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FINAL TECHNICAL MEMORANDUM RECONNAISSANCE PHASE FLOW CONTROL PILOT STUDY AT OPERABLE UNIT 1 (OU 1) NAS PENSACOLA FL
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TETRA TECH

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Technical Memorandum

Reconnaissance Phase Flow Control Pilot Study Operable Unit 1

Naval Air Station Pensacola
Pensacola, Florida

Contract Task Order 0067

September 2009

Naval Facilities Engineering Command
NAVFAC SOUTHEAST

NAS Jacksonville
Jacksonville, Florida 32212-0030

TETRA TECH NUS, Inc.

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TECHNICAL MEMORANDUM

for

RECONNAISSANCE PHASE FLOW CONTROL PILOT STUDY
OPERABLE UNIT 1

NAVAL AIR STATION
PENSACOLA, FLORIDA

Submitted to:
Naval Facilities Engineering Command
Southeast
Naval Air Station
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Contract Number N62467-04-D-0055
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EXECUTIVE SUMMARY

Tetra Tech NUS, Inc. (TtNUS) has prepared this technical memorandum (memo) for the Reconnaissance Phase Flow Control Pilot Study for Wetland 3 at Naval Air Station (NAS) Pensacola, Florida. This Pilot Study is being conducted as specified in the revised Optimization Study for Operable Unit (OU) 1, which was prepared by TtNUS and dated May 2006. This memo was prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62467-04-D-0055, Contract Task Order (CTO) 0067.

The proposed action for flow control at Wetland 3 primarily involves the blocking the culvert that connects Wetland 3 and Wetland 4D. The purpose of the culvert blocking would be to effectively isolate Wetland 3 from Wetland 4D, thereby protecting Wetland 4D by creating an infiltration area within Wetland 3 for the groundwater and surface water previously discharging to Wetland 4D through the culvert.

This memo summarizes the reconnaissance data collection activities to date and evaluates the data to determine the effect of blocking the culvert and to improve the understanding of the connection between shallow groundwater and surface water in the Wetland 3 and 4D area.

Based on an analysis of regional surface water and groundwater interaction, it has been determined that groundwater discharge to Wetland 3 will continue unless the surface water level in Wetland 3 can be increased to an elevation that causes localized flooding. At that elevation, the surface water in Wetland 3 will receive and lose flow to the groundwater at the same time, i.e., groundwater will discharge to Wetland 3 from the southeastern side, and the surface water in Wetland 3 will discharge to groundwater at the northeastern side. This analysis suggests that the proposed infiltration area cannot be created within Wetland 3 because of the persistent upward groundwater flow direction determined by high regional groundwater elevations. Therefore, blocking the culvert is not a viable approach.

The proposed flow control study was based on the overall assumption that the primary hydraulic connection between Wetland 3 and Wetland 4D is the culvert. During field sampling, it has been observed that the water in the culvert seems to be “stagnant,” which indicates that the flow rate may be low and that the overall assumption may not be true. However, the measured water depth and flow velocity data at the culvert entrance suggest significant flow through the culvert. Therefore, it has been determined, based on the data collected to date, that the culvert is the primary hydraulic connection between Wetlands 3 and 4D. It should be noted that if other hydraulic connections exist, blocking the culvert may not completely isolate Wetland 3 from Wetland 4D hydraulically, thus the contaminated water in Wetland 3 may still impact the water in Wetland 4D.

Review of the Site 41 Remedial Investigation (RI) Report (which included all wetlands in NAS Pensacola) suggests that iron concentrations in sediment and surface water in Wetland 3 and 4D do not likely pose unacceptable risks to human health or the environment. Review of the Site 41 RI sample data indicates that elevated iron concentrations are observed site wide and have significant spatial and temporal variations. Based on this information and a re-evaluation of the background calculation method used in the Site 41 RI, new site-specific iron background concentrations were developed using the statistical methods recommended in the Navy's guidance document, Procedural Guidance for Statistically Analyzing Environmental Background Data, and the guidance of Florida Department of Environmental Protection (FDEP) for background assessment.

A strategy for addressing the elevated iron concentrations at Wetlands 3 and 4D was then developed to ensure protection of the surface water in Wetland 4D and in Bayou Grande. Establishment of a point of compliance (POC) sampling location that represents surface water quality in Wetland 4D is proposed, and the newly developed site-specific background iron concentration is recommended as the alternative criterion for iron in surface water at the POC. Monitoring of surface water on an annual basis at the POC is recommended to ensure protection of the surface water body.

1.0 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS) has prepared this technical memorandum (memo) for the Operable Unit (OU) 1 located at Naval Air Station (NAS) Pensacola, Florida. This memo summarizes the reconnaissance phase flow control pilot study and evaluates the data collected to evaluate the feasibility of implementing flow control at Wetland 3. This memo was prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62467-04-D-0055, Contract Task Order (CTO) 0067.

2.0 BACKGROUND

OU 1, also referred to as Site 1 – the Sanitary Landfill, includes the former sanitary landfill and the surrounding area (Figure 1). The site is bordered on the north by an estuary of Pensacola Bay named Bayou Grande, by the Navy's A. C. Reed Golf Course to the east, by Navy property covered with vegetation to the west, and by the Barrancas Cemetery to the south. Shallow groundwater seeps and surface water runoff at OU1 are directed primarily into multiple wetlands located along the perimeter of the site – primarily to Wetland 3 and subsequently to Wetland 4D.

Wetland 3, located on the northeastern side of OU1, receives shallow groundwater and surface water runoff from the site and is primarily fed by a visible seep at the northern end of the wetland. Wetland 3 is bordered by OU1 to the north, south, and west, and by the John Tower Road and the golf course to the east. As reported in the Site 41 Remedial Investigation (RI) Report (EnSafe, 2005), a narrow surface water channel in this wetland is approximately 4 inches deep and 1 to 2 feet wide. The remaining Wetland 3 area is from 3 to 500 feet wide with relatively flat topography and consists of saturated sediment drained by a narrow and shallow stream. The lower section of this wetland flows into a drainage culvert that discharges into Wetland 4D. This culvert runs east under John Tower Road and a golf course fairway prior to discharging into Wetland 4D. Estuarine Wetland 4D is an open water body surrounded by the golf course and fed by Wetland 3 from the west and by Wetland 4C from the south. Wetland 4D discharges north into Bayou Grande through a culvert beneath an unnamed dirt road. The open water portion of Wetland 4D ranges from 1 foot to approximately 8 feet deep and has a maximum width of approximately 700 feet.

Sediment in most of Wetland 3 is highly organic, with total organic carbon (TOC) measured at up to 24 percent. The shallow open water portion contains several freshwater vegetative species such as lizard tail and cattails. The area surrounding the wetland consists of vegetation such as pine trees, oak trees, and other species. Sediment in Wetland 4D is sandy, with TOC measured at up to 7 percent. The steep topographic gradient surrounding this wetland makes the transition from upland to open water clearly visible. Vegetation surrounding Wetland 4D includes both mowed grass and tall grasses, with a small stand of pine trees and a small area of spartina at its northwestern corner. The presence of mowed grass around a portion of this wetland limits its potential to provide habitat for most species.

The final Record of Decision (ROD) for OU1 was issued on August 19, 1998 (EnSafe, 1998). One of the three Remedial Action Objectives (RAOs) is to prevent further contamination of surface water in Wetland 3. Because groundwater migrates away from the landfill and discharges into Wetland 3, the selected remedy in response to this RAO includes the construction and implementation of a groundwater interception trench system (ITS) for the treatment of iron-contaminated groundwater. However, as reported in the Optimization Study Report (TtNUS, 2008), monitoring data suggest that although the ITS may contribute to reducing the iron concentrations in shallow groundwater, it is not having an appreciable effect on iron concentrations in Wetland 3 surface water. Although performance evaluation for the ITS indicates that the designed system is insufficient to capture and extract all of the iron-contaminated groundwater, elevated iron concentrations in the wetland may also be attributed to naturally occurring site-wide high iron concentrations in groundwater and surface water.

3.0 PURPOSE OF FLOW CONTROL STUDY

In response to the NAS Pensacola Partnering Team discussions on the status of the Optimization Study Report and remedy for OU1, a pilot study was proposed to evaluate the effectiveness and impacts of blocking the culvert that connects Wetland 3 and 4D. The intent of blocking the culvert would be to effectively isolate Wetland 3 from Wetland 4D, thereby protecting Wetland 4D by creating an infiltration area within Wetland 3 for groundwater and surface water previously discharging to Wetland 4D through the culvert. The primary purpose of the Pilot Study was to determine if blockage of the culvert would be effective in creating this infiltration gallery in Wetland 3. In addition, the Pilot Study also evaluated whether blocking the culvert would cause detrimental effects such as localized flooding in Wetland 3 or the surrounding area.

The proposed method for blocking the culvert is a flow control device, which will prevent water from discharging into Wetland 4D utilizing a bladder control system. In the event of heavy rainfall and flooding of Wetland 3, the device will allow water to discharge through the pipe into Wetland 4D to prevent flooding over the road. After the water level drops below flood stage, the bladder will automatically close and prevent water from discharging into Wetland 4D.

The objectives of the overall Pilot Study were as follows:

- Determine the effect of blocking the culvert that connects Wetland 3 to Wetland 4D.
- Provide data to evaluate the connection between shallow groundwater and surface water in the Wetland 3 and 4D area.

4.0 RECONNAISSANCE DATA COLLECTION

Reconnaissance data collected to meet the objectives of the Pilot Study, as discussed below, included the following:

- Topographic data
- Surface water level data
- Shallow groundwater elevation data
- Groundwater sampling data
- Precipitation and flow data
- Soil permeability data

4.1 Topographic Data

Detailed topography survey data were collected to generate a topographic map of the OU 1 seep area, Wetland 3, and the culvert that connects Wetland 3 to Wetland 4D. The survey covered the area of Wetland 3 and extended into Wetland 4D. The topographic survey map is presented in Attachment A. The survey data were used to determine the storage capacity of the area upgradient of the Wetland 3/4D connecting culvert and to assist the generation of the groundwater potentiometric surface map.

4.2 Surface Water Level Data

Three staff gauges were installed in Wetlands 3 and 4D to monitor surface water levels over time. Contributions to fluctuations in surface water levels include runoff from storm events and recharge from the primary OU1 Wetland 3 seep (and possibly other seeps in Wetland 3). The relationship between precipitation, seep recharge, and flow rates through the culvert between Wetlands 3 and 4D and surface water levels was determined by the partnering team to be a critical element in the Pilot Study design. The staff gauge SG-01 was located at the main seep in Wetland 3, SG-02 was located near the inlet (upgradient side) of the Wetland 3/4D culvert, and SG-03 was located near the outlet of the culvert and at the water edge of Wetland 4D. The staff gauge locations are shown on Figure 2.

The staff gauges are equipped with automated data loggers set to record continuous levels, and data readings are taken every 10 minutes. Surface water level data collection began on April 1, 2008, and is continuing as of January 2009. Manual measurements of water levels were also obtained during April and May 2008. The manual measurement data are presented in Table 1.

4.3 Shallow Groundwater Elevation Data

To determine the relationship between shallow groundwater and surface water in the Wetlands 3 and 4D area, a total of six piezometers with data loggers, three on each side of the main surface flow path in the wetlands, were installed. 01PZ101 and 01PZ102 were installed near the main seep, to the northeast and southwest of SG-01. 01PZ103 and 01PZ104 were installed near the inlet of the culvert, southeast and southwest of SG-02. 01PZ105 and 01PZ106 were installed downgradient of the culvert, near the southern extent of water in Wetland 4D.

Automated data loggers were installed in the piezometers to obtain time-specific data to compare with staff gauge and precipitation data. Similar to the staff gauges, this data collection method was designed primarily for the use in conjunction with the Pilot Study implementation phase after the culvert flow control device is installed.

The piezometer locations are shown on Figure 2, and manually measured piezometer water level data collected on April 1, April 22, and May 29, 2008, are presented in Table 1.

4.4 Groundwater Sampling Data

To evaluate iron concentrations in shallow groundwater and to determine whether the iron concentrations in surface water could be affected by the groundwater discharge, groundwater samples were collected at the piezometers and staff gauges and analyzed for iron. After sampling, the samples were immediately placed in iced coolers and submitted to the laboratory under chain of custody to be analyzed for total iron. The groundwater samples were collected and handled in accordance with TtNUS Standard Operating Procedure (SOP) SA-1-1, Groundwater Sample Acquisition and Onsite Water Quality Testing. The iron data are presented in Attachment B.

4.5 Precipitation and Flow Data

A flow gauge was placed at the inlet of the Wetland 3/4D culvert, and flow velocity and water depth at the inlet were recorded. Using these measurements, the flow rate through the culvert was calculated, which can be used to evaluate the feasibility of blocking the culvert in terms of the required storage capacity of Wetland. The flow rate was 225.14 gallons per minute (gpm) on average, with a maximum of 900.55 gpm and a minimum of 108.07 gpm. The recorded flow data and the flow rate calculation are included in Attachment C.

Localized precipitation data were also collected by an automatic data logger to evaluate the relationship of flow rate to precipitation. The data show that flow velocities are closely related to precipitation.

4.6 Soil Permeability Data

Shallow soil samples were collected at four piezometer locations (Figure 2) within Wetland 3 to evaluate the potential for infiltration. ST-01 was collected at the location of 01PZ101, ST-02 was collected at 01PZ102, ST-03 was collected at 01PZ103, and ST-04 was collected at 01PZ104. The soil samples were collected from the soil horizon directly below the uppermost organic layer. Using a drilling rig, 3-inch-diameter Shelby tubes were advanced to collect a sample from each location. Upon retrieval, the ends of the tubes were capped and sealed, and the samples were shipped for permeability testing. The average vertical permeability in Wetland 3 was 1.3E-4 centimeters per second (cm/s). The laboratory permeability testing report is included as Attachment D.

5.0 ASSESSMENT OF THE FEASIBILITY OF FLOW CONTROL

The feasibility of flow control in Wetland 3, i.e., blocking the connecting culvert between Wetlands 3 and 4D, was evaluated based on the analysis of surface water and groundwater interaction in Wetland 3 and the surrounding area.

5.1 General Groundwater and Surface Water Interaction Patterns

From the perspective of the hydrologic cycle, surface water interacts with groundwater in three basic ways, as shown on Figure 3 (USGS, 1998): (A) surface water gains water from inflow of groundwater through the waterbed, (B) surface water loses water to groundwater by outflow through the waterbed, or (C) surface water receives and loses groundwater at the same time.

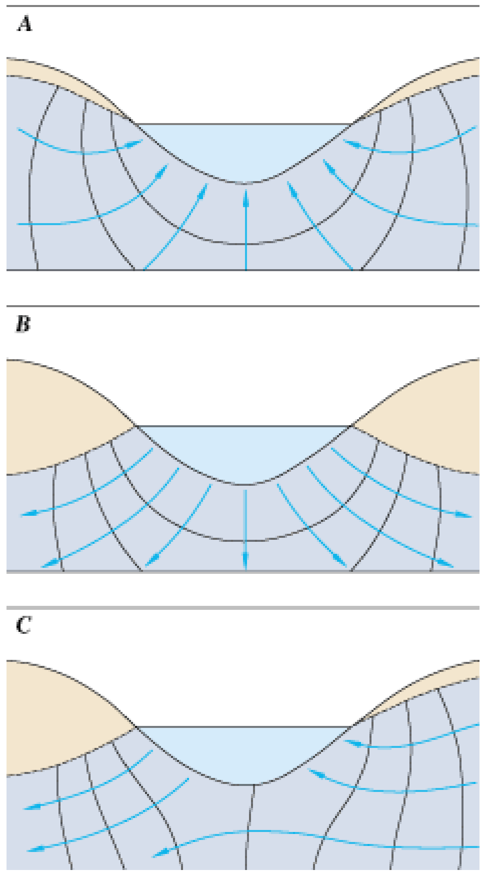

Figure 3 Surface water receives groundwater inflow (A), loses water as seepage to ground water (B), or both (C) (adapted from USGS, 1998)

Figure 3 Surface water receives groundwater inflow (A), loses water as seepage to ground water (B), or both (C) (adapted from USGS, 1998)

As can be seen from this figure, a gaining situation (Figure 3A) occurs when the surrounding groundwater level is higher than the surface water level, and a losing situation (Figure 3B) occurs when the surface water level is higher. The surface water body can also partially gain flow and lose flow at the same time, as shown on Figure 3C.

5.2 Current Groundwater and Surface Water Interaction Pattern in Wetland 3 Area

Based on the staff gauge and piezometer water elevation data in Table 1, Wetland 3 groundwater currently discharges to surface water. On two sides of the flow path, groundwater elevations at the six newly installed piezometers, located on the sides of the main stream path, are approximately 0.8 to 2 feet higher than the surface water levels measure in the staff gauges located along the main stream path in the wetland.

A shallow groundwater potentiometric surface map for the entire OU1 area (Figure 4) was generated to evaluate groundwater flow directions using the reconnaissance data (average of manual measurements in April 2008) and historical water level data (Table 2). Similar to what has been identified in previous studies, the groundwater at OU1 generally flows north toward Bayou Grande. The reconnaissance data show that in Wetland 3 and the surrounding area, groundwater either flows toward Wetland 4D directly or discharges to Wetland 3 first and then flows into Wetland 4D. Two cross sections perpendicular to the main stream path in Wetland 3 were generated to show the groundwater-surface water interaction pattern in Wetland 3. Cross section A-A’ (Figure 5) was located near the inlet of the culvert, and cross section B-B’ (Figure 6) was located in the center area of Wetland 3. The current water table shown on the cross sections clearly illustrates that the groundwater surface water interaction pattern in the Wetland 3 area is pattern (A) on Figure 3, i.e., surface water receives inflow from groundwater.

5.3 Feasibility of Flow Control

The purpose of the proposed flow control (blocking the culvert) is to hydraulically disconnect Wetland 3 and 4D by creating an infiltration area in Wetland 3. Currently, the stream in Wetland 3 receives water from surface water runoff, groundwater seeps, and precipitation. The stream flows into Wetland 4D primarily through the connecting culvert. Therefore, if the culvert is blocked, the amount of water previously transported through will be stored in Wetland 3. For Wetland 3 to reach a steady water level without creating localized flooding, the amount of water currently discharging to Wetland 4D must be transferred to groundwater through seepage. Because of the current groundwater-surface water interaction pattern, the feasibility of the proposed flow control method is dependant on whether the current gaining situation can be reversed and a losing situation can be created, i.e., whether a downward groundwater flow direction can be created.

Examination of groundwater flow conditions in the area (Figure 4) indicates that a losing situation cannot be created at the wetland without causing localized flooding. As shown on cross section A-A’, the maximum groundwater elevation in the northwestern portion of the area, approximately halfway between the culvert and Bayou Grande, is 7.07 feet above mean sea level. Southeast of the culvert, groundwater elevations increase with increasing distance from the culvert, and the maximum groundwater elevation along cross section A-A’ is at the southeastern end (8 feet above mean sea level). Based on these elevations, the gaining situation will persist in the cross section A-A’ area until the surface water level is increased to at least 7.07 feet. When the surface water elevation reaches this level, the groundwater-surface water interaction pattern will change, and although groundwater will still discharge to surface water in the southeastern portion of the wetland, surface water will lose flow to groundwater through the northeastern waterbed. However, because the lowest elevation of John Tower Road is about 6.45 feet, the road will be flooded before the pattern change. Note that the 7.07-foot elevation is only the minimum elevation needed to cause this change in groundwater surface-water interaction pattern. The stabilized water level in Wetland 3 may be even higher, depending on the regional groundwater flow in the OU1 area.

The feasibility of the proposed flow control method was also evaluated by predicting the shallow zone potentiometric surface assuming water depth in Wetland 3 can be increased to 5 feet. The value of 5 feet is used as the maximum allowable water depth in the wetland, considering seasonal variations, storm events, and safety factors. The predicted potentiometric surface is shown on Figure 8 and was obtained by assuming that groundwater elevations far away from the 5-foot contour would not be affected. Figure 8 shows that increasing the water depth to 5 feet cannot change the gaining situation. As shown on cross section A-A' and B-B', groundwater still discharges to Wetland 3, and the groundwater and surface flow in this area is still towards Wetland 4D. The longitudinal cross section C-C' (Figure 7) also shows that the stream would still flow toward Wetland 4D, only with a larger gradient downstream of the culvert. Because a losing situation cannot be created by raising the water depth to 5 feet, the 5-foot would just be a transient point if blocking the culvert. The water depth would keep increasing, and John Tower Road would be flooded before the water level reaches a steady point.

Based on the analysis of groundwater-surface water interaction patterns, it is clear that blocking the culvert is not feasible because an infiltration area cannot be created in Wetland 3 under a gaining condition. To account for possible uncertainties in water level measurements and potentiometric surface contouring the feasibility was furthered evaluated using a simplified infiltration calculation. This calculation assumes a steady and flat regional groundwater table, which arbitrarily makes downward infiltration possible. The area inside the 5-foot topographic contour is considered the storage area of Wetland 3. The most favorable conditions for a high infiltration flow rate were used in this calculation to test the possibility of blocking the culvert: the lowest surface water depth (2.85 feet), the highest vertical permeability value (1.2E-5 cm/s) measured within the 5-foot contour, and the minimum flow rate in the culvert were used. Based on the calculation, after the culvert is blocked, the water level would reach 5 feet in several days. The water level would keep increasing and stabilize at about 26 feet if the storage area (5-foot contour) is not increased, which means that Wetland 3 would be flooded horizontally, and the water would also flood the nearby road and golf course. The calculation details are provided in Attachment E.

This calculation highly simplified the flow system, and the assumption of a flat groundwater table is questionable; therefore, the detailed calculation results should not be used. The purpose of this calculation is only to show that even the groundwater flow direction can be reversed, the infiltration rate may still be insufficient to accommodate the blocked flow.

The proposed flow control study was based on the overall assumption that the primary hydraulic connection between Wetland 3 and Wetland 4D is the culvert. During field sampling, it has been observed that the water in the culvert seems to be “stagnant,” which indicates that the flow rate may be low and that the overall assumption may not be true. However, the measured water depth and flow velocity data at the culvert entrance suggest significant flow through the culvert. Therefore, it has been determined, based on the data collected to date, that the culvert is the primary hydraulic connection between Wetlands 3 and 4D. It should be noted that if other hydraulic connections exist, blocking the culvert may not completely isolate Wetland 3 from Wetland 4D hydraulically, thus the contaminated water in Wetland 3 may still impact the water in Wetland 4D.

6.0 CONCLUSIONS AND RECOMMENDATIONS FOR FLOW CONTROL PILOT STUDY

Based on the potentiometric surface maps and the simplified infiltrate rate calculation, the conclusions of the feasibility analysis are as follows:

- Groundwater currently discharges to surface water in Wetland 3.
- The groundwater-surface water interaction pattern cannot be changed unless the water level is increased to 7.07 feet at the inlet of the culvert. Water levels required for the upstream area would be even higher.
- Even if the water level can be sufficiently increased to change the current gaining situation, it is not clear whether a losing situation can be created in the area because of the high groundwater elevations southeast of the culvert. The high groundwater elevations will keep groundwater discharging to the surface water from the southeastern side.
- Considering the relatively low elevation of John Tower Road near the culvert, blocking the culvert would result in flooding over the road and golf course.

Based on these conclusions, it is recommended that no further flow control evaluation be conducted. It is recommended that automatic water level monitoring at the newly installed staff gauges and piezometers and the automatic precipitation recording be discontinued.

7.0 EVALUATION OF IRON CONCENTRATIONS AT WETLAND 3 AND 4D

The flow control study was conducted to evaluate methods of addressing elevated iron concentrations in Wetland 3. In the ROD for OU1, issued in 1998, one of the RAOs specifically related to iron contamination in Wetland 3 is “prevention of further contamination of surface water in Wetland 3”. In response to this RAO, the selected remedy is a groundwater interceptor trench system that was installed upgradient of a visible groundwater seep (Figure 2) and that treats the iron-contaminated groundwater. After the ROD, two rounds of optimization study were conducted for OU1 to evaluate site conditions and remedy performance (TtNUS 2004 and 2008). A related effort, the Site 41 RI, was conducted to investigate all of the wetlands at NAS Pensacola potentially impacted by site activities (EnSafe, 2007). This section summarizes the findings related to Wetland 3 and 4D from the studies mentioned above, and discusses a potential strategy for addressing elevated iron concentrations at Wetland 3/4D.

7.1 <u>Protection of Human Health and the Environment</u>

As a part of the Site 41 RI, a human health risk assessment (HHRA) and an ecological risk assessment (ERA) were performed for all of the wetlands in NAS Pensacola to investigate the potential adverse impact of constituents in wetland surface water and sediment on human and ecological receptors.

The HHRA and ERA were conducted using the RI data, which were collected in several phases. Phase I was conducted during August 1994 to investigate the wetlands of greatest concern and to determine sample locations for Phase II sampling. Phase II was conducted from November 1995 through January 1996 to further investigate the wetlands identified during Phase I, and Phase III was conducted in August and September 1997 to further characterize risk at the wetlands. Confirmation sampling (Phase IV) was conducted in 2001 and 2004 for Wetland 64 and Wetlands 5B, 6, 10, 15, 17, 19A, 63A, and 72, respectively. This sampling event was conducted to develop site-specific biota sediment accumulation factor for use in modeling mercury accumulation because fish were not analyzed for mercury during Phase III. Although mercury was the primary contaminant of concern (COC), the scope of Phase IV sampling was expanded to include pesticides/PCBs, SVOCs and metals.

Wetland 3

Wetland 3 is categorized as a fresh water wetland and was evaluated during Phases I through III of the RI. In Phase II, 10 sediment samples and 7 surface water samples were collected. In Phase III, two sediment samples and one surface water samples were collected.

The HHRA identified child trespassers and adult maintenance workers as the current and future potential receptors. For sediment and surface water, iron was not retained as a COC using the data from both phases because of no risk to the identified receptors, although some iron concentrations exceeded the background iron concentration for fresh water wetlands at NAS Pensacola (2,360 μg/L) established as part of the RI.

In the ERA, sediment concentrations were compared to United States Environmental Protection Agency (EPA) Region 4 sediment screening values (SSVs), threshold effect levels (TELs) from the Sediment Quality Assessment Guidelines (MacDonald, 1994), and facility background concentrations. For surface water, concentrations were compared to Florida Class III surface water standards (fresh waters and marine waters) and facility background concentrations. For iron, some Phase II iron concentrations exceeded the screening values mentioned above. Therefore, Phase III data were collected and toxicity tests were conducted at representative locations (Ensafe, 2005). Two sediment samples collected during Phase III were used for the toxicity tests. For iron, the maximum concentration of 246,000 mg/kg was detected at sample location 041M030201. Toxicity test results indicated no observable effect at the 041M030201 sediment sample. Although the toxicity test results for the other sediment sample indicated a potential adverse impact, the iron concentration in that sample was an order of magnitude lower (67,100 µg/L).

The toxicity test for surface water used a sample collected in Wetland 3 at a location close to the inlet of the culvert that connects Wetlands 3 and 4D. The iron concentration in this sample is 19,600 µg/L, and toxicity test results for this sample indicated no observable effect on the tested ecological species.

In summary, based on the results of the HHRA and ERA, iron in sediment and surface water of Wetland 3 does not pose unacceptable risks to b human or ecological receptors. The RI recommended a Feasibility Study (FS) for Wetland 3 based on risks associated with contaminants other than iron.

Wetland 4D

Phase I and II RI sampling were conducted at Wetland 4D. Wetland 4D is categorized as a salt water wetland and is adjacent to and tidally influenced by Bayou Grande. Five sediment samples and two surface water samples were collected during the Phase II RI. The maximum iron concentration in Wetland 4D sediment samples was 39,400 mg/kg, detected at a location near the center of the wetland. The maximum iron concentration in surface water was 1580 µg/L, detected near the outlet of the culvert that connects Wetland 3 and Wetland 4D. The established background iron concentration for salt water wetlands at NAS Pensacola is 1,352 µg/L.

The HHRA identified arsenic as the only risk driver for sediment in Wetland 4D, and no unacceptable risk was identified for surface water.

The ERA was firstly performed by screening and refining the contaminant of potential concern (COPC) list by comparing constituent concentrations to screening values as described above. Food-chain modeling was then performed for bioaccumulative contaminants. After the screening and refinement, iron was retained as a COPC for both sediment and surface water at Wetland 4D. Phase III investigation was not performed at Wetland 4D because after Phase II, wetlands were grouped based on the nature of contamination and geographic locations, and two wetlands (Wetlands 16 and 18) were selected to represent the wetland group including Wetland 4D, and these Wetlands entered the Phase III stage.

Although iron was identified as a COPC at Wetland 4D because the maximum detected concentration exceeded the site background value and other screening values, Wetland 4D was not recommended for an FS in the RI because the Phase III results for the group including Wetland 4D (represented by Wetland 16 and 18) indicated no need for further evaluation (EnSafe, 2007). The maximum detected iron concentrations in Wetland 4D sediment and surface water are an order of magnitude less than the iron concentrations in the samples used for toxicity tests at Wetland 3.

In summary, based on the results of the HHRA and ERA iron in sediment and surface water at Wetland 4D does not cause unacceptable risk to human or ecological receptors.

7.2 Site-Wide Iron Concentrations

Elevated iron concentrations in surface water were detected in wetlands site wide. Site 41 RI surface water iron concentrations varied from non-detect to 715,000 µg/L (Wetland 15). For fresh water wetlands, surface water iron concentrations greater than the background value (2,360 µg/L) were detected in Wetlands 1A, 3, 5A, 5B, 6, 10, 13, 18A, 19A, 57, 58, and W1 (from Phase II to Phase IV). For salt water wetlands, concentrations greater than the background level (1352 µg/L) were detected in Wetlands 4D, 15, 16, 18B, 19B, and 63B (Phase II and IV). Note that, among these wetlands, 1A, 4D, 5B, 6, 13, 19A, 19B, 57, 58, and 63B were recommended for no further action (NFA) in the approved RI.

As an example of the listed wetlands with higher-than-background iron concentrations and NFA recommendations, the second highest iron concentration, 332,000 µg/L, was detected in Wetland 19A during Phase II RI sampling in 1996. After the Phase II sampling, Wetland 19A was categorized as a blue-coded wetland in the approved Final RI/FS SAP Addendum (E/A&H, 1997), indicating that contaminants were present at concentrations generally less than screening values (for surface water, background values), and contaminants did not appear to be site related. Blue-coded wetlands were not considered for further evaluation because the detected parameters were determined not to be site related (EnSafe, 2007). This categorization of Wetland 19A suggests that an iron concentration as high as 332,000 µg/L could be naturally occurring.

The facts summarized above suggest that the current background concentrations, which were developed using a limited number of samples collected in a limited number of wetlands (two fresh water wetlands and two salt water wetlands) in 1990s, are too low and need to be updated using a more complete data set because iron concentrations exceeding the current background values have been detected in many wetlands, and several wetlands with iron exceedances have been approved for NFA based on a determination that the elevated iron concentrations were not site related.

7.3 Background Analysis for Iron

The original background values were established as part of the Site 41 RI by identifying "pristine" wetlands and using only the sample data from these wetlands. Wetlands 25 and 32 were identified as background wetlands for fresh water wetlands, and Wetlands 27 and 33 were identified as background wetlands for salt water wetlands. Two samples were collected from each wetland, and the four samples from each type of wetlands (fresh water and salt water) were used for the background calculation. The background values were set at two times the average concentrations of each four-sample data set.

As stated in Section 7.2, highly variable iron concentrations have been detected in the over 80 wetlands at NAS Pensacola, and many iron concentrations exceeding the original background values were determined to be naturally occurring. Because the original method of determining background values used only small, potentially non-representative background data sets, the iron background concentrations were updated as part of this study using statistical methods that extract a more representative background data set from existing site data using various statistical measures. The details of this background value calculation are described in the following paragraphs.

The background analysis was conducted using the Navy's guidance document Procedural Guidance for Statistically Analyzing Environmental Background Data (NAVFAC, 1998). The Navy's Installation Restoration Program utilizes two methods for analyzing background constituent levels, the comparative method and the on-site background evaluation. For this work, the on-site background evaluation method was used, where the background data range is extracted from the complete data set of the suspected contaminated site using statistical methods.

To extract a background data range, an initial data set must be developed. The relevant data for this work includes all of the iron concentrations measured from the surface water samples from all wetlands, including those categorized in Site 41 and OU1, and surface water data from near-shore locations in Bayou Grade and Pensacola Bay (Site 40) (Figure 9).

Because Wetland 4D is the wetland that receives flow from Wetland 3 (and other wetlands) and directly drains into Bayou Grande, the Partnering Team agreed that Wetland 4D is the concern in this study. Wetland 4D is a salt water wetland; therefore background analysis should be conducted for salt water wetlands to determine the appropriate background concentration to be used for comparison with Wetland 4D data. Figure 10 shows the data locations for all of the salt water wetlands.

Although from purely statistical perspective the background data range can be extracted from the data set of all salt water wetlands, the initial salt water data set that should be used in this background analysis was further evaluated based on the site specific conditions.

As shown on Figure 10, although many of the data were obtained from wetlands recommended for NFA, some data were collected from wetlands close to the former landfill area. A conservative approach is to develop the initial data set by excluding data from the wetlands that may potentially be influenced by the landfill, including Wetlands 4D, 15, 16, 17, and 18B. In addition, Wetlands 10, 12, 13 and 19A were categorized as fresh water wetlands; however, as shown on Figure 9, these wetlands are located very close to the shore line, and the Partnering Team considers the water in these wetlands to be brackish. Therefore, the Partnering Team agreed that the initial data set for this background analysis should include the surface water data from Wetlands 10, 12, 13 and 19A and the surface water data from all salt water wetlands, except Wetlands 4D, 15, 16, 17, and 18B.

A background data range can then extracted from the initial data set. To extract a background range, various statistical analyses can be conducted and different tools can be used, including histograms, box plots, and normal probability plots. Box plots and histograms can be used to examine if there are differences between concentrations (greater concentrations represent potential contamination). Probability plots can be used to evaluate distinct changes in slope (i.e., inflection points), where the upper inflection point may be indicative of concentrations that are not within the background range. The background data set can then be established by removing the outliers identified by these statistical analyses.

Analyses of the initial data set suggest that there is only one potential outlier as identified by the box plot; however, the Shapiro-Wilk test suggests there is insufficient evidence to conclude this data is an outlier (Attachment F). Review of the Site 41 RI shows that this data is from Wetland 13. Wetland 13 was categorized as a blue-coded wetland and was approved for NFA because the chemical concentrations in blue-coded wetlands were found to be either below screening values or contaminants did not appear to be site related (EnSafe, 2007). Therefore, the Partnering Team agreed to include this data in the background range.

Based on the Guidances of Florida Department of Environmental Protection (FDEP) (FDEP, 2008 and 2009), the basic approach to define the background threshold for comparing site and background data is to use the lower of:

1) the maximum background concentration, or
2) twice the mean background concentration.

For this study, the background threshold was determined to be twice the mean background concentration, and the value is 5,862 µg/L.

7.4 Recommended Strategy for Iron Surface Water Compliance

As stated in Section 7.1, iron concentrations in surface water and sediment of Wetland 3 and Wetland 4D were determined not to pose unacceptable risks to current or potential future human or ecological receptors. Under this situation, an appropriate strategy for the iron issue in Wetland 3 and 4D needs to developed to ensure protection of the surface water body.

The recommended strategy is to establish a point of compliance (POC) in Wetland 4D and to monitor iron concentrations in surface water at this POC. Based on Chapter 62-302.800, Florida Administrative Code (F.A.C.), the newly established site-specific value of the background range for salt water wetlands can be used as the alternative criterion for this POC. As calculated in Section 7.3., the background threshold is 5,862 µg/L, and this concentration is recommended as the alternative criterion.

The recommended POC location is shown on Figure 11. This location is selected because it represents surface water quality in Wetland 4D. Wetland 4D receives water from Wetland 3 at the southwestern side and from Wetlands 4A-4B-4C at the southeastern side. Wetland 4D drains to Bayou Grande through a culvert near the northern corner of the wetland. The POC location is approximately midway between the mixing point of the two water sources and the culvert.

Because all surface water iron concentrations in Wetland 4D are less than or nearly equal to the proposed alternative criterion, monitoring on an annual basis is recommended at the POC for comparison to the alternative criterion. Note that the criterion was established using a tolerance interval. As noted in the EPA guidance (1992), “the nature of a tolerance interval practically ensures that a few measurements will be above the upper tolerance limit, even when no contamination has occurred.” The guidance recommends resampling in case of exceedances to verify whether there is definite evidence of contamination. Therefore, if an above-criterion concentration is observed, the POC should continue to be monitored to collect more data, which can be used to confirm an exceedance. The data would then be evaluated during the Five-Year Review for protectiveness and for any changes to the sampling protocol deemed necessary.

In the interim, operation of the ITS should be stopped because both optimization studies for OU1 (TtNUS 2004 and 2008) have demonstrated that this system is not effectively reducing iron concentrations in Wetland 3 surface water, and other studies, including the Site 41 RI and this memorandum, indicate that this system is not necessary to address iron in the wetlands.

8.0 REFERENCES

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TABLE 1

GROUNDWATER AND SURFACE WATER ELEVATIONS
OPERABLE UNIT 1
NAS PENSACOLA, FLORIDA

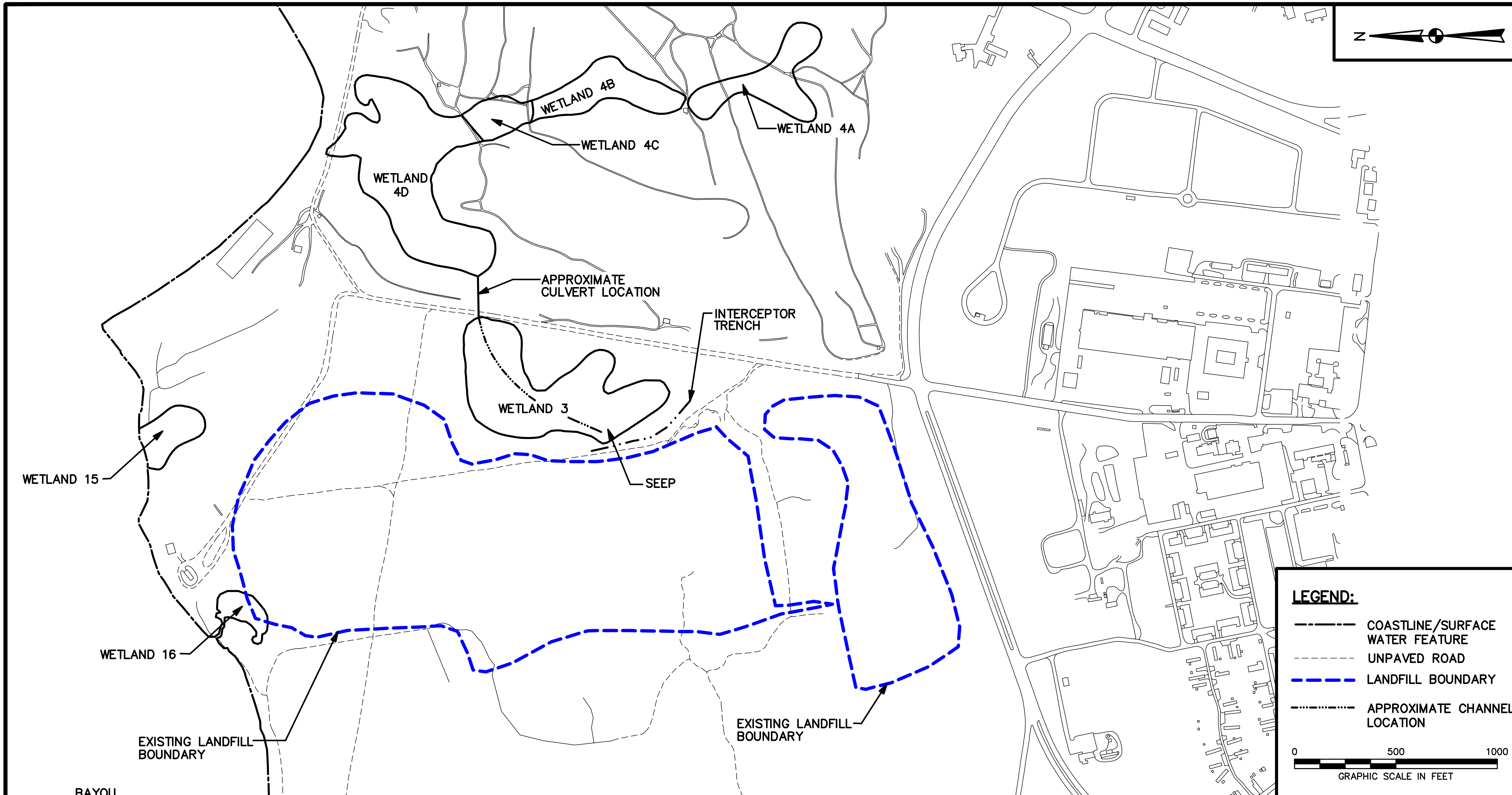
Location	DRMP Elevation - Top of Reference Point - NAVD88	4/1/08 - Depth to Water (ft-frp)	Water Elevation (ft-NAVD88)	4/22/08 - Depth to Water (ft-frp)	Water Elevation (ft-NAVD88)	5/29/08 - Depth to Water (ft-frp)	Water Elevation (ft-NAVD88)
01PZ101	14.20	5.04	9.16	5.18	9.02	5.33	8.87
01PZ102	13.40	5.69	7.71	5.89	7.51	6.23	7.17
SG-01 (01W01)	10.67	3.52	7.15	3.48	7.19	3.59	7.08
01PZ103	8.57	4.15	4.42	4.10	4.47	4.20	4.37
01PZ104	8.69	4.96	3.73	5.12	3.57	5.35	3.34
SG-02 (01W02)	6.00	3.11	2.89	3.19	2.81	3.29	2.71
Culvert Headwall - Inlet	6.95	5.35	1.60	5.30	1.65	5.30	1.65
SG-03 (01W03)	3.98	3.29	0.69	2.91	1.07	3.32	0.66
01PZ105	3.34	1.18	2.16	1.03	2.31	1.07	2.27
01PZ106	4.08	2.76	1.32	2.56	1.52	2.86	1.22

TABLE 2

WATER LEVEL DATA USED FOR
POTENTIOMETRIC SURFACE CONTOURING
OPERABLE UNIT 1
NAS PENSACOLA, FLORIDA

Well ID	Northing (ft)	Easting (ft)	Water Level Elevation (ft)
01GGM38	506212.91	1089068.75	10.66
01GGM04	508435.56	1088195.75	0.99
01GS64	506601.16	1088513.38	10.68
01PZ101	506426.89	1088846.95	9.09
01PZ102	506623.74	1088745.27	7.61
SG-01	506553.04	1088805.89	7.17
01PZ103	506800.35	1089152.04	4.45
01PZ104	506919.13	1089124.23	3.65
SG-02	506891.73	1089180.51	2.85
SG-03	507000.85	1089449.86	0.88
01PZ105	506894.41	1089456.05	2.24
01PZ106	507154.39	1089471.87	1.42
01GS01*	507139.59	1087457.13	6.94
01GS37*	505885.28	1089100.00	12.01
01GS39*	505148.72	1087223.38	11.91
01GS40*	505715.81	1087122.25	10.99
01GS42*	506444.69	1087317.75	8.4
01GS53*	504010.91	1088138.63	15.74
01GS57*	507999.66	1089463.88	1.06
01GS58*	505266.31	1088972.38	13.92
01GS60*	506777.31	1087184.25	6.93
01GS62*	505890.72	1087404.13	11.26
01GGM05*	507891.94	1087588.38	1.12
01GGM33*	507314.16	1087666.75	7.6
01GGM39*	506943.16	1089181.38	2.83
01GGM41*	507015.66	1086412.38	0.85

*Historical Data (shallow wells, from the RI report, 1994)



SOURCE: CONCEPTUAL REMEDIATION DESIGN AT OPERABLE UNIT 1 NAVAL AIR STATION PENSACOLA REVISION 1, SEPTEMBER 1, 1998 PREPARED BY: ENSAFE INC.

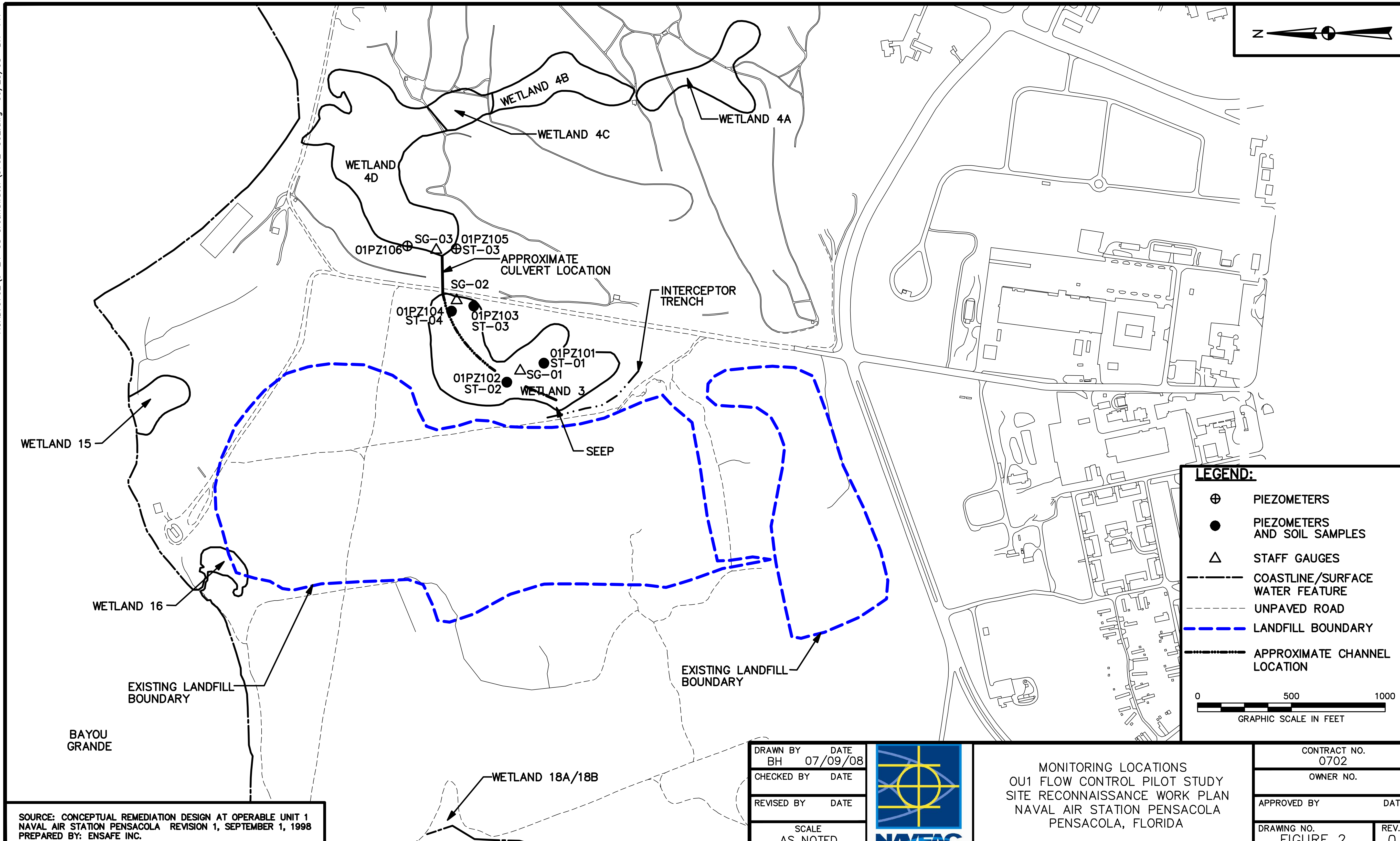
DRAWN BY	DATE
BH	07/09/08
CHECKED BY	DATE
REVISED BY	DATE
SCALE AS NOTED	

SITE LAYOUT
OU1 FLOW CONTROL PILOT STUDY
SITE RECONNAISSANCE REPORT
NAVAL AIR STATION PENSACOLA
PENSACOLA, FLORIDA

CONTRACT NO. 0702
OWNER NO.
APPROVED BY DATE
DRAWING NO. FIGURE 1
REV. 0

ACAD: 0702\6-24-08 Groundwater\0702-G01.dwg 06/25/08 BH PIT

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98



ACAD: 0702\6-24-08 Groundwater\0702-G02.dwg 06/25/08 BH PIT

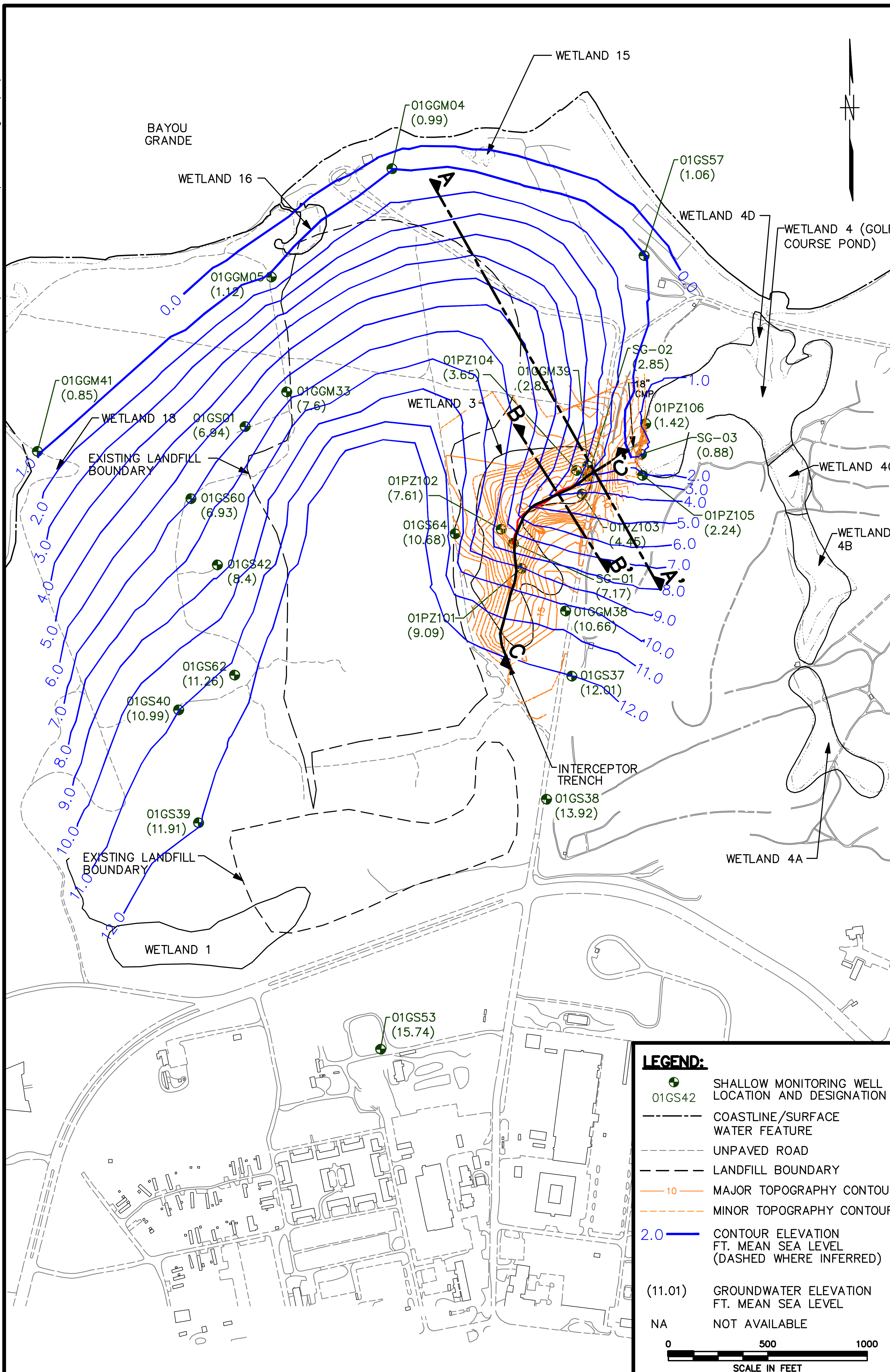
SOURCE: CONCEPTUAL REMEDIATION DESIGN AT OPERABLE UNIT 1
NAVAL AIR STATION PENSACOLA REVISION 1, SEPTEMBER 1, 1998
PREPARED BY: ENSAFE INC.

DRAWN BY BH	DATE 07/09/08
CHECKED BY	DATE
REVISED BY	DATE
SCALE AS NOTED	

MONITORING LOCATIONS
OU1 FLOW CONTROL PILOT STUDY
SITE RECONNAISSANCE WORK PLAN
NAVAL AIR STATION PENSACOLA
PENSACOLA, FLORIDA

CONTRACT NO. 0702	
OWNER NO.	
APPROVED BY	DATE
DRAWING NO. FIGURE 2	REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98



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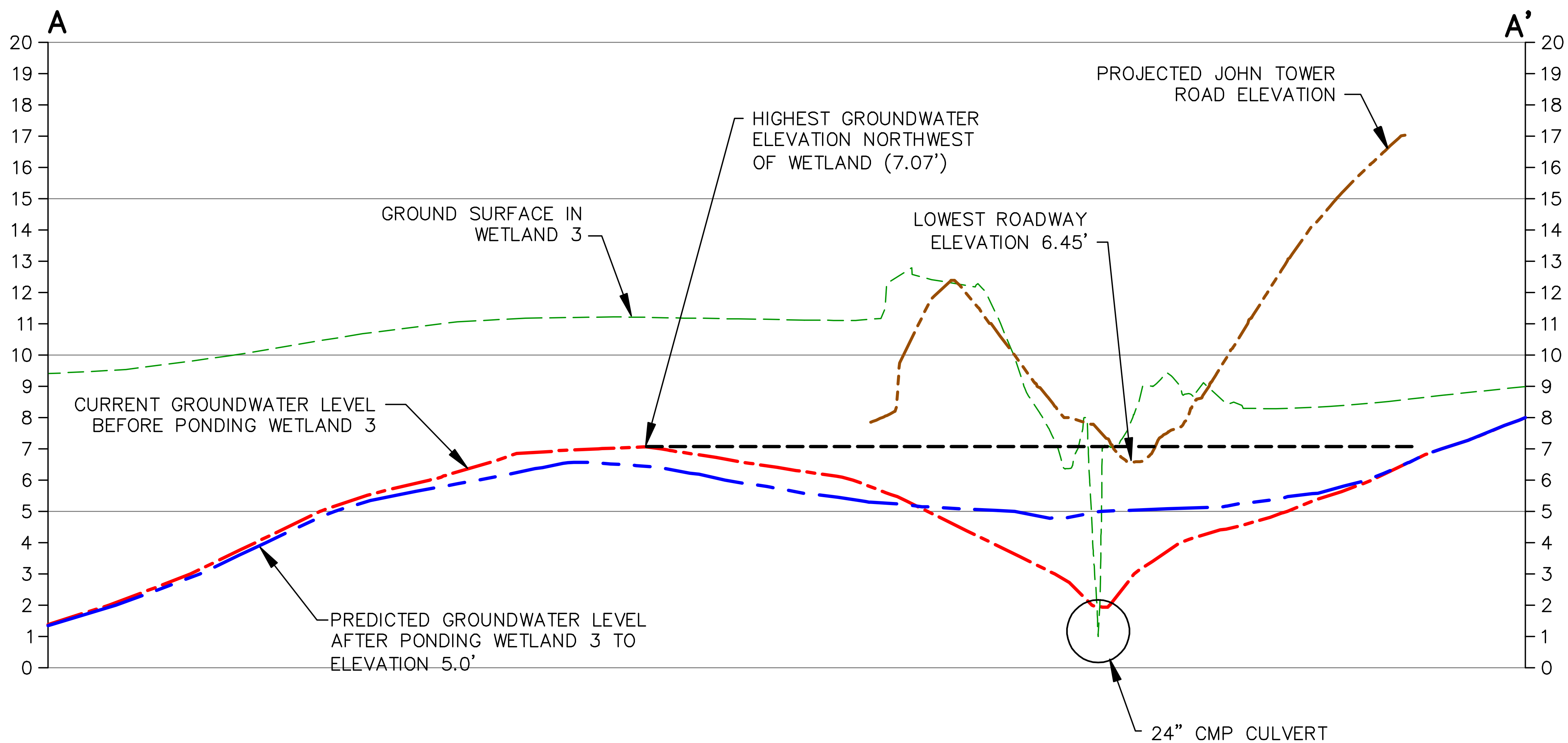
DRAWN BY BH / DATE 6/25/08	NAVFAC	SHALLOW ZONE GROUNDWATER POTENTIOMETRIC SURFACE OPERABLE UNIT 1 – JUNE 2008 NAVAL AIR STATION PENSACOLA PENSACOLA, FLORIDA	CONTRACT NO. 0702
CHECKED BY / DATE			APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4 / REV. 0

ACAD:0702\6-24-08 Groundwater\0702-C03.dwg 06/25/08 BH PIT



CROSS SECTION A–A'

SCALE: HORIZ.: 1" = 200'
VERT.: 1" = 4'

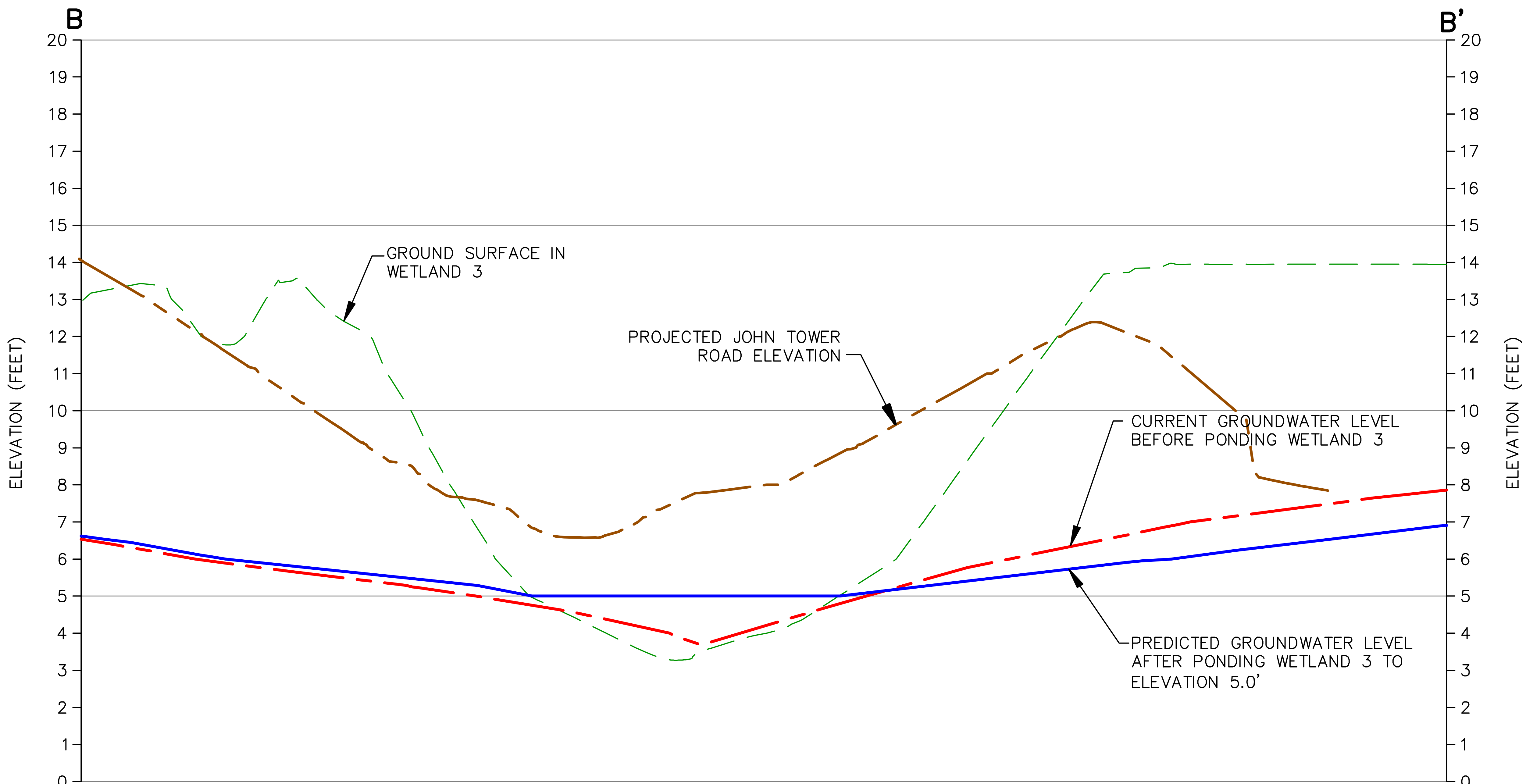
DRAWN BY BH DATE 6/25/08
CHECKED BY DATE
COST/SCHED–AREA
SCALE AS NOTED

NAVFAC

CROSS SECTION A–A'
OPERABLE UNIT 1 – JUNE 2008
NAVAL AIR STATION PENSACOLA
PENSACOLA, FLORIDA

CONTRACT NO. 0702
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5
REV. 0

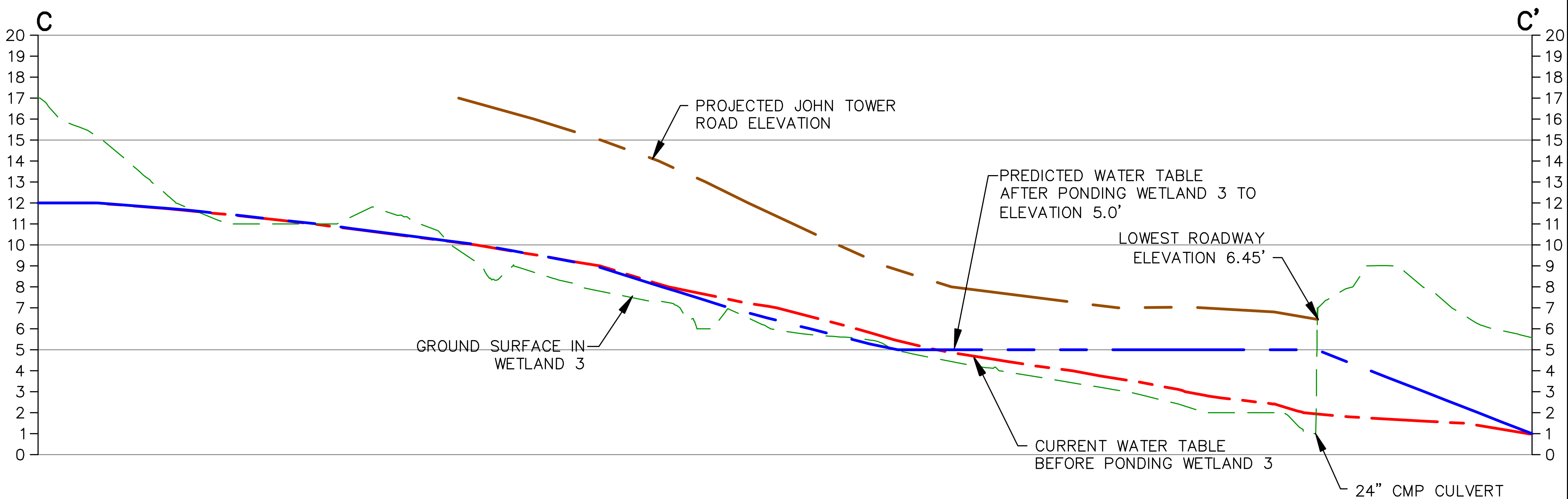
ACAD:0702\6-24-08 Groundwater\0702-C04.dwg 06/25/08 BH PIT



CROSS SECTION B–B'

SCALE: HORIZ.: 1" = 60'
VERT.: 1" = 3'

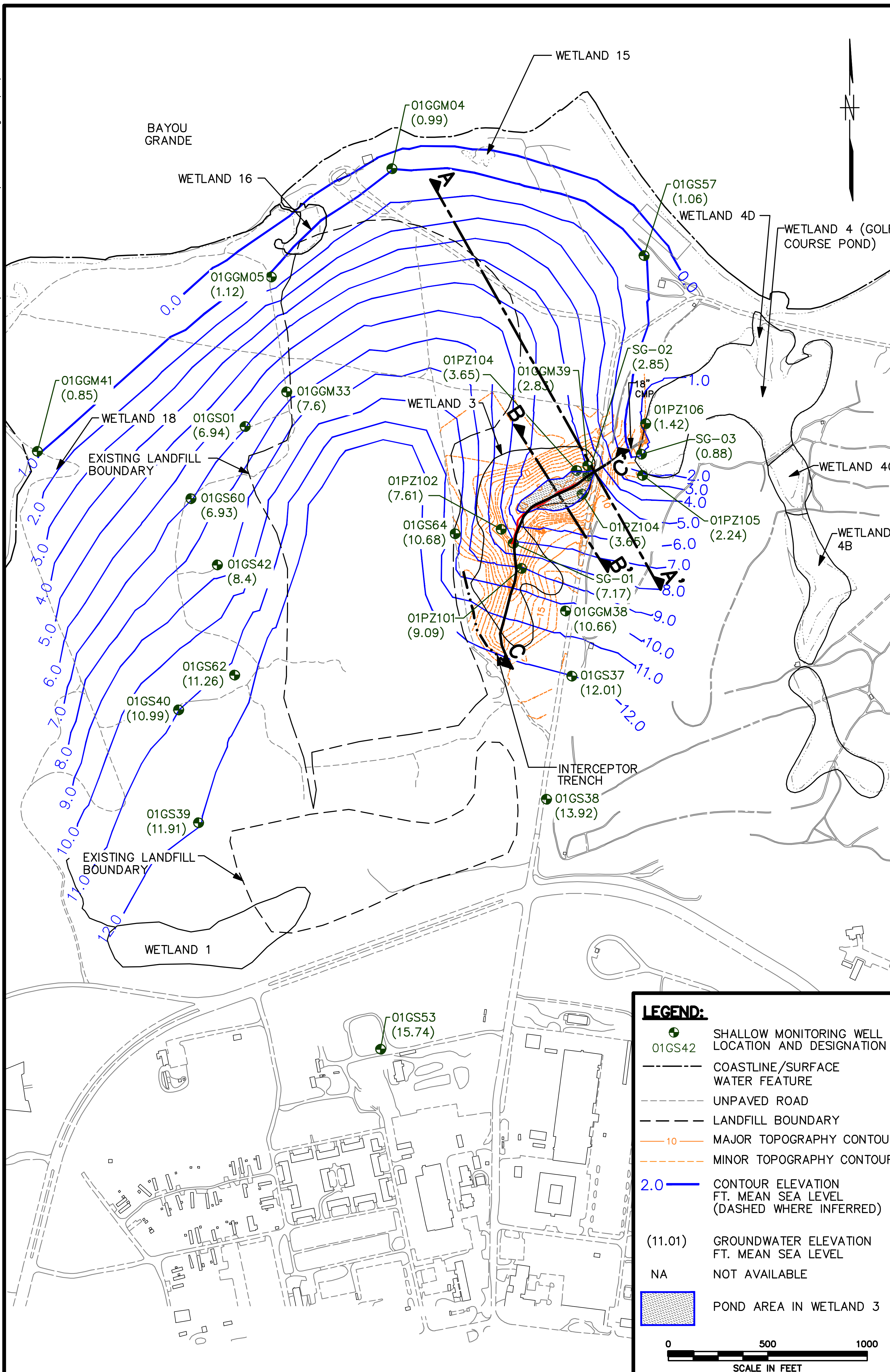
DRAWN BY BH / DATE 6/25/08	NAVFAC	CROSS SECTION B–B' OPERABLE UNIT 1 – JUNE 2008 NAVAL AIR STATION PENSACOLA PENSACOLA, FLORIDA	CONTRACT NO. 0702	
CHECKED BY / DATE			APPROVED BY / DATE	
COST/SCHED–AREA			APPROVED BY / DATE	
SCALE AS NOTED			DRAWING NO. FIGURE 6	REV. 0



CROSS SECTION C–C'

SCALE: HORIZ.: 1" = 100'
VERT.: 1" = 5'

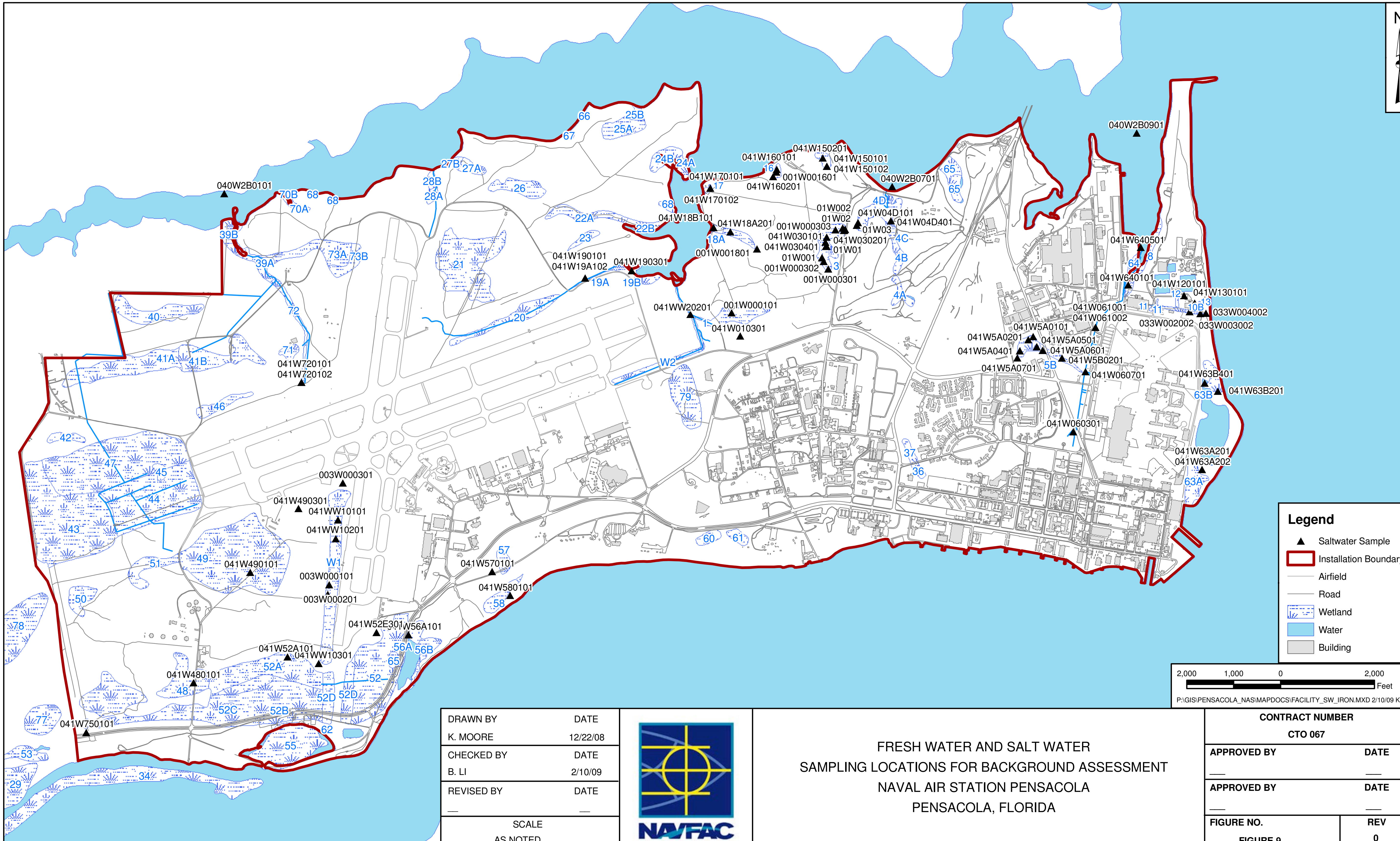
DRAWN BY BH	DATE 6/25/08	NAVFAC	CROSS SECTION C–C' OPERABLE UNIT 1 – JUNE 2008 NAVAL AIR STATION PENSACOLA PENSACOLA, FLORIDA	CONTRACT NO. 0702
CHECKED BY	DATE			APPROVED BY — DATE
COST/SCHED–AREA				APPROVED BY — DATE
SCALE AS NOTED				DRAWING NO. FIGURE 7 — REV. 0



ACAD:0702\6-24-08 Groundwater\0702-C02.dwg 06/25/08 BH PIT

DRAWN BY BH	DATE 6/25/08	**PREDICTED SHALLOW ZONE GROUNDWATER POTENTIOMETRIC SURFACE (AFTER PONDING WETLAND 3) OPERABLE UNIT 1 – JUNE 2008 NAVAL AIR STATION PENSACOLA PENSACOLA, FLORIDA**	CONTRACT NO. 0702
CHECKED BY	DATE		APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. **FIGURE 8** / REV. 0

NAVFAC



DRAWN BY	DATE
K. MOORE	12/22/08
CHECKED BY	DATE
B. LI	2/10/09
REVISED BY	DATE
___	___
SCALE AS NOTED	

NAVFAC

FRESH WATER AND SALT WATER
SAMPLING LOCATIONS FOR BACKGROUND ASSESSMENT
NAVAL AIR STATION PENSACOLA
PENSACOLA, FLORIDA

CONTRACT NUMBER	
CTO 067	
APPROVED BY	DATE
___	___
APPROVED BY	DATE
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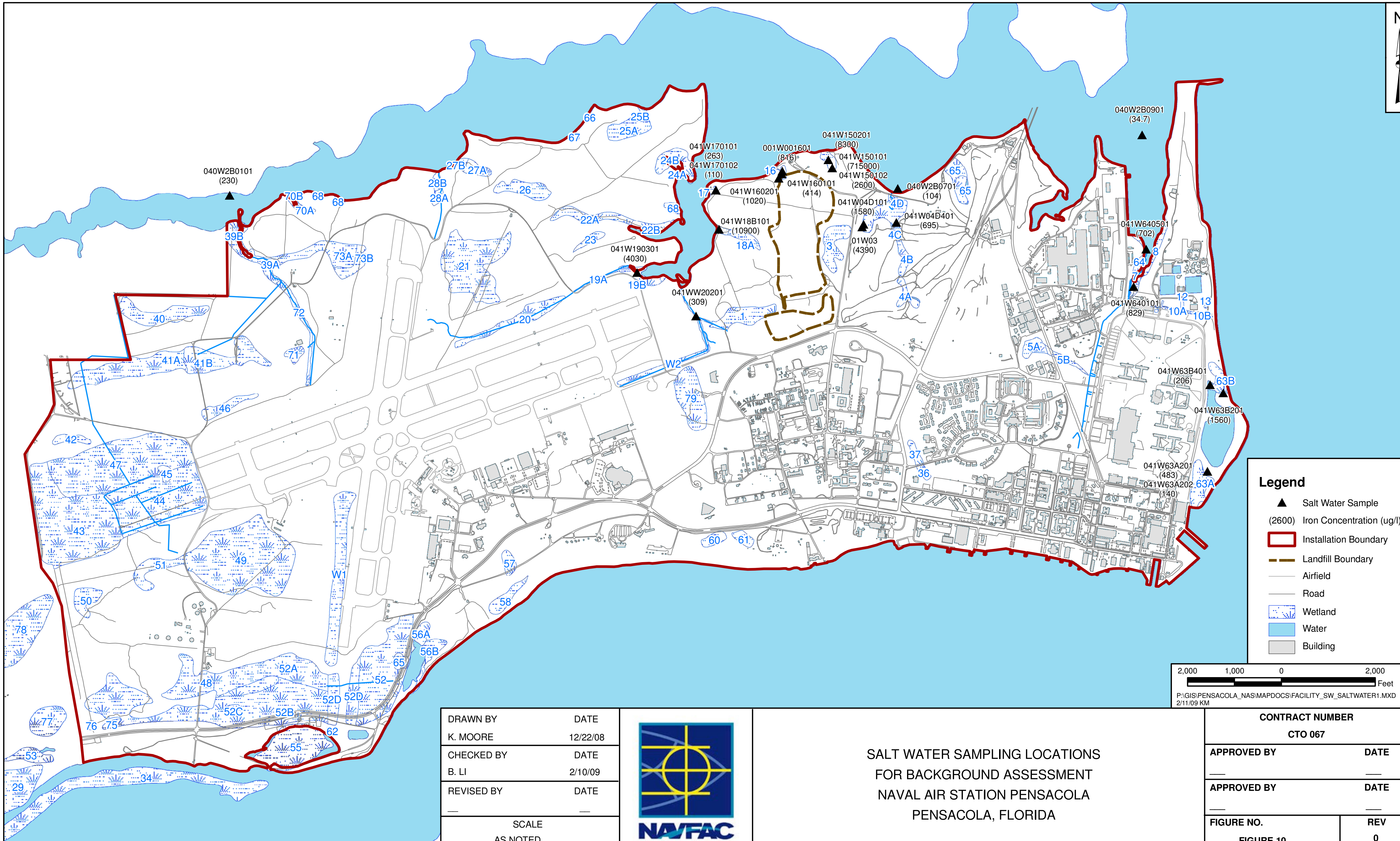
FIGURE NO.	REV
FIGURE 9	0



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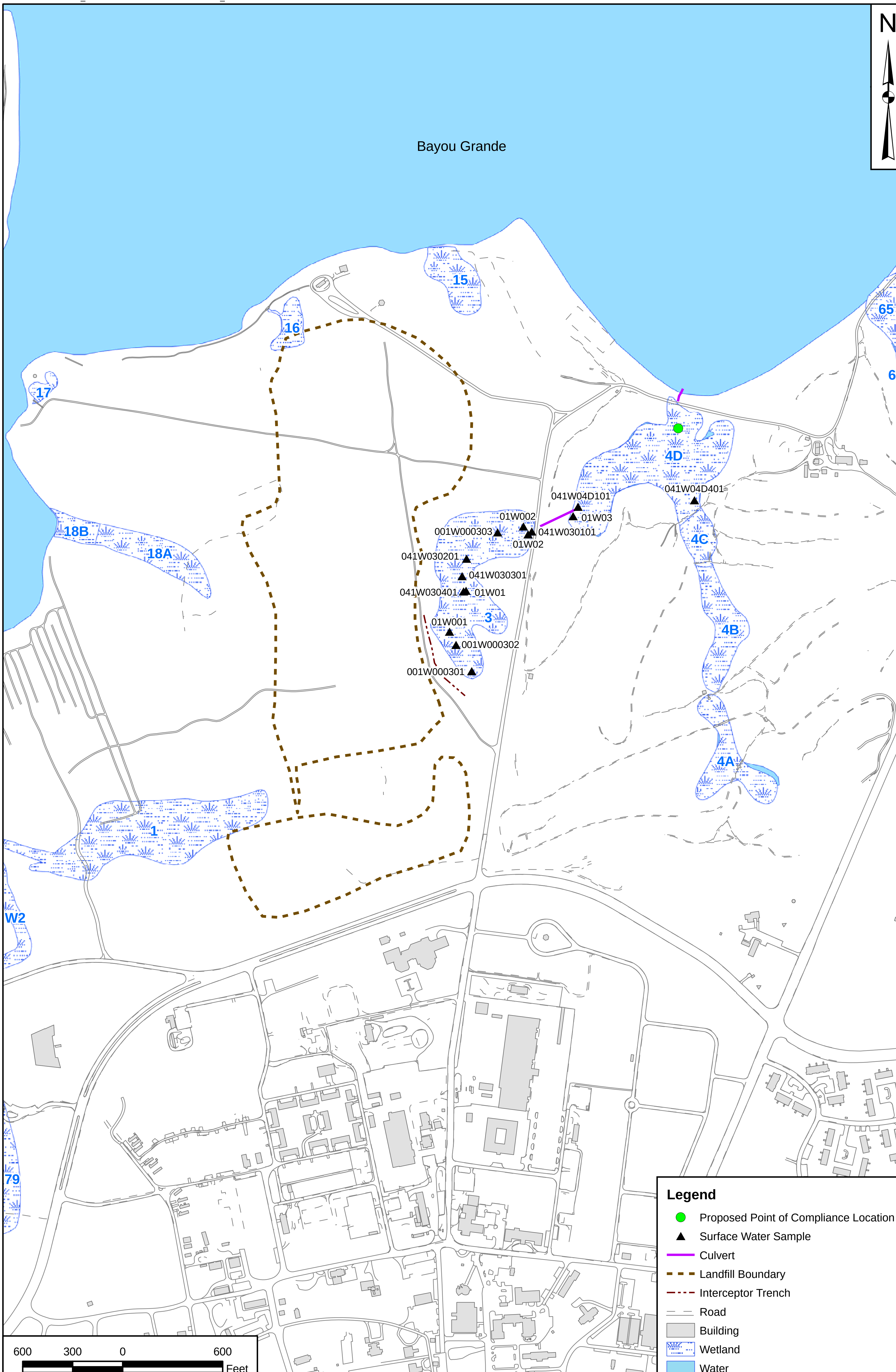
CHECKED BY	DATE
B. LI	2/10/09
REVISED BY	DATE
SCALE	
AS NOTED	

NAVFAC

SALT WATER SAMPLING LOCATIONS
FOR BACKGROUND ASSESSMENT
NAVAL AIR STATION PENSACOLA
PENSACOLA, FLORIDA

CONTRACT NUMBER	
CTO 067	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
FIGURE 10	0

P:\GIS\PENSACOLA_NAS\MAPDOCS\MXD\WETLAND04_IRON.MXD 12/31/08 SS



DRAWN BY	DATE
K. MOORE	12/22/08
CHECKED BY	DATE
B. LI	12/31/08
COST/SCHED AREA	
SCALE AS NOTED	

NAVFAC

PROPOSED POINT OF COMPLIANCE LOCATION
NAVAL AIR STATION PENSACOLA
PENSACOLA, FLORIDA

CONTRACT NUMBER CTO 0056	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO. FIGURE 11	REV 0

ATTACHMENT A

TOPOGRAPHIC SURVEY FOR THE PENSACOLA NAVAL AIR STATION – OU1 AREA

SURVEYOR'S NOTES AND SITE REPORT:

1. No underground installations or improvements, including, but not limited to, buried cables, sub-surface utilities, foundation/footers, or burial sites were located, except as shown. Any utilities shown hereon are based only on visible surface evidence, unless noted otherwise.

2. This property is subject to encumbrances, easements, and restrictions, if any, of record.

3. No instruments of record reflecting ownership or encumbrances were provided, except as noted, nor did this Surveyor abstract these lands.

4. Date of last field survey May 29, 2008.

5. The bearings shown hereon are based on the surveyed baseline, as being South 09°11'49" West, bearing from the Florida State Plane Coordinate system, Florida North Zone, NAD 1983, Adjustment of 1990. The primary horizonal control station is "ESC 4114"; an Escambia County Survey Dept. disk in concrete monument as published from the Escambia County GPS Network Map for the Florida Department of Environmental Protection, Division of State Lands, Bureau of Survey and Mapping, project number 27704.02, dated 15 October, 1997. Originating coordinates are N: 514,548.416; E: 1,087,067.452 having an average scale factor of 0.999954463.

6. Elevations shown hereon are relative to the NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) and referenced to the following primary originating BENCHMARK: Tidal Benchmark "P 26 Reset 1984"; a disk set in the bridge guardrail 3 feet above the road at the South end of the Pensacola Naval Air Station Bridge, 42 feet West of the Centerline of Navy Blvd. having a published elevation of 12.79, NAVD 1988.

7. This survey was prepared with the specific purpose of locating and depicting certain drainage features, drainage basin area, main ground seep location, outfall pipe, piezometers, stream guages and other specific features with respective elevations and topography in the areas depicted hereon as requested by the client.

8. For the purpose of this survey, elevations were taken in specific areas as requested by the client. Due to dense foliage and highly irregular terrain, this survey certifies the contour lines are accurate to within one-half the contour interval for contour lines at elevation 5.0 and below. All other contour lines above elevation 5.0 are shown for informational purposes only and are computer generated approximate interpolations based on the nearest elevation shown. All contours lines shown hereon are generated by conventional computer software interpolations and are superceded by the nearest ground elevation shown hereon. Any elevation for design purposes should be field verified if not specifically depicted hereon.

Steven M. Kieffer, P.S.M. — Date
Professional Surveyor And Mapper
State Of Florida ~ Registration #5615

TOPOGRAPHIC SURVEY CERTIFIED TO: TETRATECH NUS, INC.

DATE	REVISIONS	REVISED BY	CHECKED BY	DATE	REVISIONS	REVISED BY	CHECKED BY

WARNING
0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THIS COPY OF THIS DOCUMENT IS NOT TO SCALE

FIELD BY	S.BARNES	04/08
DRAWN BY	J.MORALES	05/08
CHECKED BY	S.KIEFFER	06/04/08
FIELD BOOK(S)	PEN; PCB6	
PAGE(S)	3–8; 13–15	
FILE: 08–0069_NAVAL_AIR_TOPO...		

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TOPOGRAPHIC SURVEY FOR THE PENSACOLA NAVAL AIR STATION – OU1 AREA

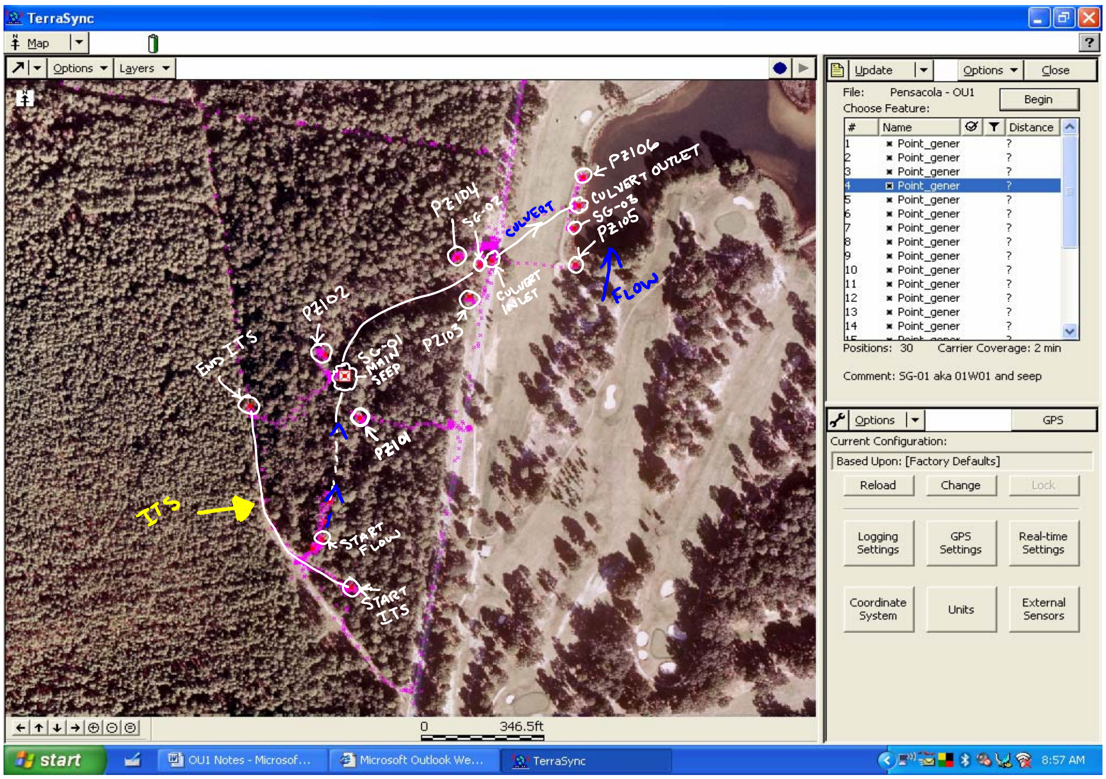
ESCAMBIA COUNTY — FLORIDA

PROJECT NO. 08–0069.000
DATE MAY, 2008
SCALE 1" = 60'
SHEET 1 OF 1

ATTACHMENT B

IRON CONCENTRATIONS IN GROUNDWATER AND SURFACE WATER IN THE WETLAND 3 AND 4D AREA

PROJ_NAME	Location ID	SAMPLE	PARA	RESULT	UNITS	VALIDATED	MDL	Notes
NAS PENSACOLA	01PZ101	01PZ1010308	IRON	1220	UG/L	N	30	south and east - between JT Road and stream - upgradient of shallow flow
NAS PENSACOLA	01W01	01W010308	IRON	6810	UG/L	N	30	SG at main seep
NAS PENSACOLA	01PZ102	01PZ1020308	IRON	14500	UG/L	N	30	north and west - between stream and ITS - downgradient of shallow flow
NAS PENSACOLA	01PZ103	01PZ1030308	IRON	312	UG/L	N	30	south and east - between JT Road and stream - upgradient of shallow flow
NAS PENSACOLA	01W02	01W020308	IRON	3260	UG/L	N	30	SG before culvert
NAS PENSACOLA	01PZ104	01PZ1040308	IRON	32200	UG/L	N	30	north and west - downgradient of shallow flow
NAS PENSACOLA	01PZ105	01PZ1050308	IRON	3780	UG/L	N	30	south - perimeter of pond - upgradient of shallow flow
NAS PENSACOLA	01W03	01W030308	IRON	4390	UG/L	N	30	SG in pond - open water
NAS PENSACOLA	01PZ106	01PZ1060308	IRON	505	UG/L	N	30	north - perimeter of pond - downgradient of shallow flow
NAS PENSACOLA	FD-033008-01	FD-033008-01	IRON	14700	UG/L	N	30	Duplicate of 01PZ1020308
NAS PENSACOLA	FD-033008-02	FD-033008-02	IRON	19700	UG/L	N	30	Duplicate of QCMB01W010308
NAS PENSACOLA	01W01	QCMB01W010308	IRON	21600	UG/L	N	30	method QC sample at SG01



ATTACHMENT C

FLOW VELOCITY, WATER DEPTH, AND FLOW RATE CALCULATION AT THE CULVERT ENTRANCE

Attachment C. Flow velocity, water depth and flow rate calculation

	Flow Velocity at the Culvert Inlet (ft/s)	Measured Water Depth at the Culvert Inlet (ft)	Culvert Diameter (ft)	Wetted Cross Section Area (ft^2)	Flow Rate (ft^3/s)	Flow Rate (gpm)
Average V	0.25	1.22	2	2.01	0.50	225.14
Max V	1	1.22	2	2.01	2.01	900.55
Min V	0.12	1.22	2	2.01	0.24	108.07

ATTACHMENT D

LABORATORY REPORT OF VERTICAL HYDRAULIC CONDUCTIVITY AT WETLAND 3 AREA

BEAVER ENGINEERING

CLIENT: **EMPIRICAL LABORATORIES**
PROJECT: **0804007**
PROJECT#: **08-5708**

LABORATORY TESTING SUMMARY

LAB ID	Client ID	PERMEABILITY
		AVERAGE CENTIMETERS PER SECOND
0804007-13A	ST-01	4.1E-05
0804007-14A	ST-02	4.7E-04
0804007-15A	ST-03	1.4E-06
0804007-16A	ST-04	1.2E-05

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NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	EMPIRICAL LABORATORIES		
PROJECT	0804007	PROJ. NO.	08-5708

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION **0804007-13A**
DESCRIPTION WET SAND, SOME TOPSOIL, ROOTS, WOOD, LEAVES, ORGANIC ODOR
SAMPLE WAS LOOSE AND HAD TO BE PARTIALLY REMOLDED
TYPE SAMPLE SHELBY TUBE

SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	6.4 cm	TEST DATE	4/11/2008
WEIGHT	439.3 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	38.89 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	24.0%	HEAD PRESSURE	83 psi
		CONSOLIDATION STRESS:	
		MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T=	20	20	20	20
INITIAL READING,influent liquid		21.6	22.6	23.6	24.6
INITIAL READING,effluent liquid		16.7	15.7	14.7	13.7
END READING, influent liquid		22.6	23.6	24.6	25.6
END READING, effluent liquid		15.7	14.7	13.7	12.7
TOTAL CUBIC CENTIMETERS	Q=	1.0	1.0	1.0	1.0
LENGTH OF SAMPLE	L=	6.4	6.4	6.4	6.4
LOSS OF HEAD	H=	205.0	203.0	201.0	199.0
CROSS SECTIONAL AREA	A=	38.89	38.89	38.89	38.89
EQUATION, K = QL/AHT	K=	**4.0E-05**	**4.1E-05**	**4.1E-05**	**4.1E-05**

4.1E-05 AVERAGE CENTIMETERS PER SECOND

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CLIENT	EMPIRICAL LABORATORIES		
PROJECT	0804007	PROJ. NO.	08-5708

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION **0804007-14A**
DESCRIPTION TOPSOIL AND SAND, ROOTS, WOOD, LEAVES, WET, ORGANIC ODOR
SAMPLE WAS LOOSE AND HAD TO BE PARTIALLY REMOLDED
TYPE SAMPLE SHELBY TUBE

SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	69.1 cm	TEST DATE	4/11/2008
WEIGHT	324.4 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	41.58 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	53.5%	HEAD PRESSURE	83 psi
		CONSOLIDATION STRESS:	
		MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T =	20	20	20	20
INITIAL READING,influent liquid		19.2	20.4	21.6	22.8
INITIAL READING,effluent liquid		25.1	23.6	22.4	21.2
END READING, influent liquid		20.4	21.6	22.8	24.0
END READING, effluent liquid		23.6	22.4	21.2	19.9
TOTAL CUBIC CENTIMETERS	Q =	1.2	1.2	1.2	1.2
LENGTH OF SAMPLE	L =	69.1	69.1	69.1	69.1
LOSS OF HEAD	H =	215.3	212.9	210.5	208.0
CROSS SECTIONAL AREA	A =	41.58	41.58	41.58	41.58
EQUATION, K = QL/AHT	K =	**4.6E-04**	**4.7E-04**	**4.7E-04**	**4.8E-04**

4.7E-04 AVERAGE CENTIMETERS PER SECOND

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CLIENT	EMPIRICAL LABORATORIES		
PROJECT	0804007	PROJ. NO.	08-5708

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION **0804007-15A**
DESCRIPTION TOPSOIL , DK BROWN, SAND, ROOTS, WOOD, LEAVES, WET, MUSTY ODOR
SAMPLE WAS LOOSE AND HAD TO BE PARTIALLY REMOLDED
TYPE SAMPLE SHELBY TUBE

SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	6.3 cm	TEST DATE	4/11/2008
WEIGHT	321.3 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	38.76 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	50.5%	HEAD PRESSURE	83 psi
		CONSOLIDATION STRESS:	
		MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T =	600	300	300	300
INITIAL READING,influent liquid		18.9	19.9	20.4	20.9
INITIAL READING,effluent liquid		10.5	9.5	8.9	8.4
END READING, influent liquid		19.9	20.4	20.9	21.4
END READING, effluent liquid		9.5	8.9	8.4	7.9
TOTAL CUBIC CENTIMETERS	Q =	1.0	0.5	0.5	0.5
LENGTH OF SAMPLE	L =	6.3	6.3	6.3	6.3
LOSS OF HEAD	H =	201.5	199.9	198.9	197.9
CROSS SECTIONAL AREA	A =	38.76	38.76	38.76	38.76
EQUATION, K = QL/AHT	K =	**1.3E-06**	**1.4E-06**	**1.4E-06**	**1.4E-06**

1.4E-06 AVERAGE CENTIMETERS PER SECOND

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615-350-8124

CLIENT	EMPIRICAL LABORATORIES		
PROJECT	0804007	PROJ. NO.	08-5708

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION **0804007-16A**
DESCRIPTION TOPSOIL , DK BROWN, SAND, ROOTS, WOOD, WET, MUSTY ODOR
SAMPLE WAS LOOSE AND HAD TO BE PARTIALLY REMOLDED
TYPE SAMPLE SHELBY TUBE

SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	6.1 cm	TEST DATE	4/11/2008
WEIGHT	291.6 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	40.21 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	46.2%	HEAD PRESSURE	83 psi
		CONSOLIDATION STRESS:	
		MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T =	60	60	60	60
INITIAL READING,influent liquid		13.0	14.1	15.2	16.3
INITIAL READING,effluent liquid		29.9	28.8	27.8	26.7
END READING, influent liquid		14.1	15.2	16.3	17.4
END READING, effluent liquid		28.8	27.8	26.7	25.6
TOTAL CUBIC CENTIMETERS	Q =	1.1	1.1	1.1	1.1
LENGTH OF SAMPLE	L =	6.1	6.1	6.1	6.1
LOSS OF HEAD	H =	226.7	224.6	222.4	220.2
CROSS SECTIONAL AREA	A =	40.21	40.21	40.21	40.21
EQUATION, K = QL/AHT	K =	**1.2E-05**	**1.2E-05**	**1.2E-05**	**1.3E-05**

1.2E-05 AVERAGE CENTIMETERS PER SECOND

P1

BEAVER ENGINEERING
PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 4-11-08

CLIENT ELAB ST 2060 PROJ NO. 08-5708

PROJECT 0804007 FACILITY I.D.

LOCATION OF SAMPLE 0804007-13A DEPTH

SHELBY TUBE OR REMOLDED

SOIL TYPE & COLOR ODOR? ORG fill?

DESCRIPTION WET SAND, SOME TOPSOIL, ROOTS, WOOD, LEAVES, LOOSE

ANY PEBBLES OR OTHER MATERIALS? HAD TO BE PARTIALLY REMOLDED

DIAMETER: 7.035 / / = MOISTURE 24.0 pcf:

LENGTH: 6.405 / / =

WEIGHT: 439.3

MOISTURE	
TARE NO	2060
TARE+WET SOIL	94.8
TARE+DRY SOIL	76.8
WATER	18.0
TARE WEIGHT	1.8
DRY SOIL	75.0
WATER %	24.0

TOTAL BACKPRESSURE
MAX CONSOLID STRESS
MIN CONS STRESS

612.8
-173.5
439.3

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	2:05	10	15	9.4	13.0			
	2:10	20	25	9.6	13.4			
	2:15	30	35	10.5	13.6			
	2:20	40	45	11.2	14.9			
	2:30	50	55	11.6	15.2			
	2:35	60	65	11.9	15.5			
	2:40	70	75	14.0	15.5			
	2:42	80	85	14.4	15.6			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

LAB I.D.: 2060

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00	83	80	85	6.0	32.5	
	0:20	20s			8.8	29.8	2.8 - 2.8
	0:40	20s			11.5	27.1	2.7 - 2.7
	1:00	20s			13.6	24.7	2.4 - 2.4
	1:20	20s			15.7	22.6	2.1 - 2.1
	1:40	20s			17.6	20.7	1.9 - 1.9
	2:00	20s			19.1	19.2	1.5 - 1.5
	2:20	20s			20.4	17.9	1.3 - 1.3
	2:40	20s			21.6	16.7	1.2 - 1.2
	3:00	20s			22.6	15.7	1.0 - 1.0 ①
	3:20	20s			23.6	14.7	1.0 - 1.0 ②
	3:40	20s			24.6	13.7	1.0 - 1.0 ③
	4:00	20s			25.6	12.7	1.0 - 1.0 ④

Done

P2

BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 4-11-08 ST 2061

CLIENT ELAB PROJ NO. 08-S708

PROJECT 0804007 FACILITY I.D.

LOCATION OF SAMPLE 0804007-14A DEPTH

SHELBY TUBE OR REMOLDED ST

SOIL TYPE & COLOR TOPSOIL, SAND, ODOR? ORG fill?

DESCRIPTION WET, LOOSE, HAD TO BE PARTIALLY REMOLDED,

ANY PEBBLES OR OTHER MATERIALS? ROOTS, WOOD, LEAVES

DIAMETER: 7.275 / / = MOISTURE 53.5 pcf:

LENGTH: 6.071 / / =

WEIGHT: 324.4

MOISTURE	
TARE NO	2061
TARE+WET SOIL	62.6
TARE+DRY SOIL	41.4
WATER	21.2
TARE WEIGHT	1.8
DRY SOIL	39.6
WATER %	53.5

TOTAL BACKPRESSURE

MAX CONSOLID STRESS

MIN CONS STRESS

494.5 w/tube
-170.0
324.4

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	1:45	10	15	6.5	10.8			
	1:50	20	25	6.7	11.3			
	1:55	30	35	7.0	12.0			
	2:05	40	45	7.3	12.2			
	2:10	50	55	8.0	13.3			
	2:15	60	65	8.2	13.5			
	2:20	70	75	8.3	13.8			
	2:35	80	85	8.5	14.1			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

LAB I.D.: 2061

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00	83	80	85	9.5	34.7	
	1:00	60.5			11.6	32.9	2.1
	2:00	↓			13.9	31.1	7.3
	3:00	↓			16.6	27.9	2.3
	4:00	↓			17.8	26.4	1.2
	6:00				19.2	25.1	1.4
	7:00	↓			20.4	23.6	1.2
	8:00	↓			21.6	22.4	1.2
	9:00	↓			22.8	21.2	1.2
	10:00	↓			24.0	19.9	1.2

Done

P3

BEAVER ENGINEERING
PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 4-11-08
ST 2062
CLIENT ELAB PROJ NO. 08-5708
PROJECT 0804007 FACILITY I.D.
LOCATION OF SAMPLE 0804007-15A DEPTH
SHELBY TUBE OR REMOLDED ST
SOIL TYPE & COLOR TOPSOIL, DK BRN ODOR? MUSTY fill?
DESCRIPTION SOFT, SANDY, ROOTS + ORG'S, LOOSE, WET,
ANY PEBBLES OR OTHER MATERIALS? HAD TO BE PARTIALLY REMOLDED

DIAMETER: 7.024 / / = MOISTURE 50.5 pcf:

LENGTH: 6.311 / / =

WEIGHT: 321.3

MOISTURE	
TARE NO	2062
TARE+WET SOIL	65.9
TARE+DRY SOIL	44.4
WATER	21.5
TARE WEIGHT	1.8
DRY SOIL	42.6
WATER %	50.5

TOTAL BACKPRESSURE
MAX CONSOLID STRESS
MIN CONS STRESS

490.9 w/tube
- 169.6
321.3

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
4-11	11:05	10	15	8.3	8.3			
	11:10	20	25	8.3	8.3			
	11:15	30	35	8.3	8.9			
	11:20	40	45	8.7	10.0			
	11:25	50	55	8.8	10.2			
	11:30	60	65	8.8	10.7			
	11:45	70	75	8.8	10.0			
	12:00	80	85	8.8	10.3			

7.21 - 6 hr

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

LAB I.D.: 2062

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES	
4-11	0:00	83	80	85	15.2	13.7		
	5:00	5 min			16.1	13.1	0.9 - 0.6	
	15:00	10 min			17.5	11.8	1.4 - 1.3	
	26:00	11 min			18.9	10.5	1.4 - 1.3	
	36:00	10 min	600s		19.9	9.5	1.0 - 1.0	①
	41:00	5 min	300s		20.4	8.9	0.5 - 0.6	②
	46:00	5 min	300s		20.9	8.4	0.5 - 0.5	③
	51:00	5 min	300s		21.4	7.9	0.5 - 0.5	④ Done

P4

BEAVER ENGINEERING
PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 4-11-08 ST 2063
CLIENT ELAB PROJ NO. 08-5708
PROJECT 0804007 FACILITY I.D.
LOCATION OF SAMPLE 0804007-16A DEPTH
SHELBY TUBE OR REMOLDED ST (DK BRN)
SOIL TYPE & COLOR TOPSOIL; SAND ORGANICS ODOR? MUSTY fill?
DESCRIPTION WET, LOOSE HAD TO BE PARTIALLY REMOLDED ROOTS + WOOD PIECES
ANY PEBBLES OR OTHER MATERIALS?

DIAMETER: 6.950 / 7.208 / 7.305 AVG = 7.154 MOISTURE 46.2 pcf:

LENGTH: 6.055 / / =

WEIGHT: 291.6

MOISTURE	
TARE NO	2063
TARE+WET SOIL	76.5
TARE+DRY SOIL	52.9
WATER	23.6
TARE WEIGHT	1.8
DRY SOIL	51.1
WATER %	46.2

TOTAL BACKPRESSURE
MAX CONSOLID STRESS
MIN CONS STRESS

461.7
-170.1
291.6

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	12:30	10	15	4.7	9.0			
	12:35	20	25	4.7	9.0			
	12:40	30	35	4.0	8.4			
	12:45	40	45	4.4	8.8			
	12:50	50	55	4.8	9.3			
	12:55	60	65	5.1	9.6			
	1:00	70	75	5.6	10.3			
	1:05	80	85	5.9	10.4			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS. LOOK FOR TREND.

LAB I.D.: 2063

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
4-11	0:00	83	80	85	7.8	34.5	
	2:00	2 min			10.7	32.1	
	3:00	1 min			11.8	31.0	1.1 - 1.1
	4:00	1 min			13.0	29.9	1.2 - 1.1
	5:00	1 min			14.1	28.8	1.1 - 1.1
	6:00	1 min			15.2	27.8	1.1 - 1.0
	7:00	1 min			16.3	26.7	1.1 - 1.1
	8:00	1 min			17.4	25.6	1.1 - 1.1

Done

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615-350-8124

CLIENT	EMPIRICAL LABORATORIES		
PROJECT	0804007	PROJ. NO.	08-5708

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION **0804007-13A**
DESCRIPTION WET SAND, SOME TOPSOIL, ROOTS, WOOD, LEAVES, ORGANIC ODOR
SAMPLE WAS LOOSE AND HAD TO BE PARTIALLY REMOLDED
TYPE SAMPLE SHELBY TUBE

SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	6.4 cm	TEST DATE	4/11/2008
WEIGHT	439.3 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	38.89 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	24.0%	HEAD PRESSURE	83 psi
		CONSOLIDATION STRESS:	
		MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T =	20	20	20	20
INITIAL READING,influent liquid		21.6	22.6	23.6	24.6
INITIAL READING,effluent liquid		16.7	15.7	14.7	13.7
END READING, influent liquid		22.6	23.6	24.6	25.6
END READING, effluent liquid		15.7	14.7	13.7	12.7
TOTAL CUBIC CENTIMETERS	Q =	1.0	1.0	1.0	1.0
LENGTH OF SAMPLE	L =	6.4	6.4	6.4	6.4
LOSS OF HEAD	H =	205.0	203.0	201.0	199.0
CROSS SECTIONAL AREA	A =	38.89	38.89	38.89	38.89
EQUATION, K = QL/AHT	K =	**4.0E-05**	**4.1E-05**	**4.1E-05**	**4.1E-05**

4.1E-05 **AVERAGE CENTIMETERS PER SECOND**

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT EMPIRICAL LABORATORIES

PROJECT 0804007 PROJ. NO. 08-5708

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION **0804007-14A**
DESCRIPTION TOPSOIL AND SAND, ROOTS, WOOD, LEAVES, WET, ORGANIC ODOR
SAMPLE WAS LOOSE AND HAD TO BE PARTIALLY REMOLDED
TYPE SAMPLE SHELBY TUBE

SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	69.1 cm	TEST DATE	4/11/2008
WEIGHT	324.4 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	41.58 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	53.5%	HEAD PRESSURE	83 psi
		CONSOLIDATION STRESS:	
		MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T =	20	20	20	20
INITIAL READING,influent liquid		19.2	20.4	21.6	22.8
INITIAL READING,effluent liquid		25.1	23.6	22.4	21.2
END READING, influent liquid		20.4	21.6	22.8	24.0
END READING, effluent liquid		23.6	22.4	21.2	19.9
TOTAL CUBIC CENTIMETERS	Q =	1.2	1.2	1.2	1.2
LENGTH OF SAMPLE	L =	69.1	69.1	69.1	69.1
LOSS OF HEAD	H =	215.3	212.9	210.5	208.0
CROSS SECTIONAL AREA	A =	41.58	41.58	41.58	41.58
EQUATION, K = QL/AHT	K =	**4.6E-04**	**4.7E-04**	**4.7E-04**	**4.8E-04**

4.7E-04 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.
7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	EMPIRICAL LABORATORIES		
PROJECT	0804007	PROJ. NO.	08-5708

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION **0804007-15A**
DESCRIPTION TOPSOIL , DK BROWN, SAND, ROOTS, WOOD, LEAVES, WET, MUSTY ODOR
SAMPLE WAS LOOSE AND HAD TO BE PARTIALLY REMOLDED
TYPE SAMPLE SHELBY TUBE

SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	6.3 cm	TEST DATE	4/11/2008
WEIGHT	321.3 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	38.76 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	50.5%	HEAD PRESSURE	83 psi
		CONSOLIDATION STRESS:	
		MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T =	600	300	300	300
INITIAL READING,influent liquid		18.9	19.9	20.4	20.9
INITIAL READING,effluent liquid		10.5	9.5	8.9	8.4
END READING, influent liquid		19.9	20.4	20.9	21.4
END READING, effluent liquid		9.5	8.9	8.4	7.9
TOTAL CUBIC CENTIMETERS	Q =	1.0	0.5	0.5	0.5
LENGTH OF SAMPLE	L =	6.3	6.3	6.3	6.3
LOSS OF HEAD	H =	201.5	199.9	198.9	197.9
CROSS SECTIONAL AREA	A =	38.76	38.76	38.76	38.76
EQUATION, K = QL/AHT	K =	**1.3E-06**	**1.4E-06**	**1.4E-06**	**1.4E-06**

1.4E-06 AVERAGE CENTIMETERS PER SECOND

BEAVER ENGINEERING, INC.

7378 COCKRILL BEND BLVD.
NASHVILLE, TENNESSEE 37209
615-350-8124

CLIENT	EMPIRICAL LABORATORIES		
PROJECT	0804007	PROJ. NO.	08-5708

SATURATED HYDRAULIC CONDUCTIVITY

TEST DESCRIPTION:
EPA 9100, SECTION 2.8, TRIAXIAL CELL METHOD WITH BACKPRESSURE
ASTM D5084 - 90, MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LOCATION **0804007-16A**
DESCRIPTION TOPSOIL , DK BROWN, SAND, ROOTS, WOOD, WET, MUSTY ODOR
SAMPLE WAS LOOSE AND HAD TO BE PARTIALLY REMOLDED
TYPE SAMPLE SHELBY TUBE

SAMPLE INFORMATION:		TEST INFORMATION:	
LENGTH	6.1 cm	TEST DATE	4/11/2008
WEIGHT	291.6 grams	TOTAL BACKPRESSURE	80 psi
CROSS SECTIONAL AREA	40.21 cmsq	CELL PRESSURE	85 psi
MOISTURE OF SAMPLE	46.2%	HEAD PRESSURE	83 psi
		CONSOLIDATION STRESS:	
		MAXIMUM	5 psi
PERMEANT:	WATER	MINIMUM	2 psi

		READING 1	READING 2	READING 3	READING 4
LAPSED TIME(in seconds)	T =	60	60	60	60
INITIAL READING,influent liquid		13.0	14.1	15.2	16.3
INITIAL READING,effluent liquid		29.9	28.8	27.8	26.7
END READING, influent liquid		14.1	15.2	16.3	17.4
END READING, effluent liquid		28.8	27.8	26.7	25.6
TOTAL CUBIC CENTIMETERS	Q =	1.1	1.1	1.1	1.1
LENGTH OF SAMPLE	L =	6.1	6.1	6.1	6.1
LOSS OF HEAD	H =	226.7	224.6	222.4	220.2
CROSS SECTIONAL AREA	A =	40.21	40.21	40.21	40.21
EQUATION, K = QL/AHT	K =	**1.2E-05**	**1.2E-05**	**1.2E-05**	**1.3E-05**

1.2E-05 AVERAGE CENTIMETERS PER SECOND

P1

BEAVER ENGINEERING
PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 4-11-08

CLIENT ELAB ST 2060 PROJ NO. 08-5708

PROJECT 0804007 FACILITY I.D.

LOCATION OF SAMPLE 0804007-13A DEPTH

SHELBY TUBE OR REMOLDED

SOIL TYPE & COLOR ODOR? ORG fill?

DESCRIPTION WET SAND, SOME TOPSOIL, ROOTS, WOOD, LEAVES, LOOSE

ANY PEBBLES OR OTHER MATERIALS? HAD TO BE PARTIALLY REMOLDED

DIAMETER: 7.035 / / = MOISTURE 24.0 pcf:

LENGTH: 6.405 / / =

WEIGHT: 439.3

MOISTURE	
TARE NO	2060
TARE+WET SOIL	94.8
TARE+DRY SOIL	76.8
WATER	18.0
TARE WEIGHT	1.8
DRY SOIL	75.0
WATER %	24.0

TOTAL BACKPRESSURE
MAX CONSOLID STRESS
MIN CONS STRESS

612.8
-173.5
439.3

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	2:05	10	15	9.4	13.0			
	2:10	20	25	9.6	13.4			
	2:15	30	35	10.5	13.6			
	2:20	40	45	11.2	14.9			
	2:30	50	55	11.6	15.2			
	2:35	60	65	11.9	15.5			
	2:40	70	75	14.0	15.5			
	2:42	80	85	14.4	15.6			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

LAB I.D.: 2060

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES	
	0:00	83	80	85	6.0	32.5		
	0:20	20s			8.8	29.8	2.8 - 2.8	
	0:40	20s			11.5	27.1	2.7 - 2.7	
	1:00	20s			13.6	24.7	2.4 - 2.4	
	1:20	20s			15.7	22.6	2.1 - 2.1	
	1:40	20s			17.6	20.7	1.9 - 1.9	
	2:00	20s			19.1	19.2	1.5 - 1.5	
	2:20	20s			20.4	17.9	1.3 - 1.3	
	2:40	20s			21.6	16.7	1.2 - 1.2	
	3:00	20s			22.6	15.7	1.0 - 1.0	①
	3:20	20s			23.6	14.7	1.0 - 1.0	②
	3:40	20s			24.6	13.7	1.0 - 1.0	③
	4:00	20s			25.6	12.7	1.0 - 1.0	④

Done

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P2

BEAVER ENGINEERING
PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 4-11-08
ST 2061
CLIENT ELAB
PROJ NO. 08-S708
PROJECT 0804007
FACILITY I.D.
LOCATION OF SAMPLE 0804007-14A DEPTH
SHELBY TUBE OR REMOLDED ST
SOIL TYPE & COLOR TOPSOIL; SAND, ODOR? ORG fill?
DESCRIPTION WET, LOOSE, HAD TO BE PARTIALLY REMOLDED,
ANY PEBBLES OR OTHER MATERIALS? ROOTS, WOOD, LEAVES

DIAMETER: 2.875 / / =
MOISTURE 53.5 pcf:

LENGTH: 6.071 / / =

WEIGHT: 324.4

MOISTURE	
TARE NO	2061
TARE+WET SOIL	62.6
TARE+DRY SOIL	41.4
WATER	21.2
TARE WEIGHT	1.8
DRY SOIL	39.6
WATER %	53.5

TOTAL BACKPRESSURE
MAX CONSOLID STRESS
MIN CONS STRESS

494.5 w/tube
-170.0
324.4

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	1:45	10	15	6.5	10.8			
	1:50	20	25	6.7	11.3			
	1:55	30	35	7.0	12.0			
	2:05	40	45	7.3	12.2			
	2:10	50	55	8.0	13.3			
	2:15	60	65	8.2	13.5			
	2:20	70	75	8.3	13.8			
	2:35	80	85	8.5	14.1			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS. LOOK FOR TREND.

LAB I.D.: 2061

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
	0:00	83	80	85	9.5	34.7	
	1:00	60s			11.6	32.9	2.1
	2:00	↓			13.9	31.1	2.3
	3:00				16.6	27.9	2.3
	4:00	↓			17.8	26.4	1.2
	6:00				19.2	25.1	1.4
	7:00	↓			20.4	23.6	1.2
	8:00				21.6	22.4	1.2
	9:00				22.8	21.2	1.2
	10:00	↓			24.0	19.9	1.2

Done

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P3

BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 4-11-08

ST 2062

CLIENT ELAB PROJ NO. 08-5708

PROJECT 0804007 FACILITY I.D.

LOCATION OF SAMPLE 0804007-15A DEPTH

SHELBY TUBE OR REMOLDED ST

SOIL TYPE & COLOR TOPSOIL, DK BRN ODOR? MUSTY fill?

DESCRIPTION SOFT, SANDY, ROOTS + ORG'S, LOOSE, WET,

ANY PEBBLES OR OTHER MATERIALS? HAD TO BE PARTIALLY REMOLDED

DIAMETER: 7.024 / / = MOISTURE 50.5 pcf:

LENGTH: 6.311 / / =

WEIGHT: 321.3

MOISTURE	
TARE NO	2062
TARE+WET SOIL	65.9
TARE+DRY SOIL	44.4
WATER	21.5
TARE WEIGHT	1.8
DRY SOIL	42.6
WATER %	50.5

TOTAL BACKPRESSURE

MAX CONSOLID STRESS

MIN CONS STRESS

490.9 w/tube
- 169.6
321.3

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
4-11	11:05	10	15	8.3	8.3			
	11:10	20	25	8.3	8.3			
	11:15	30	35	8.3	8.9			
	11:20	40	45	8.7	10.0			
	11:25	50	55	8.8	10.2			
	11:30	60	65	8.8	10.7			
	11:45	70	75	8.9	10.0			
	12:00	80	85	8.8	10.3			

7.21 - 6.61

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

LAB I.D. : 2062

DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES	
4-11	0:00	83	80	85	15.2	13.7		
	5:00	5 min			16.1	13.1	0.9 - 0.6	
	15:00	10 min			17.5	11.8	1.4 - 1.3	
	26:00	11 min			18.9	10.5	1.4 - 1.3	
	36:00	10 min	600s		19.9	9.5	1.0 - 1.0	①
	41:00	5 min	300s		20.4	8.9	0.5 - 0.6	②
	46:00	5 min	300s		20.9	8.4	0.5 - 0.5	③
	51:00	5 min	300s		21.4	7.9	0.5 - 0.5	④ Done

P4

BEAVER ENGINEERING

PERMEABILITY TEST, EPA METHOD 9100, SECTION 2.8

DATE 4-11-08

ST 2063

CLIENT ELAB PROJ NO. 08-5708

PROJECT 0804007 FACILITY I.D.

LOCATION OF SAMPLE 0804007-16A DEPTH

SHELBY TUBE OR REMOLDED ST (DK BRN

SOIL TYPE & COLOR TOPSOIL; SAND ORGANICS ODOR? MUSTY fill?

DESCRIPTION WET, LOOSE HAD TO BE PARTIALLY ROOTS + WOOD PIECES

ANY PEBBLES OR OTHER MATERIALS? REMOLDED

DIAMETER: 6.950 / 7.208 / 7.305 AVG = 7.154 MOISTURE 46.2 pcf:

LENGTH: 6.055 / / =

WEIGHT: 291.6

MOISTURE	
TARE NO	2063
TARE+WET SOIL	76.5
TARE+DRY SOIL	52.9
WATER	23.6
TARE WEIGHT	1.8
DRY SOIL	51.1
WATER %	46.2

TOTAL BACKPRESSURE

MAX CONSOLID STRESS

MIN CONS STRESS

461.7
-170.1
291.6

SATURATE AND CONSOLIDATE

CONNECT PEDISTAL AND CAP TO BACK PRESSURE; BEGIN WITH 10psi BACKPRESSURE ANDINCREASE BY 10 EVERY 30 MINUTES. CONSOLIDATE IF NEEDED AFTER REACHING 40psi; B CHECK.

DATE	TIME	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	DIAL	PORE METER	CALCULATE B VALUE
	12:30	10	15	4.7	9.0			
	12:35	20	25	4.7	9.0			
	12:40	30	35	4.0	8.4			
	12:45	40	45	4.4	8.8			
	12:50	50	55	4.8	9.3			
	12:55	60	65	5.1	9.6			
	1:00	70	75	5.6	10.3			
	1:05	80	85	5.9	10.4			

PERMEABILITY

CONNECT HEAD PRESSURE TO PEDISTAL SIDE

CONNECT BACK PRESSURE TO CAP SIDE

MAKE AND RECORD READINGS, CALCULATING DIFFERENCES IN WATER MOVEMENT UNTIL THE AMOUNT OF WATER MOVEMENT IN PEDISTAL AND CAP ARE EQUAL FOR FOUR CONSECUTIVE READINGS.
LOOK FOR TREND.

LAB I.D.: 2063

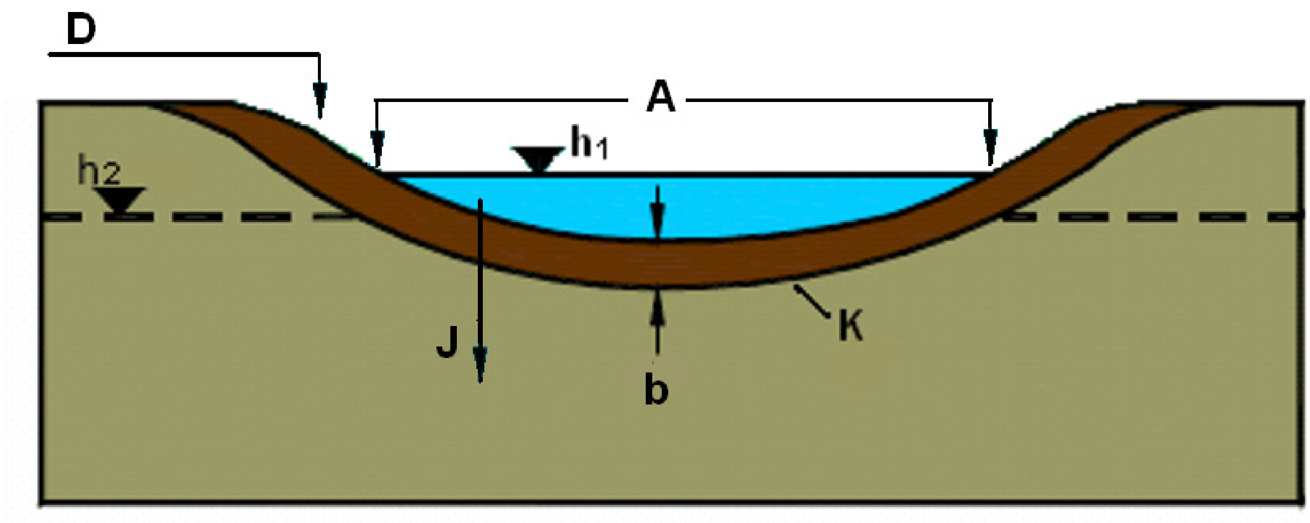
DATE	TIME	HEAD PRESSURE	BACK PRESSURE	CELL PRESSURE	PEDISTAL WATER	CAP WATER	CALCULATE DIFFERENCES
4-11	0:00	83	80	85	7.8	34.5	
	2:00	2 min			10.7	32.1	
	3:00	1 min			11.8	31.0	1.1 - 1.1
	4:00	1 min			13.0	29.9	1.2 - 1.1
	5:00	1 min			14.1	28.8	1.1 - 1.1
	6:00	1 min			15.2	27.8	1.1 - 1.0
	7:00	1 min			16.3	26.7	1.1 - 1.1
	8:00	1 min			17.4	25.6	1.1 - 1.1

Done

ATTACHMENT E

INFILTRATION CALCULATION

Schematic of the Infiltration Calculation



Groundwater Seepage Flux:

$$J = K \cdot \frac{h_1 - h_2}{b} \cdot A$$

During the incremental time span Δt:

$$h_1^{l+1} = \frac{(D - J) \cdot \Delta t}{A} + h_1^l$$

Where J is groundwater seepage flux; D is discharge including surface water runoff and precipitation; h_1 is surface water elevation; h_2 is groundwater elevation; b is wetland bottom thickness; K is vertical permeability; A is wetland area.

Infiltration Calculation

GW head h2 =	4.05	ft	
Wetland bottom thickness b =	2	ft	
Vertical Permeability K =	1.20E-05	cm/s	0.00142 ft/hour
Wetland Area A =	51300	ft2	
Discharge D =	823.148	ft3/hour	

Time (d)	Time (hr)	delta t (hr)	gw flux J (ft3/hr)	D-J	h1 (ft)
0	0		-43.62733	823.14803	2.85000
0.5	12	12	-36.25596	859.40400	3.05275
1	24	12	-28.94729	852.09532	3.25378
1.5	36	12	-21.70077	844.84880	3.45311
2	48	12	-14.51588	837.66391	3.65073
2.5	60	12	-7.39209	830.54012	3.84668
3	72	12	-0.32888	823.47692	4.04095
3.5	84	12	6.67425	816.47378	4.23358
4	96	12	13.61783	809.53020	4.42457
4.5	108	12	20.50236	802.64567	4.61393
5	120	12	27.32834	795.81969	4.80169
5.5	132	12	34.09628	789.05176	4.98784
6	144	12	40.80665	782.34138	5.17242
6.5	156	12	47.45996	775.68808	5.35542
7	168	12	54.05668	769.09135	5.53687
7.5	180	12	60.59730	762.55073	5.71677
8	192	12	67.08230	756.06573	5.89515
8.5	204	12	73.51215	749.63588	6.07200
9	216	12	79.88732	743.26071	6.24736
9.5	228	12	86.20827	736.93976	6.42122
10	240	12	92.47547	730.67257	6.59360
10.5	252	12	98.68936	724.45867	6.76452
11	264	12	104.85041	718.29762	6.93398
11.5	276	12	110.95907	712.18896	7.10201
12	288	12	117.01578	706.13226	7.26860
12.5	300	12	123.02097	700.12706	7.43378
13	312	12	128.97510	694.17293	7.59755
13.5	324	12	134.87859	688.26944	7.75993
14	336	12	140.73188	682.41616	7.92093
14.5	348	12	146.53538	676.61265	8.08056
15	360	12	152.28954	670.85850	8.23883
15.5	372	12	157.99475	665.15328	8.39576
16	384	12	163.65145	659.49658	8.55135
16.5	396	12	169.26004	653.88799	8.70562
17	408	12	174.82094	648.32710	8.85857
17.5	420	12	180.33454	642.81350	9.01023
18	432	12	185.80125	637.34678	9.16059
18.5	444	12	191.22147	631.92656	9.30968
19	456	12	196.59560	626.55244	9.45750
19.5	468	12	201.92402	621.22401	9.60406
20	480	12	207.20713	615.94091	9.74938
20.5	492	12	212.44530	610.70273	9.89346
21	504	12	217.63894	605.50910	10.03631
21.5	516	12	222.78840	600.35963	10.17795
22	528	12	227.89407	595.25397	10.31839
22.5	540	12	232.95632	590.19172	10.45763

23	552	12	237.97552	585.17252	10.59568
23.5	564	12	242.95203	580.19600	10.73256
24	576	12	247.88622	575.26181	10.86828
24.5	588	12	252.77845	570.36958	11.00285
25	600	12	257.62907	565.51896	11.13627
25.5	612	12	262.43844	560.70959	11.26855
26	624	12	267.20692	555.94112	11.39971
26.5	636	12	271.93484	551.21320	11.52976
27	648	12	276.62255	546.52549	11.65870
27.5	660	12	281.27039	541.87764	11.78654
28	672	12	285.87871	537.26932	11.91329
28.5	684	12	290.44784	532.70020	12.03897
29	696	12	294.97811	528.16993	12.16358
29.5	708	12	299.46985	523.67818	12.28713
30	720	12	303.92339	519.22464	12.40962
30.5	732	12	308.33906	514.80897	12.53108
31	744	12	312.71718	510.43085	12.65150
31.5	756	12	317.05806	506.08997	12.77090
32	768	12	321.36203	501.78600	12.88929
32.5	780	12	325.62940	497.51864	13.00666
33	792	12	329.86047	493.28756	13.12304
33.5	804	12	334.05556	489.09247	13.23843
34	816	12	338.21497	484.93306	13.35284
34.5	828	12	342.33902	480.80902	13.46627
35	840	12	346.42798	476.72005	13.57874
35.5	852	12	350.48218	472.66585	13.69026
36	864	12	354.50190	468.64614	13.80082
36.5	876	12	358.48743	464.66060	13.91045
37	888	12	362.43907	460.70897	14.01914
37.5	900	12	366.35710	456.79094	14.12691
38	912	12	370.24181	452.90623	14.23376
38.5	924	12	374.09348	449.05455	14.33970
39	936	12	377.91240	445.23563	14.44474
39.5	948	12	381.69884	441.44919	14.54889
40	960	12	385.45308	437.69495	14.65216
40.5	972	12	389.17539	433.97264	14.75454
41	984	12	392.86605	430.28199	14.85605
41.5	996	12	396.52532	426.62272	14.95671
42	1008	12	400.15347	422.99457	15.05650
42.5	1020	12	403.75076	419.39727	15.15545
43	1032	12	407.31746	415.83057	15.25355
43.5	1044	12	410.85383	412.29420	15.35082
44	1056	12	414.36013	408.78790	15.44726
44.5	1068	12	417.83660	405.31143	15.54289
45	1080	12	421.28352	401.86452	15.63770
45.5	1092	12	424.70111	398.44692	15.73170
46	1104	12	428.08965	395.05839	15.82490
46.5	1116	12	431.44936	391.69867	15.91732
47	1128	12	434.78050	388.36753	16.00894
47.5	1140	12	438.08332	385.06471	16.09979
48	1152	12	441.35804	381.78999	16.18986
48.5	1164	12	444.60492	378.54311	16.27917
49	1176	12	447.82419	375.32385	16.36772
49.5	1188	12	451.01607	372.13196	16.45551
50	1200	12	454.18081	368.96722	16.54256

50.5	1212	12	457.31864	365.82939	16.62887
51	1224	12	460.42978	362.71825	16.71444
51.5	1236	12	463.51447	359.63357	16.79929
52	1248	12	466.57292	356.57512	16.88341
52.5	1260	12	469.60536	353.54268	16.96682
53	1272	12	472.61201	350.53603	17.04952
53.5	1284	12	475.59309	347.55494	17.13152
54	1296	12	478.54882	344.59921	17.21282
54.5	1308	12	481.47941	341.66862	17.29343
55	1320	12	484.38508	338.76295	17.37335
55.5	1332	12	487.26604	335.88199	17.45259
56	1344	12	490.12250	333.02553	17.53116
56.5	1356	12	492.95467	330.19337	17.60906
57	1368	12	495.76275	327.38529	17.68630
57.5	1380	12	498.54695	324.60109	17.76288
58	1392	12	501.30747	321.84056	17.83881
58.5	1404	12	504.04451	319.10352	17.91410
59	1416	12	506.75828	316.38975	17.98874
59.5	1428	12	509.44897	313.69906	18.06275
60	1440	12	512.11678	311.03125	18.13613
60.5	1452	12	514.76190	308.38613	18.20888
61	1464	12	517.38452	305.76351	18.28102
61.5	1476	12	519.98484	303.16319	18.35255
62	1488	12	522.56305	300.58498	18.42346
62.5	1500	12	525.11933	298.02870	18.49377
63	1512	12	527.65387	295.49416	18.56349
63.5	1524	12	530.16686	292.98118	18.63261
64	1536	12	532.65847	290.48956	18.70114
64.5	1548	12	535.12890	288.01913	18.76909
65	1560	12	537.57831	285.56972	18.83647
65.5	1572	12	540.00690	283.14113	18.90327
66	1584	12	542.41483	280.73320	18.96950
66.5	1596	12	544.80229	278.34575	19.03517
67	1608	12	547.16944	275.97860	19.10028
67.5	1620	12	549.51646	273.63158	19.16483
68	1632	12	551.84351	271.30452	19.22884
68.5	1644	12	554.15078	268.99725	19.29230
69	1656	12	556.43843	266.70960	19.35523
69.5	1668	12	558.70662	264.44141	19.41762
70	1680	12	560.95553	262.19251	19.47947
70.5	1692	12	563.18530	259.96273	19.54080
71	1704	12	565.39612	257.75192	19.60161
71.5	1716	12	567.58813	255.55990	19.66191
72	1728	12	569.76150	253.38653	19.72169
72.5	1740	12	571.91639	251.23164	19.78096
73	1752	12	574.05295	249.09508	19.83973
73.5	1764	12	576.17135	246.97669	19.89799
74	1776	12	578.27172	244.87631	19.95577
74.5	1788	12	580.35424	242.79380	20.01305
75	1800	12	582.41904	240.72899	20.06984
75.5	1812	12	584.46628	238.68175	20.12615
76	1824	12	586.49612	236.65192	20.18198
76.5	1836	12	588.50869	234.63934	20.23734
77	1848	12	590.50414	232.64389	20.29223
77.5	1860	12	592.48263	230.66540	20.34665

78	1872	12	594.44429	228.70374	20.40060
78.5	1884	12	596.38927	226.75877	20.45410
79	1896	12	598.31770	224.83033	20.50715
79.5	1908	12	600.22974	222.91829	20.55974
80	1920	12	602.12552	221.02252	20.61188
80.5	1932	12	604.00517	219.14286	20.66358
81	1944	12	605.86884	217.27920	20.71484
81.5	1956	12	607.71666	215.43138	20.76567
82	1968	12	609.54876	213.59927	20.81606
82.5	1980	12	611.36528	211.78275	20.86603
83	1992	12	613.16636	209.98168	20.91557
83.5	2004	12	614.95212	208.19592	20.96469
84	2016	12	616.72269	206.42535	21.01339
84.5	2028	12	618.47820	204.66983	21.06167
85	2040	12	620.21879	202.92925	21.10955
85.5	2052	12	621.94457	201.20347	21.15702
86	2064	12	623.65567	199.49236	21.20408
86.5	2076	12	625.35223	197.79581	21.25075
87	2088	12	627.03435	196.11368	21.29702
87.5	2100	12	628.70217	194.44586	21.34289
88	2112	12	630.35581	192.79223	21.38838
88.5	2124	12	631.99538	191.15265	21.43347
89	2136	12	633.62101	189.52702	21.47819
89.5	2148	12	635.23281	187.91522	21.52252
90	2160	12	636.83091	186.31712	21.56648
90.5	2172	12	638.41542	184.73262	21.61006
91	2184	12	639.98645	183.16158	21.65327
91.5	2196	12	641.54412	181.60391	21.69612
92	2208	12	643.08854	180.05949	21.73860
92.5	2220	12	644.61983	178.52820	21.78072
93	2232	12	646.13810	177.00993	21.82248
93.5	2244	12	647.64345	175.50458	21.86388
94	2256	12	649.13601	174.01203	21.90494
94.5	2268	12	650.61587	172.53217	21.94564
95	2280	12	652.08314	171.06489	21.98600
95.5	2292	12	653.53794	169.61010	22.02602
96	2304	12	654.98036	168.16767	22.06569
96.5	2316	12	656.41052	166.73752	22.10503
97	2328	12	657.82851	165.31952	22.14403
97.5	2340	12	659.23445	163.91359	22.18270
98	2352	12	660.62843	162.51961	22.22105
98.5	2364	12	662.01055	161.13748	22.25906
99	2376	12	663.38092	159.76711	22.29675
99.5	2388	12	664.73964	158.40840	22.33413
100	2400	12	666.08680	157.06124	22.37118
100.5	2412	12	667.42250	155.72553	22.40792
101	2424	12	668.74685	154.40119	22.44435
101.5	2436	12	670.05993	153.08811	22.48047
102	2448	12	671.36184	151.78619	22.51628
102.5	2460	12	672.65269	150.49535	22.55178
103	2472	12	673.93255	149.21548	22.58698
103.5	2484	12	675.20153	147.94650	22.62189
104	2496	12	676.45972	146.68831	22.65650
104.5	2508	12	677.70721	145.44082	22.69081
105	2520	12	678.94409	144.20394	22.72483

105.5	2532	12	680.17045	142.97758	22.75856
106	2544	12	681.38638	141.76165	22.79201
106.5	2556	12	682.59197	140.55606	22.82517
107	2568	12	683.78731	139.36072	22.85805
107.5	2580	12	684.97248	138.17555	22.89065
108	2592	12	686.14758	137.00046	22.92297
108.5	2604	12	687.31268	135.83536	22.95501
109	2616	12	688.46787	134.68016	22.98679
109.5	2628	12	689.61324	133.53480	23.01829
110	2640	12	690.74886	132.39917	23.04953
110.5	2652	12	691.87483	131.27320	23.08050
111	2664	12	692.99123	130.15681	23.11121
111.5	2676	12	694.09813	129.04991	23.14165
112	2688	12	695.19561	127.95242	23.17184
112.5	2700	12	696.28376	126.86427	23.20177
113	2712	12	697.36266	125.78537	23.23145
113.5	2724	12	698.43239	124.71565	23.26087
114	2736	12	699.49301	123.65502	23.29004
114.5	2748	12	700.54462	122.60342	23.31897
115	2760	12	701.58728	121.56075	23.34765
115.5	2772	12	702.62108	120.52696	23.37608
116	2784	12	703.64608	119.50195	23.40428
116.5	2796	12	704.66237	118.48567	23.43223
117	2808	12	705.67001	117.47802	23.45995
117.5	2820	12	706.66908	116.47895	23.48743
118	2832	12	707.65966	115.48837	23.51467
118.5	2844	12	708.64182	114.50622	23.54169
119	2856	12	709.61562	113.53242	23.56847
119.5	2868	12	710.58114	112.56690	23.59503
120	2880	12	711.53845	111.60959	23.62136
120.5	2892	12	712.48761	110.66042	23.64747
121	2904	12	713.42871	109.71933	23.67335
121.5	2916	12	714.36180	108.78623	23.69902
122	2928	12	715.28696	107.86108	23.72447
122.5	2940	12	716.20424	106.94379	23.74970
123	2952	12	717.11373	106.03430	23.77471
123.5	2964	12	718.01549	105.13255	23.79952
124	2976	12	718.90957	104.23846	23.82411
124.5	2988	12	719.79605	103.35198	23.84849
125	3000	12	720.67499	102.47304	23.87267
125.5	3012	12	721.54646	101.60157	23.89664
126	3024	12	722.41051	100.73752	23.92040
126.5	3036	12	723.26722	99.88081	23.94397
127	3048	12	724.11664	99.03139	23.96733
127.5	3060	12	724.95884	98.18919	23.99050
128	3072	12	725.79388	97.35416	24.01347
128.5	3084	12	726.62181	96.52622	24.03624
129	3096	12	727.44270	95.70533	24.05882
129.5	3108	12	728.25661	94.89142	24.08121
130	3120	12	729.06360	94.08443	24.10340
130.5	3132	12	729.86373	93.28430	24.12541
131	3144	12	730.65705	92.49098	24.14723
131.5	3156	12	731.44363	91.70440	24.16887
132	3168	12	732.22352	90.92452	24.19032
132.5	3180	12	732.99677	90.15126	24.21159

133	3192	12	733.76345	89.38458	24.23268
133.5	3204	12	734.52361	88.62443	24.25358
134	3216	12	735.27730	87.87073	24.27431
134.5	3228	12	736.02458	87.12345	24.29487
135	3240	12	736.76551	86.38252	24.31525
135.5	3252	12	737.50014	85.64789	24.33546
136	3264	12	738.22852	84.91951	24.35549
136.5	3276	12	738.95071	84.19733	24.37535
137	3288	12	739.66675	83.48128	24.39505
137.5	3300	12	740.37670	82.77133	24.41458
138	3312	12	741.08062	82.06741	24.43394
138.5	3324	12	741.77855	81.36948	24.45314
139	3336	12	742.47054	80.67749	24.47217
139.5	3348	12	743.15665	79.99138	24.49104
140	3360	12	743.83693	79.31110	24.50975
140.5	3372	12	744.51142	78.63661	24.52831
141	3384	12	745.18017	77.96786	24.54670
141.5	3396	12	745.84324	77.30480	24.56494
142	3408	12	746.50067	76.64737	24.58302
142.5	3420	12	747.15250	75.99553	24.60095
143	3432	12	747.79879	75.34924	24.61873
143.5	3444	12	748.43959	74.70844	24.63635
144	3456	12	749.07494	74.07310	24.65383
144.5	3468	12	749.70488	73.44315	24.67116
145	3480	12	750.32947	72.81857	24.68833
145.5	3492	12	750.94874	72.19929	24.70537
146	3504	12	751.56275	71.58528	24.72226
146.5	3516	12	752.17154	70.97650	24.73900
147	3528	12	752.77515	70.37289	24.75561
147.5	3540	12	753.37362	69.77441	24.77207
148	3552	12	753.96701	69.18103	24.78839
148.5	3564	12	754.55535	68.59269	24.80457
149	3576	12	755.13868	68.00935	24.82062
149.5	3588	12	755.71706	67.43097	24.83652
150	3600	12	756.29052	66.85752	24.85230
150.5	3612	12	756.85910	66.28894	24.86794
151	3624	12	757.42284	65.72519	24.88344
151.5	3636	12	757.98179	65.16624	24.89882
152	3648	12	758.53599	64.61205	24.91406
152.5	3660	12	759.08547	64.06256	24.92917
153	3672	12	759.63028	63.51775	24.94416
153.5	3684	12	760.17046	62.97757	24.95902
154	3696	12	760.70604	62.44199	24.97375
154.5	3708	12	761.23707	61.91096	24.98836
155	3720	12	761.76358	61.38445	25.00284
155.5	3732	12	762.28562	60.86241	25.01720
156	3744	12	762.80321	60.34482	25.03143
156.5	3756	12	763.31641	59.83163	25.04555
157	3768	12	763.82524	59.32280	25.05955
157.5	3780	12	764.32974	58.81829	25.07342
158	3792	12	764.82995	58.31808	25.08718
158.5	3804	12	765.32591	57.82213	25.10082
159	3816	12	765.81765	57.33039	25.11435
159.5	3828	12	766.30521	56.84283	25.12776
160	3840	12	766.78862	56.35942	25.14106

160.5	3852	12	767.26792	55.88012	25.15424
161	3864	12	767.74314	55.40489	25.16731
161.5	3876	12	768.21432	54.93371	25.18027
162	3888	12	768.68150	54.46653	25.19312
162.5	3900	12	769.14470	54.00333	25.20586
163	3912	12	769.60397	53.54407	25.21849
163.5	3924	12	770.05932	53.08871	25.23102
164	3936	12	770.51081	52.63723	25.24344
164.5	3948	12	770.95845	52.18958	25.25575
165	3960	12	771.40229	51.74574	25.26796
165.5	3972	12	771.84236	51.30568	25.28006
166	3984	12	772.27868	50.86936	25.29206
166.5	3996	12	772.71129	50.43674	25.30396
167	4008	12	773.14022	50.00781	25.31576
167.5	4020	12	773.56550	49.58253	25.32746
168	4032	12	773.98717	49.16086	25.33906
168.5	4044	12	774.40525	48.74278	25.35056
169	4056	12	774.81978	48.32825	25.36196
169.5	4068	12	775.23078	47.91725	25.37326
170	4080	12	775.63828	47.50975	25.38447
170.5	4092	12	776.04232	47.10571	25.39558
171	4104	12	776.44293	46.70511	25.40660
171.5	4116	12	776.84012	46.30791	25.41753
172	4128	12	777.23394	45.91409	25.42836
172.5	4140	12	777.62441	45.52362	25.43910
173	4152	12	778.01156	45.13647	25.44975
173.5	4164	12	778.39542	44.75262	25.46031
174	4176	12	778.77601	44.37202	25.47078
174.5	4188	12	779.15337	43.99467	25.48116
175	4200	12	779.52751	43.62052	25.49145
175.5	4212	12	779.89848	43.24956	25.50165
176	4224	12	780.26629	42.88175	25.51177
176.5	4236	12	780.63097	42.51707	25.52180
177	4248	12	780.99255	42.15549	25.53174
177.5	4260	12	781.35105	41.79698	25.54161
178	4272	12	781.70651	41.44153	25.55138
178.5	4284	12	782.05894	41.08909	25.56108
179	4296	12	782.40838	40.73966	25.57069
179.5	4308	12	782.75484	40.39319	25.58022
180	4320	12	783.09836	40.04967	25.58967
180.5	4332	12	783.43896	39.70908	25.59903
181	4344	12	783.77666	39.37138	25.60832
181.5	4356	12	784.11148	39.03655	25.61753
182	4368	12	784.44346	38.70457	25.62666
182.5	4380	12	784.77262	38.37541	25.63572
183	4392	12	785.09898	38.04905	25.64469
183.5	4404	12	785.42256	37.72547	25.65359
184	4416	12	785.74339	37.40464	25.66242
184.5	4428	12	786.06150	37.08654	25.67117
185	4440	12	786.37689	36.77114	25.67984
185.5	4452	12	786.68961	36.45843	25.68845
186	4464	12	786.99966	36.14837	25.69697
186.5	4476	12	787.30708	35.84095	25.70543
187	4488	12	787.61189	35.53615	25.71381
187.5	4500	12	787.91410	35.23394	25.72213

188	4512	12	788.21374	34.93429	25.73037
188.5	4524	12	788.51083	34.63720	25.73854
189	4536	12	788.80540	34.34263	25.74664
189.5	4548	12	789.09746	34.05057	25.75468
190	4560	12	789.38704	33.76099	25.76264
190.5	4572	12	789.67415	33.47388	25.77054
191	4584	12	789.95883	33.18920	25.77837
191.5	4596	12	790.24108	32.90695	25.78613
192	4608	12	790.52093	32.62710	25.79383
192.5	4620	12	790.79841	32.34963	25.80146
193	4632	12	791.07352	32.07452	25.80903
193.5	4644	12	791.34629	31.80174	25.81653
194	4656	12	791.61674	31.53129	25.82397
194.5	4668	12	791.88490	31.26314	25.83135
195	4680	12	792.15077	30.99726	25.83866
195.5	4692	12	792.41438	30.73365	25.84591
196	4704	12	792.67575	30.47228	25.85310
196.5	4716	12	792.93490	30.21313	25.86023
197	4728	12	793.19184	29.95619	25.86729
197.5	4740	12	793.44660	29.70143	25.87430
198	4752	12	793.69919	29.44884	25.88125
198.5	4764	12	793.94963	29.19840	25.88814
199	4776	12	794.19795	28.95009	25.89497
199.5	4788	12	794.44415	28.70388	25.90174
200	4800	12	794.68826	28.45978	25.90845

ATTACHMENT F

SALT WATER WETLANDS IRON BACKGROUND ASSESSMENT

SALT WATER WETLANDS IRON BACKGROUND ASSESSMENT

To determine a background concentration range for iron the initial data set (Table 1) was first visually evaluated. Figure 1 contains a histogram, boxplot, and normal Q-Q plot of the iron concentrations. From Figure 1 it can be seen that the iron concentrations are skewed right, with the majority of the samples having lower concentrations and then a few samples with higher concentrations.

Table 1

WETLAND	FRESH/SALT	SAMPLE_ID	SAMPL_DATE	RESULT	Qualifier	Units
19B	S	041W190301	1/17/1996	4030		UG/L
63B	S	041W63B201	1/18/1996	1560		UG/L
64	S	041W640101	9/4/1997	829		UG/L
64	S	041W640501	9/4/1997	702		UG/L
63A	S	041W63A201	1/18/1996	483		UG/L
W2	S	041WW20201	1/24/1996	309		UG/L
Near Shore	S	040W2B0101	19970903	230		UG/L
63B	S	041W63B401	1/24/1996	206		UG/L
63A	S	041W63A202	4/8/2004	140		UG/L
Near Shore	S	040W2B0701	19970903	104	J	UG/L
Near Shore	S	040W2B0901	19970903	34.7	J	UG/L
10	F	033W001002	1/20/1993	5110		UG/L
10	F	033W002002	1/20/1993	1090		UG/L
10	F	033W000102	4/8/2004	900		UG/L
10	F	033W003002	1/20/1993	808		UG/L
10	F	033W004002	1/20/1993	808		UG/L
12	F	041W120101	11/28/1995	1150		UG/L
13	F	041W130101	11/27/1995	36200		UG/L
19A	F	041W19A102	4/8/2004	1000		UG/L

Figure 1

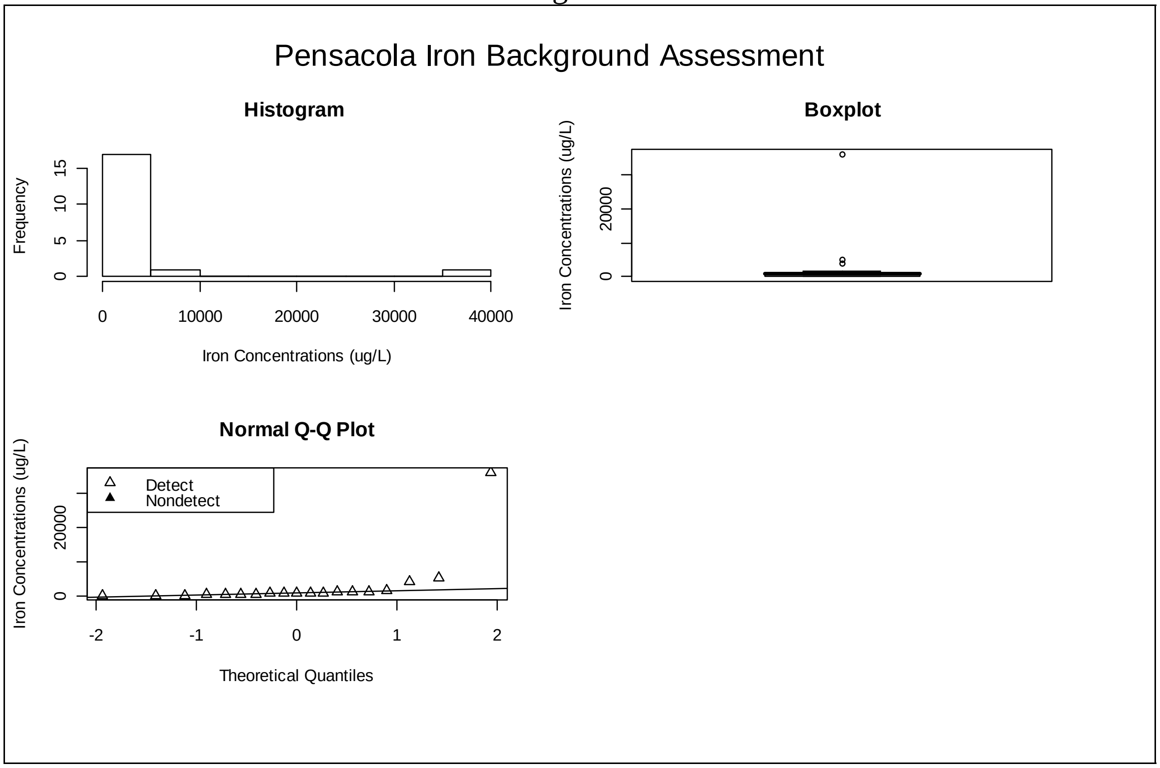
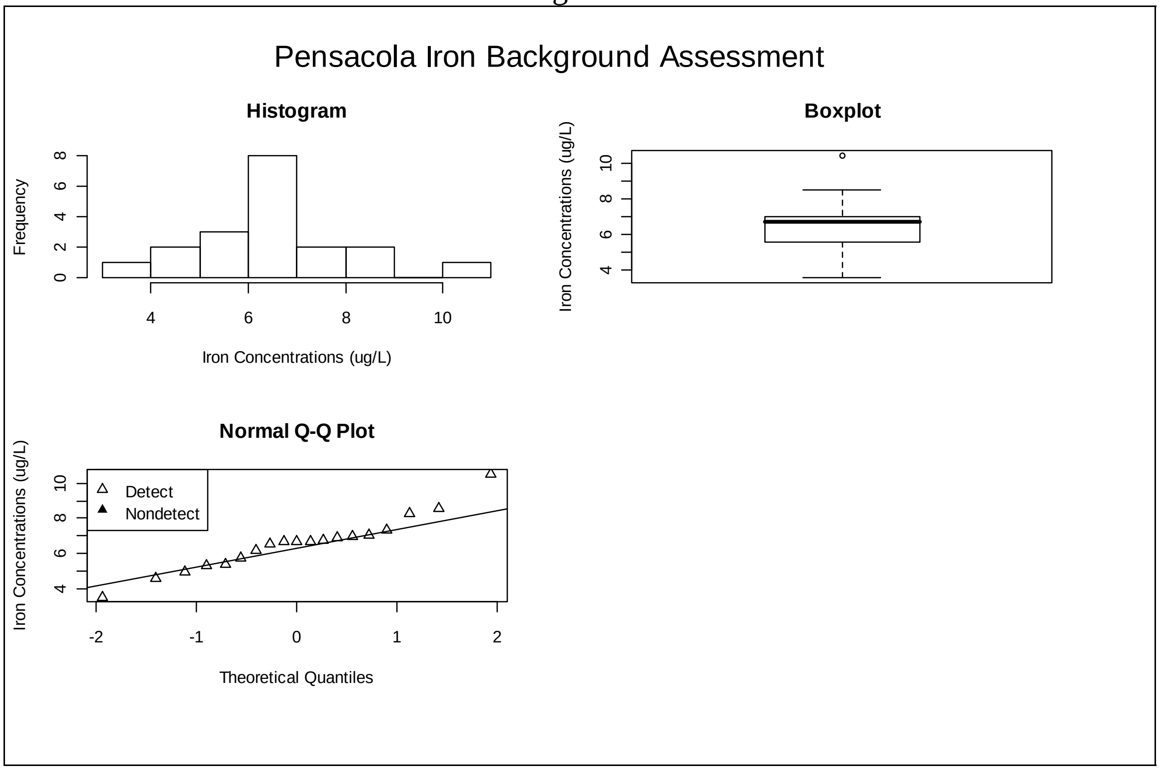


Figure 2 contains a histogram, boxplot, and normal Q-Q plot of the log-transformed iron concentrations. A log transformation was used because of the skewness discussed above. From Figure 2 it can be seen that the histogram is roughly bell shaped with one concentration separated from the rest of the data. The tails of the boxplot appear roughly the same length. One potential outlier is denoted on the boxplot. The normal plot is roughly linear with one concentration separated from the rest of the data. The Shapiro wilk p-value is 0.4697. This p-value is greater than 0.05 so there is insufficient evidence to conclude that the log transformed concentrations are not normally distributed. The extreme value test was computed to determine if the potential outlier noted on the plots is an outlier. The extreme value test computes a C statistic and compares it to a critical value. If the C statistic is greater than the critical value the null hypothesis that there is not outlier is rejected and it is concluded that there is an outlier. The C statistic is 0.39 and the critical value for a sample size of 19 and a significance level of 0.05 is 0.462 (Table A-4 from Data Quality Assessment: Statistical Methods for Practitioners, 2006). Therefore, it can be concluded that there are no statistically significant outliers in the data in Table 1.

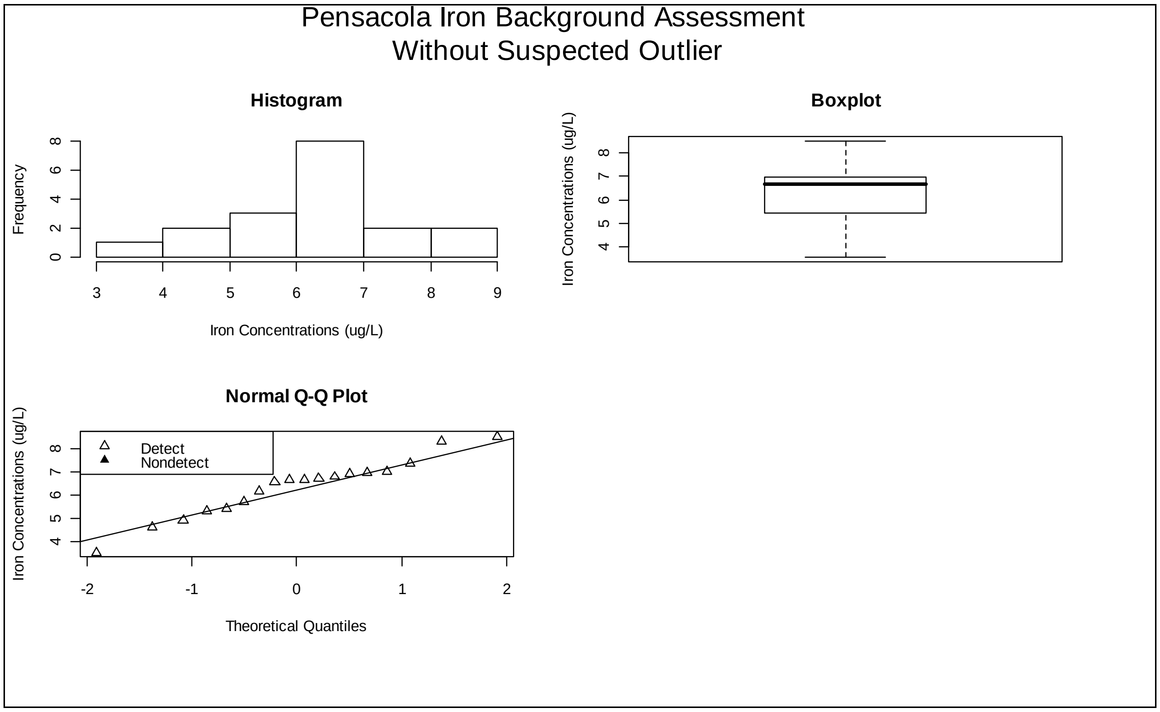
Figure 2



Although it has been concluded that there are no statistically significant outliers in the data, further statistical analyses were conducted for the data excluding the point outside of the non-outlier lines in the boxplot.

Figure 3 contains a histogram, boxplot, and normal Q-Q plot of the log-transformed iron concentrations without the suspected outlier. From Figure 3 it can be seen that the histogram is roughly bell shaped with a slightly longer left tail then right tail with no concentrations separated from the rest of the data. The tails of the boxplot are roughly the same length with no potential outliers noted. The normal plot is roughly linear with no concentrations separated from the rest of the data. The Shapiro wilk p-value is 0.5975. This p-value is greater than 0.05 so there is insufficient evidence to conclude that the log transformed concentrations without the outlier are not normally distributed.

Figure 3



Pensacola Iron Background Assessment
Without Suspected Outlier
Histogram
Frequency
0
2
4
6
8
3
4
5
6
7
8
9
Iron Concentrations (ug/L)
Boxplot
Iron Concentrations (ug/L)
4
5
6
7
8
Normal Q-Q Plot
Iron Concentrations (ug/L)
4
5
6
7
8
Detect
Nondetect
-2
-1
0
1
2
Theoretical Quantiles