Evaluation of the Performance Efficiency of the Pioneer Key Regional Stormwater Pond

Final Report

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Prepared for:

City of Ocoee, Florida

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SECTION 1

INTRODUCTION

This document provides a summary of work efforts conducted by Environmental Research & Design, Inc. (ERD) for the City of Ocoee (City) to evaluate the hydrologic and pollutant removal efficiency of the newly constructed Pioneer Key Regional Stormwater Facility. The Pioneer Key project was constructed as a regional wet detention pond to provide both retrofit water quality treatment and flood attenuation for a 123-acre drainage basin that includes the Pioneer Key I and Pioneer Key II mobile home communities as well as other developed and undeveloped areas along the Northwest Ditch in the City of Ocoee. The Northwest Ditch conveys stormwater runoff from the Pioneer Key developments, as well as areas north and south of these developments, and ultimately discharges into Lake Apopka. A general location map for the Pioneer Key regional stormwater pond is given on Figure 1-1.

Figure 1-1. Location Map for the Pioneer Key Regional Stormwater Facility.

Both the Pioneer Key I and Pioneer Key II areas have historically been plagued with chronic flooding and drainage issues. Catch basins and conveyance systems within these areas appear to be inadequate, resulting in chronic flooding which reaches depths of more than 3-4 feet at times. Much of the existing development within these areas was constructed prior to implementation of regulations requiring stormwater treatment, and many areas within the basin discharge untreated runoff directly into the Northwest Ditch and ultimately into Lake Apopka. An overview of flow patterns in the Northwest Ditch in the vicinity of the Pioneer Key project site is given on Figure 1-2.

Figure 1-2. Flow Patterns in the Northwest Ditch in the Vicinity of the Pioneer Key Sites.

1.1 <u>Project Description</u>

The Pioneer Key Regional Stormwater Pond provides treatment for approximately 124 acres of urban land use in the headwaters of the Northwest Ditch Basin consisting of two mobile home parks, as well as various commercial sites and roadways. Discharges through the Northwest Ditch are diverted into the Pioneer Key regional facility and ultimately re-enters the Ditch downstream from the pond site.

A summary of estimated pre- and post-construction pollutant load estimates for the Pioneer Key facility, developed by the City of Ocoee, is given in Table 1-1. The Pioneer Key regional facility is expected to reduce current loadings of total suspended solids (TSS) by approximately 85%, with an anticipated 51% reduction in total phosphorus, 40% reduction in total nitrogen, and 40% reduction in BOD.

TABLE 1-1

ESTIMATED PRE- AND POST-CONSTRUCTION POLLUTANT LOAD ESTIMATES FOR THE PIONEER KEY FACILITY

CONDITION	UNITS	TSS	TOTAL PHOSPHORUS	TOTAL NITROGEN	BOD
Pre-Project	kg/yr	13,685	57	459	1,841
Post-Project	kg/yr	2,053	28	271	1,105
Load Reduction	kg/yr	11,632	29	188	736
Percent Reduction	%	85	51	40	40

A summary of design criteria for the Pioneer Key Regional Stormwater Facility is given on Table 1-2. The pond area is approximately 3.02 acres at the normal water level elevation of 112.35 ft. The water quality treatment volume within the pond is equivalent to 0.47 inch over the basin area. The pond is constructed with a maximum depth of 12 ft and a mean depth of approximately 7.8 ft. The estimated mean annual residence time for the original pond design is approximately 16.6 days. Selected construction drawings for the Pioneer Key Regional Stormwater Facility are provided in Appendix A.

TABLE 1-2

DESIGN CRITERIA FOR THE PIONEER KEY REGIONAL STORMWATER FACILITY

PARAMETER	INFORMATION
Treatment System Type	Wet detention pond
Pond Area	3.02 acres at NWL
Drainage Basin Area	123.9 acres
Drainage Basin Land Use	Mobile home parks, commercial, highways
Treatment Volume	0.47-inch over basin area
Permanent Pool Volume	23.62
Pond Depth a. Maximum b. Mean	a. 12 ft b. 7.8 ft
Treatment Volume Recovery	50% in 24-30 hours
Pond Residence Time	16.6 days (mean annual)
Littoral Zone	--

A schematic of flow patterns in the vicinity of the Pioneer Key Regional Stormwater Facility is given on Figure 1-3. A concrete weir was constructed across the historic channel of the Northwest Ditch, causing water to be diverted into the Pioneer Key pond. The inflow from the Northwest Ditch represents the most significant input into the system. A photograph of the Northwest Ditch upstream from the Pioneer Key pond is given on Figure 1-4. The diversion structure causes discharges through the Northwest Ditch to be diverted into the Pioneer Key pond for treatment.

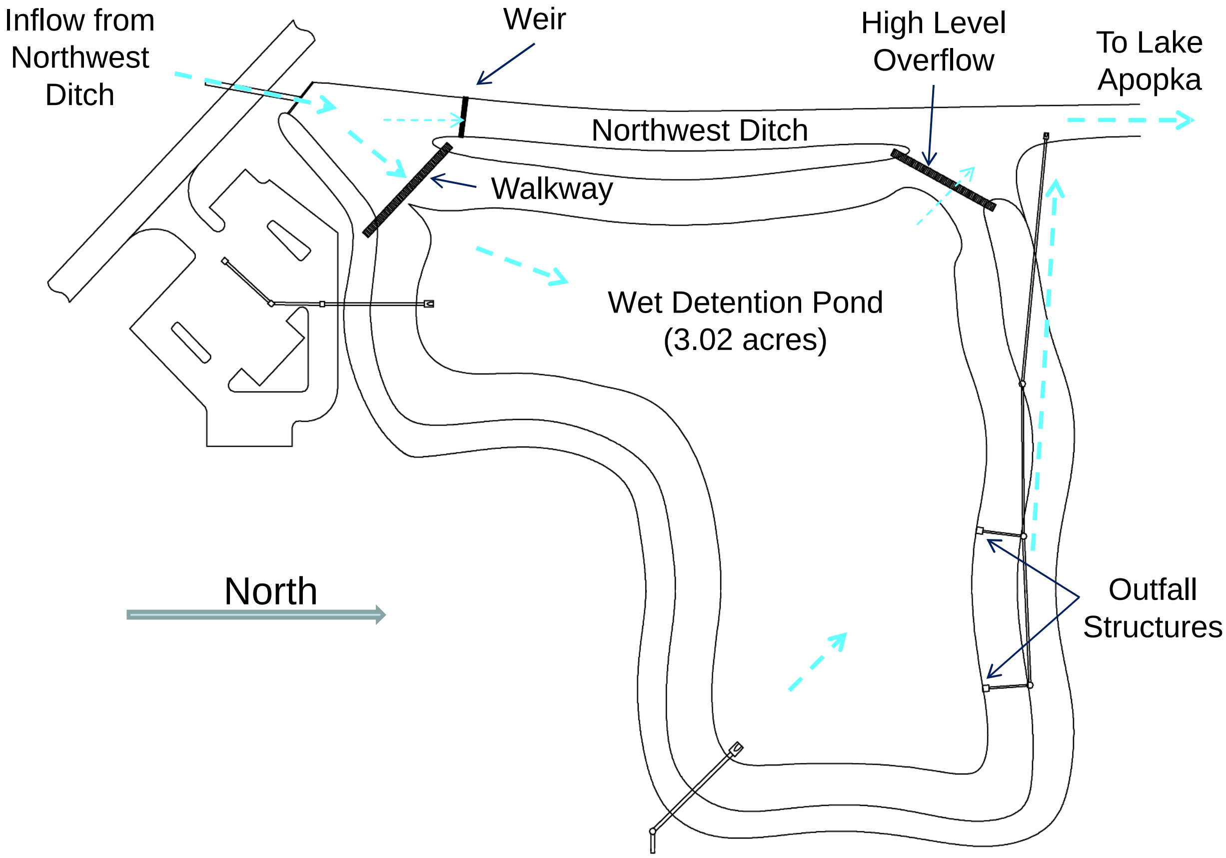
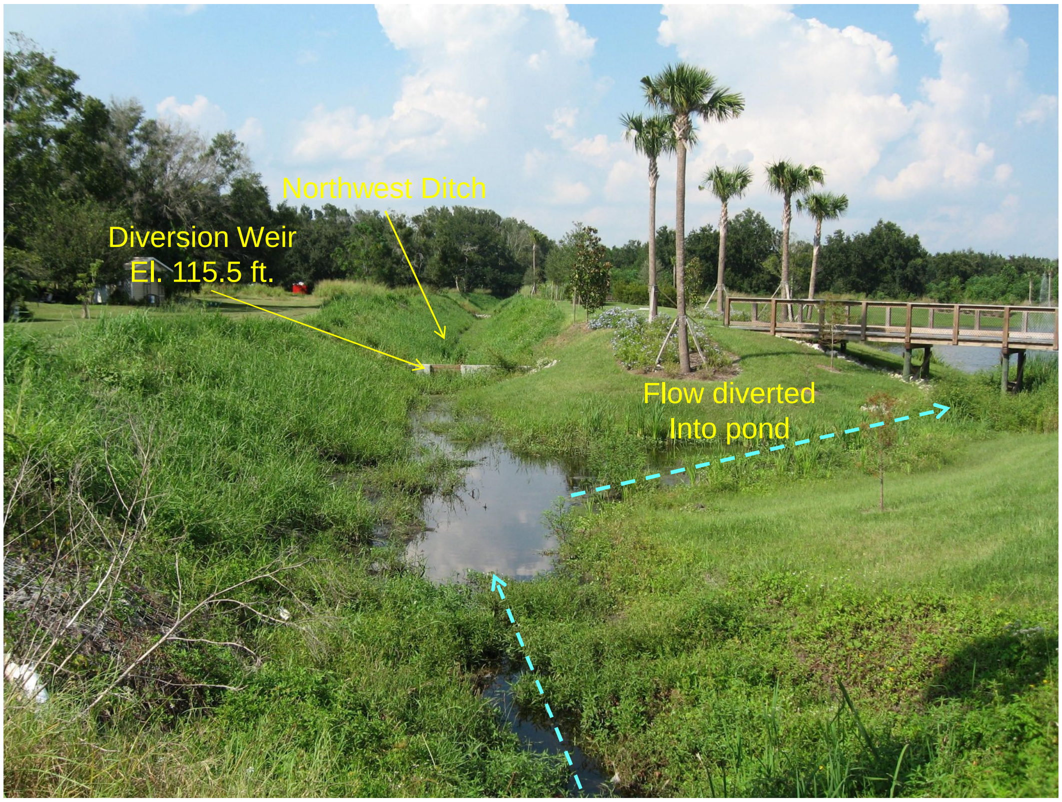


Figure 1-3. Schematic of Flow Patterns in the Pioneer Key Regional Stormwater Facility.

A smaller inflow also enters the Pioneer Key pond from the 0.51-acre asphalt parking lot for the park areas associated with the facility. Runoff inflow from this area is relatively minimal compared with inflows from the Northwest Ditch.

A photograph of the diversion weir structure within the Northwest Ditch is given on Figure 1-5. The diversion structure is constructed of concrete with a center area containing removable riser boards. These boards are used to allow easy removal in the event that a drawdown of the canal system is desired prior to anticipated severe weather conditions. The water level stage recorder installed at this site by ERD is also visible within the figure.



a. Pond Inflow from Northwest Ditch

b. Pond Inflow Area Following Vegetation Removal

Figure 1-4. Photographs of the Northwest Ditch Upstream from the Pioneer Key Pond.

Figure 1-5. Diversion Weir Structure in the Northwest Ditch.

Discharges through the Northwest Ditch are diverted into the Pioneer Key pond through a narrow inflow channel, as indicated on Figure 1-6. A wooden boardwalk was constructed across this channel to provide a recreational loop around the perimeter of the pond. After discharging through the inflow canal, the inflow reaches the main open water portion of the Pioneer Key pond, indicated on Figure 1-7.

A small inflow also occurs into the pond at the southeast corner. This inflow consists of a 42-inch RCP which was constructed to serve future development planned in areas adjacent to the pond. However, under existing conditions, this inflow contributes only a small baseflow from a drain system within the future development area.

Discharges from the pond occur through two identical outfall structures located along the north side of the pond. Locations of the outfall structures are indicated on Figure 1-3, and a photograph of the westernmost outfall structure is given on Figure 1-8. Each of the two outfall structures contains a single 5.25-inch circular orifice with an invert elevation of 112.35 ft. These two orifice structures provide a slow bleed-down from the pond and regulate the normal water level. Each outfall structure also contains an overflow grate inlet with an invert elevation of 114.0 ft for each structure. In addition, a high level overflow structure was also constructed on the northwest corner of the Pioneer Key pond to provide an additional mechanism for water to leave the pond under high flow conditions. The overflow elevation for this structure is 114.0 ft, identical to the overflow grate inlets associated with each of the two pond outfall structures. The top elevation of the diversion weir structure in the Northwest Ditch is constructed at elevation 115.5 ft. Discharges through the outfall structure enter a 24-inch RCP which conveys the pond discharges back into the Northwest Ditch, downstream of the diversion weir, where it ultimately discharges to Lake Apopka.

Figure 1-6. Inflow Channel into Pond.

Figure 1-7. Main Open Water Portion of the Pioneer Key Pond.

Figure 1-8. Outfall Structure for the Pioneer Key Pond.

The Pioneer Key pond is surrounded by a variety of both herbaceous and woody emergent wetland species. Examples of this vegetation are clearly visible in the photographs provided in Figures 1-7, 1-8, and 1-9.

Construction for the Pioneer Key facility was completed during August 2008. A period of approximately 12 months was provided to allow the vegetation and plantings to become established and the biological communities within the pond to develop fully. Monitoring of the site was initiated during October 2009. Financial assistance for construction of the Pioneer Key Regional Stormwater Facility was provided by the Florida Department of Environmental Protection (FDEP) under Agreement No. S0192 in the amount of $850,000 through a Section 319H Grant.

Figure 1-9. High Level Overflow Structure on the Northeast Corner of the Pioneer Key Pond.

1.2 Work Efforts Conducted by ERD

A Quality Assurance Project Plan (QAPP) was developed by ERD during April 2009 which provided details concerning the proposed field monitoring and laboratory analyses. Flow-weighted samples were collected at each of the three inflows to the pond, along with discharges from the pond through each of the two outfall structures. This monitoring was used to evaluate the hydraulic performance efficiency and mass load reductions achieved by the wet detention system. The results of the inflow and outflow monitoring sites are used to document changes in concentrations and load reductions for nitrogen, phosphorus, and TSS. The specific objectives of this research project were to: (1) evaluate the hydraulic performance and residence time achieved by the wet detention pond, and (2) quantify the pollutant load reductions achieved by the treatment system. Monitoring equipment was installed at the wet detention pond site by ERD during September 2009. Field monitoring was initiated on October 1, 2009 and was continued over a 6-month period until March 31, 2010.

This report has been divided into four separate sections for presentation of results. Section 1 contains an introduction to the report, a description of the Pioneer Key Regional Stormwater Facility, and a summary of work efforts performed by ERD. Section 2 provides a detailed discussion of the methodology used for field and laboratory evaluations. Section 3 provides a discussion of the hydrologic and water quality results, and a summary is provided in Section 4.

SECTION 2

FIELD AND LABORATORY ACTIVITIES

Field and laboratory investigations were conducted by ERD from October 2009-March 2010 to evaluate the effectiveness of the recently constructed Pioneer Key Regional Stormwater Facility. Field monitoring was conducted at the inflow and outflow for the wet detention pond, including a continuous record of discharge rates as well as collection of flow-weighted composite inflow and outflow samples. Laboratory analyses were conducted on collected samples for general parameters and nutrients to assist in quantifying mass removal efficiencies for the system. Specific details of monitoring efforts conducted at the Pioneer Key wet detention pond site is given in the following sections.

2.1 Drainage Basin Characteristics

A summary of existing land uses within the Pioneer Key watershed is given on Table 1-2. The largest land use within the basin is single-family residential, consisting primarily of mobile home communities, which covers approximately 34% of the basin area. Approximately 29% of the basin is covered by open space, with 22% in low-density commercial, 7% in agriculture, 6% in highway, and 1% in wetlands.

TABLE 1-2

LAND USES WITHIN THE PIONEER KEY WATERSHED

LAND USE	AREA (acres)	PERCENT OF TOTAL
Agricultural	9.21	7.4
Highway	7.49	6.0
Single-Family Residential	42.45	34.4
Low-Intensity Commercial	27.55	22.2
Open Space	35.49	28.6
Wetland	1.71	1.4
Totals:	**123.9**	**100**

2.2 Field Instrumentation and Monitoring

A schematic overview of monitoring locations used to evaluate the performance efficiency of the Pioneer Key wet detention pond is given on Figure 2-1, and an aerial photograph of inflow and outflow monitoring sites is given on Figure 2-2. Monitoring for inflows into the pond was conducted at three separate locations, indicated by Sites 1, 2, and 3 on Figures 2-1 and 2-2. Monitoring Site 1 was located inside the 48-inch RCPA which conveys the Northwest Ditch beneath Palm Drive upstream from the wet detention pond. Stormwater monitoring was conducted inside a manhole structure located just upstream from the location where the Northwest Ditch changes from an underground stormsewer to an open ditch.

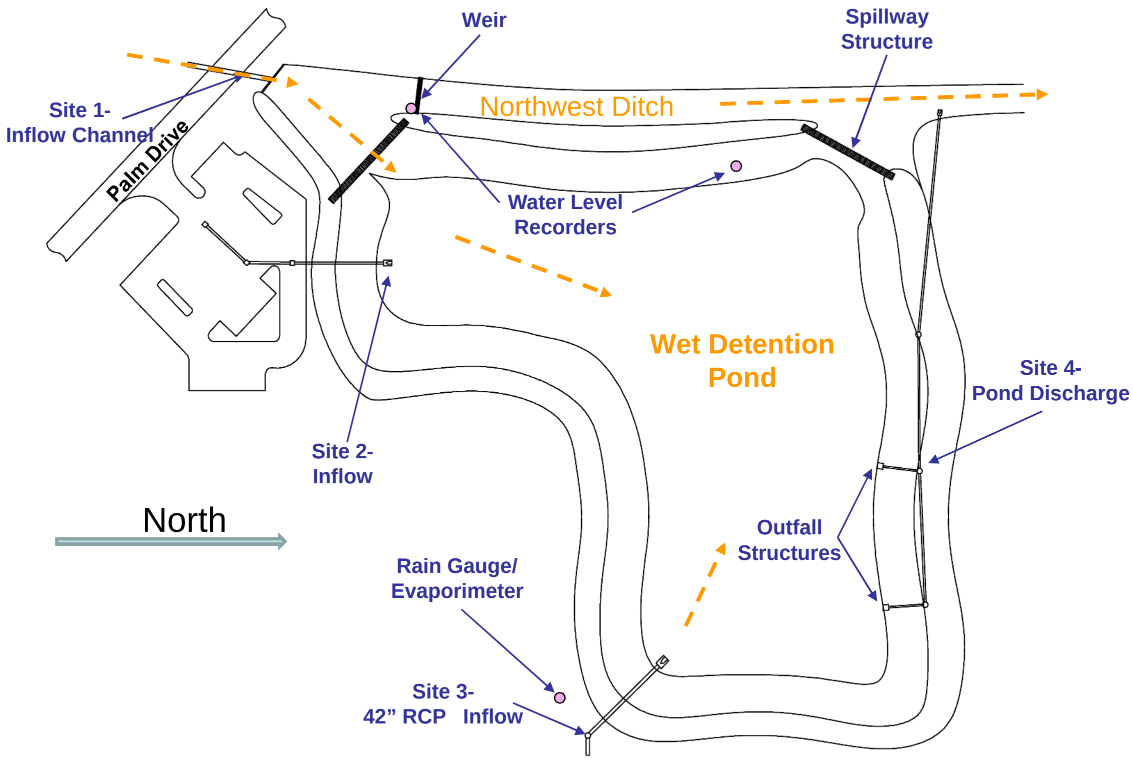


Figure 2-1. Schematic Overview of Locations for Monitoring Equipment at the Pioneer Key Regional Stormwater Facility.

A photograph of the monitoring equipment used at the Northwest Ditch inflow monitoring site is given on Figure 2-3. A stormwater sampler with integral flow meter (Sigma Model 900MAX) was installed on top of the junction manhole just upstream of the point of discharge into the channelized portion of the Northwest Ditch. The autosampler was housed inside an insulated aluminum equipment shelter. Sample tubing and an area/velocity flow meter were extended from the equipment shelter into the 48-inch RCPA. A Teflon strainer was attached to the end of the sample tubing. The strainer and flow probe were mounted to a 16-inch x 16-inch x 1.5-inch thick concrete pad which was attached to the bottom of the RCPA. The autosampler was programmed to provide continuous measurements of discharges through the 48-inch RCPA under both storm event and baseflow conditions, and to collect flow-weighted samples from the Northwest Ditch inflow over a wide variety of flow conditions.

Figure 2-2. Aerial Photograph of Inflow and Outflow Monitoring Sites.

Figure 2-3. Northwest Ditch Inflow Monitoring Pipe.

Stormwater monitoring at Site 2 was conducted inside a grate inlet for the 0.51-acre parking lot area. A compact autosampler was used at this location with a flow probe and sample intake strainer mounted to the bottom of the stormsewer pipe. The integral flow meter and autosampler were programmed to provide continuous measurements of water depth which were converted into estimates of discharge using the Manning Equation and pipe geometry.

A photograph of the inflow pipe at monitoring Site 3 is given on Figure 2-4. As discussed previously, Site 3 consists of a 42-inch RCP which is intended to provide drainage for future development. Under existing conditions, a temporary plug has been placed inside the 42-inch RCP, and a 10-inch HDPE local drain has been installed to provide drainage for an undeveloped area adjacent to the pond. A flow sensor and sample intake strainer, visible in Figure 2-4, were mounted to the bottom of the 42-inch RCP downstream from the temporary plug.

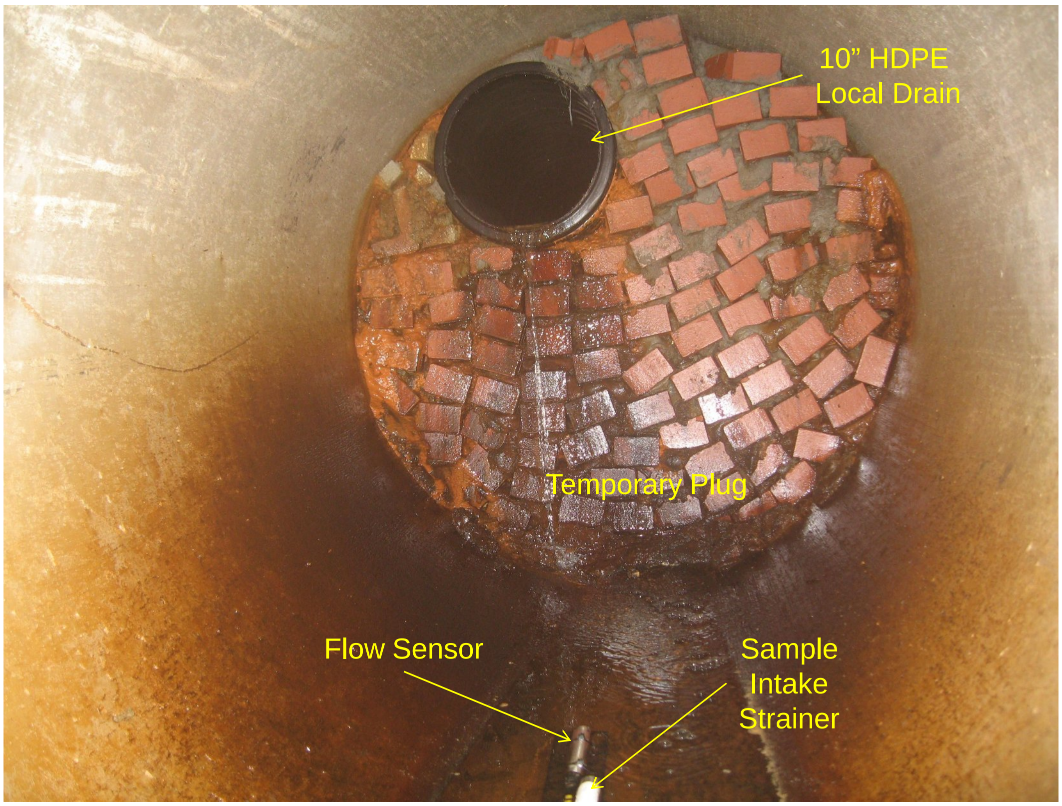


Figure 2-4. Inflow Pipe at Monitoring Site 3.

A photograph of monitoring equipment installed at Site 3 is given on Figure 2-5. An automatic sequential sampler with integral flow meter, manufactured by Sigma (Model 900MAX), was installed adjacent to a manhole structure for the 42-inch RCP. Sensor cables and sample tubing were extended from the equipment shelter to the monitoring location indicated on Figure 2-4. The automatic sampler was housed inside an insulated aluminum equipment shelter, as indicated on Figure 2-5. The integral flow meter and autosampler were programmed to provide a continuous record of discharges through the 42-inch RCP, with measurements stored into internal memory at 10-minute intervals.

Figure 2-5. Monitoring Equipment Installed at Site 3.

A Class A pan evaporimeter and rainfall recorder were also installed at this site. The rainfall recorder (Texas Electronics Model 1014-C) produced a continuous record of all rainfall which occurred at the site, with a resolution of 0.01 inch. The rainfall data were stored continuously in a data logger and retrieved by ERD field personnel on a weekly basis. The rainfall record is used to provide information on general rainfall characteristics in the vicinity of the monitoring site and to assist in evaluation of hydrologic inputs from the watershed area.

A photograph of monitoring equipment installed at the pond outfall (Site 4) is given on Figure 2-6. An automatic sequential stormwater sampler with integral flow meter, manufactured by Sigma (Model 900MAX), was installed on top of the manhole structure which connects the two outfall structures and conveys pond discharges back into the Northwest Ditch. The automatic sampler was housed inside an insulated equipment shelter. Sensor cables and sample tubing were extended from the equipment shelter into the 24-inch RCP outfall at a location downstream from the two outfall structures. The flow probe and sample intake strainer were attached to the bottom of the 24-inch RCP. The integral flow meter and auto sampler were programmed to provide a continuous record of water levels within the discharge pipe, with measurements stored into internal memory at 10-minute intervals.

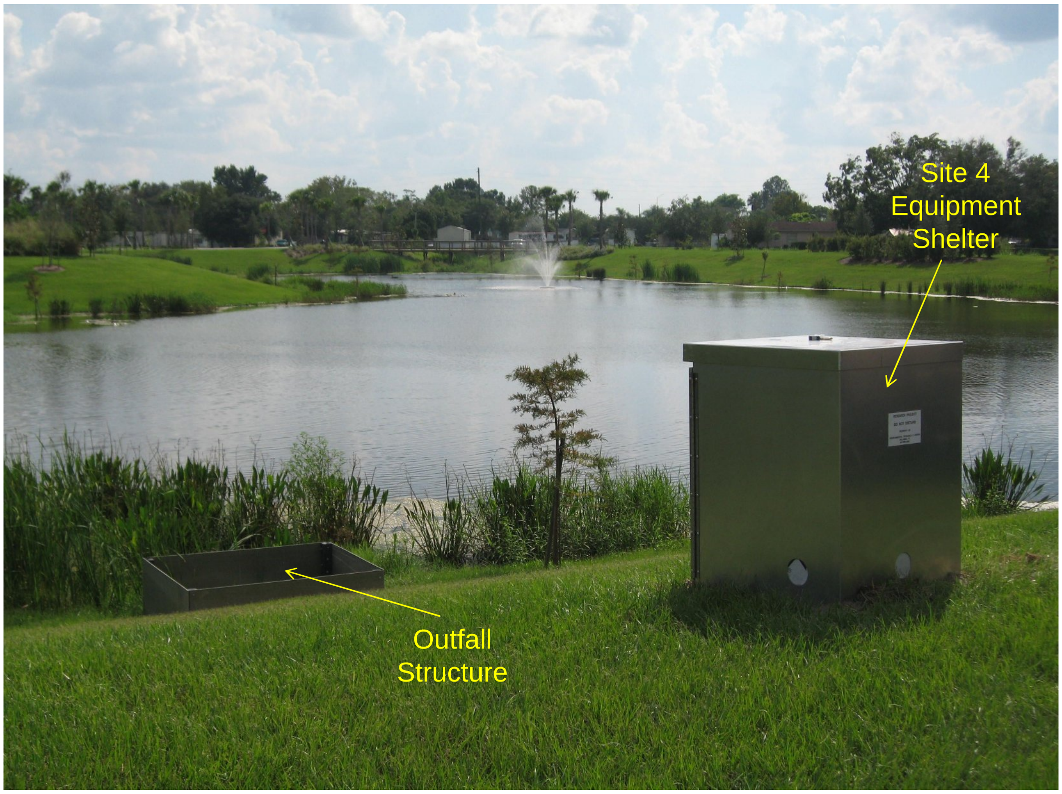


Figure 2-6. Monitoring Equipment Installed at the Pond Outfall (Site 4).

Flow measurements at the Northwest Ditch inflow monitoring site (Site 1) were performed using the area/velocity method. The flow probe used at this monitoring site provides simultaneous measurements of water depth and flow velocity. The depth measurements are converted into a cross-sectional area (A) based upon the geometry of the pipe, and the velocity of flow (V) is measured directly by the probe. Discharge (Q) is then calculated internally by the flow meter using the Continuity Equation (Q = A x V, in cubic feet per second, cfs).

Flow measurements at inflow monitoring Sites 2, 3, and 4 were performed using a pressure transducer sensor which conducts sensitive measurements of water depth at user-specified time intervals of 15 minutes. The measurements of water depth were converted into a discharge rate using the Manning Equation based upon the geometry of the pipes at each site.

Each of the four automatic samplers contained a single 20-liter composite polyethylene bottle. Both the inflow and outflow samplers were programmed to collect 500 ml sub-samples in a flow-weighted mode, with each collected sample placed into the composite bottle for each site. Since 120 VAC power was not available at any of the monitoring sites, each of the automatic samplers were operated on gel cell batteries which were replaced on a weekly basis.

A bulk precipitation collector was also installed by ERD near the monitoring equipment at Site 3 to characterize nutrient concentrations in bulk precipitation. Bulk precipitation can be a significant contributor to nutrient loadings in waterbodies and is included in this project to develop a more accurate nutrient budget. The bulk precipitation collector consisted of a 12-inch diameter polyethylene funnel which was attached to 5/8-inch sample collection tubing. The bulk precipitation samples were diverted into a 4-liter polyethylene sample container which was retrieved by ERD field personnel on a weekly basis.

2.3 Laboratory Analyses

A summary of laboratory methods and MDLs for analyses conducted on water samples collected during this project is given in Table 2-2. All laboratory analyses were conducted in the ERD Laboratory. The ERD Laboratory is NELAC-certified (No. 1031026). A Quality Assurance Project Plan (QAPP), outlining the specific field and laboratory procedures to be conducted for this project, was submitted to and approved by FDEP prior to initiation of any field and laboratory activities.

TABLE 2-2

ANALYTICAL METHODS AND DETECTION LIMITS FOR LABORATORY ANALYSES

PARAMETER	METHOD OF ANALYSIS	METHOD DETECTION LIMITS (MDLs)[1]
pH	EPA-83, Sec. 150.1[2]	N/A
Conductivity	EPA-83, Sec. 120.1[2]	0.2 μmho/cm
Alkalinity	EPA-83, Sec. 310.1[2]	0.5 mg/l
Ammonia	EPA-83, Sec. 350.1[2]	0.005 mg/l
NO_x	EPA-83, Sec. 353.2[2]	0.005 mg/l
Total Nitrogen	SM-21, Sec. 4500-N C.	0.01 mg/l
Ortho-P (SRP)	SM-21, Sec. 4500-P F.	0.001 mg/l
Total Phosphorus	Alkaline Persulfate Digestion[3]	0.001 mg/l
Turbidity	EPA-83, Sec. 180.1[2]	0.3 NTU
Color	SM-21, Sec. 2120 C.	1 Pt-Co Unit
TSS	EPA-83, Sec. 160.2[2]	0.7 mg/l

1. MDLs are calculated based on the EPA method of determining detection limits
2. Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised March 1983.
3. FDEP-approved alternate method
4. Standard Methods for the Examination of Water and Wastewater, 21st Ed., 2005.

SECTION 3

RESULTS

Field monitoring, sample collection, and laboratory analyses were conducted by ERD over a 182-day period from October 1, 2009-March 31, 2010 to evaluate the hydraulic and pollutant removal efficiencies of the Pioneer Key Regional Stormwater Facility in the City of Ocoee. A discussion of the results of these efforts is given in the following sections.

3.1 Site Hydrology

3.1.1 Rainfall

3.1.1.1 Rain Event Characteristics

A continuous record of rainfall characteristics was collected at the detention pond monitoring site from October 1, 2009-March 31, 2010 using a tipping bucket rainfall collector with a resolution of 0.01 inch and a digital data logging recorder. Characteristics of individual rain events measured at the Pioneer Key wet detention pond site from October 1, 2009-March 31, 2010 are given in Table 3-1. Information is provided for total rainfall, event start time, event end time, event duration, average rainfall intensity, and antecedent dry period for each individual rain event measured at the monitoring site. For purposes of this analysis, average rainfall intensity is calculated as the total rainfall divided by the total event duration.

A total of 20.01 inches of rainfall fell in the vicinity of the wet detention pond over the 182-day monitoring period from a total of 69 separate storm events. A summary of rainfall event characteristics measured at the wet detention pond site is given in Table 3-2. Individual rainfall amounts measured at the pond site range from 0.01-3.09 inches, with an average of 0.29 inches/event. Durations for events measured at the site range from 0.01-27.5 hours, with antecedent dry periods ranging from 0.1-13.7 days.

A comparison of measured and average "normal" rainfall in the vicinity of the Pioneer Key wet detention pond is given in Figure 3-1. Measured rainfall presented in this figure is based upon the field-measured rain events at the wet detention pond monitoring site presented in Table 3-1, summarized on a monthly basis. Average "normal" rainfall conditions are based upon historical monthly rainfall averages recorded at the City of Orlando Meteorological Site (Site 86628), located at the Orlando International Airport (OIA or McCoy), over the 30-year period from 1971-2000. Comparisons between measured and average "normal" rainfall are provided for the months of October 2009-March 2010. Historical average rainfall during the months of October-March in Orlando is approximately 15.68 inches.

TABLE 3-1

SUMMARY OF RAINFALL MEASURED AT THE PIONEER KEY REGIONAL STORMWATER FACILITY MONITORING SITE FROM OCTOBER 2009-MARCH 2010

EVENT START		EVENT END		TOTAL RAINFALL (inches)	DURATION (hours)	ANTECEDENT DRY PERIOD (days)	AVERAGE INTENSITY (inches/hour)
DATE	TIME	DATE	TIME				
10/05/09	16:02	10/05/09	16:20	0.03	0.30		0.10
10/11/09	5:57	10/11/09	6:48	0.08	0.85	5.6	0.09
10/15/09	22:23	10/16/09	2:16	0.27	3.88	4.6	0.07
10/18/09	3:40	10/18/09	4:02	0.05	0.37	2.1	0.13
10/28/09	14:11	10/28/09	14:11	0.01	---	10.4	---
11/1/09	22:17	11/1/09	22:17	0.01	---	4.3	---
11/10/09	19:35	11/10/09	21:17	0.26	1.70	8.9	0.15
11/24/09	13:57	11/24/09	13:57	0.01	---	13.7	---
11/25/09	9:49	11/25/09	13:40	0.54	3.84	0.8	0.14
11/25/09	21:12	11/25/09	23:49	0.07	2.62	0.3	0.03
12/1/09	3:53	12/1/09	4:03	0.02	0.16	5.2	0.12
12/2/09	20:49	12/3/09	0:36	0.40	3.78	1.7	0.11
12/4/09	7:00	12/5/09	10:31	3.09	27.52	1.3	0.11
12/7/09	6:57	12/7/09	8:05	0.03	1.12	1.9	0.03
12/8/09	3:45	12/8/09	4:04	0.04	0.32	0.8	0.12
12/10/09	6:20	12/10/09	6:20	0.01	---	2.1	---
12/10/09	9:37	12/10/09	16:33	0.36	6.94	0.1	0.05
12/15/09	3:44	12/15/09	3:44	0.01	---	4.5	---
12/15/09	6:59	12/15/09	6:59	0.01	---	0.1	---
12/17/09	17:03	12/17/09	17:27	0.03	0.41	2.4	0.07
12/18/09	4:33	12/18/09	8:45	0.16	4.20	0.5	0.04
12/18/09	16:22	12/18/09	17:24	0.12	1.03	0.3	0.12
12/22/09	4:02	12/22/09	4:02	0.01	---	3.4	---
12/25/09	6:55	12/25/09	10:44	0.79	3.81	3.1	0.21
12/25/09	14:21	12/25/09	14:31	0.08	0.16	0.2	0.51
12/28/09	13:17	12/28/09	13:17	0.01	---	2.9	---
12/29/09	3:49	12/29/09	4:02	0.03	0.22	0.6	0.14
1/1/10	4:46	1/1/10	7:11	0.32	2.41	3.0	0.13
1/1/10	10:12	1/1/10	13:06	0.53	2.89	0.1	0.18
1/1/10	23:13	1/1/10	23:13	0.01	---	0.4	---
1/4/10	9:38	1/4/10	9:38	0.01	---	2.4	---
1/8/10	13:47	1/8/10	13:47	0.01	---	4.2	---
1/9/10	8:00	1/9/10	12:01	0.04	4.02	0.8	0.01
1/19/10	3:44	1/19/10	6:36	0.06	2.86	9.7	0.02
1/21/10	19:49	1/22/10	6:53	0.59	11.06	2.6	0.05
1/24/10	17:51	1/24/10	22:05	0.09	4.24	2.5	0.02
1/25/10	4:57	1/25/10	7:51	0.39	2.90	0.3	0.13
1/26/10	3:40	1/26/10	5:26	0.13	1.76	0.8	0.07
1/30/10	13:58	1/30/10	15:15	0.08	1.28	4.4	0.06

TABLE 3-1 -- CONTINUED

SUMMARY OF RAINFALL MEASURED AT THE PIONEER KEY REGIONAL STORMWATER FACILITY MONITORING SITE FROM OCTOBER 2009-MARCH 2010

EVENT START		EVENT END		TOTAL RAINFALL (inches)	DURATION (hours)	ANTECEDENT DRY PERIOD (days)	AVERAGE INTENSITY (inches/hour)
DATE	TIME	DATE	TIME				
2/1/10	11:44	2/1/10	17:47	0.41	6.06	1.9	0.07
2/1/10	20:50	2/2/10	0:03	0.08	3.22	0.1	0.02
2/2/10	5:17	2/2/10	5:17	0.01	---	0.2	---
2/2/10	9:30	2/2/10	12:00	0.42	2.50	0.2	0.17
2/3/10	14:30	2/3/10	14:31	0.02	0.00	1.1	24.00
2/5/10	14:37	2/5/10	17:39	0.24	3.02	2.0	0.08
2/9/10	3:41	2/9/10	4:08	0.16	0.44	3.4	0.36
2/9/10	12:51	2/9/10	17:32	0.40	4.67	0.4	0.09
2/10/10	8:18	2/10/10	8:18	0.01	---	0.6	---
2/12/10	11:29	2/12/10	17:05	0.98	5.59	2.1	0.18
2/15/10	14:37	2/15/10	14:37	0.02	0.00	2.9	9.00
2/16/10	3:47	2/16/10	4:06	0.03	0.32	0.5	0.09
2/23/10	3:53	2/23/10	4:07	0.06	0.23	7.0	0.27
2/23/10	7:41	2/23/10	7:41	0.01	---	0.1	---
2/24/10	14:21	2/24/10	21:47	0.29	7.43	1.3	0.04
2/25/10	14:08	2/25/10	14:08	0.01	---	0.7	---
2/27/10	9:05	2/27/10	12:57	0.18	3.87	1.8	0.05
3/2/10	6:13	3/2/10	7:26	0.36	1.22	2.7	0.29
3/3/10	16:33	3/3/10	16:35	0.02	0.03	1.4	0.78
3/9/10	3:42	3/9/10	4:05	0.07	0.39	5.5	0.18
3/11/10	5:46	3/11/10	5:46	0.01	---	2.1	---
3/11/10	8:59	3/11/10	17:35	2.75	8.59	0.1	0.32
3/12/10	1:43	3/12/10	18:20	1.06	16.62	0.3	0.06
3/12/10	23:53	3/13/10	0:52	0.14	0.97	0.2	0.14
3/16/10	2:47	3/16/10	3:08	0.04	0.35	3.1	0.11
3/19/10	2:46	3/19/10	3:10	0.06	0.40	3.0	0.15
3/21/10	11:59	3/21/10	14:56	0.97	2.95	2.4	0.33
3/23/10	2:43	3/23/10	3:04	0.04	0.35	1.5	0.11
3/25/10	23:09	3/26/10	1:08	0.65	1.99	2.8	0.33
3/28/10	21:47	3/29/10	10:21	1.72	12.57	2.9	0.14
			TOTAL:	**20.01**			

TABLE 3-2

SUMMARY OF RAINFALL CHARACTERISTICS IN THE VICINITY OF THE PIONEER KEY WET DETENTION POND FROM OCTOBER 1, 2009-MARCH 31, 2010

PARAMETER	UNITS	MINIMUM VALUE	MAXIMUM VALUE	MEAN EVENT VALUE
Event Rainfall	inches	0.01	3.09	0.29
Event Duration	hours	0.01	27.5	3.40
Average Intensity	inches/hour	0.01	24.0	0.76
Antecedent Dry Period	days	0.1	13.7	2.5

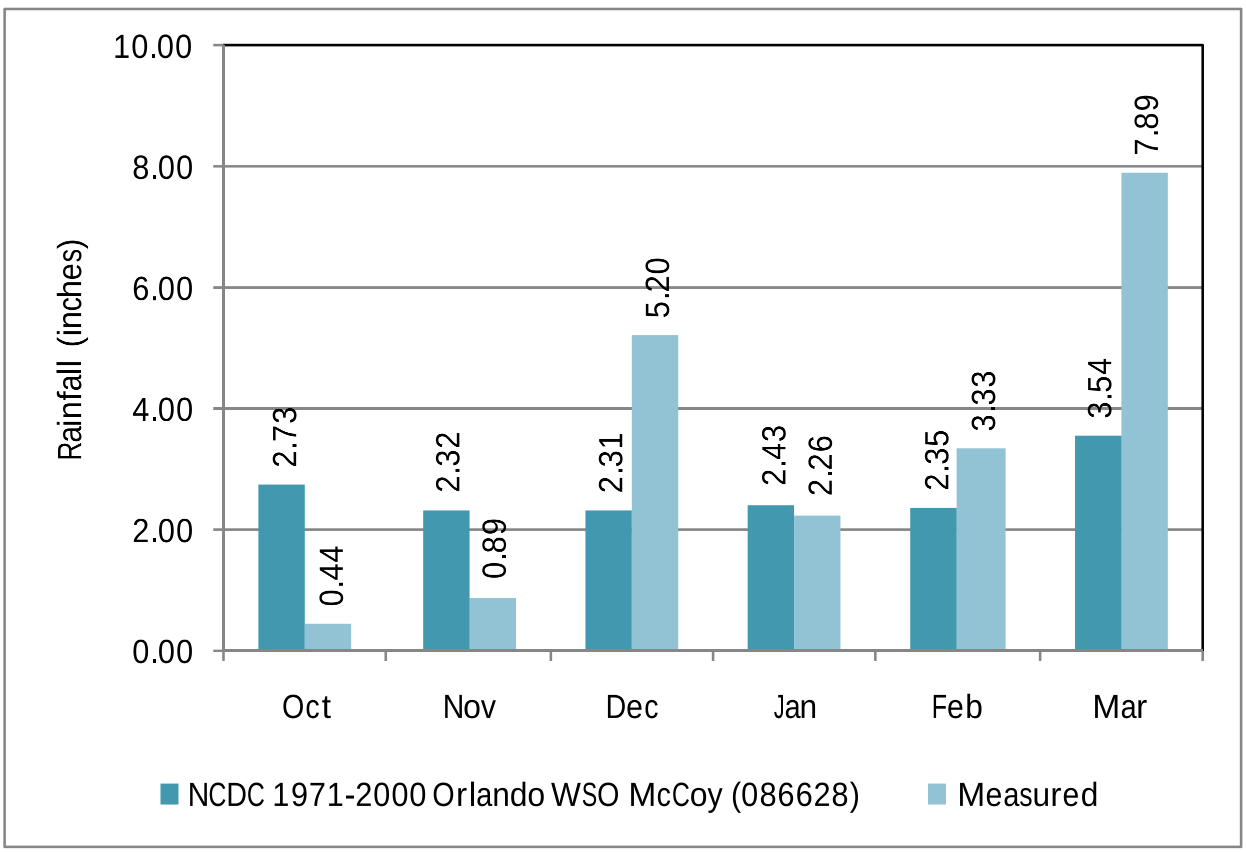


Figure 3-1. Comparison of Average and Measured Rainfall in the Vicinity of the Pioneer Key Wet Detention Pond Site.

As seen in Figure 3-1, measured rainfall in the vicinity of the wet detention pond site was substantially less than "normal" during October and November, approximately "normal" during January and February, and greater than "normal" rainfall during December and March. Overall, the field measured rainfall of 20.01 inches from October 2009-March 2010 is approximately 28% greater than the "average" rainfall of 15.68 inches which typically occurs during the period from October-March in the Orlando area.

3.1.1.2 <u>Hydrologic Inputs</u>

Estimated hydrologic inputs from direct precipitation onto the Pioneer Key wet detention pond surface were calculated by multiplying the rainfall depth for each of the 69 storm events summarized in Table 3-1 times the water surface area within the pond at the time of the rain event. The pond water surface area at the time of a given storm event was calculated based upon a stage-area relationship for the pond developed by ERD from the construction plans provided in Appendix A. A summary of stage-area-volume relationships for the Pioneer Key wet detention pond is given in Table 3-3. Information on water elevations within the pond was obtained from the digital stage recorder installed by ERD. Additional information on pond stages is given in a subsequent section.

TABLE 3-3

STAGE-AREA-VOLUME RELATIONSHIPS FOR THE PIONEER KEY REGIONAL STORMWATER FACILITY

ELEVATION (feet)	AREA (acres)	VOLUME (ac-ft)	ELEVATION (feet)	AREA (acres)	VOLUME (ac-ft)
120	4.32	51.69	109	2.14	15.47
119	4.15	47.45	108	2.06	13.37
118	3.98	43.39	107	1.98	11.35
117	3.81	39.49	106	1.91	9.40
116	3.64	35.76	105	1.84	7.53
115	3.48	32.20	104	1.76	5.73
114	3.31	28.81	103	1.69	4.00
113	3.12	25.60	102	1.62	2.35
112	2.96	22.56	101	1.55	0.76
111	2.33	19.91	100.5	1.51	0
110	2.21	17.64			

A summary of estimated monthly hydrologic inputs to the Pioneer Key wet detention pond from direct precipitation is given in Table 3-4. The inputs into the pond range from 0.11 ac-ft during October to 2.04 ac-ft during March. The information summarized in Table 3-4 is used to develop a hydrologic budget for the pond.

TABLE 3-4

ESTIMATED MEAN MONTHLY HYDROLOGIC INPUTS TO THE PIONEER KEY WET DETENTION POND FROM DIRECT PRECIPITATION

MONTH	TOTAL RAINFALL (inches)	HYDROLOGIC INPUTS (ac-ft)
October	0.44	0.11
November	0.89	0.22
December	5.20	1.33
January	2.26	0.57
February	3.33	0.85
March	7.89	2.04
TOTALS:	**20.01**	**5.12**

3.1.2 Ditch and Runoff Inputs

3.1.2.1 Hydrologic Characteristics of Monitored Inflows

A graphical summary of inflow hydrographs measured at the Northwest Ditch inflow (Site 1) from October 2009-March 2010 is given on Figure 3-2. Total daily rainfall measured at the Pioneer Key site is also provided on Figure 3-2 for comparison purposes. In general, inflow from the Northwest Ditch was highly variable throughout the monitoring program, with inflow rates highly correlated with rainfall within the drainage basin. A low level baseflow of approximately 1 cfs or less was measured from October to approximately mid-December and again from mid-March to April. Baseflow inputs were minimal or non-existent from mid-December through mid-March. In general, the vast majority of monitored inflow rates were less than approximately 20 cfs, with the exception of inflows measured during significant rain events in early-December and mid- to late-March.

A graphical summary of runoff volumes discharging from the parking lot inflow (Site 2) over the period from October 2009-March 2010 is given on Figure 3-3. Due to the small size of the parking lot area (0.51 acres), measured hydrographs through the stormsewer system reflect extremely low values for the majority of monitored storm events. Therefore, runoff inflow from the parking lot area is summarized in terms of total runoff volume for each measured storm event rather than inflow hydrographs. In general, due to the 100% impervious cover within the basin area, measured runoff volumes correspond closely to the depth of rainfall events at the site. The runoff volume values provided on Figure 3-3 can be used directly to calculate cumulative inflows from this site.

A graphical summary of inflow hydrographs to the wet detention pond measured at the southeast inflow (Site 3) from October 2009-March 2010 is given in Figure 3-4. The stormsewer at this location is a 42-inch RCP which is designed for use with future development. As discussed previously, this inflow is currently plugged with the exception of a 10-inch HDPE pipe which provides drainage for a localized area. In general, inflow hydrographs measured at this site ranged from approximately 0.05-0.15 cfs throughout the majority of the monitoring program. However, during the periods of heavy rainfall observed during March 2010, inflows from this site increased to approximately 8 cfs for a brief period.

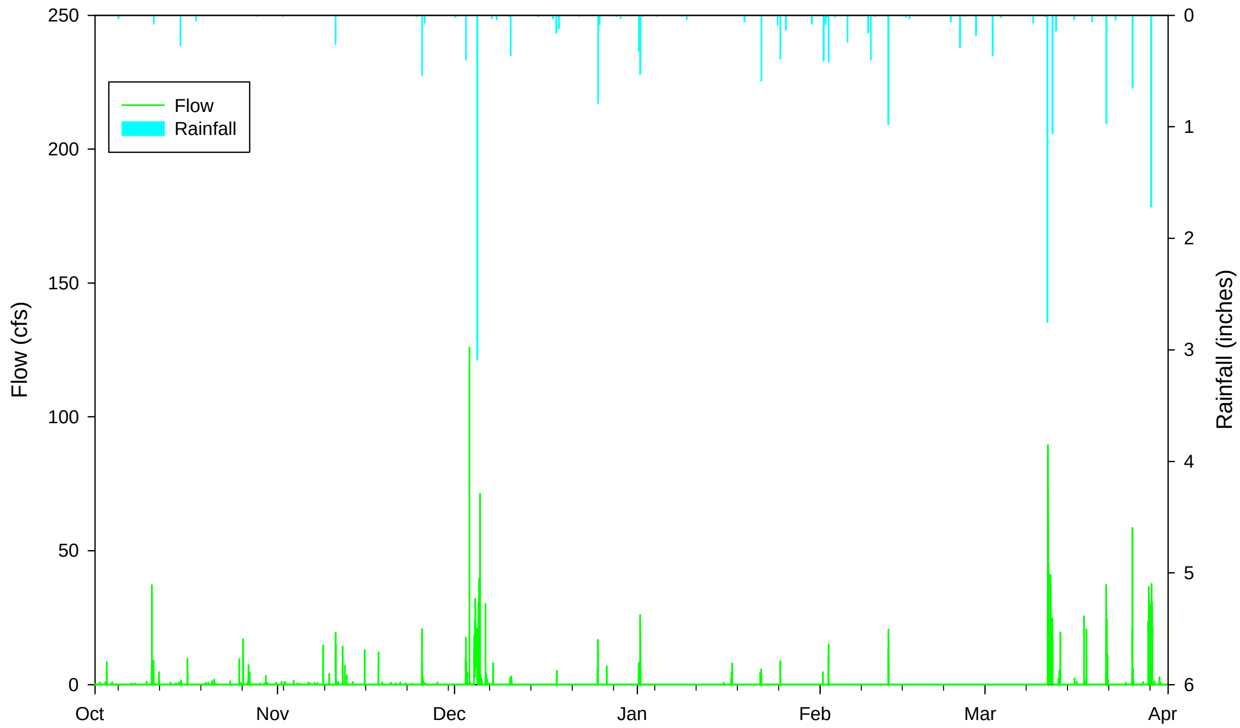


Figure 3-2. Inflow Hydrographs Measured at the Northwest Ditch Inflow (Site 1) from October 2009-March 2010.

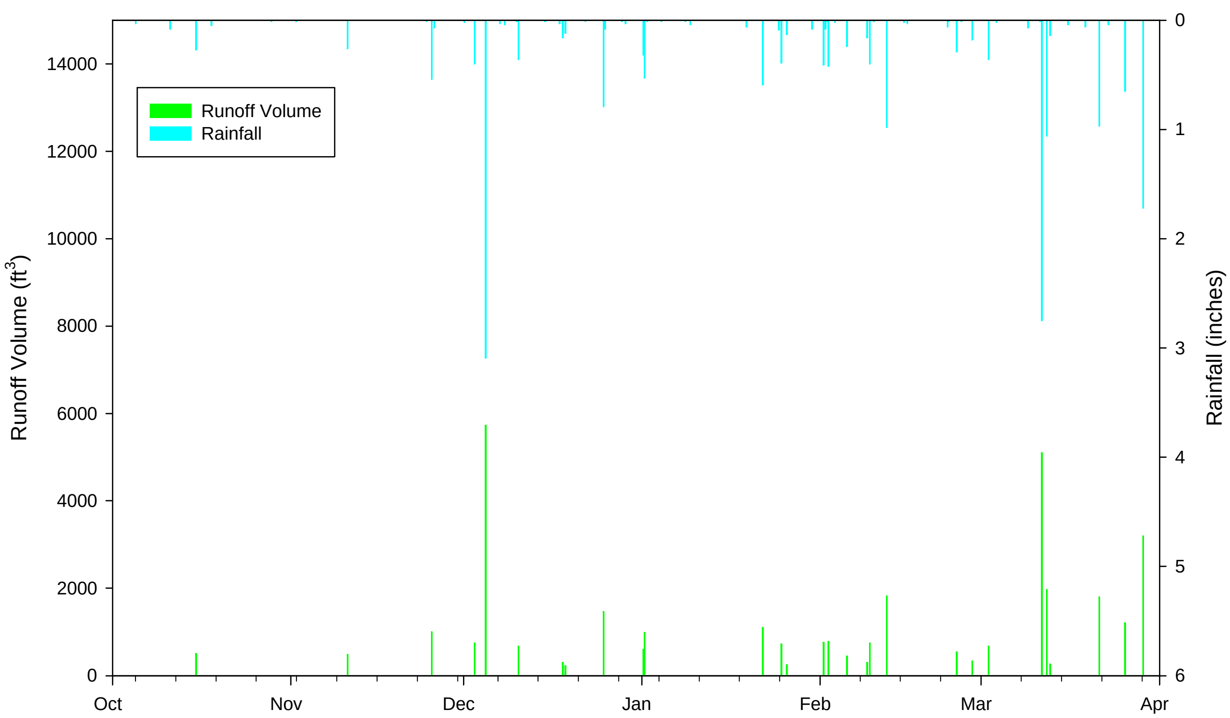


Figure 3-3. Total Runoff Volumes Measured at the Parking Lot Inflow (Site 2) from October 2009-March 2010.

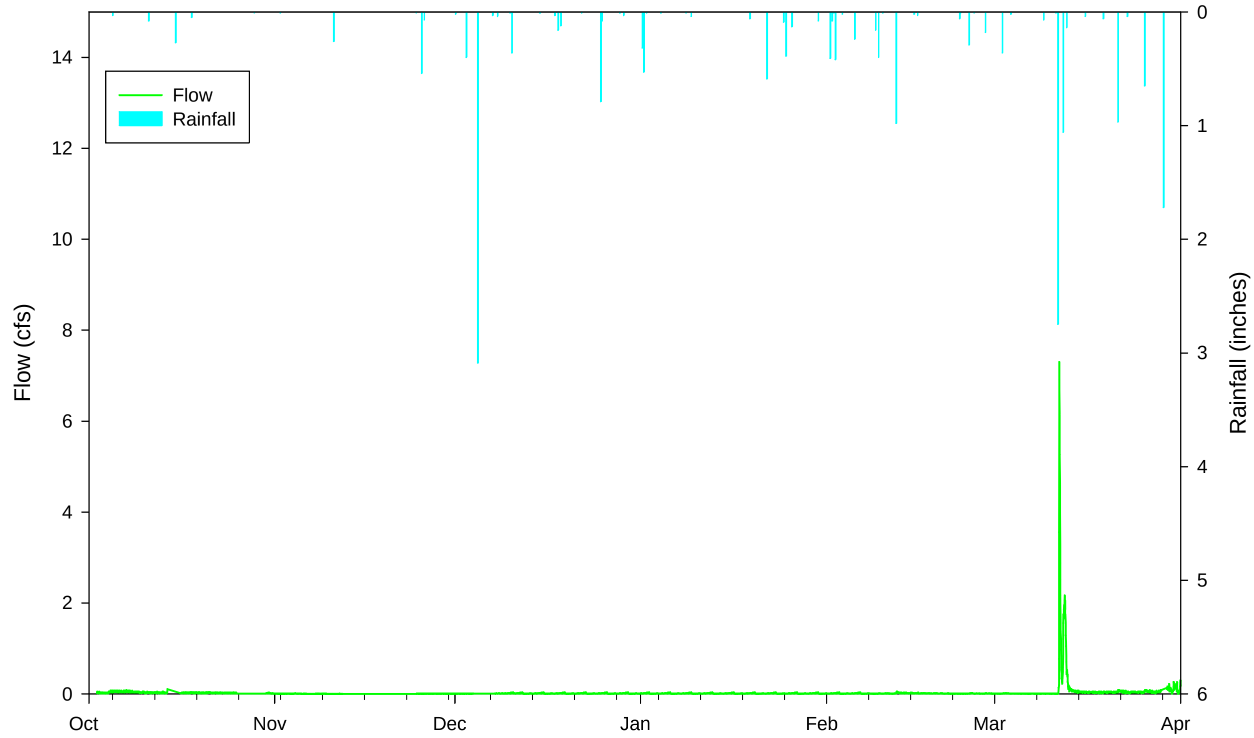


Figure 3-4. Inflow Hydrographs Measured at the Southeast Inflow (Site 3) from October 2009-March 2010.

3.1.2.2 <u>Hydrologic Inputs</u>

Estimates of monthly hydrologic inputs into the wet detention pond from the Northwest Ditch inflow (Site 1) and the southeast inflow (Site 2) were generated by integrating the inflow hydrographs summarized in Figures 3-2 and 3-4 on a monthly basis. Estimates of inputs from the parking lot area (Site 2) were generated by summing the runoff volumes provided on Figure 3-3 on a monthly basis.

A summary of estimated monthly hydrologic inputs from ditch and runoff inflows to the Pioneer Key pond from October 2009-March 2010 is given in Table 3-5. The largest inflows into the pond occur as a result of inputs from the Northwest Ditch at Site 1, with approximately 90% of the total hydrologic inputs from ditch and runoff inflows originated at this site. Approximately 10% of the hydrologic inputs from ditch and runoff inflows originated at the southeast inflow (Site 3), with a minimal contribution from the parking lot area. The information summarized in Table 3-5 is utilized in a subsequent section to develop a hydrologic budget for the wet detention pond.

An estimate of the runoff coefficient (C value) for the contributing basin area was calculated over the monitoring period from October 2009-March 2010. A summary of this analysis is given in Table 3-6. As discussed previously, the contributing basin area to the pond is approximately 123.9 acres. During the field monitoring program, a total of 20.01 inches of rainfall was recorded at the pond site. This equates to a total rainfall volume over the contributing basin area of 206.6 ac-ft. As indicated in Table 3-5, the pond inflow volume during the field monitoring program was approximately 87.7 ac-ft. The ratio of the runoff inflow to the total rainfall volume, defined as the runoff coefficient or C value, is 0.424. This value suggests that approximately 42% of the rainfall which occurred within the contributing basin area entered the wet detention pond as stormwater runoff or baseflow.

TABLE 3-5

ESTIMATED MONTHLY HYDROLOGIC INPUTS FROM DITCH AND RUNOFF INFLOWS TO THE PIONEER KEY POND FROM OCTOBER 2009-MARCH 2010

MONTH	HYDROLOGIC INPUTS (ac-ft)			TOTALS
	SITE 1	SITE 2	SITE 3	
10	0.70	0.01	1.26	1.97
11	2.59	0.03	0.06	2.68
12	23.47	0.21	0.39	24.07
1	5.63	0.08	0.44	6.15
2	3.77	0.13	0.49	4.39
3	51.5	0.33	6.91	58.7
TOTAL:	**87.7 (90%)**	**0.79 (<1%)**	**9.55 (10%)**	**98.0**

TABLE 3-6

ESTIMATED RUNOFF COEFFICIENT (C VALUE) FOR THE CONTRIBUTING BASIN AREA FOR THE NORTHWEST DITCH

PARAMETER	VALUE
Contributing Basin Area	123.9 acres
Total Rainfall[1]	20.01 inches
Total Rainfall Volume[2]	206.6 ac-ft
Pond Inflow	87.7 ac-ft
C Value	0.424

1. Measured rainfall from October 2009-March 2010
2. Total rainfall volume over 123.9-acre watershed

3.1.3 Pond Outflow

3.1.3.1 Hydrologic Characteristics

Continuous monitoring of discharges from the Pioneer Key wet detention pond was conducted from October 2009-March 2010. As discussed previously, the pond contains two separate outfall structures which combine into a single 24-inch RCP which returns the water back into the Northwest Ditch downstream of the detention pond. Flow monitoring was conducted downstream from the final outfall structure and reflected the combined discharges from the pond.

A graphical summary of discharge hydrographs from the wet detention pond during the field monitoring program is given on Figure 3-5. Discharges from the pond appear to be highly correlated with measured rain events at the monitoring site. The vast majority of discharge rates from the pond appear to be substantially less than 1 cfs. Discharge rates in excess of 1 cfs were observed during early-December, early- and mid-February, and mid- to late-March. Rainfall depths for individual rain events are also included on Figure 3-5 for comparison purposes.

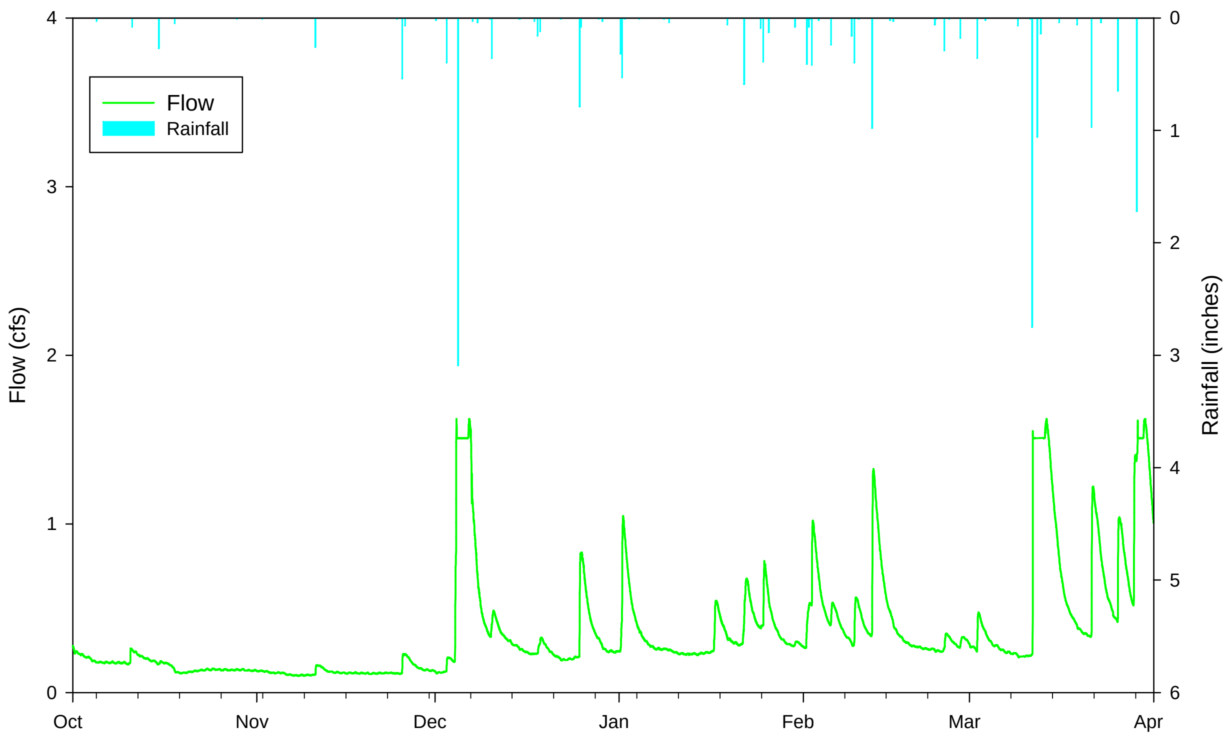


Figure 3-5. Measured Discharge Hydrographs from the Pond Outfall Structures (Site 4) from October 2009-March 2010.

3.1.3.2 <u>Hydrologic Losses</u>

Estimates of monthly hydrologic discharges from the wet detention pond were generated by integrating the discharge hydrograph summarized on Figure 3-5 on a monthly basis. A summary of estimated monthly hydrologic discharges from the Pioneer Key wet detention pond is given in Table 3-7. Measured monthly discharges from the pond ranged from a low of 5.59 ac-ft during November to a high of 31.9 ac-ft during March. The information summarized in Table 3-7 is utilized in a subsequent section to develop a hydrologic budget for the wet detention pond.

TABLE 3-7

ESTIMATED MONTHLY HYDROLOGIC DISCHARGES FROM THE PIONEER KEY WET DETENTION POND

MONTH	HYDROLOGIC DISCHARGES (ac-ft)
October	7.63
November	5.59
December	19.5
January	16.5
February	17.7
March	31.9
TOTALS:	**98.8**

3.1.4 Water Level Elevations

Water level elevations within the Pioneer Key wet detention pond were recorded on a continuous basis from October 2009-March 2010. The water level logger was installed inside the pond, attached to a 4-inch x 4-inch wooden post approximately 20 ft from the high level overflow on the northwest corner of the pond.

As discussed in Section 2, an additional water level recorder was installed at the diversion weir, as indicated on Figure 1-5. The purpose of this water level recorder was to provide data to estimate the quantity of water which bypassed the wet detention pond in the event that water elevations exceeded 115.5 ft and began to discharge directly over the diversion weir structure. However, these conditions did not occur during the field monitoring program, and the data collected at this site is not provided in this summary report.

A graphical summary of water surface elevations in the Pioneer Key wet detention pond during the monitoring program is given on Figure 3-6. A reference line is provided for the pond control elevation of 112.35 ft, corresponding to the invert elevations of the 5.25-inch bleed-down orifices in the outfall structures. A second reference line is also provided for the high level overflow weir elevation of 114.0 ft.

Water levels within the pond responded rapidly to significant rain events within the drainage basin, with a relatively rapid bleed-down occurring over a period of approximately 3-7 days following the storm events. The water level within the pond remained at or above the pond control elevation throughout the entire monitoring program. During the period from October to early-December, water elevations remained near the pond control elevation. However, beginning in early-December and continuing for the remainder of the monitoring program, the normal water level (defined as the equilibrium water level following significant storm events) increased to approximately 112.5 ft. Water elevations within the pond briefly exceeded the pond overflow weir elevation of 114 ft on two occasions during mid- to late-March, corresponding to periods of continued rainfall within the basin.

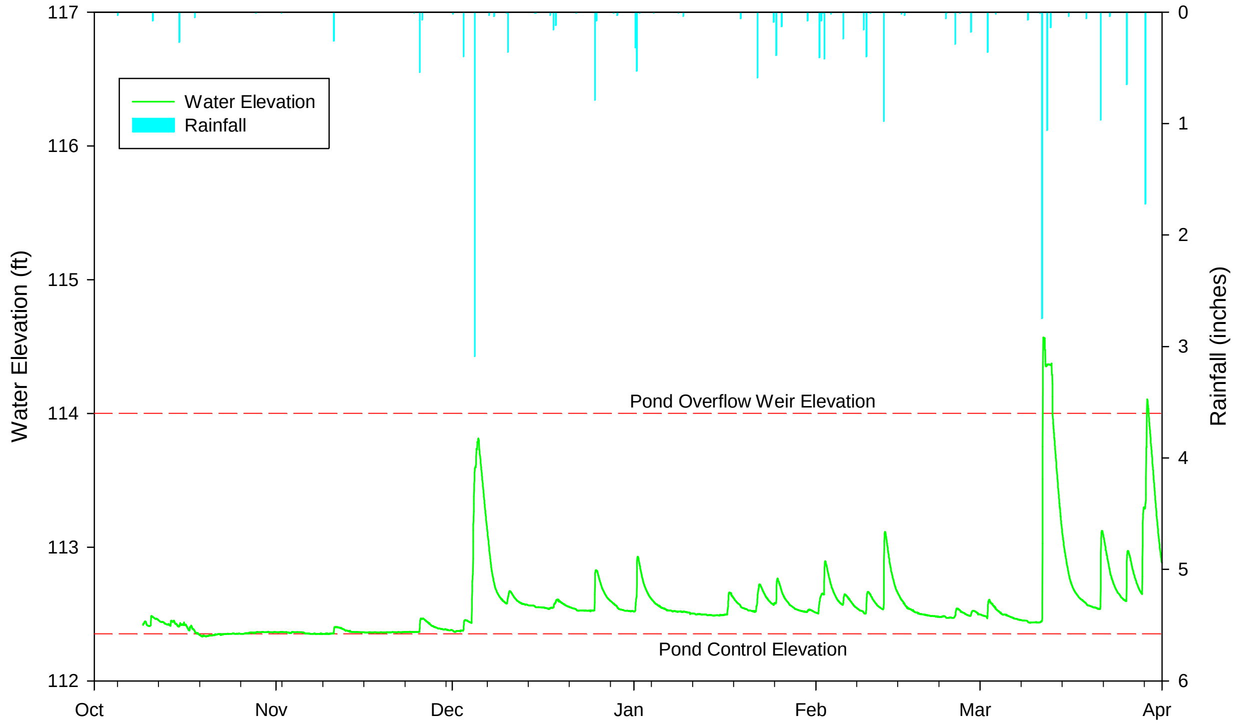


Figure 3-6. Water Surface Elevations in the Pioneer Key Pond from October 2009-March 2010.

As discussed previously, when water elevations within the pond exceed 114.0 ft, additional discharges can occur through the grated inlets on the top of the two outfall structures as well as through the overflow diversion weir located on the northwest corner of the pond. Any additional discharge through the grate inlets on the top of the pond outfall structures would be included in the measured discharge hydrograph provided on Figure 3-5 since the flow meter was located downstream from the final outfall structure. The theoretical additional discharge through the overflow weir could be calculated using a standard broad crested weir equation and the surface water elevations summarized on Figure 3-6 for the brief period during March when the water elevations within the pond exceed the invert of the weir.

The photograph provided on Figure 1-9 was taken during the period of elevated water levels during late-March. However, water levels on each side of the weir structure appear to be relatively similar, suggesting that water may have backed up within the northeast ditch to roughly the same elevation as the pond. Under these conditions, the discharge from the pond through the weir would be substantially limited. Since the elevated water conditions occur for only a brief period, and in view of the questionable hydraulics associated with areas upstream and downstream of the weir structure, discharges through the overflow structure are considered to be minimal and are not considered in subsequent hydrologic and mass loading analyses. However, any water which may have discharged through this structure would still have been treated by the wet detention pond prior to discharge, although it is possible that the discharge may have experienced a slightly lower detention time than inputs which discharged through the ordinary outfall structures. Water levels within the pond never reached the diversion weir elevation of 115.5 ft, indicating that all inflows from the Northwest Ditch were diverted into the pond during the field monitoring program.

Although increases in water surface elevations were observed during significant rain events, the pond maintained a relatively constant water surface elevation throughout the majority of the 6-month monitoring program. A gradual increase in pond elevation was observed in the final month of the monitoring program during a period of extended rainfall. Overall, the pond increased in storage by approximately 1.19 ac-ft from the beginning to the end of the monitoring program, corresponding to a water level increase of approximately 0.39 ft (4.7 inches) over the 3.02-acre surface of the pond.

3.1.5 <u>Pond Evaporation</u>

Estimates of hydrologic losses from the wet detention pond as a result of evaporation were calculated using field measurements of evaporation conducted by ERD at the Pioneer Key pond site. As discussed in Section 2, a Class A pan evaporimeter was installed adjacent to the equipment shelter and rainfall recorder installed at Site 3 (Figure 2-5). Measurements of water levels in the pan evaporimeter were conducted on a weekly basis and corrected for rainfall to provide an estimate of weekly evaporation during the monitoring program. The measured pan evaporation was multiplied by the standard coefficient of 0.75 to convert the measured values into lake surface evaporation.

A graphical comparison of average and measured evaporation at the Pioneer Key wet detention pond site is given on Figure 3-7. The measured values indicated on this figure reflect the lake surface evaporation measurements conducted at the Pioneer Key site. The “average” or “normal” evaporation values are based upon measurements conducted at the Orlando International Airport meteorological site. In general, measured evaporation at the Pioneer Key site was slightly greater than normal during October, approximately normal during December, and slightly less than normal during the months of November, January, February, and March.

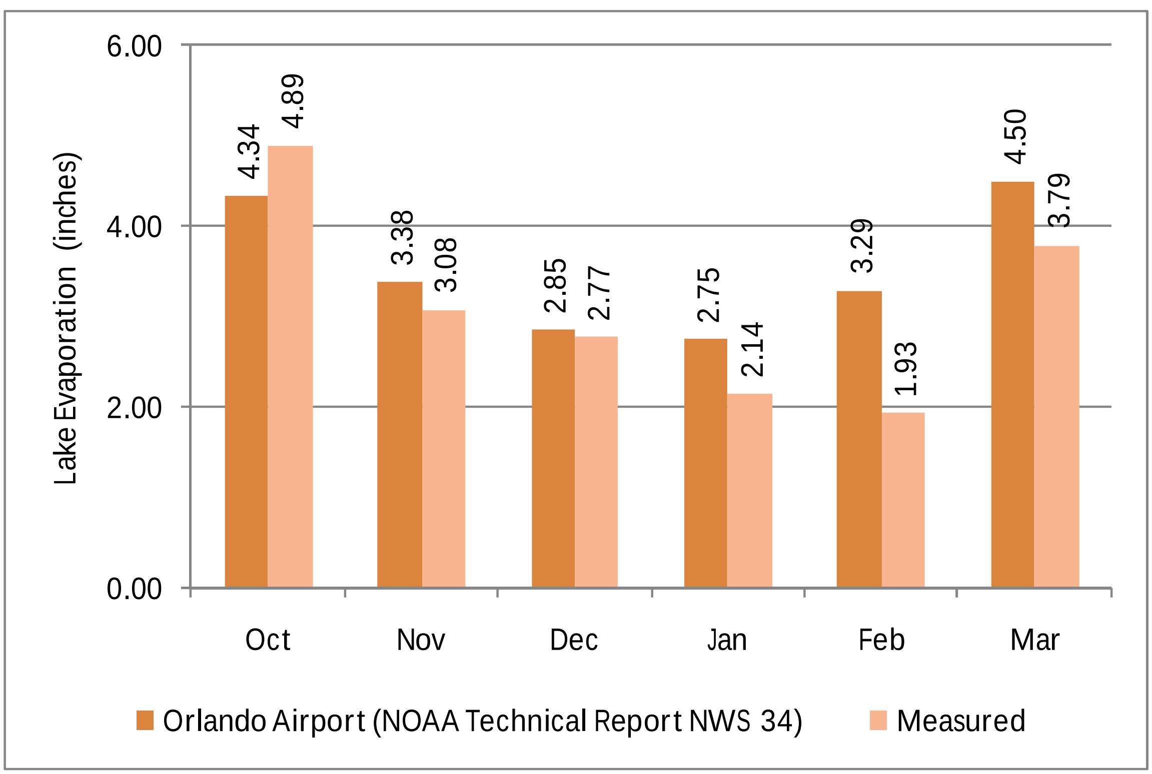


Figure 3-7. Comparison of Average and Measured Evaporation at the Pioneer Key Wet Detention Pond Site.

Overall, a total evaporation loss of approximately 18.60 inches occurred during the field monitoring program. The "normal" evaporation during this period in the Orlando area is approximately 21.11 inches. As a result, evaporation losses during the field monitoring program were approximately 12% lower than normally occurs during the period from October-March in the Central Florida area.

A summary of estimated monthly evaporation losses from the Pioneer Key wet detention pond was given in Table 3-8. Evaporation losses from the pond range from a low of 0.49 ac-ft during February to a high of 1.23 ac-ft during October. During the field monitoring program, evaporation losses removed approximately 4.69 ac-ft of water from the wet detention pond. This information is used in a subsequent section to generate a hydrologic budget for the pond.

TABLE 3-8

ESTIMATED MONTHLY HYDROLOGIC EVAPORATION LOSSES FROM THE PIONEER KEY WET DETENTION POND

MONTH	EVAPORATION (inches)	HYDROLOGIC LOSSES (ac-ft)
October	4.89	1.23
November	3.08	0.78
December	2.77	0.70
January	2.14	0.54
February	1.93	0.49
March	3.79	0.95
TOTALS:	**18.60**	**4.69**

3.1.6 Groundwater Losses

During the monitoring program, relatively small additional water inputs and losses occurred on a monthly basis which were in excess of the losses estimated from evaporation and discharge through the outfall structures. For purposes of this analysis, these additional inputs and losses are assumed to occur as a result of either infiltration of water into groundwater beneath the pond or seepage of groundwater into the pond. Groundwater inputs and losses were calculated using the equation summarized below:

$$GW = \text{Rainfall} + \text{Inflow} - \text{Outflow} - \text{Evaporation} - \Delta\ \text{Storage}$$

If the equation above results in a positive number, then groundwater is entering into the wet detention pond. If the calculation above results in a negative value, then groundwater is assumed to enter the pond. The calculations summarized in this equation were performed on a monthly basis for each month of the monitoring program. The calculation above results in a net calculation for groundwater movement during a given month. The change in storage is calculated as the change in water volume within the pond from the beginning to the end of each month.

A summary of estimated mean monthly hydrologic inputs and losses from groundwater infiltration at the wet detention pond is given in Table 3-9. A net influx of groundwater into the pond was observed during four of the six months included in the monitoring program. Net groundwater inputs occurred during October, November, January, and February. Net groundwater losses from the pond were observed during December and March. Overall, groundwater contributed a net inflow of 14.31 ac-ft during the monitoring program.

TABLE 3-9

ESTIMATED NET MONTHLY HYDROLOGIC GROUNDWATER INPUTS (+) AND LOSSES (-) FROM THE PIONEER KEY WET DETENTION POND

MONTH	GROUNDWATER LOSSES (ac-ft)
October	+ 6.62
November	+ 3.51
December	- 4.76
January	+ 10.32
February	+ 12.73
March	- 14.11
TOTALS:	**+ 14.31**

3.1.7 Hydrologic Budget

Monthly hydrologic budgets were developed for the Pioneer Key wet detention pond over the period from October 2009-March 2010 based on the measured or calculated inputs and losses summarized in previous sections. A tabular summary of the monthly hydrologic budget is given in Table 3-10. Information is provided on the volumetric inputs into the pond from the Northwest Ditch inflow runoff, groundwater, and rainfall, with hydrologic losses occurring as a result of pond outflow, evaporation, and groundwater infiltration.

A graphical comparison of overall hydrologic inputs and losses for the Pioneer Key wet detention pond is given on Figure 3-8. During the monitoring period, approximately 75% of the hydrologic inputs into the pond occurred as a result of inflow through the Northwest Ditch, with 12% from groundwater, 8% from Site 3, and approximately 4% from direct rainfall. Approximately 96% of the hydrologic losses from the pond occurred as a result of outflow from the pond, with 4% lost as a result of evaporation.

TABLE 3-10

MONTHLY HYDROLOGIC BUDGET FOR THE PIONEER KEY WET DETENTION POND FROM OCTOBER 2009-MARCH 2010

MONTH	HYDROLOGIC INPUTS (ac-ft)				HYDROLOGIC LOSSES (ac-ft)				Δ STORAGE (ac-ft)
	Inflow	Rainfall	GW	Total	Outflow	Evap.	GW	Total	
October	1.97	0.11	6.62	8.70	7.63	1.23	0	8.86	-0.16
November	2.68	0.22	3.51	6.41	5.59	0.78	0	6.37	0.04
December	24.08	1.33	0	25.41	19.53	0.70	4.76	24.99	0.42
January	6.16	0.57	10.32	17.05	16.53	0.54	0	17.07	-0.03
February	4.40	0.85	12.73	17.98	17.74	0.49	0	18.23	-0.25
March	58.73	2.04	0	60.77	44.55	0.95	14.11	59.61	1.16
Totals	**98.01**	**5.12**	**33.18**	**136.3**	**111.6**	**4.69**	**18.87**	**135.1**	**1.19**

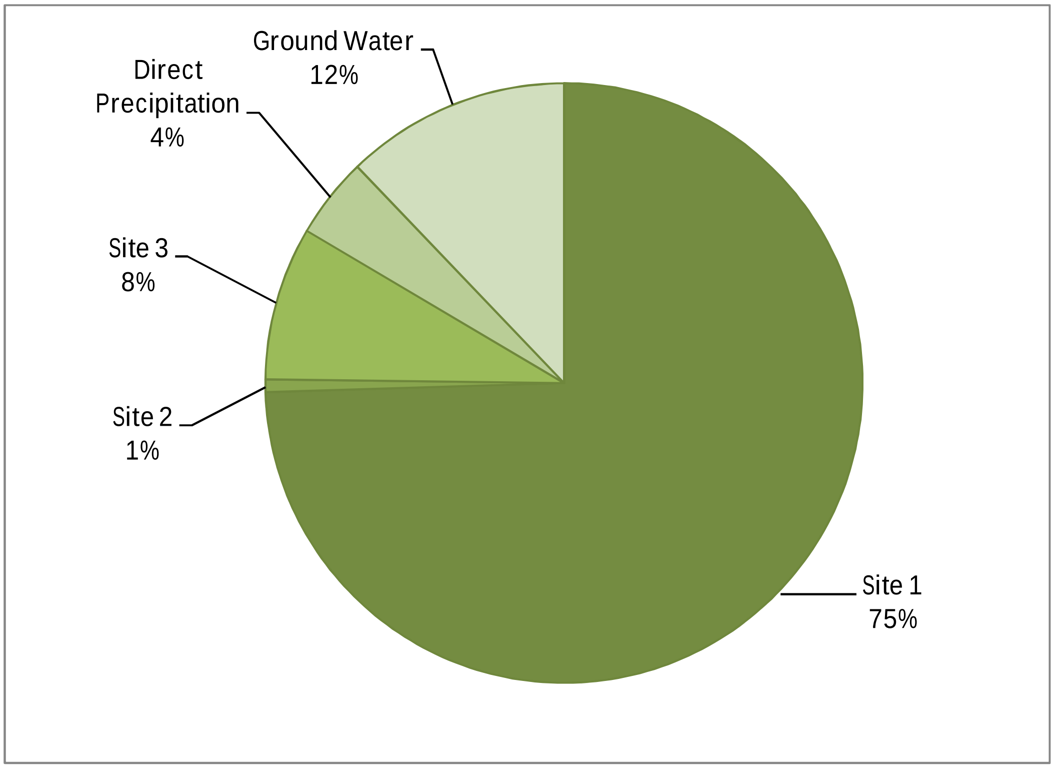
3.1.8 Pond Detention Time

The pond detention time was calculated for the period from October 2009-March 2010 by dividing the estimated pond volume by the total hydrologic inputs summarized in Table 3-10. A summary of estimated detention time for the Pioneer Key wet detention pond during the monitoring program is given in Table 3-11. Based upon the stage-area-volume relationships provided in Table 3-3, the permanent pool pond volume is approximately 23.62 ac-ft at the outfall control elevation of 112.35 ft. During the monitoring program, a total of 136.3 ac-ft of water entered the pond from all sources over a period of 182 days. This equates to a mean detention time of approximately 31.6 days during the field monitoring program.

TABLE 3-11

ESTIMATED DETENTION TIME FOR THE PIONEER KEY WET DETENTION POND

PARAMETER	VALUE
Pond Volume	23.62 ac-ft
Pond Inputs	136.3 ac-ft
Calculation Period	182 days
Mean Detention Time	31.6 days



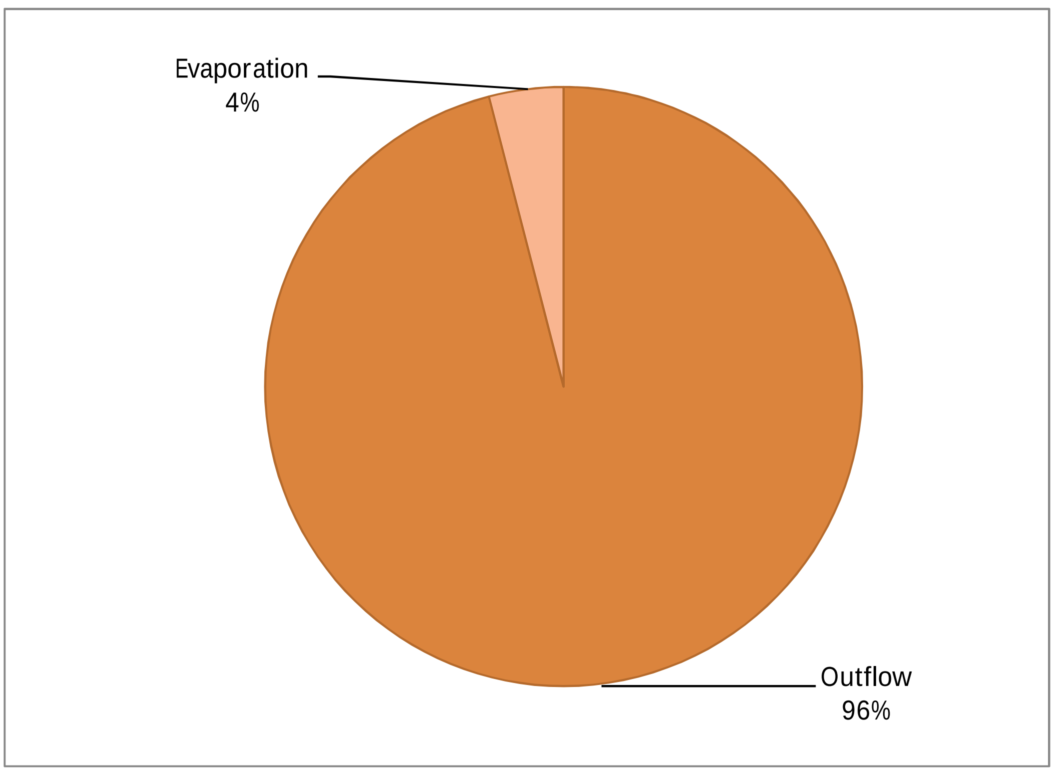


Figure 3-8. Hydrologic Inputs and Losses for the Pioneer Key Wet Detention Pond from October 2009-March 2010.

3.2 Chemical Characteristics of Monitored Inputs and Outputs

Continuous monitoring and collection of inflow and outflow samples was conducted by ERD at the Pioneer Key wet detention pond from October 2009-March 2010. In addition, bulk precipitation samples were also collected on approximately a weekly basis to identify nutrient inputs to the pond from direct rainfall. A complete listing of the chemical characteristics of individual inflow, outflow, and bulk precipitation samples is given in Appendix B. Information is provided in Appendix B for the chemical characteristics of each collected sample, along with minimum and maximum values for parameters measured at each monitoring site. A discussion of the water quality characteristics of the collected samples is given in the following sections.

3.2.1 Pond Inflow

A summary of mean characteristics of Pioneer Key inflow samples collected at Sites 1-3 from October 2009-March 2010 is given in Table 3-12. During the field monitoring program, a total of 25 flow-weighted composite samples was collected from the Northwest Ditch inflow site, with 21 composite runoff samples collected from the parking lot area at Site 2, and 17 composite samples collected at the southeast inflow.

TABLE 3-12

MEAN CHARACTERISTICS OF PIONEER KEY INFLOW SAMPLES COLLECTED AT SITES 1, 2, AND 3 FROM OCTOBER 2009-MARCH 2010

PARAMETER	UNITS	NORTHWEST DITCH (SITE 1)	PARKING LOT (SITE 2)	SOUTHEAST INFLOW (SITE 3)
pH	s.u.	7.38	6.82	7.44
Alkalinity	mg/l	127	49.5	128
Conductivity	µmho/cm	360	197	413
NH_3-N	µg/l	168	647	424
NO_X-N	µg/l	92	181	136
Dissolved Organic N	µg/l	498	718	330
Particulate N	µg/l	456	227	195
Total N	µg/l	1213	1773	1086
SRP	µg/l	50	21	2
Dissolved Organic P	µg/l	20	13	7
Particulate P	µg/l	224	62	47
Total P	µg/l	294	96	56
Color	Pt-Co	56	67	17
Turbidity	NTU	34.7	13.0	7.1
TSS	mg/l	91.8	25.9	30.3
No. of Samples	**--**	**25**	**21**	**17**

In general, inflows to the Pioneer Key wet detention pond were approximately neutral in pH, with mean values ranging from 6.82 at the parking lot site to 7.44 at the southeast inflow. Samples collected from the Northwest Ditch and the southeast inflow were well buffered, with mean alkalinity values of 127 mg/l and 128 mg/l, respectively. A moderately to poorly buffered mean alkalinity of 49.5 mg/l was observed at the parking lot site. Measured conductivity values at the three monitoring sites were highly variable, with mean values ranging from 197 μmho/cm at the parking lot site to 413 μmho/cm at the southeast inflow. However, measured values for pH, alkalinity, and conductivity at the three inflow monitoring sites were all within the range of characteristics commonly observed in urban runoff.

A high degree of variability is apparent in measured concentrations for nitrogen species at each of the three inflow monitoring sites. Mean total nitrogen concentrations range from a low of 1086 μg/l at the southeast inflow to a high of 1773 μg/l at the parking lot site. The parking lot site is also characterized by the highest mean concentrations for ammonia, NOx, and dissolved organic nitrogen. These elevated values suggest that runoff from the parking lot may be impacted by landscaping activities in adjacent areas. Nitrogen inputs at the Northwest Ditch site consisted primarily of dissolved organic nitrogen and particulate nitrogen which comprise more than 78% of the total nitrogen measured at this site. Mean concentrations for ammonia and NO_x measured in the Northwest Ditch were relatively low in value and suggest either a low loading rate for these parameters within the watershed or uptake and attenuation of these parameters within the drainage system prior to reaching the monitoring site. In contrast, approximately 53% of the total nitrogen measured at the parking lot site was contributed by dissolved organic nitrogen and particulate nitrogen, with 47% contributed by ammonia and NO_x. The mean ammonia concentration of 647 μg/l measured at this site is somewhat higher than values commonly observed in urban runoff. In contrast to the remaining sites, ammonia and NO_x appear to be the dominant nitrogen species in the southeast inflow, contributing approximately 52% of the total nitrogen input. Measured concentrations for dissolved organic nitrogen and particulate nitrogen at this site are somewhat lower in value than observed at the remaining sites.

A high degree of variability was also observed in measured concentrations of phosphorus species at the three inflow monitoring sites. The highest mean total phosphorus concentration of 294 μg/l was measured in the Northwest Ditch inflow. This value is typical of total phosphorus concentrations commonly observed in urban drainage system. Approximately 76% of the total phosphorus at this site was contributed by particulate phosphorus, with 17% by soluble reactive phosphorus (SRP) and 7% by dissolved organic phosphorus. Substantially lower mean total phosphorus concentrations were observed at the parking lot (96 μg/l) and southeast inflow (56 μg/l) sites. The dominant phosphorus species at each site was particulate phosphorus, contributing 64% of the total phosphorus at the parking lot and 83% of the total phosphorus in the southeast inflow. Mean concentrations for SRP and dissolved organic phosphorus were relatively low in value at each of these sites.

The Northwest Ditch had the highest mean values for turbidity and TSS, with values approximately 3-4 times greater than observed at the other inflow sites. In general, turbidity and TSS concentrations measured in the Northwest Ditch are typical of values commonly observed in urban runoff.

3.2.2 Pond Outflow

A summary of the chemical characteristics of pond outflow samples collected at the Pioneer Key wet detention pond site is given in Table 3-13. The values summarized in this table reflect a total of 30 composite outfall samples collected during the 6-month monitoring program.

TABLE 3-13

MEAN CHARACTERISTICS OF OUTFLOW SAMPLES COLLECTED AT THE PIONEER KEY POND FROM OCTOBER 2009-MARCH 2010

PARAMETER	UNITS	OUTFLOW (SITE 4)
pH	s.u.	7.47
Alkalinity	mg/l	126
Conductivity	μmho/cm	352
NH_3-N	μg/l	30
NO_X-N	μg/l	47
Dissolved Organic N	μg/l	483
Particulate N	μg/l	232
Total N	μg/l	792
SRP	μg/l	5
Dissolved Organic P	μg/l	14
Particulate P	μg/l	41
Total P	μg/l	60
Color	Pt-Co	31
Turbidity	NTU	5.4
TSS	mg/l	9.0
No. of Samples	**--**	**30**

Discharges from the pond were approximately neutral in pH and well buffered, with a mean alkalinity of 126 mg/l. The mean conductivity value of 352 μmho/cm is similar to the mean conductivity observed in the Northwest Ditch inflow.

Low concentrations of both ammonia and NO_x were observed in outflow samples from the pond, with values for each parameter approximately 2-10 times less than measured in inflow samples. The dominant nitrogen species in outflow samples was dissolved organic nitrogen which contributed 61% of the total nitrogen. The mean particulate nitrogen concentration of 232 μg/l measured in the outflow samples is approximately half of the particulate nitrogen measured at the Northwest Ditch inflow.

Low concentrations of SRP and dissolved organic phosphorus were observed in outflow samples from the pond. The dominant phosphorus species in outflow samples was particulate phosphorus which comprised 69% of the total phosphorus measured. The mean outflow total phosphorus concentration of 60 μg/l is approximately one-fifth of the total phosphorus inflow concentration measured in the Northwest Ditch.

Discharges from the pond were also characterized by low mean concentrations for color, turbidity, and TSS. Measured concentrations for turbidity and TSS in the outflow were lower in value than observed at any of the three inflow monitoring sites.

A graphical comparison of the chemical characteristics of general parameters measured in inflow and outflow samples collected at the Pioneer Key wet detention pond site is given in Figure 3-9. A graphical summary of data for each parameter is presented in the form of Tukey box plots, also often called "box and whisker plots". The bottom line of the box portion of each plot represents the lower quartile, with 25% of the data points falling below this value. The upper line of the box represents the 75% upper quartile, with 25% of the data falling above this value. The **blue** horizontal line within the box represents the median value, with 50% of the data falling both above and below this value. The **red** horizontal line within the box represents the mean of the data points. The vertical lines, also known as "whiskers", represent the 5 and 95 percentiles for the data sets. Individual values which fall outside of the 5-95 percentile range, sometimes referred to as “outliers”, are indicated as **red dots**.

In general, measured pH values in samples collected at Site 1, Site 3, and the pond outflow (Site 4) appear to be similar for both mean values and degree of variability. A slightly lower pH value was observed in inflow samples collected at Site 2. Similar to the trend observed for pH, alkalinity measurements at Site 1, Site 3, and the pond outflow are relatively similar with respect to mean alkalinity values. A somewhat lower mean alkalinity, combined with a higher degree of variability, was observed at the parking lot inflow (Site 2). Measured conductivity values at Site 1, Site 3, and the pond outflow appear to be similar in mean value, although the inflow samples appear to have a higher degree of variability in conductivity than observed at the pond outfall. Measured conductivity values at the parking lot site are lower than values measured at the remaining sites. Measured color concentrations at the inflow and outflow monitoring sites appear to exhibit a higher degree of variability than observed for other general parameters. Elevated concentrations, combined with a high degree of variability, were observed at inflow samples collected at Sites 1 and 2. Lower mean color concentrations, combined with a much lower degree of variability, were observed at Site 3 and at the pond outflow.

A graphical summary of statistical variability in nitrogen species measured in the inflow and outflow monitoring sites is given in Figure 3-10. In general, mean nitrogen concentrations measured at the pond outfall (Site 4) are lower in value for virtually all nitrogen species than observed in inflows to the pond. Somewhat elevated levels of ammonia were observed in inflow samples collected at Sites 2 and 3, with an elevated particulate nitrogen concentration observed at the Northwest Ditch inflow (Site 1). However, total nitrogen concentrations measured at Sites 1 and 3 appear to be relatively similar, with a somewhat higher concentration measured at Site 2.

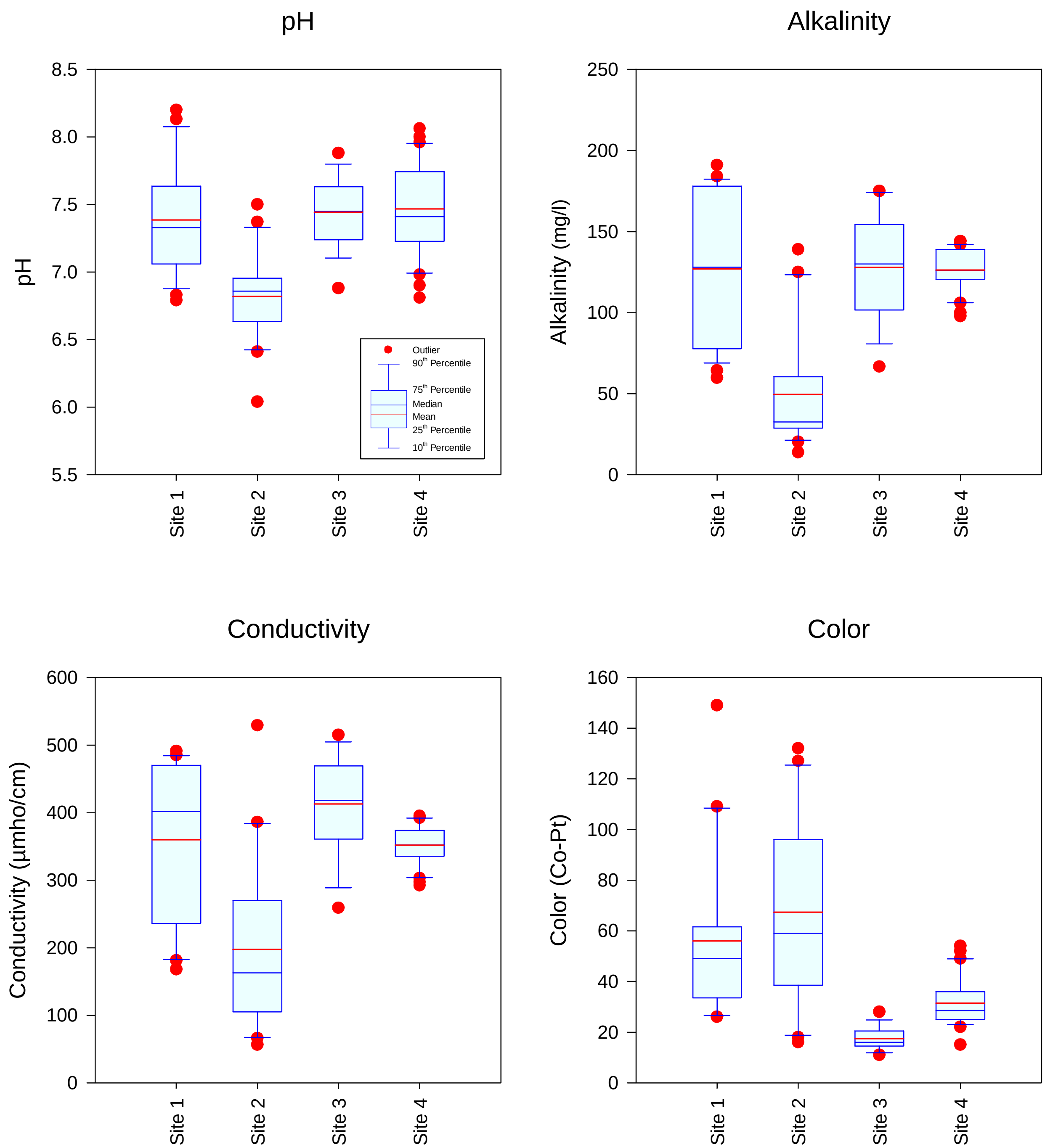


Figure 3-9. Summary of Statistical Variability in General Parameters Measured in Inflow and Outflow Samples at the Pioneer Key Wet Detention Pond Site.

A graphical comparison of statistical variability in phosphorus species measured in inflow and outflow samples at the Pioneer Key wet detention pond is given in Figure 3-11. In general, the highest phosphorus concentrations, combined with the highest degree of variability, were observed in samples collected at the Northwest Ditch inflow. A somewhat elevated concentration for SRP was also observed at Site 2. However, measured concentrations for particulate phosphorus and total phosphorus at inflow Sites 2 and 3 as well as the pond outflow were substantially lower than observed at Site 1.

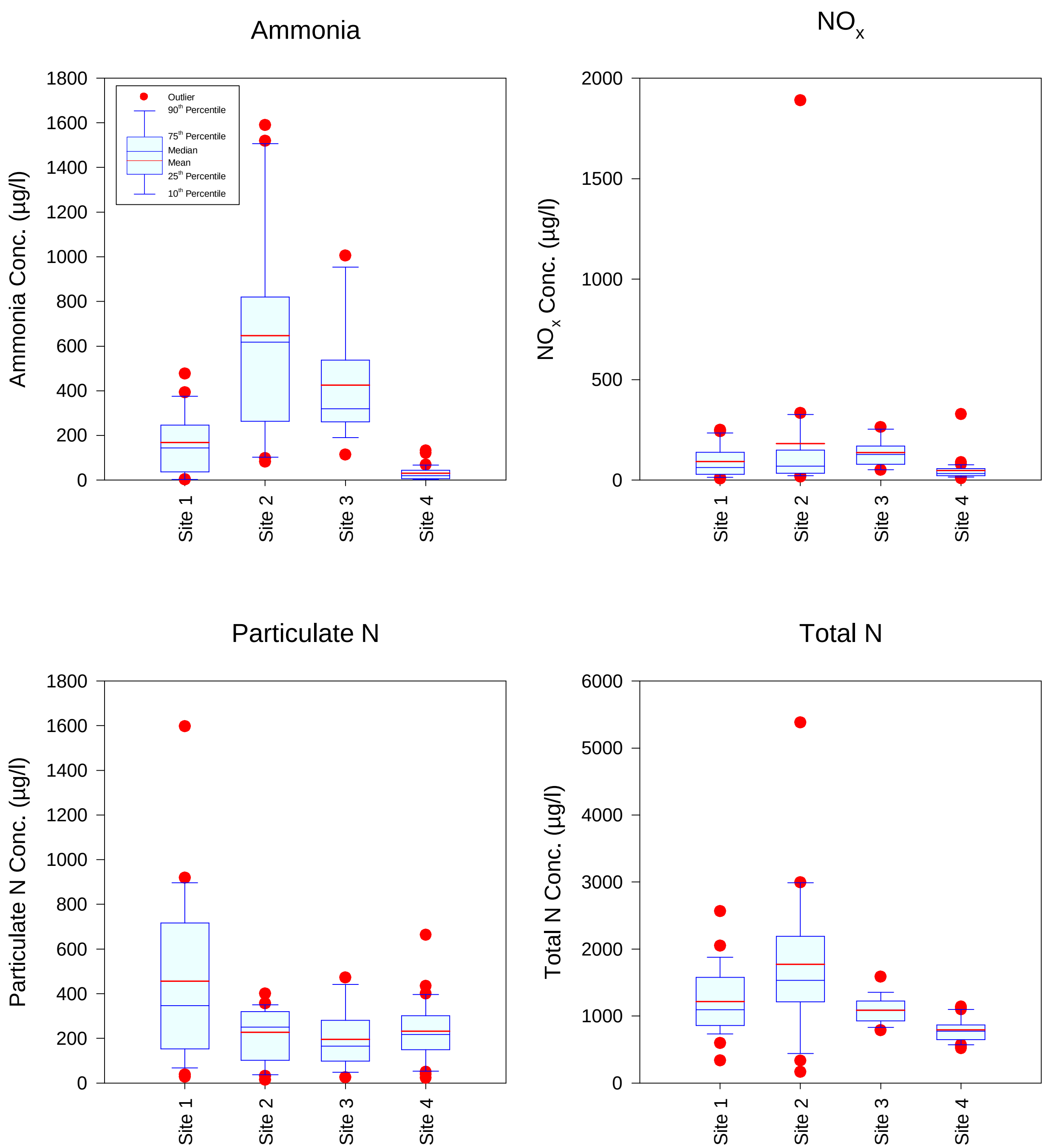


Figure 3-10. Summary of Statistical Variability in Nitrogen Species Measured in Inflow and Outflow Samples at the Pioneer Key Wet Detention Pond Site.

A graphical summary of statistical variability in turbidity and TSS concentrations measured at the inflow and outflow sites at Pioneer Key is given in Figure 3-12. A high degree of variability, combined with somewhat elevated concentrations, was observed at the Northwest Ditch inflow at Site 1. A much lower degree of variability, combined with lower mean concentrations, was observed at inflow Sites 2 and 3. The lowest measured values for turbidity and TSS were observed at the pond outfall (Site 4).

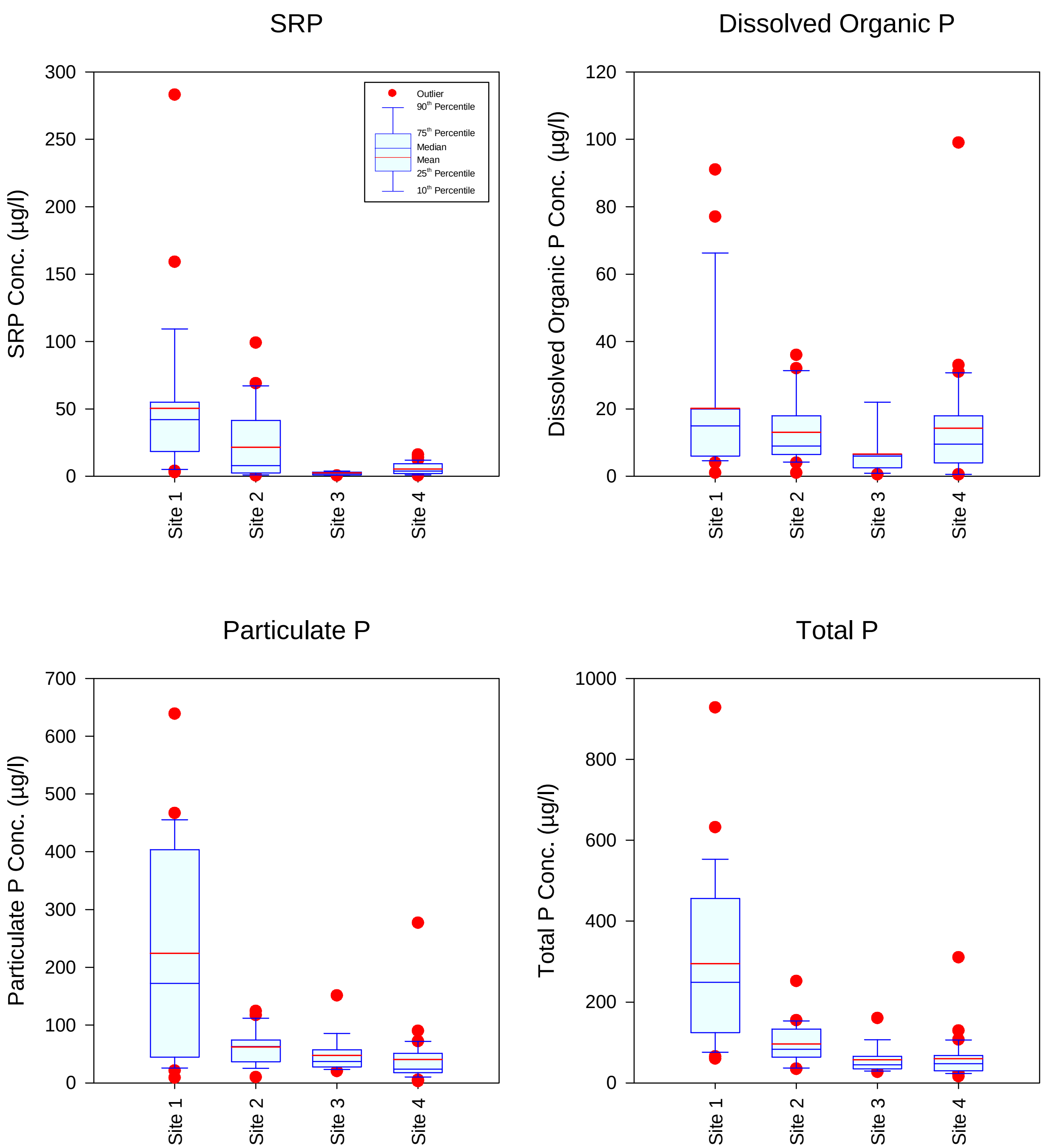


Figure 3-11. Summary of Statistical Variability in Phosphorus Species Measured in Inflow and Outflow Samples at the Pioneer Key Wet Detention Pond Site.

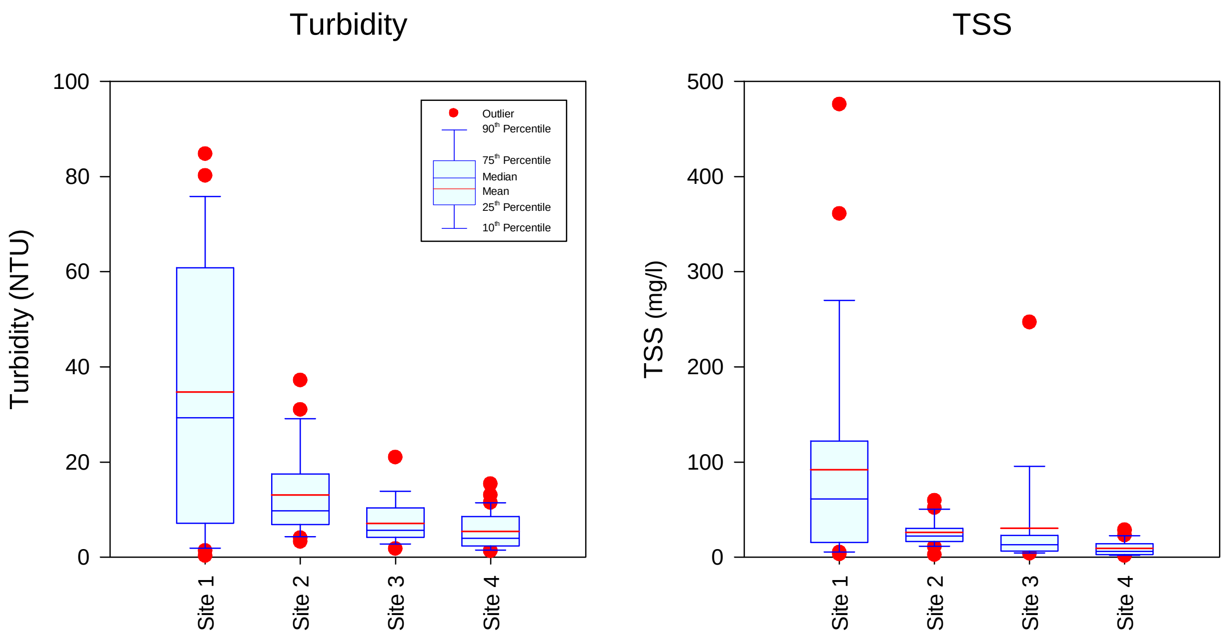


Figure 3-12. Summary of Statistical Variability in Turbidity and TSS Measured in Inflow and Outflow Samples at the Pioneer Key Wet Detention Pond Site.

3.2.3 Bulk Precipitation

A summary of the chemical characteristics of bulk precipitation samples collected at the wet detention pond site is given in Table 3-14. The samples summarized in this table reflect a total of 21 composite bulk precipitation samples collected during the monitoring program.

In general, bulk precipitation samples collected at the pond site were found to be slightly acidic, with measured pH values ranging from 5.09-6.87 and an overall mean of 5.99. Measured conductivity and alkalinity values in the bulk precipitation samples were also relatively low in value, with a relatively high degree of variability. Turbidity values in the bulk precipitation were also low, with an overall low of only 2.7 NTU. However, the mean TSS concentration of 8.0 mg/l appears to be somewhat elevated compared with TSS concentrations commonly observed in bulk precipitation from urban areas.

In general, an extremely high level of variability was observed in measured concentrations for all nitrogen species in bulk precipitation. More than a 100-fold difference was observed between minimum and maximum values for ammonia, NO_x, dissolved organic nitrogen, and particulate nitrogen in bulk precipitation samples. The mean concentrations for these parameters are somewhat higher than values commonly observed in bulk precipitation. A very large degree of variability was observed in measured concentrations of total nitrogen, with the overall mean value of 906 μg/l reflecting an elevated value for bulk precipitation.

TABLE 3-14

CHARACTERISTICS OF BULK PRECIPITATION SAMPLES COLLECTED AT THE PIONEER KEY POND FROM OCTOBER 2009-MARCH 2010

PARAMETER	UNITS	MINIMUM VALUE	MAXIMUM VALUE	MEAN VALUE
pH	s.u.	5.09	6.87	5.99
Alkalinity	mg/l	1.6	20.2	6.7
Conductivity	µmho/cm	5	100	38
NH_3-N	µg/l	18	1753	334
NO_X-N	µg/l	5	590	197
Dissolved Organic N	µg/l	13	1115	266
Particulate N	µg/l	5	400	110
Total N	µg/l	142	3247	906
SRP	µg/l	1	443	30
Dissolved Organic P	µg/l	1	129	18
Particulate P	µg/l	1	87	19
Total P	µg/l	4	659	67
Color	Pt-Co	1	64	9
Turbidity	NTU	0.8	8.0	2.7
TSS	mg/l	0.8	23.0	8.0
No. of Samples	**--**	**21**		

A high degree of variability was observed in measured concentrations for all phosphorus species in bulk precipitation. Mean values for all phosphorus species are somewhat higher at the Pioneer Key site than observed at other urban sites in the Central Florida area.

A graphical summary of statistical variability in general parameters measured in bulk precipitation at the Pioneer Key detention pond site is given in Figure 3-13. A relatively wide range of values was observed for each of the general parameters summarized on Figure 3-13. A high degree of variability is common in bulk precipitation collected from urban areas.

A graphical summary of statistical variability in nitrogen species measured in bulk precipitation samples is given on Figure 3-14. A majority of measured nitrogen species in bulk precipitation fall into a relatively narrow band of concentrations. However, substantially elevated "outliers" were observed in bulk precipitation for each nitrogen species. Extremely elevated levels of ammonia were observed during two of the monitoring events which are approximately 10 times higher than the majority of ammonia concentrations measured at this site. A similar pattern is apparent in the summary of phosphorus species given in Figure 3-15. The majority of phosphorus species appear to fall within a relatively narrow range, with elevated "outliers" apparent during some monitored events.

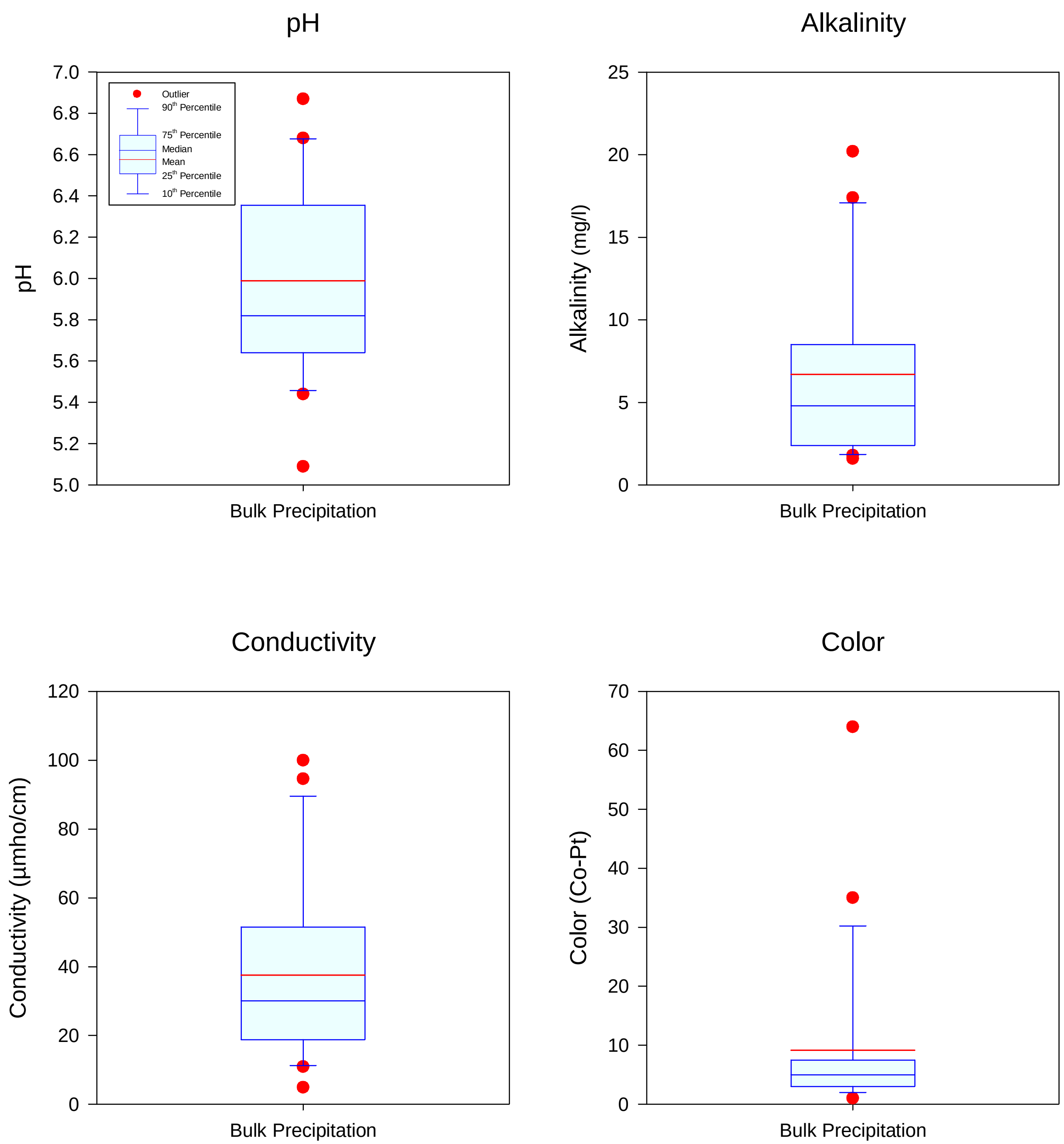


Figure 3-13. Summary of Statistical Variability in General Parameters Measured in Bulk Precipitation Samples at the Pioneer Key Detention Pond Site.

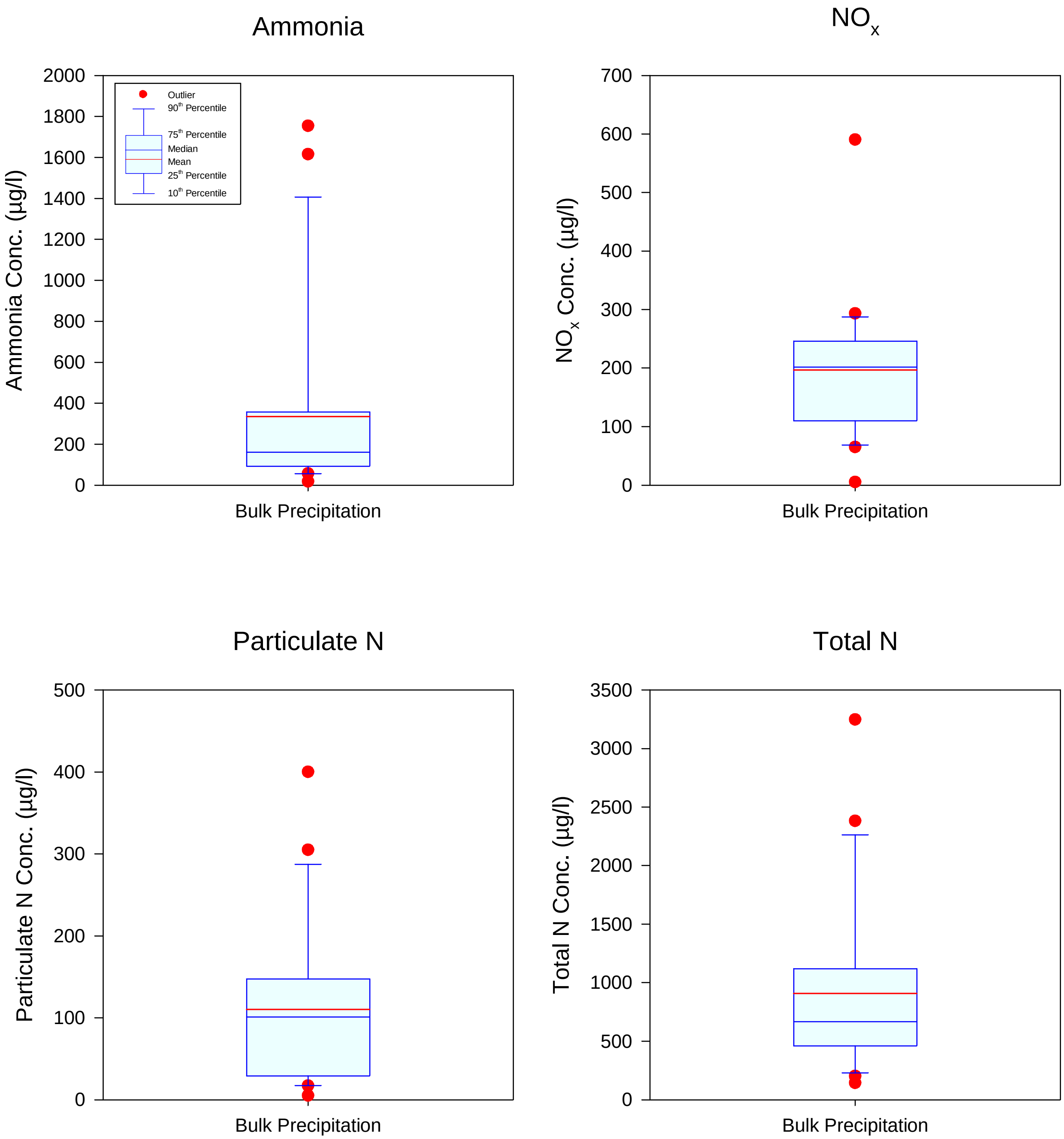


Figure 3-14. Summary of Statistical Variability in Nitrogen Species Measured in Bulk Precipitation Samples at the Pioneer Key Detention Pond Site.

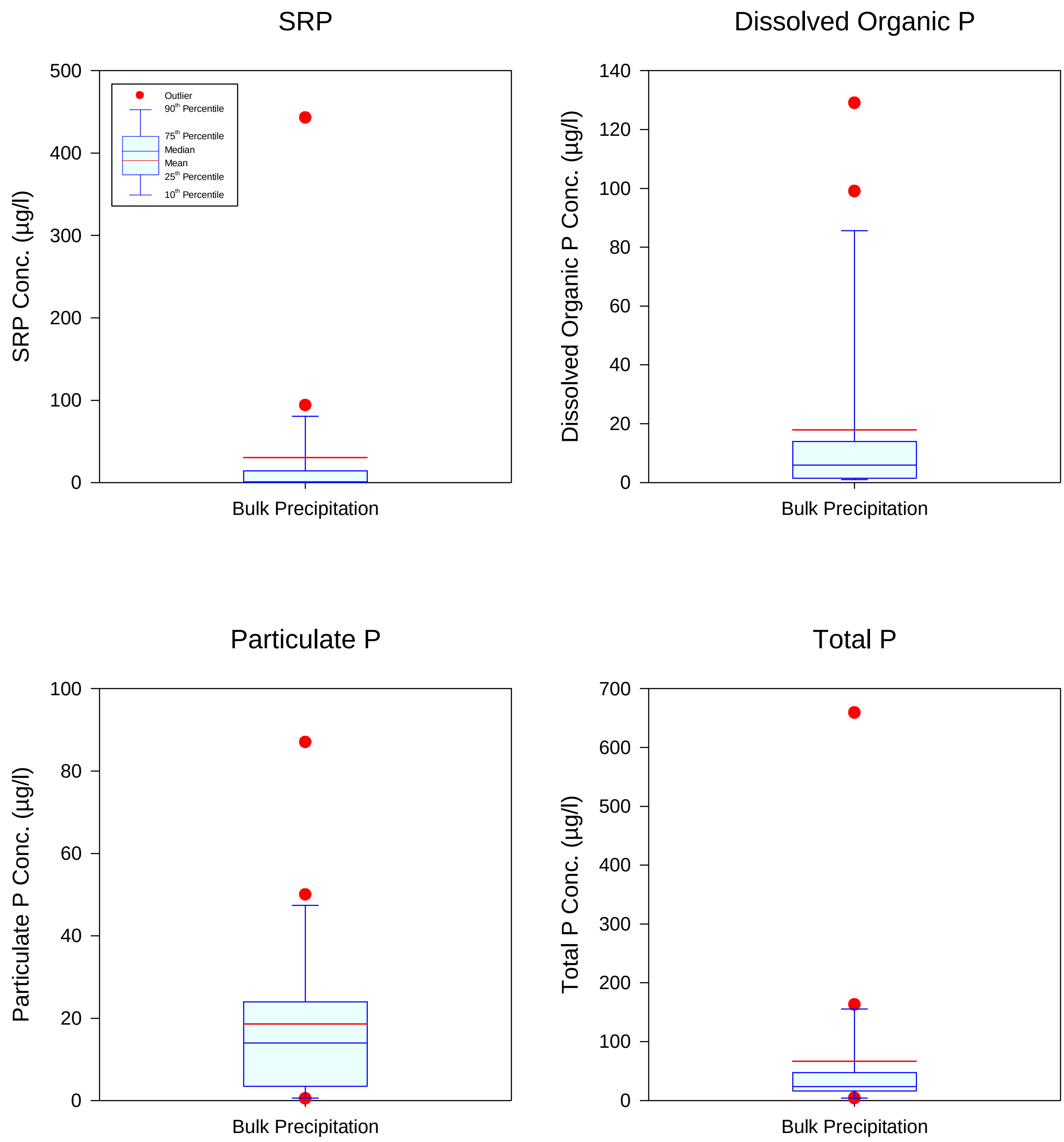


Figure 3-15. Summary of Statistical Variability in Phosphorus Species Measured in Bulk Precipitation Samples at the Pioneer Key Detention Pond Site.

When elevated nutrient concentrations are measured in bulk precipitation, bird waste is commonly thought to be a likely source of the additional nutrients. However, all bulk precipitation collectors used by ERD contain a bird-excluding monofilament mesh which extends approximately 1 ft above the lip of the collection device, making it impossible for birds to roost on the edge of the collector. ERD has observed bulk precipitation characteristics similar to the elevated event at the Pioneer Key site on previous projects as a result of soot and ashes from nearby fires, particularly land clearing activities. These previous samples were also characterized by extremely high levels of ammonia, dissolved organic nitrogen, SRP, and total phosphorus, similar to the pattern of values observed at the Pioneer Key site. However, ERD is not aware of any burning activities which occurred within the vicinity of the pond during the field monitoring program, but mentions this only as a possible explanation for the observed elevated values. The elevated values are not excluded from the data set since a possible rational explanation could exist for these values.

3.3 Pond Removal Efficiencies

Removal efficiencies for the Pioneer Key wet detention pond were calculated on both a concentration and mass load basis. Changes in concentrations between inflow and outflow sources provide an estimate of the effectiveness of the physical, biological, and chemical processes which occur within the pond that remove constituents from the water column. Mass removal efficiencies incorporate the concentration-based reductions but also include the effects of hydrologic inputs and losses from the pond. A discussion of each of these processes is given in the following sections.

3.3.1 Concentration-Based Reductions

Concentration-based removals within the Pioneer Key wet detention pond were evaluated by comparing the flow-weighted concentrations of inputs and outputs from the pond. Inputs into the pond are assumed to occur as a result of inflow from the Northwest Ditch, the parking lot area, the southeast inflow, and bulk precipitation. As indicated on Figure 3-8, inflow through the Northwest Ditch contributes approximately 75% of the hydrologic inputs, with 8% contributed by Site 3, 4% by direct precipitation, and 1% by inflow from the parking lot. Approximately 12% of the net hydrologic inputs are contributed by groundwater. However, since the chemical characteristics of groundwater inputs are not known, this parameter is excluded from the analysis of performance efficiency. A volume-weighted inflow concentration was calculated by multiplying the total hydrologic inputs (summarized in Section 3.1) times the mean chemical characteristics of the inflow samples (summarized in Table 3-12) and the bulk precipitation samples (summarized in Table 3-14). Losses from the pond are assumed to occur as a result of discharge through the outfall structure. The chemical characteristics of discharges from the pond have been previously summarized in Table 3-13.

A summary of volume-weighted concentration-based removals in the Pioneer Key wet detention pond is given in Table 3-15. Reductions in volume-weighted concentrations between the inflows and outflows were observed for ammonia, NO_x, particulate nitrogen, total nitrogen, TSS, and all measured phosphorus species. Concentrations of ammonia within the pond were reduced by approximately 85%, with a 54% reduction in NO_x, 44% reduction in particulate nitrogen, and a 33% reduction in total nitrogen concentrations.

Excellent concentration reductions were observed for phosphorus species, with an 88% reduction in concentrations of SRP, 24% reduction for dissolved organic phosphorus, 79% reduction for particulate phosphorus, and a 77% reduction in concentration for total phosphorus. TSS concentrations within the pond were reduced by approximately 82%. The concentration-based removal efficiencies summarized in Table 3-15 indicate that the physical, biological, and chemical processes within the pond provide substantial reductions in concentrations for both general parameters and nutrients.

TABLE 3-15

VOLUME-WEIGHTED CONCENTRATION-BASED REMOVALS IN THE PIONEER KEY WET DETENTION POND

PARAMETER	WEIGHTED CONCENTRATION (mg/l)		PERCENT CHANGE (%)
	Inputs	Outflow	
pH	7.31	7.47	2
Alkalinity	120	126	5
Conductivity	347	352	1
NH_3	203	30	-85
NO_x	102	47	-54
Dissolved Organic N	472	483	2
Particulate N	413	232	-44
Total N	1190	792	-33
SRP	45	5	-88
Dissolved Organic P	19	14	-24
Particulate P	196	40	-79
Total P	259	60	-77
TSS	50.1	9.0	-82

3.3.2 Mass Removal Efficiencies

Mass removal efficiencies were calculated for the Pioneer Key wet detention pond during the field monitoring program by comparing the calculated mass inputs and mass losses for the evaluated parameters. Inputs into the pond are assumed to occur as a result of inflow from the Northwest Ditch (Site 1), the parking lot area (Site 2), and the southeast inflow (Site 3), along with bulk precipitation. Mass inputs from these sources during the field monitoring program are calculated by multiplying the mean chemical characteristics of pond inflow samples (summarized on Table 3-12) and bulk precipitation samples (summarized on Table 3-14) times the hydrologic inputs for each inflow site (summarized on Table 3-5) and the hydrologic inputs from direct precipitation (summarized on Table 3-4). Mass losses from the wet detention pond are assumed to occur as a result of outflow through the various discharge structures. The chemical characteristics of pond outflow are assumed to be represented by the mean characteristics summarized in Table 3-13. The mean characteristics of the pond outflow samples are multiplied by the total volumetric losses through the pond outfalls (summarized in Table 3-7).

A summary of mass calculated inputs, mass losses, and mass removal efficiencies for the Pioneer Key wet detention pond over the period from October 2009-March 2010 is given in Table 3-16. During the field monitoring program, the wet detention pond retained approximately 84% of the mass loadings of ammonia, 49% of the mass loadings of NO_x, 38% of the mass loadings of particulate nitrogen, and 27% of the mass loadings for total nitrogen. Excellent removal efficiencies were achieved for phosphorus species, with a removal of approximately 87% for SRP, a 16% reduction in dissolved organic phosphorus loadings, a 77% reduction in particulate phosphorus loadings, and a 75% reduction for total phosphorus loadings. A mass removal of 88% was also observed for TSS.

TABLE 3-16

MASS REMOVAL EFFICIENCIES FOR THE PIONEER KEY WET DETENTION POND

PARAMETER	MASS INPUTS (kg)					MASS LOSSES (kg)			MASS REMOVAL	
	Site 1	Site 2	Site 3	Precip.	Total	Outflow	G.W.	Total	kg	%
NH_3	18.1	0.63	5.00	2.11	25.87	3.69	0.53	4.23	21.65	84
NO_x	9.92	0.18	1.61	1.24	12.95	5.73	0.83	6.56	6.39	49
Dissolved Organic N	53.8	0.70	3.88	1.68	60.08	58.90	8.52	67.42	-7.35	-12
Particulate N	49.3	0.22	2.30	0.69	52.52	28.30	4.09	32.39	20.12	38
Total N	131.2	1.74	12.79	5.72	151.41	96.63	13.98	110.6	40.8	27
SRP	5.44	0.02	0.03	0.19	5.68	0.65	0.09	0.74	4.94	87
Dissolved Organic P	2.18	0.01	0.08	0.11	2.38	1.73	0.25	1.99	0.39	16
Particulate P	24.2	0.06	0.56	0.12	24.94	4.93	0.71	5.65	19.30	77
Total P	31.8	0.09	0.66	0.42	33.00	7.32	1.06	8.38	24.62	75
TSS	9927	25.39	356.8	50.27	10359	1101	159.3	1260	9098.60	88

The observed removal efficiency for total nitrogen within the Pioneer Key wet detention pond is similar to removal efficiencies commonly observed by ERD with a 31-day detention time. However, the mass removal efficiency of 75% for total phosphorus is slightly higher than is commonly achieved in a wet detention pond with a 31-day detention time. The somewhat higher removal for total phosphorus observed at this site is likely related to the large contribution of particulate phosphorus to the overall phosphorus loadings. The additional removal of particulate phosphorus is probably a large reason why the total phosphorus removal appears to be slightly elevated.

3.4 Pollutant Removal Costs

Estimates of annual mass removal costs were generated for total nitrogen, total phosphorus, and TSS in the Pioneer Key wet detention pond. This analysis requires estimates of the annual hydrologic and mass loadings to the Pioneer Key wet detention pond. A summary of estimated annual hydrologic and mass loadings to the wet detention pond is given in Table 3-17. As indicated in Table 3-10, the combined inputs from inflows (Sites 1, 2, and 3) and direct rainfall contributed 103.1 ac-ft of water to the wet detention pond during the monitoring program (98.01 ac-ft from inflows + 5.12 ac-ft from precipitation). Since both inflows and precipitation are rain event-driven processes, the annual hydrologic inputs to the pond can be estimated as the ratio of rainfall during the monitoring program (20.01 inches) to the average annual rainfall. Average annual rainfall in the Orlando area is approximately 50.03 inches based upon the yearly average recorded at the Orlando meteorological station over the 30-year period from 1971-2000. Using this ratio, the estimated annual inflow volume is 257.8 ac-ft (103.1 ac-ft x 50.03 inches/20.01 inches).

TABLE 3-17

ESTIMATED ANNUAL HYDROLOGIC AND MASS LOADINGS TO THE PIONEER KEY WET DETENTION POND

PARAMETER	VALUE
Hydrologic Inputs	
Measured Rainfall	20.01 inches
Measured Hydrologic Inputs	103.1 ac-ft
Mean Annual Rainfall	50.03 inches/year
Estimated Annual Inflow Volume	257.8 ac-ft/yr
Total Nitrogen	
Mean Weighted Inflow Concentration	1190 µg/l
Mass Inflow	378 kg/yr
Total Phosphorus	
Mean Weighted Inflow Concentration	259 µg/l
Mass Inflow	82.3 kg/yr
TSS	
Mean Weighted Inflow Concentration	50.1 mg/l
Mass Inflow	15,927 kg/yr

Mass loadings were calculated by multiplying the mean weighted inflow concentrations for each parameter (summarized in Table 3-12) times the annual inflow volume of 257.8 ac-ft/yr. Based upon this analysis, mean annual total nitrogen loadings to the pond are approximately 378 kg/yr, with a total phosphorus loading of 82.3 kg/yr, and a TSS loading of 15,927 kg/yr.

Estimates of annual load reductions for total nitrogen, total phosphorus, and TSS in the Pioneer Key wet detention pond are given in Table 3-18. Annual removal efficiencies for total nitrogen, total phosphorus, and TSS are based upon the mass removals for the pond (summarized in Table 3-16). Therefore, a removal of approximately 27% is assumed for total nitrogen, 75% for total phosphorus, and 88% for TSS. Based upon this analysis, the Pioneer Key wet detention pond will remove approximately 86.7 kg/yr of total nitrogen, 52.5 kg/yr of total phosphorus, and 11,907 kg/yr from the Northwest Ditch.

TABLE 3-18

ESTIMATED ANNUAL LOAD REDUCTIONS FOR TOTAL NITROGEN, TOTAL PHOSPHORUS, AND TSS IN THE PIONEER KEY WET DETENTION POND

PARAMETER	ANNUAL LOADING (kg/yr)	REMOVAL IN POND (%)	ESTIMATED ANNUAL LOAD REDUCTION (kg/yr)	PRE-CONSTRUCTION ESTIMATES		
				Annual Loading (kg/yr)	Removal in Pond (%)	Annual Load Reduction (kg/yr)
Total Nitrogen	378	27	102	459	40	184
Total Phosphorus	82.3	75	61.7	57.0	51	29.1
TSS	15,927	88	14,016	13,685	85	11,632

A summary of pre-construction estimates of annual mass loadings and anticipated removal efficiencies within the wet detention pond are also included on Table 3-18 for comparison purposes. The pre-construction estimates of annual mass loadings appear to be relatively close for total nitrogen, total phosphorus, and TSS. The estimated removal efficiency of 85% for TSS in the wet detention pond is close to the observed removal of 88%. However, the pre-construction estimates appear to over-estimate nitrogen removal within the pond, with an estimated removal of 40% compared with an observed removal of 27%. The pre-construction estimate of removal efficiency for total phosphorus of 51% appears to be low compared with the observed removal of 75% within the pond.

However, the wet detention pond exceeded the pre-construction estimated annual load reductions for total phosphorus and TSS. The facility was anticipated to remove 29.1 kg/yr of total phosphorus while it appears to remove more than twice that value. Similarly, the observed mass load reduction for TSS is 21% greater than anticipated. In contrast, the pond failed to achieve the anticipated load reduction of 184 kg/yr for total nitrogen, with an actual removal of only 102 kg/yr.

An evaluation of estimated present worth costs for the Pioneer Key wet detention pond is given in Table 3-19. The total cost for the project, including design, permitting, construction, grant administration and report, and post-construction monitoring, is approximately $2,600,000. A summary of total project costs and funding sources is given in Table 4-1. For calculation of present worth costs, an annual maintenance cost of approximately $10,000/year is assumed for the facility. The present worth cost is calculated over a period of 20 years and includes the initial construction cost of $2,600,000 plus 20 years of annual operation and maintenance costs. Based upon this analysis, the estimated 20-year present worth cost for the Pioneer Key wet detention pond is approximately $2,800,000.

TABLE 3-19

EVALUATION OF PRESENT WORTH COST FOR THE PIONEER KEY WET DETENTION POND

PARAMETER	VALUE
BMP Cost ($)	$ 2,600,000
Annual Maintenance Cost ($)	$ 10,000
Present Worth Cost (20-year) ($)	$ 2,800,000

An evaluation of pollutant removal costs for the Pioneer Key wet detention pond is given in Table 3-20. Estimated mass removal costs are provided for total nitrogen, total phosphorus, and TSS over the 20-year evaluation cycle. The mass removal cost is calculated by dividing the 20-year present worth cost of $2,800,000 by the estimated mass removal for total nitrogen, total phosphorus, and TSS over the 20-year period. The resulting present worth cost per kg of pollutant removed are summarized in the last row of Table 3-20. Mass removal costs for the system are approximately $1373/kg of nitrogen removed, $2269/kg of phosphorus removed, and $10/kg of TSS removed. The calculated load reduction costs are on the upper end on the range of values commonly observed for nutrients and TSS removal in wet detention systems.

TABLE 3-20

EVALUATION OF LOAD REDUCTION COSTS FOR THE PIONEER KEY WET DETENTION POND

PARAMETER	TOTAL NITROGEN	TOTAL PHOSPHORUS	TSS
Annual Mass Removed (kg/yr)	102	61.7	14,016
Present Worth Cost per kg Removed ($)	1373	2269	10

3.5 Quality Assurance

Supplemental samples were collected during the field monitoring program for quality assurance purposes. These supplemental samples include equipment blanks and duplicate samples, along with supplemental laboratory analyses to evaluate precision and accuracy of the collected data. A summary of QA data collected as part of this project is given in Appendix C

SECTION 4

SUMMARY

A field monitoring program was conducted by ERD from October 2009-March 2010 to evaluate the performance efficiency of the Pioneer Key wet detention pond. The pond is designed to provide wet detention treatment for a 123.9-acre basin area which discharges into the Northwest Ditch upstream from the project site. Automatic samplers with integral flow meters were used to provide a continuous record of hydrologic inputs and losses for the pond, as well as collect inflow and outflow samples on a flow-weighted basis. A recording rain gauge was also installed adjacent to the monitoring site.

Sixty-three (63) composite runoff and baseflow samples were collected during the field monitoring program. The collected inflow samples were found to be highly variable with respect to chemical characteristics, with moderate concentrations for nitrogen species and elevated concentrations for phosphorus species. Thirty (30) composite outflow samples were collected at the Pioneer Key pond during the monitoring program. In general, concentrations of constituents in the outflow samples were substantially lower than concentrations measured in inflows to the pond.

During the field monitoring program, the Pioneer Key wet detention pond removed approximately 27% of the mass inputs of total nitrogen, 75% of the mass inputs of total phosphorus, and 87% of the mass TSS inputs. Based upon these estimated performance efficiencies, the Pioneer Key wet detention pond is estimated to remove approximately 102 kg/yr of total nitrogen, 61.7 kg/yr of total phosphorus, and 14,016 kg/yr of TSS. The observed loadings and removal efficiencies for the pond are similar to pre-construction estimates. Pollutant removal costs for the wet detention pond are approximately $1373/kg of nitrogen removed, $2269/kg of phosphorus removed, and $10/kg of TSS removed. These values appear to be on the upper range of pollutant removal costs normally associated with wet detention ponds.

A summary of project costs and funding sources for the Pioneer Key wet detention pond is given on Table 4-1. The total project cost was approximately $2,600,000, with $850,000 (33%) contributed by FDEP and $1,750,000 (67%) contributed by the City of Ocoee, Orange County CDBG, and a private property owner.

TABLE 4-1

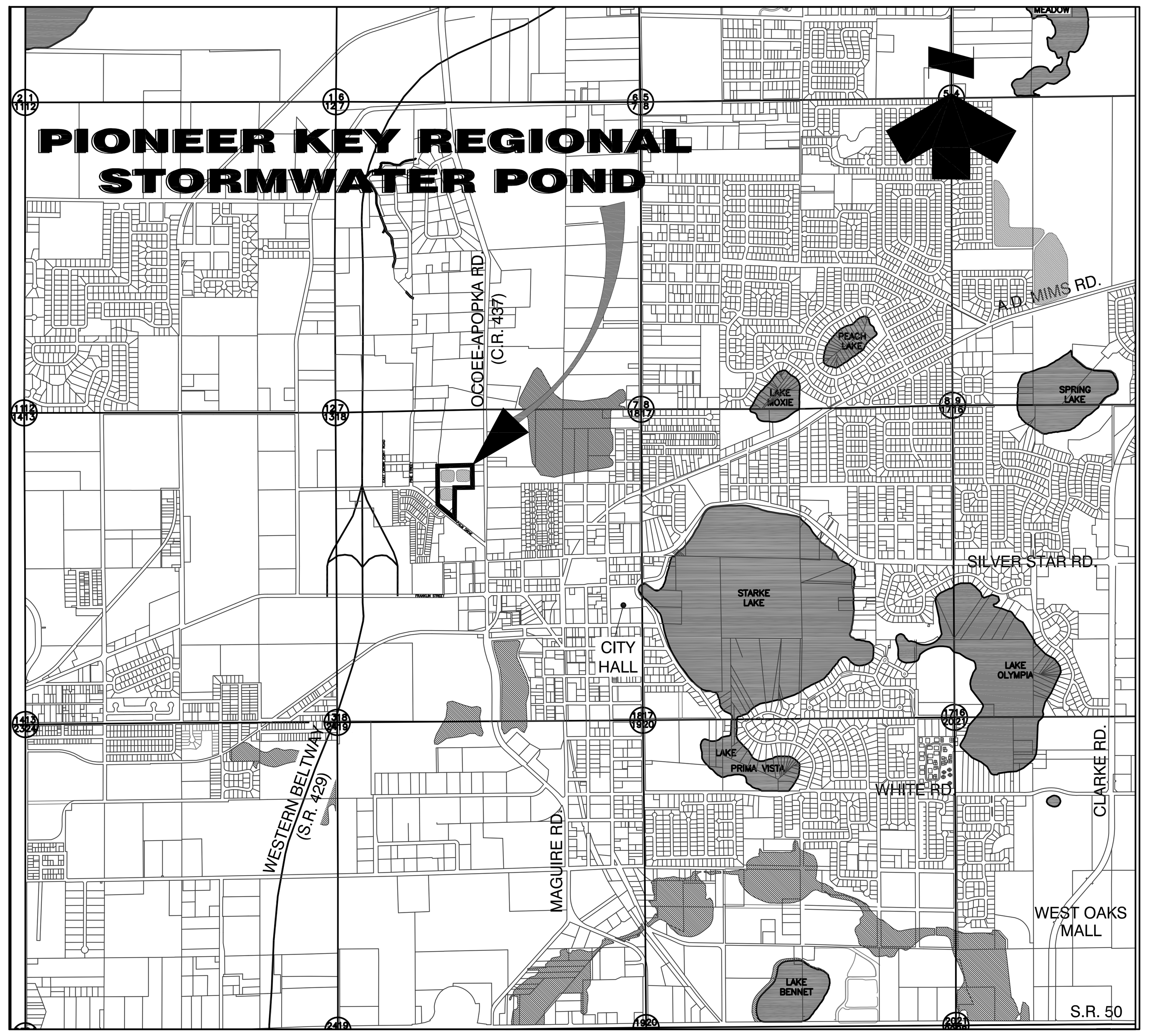
SUMMARY OF TOTAL PROJECT COSTS AND FUNDING SOURCES

PROJECT FUNDING ACTIVITY	TOTAL PROJECT COSTS ($)	DEP GRANT FUNDS ($)	MATCHING FUNDS ($)	MATCH SOURCE
Design and Permitting	$ 290,000	$ 15,000	$ 275,000	City of Ocoee
BMP Construction	2,090,000	750,000	1,340,000	City of Ocoee Orange County CDBG Private Property owner
Monitoring	100,000	85,000	15,000	City of Ocoee
Grant Administration/Reporting	120,000	--	120,000	City of Ocoee
TOTAL:	**$ 2,600,000**	**$ 850,000**	**$ 1,750.000**	
PERCENTAGE MATCH:		**33**	**67**	

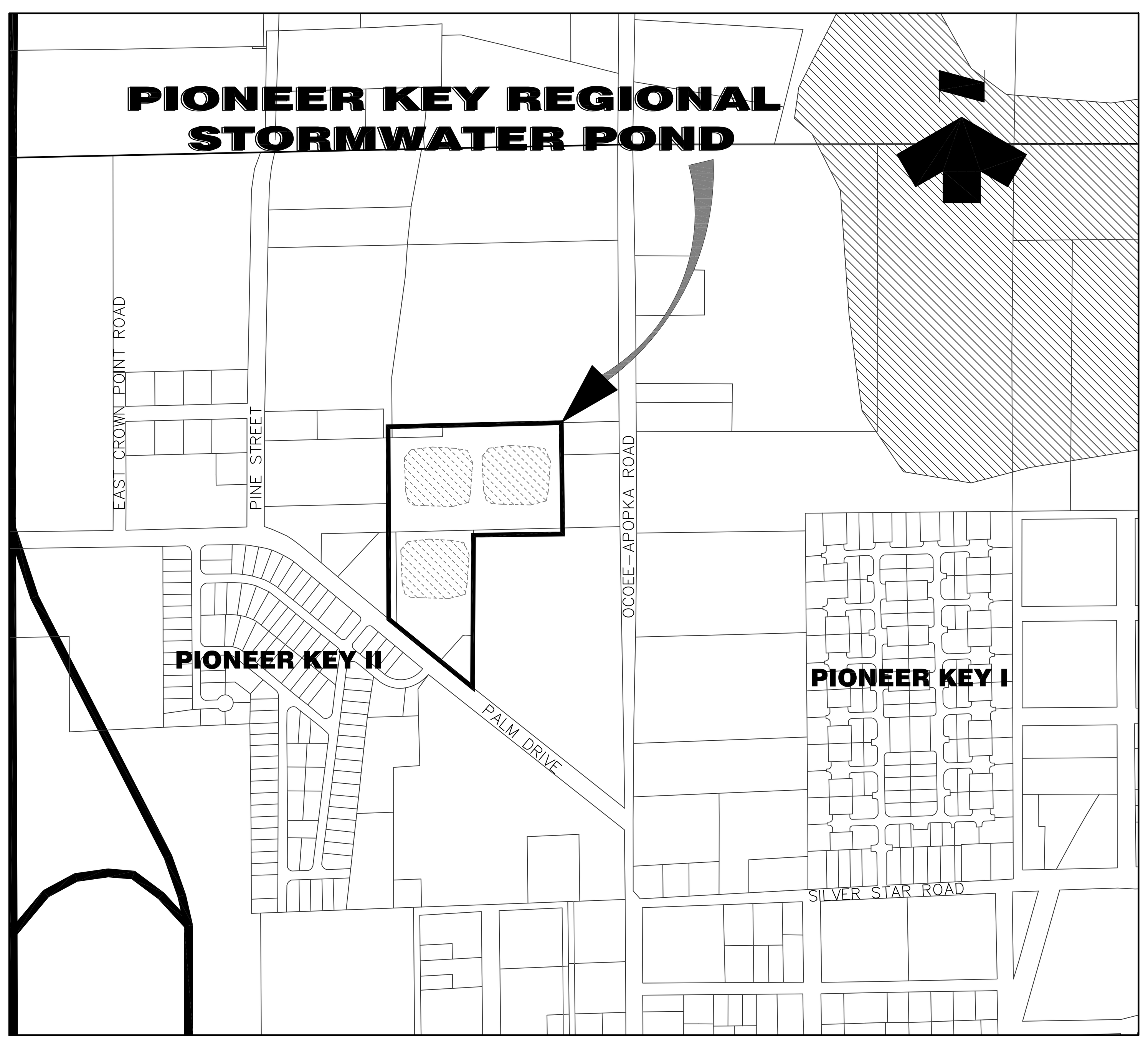
APPENDICES

APPENDIX A

SELECTED CONSTRUCTION DRAWINGS FOR THE PIONEER KEY REGIONAL STORMWATER FACILITY



VICINITY MAP
SCALE: 1" = 2000'



SECTION: 18
TOWNSHIP: 22S
RANGE: 28E

LOCATION MAP
SCALE: 1" = 400'

THESE PLANS HAVE BEEN PLOTTED AT HALF SCALE TO FIT 11" X 17" FORMAT. THIS MUST BE CONSIDERED WHEN OBTAINING SCALED DATA.

CONSTRUCTION PLANS FOR PIONEER KEY REGIONAL STORMWATER POND

The Center of Good Living
OCOEE

S. SCOTT VANDERGRIFT
MAYOR

GARY HOOD
COMMISSIONER – DISTRICT #1

SCOTT ANDERSON
COMMISSIONER – DISTRICT #2

RUSTY JOHNSON
COMMISSIONER – DISTRICT #3

JOEL KELLER
COMMISSIONER – DISTRICT #4

ROBERT FRANK
CITY MANAGER

DAVID WHEELER, P.E.
CITY ENGINEER

STEPHEN KRUG, P.E.
PUBLIC WORKS DIRECTOR

Professional Engineering Consultants, Inc.

3001 North Rocky Point Drive East, Suite 200 Orion Centre
Tampa, Florida 33607 Tel. 813-281-4692

REV.	DATE	DESCRIPTION	APP'D
1			
2			

DISCLAIMER

ATTENTION IS DIRECTED TO THE FACT THAT THESE PLANS MAY HAVE BEEN CHANGED IN SIZE BY REPRODUCTION. THIS MUST BE CONSIDERED WHEN OBTAINING SCALED DATA.

CITY APPROVAL

THESE PLANS HAVE BEEN PREPARED FOR THE CITY OF OCOEE, FLORIDA BY PROFESSIONAL ENGINEERING CONSULTANTS, INC. (PEC) AT THE DIRECTION AND APPROVAL OF THE CITY ENGINEER AND AS SUCH, WHEN SIGNED BY HIS SIGNATURE FOR APPROVAL, BECOME PART OF THE CONTRACT DOCUMENTS.

DAVID WHEELER, P.E. CITY ENGINEER

ENGINEER OF RECORD

THESE PLANS ARE NOT FOR CONSTRUCTION UNLESS SIGNED HERE:

MICHAEL L. BRUEGGER, P.E.
FLORIDA REGISTRATION NO. 44949

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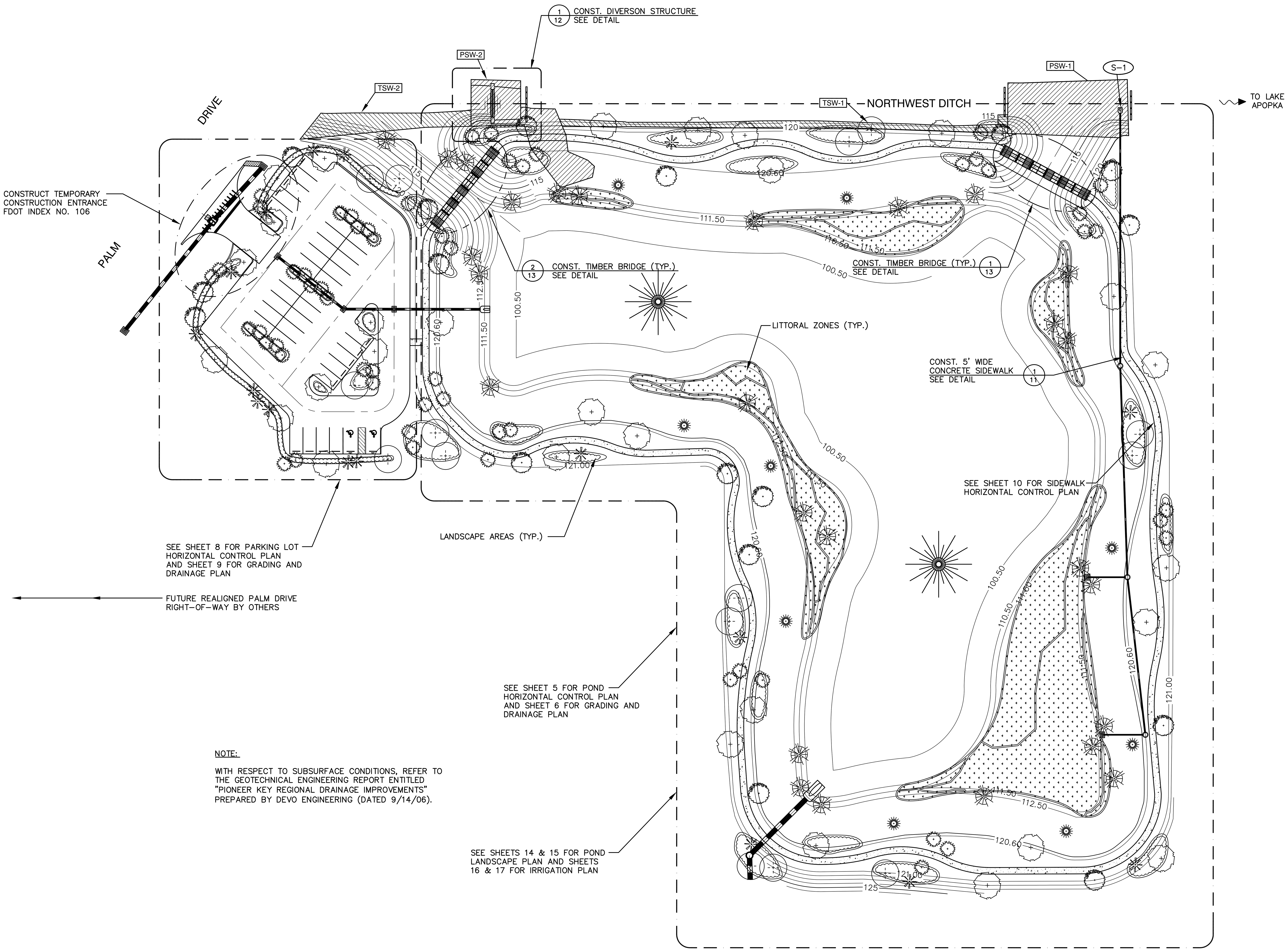

NOTE:

WITH RESPECT TO SUBSURFACE CONDITIONS, REFER TO THE GEOTECHNICAL ENGINEERING REPORT ENTITLED "PIONEER KEY REGIONAL DRAINAGE IMPROVEMENTS" PREPARED BY DEVO ENGINEERING (DATED 9/14/06).

MAGNETIC

40 20 0 40

GRAPHIC SCALE
SCALE IN FEET

SURFACE WATER IMPACTS

DESIGNATION	AREA
TEMPORARY	
TSW-1	1,662.800 s.f. or 0.038 ac.
TSW-2	1,688.230 s.f. or 0.039 ac.
	3,351.030 s.f. or 0.077 ac.
PERMANENT	
PSW-1	3,725.205 s.f. or 0.086 ac.
PSW-2	3,003.628 s.f. or 0.069 ac.
	6,728.833 s.f. or 0.154 ac.
TOTAL:	10,079.863 s.f. or 0.231 ac.

NOTE:

WITH RESPECT OT EXISTING WETLANDS, REFER TO THE ECOLOGICAL ASSESSMENT REPORT ENTITLED "PIONEER KEY REGIONAL DRAINAGE IMPROVEMENTS" PREPARED BY LOTSPEICH & ASSOCIATES, INC. (DATED 12/6/06).

LEGEND AND ABBREVIATIONS:

= CONCRETE MONUMENT
= CLEAN OUT
= MANHOLE
= DOWN GUY
= IRON PIPE
= IRON ROD
= NAIL W/DISC
= POWER POLE
= MITERED END SECTION
= BURIED TELEPHONE PEDESTAL
-X- = CHAIN LINK FENCE
LB = LICENSED BUSINESS
SSMC = SOUTHEASTERN SURVEYING & MAPPING CORPORATION
PRM = PERMANENT REFERENCE MONUMENT
INV = INVERT
RCP = REINFORCED CONCRETE PIPE
SB SWP-1 126.4 = SOIL BORINGS WITH DESCRIPTION AND ELEVATION
AKA = ALSO KNOW AS
W = WATER LINE
= WOOD FENCE
= CHAIN LINK FENCE
= CABLE TV
OHT = OVERHEAD TELEPHONE
UGT = UNDERGROUND TELEPHONE
120 = EXIST. CONTOURS - MAJOR
121 = EXIST. CONTOURS - MINOR
125 = PROP. CONTOURS - MAJOR
124 = PROP. CONTOURS - MINOR
SILT = PROP. SILT FENCE

NOTE:

ALL DISTURBED AREAS WITHIN SILT FENCE LIMITS SHALL BE SODDED (BAHIA)

ENGINEER: MICHAEL L. BRUEGGER, P.E. REG. NO. 44949

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REV.	DATE	DESCRIPTION	APP'D BY

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FIELD:
DRAWN BY: PEI
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DATE: MARCH 21, 2007

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3001 North Rocky Point Drive East, Suite 200 Orion Centre
Tampa, Florida 33607 813/281-4692
ENGINEERING BUSINESS NUMBER 3556

The Center of Good Living OCOEE

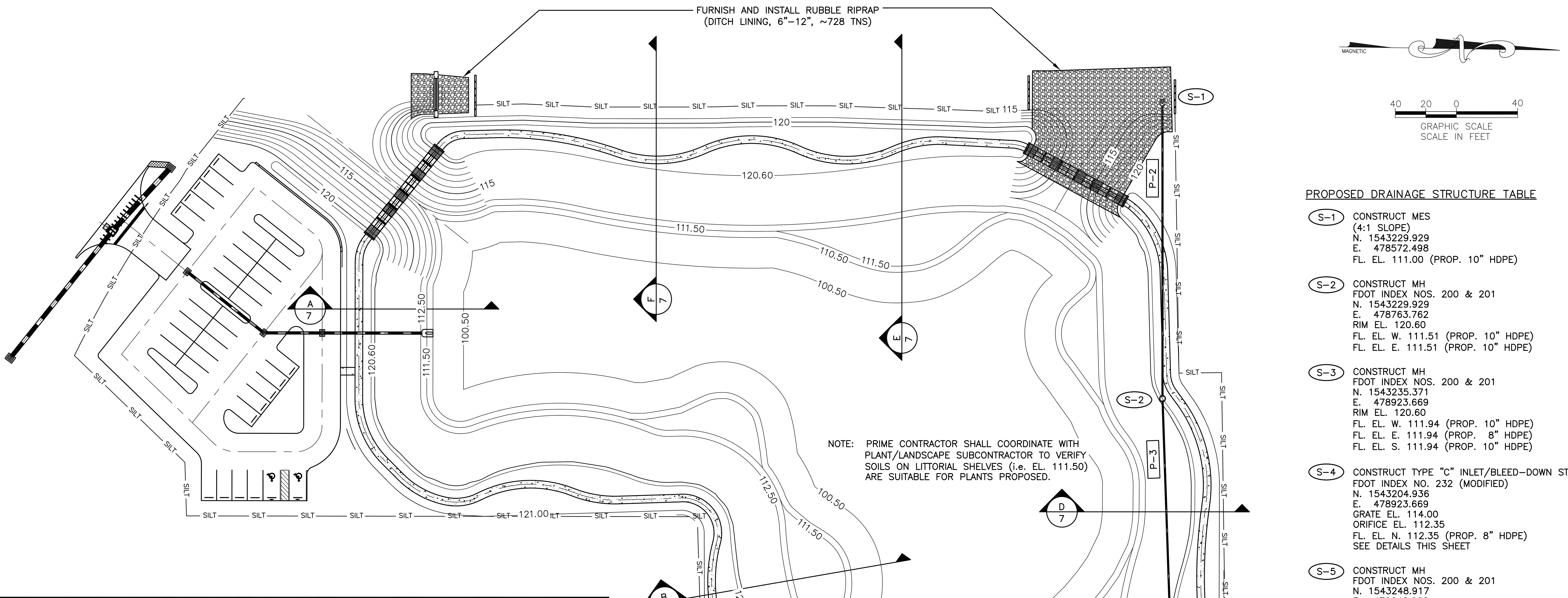
JOB No. OE-395
FILE NAME: OE395_PHI_3.DWG
ARCHIVE DISC:
SCALE: 1" = 40'

OVERALL SITE PLAN

SHEET 3 OF 19

LEGEND

× 123.0	EXIST. SPOT ELEV.
— —115— —	EXIST. CONTOUR MAJOR
— —114— —	EXIST. CONTOUR MINOR
—·—·—·—	PROPERTY BOUNDARY
——120——	PROP. CONTOUR MAJOR
——117——	PROP. CONTOUR MINOR



PROPOSED DRAINAGE STRUCTURE TABLE

S-1 CONSTRUCT MES
(4:1 SLOPE)
N. 1543229.929
E. 478572.498
FL. EL. 111.00 (PROP. 10" HDPE)

S-2 CONSTRUCT MH
FDOT INDEX NOS. 200 & 201
N. 1543229.929
E. 478763.762
RIM EL. 120.60
FL. EL. W. 111.51 (PROP. 10" HDPE)
FL. EL. E. 111.51 (PROP. 10" HDPE)

S-3 CONSTRUCT MH
FDOT INDEX NOS. 200 & 201
N. 1543235.371
E. 478923.669
RIM EL. 120.60
FL. EL. W. 111.94 (PROP. 10" HDPE)
FL. EL. E. 111.94 (PROP. 8" HDPE)
FL. EL. S. 111.94 (PROP. 10" HDPE)

S-4 CONSTRUCT TYPE "C" INLET/BLEED-DOWN STRUCTURE
FDOT INDEX NO. 232 (MODIFIED)
N. 1543204.936
E. 478923.669
GRATE EL. 114.00
ORIFICE EL. 112.35
FL. EL. N. 112.35 (PROP. 8" HDPE)
SEE DETAILS THIS SHEET

S-5 CONSTRUCT MH
FDOT INDEX NOS. 200 & 201
N. 1543248.917
E. 479042.902
RIM EL. 120.60
FL. EL. W. 112.27 (PROP. 8" HDPE)
FL. EL. E. 112.27 (PROP. 8" HDPE)

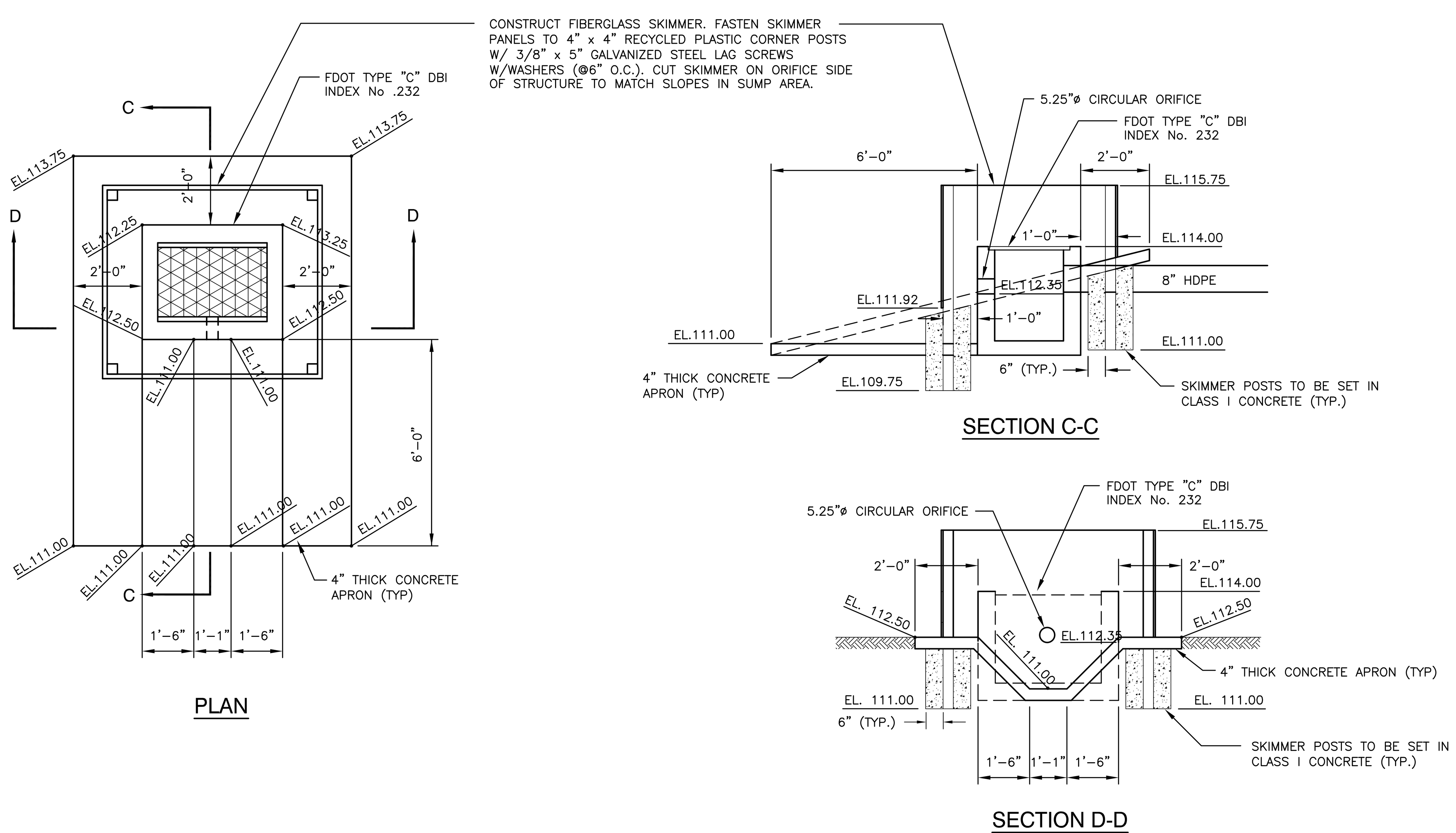
S-6 CONSTRUCT TYPE "C" INLET/BLEED-DOWN STRUCTURE
FDOT INDEX NO. 232 (MODIFIED)
N. 1543216.483
E. 479042.902
GRATE EL. 114.00
ORIFICE EL. 112.35
FL. EL. N. 112.35 (PROP. 8" HDPE)
SEE DETAILS THIS SHEET

S-7 CONSTRUCT MES (4:1 SLOPE)
FDOT INDEX NO. 272
N. 1542992.432
E. 479091.363
INV. EL. 108.50

S-8 CONSTRUCT MH
FDOT INDEX NOS. 200 & 201
N. 1542949.556
E. 479134.239
RIM EL. 122.50
FL. EL. NW. 108.65 (PROP. 42" RCP)
FL. EL. E. 114.00 (PROP. 42" RCP)

PROPOSED PIPES

P-2	CONST. 188 L.F. ~ OF 10" HDPE @ 0.27%
P-3	CONST. 154 L.F. ~ OF 10" HDPE @ 0.28%
P-4	CONST. 28 L.F. ~ OF 8" HDPE @ 1.46%
P-5	CONST. 116 L.F. ~ OF 10" HDPE @ 0.28%
P-6	CONST. 30 L.F. ~ OF 8" HDPE @ 0.27%
P-8	CONST. 58 L.F. ~ OF 42" RCP @ 0.26%
P-9	CONST. 16 L.F. ~ OF 42" HDPE @ 0.25%



BLEED-DOWN STRUCTURE DETAIL

SCALE: 1" = 3'

ENGINEER: MICHAEL L. BRUEGGER, P.E. REG. NO. 44949

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FIELD:
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DESIGNED BY: MLB
CHECKED BY: DWH
DATE: MARCH 21, 2007

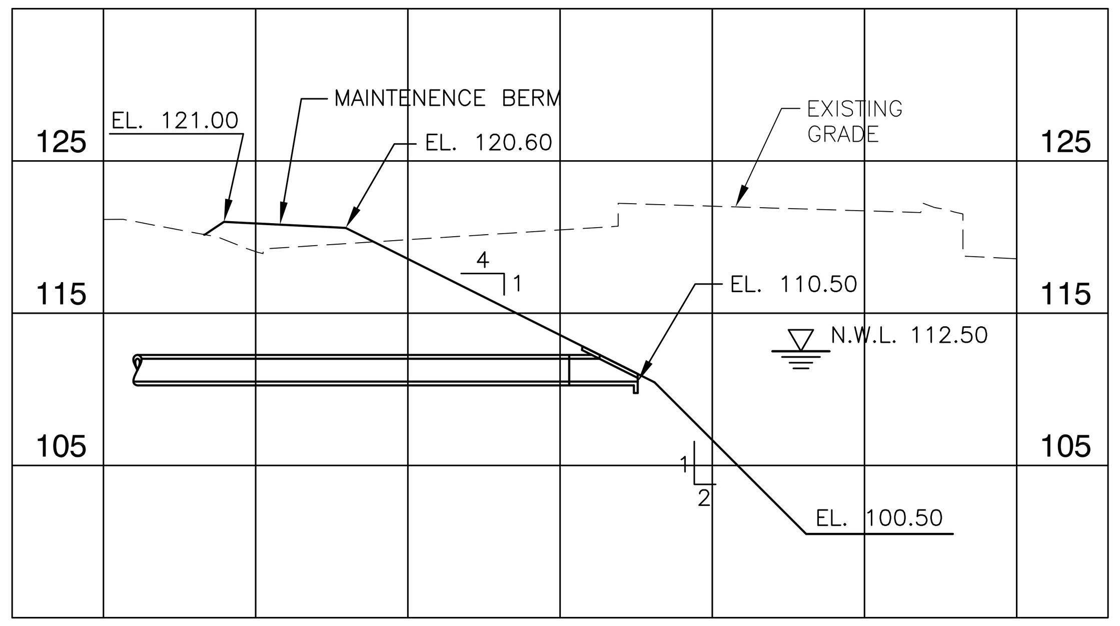
PEC PROFESSIONAL ENGINEERING CONSULTANTS, INC
3001 North Rocky Point Drive East, Suite 200 Orion Centre
Tampa, Florida 33607 813/281-4692
ENGINEERING BUSINESS NUMBER 3556

The Center of Good Living OCOEE

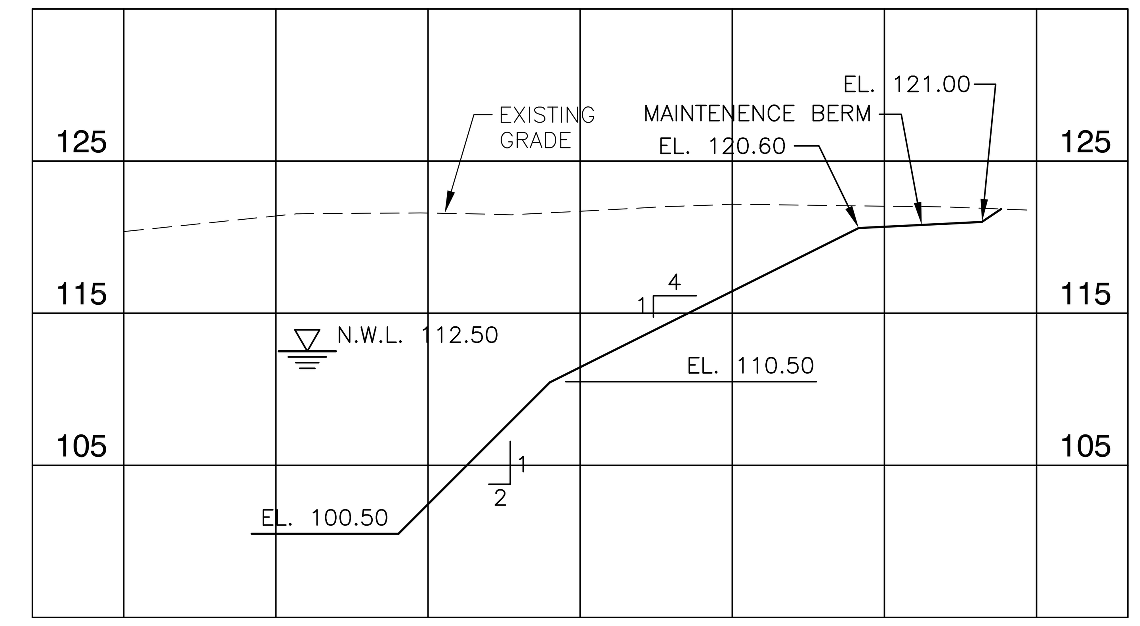
JOB No. OE-395
FILE NAME: OE395_PHI_6.DWG
ARCHIVE DISC:
SCALE: 1" = 40'

GRADING AND DRAINAGE PLAN
POND

SHEET 6 OF 19



SECTION A/6



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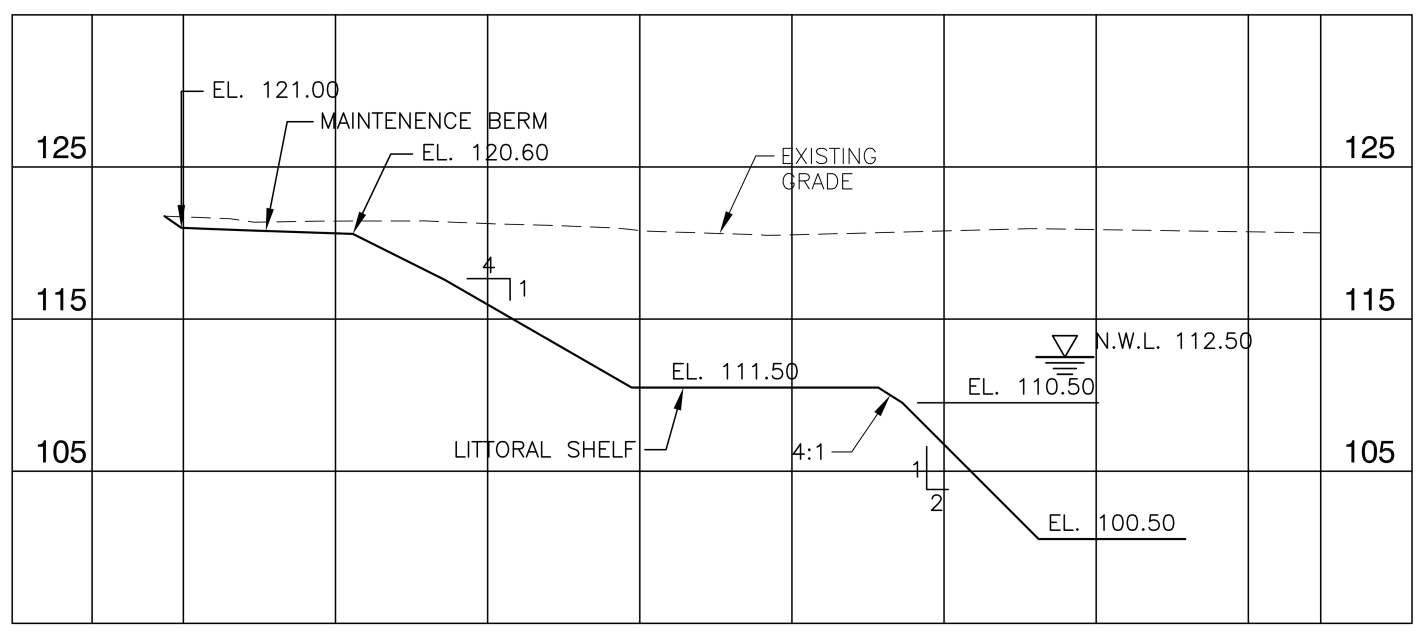

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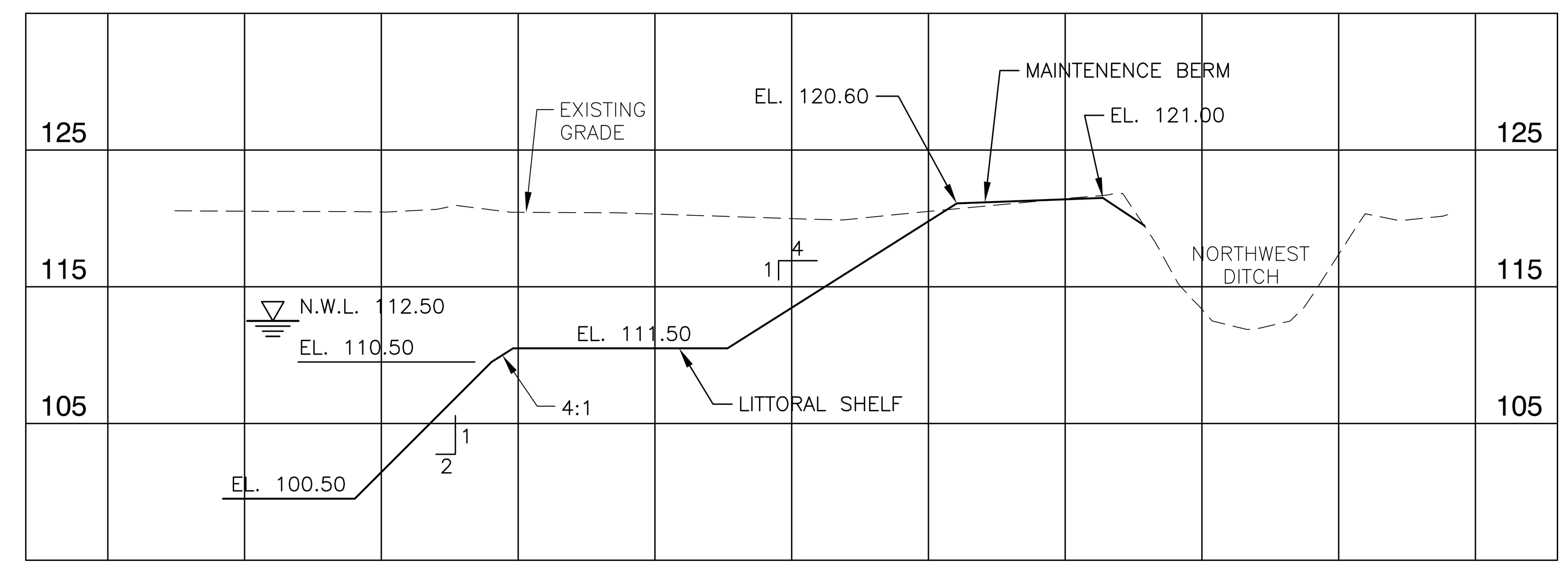

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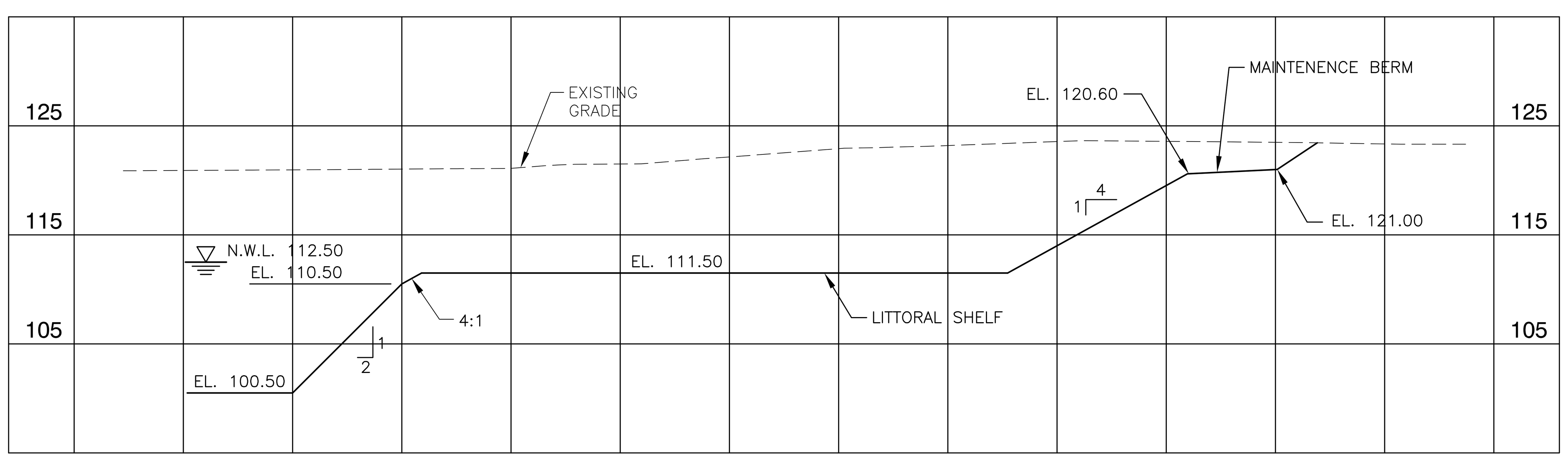

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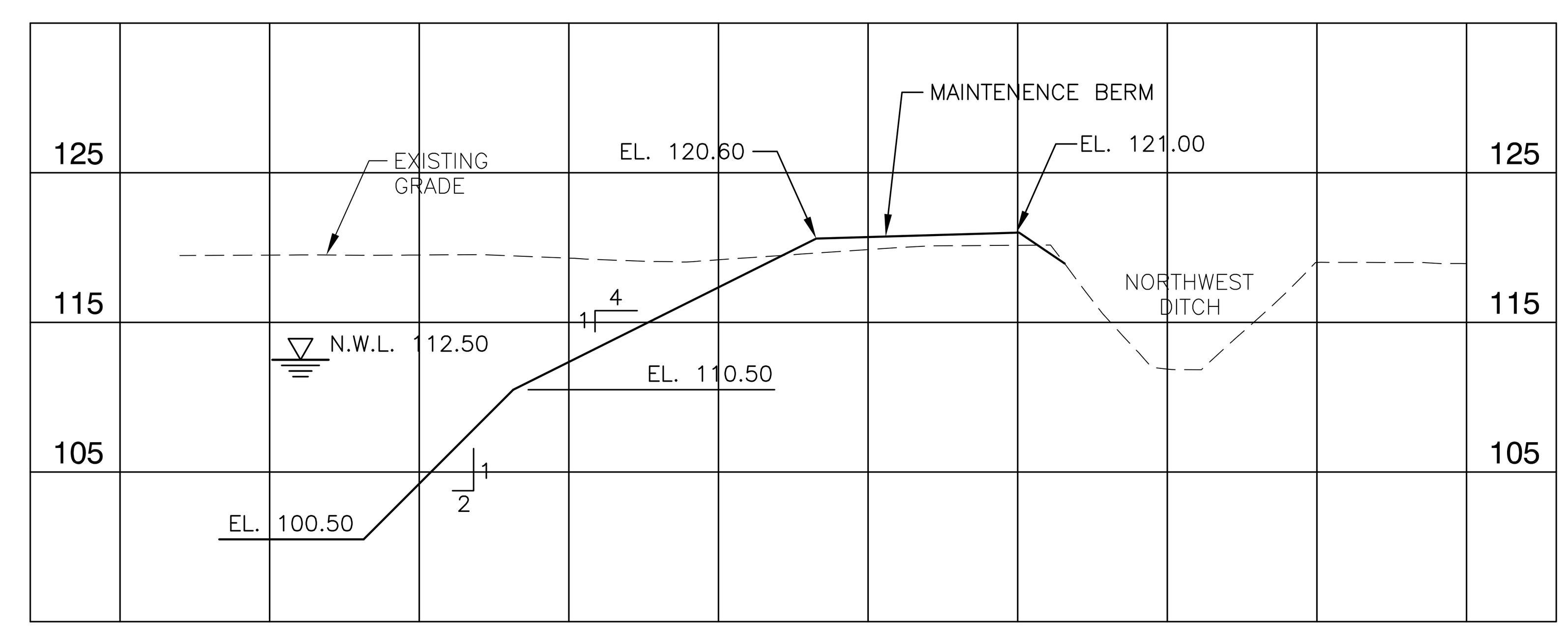

SECTION F/6

SCALE: HORIZ. 1"= 20'
VERT. 1"= 10'

ENGINEER: MICHAEL L. BRUEGGER, P.E. REG. NO. 44949

REV.	DATE	DESCRIPTION	APP'D BY	SIGN OFF		DATE

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DATE: MARCH 21, 2007

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3001 North Rocky Point Drive East, Suite 200 Orion Centre
Tampa, Florida 33607 813/281-4692
ENGINEERING BUSINESS NUMBER 3556

The Center of Good Living OCOEE

JOB No. OE-395
FILE NAME: OE395_PHI_7.DWG
ARCHIVE DISC:
SCALE: AS NOTED

CROSS SECTIONS - POND

SHEET 7 OF 19

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PROPOSED DRAINAGE STRUCTURE TABLE

S-9 CONSTRUCT MES (4:1 SLOPE)
FDOT. INDEX NO 272
N. 1542751.183
E. 478720.965
FL. EL. 110.50 (PROP. 18" RCP)

S-10 CONSTRUCT TYPE "C" INLET
FDOT. INDEX NO 232
N. 1542680.761
E. 478720.826
GRATE EL. 120.36
FL. EL. N. 110.90 (PROP. 18" RCP)
FL. EL. S. 116.60 (PROP. 18" RCP)

S-11 CONSTRUCT TYPE "C" INLET
FDOT. INDEX NO 232
N. 1542642.669
E. 478720.798
GRATE EL. 120.16
FL. EL. N. 116.75 (PROP. 18" RCP)
FL. EL. SW. 116.75 (PROP. 18" RCP)

S-12 CONSTRUCT TYPE "C" INLET
FDOT. INDEX NO 232
N. 1542592.637
E. 478680.888
GRATE EL. 120.28
FL. EL. NE. 117.00 (PROP. 18" RCP)

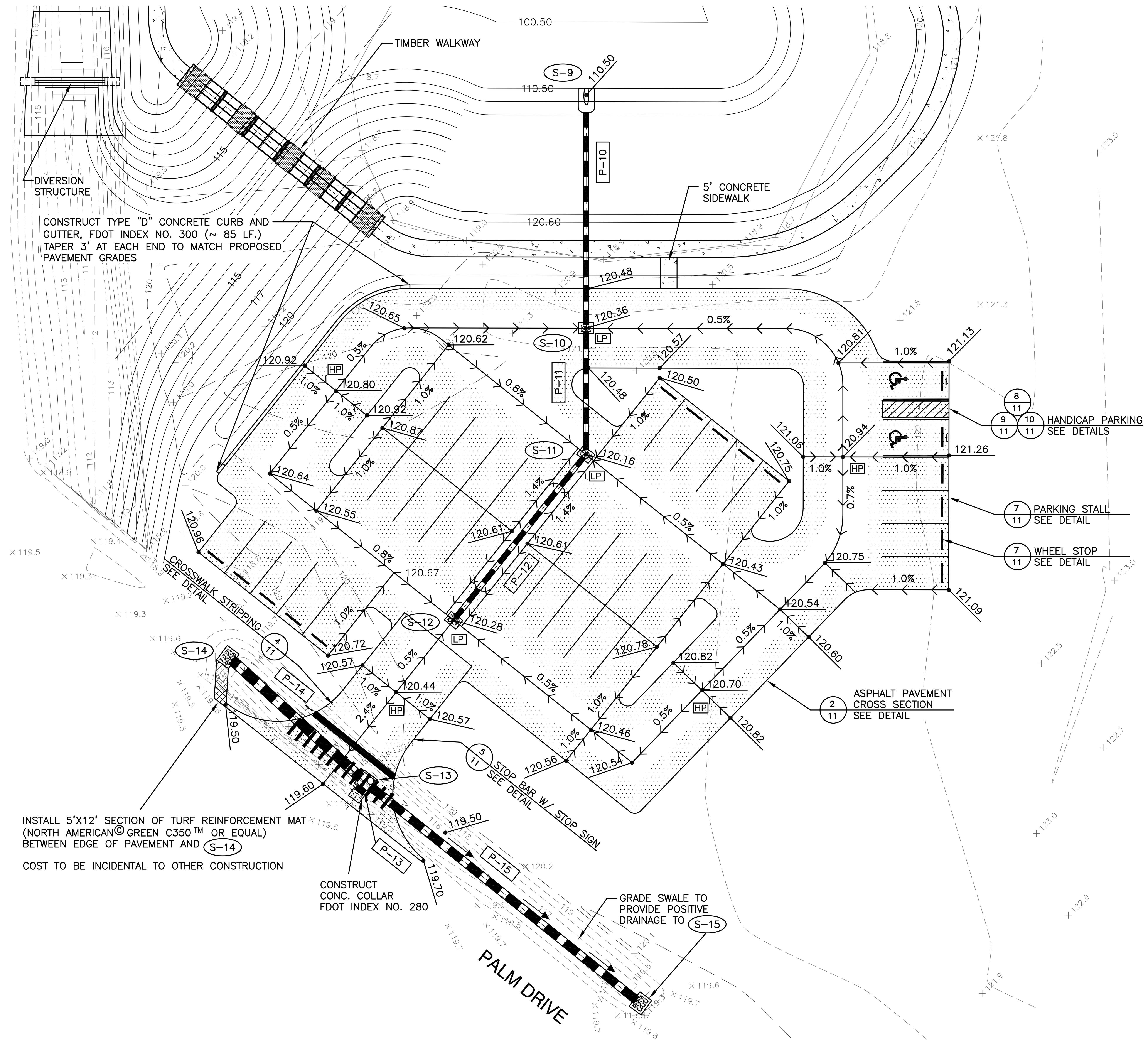
S-13 CONSTRUCT MH
FDOT INDEX NOS. 200 & 201
N. 1542547.787
E. 478657.327
RIM EL. 120.00
FL. EL. NW. 115.00 (PROP. 36" RCP)
FL. EL. SE. 115.00 (PROP. 30" RCP)
FL. EL. SW. 115.00 (PROP. 36" RCP)

S-14 CONSTRUCT TYPE "D" INLET
FDOT INDEX NO. 232
N. 1542580.965
E. 478613.462
GRATE EL. 119.00
FL. EL. SE. 114.00 (PROP. 36" RCP)
FL. EL. NW. 113.99 (EXIST. 36" RCP)

S-15 CONSTRUCT TYPE "D" INLET
WITH 2' SLOT IN NW WALL
FDOT INDEX NO. 232
N. 1542476.967
E. 478737.295
GRATE EL. 119.50
SLOT EL. 119.00
FL. EL. SE. 116.15 (EXIST. 30" RCP)
FL. EL. NW. 115.65 (PROP. 30" RCP)

PROPOSED PIPES

P-10	CONST. 65 L.F. ~ OF 18" RCP @ 0.62%
P-11	CONST. 36 L.F. ~ OF 18" RCP @ 0.42%
P-12	CONST. 62 L.F. ~ OF 18" RCP @ 0.40%
P-13	CONST. 6 L.F. ~ OF 36" RCP @ 4.00%
P-14	CONST. 52 L.F. ~ OF 36" RCP @ 1.92%
P-15	CONST. 102 L.F. ~ OF 30" RCP @ 0.64%



PLAN
SCALE: 1" = 20'

GRAPHIC SCALE
SCALE IN FEET

LEGEND

×123.0	EXIST. SPOT ELEV.
121.26	PROP. SPOT ELEV.
—115—	EXIST. CONTOUR MAJOR
—114—	EXIST. CONTOUR MINOR
— — —	PROPERTY BOUNDARY
—120—	PROP. CONTOUR MAJOR
—117—	PROP. CONTOUR MINOR

ENGINEER: MICHAEL L. BRUEGGER, P.E. REG. NO. 44949

REV.	DATE	DESCRIPTION	APP'D BY

SIGN OFF		DATE

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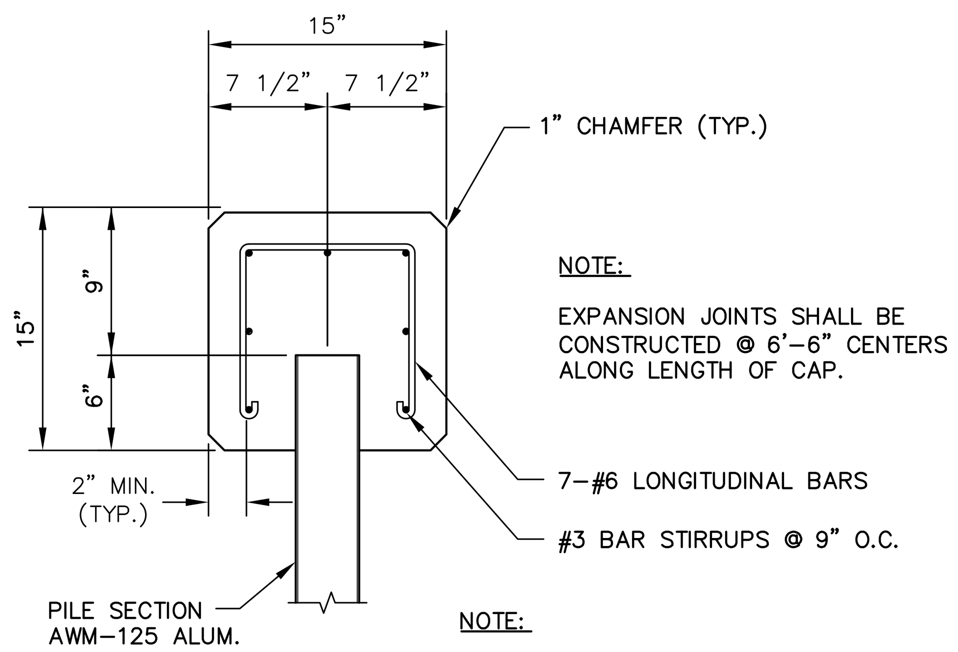
3001 North Rocky Point Drive East, Suite 200 Orion Centre
Tampa, Florida 33607 813/281-4692
ENGINEERING BUSINESS NUMBER 3556

The Center of Good Living OCOEE

JOB No. OE-395
FILE NAME: OE395_PHI_9.DWG
ARCHIVE DISC:
SCALE: 1" = 20'

GRADING AND DRAINAGE PLAN
PARKING LOT

SHEET 9 OF 19



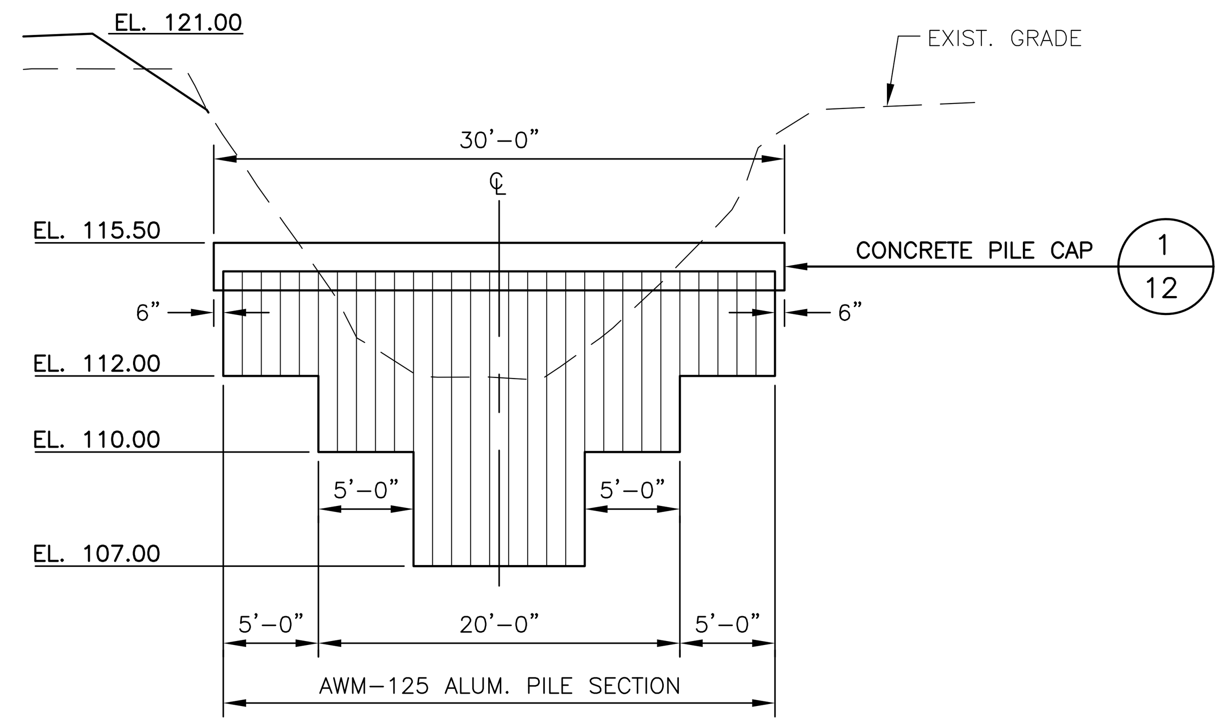
NOTE:

EXPANSION JOINTS SHALL BE CONSTRUCTED @ 6'-6" CENTERS ALONG LENGTH OF CAP.

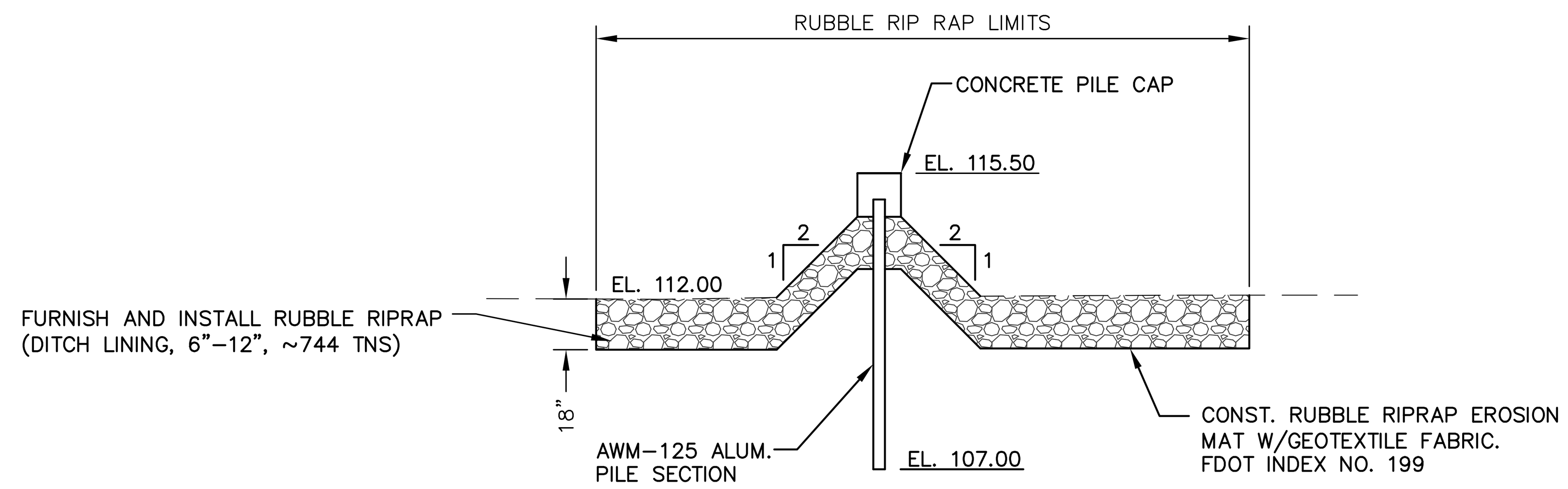
NOTE:

PILE SECTION EMBEDDED IN CONCRETE SHALL BE COATED WITH COLD TAR EPOXY.

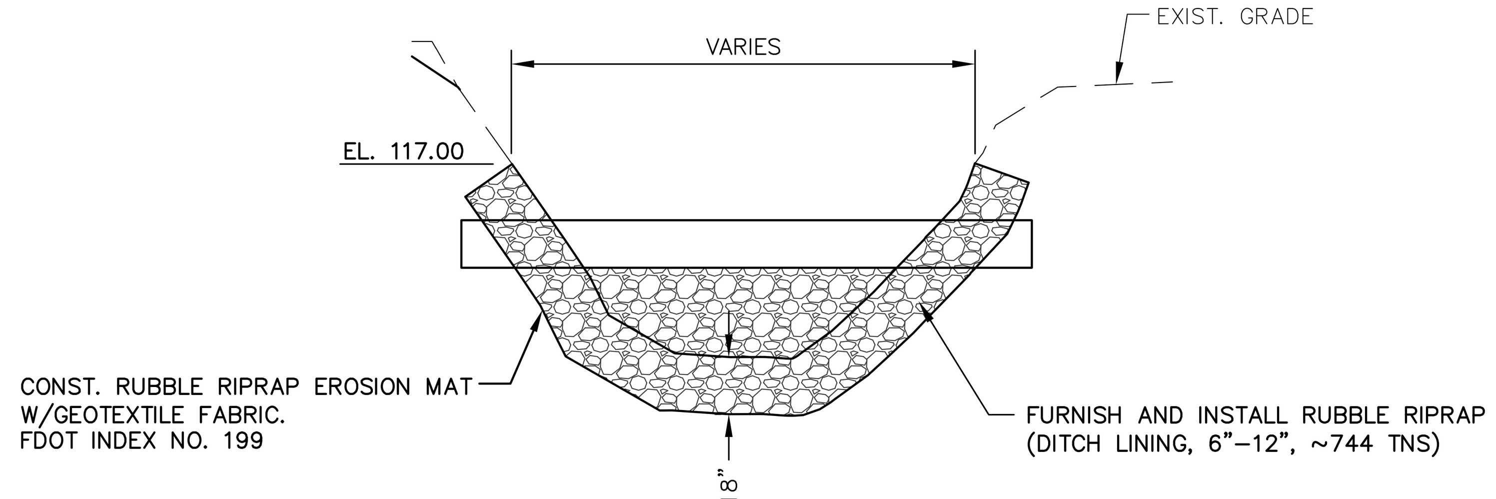
1/12 PILE CAP DETAIL
SCALE: HORIZ. 1"= 8'



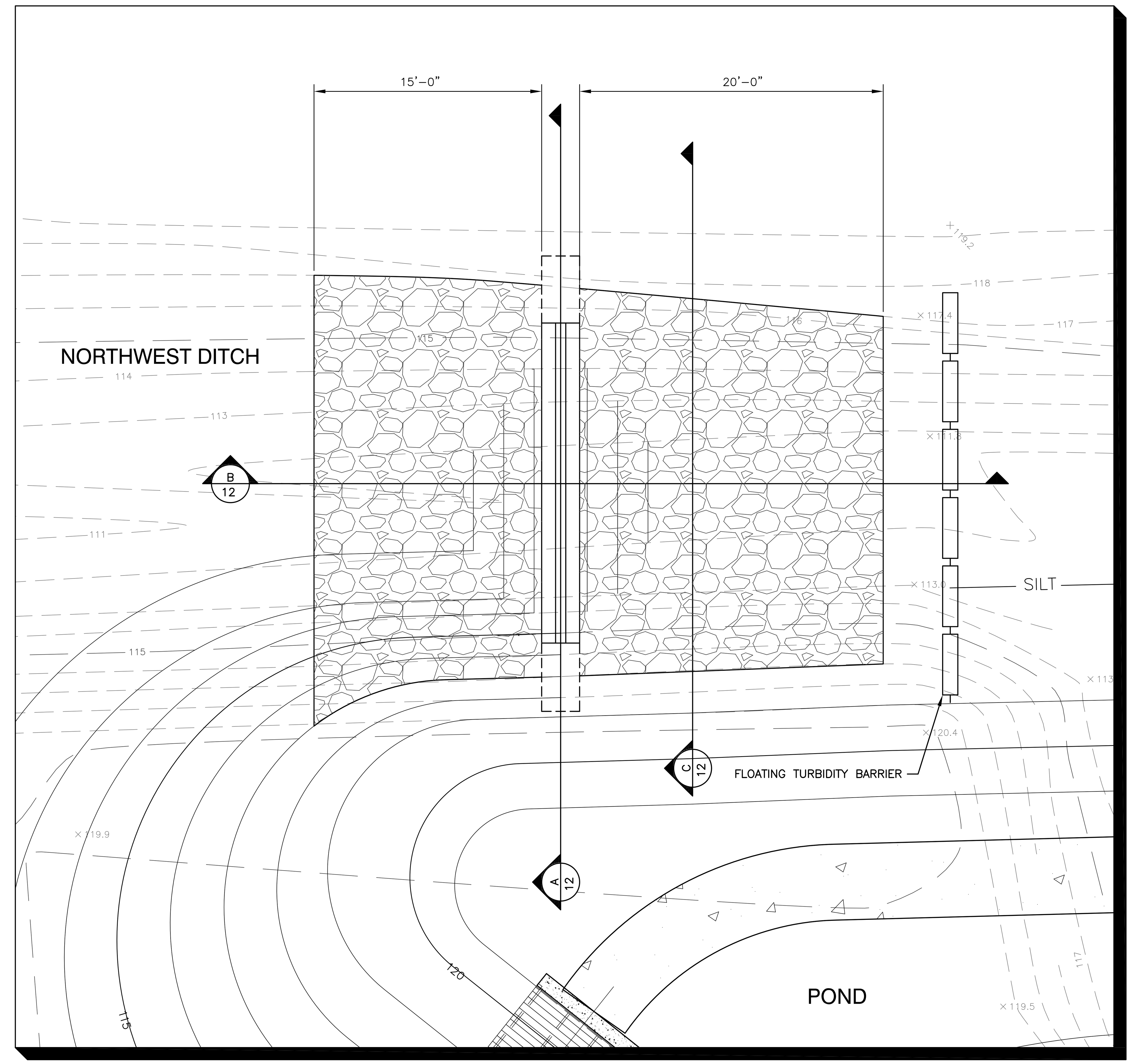
A/12 SECTION
SCALE: HORIZ. 1"= 8'
VERT. 1"= 4'



B/12 SECTION
SCALE: HORIZ. 1"= 8'
VERT. 1"= 4'



C/12 SECTION
SCALE: HORIZ. 1"= 8'
VERT. 1"= 4'



1/3 DIVERSION STRUCTURE - PLAN VIEW
SCALE: 1" = 5'

ENGINEER: MICHAEL L. BRUEGGER, P.E. REG. NO. 44949

REV.	DATE	DESCRIPTION	APP'D BY	SIGN OFF		DATE

FIELD:
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DESIGNED BY: MLB
CHECKED BY: DWH
DATE: MARCH 21, 2007

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3001 North Rocky Point Drive East, Suite 200 Orion Centre
Tampa, Florida 33607 813/281-4692
ENGINEERING BUSINESS NUMBER 3556

The Center of Good Living OCOEE

JOB No. OE-395
FILE NAME: OE395_PHI_12.DWG
ARCHIVE DISC:
SCALE: NTS

DETAILS
DIVERSON STRUCTURE
AND CONTROL STRUCTURE

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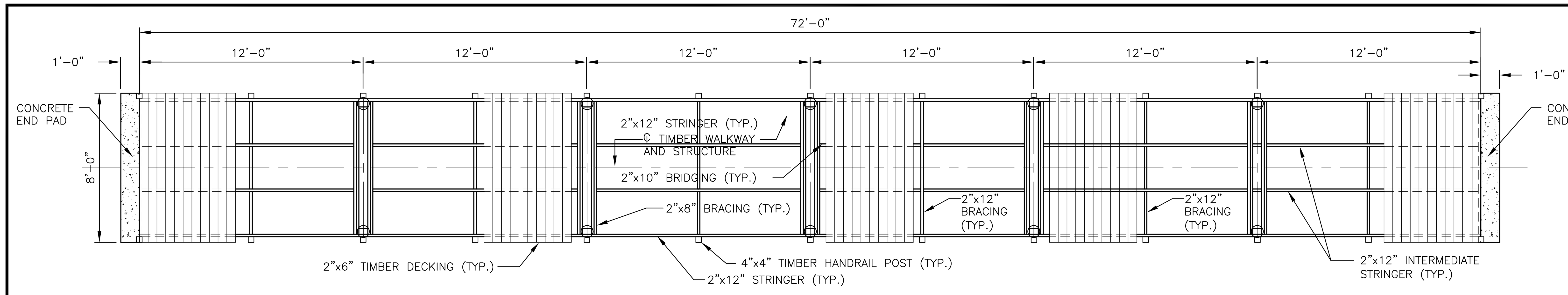
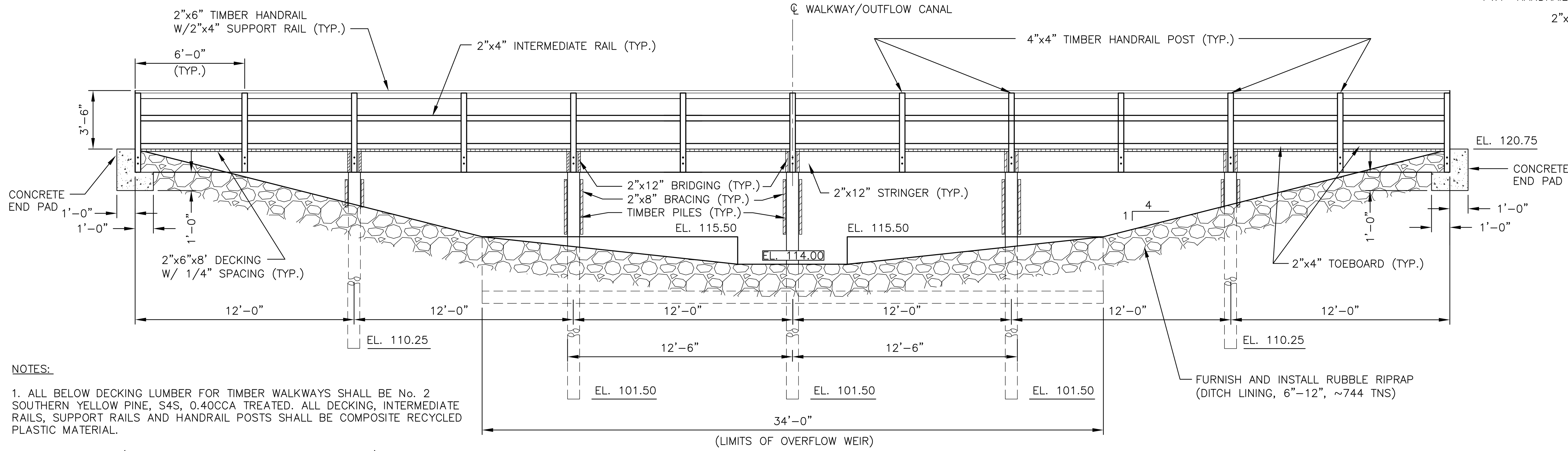


PLAN



ELEVATION

1/3 TIMBER WALKWAY DETAIL (OUTFLOW CANAL)

SCALE: 1/4"=1'-0"

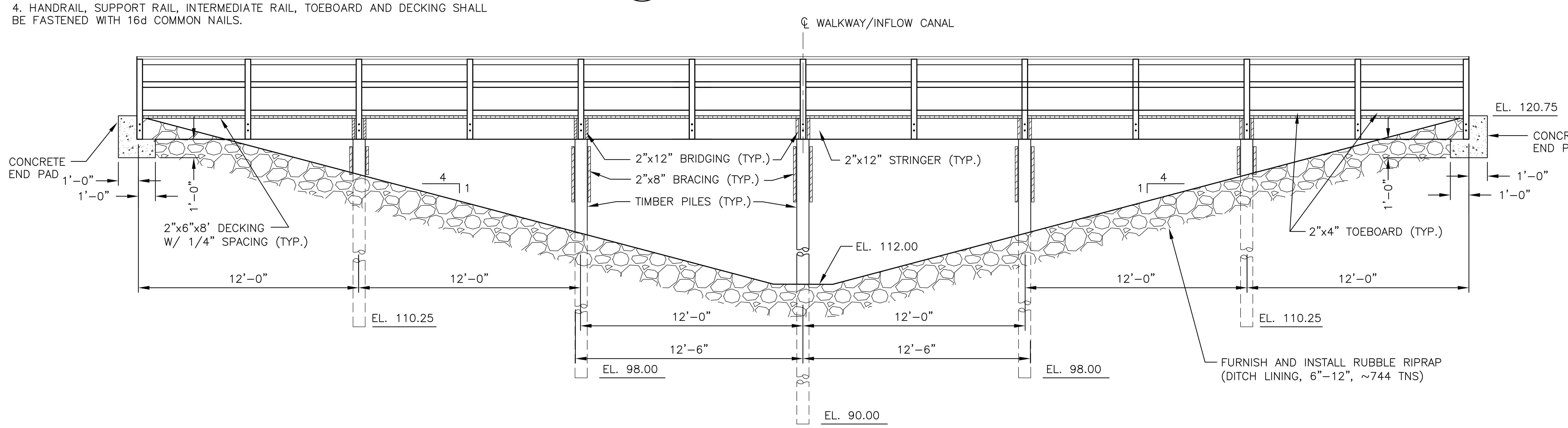
NOTES:

1. ALL BELOW DECKING LUMBER FOR TIMBER WALKWAYS SHALL BE No. 2 SOUTHERN YELLOW PINE, S4S, 0.40CCA TREATED. ALL DECKING, INTERMEDIATE RAILS, SUPPORT RAILS AND HANDRAIL POSTS SHALL BE COMPOSITE RECYCLED PLASTIC MATERIAL.

2. ALL HARDWARE (I.E., BOLTS, WASHERS, SCREWS, NAILS ETC.) FOR TIMBER WALKWAYS SHALL BE HOT DIP GALVANIZED.

3. TOP OF 10"Ø TIMBER PILES SHALL BE NOTCHED TO FORM 6"x6"x11 1/2" SEAT TO ACCOMODATE 2"x12" STRINGERS AND 2"x12" BRIDGING.

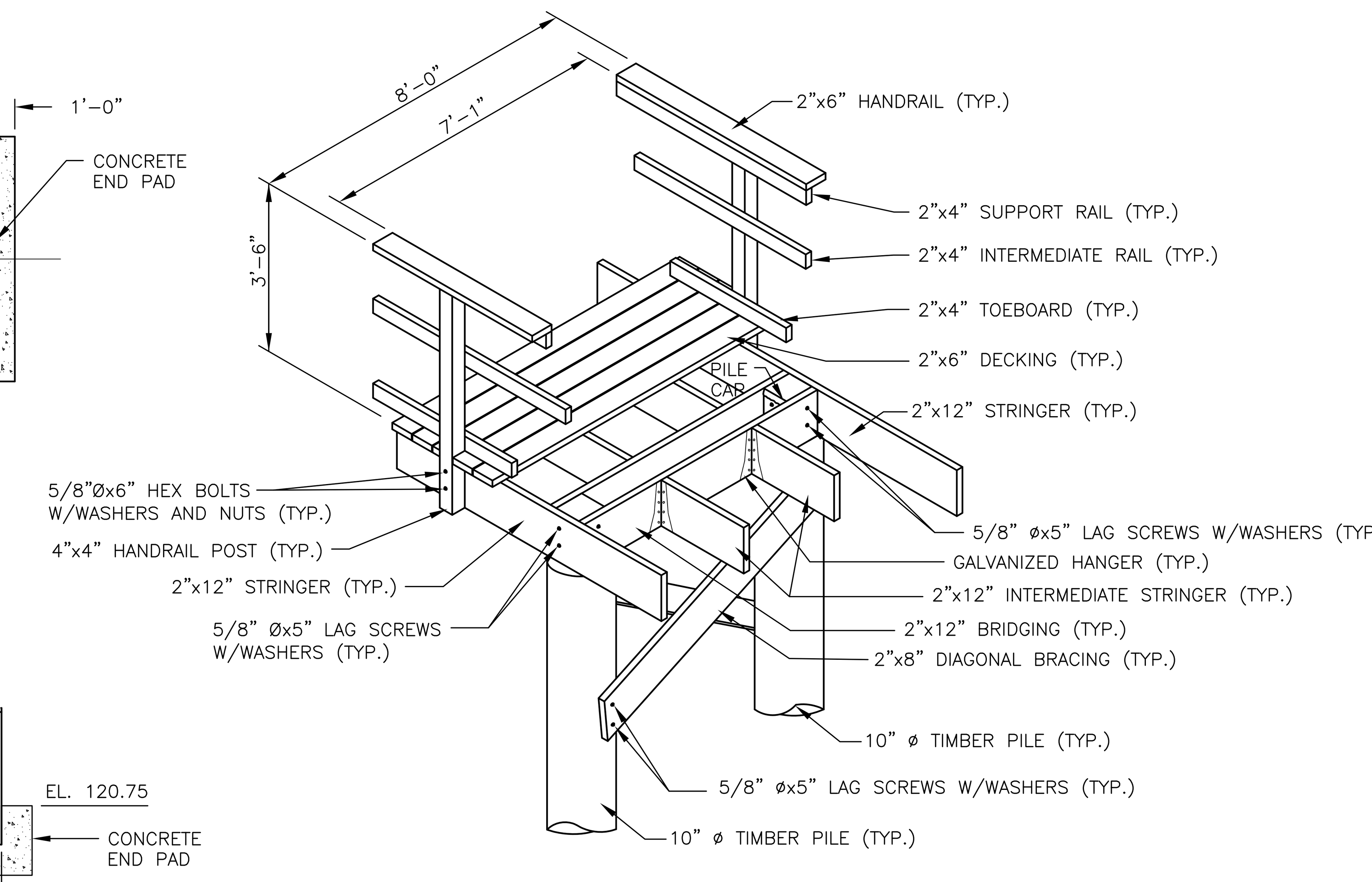
4. HANDRAIL, SUPPORT RAIL, INTERMEDIATE RAIL, TOEBOARD AND DECKING SHALL BE FASTENED WITH 16d COMMON NAILS.



ELEVATION

2/3 TIMBER WALKWAY DETAIL (INFLOW CANAL)

SCALE: 1/4"=1'-0"



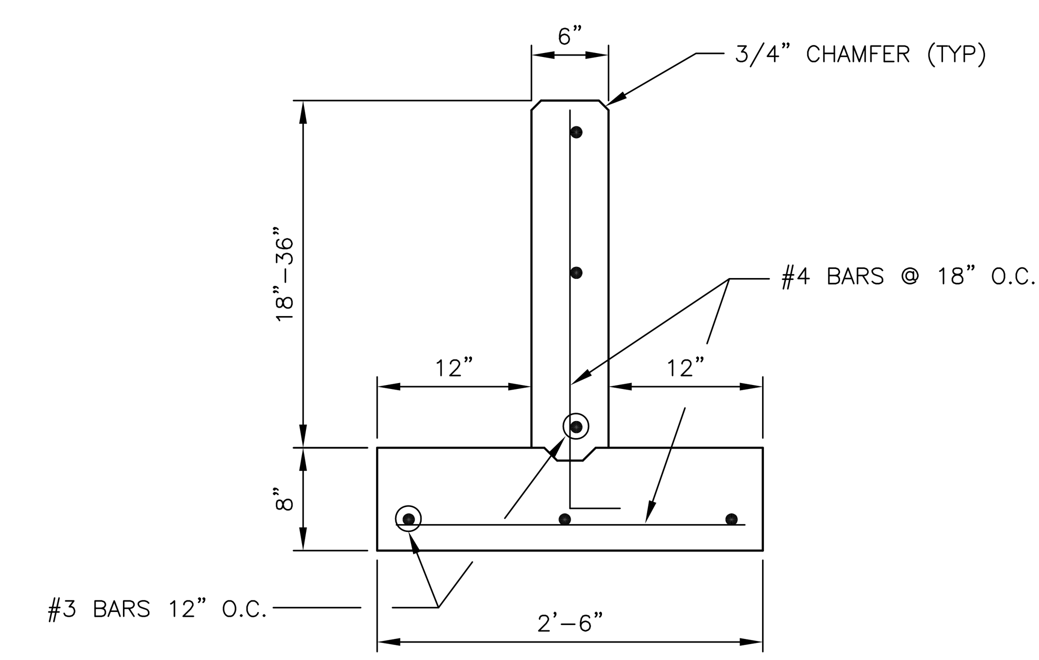
TIMBER WALKWAY ISOMETRIC

N.T.S.

NOTE:

1. BRIDGE DESIGN SHOWN IS FOR GENERAL DESIGN PURPOSE ONLY. CONTRACTOR SHALL SUBMIT SHOP DRAWINGS FOR FINAL DESIGN CERTIFIED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF FLORIDA PRIOR TO CONSTRUCTION.

2. BRIDGE DESIGN SHALL BE IN CONFORMANCE WITH LATEST ADA REQUIREMENTS.



OVERFLOW WEIR DETAIL

SCALE: 1"=1'-0"

NOTE:

1. BRIDGE DESIGN SHOWN IS FOR GENERAL DESIGN PURPOSE ONLY. CONTRACTOR SHALL SUBMIT SHOP DRAWINGS FOR FINAL DESIGN CERTIFIED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF FLORIDA PRIOR TO CONSTRUCTION.

ENGINEER: MICHAEL L. BRUEGGER, P.E. REG. NO. 44949

REV.	DATE	DESCRIPTION	APP'D BY	SIGN OFF		DATE	FIELD:
							DRAWN BY: PEI
							DESIGNED BY: MLB
							CHECKED BY: DWH
							DATE: MARCH 21, 2007

PEC PROFESSIONAL ENGINEERING CONSULTANTS, INC
3001 North Rocky Point Drive East, Suite 200 Orion Centre
Tampa, Florida 33607 813/281-4692
ENGINEERING BUSINESS NUMBER 3556

The Center of Good Living OCOEE

JOB No.	OE-395
FILE NAME:	OE395_PHI_13.DWG
ARCHIVE DISC:	
SCALE:	AS NOTED

DETAILS
INFLOW/OUTFLOW CANAL BRIDGES

SHEET 13 OF 19

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APPENDIX B

LABORATORY ANALYSES ON INFLOW, OUTFLOW, AND BULK PRECIPITATION SAMPLES COLLECTED AT THE PIONEER KEY REGIONAL STORMWATER FACILITY FROM OCTOBER 2009-MARCH 2010

1. **Inflow Samples**
2. **Outflow Samples**
3. **Bulk Precipitation Samples**

B-1. Inflow Samples

Chemical Characteristics of Inflow Samples Collected at the Pioneer Key Regional Stormwater Facility from October 2009 - March 2010

Site	Description	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Cond. (µmho/cm)	NH_3-N (µg/l)	NO_X-N (µg/l)	Diss. Org. N (µg/l)	Part. N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss. Org. P (µg/l)	Part. P (µg/l)	Total P (µg/l)	Color (Pt-Co)	Turbidity (NTU)	TSS (mg/l)
Site # 1	NW Ditch	10/09/09-10/16/09	7.55	181	451	3	147	622	88	860	42	77	151	270	63	0.3	9.2
Site # 1	NW Ditch	10/22/09-10/30/09	8.20	176	478	258	138	833	28	1257	55	32	36	123	56	3.0	5.3
Site # 1	NW Ditch	11/03/09-11/09/09	8.04	178	476	216	8	558	138	920	48	8	9	65	60	10.0	15.7
Site # 1	NW Ditch	11/10/09-11/11/09	7.08	114	332	50	38	682	548	1318	47	15	21	83	109	7.0	15.1
Site # 1	NW Ditch	11/11/09-11/16/09	8.13	178	466	110	25	504	206	845	60	5	49	114	55	10.2	18.9
Site # 1	NW Ditch	11/16 - 11/24/09	7.92	178	491	24	11	386	174	595	3	21	36	60	52	1.4	5.5
Site # 1	NW Ditch	11/25/09-11/30/09	7.71	184	485	226	48	601	169	1044	46	6	149	201	60	29.3	57.3
Site # 1	NW Ditch	12/01/09-12/03/09	7.55	152	437	95	16	557	153	821	53	1	29	83	49	2.3	8.1
Site # 1	NW Ditch	12/04/09-12/07/09	6.97	64.2	201	72	17	96	151	336	55	20	81	156	26	7.3	18.2
Site # 1	NW Ditch	12/07/09-12/17/09	7.04	72.2	402	144	112	373	874	1503	11	8	393	412	31	68.8	63.6
Site # 1	NW Ditch	12/17/09-12/21/09	6.83	59.8	484	364	243	190	414	1211	34	11	204	249	45	30.3	61.3
Site # 1	NW Ditch	12/25/09	7.35	128	343	139	155	118	532	944	6	19	267	292	26	49.3	81.3
Site # 1	NW Ditch	1/1/10	6.92	75.0	168	5	29	423	611	1068	28	4	425	457	33	72.9	124
Site # 1	NW Ditch	01/04/10-01/18/10	7.95	191	457	477	62	398	156	1093	42	6	77	125	38	16.4	35.3
Site # 1	NW Ditch	1/22/10	7.24	163	406	301	139	463	671	1574	34	17	448	499	38	69.1	97.5
Site # 1	NW Ditch	1/25/10	7.20	127	290	191	94	429	138	852	55	17	92	164	54	27.3	24.6
Site # 1	NW Ditch	02/01/10-02/02/10	7.16	88.0	181	91	51	451	267	860	21	16	233	270	30	65.1	476
Site # 1	NW Ditch	2/8/10	7.39	180	474	356	250	477	677	1760	13	20	467	500	41	56.6	120
Site # 1	NW Ditch	2/9/10	7.33	131	323	3	29	500	346	878	4	17	172	193	34	20.4	67.5
Site # 1	NW Ditch	2/12/10	7.25	75.6	187	207	133	394	919	1653	40	13	369	422	27	80.2	209
Site # 1	NW Ditch	2/25/10	7.40	79.8	441	392	227	250	756	1625	27	8	424	459	44	50.7	157
Site # 1	NW Ditch	03/11/10-03/13/10	6.91	80.6	193	235	119	615	1597	2566	283	6	639	928	108	84.8	361
Site # 1	NW Ditch	03/13/10-03/24/10	7.15	99.6	270	228	53	424	870	1575	76	6	373	455	65	48.1	110
Site # 1	NW Ditch	3/25/10	7.56	144	370	4	99	986	37	1126	16	91	40	147	105	2.2	3.2
Site # 1	NW Ditch	03/26/10-03/29/10	6.79	72.2	184	3	51	1114	881	2049	159	59	414	632	149	54.5	151
		Mean Value:	**7.38**	**127**	**360**	**168**	**92**	**498**	**456**	**1213**	**50**	**20**	**224**	**294**	**56**	**34.7**	**91.8**
		Minimum Value:	**6.79**	**59.8**	**168**	**3**	**8**	**96**	**28**	**336**	**3**	**1**	**9**	**60**	**26**	**0.3**	**3.2**
		Maximum Value:	**8.20**	**191**	**491**	**477**	**250**	**1114**	**1597**	**2566**	**283**	**91**	**639**	**928**	**149**	**84.8**	**476**
		Log-Normal Mean:	**7.37**	**118**	**338**	**76**	**62**	**437**	**300**	**1120**	**32**	**13**	**136**	**228**	**50**	**17.7**	**43.3**

Chemical Characteristics of Inflow Samples Collected at the Pioneer Key Regional Stormwater Facility from October 2009 - March 2010

Site	Description	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Cond. (µmho/cm)	NH_3-N (µg/l)	NO_X-N (µg/l)	Diss. Org. N (µg/l)	Part. N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss. Org. P (µg/l)	Part. P (µg/l)	Total P (µg/l)	Color (Pt-Co)	Turbidity (NTU)	TSS (mg/l)
Site # 2	Parking Lot	10/09/09-10/16/09	6.96	31.8	113	173	297	183	250	903	1	10	36	47	32	5.0	13.1
Site # 2	Parking Lot	11/10/09	6.69	32.6	139	292	35	613	328	1268	9	9	36	54	113	8.9	17.1
Site # 2	Parking Lot	11/25/09	6.88	25.6	97	427	94	1208	66	1795	40	25	64	129	78	17.6	29.4
Site # 2	Parking Lot	12/01/09-12/03/09	6.74	38	163	245	91	838	320	1494	20	1	62	83	119	7.5	16.2
Site # 2	Parking Lot	12/04/09-12/05/09	6.88	29.4	66	82	47	5	31	165	18	6	10	34	22	3.3	2.4
Site # 2	Parking Lot	12/17/09-12/18/09	6.94	32.2	304	1458	59	677	356	2550	9	22	124	155	94	31.0	59.6
Site # 2	Parking Lot	12/25/09	6.65	20.2	71	124	51	92	67	334	3	7	25	35	16	4.1	16.2
Site # 2	Parking Lot	1/1/10	6.95	71.2	236	702	33	668	14	1417	4	13	25	42	59	5.2	11.0
Site # 2	Parking Lot	01/16/10-01/17/10	6.64	28.8	119	482	17	437	219	1155	2	8	63	73	52	20.1	22.3
Site # 2	Parking Lot	01/21/10-01/22/10	7.18	63.8	203	1333	72	353	305	2063	99	36	117	252	51	37.2	52.0
Site # 2	Parking Lot	1/25/10	6.86	57.2	219	1589	30	1113	234	2966	2	14	63	79	127	17.3	27.2
Site # 2	Parking Lot	02/01/10-02/02/10	6.62	25.6	76	283	25	837	258	1403	6	10	72	88	33	9.3	21.9
Site # 2	Parking Lot	2/5/10	6.93	46.6	173	717	43	760	244	1764	1	8	67	76	80	16.7	22.4
Site # 2	Parking Lot	2/9/10	7.37	117	364	98	102	1046	304	1550	4	29	70	103	69	8.9	20.9
Site # 2	Parking Lot	2/12/10	6.63	31.8	141	1519	203	1032	240	2994	8	6	59	73	52	21.4	28.6
Site # 2	Parking Lot	02/16/10-02/24/10	6.49	28.6	386	327	333	547	325	1532	43	4	90	137	53	14.7	41.5
Site # 2	Parking Lot	02/27/10-03/02/10	6.04	36.2	141	858	151	908	400	2317	3	5	65	73	72	9.0	19.1
Site # 2	Parking Lot	03/11/10-03/12/10	6.99	139	529	771	1889	2433	288	5381	47	7	92	146	132	10.4	43.8
Site # 2	Parking Lot	3/21/10	7.50	125	376	781	21	568	136	1506	60	9	45	114	44	10.4	27.5
Site # 2	Parking Lot	3/25/10	6.41	13.8	56	617	146	34	60	857	69	32	37	138	18	6.2	20.9
Site # 2	Parking Lot	03/28/10-03/29/10	6.83	46	174	711	70	718	319	1818	1	12	76	89	98	9.8	31.0

	pH (s.u.)	Alkalinity (mg/l)	Cond. (µmho/cm)	NH_3-N (µg/l)	NO_X-N (µg/l)	Diss. Org. N (µg/l)	Part. N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss. Org. P (µg/l)	Part. P (µg/l)	Total P (µg/l)	Color (Pt-Co)	Turbidity (NTU)	TSS (mg/l)
Mean Value:	**6.82**	**49.5**	**197**	**647**	**181**	**718**	**227**	**1773**	**21**	**13**	**62**	**96**	**67**	**13.0**	**25.9**
Minimum Value:	**6.04**	**13.8**	**56**	**82**	**17**	**5**	**14**	**165**	**1**	**1**	**10**	**34**	**16**	**3.3**	**2.4**
Maximum Value:	**7.50**	**139**	**529**	**1589**	**1889**	**2433**	**400**	**5381**	**99**	**36**	**124**	**252**	**132**	**37.2**	**59.6**
Log-Normal Mean:	**6.81**	**41.0**	**164**	**469**	**79**	**448**	**175**	**1443**	**8**	**10**	**54**	**85**	**57**	**10.7**	**22.0**

Chemical Characteristics of Inflow Samples Collected at the Pioneer Key Regional Stormwater Facility from October 2009 - March 2010

Site	Description	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Cond. (μmho/cm)	NH_3-N (μg/l)	NO_X-N (μg/l)	Diss. Org. N (μg/l)	Part. N (μg/l)	Total N (μg/l)	SRP (μg/l)	Diss. Org. P (μg/l)	Part. P (μg/l)	Total P (μg/l)	Color (Pt-Co)	Turbidity (NTU)	TSS (mg/l)
Site # 3	Area Drain	10/02/09-10/09/09	7.78	175	486	1005	52	26	215	1298	3	22	40	65	19	10.1	14.2
Site # 3	Area Drain	10/09/09-10/16/09	7.88	172	469	940	57	522	69	1588	3	1	53	57	18	4.6	13.2
Site # 3	Area Drain	12/04/09-12/07/09	7.28	146	418	608	153	15	113	889	2	6	56	64	15	10.7	12.9
Site # 3	Area Drain	12/07/09-12/17/09	7.16	106	515	545	264	260	25	1094	3	5	26	34	12	6.4	10.0
Site # 3	Area Drain	12/21/09-12/28/09	7.65	174	469	450	106	445	161	1162	3	6	151	160	16	21.0	24.5
Site # 3	Area Drain	12/28/09 - 01/04/10	7.47	120	392	249	128	411	98	886	4	4	37	45	21	5.7	11.0
Site # 3	Area Drain	01/22/10-01/25/10	7.32	118	375	301	118	415	359	1193	2	22	69	93	18	12.1	21.3
Site # 3	Area Drain	02/01/10-02/03/10	7.39	130	416	297	146	421	434	1298	2	6	54	62	16	6.0	18.9
Site # 3	Area Drain	02/03/10-02/08/10	7.61	139	434	319	169	457	54	999	2	4	24	30	15	3.0	6.2
Site # 3	Area Drain	02/08/10-02/10/10	7.45	133	423	271	170	515	184	1140	1	6	30	37	15	4.8	4.0
Site # 3	Area Drain	02/10/10-02/15/10	7.36	131	418	352	214	515	176	1257	4	3	20	27	14	3.7	4.8
Site # 3	Area Drain	02/15/10-02/25/10	7.58	120	467	494	251	195	151	1091	1	2	31	34	13	1.8	13.2
Site # 3	Area Drain	02/25/10-03/03/10	7.60	163	502	529	170	210	97	1006	4	1	36	41	11	4.7	7.0
Site # 3	Area Drain	03/03/10-03/13/10	6.88	66.6	259	114	113	359	199	785	3	1	69	73	24	10.9	247
Site # 3	Area Drain	03/13/10-03/24/10	7.75	84.2	296	316	51	307	165	839	1	10	25	36	21	5.9	57.5
Site # 3	Area Drain	03/24/10-03/26/10	7.20	96.8	347	216	98	186	472	972	1	7	58	66	20	5.1	44.6
Site # 3	Area Drain	03/26/10-03/29/10	7.16	97.2	331	209	60	346	346	961	1	6	29	36	28	3.5	4.5
		Mean Value:	**7.44**	**128**	**413**	**424**	**136**	**330**	**195**	**1086**	**2**	**7**	**48**	**56**	**17**	**7**	**30**
		Minimum Value:	**6.88**	**66.6**	**259**	**114**	**51**	**15**	**25**	**785**	**1**	**1**	**20**	**27**	**11**	**2**	**4**
		Maximum Value:	**7.88**	**175**	**515**	**1005**	**264**	**522**	**472**	**1588**	**4**	**22**	**151**	**160**	**28**	**21**	**247**
		Log-Normal Mean:	**7.44**	**124**	**406**	**367**	**121**	**250**	**153**	**1069**	**2**	**4**	**41**	**50**	**17**	**6**	**15**

B-2. Outflow Samples

Chemical Characteristics of Outflow Samples Collected at the Pioneer Key Regional Stormwater Facility from October 2009 - March 2010

Site	Description	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Cond. (µmho/cm)	NH_3-N (µg/l)	NO_X-N (µg/l)	Diss. Org. N (µg/l)	Part. N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss. Org. P (µg/l)	Part. P (µg/l)	Total P (µg/l)	Color (Pt-Co)	Turbidity (NTU)	TSS (mg/l)
Site # 4	Pond Outflow	10/02/09-10/09/09	7.40	134	351	132	54	379	171	736	14	31	19	64	37	3.0	6.6
Site # 4	Pond Outflow	10/09/09-10/16/09	7.73	134	349	3	39	492	50	584	1	8	15	24	36	1.3	2.0
Site # 4	Pond Outflow	10/16/09-10/22/09	7.83	142	362	3	42	519	200	764	16	1	10	27	36	1.4	2.7
Site # 4	Pond Outflow	10/22/09-10/30/09	7.89	139	375	34	328	572	166	1100	3	26	21	50	30	3.1	4.2
Site # 4	Pond Outflow	10/30/09-11/03/09	7.74	139	370	40	15	780	293	1128	2	18	26	46	41	3.7	4.8
Site # 4	Pond Outflow	11/03/09-11/09/09	8.06	144	381	12	22	482	170	686	2	1	20	23	27	2.4	2.8
Site # 4	Pond Outflow	11/10/09-11/11/09	7.96	144	292	8	33	503	296	840	5	5	44	54	32	4.2	4.4
Site # 4	Pond Outflow	11/11/09-11/16/09	8.00	141	393	3	22	459	163	647	1	10	15	26	28	1.8	2.7
Site # 4	Pond Outflow	11/16 - 11/24/09	7.75	138	390	4	9	466	39	518	10	1	5	16	27	1.5	1.6
Site # 4	Pond Outflow	11/25/09-11/30/09	7.75	139	392	3	12	652	99	766	5	28	277	310	29	1.5	2.4
Site # 4	Pond Outflow	11/30/09-12/03/09	7.59	141	395	20	18	694	359	1091	5	5	51	61	27	5.1	6.4
Site # 4	Pond Outflow	12/03/09-12/07/09	6.98	116	333	12	17	302	400	731	2	15	90	107	30	11.5	11.9
Site # 4	Pond Outflow	12/07/09-12/17/09	6.81	97.8	345	19	89	387	74	569	10	10	20	40	25	1.7	3.0
Site # 4	Pond Outflow	12/17/09-12/21/09	6.90	100	340	28	33	324	257	642	6	9	23	38	27	5.6	6.2
Site # 4	Pond Outflow	12/21/09-12/28/09	7.38	124	346	3	24	351	206	584	4	15	23	42	22	3.8	2.8
Site # 4	Pond Outflow	12/28/09 - 01/04/10	7.34	122	326	6	37	383	215	641	4	3	31	38	25	6.0	6.3
Site # 4	Pond Outflow	01/04/10-01/18/10	7.37	125	338	19	68	535	309	931	5	99	25	129	23	13.1	28.6
Site # 4	Pond Outflow	01/18/10-01/22/10	7.50	125	336	121	77	442	219	859	10	18	56	84	15	9.5	13.3
Site # 4	Pond Outflow	01/22/10-01/25/10	7.56	126	339	63	32	470	325	890	9	13	72	94	25	9.8	17.4
Site # 4	Pond Outflow	01/25/10-02/01/10	7.13	126	373	60	58	403	261	782	12	1	40	53	23	10.0	13.9
Site # 4	Pond Outflow	02/01/10-02/03/10	7.42	123	353	68	43	396	277	784	3	4	17	24	27	15.4	23.1
Site # 4	Pond Outflow	02/03/10-02/08/10	7.64	128	363	45	57	462	278	842	1	11	52	64	25	10.9	15.6
Site # 4	Pond Outflow	02/08/10-02/10/10	7.65	128	368	24	25	598	434	1081	2	9	69	80	28	8.2	16.7
Site # 4	Pond Outflow	02/10/10-02/15/10	7.24	124	362	35	39	699	23	796	5	8	18	31	29	4.5	5.3
Site # 4	Pond Outflow	02/15/10-02/25/10	7.11	122	370	6	61	331	299	697	1	5	43	49	35	7.0	15.4
Site # 4	Pond Outflow	02/25/10-03/03/10	7.16	127	382	38	61	340	106	545	2	4	19	25	30	3.8	6.3
Site # 4	Pond Outflow	03/03/10-03/13/10	7.26	112	310	47	28	460	180	715	11	2	37	50	48	4.4	28.0
Site # 4	Pond Outflow	03/13/10-03/24/10	7.27	106	303	44	20	413	343	820	3	14	62	79	49	2.8	9.2
Site # 4	Pond Outflow	03/24/10-03/26/10	7.35	110	314	8	26	442	663	1139	3	33	3	39	52	2.8	5.3
Site # 4	Pond Outflow	03/26/10-03/29/10	7.19	107	297	3	20	744	82	849	3	21	10	34	54	2.4	1.8

	pH (s.u.)	Alkalinity (mg/l)	Cond. (µmho/cm)	NH_3-N (µg/l)	NO_X-N (µg/l)	Diss. Org. N (µg/l)	Part. N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss. Org. P (µg/l)	Part. P (µg/l)	Total P (µg/l)	Color (Pt-Co)	Turbidity (NTU)	TSS (mg/l)
Mean Value:	**7.47**	**126**	**352**	**30**	**47**	**483**	**232**	**792**	**5**	**14**	**40**	**60**	**31**	**5.4**	**9.0**
Minimum Value:	**6.81**	**97.8**	**292**	**3**	**9**	**302**	**23**	**518**	**1**	**1**	**3**	**16**	**15**	**1.3**	**1.6**
Maximum Value:	**8.06**	**144**	**395**	**132**	**328**	**780**	**663**	**1139**	**16**	**99**	**277**	**310**	**54**	**15.4**	**28.6**
Log-Normal Mean:	**7.46**	**125**	**350**	**16**	**35**	**468**	**187**	**773**	**4**	**7**	**27**	**48**	**30**	**4.2**	**6.4**

B-3. Bulk Precipitation Samples

Chemical Characteristics of Bulk Precipitation Samples Collected at the Pioneer Key Regional Stormwater Facility from November 2009 - March 2010

Sample Type	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Cond. (µmho/cm)	NH_3-N (µg/l)	NO_X-N (µg/l)	Diss. Org. N (µg/l)	Part N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss. Org. P (µg/l)	Part P (µg/l)	Total P (µg/l)	Color (Pt-Co)	Turbidity (NTU)	TSS (mg/l)
Bulk Precip.	11/10/09	5.09	6.0	48	136	194	387	5	722	19	8	14	41	5	2.4	9.3
Bulk Precip.	11/25/09	6.21	8.0	30	375	256	944	216	1791	27	99	37	163	64	2.4	13.5
Bulk Precip.	12/01/09-12/03/09	6.87	20.2	69	57	209	567	114	947	1	1	18	20	7	3.0	11.0
Bulk Precip.	12/04/09-12/07/09	5.61	2.4	5	18	65	41	18	142	1	1	3	5	1	1.2	3.4
Bulk Precip.	12/08/09-12/15/09	5.66	1.8	100	1615	117	1115	400	3247	443	129	87	659	7	2.6	7.3
Bulk Precip.	12/17/09-12/18/09	5.53	2.0	55	1753	266	230	132	2381	1	12	50	63	8	1.1	5.0
Bulk Precip.	12/25/09	6.32	4.4	40	339	86	187	62	674	1	15	1	17	8	1.7	1.8
Bulk Precip.	1/1/10	6.18	8.8	30	202	164	97	118	581	1	1	2	4	7	1.4	0.8
Bulk Precip.	01/16/10-01/17/10	5.82	5.0	26	480	293	212	305	1290	4	13	28	45	4	8.0	7.7
Bulk Precip.	01/21/10-01/22/10	6.39	8.2	42	220	236	110	31	597	2	8	14	24	2	2.2	4.7
Bulk Precip.	1/24/10-01/25/10	5.82	4.2	22	215	262	233	197	907	4	32	14	50	35	4.3	8.0
Bulk Precip.	02/01/10-02/02/10	5.73	2.4	11	58	83	422	125	688	1	27	15	43	2	1.1	4.8
Bulk Precip.	2/5/10	6.53	4.2	24	144	171	147	29	491	1	6	16	23	2	4.0	23.0
Bulk Precip.	2/9/10	6.68	17.4	60	155	214	189	109	667	1	4	12	17	7	6.4	14.0
Bulk Precip.	2/12/10	5.62	2.4	13	170	221	110	17	518	10	1	20	31	3	0.8	2.9
Bulk Precip.	02/16/10-02/24/10	5.71	1.6	95	573	590	194	163	1520	94	2	31	127	11	5.9	17.0
Bulk Precip.	02/27/10-03/02/10	5.97	6.2	25	161	208	28	51	448	19	1	4	24	3	1.9	19.0
Bulk Precip.	03/03/10-03/13/10	5.81	4.8	15	95	5	243	60	403	1	2	1	4	3	1.1	5.3
Bulk Precip.	03/16/10-03/23/10	6.66	12.6	42	89	202	78	101	470	1	4	14	19	7	1.7	2.2
Bulk Precip.	3/25/10	6.12	15.8	16	97	184	36	29	346	1	8	9	18	3	2.3	5.2
Bulk Precip.	03/28/10-03/29/10	5.44	2.2	22	56	103	13	28	200	2	2	1	5	3	0.9	1.3

Mean Value:	**5.99**	**6.7**	**38**	**334**	**197**	**266**	**110**	**906**	**30**	**18**	**19**	**67**	**9**	**2.7**	**8.0**
Minimum Value:	**5.09**	**1.6**	**5**	**18**	**5**	**13**	**5**	**142**	**1**	**1**	**1**	**4**	**1**	**0.8**	**0.8**
Maximum Value:	**6.87**	**20.2**	**100**	**1753**	**590**	**1115**	**400**	**3247**	**443**	**129**	**87**	**659**	**64**	**8.0**	**23.0**
Log-Normal Mean:	**5.97**	**5.0**	**30**	**179**	**154**	**157**	**69**	**688**	**3**	**6**	**9**	**27**	**5**	**2.2**	**5.7**

APPENDIX C

LABORATORY QA DATA

SAMPLE DUPLICATE RECOVERY
FOR PIONEER KEY COLLECTED FROM
OCTOBER 2009 to MARCH 2010

PARAMETERS	UNITS	SAMPLE ID	SAMPLE DESCRIPTION	DATE COLLECTED	DATE RECEIVED	DATE ANALYZED	REPEAT 1	REPEAT 2	MEAN	s	% RELATIVE STD. DEVIATION (RSD)	ACCEPTANCE RANGE (% RSD)
pH	s.u.	09-3722	Site #4	10/9 - 10/16/09	10/16/09	10/16/09	7.73	7.72	7.7	0.0	**0.09**	0-2
pH	s.u.	09-3841	Site #4	10/22 - 10/30/09	10/30/09	11/02/09	7.89	7.87	7.9	0.0	**0.18**	0-2
pH	s.u.	09-3966	Site #4	11/16/09	11/16/09	11/16/09	8.00	7.96	8.0	0.0	**0.35**	0-2
pH	s.u.	09-4068	Site #4	11/16 - 11/24/09	11/24/09	11/30/09	7.75	7.80	7.8	0.0	**0.45**	0-2
pH	s.u.	09-4167	Rain	12/1 - 12/3/09	12/04/09	12/08/09	6.87	6.86	6.9	0.0	**0.10**	0-2
pH	s.u.	09-4208	Rain Field Dup	12/1 - 12/7/09	12/08/09	12/18/09	5.63	5.63	5.6	0.0	**0.00**	0-2
pH	s.u.	09-4443	Rain	12/17 - 12/18/09	12/22/09	12/31/09	5.53	5.53	5.5	0.0	**0.00**	0-2
pH	s.u.	10-0066	Rain	1/16 - 1/17/10	01/18/10	01/20/10	5.82	5.81	5.8	0.0	**0.12**	0-2
pH	s.u.	10-0164	Rain	1/21 - 1/22/10	01/25/10	01/27/10	6.39	6.38	6.4	0.0	**0.11**	0-2
pH	s.u.	10-0169	Rain	1/24 - 1/25/10	01/25/10	01/28/10	5.82	5.81	5.8	0.0	**0.12**	0-2
pH	s.u.	10-0293	Site #1	02/08/10	02/09/10	02/09/10	7.39	7.40	7.4	0.0	**0.10**	0-2
pH	s.u.	10-0298	Rain	02/05/10	02/09/10	02/09/10	6.53	6.52	6.5	0.0	**0.11**	0-2
pH	s.u.	10-0304	Rain	02/09/10	02/10/10	02/11/10	6.68	6.69	6.7	0.0	**0.11**	0-2
pH	s.u.	10-0450	Site #1	02/25/10	02/26/10	03/07/10	7.40	7.42	7.4	0.0	**0.19**	0-2
pH	s.u.	10-0593	Rain Blank	03/13/10	03/15/10	03/18/10	5.69	5.70	5.7	0.0	**0.12**	0-2
pH	s.u.	10-0723	Rain	3/16 - 3/23/10	03/25/10	03/26/10	6.66	6.67	6.7	0.0	**0.11**	0-2
Alkalinity	mg/l	09-3722	Site #4	10/9 - 10/16/09	10/16/09	10/16/09	134	134	134.0	0.0	**0.00**	0-4
Alkalinity	mg/l	09-3841	Site #4	10/22 - 10/30/09	10/30/09	11/02/09	139	138	138.5	0.7	**0.51**	0-4
Alkalinity	mg/l	09-3966	Site #4	11/16/09	11/16/09	11/16/09	141	141	141.0	0.0	**0.00**	0-4
Alkalinity	mg/l	09-4068	Site #4	11/16 - 11/24/09	11/24/09	11/30/09	138	138	138.0	0.0	**0.00**	0-4
Alkalinity	mg/l	09-4167	Rain	12/1 - 12/3/09	12/04/09	12/08/09	20.2	19.8	20.0	0.3	**1.41**	0-4
Alkalinity	mg/l	09-4208	Rain Field Dup	12/1 - 12/7/09	12/08/09	12/18/09	2.2	2.2	2.2	0.0	**0.00**	0-4
Alkalinity	mg/l	09-4443	Rain	12/17 - 12/18/09	12/22/09	12/31/09	2.0	2.0	2.0	0.0	**0.00**	0-4
Alkalinity	mg/l	10-0066	Rain	1/16 - 1/17/10	01/18/10	01/20/10	5.0	5.0	5.0	0.0	**0.00**	0-4
Alkalinity	mg/l	10-0164	Rain	1/21 - 1/22/10	01/25/10	01/27/10	8.2	8.0	8.1	0.1	**1.75**	0-4
Alkalinity	mg/l	10-0169	Rain	1/24 - 1/25/10	01/25/10	01/28/10	4.2	4.2	4.2	0.0	**0.00**	0-4
Alkalinity	mg/l	10-0293	Site #1	02/08/10	02/09/10	02/09/10	180	180	180	0.0	**0.00**	0-4
Alkalinity	mg/l	10-0298	Rain	02/05/10	02/09/10	02/09/10	4.2	4.2	4.2	0.0	**0.00**	0-4
Alkalinity	mg/l	10-0304	Rain	02/09/10	02/10/10	02/11/10	17.4	16.8	17.1	0.4	**2.48**	0-4
Alkalinity	mg/l	10-0450	Site #1	02/25/10	02/26/10	03/07/10	79.8	79.4	79.6	0.3	**0.36**	0-4
Alkalinity	mg/l	10-0593	Rain Blank	03/13/10	03/15/10	03/18/10	0.6	0.6	0.6	0.0	**0.00**	0-4
Alkalinity	mg/l	10-0723	Rain	3/16 - 3/23/10	03/25/10	03/26/10	12.6	12.8	12.7	0.1	**1.11**	0-4

SAMPLE DUPLICATE RECOVERY
FOR PIONEER KEY COLLECTED FROM
OCTOBER 2009 to MARCH 2010

PARAMETERS	UNITS	SAMPLE ID	SAMPLE DESCRIPTION	DATE COLLECTED	DATE RECEIVED	DATE ANALYZED	REPEAT 1	REPEAT 2	MEAN	s	% RELATIVE STD. DEVIATION (RSD)	ACCEPTANCE RANGE (% RSD)
Conductivity	μΩ	09-3622	Site #4	10/02/09-10/09/09	10/09/09	10/29/09	351	351	351	0.0	**0.00**	0-5
Conductivity	μΩ	09-3900	Rain Blank	11/09/09	11/09/09	11/17/09	2.0	2.0	2.0	0.0	**0.00**	0-5
Conductivity	μΩ	09-3966	Site #4	11/11/09-11/16/09	11/16/09	11/17/09	393	393	393	0.0	**0.00**	0-5
Conductivity	μΩ	09-4074	Site #2	11/25/09	11/30/09	12/07/09	96.9	96.9	96.9	0.0	**0.00**	0-5
Conductivity	μΩ	09-4167	Rain	12/01/09-12/03/09	12/04/09	12/07/09	69.1	69.1	69.1	0.0	**0.00**	0-5
Conductivity	μΩ	09-4211	Site #3 Blank	12/07/09	12/08/09	12/29/09	1.8	1.8	1.8	0.0	**0.00**	0-5
Conductivity	μΩ	09-4333	Rain	12/08/09-12/15/09	12/17/09	12/29/09	100	99.9	100	0.1	**0.07**	0-5
Conductivity	μΩ	10-0001	Site #1	01/01/10	01/01/10	01/25/10	168	168	168	0.0	**0.00**	0-5
Conductivity	μΩ	10-0066	Rain	01/16/10-01/17/10	01/18/10	01/25/10	26.0	26.0	26.0	0.0	**0.00**	0-5
Conductivity	μΩ	10-0161	Site #1	01/22/10	01/25/10	01/25/10	406	406	406	0.0	**0.00**	0-5
Conductivity	μΩ	10-0169	Rain	01/24/10-01/25/10	01/25/10	01/25/10	22.3	22.3	22.3	0.0	**0.00**	0-5
Conductivity	μΩ	10-0231	Site #4	01/25/10-02/01/10	02/01/10	02/05/10	373	373	373	0.0	**0.00**	0-5
Conductivity	μΩ	10-0275	Site #4	02/01/10-02/03/10	02/04/10	02/05/10	353	353	353	0.0	**0.00**	0-5
Conductivity	μΩ	10-0452	Site #3	02/15/10-02/25/10	02/26/10	03/04/10	467	467	467	0.0	**0.00**	0-5
Conductivity	μΩ	10-0584	Site #1	03/11/10-03/13/10	03/15/10	03/25/10	193	194	194	0.7	**0.37**	0-5
Conductivity	μΩ	10-0721	Site #3	03/13/10-03/24/10	03/25/10	04/13/10	296	294	295	1.4	**0.48**	0-5
Turbidity	NTU	09-3616	#1 SB	10/09/09	10/09/09	10/09/09	0	0	0	0.0	**0.00**	0 - 3.7
Turbidity	NTU	09-3719	Site #1	10/16/09	10/16/09	10/16/09	0.3	0.3	0.3	0.0	**0.00**	0 - 3.7
Turbidity	NTU	09-3900	REB	11/09/09	11/09/09	11/10/09	0	0	0	0.0	**0.00**	0 - 3.7
Turbidity	NTU	09-3955	Rain	11/10/09	11/12/09	11/12/09	2.4	2.4	2.4	0.0	**0.00**	0 - 3.7
Turbidity	NTU	09-4068	Site #4	11/16/09 - 11/24/09	11/24/09	11/25/09	1.4	1.4	1.4	0.0	**0.00**	0 - 3.7
Turbidity	NTU	09-4165	Site #2	12/01/09 - 12/3/09	12/04/09	12/03/09	7.5	7.4	7.5	0.1	**0.95**	0 - 3.7
Turbidity	NTU	09-4167	Rain	12/01/09 - 12/3/09	12/04/09	12/03/09	3	3	3.0	0.0	**0.00**	0 - 3.7
Turbidity	NTU	10-0004	Site #4	12/28/09 - 01/04/10	01/04/10	01/04/10	6	6.2	6.1	0.1	**2.32**	0 - 3.7
Turbidity	NTU	10-0066	Rain	1/16 - 1/17/10	01/18/10	01/18/10	8	7.8	7.9	0.1	**1.79**	0 - 3.7
Turbidity	NTU	10-0164	Rain	1/21 - 1/22/10	01/25/10	01/25/10	2.2	2.2	2.2	0.0	**0.00**	0 - 3.7
Turbidity	NTU	10-0231	Site #4	1/25 - 2/1/10	02/01/10	02/02/10	10	9.9	10.0	0.1	**0.71**	0 - 3.7
Turbidity	NTU	10-0276	Rain	2/1 - 2/3/10	02/04/10	02/04/10	1.1	1.1	1.1	0.0	**0.00**	0 - 3.7
Turbidity	NTU	10-0281	Rain Blank	02/02/10	02/04/10	02/04/10	0	0	0	0.0	**0.00**	0 - 3.7
Turbidity	NTU	10-0371	Rain	02/12/10	02/16/10	02/16/10	0.8	0.8	0.8	0.0	**0.00**	0 - 3.7
Turbidity	NTU	10-0454	Rain	2/16 - 2/24/10	02/26/10	03/02/10	5.9	5.8	5.9	0.1	**1.21**	0 - 3.7
Turbidity	NTU	10-0473	Rain	2/27 - 3/3/10	03/04/10	03/05/10	1.9	1.9	1.9	0.0	**0.00**	0 - 3.7

SAMPLE DUPLICATE RECOVERY
FOR PIONEER KEY COLLECTED FROM
OCTOBER 2009 to MARCH 2010

PARAMETERS	UNITS	SAMPLE ID	SAMPLE DESCRIPTION	DATE COLLECTED	DATE RECEIVED	DATE ANALYZED	REPEAT 1	REPEAT 2	MEAN	s	% RELATIVE STD. DEVIATION (RSD)	ACCEPTANCE RANGE (% RSD)
TSS	mg/L	09-3622	Site #4	10/2 - 10/9/09	10/09/09	10/13/09	6.6	6.8	6.7	0.1	**2.11**	0 - 13
TSS	mg/L	09-3722	Site #4	10/9 - 10/16/9	10/16/09	10/17/09	1.6	1.5	1.5	0.1	**4.71**	0 - 13
TSS	mg/L	09-3752	Site #4	10/16 - 10/22/09	10/22/09	10/24/09	2.7	2.9	2.8	0.1	**4.98**	0 - 13
TSS	mg/L	09-3841	Site #4 Dup	10/22 - 10/30/09	10/30/09	10/30/09	3.5	3.8	3.7	0.2	**4.82**	0 - 13
TSS	mg/L	09-4068	Site #4	11/16 - 11/24/09	11/24/09	11/24/09	1.6	1.6	1.6	0.0	**0.00**	0 - 13
TSS	mg/L	09-4167	Rain	12/1 - 12/3/09	12/04/09	12/07/09	11	11	11.0	0.0	**0.00**	0 - 13
TSS	mg/L	09-4208	Rain Field Dup	12/4 - 12/7/09	12/08/09	12/11/09	3.5	3.5	3.5	0.0	**0.00**	0 - 13
TSS	mg/L	10-0164	Rain	1/21 - 1/22/10	01/25/10	01/25/10	4.74	5.15	4.9	0.3	**5.86**	0 - 13
TSS	mg/L	10-0275	Site #4	2/1 - 2/3/10	02/04/10	02/04/09	23.1	23.3	23.2	0.1	**0.61**	0 - 13
TSS	mg/L	10-0281	Rain Blank	2/1 - 2/3/10	02/04/10	02/04/10	0.3	0.3	0.3	0.0	**0.00**	0 - 13
TSS	mg/L	10-0371	Rain	02/12/10	02/16/10	02/16/10	2.9	3.0	3.0	0.1	**2.40**	0 - 13
TSS	mg/L	10-0454	Rain	2/16 - 2/24/10	02/26/10	03/02/10	17	17	17.0	0.0	**0.00**	0 - 13
TSS	mg/L	10-0587	Site #4	3/3 - 3/13/10	03/15/10	03/17/10	28.0	27.3	27.7	0.5	**1.79**	0 - 13
TSS	mg/L	10-0593	Rain	03/13/10	03/15/10	03/17/10	0.4	0.4	0.4	0.0	**0.00**	0 - 13
TSS	mg/L	10-0723	Rain	3/16 - 3/23/10	03/25/10	03/26/10	2.2	2	2.1	0.1	**6.73**	0 - 13
TSS	mg/L	10-0756	Rain	3/28 - 3/29/10	03/30/10	04/01/10	1.3	1.3	1.3	0.0	**0.00**	0 - 13
Ammonia	µg/l	09-3720p	Site #2	10/09/09-10/16/09	10/16/09	10/28/09	297	295	296.0	1.4	**0.48**	0-10
Ammonia	µg/l	09-3841p	Site #4	10/22/09-10/30/09	10/30/09	10/30/09	22	25	23.5	1.5	**6.33**	0-10
Ammonia	µg/l	09-3897p	Site #2 Sampler Blank	11/09/09	11/09/09	11/30/09	0	0	0	0.0	**0.00**	0-10
Ammonia	µg/l	09-4068p	Site #4	11/16 - 11/24/09	11/24/09	12/01/09	9	7	8.0	0.8	**9.78**	0-10
Ammonia	µg/l	09-4208p	Rain Field Dup	12/04/09-12/07/09	12/08/09	12/18/09	21	18	19.5	1.5	**7.63**	0-10
Ammonia	µg/l	10-0010P	Rain Equipment Blank	01/04/10	01/04/10	01/15/10	1	1	1.0	0.0	**0.00**	0-10
Ammonia	µg/l	10-0066P	Rain	01/16/10-01/17/10	01/18/10	02/09/10	480	487	483.5	4.9	**1.02**	0-10
Ammonia	µg/l	10-0169P	Rain	1/24/10-01/25/10	01/25/10	02/09/10	215	213	214.0	1.4	**0.66**	0-10
Ammonia	µg/l	10-0273P	Site # 2	02/01/10-02/02/10	02/04/10	02/09/10	26	22	24.0	2.2	**9.15**	0-10
Ammonia	µg/l	10-0273P	Site # 2	02/01/10-02/02/10	02/04/10	02/10/10	25	27	26.0	1.4	**5.44**	0-10
Ammonia	µg/l	10-0294P	Site # 2	02/05/10	02/09/10	02/10/10	43	40	41.5	2.1	**5.11**	0-10
Ammonia	µg/l	10-0368P	Site # 2	02/12/10	02/16/10	03/01/10	203	196	199.5	4.9	**2.48**	0-10
Ammonia	µg/l	10-0720P	Site # 2	03/21/10	03/25/10	03/25/10	19	19	19.0	0.0	**0.00**	0-10
Ammonia	µg/l	10-0754P	Site # 3	03/26/10-03/29/10	03/30/10	04/12/10	60	54	57.0	4.2	**7.44**	0-10

SAMPLE DUPLICATE RECOVERY

FOR PIONEER KEY COLLECTED FROM

OCTOBER 2009 to MARCH 2010

PARAMETERS	UNITS	SAMPLE ID	SAMPLE DESCRIPTION	DATE COLLECTED	DATE RECEIVED	DATE ANALYZED	REPEAT 1	REPEAT 2	MEAN	s	% RELATIVE STD. DEVIATION (RSD)	ACCEPTANCE RANGE (% RSD)
NOx	µg/l	09-3719f	Site #1	10/09/09-10/16/09	10/16/09	10/17/09	0	0	0	0.0	**0.00**	0-4
NOx	µg/l	09-3841f	Site #4	10/22/09-10/30/09	10/30/09	10/30/09	28	29	28.5	0.7	**2.48**	0-4
NOx	µg/l	09-3955f	Rain	11/10/09	11/12/09	11/13/09	194	184	188.8	6.7	**3.56**	0-4
NOx	µg/l	09-4067f	Site #1	11/16 - 11/24/09	11/24/09	11/25/09	3	4	3.5	0.1	**2.05**	0-4
NOx	µg/l	09-4167f	Rain	12/01/09-12/03/09	12/04/09	12/04/09	209	207	208.0	1.4	**0.68**	0-4
NOx	µg/l	09-4208f	Rain Field Dup	12/04/09-12/07/09	12/08/09	12/09/09	64	62	63.0	1.4	**2.24**	0-4
NOx	µg/l	09-4333f	Rain	12/08/09-12/15/09	12/17/09	12/18/09	104	98	100.8	3.9	**3.86**	0-4
NOx	µg/l	10-010	Rain Equipment Blank	01/04/10	01/04/10	01/06/10	1	1	1.0	0.0	**0.00**	0-4
NOx	µg/l	10-066	Rain	01/16/10-01/17/10	01/18/10	01/20/10	293	300	296.5	4.9	**1.67**	0-4
NOx	µg/l	10-275	Site # 4	02/01/10-02/03/10	02/04/10	02/05/10	68	64	65.8	2.5	**3.76**	0-4
NOx	µg/l	10-302	Site # 3	02/08/10-02/10/10	02/10/10	02/10/10	271	273	272.0	1.4	**0.52**	0-4
NOx	µg/l	10-0473F	Rain	02/27/10-03/02/10	03/04/10	03/05/10	208	209	208.5	0.7	**0.34**	0-4
NOx	µg/l	10-0588F	Rain	03/03/10-03/13/10	03/15/10	03/17/10	157	150	153.5	4.9	**3.22**	0-4
NOx	µg/l	10-0720F	Site # 2	03/21/10	03/25/10	03/26/10	771	770	770.5	0.7	**0.09**	0-4
NOx	µg/l	10-0754F	Site # 3	03/26/10-03/29/10	03/30/10	03/31/10	209	203	206.0	4.2	**2.06**	0-4
Total N	µg/l	09-3720fp	Site #2	10/09/09-10/16/09	10/16/09	11/03/09	653	670	661.5	12.0	**1.82**	0-10
Total N	µg/l	09-3616p	Site #1 Sampler Blank	10/09/09	10/09/09	11/09/09	0	0	0	0.0	**0.00**	0-10
Total N	µg/l	09-3621fp	Site #3	10/02/09-10/09/09	10/09/09	11/09/09	1083	1164	1123.7	57.0	**5.07**	0-10
Total N	µg/l	09-3955p	Rain	11/10/09	11/12/09	12/15/09	722	734	728.0	8.5	**1.17**	0-10
Total N	µg/l	09-3895fp	Site #4	11/03/09-11/09/09	11/09/09	12/15/09	516	497	506.5	13.4	**2.65**	0-10
Total N	µg/l	09-4077p	Rain	11/25/09	11/30/09	12/22/09	419	425	422.0	4.2	**1.01**	0-10
Total N	µg/l	09-4164p	Site #1	12/01/09-12/03/09	12/04/09	12/22/09	481	479	480.0	1.4	**0.29**	0-10
Total N	µg/l	10-066P	Rain	01/16/10-01/17/10	01/18/10	02/11/10	1290	1263	1276.5	19.1	**1.50**	0-10
Total N	µg/l	10-010P	Rain Equipment Blank	01/04/10	01/04/10	02/12/10	0	0	0	0.0	**0.00**	0-10
Total N	µg/l	10-010FP	Rain Equipment Blank	01/04/10	01/04/10	02/12/10	0	0	0	0.0	**0.00**	0-10
Total N	µg/l	10-168P	Site # 4	01/22/10-01/25/10	01/25/10	02/15/10	890	897	893.5	4.9	**0.55**	0-10
Total N	µg/l	10-168FP	Site # 4	01/22/10-01/25/10	01/25/10	02/15/10	565	565	565.0	0.0	**0.00**	0-10
Total N	µg/l	10-0296f	Site # 3	02/03/10-02/08/10	02/09/10	02/22/10	945	918	931.5	19.1	**2.05**	0-10
Total N	µg/l	10-0300f	Site # 1	02/09/10	02/10/10	02/22/10	530	513	521.5	12.0	**2.31**	0-10
Total N	µg/l	10-0453FP	Site # 4	02/15/10-02/25/10	02/26/10	03/05/10	398	397	397.5	0.7	**0.18**	0-10
Total N	µg/l	10-0471FP	Site # 3	02/25/10-03/03/10	03/04/10	03/29/10	1034	1009	1021.5	17.7	**1.73**	0-10

SAMPLE DUPLICATE RECOVERY

FOR PIONEER KEY COLLECTED FROM

OCTOBER 2009 to MARCH 2010

PARAMETERS	UNITS	SAMPLE ID	SAMPLE DESCRIPTION	DATE COLLECTED	DATE RECEIVED	DATE ANALYZED	REPEAT 1	REPEAT 2	MEAN	s	% RELATIVE STD. DEVIATION (RSD)	ACCEPTANCE RANGE (% RSD)
SRP	µg/l	09-3719	Site #1	10/09/09-10/16/09	10/16/09	10/17/09	42	43	42.5	0.7	**1.66**	0-5
SRP	µg/l	09-3841f	Site #4	10/22/09-10/30/09	10/30/09	10/30/09	3	2	2.5	0.1	**2.89**	0-5
SRP	µg/l	09-3955f	Rain	11/10/09	11/12/09	11/13/09	19	20	19.7	0.4	**1.99**	0-5
SRP	µg/l	09-4067f	Site #1	11/16 - 11/24/09	11/24/09	11/25/09	10	11	10.5	0.1	**0.68**	0-5
SRP	µg/l	09-4167f	Rain	12/01/09-12/03/09	12/04/09	12/04/09	1	1	1.0	0.0	**0.00**	0-5
SRP	µg/l	09-4208f	Rain Field Dup	12/04/09-12/07/09	12/08/09	12/09/09	0	0	0	0.0	**0.00**	0-5
SRP	µg/l	09-4333f	Rain	12/08/09-12/15/09	12/17/09	12/18/09	377	382	379.5	3.5	**0.93**	0-5
SRP	µg/l	10-0010f	Rain Equipment Blank	01/04/10	01/04/10	01/06/10	0	0	0	0.0	**0.00**	0-5
SRP	µg/l	10-0066f	Rain	01/16/10-01/17/10	01/18/10	01/20/10	4	3	3.5	0.1	**2.05**	0-5
SRP	µg/l	10-0275f	Site # 4	02/01/10-02/03/10	02/04/10	02/05/10	3	2	2.5	0.1	**2.89**	0-5
SRP	µg/l	10-0302f	Site # 3	02/08/10-02/10/10	02/10/10	02/10/10	1	1	1	0.0	**0.00**	0-5
SRP	µg/l	10-0473F	Rain	02/27/10-03/02/10	03/04/10	03/05/10	19	18	18.5	0.7	**3.82**	0-5
SRP	µg/l	10-0588F	Rain	03/03/10-03/13/10	03/15/10	03/17/10	1	1	1	0.0	**0.00**	0-5
SRP	µg/l	10-0720F	Site # 2	03/21/10	03/25/10	03/26/10	60	60	60.0	0.0	**0.00**	0-5
SRP	µg/l	10-0754F	Site # 3	03/26/10-03/29/10	03/30/10	03/31/10	1	2	1.5	0.1	**4.88**	0-5
Total P	µg/l	09-3720fp	Site #2	10/09/09-10/16/09	10/16/09	11/03/09	10	11	10.5	0.1	**0.68**	0-5
Total P	µg/l	09-3616p	Site #1 Sampler Blank	10/09/09	10/09/09	11/09/09	8	8	8.0	0.0	**0.00**	0-5
Total P	µg/l	09-3621fp	Site #3	10/02/09-10/09/09	10/09/09	11/09/09	51	48	49.0	2.1	**4.33**	0-5
Total P	µg/l	09-3955p	Rain	11/10/09	11/12/09	12/15/09	41	42	41.5	0.7	**1.70**	0-5
Total P	µg/l	09-3895fp	Site #4	11/03/09-11/09/09	11/09/09	12/15/09	2	2	2.0	0.0	**0.00**	0-5
Total P	µg/l	09-4077P	Rain	11/25/09	11/30/09	12/22/09	163	159	161.0	2.8	**1.76**	0-5
Total P	µg/l	09-4164P	Site #1	12/01/09-12/03/09	12/04/09	12/22/09	83	87	85.0	2.8	**3.33**	0-5
Total P	µg/l	10-0066P	Rain	01/16/10-01/17/10	01/18/10	02/11/10	45	46	45.5	0.7	**1.55**	0-5
Total P	µg/l	10-0010P	Rain Equipment Blank	01/04/10	01/04/10	02/12/10	0	0	0	0.0	**0.00**	0-5
Total P	µg/l	10-0010FP	Rain Equipment Blank	01/04/10	01/04/10	02/12/10	0	0	0	0.0	**0.00**	0-5
Total P	µg/l	10-0168P	Site # 4	01/22/10-01/25/10	01/25/10	02/15/10	93	94	93.5	0.7	**0.76**	0-5
Total P	µg/l	10-168FP	Site # 4	01/22/10-01/25/10	01/25/10	02/15/10	22	21	21.5	0.7	**3.29**	0-5
Total P	µg/l	10-0296f	Site # 3	02/03/10-02/08/10	02/09/10	02/22/10	6	7	6.5	0.1	**1.10**	0-5
Total P	µg/l	10-0300f	Site # 1	02/09/10	02/10/10	02/22/10	21	20	20.5	0.7	**3.45**	0-5
Total P	µg/l	10-0370FP	Site # 4	02/10/10-02/15/10	02/16/10	02/22/10	13	12	12.5	0.1	**0.57**	0-5
Total P	µg/l	10-0453FP	Site # 4	02/15/10-02/25/10	02/26/10	03/05/10	6	6	6.0	0.0	**0.00**	0-5

SAMPLE DUPLICATE RECOVERY

FOR PIONEER KEY COLLECTED FROM

OCTOBER 2009 to MARCH 2010

PARAMETERS	UNITS	SAMPLE ID	SAMPLE DESCRIPTION	DATE COLLECTED	DATE RECEIVED	DATE ANALYZED	REPEAT 1	REPEAT 2	MEAN	s	% RELATIVE STD. DEVIATION (RSD)	ACCEPTANCE RANGE (% RSD)
Color	PCU	09-3622	Site #4	10/02/09-10/09/09	10/09/09	10/09/09	38	40	39.0	1.4	**3.63**	0-5
Color	PCU	09-3722	Site #4	10/9/2009-10/16/09	10/16/09	10/16/09	36	37	36.5	0.7	**1.94**	0-5
Color	PCU	09-3841	Site #4	10/22/09-10/30/09	10/30/09	10/30/09	30	30	30.0	0.0	**0.00**	0-5
Color	PCU	09-3955	Rain	11/10/09	11/12/09	11/13/09	5	5	5.0	0.0	**0.00**	0-5
Color	PCU	09-4068	Site #4	11/16/09-11/24/09	11/24/09	11/25/09	34	34	34.0	0.0	**0.00**	0-5
Color	PCU	09-4167	Rain	12/1/09-12/3/09	12/04/09	12/04/09	7	7	7.0	0.0	**0.00**	0-5
Color	PCU	09-4213	Rain Blank	12/07/09	12/08/09	12/08/09	0	0	0	0.0	**0.00**	0-5
Color	PCU	10-010F	Rain Blank	01/04/10	01/04/10	01/05/10	0.1	0.1	0.1	0.0	**0.00**	0-5
Color	PCU	10-169F	Rain	01/24/10-01/25/10	01/25/10	01/26/10	35	35	35.0	0.0	**0.00**	0-5
Color	PCU	10-275F	Site #4	02/01/10-02/03/10	02/04/10	02/04/10	27	27	27.0	0.0	**0.00**	0-5
Color	PCU	10-281F	Rain Blank	02/03/10	02/04/10	02/04/10	0	0	0	0.0	**0.00**	0-5
Color	PCU	10-454F	Rain	02/16/10-02/24/10	02/26/10	02/26/10	11	11	11.0	0.0	**0.00**	0-5
Color	PCU	10-473F	Rain	02/27/10-03/02/10	03/04/10	03/05/10	3	3	3.0	0.0	**0.00**	0-5
Color	PCU	10-593F	Rain EB	03/13/10	03/15/10	03/16/10	0	0	0	0.0	**0.00**	0-5
Color	PCU	10-721F	Site #3	03/13/10-03/24/10	03/25/10	03/26/10	21	21	21.0	0.0	**0.00**	0-5
Color	PCU	10-754F	Site #3	03/26/10-03/29/10	03/30/10	03/30/10	28	28	28.0	0.0	**0.00**	0-5

MATRIX SPIKE RECOVERY STUDY
PIONEER KEY SAMPLES COLLECTED FROM:
August 2008 - February 2009

PARAMETERS	UNITS	SAMPLE ID	SAMPLE DESCRIPTION	DATE COLLECTED	DATE RECEIVED	DATE ANALYZED	INITIAL CONC.	INITIAL VOLUME (ml)	SPIKE CONC.	SPIKE VOLUME ADDED (ml)	Dilution Factor	THEOR. CONC.	ACTUAL CONC.	PERCENT RECOVERY	ACCEPTANCE RANGE
Alkalinity	mg/l	09-3841	Site #4	10/22 - 10/30/09	10/30/09	11/02/09	138	50	1000	0.4	1	146	148	101%	95.6 - 105
Alkalinity	mg/l	09-3966	Site #4	11/16/09	11/16/09	11/16/09	141	50	1000	0.4	1	149	150	101%	95.6 - 105
Alkalinity	mg/l	09-4068	Site #4	11/16 - 11/24/09	11/24/09	11/30/09	138	50	1000	0.4	1	146	147	101%	95.6 - 105
Alkalinity	mg/l	09-4443	Rain	12/17 - 12/18/09	12/22/09	12/31/09	2	50	1000	0.4	1	10.0	10.4	104%	95.6 - 105
Alkalinity	mg/l	10-0066	Rain	1/16 - 1/17/10	01/18/10	01/20/10	5	50	1000	0.3	1	11.0	11.6	105%	95.6 - 105
Alkalinity	mg/l	10-0298	Rain	02/05/10	02/09/10	02/09/10	4.2	50	1000	0.3	1	10.2	10.0	98%	95.6 - 105
Alkalinity	mg/l	10-0304	Rain	02/09/10	02/10/10	02/11/10	16.8	50	1000	0.3	1	22.8	23.2	102%	95.6 - 105
Alkalinity	mg/l	10-0593	Rain Blank	03/13/10	03/15/10	03/18/10	0.6	50	1000	0.3	1	6.6	6.8	103%	95.6 - 105
Alkalinity	mg/l	10-0723	Rain	3/16 - 3/23/10	03/25/10	03/26/10	12.8	50	1000	0.3	1	18.8	19.2	102%	95.6 - 105
Turbidity	NTU	09-3616	#1 Sample Blank	10/09/09	10/09/09	10/09/09	0	50	4000	0.375	1	30.0	31.0	103%	87.4 - 110
Turbidity	NTU	09-3719	Site #1	10/16/09	10/16/09	10/16/09	0.3	50	4000	0.375	1	30.3	31.2	103%	87.4 - 110
Turbidity	NTU	09-3900	Rain Equipment Blank	11/09/09	11/09/09	11/10/09	0.1	50	4000	0.375	1	30.1	30.1	100%	87.4 - 110
Turbidity	NTU	09-3955	Rain	11/10/09	11/12/09	11/12/09	2.4	50	4000	0.375	1	32.4	33.5	103%	87.4 - 110
Turbidity	NTU	10-0066	Rain	1/16 - 1/17/10	01/18/10	01/18/10	7.8	50	4000	0.25	1	27.8	28.2	101%	87.4 - 110
Turbidity	NTU	10-0164	Rain	1/21 - 1/22/10	01/25/10	01/25/10	2.2	50	4000	0.25	1	22.2	22.3	100%	87.4 - 110
Turbidity	NTU	10-0231	Site #4	1/25 - 2/1/10	02/01/10	02/02/10	9.9	50	4000	0.25	1	29.9	31.1	104%	87.4 - 110
Turbidity	NTU	10-0276	Rain	2/1 - 2/3/10	02/04/10	02/04/10	1.1	50	4000	0.25	1	21.1	20.9	99%	87.4 - 110
Turbidity	NTU	10-0371	Rain	02/12/10	02/16/10	02/16/10	0.8	50	4000	0.25	1	20.8	22.2	107%	87.4 - 110
Ammonia	µg/l	09-3720P	Site #2	10/09/09-10/16/09	10/16/09	10/28/09	297	10	10000	0.15	1	447.0	430	96%	80-120
Ammonia	µg/l	10-0294P	Site # 2	02/05/10	02/09/10	02/10/10	40	10	10000	1.0	1	1040.0	943	91%	80-120
Ammonia	µg/l	10-0368P	Site # 2	02/12/10	02/16/10	03/01/10	203	10	10000	1.0	1	1203.0	1051	87%	80-120
Ammonia	µg/l	10-0593	Rain Equipment Blank	03/13/10	03/15/10	03/25/10	0	10	10000	1.0	1	1000.0	971	97%	80-120
Ammonia	µg/l	10-0720P	Site # 2	03/21/10	03/25/10	03/25/10	19	10	10000	1.0	1	1019.0	1091	107%	80-120
NOx	µg/l	09-3841F	Site #4	10/22/09-10/30/09	10/30/09	10/30/09	34	10	100000	0.35	1	3534.0	3422	97%	92-111
NOx	µg/l	09-4333F	Rain	12/08/09-12/15/09	12/17/09	12/18/09	118	10	10000	0.35	1	468.0	478	102%	92-111
NOx	µg/l	10-0275F	Site # 4	02/01/10-02/03/10	02/04/10	02/05/10	68	10	11300	0.2	1	294.0	294	100%	92-111
NOx	µg/l	10-0473F	Rain	02/27/10-03/02/10	03/04/10	03/05/10	208	10	11300	0.2	1	434.0	430	99%	92-111
NOx	µg/l	10-0720F	Site # 2	03/21/10	03/25/10	03/26/10	771	10	11300	0.15	1	940.5	963	102%	92-111
NOx	µg/l	10-0754F	Site # 3	03/26/10-03/29/10	03/30/10	03/31/10	209	10	11300	0.15	1	378.5	397	105%	92-111
Total N	µg/l	09-3616P	Site #1 Sampler Blank	10/09/09	10/09/09	11/09/09	0	5	100000	0.1	1	2000.0	2095	105%	90-110
Total N	µg/l	09-4442FP	Site #4	12/17/09-12/21/09	12/22/09	02/04/10	385	5	226000	0.05	1	2645.0	2545	96%	90-110
Total N	µg/l	10-0066P	Rain	01/16/10-01/17/10	01/18/10	02/11/10	1263	5	226000	0.05	1	3523.0	3299	94%	90-110
Total N	µg/l	10-0010FP	Rain Equipment Blank	01/04/10	01/04/10	02/12/10	0	5	226000	0.05	1	2260.0	2176	96%	90-110
Total N	µg/l	10-0168FP	Site # 4	01/22/10-01/25/10	01/25/10	02/15/10	565	5	226000	0.05	1	2825.0	2952	104%	90-110
Total N	µg/l	10-0300FP	Site # 1	02/09/10	02/10/10	02/22/10	530	5	226000	0.06	1	3242.0	3104	96%	90-110
Total N	µg/l	10-0588FP	Rain	03/03/10-03/13/10	03/15/10	04/05/10	343	5	226000	0.05	1	2603.0	2596	100%	90-110
Total N	µg/l	10-0719P	Site # 1	03/13/10-03/24/10	03/25/10	04/15/10	1575	5	226000	0.04	1	3383.0	3619	107%	90-110
Total N	µg/l	10-0752FP	Site # 1	03/26/10-03/29/10	03/30/10	04/16/09	1168	5	226000	0.04	1	2976.0	3055	103%	90-110

MATRIX SPIKE RECOVERY STUDY
PIONEER KEY SAMPLES COLLECTED FROM:
August 2008 - February 2009

PARAMETERS	UNITS	SAMPLE ID	SAMPLE DESCRIPTION	DATE COLLECTED	DATE RECEIVED	DATE ANALYZED	INITIAL CONC.	INITIAL VOLUME (ml)	SPIKE CONC.	SPIKE VOLUME ADDED (ml)	Dilution Factor	THEOR. CONC.	ACTUAL CONC.	PERCENT RECOVERY	ACCEPTANCE RANGE
SRP	µg/l	09-3841F	Site #4	10/22/09-10/30/09	10/30/09	10/30/09	3	10	10000	0.75	1	753	743	99%	90-110
SRP	µg/l	09-3955F	Rain	11/10/09	11/12/09	11/13/09	19	10	10000	0.5	1	519	505	97%	90-110
SRP	µg/l	09-4333F	Rain	12/08/09-12/15/09	12/17/09	12/18/09	443	10	10000	0.3	1	743	780	105%	90-110
SRP	µg/l	10-0275F	Site # 4	02/01/10-02/03/10	02/04/10	02/05/10	3	10	10000	0.2	1	203	216	106%	90-110
SRP	µg/l	10-0473F	Rain	02/27/10-03/02/10	03/04/10	03/05/10	19	10	10000	0.4	1	419	439	105%	90-110
SRP	µg/l	10-0720F	Site # 2	03/21/10	03/25/10	03/26/10	60	10	10000	0.2	1	260	261	100%	90-110
SRP	µg/l	10-0754F	Site # 3	03/26/10-03/29/10	03/30/10	03/31/10	1	10	10000	0.15	1	151	159	105%	90-110
Total P	µg/l	09-3616P	Site #1 Sampler Blank	10/09/09	10/09/09	11/09/09	8	5	50000	0.05	1	508.0	496	98%	94-106
Total P	µg/l	09-4442FP	Site #4	12/17/09-12/21/09	12/22/09	02/04/10	15	5	10000	0.25	1	515.0	540	105%	94-106
Total P	µg/l	10-066P	Rain	01/16/10-01/17/10	01/18/10	02/11/10	46	5	10000	0.25	1	546.0	567	104%	94-106
Total P	µg/l	10-010FP	Rain Equipment Blank	01/04/10	01/04/10	02/12/10	23	5	10000	0.25	1	523.0	523	100%	94-106
Total P	µg/l	10-168FP	Site # 4	01/22/10-01/25/10	01/25/10	02/15/10	22	5	10000	0.25	1	522.0	495	95%	94-106
Total P	µg/l	10-0300FP	Site # 1	02/09/10	02/10/10	02/22/10	21	5	10000	0.25	1	521.0	526	101%	94-106
Total P	µg/l	10-0588FP	Rain	03/03/10-03/13/10	03/15/10	04/05/10	0	5	10000	0.25	1	500.0	468	94%	94-106
Total P	µg/l	10-0719P	Site # 1	03/13/10-03/24/10	03/25/10	04/15/10	455	5	10000	0.25	1	955.0	957	100%	94-106
Total P	µg/l	10-0752FP	Site # 1	03/26/10-03/29/10	03/30/10	04/16/09	218	5	10000	0.25	1	718.0	696	97%	94-106
Color	PCU	09-3622	Site 4	10/02/09-10/09/09	10/09/09	10/09/09	40	25	500	0.75	5	115.0	119	103%	80-120
Color	PCU	09-3722	Site 4	10/09/09-10/16/09	10/16/09	10/16/09	37	25	500	0.75	5	112.0	115	103%	80-120
Color	PCU	09-3841	Site 4	10/22/09-10/30/09	10/30/09	10/30/09	30	25	500	0.75	2	60.0	64	107%	80-120
Color	PCU	09-3955	Rain	11/10/09	11/12/09	11/13/09	5	25	500	0.75	1	20.0	21	105%	80-120
Color	PCU	09-4068	Site 4	11/16/09-11/24/09	11/24/09	11/25/09	34	25	500	0.75	5	109.0	110	101%	80-120
Color	PCU	09-4167	Rain	12/1/09-12/3/09	12/04/09	12/04/09	7	25	500	0.75	1	22.0	22	100%	80-120
Color	PCU	09-4213	Rain Blank	12/07/09	12/08/09	12/08/09	0	25	500	0.75	1	15.0	15	100%	80-120
Color	PCU	09-4333	Rain	12/8/09-12/15/09	12/17/09	1218/09	7	25	500	1	1	27.0	27	100%	80-120