A.R.M. LOXAHATCHEE NATIONAL WILDLIFE REFUGE

ENHANCED WATER QUALITY PROGRAM

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ACRONYMS AND ABBREVIATIONS

ACME Special Drainage District, Village of Wellington
acre-ft acre-feet (volume reported as one acre in area by one foot in depth)
cfs cubic feet per second
Cl chloride
cm centimeter
DBHYDRO SFWMD's web portal for water quality data
DCS depth from water surface to consolidated substrate
DOI US Department of Interior
EAA Everglades Agricultural Area
EDEN Everglades Depth Estimation Network
EVPA Federal Consent Decree compliance sampling network for Refuge
ft feet
FWM flow-weighted mean
km kilometer
L liter
LOXA Refuge's expanded water quality monitoring network station nomenclature
m meter
mg milligram
MIKE-FLOOD coupled one and two-dimensional finite difference model
mm millimeter
NGVD National Geodetic Vertical Datum
NO_x total concentration as nitrogen of oxides of nitrogen, NO_2 + NO_3
ppb Parts-per-billion
ppm Parts-per-million
Refuge A.R.M. Loxahatchee National Wildlife Refuge
s second
SFWMD South Florida Water Management District
SFWMM South Florida Water Management Model
SO_4 sulfate
STA Stormwater Treatment Area
Tdepth depth of clear water column
TN total nitrogen
TP total phosphorus
µg microgram
$\mu S\ cm^{-1}$ microSiemens per centimeter (measure of conductivity)
USACE U.S. Army Corps of Engineers
USFWS U.S. Fish and Wildlife Service
USGS U.S. Geological Survey
WCA Water Conservation Area
XYZ monitoring and research transect in southwest Refuge

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EXECUTIVE SUMMARY

Congress appropriated funds to the U.S. Fish and Wildlife Service in 2004 which funded an enhanced water quality monitoring network and hydrodynamic and water quality models to improve the scientific understanding of water quality in the Arthur R. Marshall Loxahatchee National Wildlife Refuge[1] (Refuge). The network and models provide information that is used in management decisions to better protect Refuge resources. The enhanced water quality monitoring network complements the compliance network monitored as a part of the 1992 Federal Consent Decree (Case No. 88-1886-CIV-MORENO) by characterizing the water quality of a larger Refuge area, particularly the fringe area potentially impacted by canal water intrusions. Monthly grab samples have been collected at 37 to 39 sites located in the marsh and canal since June 2004. The number of grab sample sites has reduced to 37 in recent years because two sites located near the canal were overrun with cattail making them inaccessible. Continuous measurements of conductivity additionally have been collected along seven transects, four of which extend from surface water discharge points in the canal into the interior. This report is the fifth annual report, with analyses focused on January through December 2008, and with comparisons made to the preceding years (2004 through 2007).

Water quality data and analyses of canal water intrusion into the Refuge marsh presented in this report document continued intrusion of rim canal water into the Refuge interior, adding to a growing information base about canal water impacts to the Refuge. Intrusion of nutrient-rich and high conductivity water from the canal network surrounding the Refuge has been shown to negatively impact Refuge flora and fauna. Important insights gained from 2008 canal water intrusion analyses include:

- Canal water intruded into the marsh from 0.5 to 2.8 km (0.3 to 1.74 miles) depending on timing and location.
- Rainfall in 2008 was slightly greater than the historic average (1963 through 2008). Regardless, inflows to the Refuge were lower than inflow volumes during average rainfall years (i.e., 2004). It appears the reduction in Refuge inflow volumes did not directly result from water shortage or drought conditions.
- Intrusion into the marsh was sustained for a considerable period after inflows declined at the end of October. The extent of canal water intrusion into the marsh was maintained by the lack of water discharges from the Refuge during and after the high rate inflows from August through October. These conditions have been shown to exacerbate Consent Decree excursions and likely resulted in the November 2008 TP excursion even though inflows during November were low.

One additional water management recommendation resulted from the water quality and hydrodynamic analysis this year. To reduce canal water intrusion into the marsh when

[1] Public Law 108-108; see House Report No. 108-195, p. 39-41 (2004)

possible, we recommend that, within the constraints of the regulation schedule and conditions outside the Refuge, discharge of water from the Refuge occur as early as possible during or following long periods of high rate inflows. Beyond this recommendation, our analyses continue to support previously suggested management practices that have the potential to minimize intrusion. A few of these recommendations are summarized as balancing inflow and outflow volumes, reducing the duration of inflows, and reducing inflow rates when the canal stage is lower than the marsh stage.

Based on the surface water conductivity data, we classified the Refuge into four geographic zones: (1) Canal Zone; (2) Perimeter Zone, located from the canal to 2.5 km (1.6 miles) into the marsh; (3) Transition Zone, located from 2.5 km (1.6 miles) to 4.5 km (2.8 miles) into the marsh; and (4) Interior Zone, greater than 4.5 km (2.8 miles) into the marsh. Overall, water quality conditions in the Perimeter and Transition Zones continue to be different from, and more impacted than, the Interior Zone. Cattail expansion in the Refuge marsh, negative impacts to *Xyris* spp. (yellow-eyed-grass) from nutrient and mineral enrichment, and displacement of sawgrass in the canal water-exposed areas of the marsh are examples of deleterious marsh ecosystem changes associated with canal water intrusion.

This report continues to document that water movement between the canals and the marsh is influenced by rainfall, structure-controlled water inflow and outflow into perimeter canals, the difference between canal and marsh stages, and marsh elevation. When combined with our understanding of canal water intrusion's influence on the marsh, the data presented in this report continue to suggest that high-nutrient water is having a negative impact on the Refuge marsh (e.g., enriched soil TP, displacement of sawgrass by cattails, loss of *Xyris* spp., etc.).

An excursion of the long-term TP level, as defined by the Consent Decree, occurred in November 2008. Rainfall, inflows, and canal water intrusion suggest that conditions were prime for an excursion event in October, but the geometric mean TP concentration in October was equal to the long-term compliance level. In November 2008, rainfall and canal inflows diminished, but intrusion remained extensive. The extended period of canal water intrusion likely was associated with the November 2008 excursion.

In 2008, we designed and initiated a study to investigate the growth and survival of native Florida apple snails (*Pomacea paludosa*) as a response to periphyton compositions from the Perimeter, Transition, and Interior Zones. We also began a study investigating how *P. paludosa* life histories are affected by water chemistry in the Northern Everglades. Analysis of the data from these studies will be available in a future annual report.

Model development for the suite of Refuge models continued during 2008. Water quality constituents were incorporated into the simple and complex models to enhance our understanding of water movement in the marsh and phosphorus dynamics in the water column. The independent model advisory review panel provided valuable insights that have been incorporated into the modeling program, and results of calibration runs for each model were presented at several conferences this year. Public workshops enhanced modeling effectiveness through interagency/interdisciplinary dialog.

Based on our water quality and hydrodynamic analyses, we submitted two manuscripts for peer-review journal publication. One paper was submitted to *Wetlands* and focused on canal water intrusion into the marsh, and a second paper was submitted to *Environmental Monitoring and Assessment* and focused on impacts of canal water intrusion on the water quality in the marsh.

A. REFUGE ENVIRONMENTAL CONDITIONS[2]

The objective of this chapter is to provide a general descriptive summary of environmental conditions, canal water intrusion into the Refuge marsh (movement of water from the perimeter canal into the marsh interior), and associated water quality in the Refuge from January through December 2008. This section of the report follows approaches presented in previous annual reports (USFWS 2007a, b; USFWS 2009). Further, we compare results, particularly total phosphorus (TP), in 2008 to results presented in previous water quality reports covering the period from January 2004 through December 2007 (Harwell et al. 2005; USFWS 2007a, b; USFWS 2009). Thus, this chapter serves as an update to the 2007 annual report (USFWS 2009). This chapter briefly characterizes environmental conditions (e.g., rainfall, canal flows, and marsh and canal stages) associated with events of canal water intrusion into the marsh and water quality conditions during 2008. We also describe conditions of canal water intrusion during a Consent Decree excursion event in November 2008. We finalize our discussion with a case where canal water intrusion into the marsh was minimized and inflow and outflow operations were consistent with recommendations provided in previous annual reports.

Background

Prior to June 2004, water quality in the Refuge interior primarily was monitored using the 1992 Consent Decree (Case No. 88-1886-CIV-MORENO) compliance network (EVPA). These 14 stations (**Figure 1**), monitored since 1978, characterize the central region of the interior marsh, leaving a relatively large region uncharacterized, predominantly in the outer, impacted fringe of the wetland (Harwell et al. 2005; USFWS 2007a, b; USFWS 2009). In June 2004, the Refuge initiated an enhanced water quality monitoring network (LOXA) intended to improve the scientific understanding of water movement in and out of the Refuge marsh, water quality in the marsh, and to provide information that can be incorporated into water management decisions to better protect Refuge resources (Brandt et al. 2004). The enhanced monthly sampling focuses on areas near surface water discharge sites in areas uncharacterized by the EVPA network (**Figure 1**).

Water levels in the Refuge are managed by the U.S. Army Corps of Engineers (USACE) based on the 1995 Water Regulation Schedule (USFWS 2000; USFWS 2007a, b; **Figure 2**).

Methods

Environmental Conditions. Rainfall, flow, stage, and additional water quality data were downloaded from the South Florida Water Management District (SFWMD) data web portal, DBHYDRO and data were current as of September 20, 2010 (http://my.sfwmd.gov/portal/page?_pageid=2235,4688582&_dad=portal&_schema=PORTAL). All stage data presented in this report are relative to the NGVD 1929 datum.

[2] Prepared by: Donatto D. Surratt, Matthew C. Harwell, Michael G. Waldon

Data from the USGS 1-7 stage gage (**Figure 1**) were used as estimates of marsh stage values; canal stage data from the headwater gage of the G-94C outflow spillway structure (**Figure 1**) were used for continuity with previous reports. Refuge inflow and outflow were aggregated as the total daily average flow. Inflow records for ACME-1, ACME-2, G-310, G-251, S-362, G-300, and G-301 were used for daily average inflow into the canals; outflow records at G-300, G-301, G-94A, G-94B, G-94C, S-10A, S-10C, S-10D, and S-39 were used for daily average outflow out of the canals (**Figure 1**). Data from G-338 also were considered, but the flows were sparse and not included in these analyses. Daily rainfall data were averaged from the LOXWS, S-6, S-39, and S-5A weather stations (**Figure 1**).

Intrusion Monitoring. We determined the spatial and temporal extent of high conductivity canal water intrusion into the Refuge under different hydrologic conditions with emphasis on six of the seven Refuge conductivity transects (**Figure 1**), where temperature-compensated conductivity is collected hourly using conductivity data loggers. Also, we related changes in the extent of intrusion to water management activities affecting canal stages and flows into the Refuge, and determined the influence of natural meteorological events and hydrologic mechanisms on intrusion of high conductivity canal water.

We used the six conductivity transects to track water movement between the canal and the first six kilometers of the marsh (**Figure 1**). Two transects (STA-1E and STA-1W) were established near the outflow of STA-1W and STA-1E discharge structures. Two of the remaining transects (ACME-2 and Southeast) were established on the east side of the Refuge south of the STA-1E discharge structure. We established the Southeast (SE) transect late in July 2007 to capture canal water intrusion in areas not previously characterized. The final two transects (S-6 and Extreme Southwest) were established on the west side of the Refuge south of the STA-1W discharge structure. The Extreme Southwest (ESW) transect also was established late in July 2007 to capture canal water intrusion signals in areas previously not characterized.

Conductivity acts as a conservative tracer of canal water; there are no biological or chemical processes in the surface water that significantly alter conductivity. Thus, these data can be used to track canal water intrusion into the marsh, which ultimately can be examined in relationship to water management operations.

Seventy-five percent of canal monthly conductivity values were greater than 520 µS cm^{-1} and the maximum was 907 µS cm^{-1}. Monthly conductivity in the Interior Zone of the marsh remained below 195 µS cm^{-1} through 2008. Given this large difference in conductivity levels between the canal and the interior marsh, we use two conductivity levels, 350 and 500 µS cm^{-1}, to help identify the distance into the interior marsh that canal water penetrated in 2008. Tracking was done using isopleths of conductivity generated from the hourly conductivity data. Isopleths are lines connecting points of equal value for a given metric. Elevation contours on a topographic map are examples of isopleths.

The two isopleths (350 and 500 µS cm^{-1}) were chosen to sufficiently cover the conductivity gradient observed from the canal into the marsh. Further, laboratory and field studies have shown that higher conductivity waters (>300 µS cm^{-1}) have adverse impacts on the ecosystem community structure (e.g., reduced growth rate of *Xyris* spp. (McCormick and Crawford 2006), shifts from sawgrass to cattail communities (Richardson 2010), altered periphyton community structure (Sklar et al. 2005)).

Marsh Water Quality and Water Quality Zone. As in past years, monthly water quality samples were collected from the EVPA and LOXA monitoring networks (**Figure 1**). The EVPA network consists of 14 interior marsh sites collected cooperatively with the South Florida Water Management District and Refuge staff. Refuge staff solely collect water samples from the 37 sites (five in the canal and 32 in the marsh) in the LOXA network. The number of grab sample sites has reduced from 39 to 37 in the last few years because two sites located near the canal were overrun with cattail making them inaccessible for water quality sampling. Samples for both networks generally are analyzed for more than 20 water quality parameters. Sample collection is confounded by water depth and sample site accessibility. When clear water depths are between 10 and 20 cm (4 and 8 inches), only partial samples are collected and analyzed for 6 of the 29 water quality parameters including: TP, chloride, sulfate, temperature, depth, and specific conductance. When the water depths are below 10 cm (4 inches), no samples are collected and no data are recorded. This report only presents analysis of TP data. **Appendix A** presents summary statistics for all water quality parameters measured in the LOXA network.

The Refuge interior was classified into several geographic zones based upon conductivity data variability and changes in median conductivity as a function of distance from the perimeter canal as presented in USFWS (2007a, b; 2009). For the analyses presented here, the following zones were identified:

- Canal: sites located in the canal
- Perimeter: sites located from the canal to 2.5 km (1.6 miles) into the marsh
- Transition: sites located from 2.5 km to 4.5 km (1.6 to 2.8 miles) into the marsh
- Interior: sites located greater than 4.5 km (2.8 miles) into the marsh

Results

Environmental Conditions. Refuge rainfall volumes in 2008 returned to normal levels following two years of drought (2005 through 2007). Rainfall on the Refuge in 2008 was approximately 688,000 acre-ft, 28% greater than in 2007, 23% greater than in 2006, 14% greater than in 2005, 31% greater than in 2004, and 6% greater than the historic (1963 through 2008) average (**Figure 3a**).

Canal inflow volume was greater than 400,000 acre-ft in 2008, more than twice the 2007 inflow volumes, and almost 1.5 times the 2006 and 2005 inflow volumes (**Figure 3b**). The volume of inflow in 2008 has not been observed since 2004 when the inflow volume was approximately 490,000 acre-ft. Daily inflow rates to the Refuge are presented in **Figure 4a**.

In 2008, canal stages were greater than 16.2 ft (4.9 m) and marsh stages were greater than 16.5 (5.0 m) ft 75% of the year (**Figure 4b**). Canal stages were greater than 14.8 ft (4.5 m) and marsh stages were greater than 15.9 ft (4.8 m) 75% of 2007. In 2006, canal stages were greater than 15.9 (4.8 m) ft and marsh stages were greater than 16.1 ft (4.9 m) 75% of the year.

Intrusion Monitoring. In general, intrusion on the east side of the Refuge in 2008 peaked to more than 1.5 km (0.9 miles) during the June and July period and more than 2 km (1.2 miles) during the August through December period (**Figure 4c-e**). This pattern of increased intrusion was observed in 2006 and 2007 to different extents. These intrusion events were coincident with continuous inflows and rising canal and marsh stage. Maximum intrusion on the east side of the Refuge was observed in October 2008 with intrusion greater than 2.8 km (1.7 miles) into the marsh. This intrusion distance was observed after inflows were sustained at daily inflow rates greater than 2,000 cfs (57 $m^3 s^{-1}$) for a little more than a week, after which canal and marsh stages rapidly increased above 17 ft (5.2 m). The pattern of intrusion was similar on the west side of the Refuge (**Figure 5c-e**), but intrusion was less extensive, reaching a maximum of 1.9 km (1.2 miles) in October 2008.

Total Phosphorus and Intrusion Dynamics. Flow-weighted mean TP concentrations discharged to the Refuge through 2008 were generally highest from STA-1E (S362), relative to discharge from and STA-1W (G251 and G310) structures (**Figure 6a**). These concentrations, particularly from STA-1W, ranged from 20 to 60 µg TP L^{-1}, while discharge from STA-1E ranged from 60 to 300 µg TP L^{-1}. There were no discharges to the Refuge from the by-pass structures in 2008. Canal TP concentrations generally followed STA-1W patterns but ranged from 20 to 50 µg L^{-1} (**Figure 6a**). Peak TP concentration occurred in April from STA-1E followed by peaks from STA-1W, STA-1E, and the canal in August or September following the onset of stage rise in the Refuge. Variability (coefficient of variability) in the FWM-TP concentration from the G310 discharge structures and in the canal decreased from variability observed in previous years.

In 2008, Perimeter Zone TP concentrations ranged from 7 to 15 µg L^{-1}, Transition Zone TP concentrations ranged from 4 to 9.5 µg L^{-1}, and Interior Zone TP concentrations ranged from 5.7 to 28 µg L^{-1}. Interior Zone TP concentrations peaked in April after three consistent months of high (> 160 µg L^{-1}) FWM TP concentration discharges from STA-1E. Intrusion during the month of April was not monitored because the marsh was too dry for the conductivity probes to measure surface water near the canals. Perimeter and Transition Zone TP concentrations peaked in October, two to three weeks after the peaks observed from G310 and S362 (**Figure 6b**). Intrusion increased to 2.5 km (1.6 miles) in late August and increased to 2.7 km (1.7 miles) by early October, particularly on the east side of the Refuge. Three consecutive months of elevated FWM TP concentrations from the discharge structures coupled with the increase in canal water intrusion during these months coincides with the elevated TP concentrations observed in the Perimeter and Transition Zones in October.

When considering only the compliance network (sites labeled LOX## in **Figure 1**), no Consent Decree excursion was associated with the elevated intrusion observed in October 2008; however, the geometric mean was equal to the long-term level. The elevated October 2008 intrusion events continued through December, and in November 2008 an excursion event was observed (**Figure 4 and 5**). Although inflow rates slowed at the end of October, outflow rates were not high enough to move water from the marsh to the canal. These and previous analyses indicate that when inflow rates are elevated above 1,000 cfs (28 $m^3 s^{-1}$) for a week or two after the marsh stage has been low, canal and marsh stages rise rapidly, and canal water intrudes into the marsh more than 1 km (0.6 miles). These conditions have been coincident with most excursions since 2005, as observed in March 2005, September 2006, October 2007, and November 2008.

Discussion and Conclusions

Canal Water Intrusion Minimization: A Case Study. In February 2008, an opportunity occurred to better manage Refuge inflows and outflows in order to minimize canal water intrusion. In this example, three operational management scenarios were possible: 1) increase STA discharges to the Refuge; 2) divert the water by sending it to the estuaries; or 3) send untreated water (bypassing the STAs) directly into the Refuge. The latter two options were much less preferred than the first option. Water discharges to the coast were not preferable because South Florida had experienced drought conditions the previous years and it was not clear whether drought conditions would continue in 2008. Sending untreated water (bypass) into the Refuge was not preferred because of the poor water quality and negative impacts it has on the Refuge ecology. Thus, the only practical option was to increase the discharges from the STAs into the Refuge canals.

Previous recommendations from our intrusion analysis (the LOXA programs 2nd, 3rd, and 4th Annual Reports; http://sofia.usgs.gov/lox_monitor_model/reports/) suggested that if inflows had to be high (>1,000 cfs ; >28 $m^3 s^{-1}$), then concurrent high outflows could reduce canal water intrusion. In February 2008, inflow and outflow operations were consistent with previous water management recommendations designed to reduce canal water intrusion. The result of this scenario was that canal water intrusion was minimized (<0.5 km; 0.3 miles) on the Refuge's east side during this high inflow event, and was estimated to be approximately 50% less than the intrusion than expected when inflows are high, but outflows are low. This operation compared favorably to past high inflow/low outflow events that occurred in March 2005, February 2006, August 2006, and August 2007 when the Refuge experienced intrusion distances greater than 1 km (0.6 miles). Harwell et al. (2008) examined the comparison between March 2005 and February 2008 events. Overall, we continue to support our previous recommendation that high inflows to the Refuge should be moderated by concurrent equal or higher outflows consistent with the constraints of the regulation schedule mandates.

The 2008 environmental conditions in the Refuge mark the first year of normal rainfall levels following the two-year drought (2005 through 2007). Rainfall in 2008 was the highest observed since 2004. Inflows to the Refuge in 2008 were lower than in 2004 – a year marked by lower rainfall than in 2008.

All the observed excursions since 2005 have coincided with intrusion events which extend more than 1.5 km (0.9 miles) into the marsh. Our data and the February 2008 case study show that keeping canal water intrusion to less than 1 km (0.6 miles) during high inflow events reduces the risk of excursion of the long-term TP levels.

The high intrusion distance observed from late August through October 2008 was driven by the high rates and duration of canal inflows that were not moderated by concurrent outflows - outflows were 7% of inflows during this period. By the end of October 2008, inflows to the Refuge dropped to below 200 cfs (5.7 $m^3 s^{-1}$). Regardless, in November and December 2008, canal water intrusion remained more than 1.5 km (0.9 miles) into the marsh. This extent of intrusion was maintained by the lack of outflows moderating inflows during the August through October high inflow events. While we recognize water movement to and from the Refuge are influenced by conditions outside the Refuge, we recommend discharging water from the Refuge to reverse the extent of canal water intrusion as soon as possible. In the case of the November exceedance of the long-term level, however, this recommended action is restricted by the Refuge water regulation schedule as water stages were in Zone A2, below 17.5 ft (5.3 m) and only slightly above 17 ft (5.2 m. Without discharging water from the canal, water does not move to the canal from the marsh and the only other mechanism reducing the canal's influence on the marsh is rainfall dilution. This condition is problematic, particularly beginning in November, because rainfall declines significantly during the onset of the dry season (November). Thus, in 2008, it took a little more than two month to ameliorate the extent of intrusion from August through October as outflows from the Refuge were maintained below 200 cfs (5.7 $m^3 s^{-1}$) from late October through early January.

Previous annual reports for the Refuge (Harwell et al. 2005; USFWS 2007a, b; USFWS 2009) have presented water management suggestions including dry-down frequencies and minimization of canal water intrusion. Some of those suggestions focused on controlling inflows and outflows to minimize canal water intrusion into the marsh. In the 2005, 2006, and 2007 annual reports, we suggested that if canal water inflows were necessary, the inflow rate should be below 200 cfs (5.7 $m^3 s^{-1}$) and for a short duration (< five days). Alternatively, if high inflows were necessary and canal and marsh stages were greater than the marsh sediment elevation, then outflows should be timed to inflows and be greater than inflows. The recommended timing, volume, or duration of outflows to inflows was not extensively observed in 2008, similar to 2004 through 2007. Because the environmental conditions presented in this report are similar to those reported for 2004, we continue to support the water management recommendation to reduce canal water intrusion as characterized here and in previous reports (USFWS 2007a, b; USFWS 2009). Some of these management recommendations include (**Table 1**):

- Refuge inflows should be short duration (≤ 5 days) pulses of < 200 cfs (5.7 $m^3 s^{-1}$) when absolute canal/marsh stage difference is < 0.2 ft (< 0.1 m) and interior water depths are < 0.5 ft (< 0.2 m).

- Refuge inflow rates can be moderate (200 to 400 cfs; 5.7 to 11 $m^3 s^{-1}$) for short durations if marsh stage is > 0.6 ft (> 0.2 m) higher than canal stage and waters depths are < 0.3 ft (< 0.1 m).

Finally, we provide an additional recommendation in light of the extended November and December 2008 canal water intrusion events:

- If Refuge inflows must be extended beyond short-duration pulses at high volumes and there is nowhere to send water during these inflows, outflow should occur as soon as possible to moderate the extent of intrusion.

We have presented our recommendations at several forums to water managers and the various agencies responsible for making water management decisions. These forums include direct communication from Refuge managers; quarterly regional water coordination meetings; and periodic calls with the Corps of Engineers. The quarterly water coordination meetings focus on water management for the northern portion of the Everglades (from Lake Okeechobee down to Water Conservation Area 2) and consist of multiple agencies (e.g., U.S. Fish and Wildlife Service, National Park Service, Corps of Engineers, Lake Worth Drainage District, Florida Fish and Wildlife Conservation Commission, South Florida Water Management District). Periodic calls with the Corps of Engineers focus on water management under the various water regulation schedules for each of the Water Conservation Areas.

Finally, based on our water quality and hydrodynamic analyses, we submitted two manuscripts for peer-review journal publication. One report was submitted to *Wetlands* and focused on canal water intrusion into the marsh. The second was submitted to *Environmental Monitoring and Assessment* and focused on impacts of canal water intrusion on the water quality in the marsh.

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Table 1. Evolution of water management recommendation based on water quality analysis since 2004.

Recommendation ID	Recommendation	2006	2007	2008
1	Refuge inflows should be short duration (≤5 days) pulses of <5655 $L\,s^{-1}$ (<200 cfs) when absolute canal /marsh stage difference is <0.1 m (<0.2 ft) and interior water depths are 0.2 m (<0.5 ft).	X	V	V
2	Refuge inflow rates can be moderate 5655 to 11,310 $L\,s^{-1}$ (200 to 400 cfs) for short durations if marsh stage is >0.2 m (>0.6 ft) higher than canal stage by and waters dept are <0.1 m (<0.3 ft).	X	V	V
3	Refuge inflows should be discontinued when the canal stage is >0.1 m (>0.2 ft) higher than marsh stage, unless the rainfall or outflow volumes are 3 to 4-times higher than t inflows.	X	U	Refined
3.a	Refuge inflows should be discontinued when the canal stage is >0.2 ft (>0.1 m) higher than marsh stage, unless the rainfall or outflow volumes are equal to or greater than inflows.			X
4	If Refuge inflows must be extended beyond short-duration pulses, outflow should be greater than inflow and last several days longer.	X	U	Refined
4.a	If Refuge inflows must be extended beyond short-duration pulses, outflow should be equal to or greater than inflow and last several days longer.			V
5	If Refuge inflows must be maintained at high rates, the S-10s and S-39 should be opene to create outflow 3 or 4-times higher than inflow.	X	U	Refined
5.a	If Refuge inflows must be maintained at high rates, the S-10s and S-39 should be opene in conjunction with canal inflows to create outflow equal to higher than inflow.			X
6	If Refuge inflows must be extended beyond short-duration pulses at high volumes and there is nowhere to send water during these inflows, outflow should proceed as soon a practicable to moderate the extent of intrusion the marsh receives from the original inflows.			

V = Analyses continue to verify this recommendation

X = Inflow and outflow operations were similar to recommendation

U = Environmental conditions did not allow for verification of the recommendations

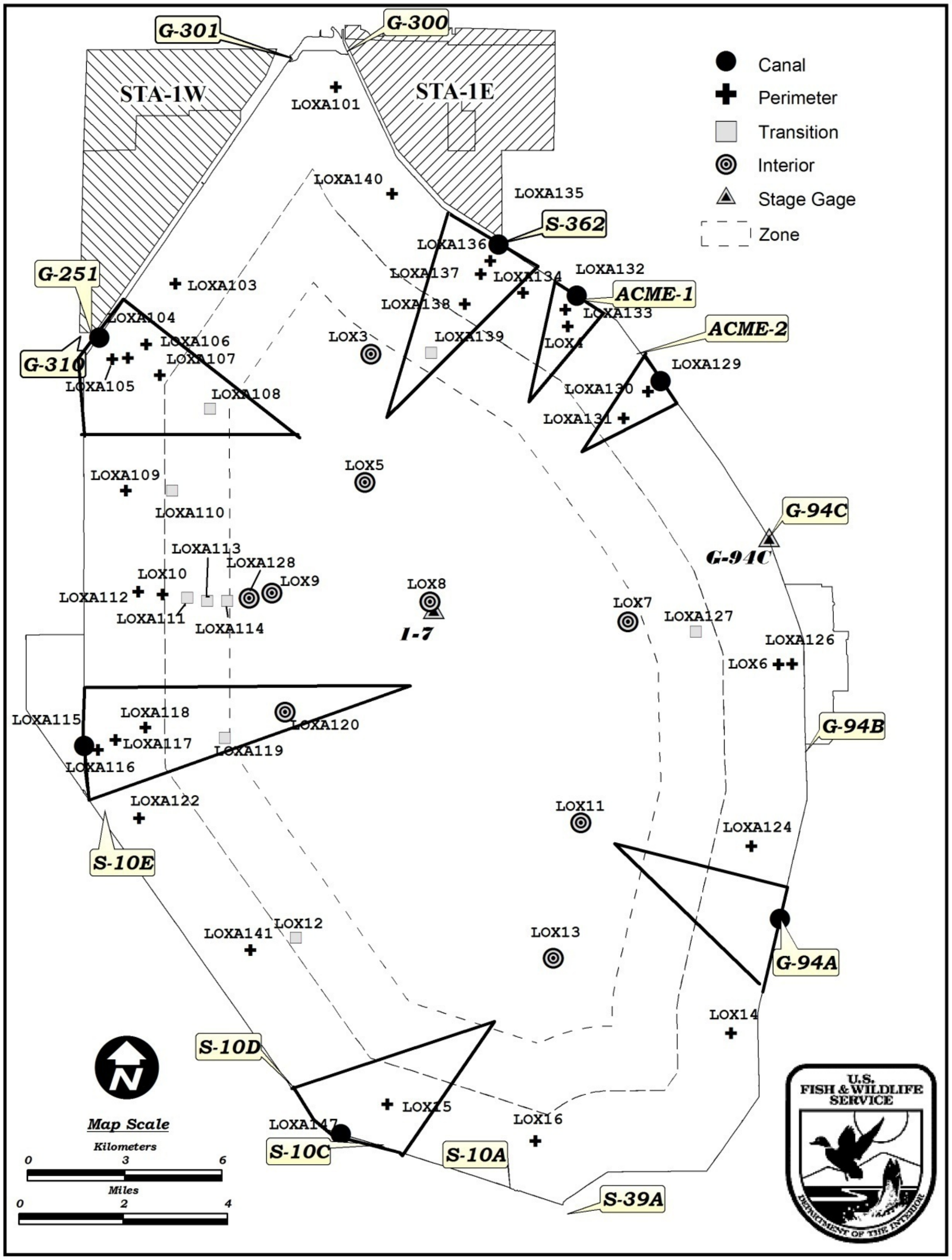
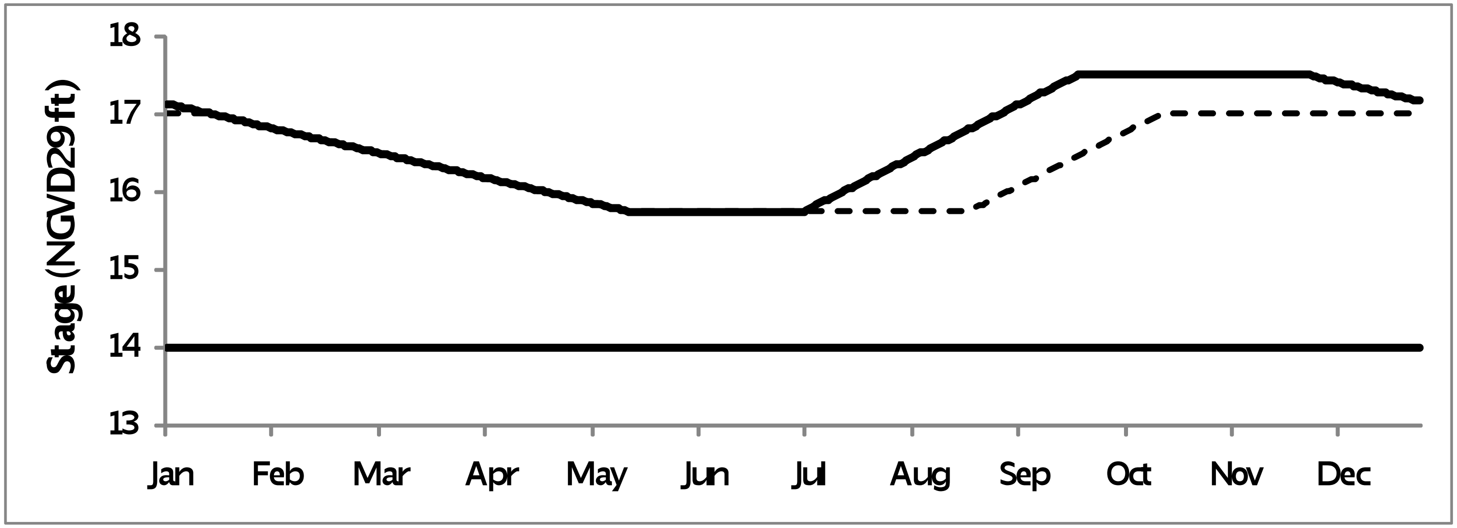


Figure 1. LOXA (LOXA###) and EVPA (LOX#) water quality monitoring sites, inflow and outflow structures, and canal and marsh stage gages used in this report. Solid polygons delineate transects, dashed polygons represent marsh zones.



DATES	USE GAGE	CONDITIONS
1 Jan – 30 Jun	1-8 Canal	All
1 Jul – 31 Dec	1-8 Canal	Except as noted below
	Avg. 1-7, 1-8T, 1-9	During rising stage when canal stage exceeds average.

ZONE	RELEASES
A1	Up to maximum at S-10 (and S-39 when agreed between Corp and SFWMD). Water supply releases as needed.
A2	S-10 releases based on Corps forecasts. Water supply releases as needed. If Lake Okeechobee stage is above WCA-1 stage or no more than one foot below WCA-1 stage, then water supply release from WCA-1 must be preceeded by an equivalent volume of inflow.
B	Water supply is needed. If Lake Okeechobee stage is above WCA-1 stage or no more than one foot below WCA-1 stage, then water supply releases from WCA must be preceeded by an equivalent volume of inflow.
C	No net releases from WCA-1. Any water supply releases must be preceeded by an equivalent volume of inflow.

Figure 2. Water Regulation Schedule for the Arthur R. Marshall Loxahatchee National Wildlife Refuge (USACE 1994).

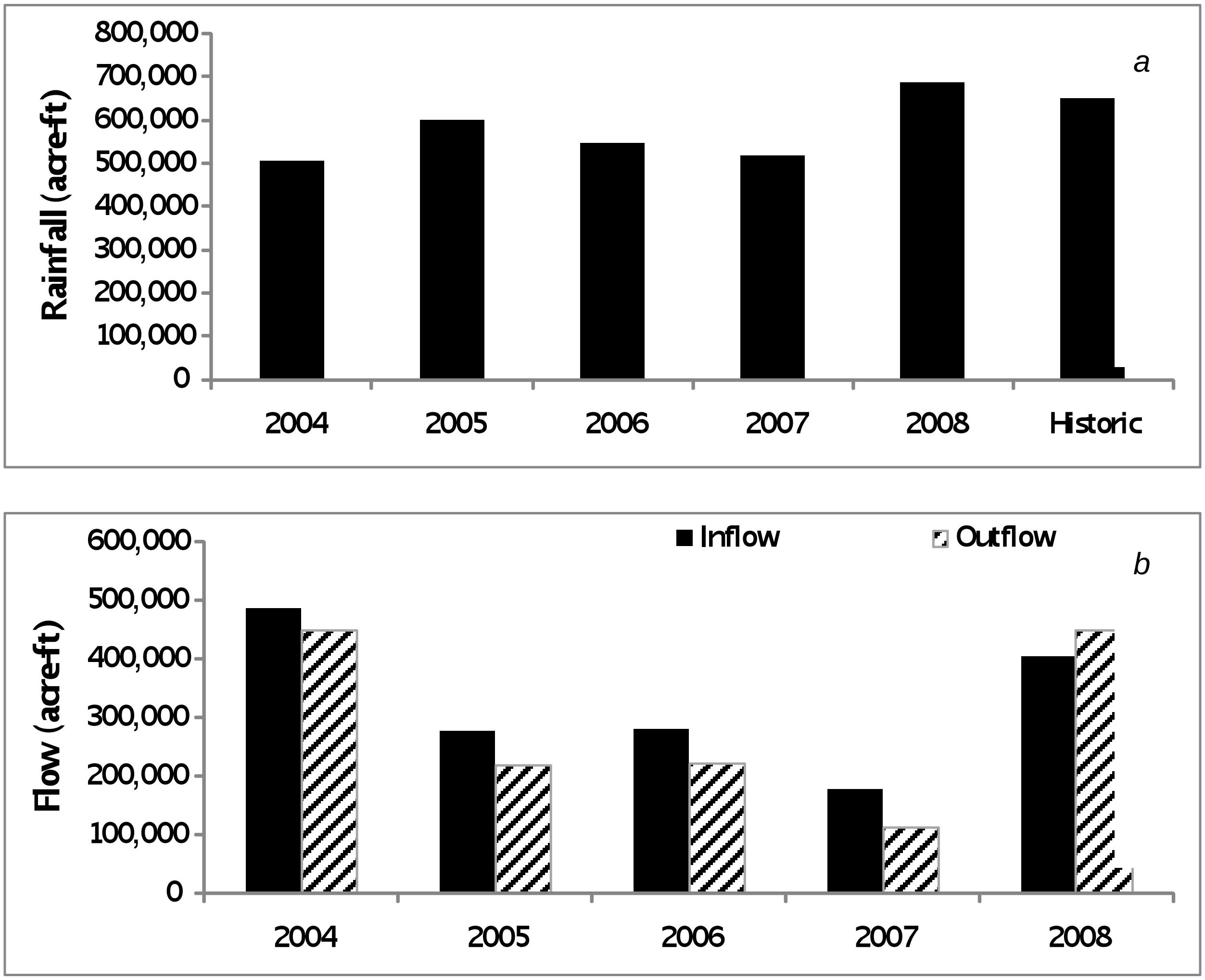


Figure 3. (*a*) Total volume of annual rainfall on the Refuge and (*b*) inflow and outflow volumes for the Refuge. Historic rainfall was determined from 1963 through 2008 using the S5A, LOXWS, S39, and S6 when data were available.

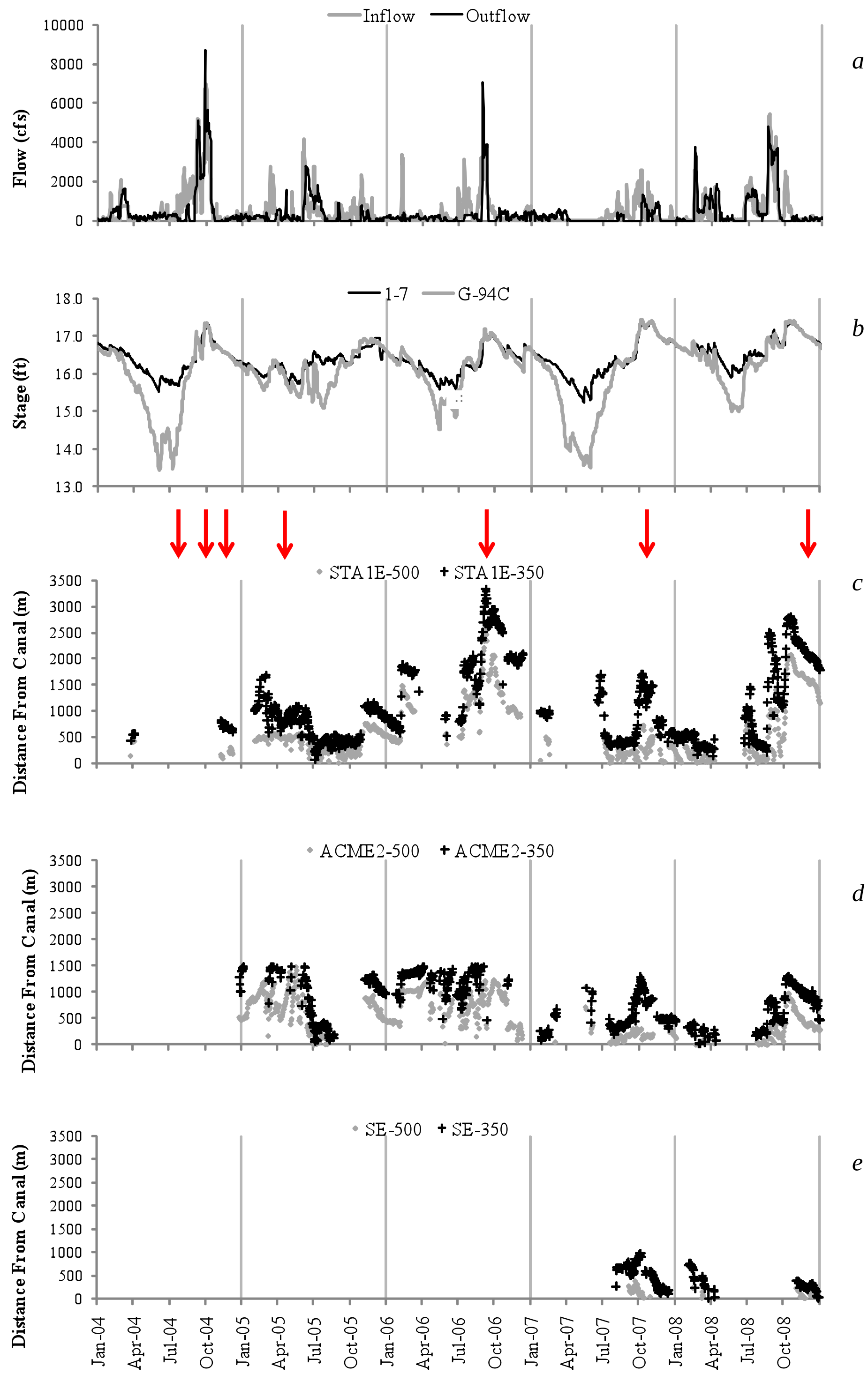


Figure 4. a) Inflow and outflow rates (cfs) summed for all structures from January 2004 to December 2008. b) Canal (G-94C) and marsh (1-7) stage levels (NGVD29). The 350 µS cm^{-1} and 500 µS cm^{-1} conductivity isopleths used to track canal water movement

into and out of the marsh interior for: c) STA-1E, d) ACME-2, and e) SE transects. Red arrows indicate Consent Decree excursions.

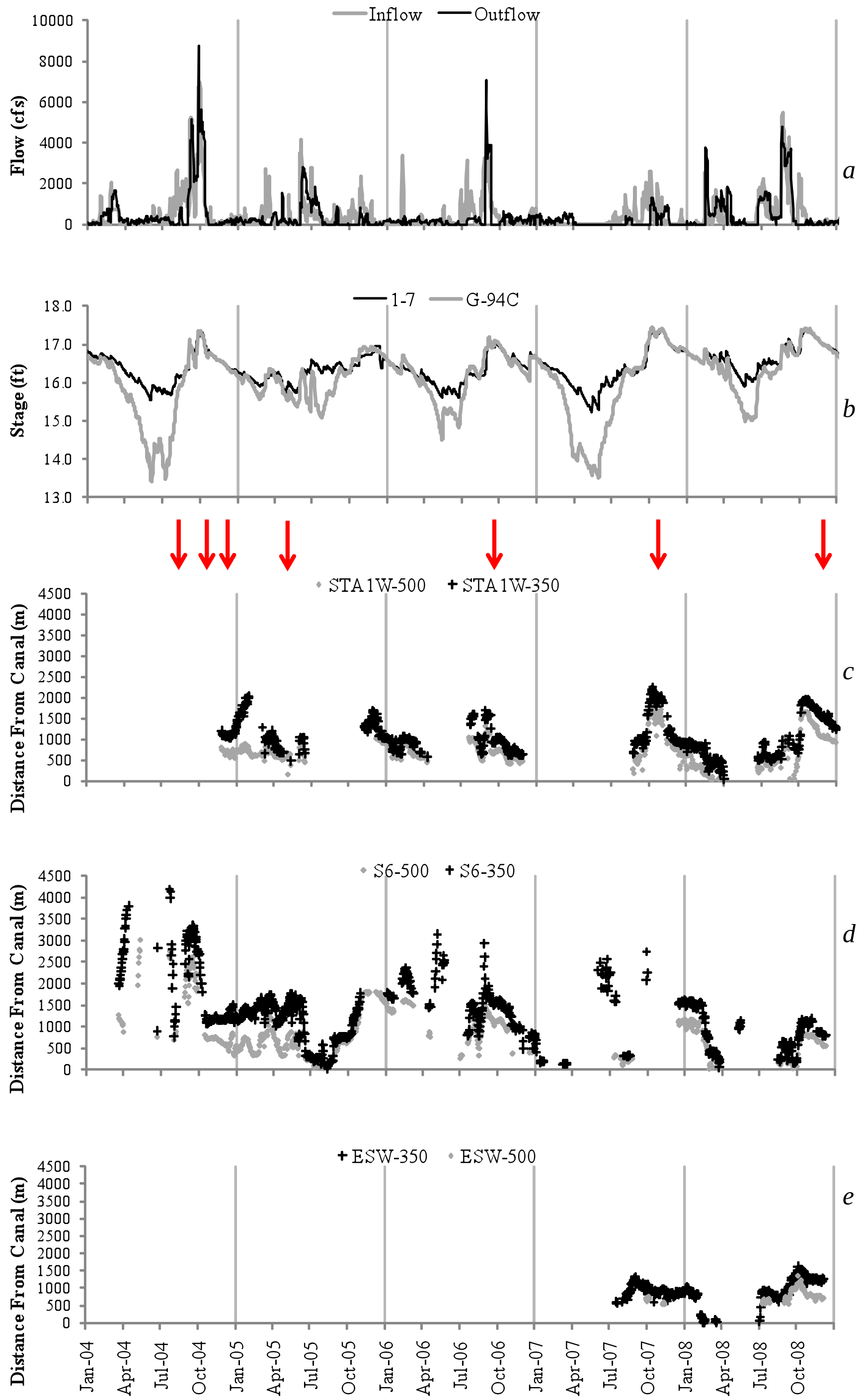


Figure 5. a) Inflow and outflow rates (cfs) summed for all structures from January 2004 to December 2008. b) Canal (G-94C) and marsh (1-7) stage levels (NGVD29). The 350 µS cm^{-1} and 500 µS cm^{-1} conductivity isopleths used to track canal water movement into and out of the marsh interior for: c)

STA-1W, d) S-6, and e) the new ESW transects. Red arrows indicate Consent Decree excursions.

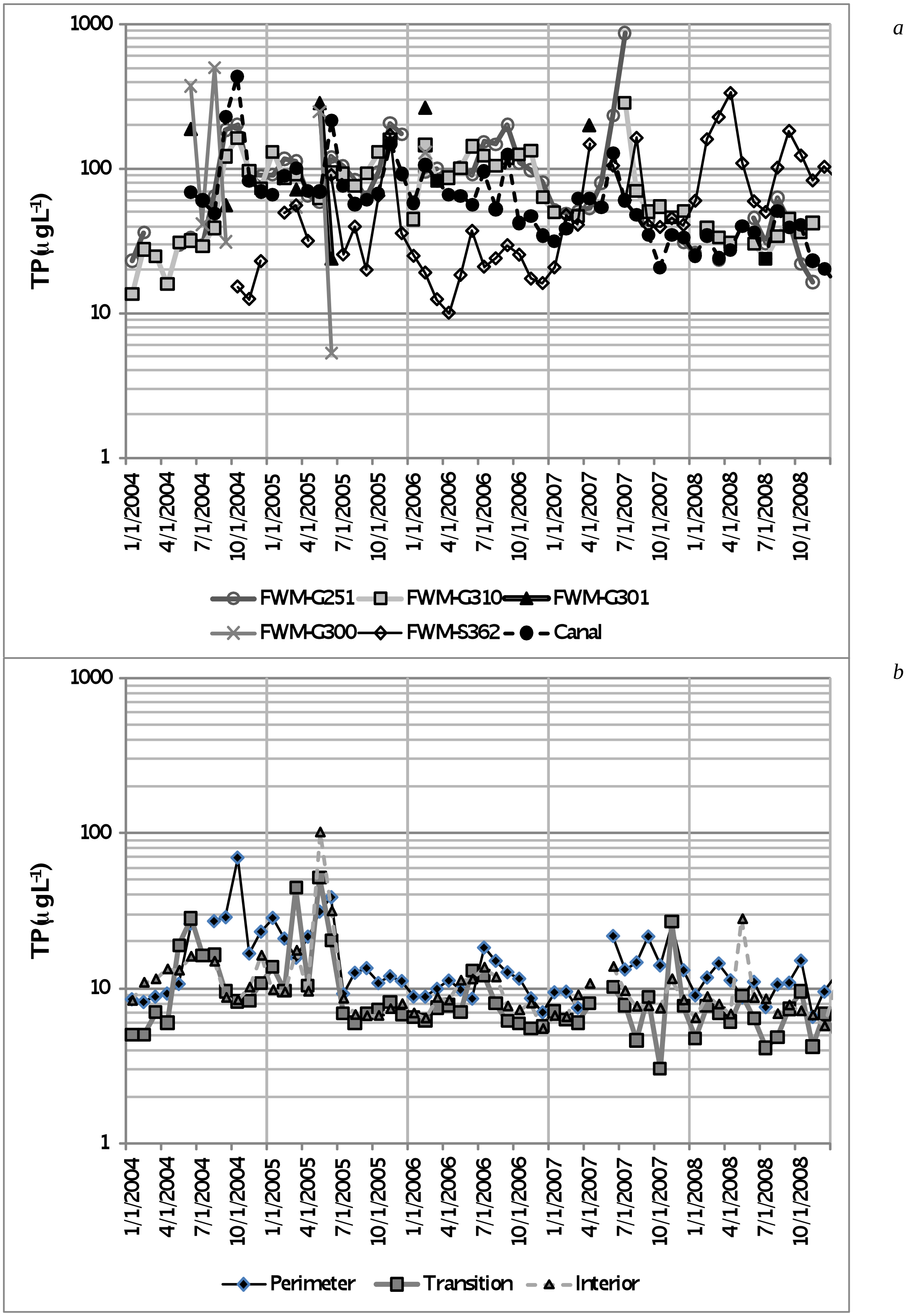


Figure 6. (a) Monthly TP FWM from Refuge inflow structures and TP concentration in the canal. (b) Monthly mean TP concentrations in marsh zones.

B. ECOLOGICAL IMPACT OF MINERAL ENRICHMENT[3]

The ecological effects program continued exploring various aspects of mineral enrichment impacts to flora and fauna in the Refuge (Gleason et al, 1975). One of the main drivers for mineral enrichment is canal water intrusion into the marsh. Four major research projects have been implemented since the inception of the ecological effects program and include collaborations with various inter- and intra-agency researchers. Projects include:

- characterization of vegetation and topographic dynamics at existing water quality sites;
- germination of interior seed banks under different water quality and hydrology treatments;
- development of a periphyton econiche model; and
- an apple snail (*Pomacea paludosa)* grazing study.

All of these projects were designed to probe mineral enrichment effects at multiple trophic levels within the Refuge. All data and related files (e.g., approved project sheets and final reports) are available upon request. This section of the report serves as an update to the status of ongoing projects.

Vegetation and Topographic Characterization Project

The vegetation and topographic characterization project was originally envisioned to answer questions about hydrologic and water quality dynamics that exist for each water quality site. Some marsh water quality sites appeared to be more protected from canal water influence than other sites even though these sites are in the direct vicinity of canal water intrusion. To better understand dynamics at these unusual sites, we attempted to characterize vegetation and topographic resistance to water flow into and out of all the individual water quality sites.

Upon realizing that vegetation at the water quality sites might be heavily impacted by physical disturbance (e.g., samplers stepping on and uprooting vegetation in the sampling area), vegetation sampling was established as transects across open prairie, slough, and into dense vegetation areas (e.g., sawgrass, cattail, etc.), within 100 m of the water quality site. At present, we have quantified vegetation as percent abundance for the various species and quantified topographic slopes to and from the center of each water quality site. Slope analysis did not indicate any significant impedance to surface water flow to and from the sites. In 2009, we will perform another round of vegetation transect sampling to assess change over time. For more detail on the monitoring design see the 2007 Refuge Annual Narrative (USFWS 2009).

Vegetation Germination Project

Changes in vegetation communities within the Refuge have been attributed to human-induced alterations in hydrology and water quality. Species such as cattail (*Typha domingensis)* have displaced sawgrass (*Cladium jamaicense*) and slough habitats in

[3] Prepared by: Rebekah E. Gibble, Donatto D. Surratt, Marcie A. Dixson

canal-influenced areas around the Refuge perimeter (Richardson 1990). Several other species such as *Xyris* spp. and some *Rhynchospora* spp. occur only in the Refuge interior (McCormick 2007). We performed an experiment to measure the effects of hydrology and water chemistry on plant community development from the seed bank in order to understand the drivers of observed plant community distributions within the Refuge. Results of these analyses have been presented in the 4th Annual Report (USFWS 2009), but presently a manuscript for journal submission is in preparation.

Apple Snail (*Pomacea paludosa*) Grazing Study

In 2008, we designed and initiated a study to.The apple snail grazing study investigates the growth and survival of native Florida apple snails (*Pomacea paludosa*) as a response to periphyton compositions from the Perimeter, Transition, and Interior Zonesas periphyton is the primary food source for apple snails. Changes in periphyton communities across the Refuge are hypothesized to result in a food quality/edibility gradient from impacted to unimpacted wetlands (Browder et al. 1994; Williams and Trexler 2006). To test this hypothesis within the Refuge, laboratory-raised juvenile *P. paludosa* were exposed to the existing water quality gradient in the Refuge. Egg clusters were collected from the Refuge interior and allowed to hatch in aquaria containing 5 to 10 gallons (18.9 to 37.9 L) of aerated surface water (~350 μS cm^{-1}) housed in a constructed greenhouse at the Refuge headquarters. Water was collected from a small impoundment adjacent to the Refuge headquarters (~350 μS cm^{-1}). Snails were fed romaine lettuce *ad libitum* daily. Leftover food from the previous day was removed at each feeding. Half of the water in each aquarium was replaced three times weekly to remove waste and maintain water quality (monitored using real-time conductivity and dissolved oxygen). Snails were grown in aquaria for approximately 60 days (reaching an average shell length of 15 mm (0.6 inches) and average wet mass of 1.5 g; 0.053 ounces) prior to use in the field experiments. Individual snails were marked with brightly colored nail polish before release to facilitate relocating them during sampling.

Snails were transplanted to eight sites within the Refuge interior at two different times (April to June and October to December). Site selection was designed to cover water quality and hydrology gradients within the interior. At each site, 15 randomly selected snails were placed into one of six replicate cages constructed of nylon mesh (1/16” x 1/16”; 1.6 x 1.6 mm) around a $1m^2$ (3.28 ft^2) PVC frame. Additionally, periphyton and associated *Utricularia* spp. (3 L) was placed within each replicate cage to serve as a food source and provide habitat structure. The periphyton used at each site was locally collected so that snails at each site were provided a different, site-dependent food source.

Snails remained in cages for 8 weeks and selected metrics (aperture length, shell length, and survival) were measured at weeks 4 and 8. Additionally, water quality conditions (specific conductivity, dissolved oxygen, temperature, pH, total phosphorus, calcium, and sulfate) were monitored at each sampling event. Collected data currently are being processed and analyzed. An update to the status of the experiment and analysis will be provided in the 2009 annual report.

Apple Snail (*Pomacea paludosa*) Egg Cluster study

This study investigates how *P. paludosa* reproductive life histories are affected by water chemistry in the northern Everglades. Egg clusters are collected from different sites at each water quality zone in the Refuge (Perimeter, Transitional, and Interior). Egg clusters are transported to Refuge headquarters and measured for individual egg diameters and egg number per cluster. Eggs are placed in aquaria and given three weeks to hatch. Hatchlings are collected and measured for wet weight at birth. Separate egg clusters are harvested at each collection site and analyzed for C:N ratios. Egg measurements and analysis will be completed in June 2009.

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C. MODELING UPDATE[4]

The modeling team continued developing the simple and complex models in 2008. The models provide insight into the spatial and temporal variation of flow conditions (stage and velocity), and constituent (TP, Cl, and SO_4) transport and transformation within the marsh and in the perimeter canal. These models provide a valuable tool in support of Refuge management. Though the models are not regional in scope, they can project the response of the natural system inside the Refuge's boundaries to external management alterations through imposed changes in boundary flows and concentrations. These models can provide detailed information about the response of the Refuge to regional management changes and alterations. However, the impact of regional changes on the Refuge model boundary conditions must be assumed or obtained from regional modeling efforts (e.g., the SFWMM).

Several milestones were achieved in the model program during 2008. Results from the simple and complex models on water and nutrient budgets were presented in several forums this year, including the 2nd USGS Modeling Conference and the Refuge Annual Science Workshop. Oral and poster presentation from these forums are presented below. Calibration of the TP concentration component in the spatially explicit MIKE-FLOOD model was completed. Work also began on implementation of the MIKE-SHE model which links surface and groundwater dynamics in the Refuge. The simple and complex spatially explicit MIKE-FLOOD models were quantitatively compared to further develop our understanding of model dynamics and better assure the model credibility. Cumulative and annual budgets for both water volume and constituents were developed for the models. Efforts also were directed toward documentation of model use and appropriate application. Finally, the models were set up to be introduced as publicly available versions.

[4] Prepared by: Michael G. Waldon, Donatto D. Surratt, Matthew C. Harwell

D. 2008 PRESENTATION, REPORTS, AND PUBLICATIONS

Presentations

Chen C, Meselhe EA, Waldon MG, Wang H, Harwell MC, 2008. Hydrodynamic and water quality modeling of the A.R.M. Loxahatchee Refuge, North Everglades, Florida. Poster at the 2nd USGS Modeling Workshop. February, 2008.

Chen C, Meselhe EA, Waldon MG, Wang H, Harwell MC, Griborio A, 2008. Spatially-explicit hydrodynamic and water quality modeling of the A.R.M. Loxahatchee National Wildlife Refuge, Part I - Model setup. Oral Presentation at the 2008 Greater Everglades Ecosystem Restoration Conference. July, 2008.

Entry JA, Surratt DD, Harwell MC, Waldon MG, Aumen NG, 2008. Influence of stormwater inflow on water quality gradients in the Arthur R. Marshall Loxahatchee National Wildlife Refuge. Oral presentation at the 2008 Greater Everglades Ecosystem Restoration Conference. July, 2008.

Gibble RE, McCormick PV, Harwell MC, 2008. Effects of chemistry and hydrology on seed germination and plant community development in a northern Everglades wetland. Poster presentation at the 2008 Greater Everglades Ecosystem Restoration Conference. July, 2008.

Gibble R, Trent T, Harwell MC, 2008. Investigating food quality effects on the Florida Apple Snail: water chemistry effects on periphyton assemblages in the northern Everglades. Oral presentation at the 2008 Greater Everglades Ecosystem Restoration Conference. July, 2008.

Harwell MC, Aumen NG, Brandt L A, Surratt DD, Waldon MG, 2008. Adaptive management in a learning environment – a case study of hydrology and water quality in the A.R.M. Loxahatchee National Wildlife Refuge. Oral presentation at the 2008 Greater Everglades Ecosystem Restoration Conference. July, 2008.

Harwell MC, 2008. What managers need to know about system-wide science to improve restoration planning and maximize adaptive management. Oral presentation at the 2008 Greater Everglades Ecosystem Restoration Conference. July, 2008.

Meselhe EA, Chen C, Waldon MG, Wang H, Harwell MC, Griborio A, 2008. Spatially-explicit hydrodynamic and water quality modeling of the A.R.M. Loxahatchee National Wildlife Refuge, Part II - Model application. Oral presentation at the 2008 Greater Everglades Ecosystem Restoration Conference. July, 2008.

Meselhe E, Waldon MG, Chen C, Roth W, Wang H, Harwell MC, Arceneaux J, 2008. Hydrodynamic and water quality modeling of the A.R.M. Loxahatchee National Wildlife Refuge, Northern Everglades, Florida. Oral presentation at the American Water Resources Association 2008 Annual Conference. November, 2008.

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Waldon MG, Roth W, Meselhe E, 2008. Comparison of the South Florida Water Management Model (SFWMM) with a Simple Refuge Stage Model (SRSM) for the A.R.M. Loxahatchee National Wildlife Refuge. Oral presentation at the American Water Resources Association 2008 Annual Conference. November, 2008.

Wang H, Waldon MG, Meselhe EA, Harwell MC, Roth W, Chen C, 2008. Simplified modeling of surface water sulfate dynamics in the A.R.M. Loxahatchee National Wildlife Refuge, Florida. Poster presentation at the 2008 Greater Everglades Ecosystem Restoration Conference. July, 2008.

Reports

Chen C, Meselhe E, Waldon M, 2008. A.R.M Loxahatchee National Wildlife Refuge hydrodynamic modeling with MIKE FLOOD (Version 1.0.0). LOXA08-001, U.S. Fish and Wildlife Service, Boynton Beach, FL.

Harwell M, Surratt D, Waldon M, 2008. Quarterly Update on Enhanced Water Quality Monitoring and Modeling Program for the A.R.M. Loxahatchee National Wildlife Refuge (January 2008). LOXA08-002, U.S. Fish and Wildlife Service, Boynton Beach, FL.

Harwell M, Surratt D, Waldon M, 2008. Quarterly Update on Enhanced Water Quality Monitoring and Modeling Program for the A.R.M. Loxahatchee National Wildlife Refuge (April 2008). LOXA08-003, U.S. Fish and Wildlife Service, Boynton Beach, FL.

Waldon M, 2008. Estimation of Refuge Water Needs. LOXA08-004, U.S. Fish and Wildlife Service, Boynton Beach, FL.

Harwell M, Surratt D, Waldon M, 2008. Quarterly Update on Enhanced Water Quality Monitoring and Modeling Program for the A.R.M. Loxahatchee National Wildlife Refuge (July 2008). LOXA08-005, U.S. Fish and Wildlife Service, Boynton Beach, FL.

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tracking of polluted canal water intrusion into wetlands of a national wildlife refuge in Florida, USA. *Wetlands*, v28, p176-183.

Wang H, Meselhe EA, Waldon MG, Surratt D, Abdou S, Chen C, Harwell MC, 2008. Compartment delineation for a wetland water quality model in the northern Everglades, Florida, USA. *Journal of Environmental Hydrology*, v16, pg13.

APPENDIX A

Table A-1. Individual EVPA and LOXA station summary statistics of water quality data for calendar year 2007. Where values were below the minimum detection limits, one-half of the minimum detection limit is reported (Weaver et al. 2008). Previous summary statistics (2004 – 2006) can be found in the previous annual reports (USFWS 2007a, b).

	STAT	TEMP	DO	SPCOND	PH	TURB	TSUSSD	NOX	TKN	TN	OPO4	TP	SIO2	CA	CL	SO4	ALKALINITY	TDORGC	TDSSOL	TOTORC
	unit	Celcius	mg L^{-1}	$\mu S\ cm^{-1}$		NTU	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	$\mu g\ L^{-1}$	$\mu g\ L^{-1}$	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
A101	Count	9	9	9	9	8	9	8	8	8	8	9	8	8	9	9	8	8	8	8
	Mean	23	2.9	586	7.2	0.5	1.0	0.006	1.45	1.46	3.0	9.3	9.5	51.6	85	16.2	150	29.5	386	29
	StDev	4	0.9	190	0.1	0.1	0.5	0.004	0.24	0.24	0.0	3.9	6.2	10.6	20	11.4	41	6.6	89	7
	Min	19	1.8	179	6.9	0.4	0.7	0.003	1.10	1.10	3.0	3.0	1.5	32.0	51	1.8	80	17.0	260	18
	Max	29	4.6	830	7.3	0.6	1.6	0.011	1.80	1.81	3.0	15.0	18.0	63.0	120	29.0	200	36.0	540	37
A102	Count	9	9	9	9	6	9	6	6	6	6	9	6	6	9	9	6	6	6	6
	Mean	24	4.0	252	6.8	0.7	1.6	0.006	1.01	1.02	4.3	10.3	14.5	20.0	35	5.1	79	21.3	207	21
	StDev	4	1.8	136	0.2	0.3	0.9	0.003	0.23	0.22	2.6	7.6	5.6	8.2	21	9.6	36	2.2	91	2
	Min	19	1.0	129	6.5	0.2	0.7	0.003	0.78	0.79	3.0	3.0	5.2	11.0	16	0.3	39	20.0	110	19
	Max	30	7.4	562	7.1	1.2	3.5	0.009	1.40	1.41	9.6	28.0	21.0	33.0	83	30.0	130	25.0	370	24
A103	Count	9	9	9	9	7	9	7	7	7	7	9	7	7	9	9	7	7	7	7
	Mean	22	2.0	213	6.6	0.5	1.4	0.006	1.00	1.01	3.4	8.7	14.4	15.9	30	4.7	53	22.6	171	24
	StDev	4	1.0	135	0.2	0.1	1.2	0.003	0.22	0.22	1.0	4.7	6.1	8.3	22	8.2	23	2.2	73	4
	Min	18	0.6	102	6.3	0.4	0.7	0.003	0.76	0.77	3.0	3.0	3.6	8.4	12	0.5	28	19.0	97	19
	Max	29	3.3	511	7.1	0.7	4.5	0.009	1.30	1.30	5.7	16.0	21.0	31.0	78	25.0	95	25.0	300	31
A104	Count	12	12	12	12	12	12	12	12	12	12	12	12	12	11	11	12	12	12	12
	Mean	25	5.1	579	7.6	3.8	3.7	0.074	1.46	1.53	3.7	34.7	10.6	45.9	75	25.6	147	25.4	364	26
	StDev	4	1.1	192	0.1	2.7	2.1	0.132	0.34	0.33	1.9	8.2	6.9	11.0	31	15.6	38	7.1	118	7
	Min	20	3.0	283	7.4	1.1	0.7	0.003	1.00	1.06	2.0	24.0	4.1	28.0	31	5.2	87	17.0	190	17
	Max	31	6.6	818	7.7	9.4	8.0	0.470	2.00	2.01	8.6	54.0	22.0	61.0	110	49.0	200	36.0	530	35
A105	Count	9	9	9	9	8	9	8	8	8	8	9	8	8	8	8	8	8	8	8
	Mean	23	3.3	496	7.0	0.7	1.0	0.012	1.41	1.42	3.1	12.7	13.8	41.3	66	18.8	140	26.8	341	26
	StDev	4	2.1	245	0.3	0.2	0.5	0.015	0.35	0.35	0.2	5.0	9.3	15.9	36	18.0	49	7.5	145	8
	Min	17	0.8	191	6.4	0.5	0.7	0.003	0.98	0.98	3.0	3.4	3.0	21.0	21	0.7	68	18.0	170	13
	Max	30	7.0	851	7.3	1.0	1.6	0.049	1.90	1.91	3.6	18.0	29.0	60.0	110	46.0	200	38.0	560	37
A106	Count	9	9	9	9	7	9	7	7	7	7	9	7	7	8	8	7	7	7	7
	Mean	23	3.9	351	6.9	0.6	1.3	0.006	1.01	1.02	3.2	8.9	10.6	30.6	48	10.4	98	22.3	254	23
	StDev	4	1.1	204	0.3	0.3	0.9	0.003	0.17	0.17	0.5	3.2	7.9	14.1	29	13.4	39	6.3	134	6
	Min	17	2.6	155	6.4	0.4	0.7	0.003	0.75	0.75	3.0	3.0	0.4	15.0	19	0.6	58	16.0	130	16
	Max	30	5.9	775	7.5	1.2	3.5	0.009	1.20	1.21	4.2	14.0	24.0	54.0	100	39.0	170	34.0	510	34
A107	Count	7	7	7	7	3	7	3	3	3	3	7	3	3	6	6	3	3	3	3
	Mean	22	3.4	219	6.7	0.4	1.5	0.007	0.88	0.88	3.0	6.1	16.7	18.7	33	6.2	61	21.3	223	21
	StDev	5	1.1	140	0.5	0.0	0.4	0.003	0.37	0.37	0.0	2.0	3.5	10.8	24	12.7	29	4.9	129	5
	Min	17	2.0	111	6.5	0.4	0.7	0.003	0.60	0.61	3.0	3.8	13.0	11.0	13	0.7	37	18.0	130	18
	Max	31	5.3	528	7.7	0.4	2.0	0.009	1.30	1.30	3.0	9.7	20.0	31.0	82	32.0	94	27.0	370	27
A108	Count	9	9	9	9	4	9	4	4	4	4	9	4	4	9	9	4	4	4	4
	Mean	25	5.6	114	6.7	0.8	1.9	0.006	1.23	1.23	3.0	6.5	3.9	4.7	22	0.1	14	20.3	76	21
	StDev	5	2.2	35	0.3	0.2	0.9	0.003	0.33	0.33	0.0	3.4	1.4	0.5	10	0.2	2	3.3	15	3
	Min	19	2.5	67	6.3	0.7	0.7	0.003	0.92	0.93	3.0	3.0	2.1	4.0	10	0.0	11	17.0	55	17
	Max	33	9.4	178	7.5	1.1	4.0	0.009	1.60	1.60	3.0	13.0	5.4	5.1	38	0.5	15	24.0	90	24

	STAT	TEMP	DO	SPCOND	PH	TURB	TSUSSD	NOX	TKN	TN	OPO4	TP	SIO2	CA	CL	SO4	ALKALINITY	TDORGC	TDSSOL	TOTORC
	unit	Celcius	mg L^{-1}	$\mu S\ cm^{-1}$		NTU	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	$\mu g\ L^{-1}$	$\mu g\ L^{-1}$	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
A109	Count	10	10	10	10	8	10	9	9	9	9	10	9	9	9	9	9	9	9	9
	Mean	24	4.0	221	7.0	0.6	1.5	0.006	1.11	1.11	4.0	10.5	8.6	15.3	32	4.3	56	20.7	158	21
	StDev	4	1.9	120	0.5	0.2	1.0	0.005	0.11	0.11	2.6	5.2	5.1	7.5	19	6.5	22	3.1	83	3
	Min	17	1.7	104	6.3	0.4	0.7	0.003	0.95	0.95	3.0	3.0	2.9	8.1	11	0.4	27	17.0	74	16
	Max	30	6.4	497	7.8	1.1	3.3	0.016	1.30	1.30	11.0	20.0	19.0	31.0	70	20.0	100	28.0	330	26
A110	Count	8	8	8	8	5	8	5	5	5	5	8	5	5	7	7	5	5	5	5
	Mean	23	6.1	109	7.2	0.6	1.2	0.008	1.05	1.06	3.0	6.3	4.3	6.4	19	0.5	24	19.2	94	19
	StDev	5	1.7	19	0.6	0.2	0.6	0.005	0.15	0.14	0.0	2.0	2.0	0.7	7	0.4	7	1.8	21	3
	Min	16	3.8	83	6.4	0.5	0.7	0.003	0.87	0.89	3.0	3.4	1.2	5.6	13	0.1	15	17.0	67	16
	Max	32	8.5	140	8.1	0.9	2.0	0.016	1.20	1.21	3.0	10.0	6.9	7.4	31	1.4	30	22.0	120	24
A111	Count	10	10	10	10	7	10	8	7	8	7	10	7	7	9	9	7	7	7	7
	Mean	23	4.2	122	6.9	0.7	2.2	0.006	0.85	0.75	3.0	5.7	4.3	8.2	17	0.8	29	17.7	95	17
	StDev	4	1.9	28	0.6	0.2	2.0	0.005	0.10	0.32	0.0	3.1	1.0	1.6	7	1.4	8	2.1	27	2
	Min	16	2.1	85	6.1	0.5	0.7	0.003	0.70	0.00	3.0	3.0	3.3	6.0	9	0.0	18	15.0	66	14
	Max	31	7.0	177	7.9	1.1	7.0	0.018	1.00	1.01	3.0	11.0	6.1	11.0	26	4.5	44	20.0	140	20
A112	Count	10	10	10	10	9	10	9	9	9	9	10	9	9	9	9	9	9	9	9
	Mean	23	3.2	156	7.0	0.6	2.0	0.016	0.95	0.97	3.0	9.7	5.2	11.3	20	0.9	39	17.3	111	18
	StDev	4	1.4	47	0.5	0.2	1.2	0.024	0.14	0.15	0.0	5.1	2.2	3.1	8	0.5	15	1.3	23	1
	Min	17	1.7	109	6.4	0.3	0.7	0.003	0.73	0.73	3.0	3.0	2.1	7.7	12	0.4	17	15.0	81	16
	Max	30	5.6	268	7.9	1.0	5.0	0.065	1.20	1.25	3.0	21.0	8.1	18.0	38	2.0	72	19.0	150	21
A113	Count	10	10	10	10	8	10	8	8	8	8	10	8	8	9	9	8	8	8	8
	Mean	23	4.3	108	7.0	0.6	1.5	0.006	0.92	0.93	3.0	6.2	4.3	6.8	16	0.5	23	18.0	80	18
	StDev	5	1.9	24	0.7	0.2	0.6	0.005	0.18	0.18	0.0	3.7	1.9	1.1	6	0.7	6	2.9	23	3
	Min	16	2.1	73	6.2	0.4	0.7	0.003	0.62	0.62	3.0	3.0	2.0	5.2	10	0.0	13	13.0	47	13
	Max	31	8.7	154	8.1	1.0	2.5	0.015	1.10	1.10	3.0	14.0	6.9	8.6	25	2.2	32	23.0	120	22
A114	Count	10	10	10	10	9	10	9	9	9	8	10	9	9	9	9	9	9	9	9
	Mean	23	3.6	106	7.2	0.5	1.2	0.006	1.02	1.02	3.0	5.6	3.5	6.4	17	0.2	19	18.2	83	19
	StDev	4	2.0	24	0.5	0.1	0.5	0.003	0.13	0.13	0.0	2.0	1.5	1.1	6	0.2	7	2.5	19	2
	Min	16	1.0	67	6.3	0.4	0.7	0.003	0.86	0.86	3.0	3.0	1.5	4.7	9	0.0	8	15.0	52	16
	Max	30	7.4	147	7.9	0.7	2.0	0.009	1.20	1.20	3.0	9.5	6.0	8.0	25	0.5	28	23.0	110	23
A115	Count	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Mean	25	4.7	568	7.5	2.3	6.2	0.056	1.48	1.54	5.2	27.8	11.1	45.4	73	28.2	143	25.9	356	26
	StDev	3	1.2	217	0.2	1.4	12.0	0.106	0.37	0.44	4.1	8.9	5.5	12.8	35	18.8	43	7.1	130	7
	Min	19	2.3	212	6.9	0.7	0.7	0.003	0.61	0.61	3.0	12.0	3.4	22.0	26	2.6	68	16.0	140	16
	Max	29	6.9	862	7.8	5.2	44.0	0.380	2.00	2.38	16.0	46.0	20.0	64.0	130	53.0	200	36.0	570	36
A116	Count	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	Mean	21	1.1	424	7.0	3.3	26.9	0.003	2.10	2.10	4.9	70.8	12.4	32.3	63	10.1	107	25.5	273	27
	StDev	2	0.6	234	0.2	1.5	20.9	0.000	0.62	0.62	2.2	34.4	9.1	15.6	39	8.8	51	5.7	152	8
	Min	19	0.4	175	6.9	2.3	3.5	0.003	1.60	1.60	3.0	46.0	4.1	16.0	22	1.8	55	19.0	120	19
	Max	22	1.9	661	7.3	5.5	45.0	0.003	3.00	3.00	7.4	120.0	24.0	48.0	100	20.0	160	32.0	440	33

	STAT	TEMP	DO	SPCOND	PH	TURB	TSUSSD	NOX	TKN	TN	OPO4	TP	SIO2	CA	CL	SO4	ALKALINITY	TDORGC	TDSSOL	TOTORC
	unit	Celcius	mg L^{-1}	μS cm^{-1}		NTU	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	μg L^{-1}	μg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
A117	Count	9	9	9	9	8	9	8	8	8	8	9	8	8	9	9	8	8	8	8
	Mean	22	1.7	267	6.6	1.1	1.5	0.007	0.96	0.96	4.4	13.7	13.3	21.4	37	5.4	67	21.5	198	23
	StDev	4	1.1	141	0.4	1.1	0.7	0.004	0.19	0.19	3.9	4.6	4.3	9.6	23	4.9	26	5.2	92	6
	Min	15	0.6	103	6.1	0.4	0.7	0.003	0.76	0.77	3.0	9.2	6.8	8.7	12	1.0	28	14.0	85	15
	Max	28	3.8	493	7.1	3.7	2.5	0.014	1.30	1.30	14.0	24.0	19.0	35.0	77	14.0	100	29.0	340	31
A118	Count	11	11	11	11	9	11	9	9	9	9	11	9	9	11	11	9	9	9	9
	Mean	23	2.9	130	6.5	0.5	1.8	0.008	0.84	0.84	3.3	8.7	10.3	10.0	18	1.2	32	17.4	104	18
	StDev	4	1.0	55	0.4	0.1	1.2	0.005	0.15	0.15	0.7	3.1	5.5	4.0	8	0.8	15	2.9	36	3
	Min	16	1.1	76	6.0	0.4	0.7	0.003	0.65	0.66	3.0	3.6	4.6	6.2	9	0.6	18	12.0	71	13
	Max	29	4.4	254	7.2	0.7	4.5	0.016	1.00	1.01	4.9	15.0	19.0	18.0	36	3.5	60	21.0	180	24
A119	Count	11	11	11	11	9	11	9	9	9	9	11	9	9	11	11	9	9	9	9
	Mean	24	4.5	184	6.7	0.5	1.9	0.006	0.90	0.91	3.3	6.5	9.9	7.0	16	0.4	28	18.8	96	21
	StDev	4	1.5	251	0.4	0.1	1.1	0.003	0.18	0.18	0.8	2.7	4.0	1.6	5	0.2	15	3.5	22	11
	Min	15	2.0	71	6.1	0.4	0.7	0.003	0.56	0.57	3.0	3.0	4.4	4.6	9	0.0	13	12.0	82	13
	Max	31	6.4	936	7.4	0.7	4.5	0.011	1.20	1.20	5.3	12.0	18.0	9.8	22	0.8	62	25.0	150	50
A120	Count	12	12	12	12	11	12	11	11	11	11	12	11	11	12	12	11	11	11	11
	Mean	25	6.4	186	6.7	0.6	1.8	0.008	0.99	1.00	3.0	12.9	3.9	5.5	21	0.1	18	16.6	85	17
	StDev	4	2.1	251	0.4	0.2	1.0	0.009	0.31	0.30	0.0	27.5	0.9	1.0	10	0.1	8	2.2	22	2
	Min	15	2.9	67	6.1	0.5	0.7	0.003	0.53	0.54	3.0	3.0	2.2	3.9	10	0.0	12	12.0	41	12
	Max	30	9.3	972	7.2	1.2	4.5	0.025	1.50	1.50	3.0	100.0	5.4	7.0	45	0.4	35	20.0	120	20
A122	Count	10	10	10	10	9	10	9	9	9	9	10	9	9	10	10	9	9	9	9
	Mean	23	1.6	268	6.7	0.6	1.2	0.005	0.93	0.94	3.1	10.2	10.0	23.2	35	4.9	81	20.9	190	21
	StDev	4	1.2	151	0.5	0.1	0.8	0.003	0.18	0.18	0.2	4.3	5.3	11.8	23	4.3	41	3.9	91	5
	Min	16	0.5	103	6.2	0.4	0.7	0.003	0.66	0.66	3.0	3.0	3.1	9.4	11	1.1	28	15.0	87	15
	Max	29	4.1	554	7.5	0.8	3.0	0.009	1.30	1.30	3.6	15.0	19.0	43.0	80	13.0	130	25.0	350	29
A124	Count	10	10	10	10	9	10	9	9	9	9	10	8	9	10	10	9	9	9	9
	Mean	23	2.6	141	6.9	0.6	1.5	0.007	0.87	0.88	4.7	8.4	3.8	11.2	22	0.2	29	17.6	100	18
	StDev	4	2.5	36	0.7	0.2	0.7	0.005	0.18	0.18	5.0	6.0	1.0	2.8	8	0.2	7	2.7	27	2
	Min	15	0.5	86	5.7	0.4	0.7	0.003	0.57	0.58	3.0	3.0	2.3	7.6	12	0.0	21	13.0	53	14
	Max	28	8.5	196	7.9	0.9	2.7	0.018	1.10	1.11	18.0	20.0	5.1	16.0	35	0.4	40	20.0	140	21
A126	Count	10	10	10	10	8	10	8	8	8	8	10	7	8	10	10	8	8	8	8
	Mean	24	8.3	214	7.5	0.6	1.7	0.007	1.04	1.05	8.3	7.3	4.7	16.5	33	1.4	52	17.1	139	18
	StDev	6	11.2	112	0.9	0.1	1.3	0.006	0.25	0.25	11.8	3.9	2.4	6.8	21	1.3	23	2.6	67	2
	Min	17	1.7	121	6.4	0.5	0.7	0.003	0.54	0.55	3.0	3.0	0.9	11.0	14	0.4	32	14.0	73	15
	Max	36	39.3	420	9.7	0.8	5.0	0.021	1.30	1.30	37.0	16.0	8.0	27.0	73	3.9	89	21.0	240	22
A127	Count	10	10	10	10	8	10	8	8	8	8	10	8	8	10	10	8	8	8	8
	Mean	25	5.7	109	7.1	0.6	1.6	0.005	1.02	1.02	9.0	5.5	6.1	6.0	19	0.2	22	18.5	70	19
	StDev	6	2.5	33	0.7	0.1	0.9	0.003	0.24	0.24	15.4	3.1	5.3	1.8	7	0.2	17	5.2	26	5
	Min	17	2.8	59	6.1	0.4	0.7	0.003	0.67	0.68	3.0	3.0	2.6	3.9	9	0.0	8	11.0	37	13
	Max	38	11.3	166	8.1	0.7	3.0	0.009	1.40	1.40	47.0	11.0	19.0	8.5	33	0.5	54	26.0	110	25

	STAT	TEMP	DO	SPCOND	PH	TURB	TSUSSD	NOX	TKN	TN	OPO4	TP	SIO2	CA	CL	SO4	ALKALINITY	TDORGC	TDSSOL	TOTORC
	unit	Celcius	mg L^{-1}	$\mu S\ cm^{-1}$		NTU	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	$\mu g\ L^{-1}$	$\mu g\ L^{-1}$	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
A128	Count	10	10	10	10	7	10	7	7	7	7	10	7	7	10	10	7	7	7	7
	Mean	24	5.4	104	6.5	0.6	1.9	0.008	0.98	0.99	4.3	6.5	2.9	5.3	19	0.1	16	18.9	91	19
	StDev	4	1.6	26	0.3	0.2	1.0	0.006	0.16	0.16	3.4	4.2	1.5	1.1	7	0.1	5	2.5	13	3
	Min	15	3.5	65	6.1	0.4	0.7	0.003	0.74	0.75	3.0	3.0	0.7	4.2	9	0.0	10	14.0	74	14
	Max	30	8.8	138	7.0	1.1	4.0	0.021	1.20	1.20	12.0	15.0	4.7	6.9	28	0.4	24	21.0	110	24
A129	Count	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Mean	25	3.8	530	7.4	2.1	4.8	0.123	1.37	1.49	6.0	32.8	8.9	45.8	70	19.4	135	23.1	325	24
	StDev	5	1.7	187	0.2	0.7	2.4	0.371	0.26	0.58	8.0	11.7	5.7	14.6	24	16.7	41	5.0	121	5
	Min	19	1.2	257	7.1	1.1	2.0	0.003	1.00	1.00	2.0	18.0	2.8	26.0	34	2.6	75	19.0	190	19
	Max	31	7.0	958	7.6	3.3	10.0	1.300	1.90	3.20	31.0	52.0	22.0	79.0	120	60.0	230	36.0	620	36
A130	Count	11	11	11	11	9	11	9	9	9	9	11	9	9	11	11	9	9	9	9
	Mean	24	2.8	317	7.0	0.7	1.5	0.006	0.97	0.98	3.0	10.9	9.6	28.9	43	6.0	90	20.0	229	21
	StDev	6	1.3	160	0.3	0.4	1.0	0.005	0.16	0.16	0.0	3.0	6.3	11.9	22	8.2	33	2.3	82	4
	Min	16	0.9	109	6.4	0.4	0.7	0.003	0.73	0.73	3.0	6.7	1.1	16.0	12	0.6	51	16.0	130	16
	Max	34	5.4	638	7.6	1.7	4.0	0.017	1.30	1.31	3.0	16.0	18.0	52.0	85	26.0	150	24.0	400	27
A131	Count	10	10	10	10	9	10	9	9	9	9	10	9	9	10	10	9	9	9	9
	Mean	25	6.1	169	7.2	0.6	1.2	0.007	1.14	1.15	9.2	7.7	5.0	13.2	25	0.6	42	20.3	118	21
	StDev	6	2.7	49	0.5	0.1	0.8	0.008	0.35	0.35	18.3	5.1	4.1	3.0	9	0.5	9	5.5	30	6
	Min	16	3.4	90	6.6	0.4	0.7	0.003	0.72	0.75	3.0	3.0	0.1	9.0	11	0.2	28	13.0	56	14
	Max	37	11.1	227	7.9	0.8	3.0	0.026	1.70	1.70	58.0	21.0	11.0	18.0	37	1.5	55	29.0	150	31
A132	Count	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Mean	25	3.6	566	7.4	2.4	3.7	0.124	1.34	1.46	10.4	32.4	8.7	47.7	78	22.5	143	22.8	350	23
	StDev	4	1.5	192	0.2	1.1	2.0	0.371	0.31	0.59	14.1	11.1	5.9	14.7	28	16.2	37	5.4	121	6
	Min	19	1.0	253	7.1	0.8	1.5	0.003	0.97	0.97	2.0	20.0	2.3	25.0	33	2.8	95	16.0	170	17
	Max	31	6.0	937	7.8	4.3	8.0	1.300	1.90	3.10	43.0	56.0	22.0	78.0	120	57.0	220	36.0	600	36
A133	Count	8	8	8	8	3	8	3	3	3	3	8	3	4	8	8	3	3	3	3
	Mean	23	2.7	449	6.9	1.7	2.0	0.007	1.37	1.37	3.0	23.9	14.7	36.8	59	10.9	147	24.8	347	26
	StDev	5	1.2	212	0.3	0.7	1.5	0.003	0.15	0.16	0.0	7.8	4.5	25.7	28	10.7	35	7.7	96	7
	Min	16	1.1	152	6.5	0.9	0.7	0.003	1.20	1.20	3.0	16.0	10.0	0.0	24	0.7	110	16.0	260	18
	Max	30	4.8	775	7.4	2.2	5.0	0.009	1.50	1.51	3.0	38.0	19.0	60.0	95	27.0	180	30.0	450	30
A134	Count	10	10	10	10	8	10	8	8	8	8	10	8	8	10	10	8	8	8	8
	Mean	25	4.4	381	7.2	0.6	2.2	0.014	1.19	1.20	13.6	10.9	11.2	36.4	51	11.4	99	23.6	271	24
	StDev	6	2.7	228	0.4	0.2	1.6	0.021	0.21	0.20	24.9	3.3	5.9	17.7	31	12.3	44	4.9	129	6
	Min	17	0.5	131	6.8	0.4	0.7	0.003	0.94	0.95	3.0	7.5	2.6	12.0	18	0.5	38	17.0	110	17
	Max	37	10.6	708	7.9	0.9	5.5	0.066	1.40	1.41	75.0	18.0	20.0	60.0	93	33.0	150	30.0	450	31
A135	Count	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Mean	25	4.0	606	7.5	2.3	2.6	0.100	1.36	1.46	7.8	32.6	9.0	50.5	86	25.4	143	21.8	371	21
	StDev	4	1.9	198	0.2	1.4	2.0	0.257	0.31	0.50	13.3	16.5	5.9	14.5	32	16.2	39	5.2	126	10
	Min	20	1.3	255	7.1	0.7	0.7	0.003	0.87	0.87	2.0	13.0	2.2	24.0	34	2.7	79	15.0	170	0
	Max	30	6.8	963	7.7	4.8	7.5	0.910	1.90	2.81	49.0	65.0	23.0	80.0	140	55.0	230	35.0	620	42

	STAT	TEMP	DO	SPCOND	PH	TURB	TSUSSD	NOX	TKN	TN	OPO4	TP	SIO2	CA	CL	SO4	ALKALINITY	TDORGC	TDSSOL	TOTORC
	unit	Celcius	mg L^{-1}	μS cm^{-1}		NTU	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	μg L^{-1}	μg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
A136	Count	9	9	9	9	6	9	7	7	7	7	9	7	7	9	9	7	7	7	7
	Mean	23	1.9	412	7.0	1.0	3.1	0.032	1.70	1.73	3.0	20.9	11.1	40.1	60	11.2	147	26.4	339	28
	StDev	4	0.9	252	0.2	0.7	3.0	0.070	0.61	0.61	0.0	17.1	6.3	18.3	32	12.1	65	4.5	178	6
	Min	19	0.8	7	6.6	0.5	0.7	0.003	1.20	1.20	3.0	8.6	1.1	15.0	20	0.6	50	21.0	110	21
	Max	29	3.3	729	7.2	2.3	8.0	0.190	3.00	3.01	3.0	64.0	18.0	61.0	110	34.0	230	32.0	620	34
A137	Count	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Mean	23	2.0	344	6.9	0.7	1.1	0.006	1.34	1.34	3.3	10.1	10.1	30.5	51	10.1	90	24.7	244	25
	StDev	4	0.9	254	0.3	0.1	0.5	0.004	0.21	0.21	0.9	5.0	7.4	17.9	33	12.6	50	4.6	133	6
	Min	19	0.5	6	6.4	0.4	0.7	0.003	1.00	1.00	3.0	3.0	1.0	11.0	18	0.4	32	19.0	90	17
	Max	30	3.8	724	7.1	0.9	2.0	0.014	1.60	1.60	5.8	17.0	21.0	58.0	100	33.0	150	32.0	450	34
A138	Count	10	10	10	10	6	10	6	6	6	6	10	6	6	10	10	6	6	6	6
	Mean	23	5.1	227	7.2	0.6	1.9	0.006	1.23	1.24	3.0	7.0	11.5	24.5	36	3.7	76	22.0	208	22
	StDev	5	2.8	149	0.3	0.3	0.6	0.003	0.31	0.31	0.0	3.5	5.7	10.3	18	6.4	31	3.8	59	4
	Min	19	2.6	7	6.7	0.4	0.7	0.003	0.89	0.90	3.0	3.0	3.1	11.0	15	0.3	37	16.0	140	16
	Max	31	11.2	447	7.5	1.3	2.5	0.009	1.80	1.80	3.0	15.0	20.0	36.0	62	20.0	110	28.0	290	27
A139	Count	9	9	9	9	4	9	4	4	4	4	9	4	4	9	9	4	4	4	4
	Mean	23	5.0	87	7.0	0.7	1.7	0.008	1.20	1.21	3.0	7.5	6.2	6.2	17	0.3	16	20.5	91	22
	StDev	5	2.6	36	0.5	0.1	0.9	0.002	0.12	0.11	0.0	4.2	2.7	1.2	6	0.2	4	4.0	41	5
	Min	19	2.1	8	6.4	0.5	0.7	0.004	1.10	1.11	3.0	3.0	3.4	4.5	8	0.0	13	15.0	35	15
	Max	30	10.4	120	7.5	0.9	3.0	0.009	1.30	1.31	3.0	14.0	9.9	7.1	26	0.6	21	24.0	130	27
A140	Count	9	9	9	9	5	9	5	5	5	5	9	5	5	9	9	5	5	5	5
	Mean	23	5.0	238	6.9	0.7	2.1	0.008	1.01	1.01	3.0	7.3	11.8	23.8	35	4.4	74	21.2	220	22
	StDev	5	2.0	112	0.4	0.3	1.1	0.003	0.12	0.12	0.0	3.6	6.1	11.9	14	7.5	36	3.7	87	4
	Min	19	2.7	116	6.4	0.4	0.7	0.003	0.88	0.89	3.0	3.0	2.2	11.0	17	0.4	35	17.0	130	17
	Max	31	8.5	458	7.8	1.2	4.7	0.010	1.20	1.20	3.0	12.0	19.0	42.0	55	23.0	130	27.0	360	28
A141	Count	10	10	10	10	10	10	10	10	10	10	10	9	10	10	10	10	10	10	10
	Mean	23	2.7	190	6.9	0.7	1.6	0.009	0.95	0.96	3.0	8.9	6.8	14.8	26	2.3	50	17.3	129	17
	StDev	4	1.6	89	0.6	0.3	0.8	0.011	0.19	0.18	0.0	3.7	3.9	5.8	14	2.5	21	2.9	53	4
	Min	16	0.6	90	6.0	0.4	0.7	0.003	0.72	0.72	3.0	4.1	3.4	7.2	10	0.0	25	12.0	63	12
	Max	30	4.6	386	7.8	1.3	3.3	0.037	1.20	1.20	3.0	15.8	15.0	27.0	57	6.8	93	21.0	250	25
LOX10	Count	10	8	10	9	7	7	4	7	7	6	10	7	7	10	10	7	7	7	7
	Mean	24	4.8	148	6.8	0.8	2.4	0.010	1.14	1.14	2.3	8.2	5.2	11.1	20	0.4	41	17.1	123	17
	StDev	5	1.3	44	0.3	0.2	0.7	0.012	0.10	0.10	0.5	1.1	1.2	3.5	7	0.1	12	2.0	55	2
	Min	18	3.5	107	6.2	0.5	1.6	0.003	0.99	0.99	2.0	7.0	3.3	7.3	12	0.2	27	14.7	75	14
	Max	30	6.9	228	7.1	1.0	3.0	0.027	1.29	1.29	3.0	10.0	6.6	16.2	32	0.5	58	19.7	223	20
LOX11	Count	12	12	11	12	11	11	9	11	11	9	12	11	11	12	12	11	11	11	11
	Mean	24	4.3	108	6.5	0.8	2.2	0.006	1.05	1.06	2.4	6.8	3.5	5.5	19	0.0	10	17.6	90	18
	StDev	4	1.8	39	0.5	0.2	0.7	0.004	0.18	0.18	0.5	1.3	1.5	1.3	6	0.0	2	3.3	33	3
	Min	16	1.1	57	6.1	0.5	1.6	0.003	0.83	0.84	2.0	4.0	2.3	3.8	9	0.0	8	13.8	35	13
	Max	29	7.7	179	7.8	1.1	3.0	0.017	1.50	1.52	3.0	8.0	7.5	8.6	30	0.1	16	24.5	150	24

	STAT	TEMP	DO	SPCOND	PH	TURB	TSUSSD	NOX	TKN	TN	OPO4	TP	SIO2	CA	CL	SO4	ALKALINITY	TDORGC	TDSSOL	TOTORC
	unit	Celcius	mg L^{-1}	μS cm^{-1}		NTU	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	μg L^{-1}	μg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
LOX12	Count	12	12	11	12	12	12	10	12	12	10	12	12	12	12	12	12	12	12	12
	Mean	25	4.6	126	6.8	0.6	2.2	0.005	0.88	0.89	2.5	6.9	5.3	9.1	22	0.3	32	14.2	103	14
	StDev	4	1.7	33	0.4	0.2	0.7	0.005	0.19	0.19	0.5	1.6	2.2	2.1	12	0.2	7	2.6	32	3
	Min	18	1.8	80	6.2	0.3	1.6	0.003	0.71	0.71	2.0	4.0	3.2	6.5	9	0.0	22	10.8	40	11
	Max	30	6.5	184	7.5	1.0	3.0	0.018	1.24	1.24	3.0	9.0	10.0	12.7	54	0.7	45	17.6	149	18
LOX13	Count	12	12	11	12	10	10	7	10	10	8	12	10	10	12	12	10	10	10	10
	Mean	24	4.5	113	6.5	0.7	2.2	0.006	1.03	1.03	2.5	7.1	4.3	7.2	19	0.0	14	16.3	93	16
	StDev	4	2.3	32	0.4	0.1	0.7	0.004	0.20	0.20	0.5	1.7	2.0	1.6	5	0.0	4	2.9	21	3
	Min	17	1.1	65	5.9	0.5	1.6	0.003	0.74	0.74	2.0	4.0	2.7	4.6	11	0.0	10	12.0	53	12
	Max	29	8.1	172	7.1	0.8	3.0	0.014	1.47	1.48	3.0	10.0	8.8	10.2	27	0.1	23	21.7	123	21
LOX14	Count	12	12	11	12	12	12	10	12	12	10	12	12	12	12	12	12	12	12	12
	Mean	24	3.4	171	6.5	0.6	2.4	0.005	0.84	0.85	2.5	6.6	4.3	13.3	23	2.2	33	15.3	130	15
	StDev	4	1.7	84	0.3	0.2	0.9	0.002	0.21	0.21	0.5	1.4	3.0	6.0	15	3.6	10	2.5	60	3
	Min	18	0.6	110	5.9	0.4	1.6	0.003	0.64	0.65	2.0	4.0	1.6	8.7	11	0.0	18	11.9	78	12
	Max	29	6.4	404	7.0	1.2	4.0	0.007	1.26	1.27	3.0	9.0	10.6	28.1	69	11.4	59	19.7	278	20
LOX15	Count	12	12	12	12	12	12	10	12	12	10	12	12	12	12	12	12	12	12	12
	Mean	25	4.9	248	7.0	0.7	2.2	0.009	1.25	1.25	2.5	7.3	4.7	19.5	33	7.6	62	17.2	176	17
	StDev	4	1.9	96	0.5	0.2	0.7	0.009	0.19	0.18	0.5	1.8	2.7	8.1	12	8.3	24	1.7	62	2
	Min	19	1.5	142	6.2	0.4	1.6	0.003	1.03	1.04	2.0	5.0	1.7	9.3	10	0.7	30	14.3	88	15
	Max	29	7.7	467	7.4	1.0	3.0	0.034	1.68	1.69	3.0	11.0	10.6	35.2	56	26.2	106	20.5	298	20
LOX16	Count	12	12	12	12	10	10	7	10	10	9	12	10	10	12	12	10	10	10	10
	Mean	24	3.2	155	6.6	0.6	2.3	0.006	0.81	0.81	2.4	7.4	4.2	12.4	22	1.0	37	14.0	118	14
	StDev	4	1.5	48	0.5	0.1	0.7	0.005	0.18	0.18	0.5	1.8	1.7	3.4	10	0.9	9	1.4	33	1
	Min	18	1.3	99	6.0	0.3	1.6	0.003	0.65	0.65	2.0	4.0	1.6	8.4	8	0.2	25	11.8	81	12
	Max	29	6.0	248	7.7	0.7	3.0	0.018	1.23	1.23	3.0	10.0	7.0	17.2	40	2.9	52	15.7	165	16
LOX3	Count	10	8	10	9	3	3	1	3	3	4	10	3	3	10	10	3	3	3	3
	Mean	23	4.5	101	6.5	1.2	3.0	0.005	1.42	1.43	2.3	8.3	3.3	3.8	18	0.0	10	20.1	80	20
	StDev	5	2.3	28	0.5	0.3	0.0		0.14	0.14	0.5	1.1	0.2	0.1	7	0.0	0	1.1	30	2
	Min	16	1.8	64	5.8	1.0	3.0	0.005	1.27	1.27	2.0	7.0	3.1	3.7	9	0.0	10	18.8	46	18
	Max	32	7.3	158	7.3	1.6	3.0	0.005	1.55	1.56	3.0	10.0	3.5	3.8	30	0.1	10	21.0	104	21
LOX4	Count	10	8	10	10	10	10	6	10	10	9	10	10	10	10	10	10	10	10	10
	Mean	23	3.7	332	6.8	0.7	2.3	0.008	1.23	1.24	2.6	9.8	10.4	26.5	44	6.2	79	23.9	234	25
	StDev	4	2.0	186	0.4	0.2	0.7	0.008	0.27	0.26	0.5	4.8	5.5	13.8	29	9.4	49	3.9	100	4
	Min	18	1.0	140	6.2	0.4	1.6	0.003	0.80	0.80	2.0	6.0	2.0	12.7	18	0.6	10	15.8	146	16
	Max	29	6.7	685	7.4	1.1	3.0	0.023	1.62	1.62	3.0	21.0	17.8	52.5	93	29.5	165	28.0	465	30
LOX5	Count	10	8	10	9	3	3	1	3	3	3	10	3	3	10	10	3	3	3	3
	Mean	24	5.2	99	6.4	1.3	3.0	0.005	1.25	1.26	2.0	7.5	4.9	3.2	19	0.1	8	16.3	70	16
	StDev	5	1.8	31	0.6	0.6	0.0		0.09	0.09	0.0	0.8	0.9	0.2	7	0.1	1	0.7	21	1
	Min	17	2.9	61	5.9	0.8	3.0	0.005	1.17	1.17	2.0	6.0	3.9	3.0	11	0.0	8	15.5	47	15
	Max	32	7.6	155	7.8	2.0	3.0	0.005	1.34	1.35	2.0	9.0	5.8	3.3	33	0.2	9	16.8	88	17

	STAT	TEMP	DO	SPCOND	PH	TURB	TSUSSD	NOX	TKN	TN	OPO4	TP	SIO2	CA	CL	SO4	ALKALINITY	TDORGC	TDSSOL	TOTORG
	unit	Celcius	mg L^{-1}	$\mu S\ cm^{-1}$		NTU	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	$\mu g\ L^{-1}$	$\mu g\ L^{-1}$	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
LOX6	Count	11	11	11	11	10	10	8	10	10	9	11	10	10	11	11	10	10	10	10
	Mean	23	4.1	207	6.9	0.7	2.3	0.004	1.10	1.11	2.4	7.0	5.8	14.7	30	0.7	45	15.9	155	16
	StDev	4	1.6	101	0.3	0.1	0.7	0.002	0.12	0.12	0.5	4.3	3.4	6.3	20	0.7	18	2.7	59	3
	Min	17	1.9	100	6.4	0.5	1.6	0.003	0.95	0.95	2.0	4.0	1.1	8.8	12	0.2	28	11.7	91	12
	Max	29	6.9	394	7.5	0.8	3.0	0.007	1.26	1.26	3.0	18.0	11.5	25.3	66	2.3	76	19.7	270	20
LOX7	Count	12	10	12	11	10	10	6	10	10	9	12	10	10	12	12	10	10	10	10
	Mean	24	5.0	122	6.4	0.8	2.3	0.004	1.13	1.14	2.3	7.6	4.6	5.0	22	0.1	16	19.5	99	20
	StDev	4	2.3	43	0.6	0.1	0.7	0.001	0.18	0.18	0.5	1.4	1.4	1.0	10	0.1	19	3.9	26	5
	Min	19	2.3	66	5.8	0.6	1.6	0.003	0.88	0.88	2.0	6.0	2.2	3.4	9	0.0	8	12.5	52	12
	Max	30	8.3	196	7.8	1.0	3.0	0.006	1.41	1.41	3.0	10.0	6.5	6.4	44	0.2	69	25.9	138	30
LOX8	Count	12	10	12	11	12	12	9	12	12	10	12	12	12	12	12	12	12	12	12
	Mean	24	4.5	99	6.2	1.0	2.2	0.006	1.20	1.21	2.5	11.1	3.9	4.6	17	0.0	10	18.8	92	19
	StDev	4	2.4	36	0.4	0.2	0.7	0.007	0.27	0.27	0.5	2.8	2.0	1.8	7	0.0	5	4.5	41	5
	Min	17	1.4	58	5.8	0.7	1.6	0.003	0.90	0.90	2.0	8.0	1.5	2.8	8	0.0	6	13.3	26	13
	Max	30	8.6	151	7.1	1.4	3.0	0.026	1.66	1.66	3.0	18.0	8.2	8.5	29	0.1	22	25.7	171	26
LOX9	Count	10	8	10	9	8	8	4	8	8	7	10	8	8	10	10	8	8	8	8
	Mean	24	5.2	119	6.5	0.8	2.3	0.017	1.32	1.33	2.4	6.5	2.6	5.7	22	0.0	16	18.1	99	18
	StDev	5	1.5	35	0.3	0.1	0.7	0.027	0.30	0.29	0.5	1.2	1.6	1.9	9	0.0	5	4.1	38	4
	Min	18	3.2	77	6.0	0.6	1.6	0.003	1.07	1.09	2.0	4.0	0.6	4.1	10	0.0	12	13.6	46	14
	Max	31	7.7	185	6.9	0.9	3.0	0.058	1.82	1.82	3.0	8.0	4.4	8.9	36	0.1	25	24.4	161	25

[1] $\mu g\ L^{-1}$ = ppb

[2] to convert degrees Celsius to degrees Fahrenheit ; degrees Celsius = (5/9)*(degrees Fahrenheit -32)

APPENDIX B

Table A-2. EVPA and LOXA sites classified into zones for analyses.

Canal	LOXA104, LOXA115, LOXA129, LOXA132, LOXA135
Perimeter (<2.5 km; 1.6 miles)	LOX4, LOX6, LOX10, LOX14, LOX15, LOX16, LOXA101, LOXA102, LOXA103, LOXA105, LOXA106, LOXA107, LOXA109, LOXA112, LOXA116, LOXA117, LOXA118, LOXA122, LOXA124, LOXA126, LOXA130, LOXA131, LOXA133, LOXA134, LOXA136, LOXA137, LOXA138, LOXA140
Transition (2.5 - 4.5 km 1.6 – 2.8 miles))	LOX12, LOXA108, LOXA110, LOXA111, LOXA113, LOXA114, LOXA119, LOXA127, LOXA139
Interior(>4.5 km; 2.8 miles)	LOX3, LOX5, LOX7, LOX8, LOX9, LOX11, LOX13, LOXA120, LOXA128

APPENDIX C

Table A-3. Monthly summary statistics (Count = # of samples, Mean = arithmetic mean, StDev = one standard deviation, Min = minimum, Max = maximum) for calendar year 2008. Previous summary statistics (2004 – 2007) can be found in the previous annual reports.

	Zone	STAT	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
TP ($\mu g L^{-1}$)	C	Count	5	5	5	5	5	5	5	5	5	5	5	5
	C	Mean	25.0	34.3	24.0	27.4	39.8	36.2	23.8	51.0	39.0	41.0	23.0	20.2
	C	StDev	2.2	4.8	7.1	6.5	8.6	10.7	7.9	10.9	8.4	7.8	7.5	5.2
	C	Min	22.0	27.0	18.0	18.0	26.0	26.0	13.0	36.0	34.0	33.0	13.0	12.0
	C	Max	28.0	40.0	35.0	34.0	49.0	54.0	32.0	65.0	54.0	49.0	34.0	26.0
	P	Count	29	29	28	19	4	5	26	28	28	28	28	28
	P	Mean	9.0	11.7	14.4	11.3	8.8	11.0	7.6	10.6	10.9	15.1	6.6	9.5
	P	StDev	7.9	8.5	21.1	14.5	2.5	2.9	6.3	6.4	5.4	11.1	3.3	5.3
	P	Min	4.0	5.0	5.0	4.0	6.0	9.0	3.0	3.2	3.0	5.0	3.0	3.8
	P	Max	46.0	48.0	120.0	69.0	12.0	16.0	26.0	38.0	21.0	64.0	18.0	28.0
	T	Count	9	9	9	6	1	2	8	9	9	9	9	9
	T	Mean	4.8	7.7	6.9	6.1	9.0	6.4	4.1	4.8	7.3	9.5	4.2	6.8
	T	StDev	1.1	2.9	2.4	4.1		0.6	2.1	1.6	3.1	1.6	1.7	3.3
	T	Min	4.0	3.1	4.2	3.0	9.0	6.0	3.0	3.0	3.7	7.0	3.0	3.0
	T	Max	7.0	12.0	11.0	14.0	9.0	6.8	9.0	7.4	14.0	12.0	6.8	13.0
	I	Count	9	9	9	9	5	5	9	9	9	9	9	9
	I	Mean	6.4	8.8	7.8	6.8	28.0	8.6	8.5	6.8	7.7	7.1	6.7	5.7
	I	StDev	1.5	2.8	2.0	2.8	40.3	2.1	4.0	2.7	1.3	1.4	2.4	1.9
	I	Min	4.0	6.0	6.0	4.0	8.0	5.2	4.3	3.0	5.3	5.0	3.0	3.0
	I	Max	9.0	15.0	12.0	13.0	100.0	10.0	18.0	12.0	9.0	9.0	10.0	8.0
TN ($mg L^{-1}$)	C	Count	5	5	5	5	5	5	5	5	5	5	5	5
	C	Mean	1.26	1.46	1.25	1.00	1.31	1.40	1.40	2.67	1.49	1.79	1.64	1.28
	C	StDev	0.17	0.23	0.42	0.23	0.17	0.21	0.38	0.55	0.23	0.13	0.14	0.21
	C	Min	1.11	1.30	0.87	0.61	1.06	1.16	1.12	1.87	1.20	1.61	1.49	1.11
	C	Max	1.53	1.81	1.80	1.20	1.50	1.65	2.01	3.20	1.81	1.91	1.81	1.64
	P	Count	27	24	20	10	2	2	14	27	24	28	27	27
	P	Mean	1.17	1.19	1.16	1.09	1.27	1.33	1.17	1.13	1.00	1.09	1.08	1.05
	P	StDev	0.25	0.30	0.48	0.35	0.18	0.09	0.21	0.33	0.16	0.48	0.32	0.33
	P	Min	0.77	0.75	0.72	0.65	1.15	1.27	0.85	0.66	0.71	0.55	0.58	0.66
	P	Max	1.80	2.00	3.00	1.60	1.40	1.40	1.60	1.91	1.41	3.01	1.71	1.81
	T	Count	7	7	4	1	1	1	5	9	8	9	9	6
	T	Mean	1.09	0.97	1.08	0.83	1.24	1.20	0.85	0.87	1.08	0.85	1.06	0.82
	T	StDev	0.12	0.22	0.15				0.49	0.15	0.28	0.17	0.21	0.10
	T	Min	0.94	0.76	0.94	0.83	1.24	1.20	0.00	0.62	0.71	0.57	0.75	0.72
	T	Max	1.20	1.40	1.20	0.83	1.24	1.20	1.20	1.11	1.60	1.11	1.41	1.00
	I	Count	7	7	6	5	3	2	6	5	9	9	9	7
	I	Mean	1.27	1.30	1.19	1.09	1.55	1.48	1.11	0.95	1.13	0.92	1.07	0.96
	I	StDev	0.21	0.29	0.16	0.24	0.09	0.25	0.13	0.20	0.15	0.24	0.24	0.15
	I	Min	1.04	0.97	1.00	0.93	1.48	1.30	0.90	0.65	0.98	0.54	0.86	0.65
	I	Max	1.69	1.82	1.45	1.50	1.66	1.66	1.27	1.18	1.45	1.27	1.56	1.10

	Zone	STAT	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
COND ($\mu S\ cm^{-1}$)	C	Count	5	5	5	5	5	5	5	5	5	5	5	5
	C	Mean	523	551	513	252	364	564	577	553	566	907	773	696
	C	StDev	91	141	130	25	73	236	137	75	70	64	36	44
	C	Min	445	445	368	212	283	314	475	447	476	818	733	630
	C	Max	630	795	668	283	455	854	811	651	662	963	815	737
	P	Count	28	29	28	19	4	5	26	28	28	28	28	28
	P	Mean	303	243	179	143	177	176	185	296	211	409	344	322
	P	StDev	139	140	65	24	59	35	105	183	141	255	221	212
	P	Min	161	6	113	107	128	137	90	76	85	86	102	113
	P	Max	661	583	423	185	261	220	576	595	644	851	771	830
	T	Count	8	9	9	6	1	2	8	9	9	9	9	9
	T	Mean	146	125	127	124	155	148	110	81	84	89	193	112
	T	StDev	18	53	13	15		24	17	17	7	18	279	9
	T	Min	111	8	102	111	155	131	84	60	74	59	80	96
	T	Max	177	184	150	151	155	165	141	112	94	120	936	125
	I	Count	7	9	9	9	5	5	9	9	9	9	9	9
	I	Mean	136	136	131	100	183	154	193	90	71	95	81	96
	I	StDev	17	25	31	15	27	19	293	25	8	27	13	11
	I	Min	110	112	95	77	150	125	68	62	58	57	62	75
	I	Max	166	185	196	123	225	177	972	131	81	129	102	106
SO4 ($mg\ L^{-1}$)	C	Count	5	4	5	5	5	5	5	5	5	5	5	5
	C	Mean	11.7	11.9	21.0	3.5	8.6	21.7	28.2	39.2	27.0	54.2	32.4	28.4
	C	StDev	8.9	13.4	10.9	1.9	4.8	15.8	12.2	10.5	7.0	5.3	10.8	11.1
	C	Min	5.3	4.0	8.8	2.6	3.6	3.7	17.0	23.0	20.0	46.0	21.0	18.0
	C	Max	25.0	32.0	35.0	7.0	15.0	39.0	49.0	52.0	38.0	60.0	49.0	46.0
	P	Count	29	24	28	19	4	5	26	28	28	28	28	28
	P	Mean	3.3	1.9	0.9	0.6	0.5	0.8	1.5	13.4	4.2	14.9	7.9	5.1
	P	StDev	4.2	3.1	0.8	0.4	0.4	0.5	2.6	13.3	6.2	13.9	8.7	6.4
	P	Min	0.2	0.0	0.2	0.2	0.0	0.0	0.3	0.4	0.0	0.3	0.0	0.0
	P	Max	20.0	15.0	3.7	1.8	1.0	1.4	11.4	36.0	27.0	46.0	33.0	23.0
	T	Count	9	5	9	6	1	2	8	9	9	9	9	9
	T	Mean	0.2	0.4	0.3	0.2	0.2	0.4	0.2	0.5	0.3	0.2	0.9	0.2
	T	StDev	0.3	0.2	0.1	0.1		0.1	0.1	0.1	0.2	0.2	1.5	0.5
	T	Min	0.1	0.2	0.1	0.1	0.2	0.3	0.0	0.2	0.0	0.0	0.0	0.0
	T	Max	0.8	0.7	0.4	0.4	0.2	0.5	0.4	0.6	0.5	0.4	4.5	1.4
	I	Count	9	9	9	9	5	5	9	9	9	9	9	9
	I	Mean	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0
	I	StDev	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.2	0.1	0.1	0.0
	I	Min	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	I	Max	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.0	0.4	0.2	0.2	0.0
Tdepth (m)	C	Count	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	C	Mean	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	C	StDev	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	C	Min	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	C	Max	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	P	Count	28	28	29	19	4	5	26	28	28	28	26	28
	P	Mean	0.38	0.35	0.31	0.22	0.25	0.21	0.25	0.45	0.35	0.52	0.42	0.41
	P	StDev	0.17	0.15	0.19	0.12	0.12	0.11	0.13	0.16	0.15	0.19	0.15	0.16
	P	Min	0.15	0.16	0.07	0.08	0.11	0.11	0.13	0.14	0.15	0.25	0.18	0.16
	P	Max	0.81	0.88	0.85	0.53	0.37	0.40	0.71	0.92	0.74	1.17	0.90	0.84
	T	Count	9	9	9	6	1	2	8	9	9	9	9	9
	T	Mean	0.34	0.34	0.28	0.24	0.38	0.22	0.25	0.43	0.33	0.48	0.41	0.33
	T	StDev	0.18	0.17	0.20	0.19		0.15	0.16	0.11	0.17	0.18	0.14	0.14
	T	Min	0.19	0.11	0.12	0.10	0.38	0.11	0.10	0.30	0.19	0.25	0.23	0.17
	T	Max	0.77	0.71	0.74	0.62	0.38	0.32	0.63	0.68	0.75	0.86	0.70	0.56
	I	Count	9	9	9	9	5	3	9	9	9	9	5	9
	I	Mean	0.36	0.32	0.33	0.27	0.20	0.18	0.25	0.28	0.37	0.53	0.40	0.37
	I	StDev	0.15	0.14	0.14	0.14	0.02	0.10	0.10	0.13	0.11	0.18	0.14	0.14
	I	Min	0.15	0.10	0.18	0.10	0.18	0.11	0.13	0.15	0.25	0.27	0.16	0.17
	I	Max	0.59	0.53	0.54	0.51	0.22	0.29	0.42	0.49	0.51	0.77	0.51	0.51

[1] mg L^{-1} = ppm; µg L^{-1} = ppb; 1 m = 0.3 ft.