Water Quality Monitoring and Modeling of the Byram River

Final Report

December 2011

Prepared by the Interstate Environmental Commission

For the New York State Department of Environmental Conservation

American Recovery and Reinvestment Act (ARRA) Clean Water Act Section 604(b)

Final Report

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Project/Organization Information

Project Information

Project Name	Water Quality Monitoring and Modeling of the Byram River
Primary Project Type	Total Maximum Daily Loads (TMDL) Elements
State Contract Number	C304269
Project Start Date	Dec 1, 2009
Project End Date	Dec 31, 2011
ARRA Award Amount	$87,171.00
Total Project Cost	$100,039.81

Organization Information

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Introduction

Project Introduction & Description

The primary purpose of the project should be described, along with a general overview of major project goals and outcomes. Affected bodies of water and project locations should also be noted.

Project Goals and Objectives

The improvement of Byram River water quality aims to meet the goal of the Clean Water Act, to restore the nation's water to the “swimmable/fishable” standard. This project serves as the first stepping stone towards achieving these goals in the study area.

In addition, downstream public beaches and shellfishing beds are susceptible to pathogenic pollution consequent to tidal exchange with Byram River, along with other local sources, including mooring areas and waterfowl. This project will examine the extent of contamination in the study area, and help to understand the transport and fate of pollutant loads, which, in turn, can minimize public health risks associated with pathogenic contamination.

The project will do this by creating **inputs from GIS databases for the** watershed planning tool involving the following tasks: (a) design of specific flow and water quality monitoring programs, (b) identification of sub-basins that contribute significant nutrient and pathogen loads through model calibration and application to a long-term average hydrologic year, and (c) quantification of benefits (peak flow and pollutant load reductions) from implementation of up to four conceptual green infrastructure elements (best management practices, BMP and low impact development practices, LIDs) within the watershed. This will be accomplished first by IEC sampling the Byram River then by using the academic resources at Columbia University.

One of the projects priorities is to support the Long Island Sound (LIS) TMDL that requires an overall 10% reduction in total nitrogen (TN) pollution loads from urban and non-urban non-point sources. The parameters sampled in this project will be used to establish the baseline conditions for LIS TMDL and other potential TMDL development efforts in the watershed. Specifically, the baseline loads for nutrients (total nitrogen and total phosphorus) and pathogens (fecal coliforms, E.coli and enterococci) are developed in this project. The modeling framework developed in this project can serve as the foundation to prioritize the pollution control programs in the watershed by the various municipalities and BWC in a coordinated manner and that regulatory agencies may implement TMDLs to meet the Clean Water Act requirements.

Project Area

The project will focus on the Byram River which starts upstream by Byram Lake in Upper Westchester County, flows through Fairfield Connecticut and then creates the New York-Connecticut border between Westchester and Fairfield Counties before it flows into Port Chester Harbor and ultimately the Long Island Sound.

The project will encompass sampling of numerous parameters (including nutrients and pathogens) that are identified by the two states, New York and Connecticut, as possibly leading to impairment in river water quality. The Byram River is currently on the New York State (as well as Connecticut's) 303 (d) for Enterococcus and E-coli.

Summary of Activity

Objectives, Tasks, & Outcomes

Work plan objectives should be clearly linked to final project outcomes. For each objective listed on the work plan, a brief summary of the tasks and activities should demonstrate how project deliverables and outcomes have accomplished that objective.

Objective

1a. Compile, evaluate and format existing data and prepare technical approach

Task Summary & Project Outcomes

IEC has previously performed sampling on outfalls entering into the Byram River in an effort to locate potential sources of contamination in the river. This prior sampling survey was performed on the lower or downstream portion of the Byram River, which is in the vicinity of Port Chester and Greenwich. Westchester County Health Department also performed sampling on the Lower portion of the Byram River, which IEC Reviewed. IEC also reviewed data from Greenwich Department of Health, which was doing its own sampling of the Byram River. The Greenwich sampling continues upstream of IEC's sampling and goes North to the Connecticut /New York State Border. IEC will be using all of this historic data to gather background information for the project and use this information to set up the sampling points for the project. Historically, the Byram River has been subjected to elevated levels of pathogens, which has generated attention towards this waterway.

Objective

1b. Site Reconnaissance, Finalize Sampling Logistics

Task Summary & Project Outcomes

IEC met with the project team at a kickoff meeting to discuss potential sampling locations that would fit in the scope of the project and give a good representation of the watershed. That gave IEC an idea for the potential number of sites that were needed for the project. Starting with the list of locations that were previously sampled by IEC, Westchester Heath Department and Connecticut Department of Health, IEC began to do field surveys to look for potential sites for this project. In the upper section of the Byram, there were no known sampling sites, so IEC met with a representative of the North Castle Conservation. This representative of the North Castle Conservation spent a few hours with the IEC field personnel, first familiarizing them with the area and then taking them out into the field to look at potential sampling locations.

When looking at potential sites, IEC's first concern was the spatial relationships to other sites. The goal was to get the best representative samples of the entire area within the project's scope and budget. Also IEC was looking at the logistics of the sampling location. Logistics entailed many factors including public access, area parking, potential flooding, ease of sampling, safety of sampling, etc. These were important factors to be considered.

Originally, IEC submitted a list of 9 potential sites for project to the NYSDEC for approval. Upon review, NYS DEC asked for an additional site downstream of the Wooley Pond. IEC was able to add the requested site and a total of ten sites were approved by the NYS DEC. The sites are described in the next paragraph.

The first sampling location (BR1) is at the intersection of Byram Lake Road and the Byram River in Armonk, NY, selected due to its proximity to the headwaters of the Byram River. The second and third (BR2 and BR3) sampling locations were selected because they are on the Byram and Wampus “branches”

of river, respectively, before the Byram and Wampus branches merge. BR3 is also just south of the Armonk Water Treatment Plant. The fourth sampling location (BR4), at the intersection of Cliffdale Road and the Byram River, in Greenwich, CT, was selected due to its location south of Wooley Pond, into which several streams flow, acting as tributaries to Byram River. The fifth and sixth (BR5 and BR6) sampling locations are on the East and West Branches of the Byram River in Greenwich, CT. The seventh and eighth (BR7 and BR8) sampling locations were selected due to their location in the more populated "downtown" area of Greenwich, CT. The last two sampling locations, BR9 and BR10 are sampling locations on the border of New York and Connecticut, in the heavily populated and trafficked area of downtown Port Chester, NY.

Objective

1-c. Develop Quality Assurance Project Plan (QAPP) and submit for review and approval

Task Summary & Project Outcomes

Right after the kick-off meeting for this project, IEC began working on its Quality Assurance Project Plan (QAPP). Work on the QAPP and the selection of the sampling stations was performed concurrently. A major part of the QAPP is selecting the sampling procedures and the parameters that would be sampled for. The QAPP describes the project plan as the following:

IEC will collect all of the samples, perform the field measurements (temperature, specific conductance, pH, dissolved oxygen, velocity), and perform laboratory analyses for the following parameters:

Settleable solids
Turbidity
Chlorides
Total Nitrogen
Total Phosphorous
Pathogen Indicators - fecal coliform, total coliform, fecal streptococcus, enterococcus and e. coli.

The parameters were selected based upon IEC's previous experience with ambient sampling and consultation with NYS DEC. All parameters (with the exception of Total Phosphorous and Total Nitrogen) can be analyzed in house by IEC that is a major factor in keeping our costs down for the project. The IEC's laboratory is currently a NELAP certified laboratory through ELAP for all of the parameters analyzed in this project, except for Total Nitrogen and Total Phosphorous. These parameters will be analyzed by a certified laboratory.

All samples collected will be aqueous samples. Sampling will be performed during three wet weather and three dry weather events to better gauge the river water quality under different conditions. Data from the first 4 runs (2 dry and 2 wet) will be used to calibrate the hydrologic and hydraulic water quality model while data from the third set of runs (1 dry and 1 wet) will be used to verify the model. Wet weather will be defined as having a minimum 0.25" of rain fall in the previous 24 hours before the first sample is taken, as per the rain gauge at the Westchester County Airport. IEC will conduct instantaneous flow sampling in support of the overall assessment and planning.

In addition to the list of sampling locations that had to be selected the project team needed to select a list of parameters that had to be sampled for and a list of sampling protocols that had to be followed to make sure the project would be completed correctly. Included in these protocols are Sampling Procedures; Sampling Equipment; Sample Handling Preservation, Storage and Custody; Sample Transport Procedure; Sample Packaging; Sample Transport; Analytical Procedures; Calibration Requirements and Supplies and

Consumables.

In addition to these protocols for sampling, there are also quality assurance protocols that must be followed. These include Precision; Accuracy; Method Detection Limit; Completeness; Measurement Range; Qualitative QA Objectives: Comparability and Representativeness and Certification and Training.

IEC submitted the first draft of the QAPP on March 30, 2010 to the NYS DEC. After a thorough review the QAPP was returned to IEC with comments. Over the next few months, IEC and DEC maintained a healthy dialogue to make the necessary change to the QAPP to make it approvable. On June 24, 2011, the QAPP was officially approved and IEC could begin sampling.

Objective

1-d. Complete monitoring and sample analyses

Task Summary & Project Outcomes

IEC successfully completed its six required sampling Runs. The runs were performed on:

Date Type of Sampling

July 6, 2010 Dry Weather

July 19, 2010 Wet Weather

August 3, 2010 Dry Weather

August 16, 2010 Wet Weather

September 8, 2011 Wet Weather

September 20, 2011 Dry Weather

After IEC completed the first four runs, they submitted the results to the sub-contractor as described in the QAPP. The sub contractor used these results to calibrate the model. Once the model was calibrated and IEC received the sub contractor's approval IEC performed the last two sampling runs. All of the sampling and analysis were performed according to the protocols described in the QAPP.

Objective

Task 2-a: Development of Modeling QAPP and Finalization

Task Summary & Project Outcomes

The faculty team member prepared a Modeling Quality Assurance Project Plan (QAPP) that described the technical work to be performed, including the procedures that were used in this project to ensure that model results are scientifically valid and defensible while minimizing uncertainty. The QAPP was developed based on EPA guidance documents and the project team's recent experience and was submitted to the New York State DEC for review and revisions. This document also summarized the model selection process, as well as the methods for data compilation and synthesis, model development and calibration, and sensitivity analysis. Based on the feedback provided by the DEC staff, the QAPP was

finalized and used throughout this project.

Objective

2-b. Preliminary hydrologic and hydraulic model and water quality model setup and calibration

Task Summary & Project Outcomes

The Columbia University faculty used the U.S. Environmental Protection Agency's Storm Water Management Model (EPA SWMM) selected for this project to characterize the flows and pollutant loads from various sub-basins within the Byram River watershed. Available physiographic and climate data from the CTDEP (UCONN - CLEAR database), Westchester County Department of Planning, NYSDEC, IEC and the Township of Greenwich (CT) were compiled and reviewed to reconcile any differences in landuse codes or resolution of data. The Township of Greenwich (TOG) also provided the floodplain hydrologic and hydraulic (H&H) model developed by the U.S. Army Corps of Engineers and subsequently modified by its consultant as part of the Town's flood mapping project.

Flow, precipitation and water quality data available from various sources were compiled and reviewed. After quality check, appropriate climate, data from NOAA sources and flow data from USGS were used to construct a preliminary H&H model of the Byram River watershed.

Objective

2-c. Validation and interpretation of data

Task Summary & Project Outcomes

Water quality data compiled in the first IEC survey was reviewed and analyzed to assess the water quality conditions in the Byram River during wet and dry weather periods. Data provided by TOG were also used to interpret wet weather sources versus potential illicit connections that led to increased pathogen concentrations during dry weather. Available data from nearby watersheds such as Saugatuck River and Bronx River were reviewed for comparative assessment and interpretation.

Objective

2-d. Final model calibration and validation

Task Summary & Project Outcomes

The Columbia University faculty conducted the final calibration and validation of the H&H and water quality models of the Byram Watershed using data from the two IEC surveys. Seasonality in flows was a major factor and the modeling approach had to be tailored to represent the summer and winter conditions separately, since the winter storms caused much larger volumes and for prolonged periods potentially due to highly saturated soil conditions in the pervious portions of the watershed. Several summer and winter storms from the period of record available at the Pemberwick flow monitoring station maintained by the USGS were chosen to support the final calibration and validation. Water quality data comparisons were made at the IEC monitoring stations. Subsequent to calibration, a recent hydrologic year, 2008, was used to develop baseline flows and pollutant loads for the watershed.

Objective

2-e. Sensitivity analysis for model parameters and also for evaluation of green infrastructure elements

Task Summary & Project Outcomes

Considering the variability in pollutant loads from various types of land uses, a sensitivity analysis of model parameters was performed by the Columbia University faculty and interpreted in terms of the variability in pollutant loads. A GIS-based tool, called the Siting Tool available as one component of the USEPA's SUSTAIN suite of optimization model, was used to identify potential locations for large-scale and site-scale best management or low impact development practices (BMP/LIDs) within the entire watershed. These BMP/LIDs included rooftop controls, wetponds, wetlands, and transportation corridor controls. Three different green infrastructure evaluations were performed to characterize the potential benefits of rooftop controls, wetponds/wetlands, and transportation corridor controls and compared in terms of flow volume/ pollutant load reductions achieved from these practices.

Objective

3- a. Prepare Quarterly Reports and submit them to DEC by the deadline in the contract.

Task Summary & Project Outcomes

As required by the contract, IEC had submitted a quarterly report on the first business day after the close of the quarter. All of these reports have been reviewed and accepted by the NYS DEC.

Objective

3-b. Prepare reimbursement requests using the correct forms and documentation.

Task Summary & Project Outcomes

IEC has been submitting their reimbursement requests using the correct forms and documentations. All of these requests have been reviewed and accepted by the NYS DEC. IEC will be submitting its final reimbursement request by January 21, 2012.

Objective

3-c. Prepare Final Report at end of project and submit by project end date.

Task Summary & Project Outcomes

This submittal is the required final report and IEC is submitting it in the required format. Since there are other deliverables that cannot be submitted in this format, in addition to this final report, Columbia University will be submitting to IEC and NYSDEC a report including attachments on a DVD that will contain the summation of the findings of the project. Below is an outline of the report:

Report Outline:

Public Summary - High-level summary of watershed, data compilation, model calibration and validation, baseline pollutant loads and scenario comparison for three green infrastructure (GI) options

Section 1. Introduction of watershed and study goals and outcomes, and reference to draft watershed-

based plan from BWC for problems/issues in the watershed

Section 2. Databases compiled from public sources (Westchester County Planning GIS department and Township of Greenwich, CT) - landuse/landcover, ground slope, impervious cover, FEMA stream cross-sections, Pemberwick gage flow data, precipitation data from Westchester County airport, WQ data from Township of Greenwich, WQ data from IEC compiled in this project. Time-series plotting of Township data to show data trends, but these were not used for calibration since those aren't subjected to the QAPP established for this project.

Section 3. Model construction, calibration and validation, including sensitivity analysis done for model parameter selection - specific events chosen for calibration and validation, including a continuous simulation performed with IEC data compiled in this project and the USGS data at Pemberwick gage.

Section 4. Baseline flows and pollutant loads - continuous simulation done for the 2008 period, summary of total annual pollutant loads based on individual sub-basins (113, that can be rolled up to a few tributary basins, with color coding. I'll present all 113 basins in this summary). Also, monthly summary of pollutant loads for TN, TP, Fecal coliforms and E. coli, to show the seasonal variations in loads

Section 5. Three GI scenarios - (1) 100% implementation of rooftop controls to achieve 1” reduction in runoff; (2) 100% implementation of underground storage or porous pavers to achieve 1” reduction in runoff; and (3) potential implementation of wetponds/wetlands at locations identified using a GIS-analysis. Outputs will summarize the reductions in flow volumes and pollutant loads achieved from the three scenarios, in comparison to the baseline.

Attachments in a DVD:

GIS Files compiled from Township of Greenwich and Westchester County GIS website

Processed GIS files including sub-basin delineations and excel spreadsheet used for parameter sensitivity analysis

GIS files used to create inputs for three GI scenarios

Calibrated EPA SWMM model input and outputs that are shown in calibration plots

Baseline and three GI scenarios' EPA SWMM model input and the output files

Submittal:

Two hard copies to IEC for submittal to the DEC, and an electronic version in MS-Word format.

Problems Encountered/How Solved

A comprehensive summary of any problems encountered during the life of the project and how those problems were resolved should be listed. The list should include any information reported in the "Problems Encountered/How Solved" box on the Quarterly Report Cover Pages throughout the project.

Two student interns hired during the course of this project did not continue and make full contributions as intended. One of the interns was supported by the Department of Earth and Environmental Engineering's internship and the other intern had health problems that led to some coordination problems. The faculty member took the extra responsibility to perform the work during the latter stages of the project to complete the deliverables.

Water quality data to quantify the potential contributions of illicit connections were not available or were not sufficient enough to explicitly include in the modeling process. Additional recommendations have been developed to quantify these loads that can enhance the overall component load quantification for future mitigation through appropriate management measures.

Other potential contributions from sources such as failing septic systems, waterfowl and horse farms are being planned for quantification through additional studies to be performed by the Byram Watershed Coalition (BWC). In this project, approximations have been made to quantify these loads, however, these can be updated in the future with BWC's additional work.

Changes to Project Work Plan

Any changes that were made to the project work plan during the life of the project should be noted, including a brief description of why the changes were necessary.

All tasks identified in the work plan have been completed and no changes were necessary.