Tech Memo Approval Form

Tech Memo Number: 338884-TMEM-131
Revision: 1
Project: 338884
Review Date: 09/07/2011

Tech Memo Title:
Effects of Temporary Dewatering on Wetlands for the Construction of the Levy Nuclear Plant, Levy County, Florida

Revision History:

Revision Number	Description	Approval Date	Affected Pages
0	Initial submittal	08/15/2011	All
1	Response to Progress Energy comments on initial submittal	09/07/2011	All

Document Review and Approval

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Effects of Temporary Dewatering on Wetlands for the Construction of the Levy Nuclear Plant Levy County, Florida

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Prepared by

CH2MHILL.

September 2011

Contents

Figures

Attachment

Acronyms and Abbreviations

BMPs	Best Management Practic
CFBC	Cross Florida Barge Canal
COC	Conditions of Certification
COLA	Combined Operating License Application
CREC	Crystal River Energy Complex
ER	Environmental Report
ERP	Environmental Resource Permit
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FLUCCS	Florida Land Use and Cover Classification System
LNP	Levy Nuclear Plant, Units 1 and 2
NRC	Nuclear Regulatory Commission
PEF	Progress Energy Florida
ROW	right-of-way
SWFWMD	Southwest Florida Water Management District
TMEM	technical memorandum
UMAM	Uniform Mitigation Assessment Method
USACE	U.S. Army Corps of Engineers

1.0 Introduction

This technical memorandum (TMEM) addresses the potential effects on adjacent wetlands due to the dewatering associated with the construction of the Progress Energy Florida (PEF) Levy Nuclear Plant Units 1 and 2 (LNP) and associated facilities. Groundwater flow models were run to evaluate the effects of LNP construction dewatering on shallow groundwater levels.

Functional analyses for wetlands potentially affected by construction dewatering were also conducted as part of field investigations by PEF consulting ecologists between 2006 and 2010. Results of these investigations are documented in the Environmental Report (ER) for the Combined Operating License Application (COLA) (PEF, 2008b) and the LNP Wetland Mitigation Plan (BRA, 2009). The extent and duration of construction dewatering for the circulating water system is based on engineering plans and assumptions included in the memorandum entitled, *Groundwater Level Depression in Response to Makeup and Blowdown Pipe Trench Dewatering* (Sargent &Lundy, 2011), provided as Attachment A.

Section 2 provides an overview of the LNP project, proposed facilities, and adjacent wetlands. Section 3 describes the LNP construction dewatering activities and groundwater modeling. Section 4 includes a summary of the conclusions of this evaluation.

2.0 Project and Site Overview

This section provides an overview of the project and potentially affected wetlands.

2.1 Project Facilities

PEF proposes to build and operate two AP1000 nuclear plant units at the LNP site located in Levy County, Florida. The AP1000 units will use a recirculating cooling water system, and waste heat will be dissipated by a series of mechanical draft cooling towers, which will draw makeup cooling water from the Cross Florida Barge Canal (CFBC). Cooling tower blowdown will be transported in two pipelines (one for each unit) from the LNP and discharged into the Crystal River Energy Complex (CREC) discharge canal and, ultimately, into the Gulf of Mexico (CH2M HILL, 2009). The blowdown and makeup pipelines are collectively referred to as the circulating water pipelines. Figure 2-1 shows the circulating water pipeline route. The project also includes new electrical transmission lines and substations and associated facilities both onsite and offsite. The circulating water pipelines, transmission lines, and a heavy haul road extend south from the LNP site.

Detailed descriptions of the LNP facilities, the LNP site, and potential environmental impacts are provided in the ER. A brief description of wetlands in the project vicinity is provided in this section.

2.2 Site Description

The LNP site encompasses 3,105 acres, with the primary location for the two reactors and ancillary power production support facilities near the center of the site. PEF also owns approximately 2,114 acres of land immediately south of the LNP site, referred to as the PEF South Property. The LNP site, as well as the PEF South Property, was managed for pine production for several decades prior to purchase by PEF. Vegetation, soils, and localized drainage patterns have been extensively altered through silvicultural activities including clearing, logging, road development, ditching, grading, bedding, and replanting.

2.2.1 Wetlands

Wetlands are a dominant feature onsite and in the vicinity, comprising about two thirds of the LNP site's total land cover. Each wetland on the LNP site and along the circulating water pipeline right-of-way (ROW) and transmission ROWs, was delineated in accordance with the 1987 U.S. Army Corps of Engineers (USACE) *Wetland Delineation Manual and State of Florida Wetland Delineation Methodology* (Chapter 62-340 Florida Administrative Code [F.A.C.]) and was evaluated using the Uniform Mitigation Assessment Method (UMAM). A USACE Approved Jurisdictional Determination was issued and a Florida Department of Environmental Protection (FDEP) Formal Jurisdictional Determination is pending for the LNP site and the PEF South Property. Results of the UMAM analyses are presented in the Wetland Mitigation Plan (BRA, 2009) prepared for the LNP project, and summarized in the following paragraphs.

The most common types of wetlands onsite are Wet Planted Pine (Florida Land Use and Cover Form Classification System [FLUCCS] 629); Wetland Forested Mixed (FLUCCS 630) and Wetland Forested Mixed, logged (FLUCCS 630-1); Cypress (FLUCCS 621), and Cypress, logged (FLUCCS 621-1); Wet Prairie (FLUCCS 643); and Freshwater Marsh (FLUCCS 641).

Wet planted pine occupies wetter portions of former pine flatwoods and drier portions of former wetlands where natural wetland vegetation has been cleared and replaced by planted rows of commercial pine seedlings, mostly slash pine, that can tolerate limited ground saturation or inundation. Wetland forested mixed systems are characterized by a mix of hardwood and conifer species. Cypress swamps occur as isolated, circular depressions or occupy shallow sloughs or drainage ways linked during seasonally wet periods. Wet prairie is characterized as an infrequently inundated treeless plain with a groundcover of grasses and herbs. Freshwater marshes are dominated mostly by grasses, sedges, and forbs tolerant of wet conditions. Most freshwater marshes on the LNP site appear to be successional habitats that developed after cypress swamps or pine flatwoods were logged.

The offsite portion of the circulating water pipeline ROW crosses predominantly disturbed upland areas by following the CFBC berm through planted pine to the west, then turning south and crossing lands disturbed by mining activities. A large portion of the pipeline will be installed beneath an existing limerock access road. Potentially affected wetland areas are limited to the southern extent of the pipeline ROW within an active mining area. A large freshwater tidal wetland in the southern portion of the ROW is characterized by both forested (Wetland Forested Mixed) and herbaceous areas (Freshwater Marsh).

2.2.2 UMAM Functional Assessment

The UMAM was developed by FDEP and is currently used by the State of Florida and the USACE, Jacksonville District to assess wetland functions and to determine mitigation credit requirements. Three major variables are considered for each assessment area and assigned a value between 0 and 10, where 10 represents the best a system can function and 0 represents a severely impacted system. The variables are as follows:

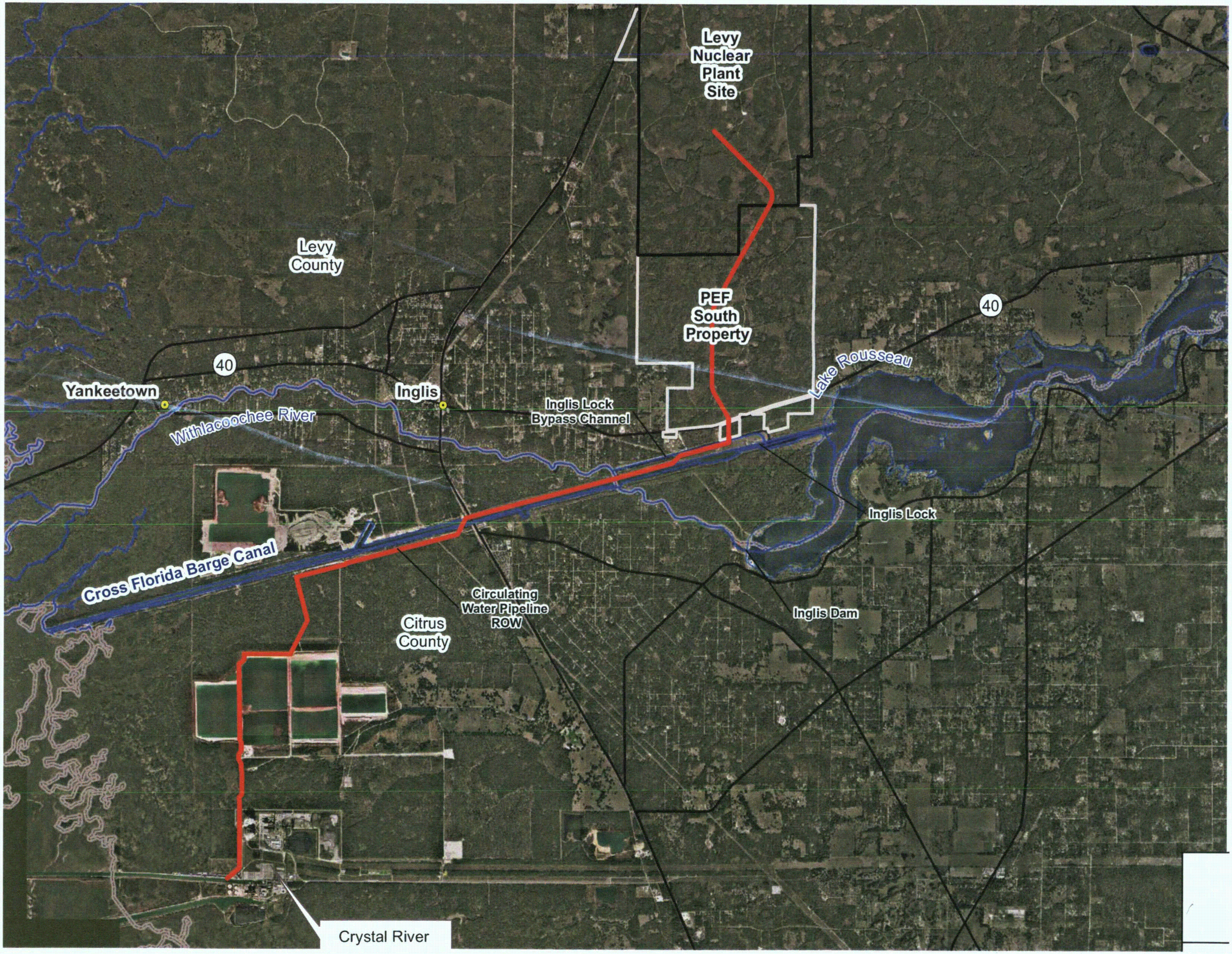
- Location and Landscape Support
- Water Environment
- Vegetative or Benthic Community (Community Structure)

The Location and Landscape Support score is based on benefits provided through the landscape position and surrounding habitats. The Water Environment score reflects water quality and quantity, based on the ability to promote the existence of fish and wildlife. The Community Structure score is a measure of the composition and utility of the vegetative structure of the assessment area, considering species composition, age distribution and recruitment, and zonation of the assessment area.

The methodology used to characterize the LNP wetlands follows the guidelines set forth in Chapter 62-345, F.A.C. and was performed by first classifying separate assessment areas on the basis of FLUCCS (Florida Department of Transportation [FDOT], 1999). Wetlands occurring on all potential impact areas were given unique identifiers and were evaluated using UMAM. The assessment areas were visited by a team of ecologists to evaluate current conditions. Data recorded at each site included vegetative cover and composition in all strata, presence and degree of disturbance observed, visible signs of hydrologic stress, soil characteristics, and surrounding land uses.

Each assessment area was scored based on the criteria established in Chapter 62-345.500(6)(b) F.A.C. to determine baseline and anticipated post-project conditions. The composite UMAM scores for most wetlands on the LNP site and utility corridors were in the low to moderate range, reflecting the area's history of conversion of native habitats to planted pine plantations, soil disturbance, and modifications of localized drainage patterns.

The wetlands that are potentially affected by temporary dewatering are part of a regionally common, large and interconnected complex of wetlands. The functions provided by these wetlands include the interception, detention and attenuation of stormwater; aquifer recharge; stabilization and retention of sediments; and nutrient removal. The wetlands support primary production in the growth of native plant species. They provide forage and cover habitat for wading birds, and forage and breeding habitat for invertebrates, reptiles and amphibians. These wetlands are generally temporarily or seasonally flooded, and lack a permanent pool of water. The wetlands are vegetated with a variety of plant forms that contribute organic detritus to the surrounding environment. The detrital export function is higher for the wetlands south of the CFBC than for the wetlands on the LNP site, where the connection to downstream aquatic systems has been disturbed through construction of the CFBC and County Road 40.


Levy Nuclear Plant Site
Levy County
PEF South Property
40
Yankeetown
40
Inglis
Lake Rousseau
Inglis Lock Bypass Channel
Withlacoochee River
Inglis Lock
Cross Florida Barge Canal
Circulating Water Pipeline ROW
Citrus County
Inglis Dam
Crystal River

3.0 Construction Dewatering Plan

This section describes the proposed LNP construction dewatering activities, associated groundwater modeling, and the affected area of wetlands .

Because of the high groundwater table on and in the vicinity of the LNP site, localized dewatering will be required for construction of the nuclear island and certain support facilities, including the circulating water pipelines. No dewatering will be required for construction of the transmission lines.

As part of the State of Florida Conditions of Certification (COCs), PEF is required to submit a construction dewatering plan to SWFWMD for approval 6 months prior to the commencement of dewatering (FDEP, 2010). This plan will include the detailed dewatering system, discharge quantities and locations, a monitoring plan, and other details as appropriate to demonstrate that the dewatering plans meet the SWFWMD and FDEP's requirements. The COCs prohibit any adverse impacts to wetlands resulting from construction dewatering.

3.1 Nuclear Islands and Support Facilities Dewatering

The nuclear island for each unit consists of the containment vessel, shield building, and auxiliary building. Dewatering beneath the nuclear islands will be conducted using reinforced diaphragm walls to isolate the construction area so that only the interior of the excavation will require dewatering. In this way, groundwater drawdown outside the excavation is minimized and adjacent wetlands will not be affected. A detailed description of the construction methods for the nuclear islands is found in the ER, Subsection 4.2.1.4 (PEF, 2008a).

Water from the excavations will be pumped to temporary ponds constructed to allow the water to percolate into the subsurface. Sedimentation traps or filtration will be placed to minimize erosion or siltation during the dewatering operation (PEF, 2009a).

A hydrologic monitoring program during building activities will be implemented to monitor dewatering impacts at the two nuclear island excavations. Over an approximate 2- to 4-year period (depending on the extent of overlap between building the powerblocks for LNP Units 1 and 2), inflow and stormwater from within the excavations will be intermittently pumped for each nuclear island and discharged to an infiltration basin sized for the estimated flow rate (PEF, 2008a). These actions will prevent significant drawdowns from occurring in the surficial aquifer system surrounding the excavations that support hydrologically connected adjoining wetlands. No long-term changes to local groundwater levels are expected as a result of the dewatering, and groundwater is expected to return to pre-disturbance levels after dewatering ceases.

PEF has committed to monitoring adjacent surface water and groundwater levels to ensure dewatering impacts are minimized. If any detrimental impact on water levels affecting adjacent wetlands are detected during monitoring, mitigative measures such as drilling and grouting, sheeting, or re-design of the recharge basins will be implemented (PEF, 2009b).

Shallow excavations for foundations for other buildings and trenching for pipelines may also require dewatering. Outside the nuclear islands, construction dewatering will be of short duration or in areas that will be filled as part of construction activities. More sustained dewatering (when considering total duration of dewatering for the facility), or dewatering of areas that will not be filled, will occur along the circulating water pipeline ROW, and is addressed in the following section.

3.2 Dewatering along the Circulating Water Pipeline ROW

Dewatering will be required to install the pipelines conveying makeup water to the nuclear units from the CFBC, and convey the blowdown water from the LNP to the CREC discharge. The circulating water pipeline ROW extends 12.2 miles from the LNP cooling towers to the CREC discharge and can be considered in two segments, on the north and south sides of the CFBC. The north pipeline ROW will include both makeup and blowdown pipelines (total of six pipelines), while the south pipeline ROW will contain only the two blowdown pipelines.

The circulating water pipelines will be installed in sequential segments of 400 to 500 linear feet, so that only a relatively small area will be dewatered at any one time. The dewatering system will be composed of a series of wellpoints capable of producing up to 14 to 15 feet of drawdown at the midpoint of the excavated trench to achieve dry working conditions inside the excavated area. Trench dewatering, excavation, pipe installation, and backfill will be completed for each segment over a period of approximately 8 weeks. Dewatering equipment will be removed immediately following placement of the pipeline segment, and installed for use in the next segment to be constructed.

To estimate the potential dewatering effects on groundwater levels along the circulating water pipeline ROW, a series of groundwater models were run (see Attachment A). The objectives of the groundwater modeling were as follows:

- To estimate the areal extent of groundwater drawdown in adjacent areas occurring during dewatering along the pipeline trench, and
- To estimate the transient recovery in groundwater levels following cessation of the dewatering.

Based on the results of the groundwater modeling (see Attachment A), trench dewatering after a period of 4 weeks will result in temporary drawdown in shallow groundwater levels ranging from 13 feet inside the trench, to 6 inches about 300 feet from either side of the center line of the pipeline trench. The level of drawdown is correlated to the distance from the pipe trench in conjunction with the duration of dewatering. Along the southern pipeline ROW segment, the extent of temporary groundwater drawdown is less because less groundwater needs to be withdrawn for the more narrow trench, compared to the northern segment where intake as well as discharge pipes are to be located. Once pumping ceases, the model results indicate that the groundwater table will recover rapidly during the first week, with minor residual effects (less than 6 inches of drawdown) near the trench 6 months after pumping. The recovery period in the model is conservative since it does not include recharge from the water generated through pumping. Groundwater levels are expected to recover fully within a few months following construction.

In considering the potential effects of construction dewatering on adjacent wetlands, it must be recognized that a temporary change in soil moisture does not necessarily equate to harm. On the contrary, groundwater levels are dynamic, and most wetlands, including those in the LNP vicinity, are adapted to a range of seasonal and annual variability in groundwater levels, including periodic drought. Monitoring on the LNP site has shown shallow groundwater level fluctuation up to several feet over the course of a year. Some wetland plant species, such as cypress (*Taxodium* spp.), depend on these natural drawdown periods for seed germination.

Whether natural or induced, extended drawdown conditions can cause a shift in the vegetative community to one representative of drier conditions. These shifts may favor some faunal species over others, and mobile, wetland-dependent species may be temporarily displaced. However, because the duration of water level drawdown along the circulating water pipeline ROW is brief and groundwater levels will recover completely after the dewatering equipment is removed, no permanent effects on adjacent wetlands are expected. Additionally, by installing the pipeline in sequential segments, only a relatively small area is affected at any one time.

To minimize the effects on adjacent wetlands as a result of dewatering, pumped water may be discharged to infiltration basins situated between the excavation and adjacent wetlands to rehydrate the area, if site conditions warrant. Where wetlands are adjacent to the pipeline ROW, sediment barriers will be installed to contain spoil and sediment and minimize turbidity. Details of these and other Best Management Practices (BMPs) will be provided in the site dewatering plan.

4.0 Summary

Temporary dewatering will be required for the construction of the LNP Units 1 and 2 and associated facilities. This memorandum focuses on temporary dewatering beneath the nuclear islands and along the circulating water pipeline ROW, where most of the construction dewatering will occur. Hydrologic exclusion methods will minimize effects on adjacent wetlands resulting from dewatering in the vicinity of the nuclear islands. Construction dewatering will temporarily depress shallow groundwater levels along the circulating water pipeline ROW, but groundwater levels will recover to pre-construction levels upon termination of dewatering, and wetland functions will be unchanged.

Wetland delineations and functional analyses using the UMAM were conducted on wetlands on the LNP site and along the circulating water pipeline ROW. Results of these UMAM analyses, provided in the Wetland Mitigation Plan (BRA, 2009), will be used as the baseline for monitoring wetlands during construction, as required by the COCs.

The temporary reduction in groundwater levels from construction dewatering along the circulating water pipeline ROW will not result in permanent effects on wetland functions, based on the following:

- The drawdown will be short-term (approximately eight weeks per pipeline segment), and shallow groundwater levels are expected to recover quickly, as shown by the groundwater modeling results;
- The period of groundwater drawdown is within normal seasonal variability for the wetlands;
- Only a relatively narrow, 400 to 500 foot long area will be dewatered at any one time, spanning areas that are impacted by logging and mining operations. The abundance of similar habitats in the vicinity will reduce potential impacts to wildlife utilizing the area;
- The wetlands are not isolated, but part of a large complex of similar systems. The interconnections provide a degree of protection from localized, induced changes in groundwater levels; and
- Groundwater monitoring infiltration trenches may be used to rehydrate adjacent wetlands during construction dewatering.

No permanent adverse impacts to wetlands will occur as a result of construction dewatering for the LNP project, and therefore no additional wetland mitigation will be required.

5.0 References

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Attachment A
Groundwater Level Depression in Response to Makeup and Blowdown Pipe Trench Dewatering

PROGRESS ENERGY

Levy Units 1 & 2

Groundwater Level Depression in Response to Blowdown Pipeline Trench Dewatering

(Non-Safety Related)

Report No. LNG-0000-X7R-001 Rev. 0

Prepared by

Sargent & Lundy LLC

July 26, 2011

S&L Project No. 11945-111

Signature Page

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1.0 Purpose and Scope

Installation of Makeup and Blowdown pipelines at Levy Nuclear Power Plant (LNP) will require excavation of a temporary trench within the Blowdown Right-of-Way (ROW). Dewatering of the temporary trench will also be required to conduct installation of the pipelines. The purpose of this report is to evaluate the groundwater level drawdown due to trench dewatering in wetland areas.

The scope of the report consists of:

- Modeling of the time-rate of drawdowns in the groundwater table and the progression of the groundwater level depression zone toward the wetland areas during pipeline installation inside the pipe ROW, and
- Modeling of the rate of recovery in the groundwater levels once the temporary dewatering has been terminated.

Additionally, considerations regarding excavation dewatering along the Blowdown ROW segment west of the Inglis Lock are provided.

2.0 Design Inputs

- The Blowdown ROW and the Heavy Haul Road are routed through an area that is currently occupied by wetlands. The ground elevation between the plant area and the Inglis Lock south of the plant varies from approximately 45 feet to 30 feet. For modeling purposes, the ground surface was considered at El. 42 feet. This is one foot below the ground level shown in COLA Figure 2.5.4.6-201-LNP, Construction Dewatering (Reference 1).
- The pipeline trench has a base width of approximately 40 feet along the section between the plant and the Inglis Lock (northern section). The trench base width along the section between the Inglis Lock and the Crystal River Discharge Canal (southern section) is approximately 14 feet. The side slopes of the trench are 1.5 Horizontal:1 Vertical.
- The approximate depth of the trench is 12 feet along the northern section, and 11 feet along the southern section. In the analyses, the trench depth was considered as 12 feet throughout the entire length of the pipeline ROW.
- The groundwater is very near the ground surface. In the analyses, the groundwater table was considered to be at the ground surface (El. 42 feet).
- Soil/rock profile was obtained from Reference 1.
- Hydraulic conductivities of the soil and rock layers were obtained from Reference 2.

3.0 Assumptions

- There are no borings drilled along the Blowdown ROW to accurately determine the soil/rock conditions, as well as the characteristics of the geological materials. For this reason, the in-situ stratigraphy and the values of the soil/rock parameters determined from the borings drilled within the power block area, and as documented in COLA, are used in this evaluation.

- Pipeline installation will take place in segments along the route, and each segment will be approximately 400 to 500 feet in length.
- In each segment, the working period will be approximately two months. Excavation, pipeline installation, and trench backfilling will be completed within this period.
- The maximum estimated drawdown due to excavation dewatering that could be tolerated within the wetland area is six inches.

4.0 Site Conditions

4.1 Soil/Rock Profile

The soil/rock profile considered is essentially the same as the one depicted in Reference 1. However, the rock layers below El. -155' were neglected because of the diminishing contribution of the deep rock to the groundwater flow near the ground surface. The physical soil/rock parameters used in the analyses are shown in Table 1. Storage Coefficient and Specific Yield values were estimated based on the condition of the soil/rock as well as the unconfined nature of the aquifer considered.

Table 1 – Soil and Rock Parameters (from Reference 2)

Layer	Thickness (ft)	Hydraulic Conductivity (ft/day)	Storage Coefficient	Specific Yield
Fine Sand/ Silty Sand	65	9.2	0.2	0.2
Limestone	32	13.9	0.1	0.1
Limestone	100	27.8	0.15	0.15

4.2 Groundwater Conditions

As indicated above, the entire soil/rock profile was considered to be completely saturated. Based on Reference 3, the hydraulic gradients in the vertical direction are very small, and for this reason the same initial head (42 feet) was associated with each layer in the geologic profile. In this calculation, the term "groundwater level" corresponds to the elevation of the groundwater table within the uppermost water bearing layer of an unconfined aquifer; i.e., "phreatic surface".

The groundwater drawdown induced by a dewatering system can be limited to a small area, or can reach considerable distances. The length of the period that is required for the drawdown to reach a stable condition is a function of the aquifer storativity and the aquifer transmissivity. Aquifer storativity is the volume of water released from storage per unit decline in hydraulic head in the aquifer per unit area of the aquifer ("Drainable Porosity" in unconfined aquifers). Aquifer transmissivity is defined as the product of the hydraulic conductivity of the aquifer material and the aquifer thickness. For unconfined aquifers, the thickness of the saturated portion of the aquifer replaces the aquifer thickness, and this causes the transmissivity to become dependent upon the saturated thickness of the aquifer. Storativity influences the transient response of an aquifer to groundwater pumping whereas the transmissivity determines the long-term withdrawal rates from an aquifer as it controls the rate of replenishment of the groundwater within the area of interest.

The limestone layers beneath the in-situ soils along the Blowdown ROW have hydraulic conductivity values considerably higher than most types of rocks, and therefore, have a potential to deliver substantial quantities of groundwater into the dewatered area. This will also limit the lateral extent of the zone of depression adjacent to and beneath the trench excavation, and should result in generally small drawdowns inside the adjacent wetlands.

5.0 Dewatering System

The pipeline trench will need to be excavated in segments and backfilled after installation of the piping in order to minimize the groundwater drawdown in wetland areas. This type of schedule also enables the contractor to handle dewatering with a wellpoint system that is reasonably small scale so that the same system can be removed and re-installed a number of times along the route as the work progresses, the pump capacity can be optimized, and the vacuum losses along the headers can be minimized.

In order to achieve dry working conditions inside the excavated area, the groundwater level will need to be lowered to an elevation below the base of the excavation. Therefore, the dewatering system in this area should be able to achieve 14 to 15 feet of drawdown at the midpoint of the excavation, and this will require a drawdown of 20 feet or more at the wellpoint locations. In dewatering practice, such drawdowns can usually be achieved by means of wellpoint systems that draw water from the below the groundwater table under a vacuum application. The wellpoints are generally capable of removing groundwater from depths of up to about 15 to 20 feet. For maximum efficiency, the depth of the wellpoints is usually kept around 15 feet. Considering the width of the excavation, a wellpoint system installed at the top of the excavation slope on both sides of the excavation may not be able to achieve such drawdowns at the midpoint of the excavation. Therefore, it is likely that the dewatering system for the pipe trench will require a two-level wellpoint system, each operating under 8 to 10 feet of vacuum. The upper wellpoint line can be installed from the existing ground level near the excavation slope (within approximately five feet of the slope), and the second wellpoint line can be installed from a bench on the side slope once the grades inside the excavation have reached an elevation near the base of the excavation. Excavation work can start before the maximum drawdowns are achieved for as long as the excavation base is kept dry as the groundwater levels continue to drop beneath the excavation. If, during the excavation, the actual site conditions indicate that a single-level wellpoint system at the top of the slope can provide the required drawdowns, there may not be a need for the lower-level wellpoints. The effect of this modification in the dewatering plan will be minimal on the groundwater levels at distances exceeding approximately 200 feet from the excavation.

Discharge from dewatering activities should be conducted using the appropriate best management practices. Best management practices in this regard include discharge to temporary infiltration swales west of the excavation for the entire length of the pipe and permanent dry swales along the Heavy Haul Road for the portion north of County Road 40. Discharge from swales and trenches should be monitored for turbidity and should only be discharged to upland areas.

5.1 Modeling

This calculation does not directly address the design of the dewatering system to effect the required drawdowns within the pipe trench area. However, the dewatering system should be designed properly to withdraw the estimated quantities of groundwater.

As shown in Table 1, the geologic profile consists of a sand layer approximately 65 feet in thickness, underlain by limestone. Only the upper 132-ft portion of the limestone (lower two layers in the model) was considered in the model. The limestone within this interval has a relatively high permeability, and has the potential of supplying significant quantities of groundwater into the pipe trench excavation.

The dewatering system was considered in the form of two large-conductance gravity-flow drains located at two different depths along both sides of the excavation, at Elevations of 30 feet and 18 feet. These elevations represent the mid-height of the wellpoint screens. Individual wellpoints can be spaced at every 3 feet to 12 feet, but are generally spaced at 4 feet to 5 feet. Therefore, on a large-scale, the well point system approximates a lateral drain system running parallel to the excavation slopes. Large drain conductance was used to avoid impeding the flow of water into the dewatering system. The effect of the vacuum applied to the wellpoint system was not considered.

5.2 Description of the Software used in Groundwater Flow Analyses

The analyses were performed using the pre- and post-processor software PMWIN (Reference 4) that also includes the 1996 version of the 3-dimensional USGS groundwater flow modeling program MODFLOW (Reference 5). Two verification runs were performed and included in Attachment A to confirm the validity of the results obtained from the MODFLOW program.

5.3 Groundwater Model Runs

The groundwater flow induced by dewatering is two-dimensional. However, a three-dimensional 300-ft long and 2000-ft wide grid was used in the calculations (Figure 1). The size of the grid elements is generally 20' x 20' square with the exception of several elements in the vicinity of the excavation and the drain locations where the element width was reduced to 10 feet for better accuracy. The pipe trench was located through the center of the grid.

As it was stated above, installation of the pipeline will very likely take place in segments, and the length of each segment would be determined in accordance with the construction schedule of the project. Ideally, this condition requires a three-dimensional analysis of the groundwater flow into the excavation. Based on an estimated average excavation length of 400 to 500 feet for each segment, and the width of the excavation base, the plan length-to-width ratio of the excavated area is approximately 10, and therefore, a two-dimensional analysis is considered appropriate.

Groundwater is assumed to be at the ground surface but not ponded at the surface. If water is continuously ponded at the surface, i.e., replenished by surface flow from adjacent areas, this condition will reduce the efficiency of the dewatering system, will require a higher capacity dewatering system, and a positive cutoff feature to keep the surface water away from the pipe trench excavation (such as, a berm or a sheet pile wall) will be required to induce the required groundwater depression around the excavation.

Initial model runs were performed with and without recharge from precipitation. The effect of the recharge on the overall water budget was considered in a simplified fashion. The annual precipitation was considered as 52 inches with approximately 80 percent of the precipitation evaporated back into the atmosphere (Reference 6). Also, runoff from the wetland areas was not considered. This represents a net annual recharge rate of approximately 10 inches. A comparison of the runs with and without recharge indicated that recharge is a small component of the overall water budget (on the order of two percent) and causes a negligible difference in the calculated groundwater profiles. Therefore, the final runs were conducted without recharge, which is conservative.

Model runs were performed to evaluate:

- Development of the drawdown profile as a function of time (Transient Condition). Assuming a period of approximately two months for excavation, pipeline installation, and backfill placement in each section, a four-week period was considered to represent the drawdown period.
- Effect of recycling the water collected from the dewatering system into the ground during the dewatering period. In the model runs, a separate case was analyzed assuming that the water collected from the dewatering system would be discharged into an area that is located approximately 150 feet away from the centerline of the excavation.
- Transient recovery in the groundwater levels following termination of the dewatering activity. For these runs, the piezometric levels inside each model layer obtained at the end of the last drawdown time step (end of week four) were used as input for the starting heads. Drainage from the dewatering system was set to zero. A 28-day period was considered for the first series of transient runs to evaluate the recovery within the first month. Subsequently, the recovery period was extended up to six months. Considering the duration of the recovery period, recharge due to precipitation, which was neglected for the drawdown period, was applied at the rate of 0.024 inches/day with the exception of the area covered by the Heavy Haul Road.

The results are summarized below:

- The transient groundwater surface profiles for the dewatering period are shown on Figures 2 and 3. As indicated above, the transient runs cover a period of four weeks. Based on the progression of the groundwater level profiles, it is estimated that beyond an approximate distance of 300 feet from the center line of the excavation, the drawdowns will be limited to six inches or less at the end the first four weeks of dewatering. Within the first week of dewatering, the ground water levels inside the pipe trench are likely to have been depressed enough to enable excavation to nearly the base elevation of the pipe trench.
- Based on the trend shown in Figure 2, if dewatering is continued for a few more weeks beyond the four-week period, significant changes are not anticipated in the groundwater surface profile. Beyond a distance of approximately 400 feet, the effect of dewatering is practically non-existent (Figure 3).
- During the four-week dewatering period, the average rate of groundwater collected by the wellpoint system was calculated as approximately 2 gallons/min/linear ft along the excavation.
- Recycling of the groundwater collected from the dewatering system at locations beyond 150 feet of the trench centerline will likely overwhelm the infiltration capacity of the upper soils as the drawdowns in these areas are on the order of one foot or less, and the ground has very little capacity to accommodate additional water. With a band of land of up to 200 feet in width on both sides of the excavation to represent the recharge area, hydraulic heads of up to five feet above the existing ground were obtained within, as well as a certain distance outside, this band. Such a result indicates a temporary local flooding condition within the groundwater recirculation area. In reality, the excess water will be redistributed into other areas of the wetlands as surface water if not temporarily diverted, by means of ditches, into other sections of the ROW not undergoing construction activity.
- Groundwater recycling also increases the required collection capacity of the wellpoint system by approximately 40 to 50 percent. The load on the wellpoint system will further increase if recharge is performed closer to the excavation.
- Once dewatering has been terminated after backfilling of the trench, there will be a relatively fast recovery during the first week in the groundwater levels in the area of the excavation (Figure 4). After a four-week recovery period, the groundwater surface beyond a distance of approximately 200 feet from the trench centerline will be within six inches of its original level when precipitation is included in the analysis. On Figure 4, the groundwater levels beyond a distance of approximately 400 feet from the trench appear to achieve an elevation greater than that of the ground surface. This is obviously an artifact of the model, and in reality represents the contribution from the precipitation in excess of the amount that could infiltrate into the ground. This excess precipitation will very likely transform into surface runoff. A portion of the runoff migrating into the Blowdown ROW should increase the rate of recovery of the groundwater levels in the area of the ROW. The groundwater surface profile on Figure 4 is not exactly

symmetrical about the blowdown trench because of the lack of precipitation recharge assumed under the Heavy Haul Road embankment.

- Groundwater levels can be considered to have completely recovered within the Blowdown ROW area with an estimated maximum residual drawdown of approximately six inches after a period of two to three months following termination of dewatering (Figure 4).

5.4 Trench Section West of the Inglis Lock

In this section, a discussion is presented regarding:

- Estimated soil/rock conditions and potential dewatering methods for the Blowdown Pipe trench between the Inglis Lock and the Crystal River Discharge Canal, and
- Effect of the width of the pipe trench excavation (six-pipe trench vs. two-pipe trench) on the groundwater table drawdowns in areas adjacent to the excavation. West of the Inglis Lock, the trench will contain only two blowdown pipes.

5.5 Soil/Rock Conditions - Inglis Lock to Crystal River Discharge Canal

The ground elevations along the segment of the Blowdown Pipe ROW between the Inglis Lock and Crystal River Discharge canal vary from about 31 feet MSL to nearly 0 feet MSL. The geologic profile near the Inglis Lock contains an upper sandy in-situ soil that varies from approximately 10 to 25 feet. Limestone or sandstone rock is present beneath the in-situ soil. Further to the west, the sand thickness gradually tapers off to zero at many locations. This information has been obtained from a set of drawings depicting the results of a boring program along the Cross-Florida Barge Canal performed by the U.S. Army Corps of Engineers 1970 (Reference 7).

Therefore, the great majority of the excavation work to be performed to install the two blowdown pipes west of the Inglis Lock will take place inside an area that have a sandy upper soil layer that varies in thickness along the route. Similarly, the base of the excavation for the blowdown pipes may be located within soil, near the bedrock, or inside the bedrock depending upon the elevation of the pipes. In this regard, the contribution of the bedrock to seepage into an excavation along this route is expected to be significant, in particular if and when the hydraulic conductivity of the bedrock is high enough to supply large quantities of water into the excavation.

The blowdown pipes are planned to cross the barge canal west of U.S. Route 19. Based on the as-built Canal profiles in Reference 7, base elevations of the concrete Guide Walls on both sides of the Canal vary from El. -16 ft to -26 ft, and the walls are shown to have rock foundations. Therefore, crossing of the Canal by means of a tunnel will require considerable amount of rock excavation.

The method of dewatering for the excavation will likely be revised in this sector of the ROW to suit the anticipated ground conditions. Along the sector to the north of the Inglis Lock, a system of wellpoints installed in the upper soils is considered as an effective means of achieving the required dewatering. However, along the western sector, wellpoints will be only partially effective as the soil cover thickness above the rock is gradually reduced to the west and south. Along this sector, the following dewatering measures can be considered:

- Drainage trenches cut on both sides of the excavation will be able to intercept the lateral flow from the surrounding wetlands, but will be largely ineffective in cutting off the flow through the base of the excavation.
- Dewatering wells drilled into the highly transmissive intervals of the bedrock,
- Wellpoints installed inside holes predrilled into the upper five to 10 feet of the rock,

Dewatering wells and the wellpoints in pre-drilled holes can at least be partially effective in removing the groundwater from below the pipe ROW excavation.

Because of the large linear extent of the trench, grouting of the rock is not considered as a viable option.

A combination of these methods may also need to be used as required by the actual site conditions.

5.6 Effect of Trench Width

Groundwater flow model runs were performed to evaluate the approximate water table profiles in and around the area of the excavations. In both cases, the soil profile and soil properties within the power plant area were used. The six-pipe section excavation was considered to have a bottom width of approximately 40 feet whereas for the two-pipe section, the bottom width was 14 feet. Due to significantly thinner soil cover along the sector west of the Inglis Lock where the two-pipe trench configuration is planned, the profile modeled is not considered an accurate representation of large portions of this sector. However, the analyses serve to comparatively illustrate the effect of the trench width all other parameters being equal.

The following observations are made:

- Both the six-pipe and two-pipe sections can be dewatered to a depth of approximately 13 feet within the first week (Figure 5).
- The groundwater table profile for the two-pipe section is higher outside the excavation compared to the six-pipe trench up to a distance of approximately 250 feet from the centerline of the excavation. This is largely due to a smaller rate of groundwater removal required for a smaller-width excavation to achieve the required drawdowns inside the trench.
- For the two-pipe section, the drop in the groundwater levels beyond 150 feet is insignificant at the end of Week 1. After four weeks of dewatering, this distance increases to approximately 300 feet (Figure 6).

- At the end of Week 4, the calculated drawdowns at 300 feet distance from the trenches are approximately six inches for both types of trenches.
- The calculated rate of flow into the dewatering system for the 40-ft wide trench is greater than that for the 14-ft wide trench by approximately 20 to 30 percent.

6.0 Conclusions

The following conclusions were derived from the results of the groundwater modeling:

- The level of drawdown that will occur in the groundwater levels within the wetland areas will be primarily dependent upon the distance from the pipe trench in conjunction with the length of the dewatering period. The groundwater table, after a dewatering period of four weeks, will achieve a semi-steady state condition that is not likely to change significantly if dewatering were to be continued for a few more weeks beyond the four-week period analyzed.
- Beyond a distance of approximately 300 feet from the pipe trench centerline, the induced groundwater drawdown is smaller than six inches at the end of the four-week dewatering period.
- During the dewatering period, the average rate of groundwater collected by the wellpoint system as approximately 2 gallons/min/linear ft along the excavation.
- Recycling of the water collected from the dewatering system into a limited-size area within the ROW can result in localized flooding by exceeding the infiltration capacity of the site soils. Best management practices in this regard include discharge to temporary infiltration swales west of the excavation for the entire length of the pipe and permanent dry swales along the Heavy Haul Road for the portion north of County Road 40. Discharge from swales and trenches should be monitored for turbidity and should only be discharged to upland areas.
- Once dewatering is terminated, the groundwater table should recover to within six inches of its original elevation within a period of two to three months.
- West of the Inglis Lock, the thickness of the in-situ soil above the bedrock gradually diminishes to near zero toward the Gulf of Mexico. Therefore, the use of wellpoints installed into the in-situ soils as a dewatering measure will be only partially effective to control the inflow. Other methods of dewatering or cutoffs may be necessary to complement the wellpoint systems such as drainage trenches, wellpoints installed inside holes predrilled into the rock, and large-capacity dewatering wells.
- All other parameters being the same, the width of the trench excavation has a significant effect of the groundwater levels within a zone approximately 250 feet in width on both sides of the excavation. The groundwater table profile for the two-pipe section is higher outside the excavation compared to the six-pipe trench within this zone. This is largely due to a smaller rate of groundwater removal required for a smaller-width excavation to achieve the required drawdowns inside the trench. The calculated rate of flow into the dewatering system for the 40-ft wide trench is greater than that for the 14-ft wide trench by approximately 20 to 30 percent.

7.0 References

1. LNP COLA Part 2 FSAR Figure 2.5.4.6-201 "LNP Construction Dewatering MODFLOW Cross Section," Rev. 0.
2. LNP COLA Part 2 FSAR Table 2.5.4.6-201 "Hydraulic Conductivities and Calculated Dewatering Rates," Rev. 2.
3. Calculation LNG-0000-X7C-004 "Groundwater Vertical Gradients," Rev. 0, dated 4/23/2008.
4. Chiang, Wen-Hsing (2005) "3D-Groundwater Modeling with PMWIN," 2nd Edition, Springer-Verlag, Berlin.
5. McDonald, Michael G. and Harbaugh, Arlen W. (1988) "A Modular Three-Dimensional Finite Difference Ground-Water Flow Model," Book 6, Chapter A1 – Modeling Techniques, USGS Open File Report 83-875.
6. McPherson, B.F. and Halley, R. (1996) "The South Florida Environment," USGS Circular 1134.
7. Department of the Army (1970) "Cross-Florida Barge Canal Plans for Construction of Inglis Spillway and Dam," Corps of Engineers - Jacksonville District.
8. U.S. Department of Defense (2004) "Unified Facilities Criteria (UFC) - Dewatering and Groundwater Control," UFC 3-220-05.

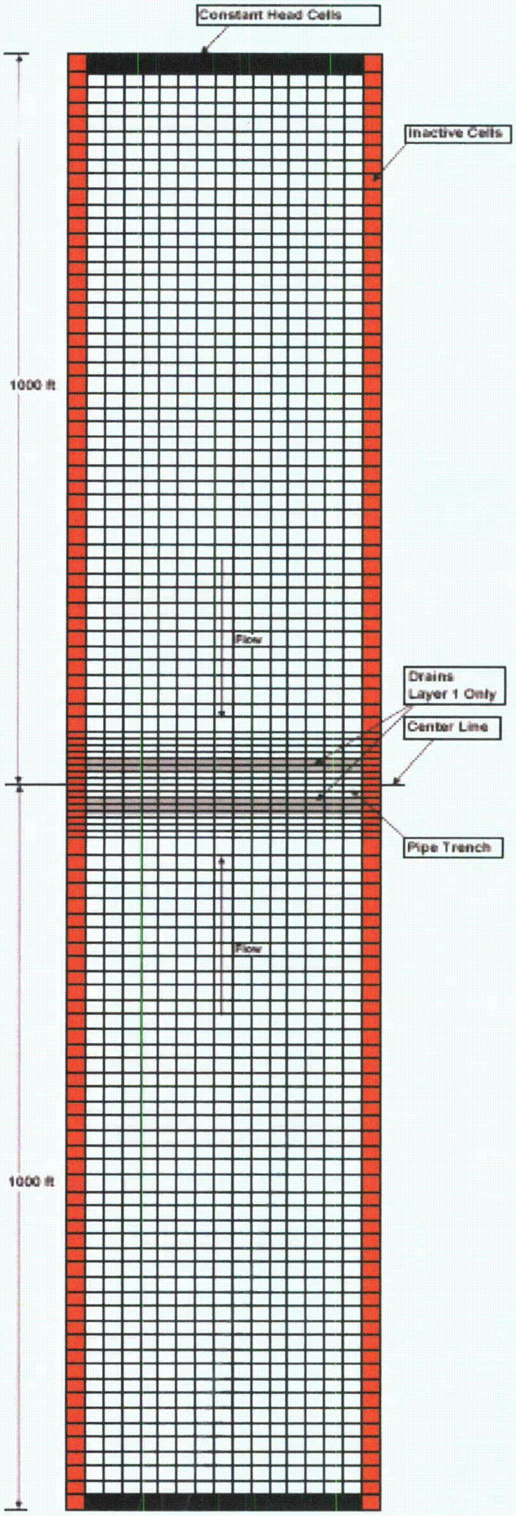


Figure 1 – Model Domain

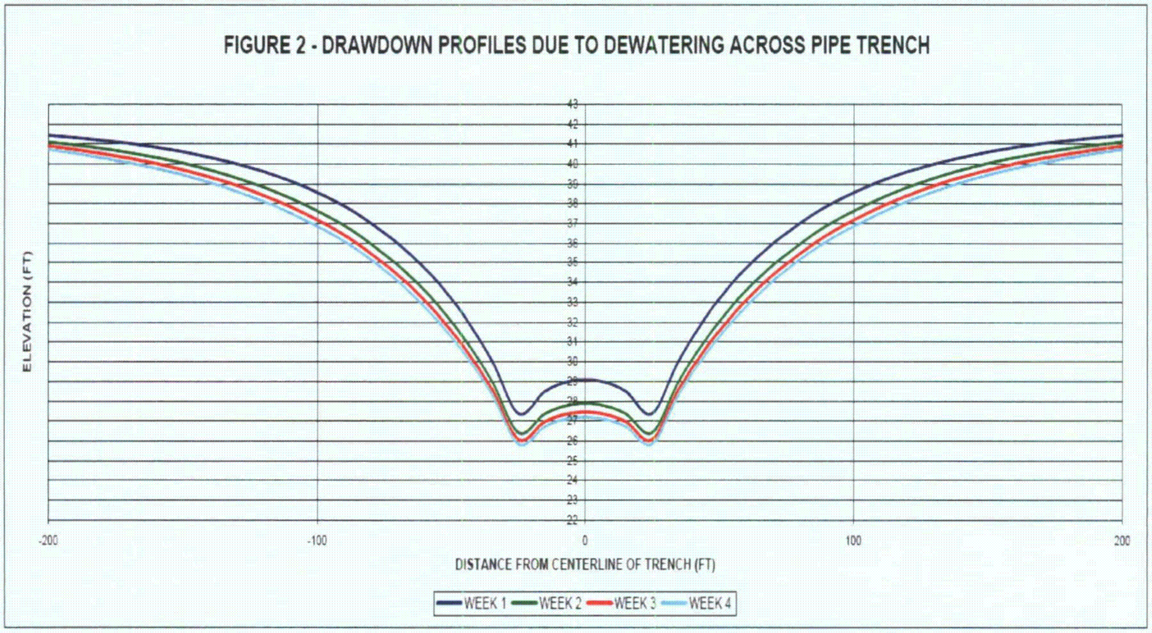


Figure 2 – Drawdown Profiles Due to Dewatering Across Pipe Trench

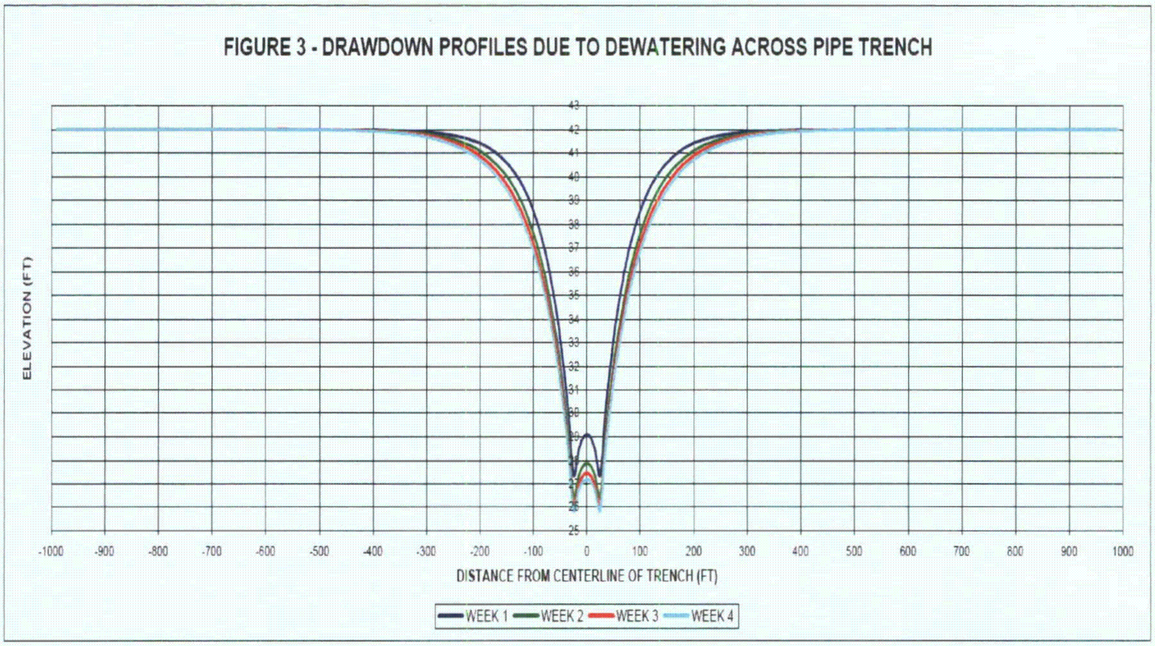


Figure 3 – Drawdown Profiles Due to Dewatering Across Pipe Trench

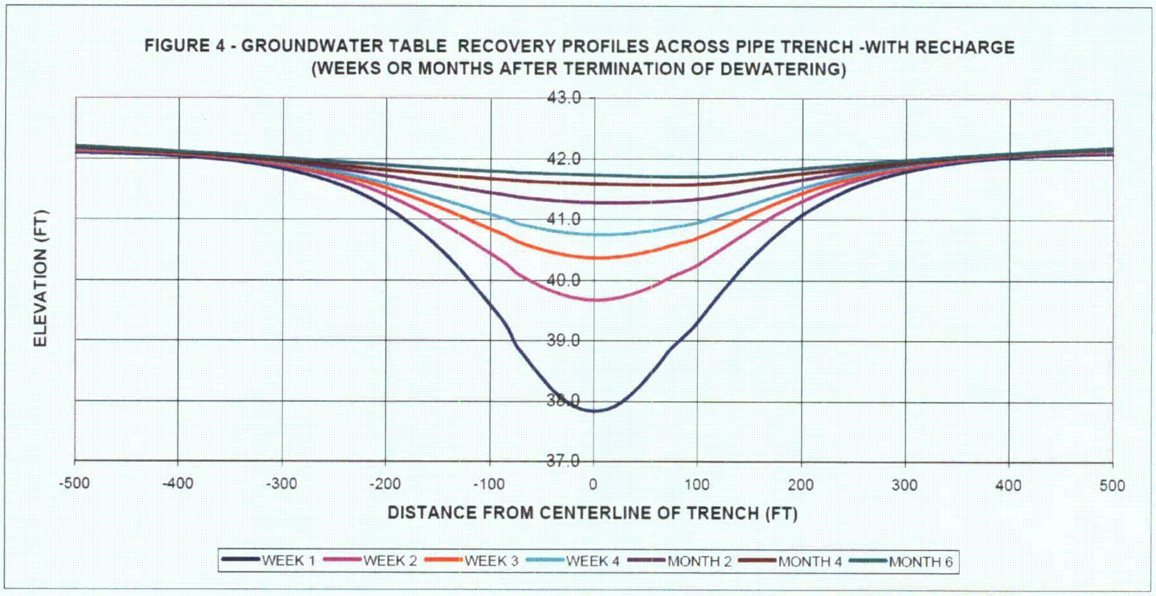


Figure 4 – Drawdown Profiles Due to Dewatering Across Pipe Trench – with Recharge (Weeks or Months After Termination of Dewatering)

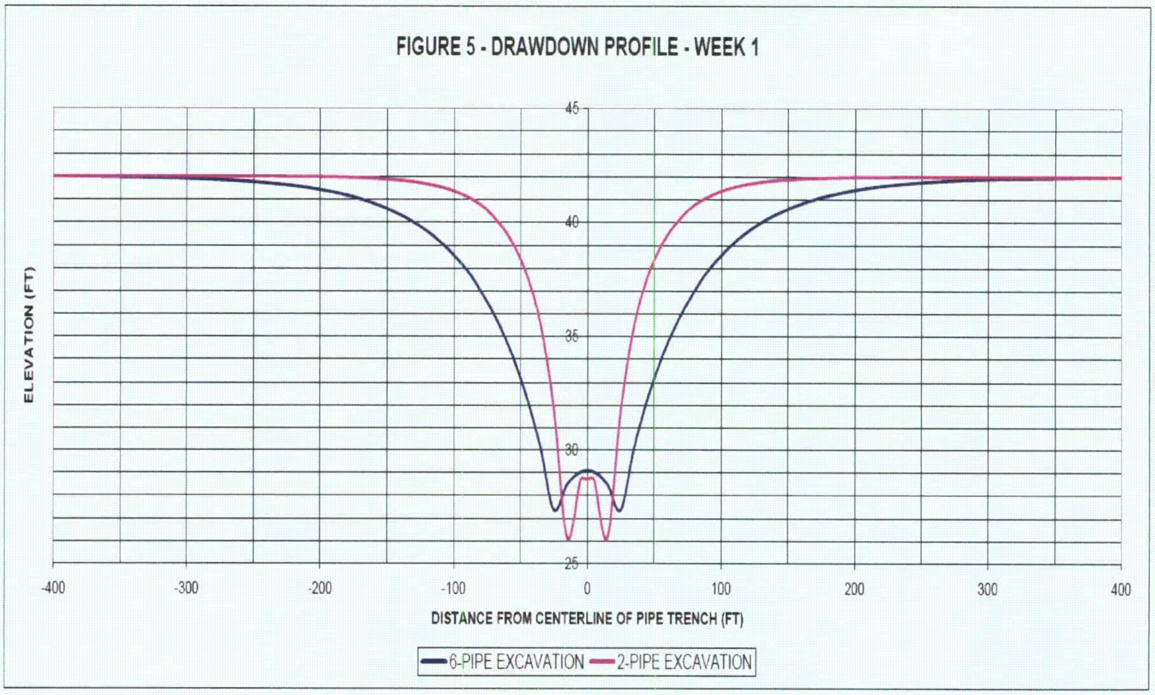


Figure 5 – Drawdown Profile – Week 1

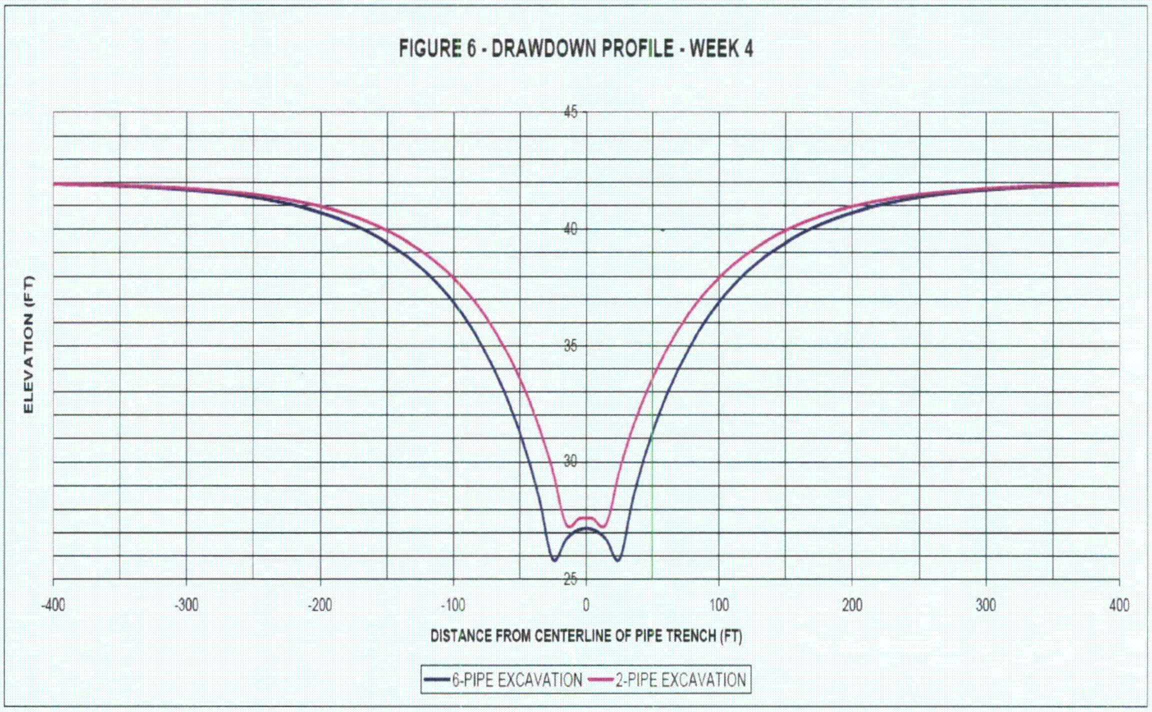


Figure 6 – Drawdown Profile – Week 4

Attachment A

MODFLOW Model Validation with Example Problems

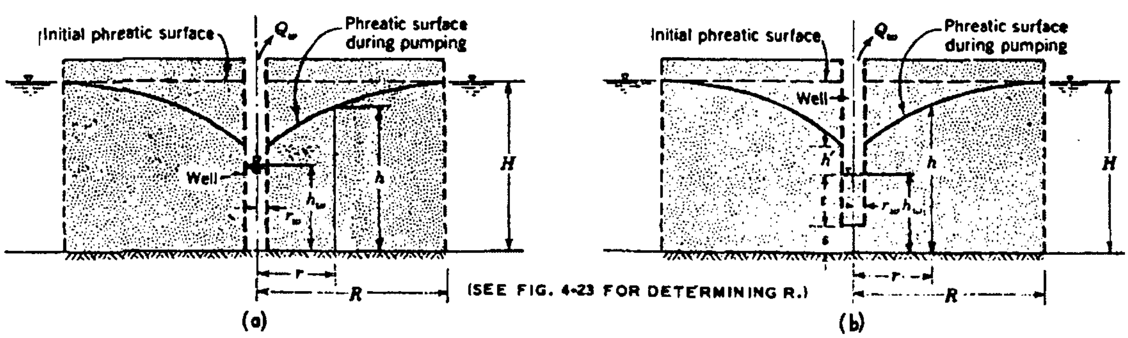
Validation of the results obtained from the MODFLOW software was performed using two groundwater flow cases for which analytical solutions are available (Reference 8). These are:

Case 1. Flow into a fully-penetrating well located at the center of a circular-shaped island, and

Case 2. Flow into a fully-penetrating ditch.

A 100 x 100 grid with 10-ft square grid elements was used in both cases. Only one soil layer located over an impermeable rock layer was considered for consistency with the analytical solutions. Initial saturated thickness of the soil layer was H = 50 feet.

<u>Case 1:</u> This is an axisymmetric problem (Reference 8, page 4-12). The 1000 ft x 1000 ft square grid was used to approximately represent an island with a 1000 foot diameter. The idealized profile and the analytical formula to determine the flow rate into the well are shown below (figure on the left). The initial groundwater elevation was assumed to be 90 feet. Bottom elevation of the aquifer was assumed at El. 40 feet. Therefore, the initial thickness of the aquifer is 90-40=50 feet. The flow rate from the well was set as 100,000 ft^3/day. Hydraulic conductivity of the soil was considered as 283 feet/day (0.1 cm/s).



FULLY PENETRATING WELL

FLOW, Q_w, OR DRAWDOWN, $H^2 - h^2$, NEGLECTING HEIGHT OF FREE DISCHARGE, h' (CONDITION (a)).

$$Q_w = \frac{\pi k (H^2 - h^2)}{\ln (R/r)} \quad (1) \qquad \text{OR} \qquad Q_w = \frac{\pi k (H^2 - h_w^2)}{\ln (R/r_w)} \quad (2)$$

The steady-state analysis based on the model grid yielded the hydraulic head inside the well as 83.25 feet. The heads in three cells adjacent to the well (10 feet, 20 feet, and 30 feet away from the well center line) were 85.25 feet, 86.13 feet, and 86.63 feet, respectively. Based on these three values, the head at the side wall of the well (5 ft from the well center line) was calculated as 84.67 ft.

The radius of the square grid (1000' x 1000') and that of the well (10' x 10') were calculated as 564 feet and 5.64 feet, respectively. The calculated head at the side wall of the well and the constant groundwater level along the grid boundaries (90 feet) were used in the formula above to calculate the flow rate into the well as shown below:

$$Q_w = \pi k(H^2-h^2)/\ln(R/r) = \pi \times 283 \times [(90-40)^2-(84.67-40)^2]/\ln(564/5.64) = 97{,}420 \text{ ft}^3/\text{day}$$

The difference between the flow rate entered into the model (100,000 ft^3/day) and the flow rate calculated using the model generated heads in an analytical formula was approximately 2.6 percent. This is a small difference and is mainly attributable to the use of a well drawdown generated with a square grid in an analytical formula which considers the constant head boundary (edge of the grid) as a circle. Additionally, it is expected that a finer grid for the entire flow region, or a grid which is discretized more finely in the areas adjacent to the well would provide drawdowns that would result in calculated flow rates even closer to the initially assumed constant flow rate.

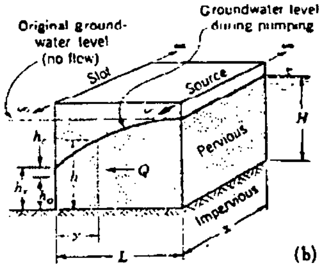
Case 2: This is an infinitely long linear system (Reference 8 page 4-2). A 1000-ft long and 10-ft wide ditch was created in the center portion of the grid by using a very high hydraulic conductivity for the cells that constitute the ditch. Also a very-high conductance drain was placed into the ditch near the bottom of the soil layer. The groundwater level at the edges of the grid was considered as constant. The model-calculated drainage rate into the ditch was 1,414 ft^3/ft/day.

The hydraulic head at the side wall of the ditch was calculated as 41.32 feet in the same manner as that used for Case 1. The flow rate into the ditch was calculated using Formula 3 below as:

$$Q = [k/(2L)](H^2-h_c^2) = [283/(2 \times (500-5))] \times [(90-40)^2 - (41.32-40)^2] = 714 \text{ ft}^3/\text{day/ft}$$

Considering flow from both sides of the ditch, the total flow rate calculated from the analytical formula is 1,428 ft^3/ft/day.

This value is within one percent of the flow rate shown in the above paragraph.



FLOW

$$Q = \frac{kx}{2L}(H^2 - h_o^2) \quad (3)$$

DRAWDOWN

AT ANY DISTANCE y FROM SLOT

$$H^2 - h^2 = \frac{L - y}{L}(H^2 - h_e^2)$$

WHERE $h_e = h_o + h_s$ AND h_s IS OBTAINED FROM FIG. 4-2

GRAVITY FLOW

Note: For large drawdowns (as in the example case above), h_o should be replaced by h_e.

These two cases demonstrate the validity of the results obtained from the Modflow analyses.