, when available, will be similarly analyzed and compared with the results from the baseline photography (1995, 2000). This survey will allow landscape-level vegetation monitoring over the long term.

Task 2. Documentation of Activities

A report outlining the documentation from the GIS analysis will be compiled and distributed to participating agencies (COUNTY, ERM and the DISTRICT) each year following completion of two 5-year monitoring cycles (i.e. 2002, 2007). The first report, due before January 1, 2003, will contain results from the 1995 and 2000 DOQ analysis. It will also serve as baseline data and will include an introduction, methods, results, and discussion section. Accessory data and information will be included as an appendix. This report will pass through the

appropriate review process by both the COUNTY and the DISTRICT prior to being released for public distribution. This report will be combined with the annual report prepared by the COUNTY.

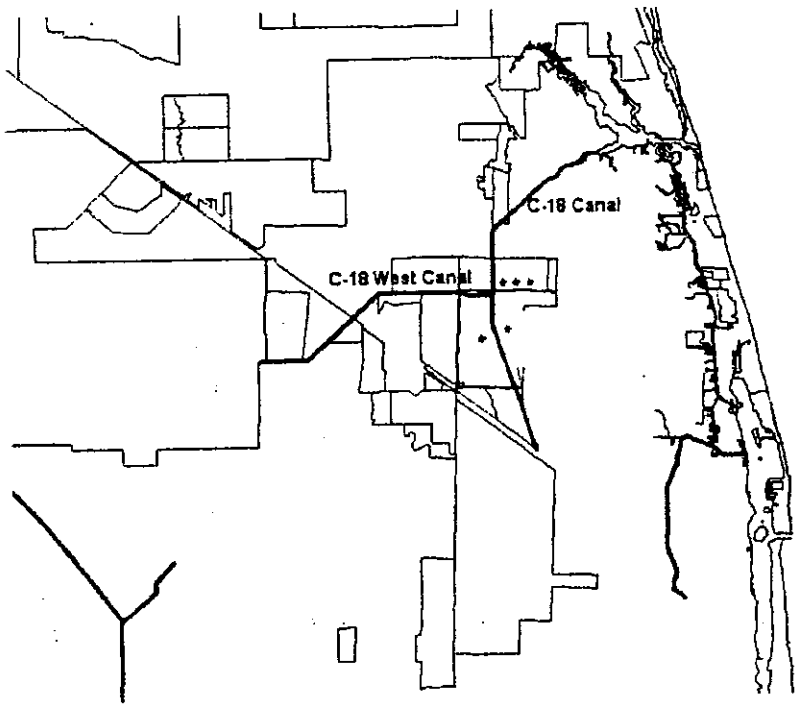


Figure 1. Location of proposed vegetation monitoring sites (indicated by a star *).

5.0 SCHEDULE OF DELIVERABLES

The **COUNTY**'s tasks will be conducted as follows:

Task 1.	Establish five (5) Vegetation Monitoring Sites
Deliverable:	August – September 2002
Task 2.	Installation of Staff Gauges and Record Water Elevation at C-18 Canal
Deliverable:	August – September 2002
Task 3.	Establish three (3) 3m x 3m plant based plots
Deliverable:	August – September 2002
Task 4.	Develop a baseline vegetation survey on established plots
Deliverable:	Conduct analysis during the wet season between the months of August and September, and during the dry season months of February – March 2003
Task 5.	Vegetation and Hydrological Monitoring Survey
Deliverable:	Summer 2002 and Spring 2003
Task 6.	Photography of Monitoring Plots
Deliverable:	Conducted during each survey activity
Task 7.	Prepare and Distribute Annual Report
Deliverable:	Distributed each year commencing 2002 and terminating 2007

The **DISTRICT**'s tasks will be conducted as follows:

Task 1. Develop a Geographical Information System analysis of identified acreage Provide Digital aerial photography for evaluation and documentation of historical data base for cultivated plots

Deliverable: Reports and Photographs

Task 2. Generate Reports including accessory data and information

Deliverable: Distribution of Reports for a period of two 5-year monitoring cycles (2002 and 2007)

SECTION 02435 TURBIDITY CONTROL AND MONITORING

1. GENERAL

1.01 SCOPE: The Work covered by this Section consists of furnishing all necessary equipment, labor and materials necessary to conform to State water quality standards as prescribed in Chapter 62-302, Florida Administrative Code.

2. MATERIALS

2.01 FABRIC: Fabric shall be flexible and impermeable or of sufficiently fine mesh to prevent passage of suspended material through the fabric. Fabric shall provide not less than 60 inches vertical depth of barrier where existing depths are 6 feet or greater. Where existing depths are less than 6 feet, the fabric depth may be decreased in 12 inch increments to not less than 12 inches to conform to existing bottom depths.

2.02 FLOATS: The barriers shall be buoyed with floats of sufficient buoyancy to prevent the top of the barrier from submerging under any water and wind conditions. If the top of the barrier becomes submerged for any reason, Contractor shall suspend construction operations until the condition is corrected.

2.03 ANCHORS AND WEIGHTS: Provide and maintain an anchor system to secure the barrier in position. Attach weights to the barrier as necessary to keep the fabric at an angle to the vertical of 30 degrees or less. Fabric material shall not be attached to the canal bottom.

3. EXECUTION

3.01 Install and maintain turbidity barriers as noted in the drawings and as directed by the District's representative. Barriers shall be installed prior to any filling, backfilling, or excavation and maintained in place until construction is complete and turbidity from construction has dissipated. All barriers shall be adequately marked and appropriate signage erected to identify them as obstructions to navigation.

3.02 Any rips or tears that occur in the turbidity barrier material during use shall be repaired or replaced immediately by the Contractor at his expense. Rips or tears that occur in the turbidity barrier material in use that are not repaired or replaced immediately by the Contractor will result in a suspension of excavation and/or construction operations, and shall require repairs and replacements as a prerequisite to the resumption of work.

3.03 All barriers shall remain in place until turbidity levels return to background levels based on visual inspection. Upon completion of use, the Contractor shall remove the turbidity barriers and associated items to an off-site location at his own expense.

3.04 Operations shall be conducted at all times in a manner that minimizes turbidity. The Contractor is required to conform to State water quality standards as prescribed in F.A.C. Chapter 62-302, and to meet the special requirements of any environmental permits that have been issued to the District.

4. MONITORING

4.01 The Contractor shall conduct turbidity monitoring every four hours during any active excavation; and once daily, prior to project completion, when no excavation is occurring.

A. Background Monitoring Location: 500 feet upstream of the construction area at mid-depth in the water column.
B. Compliance Monitoring Location: Within the densest portion of any noted plume.

4.02 All monitoring data shall be submitted within one week of analysis. Documents submitted shall contain the following information:

A. Permit number
B. Dates of sampling and analysis
C. A statement describing the methods used in collection, handling, storage and analysis of the samples
D. A map indicating the sampling locations
E. A statement by the individual responsible for implementation of the sampling program concerning the authenticity, precision, limits of detection and accuracy of the data.

4.03 Monitoring reports shall also include the following information for each sample that is taken:

A. Time of day samples taken
B. Depth of water body
C. Depth of sample
D. Antecedent weather conditions
E. Velocity of flow

If monitoring reveals apparent exceedences of the State water quality standard for turbidity, construction activities shall cease immediately and not resume until corrective measures have been taken and turbidity has returned to acceptable levels. Apparent exceedences and corrective measures shall be documented in the monitoring reports.

END OF SECTION

APPENDIX B

Four-Party Agreement

BEFORE THE GOVERNING BOARD OF THE
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

IN RE: AGREEMENT BETWEEN THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT, THE CITY OF PALM BEACH GARDENS, FLORIDA, NORTHERN PALM BEACH COUNTY IMPROVEMENT DISTRICT AND SOUTH INDIAN RIVER WATER CONTROL DISTRICT REGARDING INTERIM OPERATIONS OF THE G-160 STRUCTURE

WHEREAS, the **SOUTH FLORIDA WATER MANAGEMENT DISTRICT** is a public corporation of the State of Florida, the mailing address of which is P.O. Box 24680, West Palm Beach, Florida 33416-4860 (hereafter referred to as "SFWMD"), and is authorized to enter into agreements pursuant to Section 373.083, Florida Statutes; and

WHEREAS, the **CITY OF PALM BEACH GARDENS** is a Florida municipal corporation, the mailing address of which is c/o City Manager, 10500 North Military Trail, Palm Beach Gardens, Florida 33410, (hereafter referred to as "CITY"); and

WHEREAS, the **NORTHERN PALM BEACH COUNTY IMPROVEMENT DISTRICT** is an independent special district of the State of Florida, the mailing address of which is 357 Hiatt Drive, Palm Beach Gardens, Florida 33418, (hereafter referred to as "NPBCID"); and

WHEREAS, the **SOUTH INDIAN RIVER WATER CONTROL DISTRICT** is an independent special district of the State of Florida, the mailing address of which is 15600 Jupiter Farms Road, Jupiter, Florida 33478, (hereafter referred to as "SIRWCD"); and

G160

WHEREAS, Section 163.01, Florida Statutes, known as the "Florida Interlocal Cooperation Act of 1969" authorizes units and agencies of local governments to make the most efficient use of their respective powers by enabling them to cooperate with other governmental agencies on a basis of mutual advantage and thereby provide services and facilities that will harmonize the geographic, economic, population and other factors influencing the needs and development of local communities and residential developments; and

WHEREAS, SFWMD, CITY, NPBCID and SIRWCD (referred to herein collectively as the "Parties"), share the goal of achieving sufficient flow of surface water through the Loxahatchee Slough and the C-18 Canal in order to reduce the likelihood of significant harm to the water resources and ecology of the Northwest Fork of the Loxahatchee River, as identified in SFWMD Rule 40E-8.221(4), F.A.C., and by providing a more natural hydroperiod, preserving sensitive wetlands, maintaining existing levels of service for flood protection, and providing a reliable supply of surface water; and

WHEREAS, this goal is being implemented by SFWMD as part of the minimum flows and levels and recovery strategy for the Northwest Fork of the Loxahatchee River (Rule 40E-8.421(7), F.A.C.), which includes the construction of certain water resource and drainage related improvements that have been identified in various planning study recommendations approved by SFWMD, including the *Lower East Coast Water Supply Plan* ("LEC"), the *Comprehensive Everglades Restoration Plan* ("CERP") and the *Northern Palm Beach County Comprehensive Water Management Plan* ("NPBCCWMP"); and

WHEREAS, one of the recommended water resource and drainage related improvements is the Loxahatchee Slough Spillway (herein referred to as the "G-160 Structure"), that was constructed by SFWMD on the East Leg of C-18 Canal just south of its junction with the West Leg of the C-18 Canal; and

WHEREAS, SFWMD designed the G-160 Structure to maintain the existing level of flooding protection under the existing conditions and, it has sufficient capacity to release flood flows and to regulate the outfall of surface water from the C-18 Basin to the Loxahatchee River, thereby partially restoring historic water levels and seasonal timing of water flow; and

WHEREAS, in order to address the concerns raised by the Parties that operation of the G-160 structure not cause substantial adverse flooding impacts, SFWMD completed a study entitled "*Loxahatchee Slough Restoration Impact Analysis*" (Contract No. C-C20106P-WO02) on May 7, 2004 (hereafter "Loxahatchee Slough Final Report"), which determined that the G-160 Structure can be safely and efficiently operated on an interim basis; and

WHEREAS, in addition to the Loxahatchee Slough Final Report, supplemental modeling and historical information is currently available, to provide reasonable assurance that SFWMD may operate the G-160 Structure on an interim basis in a manner that will generate environmental benefits without causing substantive adverse flooding impacts beyond the existing conditions; and

WHEREAS, the purpose of this Agreement is to identify an Interim Operating Schedule and Criteria for the G-160 Structure, based on existing information; and

WHEREAS, the Parties have requested the SFWMD to continue evaluation and refinement of the G-160 Structure operations in the future through continued engineering analysis and modeling, in coordination with development of an operating schedule for the G-161 structure, which may lead to an amendment of the Interim Operating Schedule and Criteria set forth in this Agreement.

NOW, THEREFORE, for and in consideration of the mutual covenants and conditions contained herein and the mutual benefits to be derived from the understanding and agreements set forth herein, plus other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the Parties agree as follows:

SECTION 1. RECITALS. The above recitals are true and correct to the best of the PARTIES knowledge and are incorporated herein by this reference.

SECTION 2. PURPOSE AND INTENT. This Agreement sets forth the mutual understandings between and among the Parties that establish the hereafter described Interim Operating Schedule and Criteria for operation of the G-160 Structure.

SECTION 3. COMPENSATION/CONSIDERATION. This Agreement defines in general terms the basis on which the parties to this Agreement will cooperate on the subject matter hereof. No funds will be exchanged between the parties on the basis of this Agreement.

SECTION 4. ESTABLISHMENT OF INTERIM OPERATING SCHEDULE AND CRITERIA.

A. The Parties acknowledge and agree that SFWMD shall operate the G-160 Structure in accordance with and pursuant to the Interim Operating Schedules and Criteria for the G-160 Structure that is attached hereto and identified as **EXHIBIT "A"** (the "Interim Operating Schedule and Criteria"), and shall continue to do so as authorized in this Agreement or until this Agreement is modified or superseded including when the revised operational criteria for both G-160 and G-161 have been developed and agreed upon by the Parties, using the principles of adaptive management.

B. The Parties accept the Interim Operating Schedule and Criteria.

SECTION 5. MONITORING PROCEDURES.

Based on the conclusions set forth in the *Loxahatchee Slough Final Report* and historical measured stage data at the project culverts PC-13 and PC-15, the Parties agree that water levels will be measured by SFWMD using Campbell Scientific Datalogger (CR10), telemetry, or SFWMD approved equivalent stage recording equipment that transmit data daily or faster, at the following locations, as more specifically identified in **EXHIBIT "B"**:

a. G-160 Structure headwater

b. Loxahatchee Slough E and W

c. C-18 Canal stage at PC-15

This does not preclude the installation of additional monitoring stations that may be desired and installed by the other Parties.

SECTION 6. PARTIES' RESPONSIBILITIES

A. Parties shall each designate, in writing, a principal contact person to coordinate the provisions of this Agreement. The Project Manager for SFWMD is Mike Voich, at P.O. Box 24680, West Palm Beach, FL 33416-4680, telephone (561) 682-6754. All notices, demands, or other communications to a party under this Agreement shall be in writing and shall be deemed received if sent by certified mail or such other delivery process by which verification of delivery is available.

B. Parties shall meet quarterly each year to review monitoring data and assess compliance with this Agreement and its effectiveness in achieving the herein stated objectives. Any concerns with the terms and conditions of this Agreement or any problems with it's implementation shall also be addressed at these quarterly meetings.

C. SFWMD shall operate the G-160 Structure in accordance with the Interim Operating Schedule and Criteria set forth in the attached Exhibit A, commencing as of the effective date of this Agreement.

D. SFWMD shall continue to monitor water levels at the locations identified in Section 5.

E. Should any Party request changes to the operations of the G-160 structure that are not consistent with this Agreement before its termination date, the other Parties shall be duly notified in writing of the requested changes. Prior to implementing any changes to the operations of the G-160 Structure, the PARTIES must agree to the changes in a duly executed amendment to this agreement.

F. SFWMD shall continue to coordinate with the Parties (including following receipt of any written inquiry from Parties) as to the identified water levels caused by the G-160 Structure operation, and, after taking into account the degree of urgency of the inquiry, shall respond within a reasonable time period, in order to ensure that operation of the G-160 Structure is in accordance with this Agreement.

G. SFWMD shall coordinate with the Parties to share monitoring information on water levels collected and the methods used to collect the data and dates to ensure compliance with this Agreement. Real-time (instant) water level information can be obtained by the PARTIES at the following SFWMD website: www.sfwmd.gov..

H. Within six months following the effective date of this Agreement, SFWMD shall enter into a separate cooperative agreement with NPBCID to undertake additional investigations and evaluations assessing the G-160 Structure's operations on the Parties' existing

infrastructure or surface water management systems. Such impacts, if any, directly resulting from the construction and operation of the G-160 Structure shall be identified and will be mitigated by the SFWMD. An initial meeting will be held between the Parties to determine the scope and funding of this additional investigation.

I. Parties agree that as impacts identified in subparagraph H above are mitigated, the Interim Operating Schedule and Criteria for G-160 will be amended and adapted as agreed upon by the Parties to the improved conditions until full implementation of the FDEP Permit is achieved.

SECTION 7. MODIFICATION AND COMPLIANCE WITH INTERIM OPERATING SCHEDULE AND CRITERIA.

A. This Agreement may be amended, extended or renewed only by mutual written agreement of the Parties, which amendments may include but are not limited to those needed to authorize changes in the G-160 Structure's operational parameters or physical modifications to the G-160 Structure.

B. The Parties acknowledge and agree that only SFWMD shall operate the G-160 Structure.

C. This Section does not preclude the Parties from coordinating the operations of their respective primary and secondary systems with the SFWMD Operations Control Room during "emergency events" utilizing existing protocols established by each party.

SECTION 8. EFFECTIVE DATE AND TERM OF AGREEMENT.

This Agreement shall become effective and binding on the Parties from the date the last Party signs and shall continue in full force and effect for a period not to exceed five (5) years thereafter, and/or until execution of an agreement that supersedes this Agreement or the date the revised operation schedules for G-161 and G-160 are developed and agreed upon by the Parties, whichever is earliest. This Agreement can be extended once for an additional five-year term or less upon written approval by all Parties.

SECTION 9. TERMINATION/REMEDIES.

If SFWMD operates the G-160 Structure and fails to comply, in any substantive or material respect, with the terms, conditions and provisions of this Agreement, then any Party to this Agreement, if it so chooses and at its own discretion, may exercise any and all

administrative or judicial remedies to compel such compliance; provided, however, that prior to initiating any such action, the initiating Party shall first be obligated to provide at least ten (10) business days advance written notice to SFWMD and the other Parties of the nature of the alleged failure, during which period of time SFWMD shall have the right to cure the alleged failure. Termination of this Agreement under this provision shall not be construed by the Parties in any way to affect the SFWMD's ability to fulfill the conditions set forth in the FDEP permit. If the Agreement is terminated prior to the Parties execution of an agreement that supersedes this Agreement or the date the revised operation schedules for G-161 and G-160 Structures are developed and agreed upon, the operation of the G-160 Structure will remain as specified in the Interim Operating Schedule and Criteria as set forth in Exhibit A until the Parties can develop a new agreement.

SECTION 10. MISCELLANEOUS PROVISIONS

A. This Agreement incorporates, embodies and expresses all agreements and understandings regarding the G-160 Structure between the Parties, and may not be altered except as authorized in Section 7 above.

B. This Agreement shall not constitute a waiver of SFWMD's regulatory jurisdiction, nor be construed to authorize any activity within the jurisdiction of SFWMD except in accordance with the express terms of this Agreement and the FDEP Permit.

C. Nothing in this Agreement, whether expressed or implied, is intended to confer upon any person other than the Parties hereto any rights or remedies under or by reason of this Agreement.

D. There shall be no waiver of any right contained in this Agreement unless in writing signed by the Party waiving such right. No delay or failure to exercise a right under this Agreement shall impair such right or be construed to be a waiver thereof. Any waiver shall be limited to the particular rights so waived and shall not be deemed a waiver of the same right at a later time, or of any other right under this Agreement.

E. The invalidity of one or more of the terms or conditions contained in this Agreement shall not affect the validity of the remaining portion of the Agreement provided that the material purposes of this Agreement can be determined and effectuated.

F. This Agreement, and any work performed hereunder, is subject to the laws of the State of Florida. Nothing in this Agreement will bind any of the Parties to perform beyond their

respective authority, nor does this Agreement alter the legal rights and remedies which the respective Parties would otherwise have, under law or at equity.

G. The laws of the State of Florida shall govern all aspects of this Agreement. In the event it is necessary for a Party to initiate legal action regarding this Agreement, venue shall be in the Fifteenth Judicial Circuit for claims under state law and in the Southern District of Florida for any claims which are justiciable in federal court.

H. The Parties to this Agreement assure that no person shall be excluded on the grounds of race, color, creed, national origin, handicap, age or sex, from participation in, denied the benefits of, or be otherwise subjected to discrimination in any activity under this Agreement.

I. The Parties to this Agreement are independent entities and are not employees or agents of the other Parties. Nothing in this Agreement shall be interpreted to establish any relationship other than that of independent entities, between the Parties, their employees, agents, subcontractors or assigns, during or after the term of this Agreement. The Parties to this Agreement shall not assign, delegate or otherwise transfer their rights and obligations as set forth in this Agreement without the prior written consent of the other Parties.

J. (i)The Parties to this Agreement act in an independent capacity in the performance of their respective functions under this Agreement, and none of the parties are to be considered the officers, agents, or employees of the other.

(ii) The Parties will maintain a program of insurance (which may include self-insurance) covering any liabilities it may incur by acts or omissions of its officers, employees, servants, and agents in the event such acts or omissions result in injury to persons, damage to property or violations of state or federal law.

(iii) In the implementation of this Agreement , the Parties to this Agreement shall be responsible for compliance with all applicable Federal, State and local laws relating to environmental protection and pollution abatement.

(iv) The Parties to this Agreement acknowledge its liability for torts to the extent provided and allowed under Section 768.28, Florida Statutes.

K. The Parties, its employees, subcontractors or assigns, shall comply with all applicable federal, state and local laws and regulations relating to the performance of this Agreement.

L. The Parties shall allow public access to all project documents and materials in accordance with the provisions of Chapter 119, Florida Statutes. Should the Parties assert any exemptions to the requirements of Chapter 119 and related Statutes, the burden of establishing such emption,

by way of injunctive or other relief as provided by law, shall be upon the Parties.

M. The Parties agree to retain and make available for inspection all records, collected data, financial records, supporting documents, statistical records, and any other documents (including electronic storage media) pertinent to this Agreement during the term hereof and for a period of five (5) years from the expiration or termination of this Agreement in accordance with generally accepted governmental auditing standards. In the event the Parties shall become involved in a legal dispute with a non-party arising from performance under this Agreement, the period of performance for all records relating to the Agreement shall be extended until the final disposition of the legal dispute. The Parties shall have full access to and the right to examine any of said records and documents during the term of this Agreement and retention periods.

N. The Parties shall have joint ownership rights to all work items, including but not limited to, all documents, technical reports and research notes which are developed, created or otherwise originated hereunder by the parties, its subcontractor(s), assign(s), agent(s) and/or successor(s) as required by the Agreement. The Parties rights to deliverables received under this Agreement shall include the unrestricted and perpetual right to use, reproduce, modify and distribute such deliverables at no additional cost to the parties.

O. Any dispute arising under this Agreement which cannot be readily resolved shall be submitted jointly to the signatories of this Agreement with each party agreeing to seek in good faith to resolve the issue through negotiation or other forms of non-binding alternative dispute resolution mutually acceptable to the Parties. A joint decision of the signatories, or their designees, shall be the disposition of such dispute.

P. The Governing Board of SFWMD authorized its Executive Director, or designee, to execute this Agreement.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be executed in counterpart originals by their duly authorized representative(s) on the latest day and year noted below.

EXECUTED by SFWMD this 1st day of August, 2005.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT GOVERNING BOARD

By: _____
Kevin McCarty, Chairman

ATTEST: / **LEGAL FORM APPROVED:**

By: _____

SFWMD Office of Counsel

By: _____

Date: _____

FILED WITH SFWMD CLERK

By _____

On _____

EXECUTED by the CITY this 4th day of August, 2005.

ATTEST:

City Clerk

CITY OF PALM BEACH GARDENS,
a Florida Municipal Corporation

By: _____

{CITY SEAL}

Approved as to form and legal sufficiency:

CITY ATTORNEY
By: _____

Date: April 4, 2005

EXECUTED by NPBCID this 29th day of July, 2004.

ATTEST:

By: _____
O'Neal Bardin, Jr., Secretary

NORTHERN PALM BEACH COUNTY IMPROVEMENT DISTRICT, an Independent Special District of the State of Florida

By: _____
Marilyn Lew-Jacobs, Board Supervisor

{DISTRICT SEAL}

EXECUTED by SIRWCD this 9th day of August, 2005.

ATTEST:

SOUTH INDIAN RIVER WATER CONTROL DISTRICT

By: Jane Woodard
JANE WOODARD, Secretary

By:

{SIRWCD SEAL}

Approved as to legal form and sufficiency:

By:

"EXHIBIT A"

INTERIM OPERATING SCHEDULE AND CRITERIA FOR THE G-160 STRUCTURE

SFWMD will implement an interim seasonal operation schedule prior to the construction and development of a revised operation schedule for G-160 and G-161 Structures as follows:

A. The "dry season" (November 1 to May 31) operating schedule will maintain an interim headwater stage of 15.5 ft NGVD in the C-18 Canal. G-160 headwater stages below 15.5 ft will be maintained at the discretion of SFWMD and include the goals to enhance delivery of the MFL to the Northwest Fork of the Loxahatchee River.

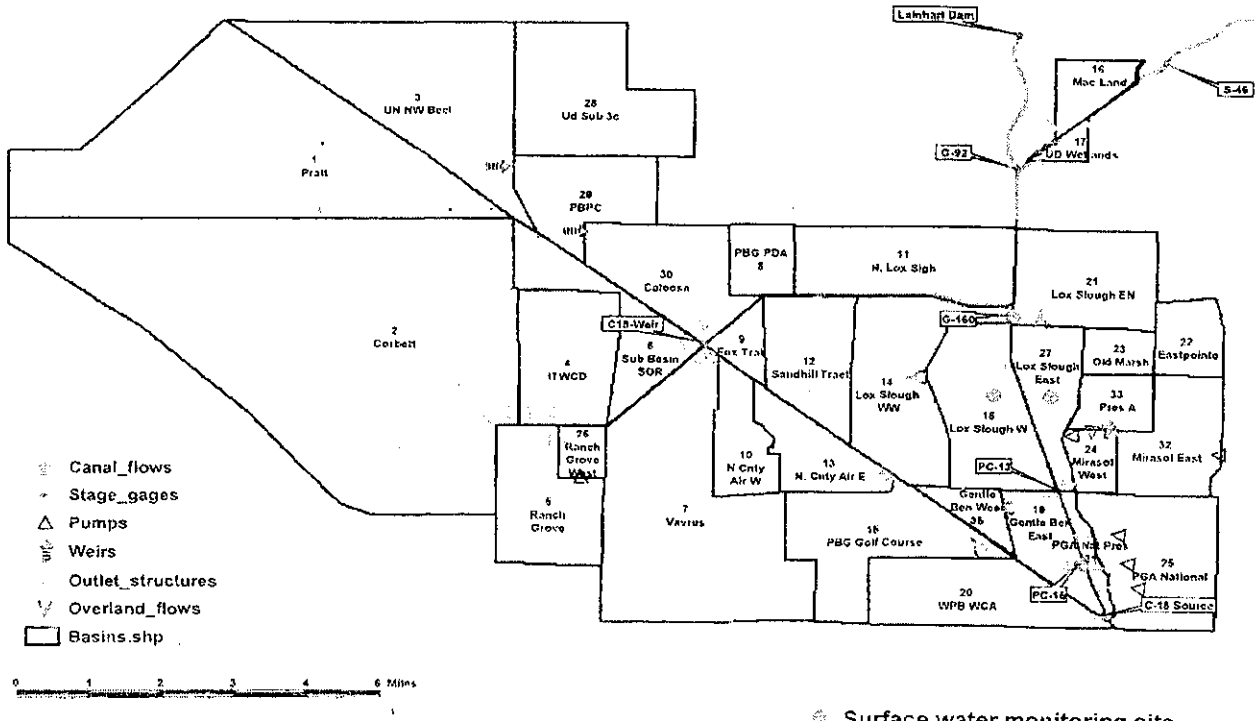
B. The "wet season" (June 1 to October 31) operating schedule will maintain an interim optimum headwater stage of 15.0 ft NGVD in the C-18 Canal at G-160.

C. In the event of an impending storm, hurricane or other significant predicted rainfall event exceeding 3 inches a day, SFWMD may at its discretion, open partially or fully the gates of the G-160 to lower the water levels in the C-18 Canal to maintain the existing flood protection consistent with the following:

1. **Condition**: Predicted local maximum rainfall of 3 or more inches per storm event as forecast by SFWMD and depending on the stage conditions.
2. **Operation**: Open the gate of the operable structure. The gate shall remain in an "open" position until such time as the referenced storm event has passed and the water levels have receded to the water control elevation specified above.
3. **Notification Procedures**: Notification will be provided to NPBCID within 24 hours of opening the G-160 Structure. Notification will also be provided within 24 hours of closing the gates.
4. **Reference Elevations**: All vertical measurements are referenced to the National Geodetic Vertical Datum (NGVD) of 1929.

"EXHIBIT B": MAP OF MONITORING LOCATIONS

C-18 Drainage Subbasins



APPENDIX C

Lithologic Logs

SFWMD

/ Fax

Page 1 of 3

TEST BORING LOG

BORING/WELL LOCATION SKETCH MAP

N

BORING/WELL NO. **C-18P**	
PROJECT NO./NAME **G-160 GW-SW Study**	LOCATION **Palm Beach Gardens, Florida**
DRILLING CONTRACTOR/DRILLER **Earth Tech Drilling/Paul Lemenze**	
GEOLOGIST/OFFICE **Brian Collins/SFWMD, West Palm Beach, Florida**	

DRILLING EQUIPMENT/METHOD	SIZE/TYPE OF BIT	SAMPLING METHOD	START/FINISH DATE
Mobile B-59/Hollow Stem Auger	**4-1/4 Bullet**	**SPT**	**03/31/10-03/31/10**

WELL INSTALLED?	CASING MAT./DIA.	SCREEN:				
YES [X] NO [ ]	**PVC/2**	TYPE **Slotted**	MAT. **PVC**	LENGTH **10**	DIA. **2**	SLOT SIZE **0.010**

ELEVATION OF:	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
(FT. ABOVE M.S.L.)	**19.5**	**19.53**	**-40.5/-50.5**		

REMARKS: **All vertical elevations in 1929 NGVD**

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING DESCRIPTION	REMARKS
					Surface soil/fill, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; organic material; 5% shell fragments. 2.0	
		1	1/1/1/2 2		Surface soil/fill, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; organic material; 15% shell fragments. 4.0	
5		2	1/1/2/2 3		Sand, moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded; trace organic material; 15% shell fragments. 6.0	
		3	1/2/1/2 3		Sand, dusky yellowish brown (10YR 2/2), quartz fine to medium-grained, sub-rounded; organic material. 8.0	
		4	1/1/2/2 3		Sand, dusky yellowish brown (10YR 2/2), quartz fine to medium-grained, sub-rounded; organic material; trace shell fragments. 10.0	
10		5	2/3/3/5 6		Sand, dusky yellowish brown (10YR 2/2)/pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; organic material; 30% shell fragments. 12.0	
		6	1/2/2/2 4		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; trace organic material; 40% shell fragments. 14.0	
15		7	2/2/2/3 4		Sand, dark yellowish orange (10YR 6/6)/moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded; trace organic material; trace shell fragments. 16.0	
		8	1/2/2/2 4		Sand, dark yellowish brown (10YR 4/2), quartz fine to medium-grained, sub-rounded; 15% shell fragments. 18.0	
		9	1/2/1/2 3		Sand, dark yellowish orange (10YR 6/6)/moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded. 20.0	

▲ SPT N VALUE ▲ 20 40 60 80

Graphic Litho Log

Well Construction

Concrete around pipe | Bentonite Pellets | Fine Sand with Slotted Pipe

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
C-18P

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS
		10	1/2/2/2 4		Sand, dark yellowish orange (10YR 6/6)/moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded. 22.0	
		11	1/1/1/2 2		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; trace organic material. 24.0	
25		12	1/1/1/1 2		Sand, moderate yellowish brown (10YR 5/4)/dark yellowish brown (10YR 4/2), quartz fine to medium-grained, sub-rounded. 26.0	
		13	1/2/2/2 4		Sand, moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded. 28.0	
		14	2/3/3/5 6		Sand, moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded. 30.0	Test case
30		15	2/3/5/2 8		Sand, moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded; trace shell fragments. 32.0	
		16	3/5/6/6 11		Sand, moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded; trace shell fragments. 34.0	Really hard
35		17	2/5/5/6 10		Sand, moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded. 36.0	
		18	3/5/7/8 12		Sand, moderate yellowish brown (10YR 5/4)/dark yellowish brown (10YR 4/2), quartz fine to medium-grained, sub-rounded. 38.0	
		19	21/24/18/31 42		Sand, dark yellowish brown (10YR 4/2), quartz fine to medium-grained, sub-rounded. 40.0	
40		20	19/39/50/5 89		Limestone, medium gray (N5); sand, light olive gray (5Y 5/2), quartz, fine to medium-grained, sub-rounded. 42.0	
		21	24/37/21/22 58		Limestone, medium gray (N5); sand, light olive gray (5Y 5/2), quartz, fine to medium-grained, sub-rounded. 44.0	
45		22	16/50/3/40 53		Limestone, medium gray (N5); sand, light olive gray (5Y 5/2), quartz, fine to medium-grained, sub-rounded. 46.0	
		23	27/23/12/32 35		Limestone, medium gray (N5); sand, yellowish gray (5Y 7/2), quartz, fine to medium-grained, sub-rounded. 48.0	Lost my shoe in the hole
		24	16/22/23/24 45		Limestone, medium gray (N5); sand, yellowish gray (5Y 7/2), quartz, fine-grained, sub-rounded. 50.0	

▲ SPT N VALUE ▲ (20, 40, 60, 80)

Graphic Litho Log

Well Construction

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
C-18P

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS	▲ SPT N VALUE ▲ 20 40 60 80	Graphic Litho Log	Well Construction
		25	18/11/19/11 30		Limestone, medium gray (N5); sand, yellowish gray (5Y 7/2), quartz, fine-grained, sub-rounded; trace shell fragments.				
					52.0				
		26	13/50/2/14 52		Limestone, medium gray (N5); sand, yellowish gray (5Y 7/2), quartz, fine-grained, sub-rounded.				
					54.0				
55		27	50/5/30/11 35		Limestone, medium gray (N5); sand, yellowish gray (5Y 7/2), quartz, fine-grained, sub-rounded.				
					56.0				
		28	23/11/10/13 21		Limestone, medium gray (N5); sand, yellowish gray (5Y 7/2), quartz, fine-grained, sub-rounded.				
					58.0				
		29	5/7/8/11 15		Limestone, medium gray (N5); sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded.				
					60.0				
60		30	3/5/5/7 10		Limestone, medium gray (N5); poor recovery.				
					62.0				
		31	50/2/35/9 37		Limestone, medium gray (N5); sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 15% shell fragments.				
					64.0				
		32	23/11/17/9 28		Limestone, medium gray (N5); sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 15% shell fragments.				
65					66.0				
		33	7/7/9/15 16		Limestone, medium gray (N5); sand, yellowish gray (5Y 8/1), quartz, fine-grained, sub-rounded; 10% shell fragments.				
					68.0				
		34	12/13/19/22 32		Limestone, medium gray (N5); sand, yellowish gray (5Y 8/1), quartz, fine-grained, sub-rounded; 10% shell fragments.				
					70.0				
		35	5/7/8/12 15						

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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TEST BORING LOG

BORING/WELL LOCATION SKETCH MAP

N

BORING/WELL NO. **E-BERM**	
PROJECT NO./NAME **G-160 GW-SW Study**	LOCATION **Palm Beach Gardens, Florida**
DRILLING CONTRACTOR/DRILLER **Earth Tech Drilling/Paul Lemenze**	
GEOLOGIST/OFFICE **Brian Collins/SFWMD, West Palm Beach, Florida**	

DRILLING EQUIPMENT/METHOD	SIZE/TYPE OF BIT	SAMPLING METHOD	START/FINISH DATE
Mobile B-59/Hollow Stem Auger	**4-1/4 Bullet**	**SPT**	**03/24/10-03/24/10**

WELL INSTALLED?	CASING MAT./DIA.	SCREEN:				
YES [X] NO [ ]	**PVC/2**	TYPE **Slotted**	MAT. **PVC**	LENGTH **10**	DIA. **2**	SLOT SIZE **0.010**

ELEVATION OF:	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
(FT. ABOVE M.S.L.)	**20.6**	**20.6**	**-39.4/-49.4**		

REMARKS: **All vertical elevations in 1929 NGVD**

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING DESCRIPTION	REMARKS
					Surface soil, dusky yellowish brown (10YR 2/2), fine-grained, sub-rounded; organic material. 2.0	
		1	2/3/3/4 6		Surface soil, dusky yellowish brown (10YR 2/2), fine-grained, sub-rounded; organic material. 4.0	
		2	2/3/3/3 6		Surface soil, dusky yellowish brown (10YR 2/2), fine-grained, sub-rounded; organic material. 6.0	
5		3	4/5/7/10 12		Sand, dusky yellowish brown (10YR 2/2), fine-grained, sub-rounded; organic material. 8.0	
		4	7/12/13/15 25		Sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-rounded; organic material. 10.0	
10		5	16/17/19/15 36		Sand, dark yellowish orange (10YR 6/6), quartz, fine-grained, sub-rounded; trace organics. 12.0	
		6	2/1/1/1 2		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded. 14.0	
		7	1/1/1/1 2		Sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-rounded; organic material. 16.0	
15		8	1/2/2/1 4		Sand, dark yellowish brown (10YR 4/2), quartz, medium-grained, sub-rounded; 20% shell fragments. 18.0	
		9	1/1/1/1 2		Sand, pale yellowish brown (10YR 6/2), quartz, medium-grained, sub-rounded; 30% shell fragments. 20.0	

▲ SPT N VALUE ▲ 20 40 60 80

Graphic Litho Log

Well Construction

Concrete around pipe | Bentonite Pellets | Fine Sand with Slotted Pipe

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
E-BERM

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS	▲ SPT N VALUE ▲ 20 40 60 80	Graphic Litho Log	Well Construction
		10	1/1/1/1 2		Sand, dark yellowish brown (10YR 4/2), quartz, medium-grained, sub-rounded; 20% shell fragments. 22.0				
		11	1/1/2/2 3		Sand, dusky yellowish brown (10YR 2/2), quartz, medium-grained, sub-rounded; 20% shell fragments. 24.0				
25		12	1/2/2/2 4		Sand, dark yellowish brown (10YR 4/2), quartz, medium-grained, sub-rounded; 20% shell fragments. 26.0				
		13	2/2/2/2 4		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 28.0				
		14	1/1/1/1 2		Sand, moderate yellowish brown (10YR 5/4), quartz, fine to medium-grained, sub-rounded; 15% shell fragments. 30.0				
30		15	2/2/3/4 5		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 32.0				
		16	1/2/2/2 4		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 34.0				
35		17	2/4/7/12 11		Marl, white; sand, white (N9), quartz, very fine to fine-grained, sub-rounded; >5% shell fragments. 36.0				
		18	8/9/10/12 19		Sand, light olive gray (5Y 6/1), quartz, fine to medium-grained, sub-rounded; 5% shell fragments; 5% sandstone, light olive gray (5Y 6/1). 38.0				
		19	7/12/14/15 26		Sand, light olive gray (5Y 6/1), quartz, fine to medium-grained, sub-rounded; 5% shell fragments; 5% sandstone, light olive gray (5Y 6/1). 40.0				
40		20	10/12/12/10 24		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 5% shell fragments; 10% sandstone, dark yellowish brown (10YR 4/2). 42.0				
		21	6/6/7/8 13		Sand, pale yellowish gray (5Y 8/1), quartz, fine to medium-grained, sub-rounded; 5% shell fragments; 15% sandstone, pale yellowish gray (5Y 8/1). 44.0				
45		22	9/12/15/31 27		Sand, pale yellowish gray (5Y 8/1), quartz, fine to medium-grained, sub-rounded; 5% shell fragments; 15% sandstone, pale yellowish gray (5Y 8/1). 46.0				
		23	24/25/21/25 46		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; >5% shell fragments; trace sandstone, olive gray (5Y 4/1). 48.0				
		24	12/15/15/17 30		Sand, pale yellowish brown (10YR 6/2) to light olive gray (5Y 5/2), quartz, fine to medium-grained, sub-rounded; trace shell fragments. 50.0				

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
E-BERM

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS
		25	17/21/12/19 33		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% sandstone, dark yellowish brown (10YR 4/2). 52.0	
		26	6/9/10/8 19		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; trace shell fragments. 54.0	
55		27	7/7/14/10 21		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 5% shell fragments; 10% sandstone, light olive gray (5Y 5/2). 56.0	
		28	10/11/12/12 23		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 58.0	
		29	7/10/10/12 20		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; trace shell fragments; 5% sandstone, light olive gray (5Y 5/2). 60.0	
60		30	12/15/15/18 30		Sand, very pale orange (10YR 8/2), quartz, fine to course-grained, sub-rounded; 40% shell fragments 62.0	
		31	4/7/10/10 17		Sand, pale yellowish brown (10YR 6/2), quartz, fine to course-grained, sub-rounded; 40% shell fragments. 64.0	
65		32	12/14/14/16 28		Sand, pale yellowish brown (10YR 6/2), quartz, fine to course-grained, sub-rounded; 40% shell fragments. 66.0	
		33	10/10/11/12 21		Sand, pale yellowish brown (10YR 6/2), quartz, fine to course-grained, sub-rounded; 30% shell fragments. 68.0	
		34	10/7/5/4 12		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 15% shell fragments. 70.0	
		35	4/4/5/5 9			

▲ SPT N VALUE ▲ (20 40 60 80)

Graphic Litho Log

Well Construction

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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TEST BORING LOG

BORING/WELL NO.: **NE-BERM**

BORING/WELL LOCATION SKETCH MAP

N

PROJECT NO./NAME: **G-160 GW-SW Study**	LOCATION: **Palm Beach Gardens, Florida**
DRILLING CONTRACTOR/DRILLER: **Earth Tech Drilling/Paul Lemenze**	
GEOLOGIST/OFFICE: **Brian Collins/SFWMD, West Palm Beach, Florida**	

DRILLING EQUIPMENT/METHOD	SIZE/TYPE OF BIT	SAMPLING METHOD	START/FINISH DATE
Mobile B-59/Hollow Stem Auger	**4-1/4 Bullet**	**SPT**	**03/25/10-03/25/10**

WELL INSTALLED?	CASING MAT./DIA.	SCREEN: TYPE	MAT.	LENGTH	DIA.	SLOT SIZE
YES [X] NO [ ]	**PVC/2**	**Slotted**	**PVC**	**10**	**2**	**0.010**

ELEVATION OF:	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
(FT. ABOVE M.S.L.)	**20.2**	**20.15**	**-39.9/-49.9**		

REMARKS: **All vertical elevations in 1929 NGVD**

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS
					Surface soil/fill, dark yellowish brown (10YR 4/2), quartz fine to medium-grained, sub-rounded; organic material; 30% shell fragments. 2.0	
		1	1/3/5/7 8		Surface soil/fill, dark yellowish brown (10YR 4/2), quartz fine to medium-grained, sub-rounded; organic material; 30% shell fragments. 4.0	
5		2	2/3/3/4 6		Surface soil/fill, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; trace organic material. 6.0	
		3	2/4/5/6 9		Surface soil/fill, moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded; trace organic material. 8.0	
		4	3/5/5/8 10		Surface soil/fill, brownish black (5YR 2/1), quartz fine to medium-grained, sub-rounded; trace organic material. 10.0	
10		5	3/5/7/10 12		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 30% shell fragments. 12.0	
		6	3/5/4/5 9		Sand, yellowish gray (5Y 7/2), quartz, fine to medium-grained, sub-rounded; 20% shell fragments. 14.0	
15		7	2/3/4/5 7		Sand, yellowish gray (5Y 7/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 16.0	
		8	4/4/2/2 6		Sand, dark yellowish brown (10YR 4/2), quartz, medium-grained, sub-rounded; 30% shell fragments; trace sandstone, moderate yellowish brown (10YR 5/4). 18.0	
		9	1/2/1/2 3		Clayey sand, dark yellowish brown (10YR 4/2), quartz, medium-grained, sub-rounded; 30% shell fragments. 20.0	

▲ SPT N VALUE ▲ (20 40 60 80)

Graphic Litho Log

Well Construction

Concrete around pipe | Bentonite Chips | Fine Sand with Slotted Pipe

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
NE-BERM

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS
		10	1/2/1/1 3		Sand, very pale orange (10YR 8/2), quartz and calcareous, medium-grained, sub-rounded; 40% shell fragments; sandstone, calcite cemented. 22.0	
		11	1/7/11/3 18		Sand, very pale orange (10YR 8/2), quartz and calcareous, fine-grained, sub-rounded; 50% shell fragments; shell hash, calcite cemented. 24.0	
25		12	4/12/24/27 36		Sand, very pale orange (10YR 8/2), quartz and calcareous, medium-grained, sub-rounded; 40% shell fragments; shell hash, calcite cemented. 26.0	
		13	18/10/7/10 17		Sand, very pale orange (10YR 8/2), quartz and calcareous, medium-grained, sub-rounded; 20% shell fragments; shell hash, calcite cemented. 28.0	
		14	9/18/27/21 45		Sand, very pale orange (10YR 8/2), quartz and calcareous, medium-grained, sub-rounded; 40% shell fragments; shell hash, calcite cemented. 30.0	
30		15	24/18/10/7 28		Sand, pale yellowish brown (10YR 6/2), quartz and calcareous, medium-grained, sub-rounded; 40% shell fragments; sandstone, pale yellowish brown (10YR 6/2). 32.0	
		16	6/4/9/14 13		Sand, pale yellowish brown (10YR 6/2), quartz and calcareous, medium-grained, sub-rounded; 40% shell fragments; sandstone, pale yellowish brown (10YR 6/2). 34.0	
35		17	12/12/18/16 30		Sand, pale yellowish brown (10YR 6/2), quartz and calcareous, medium-grained, sub-rounded; 40% shell fragments; sandstone, pale yellowish brown (10YR 6/2). 36.0	
		18	14/23/18/12 41		Sand, light olive gray (5Y 5/2), quartz, fine to medium-grained, sub-rounded; 15% shell fragments; sandstone, light olive gray (5Y 6/1). 38.0	
		19	7/12/16/32 28		Sand, pale yellowish brown (10YR 6/2), quartz, medium-grained, sub-rounded; 20% shell fragments; sandstone, light olive gray (5Y 6/1). 40.0	
40		20	49/44/12/12 56		Sand, moderate yellowish brown (10YR 6/6), quartz, fine-grained, sub-rounded; 10% shell fragments. 42.0	
		21	1/1/2/2 3		Sand, moderate yellowish brown (10YR 6/6), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 44.0	
45		22	2/3/3/0 6		Sand, dark yellowish brown (10YR 4/2), quartz, fine to medium-grained, sub-rounded; 5% shell fragments. 46.0	
		23	3/3/4/5 7		Limestone, light gray (N7); sand, pale yellowish brown (10 YR 6/2), quartz, fine to medium-grained, sub-rounded; 30% shell fragments. 48.0	
		24	7/12/14/15 26		Limestone, light gray (N7); sand, pale yellowish brown (10 YR 6/2), quartz, fine to medium-grained, sub-rounded; 40% shell fragments. 50.0	

▲ SPT N VALUE ▲ (20, 40, 60, 80)

Graphic Litho Log

Well Construction

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
NE-BERM

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS
		25	29/7/2/3 9		Limestone, light olive gray (5 Y 5/2); sand, light olive gray (5 Y 5/2), quartz, fine to medium-grained, sub-rounded. 52.0	
		26	2/3/2/2 5		Limestone, light olive gray (5 Y 5/2); sand, light olive gray (5 Y 5/2), quartz, fine to medium-grained, sub-rounded. 54.0	
55		27	1/2/1/2 3		Limestone, light olive gray (5 Y 5/2); sand, light olive gray (5 Y 5/2), quartz, fine to medium-grained, sub-rounded. 56.0	
		28	2/2/3/3 5		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 15% shell fragments; 5% sandstone, light olive gray (5Y 6/1). 58.0	
		29	2/4/5/4 9		Clayey sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 20% shell fragments. 60.0	
60		30	3/3/4/4 7		Clayey sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 62.0	
		31	2/3/3/3 6		Clayey sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 64.0	
65		32	1/3/5/4 8		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 15% shell fragments; 15% sandstone, yellowish gray (5Y 8/1). 66.0	
		33	2/5/7/9 12		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments; 15% sandstone, yellowish gray (5Y 8/1). 68.0	
		34	3/5/7/7 12		Limestone, medium light gray (N6); sand, yellowish gray (5 Y 8/1), quartz, fine -grained, sub-rounded. 70.0	
		35	4/5/4/5 9			

▲ SPT N VALUE ▲ (20 40 60 80)

Graphic Litho Log

Well Construction

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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TEST BORING LOG

BORING/WELL LOCATION SKETCH MAP

N

BORING/WELL NO.	**NW-BERM**
PROJECT NO./NAME	**G-160 GW-SW Study**
LOCATION	**Palm Beach Gardens, Florida**
DRILLING CONTRACTOR/DRILLER	**Earth Tech Drilling/Paul Lemenze**
GEOLOGIST/OFFICE	**Brian Collins/SFWMD, West Palm Beach, Florida**
DRILLING EQUIPMENT/METHOD	**Mobile B-59/Hollow Stem Auger**
SIZE/TYPE OF BIT	**4-1/4 Bullet**
SAMPLING METHOD	**SPT**
START/FINISH DATE	**03/29/10-03/29/10**
WELL INSTALLED? YES [X] NO [ ]	
CASING MAT./DIA.	**PVC/2**
SCREEN: TYPE **Slotted** MAT. **PVC** LENGTH **10** DIA. **2** SLOT SIZE **0.010**	

ELEVATION OF: (FT. ABOVE M.S.L.)	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
	18.4	**18.41**	**-41.6/-51.6**		

REMARKS: **All vertical elevations in 1929 NGVD**

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING DESCRIPTION	REMARKS
					Surface soil/fill, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; organic material; trace shell fragments. 2.0	
		1	1/2/3/3 5		Surface soil/fill, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; organic material; 15% shell fragments. 4.0	
5		2	2/4/5/5 9		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; organic material; 10% shell fragments. 6.0	
		3	2/3/3/2 6		Sand, grayish orange (10YR 7/4), quartz fine to medium-grained, sub-rounded; trace organic material; 10% shell fragments. 8.0	
		4	2/5/7/8 12		Sand, grayish orange (10YR 7/4)/dusky yellowish brown, quartz fine to medium-grained, sub-rounded; trace organic material; 15% shell fragments. 10.0	
10		5	4/7/8/12 15		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; 40% shell fragments. 12.0	
		6	1/2/2/3 4		Clayey sand, dark yellowish brown (10YR 4/2), quartz fine to medium-grained, sub-rounded; organic material; 15% shell fragments. 14.0	
15		7	1/1/1/2 2		Sand, olive gray (5Y 3/2), quartz fine to medium-grained, sub-rounded; 40% shell fragments. 16.0	
		8	1/1/1/1 2		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; 15% shell fragments. 18.0	
		9	1/1/1/1 2		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; 20% shell fragments. 20.0	

▲ SPT N VALUE ▲ 20 40 60 80

Graphic Litho Log

Well Construction

Concrete around pipe Bentonite Chips Fine Sand with Slotted Pipe

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
NW-BERM

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS	▲ SPT N VALUE ▲ 20 40 60 80	Graphic Litho Log	Well Construction
		10	2/3/3/4 6		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; trace shell fragments. 22.0				
		11	2/3/2/3 5		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; trace shell fragments. 24.0				
25		12	2/4/4/4 8		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; 10% shell fragments. 26.0				
		13	3/4/5/5 9		Sand, moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded; trace shell fragments. 28.0				
		14	2/2/2/3 4		Sand, moderate yellowish brown (10YR 5/4), quartz fine to medium-grained, sub-rounded; trace shell fragments. 30.0				
30		15	2/3/3/3 6		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; trace shell fragments. 32.0				
		16	2/3/4/4 7		Sand, pale yellowish brown (10YR 6/2), quartz fine to medium-grained, sub-rounded; 10% shell fragments. 34.0				
35		17	2/4/3/3 7		Sand, dusky brown (5YR 2/2), quartz fine to medium-grained, sub-rounded; trace shell fragments. 36.0				
		18	1/2/3/4 5		Sand, dark yellowish brown (10YR 4/2), quartz, fine to medium-grained, sub-rounded; 5% shell fragments; sandstone, dark yellowish brown (10YR 4/2). 38.0				
		19	1/2/2/2 4		Coquina, pale yellowish brown (10YR 6/2); sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments; sandstone, dark yellowish brown (10YR 4/2). 40.0				
40		20	37/7/6/50 13		Limestone, medium gray (N5); sand, light olive gray (5Y 5/2), quartz, fine to medium-grained, sub-rounded. 42.0				
		21	3/8/8/6 16		Limestone, medium gray (N5); sand, light olive gray (5Y 6/1), quartz, fine -grained, sub-rounded. 44.0				
45		22	4/2/1/12 3		Limestone, medium gray (N5); sand, light olive gray (5Y 6/1), quartz, fine -grained, sub-rounded. 46.0				
		23	7/11/15/18 26		Limestone, medium gray (N5); sand, light olive gray (5Y 6/1), quartz, fine -grained, sub-rounded. 48.0				
		24	10/7/4/9 11		Limestone, medium gray (N5); sand, light olive gray (5Y 6/1), quartz, fine -grained, sub-rounded. 50.0				

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
NW-BERM

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS
		25	4/5/4/5 9		Limestone, medium gray (N5); sand, light olive gray (5Y 6/1), quartz, fine -grained, sub-rounded. 52.0	
		26	3/18/12/15 30		Limestone, medium gray (N5); sand, light olive gray (5Y 6/1), quartz, fine -grained, sub-rounded. 54.0	
55		27	10/15/31/18 46		Limestone, medium gray (N5); sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded. 56.0	
		28	19/32/41/22 73		Limestone, medium gray (N5); sand, light olive gray (5Y 5/2), quartz, fine to medium-grained, sub-rounded. 58.0	
		29	7/18/18/20 36		Limestone, medium gray (N5); sand, light gray (N7), quartz, fine to medium-grained, sub-rounded. 60.0	
60		30	9/11/10/11 21		Limestone, medium gray (N5); sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; trace shell fragments. 62.0	
		31	7/9/11/13 20		Limestone, medium gray (N5); sand, light gray (N7), quartz, fine to medium-grained, sub-rounded; 5% shell fragments. 64.0	
65		32	10/17/12/15 29		Limestone, medium gray (N5); sand, light gray (N7), quartz, fine to medium-grained, sub-rounded; 15% shell fragments. 66.0	
		33	16/18/21/18 39		Limestone, medium gray (N5); sand, light gray (N7), quartz, fine to medium-grained, sub-rounded; 15% shell fragments. 68.0	
		34	10/10/12/14 22		Limestone, medium gray (N5); sand, light gray (N7), quartz, fine to medium-grained, sub-rounded; 15% shell fragments. 70.0	
70		35	7/9/13/15 22			

▲ SPT N VALUE ▲ (20 40 60 80)

Graphic Litho Log

Well Construction

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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TEST BORING LOG

BORING/WELL LOCATION SKETCH MAP

N

BORING/WELL NO.	**OM-N**
PROJECT NO./NAME	**G-160 GW-SW Study**
LOCATION	**Palm Beach Gardens, Florida**
DRILLING CONTRACTOR/DRILLER	**Earth Tech Drilling/Paul Lemenze**
GEOLOGIST/OFFICE	**Brian Collins/SFWMD, West Palm Beach, Florida**
DRILLING EQUIPMENT/METHOD	**Mobile B-59/Hollow Stem Auger**
SIZE/TYPE OF BIT	**4-1/4 Bullet**
SAMPLING METHOD	**SPT**
START/FINISH DATE	**03/23/10-03/23/10**
WELL INSTALLED?	YES [X] NO [ ]
CASING MAT./DIA.	**PVC/2**
SCREEN:	TYPE **Slotted** MAT. **PVC** LENGTH **10** DIA. **2** SLOT SIZE **0.010**

ELEVATION OF: (FT. ABOVE M.S.L.)	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
	18.1	**18.13**	**-41.3/-51.3**		

REMARKS: **All vertical elevations in 1929 NGVD**

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING DESCRIPTION	REMARKS
					Surface soil, dusky yellowish brown (10YR 2/2), fine-grained, sub-rounded; organic material. 2.0	
		1	7/9/9/10 18		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 20% shell fragments; trace organics. 4.0	
5		2	7/8/8/9 16		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; >5% shell fragments; trace organics. 6.0	
		3	4/5/7/10 12		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 10% shell fragments; trace organics. 8.0	
		4	7/9/10/12 19		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 10% shell fragments; trace organics. 10.0	
10		5	7/10/10/12 20		Sand, pale yellowish brown (10YR 6/2), quartz, medium to fine-grained, sub-rounded; >5% shell fragments. 12.0	
		6	9/7/5/4 12		Sand, pale yellowish brown (10YR 6/2), quartz, medium to fine-grained, sub-rounded; 20% shell fragments. 14.0	
15		7	5/3/3/3 6		Sand, dark yellowish brown (10YR 4/2), quartz, medium to fine-grained, sub-rounded; 15% shell fragments; sandstone fragments. 16.0	
		8	1/1/1/1 2		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; 30% shell fragments. 18.0	
		9	1/2/1/2 3		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; 15% shell fragments. 20.0	

▲ SPT N VALUE ▲ (20 40 60 80)

Graphic Litho Log

Well Construction

Concrete around pipe | Bentonite Chips | Fine Sand with Slotted Pipe

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

BORING/WELL NO.
OM-N

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	DESCRIPTION	REMARKS
		10	1/2/1/1 3		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; 15% shell fragments.	
					22.0	
		11	1/2/1/2 3		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; 5% shell fragments.	
					24.0	
25		12	1/2/1/2 3		Sand, dark yellowish brown (10YR 4/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments.	
					26.0	
		13	1/2/1/1 3		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments.	
					28.0	
		14	1/1/1/2 2		Sand, pale yellowish brown (10YR 6/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments.	
					30.0	
30		15	1/1/1/1 2		Clay, gray with sand, yellowish gray (5Y 7/2), quartz, fine-grained, sub-rounded; 10% shell fragments.	
					32.0	
		16	1/2/1/2 3		Clay, gray with sand, yellowish gray (5Y 7/2), quartz, fine-grained, sub-rounded; 20% shell fragments.	
					34.0	
		17	1/1/1/1 2		Clay, olive with sand, light olive gray (5Y 5/2), quartz, fine-grained, sub-rounded; 5% shell fragments.	
35					36.0	
		18	1/1/2/2 3		Clay, dark brown with sand, dusky yellowish brown (10Y 2/2), quartz, fine-grained, sub-rounded; >5% shell fragments.	
					38.0	
		19	1/1/1/1 2		Clay, dark brown with sand, dusky yellowish brown (10Y 2/2), quartz, fine-grained, sub-rounded; >5% shell fragments.	
					40.0	
40		20	2/2/2/2 4		Clay, black with sand, dusky yellowish brown (10Y 2/2), quartz, fine-grained, sub-rounded; >5% shell fragments.	
					42.0	
		21	1/2/1/1 3		Clay, black with sand, dusky yellowish brown (10Y 2/2), quartz, fine-grained, sub-rounded; 5% shell fragments.	
					44.0	
45		22	1/2/2/2 4		Clay, black with sand, dusky yellowish brown (10Y 2/2), quartz, fine-grained, sub-rounded; >5% shell fragments.	
					46.0	
		23	2/3/3/4 6		Clayey sand, dusky yellowish brown (10Y 2/2), quartz, fine-grained, sub-rounded; 5% shell fragments.	
					48.0	
		24	1/1/2/2 3		Sand, dark yellowish brown (10YR 4/2), quartz, fine to medium-grained, sub-rounded; 30% shell fragments.	
					50.0	

▲ SPT N VALUE ▲
20 40 60 80

Graphic Litho Log

Well Construction

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
OM-N

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS
		25	2/3/2/2 5		Sand, dark yellowish brown (10YR 4/2), quartz, fine to medium-grained, sub-rounded; 30% shell fragments. 52.0	
		26	2/1/1/2 2		Clay, gray with sand, light olive gray (5Y 5/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 54.0	
55		27	10/18/12/27 30		No Recovery. 56.0	
		28	25/37/40/40 77		No Recovery. 58.0	
		29	13/18/32/22 50		Sand, light olive gray (5Y 5/2), quartz, fine to medium-grained, sub-rounded; 10% shell fragments. 60.0	
60		30	28/31/14/18 45		Sand, dark yellowish brown (10YR 4/2), quartz, fine to medium-grained, sub-rounded; 20% shell fragments. 62.0	
		31	3/8/9/10 17		Sand, pale yellowish brown (10YR 6/2), quartz, medium to fine-grained, sub-rounded; 40% shell fragments. 64.0	
65		32	4/7/7/8 14		Sand, pale yellowish brown (10YR 6/2), quartz, medium to fine-grained, sub-rounded; 30% shell fragments. 66.0	
		33	9/9/12/14 21		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 50% shell fragments; trace limestone, dark gray. 68.0	
		34	4/5/5/4 10		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 70% shell fragments; limestone, dark gray. 70.0	
		35	4/3/3/2 6			

▲ SPT N VALUE ▲
20 40 60 80

Graphic Litho Log

Well Construction

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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TEST BORING LOG

BORING/WELL LOCATION SKETCH MAP

N

BORING/WELL NO.: **OM-S**			
PROJECT NO./NAME: **G-160 GW-SW Study**	LOCATION: **Palm Beach Gardens, Florida**		
DRILLING CONTRACTOR/DRILLER: **Earth Tech Drilling/Paul Lemenze**			
GEOLOGIST/OFFICE: **Brian Collins/SFWMD, West Palm Beach, Florida**			
DRILLING EQUIPMENT/METHOD: **Mobile B-59/Hollow Stem Auger**	SIZE/TYPE OF BIT: **4-1/4 Bullet**	SAMPLING METHOD: **SPT**	START/FINISH DATE: **03/22/10-03/22/10**

WELL INSTALLED? YES [X] NO [ ] | CASING MAT./DIA.: **PVC/2** | SCREEN: TYPE **Slotted** MAT. **PVC** LENGTH **10** DIA. **2** SLOT SIZE **0.010**

ELEVATION OF: (FT. ABOVE M.S.L.)	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
	18.1	**18.07**	**-40.6/-50.6**		

REMARKS: **All vertical elevations in 1929 NGVD**

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS
					Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; 10% shell fragments. 2.0	
		1	6/12/18/21 30		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; 10% shell fragments. 4.0	
5		2	12/16/22/25 38		Sand, light brownish gray (5YR 6/1), quartz, fine-grained, sub-rounded; 10% shell fragments. 6.0	
		3	12/10/10/12 20		Sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-rounded; 10% shell fragments. 8.0	
		4	9/10/10/8 20		Sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-rounded; 15% shell fragments. 10.0	
10		5	7/10/9/10 19		Sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-rounded; 10% shell fragments. 12.0	
		6	4/3/2/2 5		Sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-rounded; 10% shell fragments. 14.0	
15		7	1/2/1/2 3		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; 15% shell fragments. 16.0	
		8	1/1/1/1 2		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; 15% shell fragments. 18.0	
		9	1/2/2/2 4		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; 10% shell fragments 20.0	

▲ SPT N VALUE ▲ (20, 40, 60, 80)

Graphic Litho Log | Well Construction

Concrete around pipe | Bentonite Pellets | Fine Sand with Slotted Pipe

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
OM-S

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS	▲ SPT N VALUE ▲ 20 40 60 80	Graphic Litho Log	Well Construction
		10	2/2/2/2 4		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; >5% shell fragments. 22.0				
		11	1/1/2/2 3		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; >5% shell fragments. 24.0				
25		12	2/2/2/2 4		Sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; >5% shell fragments. 26.0				
		13	2/3/3/4 6		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; >5% shell fragments. 28.0				
		14	1/3/4/5 7		Sand, yellowish gray (5Y 8/1), quartz, medium-grained, sub-rounded; 10% shell fragments. 30.0				
30		15	2/3/3/4 6		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; >5% shell fragments. 32.0				
		16	3/5/7/6 12		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; >5% shell fragments. 34.0				
35		17	4/5/6/7 11		Sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-angular to sub-rounded; >5% shell fragments. 36.0				
		18	3/4/3/2 7		Sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-angular to sub-rounded; >5% shell fragments. 38.0				
		19	1/1/1/1 2		Sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-angular to sub-rounded; >5% shell fragments. 40.0				
40		20	1/2/1/2 3		Muddy sand, moderate yellowish brown (10YR 5/4), quartz, fine-grained, sub-angular to sub-rounded; >5% shell fragments. 42.0				
		21	1/2/1/2 3		Muddy sand, dark yellowish brown (10YR 4/2), quartz, fine-grained, sub-rounded; >5% shell fragments. 44.0				
45		22	1/1/2/2 3		Muddy sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 30% shell fragments. 46.0				
		23	2/4/4/4 8		Muddy sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 30% shell fragments. 48.0				
		24	2/2/4/4 6		Muddy sand, yellowish gray (5Y 7/2), quartz, fine-grained, sub-rounded; 30% shell fragments. 50.0				

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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BORING/WELL NO.
OM-S

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	DESCRIPTION	REMARKS
		25	3/5/4/5 9		Muddy sand, yellowish gray (5Y 7/2), quartz, fine-grained, sub-rounded; 20% shell fragments. 52.0	
		26	6/7/10/9 17		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded to angular; 10% shell fragments. 54.0	
55		27	4/10/4/5 14		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 10% shell fragments. 56.0	
		28	2/1/2/2 3		Muddy sand, very pale orange (10YR 8/2), quartz, fine to very fine-grained, sub-rounded; 20% shell fragments. 58.0	
		29	2/3/5/9 8		Muddy sand, pale yellowish brown (10YR 6/2), quartz, fine to very fine-grained, sub-rounded; 20% shell fragments; 10% grey limestone fragments. 60.0	
60		30	7/9/3/8 12		Muddy sand, pale yellowish brown (10YR 6/2), quartz, fine to very fine-grained, sub-rounded; 10% shell fragments; 10% grey limestone fragments. 62.0	
		31	5/7/9/8 16		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 30% grey limestone fragments, lime mud. 64.0	
65		32	10/18/14/7 32		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 20% grey limestone fragments, lime mud. 66.0	
		33	9/9/9/10 18		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 30% grey limestone fragments, lime mud. 68.0	
		34	6/7/9/10 16		Sand, pale yellowish brown (10YR 6/2), quartz, fine-grained, sub-rounded; 30% grey limestone fragments, lime mud. 70.0	
		35	11/12/15/21 27			

▲ SPT N VALUE ▲
20 40 60 80

Graphic Litho Log

Well Construction

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

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TEST BORING LOG

BORING/WELL LOCATION SKETCH MAP

N

BORING/WELL NO. **PGA-N**	
PROJECT NO./NAME **G-160 GW-SW Study**	LOCATION **Palm Beach Gardens, Florida**
DRILLING CONTRACTOR/DRILLER **Earth Tech Drilling/Paul Lemenze**	
GEOLOGIST/OFFICE **Brian Collins/SFWMD, West Palm Beach, Florida**	

DRILLING EQUIPMENT/METHOD	SIZE/TYPE OF BIT	SAMPLING METHOD	START/FINISH DATE
Mobile B-59/Hollow Stem Auger	**4-1/4 Bullet**	**SPT**	**03/17/10-03/17/10**

WELL INSTALLED?	CASING MAT./DIA.	SCREEN:				
YES [X] NO [ ]	**PVC/2**	TYPE **Slotted**	MAT. **PVC**	LENGTH **2**	DIA. **2**	SLOT SIZE **0.010**

ELEVATION OF:	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
(FT. ABOVE M.S.L.)	**17.2**	**17.16**	**-0.8/-2.8**		

REMARKS: **All vertical elevations in 1929 NGVD**

Depth (ft)	Sample Type & Recovery	Sample Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING — DESCRIPTION	REMARKS	▲ SPT N VALUE ▲ 20 40 60 80	Graphic Litho Log	Well Construction
					Sand, very dark gray (7.5YR 3/1), quartz, very fine-grained, sub-rounded to sub-angular; 30% fine dark organic material.				
5					5.0 Sand, very dark gray (7.5YR 3/1), quartz, very fine-grained, sub-rounded; 5% fine dark organic material, 30% shell fragments, 10% clay.				
10					10.0 Sand, dark grayish brown (10YR 4/2), quartz fine-to medium-grained, sub-rounded to sub-angular; 40% shell fragments, 20% clay.				
15					15.0 Sand, very dark grayish brown (10YR 3/2), quartz, very fine to fine-grained, sub-rounded; 5% fine dark organic material, 20% shell fragments, 10% clay.				
					20.0				

TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

Concrete around pipe Bentonite Chips Fine Sand with Slotted Pipe

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TEST BORING LOG

BORING/WELL LOCATION SKETCH MAP

N

BORING/WELL NO. **PGA-S**	
PROJECT NO./NAME **G-160 GW-SW Study**	LOCATION **Palm Beach Gardens, Florida**
DRILLING CONTRACTOR/DRILLER **Earth Tech Drilling/Paul Lemenze**	
GEOLOGIST/OFFICE **Brian Collins/SFWMD, West Palm Beach, Florida**	

DRILLING EQUIPMENT/METHOD	SIZE/TYPE OF BIT	SAMPLING METHOD	START/FINISH DATE
Mobile B-59/Hollow Stem Auger	**4-1/4 Bullet**	**SPT**	**03/17/10-03/17/10**

WELL INSTALLED?	CASING MAT./DIA.	SCREEN:				
YES [X] NO [ ]	**PVC/2**	TYPE **Slotted**	MAT. **PVC**	LENGTH **2**	DIA. **2**	SLOT SIZE **0.010**

ELEVATION OF:	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
(FT. ABOVE M.S.L.)	**17.1**	**17.09**	**-0.9/-2.9**		

REMARKS: **All vertical elevations in 1929 NGVD**

Depth (ft)	Sample: Type & Recovery	Sample: Number	Penetration Resistance Blows/6" N-Value	Unified Classification	LOG OF TEST BORING: DESCRIPTION	REMARKS	▲ SPT N VALUE ▲ 20 40 60 80	Graphic Litho Log	Well Construction
					Sand, very dark gray (2.5Y 4/1), quartz, very fine-grained, sub rounded; 30% fine dark organic material.				
5					5.0 Sand, gray (7.5YR 5/1), quartz, very fine-grained, sub rounded; 5% fine dark organic material; 20% shell fragments; 10% clay.				
10					10.0 Sand, gray, (7.5YR 6/1), quartz, fine-to medium-grained, sub-rounded to sub-angular; 40% shell fragments; 20% clay.				
15					15.0 Sand, dark gray (7.5YR 4/1), quartz, very fine-to fine-grained, sub-rounded; 5% fine dark organic material; 20% shell fragments; 10% clay.				
					20.0				

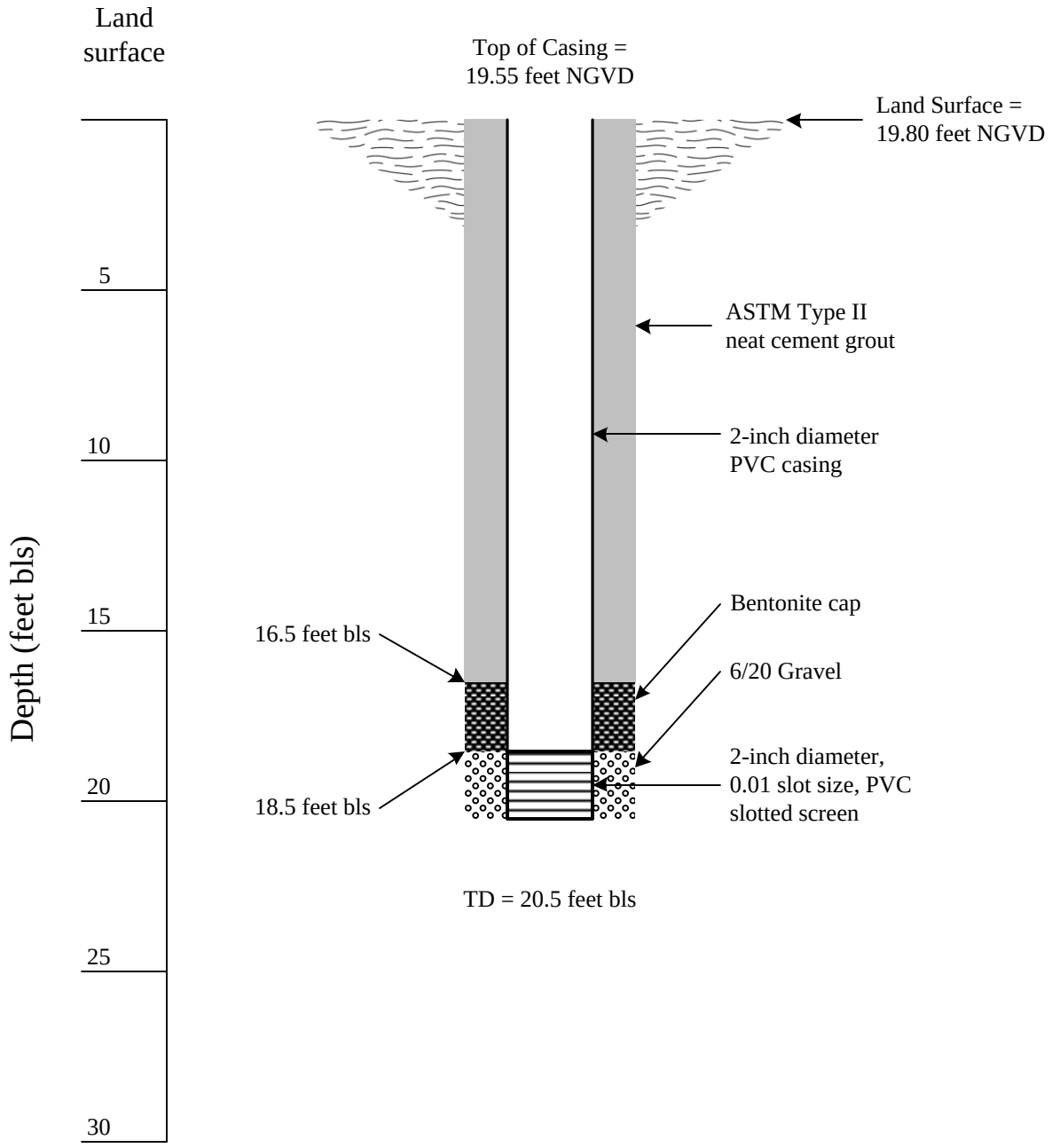
TEST BORING LOG WITH SPT N VALUES G-160 GW-SW STUDY.GPJ SFWMD.GDT 07/12/13

Concrete around pipe | Bentonite Chips | Fine Sand with Slotted Pipe

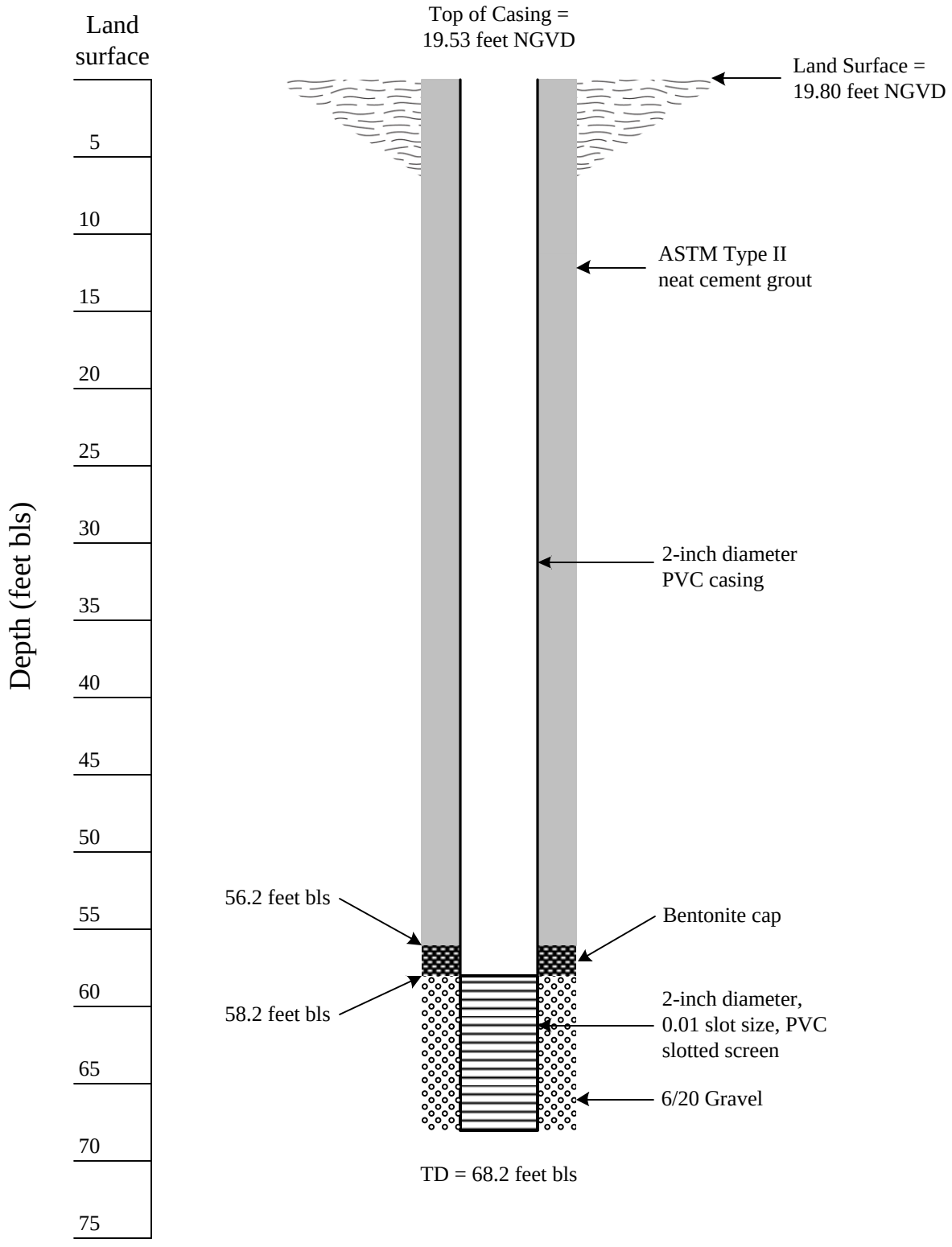
APPENDIX D

Well Construction Diagrams

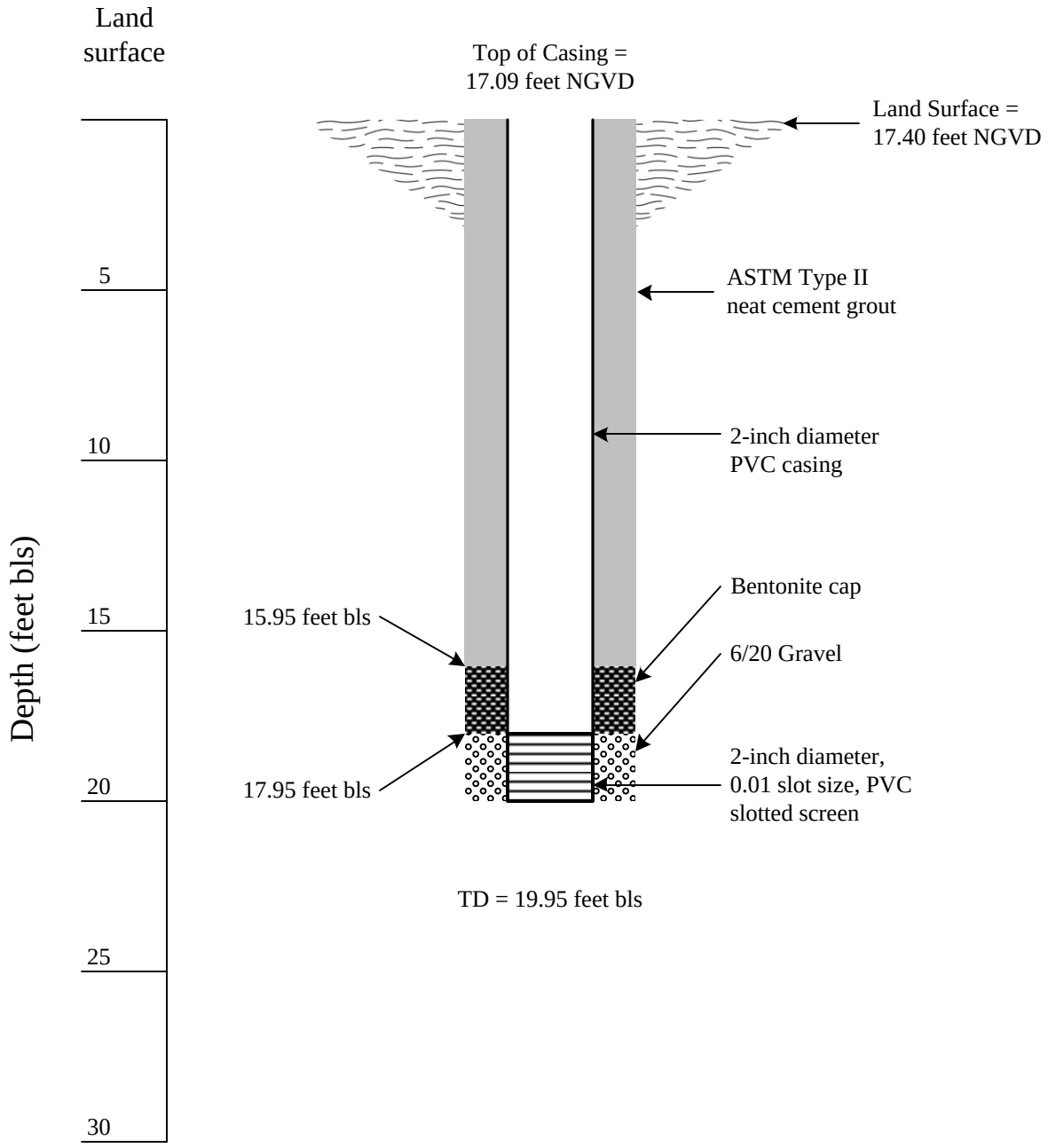
G-160 Groundwater - Surfacewater Study
Monitor Well C-18P-S



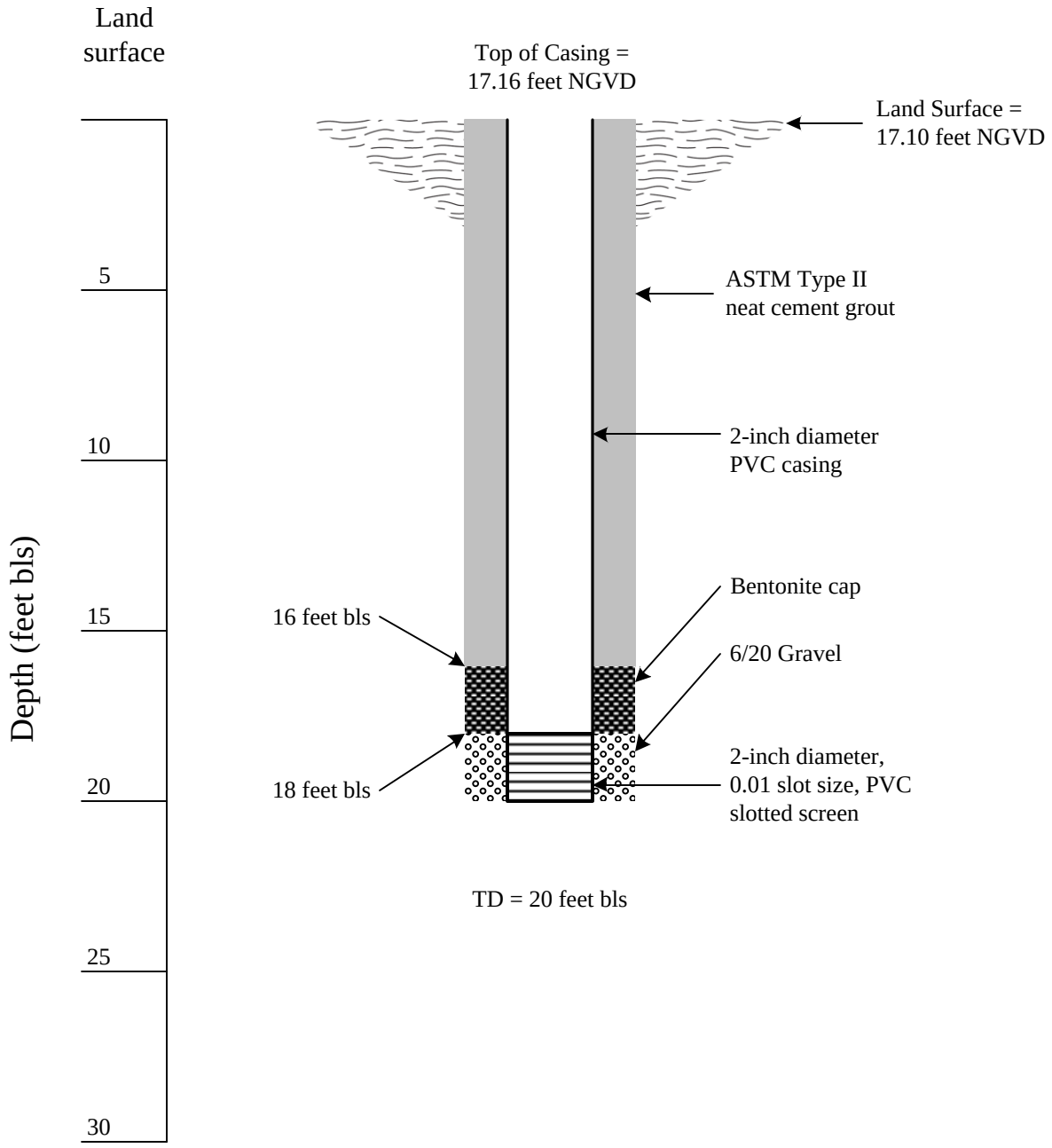
G-160 Groundwater - Surfacewater Study
Monitor Well C18-P-D



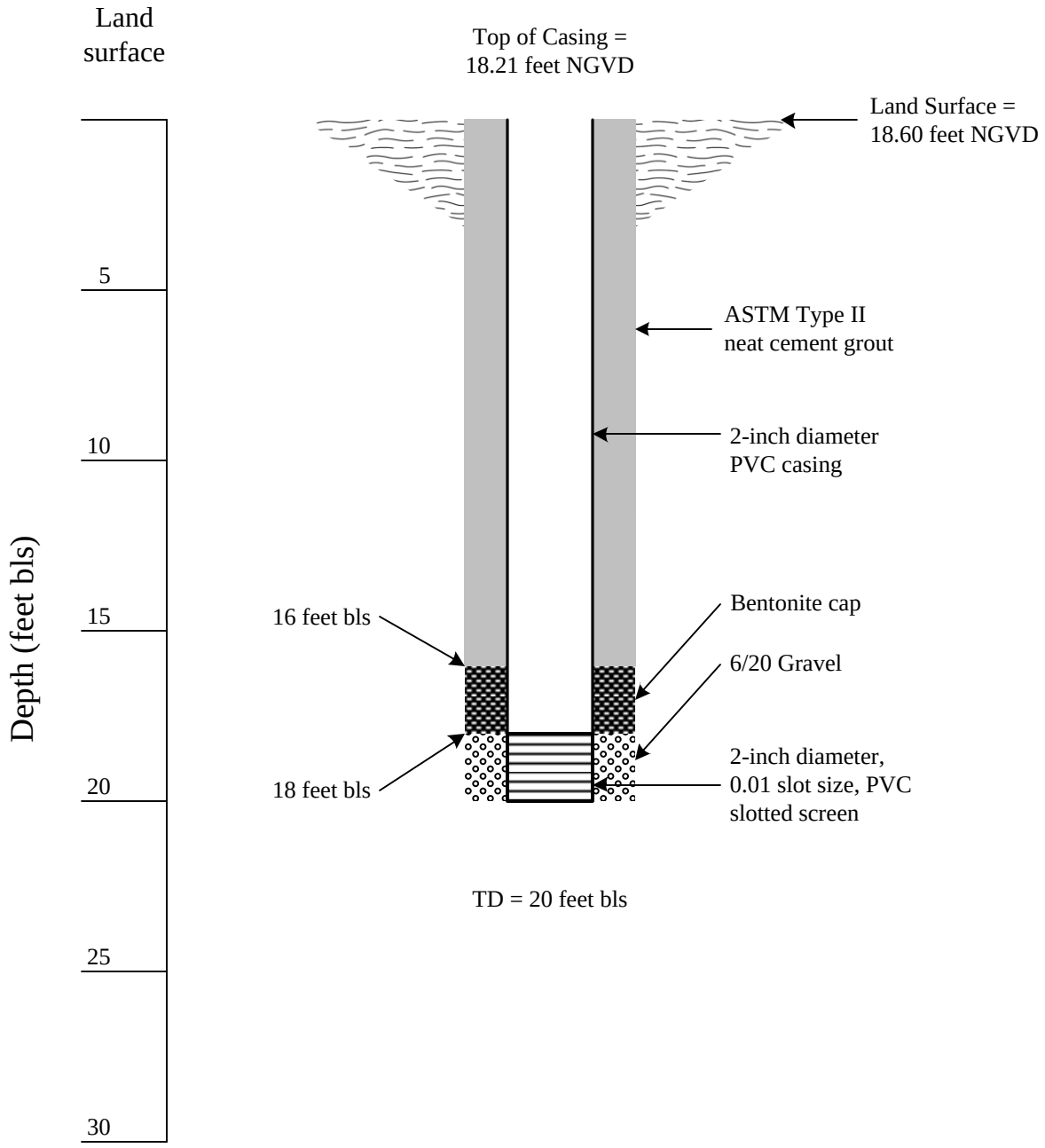
G-160 Groundwater - Surfacewater Study
Monitor Well PGA-S



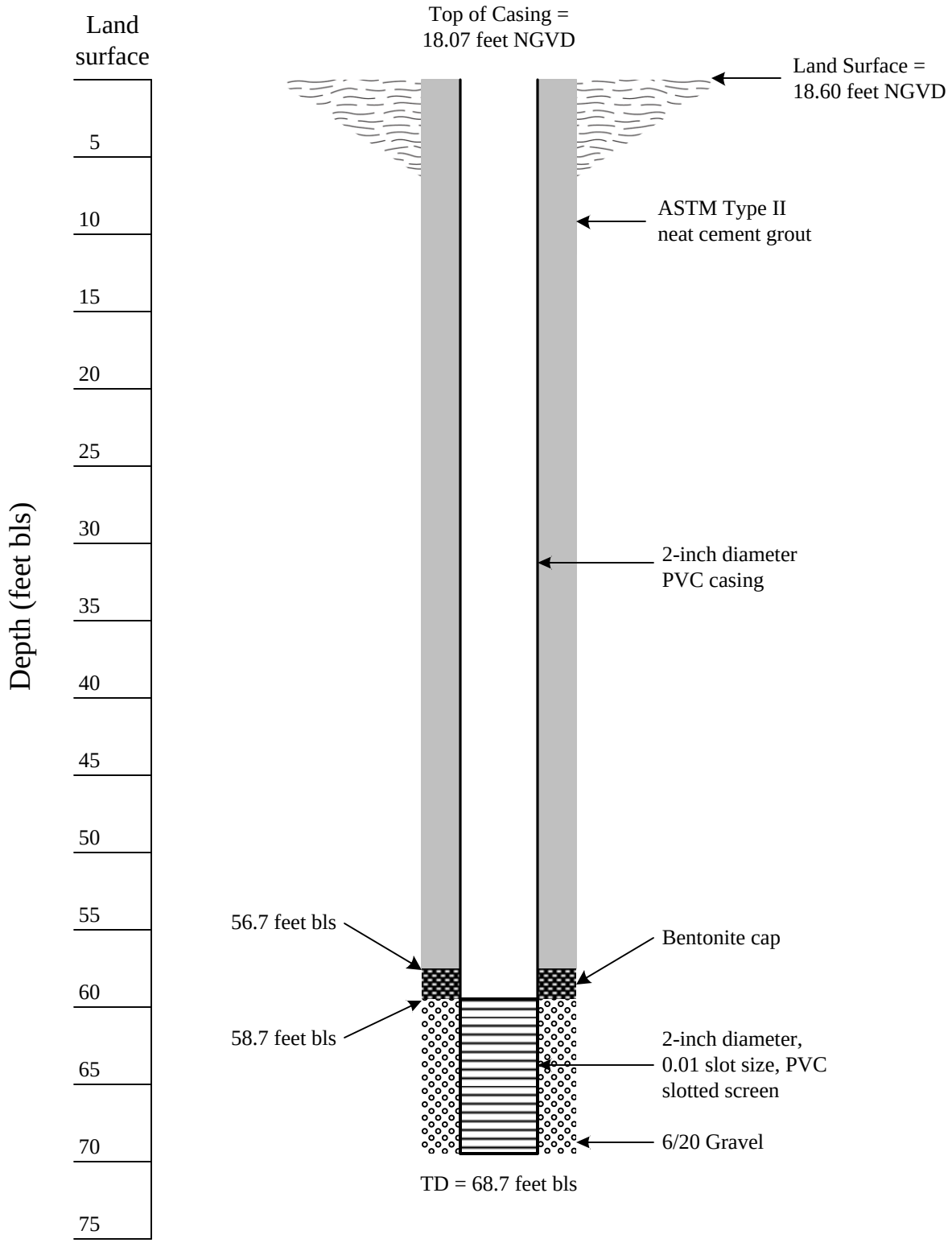
G-160 Groundwater - Surfacewater Study
Monitor Well PGA-N



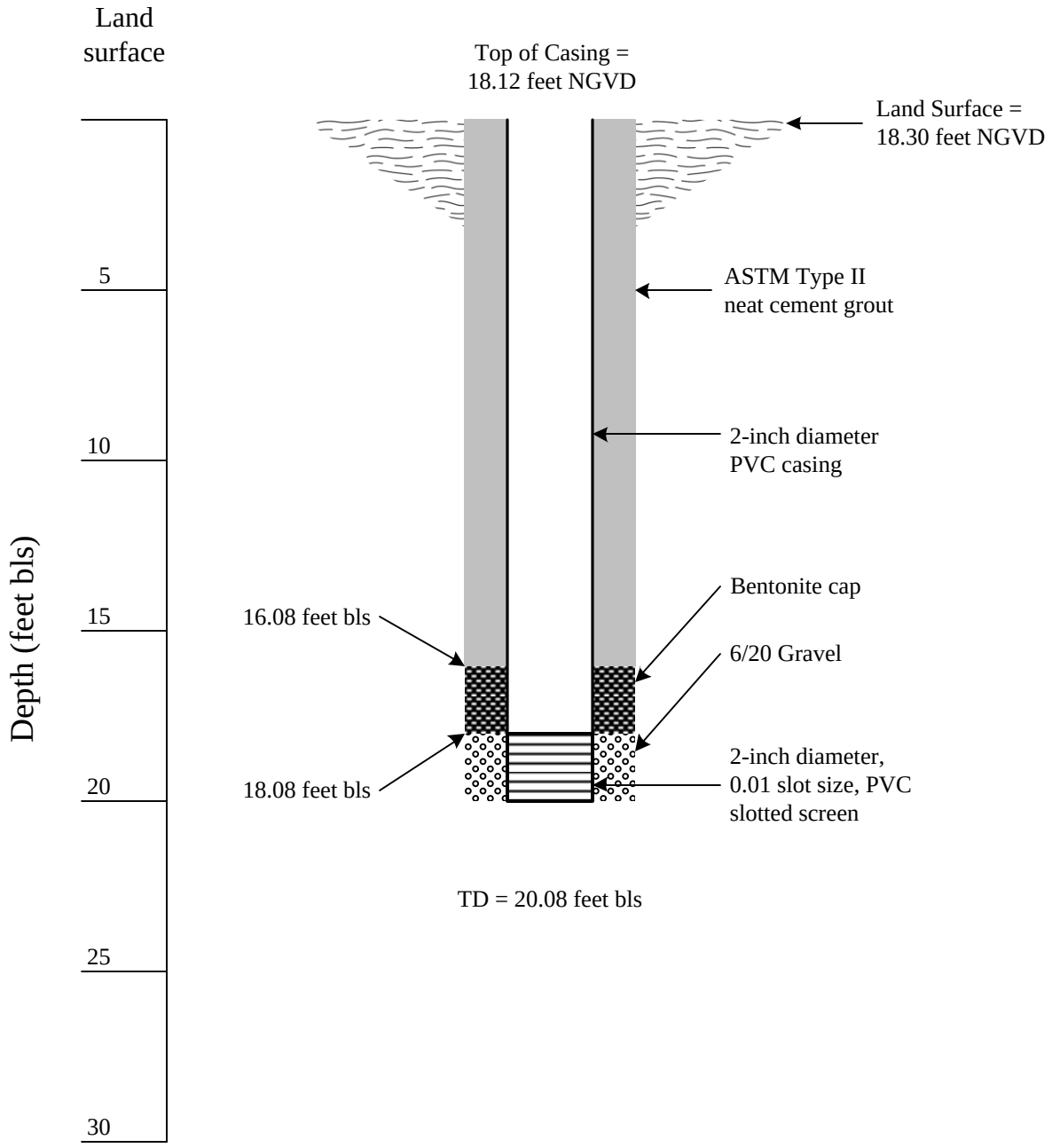
G-160 Groundwater - Surfacewater Study
Monitor Well OM-S-S



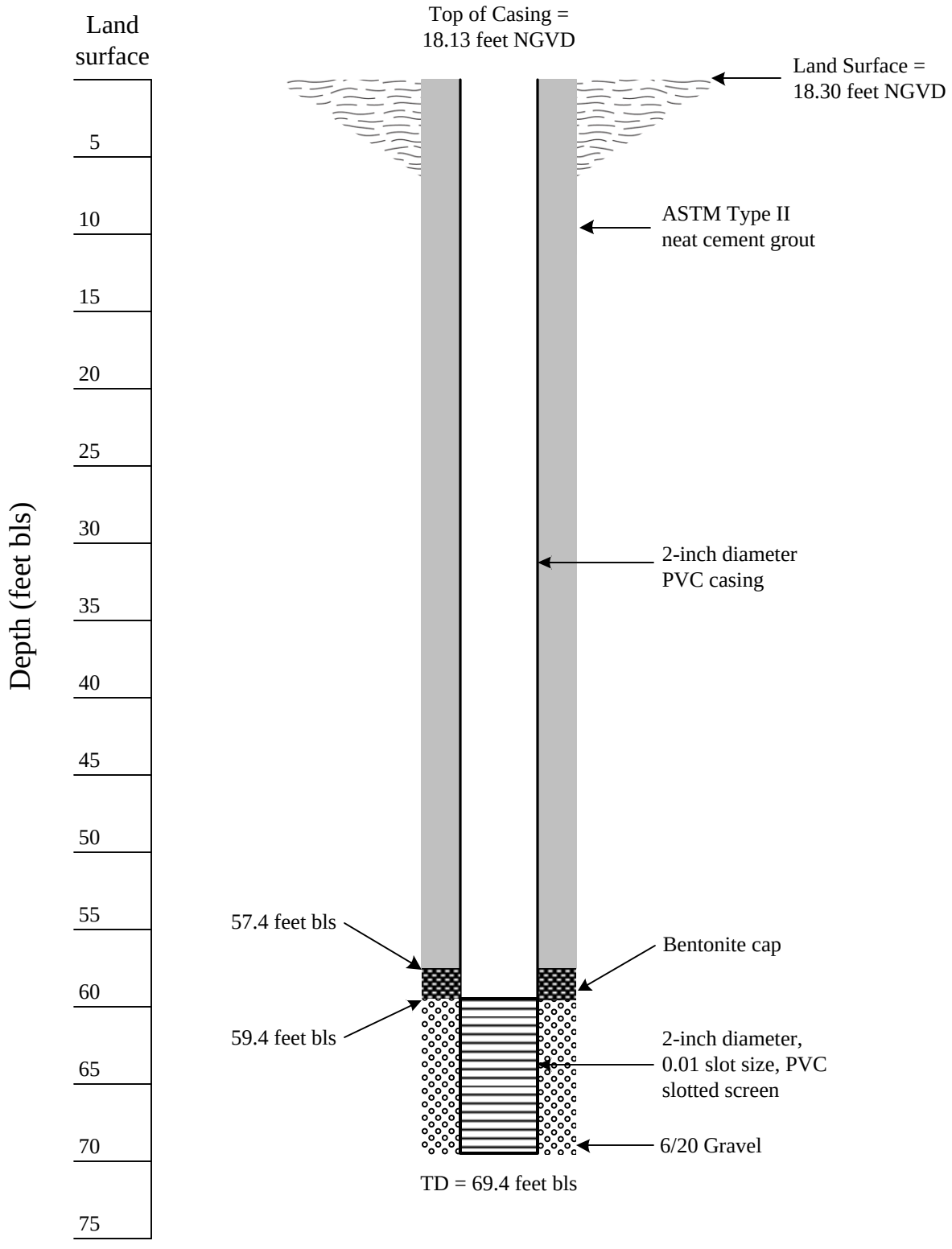
G-160 Groundwater - Surfacewater Study
Monitor Well OM-S-D



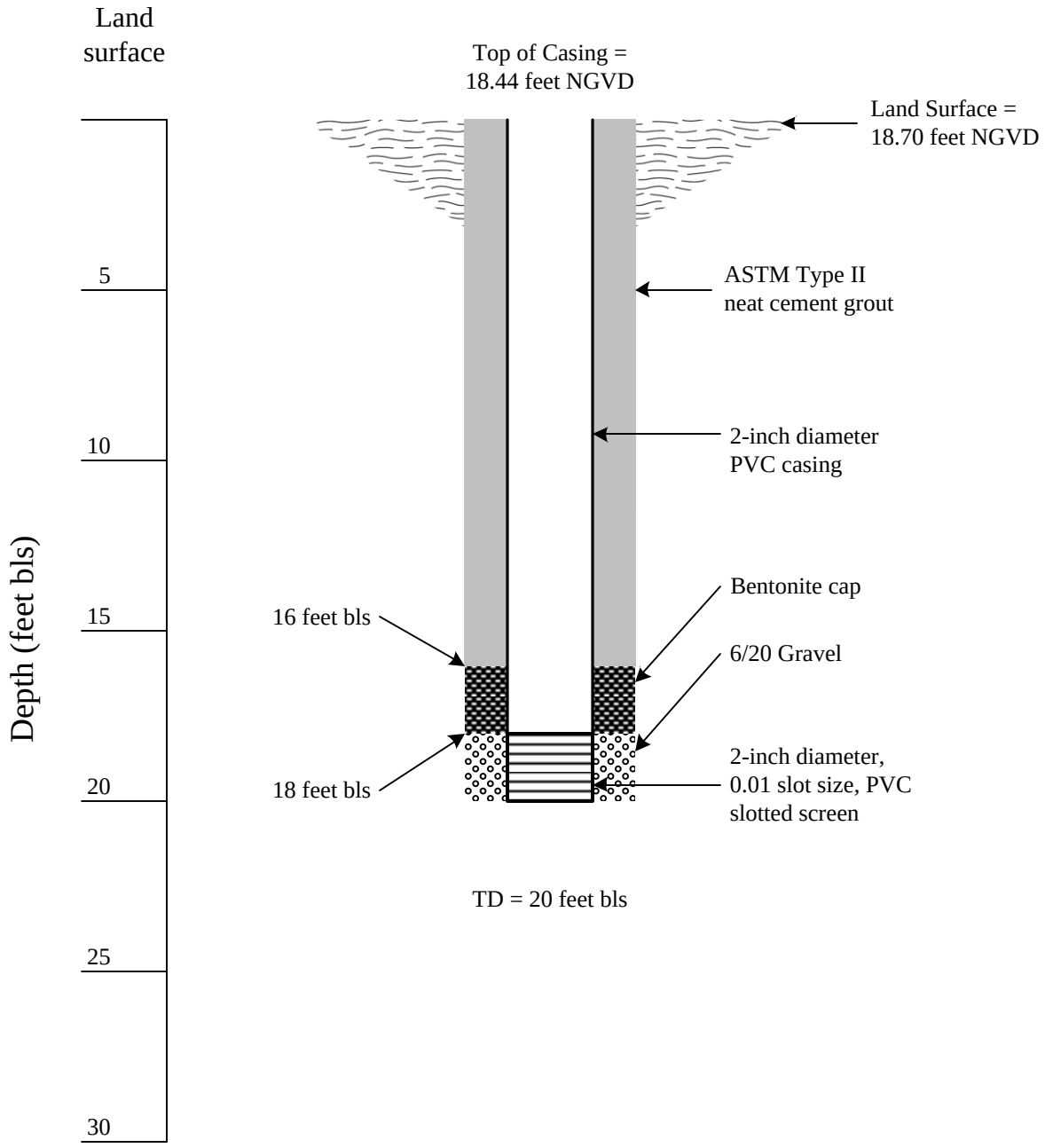
G-160 Groundwater - Surfacewater Study
Monitor Well OM-N-S



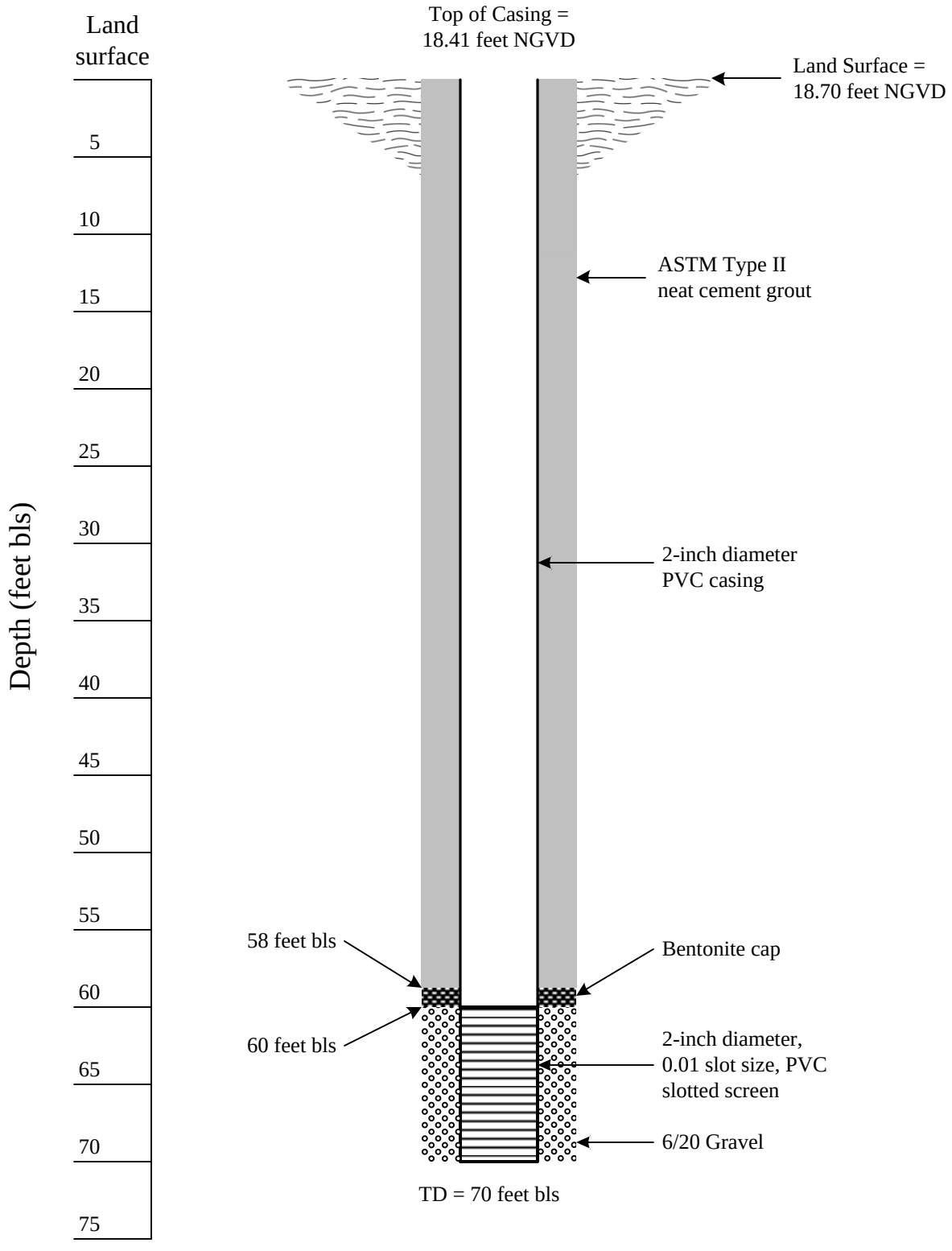
G-160 Groundwater - Surfacewater Study
Monitor Well OM-N-D



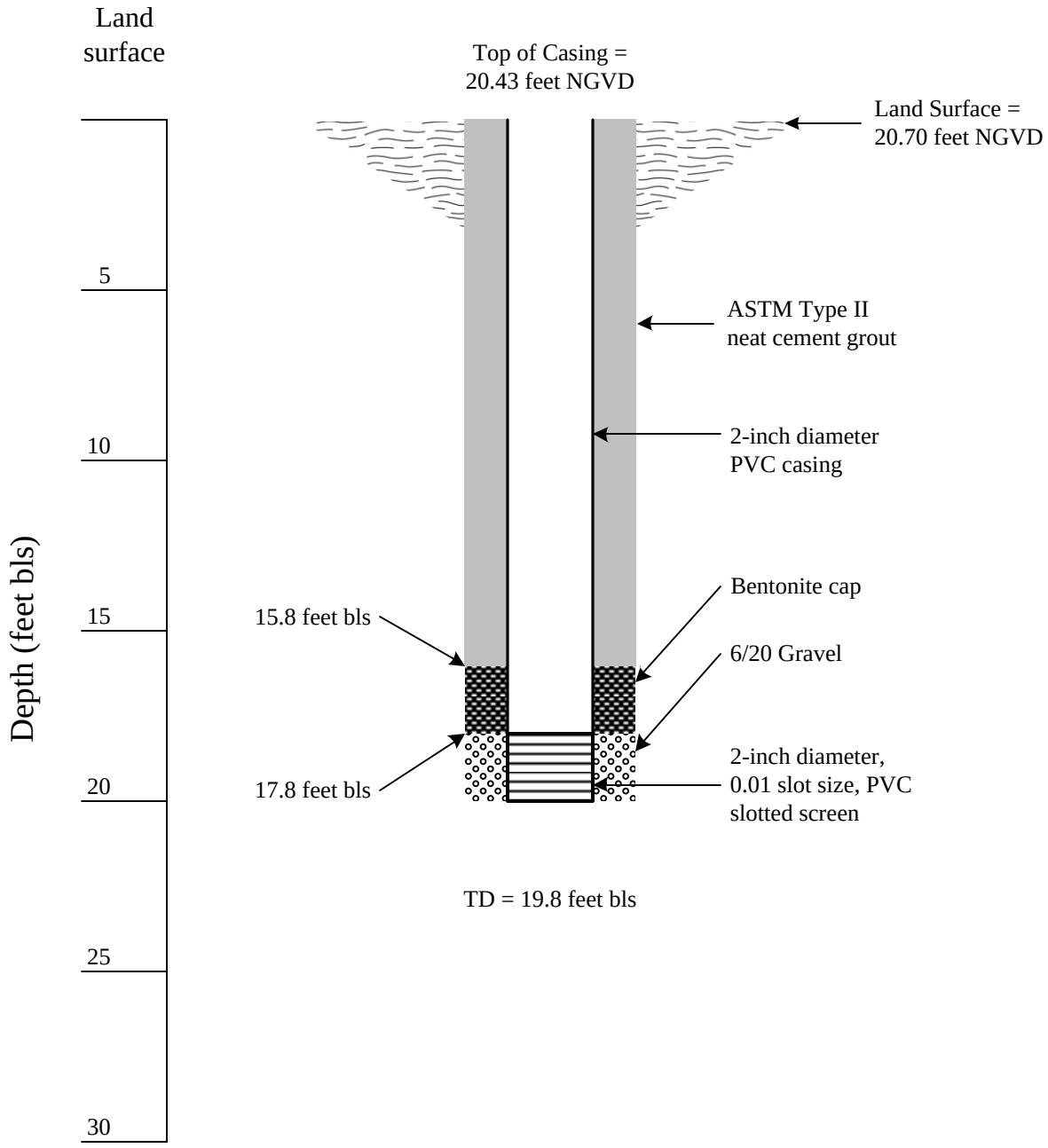
G-160 Groundwater - Surfacewater Study
Monitor Well NW-Berm-S



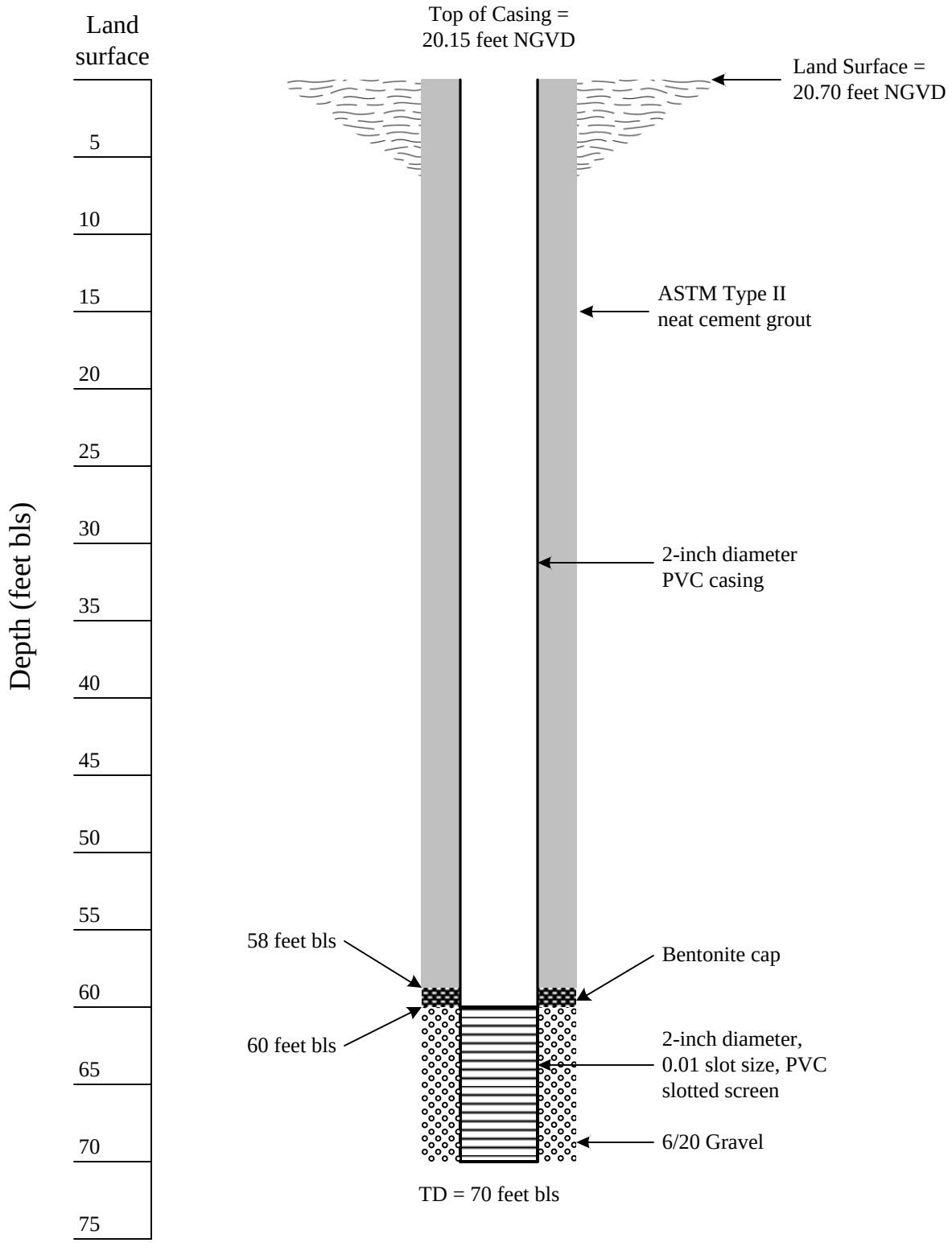
G-160 Groundwater - Surfacewater Study
Monitor Well NW-Berm-D



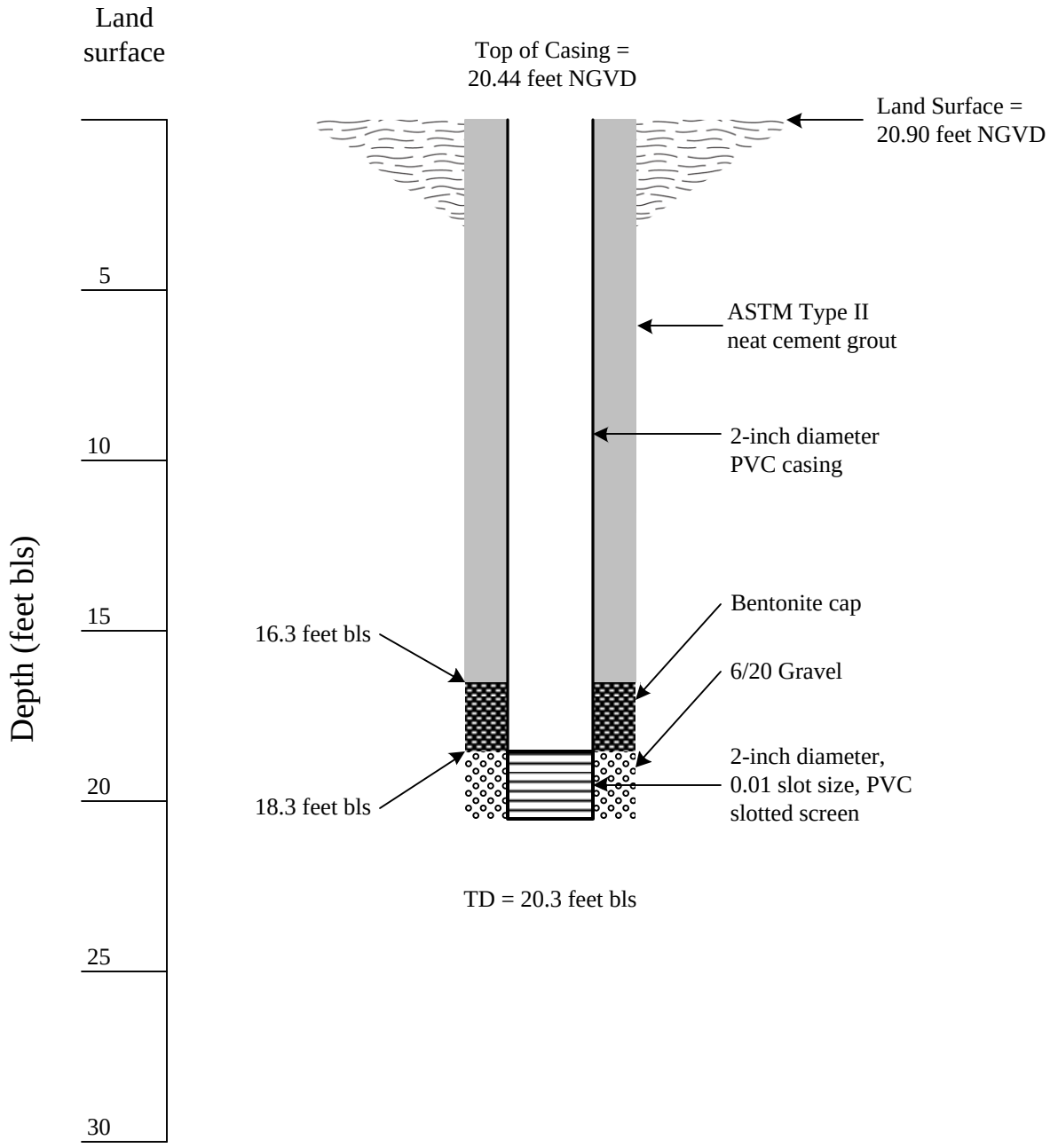
G-160 Groundwater - Surfacewater Study
Monitor Well NE-Berm-S



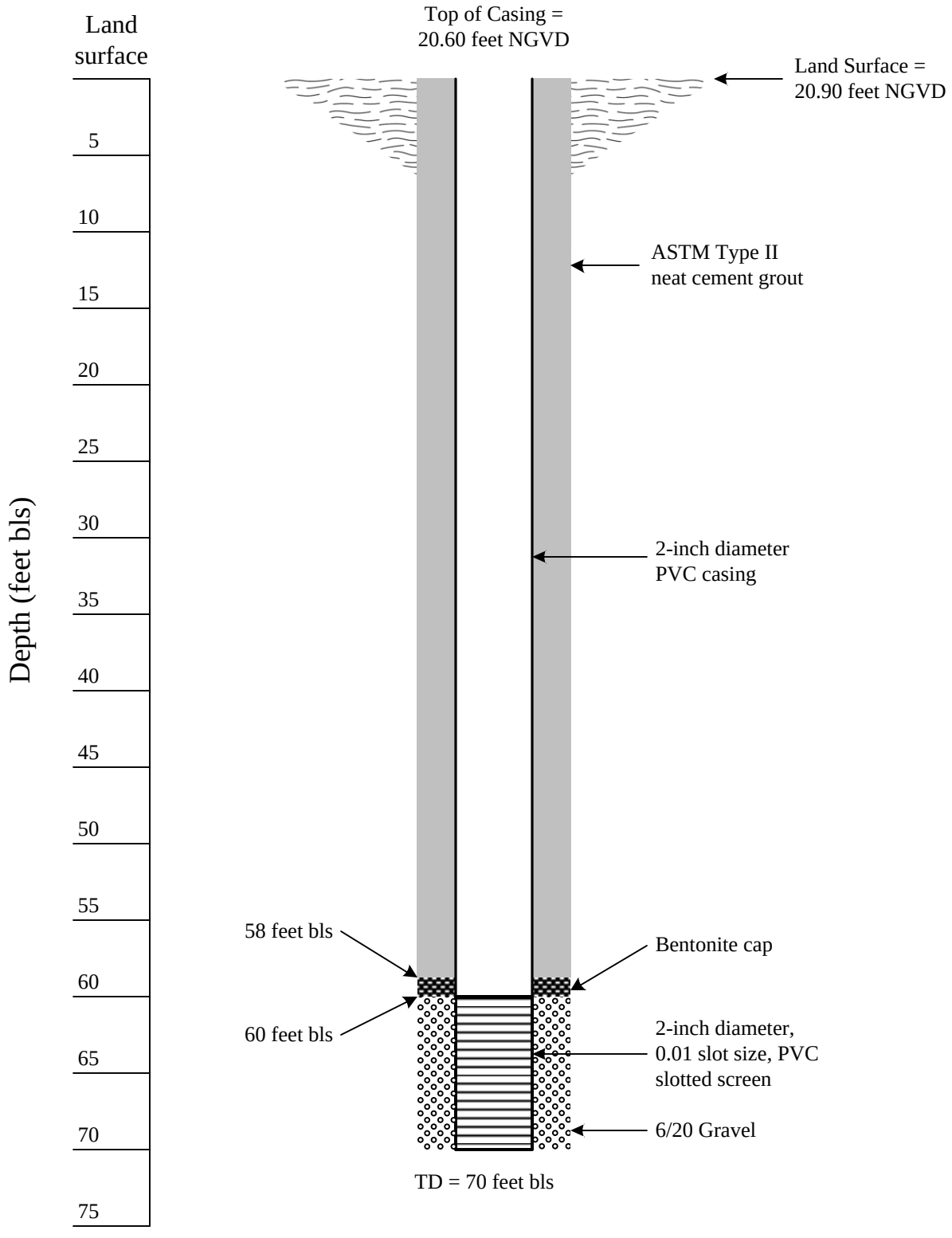
G-160 Groundwater - Surfacewater Study
Monitor Well NE-Berm-D



G-160 Groundwater - Surfacewater Study
Monitor Well E-Berm-S



G-160 Groundwater - Surfacewater Study
Monitor Well E-Berm-D



APPENDIX E

Well Construction Information, Vertical and Horizontal Nomographs, and Surveyor's Report

Well Construction Information

Station ID	Station Type	Drilling Contractor	Drilling Method	Geologic Sampling	Drilling Mud	State Planar (feet)		Ground Surface Elevation 1929 NGVD (feet)	Elevation at TOC 1929 NGVD (feet)	Depth of Well from TOC (feet)	Screen Length (feet)	Screen Interval (feet)	Elevation at Top of Screen 1929 NGVD (feet)	Elevation at Bottom of Screen 1929 NGVD (feet)	Well Construction Material	Screen Slot Size (inch)	Gravel Pack at Screen Interval	Centralizer Used	Source of Well
						Northing 1927 Datum	Easting 1927 Datum												
PGA-S	Well	Earth Tech	Hollow Stem Auger	YES	No	902832.210	932096.160	17.40	17.09	19.95	2.0	17.95-19.95	-0.9	-2.9	2 Inch PVC	0.010	6/20	No	Collins
PGA-N	Well	Earth Tech	Hollow Stem Auger	Yes	No	911575.030	929518.100	17.10	17.16	19.99	2.0	18-20	-0.8	-2.8	2 Inch PVC	0.010	6/20	No	Collins
OMS-S	Well	Earth Tech	Hollow Stem Auger	Yes	No	921761.050	929738.830	18.60	18.21	20.00	2.0	18-20	0.2	-1.8	2 Inch PVC	0.010	6/20	No	Collins
OMS-D	Well	Earth Tech	Mud Rotary/Split Spoon	Yes	Yes	921760.850	929744.240	18.60	18.07	68.70	10.0	58.7-68.7	-40.6	-50.6	2 Inch PVC	0.010	6/20	No	Collins
OMN-S	Well	Earth Tech	Hollow Stem Auger	Yes	No	924924.080	932468.990	18.30	18.12	20.08	2.0	18.08-20.08	0.0	-2.0	2 Inch PVC	0.010	6/20	No	Collins
OMN-D	Well	Earth Tech	Mud Rotary/Split Spoon	Yes	Yes	924924.670	932463.010	18.30	18.13	69.40	10.0	59.4-69.4	-41.3	-51.3	2 Inch PVC	0.010	6/20	No	Collins
EB-S	Well	Earth Tech	Hollow Stem Auger	Yes	No	928473.320	935162.280	20.90	20.44	20.3	2.0	18.3-20.3	2.1	0.1	2 Inch PVC	0.010	6/20	No	Collins
EB-D	Well	Earth Tech	Mud Rotary/Split Spoon	Yes	Yes	928478.560	935163.070	20.90	20.60	69.9	10.0	60-70	-39.3	-49.3	2 Inch PVC	0.010	6/20	No	Collins
NEB-S	Well	Earth Tech	Hollow Stem Auger	Yes	No	932566.190	931920.800	20.70	20.43	19.8	2.0	17.8-19.8	2.6	0.6	2 Inch PVC	0.010	6/20	No	Collins
NEB-D	Well	Earth Tech	Mud Rotary/Split Spoon	Yes	Yes	932566.120	931926.290	20.70	20.15	69.9	10.0	60-70	-39.8	-49.8	2 Inch PVC	0.010	6/20	No	Collins
NWB-S	Well	Earth Tech	Hollow Stem Auger	Yes	No	932579.890	924997.840	18.70	18.44	20.0	2.0	18-20	0.4	-1.6	2 Inch PVC	0.010	6/20	No	Collins
NWB-D	Well	Earth Tech	Mud Rotary/Split Spoon	Yes	Yes	932579.660	924992.210	18.70	18.41	70.0	10.0	60-70	-41.6	-51.6	2 Inch PVC	0.010	6/20	No	Collins
C18P-S	Well	Earth Tech	Hollow Stem Auger	Yes	No	921739.790	924720.760	19.80	19.55	20.5	2.0	18.5-20.5	1.1	-0.9	2 Inch PVC	0.010	6/20	No	Collins
C18P-D	Well	Earth Tech	Mud Rotary/Split Spoon	Yes	Yes	921734.420	924723.030	19.80	19.53	68.2	10.0	58.2-68.2	-38.7	-48.7	2 Inch PVC	0.01	6/20	No	Collins

Vertical Nomograph

Station ID		PGA-S	PGA-N	OMS-S	OMS-D	OMN-S	OMN-D	EB-S	EB-D	NEB-S	NEB-D	NWB-S	NWB-D	C18P-S	C18P-D
	Elevation at Top of Screen	-0.9	-0.8	0.2	-40.6	0.0	-41.27	2.14	-39.3	2.63	-39.75	0.44	-41.59	1.05	-38.67
PGA-S	-0.9	0.00	-0.03	-1.07	39.77	-0.90	40.41	-3.00	38.44	-3.49	38.89	-1.30	40.73	-1.91	37.81
PGA-N	-0.8	0.03	0.00	-1.04	39.80	-0.87	40.44	-2.97	38.47	-3.46	38.92	-1.27	40.76	-1.88	37.84
OMS-S	0.2	1.07	1.04	0.00	40.84	0.17	41.48	-1.93	39.51	-2.42	39.96	-0.23	41.80	-0.84	38.88
OMS-D	-40.6	-39.77	-39.80	-40.84	0.00	-40.67	0.64	-42.77	-1.33	-43.26	-0.88	-41.07	0.96	-41.68	-1.96
OMN-S	0.0	0.90	0.87	-0.17	40.67	0.00	41.31	-2.10	39.34	-2.59	39.79	-0.40	41.63	-1.01	38.71
OMN-D	-41.27	-40.41	-40.44	-41.48	-0.64	-41.31	0.00	-43.41	-1.97	-43.90	-1.52	-41.71	0.32	-42.32	-2.60
EB-S	2.14	3.00	2.97	1.93	42.77	2.10	43.41	0.00	41.44	-0.49	41.89	1.70	43.73	1.09	40.81
EB-D	-39.3	-38.44	-38.47	-39.51	1.33	-39.34	1.97	-41.44	0.00	-41.93	0.45	-39.74	2.29	-40.35	-0.63
NEB-S	2.63	3.49	3.46	2.42	43.26	2.59	43.90	0.49	41.93	0.00	42.38	2.19	44.22	1.58	41.30
NEB-D	-39.75	-38.89	-38.92	-39.96	0.88	-39.79	1.52	-41.89	-0.45	-42.38	0.00	-40.19	1.84	-40.80	-1.08
NWB-S	0.44	1.30	1.27	0.23	41.07	0.40	41.71	-1.70	39.74	-2.19	40.19	0.00	42.03	-0.61	39.11
NWB-D	-41.59	-40.73	-40.76	-41.80	-0.96	-41.63	-0.32	-43.73	-2.29	-44.22	-1.84	-42.03	0.00	-42.64	-2.92
C18P-S	1.05	1.91	1.88	0.84	41.68	1.01	42.32	-1.09	40.35	-1.58	40.80	0.61	42.64	0.00	39.72
C18P-D	-38.67	-37.81	-37.84	-38.88	1.96	-38.71	2.60	-40.81	0.63	-41.30	1.08	-39.11	2.92	-39.72	0.00

Elevations are in 1929 NGVD.

Horizontal Nomograph

Station ID			PGA-S	PGA-N	OMS-S	OMS-D	OMN-S	OMN-D	EB-S	EB-D	NEB-S	NEB-D	NWB-S	NWB-D	C18P-S	C18P-D
	Northing		902832.210	911575.030	921761.050	921760.850	924924.080	924924.670	928473.320	928478.560	932566.190	932566.120	932579.890	932579.660	921739.790	921734.420
		Easting	932096.160	929518.100	929738.830	929744.240	932468.990	932463.010	935162.280	935163.070	931920.800	931926.290	924997.840	924992.210	924720.760	924723.030
PGA-S	902832.210	932096.160	0.000	9115.004	19075.062	19074.196	22095.016	22095.506	25823.780	25829.077	29734.497	29734.395	30582.848	30583.932	20295.150	20289.322
PGA-N	911575.030	929518.100	9115.004	0.000	10188.411	10188.330	13671.316	13670.603	17815.975	17821.196	21128.222	21128.777	21485.737	21486.697	11239.965	11234.140
OMS-S	921761.050	929738.830	19075.062	10188.411	0.000	5.414	4178.341	4174.883	8629.506	8634.079	11023.250	11024.270	11812.040	11814.090	5018.115	5015.871
OMS-D	921760.850	929744.240	19074.196	10188.330	5.414	0.000	4174.959	4171.507	8626.263	8630.837	11022.377	11023.393	11814.395	11816.448	5023.524	5021.280
OMN-S	924924.080	932468.990	22095.016	13671.316	4178.341	4174.959	0.000	6.009	4455.437	4460.089	7661.746	7661.286	10697.173	10700.941	8377.038	8376.982
OMN-D	924924.670	932463.010	22095.506	13670.603	4174.883	4171.507	6.009	0.000	4458.584	4463.234	7660.732	7660.276	10692.575	10696.342	8371.732	8371.678
EB-S	928473.320	935162.280	25823.780	17815.975	8629.506	8626.263	4455.437	4458.584	0.000	5.299	5220.994	5217.532	10962.653	10967.787	12424.402	12425.406
EB-D	928478.560	935163.070	25829.077	17821.196	8634.079	8630.837	4460.089	4463.234	5.299	0.000	5217.378	5213.913	10961.424	10966.559	12427.906	12428.912
NEB-S	932566.190	931920.800	29734.497	21128.222	11023.250	11022.377	7661.746	7660.732	5220.994	5217.378	0.000	5.490	6922.974	6928.603	13001.981	13005.196
NEB-D	932566.120	931926.290	29734.395	21128.777	11024.270	11023.393	7661.286	7660.276	5217.532	5213.913	5.490	0.000	6928.464	6934.093	13004.964	13008.177
NWB-S	932579.890	924997.840	30582.848	21485.737	11812.040	11814.395	10697.173	10692.575	10962.653	10961.424	6922.974	6928.464	0.000	5.635	10843.641	10848.951
NWB-D	932579.660	924992.210	30583.932	21486.697	11814.090	11816.448	10700.941	10696.342	10967.787	10966.559	6928.603	6934.093	5.635	0.000	10843.268	10848.580
C18P-S	921739.790	924720.760	20295.150	11239.965	5018.115	5023.524	8377.038	8371.732	12424.402	12427.906	13001.981	13004.964	10843.641	10843.268	0.000	5.830
C18P-D	921734.420	924723.030	20289.322	11234.140	5015.871	5021.280	8376.982	8371.678	12425.406	12428.912	13005.196	13008.177	10848.951	10848.580	5.830	0.000

Numbers are in feet.
Northing and Easting provided in NAD83 (2007).

SURVEY REPORT

Specific Purpose Survey
Lox Slough Monitoring Wells
Palm Beach County, Florida
Work Order # 4600000940-WO10
Date: 40339.00
Revised:
EA Project No.: 60134.10
English Units, US Survey Feet
Florida East Zone 901
Horizontal Datum = NAD 83/2007
Vertical Datum = NAVD 1988 & NGVD 1929

ERDMAN ANTHONY
1402 Royal Palm Beach Blvd., Bldg 500
Royal Palm Beach, Florida 33411
LB# 7334 EB# 25912

WELL	NORTHING	EASTING	LATITUDE	LONGITUDE	ELEV(29)	ELEV(88)
BM-BERM-NW	932580.09	925003.90	26 53 48.94306	80 10 30.54066	18.56	17.05
East Well	932579.89	924997.84	26 53 48.94147	80 10 30.60760	18.44	16.93
West Well	932579.66	924992.21	26 53 48.93956	80 10 30.66980	18.41	16.90
Ground					18.7	17.2
BM-BERM-NE	932566.05	931916.27	26 53 48.35247	80 09 14.19728	20.50	18.99
East Well	932566.12	931926.29	26 53 48.35250	80 09 14.08661	20.15	18.64
West Well	932566.19	931920.80	26 53 48.35356	80 09 14.14724	20.43	18.92
Ground					20.7	19.2
BM-BERM-NS	928462.23	935161.95	26 53 07.49808	80 08 38.65648	20.77	19.26
South Well	928473.32	935162.28	26 53 07.60788	80 08 38.65201	20.44	18.93
North Well	928478.56	935163.07	26 53 07.65972	80 08 38.64289	20.60	19.09
Ground					20.9	19.4
BM-MARSH-N	924924.17	932473.72	26 52 32.64101	80 09 08.60517	18.15	16.64
Well East	924924.08	932468.99	26 52 32.64043	80 09 08.65741	18.12	16.61
Well West	924924.67	932463.01	26 52 32.64667	80 09 08.72340	18.13	16.62
Ground					18.3	16.8
BM-MARSH-S	921750.07	929744.18	26 52 01.38889	80 09 38.97826	18.38	16.87
Well East	921760.85	929744.24	26 52 01.49564	80 09 38.97681	18.07	16.56
Well West	921761.05	929738.83	26 52 01.49797	80 09 39.03653	18.21	16.70
Ground					18.6	17.1
BM-PGA-N	911570.40	929521.33	26 50 20.59750	80 09 42.18179	17.13	15.62
Well	911575.03	929518.10	26 50 20.64356	80 09 42.21711	17.16	15.65
Ground					17.1	15.6
BM-C-18-P	921737.11	924721.71	26 52 01.58676	80 10 34.43592	19.64	18.13
Well South	921734.42	924723.03	26 52 01.56003	80 10 34.42154	19.55	18.04
Well North	921739.79	924720.76	26 52 01.61336	80 10 34.44622	19.53	18.02
Ground					19.8	18.3
BM-PGA-S	902833.32	932091.17	26 48 53.90795	80 09 14.45613	17.21	15.70
Well	902832.21	932096.16	26 48 53.89663	80 09 14.40114	17.09	15.58
Ground					17.4	15.9

SURVEYORS REPORT:

VERTICAL VALUES BASED UPON NGS MONUMENT(S): M600, G160, G161 & Y547 & JUPITER FARMS
HORIZONTAL VALUES BASED UPON MONUMENT(S): SKY AND JUPITER FARMS
VERTICAL ACCURACY ESTIMATED TO BE 0.01'
HORIZONTAL ACCURACY ESTIMATED TO BE 0.1'
HORIZONTAL INFORMATION SHOWN HEREON OBTAINED USING GPS RTK TIED TO THE LENGEMANN RTN
VERTICAL INFORMATION SHOWN HEREON OBTAINED USING TOPCON DIGITAL LEVEL 102-C
THERE WERE NO CONDITIONS ENCOUNTERED THAT PREVENTED FAC 5J-17 FROM BEING MET
FIELD BOOK: EA SFWMD 6 PAGES 6 - 31
DATE OF LAST FIELD WORK: 6/9/2010

ABBREVIATIONS

BM-SITE BENCHMARK
EA-ERDMAN ANTHONY
FAC-FLORIDA ADMINISTRATIVE CODE
GPS-GLOBAL POSITIONING SYSTEM
LB-LICENSED BUSINESS
NAD-NORTH AMERICAN DATUM
NGS-NATIONAL GEODETIC SURVEY
NGVD-NATION GEODETIC VERTICAL DATUM
NAVD-NORTH AMERICAN VERTICAL DATUM
PID-POINT IDENTIFIER
PSM-PROFESSIONAL SURVEYOR AND MAPPER
RTN-REAL TIME NETWORK
RTK-REAL TIME KINEMATICS
SFWMD-SOUTH FLORIDA WATER MANAGEMENT DISTRICT

CERTIFICATION:

I HEREBY CERTIFY THAT THE INFORMATION HEREWITH IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF AS SURVEYED AND DEPICTED UNDER MY SUPERVISION. THIS SURVEY MEETS THE INTENT OF THE MINIMUM TECHNICAL STANDARDS FOR SURVEYING IN THE STATE OF FLORIDA AS SET FORTH BY THE FLORIDA BOARD OF PROFESSIONAL SURVEYORS AND MAPPERS PURSUANT TO SECTION 472.027, FLORIDA STATUTES AND ADOPTED IN CHAPTER 5J-17, FLORIDA ADMINISTRATIVE CODE.

NOT VALID WITHOUT THE RAISED SEAL AND SIGNATURE OF A FLORIDA LICENSED SURVEYOR AND MAPPER.

ADDITIONS OR DELETIONS TO SURVEY MAPS OR REPORTS BY OTHER THAN THE SIGNING PARTY OR PARTIES IS PROHIBITED WITHOUT THE WRITTEN CONSENT OF THE SIGNING PARTY OR PARTIES.

ERDMAN ANTHONY OF FLORIDA, INC.

_____ DATE: _____

MICHAEL E. ROSS, PSM
PROFESSIONAL SURVEYOR AND MAPPER
NO. 6622, STATE OF FLORIDA

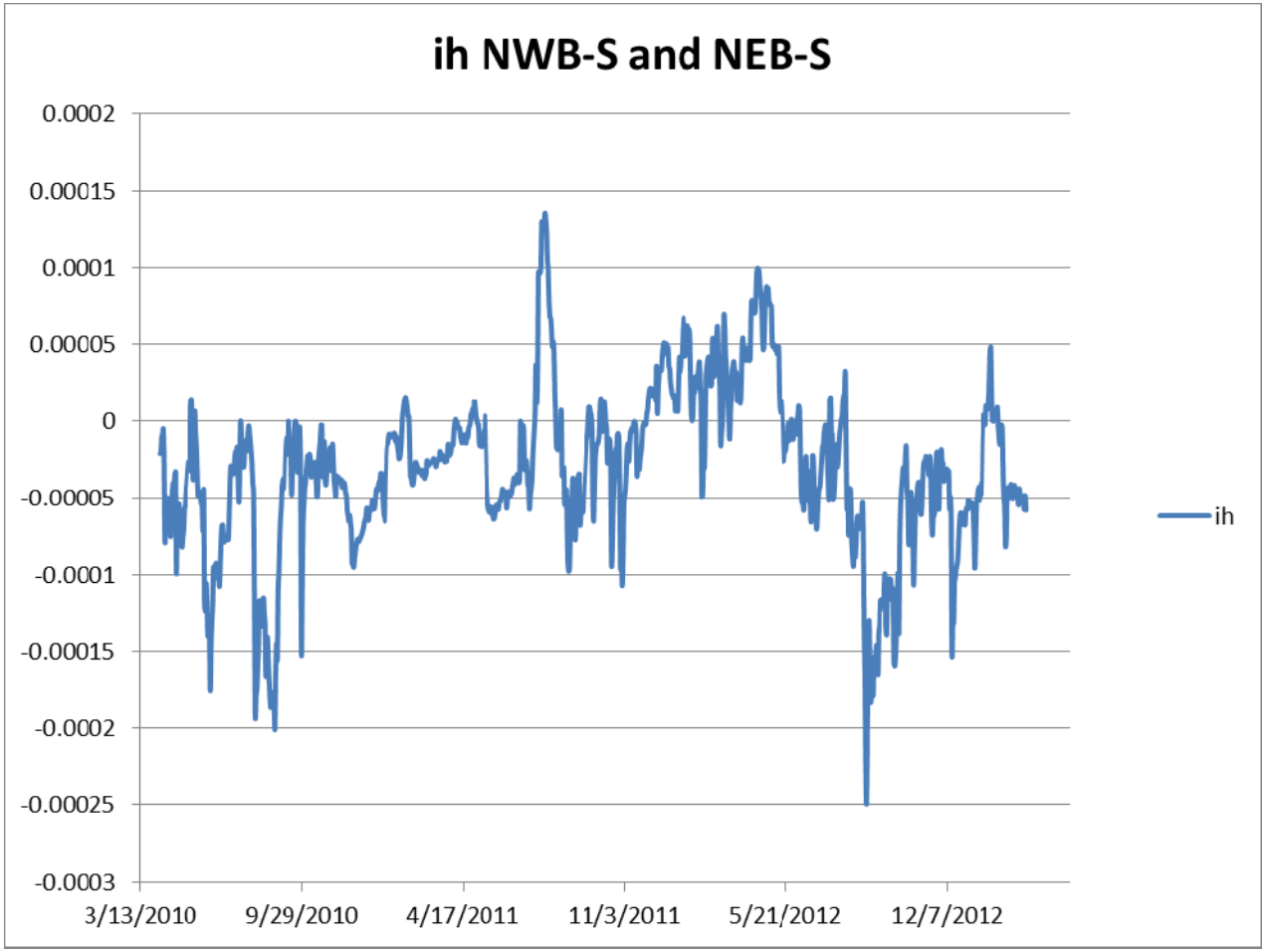
APPENDIX F

Horizontal Gradient Hydrographs
Vertical Gradient Hydrographs
Rainfall and Horizontal Gradient Hydrographs

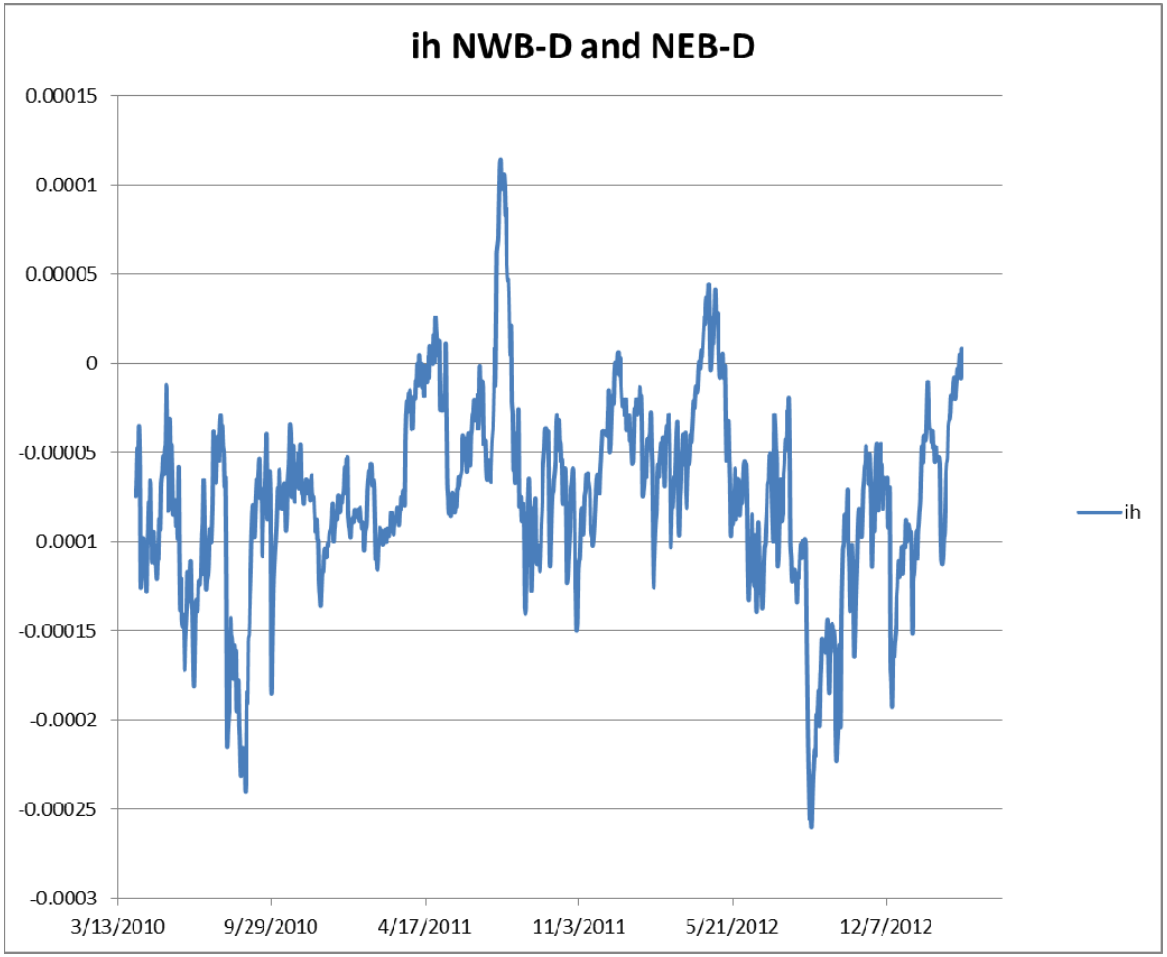
Horizontal Gradient

ih =	the horizontal gradient (unitless)					
h1 =	hydraulic head at location 1 (ft NGVD)					
h2 =	hydraulic head at location 2 (ft NGVD)					
Δl =	horizontal distance between location 1 and 2 (ft)					
	ih =	$\frac{(h1 - h2)}{\Delta l}$				
A positive result indicates flow is from location 1 towards location 2						

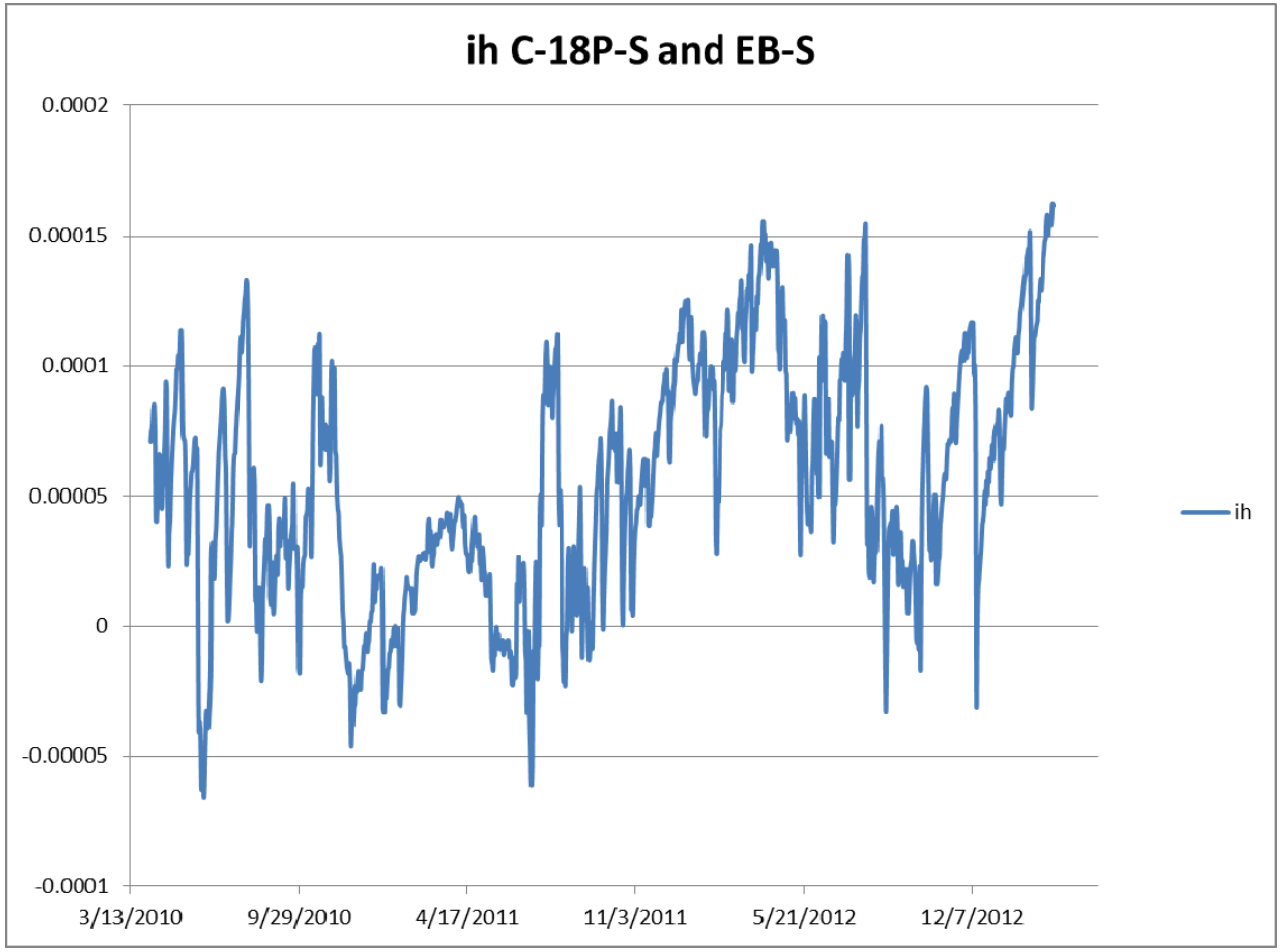
NWB-S and NEB-S



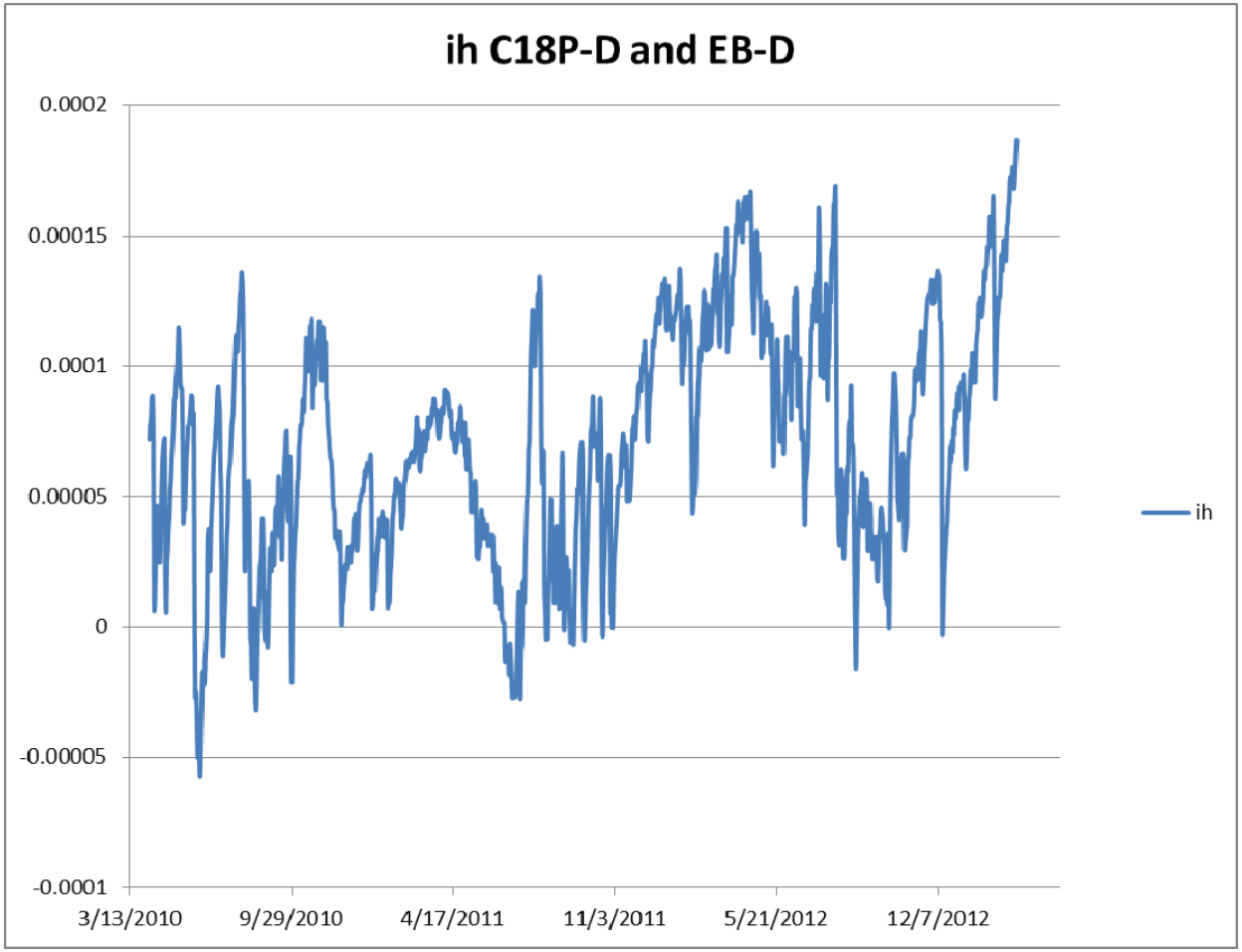
NWB-D and NEB-D



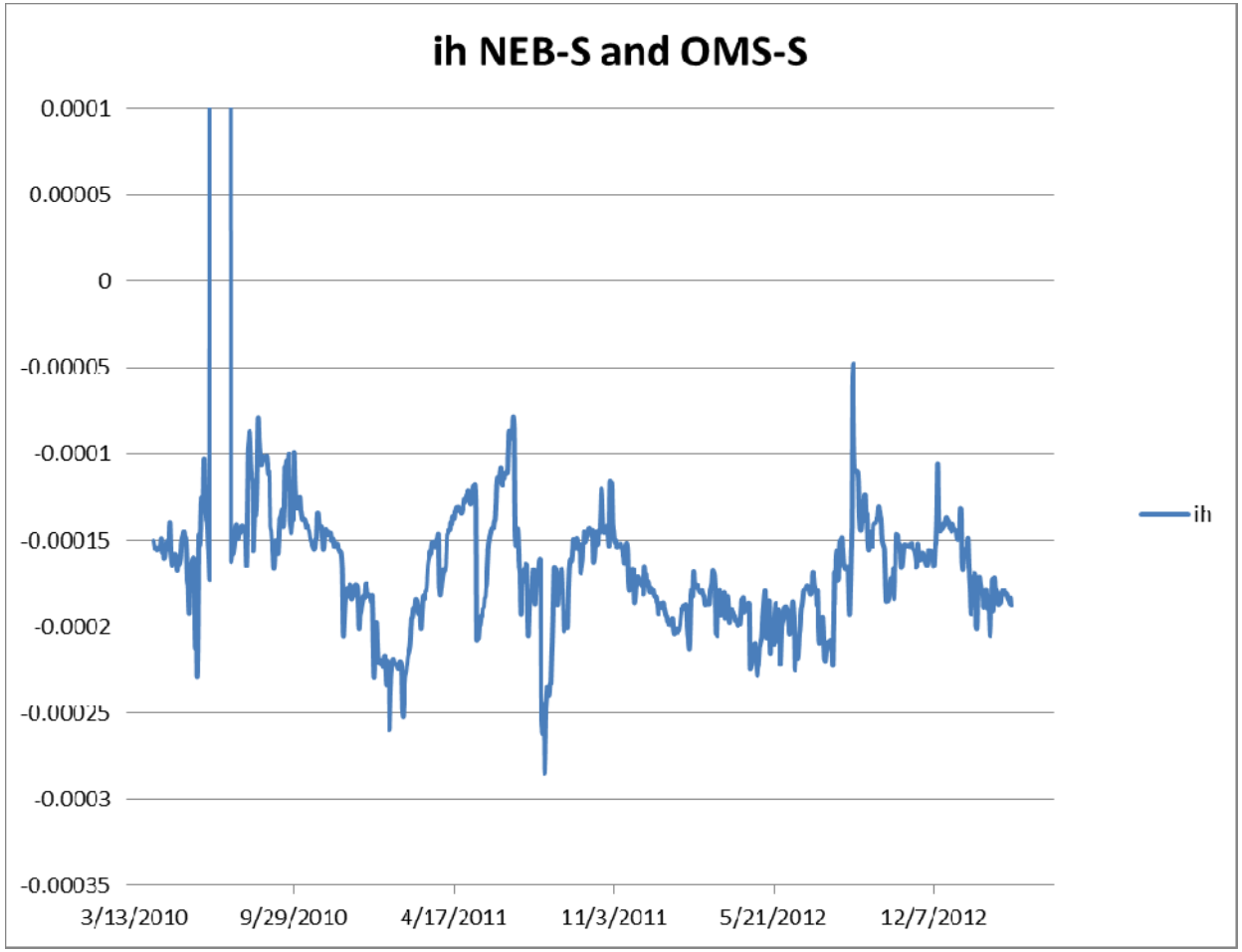
C18P-S and EB-S



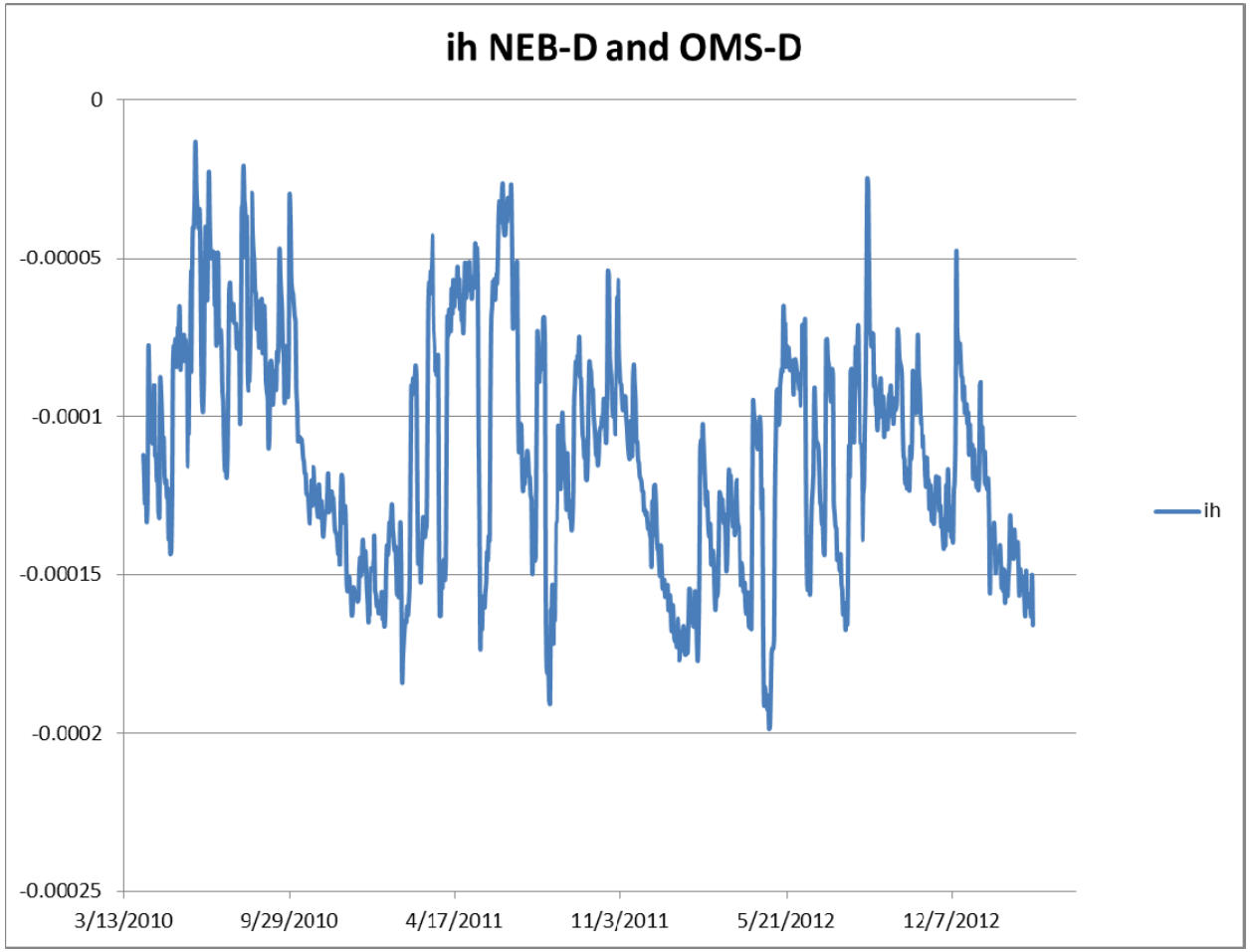
C18P-D and EB-D



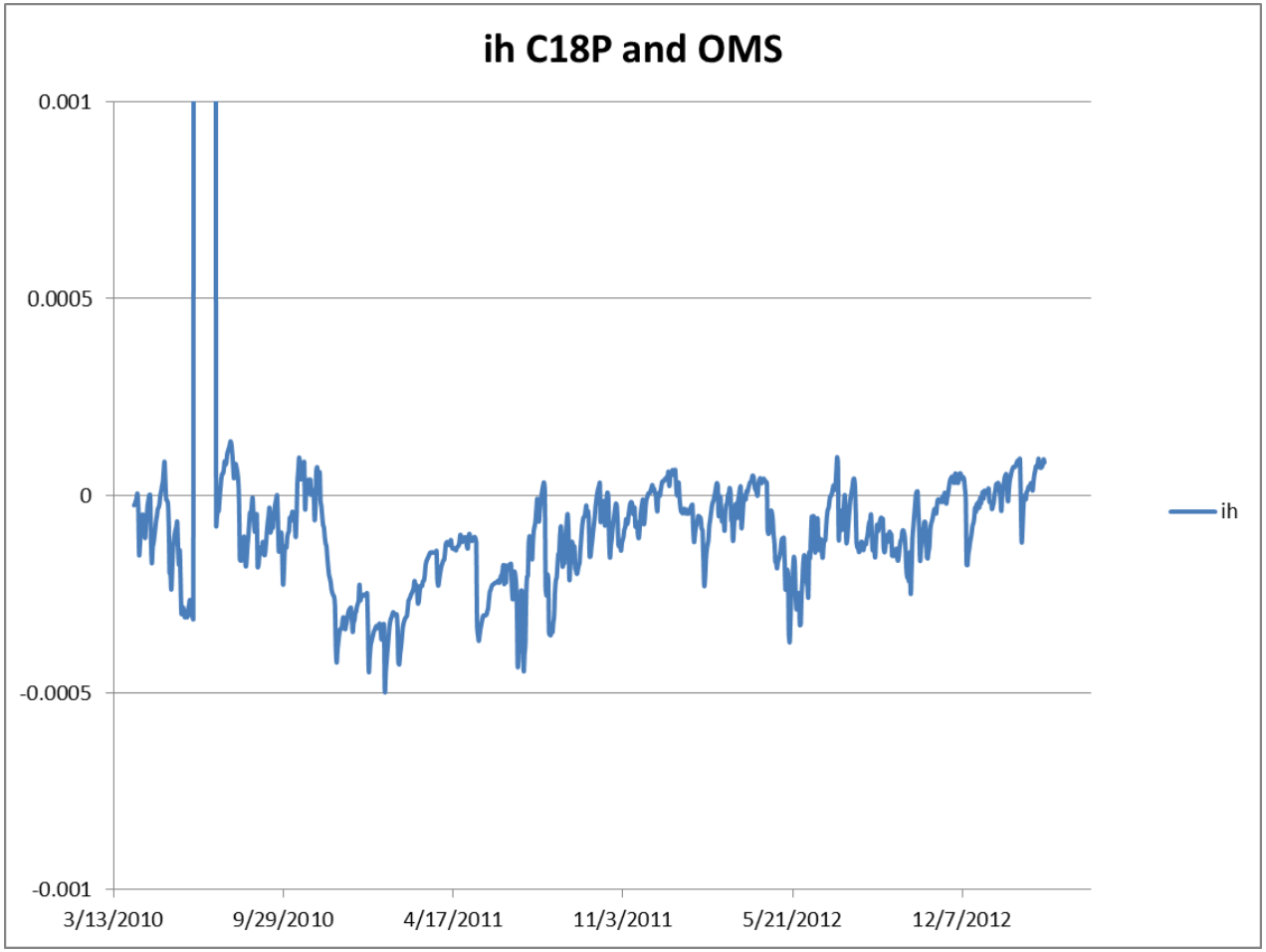
NEB-S and OMS-S



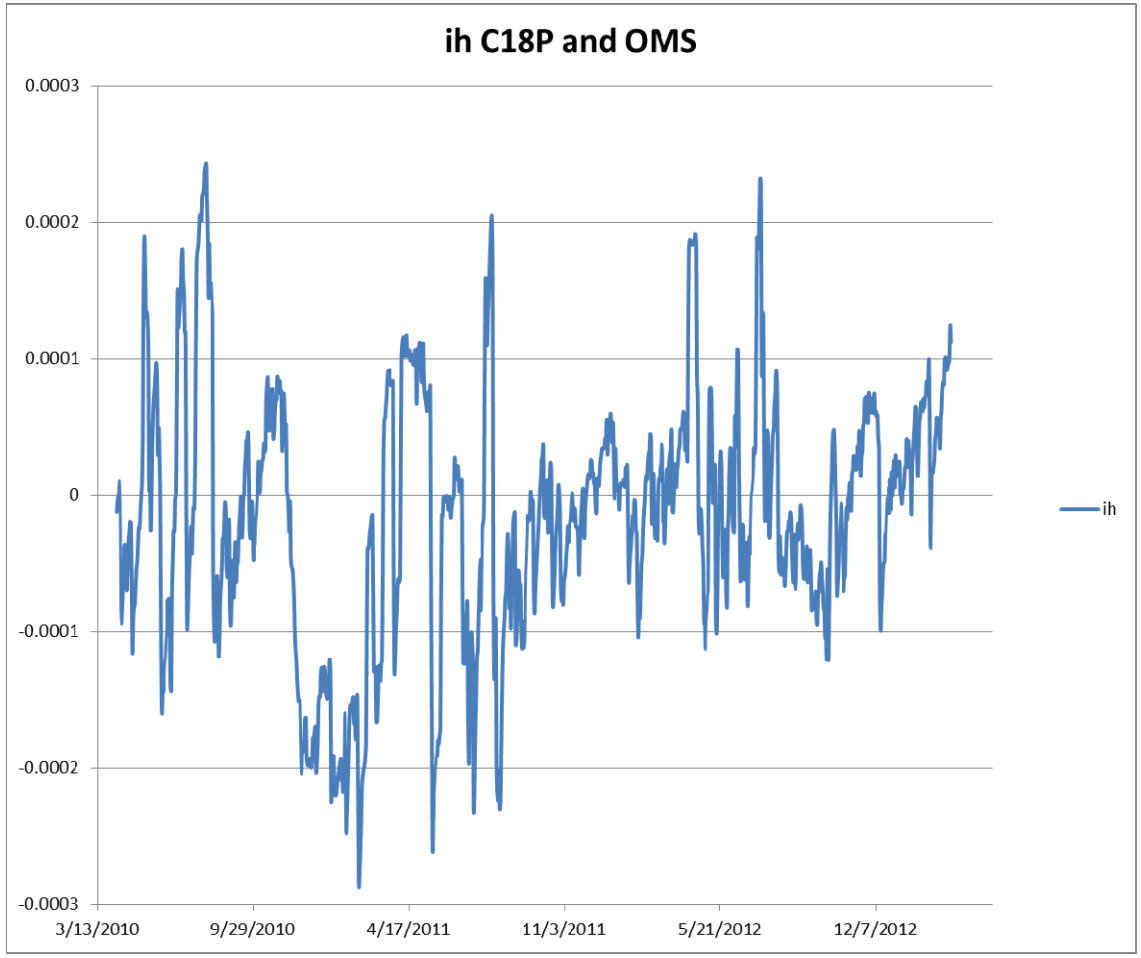
NEB-D and OMS-D



C-18P-S and OMS-S



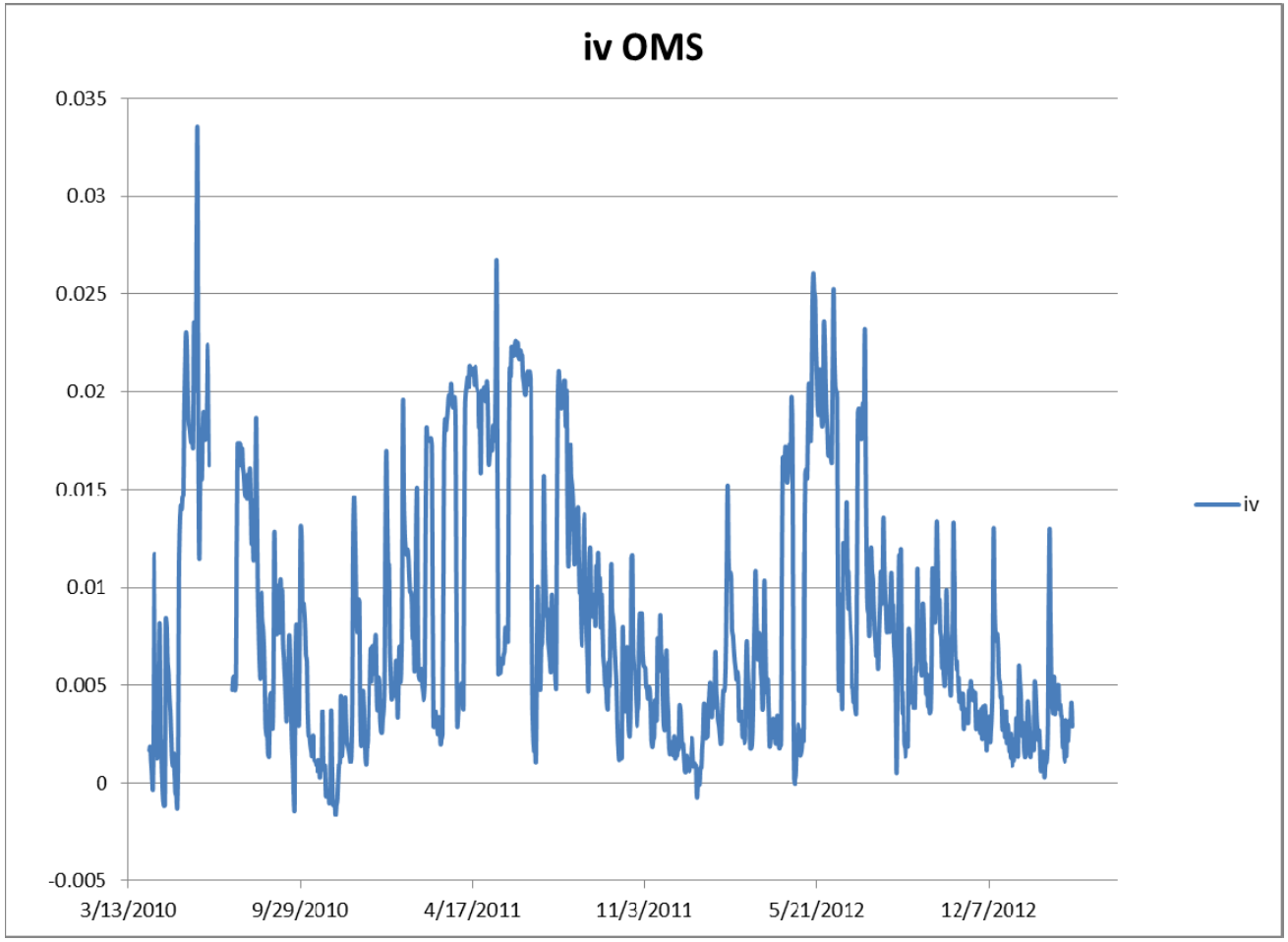
C18P-D and OMS-D



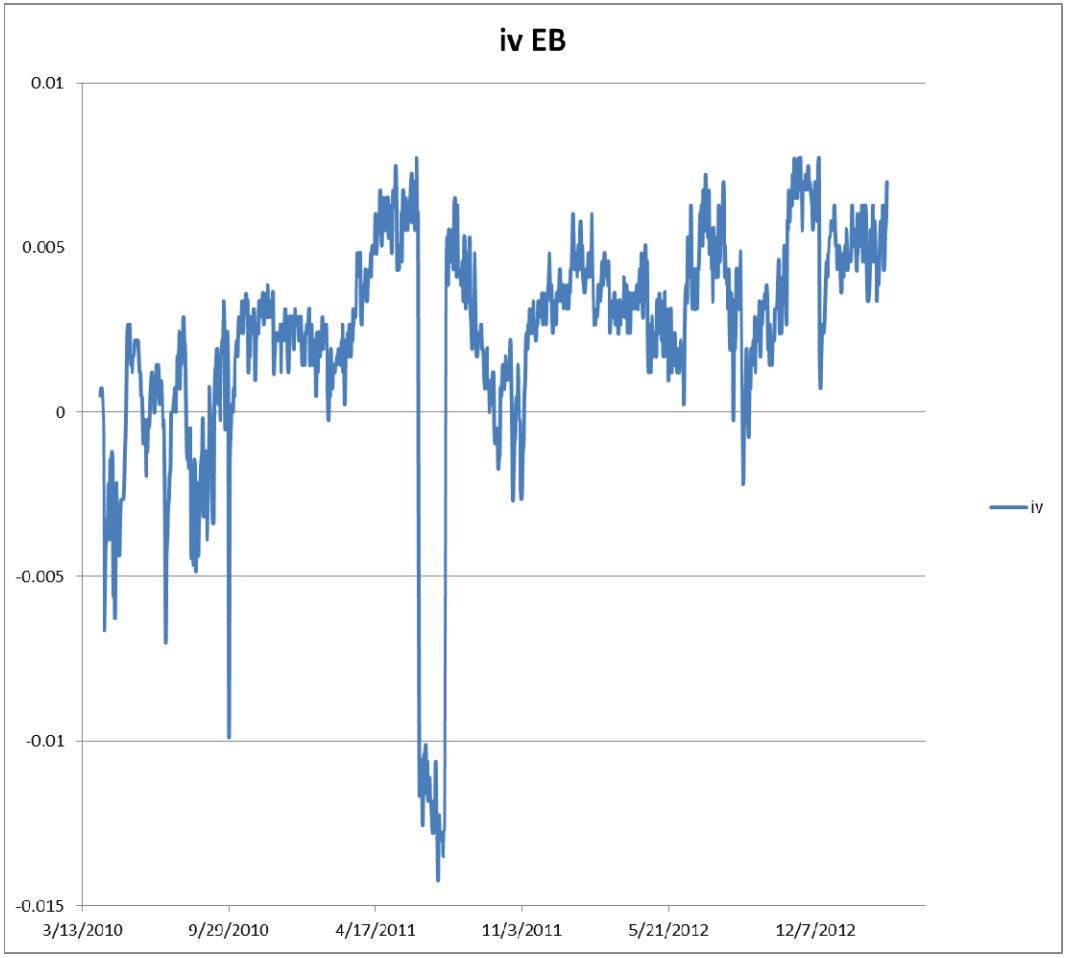
Vertical Gradient

iv =	the gradient (unitless)							
h1 =	hydraulic head at shallow location (ft NGVD)							
h2 =	hydraulic head at deeper location (ft NGVD)							
Δz =	vertical distance between top of shallower screen and top of deeper screen (ft)							
	iv =	$\frac{(h1 - h2)}{\Delta z}$						
A positive result indicates flow is downwards								

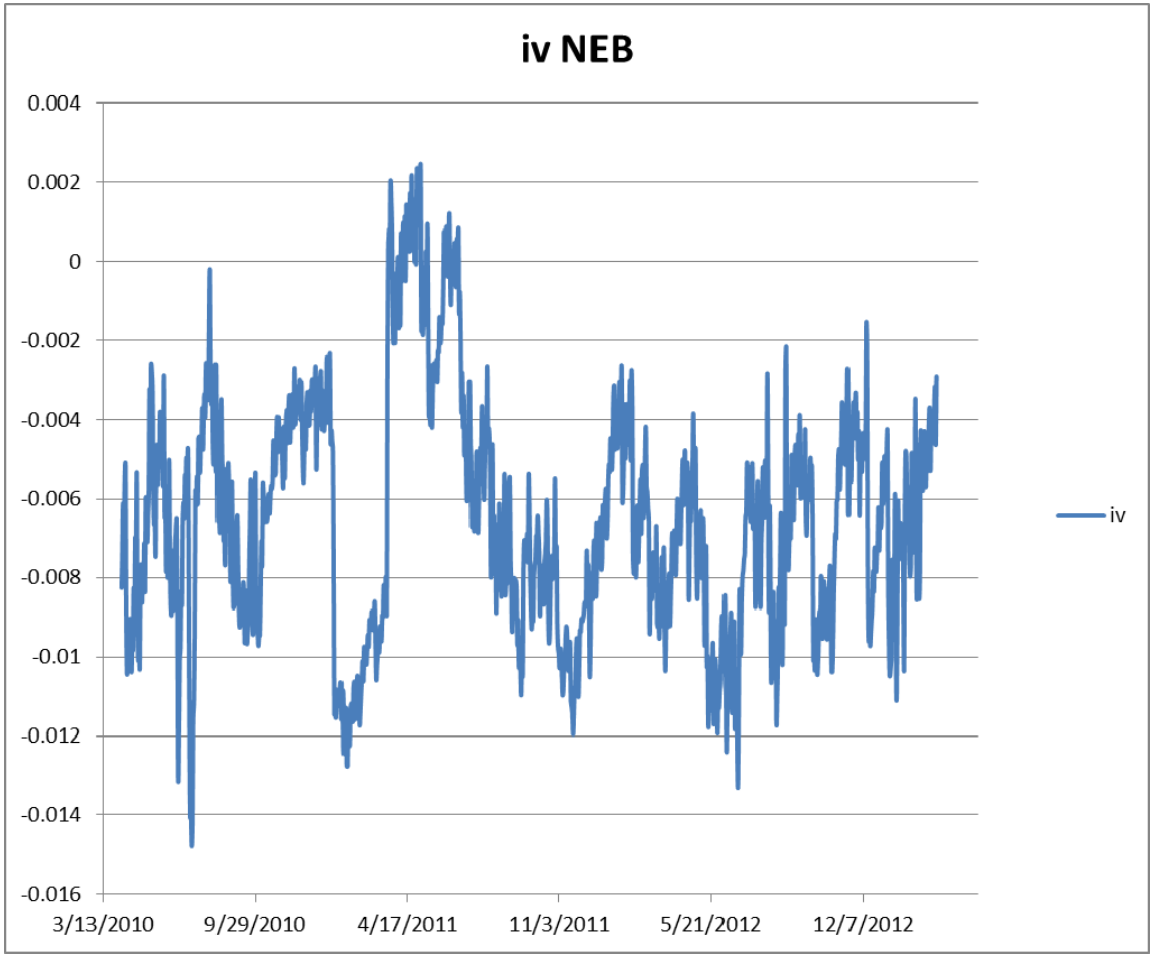
OMS


iv OMS
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
3/13/2010
9/29/2010
4/17/2011
11/3/2011
5/21/2012
12/7/2012
iv

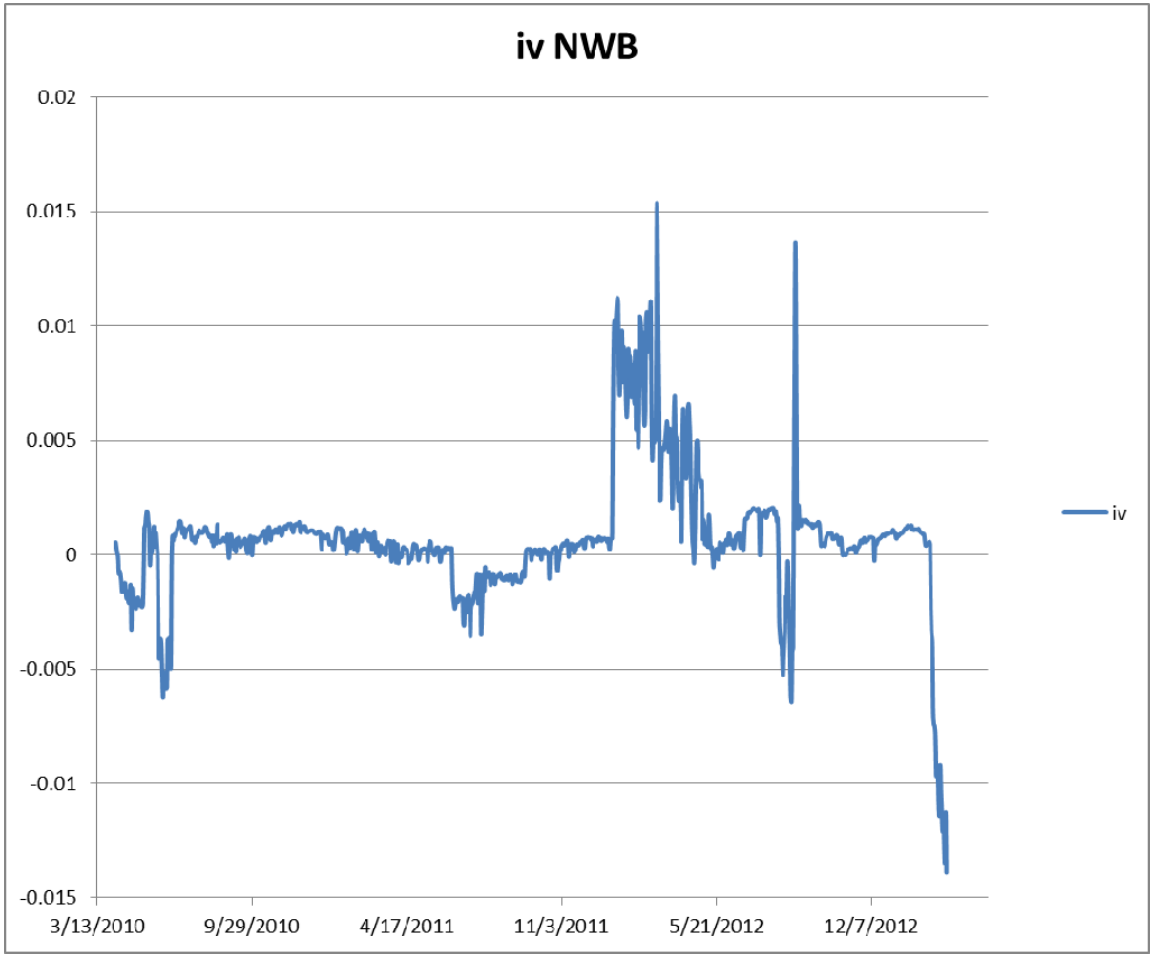
EB


iv EB
0.01
0.005
0
-0.005
-0.01
-0.015
3/13/2010
9/29/2010
4/17/2011
11/3/2011
5/21/2012
12/7/2012
iv

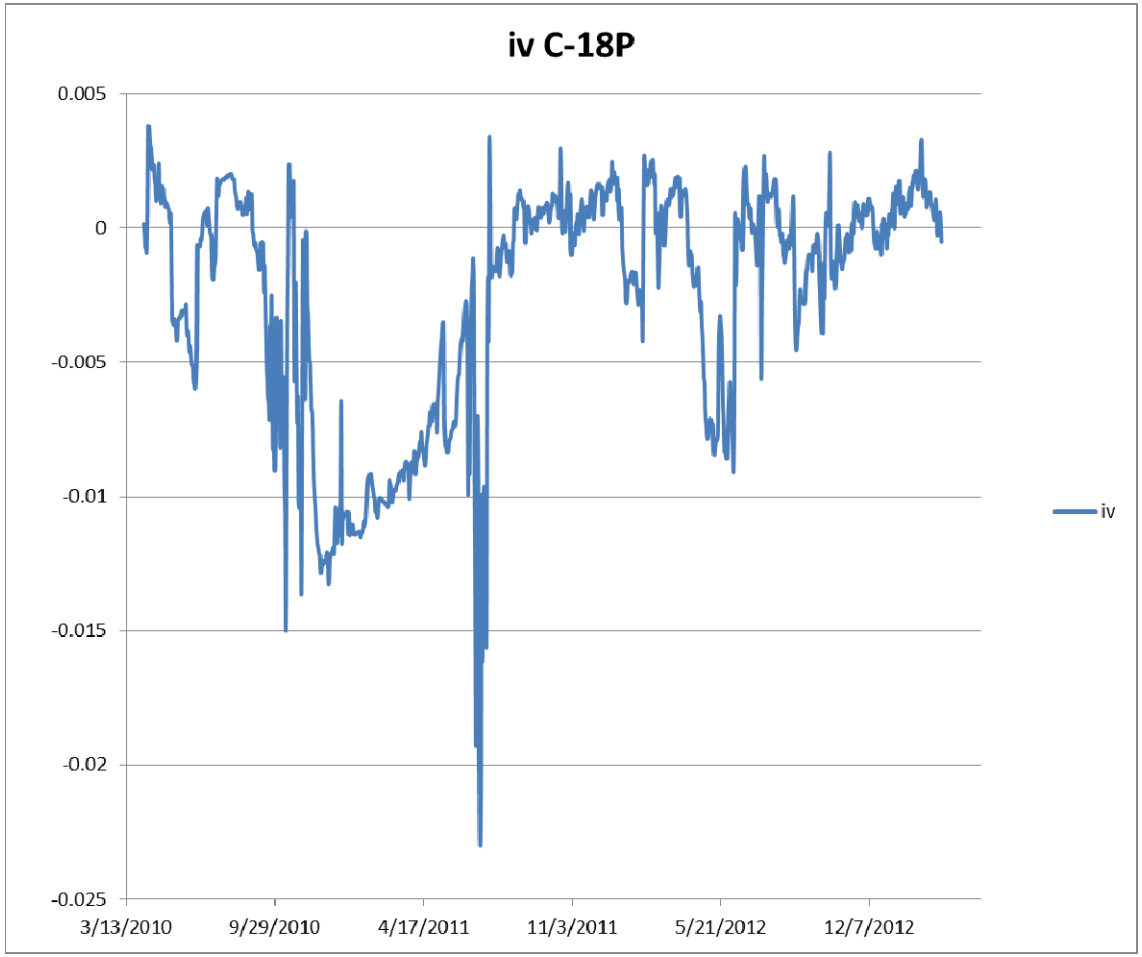
NEB


iv NEB
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
-0.01
-0.012
-0.014
-0.016
3/13/2010
9/29/2010
4/17/2011
11/3/2011
5/21/2012
12/7/2012
iv

NWB

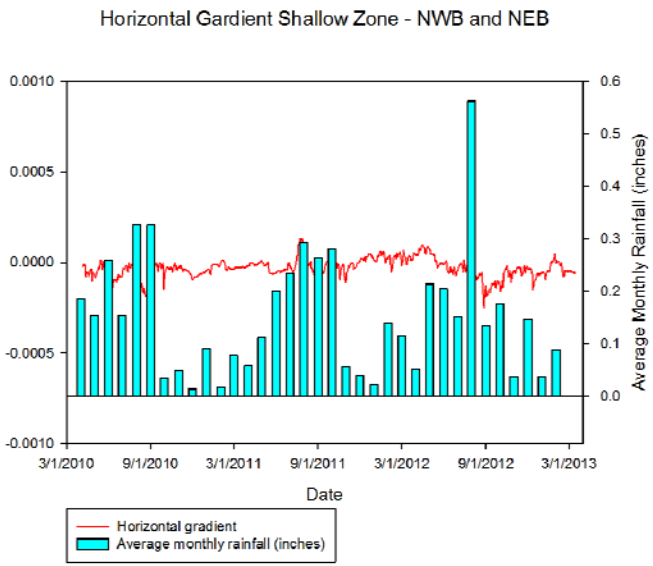

iv NWB
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
3/13/2010
9/29/2010
4/17/2011
11/3/2011
5/21/2012
12/7/2012
iv

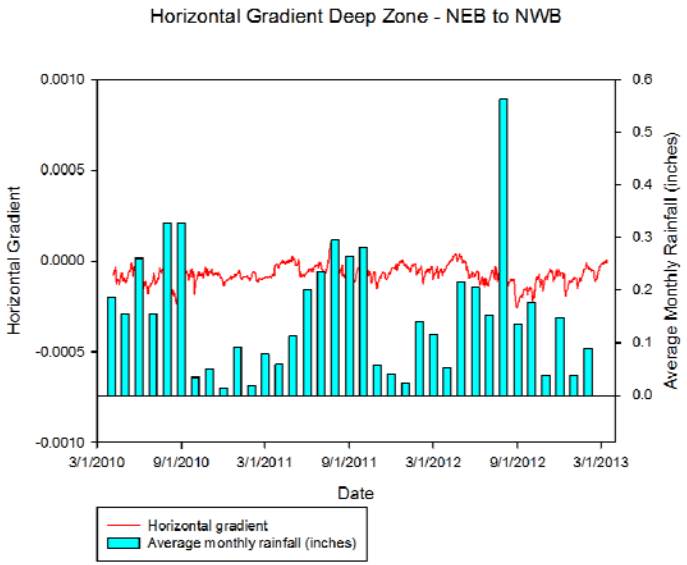
C-18P


iv C-18P
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
3/13/2010
9/29/2010
4/17/2011
11/3/2011
5/21/2012
12/7/2012
iv

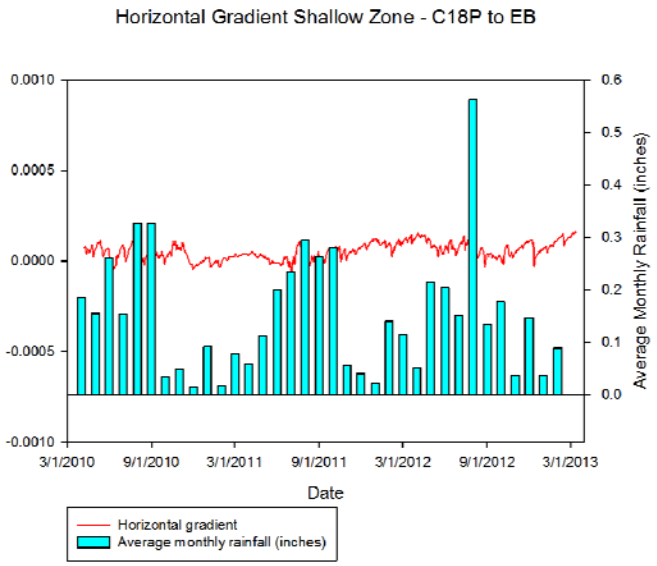
Average Monthly Rainfall and Horizontal Gradients

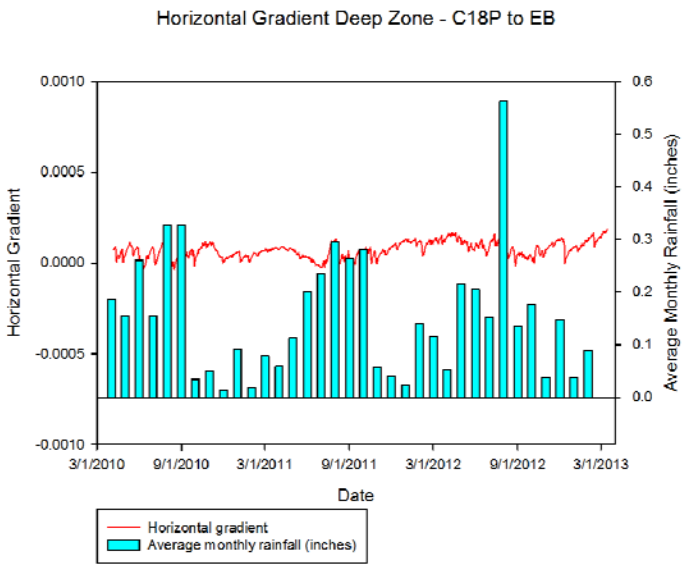
NWB and NEB


Horizontal Gardient Shallow Zone - NWB and NEB
0.0010
0.0005
0.0000
-0.0005
-0.0010
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Average Monthly Rainfall (inches)
3/1/2010
9/1/2010
3/1/2011
9/1/2011
3/1/2012
9/1/2012
3/1/2013
Date
Horizontal gradient
Average monthly rainfall (inches)

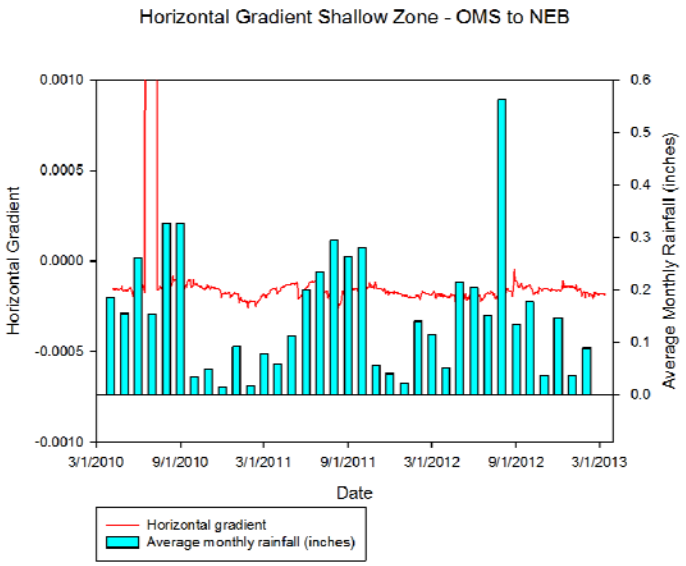

Horizontal Gradient Deep Zone - NEB to NWB
Horizontal Gradient
0.0010
0.0005
0.0000
-0.0005
-0.0010
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Average Monthly Rainfall (inches)
3/1/2010
9/1/2010
3/1/2011
9/1/2011
3/1/2012
9/1/2012
3/1/2013
Date
Horizontal gradient
Average monthly rainfall (inches)

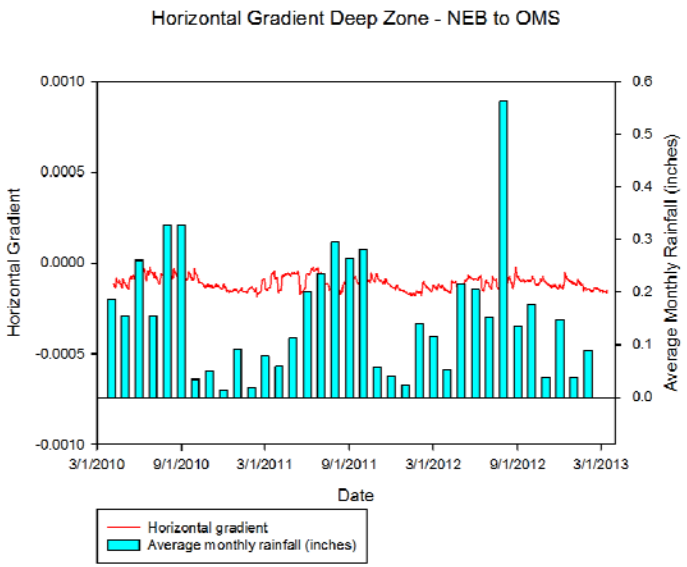
C18P and EB


Horizontal Gradient Shallow Zone - C18P to EB
0.0010
0.0005
0.0000
-0.0005
-0.0010
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Average Monthly Rainfall (inches)
3/1/2010
9/1/2010
3/1/2011
9/1/2011
3/1/2012
9/1/2012
3/1/2013
Date
Horizontal gradient
Average monthly rainfall (inches)

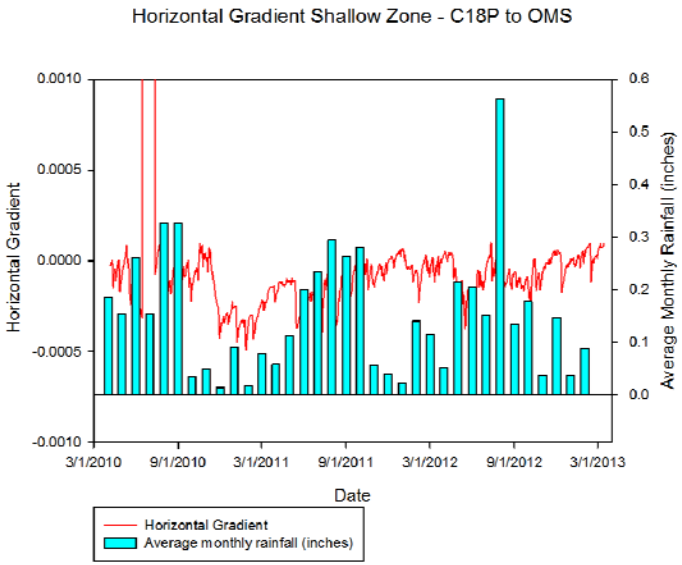

Horizontal Gradient Deep Zone - C18P to EB
Horizontal Gradient
0.0010
0.0005
0.0000
-0.0005
-0.0010
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Average Monthly Rainfall (inches)
3/1/2010
9/1/2010
3/1/2011
9/1/2011
3/1/2012
9/1/2012
3/1/2013
Date
Horizontal gradient
Average monthly rainfall (inches)

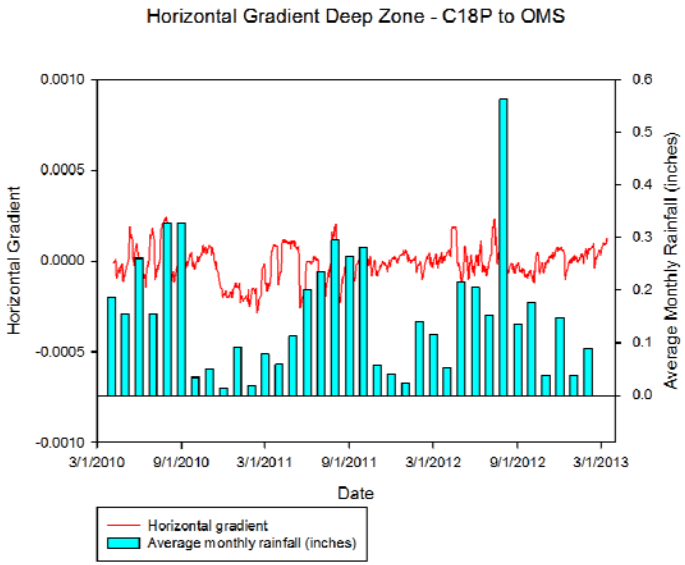
NEB and OMS


Horizontal Gradient Shallow Zone - OMS to NEB
Horizontal Gradient
0.0010
0.0005
0.0000
-0.0005
-0.0010
Average Monthly Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3/1/2010
9/1/2010
3/1/2011
9/1/2011
3/1/2012
9/1/2012
3/1/2013
Date
Horizontal gradient
Average monthly rainfall (inches)


Horizontal Gradient Deep Zone - NEB to OMS
Horizontal Gradient
0.0010
0.0005
0.0000
-0.0005
-0.0010
Average Monthly Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3/1/2010
9/1/2010
3/1/2011
9/1/2011
3/1/2012
9/1/2012
3/1/2013
Date
Horizontal gradient
Average monthly rainfall (inches)

C18P and OMS


Horizontal Gradient Shallow Zone - C18P to OMS
Horizontal Gradient
0.0010
0.0005
0.0000
-0.0005
-0.0010
Average Monthly Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3/1/2010
9/1/2010
3/1/2011
9/1/2011
3/1/2012
9/1/2012
3/1/2013
Date
Horizontal Gradient
Average monthly rainfall (inches)


Horizontal Gradient Deep Zone - C18P to OMS
Horizontal Gradient
0.0010
0.0005
0.0000
-0.0005
-0.0010
Average Monthly Rainfall (inches)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3/1/2010
9/1/2010
3/1/2011
9/1/2011
3/1/2012
9/1/2012
3/1/2013
Date
Horizontal gradient
Average monthly rainfall (inches)