STORMWATER POLLUTANT ASSESSMENT AT THE CITY OF KISSIMMEE

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ABSTRACT

Historically, the City of Kissimmee has hired consultants to prepare Master Drainage Studies and analyze individual drainage basins to identify capital improvement projects which reduce flooding and pollutant loads. To date, this approach has met with moderate success. However, with the advent of Total Maximum Daily Loads (TMDLs) and their corresponding pollutant load reduction goals, the City's approach to stormwater management has had to become more sophisticated if it was to stay within compliance with the new criteria. The City was able to take an aggressive, proactive approach towards stormwater management and began collecting water quality data to adequately assess the City's pollutant loads. A successful monitoring program and corresponding stormwater management model was essential in meeting the new criteria and in turn significantly reduce the cost shared by the residents and business owners of the City of Kissimmee. The monitoring and modeling are also vital in assessing the effectiveness of the corrective measures and or BMPs once they are employed in the summer of 2008.

To meet the challenge of the City's accelerated monitoring task the Public Works and Engineering Department of the City has embanked on constructing thirty-two automatic data collection stations which will be installed in three tiers. The first and second tiers, consisting of twenty stations, have already been installed to determine the exterior boundary conditions, as well as, the internal hydrologic, hydraulic and water quality conditions of the City. The third tier represents the remaining twelve stations, which will be added at a later date, as the areas requiring model refinement are identified. YSI EcoNet automatic water quality samplers and telemetry were used for data collection since June 2005. Isco Avalanche - a portable refrigerated automated water sampler that was used to collect flow weighted samples. These samples were sent to EPA certified laboratory for analyses. The concentrations of the nutrient, suspended and dissolved solids, bacteria and heavy metals were used to evaluate the current levels of pollutants. Conductivity, pH, and dissolved oxygen, temperature, and turbidity; were also monitored using YSI 6600 EDS multi-parameter water quality instruments. Sontek Argonaut (SL/SW) was used to measure water velocity and water level; while rainfall volumes were measured using Sutron Rain Gauge.

The surface water model was established with MIKE SHE using the City's extensive Geographic Information System (GIS) and the water quality model was created using the corresponding MIKE SHE ECO Lab module. Historical data is being used to calibrate these models. As data is collected from the automatic water quality samplers these models will be integrated and further refined. Once the models have been fully

integrated, significant pollutant load areas can be identified for specific corrective measures. Preliminary results suggested some areas with gross pollution.

INTRODUCTION

The Clean Water Act passed in 1972 set the framework for the water quality standards in the State of Florida. Although this framework has existed for over thirty years, it has only been through the recent creation of the Florida Watershed Restoration Act in 1999 that a quantifiable stormwater quality criterion was established. This criterion is defined by the Total Maximum Daily Load (TMDL) levels which will be set for each impaired waterbody in the State of Florida. These TMDLs have been incorporated into the Environmental Protection Agency's (EPA's) National Pollutant Discharge Elimination System (NPDES) permitting requirements and are managed by the Florida Department of Environmental Protection (FDEP).

The City of Kissimmee falls within Group 4 of the State's pollutant reduction program which started in July of 2003. Where adequate flow levels exist, the FDEP has collected water quality samples from the various tributaries of Lake Tohopekaliga and has prepared a list of impaired waterbodies for EPA's review and subsequent adoption. In areas where the FDEP was unable to collect the necessary samples to meet the EPA's approval, EPA must estimate the pollutant loads for the tributaries by assuming loading rates according to land use. This land use based loading rate is a procedure that EPA has admitted will overestimate the pollutant levels. The consequence of these inflated pollutant load values has already proven to be problematic for the lower groups in the program, such as Tallahassee (Group 1), which are a few years ahead of Group 4 in the State's program.

To be considered a valid set of water quality data, a full cycle of monitoring must be conducted which consists of at least one wet and one dry season. The City is taking an aggressive, proactive approach towards stormwater management and has already started water quality monitoring. It is hoped that enough data will be collected to adequately estimate the City's allocation of pollutant loads for the Basin Management Action Plan (BMAP) development which is planned to occur within the next year.
This BMAP establishes the corrective measures to be conducted by each contributor of pollutants to tributaries of the impaired waterbodies. A successful monitoring program and corresponding regional stormwater model will accurately assess the required improvements necessary to meet the new criteria and in turn significantly reduce the cost shared by the residents and business owners of the City of Kissimmee. The monitoring and modeling are also vital to the final phase of the State's program scheduled to start after adoption of the BMAP which consists of assessing the effectiveness of corrective measures once they have been implemented.

One of the main benefits of the monitoring and modeling project will be in the cost reduction of corrective measures. Previous studies conducted for the City have estimated the cost associated with retrofitting stormwater improvements within one of the City's six basins at approximately thirty million dollars. It is estimated that the cost of improvements to meet the TMDL criteria throughout the entire city without a monitoring and modeling program in place will exceed one hundred million dollars. The adoption of this Integrated Regional Stormwater Program by the City of Kissimmee will lead to future cost reductions. The first of these cost reduction benefits comes from obtaining actual water quality data and eliminating the potential for EPA to overestimate the pollutant loads which obligates the City of Kissimmee to construct larger capital improvements. An additional cost reduction is gained by the level of detail used during the evaluation of the pollutant loads and their associated transport processes. Once the model has been prepared, the exact location to construct the necessary corrective measures can be identified and small local improvements installed rather than constructing large, expensive improvements at the receiving water body in response to the estimated regional loads of the tributary.

BACKGROUND

The Clean Water Act (CWA) [40 CFR Part 130] requires each State to identify waters within its boundaries not meeting water quality standards applicable to the water's designated uses. This list of identified waters (referred to as the 303(d) list) must be submitted to the U.S. Environmental Protection Agency (EPA) for review and approval. The "listed" waters identified by the State are prioritized for Total Maximum Daily Loads (TMDL) development based on factors described in CWA regulations, such as the use of the water and the severity of pollution. A separate TMDL is established for each pollutant at a level necessary to attain the applicable water quality standards taking into account seasonal variations and a margin of safety. The TMDL establishes allowable loadings of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. With this information, States can establish water-quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (USEPA, 1991).

The objective of this study is to generate efficient and effective data that management decision needs. Moreover, this project aims to determine water quality status and trends, aid in the preparation of an accurate list of impaired waters and TMDLs, identify causes and sources of water quality problems, and implement water quality management programs. The study aims to aid in determining allowable limits for pollutant loadings to meet water quality standards and designated uses for the Lake Tohopekaliga, Florida. Pollutant load reductions will be allocated among sources and provide a scientific basis for restoring surface water quality in this water body. The monitored parameters (contaminants) of this study are shown in Table 1.

Table 1. List of Analytical Parameters

No.	Parameter	Matrix
1	Ammonia as N	Water
2	Kjeldahl Nitrogen-total	Water
3	Nitrate-Nitrite as N	Water
4	Organic Nitrogen	Water
5	Orthophosphorous	Water
6	Phosphorous, total	Water
7	Residue-filterable (TDS)	Water
8	Residue-nonfilterable (TSS)	Water
9	Biological Oxygen Demand-BOD_5	Water
10	Chemical Oxygen Demand (COD)	Water
11	Total Coliforms	Water
12	Fecal Coliforms	Water
13	E. Coli (if Fecal Coliform is positive)	Water
14	Turbidity	Water
15	pH	Water
16	Chlorophyll a	Water
17	Mercury, total	Water
18	Lead, total	Water
19	Copper, total	Water
20	Zinc, total	Water
21	Iron, total	Water
22	Cadmium, total	Water
23	Chromium, total	Water
24	Nickel, total	Water
25	Arsenic, total	Water
26	Silver, total	Water
27	Barium, total	Water
28	Selenium, total	Water
29	Total Petroleum Hydrocarbons	Water

DATA COLLECTION

Twenty automatic data collection stations were constructed to perform flow measurement and water quality monitoring at multiple locations throughout the City of Kissimmee and surrounding areas. Figure 1 shows the location of the collection stations of this study. These stations are installed to determine the internal hydrologic, hydraulic and water quality conditions of the City as well as the exterior boundary conditions of the City. Information is being gathered over a range of stream flow conditions and in all seasons. Each installed station consists of the following components:

(i) YSI EcoNet - used for data collection and telemetry;

(ii) YSI 6600 EDS Component - a multi-parameter water quality instruments used to measure temperature, dissolved oxygen, pH, and turbidity;

(iii) Sontek Argonaut (SL/SW) - used to measure water velocity and water level;

(iv) Sutron Rain Gauge - used to measure the rainfall; and

(v) Isco Avalanche - a portable refrigerated automated water sampler that is used to collect sample.

The cause-and-effect relationship between pollutant sources, receiving water chemistry, and biology is being simulated using a modeling approach in which pollutants are loaded onto the watershed and then transported to the downstream waterbodies. The linkage between water chemistry and biology will be established through the adoption of nutrient and sediment targets associated with the desired biocriteria. Several factors will be considered in choosing a methodology by which to estimate the targeted pollutant loadings. These include identifying the various types of sources (i.e., point, non-point, background, atmospheric), the relative location of each of the sources with respect to the impaired waterbody, the transport mechanisms of concern (i.e., direct discharge, storm-event runoff), and the time scale of loading to the waterbody (i.e., duration and frequency of loading to the receiving waters). Based on these considerations the models MIKESHE and ECO Lab have been selected for this application. The models will be used to determine which implementation measures may be taken to decrease the input levels of the targeted pollutants to the system, with the long term goal of achieving the appropriate biocriteria.

A sampling protocol for the water quality monitoring program of this study was developed. This protocol includes procedures during the water quality monitoring phase of the project to assure the samples are properly collected, handled, and transported to the environmental lab for analyses. A training program was held at the City of Kissimmee to demonstrate the sampling protocol to the sampling team. The training included a demonstration of the following: sample collection procedures, sampling equipment, sampler programming, sample volume and containers, field quality assurance/quality control (QA/QC) procedures, field sampling documentation, equipment decontamination, waste management, sampler maintenance, sample handling and documentation, subsampling, sample labeling, chain-of-custody, and sample shipment.

Grab samples were generally conducted on Mondays, Wednesdays, and Thursdays and the sites were divided into four groups designated by A, B, C, and D. Each site group included four to six sites as shown in Table 2. Three samples were collected from all sites each month and for each site, duplicate samples were collected during the first, seventh, and fifteenth sampling events. Each field duplicate was obtained by subsampling the composite sample. Field blank samples were also collected in three sampling events for quality control purposes. These field blanks were used to test the purity of the chemical preservatives, check for contamination of sample containers and equipments that used in sample collection, handling or transportation, and detect other systemic and random errors.

Table 2. Designated Site Groups

Site Group	Site Number	Basin
A	3, 4, 5, 6, 7	Mill Slough and Bass Slough
B	2, 8, 9, 11, 12, 13	East City Ditch and West City Ditch
C	1, 10, 15, 17, 20	Downtown and Upper Shingle Creek
D	14, 22, 23, 24	Lower Shingle Creek

The reported preliminary results of the analyzed samples were checked for data quality assurance. The labs that performed the analyses were asked to verify any doubtful results. In addition, the preliminary results were checked if they exceeded the EPA threshold points for Class III water (i.e., water for recreation and propagation uses). Based on that check, the lab detection limits for some of the studied parameters (i.e., mercury and silver) were found to be higher than the threshold points. Therefore, it was recommended to lower their detection limits in the coming analyses. Also, threshold points of some parameters (i.e., metals) depend on the water hardness. Therefore, it was recommended to analyze the samples for hardness. In order to have a better comparison of the chromium to the thresholds, it was also recommended to analyze the samples for hexavalent and trivalent chromium instead of only total chromium.

CONCLUSIONS

The lab results for all sites were prepared in spreadsheets in order to plot the parameters (i.e., contaminants) versus date of sampling. For each site, three EXCEL-spreadsheets and plots were prepared for the nutrients, coliforms, and metals. The threshold of each parameter was also plotted for initial assessments. The mean concentrations of the fifteen sampling events for the studied parameters (nutrients, solids, bacterial parameters and coliforms, and metals) at all of the sites were plotted. The statistical data (i.e., mean, minimum, maximum, standard deviation, P25, and P75) for the metals of all sites are shown in Table 3. The statistical data for the remaining parameters (solids and nutrients) of all sites are shown in Table 4.

Based on the initial base-flow assessment of the parameters for all sites, the City of Kissimmee has decided to stop testing some of the parameters for the coming sampling events. Those parameters are silver, mercury, chromium, nickel, cadmium, barium, zinc, and arsenic. The City of Kissimmee also decided to stop testing total hydrocarbons and chemical oxygen demand to reduce testing costs. Non-event grab sampling is continuing for all the sites even though all of the auto-samplers installations have been completed.

The following are the remaining tasks of this project:

- Continue sampling and monitoring the twenty sites.
- Continue monitoring the conductivity, pH, and dissolved oxygen using YSI EcoNet.
- Building and calibrating the MIKE SHE / 11 computer model.
- Assessment Program
    - Data analysis and evaluation
    - TMDLs development

    - BMAP development
- Implementation plan for BMAP corrective measures,
- Public participation, and
- Integrated water quality monitoring and assessment report preparation.

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Figure 1. Location of the Monitoring Stations of this Study in the City of Kissimmee, Florida (City of Kissimmee, 2005).

Table 3. Summary results for the total metals at all sites

Parameter	Hardness	Mercury	Lead	Copper	Zinc	Iron	Cadm-ium	Chrom-ium	Nickel	Arsenic	Silver	Barium	Selenium
n	354	80	474	474	294	474	294	294	294	294	80	294	294
Mean (mg/L)	78.49	0.0001	0.0018	0.0064	0.0185	0.4661	0.0012	0.0368	0.0184	0.0017	0.0050	0.0929	0.0020
Min (mg/L)	16.0	0.0001	0.0004	0.0003	0.0050	0.0400	0.0001	0.0030	0.0020	0.0003	0.0050	0.0050	0.0002
Max (mg/L)	194.0	0.0001	0.0180	0.4100	0.3500	3.3400	0.0040	0.0400	0.0200	0.0150	0.0050	0.1000	0.0050
Stand. Dev.	26.94	0.0000	0.0019	0.0202	0.0246	0.3917	0.0017	0.0104	0.0051	0.0023	0.0000	0.0227	0.0002

Table 4. Summary results for solids and nutrients at all sites

Parameter	pH	BOD (mg/L)	COD (mg/L)	TSS (mg/L)	TDS mg/L	Turbidity (NTU)	Petroleum Hydrocarbon (mg/L)	Ammonia Nitrogen (mg/L}	Kjeldehl Nitrogen (mg/L)	Nitrate-Nitrite (mg/L)	Organic Nitrogen (mg/L)	Chlorophyll a (mg/m^3)	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)
n	474	474	294	474	474	294	294	474	474	474	474	474	474	474
Mean	7.14	2.46	42.27	8.95	166.9	4.49	5.94	0.21	0.90	0.07	0.77	1.93	0.20	0.07
Stand. Dev.	0.47	1.86	26.11	30.61	82.24	4.99	2.19	0.22	1.33	0.09	1.38	1.55	0.46	0.05
Min	5.58	2.00	0.10	1.00	1.00	1.10	0.10	0.01	0.10	0.02	0.09	0.10	0.02	0.01
Max	8.58	24.70	138.90	448.0	732.0	62.80	16.80	2.50	14.20	1.48	13.35	14.10	7.00	0.20
P25	6.85	2.00	22.25	2.0	127.7	2.30	5.00	0.10	0.40	0.05	0.20	1.22	0.10	0.01
P75	7.42	2.00	57.25	8.0	198.0	5.30	7.10	0.30	0.90	0.05	0.70	2.26	0.20	0.10