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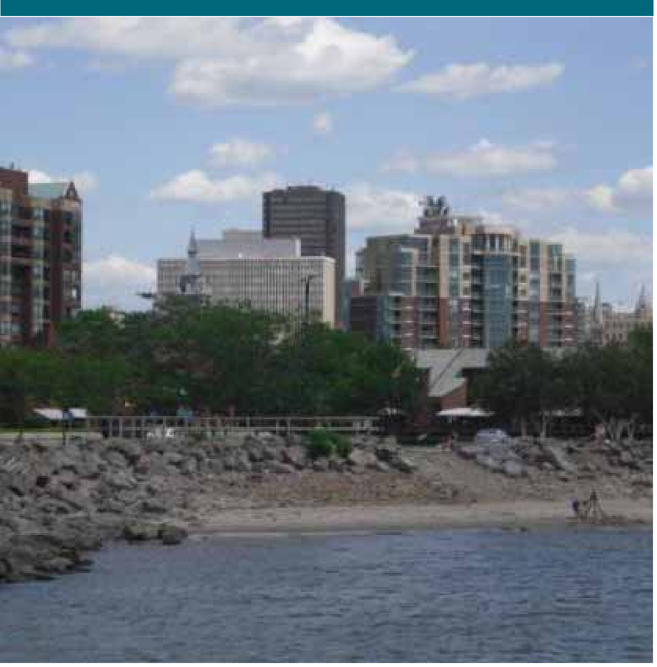
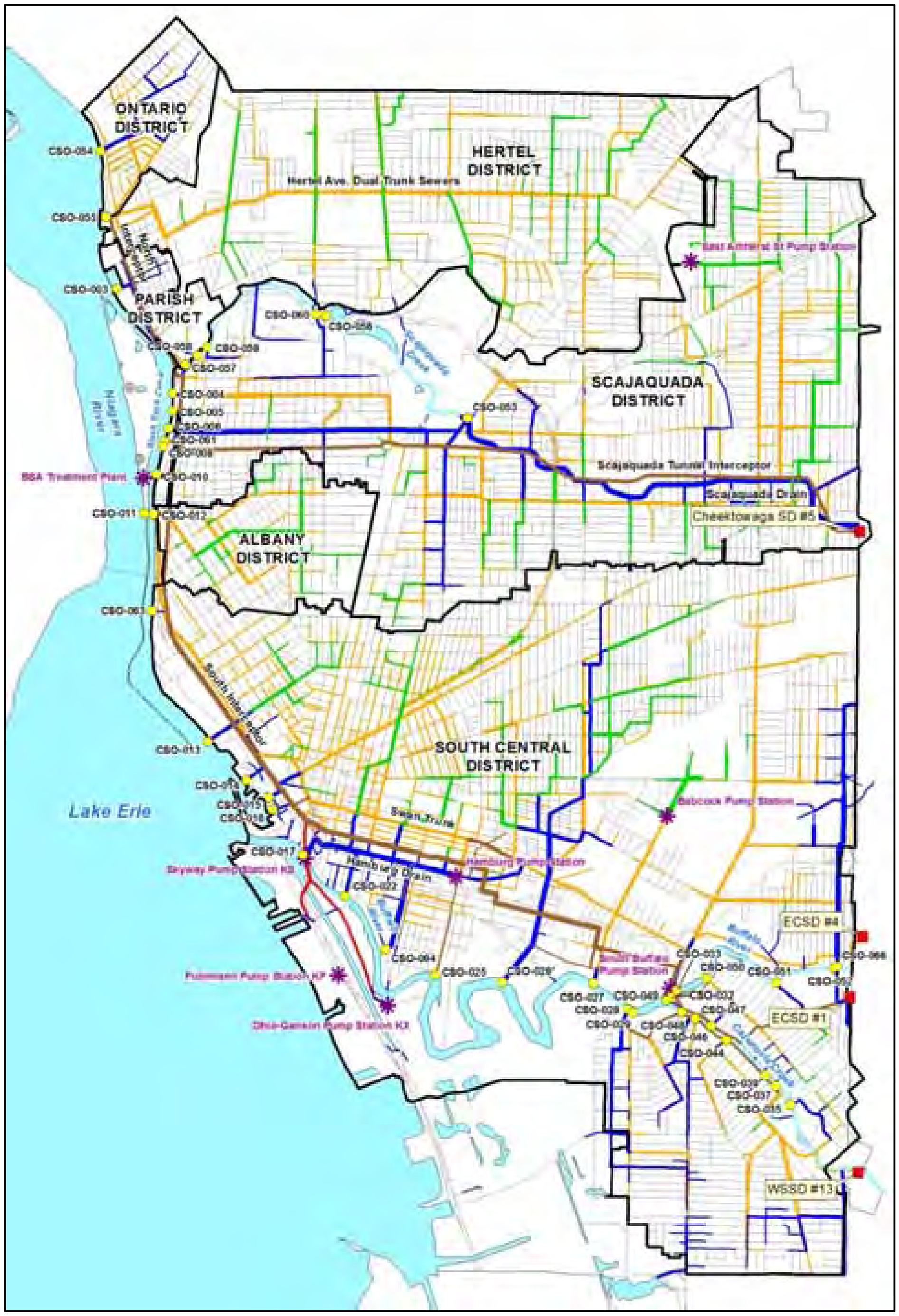
Long Term Control Plan - FINAL

January 2014





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Acronyms and Abbreviations

Tables

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Figures

Appendices

LIST OF DOCUMENTS PREVIOUSLY COMPLETED IN SUPPORT OF SYSTEM-WIDE LTCP

(NOT INCLUDED)

1 System Mapping Procedures Manual and Desktop Geographic Information System, Volumes 1 and 2, February 2001

2 Flow Monitor Data Analysis Report, Volumes 1 through 5, March 2001

3 Water Quality Monitoring Program Analytical Results, February 2001

4 Water Quality Assessment Report, Volumes 1 and 2, April 2001

5 Model Calibration Report, Volumes 1 and 2, September 2001

6 Bird Island WWTP Wet Weather Capacity Evaluation, May 2004

7 System-wide Long Term Control Plan for CSO Abatement, 2004

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Acronyms and Abbreviations

AACE	Association for the Advancement of Cost Engineering International
AO	Administrative Order
BFSA	Buffalo Fiscal Stability Authority
BNRK	Buffalo-Niagara Riverkeepers
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
BRIC	Buffalo River Improvement Corporation
BSA	Buffalo Sewer Authority
CBOD	Carbonaceous Biochemical Oxygen Demand
CD	Consent Decree
CIP	Capital Improvements Program
CMOM	Capacity, Management, Operations, and Maintenance
CPH	Cost per Household
CPI	Consumer Price Index
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CRA	Conestoga Rovers Associates
DO	Dissolved Oxygen
EHRC	Enhanced High-Rate Clarification
EHRT	Enhanced High-Rate Treatment
EMC	Event Mean Concentration
ENRCCI	Engineering News Record Construction Cost Index
EOP	End of Pipe
FCI	Financial Capability Indicator
FCM	Financial Capability Matrix
ft	feet
$g/m^2/day$	grams per square meter per day
GI	Green Infrastructure
GIS	Geographic Information System
gpm/sq ft	gallons per minute per square foot
IET	Inter-event Time

I&C	Instrumentation and Control
IJC	International Joint Committee
KOC	Knee of the Curve
lb/d/sf	pounds per day per square foot
LF	linear feet
LID	Low Impact Development
LOC	Level of Control
LTCP	Long Term Control Plan
mg/L	milligram per liter
MHI	Median Household Income
mL	milliliter
MG	million gallons
MGD	million gallons per day
MLSS	Mixed Liquor Suspended Solids
NMC	Nine Minimum Controls
NWS	National Weather Service
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OF	Overflow
O&M	Operation and Maintenance
OSP	Office of Strategic Planning
POTW	Publicly-Owned Treatment Works
PVC	Polyvinyl Chloride
RAP	Remedial Action Plan
RAS	Return Activated Sludge
RFP	Request for Proposals
RI	Residential Indicator
R&R	Renewal and Replacement
RTC	Real Time Control
RWB	Receiving Water Body
RWWPS	Raw Wastewater Pump Station

SCADA	Supervisory Control and Data Acquisition
SIU	Significant Industrial User
SOD	Sediment Oxygen Demand
SPDES	State Pollutant Discharge Elimination System
SPP	Sewer Patrol Point
sq mi	square mile
SRF	State Revolving Fund
SUNY	State University of New York
SWMM	Stormwater and Wastewater Management Model
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
TY	Typical Year
UAA	Use Attainability Analysis
US	United States
USACE	United States Army Corps of Engineers
USEPA	Unites States Environmental Protection Agency
WAS	Waste Activated Sludge
WQS	Water Quality Standard
WWTP	Wastewater Treatment Plant

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Executive Summary

Introduction

This document comprises the Buffalo Sewer Authority's (BSA's) Final Long-Term Control Plan (LTCP or the Plan) to address sewer overflows to area waterways, which occur during rain and/or snow melt events. It builds on an LTCP that was developed in 2004. Thanks to the relentless and impressive progress the BSA has made over the past several decades, the BSA is now in a position to propose and implement a plan to finally resolve its sewer overflow challenge. The recommended plan contains a careful balance of traditional "gray" infrastructure as well as innovative "green" solutions. The BSA believes the LTCP is the right approach for this community, and although it is financially burdensome, feels that it protects the environment and addresses water quality in receiving streams in the most affordable and cost-effective manner possible. The LTCP was developed in consultation with BSA's community stakeholder panel and has benefited from formal and informal stakeholder input over the past decade.

Including the wet weather treatment improvements at the BSA's Bird Island Wastewater Treatment Plant (WWTP), the Plan has an expected capital cost of approximately $380 million to implement over a 20 year period. This does not include the over $50 million the BSA has already invested in engineering and previously completed and ongoing construction projects (referred herein as "Phase I projects") or future operations and maintenance costs for the proposed facility improvements. The details of the development of the LTCP and the specific recommended plan are provided in the pages that follow. The BSA submitted this plan to the United States Environmental Protection Agency (USEPA) and the New York State Department of Environmental Conservation (NYSDEC), (collectively referred to as the Agencies or Regulatory Agencies) in April 2012, as ordered by the USEPA, and concurrently solicited public comments on the April 2012 submission. The BSA has revised this LTCP in response to final community input and comments issued by the Regulatory Agencies following the April 2012 submittal.

The BSA is a public benefit corporation of the State of New York (NYS), established by NYS in 1935 with exclusive jurisdiction, ownership, and possession of the sewage collection and treatment system that serves the City of Buffalo and, through inter-jurisdictional agreements, several communities adjacent to the City of Buffalo. The BSA is a legal entity separate from the City of Buffalo and NYS. The Buffalo Sewer Authority system consists of a secondary treatment plant located on Bird Island and a collection system of approximately 850 miles (790 miles of combined sewer and 60 miles of storm sewer) of sewer lines.

The service area of the BSA, within the City of Buffalo, is served primarily by a combined sewer system (CSS). The CSS was constructed with 65 permitted combined sewer overflow (CSOs) outfalls to relieve the CSS during wet weather events in order to protect downstream treatment facilities and prevent basement flooding. Over the years, the BSA has completed numerous CSS improvement projects resulting in the elimination of seven CSO outfalls. Currently, the system consists of 52 permitted CSO outfalls. The USEPA issued a national CSO Control Policy in 1994, requiring communities with CSSs to develop Long Term

Control Plans (LTCPs) that will provide for compliance with the requirements of the Clean Water Act, including attainment of current or revised (to reflect wet weather in-stream realities) water quality standards (WQS). This document is the BSA's LTCP.

Further, the BSA is required under the terms of its New York State issued State Pollutant Discharge Elimination System (SPDES) permit (Permit No. 002 8410) to implement Best Management Practices (BMPs) for CSOs. The BSA has successfully implemented the BMPs as required by its SPDES permit.

While this LTCP program focuses primarily on the collection system, the Bird Island WWTP is also an integral part of the CSS. Immediately after the establishment of the BSA in 1935, a primary wastewater treatment plant was constructed and began operation on July 1, 1938. The original WWTP was constructed to include bar screens, grit removal equipment, primary settling tanks (clarifiers) and disinfection facilities. Solids generated during the treatment process were disposed of in three multiple hearth incinerators. The Bird Island WWTP operated in this configuration until the mid-1970s, when in response to the federal Clean Water Act, the BSA upgraded the plant to meet new secondary treatment standards. Secondary treatment facilities were added at the plant between 1975 and 1979. Pursuant to this upgrade, aeration and secondary clarification equipment were added along with upgrades to the disinfection system. Completed and current upgrades to the facility will allow for improved treatment for up to 320 MGD of flow through the secondary treatment system and following completion of the upgrades recommended in the No Feasible Alternatives analysis up to 400 MGD through the secondary system. Flows in excess of the secondary treatment system capacity are treated through the original primary facilities or a combination of both primary and secondary. All treated flows are discharged to the Niagara River via two permitted outfalls. The WWTP is also equipped with a third emergency outfall which is used to protect the WWTP in the event of extreme wet weather or equipment malfunction to prevent the plant influent flow from exceeding the plant's treatment capacity. Recognizing the multiple modes of operation and in particular the partial treatment mode, a No Feasible Alternative (NFA) analysis was conducted as part of the LTCP development to confirm the WWTP wet weather capacity and evaluate feasible alternatives, if any, to reduce the volume of or provide additional treatment for the wet weather flows currently bypassing the secondary treatment and discharged directly following primary treatment and disinfection in the primary clarifiers.

LTCP Development Process

This report reviews the evaluations completed in the development of the previously submitted LTCP and documents the development of this LTCP for CSO abatement within the City of Buffalo.

The BSA originally submitted its LTCP for CSO abatement to the NYSDEC in July 2004 (2004 LTCP). The BSA received comments from the NYSDEC in 2006, and subsequently, the NYSDEC and the USEPA requested additional evaluations to address questions and comments derived from their regulatory review. The BSA began additional work in 2008 and completed the update of the 2004 LTCP in two phases:

- Additional evaluations, including water quality model development, collection system model refinement, and the associated data collection (rainfall, flow, water quality) to support these modeling tasks.

- Development and evaluation of CSO abatement alternatives and update of the 2004 LTCP documents as well as refinement of the previously prepared financial capability analysis.

The BSA retained Malcolm Pirnie, the Water Division of ARCADIS (Pirnie/ARCADIS), along with LimnoTech, GHD, and the State University of New York College at Buffalo, to address the USEPA's and NYSDEC's comments and to update the 2004 LTCP. The BSA also retained CRA Infrastructure and Engineering, Inc. (CRA) to update the Financial Capability Assessment. This document, referred to as the BSA's "LTCP", builds upon the 2004 LTCP and presents the additional evaluations performed and the BSA's revised preferred CSO abatement program.

Most, if not all, of the CSO communities in the country have had several rounds of LTCP development. This is due to a number of factors including, but not limited to:

- The community-specific nature of CSO control solutions.

- The massive scale of CSO control programs (usually the largest public works projects in community history)

- The incorporation by reference of the National CSO Policy into the Clean Water Act in 1999.

- Changing regulatory expectations.

- Funding constraints.

- Changes in technologies (such as a move away from sewer separation to evolving technologies including green solutions; the development of Real Time Control, etc).

- Smart growth considerations.

- A movement to watershed planning.

- Rapidly evolving urban stormwater control requirements.

- NPDES authorities' difficulty in developing wet weather water quality standards.

From 2008 through early 2012, the BSA and the Government Agencies had multiple meetings and discussions to discuss data collection, model development and results, and engineering analyses to support the development of a revised LTCP. On March 15, 2012, the USEPA unilaterally issued to the BSA an Administrative Order (AO) that required, in part, that the BSA submit an updated LTCP to the USEPA and NYSDEC no later than April 30, 2012. The AO is attached to this Executive Summary as Exhibit ES-1. The BSA subsequently sought clarification and revision of two key requirements and related issues imposed by the AO, in a letter dated March 28, 2012 to the USEPA (Exhibit ES-2). The USEPA responded in a letter dated March 29, 2012 (Exhibit ES-3). While the April 30th deadline required the BSA to expedite completion of updating the LTCP and submit it ahead of an opportunity for public notice, the BSA had no choice, but to make best efforts to comply with the USEPA's AO.

Following submission of the April 2012 LTCP, the Agencies provided comments in a letter dated December 6, 2012 (attached as Exhibit ES-4). The BSA and the Agencies subsequently discussed these comments through a series of meetings and correspondence. A major effort in addressing this set of comments was the development of an updated NFA analysis and a Green Infrastructure Master Plan. Based on the comments provided by the Agencies, the LTCP has been revised in general to incorporate the findings of both of these documents and address a number of other comments. This LTCP reflects the revisions developed by the BSA in response to those comments and concurred with by the Agencies in October 2013. Exhibit ES-5 includes a copy of the October 2013 correspondence.

In addition to developing this LTCP update, the BSA has continued to work diligently to reduce CSO overflow volumes and frequencies. Along the way, the BSA has invested tens of millions of dollars in capital improvements both at the WWTP and in the collection system, many of which pertain directly to this CSO Abatement program, not to mention the investment of over ten million dollars in the development and update of the LTCP documents. More recently, the BSA has had to be agile and adjust the LTCP development process to address numerous agency comments, many of which required not only changes in approach, but also, at times, significant technical re-analyses and rework. The BSA has made best efforts to accommodate and implement these Agency directives.

Development of Models to Predict Overflow Control Results and Benefits

Upon review of the 2004 LTCP, the NYSDEC and the USEPA asked the BSA to refine the BSA's sewer collection system model and to develop CSO receiving stream water quality models for waterways receiving CSO discharges. Additional flow/rainfall monitoring and receiving water quality sampling activities were necessary to support the requested modeling work. Of necessity, these additional requirements have extended the process and scope of gathering and evaluation of data for the updated LTCP. Collectively, this additional monitoring and modeling work was referred to as the "Phase II LTCP activities" and consisted of:

- Additional rainfall and in-system flow monitoring of the BSA's collection system to support the collection system model refinement.

- Additional receiving water quality sampling to support the water quality model development and calibration.

- More specific water quality models developed, calibrated, and validated for the Buffalo River, Scajaquada Creek, Niagara River, and Black Rock Canal receiving water bodies.

- Additional validation and refinement of the BSA collection system model.

Development and Evaluation of Alternatives

Using the collection system and water quality models, new CSO abatement alternatives were developed and evaluated for comparison to the updated Preferred Alternative from the 2004 LTCP. The first new alternative included innovative and/or emerging technologies such as real-time control (RTC), green infrastructure (GI) and a new relief line with an enhanced high rate treatment (EHRT) facility in the northern portion of Bird Island. Two additional system wide alternatives were developed based on requests from the USEPA and NYSDEC in the spring of 2011. The additional alternatives were system wide tunnels (to store wet weather flows underground until the storm passes and the flows can be pumped to the WWTP for treatment) and a combination of tunnels and a new relief line to an EHRT facility in the northern portion of Bird Island. These three new alternatives were then compared to the updated 2004 preferred system wide alternative to determine whether the 2004 LTCP could be improved upon.

The new alternatives are based on a Revised Foundation Plan. The Revised Foundation Plan represents an update of the original Foundation Plan implemented after the submittal of the 2004 LTCP. The objective of the Foundation Plan was to implement a set of controls that were likely to be part of the final LTCP so that progress could be made during the LTCP update development. However, the Revised Foundation Plan represents a shift in management philosophy by the BSA away from sewer separation as a primary control technology to a combination of low-cost system optimizations and cost-effective real time control (RTC) projects. While some sewer separation projects are carried forward in this Revised Foundation Plan, the extent of the areas to be separated has been reduced and replaced in favor of alternative technologies. Alternatives UA2 (Updated Alternative No. 2), UA3, and UA3A all build upon the Revised Foundation Plan. Alternative UA1 uses the original Foundation Plan as recommended in the 2004 LTCP as its starting point.

The Revised Foundation Plan comprises the following core components:

- Phase I Projects (recently completed or scheduled to be done by late 2014): Referred to as the “Phase I” projects, these are an initial series of projects identified during the development of the 2004 LTCP. Recognizing that these projects would likely be constructed regardless of the final LTCP program, the BSA, with the concurrence of the Regulatory Agencies, chose to undertake these projects. They include a mix of sewer separation, CSO regulator optimizations (for example, raising weirs and/or removing orifice plates), and supplemental sewer system capacity projects. As the implementation of these projects evolved, several projects were modified to include real time control and green infrastructure elements. Most of these projects have been completed, with the remainder slated to be completed by the end of 2014.

- Other Projects (previously completed): These projects are primarily sewer separation projects carried over from the original Foundation Plan and completed prior to the Phase I projects.

- Real Time Control Program: 16 RTC projects (including the two included within the Phase I project list) that were selected after evaluations conducted as part of this LTCP effort.

- Additional Sewer Patrol Point (SPP) Optimizations: 20 additional optimization projects were identified as part of the alternatives evaluations conducted for this LTCP update. These modifications include optimizing weir elevations and orifice plate openings, increasing underflow pipe capacity, and flow redirection at a limited number of locations.

- Additional Storage Projects: Three projects to increase capture of CSO flows have been identified and are currently in various stages of design by BSA.

Summary descriptions of each system wide alternative evaluated are presented below.

- **Alternative UA1** consists of the updated 2004 preferred system wide alternative modified to provide better control of bacteria for the Buffalo River and Erie Basin receiving water bodies (RWBs). After review of the 2004 LTCP, the NYSDEC raised a concern that the 2004 LTCP Preferred Alternative did not provide for adequate bacteria control in the Class C receiving waters (this classification is made by the NYSDEC); therefore, each alternative was re-evaluated for the Buffalo River and Erie Basin. The updated 2004 LTCP preferred system wide alternative changes only the Buffalo River and Erie Basin alternatives, while keeping the alternatives in the other receiving water bodies the same. Note that unlike the other system wide alternatives evaluated in this LTCP, Alternative UA1 was built upon the original Foundation Plan. The original Foundation Plan consisted primarily of weir modifications and partial sewer separation projects. No RTC or GI projects were evaluated as part of this alternative. Alternative UA1 is intended to provide a benchmark system wide gray infrastructure alternative (with no emerging technologies or sustainability elements) against which all other alternatives will be evaluated.

- **Alternative UA2** consists of some elements of Alternative UA1 (updated 2004 preferred system wide alternative) plus a North interceptor relief sewer that will convey additional flows to the siphon across Black Rock Canal and into the headworks of the Bird Island WWTP. Additionally, under greater levels of control, a new pump station will be constructed to pump flows to a new EHRT facility located on the north side of the WWTP. Unlike Alternative UA1, however, Alternative UA2 builds upon the Revised Foundation Plan (which contains SPP optimizations and weir modifications as well as selected RTC projects). In addition, Alternative UA2 uses the recommended GI results and applies a range of GI control of impervious surface from 10% to 20% with the initial target of controlling 1,620 acres system wide. Note that the initial GI acreage target was developed prior to the SPP level refinement completed during the development of the BSA's Green Infrastructure Master Plan and as such, represents the upper limit of GI control acreage under consideration by the BSA.

- **Alternative UA3** consists of the construction of deep-rock tunnels to provide storage for the majority of the BSA's CSOs. The mining of tunnels below grade is typically an effective method of providing off-line storage in congested urban areas. Seven remaining CSOs not controlled by the system wide tunnels (CSO 003, 051, 052, 055, 056, 060, and 066) would be controlled through satellite storage facilities. As specified by the Regulatory Agencies, Alternative UA3 is an 'all-gray' alternative and therefore, does not include green infrastructure as part of the alternative technologies.

- **Alternative UA3A** consists of the construction of deep-rock tunnels to provide storage for the majority of the BSA's CSOs, with the exception of the tunnel along Black Rock Canal. There, the leg of the North-South Tunnel that runs along the Black Rock Canal is replaced with a relief sewer that will convey additional flows to the siphon across the Canal and into the headworks of the Bird Island WWTP. In addition, under greater levels of control, a new pump station will be constructed to pump flows to a new EHRT facility located on the north side of the WWTP. As with Alternative UA3, any remaining CSOs not controlled by the tunnels/relief sewer would be handled through a combination of satellite storage facilities and the Revised Foundation Plan. As specified by the Agencies, Alternative UA3A is an 'all-gray' plan and does not include green infrastructure as part of the alternative technologies. This alternative maintains nearly all of the tunnels proposed in Alternative UA3, but incorporates alternative gray technologies for the Black Rock Canal CSOs to determine if they are more cost-effective.

Table ES-1 presents a summary of the overall framework for the additional alternatives evaluated as part of this LTCP. Alternative UA2 is the only alternative with the proposed GI program. As is noted later in this LTCP, the BSA proposes to implement components of this alternative as the BSA's Recommended Plan/LTCP with a 20-year implementation schedule.

Table ES-1: Predicted Components of Additional Alternatives for Evaluation in the LTCP

Alt.	Description	RTC	GI	Satellite Treatment	Satellite Storage	Tunnel	North Relief	Partial Sewer System Separation
UA1	Updated 2004 Preferred System wide Alternative with Original Foundation			X	X	X		X
UA2	RTC & GI & North Relief (1) + Revised Foundation + Selected Elements of UA1	X	X	X	X	X	X	
UA3	System wide Tunnel + Revised Foundation	X			X	X		
UA3A	System wide Tunnel + Revised Foundation + North Relief (1)	X		X	X	X	X	

Notes: (1) – For alternatives UA2 and UA3A, HRT will be required for higher levels of control but not universally.

Per the requirements of the AO, each alternative was evaluated for five different levels of control (LOCs) in terms of CSO activation frequency. Other regulatory metrics such as residual CSO volumes, system wide percent capture of wet weather flows, and remaining pollutant (bacteria) loadings were estimated as well for BSA's informational purposes. The costs and benefits (in the form of Water Quality Standards (WQS)) attainment and CSO frequency/volume reductions) for each alternative at each LOC were evaluated for each individual CSO receiving water body. The benefits of the alternatives were evaluated using 12-month continuous simulations with the 1993 modified typical precipitation year. As agreed upon with the USEPA, water quality benefits were evaluated only for select alternatives (UA1 and UA2) because the composition of technologies for UA3 and UA3A would yield very similar water quality results for the level of control being obtained by the UA1 and UA2 alternatives.

Compliance with WQS is the primary consideration for CSO LOCs, followed by affordability and cost-effectiveness. Thus, just because a particular LOC may appear to be cost-effective, it may be neither necessary (if WQS are met short of that level of CSO control) nor affordable. Moreover, it is important to note that the data inputs to these graphs are the best available information at this time, but are still only planning level estimates.

That said, the system wide cost-benefit curves for each alternative were compared for the different types of benefits. The cost curves for attainment of water quality standards, level of control (activations per year), residual CSO volume (million gallons), and percent capture were compared to assess the relative effectiveness of each alternative. Water quality attainment was evaluated on a receiving water body-specific basis rather than a system wide basis.

Figures ES-1, ES-2 and ES-3 present a comparison of the system wide cost curves comparing the costs for each system wide alternative versus the benefits gained by the alternatives. Figure ES-1 compares cost versus overflow frequency of activation, ES-2 compares cost versus remaining CSO volume and finally Figure ES-3 compares cost versus system wide percent capture.

As can be seen from all three figures, Alternative UA1 (Updated 2004 Preferred Alternative) presents the highest cost for all LOCs. This is due in part to the original Foundation Plan's reliance on a significant number of sewer separation projects. Also, there are two proposed storage tunnels (East-West for Scajaquada Creek and North-South for Black Rock Canal/Niagara River) included in this alternative.

Alternative UA2 has the lowest costs out of the three new alternatives evaluated in this LTCP and therefore, formed the basis of the Recommended Plan. While the majority of the evaluations were done on a cost-effectiveness basis, Alternative UA2 also represents a significant update of Alternative UA1 and incorporates emerging technologies such as RTC to better utilize the existing infrastructure, and also supports the USEPA's broader national sustainability objectives by including a substantial (but realistic and achievable) GI component.

Alternatives UA3 and UA3A are essentially bracketed by UA1 and UA2 and as shown provide greater cost effectiveness than UA1 for most levels of control but lesser cost effectiveness than UA2. Note that for the purposes of this update effort, the technologies evaluated for Alternatives UA1 remain unchanged from the 2004 LTCP, but were, however, evaluated using the 2012 models and the 1993 TY, and the costs were updated to 2012 dollars.

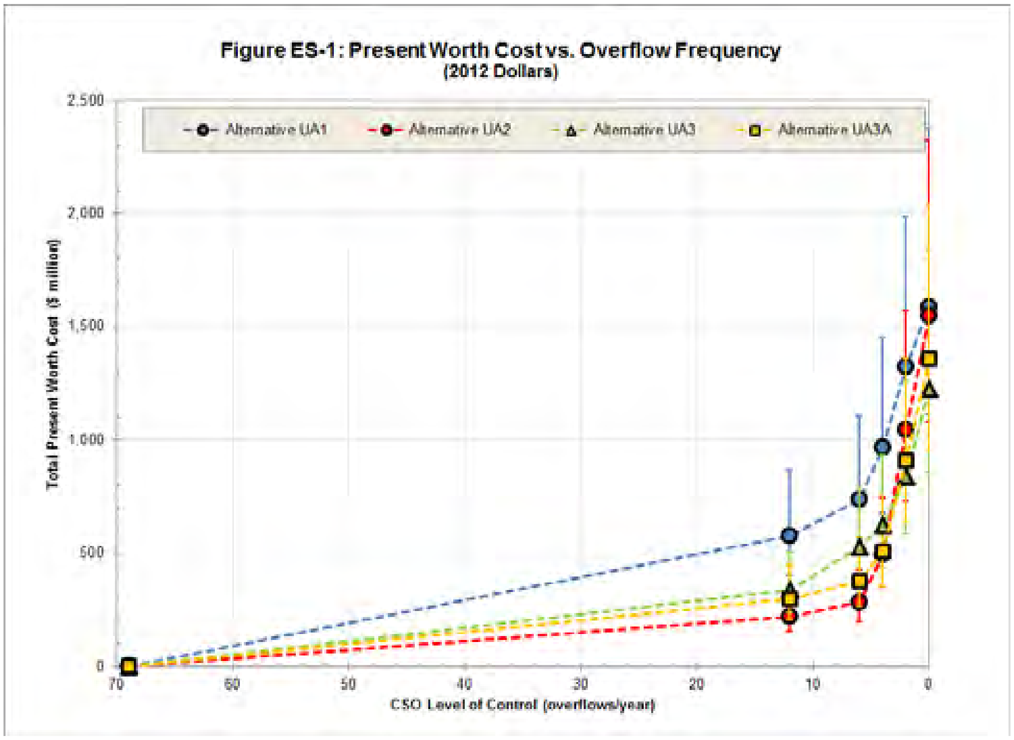


Figure ES-1: Present Worth Cost vs. Overflow Frequency
(2012 Dollars)
Alternative UA1
Alternative UA2
Alternative UA3
Alternative UA3A
Total Present Worth Cost ($ million)
2,500
2,000
1,500
1,000
500
0
70
60
50
40
30
20
10
0
CSO Level of Control (overflows/year)

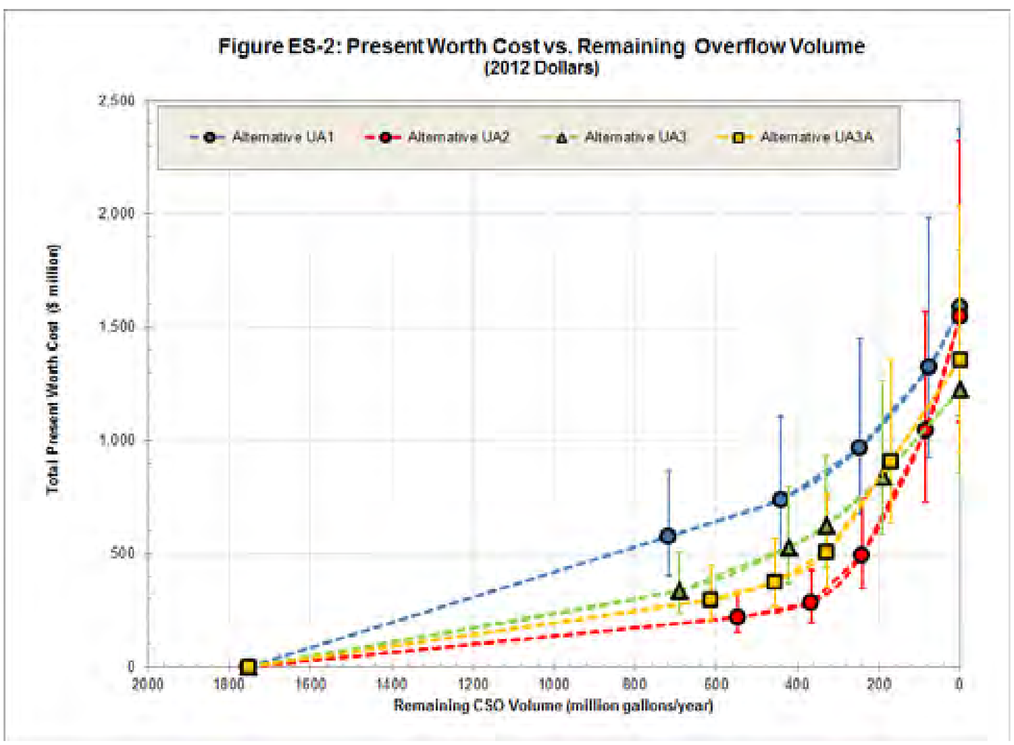


Figure ES-2: Present Worth Cost vs. Remaining Overflow Volume
(2012 Dollars)
Alternative UA1
Alternative UA2
Alternative UA3
Alternative UA3A
Total Present Worth Cost ($ million)
2,500
2,000
1,500
1,000
500
0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Remaining CSO Volume (million gallons/year)

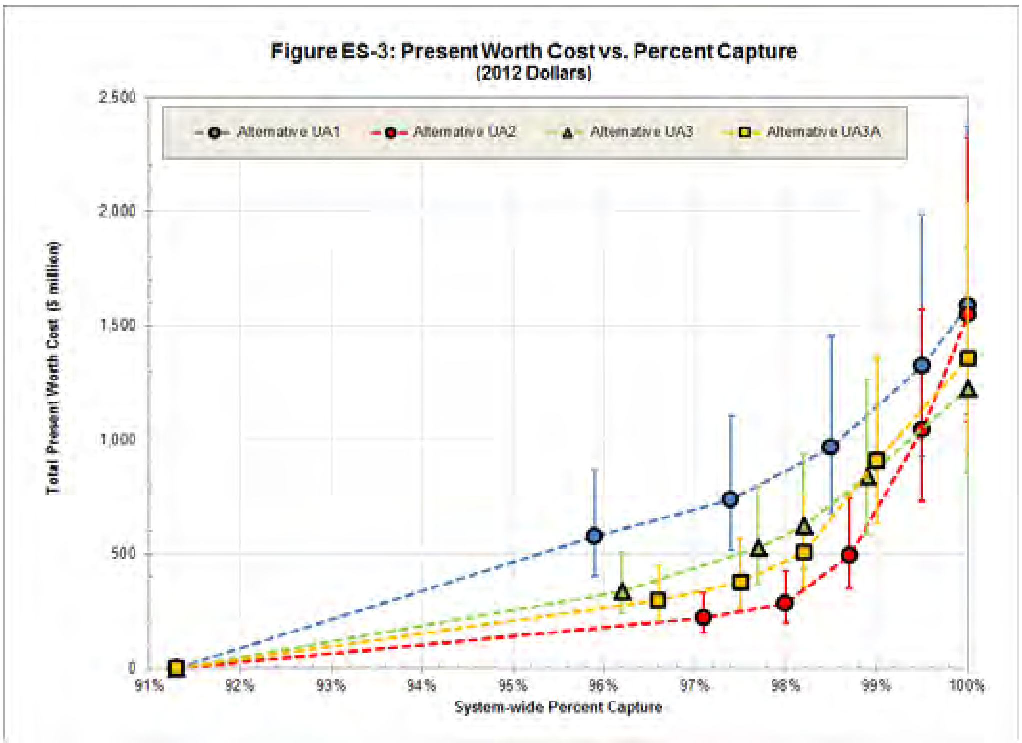


Figure ES-3: Present Worth Cost vs. Percent Capture
(2012 Dollars)

Additional Evaluations

In response to Agencies' comments on the April 2012 LTCP, the BSA provided additional detail on their green infrastructure (GI) program by developing a Green Infrastructure Master Plan (GI Master Plan) as well as addressed treatment plant flow maximization processes by updating the No Feasible Alternatives (NFA) Analysis for the WWTP.

Generally speaking, the GI Master Plan includes further refinement of the GI impervious surface control targets presented in the April 2012 LTCP document to determine, on the SPP level, where the system would most benefit from GI technologies, as well as provides requested detail on the Phase 1 GI projects to be implemented over the first five-year period. A summary of the revised impervious acreage to be controlled by GI for each receiving water body, as well as the original acreage recommended to be managed by GI is presented in Table ES-2. Refining the impervious control acreage to the SPP level allowed for better identification of SPPs (and by extension CSO outfalls) that would benefit most from implementing GI technologies, and also for determining which SPPs would not benefit because they were already at or below the recommended RWB LOC or do not discharge directly to a RWB.

Table ES-2: Updated Impervious Area Target for Control by GI

Receiving Water	Original Area Managed (acres) by GI Based on CSO Level	Updated Area Managed (acres) by GI Based on SPP Level
Black Rock Canal	168	198
Buffalo River	418	319
Cazenovia Creek - B	3	3
Cazenovia Creek - C	60	58
Erie Basin	49	53
Niagara River	412	378
Scajaquada Creek	510	305
Total	**1,620**	**1,315**

As shown in Table ES-2, this refinement resulted in minimal to moderate changes in controlled acreage on a receiving water body basis. Recommended acreages increased in the Black Rock Canal and Erie Basin, and decreased in the Cazenovia Creek–C, Buffalo River, Niagara River, and Scajaquada Creek. Because the SPP-level GI allocation provides a more refined and cost-effective approach, the BSA will work towards a 1,315-acre total green infrastructure program effort. However, the BSA will utilize modeling and post-construction monitoring of the first three phases of GI projects to confirm that the 1,315 target acres will be sufficient to meet the level of control objectives. If needed, the acreage target for the fourth phase of GI projects will be adjusted to achieve the CSO outfall typical year frequency of activation requirements.

The Recommended Plan with the refined impervious surface control acreages was evaluated for each receiving water body in terms of targeted reduction in CSO activations and volumes. The projected activation frequencies in any given receiving water body remained the same or decreased for all but three CSOs. For the CSOs that showed an increase in activations, the resulting activations remained within the targeted typical year LOCs for each receiving water body. The total system wide CSO volume remaining increased slightly (approximately 4 percent); however, the projected increase in residual volume is within the uncertainty of the modeling tools and, accordingly, is insignificant, particularly in light of the conservative factors used elsewhere in the GI program and LTCP.

The GI Master Plan also identified the Phase 1 GI projects, which are summarized in Table ES-3. These GI projects rely upon demolition/vacant lot management, as well as runoff reduction from seven green streets projects to achieve the impervious surface management goal. While the BSA is accounting for Phase 1 GI projects in all sub-catchments in the model, some of these projects may be located in a sub-catchment that is not targeted for impervious surface control. For the purpose of determining the GI implementation acreage towards target goals, the projects (primarily building demolitions) outside of the refined target areas were removed. Table ES-3 presents both the total impervious acreage controlled and the impervious acreage that would be applied to the proposed GI target acreage. The Phase 1 GI projects will control 448 acres of impervious area, of which 267 acres will be applied to the SPP-based GI acreage targets.

Table ES-3: BSA's Phase 1 Green Infrastructure Program Summary

Project Group	Sub Group	Impervious surface controlled (acres)	Impervious Acreage Applied to SPP-based Target CSO Control (acres)
Demolitions and Vacant Lot Management	2001 – 2013 Demolitions (excl. 2001-2009 demos in CSO 12)	354	210
	CSO 53 Pilot Project and 2014-2018 Demolitions	50	31
	Fillmore Ave green lots	0	0
	PUSH Blue Projects	1.0	1.0
Green Streets	Carlton Street porous asphalt	1.0	0
	Fillmore Ave porous parking lots	0.4	0.4
	Ohio Street	6.1	2.1
	Kenmore Ave(1)	4.1	4.1
	Kensington Ave(1)	5.5	2.5
	Allen Street(1)	2.5	2.5
	Niagara Street(1)	23	14.3
	TOTAL	448	267

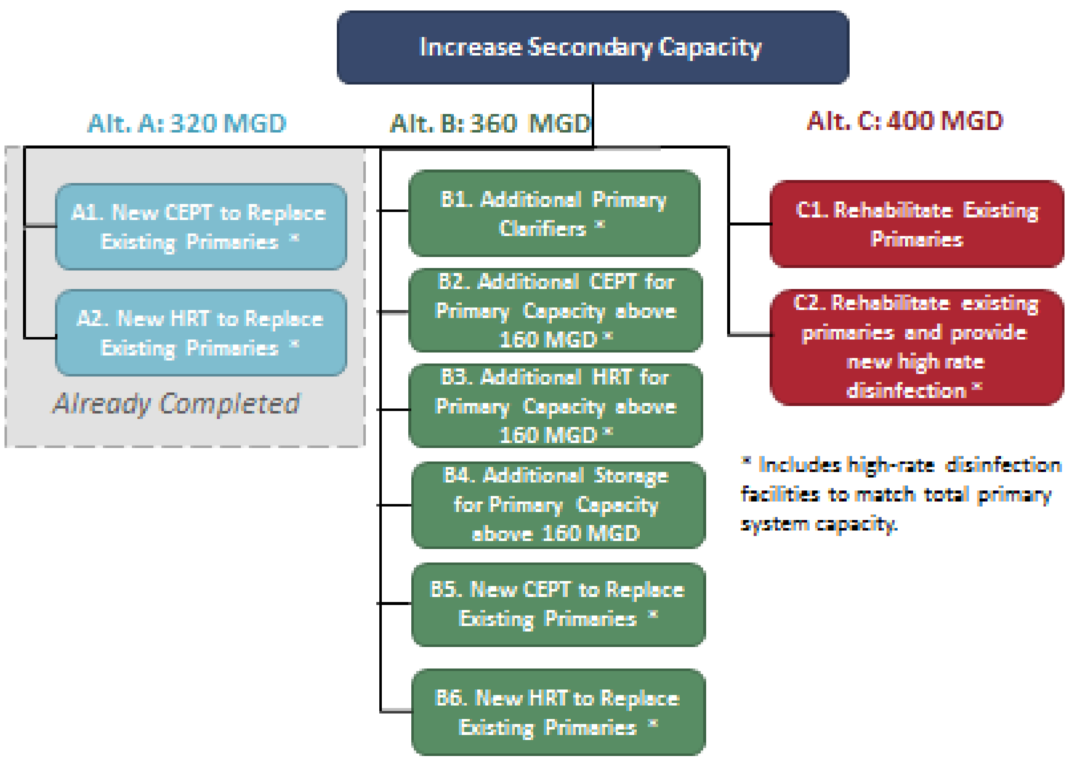
Note: (1) Specific designs are not available for these projects at this time. The impervious acreage controlled was estimated based on the assumptions provided in Section 8 of the GI Master Plan.

In response to public comment on the April 2012 submission, the BSA remains committed to evaluating opportunities to maximize the use of additional cost-effective green infrastructure approaches. The target acreage above is a minimum program commitment. Any additional green infrastructure acreage proposed in conjunction with the optimization of gray projects would be in addition to the acreage above. This approach allows the BSA to adaptively manage the green infrastructure program to incorporate lessons learned in each five year program and take advantage of land use and infrastructure investments projected for each period to deliver the maximum public benefits at the lowest cost.

As briefly stated above, in order to address the Agencies' concerns regarding the secondary treatment plant bypasses and in particular the method by which the BSA disinfects these bypass flows, the BSA also updated the No Feasible Alternative (NFA) analysis initially prepared for the April 2012 document. While the NFA analysis in general concluded that the BSA has demonstrated, through operational modifications and capital improvements, that the plant is currently maximizing the treatment of wet weather flows conveyed to the plant through a combination of the three operating modes (normal, primary bypass and partial treatment), the BSA agreed to evaluate several alternatives to provide a higher level of treatment for wet weather flows reaching the WWTP that currently do not receive secondary treatment.

During completion of the NFA analysis, a number of alternatives were evaluated to provide treatment of plant influent flows of up to 560 MGD. Figure ES-4 below presents a summary of the evaluated alternatives.

Figure ES-4: Summary of Alternatives Evaluated in the No Feasible Alternative Analysis



The NFA considered three options for secondary system capacity: maintain the current secondary capacity of 320 MGD and replace the entire primary clarification system (240 MGD capacity), increase the secondary capacity to 360 MGD with several options for 200 MGD primary clarification capacity, and increase the secondary treatment capacity to 400 MGD. Each of these options was developed to address the Agencies' concerns relative to the effective capacity of the primary clarifiers and the method by which the BSA disinfects primary effluent when operating in the partial treatment mode.

Alternatives A1 and A2 considered a secondary treatment process hydraulic capacity of 320 MGD (current capacity), which would require providing 240 MGD of primary treatment capacity. Alternatives B1 through B6 considered increasing the secondary treatment sustained peak flow capacity up to 360 MGD with the remaining 200 MGD treated in the primary treatment process using various options as shown on Figure ES-4. In order to ensure a total flow through the secondary clarifiers of 360 MGD, for each Alternative B1 through B6, it was recommended to install additional orifices in the secondary clarifier influent channels in each clarifier. Finally, Alternatives C1 and C2 considered hydraulic and process improvements to the existing secondary treatment process to treat sustained peak flows up to 400 MGD in partial treatment mode, while addressing the Agencies' concerns relative to primary clarifier capacity and primary effluent disinfection. Each of these alternatives (C1 and C2) includes the construction of two additional secondary clarifiers, expansion of the existing secondary chlorine contact tank to accommodate an additional 40 MGD of flow at a minimum 15-minute contact time, and the addition of orifices in the secondary clarifier influent channels to increase the secondary treatment capacity to 400 MGD.

Following the completion of the NFA evaluations, Alternative C2 was recommended as the preferred WWTP alternative for implementation. In general, this alternative increases the capacity of the secondary treatment process to 400 MGD, addresses the concern relative to primary capacity and effluent disinfection and, more importantly, provides post-clarification disinfection of all primary effluent. Alternative C2 includes:

- Replacement of the sludge and scum collection systems in each of the four existing primary clarifiers.

- Replacement of the primary sludge pumps.

- Miscellaneous other repairs (including contract required to ensure that the primary clarifiers remain functional).

- Addition of a high rate disinfection system including a new chlorine contact tank and associated chemical storage and feed equipment to provide a minimum 5-minute detention time for high-rate disinfection for primary effluent flows up to 160 MGD.

- Improving hydraulics through the sixteen existing secondary clarifiers by providing additional orifices in the peripheral influent channel of each secondary clarifier.

- Construction of two new secondary clarifiers.

- Expanding the existing chlorine contact tank to disinfect a total secondary process effluent of 400 MGD, with a contact time of 15 minutes.

This alternative (C2) was recommended as the most technically and financially feasible alternative to be implemented for the following reasons:

- Maximizes secondary treatment of plant wet weather flows.

- Optimizes primary effluent disinfection.

- Offers the most appropriate life-cycle cost benefit.

- Involves relatively straightforward construction with minimal impact to other plant treatment processes during construction.

- Can be implemented within the limited available space on the WWTP property.

- Is similar to current treatment plant operations, providing a manageable learning curve for plant operations staff.

Recommended Plan

A careful analysis of detailed receiving stream water quality modeling results revealed that a uniform level of CSO control for all BSA receiving water bodies is neither cost effective nor necessary to meet the established WQS in each water body. This is a logical finding given the extremely varied nature of the CSO receiving waters. The modeling reveals that each receiving water body has a unique combination of the current WQS attainment status, impacts from CSOs versus background sources, and CSO control costs. Furthermore, the evaluation results show that the knee of the curve points for Alternative UA2 for each receiving water body already provides 100% attainment of the New York State (NYS) recreational (bacteria) WQS. Therefore, the BSA's recommended alternative was assembled with a primary focus on providing a cost-effective attainment of the current NYS bacteria WQS in each water body and the associated frequency of activation necessary to accomplish those WQS. This frequency of activation performance measure targets the USEPA CSO Control Policy presumption approach criterion of 4 to 6 overflow events per year. Following implementation of the Recommended Plan, all water bodies in the BSA system will meet the 4 to 6 events per typical year level of control, with the following clarifications:

- **Erie Basin -** The Erie Basin was identified as a sensitive area, and as such, has the highest selected cost-effective target LOC of 2 events per typical year. While water quality modeling reveals that the WQS are met under existing conditions in the Erie Basin, the BSA has elected to target the higher LOC as part of the Recommended Plan.

- **Buffalo River** - Based on the water quality modeling results, the Buffalo River would achieve 100% compliance with WQS at the lowest evaluated LOC of 12 events per typical year (provided that the USEPA and NYSDEC reasonably address upstream sources of pollutants by other parties); however, the BSA has targeted a higher level of control (6 events per year) based on the activation frequency versus project present worth costs knee of the curve for the Buffalo River.

- **Niagara River** - Water quality modeling results also reveal that the Niagara River already meets the current NYS bacteria WQS under the baseline conditions with 100% attainment. At the same time, the activation frequency versus project present worth costs knee of the curve for the Niagara River fell at approximately 8 to 10 events per year. Increased LOCs for the Niagara River provided marginal benefits in terms of CSO volume reduction and no additional benefits in terms of WQS attainment. However, through the LTCP program, the BSA will reduce overflow events in all Niagara River CSOs, with three of the four fully meeting the USEPA goal of 4 to 6 events per year. For the third CSO, 055, the BSA selected a cost-effective LOC of approximately 9 events during the typical year.

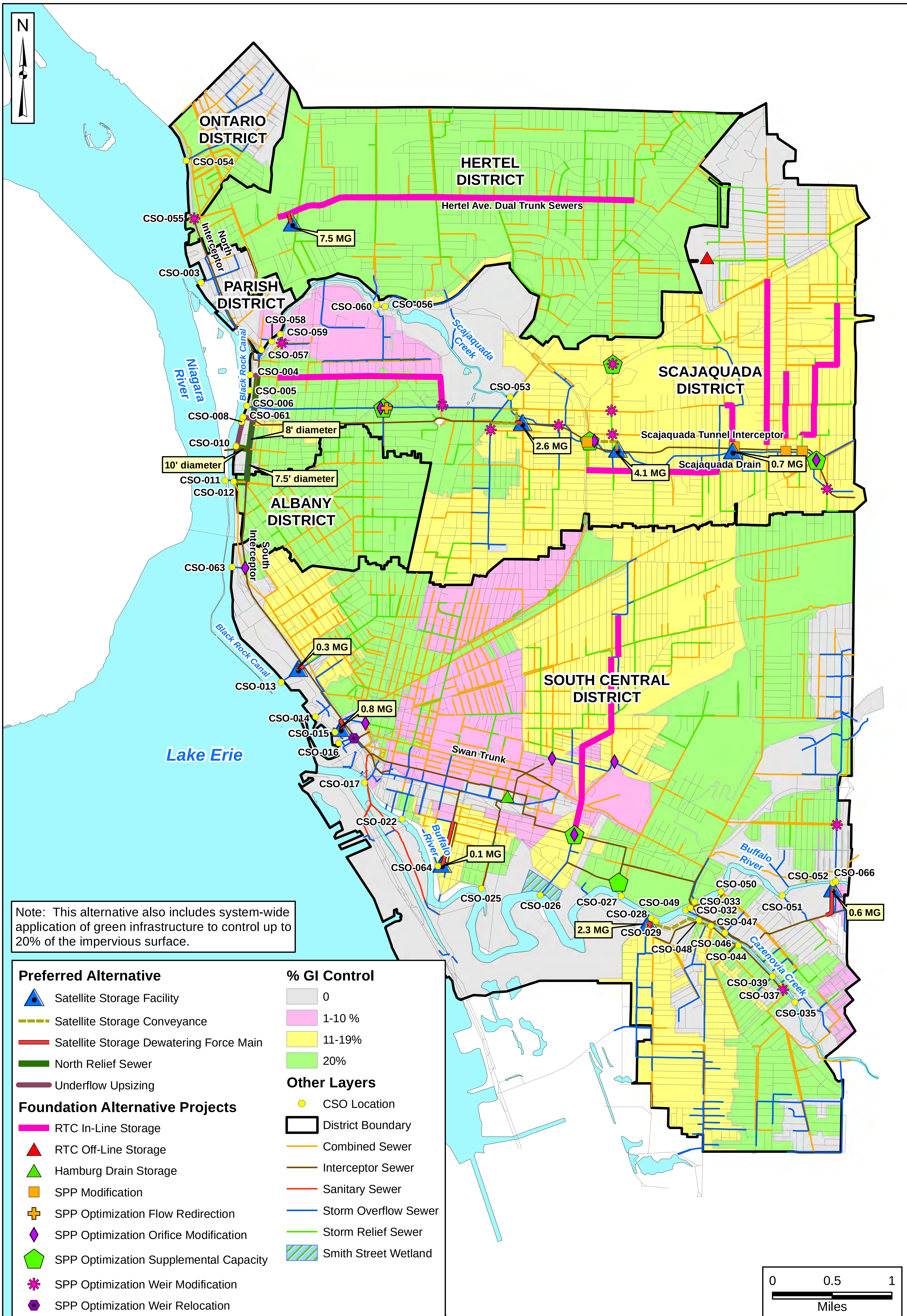
Table ES-4 below presents a more detailed listing of the projects that comprise the Recommended Plan. As shown, the list presents the projects proposed for each general type of project for each water body. Figure ES-5 presents a graphical representation of the components of the Recommended Plan.

Table ES-4: Summary of Recommended Plan Projects

Project Grouping	Specific Projects (Concept Level Approximate Sizing)
Revised Foundation Projects: Focus is on combination of low-cost system optimizations, pilot GI projects and cost-effective RTC projects	• Phase 1 Projects: Includes all Phase 1 projects described in Section 11.2. • Non-Phase 1 Projects: These projects are primarily sewer separation projects carried over from the original Foundation Plan and completed prior to the Phase 1 projects. These are also described in Section 11.2. • Real Time Control: 16 real-time control (RTC) projects that were selected after the evaluation described in Section 11.3 • Green Infrastructure Pilot Projects o CSO 060 – Combination of pervious pavements, rain gardens and downspout disconnections/rain barrel installations o Downspout disconnect/rain barrel pilot projects in the Old First Ward and Hamlin Park neighborhoods • Additional SPP Optimizations: 20 additional optimization projects were identified as part of the alternatives evaluations conducted for this LTCP update. These modifications include optimizing weir elevations and orifice plate openings, increasing underflow pipe capacity, and flow redirection at a limited number of locations. Details on these SPP optimization projects are presented in Section 11.4 • Additional Storage Projects: Three projects designed to increase capture of CSO flows

Project Grouping	Specific Projects (Concept Level Approximate Sizing)
	have been identified and are currently in various stages of design by BSA. o Hamburg Drain Storage - 5 MG offline storage facility o Smith Street Storage - 0.5 MG offline storage facility o CSO-016 Storage - 60,000 gallon inline storage
Gray Infrastructure Projects	• Black Rock Canal and Niagara River o Underflow pipe upsizing (to maximize flow to the existing interceptors) o New Northern Relief Sewer that runs parallel to the Black Rock Canal between CSO 004 and CSO 011/012 with an additional parallel relief sewer from CSO 004 to the existing siphon crossing at the WWTP influent. Northern Relief consists of the following components: ▪ 5,310 feet of 96-inch pipe ▪ 571 feet of 120-inch pipe o CSO 055 – 7.5 MG offline storage facility o CSO 013 – 0.3 MG offline storage facility • Scajaquada Creek o SPP 337: 0.7 MG offline storage facility o Jefferson Avenue & Florida Street: 2.6 MG offline storage facility o SPP 336 a & b: 4.2 MG offline storage facility • Buffalo River and Cazenovia Creek: o CSOs 028, 044 and 047: 2.3 MG offline storage facility o CSO 052: 0.6 MG offline storage facility o CSO 064: 0.1 MG offline storage facility • Erie Basin o CSO 014 and 015 – 0.8 MG offline storage facility
Green Infrastructure Projects	Green Infrastructure projects will include a mixture of the following techniques based upon the results of pilot studies undertaken during the early years of the LTCP implementation schedule and will be focused primarily on publically owned properties. • Vacant property demolitions • Modifications to vacant lots to store and infiltrate street runoff • Pervious pavements (public streets and parking lots) • Rain gardens • Downspout disconnections/rain barrels Green Infrastructure technology implementation will be based upon the control of up to 20% of the impervious surfaces (generally assumed to be publically owned) within selected sewer sheds as follows based on the SPP-level refinement outlined in the GI Master Plan: • Black Rock Canal – 198 acres • Buffalo River – 319 acres • Cazenovia Creek (Class B section) – 3 acres • Cazenovia Creek (Class C section) – 58 acres • Erie Basin – 53 acres • Niagara River – 378 acres • Scajaquada Creek – 305 acres Total controlled acreage – 1,315 acres

The planning level project costs were developed using a two-step approach for the Recommended Plan. The first step included assembling the costs for each alterative using the developed technology cost curves; this resulted in the cost performance curves. The opinion of probable project costs for the Recommended



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Long Term Control Plan Update

FIGURE ES-5

RECOMMENDED PLAN WITH APPROXIMATE GI 2 - 9 OF/yr

Plan under this methodology was estimated at approximately $273 million. A summary of probable capital costs using the cost curve methodology is presented in Table ES-5 below. Please note that while the refinement of the GI control acreage at the SPP level reduced the target control acreage to 1,315 acres, the GI cost was conservatively held at the initial $92.6 million estimate (based on $57,000/acre using the initial 1,620 acres impervious surface control) to reflect the BSA's commitment to increasing GI if necessary in the future and in response to the Agencies' view that GI costs were not conservative enough.

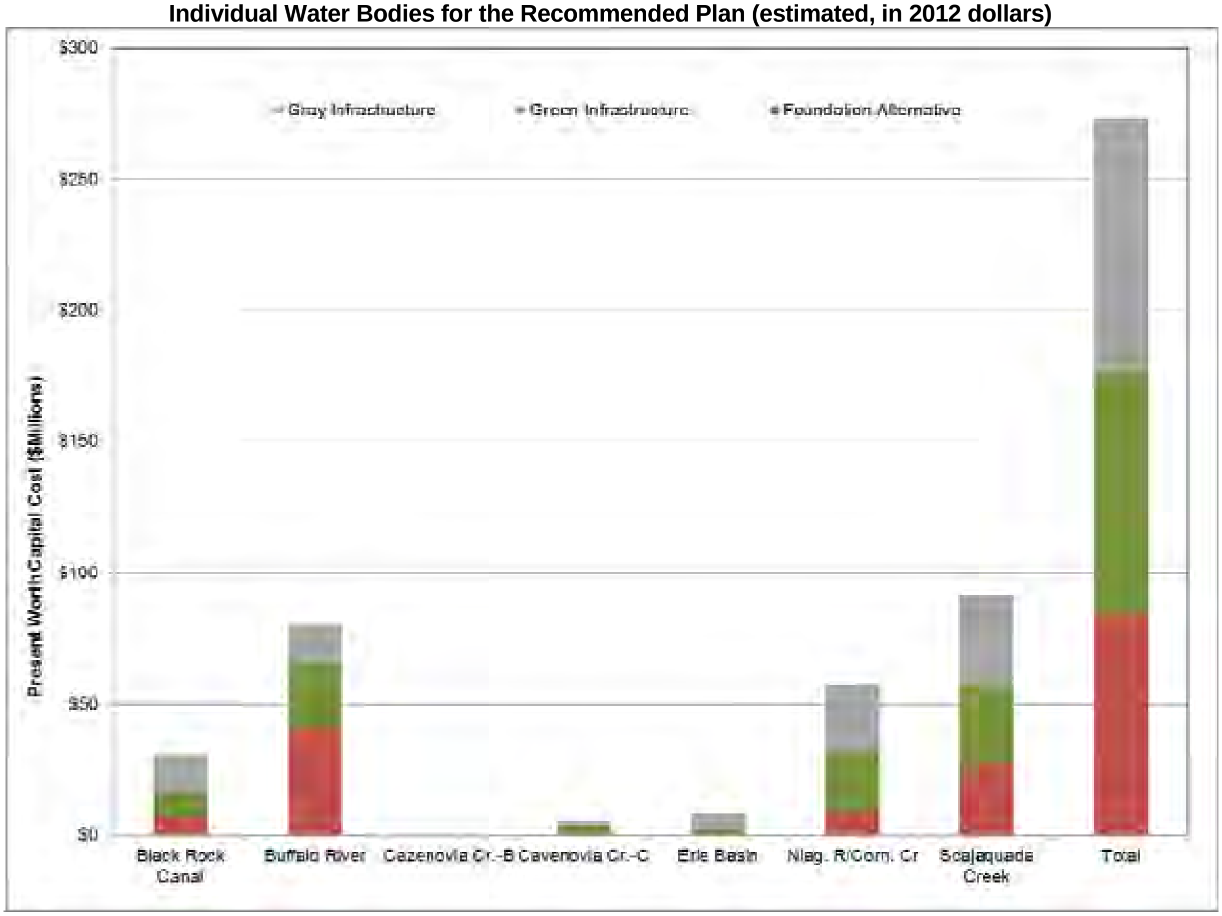
A cost breakdown (using present worth costs) by each receiving stream and general technology is shown on Figure ES-6. The estimated annual O&M cost associated with the Recommended Plan is approximately $350,000, resulting in a total 20-year Present Worth project cost (including O&M) of approximately $278 million.

Table ES-5: Summary of Recommended Plan Project Costs (estimated, in millions of dollars)
(Cost Curve Methodology, not including O&M, 2012 dollars)

Receiving Water Body	Green Infrastructure[1]	Gray Infrastructure	Foundation	Total Construction Cost
Black Rock Canal	$9.51	$14.41	$6.89	$30.80
Buffalo River	$23.83	$15.15	$41.13	$80.11
Cazenovia Cr.-B	$0.17	$0.00	$0.00	$0.17
Cazenovia Cr.-C	$3.42	$1.85	$0.02	$5.28
Erie Basin	$2.87	$5.43	$0.01	$8.30
Niagara River (includes CSO-055 (Cornelius Creek)	$23.50	$25.01	$8.70	$57.20
Scajaquada Creek	$29.32	$34.33	$27.75	$91.40
Total	**$92.61**	**$96.18**	**$84.49**	**$273.27**

NOTE: [1]GI cost based on initial target control of 1,620 acres as a conservative estimate.

Figure ES-6: Distribution of Gray, Green, and Foundation Alternative Present Worth Project Costs in the Individual Water Bodies for the Recommended Plan (estimated, in 2012 dollars)



NOTE: GI cost based on initial target control of 1,620 acres as a conservative estimate.

Next, a more detailed, yet still planning level, opinion of probable project costs was developed. This cost was developed using more specific information such as conceptual facility layouts, local knowledge of construction costs, costs for similar projects constructed elsewhere, etc. The probable project cost for the Recommended Plan under this methodology was estimated at $340 million, as shown in Table ES-6. In addition to the Recommended Plan cost, the costs for upgrades at the WWTP from the NFA Report (Alternative C2) have been added to reflect the overall expense for improvements across the BSA system ($380 million). For the purposes of this document, the O&M costs for all CSO-related construction projects are considered to be the same as presented above. However, the additional O&M cost for the NFA-related projects was estimated at $282,000 per year. It should be noted that while more detailed and refined, this cost estimate is still considered, at most, AACE Class 3 in that the costs are still based upon very limited design concepts. The refined system wide project cost estimate of $380 million was used as a conservative value cost for the affordability evaluations and initial project budgeting and scheduling.

Table ES-6: Summary of System Wide Estimated Project Costs

Receiving Water Body / Projects	Project Cost [1,2,3]
Black Rock Canal	
CSO 013 (300,000 gallons)	$3,000,000
North Relief Sewer	$36,000,000
CSO 008/010, 061, 004 Underflow Upsizing	$500,000
Erie Basin Marina	
CSO 014/015 (800,000 gallons)	$6,700,000
Cazenovia Creek – C	
CSO 028/044/047 (2,300,000 gallons)	$12,200,000
Buffalo River	
CSO 052 (600,000 gallons)	$3,900,000
CSO 064 (100,000 gallons)	$2,000,000
Scajaquada Creek	
Jefferson Avenue & Florida Street (SPP 170B) (2,600,000 gallons)	$9,500,000
SPP 336 a/b (SPP165A, SPP165B, SPP 336A, SPP336B) (4,200,000 gallons)	$11,500,000
SPP 337 (700,000 gallons)	$4,000,000
Niagara River (Cornelius Creek)	
CSO 055 (7,500,000 gallons)	$18,500,000
Subtotal	*$107,800,000*
Contingency (20%)	$21,500,000
Probable Construction Cost	*$129,300,000*
Administrative and Legal (5%)	$6,500,000
Engineering (20%)	$26,000,000
Total Recommended Plan Cost	**$161,800,000**
Revised Foundation Plan Cost (for projects not already completed, see Table 11-11)	*$85,000,000*
Green Infrastructure (system wide) [5]	*$92,600,000*
Revised Foundation Plan + Recommended Plan	**$339,400,000**
NFA Alternative C2 at WWTP	*$41,000,000*
System Wide Improvements	***$380,400,000***

NOTES:
[1] Year 2012 dollars.
[2] All Costs Rounded.
[3] Planning Level Estimate.
[4] Right-of-Way and/or land acquisition not included.
[5] GI cost based on initial target control of 1,620 acres.

Summary of Recommended Plan Benefits

The Recommended Plan offers significant benefits by focusing efforts and associated costs to tailor CSO improvements to achieve receiving water in stream improvements. The benefits of the Recommended Plan were evaluated for activation frequency for each receiving water body in terms of targeted CSO activation frequency LOC. Reduction in CSO volumes and the overall system wet weather percent capture have also been calculated and are included for informational purposes. The proposed performance measure at this time is the activation frequency criterion consistent with the presumption approach as provided in the CSO Control Policy. The Recommended Plan also meets the demonstration approach because each CSO receiving water will meet applicable water quality standards.

Table ES-7 presents a summary of the predicted frequencies, residual CSO volumes and percent capture for the Recommended Plan. Residual volumes and remaining overflows are presented for each receiving water body, while percent capture is presented on a system wide basis. As shown in Table ES-7, the Recommended Plan is predicted to achieve the 4 to 6 overflow events in a typical year at all but one of the Niagara River CSOs.

Table ES-7: Summary of Recommended Plan Benefits *

Receiving Water Body	CSO	Baseline Activations	Baseline CSO Volume (MG)	Projected Activations (LOC)	Residual CSO Volume (MG)	Remaining Fecal Coliform Annual Loadings (MPN)
Black Rock Canal	004	5	11.2	3	8.7	1.25E+14
	005	4	0.1	4	0.1	
	006	65	198.9	4	21.7	
	008	39	6.1	0	0.0	
	010	44	11.9	1	0.0	
	012	42	52.5	2	0.9	
	013	7	6.8	4	2.7	
	061	10	31.2	2	1.2	
	063	13	0.6	4	0.3	
	Total	**≤65**	**319.3**	**0 – 4**	**35.6**	
Buffalo River	017	49	71.3	4	34.8	6.26E+14
	022	49	29.8	5	2.0	
	025	11	1.4	6	1.2	
	026	63	124.2	3	29.6	
	027	36	31.7	6	39.1	
	028	69	45.5	6	22.7	

Receiving Water Body	CSO	Baseline Activations	Baseline CSO Volume (MG)	Projected Activations (LOC)	Residual CSO Volume (MG)	Remaining Fecal Coliform Annual Loadings (MPN)
	029	0	0.0	0	0.0	
	032	0	0.0	0	0.0	
	033	9	37.8	5	31.8	
	034	Closed	Closed	0	Closed	
	049	0	0.0	0	0.0	
	050	14	3.2	5	2.8	
	051	4	1.2	4	1.2	
	052	10	10.9	3	6.3	
	064	56	21.1	3	6.9	
	066	10	1.7	4	0.4	
	Total	≤69	**379.7**	**2 – 6**	**178.8**	
Cazenovia Cr.-B	035	0	0	0	0	0.00E+00
Cazenovia Cr.-C	037	13	23.3	6	11.9	5.38E+13
	039	0	0.0	0	0.0	
	044	7	2.3	2	0.7	
	046	1	1.3	0	1.3	
	047	44	8.7	3	1.5	
	048	0	0.0	0	0.0	
	Total	≤44	**35.6**	**0 – 6**	**15.4**	
Erie Basin	014	4	4.2	2	3.1	1.30E+13
	015	12	6.1	1	0.6	
	016	0	0.0	0	0.0	
	Total	≤12	**10.3**	**0 - 2**	**3.7**	
Niagara River (incl. CSO 055)	055	41	601.1	9	206.2	7.66E+14
	003	6	0.1	5	0.8	
	011	41	134.3	4	11.7	
	054	0	0.0	0	0.0	
	Total	≤41	**735.5**	**4 - 9**	**218.7**	
Scajaquada Creek	053	65	268.0	4	52.1	1.82E+14
	056	5	0.0	3	0.0	
	057	0	0.0	0	0.0	

Receiving Water Body	CSO	Baseline Activations	Baseline CSO Volume (MG)	Projected Activations (LOC)	Residual CSO Volume (MG)	Remaining Fecal Coliform Annual Loadings (MPN)
	058	0	0.0	0	0.0	
	059	0	0.0	0	0.0	
	060	5	0.7	0	0.0	
	Total	≤65	**268.7**	**0 - 4**	**52.1**	
Totals		**NA**	**1749.1**	**NA**	**504.3**	**1.77E+15**
Percent Capture		**NA**	**91.3%**	**NA**	**97.2%**	**NA**

NOTE: All model projections of frequency, volume and percent capture are based on selected 1993 typical year precipitation conditions and represent planning-level estimates that may vary within accepted industry standards.

The Recommended Plan was also evaluated for each receiving water body in terms of remaining pollutant loadings and water quality compliance (bacteria is the pollutant of concern). As agreed with the Regulatory Agencies at technical meetings conducted in 2011, for purposes of evaluating water quality compliance, a baseline scenario representing somewhat improved upstream water quality was chosen. This baseline scenario incorporates upstream water quality conditions set at 75% of the WQS. These modified upstream boundary conditions were identical for both the baseline scenario used in this report and for the Recommended Plan. Stormwater and upstream fecal coliform bacteria concentrations were set to 150 counts/100 mL, and BOD concentrations set to 75% of baseline in-stream conditions.

Attainment of the bacteria WQS for each water body under the Recommended Plan was calculated from model output and compared to the bacteria WQS attainment for the baseline condition. Table ES-8 presents a summary of annual percent attainment of bacteria WQS for all modeled water bodies under these two scenarios. Attainment was first calculated for each model segment and then spatially averaged across each water body.

Table ES-8: Water Quality Standards Attainment for Bacteria (Background Loadings set at 75% of WQS)

Scenario	**Bacteria: Annual Percent Attainment (%) of WQS**					
	Upper Scajaquada Creek	**Lower Scajaquada Creek**	**Buffalo River**	**Black Rock Canal**	**Erie Basin**	**Niagara River (incl. CSO 055)**
Baseline (Background 75% of WQS)	99	77	93	86	100	100
Recommended Plan	100	100	100	100	100	100

All water bodies demonstrated 100% attainment of the bacteria WQS under the Recommended Plan for the targeted levels of control presented previously (note that Black Rock Canal was rounded from 99.9% to 100%). The greatest improvement was seen for Lower Scajaquada Creek, where attainment increased from 77% in the baseline scenario to 100%. Additionally, bacteria WQS attainment increased from 86% to 100% in the Black Rock Canal, 93% to 100% for the Buffalo River, and from 99% to 100% for the Upper Scajaquada Creek. Bacteria WQS attainment in the Erie Basin and the Niagara River remained unchanged at 100% attainment for baseline conditions.

GI Sensitivity

The Recommended Plan has a significant GI component with most of the areas within the BSA CSS targeted for up to 20% of impervious area control by GI projects. Note that GI target percentages have been developed on a sewershed (area of collection system tributary to an individual CSO) basis. As such, the performance of the Recommended Plan is dependent on the future performance of the GI projects. While GI has evolved significantly over the last decade and is gaining strong public and regulatory support, many GI technologies are still evolving and their application and long-term performance can vary significantly among communities. Furthermore, GI performance in cold climates, such as the City of Buffalo, requires additional time and attention to assess and implement effectively. Finally, the ultimate effectiveness of a GI program in the longer term is heavily dependent upon community acceptance. These factors are why the BSA plans on conducting selected GI pilot projects to inform the proposed system wide GI implementation program.

Currently, the BSA is in the process of constructing a demonstration project in the CSO 060 project. This project includes a number of different GI techniques including pervious pavements, rain gardens and downspout disconnections and will begin to provide a database of local performance metrics. Additional GI pilot projects also are considered for the early years of the LTCP implementation. Further, the BSA is embarking on a broader downspout disconnect/rain barrel pilot program in two neighborhoods to assess the effectiveness of these measures at reducing CSOs and the public's willingness to participate in such a program.

In order to evaluate the sensitivity of the program to GI effectiveness, a model run was completed incorporating only the gray components of the recommended plan. This run was intended to determine how the system would react in the event that in the worst case, GI proved to be ineffective. The sensitivity evaluation results are presented in Table ES-9.

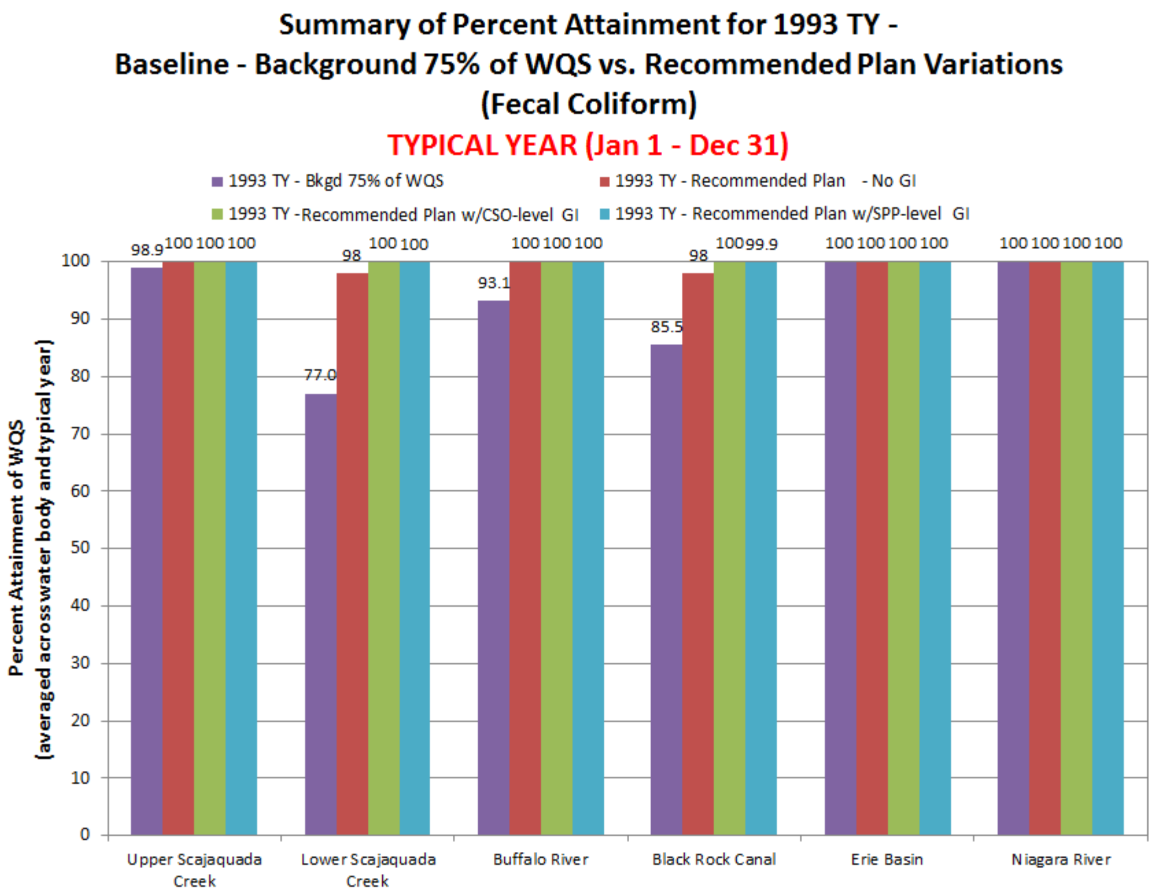
Table ES-9: Green Infrastructure Sensitivity Analysis Results

	Projected Activations (LOC)		Residual CSO Volume (MG)	
Receiving Water Body	**GI (SPP-level)**	**No GI**	**GI (SPP-level)**	**No GI**
Black Rock Canal	0 – 4	0 - 7	35.6	57.3
Buffalo River	2 – 6	3 - 10	178.8	233.9
Cazenovia Cr.-B	0	0	0.0	0.0
Cazenovia Cr.-C	0 - 6	0 - 8	15.4	20.6
Erie Basin	0 - 2	0 - 2	3.7	6.8
Niagara River (incl. CSO 055)	4 - 9	6 - 12	218.7	321.2
Scajaquada Creek	0 - 4	0 - 7	52.1	74.2
Totals	**NA**	**NA**	**504.3**	**713.9**
Percent Capture	**NA**	**NA**	**97.2%**	**96.5%**

The SPP-level GI scenario represents the impervious surface area control associated with the SPP-level refinement discussed above. As can be seen from Table ES-9, with no GI assumed, the effect on projected activations is relatively minor; however, the implementation of GI results in an annual CSO volume reduction of approximately 210 MG. This evaluation demonstrates that even if the GI program falls significantly short of the established goals, the resulting reduction in system performance will be negligible given the significant progress and high LOC achieved to date.

In addition to the hydraulic modeling comparison discussed above, the BSA also evaluated the water quality impact of no GI. Figure ES-7 shows a graphical comparison of the resulting water quality impacts.

Figure ES-7



NOTE: The 99.9 percent capture in Black Rock Canal for the "Recommended Plan w/SPP-level GI" scenario was rounded to 100 percent.

The water quality modeling results reveal that the Recommended Plan with no GI will result in 100% attainment of the current NYS bacteria WQS in all receiving water bodies, except for the Lower Scajaquada Creek and Black Rock Canal (both at approximately 98%). This suggests that much of the system will not be affected appreciably by reductions in GI.

That said, the GI controls are an important part of the Recommended Plan for reasons beyond water quality compliance. For example, the GI controls will provide multiple environmental and community benefits as compared to gray infrastructure designed solely to address bacteria loadings. GI controls will also serve to engage the public in tangible aspects of this important water quality program in a way that underground sewer pipes could never accomplish. Also, if GI is successful, there is the strong likelihood that GI can be expanded beyond the levels proposed in the Recommended Plan. This will allow the BSA to resize/right-size future gray infrastructure and/or provide an even higher LOC. The more GI, the more sustainable the program will be over the long-term.

Implementation Schedule

The LTCP Recommended Plan will have a probable project cost of $380 million, and will be implemented over a 20-year period. Figure ES-8 presents the implementation of the BSA's Recommended Plan over the course of 20 years, resulting in a substantial reduction in annual CSO activation frequencies and volumes. Remaining Phase I and Revised Foundation Plan projects are scheduled to be implemented first, with the next priority given to Erie Basin Marina (sensitive area) and Black Rock Canal (water quality most affected by wet weather discharges). Storage and conveyance projects in the Scajaquada Creek, Buffalo River (with the exception of Smith Street project), and Niagara River sewersheds would primarily be implemented starting about halfway through the overall 20-year implementation, after evaluating the GI pilot project performance.

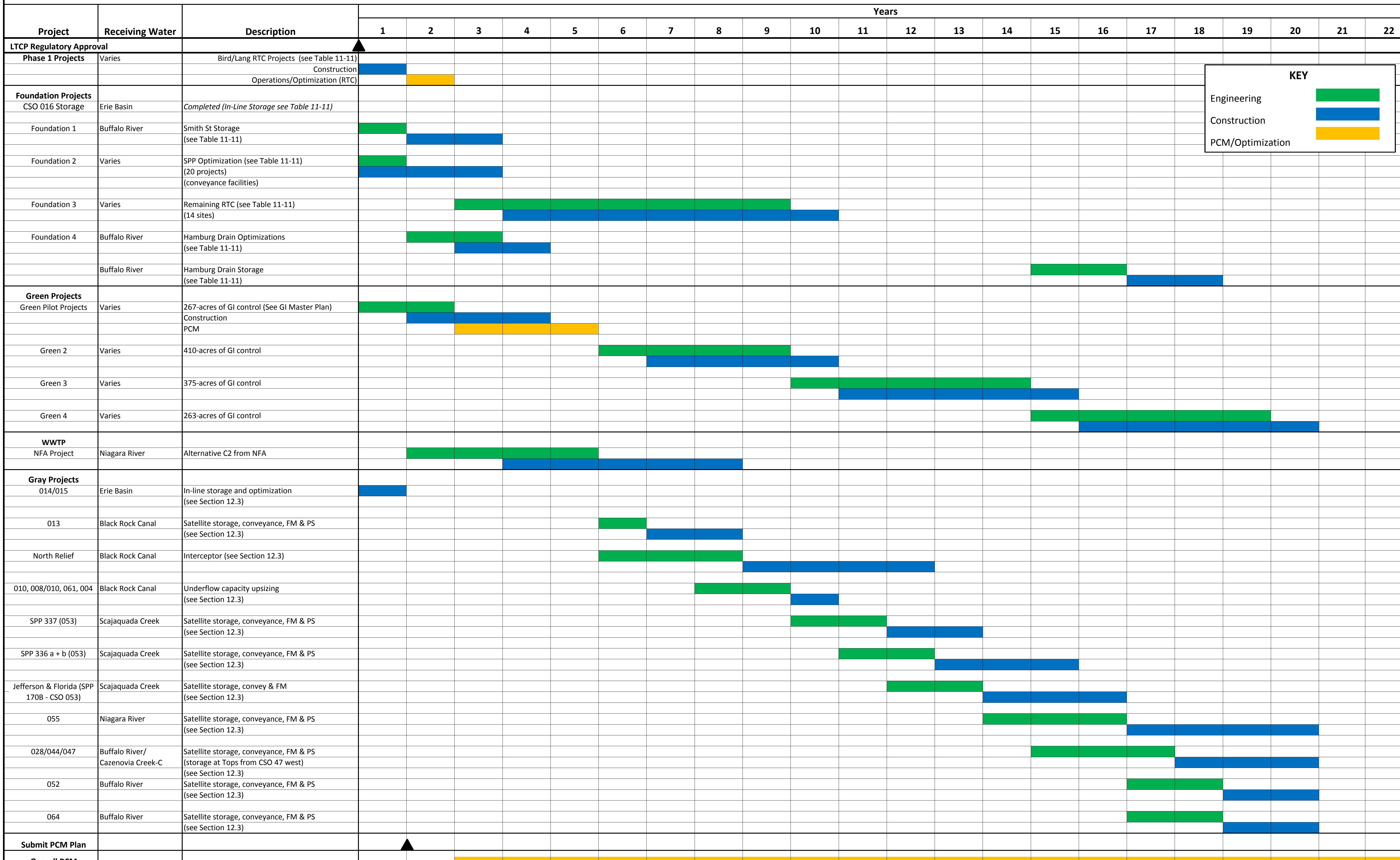
Most notably, the Recommended Plan has a significant (but reasonable and realistic) green component, with a plan to control a range of between 1,315 and 1,620 acres of impervious surface city-wide through the use of GI. These areas are distributed by receiving water body as previously shown in Table ES-2.

Because of the need for post-construction monitoring to evaluate the effectiveness of GI technologies, the minimum impervious surface control implementation is phased throughout the 20-years as follows:

- 267-acres controlled in Years 1-5 (20% of total GI, *i.e.*, 1,315-acres)
- 410-acres controlled in Years 6-10 (~30% of total GI)
- 375-acres controlled in Years 11-15 (~30% of total GI)
- 263-acres controlled in Years 16-19 (20% of total GI)

This scheduling allows for the upfront construction of gray infrastructure and technologies required to capture a significant amount of remaining wet weather flow in strategic areas and those that are relatively independent from the GI performance, while allowing the BSA adequate time to evaluate the effectiveness of the GI technologies implemented within the first five years. Consistent with the CSO Control Policy, the BSA will conduct post-construction monitoring (PCM) to verify the effectiveness of the CSO controls to meet the performance criteria specified in this LTCP. The PCM plan is due to the Agencies within one year from the approval of this LTCP. The performance feedback received from the GI projects during the post-construction monitoring, following the five-year initial period, is critical to the BSA's ability to right size the subsequent gray projects and more accurately determining the types of GI technologies to be used in

Figure ES-8: BSA CSO LTCP
Implementation Schedule - Recommended Plan



NOTE: The BSA reserves the right to substitute projects within the same general timeframe as the projects listed in the schedule, either by implementing a project of equal cost value or one that achieves the same benefit as the original project.

subsequent implementation periods, as well as to make adjustments to the amount of GI to be constructed. Should the PCM results for the program suggest that the predicted level of activation performance criteria are not being met or are being out performed, the BSA will propose alternative projects (green or gray) to achieve the predicted outfall frequency of activation. Depending on the specific project area, this may include adjustments to impervious surface acreage controlled by GI, rightsizing an already proposed gray project or designing an entirely new project. The BSA will use the PCM data collected, as well as the models to fine-tune the program to meet the frequency of activation performance criteria. This fine-tuning process will determine whether the facilities need to be smaller or larger than what is estimated in this Recommended Plan.

Financial Impacts

To further address the USEPA's AO requirements, the BSA has evaluated financial affordability and rate impacts. The BSA updated and replaced the Financial Capability Assessment (FCA) originally submitted as part of the 2004 LTCP. The updated FCA was prepared by CRA in 2010 (revised in 2011), in accordance with the USEPA's *Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development, 1997* (Financial Capability Guidance). While BSA agrees with the conclusion that BSA ratepayers will be heavily burdened to implement the Recommended Plan, the BSA does not fully agree with the Financial Capability Guidance, as it does not present a complete and accurate picture of Buffalo's financial condition and capability. BSA believes that additional factors should be considered which would reveal that implementing the Recommended Plan will be an even heavier burden than demonstrated through the factors in USEPA's financial capability guidance.

Many local factors, trends, and financial conditions are neither contemplated nor considered within the Guidance's approach. Thus, the affordability of the LTCP relative to the BSA and its ratepayers cannot be determined solely on the results of the methodology prescribed by the Guidance. The Financial Capability Guidance itself acknowledges that local factors should be considered. Consequently, the BSA must reserve its rights to include such local factors and considerations, and or/seek schedule relief consideration relative to the LTCP implementation schedule.

Even using the Financial Capability Guidance results in a finding that the BSA's ratepayers will be heavily burdened to implement the LTCP. For the vast majority of other CSO communities in the heavy burden category, the USEPA has allowed 18 years or more to implement their LTCPs (see consent decrees for DC (20 years), Indianapolis (20 years), Cincinnati, ALCOSAN, Elkhart (20-plus years), Evansville (20-plus years), Kansas City, MO (25 years), Memphis, to name just a few recent communities). Therefore, the BSA believes that the Agency approved 20-year implementation schedule is not only appropriate, but in line with other approved programs.

Conclusions

The BSA believes that the Recommended Plan selected following the 2004 LTCP development process coupled with this update fully meets the requirements of the USEPA's CSO Policy, the BSA's SPDES Permit, and the terms and conditions of the USEPA's AO. More importantly, it will provide the greatest water quality and community benefits, and can be implemented within the approved 20 year implementation schedule.

The BSA's Recommended Plan was selected based on the following key factors:

- ***Satisfying the requirements of the USEPA CSO Control Policy***. A major tenet of satisfying the USEPA's CSO Control Policy is that the implemented LTCP should not preclude the attainment of WQS for CSO receiving water bodies. The Recommended Plan follows the frequency of activation option within the "presumption approach" provided in the CSO Policy. In addition, compliance with WQS (the "demonstration" approach under the CSO Control Policy) is achieved in all CSO receiving water bodies. Notably, despite the extreme economic challenges in the Buffalo region, the LOC provided by the Recommended Plan is fully consistent with (or exceeds) many other approved CSO LTCPs for communities around the country.

- ***Considering the City of Buffalo's financial condition***. Implementation of the Recommended Plan will result in a "high" burden to the BSA's residential and business customers using any financial measure – whether the USEPA's Financial Capability Guidance or a number of common criteria which are used to compare the financial health of communities. Notably, the State of New York has created and imposed the Buffalo Fiscal Stability Authority (BFSA) to oversee the budgetary expenditures and contractual obligations of the City of Buffalo and has jurisdiction over the BSA. These burdens necessitate the 20-year implementation schedule.

- ***Pollutant mass loading from upstream sources***. The pollutant mass loadings to the CSO receiving water bodies from upstream of the point where the loadings pass through the City of Buffalo were found to be significantly higher than the pollutant mass loadings contributed by the BSA's CSOs. The Recommended Plan calls for the BSA to continue its impressive CSO control efforts to date culminating in the target frequency of activation in the typical year in all receiving water bodies, as presented in detail in Section 12. The Plan assumes that modest improvements will be made by upstream sources (see Baseline Scenarios above) that will then allow applicable WQS to be met. To the extent the NYSDEC and the USEPA do not effectively address upstream sources (including through the imposition of a Total Maximum Daily Load for bacteria for impaired waters in and around the City), then a use attainability analysis (UAA) will be warranted as specified in the CSO Control Policy, before any further CSO controls are required. The CSO Control Policy mandates that the NYSDEC is responsible for coordinating the evaluation of wet weather WQS with the development of the CSO LTCP.

- ***Watershed Approach***: Even complete removal of the CSOs within the BSA's control, without the abatement of upstream pollutant loading, will not achieve attainment of WQS in a number of the water bodies evaluated as part of this LTCP. Moreover, requiring CSO control beyond the Recommended Plan is unfair to the BSA's ratepayers when modest reductions in upstream source loadings will allow WQS to be achieved.

- ***Implementation Schedule:*** The BSA's Recommended Plan is dependent on a 20-year implementation schedule that results in a substantial reduction in activation frequencies, as well as a reduction in annual CSO volume and an extremely high model predicted wet weather system wide percent capture rate of over 97 percent. This Recommended Plan also has a large GI component, with a commitment to control a minimum of approximately 1,315 acres city-wide through the use of GI. The 20-year schedule is essential to allow for the upfront construction of gray technologies required to capture a significant amount of wet weather flow in strategic areas, particularly those that are relatively independent from the GI performance, while also allowing the BSA adequate time to evaluate the effectiveness of a range of GI technologies to be implemented within the first five to seven years of the program. The scope and performance of the GI will be established through post-construction monitoring and will assist the BSA in rightsizing subsequent gray projects, more accurately determining the optimum GI technologies to be used in subsequent implementation periods, as well as to make adjustments to the amount of GI constructed.

- ***Public/Stakeholder Input –*** The CSO Policy recognizes that CSO control is a community-specific undertaking and the Recommended Plan reflects this reality having benefited from the BSA's implementation of the approved Public Participation Plan as part of the development of this Recommended Plan. In addition to formal stakeholder input and public meetings, the BSA's officials have worked tirelessly to obtain informal input and advice for a wide range of ratepayers, stakeholders, and public officials. The final 30-day public comment period and public meetings following the April 2012 LTCP submission found the public to be supportive of the Recommended Plan and suggest that the public is particularly pleased with the green infrastructure components of the plan. The BSA is greatly appreciative of and indebted to the many stakeholders and members of the public who have lent their time and talent to the development of this critical program for our community.

Finally, one must not understate the significance of the BSA embarking on a $380 million capital program in terms of community affordability, allocation of scarce public financial resources, disruption of multi-year capital improvement programs, and other impacts. The BSA calls on the Federal and State government to do their part by providing some grant (or grant-equivalent) funding toward the BSA's implementation of the Recommended Plan – an unfunded Federal and State mandate. This funding support can readily come from the State Revolving Fund program or federal grant funding. BSA is committed to seeking such funding to help minimize financial burdens on BSA's ratepayers.

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Exhibit ES-1

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

MAR - 9 2012

CERTIFIED MAIL – RETURN RECEIPT REQUESTED
Article Number: 7005 3110 0000 5954 7441

David Comerford, General Manager
Buffalo Sewer Authority
1038 City Hall
Buffalo, New York 14202-3310

Re: **Buffalo Sewer Authority**
Administrative Order
Docket No. CWA-02-2012-3024
NPDES Tracking No. NY0028410

Dear Mr. Comerford:

The United States Environmental Protection Agency ("EPA"), Region 2, has made a finding that the Buffalo Sewer Authority ("BSA") located in Buffalo, New York is in violation of the Clean Water Act (33 U.S.C. § 1251 et seq) ("CWA" or "the Act") for violating the New York State Department of Environmental Conservation ("NYSDEC") State Pollution Discharge Elimination System ("SPDES") Permit number NY0028410. Enclosed are two (2) originals of ORDER CWA-02-2012-3024 issued pursuant to Section 309 of the Act, which detail the findings.

Please acknowledge receipt of this ORDER on one of the originals, and return by mail in the enclosed envelope. Failure to comply with the enclosed ORDER may subject the facility to civil/criminal penalties pursuant to Section 309 of the Act. Failure to comply with this ORDER shall also subject the facility to ineligibility for participation in work associated with Federal contracts, grants or loans.

This ORDER may be superseded by a Consent Decree addressing this violation, executed by the United States of America, State of New York and Buffalo Sewer Authority and entered in the United States District Court for the Western District of New York.

If you have any questions regarding the Administrative Order please contact Doughlas McKenna, Chief, Water Compliance Branch, at (212) 637-4244.

Sincerely,

Dore LaPosta, Director
Division of Enforcement and Compliance Assistance

Enclosures

cc: Joe DiMura, NYSDEC w/enclosures

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION 2

IN THE MATTER OF: Buffalo Sewer Authority 1038 City Hall Buffalo, New York 14202-3310 **SPDES Permit No. NY0028410** **Respondent** Administrative Order for Compliance pursuant to Sections 308(a) and 309(a) of the Clean Water Act, 33 U.S.C. §§ 1318(a) and 1319(a).

ADMINISTRATIVE ORDER

CWA-02-2012-3024

STATUTORY AUTHORITY

The following Findings of Violation and Order for Compliance ("Order") are made and issued pursuant to Sections 308(a) and 309(a) of the Clean Water Act ("CWA"), 33 U.S.C. §§ 1318(a) and 1319(a). This Authority has been delegated by the Administrator of the United States Environmental Protection Agency ("EPA") to the Regional Administrator, EPA Region 2 and further delegated to the Director of the Division of Enforcement and Compliance Assistance, Region 2, EPA.

1. Section 301(a) of the CWA, 33 U.S.C. § 1311 (a), makes it unlawful for any person to discharge any pollutant from a point source to waters of the United States, except, inter alia, with the authorization of, and in compliance with, a National Pollutant Discharge Elimination System ("NPDES") permit issued pursuant to Section 402 of the CWA, 33 U.S.C. § 1342.

2. Section 402 of the CWA, 33 U.S.C. § 1342, authorizes the Administrator of EPA to issue a NPDES permit for the discharge of any pollutant, or combination of pollutants subject to certain requirements of the CWA and conditions which the Administrator determines are necessary. The New York State Department of Environmental Conservation ("NYSDEC") is the agency with the authority to administer the federal NPDES program in New York pursuant to Section 402 of the CWA, 33 U.S.C. § 1342. EPA maintains concurrent enforcement authority with authorized states for violations of the CWA. Additionally, under the authority granted to the NYSDEC by the EPA under Section 402(b) of the CWA, 33 U.S.C. § 1342(b), a State Pollutant Discharge Elimination System ("SPDES") permit is required to be issued to facilities by the NYSDEC for the discharge of pollutants from said facilities from a point source to a navigable water of the United States.

3. Section 308 of the Act, 33 U.S.C. § 1318, provides, in relevant part, that the Administrator of EPA may require the owner or operator of any point source to, among other things: establish and maintain such records; make such reports; install, use and monitor such equipment; sample

such effluents; and provide such other information as may reasonably be required in order to carry out Section 402 of the Act, 33 U.S.C. § 1342.

4. "Person" is defined by Section 502(5) of the CWA, 33 U.S.C. § 1362(5), to include an individual, corporation, partnership, association or municipality.

5. "Municipality" is defined by Section 502(4) of the CWA, 33 U.S.C. § 1362(4), to include among other things, a city, town, borough, county, parish, district, associations, or other public body created by or pursuant to State law and having jurisdiction over disposal of sewage, industrial wastes, or other wastes.

6. "Pollutant" is defined by Section 502(6) of the CWA, 33 U.S.C. § 1362(6), to include among other things, solid waste, dredged spoil, rock, sand, cellar dirt, sewage, sewage sludge and industrial, municipal and agricultural waste discharged into water.

7. "Point source" is defined by Section 502(14) of the CWA, 33 U.S.C. § 1362(14), to include any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

8. "Navigable waters" is defined by Section 502(7) of the CWA, 33 U.S.C. § 1362(7), to include the waters of the United States.

9. "Discharge of a pollutant" is defined by Section 502(12) of the CWA, 33 U.S.C. § 1362(12), to include any addition of any pollutant to navigable waters from any point source.

10. Section 402(q) of the CWA, 33 U.S.C. § 1342(q), provides that each permit, order, or decree issued pursuant to the chapter after December 21, 2000, for a discharge from a municipal combined storm and sanitary sewer shall conform to the Combined Sewer Overflow Policy ("CSO Policy") signed by the Administrator on April 11, 1994.

11. The CSO Policy states that "permittees with CSOs are responsible for developing and implementing long-term CSO control plans that will ultimately result in compliance with the requirements of the CWA."

12. Section 309(a) of the CWA, 33 U.S.C. § 1319(a), authorizes the Administrator to issue an order requiring compliance or commence a civil action when any person is found to be in violation of Section 301 of the CWA, 33 U.S.C. § 1311, or in violation of any permit condition or limitation in a permit issued under Section 402 of the CWA, 33 U.S.C. § 1342.

FINDINGS OF FACT AND FINDINGS OF VIOLATION

1. The Buffalo Sewer Authority ("BSA" or "Respondent"), is a public benefit municipal corporation, organized and existing under the laws of the State of New York, and located in Buffalo, New York. BSA has authority, control over and operates the sewer system within its boundaries, including, but not limited to the combined sewer system, the sanitary sewer system, and the related wastewater treatment plant.

2. BSA is a "person" and "municipality" within the meaning of Sections 502(5) and 502(4) of the CWA, 33 U.S.C. §§ 1362(5) and 1362(4).

3. BSA has discharged and continues to discharge "pollutants" within the meaning of Sections 502(6) and 502(12) of the CWA, 33 U.S.C. §§ 1362(6) and 1362(12), from the Buffalo wastewater treatment plant and sewer system through "point sources" within the meaning of Section 502(14) of the CWA, 33 U.S.C. § 1362(14) into the Niagara River, Black Rock Canal, Erie Basin, Buffalo River, Scajaquada Creek, Cazenovia Creek, and Cornelius Creek, each of which is a "navigable water" within the meaning of Section 502(7) of the CWA, 33 U.S.C. § 1362(7).

4. The NYSDEC, under the authority of Section 402(b) of the CWA, 33 U.S.C. § 1342(b), issued SPDES Permit No. NY0028410 (the "SPDES Permit") to BSA, with an effective date of July 1, 1999. The NYSDEC renewed the SPDES permit on February 3, 2004 and again on June 25, 2009. It is scheduled to expire on June 30, 2014. The SPDES Permit authorizes BSA to discharge pollutants from a single wastewater treatment plant outfall and fifty-eight (58) combined sewer overflow structures ("CSO structures") at locations specified in the SPDES Permit, subject to certain limitations and conditions.

5. The Schedule of Compliance in the July 1, 1999 SPDES Permit provided in pertinent part as follows:

"Development of Abatement Plan for Combined Sewer Overflow

The permittee shall develop a combined sewer overflow abatement facility plan in accordance with the Phase I Long Term CSO Control Plan requirements specified in the USEPA Combined Sewer Overflow Policy (Federal Register Vo. 59, No. 75 4/19/94).

This Abatement Plan shall contain all of the Long Term Plan elements specified in Section II C of the National CSO Policy, and further delineated in the USEPA document, "Combined Sewer Overflows, Guidance for Long-Term Control Plan" dated September, 1995. The permittee may choose either the "Presumption" or the "Demonstration" approach for the evaluation of alternatives.

The Abatement Plan should integrate the pollutant reduction achievable by the implementation of the CSO Best Management Practices (BMPs) as required on pages 19-21 of this permit into the long term control plan. The Department will consider work or studies already completed or currently in progress for integration into the long term control plan.

The permittee shall submit a completed CSO Abatement Facility Plan including a schedule of implementation to the Department.

The permittee shall report to the NYSDEC progress/status of plan development in intervals not to exceed 90 days.

Upon approval of the CSO Abatement Facility Plan, the NYSDEC will propose a SPDES permit modification, pursuant to Uniform Procedures – 6 NYCRR – Part 621, to include the schedule of implementation."

6. The SPDES Permit was modified October 2, 2001 to, among other changes, modify the deadline for submittal of a CSO Abatement Plan (hereinafter either "Abatement Plan," "combined sewer overflow abatement facility plan," "Long-Term Control Plan," "LTCP" or "updated LTCP") from July 1, 2001 to July 1, 2002. On August 29, 2002, the CSO Abatement Plan deadline was amended, by permit modification, again to July 1, 2003. On January 12, 2004, the CSO Abatement Plan deadline was again amended, by permit modification, to February 1, 2004.

7. BSA failed to submit the required Abatement Plan by February 1, 2004. BSA did not submit an Abatement plan until July 14, 2004, 164 days late.

8. BSA's failure to timely submit the required Abatement Plan is a violation of the SPDES Permit and is, therefore, a violation of Section 301 of the CWA, 33 U.S.C. § 1311.

9. Under a cover letter dated April 20, 2006, the NYSDEC notified the BSA that the Abatement Plan submitted by BSA on July 14, 2004 was not acceptable in that it would not meet the water quality objectives of the CSO Control Policy and had therefore failed to satisfy the SPDES Permit requirements of a combined sewer overflow abatement facility plan, as described in paragraph 5 above. This NYSDEC cover letter required that BSA revise its LTCP accordingly and submit it to the NYSDEC by July 31, 2006. BSA failed to submit such a revised LTCP to the NYSDEC by July 31, 2006.

10. Accordingly, EPA, NYSDEC, the U. S. Department of Justice ("USDOJ"), and the New York State Office of Attorney General commenced discussions with BSA to settle the violation. The settlement was to be embodied in a Consent Decree, under the auspices of federal court, for the development and implementation of a LTCP.

11. Since those discussions were on-going when the SPDES Permit was renewed in 2009, Section VIII was included, entitled "CSO LONG-TERM CONTROL PLAN," which states the following:

"BSA submitted a CSO Long-Term Control Plan (LTCP) in July 2004 in accordance with the requirements of their SPDES permit. Currently, the USEPA, USDOJ, NYSDEC and the permittee are engaged in negotiations concerning the LTCP, and anticipate that these negotiations will result in the entry of a Consent Decree. The Consent Decree will govern the permittee's obligations in ensuring that the WWTF and the combined sewer overflow discharges comply with the requirements of the Clean Water Act and the 1994 CSO Control Policy. This permit may be modified upon the ratification of the Consent Decree in accordance with 6 NYCRR Part 621."

12. To date, however, the parties have not reached a settlement nor entered into a Consent Decree.

13. To date, BSA has still not submitted an approvable Abatement Plan that satisfies the SPDES Permit requirements of a combined sewer abatement facility plan, as described in paragraph 5 above.

ORDERED PROVISIONS

Based on the Findings of Fact and Findings of Violation set forth above, and pursuant to the authority of Sections 308(a) and 309(a) of the CWA, 33 U.S.C. §§ 1318(a) and 1319(a), and in accordance with Section 402(q) of the CWA, 33 U.S.C. § 1342 (q), it is hereby ORDERED that:

1. Immediately upon receipt of the original copies of this Order, a responsible official of BSA shall complete and sign the acknowledgment of receipt of one of the originals of the Order and return said original to the Chief, Compliance Section, Water Compliance Branch, Division of Enforcement and Compliance Assistance, in the enclosed envelope to the address listed below.

2. Development of Updated Long Term Control Plan: BSA shall revise and implement an approved Updated LTCP consistent with the requirements of the CSO Policy and applicable State law and regulation. The Updated LTCP shall provide for the construction and implementation of all wastewater treatment plant ("WWTP") and sewer system improvements and other measures necessary to ensure that: (i) CSO discharges from all CSO discharge outfalls comply with the technology-based and water quality-based requirements of the CWA, the CSO Control Policy and state law and regulation; and (ii) bypasses at the WWTP are in compliance with the bypass conditions in 40 C.F.R. § 122.41(m), 327 IAC 5- 2-8(11), and shall demonstrate that there are no feasible alternatives to the remaining bypasses, in accordance with Section II.C.7 of the CSO Control Policy.

   a. By no later than April 30, 2012, BSA shall submit to EPA and NYSDEC an Updated LTCP. The schedule included in the Updated LTCP shall require the design, construction, and implementation of all control/treatment measures selected by BSA as expeditiously as practicable, following any applicable environmental impact assessment review pursuant to the New York State Environmental Quality Review Act ("SEQR review"), but in any event by no later than December 31, 2027.

   b. The Updated LTCP shall include, at a minimum:
      i. An update of the system characterization information, receiving water characterization information, existing conditions information, CSO control objectives, and any other information presented in the 2004 LTCP that is no longer current;
      ii. BSA's previous screening and subsequent evaluation of individual CSO control technologies and site-specific CSO controls. The Updated LTCP shall: (1) reassess the results of that original evaluation in light of the applicability of recreation-protective bacteria standards in BSA's receiving waters; (2) include, as appropriate, new technologies and controls (such as green infrastructure ("GI") and bio-ballasted flocculation treatment) not considered in the 2004 LTCP; and (3) in particular, carry out a new evaluation of a range of updated system-wide alternatives. Together, BSA's prior and updated system-wide alternatives evaluation shall include a sufficiently wide range of alternatives for eliminating, reducing, or treating CSO discharges, and for eliminating or reducing bypass discharges (except as permitted in the bypass conditions in 40 C.F.R. § 122.41(m) and 327 IAC 5-2-8(11)). The updated evaluation shall consider the costs and effectiveness (in terms of reduction in number of overflow events, overflow volume reduction, pollutant loading reductions, water

quality improvements, etc.) predicted to result from implementation of each of the updated system-wide alternatives.

iii. In evaluating the relative performance of the updated system-wide alternatives and in selecting a preferred alternative, BSA shall give the highest priority to controlling overflows to sensitive areas as required under the CSO Control Policy, at section II.C.3.

iv. BSA's Updated LTCP shall include past and current alternative evaluation efforts that together include at a minimum: (1) taking no-action; (2) complete sewer separation (3) partial separation of various portions of the combined sewer system; (4) installation of various sizes of storage or equalization basins at the Buffalo Sewer Authority WWTP and/or in the sewer system; (5) construction of new secondary or advanced wastewater treatment plants; (6) construction of increased treatment capacities at the existing facilities; (7) construction of additional facilities (such as high rate treatment or ballasted flocculation facilities or its equivalent) for providing primary treatment or better than primary treatment of discharges from CSO discharge outfall structures; (8) construction of new intercepting sewers from the sewer system to the facilities; (9) construction of facilities for providing disinfection (and dechlorination, if necessary) of CSO discharges; (10) construction of facilities for removing floatables from CSO discharges; (11) construction of relief sewers; (12) relocation of CSO discharge outfall structures; (13) implementation of pretreatment measures to reduce flows and/or pollutants discharged into the sewer system from industrial users; (14) consideration of the use of GI where feasible, and (15) construction and/or implementation of combinations of these alternatives. These evaluations shall be carried out in accordance with Chapter 3 of EPA's "Combined Sewer Overflows Guidance for Long-Term Control Plan."

v. The Updated LTCP shall describe BSA's prior technology screening assessments and shall include, at a minimum, BSA's evaluation of the technical feasibility and applicability of each alternative or combination of alternatives at each CSO discharge outfall or grouping of CSO discharge outfalls. Where necessary, BSA shall update said assessments in light of the applicability of recreation-protective bacteria standards in BSA's receiving waters.

vi. BSA's updated evaluation of system-wide alternatives shall include:

1. An evaluation of a range of "sizes" of each updated system-wide alternative that will, for the typical year achieve an average volume of wet weather percent capture from 75 to 100 percent and reduce the average number of untreated CSO Discharge events to 0, 1-3, 4-7 and 8-12 per year. The updated LTCP shall include a detailed description of the 12 month rainfall record that BSA has utilized in developing its Updated LTCP, and that BSA will utilize in implementing its Post Construction Monitoring Program. The Updated LTCP shall describe in detail BSA's analysis of its available long term rainfall record, its basis for selecting its "typical year," and, in the event that BSA selects a "modified year" as its "typical year," shall discuss in detail all modifications made to the actual rainfall record to arrive at the "modified" rainfall record. The updated LTCP shall include a detailed tabular summary of the "modified" rainfall record, such that it is clear exactly what rainfall record shall be used in implementing the PCMP;

2. A determination of the estimated "project costs," as that term is described on pages 3-49 through 3-51 of the EPA's "Combined Sewer Overflows Guidance for Long-Term Control Plan," for each size of each updated system-wide alternative. The determination of the estimated "project costs" shall include: (a) "capital costs," "annual operation and maintenance costs," and "life cycle costs," as those terms are described on pages 3-49 through 3-51 of EPA's "Combined Sewer Overflows Guidance for Long-Term Control Plan;" and (b) an itemization of the "capital costs" and "annual operation and maintenance costs" used to determine the total "project costs" for each separate component of each alternative or combination of alternatives; and

3. An evaluation, using a validated collection system model, of the expected reduction in number of CSO events, CSO discharge volume and pollutant discharge quantity from each CSO discharge point for each size of each updated system-wide alternative. The evaluation shall include, at a minimum, an analysis of the improvement in every pollutant of concern, which are: fecal coliform in all receiving waters, and DO/BOD/SOD in the Buffalo River, Scajaquada Creek, and the Black Rock Canal.

vii. For each system-wide alternative, BSA's assessment shall include an evaluation, using water quality models, of the expected water quality improvements in the receiving waters that will result from implementation of each updated system-wide alternative. The evaluation shall include, at a minimum, an analysis of the improvement in every pollutant of concern in that receiving water.

viii. For each updated system-wide alternative, BSA shall include a cost-performance analysis, such as a "knee of the curve" analysis, for each alternative or combination of alternatives that will allow for the comparison of the costs to: (1) the associated expected water quality improvements; (2) the reduction of CSO discharge and bypass discharge volume; (3) the reduction in CSO discharge and bypass discharge events; (4) the increase in percent wet weather capture; and/or (5) the reduction in pollutant loading from CSO discharge and bypass discharge events.

ix. The Updated LTCP shall include a financial capability analysis that complies with USEPA's "Combined Sewer Overflows – Guidance for Financial Capability Analysis and Schedule Development" February 1997).

x. The Updated LTCP shall include the selection of CSO control measures, including the construction of all sewer system and facility improvements necessary to ensure compliance with the technology-based and water quality-based requirements of the CWA, state law and regulation and BSA's SPDES permit. The Updated LTCP shall include the selection of bypass discharge control measures, so as to ensure that all remaining bypasses are in compliance with the bypass conditions in 40 C.F.R. § 122.41(m), 327 IAC 5- 2-8(11), and shall demonstrate that there are no feasible alternatives to the remaining bypasses, in accordance with Section II.C.7 of the CSO Control Policy.

xi. The Updated LTCP shall include an expeditious schedule for the design, construction, and implementation of all CSO control measures selected by BSA. If it is not possible for BSA to design and construct all measures simultaneously, the Updated LTCP shall include a phased schedule based on the relative importance of each measure, with highest priority being given to eliminating discharges to sensitive areas and to those projects which most reduce the discharge of pollutants. The schedule shall specify critical construction milestones for each specific measure, including, at a minimum, dates for: (1) submission of applications for all permits required by law; (2) start of design; (3) commencement of construction; (4) completion of construction; (5) completion of construction; and (6) achievement of full operation.

c. The alternatives evaluated should include the use of GI wherever feasible to reduce CSO volumes and handle separated storm water. GI shall generally mean systems and practices that use or mimic natural processes to infiltrate, evapotranspire, and/or harvest storm water on or near the site where it is generated. GI applications and approaches that may be considered include, but are not limited to, green roofs, downspout disconnection, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, permeable pavements, reforestation, and protection and enhancement of riparian buffers and floodplains. EPA and NYSDEC encourage BSA to utilize GI projects as appropriate to reduce or replace gray infrastructure projects included in the Updated LTCP provided that any GI project proposed is anticipated to provide substantially the same or greater level of control as the alternative gray infrastructure project. Should BSA rely on other entities to implement GI projects, BSA must have in place agreements as appropriate, to ensure proper operation and maintenance of the GI project. For any GI project submitted as part of the Updated LTCP, BSA shall submit to EPA and NYSDEC a detailed GI project proposal outlining each proposed project.

i. The GI project proposal shall be consistent with this Administrative Order and shall at a minimum include the following for each project:

1. Data on location, sizing, design, and the performance criteria expected to be achieved with the implementation of the GI project, utilizing the information and models that BSA used in developing the Updated LTCP, and any monitoring information used in formulating the proposal; along with a demonstration of the long term effectiveness and performance expected to be achieved with implementation of the project;
2. A description of the work required to implement the GI project and a schedule for completion of this work and implementation of the project that is consistent with this Administrative Order and the date set forth herein in Paragraph 2(a) for completion of construction and full implementation of all remedial and control measures;
3. A description of the proposed ownership of and access to the GI project, and should BSA rely on other entities to implement the GI project, BSA must explain what agreements will be necessary to ensure proper operation and maintenance of the GI project (i.e., permanent access, sufficient control over key aspects of the project), and how they will be enforced to ensure proper operation and maintenance of the GI project; and
4. A description of any post-construction monitoring and modeling to be performed that is necessary to determine whether the performance criteria set forth, as noted above, will be met upon completion and implementation of the GI project.

ii. Upon review of BSA's GI project proposal, EPA and NYSDEC will comment, approve, disapprove, or approve in part, the proposal:

1. BSA shall implement each GI project approved by EPA and NYDEC in accordance with the provisions and schedule in the approved proposal;
2. If the GI project proposal is approved in part, BSA shall, upon written direction from EPA and NYSDEC, take all actions in the approved portion of the GI proposal that EPA and NYSDEC determine are technically severable from any disapproved portions. For the disapproved portions, BSA shall, within 90 Days, correct all deficiencies and resubmit the proposal for approval. If the resubmission is approved in whole or in part, BSA shall proceed in accordance with this subparagraph; or
3. If the GI project proposal is disapproved, EPA and NYSDEC's decision is final. For each project which is disapproved, BSA shall propose an alternative GI project or gray infrastructure project, or combined green and gray infrastructure project, within 90 days of the date of disapproval. In the event that BSA's alternative proposal is disapproved by EPA and NYSDEC due to the GI project component of the proposal, BSA shall propose an alternative gray infrastructure project within 90 days of the date of disapproval.

iii. In the event that BSA implements an approved GI project proposal that fails to meet the specified performance criteria set forth in the project proposal and Updated LTCP, BSA shall propose, within 180 days after submittal of the applicable post-construction monitoring report documenting said failure, an additional green or gray infrastructure project designed to achieve the performance criteria with a schedule for completion of this work and implementation of the project that is consistent with this Administrative Order and the date set forth herein in Paragraph 2(a) for completion of construction and full implementation of all remedial and control measures. In the alternative, where BSA has substantially met the performance criteria, BSA may, within sixty (60) days after its knowledge of a project's failure to meet the performance criteria, petition EPA and NYSDEC for a change in the performance criteria. After consideration of any such request by BSA, EPA and NYSDEC's decision will be final. In the event that EPA and NYSDEC disapprove of BSA's request for a change in the performance criteria, BSA shall, within 180 days after EPA and NYSDEC's disapproval, propose additional control measures designed to achieve the performance criteria with a schedule for completion of this work and implementation of the Project that is consistent with this Administrative Order and the date set forth herein in Paragraph 2(a) for completion of construction and full implementation of all remedial and control measures.

iv. BSA shall submit to EPA an update on its implementation of GI projects as part of the semi-annual reports due on March 1st and September 1st of each year.

d. If BSA seeks to replace any gray infrastructure projects provided in the Updated LTCP, BSA shall submit to EPA and NYSDEC a detailed GI project proposal outlining each proposed project consistent with the requirements of Paragraph 2(c).

e. EPA and NYSDEC may approve the Updated LTCP or decline to approve it and provide written comments. Within 120 days of receiving EPA's and NYSDEC's written comments, BSA shall modify the Updated LTCP consistent with EPA's and

NYSDEC's written comments, and resubmit the Updated LTCP to EPA and NYSDEC for final approval.

f. Upon receipt of EPA's and NYSDEC's final approval of the Updated LTCP, BSA shall implement the measures in Updated LTCP in accordance with the schedule in the Plan.

3. <u>Post Construction Monitoring Plan</u>: Within one year of approval of the Updated LTCP, BSA shall submit to EPA and NYSDEC for approval, a work plan for conducting an ongoing study or series of studies ("Post-Construction Monitoring Plan") to help determine: (1) whether the Updated LTCP measures, when completed, meet all performance criteria specified in the Updated LTCP; (2) whether BSA's CSOs comply with the technology-based and water quality-based requirements of the CWA, state law, the CSO Control Policy, all applicable federal and state regulations, and its SPDES Permit, for all CSO-receiving waters; and (3) whether all remaining bypasses are in compliance with the bypass conditions in 40 C.F.R. § 122.41(m), 327 IAC 5- 2-8(11), and demonstrate that there are no feasible alternatives to the remaining bypasses, in accordance with Section II.C.7 of the CSO Control Policy. The Post-Construction Monitoring Plan shall be consistent with the guidance "Combined Sewer Overflows Guidance for Long-Term Control Plan."

a. The Post-Construction Monitoring Plan shall contain a schedule for performance of the study or series of studies at key points during the course of the implementation of the remedial measures, as well as after completion of the remedial measures, specified in the Updated LTCP. The Post-Construction Monitoring Plan also shall indicate the years (at least biannually) in which data generated during implementation of the Post-Construction Monitoring Plan will be submitted in the reports in Paragraph 4 to EPA and NYSDEC.

b. EPA and NYSDEC may approve the Post-Construction Monitoring Plan or may decline to approve it and provide written comments. Within ninety (90) days of receiving EPA's and NYSDEC's comments, BSA shall alter the Post-Construction Monitoring Plan consistent with EPA's and NYSDEC's comments, and resubmit the Plan to EPA and NYSDEC for final approval.

c. Upon final approval of the Post Construction Monitoring Plan, BSA shall implement, in accordance with the schedule therein, the Post-Construction Monitoring Plan. If the results of the Post-Construction Monitoring Plan indicate areas of non-compliance, BSA shall, within 120 days, (unless a different period is specified) of being requested in writing to do so, submit to EPA and NYSDEC a Supplemental Compliance Plan which includes the actions that BSA will take to achieve compliance and a schedule for taking such actions. Upon approval by the EPA and NYSDEC, BSA shall implement the Supplemental Compliance Plan, in accordance with the schedule specified in the approved Plan.

d. Within one hundred twenty (120) days after completion and implementation of the Post-Construction Monitoring Plan, BSA shall submit a Final Post-Construction-Monitoring Report to EPA and NYSDEC, for review, comment and approval, that:

   i. demonstrates that BSA performed the Post-Construction Monitoring Plan in accordance with the approved Plan and schedule set forth in the approved Post-Construction Monitoring Plan; and

ii. summarizes the data collected during Post-Construction Monitoring and analyzes whether the completed control measures have met and/or are meeting the performance criteria specified in the Updated LTCP; whether BSA's CSOs comply with the requirements of the CWA, state law, the CSO Control Policy, all applicable federal and state regulations, and BSA's SPDES Permits; and whether all remaining bypasses are in compliance with the bypass conditions in 40 C.F.R. § 122.41(m), 327 IAC 5- 2-8(11), and demonstrate that there are no feasible alternatives to the remaining bypasses, in accordance with Section II.C.7 of the CSO Control Policy.

e. EPA and NYSDEC may approve the Final Post-Construction Monitoring Report or may decline to approve it and provide written comments. Within sixty (60) days of receiving EPA's and NYSDEC's comments, BSA shall alter the Final Post-Construction Monitoring Report consistent with EPA's and NYSDEC's comments, and resubmit the Report to EPA and NYSDEC for final approval. Approval of the Final Post-Construction Monitoring Report only constitutes EPA's and NYSDEC's approval that the report contains the information required by this Administrative Order; it does not mean that EPA and NYSDEC believe BSA has complied with any other requirement of this Administrative Order or federal or state law.

4. Reporting Requirements

a. Semi-Annual Status Reports. Upon the effective date of this Administrative Order, until EPA and NYSDEC's approval of the Final Post-Construction-Monitoring Report, BSA shall submit written Semi-Annual Status Reports to EPA and NYSDEC. These reports shall be submitted by no later than March 1st of each year (for the "reporting period" from July 1 through December 31 of the previous calendar year) and September 1st of each year (for the "reporting period" from January 1 through June 30 of the current calendar year). The Semi-Annual Status Reports may be provided either as paper documents or in electronic format, provided that the electronic format is compatible with EPA and NYSDEC software and is accompanied by a written certification on paper in accordance with Paragraph 4(d). The written certification must be sent via certified or overnight mail. The frequency of reports, and the reporting period, may be amended upon written agreement from EPA and NYSDEC. In each written Semi-Annual Status Report, BSA shall provide, at a minimum, the following:

i. a statement setting forth (1) the deadlines and other terms that BSA has been required to meet since the date of the last statement; (2) whether and to what extent BSA has met those requirements; and (3) the reasons for any noncompliance (notification to EPA and NYSDEC of any anticipated delay shall not, by itself, excuse the delay);

ii. (1) a general description of the work completed within the prior reporting period; (2) to the extent known, a statement as to whether the work completed in that period meets applicable design criteria; (3) a projection of work to be performed during the next six-month period; (4) notification of any anticipated delays for the upcoming six month period of time; and (5) any changes in key personnel.

iii. If any public meetings were held, the report should include a copy of any advertisements placed for the meeting, any materials or handouts, formal meeting notes, and a summary of the meeting.

iv. BSA shall also submit, with each written status report, copies (to EPA only) of all monthly monitoring reports or other reports pertaining to CSOs and bypasses that BSA submitted to NYSDEC during the reporting period.

b. Semi-Annual Status Meetings. Representatives of EPA, NYSDEC and BSA shall conduct semi-annual meetings to discuss BSA's compliance status with the provisions of this Order. These meetings shall be scheduled during the months of March or April to discuss the previous reporting period, and September or October to discuss the previous reporting period. The meetings can be conducted telephonically if agreed in writing (including electronic correspondence) by all parties in advance. The frequency of such compliance meetings may be reduced upon written agreement (including electronic correspondence) from EPA and NYSDEC.

c. Annual Post Construction Monitoring Report. Upon the effective date of this Administrative Order, until EPA and NYSDEC's approval of the Final Post-Construction-Monitoring Report, BSA shall submit annually with its September 1st Semi-Annual Reports, an Annual Post Construction Monitoring Report containing information generated in accordance with the Post-Construction Monitoring Plan. The Annual Post Construction Monitoring report may be provided either as paper documents or in electronic format, provided that the electronic format is compatible with EPA and NYSDEC software and is accompanied by a written certification on paper in accordance with Paragraph 4(d). The written certification must be sent via certified or overnight mail. The frequency of reports, and the reporting period, may be amended upon written agreement from EPA and NYSDEC.

d. Permits or Approvals. When it is necessary for BSA to obtain a federal, state, or local permit or approval or perform SEQR review, BSA shall submit timely and complete applications, or timely perform the SEQR review, and take all other actions necessary to obtain all such permits or approvals or to ensure compliance with SEQR.

e. Certification. Each report, notice or submission made by BSA under this Administrative Order shall be signed by an official of BSA and include the following certification:

> "I certify under penalty of law that I have examined and am familiar with the information submitted in this document and all attachments and that this document and its attachments were prepared under my direction or supervision in a manner designed to ensure that qualified and knowledgeable personnel properly gather and present the information contained therein. I further certify, based on my inquiry of those individuals immediately responsible for obtaining the information, that I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment."

5. All notifications, reports, submissions and communications required by this Order shall be sent by certified mail or its equivalent to the following addresses:

Doughlas McKenna, Chief
Water Compliance Branch
Division of Enforcement and Compliance Assistance
United States Environmental Protection Agency, Region 2
290 Broadway, 20th Floor
New York, New York 10007-1866

Joseph DiMura, P.E.
Director, Bureau of Water Compliance Programs
Division of Water
New York State Department of Environmental Conservation
625 Broadway
Albany, New York 12233-3506

Regional Water Engineer
New York State Department of Environmental Conservation
Region 9
270 Michigan Avenue
Buffalo, New York 14203-2915

GENERAL PROVISIONS

Compliance with the terms of this Order shall not relieve BSA of liability for, or preclude EPA from, initiating an administrative or judicial enforcement action to recover penalties for any violations of the CWA, or to seek additional injunctive relief, pursuant to Section 309 of the CWA, 33 U.S.C. § 1319. Issuance of an Administrative Order shall not be deemed an election by EPA to forego any civil or criminal actions which would seek penalties, fines, or other appropriate relief under the CWA. The approved Updated LTCP, and all reports submitted pursuant to this Administrative Order, shall be incorporated into and made an enforceable part of this Administrative Order.

EFFECTIVE DATE

In order to provide Respondent adequate time to confer with EPA concerning this violation, this Order shall become effective thirty (30) days from the date of execution by the Director, Division of Environmental Planning and Protection, of EPA, Region 2.

Dated: 3/9/12 Signed: D LaPosta

Dore LaPosta, Director
Division of Enforcement and Compliance Assistance

Exhibit ES-2

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AQUALAW
WATER AND WASTEWATER SOLUTIONS

F. PAUL CALAMITA
PAUL@AQUALAW.COM

PH: 804.716.9021
FX: 804.716.9022

March 28, 2012

By First Class and Electronic Mail

Kim M. Kramer
Assistant Regional Counsel
United States Environmental Protection Agency
Region 2
290 Broadway - 16th Fl.
New York, NY 10007-1866

RE: Administrative Order to Buffalo Sewer Authority Regarding Updated CSO LTCP Submittal (Subject to FRE section 408)

Dear Ms. Kramer:

As we discussed March 23, 2012, I am writing to seek clarification and revision of two key requirements and related issues presented by the Unilateral EPA Administrative Order (Order), which the Buffalo Sewer Authority (BSA) received on March 15, 2012.

To recap our discussion, it is BSA's intention to try to meet the April 30, 2012 deadline in the Order for the submittal of the Updated CSO LTCP. However, we will have to initiate the 30-day public comment period on the recommended plan at the same time as submittal. Thus, BSA's submittal will be expressly subject to being updated to address any material public comment which warrants a revision to the LTCP.

Meeting the submittal date is dependent on a number of other tasks being completed in the interim. Importantly, we will have our last stakeholder's meeting no later than mid-April. In order to prepare materials for that meeting and for the LTCP submittal and subsequent public comment period, we will need to wrap things up no later than mid-April. Thus, we will appreciate a response from EPA on the issues raised below at the very earliest opportunity. Essentially, we have three weeks (including the Easter holiday) to pull everything together to be in a position to finalize and submit the final plan on April 30.

Regarding the two key requirements of concern, the first relates to the order's implementation period for the CSO LTCP. The order specifies 15 years (2027), while the last draft of the Consent Decree would have allowed 18 years. BSA has steadily proposed a 20 year implementation schedule (which was explained most recently when we met on October 20, 2011). By way of compromise, we propose that EPA agree to allow BSA to propose a plan with up to 19 years for implementation. This will do two things. First, it will avoid the need for us to do what engineering we can on 15-year plans between now and the April 30, 2012 submittal date. Second, it will avoid the need to raise 15-year programs with our stakeholder group, the public, and BSA/City leaders. Up to this time we have been telling everyone about a 20 year program.

If the EPA insists on a 15 year plan, then alternatively, we request that EPA agree to permit BSA to propose an Updated LTCP with a 19 year implementation schedule as BSA's recommended and preferred alternative while BSA would also provide a 15-year alternative. In that scenario, BSA would not recommend the 15 year program as its plan but would include it as an alternative (with limited engineering analysis given the mid-April deadline to complete technical work for the submittal). It should also be noted that the 15-year program would likely have a lesser extent of green infrastructure improvements and/or lower level of control than the 19-year program recommended by BSA. If EPA decided that the 15-year plan was appropriate, EPA would have to (1) reject BSA's recommended plan, and (2) order BSA to implement the 15-year plan. BSA reserves its right to challenge such a decision.

BSA very much would prefer the 19-year approach (December 31, 2031) as it would put the schedule issue behind us, avoid last minute engineering (which of necessity will be limited), avoid BSA submitting a plan with a lower green infrastructure commitment and/or a lower level of control, and avoid public confusion and concern about EPA's intentions for a 15 year program. Thus, we ask that EPA agree to allow the recommended implementation period to be up to December 31, 2031 in BSA's plan to be submitted on April 30.

The second requirement relates to technical aspects of the analyses that will be included in the submitted recommended plan. BSA believes there is a disconnect between what they have done in preparation of the Updated LTCP and the stated requirements of the Order. A summary of the issues is provided below along with our requested clarifications (as appropriate):

1. Green Infrastructure requirements. The language in the Order is essentially the same as the original Consent Decree draft, which is inconsistent with BSA's long stated position that a high level of definition for Green Infrastructure projects is not possible within the context of the Updated LTCP. Further it is also inconsistent with many recently completed consent decrees elsewhere in the country. As we have discussed, BSA anticipates including a breakdown of the acreage to be controlled (at 20% Green Infrastructure) as well as some general well-established technologies that the BSA can implement. To verify the feasibility of this plan BSA has prepared an inventory of public property (roads, sidewalks, etc.) which demonstrates that all 20% of the Green Infrastructure could occur on public property. Additionally, BSA is currently working with the local Buffalo Niagara River Keeper to identify potential Green Infrastructure projects involving both public and private property. BSA intends to identify Green Infrastructure in their recommended plan, including downspout disconnections/rain barrels, rain gardens, and other projects which are currently being piloted in the City, but the level of detail mandated in the Order is not possible for all green projects at this time. BSA will propose the best level of definition it can by April 30 (with a specific focus on the first 5-years and the targeted initial level of green implementation/performance during that period), but cannot commit to specifics such as location, sizing and design of individual Green Infrastructure projects, description of work required to implement the Green Infrastructure projects and description of proposed ownership and access for Green Infrastructure projects installed on private property. However, if EPA insists on a 15-year implementation period, this concern may be a moot point because it is unlikely BSA will be able to rely on any meaningful level of green solutions in such a short period of time.

2. Administrative Order Item 3, Page 3: This section lists Cornelius Creek as a navigable waterway. Cornelius Creek is neither a navigable nor recreational waterway. Indeed, it is mostly a large culvert sewer and, therefore, water quality within the sewer is not being discretely evaluated. However, the Niagara River water quality downstream of its terminus/discharge will be analyzed.

3. Order Section 2.b.ii, page 5: We are concerned that EPA may interpret the AO language to require a full re-evaluation of alternatives. As the EPA has been made repeatedly aware, in general, the 2004 screening of technologies has not been updated. The Updated LTCP will present the 2004 screening results. However, the alternatives have been re-evaluated in light of the new recreational Water Quality standards and the LTCP update will reflect these new results. As long as EPA agrees that this approach is consistent with the Order we are fine. Otherwise, BSA cannot perform additional alternatives analyses between now and April 30.

4. Order Section 2.b.iv, page 6: Note that BSA has not evaluated and in fact has anticipated proposing to eliminate all previously proposed partial sewer separations in favor of green infrastructure (under a 20-year implementation scenario). If a 15 year schedule is required, we will not know until late April what the EPA-mandated 15-year version looks like – it could be that BSA will need to revert to a plan that includes sewer separation and it is unclear how we will accomplish that reversal in technical approach by April 30.

5. Order Section 2.b.vi.3, page 7: As has been noted before, the requirement for DO/BOD/SOD in the Buffalo River, Scajaquada Creek, and Black Rock Canal needs to be modified. The water quality models for the Buffalo River and Black Rock Canal (as BSA demonstrated to the EPA in the fall of 2011) reveal that CSO's do not contribute to DO issues in these receiving streams. Thus, our CSO control alternatives have been focused on fecal coliform evaluations. We will provide the water quality model for DO/BOD simulations in the Buffalo River and Black Rock Canal only for the recommended alternative. It was also our understanding that in the light of the DO/BOD water quality modeling results presented to EPA, evaluations on the CSO contributions to SOD in the Buffalo River were not necessary.

6. Order Section 2.b.vii, page 7: We have discussed before that we are not performing water quality model runs for all alternatives. BSA's approach is to use the water quality model selectively to determine impacts and benefits based on various CSO discharges and background scenarios. Where alternative CSO reduction plans result in similar or the same CSO volumes, the water quality models will not be rerun as the output will not change.

Again, thank you for considering our requested revisions and clarifications. We look forward to your response so that the BSA can effectively complete its work by April 30th.

Sincerely,

F. Paul Calamita

Ms. Susan Akers
Mr. David P. Comerford
Mr. Oluwole A. McFoy
Mr. Charles C. Martorana
Mr. Michael J. Quinn
Mr. Timothy A. Ball

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Exhibit ES-3

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

March 29, 2012

Paul Calamita, Esquire
AquaLaw PLC
6 South Street
Richmond, VA 23219

Charles C. Martorana, Esquire
Hiscock & Barclay, LLP
1100 M&T Center
3 Fountain Plaza
Buffalo, NY 14203

Re: Buffalo Sewer Authority Administrative Order CWA-02-2012-3024

Dear Counsel:

I am writing in response to the March 28, 2012 letter from Paul Calamita requesting clarification and revision of certain provisions in Administrative Order CWA-02-2012-3024 ("Order"). By this letter, EPA provides clarification.

The Order requires the Buffalo Sewer Authority ('BSA") to submit a Long Term Control Plan ("LTCP"), by April 30 2012, with a schedule requiring design, construction and implementation of all selected control/treatment measures by December 31, 2027. BSA has requested that EPA agree to allow BSA to propose an LTCP with up to 19 years for implementation. EPA will accept a submittal from BSA that includes two implementation schedules, one with 15 years for implementation and the other with up to 19 years for implementation. Should BSA propose a 19-year implementation schedule, or any alternative schedule up to 19 years, this alternate schedule(s) must be supported by a detailed explanation justifying the need for additional time. Should BSA include a schedule(s) beyond December 31, 2027, in its LTCP, the Agency will evaluate the appropriateness of that schedule(s) based on the associated explanation supporting the length of the proposed schedule, as well as other criteria.

Of particular concern regarding the schedule, EPA notes your suggestion that the level of control BSA selects would be less with a 15-year schedule than with a longer one. Under EPA's CSO Policy, the alternatives analysis should guide the selection of the appropriate level of control. After the appropriate level of control is selected, the schedule to implement the controls may be influenced by financial capability. In other words, the level of control may not be varied based on the implementation schedule. If BSA chooses to submit an alternative to the 15-year schedule required by the Order, the alternative must have the same level of control with the same cost as the 15-year alternative. BSA may then offer explanations as to why it believes that costs need to be spread over a longer time period.

In terms of the technical clarifications you requested, the Agency provides the following:

1. Green Infrastructure. BSA has long been aware of the information the Agency expects for each green infrastructure proposal. EPA acknowledges BSA's concern that some of the information may not be available by April 30, 2012. EPA further acknowledges BSA's commitment to provide the "best level of definition" it can by that date. If BSA cannot provide some of the information described in the Order by April 30, 2012, EPA expects BSA to provide an explanation of why that information could not be provided and a schedule identifying when it will provide it.

2. Cornelius Creek. EPA has confirmed with NYSDEC that Cornelius Creek is, in fact, not a navigable water.

3. Re-evaluation of 2004 Alternatives. EPA is in agreement that BSA need not revise the initial screening of technologies in the 2004 LTCP. BSA should however, re-evaluate, and revise, if appropriate, the alternatives in the 2004 LTCP in light of the new recreational water quality standards. A full evaluation is expected for any alternatives not included in the 2004 LTCP.

4. Range of Alternatives. EPA expects BSA to, at a minimum, evaluate the 15 alternatives in paragraph 2.b.iv. on page 6 of the Order. EPA acknowledges that some of these 15 alternatives may not be appropriate, however, EPA expects BSA to provide an explanation as such in its LTCP.

5. Pollutants of Concern. EPA agrees with BSA's approach for evaluating the improvement in DO/BOD/SOD in the Buffalo River, Scajaquada Creek and the Black Rock Canal. EPA expects BSA to document, in its LTCP, that the water quality models for the Buffalo River and Black Rock Canal reveal that CSOs do not contribute to DO concerns in these waters and acknowledges that BSA therefore, focused its alternatives analysis on reducing fecal coliform. EPA further acknowledges that BSA intends to provide the water quality model simulations for DO/BOD in the Buffalo River and Black Rock Canal only for the recommended alternative(s). EPA confirms the understanding that in light of the DO/BOD water quality modeling results, evaluations of CSO contributions to SOD in the Buffalo River were not necessary. EPA expects BSA to document this in its LTCP as well.

6. Water Quality Model Runs. EPA agrees with BSA's position that in cases of the same or similar CSO volumes, BSA will not re-run water quality models since the output will not change. EPA expects that BSA will document this in its LTCP and identify cases for which water quality model runs were not conducted due to projected similar outputs.

EPA looks forward to receiving BSA's LTCP on April 30, 2012.

Sincerely,

Kim Kramer
Assistant Regional Counsel

cc: Susan Akers
Doughlas McKenna
Larry Gaugler
Katherine Mann
Robert Fentress
Andy Crossland

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Exhibit ES-4

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

DEC 0 6 2012

CERTIFIED MAIL - RETURN RECEIPT REQUESTED
Article Number: 7005 3110 0000 5966 1963

Mr. David P. Comerford
General Manager
Buffalo Sewer Authority
1038 City Hall
65 Niagara Square
Buffalo, New York 14202-3378

Re: Buffalo Sewer Authority Administrative Order
Docket No. CWA-02-2012-3024
SPDES Permit No. NY0028410

Dear Mr. Comerford:

On March 9, 2012, the United States Environmental Protection Agency ("EPA"), Region 2, issued an Administrative Order, Docket No. CWA-02-2012-3024, to the Buffalo Sewer Authority ("BSA") to address certain violations of the Clean Water Act (33 U.S.C. § 1251 et seq) ("CWA" or "the Act") and the New York State Department of Environmental Conservation ("NYSDEC") State Pollution Discharge Elimination System ("SPDES") Permit number NY0028410.

In accordance with the Administrative Order, BSA submitted an Updated Combined Sewer Overflow ("CSO") Long Term Control Plan ("Updated LTCP"), dated April 30, 2012, to the EPA and the NYSDEC for review and approval. Pursuant to "Ordered Provisions," Item 2(e) of the Administrative Order, based on a joint review of the Updated LTCP, the agencies are declining to approve the document for the reasons set forth in the enclosed joint comments.

As you are aware, pursuant to "Ordered Provisions" Item 2(e) of the Administrative Order, within 120 days of receiving EPA's and NYSDEC's written comments, BSA is to modify the Updated LTCP consistent with the joint comments and resubmit the modified Updated LTCP to the agencies for final approval. Upon BSA's agreement to the LTCP revisions requested by EPA and NYSDEC, EPA and NYSDEC are willing to discuss the 19-year schedule that you have indicated is your preference for implementation.

If you have any questions regarding the Administrative Order please contact me at (212) 637-4244.

Sincerely yours,

Douglas McKenna, Chief
Water Compliance Branch

Enclosure

EPA/DEC Comments on BSA's Updated 2012 CSO LTCP

(12/06/12)

The main issues with BSA's 2012 Updated LTCP are:

1. WWTP bypassing and BSA's No Feasible Alternatives Analysis
2. Green Infrastructure
3. CSO level of control

EPA's and DEC's comments on the first three issues are addressed in sections 1-3 below. Section 4 below covers EPA's and DEC's other miscellaneous comments and questions on the Updated LTCP.

Section 1: Bypassing at the WWTP and BSA's No Feasible Alternatives Analysis

The BSA WWTP is not providing adequate primary treatment at flows exceeding about 160 MGD in partial treatment mode. The BSA's current practice of adding chlorine to the inlet of the primary clarifiers during partial treatment mode is not achieving effective disinfection.

These conclusions are supported by BSA's July 2004 Report of Primary Clarifier Studies at the BSA Bird Island WWTP and current design standards from the most recent edition (2004) of the Recommended Standards for Wastewater Facilities (aka Ten State Standards), and routine monitoring results for fecal coliform.

BSA's July 2004 studies evaluated the primary clarifiers at flow rates of about 40 MGD per clarifier (160 MGD total) and at about 60 MGD per clarifier (240 MGD total). The report concludes "The hydraulic conditions in these clarifiers at the flow rates tested appear to be limiting the formation of a sludge blanket and limiting the capture of suspended solids. Given the basic design of the clarifiers, there is little that can be changed without major modifications." The lack of settled sludge at high flow rates can be attributed to the high velocity currents that were reported near the floor of the clarifiers. The WEF Manual of Practice No. 8 recommends limiting the linear flow-through velocity in primary clarifiers to 4 to 5 ft/min to avoid re-suspension of settled solids. BSA's studies found that at a flow of about 40 MGD the maximum velocity current along the bottom of the clarifier was 9 ft/min at 20 feet from the tank center and 3 ft/min at 40 feet from the tank center. At a flow of about 60 MGD the maximum velocity current along the bottom of the clarifier was 13 ft/min at 20 feet from the tank center and 11 ft/min at 40 feet from the tank center. These conditions indicate that the primary clarifiers are hydraulically overloaded and not providing effective treatment at flows in excess of about 160 MGD.

The current Ten State Standards (2004 edition) recommends that the surface overflow rate (SOR) of primary settling tanks should not exceed a design peak hourly flow of 1500 to 2000 gpd/sf. The total surface area of the four primary clarifiers at the BSA WWTP is about 80425 sf. Therefore, at the maximum SOR of 2000 gpd/sf, the peak hourly flow should not exceed (80425 sf)(2000 gpd/sf) = 160 MGD.

The results of BSA's routine monitoring for fecal coliform in the primary effluent during partial treatment (outfall 001) demonstrate ineffective disinfection. For the three year period 2008 through 2010, daily fecal coliform values ranged from 20 counts/100 ml to 24 million counts/100 ml. The high end of that range is indicative of raw wastewater (untreated and not disinfected). For comparison, the SPDES permit fecal coliform limits at BSA's secondary treatment effluent (outfall 002) are a 30 day geometric mean not to exceed 200 counts/100 ml and a 7 day geometric mean not to exceed 400 counts/100 ml.

Specific comments on BSA's NFA analysis are presented below.

1. The detailed evaluation in BSA's July 2004 Report of Primary Clarifier Studies provides a better picture of clarifier performance at high flows than the comparison of TSS removal presented in the NFA analysis. The TSS comparison uses averages which tend to obscure the differences in performance at different flow rates and TSS loadings that occur during a storm event. In contrast, the July 2004 Primary Clarifier Studies were conducted with the express purpose of evaluating the hydraulic performance characteristics of the primary clarifiers under high flow conditions and employed methods that are more comprehensive and more technically rigorous than comparisons of average TSS removal used in the NFA analysis. The July 2004 studies concluded that primary clarifier performance is significantly decreased at flows above 160 MGD which contradicts the conclusion of the NFA analysis that the primary clarifiers are capable of handling up to 240 MGD.

2. The current version of the Ten State Standards is an appropriate standard for evaluating the existing primary treatment facilities at the BSA WWTP. The statement in the NFA analysis (page 29) that the current standards do not affect the existing facility rating is not in accordance with the purpose of this part of the LTCP development which is to ascertain what facilities (existing, new, modified, or any combination thereof) are necessary to provide the required treatment in terms of performance and capacity.

   The adequacy of primary treatment at the WWTP must be considered in the context of reducing WWTP bypasses and controlling CSO discharges. The solutions to these issues must be determined concurrently. BSA must provide additional treatment to flows that are passed through outfall 001.

3. The NFA analysis understates the frequency and volume of bypasses at the WWTP. Table 5-2 indicates that based on the model simulation, the predicted partial treatment volume for the 2006 typical year is 1626.8 MG/yr. The model simulation includes improvements at the WWTP that would increase the conveyance capacity to the secondary treatment system during partial treatment from the current capacity of about 290 MGD to about 320 MGD. Tallying the actual partial treatment event data for 2006 (BSA submits this data to DEC on an ongoing basis) indicates there were 81 bypass events for a partial treatment volume of 4817 MG. A similar tally for 2011 indicates 90 bypass events and a partial treatment volume was 4739 MG. For comparison with the volume predicted by the model, these figures need to be adjusted to account for the increased capacity during partial treatment simulated in the model. The maximum additional amount treated due to the 30 MGD improvement in WWTP conveyance capacity is 2430 MGD (81 events x 30 MGD). [Note that this is a very conservative estimate because many of

the events probably did not last a full day.] Using these figures, a better measure of the partial treatment volume is 4817 – 2430 = 2387 MGD which is about 50% higher than the predicted volume [Note also that the 2006 TY was modified by BSA which would lower the predicted volume by some undetermined amount]. For context, the total CSO volume predicted by BSA’s system model for the 1993 typical year is 1752.3 MG/yr. The bypass frequency reduction expected from the WWTP conveyance improvements can be approximated for 2006 by counting the number of events with a total bypass volume of 30 MGD or less (This is a conservative estimate because some of these could have been due to short duration high intensity events). For 2006, the frequency would be reduced from 90 events to 53 events which is a significant reduction, but 53 events per year is still not infrequent.   Section 5.4 of the NFA cites relatively infrequent bypassing as justification for not pursuing other treatment alternatives. Even after the WWTP improvements are factored in, bypasses at the WWTP will continue to occur relatively frequently and the volume will be significant. The total volume bypassed will also continue to be significantly higher than the total volume for all the CSOs. Given these statistics, it especially important that BSA provides the level of treatment at the WWTP required by the CSO Control Policy (and other federal and state requirements).

4. BSA’s preferred alternative in the updated LTCP (Alternative UA2) includes a North relief sewer and upsizing underflow pipes that will result in higher flows to the treatment plant (Alternative UA3A also includes a North relief sewer). CSO control alternatives that result in additional flow to the WWTP should also ensure that the additional flow receives at least primary treatment and adequate disinfection

   The maximum flow to the WWTP is currently constrained by the conveyance capacity of the conduits under the Black Rock Canal to about 560 MGD (design capacity). The effect of the North relief sewer and the larger underflow pipes will be to increase flows by some amount depending on the storm event up to a maximum of 560 MGD. In Alternatives UA2 and UA3A, flows above the maximum would continue to be discharged through CSOs. The LTCP does not identify how much additional flow could potentially be conveyed to the WWTP. As discussed above, BSA is currently not providing adequate treatment for high flows during partial treatment and the additional flows from the North relief sewer will exacerbate that situation. BSA must evaluate how much additional flow would be conveyed to the treatment plant from a North Relief sewer and upsized underflow pipes under the various levels of control considered in the LTCP. BSA must factor the additional flow into its evaluation of the required primary treatment capacity.

   SPP optimization which is included in the Revised Foundation Plan and therefore a component of each of the alternatives will also result in higher volumes of wastewater to the WWTP. However, the effect of SPP optimization on flow rates and bypassing at the WWTP is unknown. BSA must evaluate the effect on flow rates and bypassing using the existing models and determine what additional storage or treatment capacity is necessary to handle increased flows that result from SPP optimization.

5. The NFA analysis appears to be biased by the claim (see NFA page 8-6 and LTCP page 11-1) that the assimilative capacity of the Niagara River is so large that modest reductions in pollutant loading from the WWTP would have an insignificant impact on water quality. At a minimum, BSA must provide effective primary treatment regardless of the assimilative capacity of the receiving water.

   LTCP implementation must result in compliance with minimum treatment requirements as well as WQ based requirements. The CSO Control Policy requires that all flows captured by the CSS receive primary treatment (and disinfection if required to meet WQS, designated uses, and protect human health), that POTWs provide treatment to the greatest extent practicable, and that treatment system bypasses must be reduced to the maximum extent feasible.

6. The LTCP must investigate the possibility of conveying additional flow to the treatment plant beyond the current conveyance capacity of 560 MGD. The LTCP states that while the WWTP is in partial treatment mode, the existing facilities are capable of providing primary treatment for up to 240 MGD and secondary treatment for up to 320 MGD for a total of 560 MGD which is the same as the maximum conveyance capacity to the WWTP. One consequence of not considering additional conveyance capacity is that the latter part of the NFA analysis focuses on providing better pollutant removal rather than additional hydraulic capacity.

7. The evaluation of storage technologies in the NFA (Section 5.1.2) concluded that additional storage on Bird Island was infeasible because of space constraints so that option was not retained for further consideration. The BSA should consider the potential for using the land north of the WWTP (former landfill and incinerator site) for additional storage. Also, there appear to be areas on Bird Island where the small footprint of an EHRT system could be a viable option for additional treatment capacity rather than replacing existing primary treatment facilities.

   The NFA must investigate the possibility of reducing WWTP bypassing by providing additional storage off the island beyond the storage needed to achieve specific LOCs for the updated system-wide alternatives. The system-wide alternatives analysis was based on an invalid premise that there is no need for additional primary treatment capacity at the WWTP.

Section 2: Green Infrastructure

EPA and DEC support the use of Green Infrastructure wherever feasible to reduce CSO volumes and handle separated storm water. However, BSA's LTCP evaluation of CSO control alternatives, which compares one alternative that includes both green and grey infrastructure to three other alternatives that consist exclusively of grey infrastructure, is flawed. BSA's approach excludes GI unless alternative 2 is selected. While BSA's analysis resulted in the selection of alternative 2, this might not be the case if the alternatives are re-evaluated to address the comments below (especially if more realistic GI cost estimates are used and if different and more costly types of GI are needed because of the unsuitability of BSA's proposed GI measures).

Also, there is significant uncertainty regarding how BSA's proposed GI program will perform. The LTCP acknowledges this and includes 5 or 6 years to evaluate GI before implementing any of the grey infrastructure in BSA's preferred plan. This uncertainty, coupled with the fact that GI makes up a large percentage of alternative 2, results in a biased comparison between alternative 2 and the other alternatives. It would be preferable to compare alternatives that have similar likelihood of achieving the goals and similar level of uncertainty. BSA previously communicated to EPA and DEC that it intended to include GI in each alternative.

If GI is to be a part of the Long Term Control Plan, EPA and DEC prefer an approach where GI is incorporated into the LTCP Revised Foundation Plan. The Revised Foundation Plan consists of CSO controls that are common to all of the alternatives and currently includes SPP optimizations, real time control projects, and additional storage projects. Including GI in the Revised Foundation Plan would ensure that the selected alternative includes GI and it would set up a more logical comparison of the grey infrastructure components of all the alternatives.

EPA and DEC recognize that at present, BSA does not have all the information necessary to fully define a GI program. A fully defined program would address the following:

1. Identify the types of GI that are most likely to be effective, given local conditions. The evaluation should compare different GI alternatives and provide a rationale for the types that were selected for implementation.
2. Identify whether each GI project will drain to a storm sewer, or to a combined sewer, or by infiltration into local soil and groundwater, or to some combination of these. For any combination, identify the approximate percentage of flow to storm sewers/combined sewers/soils and groundwater.
3. Determine the size/capacity of the GI and where it will be located.
4. Identify ownership and/or operation and maintenance responsibility for each GI measure.
5. Determine what level of reduction GI will achieve in terms of wet weather flows entering the combined sewer system.
6. Develop a monitoring plan for each project that will accurately establish the existing (baseline) wet weather flows for a range of flow conditions and measure the reduction due to the GI project in terms of wet weather flows entering the combined sewer system.

BSA has proposed implementing several pilot projects that should provide much of this critical information, but those projects would not be completed and assessed until 5 or 6 years into the LTCP. However, a measure or estimate of flow reductions possible with GI is needed now so that grey infrastructure alternatives can be sized and a sound alternatives analysis can be conducted. BSA's assumption that GI will result in the removal of runoff equivalent to one inch of rain from the controlled impervious surfaces (either 10 or 20% depending on sewershed) appears unrealistic. The information to justify this or other assumptions about GI runoff control in the BSA collection system is not currently available.

Therefore, EPA and DEC propose an alternative approach that sets a target for GI implementation based on the volume of CSO reduction necessary to achieve a certain level of control in terms of CSO activations. The target should be a significant level of GI yet have a high likelihood of being achievable (based on GI programs being implemented elsewhere). Given the uncertain performance of GI, the level of data presented to date, the challenges to implementing GI in Buffalo, and the concerns noted below in specific comments, EPA and DEC believe that it will be difficult to justify a base level of GI of higher than that needed to achieve 10% of the total CSO reduction necessary to meet a level of control of 4 activations per year. A higher base level of GI implementation will be considered if BSA provides additional information that justifies a higher level.

With the agencies' approach, the achievability of a 10% CSO reduction with GI would be ascertained through implementation of several GI pilot projects and associated post-construction monitoring. These pilot projects would be implemented within 5 – 6 years of LTCP approval concurrently with the grey infrastructure components of the selected alternative. After completion of the post construction monitoring and an evaluation of the effectiveness of the GI pilot projects, a GI Plan would be required as a deliverable under the LTCP. The GI Plan would provide a detailed proposal for implementing the remainder of the GI program and would include the information outlined in items 1 – 6 above. If the GI pilot projects are demonstrated to be effective, additional GI (beyond that needed to achieve 10% CSO reduction) can be proposed to be substituted for grey infrastructure where appropriate and cost effective. In the event the GI pilot projects do not meet the objectives, the GI Plan would have to include additional green or grey infrastructure to make up the shortfall. BSA should use adaptive management approaches as necessary to develop modifications to the planned grey or green infrastructure controls to ensure that overall performance goals are still met by the date certain for completion of all work. All submittals for LTCP modification using this adaptive management approach would be subject to EPA and DEC approval.

The set of GI pilot projects should provide information on the potential effectiveness of GI in different parts of the city which may have different implementation challenges. Pilot area selection should be geared to show how well GI can be implemented in areas with differing land use, such as in a denser downtown area as compared to residential areas. The pilot projects should also establish the degree to which GI can be implemented based on depth to groundwater, depth to bedrock, type of soils or other variations in physical land features. The appropriate number and size of the pilot projects will depend on the number of GI technologies being demonstrated and desire to investigate implementation in areas with different land uses and features.

The GI pilot projects proposals should include as much of the information outlined in items 1 - 6 above as is currently available based on a desktop level, GIS based study of the opportunities for implementation of GI across the city. Presently, the LTCP notes that some studies along these lines have been conducted, but no details are provided. It is expected that some reasonable assumptions will be made regarding anticipated performance of the GI pilot projects. A detailed post construction monitoring plan (item 6 above) for the GI pilot projects must be submitted for agency review and approval prior to implementation.

Specific comments on BSA's GI program are presented below.

1. An adequately defined GI program includes:

   a) The intended mix of GI types to be implemented to meet targets and an estimate of how much of the proposed GI would be on public land versus private land.

   b) The expected drainage (percent drainage to storm sewers/combined sewers/soils and groundwater) and performance measures for the types of GI projects being proposed. This should include an understanding of the timing and amount of water that would be reintroduced to the combined sewer system as it drains from the distributed GI implementations.

   c) Information on different types of hydrogeologic characteristics found across the city of Buffalo (such as soil type, percolation rate and groundwater level) that would be expected to affect infiltration.

   d) The LTCP (page 11-18) refers to "…GI implementation through reasonable measures by the BSA and the City." Describe the role of the City of Buffalo and what commitments the City has made to implementing BSA's GI program.

   e) Measures ensuring that GI projects will be properly operated and maintained.

      i) A strictly voluntary downspout disconnection program as proposed in the LTCP is not acceptable. Voluntary participation by the public will not ensure preservation/protection of GI over time. As stated in the Administrative Order: "....should BSA rely; on other entities to implement the GI project, BSA must explain what agreements will be necessary to ensure proper operation and maintenance of the GI project (i.e., permanent access, sufficient control over key aspects of the project), and how they will be enforced to ensure proper operation and maintenance of the GI project;" For a downspout disconnection program, a local ordinance (with enforcement) would be an acceptable alternative to individual agreements.

ii) Identify who will maintain the projects that are part of the vacant land management program and provide assurances from the City of Buffalo that program properties will be permanently removed from the tax rolls to prevent future development or reversion back to non-GI use (unless offsets are provided).

2. BSA intends to rely in part on private property GI controls to achieve its intended impervious surface control goals. It is not clear to what degree that is the case. BSA states that it is “targeting impervious surface control primarily within publicly-owned property at earlier stages of the program…” Does that suggest an expectation on BSA’s part for an increasing role for private GI in the later part of the program? EPA and DEC have previously discussed with BSA their concerns regarding the reliability of GI measures sited on private property. Also, BSA has stated that it anticipates relying on the results of its early GI projects to more firmly establish GI performance expectations. If the early GI projects are more publically owned than those built later in the program, the early projects may not be good indicators of the performance of GI projects in which a greater percentage of the GI measures are sited on private property. BSA should also describe in detail all anticipated ordinance changes it will seek to require/foster private sector GI.

3. Land characteristics in the City of Buffalo are not uniformly suitable for the types of GI proposed in the LTCP.

   a) North Buffalo and some other areas have relatively few vacant properties where GI land management utilizing infiltration could be implemented.
   b) Much of the Outfall 060 demonstration project is essentially a partial sewer separation project that involves installing infiltration basins/rain gardens or permeable pavement with underdrains connected to new storm sewers. Projects that involve the installation of storm sewers are viable only in areas that are relatively close to receiving waters or existing storm drainage (the LTCP states that on page 7-31). Much of the area of the City does not meet this criterion and therefore appears unsuitable for that type of project. Costs for these projects which include partial sewer separation with GI will be higher than if they included just partial sewer separation. The LTCP (page 11-68) states that the reason for the high costs of Alternative UA1 is that it includes a large number of partial sewer separation projects.

   c) The GI Plan does not include information on expected flow reduction from green streets, on the type of drainage (drainage to storm sewers/combined sewers/soils and groundwater), and whether the City street rebuilding program is likely to meet that goal. Green streets can be implemented only at the rate at which the City rebuilds streets.

d) The outfall 060 demonstration project includes a street segment (Elmwood Ave) with curb cutouts and rain gardens without under drains or storm sewers. This type of project would rely on infiltration. However, the LTCP does not provide information on site characteristics (such as soil type, percolation rate, and groundwater level) that would be expected to affect infiltration. Nor does it provide information on how baseline flows will be established and how the effectiveness of this system will be monitored.

e) The LTCP (page 11-19) states that 20% of the impervious surface will be controlled in areas that have higher CSO discharge frequency and 10% will be controlled in areas with lower CSO discharge frequency. Given the issues discussed above, BSA may not be able to target the GI program this way. The LTCP proposes GI based on where it is most needed to provide the necessary LOC rather than basing it on where it (GI) is most likely to be effective.

4. BSA’s cost estimates for GI appear low.

a) The LTCP states (page 7-44) that an all inclusive cost of $57000 per acre of GI was used because it is “within the average ranges for redevelopment and retrofit application” from Table 7-5. Actually, $57000 is at the low end of the cost range. The applicable part of Table 7-5 is given below:

	Min Cost ($/ac)	Mean Cost ($/ac)	Max Cost ($/ac)
Average retrofit	57250	133000	334000
Average Redevelopment	39250	92500	164500

b) If GI costs turn out to be closer to the mean in Table 7-5, then the costs of the other alternatives compare more favorably with BSA’s selected alternative, UA2. At a GI cost of $112750 per acre [the average of the mean costs: (133000 + 9250)/2], Alternative UA2 equals the cost of Alternative UA3A ($377M) at a LOC of 6 overflows per year and exceeds the cost of Alternative UA3A at a LOC of 4 overflows per year ($582.8M vs. $505.6M).

c) The LTCP cites $70000 per acre as an average cost of GI technologies from Table 11-9. However, Table 11-9 includes a number of GI technologies that BSA does not intend to use, so it is not applicable.

d) In Section 11.4.3, BSA lists assumed average costs for Kansas City ($54,000/acre) and Albany ($40,000/acre for redevelopment and $57,000/acre for retrofit projects). BSA also presents Table 11-9 that summarizes cost assumptions from Philadelphia, PA. Based on the lower unit costs presented in Section 11, BSA selected $57,000/acre as its assumed average GI control cost. This resulted in an estimated $92.3 million GI program that would control runoff from 1,620 impervious acres. How does BSA reconcile the costs presented in Section 7.5.7 with the lower Section 11 costs? It would be helpful if, based on its understanding of land use, BSA developed at least a preliminary estimate of possible overall distribution of GI controls by type, and then applied type-specific unit cost estimates to generate a somewhat more refined overall GI program cost estimate.

5. The GI demonstration period of 5 – 6 years (construction and evaluation) should not preclude the start of grey infrastructure projects that are approvable and provide more certainty in achieving the desired LOC. BSA's stated preference is to evaluate the effectiveness of GI as a necessary step before building grey technologies to avoid construction of oversized grey facilities. However, grey infrastructure controls can be designed to incorporate sizing flexibility. The CSO Control Policy demonstration approach states that "The planned control program is designed to allow cost effective expansion or cost effective retrofitting…" BSA may be able to identify grey projects that are the least risky in terms of being oversized, and schedule those to be constructed first.

6. Section 11.4 describes BSA's evaluation of Green Infrastructure. BSA's six sample basins represent a very small fraction of the total combined service area – approximately 0.33% of the total 33,500 acres of combined service area. BSA notes that it did subsequently evaluate land uses and impervious surface statistics within each CSO basin; however, detailed information regarding the results of that effort is not provided. BSA did provide Figure 11-4 which illustrates the results of that analysis for CSO 012's basin. BSA should provide documentation of this analysis, including similar graphics for the entire combined service area.

Section 3: CSO Level of Control

1. CSO activation frequency is a more appropriate measure of performance than percent capture based on bacteria being the primary pollutant of concern. Compliance with the WQSs for bacteria is more highly influenced by activation frequency than by percent capture (or conversely CSO volume) because the WQS for bacteria are based on a 30 day geometric mean. This performance measure cannot be changed unilaterally by BSA as claimed in the LTCP.

2. BSA states that the 2012 LTCP is based on the 85% wet weather capture provision of the Presumptive Approach. In carrying out the LTCP Update, BSA has in fact carried out its updated alternative analysis as a Demonstration Approach. Once the WQ modeling was carried out and typical year WQS compliance evaluated, the LTCP became a Demonstration Approach.

Section 4: Other comments on BSA’s LTCP

1. Regarding Table 2-1, what are the peak daily flow contributions from each tributary community? BSA should note whether all tributary communities have completely separate sewer systems.

2. On page 3-10, a reference to Table 3-2 includes the statement “CSO 006 and CSO 053 include Scajaquada Creek volumes …” This should say “CSO 006 and CSO 053 do not include Scajaquada Creek volumes …” to be consistent with footnote 2 in Table 3-2.

3. BSA notes that “*Scajaquada separate storm water flow, non-BSA-storm water flows, and storm water flows entering the outfall system downstream of the final SPP were removed from CSOs 021, 028, 054, and 066.”* BSA should specifically note what that removed volume was.

4. In Section 5.2, BSA notes that *“a hydraulic capacity evaluation of the collection system and an evaluation of maximizing storage by adjusting regulators and weirs were performed as part of the LTCP development, the results of which are presented in this report.”* BSA is requested to identify where in the report the results of these evaluations are presented in detail, or to provide technical memoranda presenting such detail.

5. In Section 5.9, does BSA mean to say that additional sources of storm water are NOT connected to the system?

6. In Section 5.11, BSA notes that septage and hauled wastes are only accepted at the WWTP. Are such wastes discharged directly into the influent stream, or are they captured in a holding tank and bled into the influent stream? Are septage and hauled wastes received and/or treated during wet weather events in which bypassing takes place?

7. In Section 5.16, completion dates should be provided for all implemented Phase 1 CSO Projects. In the CSO SPP 240 project description, BSA notes that it will be installing rain gardens/infiltration basins along a typical residential street and a typical commercial street, placing pervious pavement along two residential streets, implementing a downspout disconnect/rain barrel program, carrying out “selective separation,” and raising the weirs on a number of SPPs. Will this project (which may be already under construction) include flow monitoring equipment? Has BSA already collected “before” runoff data for the areas in which the GI will be installed? Will monitoring of individual GI technologies be provided? It would seem that “selective separation” and the raising of numerous weirs could complicate quantification of the performance of the pilot GI measures.

8. On page 6-8 a description of Class A waters should be added because the lower Scajaquada Creek was reclassified as a Class A water. The descriptions in the regulations of Class A and Class A-Special are the same except that Class A-Special applies to international boundary waters.

9. Figures 6-4 through 6-8 use symbols with very similar colors to indicate “no exceedance” and “one exceedance”. The colors should be changed to those that contrast better.

10. On page 6-16, BSA notes that “*studies have shown that low DO levels in the Buffalo River have been attributed to a combination of stratification in the river at low flows, high sediment oxygen demand and long residence time due to system hydraulics*.” BSA should note that CSOs contribute directly to high sediment oxygen demand (SOD), and that CSO control can be expected to reduce SOD.

11. Section 6.6 refers to “critical cell” in the receiving water model (in regard to the evaluation of WQS attainment). “Critical cell” must be explained as well as how the averaging was performed.

12. Section 7.5 presents the revised unit pricing for the 2012 LTCP Update. Costs were updated by comparing BSA’s 2004 costs to cost estimating curves from a number of recent CSO LTCPs and to costs from “recently completed projects of a similar nature to the proposed improvements. ” All costs were brought to 2012 dollars using the ENR Construction Cost Index (CCI). Other than for separation and sewer replacement projects, did BSA use actual project costs to develop its 2012 cost curves? Can BSA explain in Figure 7-11, why its cost estimates for specific EHRT options fall below BSA’s own EHRT cost curve? How were those EHRT option-specific costs developed?

13. In costing EHRT high rate disinfection, it does not appear that BSA has included a cost for a contact tank (see page 7-36). Did BSA in fact assume that contact would occur within the EHRT unit? If so, it should be noted that such practice would be subject to many of the same technical disadvantages as simultaneous disinfection in traditional CSO treatment basins. Regarding its tunnel-specific cost curves, BSA should confirm that tunnel length was held constant, and should identify that length for each tunnel. Finally, Section 7.5 references a number of cost equations that appear to have been omitted – see 7.5.1.2, 7.5.2.2, 7.5.4.1, and 7.5.6.2.

14. In Section 9’s description of Alternative 2, BSA notes that one of the Black Rock Canal in-line storage facilities actually results in an increase in overflow volume to Scajaquada Creek. Additional discussion of this effect should be provided. Alternative 4 involved the installation of Enhanced High Rate Clarification (EHRC) at all of BSA’s CSOs. Section 9.6.3 notes that disinfection would be included at each EHRC facility; however, BSA should describe the disinfection system to be used.

15. Section 11.3 describes BSA’s evaluation of Real Time Control (RTC) and the development of recommended RTC projects. BSA notes that it will implement one off line storage facility (utilizing the existing Amherst Quarry), thirteen in-line storage facilities and three line storage facilities – see Table 11-6. BSA should clarify the

distinction being made between "in-line" storage and "line" storage. BSA should provide the RTC studies as LTCP appendices.

16. Table 11-6 lists 17 RTC projects included in the recommended alternative, but states that only 2 will be built and states that the others will be built only if the 2 are successful. The LTCP must include alternatives if the RTCs prove to be unsuccessful or if BSA chooses not to implement a particular RTC alternative.

17. On page 11-18, the LTCP should describe the rationale for selecting the target of controlling runoff from 20% of impervious surfaces. In Table 11-8, the available public areas are given in percentages, but the LTCP should clarify whether the listed percentages are percentages of the total area or percentages of the impervious area.

18. In Section 11.4, BSA does not describe how it plans to determine the effectiveness of the GI demonstration projects. The outfall 060 demonstration project includes three different types of GI (rain gardens with drains to storm sewers, rain gardens without drains, and permeable pavement) which will complicate the task of measuring performance.

19. BSA’s evaluation of the effectiveness of GI should consider the effect of salt (from road salting) on the environment, particularly groundwater.

20. Table 11-11 presents BSA’s revised Foundation Plan projects. For five non-Phase 1 projects totaling $12.5 million, the project description notes that this “*includes BSA in-kind services*.” BSA should explain this note. Also, for the last two of the three “Other” projects listed at the end of Table 11-11 (Smith Street Storage and CSO 016 Storage), how much storage volume will each provide?

21. In Section 11.6, BSA evaluates the cost performance of updated alternatives UA1, UA2, UA3 and UA4 (see Table 11-15). It would be helpful to also see these plots based only on capital costs.

22. As embodied in Tables 11-21 and 11-22, storage is replaced by HRT for higher levels of control in some areas. The text states that this is because of space limitations in installing larger storage. The level of storage for each level of control should be presented for evaluation, then, for instances where space limitations come into play, those limitations need to be fully explained and justified.

23. Consistent with the observation made above that CSO-specific activation, rather than system-wide percent capture, should be the primary performance criteria, Table 12-5 or an additional table should provide the Recommended Plan benefits on a CSO-specific basis, including both typical year activations as well as typical year overflow volume.

24. Section 12.5 presents an analysis of the sensitivity of the Recommended Plan to variation in the effectiveness of GI. BSA should confirm that "20%" is in fact the proposed mix of mostly 20% and some 10% impervious area control, and that "10%" is a uniform 10% control level.

25. On page 12-15, the LTCP should provide further explanation of how the WQ model predicted better WQS attainment in the Lower Scajaquada Creek at 0% GI than at 10% GI).

26. On page 12-15 the LTCP states that "…BSA reserves the right to couple a use attainability analysis with the recommended LOC to the extent the NYSDEC were to conclude in the future that applicable WQS are not achieved." DEC has responsibility for determining whether a UAA is needed. If a UAA were to be needed, DEC would conduct it and submit it to EPA for review and approval. BSA can request a modification of WQS or variance from WQS, but does not have a right to a UAA or any modification to WQS.

27. In Section 14.1, BSA notes that an advantage of the 19 year schedule is more time to better understand GI performance to facilitate "*rightsizing the subsequent gray projects.*" BSA should provide further discussion about "rightsizing" and how such adjustments to gray infrastructure projects would take place. BSA is to assess performance of its LTCP based on the # of overflows and where GI does not meet its projections, BSA will need to adjust its gray projects.

28. Figure 14-1 (19 year implementation schedule) is not in temporal order. BSA should list the 20 items (projects or groups of projects) in order by start of construction. Figure 14-2 should use the same ordering as Figure 14-1.

29. BSA's schedules (Figures 14-1 and 14-2) include periods of generally 2 or 3 years for performing the engineering for the storage and conveyance projects. This seems an excessive amount of time.

30. The CSO 016 storage project should be included somewhere in the schedule. It would be appropriate to include it with either the Hamburg Drain or Smith Street storage projects.

31. On page 15-2, BSA states that the PCMP "…will focus on documenting increased percent capture of CSO flows and, for informational purposes, reductions in CSO activations on a typical year basis." The primary measure of performance should be CSO activations.

32. Post construction monitoring should extend no more than 2 years after completion of LTCP improvements. BSA's proposal for post construction monitoring to extend 5 years after completion of LTCP improvements is unacceptable. The AO requires that BSA submit a PCMP within 1 year of Updated LTCP approval. BSA must, therefore, develop a PCMP and submit it to EPA for approval within one year of the approval of the Updated LTCP. The PCMP must be based on the minimum time required to assess the results of LTCP implementation.

33. EPA's Administrative Order states (on page 12) that scheduling priority will be given to eliminating discharges to sensitive areas and those projects which most reduce the discharge of pollutants. BSA did consider sensitive areas in its project scheduling, but the LTCP should clarify whether scheduling priority was also given to those projects which most reduce the discharge of pollutants.

34. The NFA states that the existing interceptors and siphons can't convey more than current peak flows to the WWTP; however, the report provides little information on the basis of that statement – a more complete discussion of this issue and provision of documentation of that analysis should be provided.

35. Page 14 and Table 3-1 of the NFA analysis cite the infrequency of peak wet weather flows (which could infer infrequent bypassing), but the table actually presents the amount of time that certain flows are exceeded, not the frequency of occurrence.

36. All costs must clearly indicate year's dollars/ENR CCI whenever presented – particularly in tables. Each time typical year performance is discussed, BSA must make clear which typical year it is referring to.

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Exhibit ES-5

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

OCT 23 2013

CERTIFIED MAIL - RETURN RECEIPT REQUESTED
Article Number: 7005 3110 0000 5952 5050

Mr. David P. Comerford
General Manager
Buffalo Sewer Authority
1038 City Hall
65 Niagara Square
Buffalo, New York 14202-3378

Re: Buffalo Sewer Authority Administrative Order
Docket No. CWA-02-2012-3024
SPDES Permit No. NY0028410

Dear Mr. Comerford:

On March 9, 2012, the United States Environmental Protection Agency ("EPA"), Region 2, issued an Administrative Order, Docket No. CWA-02-2012-3024, to the Buffalo Sewer Authority ("BSA") to address certain violations of the Clean Water Act (33 U.S.C. § 1251 et seq) ("CWA" or "the Act") and the New York State Department of Environmental Conservation ("NYSDEC") State Pollutant Discharge Elimination System ("SPDES") Permit number NY0028410.

In accordance with the Administrative Order, BSA submitted an Updated Combined Sewer Overflow ("CSO") Long Term Control Plan ("Updated LTCP"), dated April 30, 2012, to the EPA and the NYSDEC ("the Agencies") for review and approval. Pursuant to "Ordered Provisions," Item 2(e) of the Administrative Order, based on a joint review of the Updated CSO LTCP, the Agencies declined to approve the Updated CSO LTCP and provided comments to BSA in a letter dated December 6, 2012.

The Agencies met with BSA on February 12, 2013 to discuss the Agencies' comments. BSA followed up with a letter dated March 1, 2013 which, among other things, specified that BSA would submit a No Feasible Alternatives ("NFA") analysis and submit its Green Infrastructure ("GI") Master Plan to the Agencies by August 2, 2013 and would meet with the Agencies on or about August 15, 2013 to discuss those submittals.

In a letter dated April 12, 2013, BSA provided the Agencies with its responses to the thirty-six separate comments outlined in the Agencies' December 6, 2012 letter. The Agencies followed up that letter with a letter to BSA dated April 24, 2013, which clarified an issue raised by BSA in its April 12, 2013 letter, concerning the date for BSA's submission of the final revised CSO LTCP. Specifically, the Agencies' April 24, 2013 letter stated the following:

1. After the meeting with BSA on or about August 15, 2013, the Agencies will provide written comments to BSA on the revised NFA analysis, the GI Master Plan and other CSO LTCP revisions, as appropriate.

2. Within sixty (60) days of receiving the Agencies' written comments, BSA will submit its final revised CSO LTCP to the Agencies.

In an email transmission from BSA on April 30, 2013, BSA agreed with the sixty (60) day time frame for submission of its final revised CSO LTCP. Given upcoming holidays, the Agencies hereby extend that time frame such that the submission date for BSA's final revised CSO LTCP is January 10, 2014.

Technical representatives of the Agencies met with BSA to specifically discuss BSA's GI Master Plan on August 20, 2013. BSA followed up by providing the Agencies with further information on its GI Master Plan on August 28, 2013. The Agencies determined that an analogous technical meeting to discuss BSA's NFA analysis was not needed and indicated that to BSA in an email transmission dated September 11, 2013.

Based on the chronology outlined above, this letter serves to provide BSA with the Agencies' written comments on its revised CSO LTCP. Enclosed are the Agencies comments with respect to the thirty-six (36) separate items originally provided to BSA in the Agencies' letter dated December 6, 2012. These comments identify specific changes that BSA is to make to its Updated CSO LTCP, dated April 30, 2012. The following paragraphs provide the Agencies' comments on the GI Master Plan and NFA analysis components of the final revised CSO LTCP, and on the overall implementation schedule.

<u>GI Master Plan</u>
While the Agencies still have questions concerning certain assumptions used by BSA to develop its GI program, the Agencies accept the submitted Phase 1 GI Master Plan, dated August 2, 2013. The Agencies are supportive of the GI Implementation schedule outlined in Table 2-4 of the Phase 1 GI Master Plan. The Agencies expect that post-construction monitoring from earlier phases will benefit GI implementation in later phases and that BSA's sewer system and water quality models will be refined accordingly, to reflect GI implementation. In addition, to assist in the long term planning of CSO controls, the Agencies encourage, to the extent practical and feasible, the performance of short-term verification of the GI model, including the submission of periodic real time flow monitoring data, during the first five years of the LTCP.

As a reminder, under "Ordered Provisions," section 2.c.ii.3, the Administrative Order states the following:

> *Upon review of BSA's GI project proposal, EPA and NYSDEC will comment, approve, disapprove, or approve in part, the proposal. BSA shall implement each GI project approved by EPA and NYSDEC in accordance with the provisions and schedule in the approved Proposal. If the GI project proposal is disapproved, EPA and NYSDEC's decision is final. For each project which is disapproved, BSA shall propose an alternative GI project or gray*

infrastructure project, or combined green and gray infrastructure project, within 90 days of the date of disapproval. In the event that BSA's proposal is disapproved by EPA and NYSDEC due to the GI project component of the proposal, BSA shall propose an alternative gray infrastructure project within 90 days of the date of disapproval.

This section of the Administrative Order holds out gray infrastructure as a "backstop" for GI projects which do not perform as expected. In discussions with BSA, BSA has fully acknowledged this provision and is encouraged to develop its GI program with it in mind.

NFA Analysis

The Agencies are supportive of BSA's NFA analysis, dated August 2, 2013 and in particular, are supportive of BSA's recommended alternative, "Alternative C2," summarized in Section 5.4 of the NFA analysis. This alternative expands BSA's wastewater treatment plant and ensures that "Ten State Standards" are met for flows which are given only primary treatment and disinfection during wet weather.

Overall Implementation Schedule for the Final Revised CSO LTCP

The existing Administrative Order includes the following requirement under "Ordered Provisions:"

By no later than April 30, 2012, BSA shall submit to EPA and NYSDEC an Updated LTCP. The schedule included in the Updated LTCP shall require the design, construction, and implementation of all control/treatment measures selected by BSA as expeditiously as practicable, following any applicable environmental impact assessment review pursuant to the New York State Environmental Quality Review Act ("SEQR review"), but in any event by no later than December 31, 2027.

This essentially represents a fifteen (15) year implementation schedule. BSA's April 30, 2012 Updated LTCP stated that BSA's preference was to implement its CSO LTCP over nineteen (19) years. The Agencies have previously indicated a willingness to discuss such a time frame in exchange for certain CSO LTCP revisions made by BSA. Such willingness was conveyed to BSA prior to BSA's NFA analysis, in which BSA states that additional time will be necessary to implement the final revised CSO LTCP if Alternative C2 becomes a component.

At the meeting between the Agencies and BSA on February 12, 2012, BSA estimated that up to four (4) additional years would be needed for overall CSO LTCP implementation if the NFA analysis recommended certain wastewater treatment upgrade/expansion options. At the same time, BSA also stated that at that time, February 12, 2012, BSA considered it to be approximately six (6) months into a nineteen (19) year implementation schedule.

After consideration of these various time frames for CSO LTCP implementation, the Agencies can agree to an overall twenty (20) year implementation schedule, commencing upon written approval of the final revised CSO LTCP. The end date would, therefore, be in 2034.

Once the final revised CSO LTCP is approved, and given the new end date by which to complete CSO LTCP implementation, EPA will either revise the current Administrative Order or will withdraw that Administrative Order and seek an Administrative Order on Consent, signed by EPA and BSA, to govern the implementation of the approved final revised CSO LTCP. As part of BSA's final revised

CSO LTCP, BSA must provide an implementation schedule with adequate specificity in terms of interim milestones for inclusion into the enforcement mechanism that will be used.

By January 10, 2014, please submit BSA's final revised CSO LTCP to each the following:

Doughlas McKenna, Chief
Water Compliance Branch
Division of Enforcement and Compliance Assistance
United States Environmental Protection Agency, Region 2
290 Broadway, 20th Floor
New York, New York 10007-1866

Joseph DiMura, P.E.
Director, Bureau of Water Compliance Programs
Division of Water
New York State Department of Environmental Conservation
625 Broadway
Albany, New York 12233-3506

Jeffrey Konsella, P.E., Regional Water Engineer
New York State Department of Environmental Conservation
Region 9
270 Michigan Avenue
Buffalo, New York 14203-2915

If you have any questions regarding the Administrative Order please contact me at (212) 637-4244.

Sincerely yours,

Douglas McKenna, Chief
Water Compliance Branch

Enclosure

cc: Jeffrey Konsella, NYSDEC - Region 9
Rob Locey, NYSDEC - Region 9
Robert Smythe, NYSDEC - Region 9
Terri Mucha, NYSDEC - Region 9
Joseph DiMura, NYSDEC - Albany
Brian Baker, NYSDEC - Albany
Dare Adelugba, NYSDEC – Albany

Tracking of BSA's Section 4 Revisions to its Updated LTCP

(10/23/13)

Location in EPA/DEC Comments	What EPA/DEC Comments Call For	What BSA Will Do (Based on 4/12/13 Letter) and EPA Response
Section 4: Item 1	Regarding Table 2-1, what are the peak daily flow contributions from each tributary community? BSA should note whether all tributary communities have completely separate sewer systems.	BSA will provide peak flows for four tributary communities and indicate that all tributary communities have separate sanitary systems. BSA states that other tributary peak flows are inconsequential and will not be included. **EPA/DEC Response:** BSA's proposed revision to LTCP Table 2-1 can proceed, but note that contract flow from ECSD 4 to BSA was increased from 25 mgd to 37.4 mgd despite DEC disapproval. The disapproval was based on the idea that satellite communities should do more to reduce their excessive wet weather I/I before conveying more flow to BSA where it will add to the CSOs.
Section 4: Item 2	On page 3-10, a reference to Table 3-2 includes the statement "CSO 006 and CSO 053 include Scajaquada Creek volumes …" This should say "CSO 006 and CSO 053 do not include Scajaquada Creek volumes …" to be consistent with footnote 2 in Table 3-2.	BSA will revise the inconsistency. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 3	BSA notes that "*Scajaquada separate storm water flow, non-BSA-storm water flows, and storm water flows entering the outfall system downstream of the final SPP were removed from CSOs 021, 028, 054, and 066.*" BSA should specifically note what that removed volume was.	BSA will revise the language to include the total flow removed. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 4	In Section 5.2, BSA notes that "*a hydraulic capacity evaluation of the collection system and an evaluation of maximizing storage by adjusting regulators and weirs were performed as part of the LTCP*	BSA identified where to look for regulator/weir adjustment info in the LTCP and indicated that it did think that a separate model run which only provides

	development, the results of which are presented in this report." BSA is requested to identify where in the report the results of these evaluations are presented in detail, or to provide technical memoranda presenting such detail.	results related to regulator/weir adjustments is warranted. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 5	In Section 5.9, does BSA mean to say that additional sources of storm water are NOT connected to the system?	BSA will make this revision. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 6	In Section 5.11, BSA notes that septage and hauled wastes are only accepted at the WWTP. Are such wastes discharged directly into the influent stream, or are they captured in a holding tank and bled into the influent stream? Are septage and hauled wastes received and/or treated during wet weather events in which bypassing takes place?	BSA provided responses to the questions raised and will revise the LTCP to include its answers. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 7	In Section 5.16, completion dates should be provided for all implemented Phase 1 CSO Projects. In the CSO SPP 240 project description, BSA notes that it will be installing rain gardens/infiltration basins along a typical residential street and a typical commercial street, placing pervious pavement along two residential streets, implementing a downspout disconnect/rain barrel program, carrying out "selective separation," and raising the weirs on a number of SPPs. Will this project (which may be already under construction) include flow monitoring equipment? Has BSA already collected "before" runoff data for the areas in which the GI will be installed? Will monitoring of individual GI technologies be provided? It would seem that "selective separation" and the raising of numerous weirs could complicate quantification of the performance of the pilot GI measures.	**EPA/DEC Response:** BSA provided additional information about the CSO 060 demonstration project at the meeting with DEC on June 26, 2013. See attached meeting notes. **EPA/DEC Response: ACCEPTABLE**

Section 4: Item 8	On page 6-8 a description of Class A waters should be added because the lower Scajaquada Creek was reclassified as a Class A water. The descriptions in the regulations of Class A and Class A-Special are the same except that Class A-Special applies to international boundary waters.	BSA provided revised language and will utilize it in the revised LTCP. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 9	Figures 6-4 through 6-8 use symbols with very similar colors to indicate "no exceedance" and "one exceedance". The colors should be changed to those that contrast better.	BSA will make this revision. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 10	On page 6-16, BSA notes that "*studies have shown that low DO levels in the Buffalo River have been attributed to a combination of stratification in the river at low flows, high sediment oxygen demand and long residence time due to system hydraulics.*" BSA should note that CSOs contribute directly to high sediment oxygen demand (SOD), and that CSO control can be expected to reduce SOD.	BSA provided revised language and will utilize it in the revised LTCP. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 11	Section 6.6 refers to "critical cell" in the receiving water model (in regard to the evaluation of WQS attainment). "Critical cell" must be explained as well as how the averaging was performed.	BSA provided revised language and will utilize it in the revised LTCP. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 12	Section 7.5 presents the revised unit pricing for the 2012 LTCP Update. Costs were updated by comparing BSA's 2004 costs to cost estimating curves from a number of recent CSO LTCPs and to costs from "recently completed projects of a similar nature to the proposed improvements. " All costs were brought to 2012 dollars using the ENR Construction Cost Index (CCI). Other than for separation and sewer replacement projects, did BSA use actual project costs to develop its 2012 cost	BSA provided an explanation but did not commit to including that explanation into its revised LTCP (note: the comments provided to BSA did not specify such inclusion). **EPA/DEC Response: BSA should include its explanation in its revised LTCP.**

	curves? Can BSA explain in Figure 7-11, why its cost estimates for specific EHRT options fall below BSA's own EHRT cost curve? How were those EHRT option-specific costs developed?	
Section 4: Item 13	In costing EHRT high rate disinfection, it does not appear that BSA has included a cost for a contact tank (see page 7-36). Did BSA in fact assume that contact would occur within the EHRT unit? If so, it should be noted that such practice would be subject to many of the same technical disadvantages as simultaneous disinfection in traditional CSO treatment basins. Regarding its tunnel-specific cost curves, BSA should confirm that tunnel length was held constant, and should identify that length for each tunnel. Finally, Section 7.5 references a number of cost equations that appear to have been omitted - see 7.5.1.2, 7.5.2.2, 7.5.4.1, and 7.5.6.2.	BSA provided an explanation but did not commit to including that explanation into its revised LTCP. **EPA/DEC Response: BSA should include its explanation in its revised LTCP.**
Section 4: Item 14	In Section 9's description of Alternative 2, BSA notes that one of the Black Rock Canal in-line storage facilities actually results in an increase in overflow volume to Scajaquada Creek. Additional discussion of this effect should be provided. Alternative 4 involved the installation of Enhanced High Rate Clarification (EHRC) at all of BSA's CSOs. Section 9.6.3 notes that disinfection would be included at each EHRC facility; however, BSA should describe the disinfection system to be used.	BSA provided certain revised language that it will utilize it in the revised LTCP and committed to a further revision based on its explanation. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 15	Section 11.3 describes BSA's evaluation of Real Time Control (RTC) and the development of recommended RTC projects. BSA notes that it will implement one off line storage facility (utilizing the existing Amherst Quarry), thirteen in-line storage facilities and three line storage facilities - see Table 11-6. BSA should	BSA provided certain revised language that it will utilize it in the revised LTCP and committed to including additional RTC studies as part of a new Appendix (Appendix 11-7) in its revised LTCP.

	clarify the distinction being made between "in-line" storage and "line" storage. BSA should provide the RTC studies as LTCP appendices.	**EPA/DEC Response: ACCEPTABLE**
Section 4: Item 16	Table 11-6 lists 17 RTC projects included in the recommended alternative, but states that only 2 will be built and states that the others will be built only if the 2 are successful. The LTCP must include alternatives if the RTCs prove to be unsuccessful or if BSA chooses not to implement a particular RTC alternative.	BSA will revise its LTCP to clearly indicate its commitment to constructing all 17 RTC projects, while the first two are demonstration RTC projects for purposes of helping BSA learn how to operate RTC. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 17	On page 11-18, the LTCP should describe the rationale for selecting the target of controlling runoff from 20% of impervious surfaces. In Table 11-8, the available public areas are given in percentages, but the LTCP should clarify whether the listed percentages are percentages of the total area or percentages of the impervious area.	**EPA/DEC Response: BSA should ensure that the Updated LTCP is consistent with BSA's Phase I GI Master Plan. Additionally, BSA's Response refers to Appendix 11-8, but the appendix is not included in the submitted LTCP. BSA needs to include it.**
Section 4: Item 18	In Section 11.4, BSA does not describe how it plans to determine the effectiveness of the GI demonstration projects. The outfall 060 demonstration project includes three different types of GI (rain gardens with drains to storm sewers, rain gardens without drains, and permeable pavement) which will complicate the task of measuring performance.	See EPA/DEC Response to Item 7.
Section 4: Item 19	BSA's evaluation of the effectiveness of GI should consider the effect of salt (from road salting) on the environment, particularly groundwater.	BSA explained its rationale for not proposing to make this evaluation. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 20	Table 11-11 presents BSA's revised Foundation Plan projects. For five non-Phase 1 projects totaling $12.5 million,	BSA will add a specific footnote to Table 11-11 and will revise Table 11-11 to

	the project description notes that this "*includes BSA in-kind services.*" BSA should explain this note. Also, for the last two of the three "Other" projects listed at the end of Table 11-11 (Smith Street Storage and CSO 016 Storage), how much storage volume will each provide?	include storage volumes. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 21	In Section 11.6, BSA evaluates the cost performance of updated alternatives UA1, UA2, UA3 and UA4 (see Table 11-15). It would be helpful to also see these plots based only on capital costs.	BSA explained that it utilized life cycle costs and provided a breakdown of these costs (capital and O & M) for each alternative. BSA explained that it is not planning on including this breakdown in its revised LTCP. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 22	As embodied in Tables 11-21 and 11-22, storage is replaced by HRT for higher levels of control in some areas. The text states that this is because of space limitations in installing larger storage. The level of storage for each level of control should be presented for evaluation, then, for instances where space limitations come into play, those limitations need to be fully explained and justified.	BSA provided an explanation and indicated that it has completed an example comparison of potential facility footprints and land requirements for both HRTs and storage tanks at all levels of control. **EPA/DEC Response: ACCEPTABLE with one provision: BSA's Response to Item 22 refers to Figures 1 and 2 (comparisons of land requirements for storage and HRTs), but those figures are not included in BSA's response. BSA should include those Figures in its revised LTCP.**
Section 4: Item 23	Consistent with the observation made above that CSO-specific activation, rather than system-wide percent capture, should be the primary performance criteria, Table 12-5 or an additional table should provide the Recommended Plan benefits on a CSO-specific basis, including both typical year	BSA indicated that this information has already been provided and stated that it is willing to commit to a CSO activations-based LTCP only as part of a global agreement on the LTCP.

	activations as well as typical year overflow volume.	**EPA/DEC Response: ACCEPTABLE.**
Section 4: Item 24	Section 12.5 presents an analysis of the sensitivity of the Recommended Plan to variation in the effectiveness of GI. BSA should confirm that "20%" is in fact the proposed mix of mostly 20% and some 10% impervious area control, and that "10%" is a uniform 10% control level.	BSA provided and explanation and proposed to revise certain LTCP items to provide clarification. **EPA/DEC Response: ACCEPTABLE.**
Section 4: Item 25	On page 12-15, the LTCP should provide further explanation of how the WQ model predicted better WQS attainment in the Lower Scajaquada Creek at 0% GI than at 10% GI).	BSA proposed a revision to the LTCP which will clarify this situation. **EPA/DEC Response: ACCEPTABLE.**
Section 4: Item 26	On page 12-15 the LTCP states that "…BSA reserves the right to couple a use attainability analysis with the recommended LOC to the extent the NYSDEC were to conclude in the future that applicable WQS are not achieved." DEC has responsibility for determining whether a UAA is needed. If a UAA were to be needed, DEC would conduct it and submit it to EPA for review and approval. BSA can request a modification of WQS or variance from WQS, but does not have a right to a UAA or any modification to WQS.	BSA will clarify the statement to indicted that it "reserves the right to petition the NYSDEC to perform a UAA.." **EPA/DEC Response: ACCEPTABLE.**
Section 4: Item 27	In Section 14.1, BSA notes that an advantage of the 19 year schedule is more time to better understand GI performance to facilitate "*rightsizing the subsequent gray projects.*" BSA should provide further discussion about "rightsizing" and how such adjustments to gray infrastructure projects would take place. BSA is to assess performance of its LTCP based on the # of overflows and where GI does not meet its projections, BSA will need to adjust its gray projects.	BSA explained that it will utilize its PCM Program to make certain additions and to utilize its GI programs to make modifications along the way. **EPA/DEC Response: ACCEPTABLE. BSA should include its explanation in its revised LTCP.**
Section 4: Item 28	Figure 14-1 (19 year implementation schedule) is not in temporal order. BSA	BSA made a proposal on the ordering of

	should list the 20 items (projects or groups of projects) in order by start of construction. Figure 14-2 should use the same ordering as Figure 14-1.	projects and proposed to revise the LTCP based on concurrence from the agencies. **EPA/DEC Response: For this Item and for Item 33, below, BSA is encouraged to use benefit/cost ratios for the selected CSO controls to determine scheduling priorities in order to maximize environmental benefits in the short-term, with preference given to sensitive areas.**
Section 4: Item 29	BSA's schedules (Figures 14-1 and 14-2) include periods of generally 2 or 3 years for performing the engineering for the storage and conveyance projects. This seems an excessive amount of time.	BSA argued that its proposed time frames are appropriate. **EPA/DEC Response: ACCEPTABLE. BSA should include its explanation in its revised LTCP.**
Section 4: Item 30	The CSO 016 storage project should be included somewhere in the schedule. It would be appropriate to include it with either the Hamburg Drain or Smith Street storage projects.	BSA will make this revision. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 31	On page 15-2, BSA states that the PCMP "…will focus on documenting increased percent capture of CSO flows and, for informational purposes, reductions in CSO activations on a typical year basis." The primary measure of performance should be CSO activations.	BSA indicated that it is willing to craft its LTCP in terms of activations, based on a global agreement on the LTCP. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 32	Post construction monitoring should extend no more than 2 years after completion of LTCP improvements. BSA's proposal for post construction monitoring to extend 5 years after completion of LTCP improvements is unacceptable. The AO requires that BSA submit a PCMP within 1 year of Updated LTCP approval. BSA must, therefore, develop a PCMP and submit it to EPA for approval	BSA argued that the PCM period be developed under the PCM program and will revise the LTCP to indicate that. **EPA/DEC Response: ACCEPTABLE**

	within one year of the approval of the Updated LTCP. The PCMP must be based on the minimum time required to assess the results of LTCP implementation.	
Section 4: Item 33	EPA's Administrative Order states (on page 12) that scheduling priority will be given to eliminating discharges to sensitive areas and those projects which most reduce the discharge of pollutants. BSA did consider sensitive areas in its project scheduling, but the LTCP should clarify whether scheduling priority was also given to those projects which most reduce the discharge of pollutants.	BSA explained how it has prioritized such projects. **EPA/DEC Response: See related EPA/DEC response to Item 28, above.**
Section 4: Item 34	The NFA states that the existing interceptors and siphons can't convey more than current peak flows to the WWTP; however, the report provides little information on the basis of that statement – a more complete discussion of this issue and provision of documentation of that analysis should be provided.	BSA will address this in its revised NFA, to be submitted in August 2013. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 35	Page 14 and Table 3-1 of the NFA analysis cite the infrequency of peak wet weather flows (which could infer infrequent bypassing), but the table actually presents the amount of time that certain flows are exceeded, not the frequency of occurrence.	BSA will address this in its revised NFA, to be submitted in August 2013. **EPA/DEC Response: ACCEPTABLE**
Section 4: Item 36	All costs must clearly indicate year's dollars/ENR CCI whenever presented – particularly in tables. Each time typical year performance is discussed, BSA must make clear which typical year it is referring to.	BSA provided a proposal to include a list of general assumptions/definitions for costs and TY. **EPA/DEC Response: ACCEPTABLE**

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1. Introduction

The Buffalo Sewer Authority (BSA) owns and operates a combined sewer system (CSS) with 52 permitted combined sewer overflows (CSOs) located throughout the collection system to relieve the combined sewer system during wet weather events. Figure 1-1 shows the BSA's service area, and Figure 1-2 shows the BSA's interceptors and CSOs.

The United States Environmental Protection Agency (USEPA) issued a national CSO Control Policy in 1994, requiring communities with combined sewer systems to develop Long Term Control Plans (LTCPs) that will provide for compliance with the requirements of the Clean Water Act, including attainment of current or revised water quality standards.

Pursuant to this, the BSA is required under the terms of its State Pollutant Discharge Elimination System (SPDES) permit (Permit No. 9-1402-00154/00002) to implement Best Management Practices (BMPs) for CSOs and to develop a CSO Abatement Plan. The BMPs are equivalent to the Nine Minimum Controls (NMCs) required under the USEPA CSO Control Policy. The CSO Abatement Plan must satisfy the requirements for a LTCP as identified in the USEPA CSO Control Policy and must be completed in accordance with New York State Department of Environmental Conservation (NYSDEC) requirements.

In January 2000, the BSA retained a consortium of nationally recognized and local consultants to develop a LTCP to fulfill the requirements of the USEPA CSO Control Policy as well as the requirements of the BSA's SPDES permit. The project team consisted of:

- System-Wide Consultant – Malcolm Pirnie, Inc.;
- North District Consultant – O'Brien and Gere;
- Scajaquada District Consultant – Stearns and Wheler;
- South Central District Consultant – URS; and
- Water Quality Modeling – Buffalo State College, University at Buffalo.

This work resulted in the development of the system-wide LTCP for CSO abatement for the Buffalo Sewer Authority that was submitted to the NYSDEC in July 2004 (the 2004 LTCP report). The BSA received report comments from the NYSDEC in 2006, and subsequently, the NYSDEC and the USEPA requested additional evaluations be performed to address questions and comments derived from the regulatory review of the 2004 LTCP. This additional work began in 2008.

The BSA retained Malcolm Pirnie, the Water Division of ARCADIS (Pirnie), along with Limnotech, GHD, and Buffalo State College, to address the 2006 regulatory comments and update the 2004 LTCP. On March 15, 2012, the USEPA unilaterally issued to the BSA an Administrative Order (AO) that required, in part, that the BSA submit an updated LTCP to the USEPA and NYSDEC (collectively referred to as the Agencies) no later than April 30, 2012. The resulting document was submitted in April 2012 and builds upon the 2004 LTCP, presenting the additional evaluations performed and the recommended CSO abatement program for the BSA. In December 2012, the Agencies provided comments on the April 2012 document. Based on the comments provided by the Agencies, the LTCP has been revised in general to include a Green Infrastructure Master Plan, an update to the No Feasible Alternatives Analysis, and address a number of other comments. This LTCP reflects the revisions developed by the BSA in response to those comments and concurred with by the Agencies in October 2013.

1.1 Study Purpose and Scope

The purpose of this study is to summarize the activities completed in development of the LTCP, to present the system-wide LTCP, and to propose an implementation schedule.

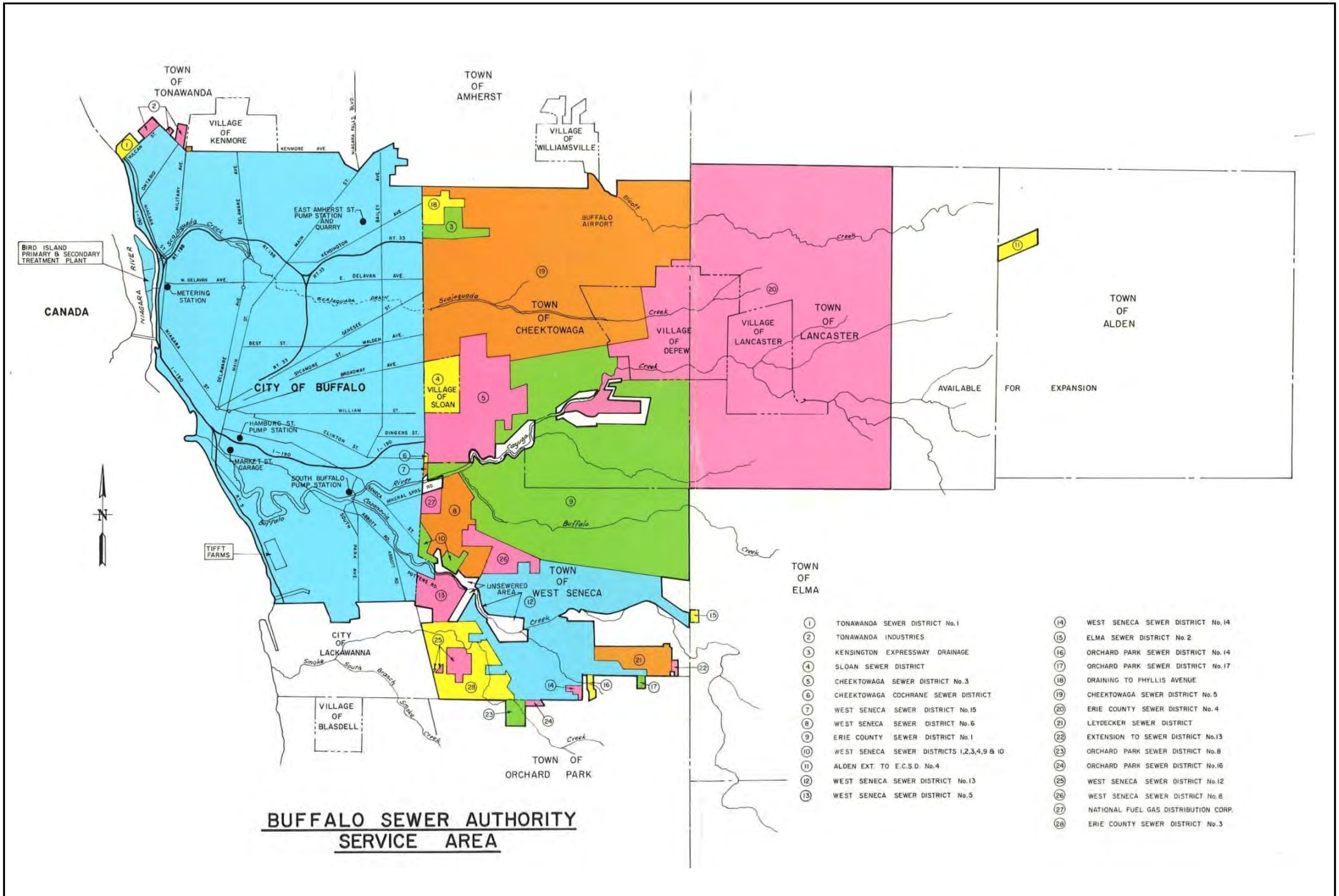
The 2004 LTCP was developed in three stages, and is referred to as Phase I in the LTCP process:

- Stage 1: System Mapping, Data Collection, and Model Development;
- Stage 2: District-Specific CSO Planning; and
- Stage 3: System-Wide LTCP Development.

Following these three stages and submittal of the 2004 LTCP, additional update work was completed in two phases:

- Phase II: Additional evaluations, including water quality modeling development, collection system modeling refinement, and the associated data collection (rainfall, flow, water quality) to support these modeling tasks.
- Phase III: Develop and evaluate CSO abatement alternatives and update the System-Wide LTCP.

In addition, based on comments provided by the Regulatory Agencies, the LTCP has been revised to include a Green Infrastructure Master Plan.



2012 1777-122

BUFFALO SEWER AUTHORITY
Long Term Control Plan Update

FIGURE 1-1
BSA SERVICE AREA

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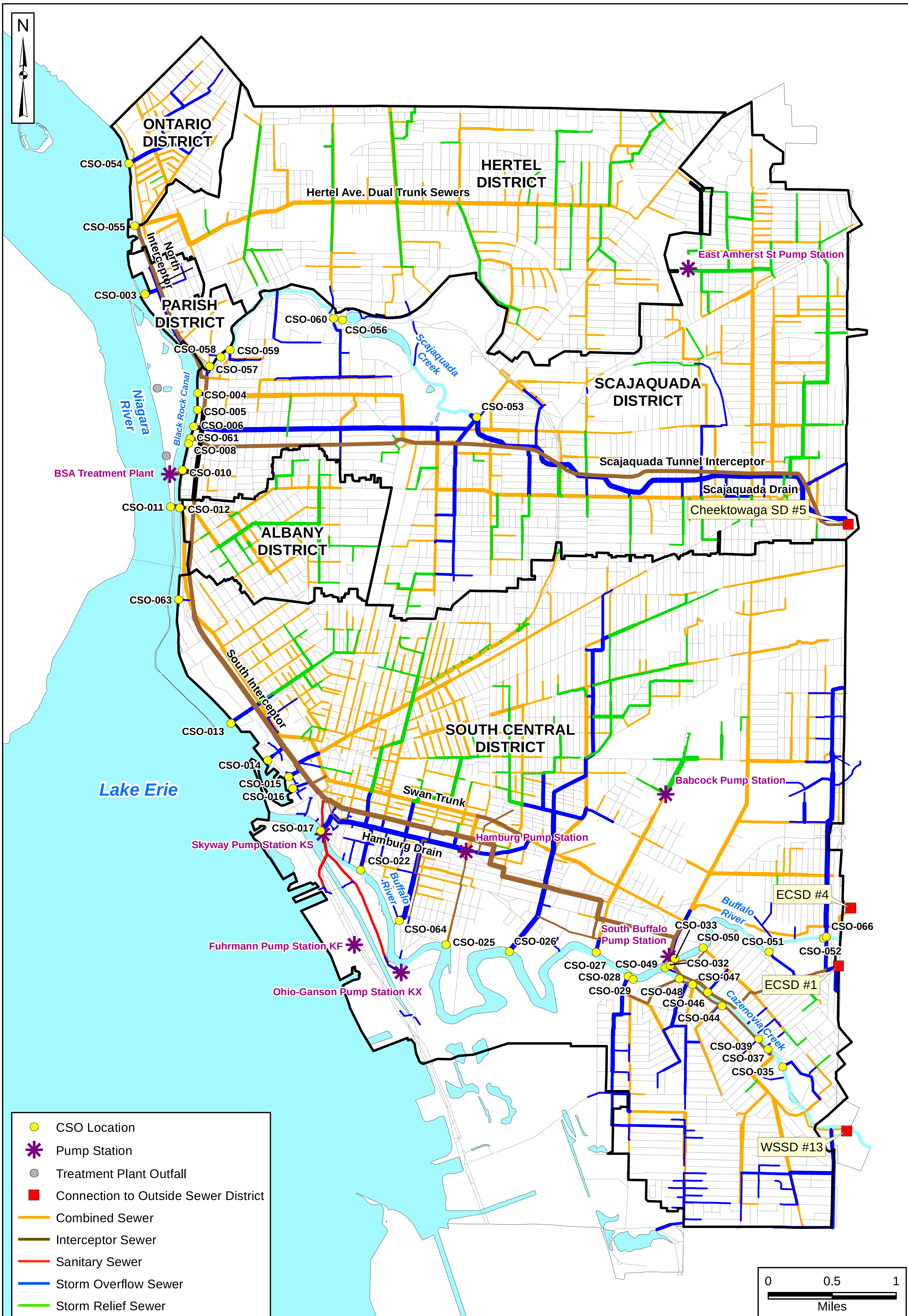

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BUFFALO SEWER AUTHORITY
Long Term Control Plan Update

FIGURE 1-2

BSA INTERCEPTORS AND CSOs

The LTCP described in this report is the culmination of all stages and phases of work. The end-goal of the project is to provide the BSA with an affordable CSO abatement program that complies with the USEPA CSO Control Policy and the NYSDEC guidelines and meets water quality goals.

1.2 Regulatory Context

The 1994 USEPA CSO Control Policy mandates that all municipalities that have CSSs with CSOs should undertake a process to:

- Accurately characterize their sewer systems;
- Demonstrate implementation of the Nine Minimum Controls (NMCs); and
- Develop a CSO LTCP.

As per the USEPA CSO Control Policy, the LTCP must address:

- Characterization, monitoring, and modeling of the CSS through collecting rainfall records, CSO and flow data, and modeling of the CSS;
- Public participation;
- Consideration of sensitive areas;
- Evaluation of alternatives;
- Cost and performance considerations;
- Operational plan;
- Maximization of wet weather flow conveyed to the existing WWTP;
- Implementation schedule; and
- Post-construction compliance monitoring program.

The BSA's SPDES permit, effective July 1, 2009, requires that the BSA develop a CSO abatement plan in accordance with the USEPA CSO Control Policy. Furthermore, the SPDES permit requires that implementation of BMPs be included in the LTCP.

1.3 Long Term Control Plan Development Process

The current project is the final phase of a three-phase process implemented by the BSA to develop its system-wide LTCP. Phase I consisted of the three stages and concluded with submittal of the 2004 LTCP to the NYSDEC. Phases II and III resulted from the NYSDEC and USEPA requesting additional evaluations and an update to the 2004 LTCP.

1.3.1 Phase I, Stage 1: System Mapping, Data Collection, and Model Development

The goal of Stage 1 was to create a consistent analysis tool to support evaluation of alternatives in Stage 2 and development of the LTCP in Stage 3. Stage 1 consisted of:

- System mapping/GIS Development;
- Field data collection; and
- Collection system model development and calibration.

System mapping and data collection occurred simultaneously. The product of the system mapping effort was a Geographic Information System (GIS) of the BSA's interceptor and trunk sewer system that served as the basis for the network of the system-wide collection system model. The product of the field data collection effort was a set of flow and precipitation data that were used in the calibration of the model, as well as water quality data that were used to perform an initial water quality assessment and calculate pollutant loadings to the receiving water bodies. The model development and calibration effort produced a consistent system-wide tool that was used in Stage 2 in the evaluation of CSO abatement alternatives.

1.3.2 Phase I, Stage 2: District-Specific CSO Planning

For Stage 2, the system-wide model developed in Stage 1 was separated into three Districts: the North District, the Scajaquada District, and the South Central District. Each District model was submitted to an independent District Consultant, who was responsible for evaluating and recommending CSO abatement alternatives in their local District. The end product of Stage 2 was a list of evaluated alternatives and recommended actions for each District.

1.3.3 Phase I, Stage 3: System-Wide LTCP Development

Stage 3 brought the District-specific alternatives into a system-wide comprehensive plan for CSO abatement. Each of the three District Consultants provided modeling files and a report summarizing alternatives for CSO abatement within each respective District. During Stage 3, four alternatives were developed, based on the District-specific recommendations as well as additional technologies.

The objective of Stage 3 was to develop and evaluate four system-wide alternatives, to establish system-wide control objectives, and to recommend the most economically-feasible alternative that meets those objectives. Stage 3 also included a financial capability assessment, and the development of an implementation schedule for the recommended alternative that considers BSA's financial capability.

1.3.4 Phase II LTCP Process

Phase II LTCP engineering consisted of additional evaluations requested by the NYSDEC and the USEPA following their review of the 2004 LTCP. This additional work began in 2008 and consisted of:

- Supplemental flow and rainfall monitoring;
- Receiving water quality sampling;
- Collection system model refinement;
- Receiving water quality model development; and
- Financial capability analysis revisions.

1.3.5 Phase III LTCP Analysis

The Phase III work used the tools generated or refined under Phase II to build upon the alternatives presented in the 2004 LTCP and incorporate innovative and emerging technologies into the alternatives analysis. This included updating the 2004 preferred system-wide alternative to meet the new NYSDEC interpretation of bacteria goals in the Class C receiving waters and using this alternative as a benchmark against other system-wide alternatives using innovative and/or emerging technologies such as real time control (RTC), green infrastructure (GI), and a new enhanced high-rate treatment (EHRT) treatment facility on Bird Island. Per USEPA's request, a system-wide tunnel alternative was also updated under this effort.

The results of the alternatives evaluation, along with the updated financial capability assessment, were used to select the recommended system-wide LTCP program for the BSA.

1.3.6 Agency Comments to the April 2012 LTCP

On December 6, 2012, the USEPA and the NYSDEC provided comments on the April 2012 LTCP, the two most significant of which requested that the BSA provide additional detail on their green infrastructure program and address the treatment plant more thoroughly, in particular, the treatment plant wet weather operations and primary effluent disinfection process. In response, the BSA has again revised the LTCP to address these comments. The BSA also developed and incorporated a Green Infrastructure Master Plan and revised the No Feasible Alternatives Analysis. In addition, as discussed in detail below, during this period the BSA also completed the remaining components of the approved public participation program.

1.4 Public Participation

The development of the system-wide LTCP includes public participation. A public participation plan was developed and this plan is included in Appendix 1-1. The public participation effort began during Stage 1 (of Phase I), with a public meeting on April 13, 2000 and several follow-up meetings with local focus groups, such as the Friends of the Buffalo River, Remedial Action Plan (RAP) committee, the Buffalo Industrial Advisory Council, and the Niagara River RAP committee. Stage 3 (of Phase I) continued the effort with a public meeting held on June 11, 2003. The purpose of the public meeting was to present the methodology being used to develop the 2004 LTCP, the range of alternatives that were being considered, and to provide the public with an opportunity and a forum to comment on the process. The June 11, 2003 meeting provided a summary of the Phase I, Stage 1 and 2 efforts and the proposed plan for Stage 3. Copies of the presentations for the April 13, 2000 and June 11, 2003 public meetings are included in Appendix 1-2.

As part of the 2004 LTCP development, the BSA participated in individual meetings with local focus groups and tributary communities to discuss CSOs and related issues, including:

- May 8, 2001 Buffalo River Advisory Committee
- May 31, 2001 Niagara River RAP
- January 3, 2002 Erie County Sewer Districts 1 and 4
- January 17, 2002 Town of West Seneca
- February 5, 2002 Town of Cheektowaga
- March 14, 2002 Town of Cheektowaga
- April 8, 2002 Town of West Seneca

Under Phase III, additional public participation activities were conducted to update the public on the project. A Stakeholder Panel was created to engage a group of key community leaders in the development and evaluation of CSO abatement alternatives and solicit their input on the community meeting agendas. The following Stakeholder Panel meetings were held:

- April 26, 2011 Introduction to the project
- May 19, 2011 Tour of WWTP
- January 18, 2012 Update and feedback from Round 2 Public Meetings
- April 25, 2012 Recommended Plan

Materials from the Stakeholder Panel meetings, including presentations and sign-in sheets, are included in Appendix 1-3. Additionally, project status update memorandums were provided to the Stakeholder Panel in lieu of meetings during the project duration. These memorandums are also included in Appendix 1-3.

In addition to the Stakeholder Panel, the BSA met with several smaller focus groups. These meetings included:

- March 18, 2011 Buffalo Niagara Riverkeeper (environmental group)
- June 24, 2011 Tributary Municipality group
- October 6, 2011 Hamlin Park Community & Taxpayers Association (community/block club group)
- July19, 2011 Buffalo Niagara Enterprise (business community)

Materials from the focus group meetings held to date are included in Appendix 1-4.

In addition to these formal meetings, BSA management has held numerous informal meetings with a wide variety of stakeholders.

In accordance with the Public Participation Plan (Appendix 1-1), three rounds of public meetings were considered in support of the LTCP Update. Each round consisted of three meetings held at various locations. The first round of community meetings was held at three different locations throughout the City in early May 2011 and presented an overview of the project and overall LTCP process, including project drivers and goals. The second round of meetings was also held at three different locations to present the alternatives evaluated; these meetings were held in early December 2011. Supporting documentation for the first two community meetings (presentations, meeting minutes, sign-sheets, etc.) is included in Appendix 1-5. Because the BSA had been ordered by the USEPA to submit the LTCP by April 30, 2012, the results of the third round of public meetings, held during the month of May 2012, were not included in the April 2012 LTCP, but are summarized in this LTCP below

The BSA also created a project website for the LTCP Update; the website address is www.bsacsoimprovements.org. The project website presented information about the BSA's system, educational materials on combined sewer systems and regulations, and the LTCP project history. The project website also served as a platform for public participation efforts including public meeting notices, presentations and question and answer summaries from the public meetings. The public were also able to submit questions on the project to the BSA using a project-specific email address. Supporting materials for the project website and responses to project emails are provided in Appendix 1-6.

Following submittal of the April 2012 LTCP, the BSA continued with the public participation program by initiating the 30-day public comment period for the LTCP and conducting the third round of public meetings in May 2012. Additional public outreach activities in support of the LTCP included:

- Issuing a public legal notice in the Buffalo News that announced the 30-day public comment period, the availability of the LTCP document, and the public meetings (issued three times starting May 4, 2012).

- Issuing a news release on the public meetings to the weekly papers in each district and to the Buffalo News.

- Posting the LTCP document, as well as the public meeting notices, on the BSA CSO LTCP project web site (www.bsacsoimprovements.org).

- Providing hard copies for public review at the Central Branch of the Erie County Library, the Office of the City of Buffalo Clerk, and the BSA's office.

- Releasing the notice to various email distribution lists, including the Office of Strategic Planning (and their Green Code listserv of more than 1,200 addresses), the Buffalo Niagara Riverkeeper, Council district offices, chambers of commerce and business associations, Buffalo Place (a weekly email), etc.

- Issuing the public meeting notices to the City's Office of Strategic Planning that targeted outreach to community based organizations, block clubs, business districts, etc., in each district where the meeting was being held.

- Conducting three public meetings, located throughout the City, to present the recommended plan to the public.

The supporting documentation for the public notice and the third round of public meetings in included in Appendix 1-7. Appendix 1-7 also includes a copy of the presentation

There were over 60 attendees total for the three public meetings, which was greater attendance than at the first two rounds. Furthermore, traffic on the BSA's LTCP website also showed an increased interest during the public comment period. The website received 432 visits from April 30 through June 4, compared to only 241 visits during the previous month.

During the 30-day public comment period, the BSA received several comments on the April 2012 LTCP, which are included in Appendix 1-8. A summary of the questions and comments received at the public meetings is also included in Appendix 1-8. Overall, the comments were supportive of the recommended plan and suggest that the public is particularly pleased with the green infrastructure components of the plan. Other than the obvious financial affordability questions, the only significant concern raised was by the Buffalo Niagara Riverkeeper (BNRK), who in a letter to the BSA dated May 15, 2012, urged the BSA to substitute an enhanced green infrastructure commitment in lieu of construction of certain off-line storage tanks. This position was also echoed by representatives of the BNRK at each of the three public meetings. After careful consideration of the BNRK comments and suggested approach, the BSA declined to revise the LTCP to include the additional green infrastructure proposed by the BNRK. However, in keeping with the BNRK's request, the BSA indicated a willingness to substitute additional green solutions for gray should green performance over time justify such additional substitutions. These substitutions will be subject to Regulatory Agency review and approval as outlined in the USEPA Administrative Order dated March 15, 2012.

1.5 Organization of this Document

This LTCP is an update of the original 2004 LTCP document and as such retains the overall organization and majority of the information provided in the original report. Most of the 2004 LTCP sections were updated as necessary to include the new information developed during Phases II and III, and to reflect the Agencies' comments on the April 2012 submittal. The LTCP is organized into the following sections:

- **Section 1 Introduction** summarizes the objectives of the study, regulatory context, LTCP development phases, and public participation.
- **Section 2 Study Area Description** provides a history of the BSA, the Bird Island WWTP and collection system, service area and tributary communities, and the environmental conditions in the City of Buffalo that affected the evaluation of CSO abatement alternatives.
- **Section 3 Relevant Findings from Previous Work** summarizes the significant findings and deliverables produced in the previous phases of the LTCP project (prior to the 2004 LTCP report).

- **Section 4 Additional Monitoring and Modeling Under Phase II LTCP Engineering** presents the sewer system monitoring program, collection system model validation, receiving water quality sampling program, and the development of the water quality model.

- **Section 5 Implementation of Best Management Practices** formally outlines the BSA's current programs and activities being performed to implement the NMCs and BMPs.

- **Section 6 Control Objectives** describes the methodology used to determine the general water quality, receiving water body, and CSO control objectives, for alternative development and evaluation. This section also includes a summary of the watershed recreational use study conducted under Phase 2 and presents the receiving water quality model results for existing conditions.

- **Section 7 Screening of Combined Sewer Overflow Control Technologies** describes the specific alternatives that were developed and evaluated, the methodology used in the analysis, the technology considered, screening process, and unit pricing.

- **Section 8 Bird Island Wastewater Treatment Plant** summarizes the operational changes that will be in effect when the LTCP is implemented as a direct result of on-going process studies and construction projects at the WWTP. Wet stream improvements implemented since the 2004 LTCP are also presented, along with an updated evaluation of the primary and secondary system capacity evaluations. A summary of the evaluations and the recommended improvements to maximize wet weather flow treatment at the WWTP is also presented.

- **Section 9 Development of System-Wide Improvement Alternatives (2004)** combines the specific alternatives along with the baseline conditions after taking into account on-going improvement projects, and summarizes the methodology used to develop the four system-wide alternatives. This section also summarizes the results of the model simulations for each of the four alternatives, and compares the benefit of implementing each alternative in terms of percent capture of CSO volume, CSO activation frequency, and affordability/ cost-effectiveness.

- **Section 10 Evaluation and Selection of Preferred System-Wide Alternative (2004)** summarizes the alternative screening process used for selection of the preferred system-wide LTCP (2004). The criteria selection and scoring process and components of the preferred system-wide LTCP are presented. The 2004 preferred alternative was updated under Phase III to address the new NYSDEC interpretation of bacteria goals in Class C receiving streams.

- **Section 11 Additional Alternative Evaluations Under Phase II and Phase III Engineering** presents the additional system-wide alternatives evaluated during Phases II and III. This includes the updated analytical and reporting approach and the cost-benefit and non-economic evaluations of the alternatives that lead to selecting the preferred system-wide alternative.

- **Section 12 Selected LTCP** presents the recommended approach for the BSA's compliance with the USEPA's CSO Policy and the projects comprising the selected plan. Additionally, Section 12 also presents the BSA's Green Infrastructure Master Plan.

- **Section 13 Affordability Screening and Financial Capability Assessment** presents a summary of an evaluation of the financial capabilities of the BSA and City of Buffalo residents following USEPA guidance. A detailed report by CRA is included in the LTCP appendices.

- **Section 14 Implementation Schedule** presents the recommended implementation approach for the projects that comprise the selected LTCP.

- **Section 15 Post-Construction Monitoring Program** presents the outline for the development and implementation of a post-construction monitoring plan. The detailed PCM will be developed within one calendar year from the Agencies' approval of this LTCP.

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2. Study Area Description

This section describes the BSA LTCP study area, the BSA organization, the area's environmental conditions, and City of Buffalo demographics.

2.1 Buffalo Sewer Authority

The purpose of forming the BSA was to have an entity responsible for the collection and treatment of wastewater generated within the City of Buffalo. This section describes the BSA's:

- History
- Bird Island Wastewater Treatment Plant
- Service area and collection system
- Tributary communities
- Receiving water bodies
- Service area Districts

2.1.1 History

The City of Buffalo developed at the terminus to the Erie Canal, which during its peak, brought industry and commerce to the area. At the turn of the nineteenth to twentieth century, grain and lumber mills, and iron, coal, steel and petroleum manufacturing facilities developed along the Buffalo River. Communities developed around the industries, and the population of Buffalo grew rapidly until the 1950s, peaking at over 580,000 people. The construction of the St. Lawrence Seaway in the 1950s however, resulted in a significant decrease in shipping and ultimately led to the closure of many industries in the area. Along with the closures of industries came the start of a steady decline in population that has continued to decline until the present day; census data for 2010 estimates the population of Buffalo to be at 261,310 people. This is a 25,000-person reduction since the 2004 LTCP document was prepared.

As the City developed initially, the Niagara River was used as an economical and convenient means of disposal for the community's sewage. As the City continued to grow, a sewer system was gradually constructed to carry combined sewage and storm water to the Buffalo River, Scajaquada Creek, and Black Rock Canal, in addition to the Niagara River. Untreated sewage was discharged directly into these water bodies at several points throughout the City. As the City grew, so did the volume and concentration of sewage discharged to the receiving water bodies. The health of the receiving water bodies and the surrounding environment became severely threatened.

In 1882, the Swan Trunk sewer was constructed to intercept wastewater flows conveyed to the Hamburg Drain from the North. Those flows were redirected via the Swan Trunk sewer to the Niagara River at the tip of Bird Island.

In the 1890s, it became apparent that pollution from the City of Buffalo to the Niagara River was principally responsible for typhoid cases in areas downstream of the City. In part, as a result of pollution in the Niagara River, the Boundary Water Treaty of 1909 between the United States (US) and Canada was drafted, mandating that the boundary waters would not be polluted by either party to the injury of health or property of the other. The treaty also established the International Joint Commission (IJC), the purpose of which was to investigate boundary water quality and use, as well as to assist the US and Canadian governments in finding solutions to boundary water quality problems.

During IJC investigations between 1909 and 1918, serious bacterial pollution in the Niagara River was noted, and gross contamination of the Buffalo River, Buffalo Harbor, and Black Rock Canal first became evident. However, implementation of remedial action to improve water quality was impeded by World War I and, subsequently, by the Great Depression.

By the 1930s, approximately 45 percent of the total volume of sewage discharged from the City entered the Niagara River from the Swan Trunk sewer, 15 percent entered the Niagara River from the Hertel Avenue sewer, and 25 percent entered the Niagara River from the Bird Avenue sewer via the Black Rock Canal, with the remaining 15 percent discharged from other smaller discharge locations into local water bodies. The Niagara River was receiving approximately 39 million gallons per day (MGD) of raw sewage, with a coliform count that ranged from 50,000 to 300,000 per milliliter (mL), resulting in septic conditions in the Black Rock Canal and Niagara River. Bacterial pollution of the waterways was evident 17 miles downstream of the City of Buffalo.

Due to the documented deteriorating conditions of these waterways, the New York State Department of Health (NYSDOH) issued a mandate in 1934 to create the BSA and begin the process of collecting and treating the wastewater then tributary to the local waterways.

2.1.2 Bird Island Wastewater Treatment Plant

Immediately after the establishment of the BSA, a primary wastewater treatment plant at Bird Island (consisting of coarse and fine screening, grit removal, primary clarifiers, and disinfection) was constructed and began operation on July 1, 1938. Pump stations were constructed throughout the City to collect and transmit wastewater to the Bird Island treatment plant: the South Buffalo Pump Station was built in 1938, the Hamburg Street Pump Station was built in 1939, and the East Amherst Street Pump Station was built between 1948 and 1949.

Intercepting sewers to convey flow to the WWTP were constructed between 1936 and 1939. The initial interceptors were designed to convey 560 MGD to the Bird Island WWTP and varied in geometry (including circular, horseshoe, and elliptical) and in size, from (3 feet (ft.) to 11.5 ft). The terminus of the intercepting sewers is located at the foot of Breckenridge Street on the mainland side of the City across the Black Rock Canal from the WWTP. The terminus of the collection system consists of two 8-ft. diameter concrete inverted siphons that convey wastewater under the Black Rock Canal to the WWTP.

In response to the escalating pollution of natural bodies of water nationwide, the federal government passed the Clean Water Act in 1972. This act requires that wastewater treatment plants operate with a secondary, or biological, treatment system. To comply with the Clean Water Act, secondary treatment facilities were added at the Bird Island WWTP between 1975 and 1979.

Recent major additions to the BSA collection system occurred in 1981 with the construction of the Kelly Island Sanitary Sewer System. This system is comprised of separate sanitary sewers and three pump stations which allowed the connection of 15 industrial facilities that had previously discharged directly to the Buffalo River to convey wastes to the collection system for treatment at the WWTP.

The most recent major addition to the collection system occurred in 1983 with the construction of the Scajaquada Tunnel Interceptor Project. This five mile tunnel crosses the City of Buffalo and conveys wastes from the Town of Cheektowaga and 5,000 acres within the City of Buffalo to the North Interceptor sewer for conveyance to and treatment at the WWTP.

Today, the BSA WWTP is the second largest wastewater treatment plant in New York. Improvements and upgrades to the plant are ongoing and over $30 million of capital investments have been made in the plant in the past ten years. The BSA currently provides secondary wastewater treatment with an average daily design capacity of 180 MGD. As detailed in Section 8, the theoretical flow capacity of 560 MGD receives only primary treatment. However, due to an existing hydraulic restriction (mainly in the primary bypass chamber), the BSA historically has not been able to maintain flows greater than approximately 250 to 280 MGD to the secondary system, with the remainder of wet weather flows up to 560 MGD going through primary treatment and disinfection. Additionally, influent flows in excess of 520 MGD activate overflows at outfall 01A (located upstream of the plant headworks). Ongoing WWTP improvement efforts will increase the hydraulic capacity of the secondary system to 320 MGD for a total plant peak flow capacity of 560 MGD.

2.1.3 Service Area and Collection System

The City of Buffalo sewer system consists of combined sewers, separate sanitary sewers, and separate storm sewers, along with four main pump stations: South Buffalo, Hamburg Street, East Amherst Street, and Babcock Street. There are three other pump stations associated with Kelly Island. In total there are more than 850 miles of sewers, 790 miles of which are combined. Collection system construction has been ongoing for over 175 years. Approximately 60 percent of the sewers were constructed prior to 1910 and only 8 percent have been installed since 1941. Sewers built before 1930 are primarily constructed of brick and stone, vitrified tile, or segmented block. Those sewers built since 1930 are primarily reinforced concrete or PVC.

Wastewater collected in the City of Buffalo and a number of surrounding tributary communities is conveyed for treatment to the WWTP via two reinforced concrete intercepting sewers built in the 1930s: the North Interceptor and the South Interceptor. The North Interceptor begins at the intersection of Niagara Street and Ontario Street at Cornelius Creek and runs to the Black Rock Canal siphon crossing at the intersection of Breckenridge and Niagara Streets. Major trunk sewers tributary to the North Interceptor are the Hertel Avenue sewers, Bird Avenue sewer, and the Scajaquada Tunnel Interceptor. The South Interceptor begins at the South Buffalo Pump Station and runs to the Black Rock Canal siphon opposite the WWTP. Major facilities tributary to the South Interceptor include the Babcock Street sewer, Swan Trunk sewer, Hamburg Street Pump Station, and the Kelly Island Pump Station. Prior to the construction of the South Interceptor, the Swan Trunk Interceptor carried all wastewater generated in the central and southern portions of the City. When the South Interceptor was constructed, the majority of the flow from the central and south portions of the City was diverted to the new interceptor. The Swan Trunk sewer was subsequently connected to the South Interceptor after flowing through a SPP at its downstream end at the foot of Albany Street.

Typical in all combined systems, regulators, designed to convey dry weather flows to the treatment plant and divert excess flows to under-capacity parts of the system or directly to receiving water bodies, were built into the collection system as relief points designed to protect the WWTP and to prevent basement flooding during wet weather. There are more than 240 regulators, referred to as Sewer Patrol Points (SPPs), throughout the BSA's collection system. Additionally, there are 52 permitted CSO outfalls that discharge directly to the receiving water bodies. Weirs or orifice plates within the SPP chambers are generally designed to permit overflows at two to three times dry weather flow. Several outfalls along the Buffalo River are often submerged and some are equipped with backwater gates.

2.1.4 Tributary Communities

As shown on Figure 1-1, the BSA receives and treats wastewater from tributary communities that are outside the corporate limits of the City. Average flow for these communities for 2009-2010 is summarized in Table 2-1. Table 2-1 also presents the peak flow contributions included in the hydraulic model for each larger-sized tributary community. These peak flow values represent the current contractual limits set between the BSA and the individual municipalities and may not represent the actual peak flow that can potentially enter the BSA system with one exception. The peak flow associated with Erie County Sewer District (ECSD) No. 4 is based on the calculated full capacity of the 66-inch sewer between ECSD No. 4 and the BSA collection system, as agreed to between the BSA and Erie County dated July 27, 1972. The BSA has agreements with each of the communities for treatment services of sanitary sewage conveyed to the WWTP. The communities are charged by the BSA based on annual flows. It should be noted that each of the tributary communities under contract for the treatment of wastewater flows by the BSA, own, operate, and maintain their own separate sanitary sewer system.

Table 2-1.
Tributary Community Summary

Tributary Community	Average Flow to BSA 2009-2010	Peak Modeled Flow
Erie County[1]		
Sewer District #1	5.6 MGD	20 MGD
Sewer District #4	13.4 MGD	37.4 MGD
Town of Cheektowaga[2]		
Cochrane Street Sewer District	1,617 gpd	(5)
Town Consolidated Sewer Districts	10.5 MGD	49 MGD
Town of West Seneca		
Sewer Districts 5 and 13[3]	6.9 MGD	13 MGD
Sewer District Resident[4]	0.5 MGD	(5)
Village of Sloan[4]	0.3 MGD	(5)

Source:
1. Email communication with Erie County Department of Environment & Planning, 8/12/2011
2. Telephone communication with William Pugh, Town of Cheektowaga Engineer, 8/16/2011. Note that Cochrane Street Sewer District is billed based on a formula of 0.14 cfs, which is a pro-rated capacity of the pipe, serving 15 to 20 homes only.
3. Email communication with Rick Henry of Clark Patterson (Town Engineer), 8/22/2011
4. Small districts – flow assumed to be the same as in the past.
5. Peak flows are deemed to be inconsequential from these communities.

Out of these tributary communities, only the connection for the Cheektowaga Cochrane Street Sewer District was not explicitly represented in the collection system model. This connection was not included in the model due to the low magnitude of the flow.

2.1.5 Receiving Water Bodies

The receiving water bodies that may be affected by CSOs in the BSA's collection system are:

- Niagara River;
- Black Rock Canal;
- Scajaquada Creek;
- Buffalo River;
- Cazenovia Creek;
- Cornelius Creek; and
- Erie Basin Marina.

For the purposes of the evaluations conducted as part of the earlier phases of the LTCP project, the BSA's collection system was divided into three Districts based on sewer service areas and the watersheds that drain to these receiving water bodies listed above. These three Districts are:

- North;
- Scajaquada; and
- South Central.

Section 3.2.2 presents a description of the North District. Section 3.2.3 presents a description of the Scajaquada District. Section 3.2.4 presents a description of the South Central District. This section presents a summary of the receiving water bodies relevant to the development of the BSA's LTCP.

2.1.5.1 Niagara River

The Niagara River begins at the terminus to Lake Erie and flows north to Lake Ontario. The river is 37 miles long and provides 83 percent of the tributary flow to Lake Ontario. The watershed on the US side of the Niagara River has a drainage area of approximately 1,225 square miles (sq mi). There are several tributaries to the river from the watershed on the US side near the City of Buffalo: Scajaquada Creek, Two Mile Creek, Tonawanda Creek, Cayuga Creek, and Gill Creek. Smokes Creek and the Buffalo River also discharge into Lake Erie at its outlet at the Niagara River. Of these tributaries, only the Buffalo River and Scajaquada Creek lie within the BSA service area. Although both Smokes Creek and the Buffalo River discharge into the Niagara River at Lake Erie, their plumes tend to stay on the eastern lake shore due to strong currents and a prevailing southwesterly wind, with little cross mixing.

Lake Erie and the Niagara River are used as sources of municipal water supply in Buffalo and downstream communities in the US and Canada, supplying water to more than 1,000,000 people. Eight active US water intakes are located along the river's east and west channels. A number of industrial users also use the river as a water supply, mostly for cooling purposes. There are 17 Significant Industrial Users (SIUs) in Buffalo that have permits allowing discharges to the Niagara River and its tributaries, and nine major US wastewater treatment plants that discharge into the river and its tributaries.

The section of the river from Buffalo downstream to Niagara Falls is used for boating, recreational fishing, swimming, and commercial bait dipping. Also, a number of state, county, and municipal park and wetland areas are located along the shoreline.

Water quality sampling has been conducted by the NYSDEC for a number of years at two locations on the Niagara River: Fort Erie at the head of the Niagara River, and Niagara-on-the-Lake at the river's terminus. Sampling results have shown that the percentage of contaminants in the Niagara River entering from Lake Erie varies considerably over time. Data also shows that loadings of priority pollutants discharged to the river have been steadily decreasing as wastewater treatment by municipalities and the quality of industrial discharges have improved, and as industries have shut down.

2.1.5.2 Black Rock Canal

Due to the strong currents in the Niagara River, the Black Rock Canal was built to allow safe navigation between the Buffalo Harbor and Tonawanda Harbor. The Black Rock Canal lies adjacent to the western shoreline of Buffalo and is formed by a breakwater that separates it from the Niagara River. The breakwater ends at the southern tip of Bird Island, which then extends the canal northward to the United States Army Corps of Engineers' (USACE) locks at the northern end of Squaw Island. The canal is roughly 19,000 ft long, and water levels in the canal are controlled by the locks. Flow in the canal can occur in either direction. The canal is used by both commercial shipping and leisure crafts.

2.1.5.3 Scajaquada Creek

Scajaquada Creek originates in the Town of Lancaster and flows west through the Town of Cheektowaga and the City of Buffalo to its outfall at the Black Rock Canal. The creek is approximately 15 miles long. The total drainage area is approximately 29 sq. mi. in Erie County, of which 16 sq. mi. lie outside the city limits. From Pine Ridge Road, 800 ft. east of the city line in Cheektowaga, the creek runs through a 19,000 ft. long, 14.75-ft. by 29.5-ft. rectangular arch called the Scajaquada Drain. From the end of the drain the creek daylights and continues for approximately three miles through Forest Lawn Cemetery and Delaware Park to its mouth. Typically flow bypasses Hoyt Lake, located within Delaware Park downstream of Forest Lawn Cemetery through a set of bypass conduits designed to convey up to 455 MGD. At higher flows, flow can overflow into Hoyt Lake at the upstream end of the bypass conduits. A diversion and trash rack structure was built at the downstream end of the Drain at Main Street to direct wet weather flows up to 455 MGD into the Delevan Avenue trunk sewer to protect Hoyt Lake from pollution and to maintain base flow in Scajaquada Creek. Consequently, flows in excess of 910 MGD from the Scajaquada Creek basin may overflow into Hoyt Lake.

2.1.5.4 Buffalo River

The Buffalo River drains an area of approximately 446 sq. mi., 4.4% of which is located within the City limits. The gradient of the river is slight, less than one foot per mile. During periods of mean or low flows, the downstream end of the river is influenced by lake level variations and has an estuarine character. The Buffalo River is a navigable waterway and is maintained by the USACE for lake vessel access by dredging from its mouth to a point just downstream of the confluence between the Buffalo River and Cazenovia Creek. The Buffalo River is dredged to a depth of 22 feet below low lake level datum. During the summer months, the river water is warm relative to lake water, and therefore less dense, resulting in the river water flowing on top of the cooler, denser lake water. This results in stratification in the water at the confluence of the river to the lake. In the fall, the situation can be reversed, with the river water being cooler and denser and flowing below the lake water.

The river is six miles long from its mouth at Lake Erie to its confluence with Cazenovia Creek. Most of Buffalo's heavy industry was formerly clustered along this reach of the river. Upstream of the confluence with the creek, the river largely flows through residential and undeveloped areas. At the city line, the river is relatively wide (ranging between approximately 200 ft and 300 ft) and is relatively shallow. Approximately one-fifth of the city's land area lies south of the Buffalo River.

The whole Buffalo River basin provides a variety of fish habitat, including brook trout, salmon, black bass and northern pike. However, due to its heavy use by industry, the Buffalo River has been the subject of numerous water quality studies throughout the years, and fishing in the river has been limited by a fish consumption advisory issued by the NYSDOH.

The Buffalo River Improvement Corporation (BRIC) was formed in the late 1960s to improve Buffalo River water quality. The BRIC has implemented a program to augment flow in the river by supplying water from the Buffalo Harbor to five major industries along the river for process and cooling water purposes. The BRIC system was designed to supply 120 MGD to industries.

2.1.5.5 Cazenovia Creek

The Buffalo River is fed by three tributaries: Cayuga Creek, Cazenovia Creek, and Buffalo Creek. Only Cazenovia Creek lies within BSA's service area, and therefore, is included in the LTCP study.

Cazenovia Creek joins the Buffalo River approximately 6 miles upstream of Lake Erie. The creek drains 138 sq mi (0.8% of the watershed lies within the City of Buffalo limits) and runs through woodlands, small residential communities and recreational areas. Approximately 2.25 miles of the creek are within the City limits. The creek joins the Buffalo River just west of Bailey Avenue Bridge. Stretches of the creeks are stocked with fish.

2.1.5.6 Cornelius Creek

Cornelius Creek once flowed through North Buffalo, along a path roughly following Hertel Avenue. As development began to occur in North Buffalo, Cornelius Creek was replaced by the first Hertel Avenue trunk sewer in the late 1880's and by the second Hertel Avenue trunk sewer in the late 1920's. With the construction of the North Interceptor in the 1930's, the Hertel trunk sewers were connected to the interceptor system to allow conveyance of flows to the WWTRP. Consequently, what remains of Cornelius Creek is its discharge into the Niagara River at the Ontario Street Boat Launch at the foot of Ontario Street, as CSO Outfall 055.

2.1.5.7 Erie Basin Marina

Lake Erie is the shallowest and smallest by volume of the Great Lakes, and as a result, the lake warms relatively quickly in the spring and summer and cools quickly in the fall. During winter, a large percentage of the lake is covered with ice, and occasionally freezes over completely.

The lake is naturally divided into three basins. The central basin is relatively uniform in depth, with an average depth of 60 ft and a maximum depth of 82 ft. The eastern basin is the deepest, with an average depth of 82 ft and a maximum depth of 210 ft. The central and eastern basins of the lake thermally stratify every year, but stratification in the shallow western basin is rare and brief, if it does occur. Stratification impacts the internal dynamics of the lake physically, biochemically, and chemically.

Erie Basin Marina is located at the eastern end of the lake, near where the Lake Erie flows into the Niagara River. Currently, this area is used heavily in the summer as the base for boating, sightseeing, walking, and sunbathing.

2.2 Environmental Conditions

A CSO LTCP addresses a number of collection system issues, but focuses on the response of the system to wet-weather conditions. Therefore, environmental conditions in the City of Buffalo are important to the LTCP development process, especially in terms of the hydrology of the study area. The hydrology of the study area has a controlling influence on the development of the projects modeling tools, with the following parameters being important to the process:

- Climate;
- Topography;
- Geology; and
- Soils.

The September 2001 Model Calibration Report describes subcatchment and hydrologic parameter development. This section presents an overview of the environmental conditions in the city that affect hydrologic model development.

2.2.1 Climate

Buffalo's weather is varied and is affected to a significant degree by its proximity to Lake Ontario and Lake Erie. Prevailing winds are from the southwest, blowing over Lake Erie before reaching the City. Annual precipitation is moderate and fairly evenly divided throughout the year, with high intensity rainstorms occurring in the summer months. Spring is typically cool and cloudy, summer dry and sunny, and autumn typically has long dry periods. The first frosts generally occur in mid-October and snowfall begins in November or December. Temperatures in the winter months generally remain below freezing, but seldom drop below zero degrees Fahrenheit, while in the summer months, rarely reach above 90 degrees Fahrenheit.

During the model development and calibration effort completed in 2001, Malcolm Pirnie obtained meteorological data for May 1969 through December 1999 from the National Weather Service (NWS) station at the Buffalo Niagara International Airport, located in Cheektowaga. These data were used to determine typical monthly and annual precipitation statistics, from which a "typical year" was selected. Average yearly and average monthly rainfall conditions for the Buffalo metropolitan area were determined and statistics for each event were computed, including depth, duration, average, and maximum intensity. Rainfall events were specified as being separated by a minimum of 6 hours of dry weather. Precipitation data for 1986, with some adjustments, were selected as the basis for the typical year hyetograph that was used to characterize the system in the 2001 Model Calibration Report and to support the alternatives evaluation in the 2004 LTCP.

At the request of the USEPA, the typical year was reevaluated by including more recent precipitation data from 2000 to 2010, while also going back further to analyze data back to 1948, the earliest year for which hourly data was available. Sixty-two years of data with a total of 9,556 rainfall events were analyzed. The month with the greatest amount of rainfall was November, with an average of 3.77 inches of rainfall per year. The month with the smallest average amount of rainfall was February, with an average of 2.33 inches per year. Table 2-2 presents the analytical results for 1948 through 2010. Table 2-3 presents the monthly precipitation averages for the same period.

Initially, the USEPA proposed the following cumulative frequency analysis approach for selecting the typical year hyetograph:

- Conduct an initial screening of the 1981-2010 rainfall years to identify those years where the rainfall meets the following criteria:
  - Annual volume within -5% to +10% of annual normal rainfall for the years 1981-2010; and
  - Annual number of rainfall events of at least 0.05" within -10% to +10% of average number of events of the years 1981-2010.
- For the years that make it through the initial screening, sum up the absolute deviations between calculated cumulative frequency distributions for the 1981-2010 period and each candidate year for the following parameters:
  - Event Peak Hourly Rainfall; and
  - Total Event Rainfall.
- Rank the candidate years based on the peak hourly rainfall absolute deviations;
- Rank the candidate years based on the total event rainfall absolute deviations; and
- Identify the year with the highest peak hourly rainfall deviation ranking that is also within the Top 6 for total event rainfall deviation ranking.

Table 2-3.
Monthly Precipitation Averages using the Revised 1948 – 2010 Precipitation Dataset

Months	Monthly Average Precipitation (inches)	Monthly Precipitation Events (number)	Event Average Total Precipitation (in)	Event Average Duration (hr)	Event Average Intensity (in/hr)
January	2.79	17	0.16	8.6	0.02
February	2.33	15	0.16	8.1	0.02
March	2.74	14	0.20	8.0	0.02
April	2.94	13	0.23	7.5	0.03
May	3.11	12	0.27	6.8	0.04
June	3.10	11	0.28	5.0	0.06
July	2.99	10	0.30	4.5	0.07
August	3.68	11	0.36	4.9	0.07
September	3.61	10	0.35	6.4	0.06
October	3.18	11	0.29	7.3	0.04
November	3.77	14	0.27	8.7	0.03
December	3.31	17	0.20	8.2	0.02
TOTAL (ANNUAL)	37.56	156	NA	NA	NA

Based on a review of the approach developed by the USEPA and the initial results, the following enhanced version of the approach was applied:

- Use the initial screening criteria proposed by the USEPA;
- For the years that make it through the initial screening, sum up the absolute deviations between calculated cumulative frequency distributions for the 1981-2010 period and each candidate year for the following parameters:
  - Event Peak Hourly Rainfall; and
  - Total Event Rainfall.
- Rank the candidate years based on the peak hourly rainfall absolute deviations;
- Rank the candidate years based on the total event rainfall absolute deviations;
- Rank the candidate years based on the monthly rainfall absolute deviations;

Table 2-2 Buffalo-Niagara International Airport NWS Rainfall Analysis
Yearly Totals 1948 - 2010

Year		Number	Total	Minimum	Maximum	Average
1948	Duration	85	627	1	40	7.38
	Intensity	85	11.69	0.01	1.02	0.14
	Volume	85	26.72	0.01	2.12	0.31
	Months	8	26.39	1.1	5.74	3.30
1949	Duration	136	959	1	41	7.05
	Intensity	136	14.74	0.01	1.19	0.11
	Volume	136	36.54	0.01	2.72	0.27
	Months	12	36.87	1.17	6.35	3.07
1950	Duration	153	1062	1	50	6.94
	Intensity	153	10.55	0.01	0.86	0.07
	Volume	153	33.84	0.01	2.27	0.22
	Months	12	33.82	0.01	5.02	2.82
1951	Duration	153	1175	1	43	7.68
	Intensity	153	14.38	0.01	0.79	0.09
	Volume	153	37.75	0.01	1.66	0.25
	Months	12	37.75	1.36	4.57	3.15
1952	Duration	143	938	1	38	6.56
	Intensity	143	9.83	0.01	0.51	0.07
	Volume	143	29.14	0.01	1.7	0.20
	Months	12	29.14	0.68	3.91	2.43
1953	Duration	143	967	1	46	6.76
	Intensity	143	13.81	0.01	1.67	0.10
	Volume	143	35,88	0.01	2.44	0.25
	Months	12	35.88	0.32	6.4	2.99
1954	Duration	161	1279	1	55	7.94
	Intensity	161	14.9	0.01	0.69	0.09
	Volume	161	44.78	0.01	2.45	0.28
	Months	12	44.78	1.35	9.13	3.73
1955	Duration	162	1146	1	46	7.07
	Intensity	162	13.43	0.01	0.69	0.08
	Volume	162	39.79	0.01	3.13	0.25
	Months	12	33.79	0.11	8.12	3.32
1956	Duration	162	1125	1	29	6.94
	Intensity	162	16.28	0.01	0.98	0.10
	Volume	162	41.93	0.01	2.09	0.26
	Months	12	41.93	0.86	5.89	3.49
1957	Duration	138	1019	1	42	7.38
	Intensity	138	13.28	0.01	0.56	0.10
	Volume	138	38.69	0.01	2.76	0.28
	Months	12	38.69	1.11	5.3	3.22
1958	Duration	161	1194	1	68	7.42
	Intensity	161	12.04	0.01	0.77	0.08
	Volume	161	34.39	0.01	1.77	0.21
	Months	12	34.39	1.39	4.75	2.87

Table 2-2 Buffalo-Niagara International Airport NWS Rainfall Analysis
Yearly Totals 1948 - 2010

Year		Number	Total	Minimum	Maximum	Average
1959	Duration	142	1198	1	55	8.44
	Intensity	142	14.5	0.01	1.12	0.10
	Volume	142	42.81	0.01	2.84	0.30
	Months	12	42.81	1.94	6.47	3.57
1960	Duration	160	1172	1	59	7.33
	Intensity	160	12.39	0.01	0.62	0.08
	Volume	160	35.16	0.01	1.71	0.22
	Months	12	35.16	1.2	5.8	2.93
1961	Duration	161	1143	1	36	7.10
	Intensity	161	14.51	0.01	1.01	0.09
	Volume	161	37.1	0.01	1.77	0.23
	Months	12	37.1	1.41	5.95	3.09
1962	Duration	157	1060	1	49	6.75
	Intensity	157	10.66	0.01	0.83	0.07
	Volume	157	28.55	0.01	2.5	0.18
	Months	12	28.55	1.22	3.14	2.38
1963	Duration	156	1031	1	53	6.61
	Intensity	156	12.5	0.01	1.75	0.08
	Volume	156	33.2	0.01	3.88	0.21
	Months	12	33.2	0.3	8.04	2.77
1964	Duration	154	992	1	30	6.44
	Intensity	154	11.66	0.01	0.56	0.08
	Volume	154	29.67	0.01	1.89	0.19
	Months	12	29.67	0.77	5.02	2.47
1965	Duration	173	1152	1	42	6.66
	Intensity	173	12.56	0.01	0.5	0.07
	Volume	173	35.48	0.01	2.3	0.21
	Months	12	35.46	1.21	5.1	2.96
1966	Duration	173	1143	1	46	6.61
	Intensity	173	12.09	0.01	0.64	0.07
	Volume	173	32.86	0.01	1.66	0.19
	Months	12	32.88	0.93	4.92	2.74
1967	Duration	163	1117	1	42	6.85
	Intensity	163	11.76	0.01	0.94	0.07
	Volume	163	34.64	0.01	4.4	0.21
	Months	12	34.59	1.18	6.36	2.88
1968	Duration	162	1163	1	44	7.18
	Intensity	162	14.03	0.01	1.3	0.09
	Volume	162	38.25	0.01	3.11	0.24
	Months	12	38.26	0.81	5.63	3.19
1969	Duration	160	1143	1	41	7.14
	Intensity	160	5.5	0.003	0.42	0.03
	Volume	160	36.16	0.01	2.28	0.23
	Months	11	36.16	0.61	4.25	3.29

Table 2-2 Buffalo-Niagara International Airport NWS Rainfall Analysis
Yearly Totals 1948 - 2010

Year		Number	Total	Minimum	Maximum	Average
1970	Duration	162	1255	1	36	7.75
	Intensity	162	5.2	0.003	0.23	0.03
	Volume	162	34.70	0.01	1.89	0.21
	Months	12	34.70	0.31	4.59	2.89
1971	Duration	167	1160	1	44	6.95
	Intensity	167	5.8	0.002	0.65	0.04
	Volume	167	32.90	0.01	2.33	0.20
	Months	12	32.90	0.01	5.15	2.74
1972	Duration	166	1480	1	46	8.92
	Intensity	166	5.5	0.004	0.71	0.03
	Volume	166	41.62	0.01	3.73	0.25
	Months	12	41.62	0.25	6.19	3.47
1973	Duration	164	1141	1	57	6.96
	Intensity	164	5.9	0.004	0.39	0.04
	Volume	164	36.80	0.01	1.75	0.22
	Months	12	36.80	0.49	5	3.07
1974	Duration	164	1301	1	43	7.93
	Intensity	164	5.7	0.003	0.29	0.04
	Volume	164	36.30	0.01	1.29	0.22
	Months	12	36.30	0.03	6.45	3.03
1975	Duration	163	1180	1	59	7.24
	Intensity	163	5.6	0.003	0.38	0.03
	Volume	163	38.52	0.01	3.56	0.24
	Months	12	38.52	0.1	8.46	3.21
1976	Duration	162	1321	1	36	8.15
	Intensity	162	6.8	0.003	0.82	0.04
	Volume	162	46.53	0.01	2.87	0.29
	Months	12	46.53	0.29	5.88	3.88
1977	Duration	182	1543	1	49	8.48
	Intensity	182	7.0	0.003	0.63	0.04
	Volume	182	53.54	0.01	2.43	0.29
	Months	12	53.54	0.1	10.18	4.46
1978	Duration	154	1200	1	60	7.79
	Intensity	154	4.9	0.003	0.3	0.03
	Volume	154	35.67	0.01	1.69	0.23
	Months	12	35.67	0.22	6.01	2.97
1979	Duration	158	1345	1	45	8.51
	Intensity	158	5.4	0.003	0.33	0.03
	Volume	158	43.72	0.01	4.94	0.28
	Months	12	43.72	0.61	6.41	3.64

Table 2-2 Buffalo-Niagara International Airport NWS Rainfall Analysis
Yearly Totals 1948 - 2010

Year		Number	Total	Minimum	Maximum	Average
1980	Duration	181	1079	1	35	5.96
	Intensity	181	6.1	0.003	0.27	0.03
	Volume	181	38.30	0.01	2.69	0.21
	Months	12	38.30	0.04	6.18	3.19
1981	Duration	170	1192	1	57	7.01
	Intensity	170	5.8	0.003	0.39	0.03
	Volume	170	36.57	0.01	1.97	0.22
	Months	12	36.57	0.13	4.87	3.05
1982	Duration	146	1171	1	53	8.02
	Intensity	146	6.0	0.003	0.41	0.04
	Volume	146	40.98	0.01	2.88	0.28
	Months	12	40.98	0.72	6.53	3.42
1983	Duration	157	1233	1	51	7.85
	Intensity	157	5.5	0.004	0.30	0.04
	Volume	157	39.49	0.01	1.63	0.25
	Months	12	39.49	0.01	5.23	3.29
1984	Duration	146	1085	1	53	7.43
	Intensity	146	5.2	0.003	0.21	0.04
	Volume	146	38.05	0.01	2.51	0.26
	Months	12	38.05	0.04	6.52	3.17
1985	Duration	161	1526	1	91	9.48
	Intensity	161	6.0	0.003	0.55	0.04
	Volume	161	45.35	0.01	5.23	0.28
	Months	12	45.35	0.01	8.88	3.78
1986	Duration	172	1057	1	45	6.15
	Intensity	172	6.1	0.003	0.23	0.04
	Volume	172	39.64	0.01	3.63	0.23
	Months	12	39.64	0.01	5.59	3.30
1987	Duration	142	1054	1	41	7.42
	Intensity	142	5.9	0.003	0.64	0.04
	Volume	142	42.14	0.01	5.01	0.30
	Months	12	42.14	0.52	8.67	3.51
1988	Duration	164	989	1	38	6.03
	Intensity	164	6.7	0.004	0.36	0.04
	Volume	164	38.59	0.01	1.67	0.24
	Months	12	38.59	0.03	6.46	3.22
1989	Duration	164	1207	1	41	7.36
	Intensity	164	6.0	0.004	0.43	0.04
	Volume	164	41.15	0.01	3.01	0.25
	Months	12	41.15	0.01	7.88	3.43
1990	Duration	154	1221	1	49	7.93
	Intensity	154	6.3	0.005	0.49	0.04
	Volume	154	50.85	0.01	2.88	0.33
	Months	12	50.85	0.14	6.35	4.24

Table 2-2 Buffalo-Niagara International Airport NWS Rainfall Analysis
Yearly Totals 1948 - 2010

Year		Number	Total	Minimum	Maximum	Average
1991	Duration	150	1083	1	73	7.22
	Intensity	150	6.7	0.003	0.55	0.04
	Volume	150	40.19	0.01	3.99	0.27
	Months	12	40.19	0.11	6.16	3.35
1992	Duration	178	1273	1	43	7.15
	Intensity	178	6.5	0.003	0.36	0.04
	Volume	178	47.55	0.01	2.3	0.27
	Months	12	47.55	0.01	8.32	3.96
1993	Duration	156	1107	1	42	7.10
	Intensity	156	6.3	0.003	0.37	0.04
	Volume	156	40.64	0.01	1.76	0.26
	Months	12	40.64	0.04	5.58	3.39
1994	Duration	146	1105	1	37	7.57
	Intensity	146	5.2	0.003	0.27	0.04
	Volume	146	36.86	0.01	2.81	0.25
	Months	12	36.86	0.14	4.28	3.07
1995	Duration	143	942	1	67	6.59
	Intensity	143	5.2	0.004	0.18	0.04
	Volume	143	30.96	0.01	2.22	0.22
	Months	12	30.96	0.71	5.34	2.58
1996	Duration	118	809	1	41	6.86
	Intensity	118	5.0	0.005	0.22	0.04
	Volume	118	31.64	0.01	2.06	0.27
	Months	12	31.64	0.03	6.47	2.64
1997	Duration	151	996	1	46	6.60
	Intensity	151	4.4	0.003	0.18	0.03
	Volume	151	31.85	0.01	1.87	0.21
	Months	12	31.85	0.03	4.98	2.65
1998	Duration	129	794	1	41	6.16
	Intensity	129	5.5	0.003	0.69	0.04
	Volume	129	30.89	0.01	2.39	0.24
	Months	12	30.89	0.35	4.32	2.57
1999	Duration	127	751	1	42	5.91
	Intensity	127	5.0	0.003	0.39	0.04
	Volume	127	28.58	0.01	1.65	0.23
	Months	12	28.58	0.26	5.48	2.38
2000	Duration	144	1037	1	41	7.20
	Intensity	144	13.9	0.01	0.66	0.10
	Volume	144	34.80	0.01	1.49	0.24
	Months	12	34.80	1.11	6.5	2.90
2001	Duration	136	948	1	62	6.97
	Intensity	136	10.42	0.01	0.72	0.08
	Volume	135	27.80	0.01	1.82	0.20
	Months	12	27.80	0.73	4.34	2.32

Table 2-2 Buffalo-Niagara International Airport NWS Rainfall Analysis
Yearly Totals 1948 - 2010

Year		Number	Total	Minimum	Maximum	Average
2002	Duration	140	1026	1	66	7.33
	Intensity	140	11.8	0.01	0.53	0.08
	Volume	140	33.35	0.01	2.28	0.24
	Months	12	33.35	1.45	5.23	2.78
2003	Duration	143	1119	1	47	7.83
	Intensity	143	13.11	0.01	0.58	0.09
	Volume	143	32.66	0.01	1.1	0.23
	Months	12	32.66	0.62	5.43	2.72
2004	Duration	151	1049	1	34	6.95
	Intensity	151	13.66	0.01	1.15	0.09
	Volume	151	37.85	0.01	3.99	0.25
	Months	12	37.85	0.82	6.04	3.15
2005	Duration	131	900	1	48	6.87
	Intensity	131	12.47	0.01	0.94	0.10
	Volume	131	35.46	0.01	3	0.27
	Months	12	35.46	0.6	5.92	2.96
2006	Duration	152	1048	1	47	6.90
	Intensity	152	15.54	0.01	0.75	0.10
	Volume	152	43.20	0.01	2.58	0.28
	Months	12	43.05	1.9	7.62	3.59
2007	Duration	147	1008	1	54	6.86
	Intensity	147	12.58	0.01	0.79	0.09
	Volume	147	33.81	0.01	2.45	0.23
	Months	12	33.96	0.87	5.36	2.83
2008	Duration	175	1210	1	43	6.91
	Intensity	175	18.35	0.01	1.14	0.11
	Volume	175	45.71	0.01	1.69	0.26
	Months	12	45.71	1.95	6.33	3.81
2009	Duration	139	1025	1	39	7.37
	Intensity	139	16.21	0.01	1	0.12
	Volume	139	43.73	0.01	2.79	0.32
	Months	12	43.72	1.81	5.65	3.64
2010	Duration	96	649	1	27	6.78
	Intensity	96	12.44	0.01	0.78	0.13
	Volume	96	27.02	0.01	2.19	0.28
	Months	9	27.03	1.59	8.13	3.00

- Aggregate the rankings for the three categories; and
- The highest ranked year would be the lowest sum of the rankings.

These enhancements to the USEPA's original approach were proposed for the following reasons, and were accepted by the USEPA during a meeting in December 2011:

- The enhanced approach accounts for seasonal/monthly distributions, which are critical for assessing a demonstration approach (water quality based approach). The originally proposed approach did not take this into consideration.
- The enhanced approach gives equal weighting to peak hourly and total event rainfalls, while original approach developed by the USEPA gives a considerably higher weighting to peak hourly rainfall. The equal weighting approach will provide a more representative typical year since many of the technologies being considered in the BSA's CSO mitigation alternatives are storage-based technologies. The sizing of these facilities is more dependent on total event rainfall than on peak hourly rainfall.

The initial screening, using the period 1981-2010, identified the following potential typical years: 1982, 1983, 1986, 1987, 1988, 1989, 1991, and 2009. Two potential front runners (1993 and 2006) were also identified at earlier stages of the process and further modified to optimize monthly precipitation distribution. These two modified years were then included in the screening and evaluation process along with unmodified precipitation years. Table 2-4 shows the results of the absolute deviation analysis for the peak hourly rainfall, total event rainfall, and monthly rainfall for each of the candidate years. Based on the results presented in Table 2-4, the modified 1993 hyetograph is the highest ranked year.

Table 2-4

Ranking of Candidate Typical Year Records Using Modified USEPA Approach

Year	Sum of Total Rainfall Absolute Deviations (in.)	Sum of Peak Hourly Rainfall Absolute Deviations (in.)	Sum of Monthly Rainfall Absolute Deviations (in.)	Ranking for Total Rainfall Absolute Deviation	Ranking for Peak Hourly Rainfall Absolute Deviation	Ranking for Monthly Rainfall Absolute Deviation	Sum of Rankings
Mod. 1993	2.35	1.04	4.13	1	2	1	4
1993	2.54	1.08	9.8	2	3	4	9
Mod. 2006	4.41	1.28	8.36	8	4	3	15
1982	3.66	0.96	14.4	6	1	9	16
1991	3.43	1.65	12.36	5	7	5	17
1986	4.02	2.35	6.48	7	10	2	19
1989	2.93	1.37	17.48	3	5	12	20
1983	4.66	1.54	13.52	9	6	7	22
1988	3.39	1.93	16.69	4	8	11	23
2006	6.49	2	15.47	10	9	10	29
1987	7.68	2.86	14.07	11	11	8	30
2009	7.96	3.09	12.74	12	12	6	30

The additional data used in the evaluation and a more rigorous analysis of event return periods indicated that 1993, with some modifications, provides a more technically accurate and reasonable representation of typical year conditions than the modified 1986 year used in the original 2004 LTCP efforts. A full description of the development of the 1993 typical precipitation year is presented in the memorandum titled “UPDATED: Revised Typical Year for Development of the Long Term Control Plan,” included as Appendix 2-1. Table 2-5 provides a detailed table of all events simulated in the modified 1993 typical year, and also identifies all modifications made to the 1993 record to develop the modified typical year. The typical year (TY) used in the LTCP evaluations in subsequent sections is the 1993 Modified TY, unless otherwise noted.

2.2.2 Topography

The topography in the City of Buffalo is relatively moderate. Ground elevations range from 580 ft above mean sea level in the southwest, to 700 ft in the northeast portion of the city. The northern half of the city slopes downwards from east to west. The southern half of the city is divided by the Buffalo River and Cazenovia Creek, both sides of which slope towards the river and creek. The area north of the Buffalo River slopes downwards to the southwest; the area south of the Buffalo River is flat and marshy in the western part, and slopes mildly northwest in the eastern part. Figure 2-1 shows the topography of the area.

Table 2-5: Modified 1993 Typical Year Rainfall Event Summary

Event	Rank	Start Time	Depth (in.)	Duration (hrs)	Peak Hourly Depth (in.)	Notes
1	97	1/3/1993 6:00	0.06	3	0.02	1.6" event on 1/3/1993 Deleted
2	98	1/8/1993 4:00	0.06	3	0.02	
3	49	1/10/1993 10:00	0.26	17	0.04	
4	137	1/11/1993 19:00	0.01	1	0.01	
5	11	1/13/1993 0:00	0.77	14	0.16	
6	126	1/14/1993 2:00	0.02	2	0.01	
7	89	1/15/1993 6:00	0.08	10	0.02	
8	127	1/16/1993 11:00	0.02	2	0.01	
9	138	1/17/1993 5:00	0.01	1	0.01	
10	22	1/21/1993 14:00	0.52	18	0.13	
11	109	1/22/1993 17:00	0.04	5	0.01	
12	30	1/24/1993 8:00	0.47	12	0.10	
13	139	1/27/1993 6:00	0.01	1	0.01	
14	110	1/28/1993 9:00	0.04	10	0.01	
15	111	1/29/1993 9:00	0.04	2	0.03	
16	44	1/30/1993 10:00	0.29	14	0.05	
17	99	1/31/1993 19:00	0.06	10	0.04	
18	66	2/5/1993 21:00	0.16	6	0.05	
19	58	2/12/1993 7:00	0.20	6	0.10	
20	119	2/12/1993 22:00	0.03	3	0.01	
21	120	2/13/1993 7:00	0.03	3	0.02	
22	128	2/13/1993 16:00	0.02	6	0.01	
23	16	2/16/1993 5:00	0.66	19	0.06	
24	112	2/17/1993 22:00	0.04	7	0.02	
25	129	2/19/1993 6:00	0.02	2	0.01	
26	113	2/19/1993 23:00	0.04	2	0.03	

Table 2-5: Modified 1993 Typical Year Rainfall Event Summary

Event	Rank	Start Time	Depth (in.)	Duration (hrs)	Peak Hourly Depth (in.)	Notes
27	18	2/21/1993 12:00	0.64	17	0.10	
28	140	2/22/1993 13:00	0.01	1	0.01	
29	141	2/23/1993 4:00	0.01	1	0.01	
30	102	2/23/1993 21:00	0.05	9	0.02	
31	34	3/4/1993 18:00	0.40	7	0.12	
32	71	3/5/1993 7:00	0.15	15	0.02	
33	114	3/6/1993 5:00	0.04	6	0.01	
34	72	3/7/1993 21:00	0.15	13	0.03	
35	86	3/8/1993 18:00	0.09	12	0.02	
36	62	3/10/1993 15:00	0.17	13	0.04	
37	100	3/11/1993 21:00	0.06	3	0.02	
38	10	3/13/1993 10:00	0.82	23	0.06	
39	19	3/16/1993 10:00	0.61	26	0.06	
40	130	3/20/1993 8:00	0.02	2	0.01	
41	103	3/20/1993 22:00	0.05	9	0.01	
42	77	3/23/1993 14:00	0.13	10	0.04	
43	53	3/28/1993 14:00	0.21	15	0.08	
44	17	3/31/1993 23:00	0.65	19	0.09	
45	90	4/2/1993 7:00	0.08	5	0.02	
46	131	4/3/1993 2:00	0.02	3	0.01	
47	142	4/3/1993 18:00	0.01	1	0.01	
48	45	4/10/1993 0:00	0.29	14	0.04	
49	63	4/16/1993 3:00	0.17	2	0.11	
50	115	4/16/1993 17:00	0.04	2	0.03	
51	121	4/17/1993 4:00	0.03	3	0.01	
52	132	4/17/1993 19:00	0.02	1	0.02	

Table 2-5: Modified 1993 Typical Year Rainfall Event Summary

Event	Rank	Start Time	Depth (in.)	Duration (hrs)	Peak Hourly Depth (in.)	Notes
53	27	4/19/1993 21:00	0.50	14	0.11	
54	43	4/20/1993 21:00	0.30	5	0.16	
55	143	4/21/1993 8:00	0.01	1	0.01	
56	104	4/24/1993 16:00	0.05	1	0.05	
57	28	4/25/1993 2:00	0.50	13	0.15	
58	54	5/5/1993 0:00	0.21	7	0.10	
59	73	5/5/1993 21:00	0.15	1	0.15	
60	4	5/6/1993 0:00	1.24	20	0.26	Historical Event Added (1.24" from 5/6/85)
61	144	5/11/1993 15:00	0.01	1	0.01	
62	145	5/12/1993 19:00	0.01	1	0.01	
63	91	5/15/1993 2:00	0.07	4	0.04	
64	146	5/19/1993 12:00	0.01	1	0.01	
65	147	5/23/1993 21:00	0.01	1	0.01	
66	82	5/24/1993 4:00	0.11	11	0.03	
67	116	5/25/1993 0:00	0.04	1	0.04	
68	148	5/29/1993 1:00	0.01	1	0.01	
69	5	5/31/1993 4:00	1.16	13	0.26	
70	92	6/1/1993 5:00	0.07	1	0.07	
71	1	6/5/1993 5:00	1.76	17	0.54	
72	101	6/7/1993 3:00	0.06	2	0.05	
73	46	6/8/1993 13:00	0.28	2	0.16	
74	78	6/9/1993 23:00	0.13	2	0.10	0.8" event on 6/9/1993 Deleted
75	60	6/15/1993 3:00	0.19	4	0.17	
76	75	6/19/1993 1:00	0.14	1	0.14	
77	41	6/19/1993 21:00	0.34	10	0.18	
78	64	6/20/1993 18:00	0.17	2	0.13	

Table 2-5: Modified 1993 Typical Year Rainfall Event Summary

Event	Rank	Start Time	Depth (in.)	Duration (hrs)	Peak Hourly Depth (in.)	Notes
79	23	6/21/1993 2:00	0.52	5	0.26	
80	117	6/21/1993 16:00	0.04	3	0.02	
81	37	6/26/1993 3:00	0.37	2	0.23	
82	105	6/27/1993 20:00	0.05	2	0.03	
83	93	6/28/1993 12:00	0.07	5	0.03	
84	106	7/2/1993 3:00	0.05	7	0.03	
85	24	7/7/1993 10:00	0.52	8	0.42	Historical Event Added (0.52" from 7/7/1961)
86	8	7/11/1993 23:00	0.88	3	0.43	
87	94	7/14/1993 11:00	0.07	3	0.05	
88	95	7/19/1993 2:00	0.07	6	0.04	
89	31	7/26/1993 8:00	0.45	7	0.20	
90	12	7/28/1993 14:00	0.77	2	0.76	Historical Event Added (0.77" from 7/28/73)
91	96	7/29/1993 18:00	0.07	2	0.04	
92	67	7/30/1993 10:00	0.16	7	0.07	
93	122	7/30/1993 23:00	0.03	1	0.03	
94	25	8/2/1993 8:00	0.51	3	0.30	
95	79	8/4/1993 1:00	0.13	5	0.05	
96	35	8/6/1993 23:00	0.39	16	0.14	
97	133	8/14/1993 14:00	0.02	1	0.02	
98	65	8/16/1993 2:00	0.17	7	0.06	
99	33	8/16/1993 18:00	0.41	2	0.33	
100	20	8/19/1993 16:00	0.60	3	0.52	Historical Event Added (0.6" from 8/19/73)
101	83	8/20/1993 5:00	0.11	2	0.10	
102	74	8/20/1993 23:00	0.15	2	0.08	1.46" event on 8/20/1993 Deleted
103	149	8/23/1993 15:00	0.01	1	0.01	
104	68	8/28/1993 3:00	0.16	2	0.15	

Table 2-5: Modified 1993 Typical Year Rainfall Event Summary

Event	Rank	Start Time	Depth (in.)	Duration (hrs)	Peak Hourly Depth (in.)	Notes
105	123	8/29/1993 20:00	0.03	2	0.02	
106	84	8/30/1993 5:00	0.10	2	0.08	
107	150	8/31/1993 4:00	0.01	1	0.01	
108	59	8/31/1993 18:00	0.20	5	0.18	
109	61	9/2/1993 14:00	0.18	9	0.08	
110	32	9/3/1993 11:00	0.44	7	0.16	
111	151	9/4/1993 0:00	0.01	1	0.01	
112	107	9/5/1993 12:00	0.05	1	0.05	
113	52	9/6/1993 13:00	0.22	5	0.06	
114	29	9/9/1993 22:00	0.50	6	0.12	
115	69	9/10/1993 14:00	0.16	4	0.11	
116	76	9/15/1993 9:00	0.14	5	0.05	
117	36	9/23/1993 5:00	0.38	10	0.11	
118	2	9/27/1993 15:00	1.42	13	0.55	1.26" event on 9/25/1993 Deleted
119	13	9/28/1993 10:00	0.76	10	0.27	
120	152	9/29/1993 14:00	0.01	1	0.01	
121	51	10/2/1993 0:00	0.23	11	0.05	
122	9	10/4/1993 12:00	0.83	8	0.18	
123	21	10/9/1993 9:00	0.53	8	0.13	
124	6	10/16/1993 15:00	1.16	29	0.11	
125	134	10/20/1993 17:00	0.02	1	0.02	
126	50	10/21/1993 3:00	0.25	4	0.11	
127	118	10/28/1993 13:00	0.04	1	0.04	
128	14	10/30/1993 20:00	0.74	36	0.06	
129	47	11/3/1993 10:00	0.28	7	0.12	
130	55	11/5/1993 1:00	0.21	17	0.06	

Table 2-5: Modified 1993 Typical Year Rainfall Event Summary

Event	Rank	Start Time	Depth (in.)	Duration (hrs)	Peak Hourly Depth (in.)	Notes
131	153	11/6/1993 0:00	0.01	1	0.01	
132	154	11/7/1993 17:00	0.01	1	0.01	
133	108	11/12/1993 0:00	0.05	2	0.03	
134	26	11/14/1993 9:00	0.51	22	0.09	
135	42	11/17/1993 11:00	0.33	7	0.13	
136	56	11/19/1993 18:00	0.21	6	0.13	
137	80	11/24/1993 11:00	0.12	5	0.03	
138	135	11/27/1993 0:00	0.02	2	0.01	
139	3	11/27/1993 8:00	1.36	25	0.12	
140	39	11/29/1993 8:00	0.36	8	0.10	
141	57	12/2/1993 19:00	0.21	4	0.08	
142	15	12/4/1993 7:00	0.72	17	0.08	
143	85	12/6/1993 14:00	0.10	5	0.04	
144	40	12/10/1993 7:00	0.36	11	0.17	
145	70	12/11/1993 0:00	0.16	29	0.02	
146	155	12/18/1993 7:00	0.01	1	0.01	
147	136	12/18/1993 16:00	0.02	2	0.01	
148	156	12/19/1993 4:00	0.01	1	0.01	
149	81	12/19/1993 22:00	0.12	7	0.04	
150	48	12/20/1993 22:00	0.27	25	0.03	
151	7	12/24/1993 12:00	1.01	9	0.32	
152	87	12/25/1993 3:00	0.09	16	0.02	
153	88	12/29/1993 18:00	0.09	2	0.05	
154	124	12/30/1993 8:00	0.03	2	0.02	
155	125	12/30/1993 22:00	0.03	1	0.03	
156	38	12/31/1993 8:00	0.37	7	0.14	

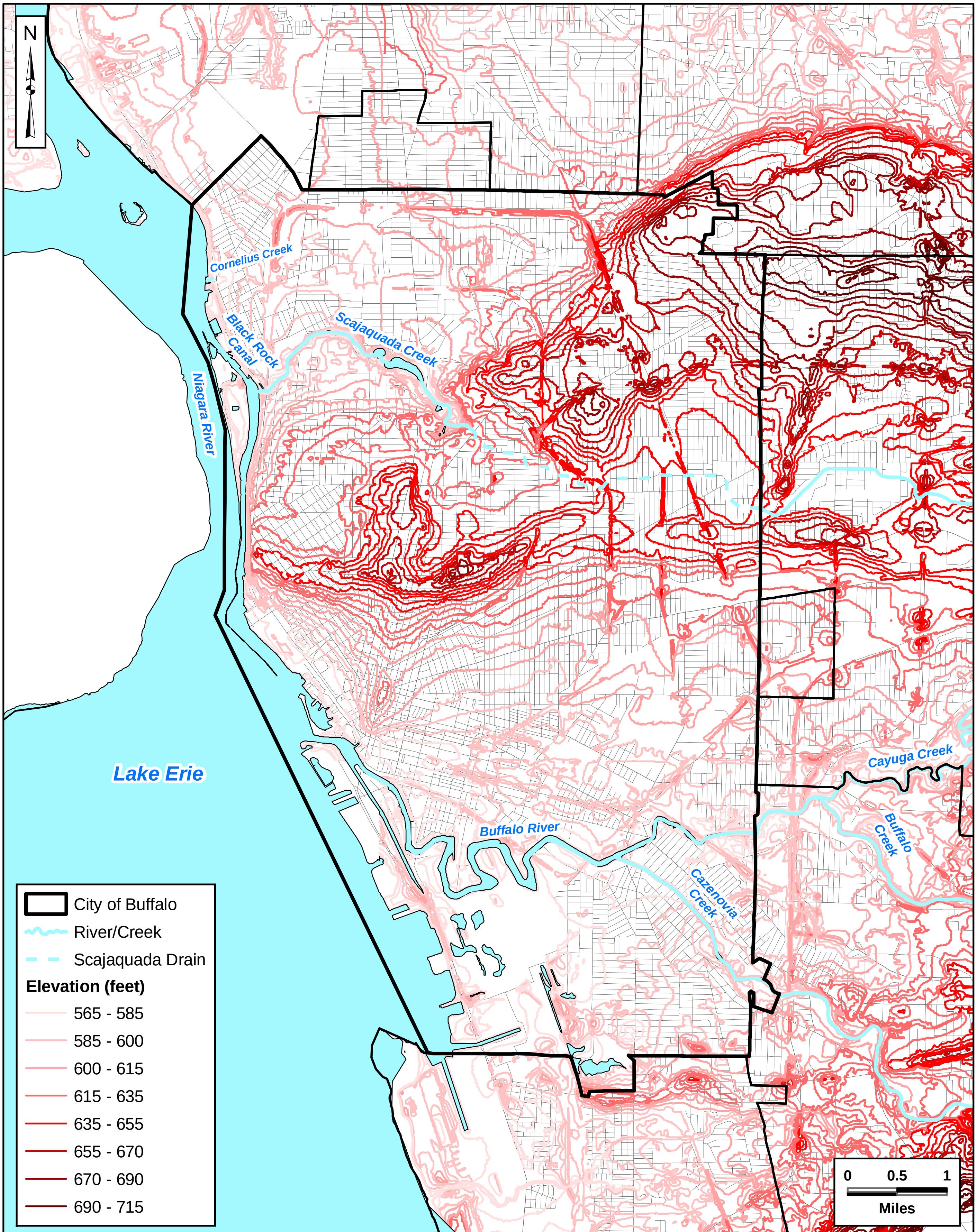

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FIGURE 2-1

TOPOGRAPHY

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2.2.3 Geology

The geology in the City can be divided into overburden and bedrock.

2.2.3.1 Overburden Geology

The City of Buffalo is located within two physiographic units, the Lake Tonawanda Plain to the north and the Lake Erie Plain to the south. These plains are separated by the Onondaga Escarpment, which runs from the northeast corner of the city at the University of Buffalo Main Street campus to Bird Island.

The Tonawanda Plain is a flat lake plain that was occupied by the glacial Lake Tonawanda in the Pleistocene period approximately 10,000 years ago. Lake Tonawanda was 8 miles wide, 35 feet deep and covered an area approximately 50 miles long, from the present day Niagara River east to Holley, New York. The Onondaga Escarpment was the south shore, and the Niagara Escarpment, which parallels the south shore of Lake Ontario, was the north shore. The present day Oak Orchard Swamp in Genesee County is regarded as the remnant of Lake Tonawanda. The Lake Tonawanda Plain is drained by westward-flowing Tonawanda Creek. Overburden deposits are mostly lake bottom silt and clay.

The rest of the City, south of the Onondaga Escarpment, is within the Lake Erie Plain. Similar to the Lake Tonawanda Plain, the Lake Erie Plain was covered by a fresh water lake during the Pleistocene period. The ancestral lakes of the Lake Erie Plain were much larger and deeper than Lake Tonawanda and several beach ridges have been mapped east of, and at higher elevations than, the City of Buffalo. Here too, overburden deposits are mostly lake sediments of clay and silt.

2.2.3.2 Bedrock Geology

Beneath the blanket of overburden deposits, the uppermost bedrock underlying the City of Buffalo consists of sedimentary rock formations of the Upper Silurian and Middle Devonian ages. The bedrock formations generally strike in an east / west direction and dip to the south at approximately 40 feet per mile. Because of this southward dip angle and the relatively flat topography, six different rock formations are present beneath the overburden within the City of Buffalo. The bedrock sequence decreases in age from north to south. The six bedrock formations represented beneath the overburden within the City limits (from oldest [north] to youngest [south]) include:

- Camillus Formation;
- Bertie Formation;
- Akron Dolostone;

- Onondaga Formation;
- Marcellus Formation; and
- Skaneateles Formation.

Figure 2-2 illustrates the location of the bedrock units. A general description of each of the six bedrock units is provided in this section. Note that formation thicknesses provided in these sections are estimates of maximum thickness of the non-eroded formations from published reports. Actual thickness of each of the uppermost bedrock formations would likely be less due to the action of glacial erosion.

Camillus Formation

The Upper Silurian age Camillus formation is the oldest bedrock formation present beneath the overburden within the City limits. The Camillus varies from thin-bedded shale to massive mudstone that is typically gray to brownish-gray in color. Gypsum and anhydrite minerals are present within the Camillus in Erie County, New York, and no fossils are reported in the Camillus in Erie County. The Camillus is approximately 400 feet thick. The Camillus does not outcrop at the surface in the City of Buffalo.

Bertie Formation

Directly above the Camillus formation, the Upper Silurian age Bertie formation contains four members totaling 50 to 60 feet in thickness. The Bertie consists primarily of brown dolostone or dolomitic limestone, but also contains beds of dark gray shale. This formation is exposed at the surface near the Main Street entrance to Forest Lawn Cemetery and at the railroad cut on Amherst Street west of Main Street.

Akron Dolostone

Directly above the Bertie formation is the relatively thin (8 feet), Akron Dolostone of the Upper Silurian age. This rock unit is described as greenish-gray to buff-colored dolostone, often with a mottled or banded appearance. The rock is fine-grained but weathers to a rough and vuggy texture often revealing coral fossils. The Akron is exposed at the surface in Forest Lawn Cemetery and at a railroad cut on Main Street near Jewett Avenue.

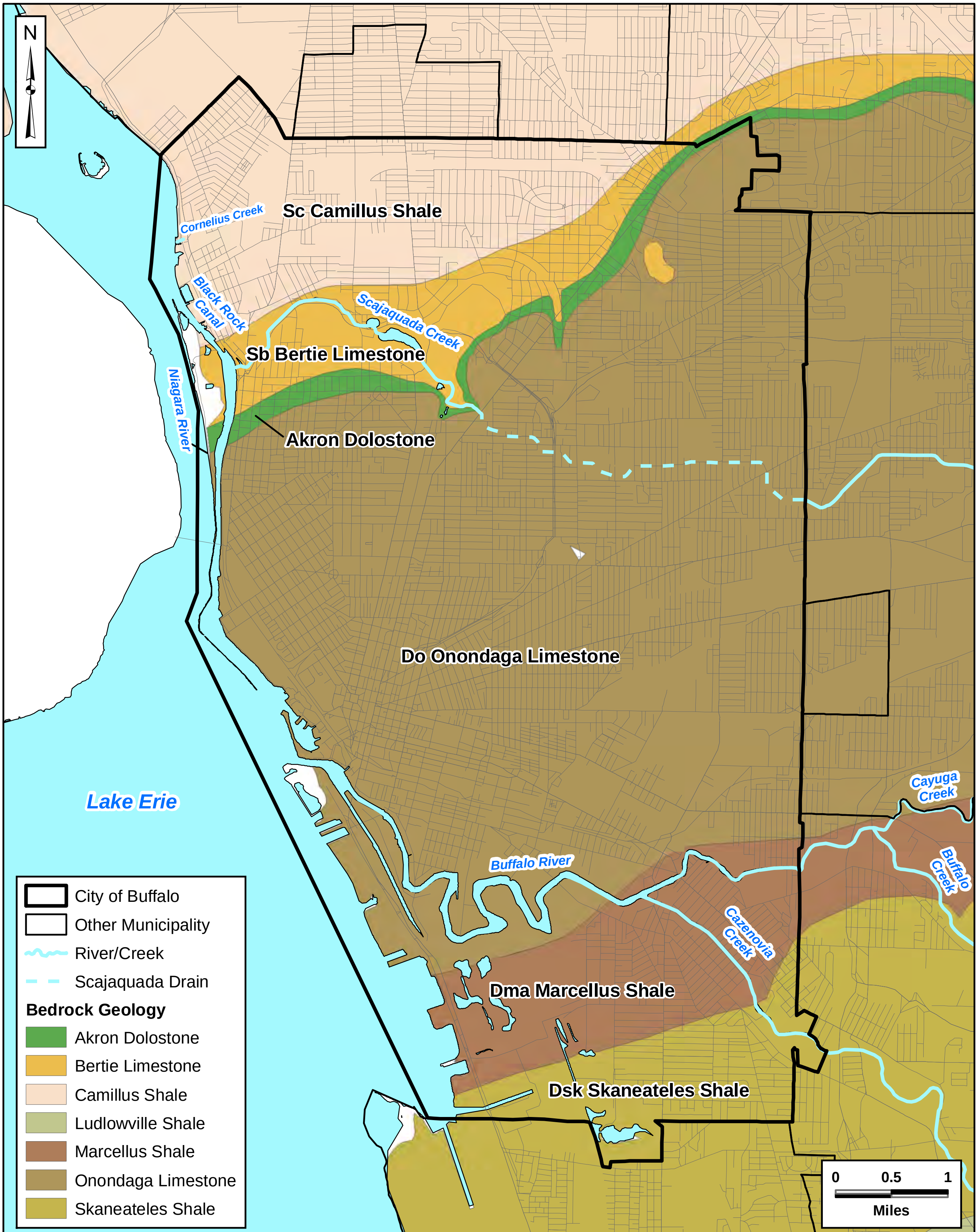

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FIGURE 2-2

BEDROCK GEOLOGY

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Onondaga Limestone

The Middle Devonian Age Onondaga Limestone lies unconformably on the Akron Dolostone. This contact represents a period of ancient and extended erosion such that no rock formations of Lower Devonian age are present. The Onondaga is the uppermost bedrock formation beneath the overburden deposits throughout most of the City. From approximately the Buffalo River north to a line between the Main Street campus of the University of Buffalo and Bird Island, the Onondaga is the uppermost bedrock unit. The Onondaga is between approximately 106 ft and 162 ft thick in Erie County, and is comprised of four limestone members that vary in color, thickness, fossil type, and amount of chert. All four members are hard relative to the overlying shale formations. The Onondaga, along with the underlying limestone and dolostone formations of the Akron, Bertie, and Camillus, forms a north-facing scarp called the Onondaga Escarpment. This escarpment creates a relatively steep cliff from east Buffalo at the University of Buffalo Main Street Campus eastward through Williamsville at Glen Falls, to the City of Rochester and beyond. The Onondaga is quarried for crushed stone at many locations along the high side of this escarpment. One such quarry that is now abandoned is located within the City near the intersection of Main and East Amherst Streets. Excavations along the high side of the escarpment encounter the thick hard limestone, at or very near, the ground surface, the most notable being the road cut of the Route 33 expressway.

Marcellus Formation

Above the Onondaga, the Marcellus Formation underlies the overburden, generally between Buffalo Creek and Tifft Street. The Marcellus is a black fissile shale that is between 30 and 55 feet thick in Erie County.

Skaneateles Formation

Above the Marcellus formation, the Skaneateles formation underlies the overburden of the southernmost areas of the City, south of Tifft Street. The Skaneateles contains two members that total 60 to 90 feet thick in Erie County. The uppermost member is the Levanna shale, which is a fissile gray to black shale. The older (deeper) member is the Stafford limestone, which is a gray limestone that weathers to chocolate brown and is massive to shaley. The Stafford is approximately 10 to 15 feet thick where present in south Buffalo.

Rock Competency

Beneath the overburden deposits, most of the City is underlain by hard limestone and dolostone bedrock formations. In the southern quarter of the City, softer shale formations overlie the limestone. No evidence of unstable or Karst bedrock conditions are known to exist in the City. Prior to construction design of any tunnels or subsurface facilities, a full geotechnical investigation must be performed to determine the depth to bedrock, as well as the type and competency of the rock.

2.2.4 Soil

The surficial geology of the Buffalo area is shown on Figure 2-3. The City sits on the Lake Erie Plain where the overburden is zero to 60 feet. The Lake Erie Plain surficial geology consists of a thin glacial till, glaciolacustrine deposits, and recent alluvium. The soils in the area have developed from these deposits.

Glacial till consists of lodgment till and ablation till. The lodgment tills were deposited sub-glacially and are characterized as a dense, poorly sorted aggregate, or clay, silt, sand, and gravel. Ablation till is generally less dense and has a coarser clastic component due to lacustrine and fluvial sorting processes. Glaciolacustrine deposits are characterized as thinly bedded to laminated silts and clays, which were deposited in lakes impounded between glacial ice and ice-free highland areas. As the glacial ice retreated, water depths decreased, and coarser grained shallow water sediments were deposited. These shallow water deposits include sandy beach ridges that define the lake edges, sandbars associated with off-shore currents, and near shore silty fine sands. In some places the glaciolacustrine deposits have been reworked and overlain by wetland deposits.

2.3 Demographics

Demographics are important to many components of the LTCP development process, from cost-affordability analyses to development of modeling tools. Demographic attributes, such as population and land use, affect model development in terms of characterizing sewer usage for dry weather flows and characterizing the hydrologic response of the service area.

2.3.1 Population

The population of Buffalo grew steadily from the 1900s until the 1950s. Census records indicate that the City's population peaked around 1950 at 580,132 people. In the late 1950s, and through the 1960s, the advent of the St. Lawrence Seaway usurped the importance of the Buffalo Harbor and Erie Canal as a transportation route, and many industries closed or left the area, resulting in a steady decline in population. In 2010, the census figure for the population of Buffalo was 261,310 people. The major drop in population occurred in the city center and surrounding areas as population shifted to the outer areas of the city and the suburbs.

Figure 2-4 shows the 2010 population density distribution in the city, which indicates that the majority of the residents live in the northern part of the city. The population density is lowest in the southern portion of the city around the Buffalo River, which is dominated by industry or old industrial (brownfield) land.

In addition to the City's population, the BSA also treats wastewater from portions of Cheektowaga, West Seneca, Sloan, and Erie County Sewer Districts 1 and 4.

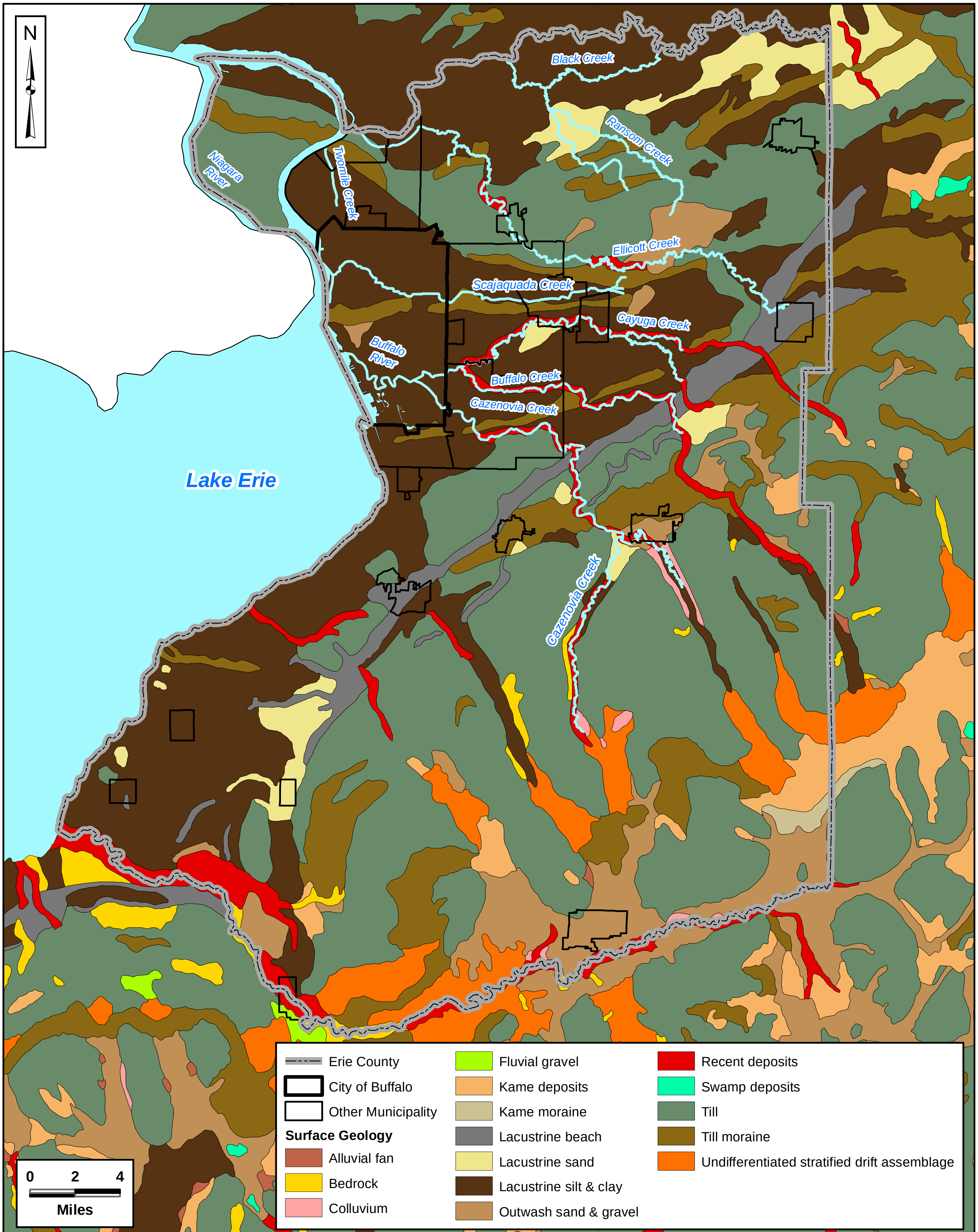

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FIGURE 2-3

SOILS (SURFICIAL GEOLOGY)

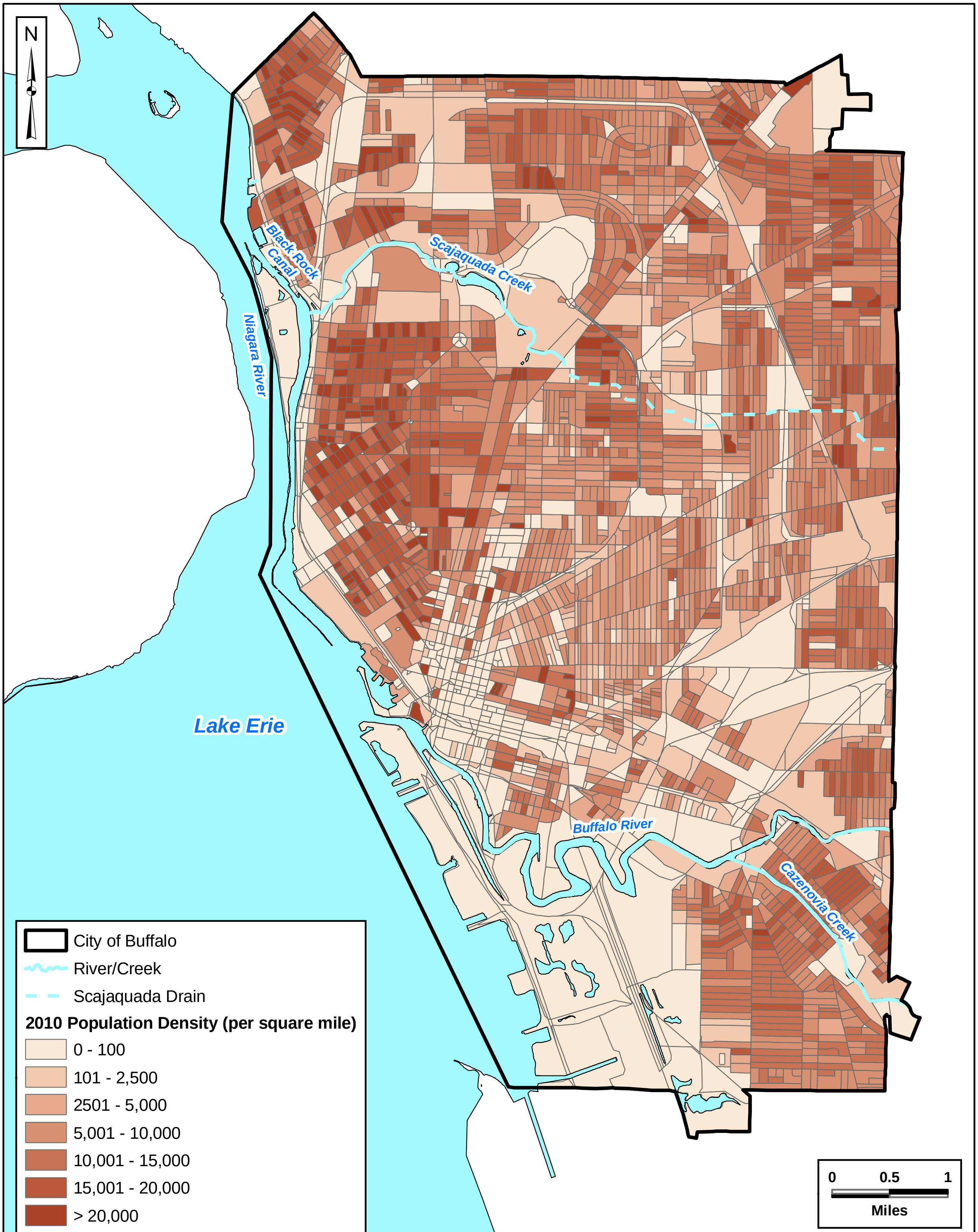

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FIGURE 2-4

POPULATION DENSITY

2.3.2 Land Use

The city encompasses approximately 33,500 acres. City land and inland waterways account for 27,311 acres; portions of Lake Erie, the Niagara River and Black Rock Canal occupy the rest. Table 2-6 presents the distribution of the major land uses as determined by the 1963 and 1999 surveys.

Table 2-6

Land Use

Land Use	Percentage of Total Area (approx.)	
	1963[1]	1999[2]
Residential	32	35.7
Streets/Railroads	30.5	--
Community Facilities	11	9.1
Public Service	--	3.9
Industrial	7	7.3
Commercial	4	17.4
Recreational	--	3.6
Conservation	--	5
Vacant and Waterways	10.5	12.7
Unassigned	5	5.3
TOTAL	100	100

Notes:
1. Source: Wegman, 1973
2. Source: City of Buffalo Planning Department (note that slightly different categories were used in the two land use surveys)

Figure 2-5 shows the land use extents in the City of Buffalo for 2010. The majority of the industrial facilities are located in the southern portions of the city or along the waterfront, with smaller industrial areas in the northeast and northwest portions of the City. Large areas of former industrial land along the Buffalo River and the lakeshore are now vacant. Commercial areas are concentrated in the City center along Niagara Street, Delaware Avenue, Franklin Street, Elmwood Avenue, and Pearl Street. Residential areas dominate the north and the periphery of the City area.

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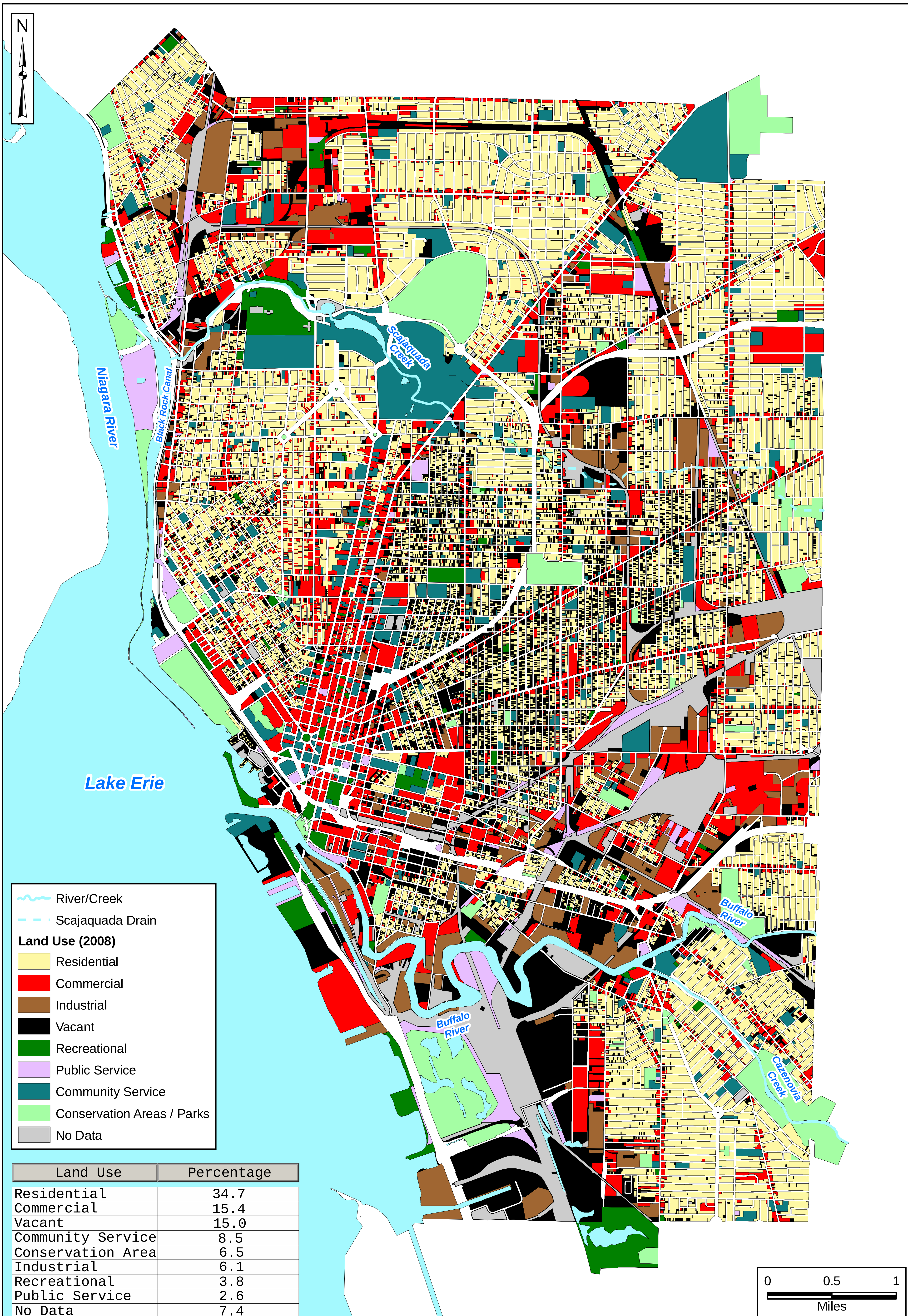

Land Use	Percentage
Residential	34.7
Commercial	15.4
Vacant	15.0
Community Service	8.5
Conservation Area	6.5
Industrial	6.1
Recreational	3.8
Public Service	2.6
No Data	7.4

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FIGURE 2-5

LAND USE

3. Relevant Findings from Work Leading to 2004 LTCP Development

The results of several previous studies had a direct effect on the compilation of the 2004 LTCP. The results of those studies as they pertain to CSO abatement in the BSA service area are summarized in this section:

- Phase I, Stage 1: System Mapping, Data Collection, and Model Development
- Phase I, Stage 2: District-Specific CSO Planning

Findings from studies related to the Bird Island WWTP are summarized in Section 8.

This section summarizes work leading to the development of the 2004 LTCP. Work completed after the development of the 2004 LTCP is discussed in subsequent sections of this LTCP.

3.1 Phase 1, Stage 1: System Mapping, Data Collection, and Model Development

Stage 1 of the LTCP development produced the following relevant reports:

- System Mapping Procedures Manual and Desktop GIS;
- Flow Monitoring Data Analysis Report;
- Water Quality Assessment Report; and
- Model Calibration Report.

3.1.1 System Mapping Procedures Manual and Desktop Geographic Information System

The goal of the system mapping task of Phase I, Stage 1, was to develop a desktop GIS of the BSA's interceptors that would:

- Consolidate existing system information into a single consistent format;
- Provide planning level mapping for model and LTCP development; and
- Serve as the basis for future formal GIS development by BSA.

The resulting system map was used to create the pipe network in the modeling software, SWMM.

Data collection and development of the GIS was performed on-site at the BSA's offices located on the 10th floor of Buffalo City Hall.

The GIS consists of a spatial representation of the interceptor system for all pipes greater than 24 inches in diameter (pipes smaller than 24 inches in diameter were also included in the GIS, where necessary, to delineate connections), as well as attribute information for each of the pipe segments and manholes. The attribute information includes:

- Manholes – rim elevation, invert elevation, type (drop, standard, etc).

- Pipes – type (combined, separate, etc.), upstream invert elevation, downstream invert elevation, length between manholes, slope between manholes, shape, dimensions (diameter or width and height), and material.

The spatial representation and attribute information was obtained from hardcopy information maintained by the BSA at its offices at City Hall. The BSA maintains an exhaustive and comprehensive collection of sewer system information, collected and organized over the entire history of its CSS. This information library was critical to the development of the GIS. The main hardcopy information used in developing the GIS included:

- Master District Map. This map depicts the 27 traditional District boundaries used by the BSA as the organizing framework for its hardcopy system information. The 27 District boundaries do not necessarily reflect drainage basins.

- District maps. There is one map for each of the 27 Districts, hand-drawn ink on paper, depicting all sewer lines in each of the Districts. The sewer lines are color-coded according to type: interceptor, storm relief, storm overflow/storm, combined, and sanitary. The majority of the lines in the BSA's system are combined. The District maps are typically updated by hand by the BSA whenever construction projects are completed. The District maps were used to characterize the type of sewer lines as a pipe attribute in the GIS, as well as to confirm (where necessary) the spatial representation and interconnection of the sewer lines in the GIS.

- Profile drawings for each sewer line in the City of Buffalo. The 27 District maps depicting all the sewer lines in the City of Buffalo also contain a number for each sewer line, keying the line to an associated profile drawing, maintained by the BSA in its fireproof vault at its offices at City Hall. The profile drawings span the entire history of the BSA's collection system, dating back to as early as the late 1800s and as recent as the Hertel reconstruction project completed in 2001. Depending on the origination date of the construction project, the format of the profile drawings ranges from hand-drawn on linen parchment to computer-generated prints using drafting computer software, such as AutoCAD. It is estimated that there are over 7,500 profile drawings contained in the BSA's vault. The profile drawings contain all the attribute information documented in the GIS for the manholes and pipe segments.

- Maintenance records and field books. These items contain dated maintenance records, complaints, and television inspection notes. Oftentimes, these handwritten, bound journals contained information that resolved discrepancies in the attribute information contained in the profile drawings as well as in the spatial representation and interconnections depicted on the District maps.

- Index cards. The cards are handwritten and alphabetized by street name, containing attribute information for sewer lines for which no profile drawing exists. These index cards provided minimal attribute information (length, shape, size, and material) for sewer lines that were added to the CSS but were not surveyed for invert information.

- CSO Points. These points are shown on maps in a City of Buffalo map book containing schematics of portions of the City, along with CSO locations and flow direction.

- BSA CSO Inspection Points. These points were derived from City of Buffalo regulator schematics at each SPP in the system, organized by CSO. An SPP is a location in the CSS where flow is redirected; the SPPs are periodically inspected by BSA personnel.

A full list of the information sources used in creation of the GIS is contained in the GIS report submitted to the BSA in February 2001.

Many of the hardcopy data sources depicted the spatial representation and attribute information of the sewer lines in varying coordinate systems and datum. After the spatial representation and attribute information had been extracted from the hardcopy data sources, the datum and coordinate systems were reconciled using conversion factors and GIS projector functions. The final GIS was consistently converted to New York State Plane Coordinates NAD 83 (feet).

In addition to the pipe and manhole spatial representation and attribute information, additional layers were also added to the GIS to further characterize the BSA's service area. These additional layers include:

- Aerial survey;

- Planimetrics depicting curb lines;

- Parcel data including information such as parcel area, perimeter, owner, and deed date;
- Street centerlines based on the U.S. Census Departments TIGER file;
- Land use;
- Topography;
- Soils;
- CSO and SPP locations;
- Demographic data;
- SIUs; and
- Significant commercial water users.

The end product of the system mapping effort was the:

- Spatial representation of the interceptors that was used to create the pipe network hydraulic portion of the model in XP-SWMM.
- Drainage basin delineations, based on the service area layers, that were used as a starting point to create the overland flow routing hydrologic portion of the model in XP-SWMM.

Figure 3-1 shows the interceptor system, coded as per the District maps, in the GIS.

Although the main intent of the system mapping effort was to create a consistent tool for evaluating CSO abatement alternatives, it also was used to develop a GIS of BSA's CSS.

3.1.2 Flow Monitoring Data Analysis Report

The goal of the flow monitoring task completed during Phase I, Stage 1, of the 2004 LTCP development was to gather current data on flows within the BSA's CSS for the purposes of characterizing the system and to provide a data set for calibration of the collection system model.

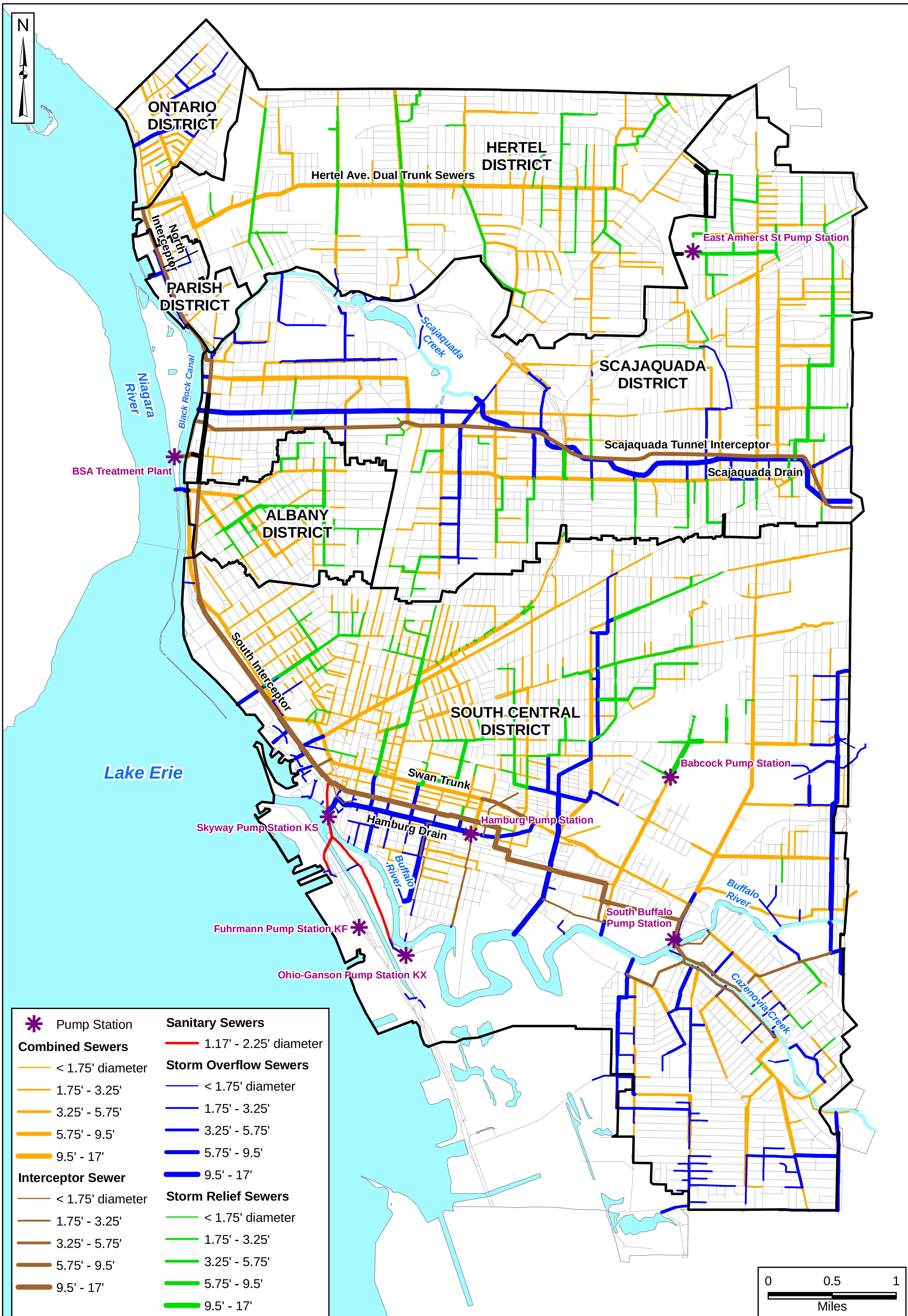

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FIGURE 3-1

INTERCEPTORS IN GIS

The flow monitoring program consisted of flow monitoring, rainfall monitoring, and staff gauge depth monitoring. A separate water quality monitoring program was conducted simultaneously with the flow monitoring program. To conduct the flow monitoring program, the BSA's service area was divided into the three Districts introduced previously: the North District, the Scajaquada District, and the South Central District. Monitoring in each District was assigned to the respective District Consultants. Malcolm Pirnie had the ultimate responsibility of overall program coordination and data validation.

The initial monitoring program was conducted from May 4, 2000, through July 21, 2000. A total of 85 flow monitors were installed throughout the service area. Also, 21 rain gauges were monitored during the same period: five were existing rain gauges maintained by the BSA, and 16 new gauges were installed specifically for the LTCP monitoring program. In addition to the 85 flow monitors, 114 staff gauges were installed at secondary regulators throughout the service area. These secondary regulators were monitored only for CSO activation. Figures 3-2a, b, and c, show the locations of the flow monitors, rain gauges, and staff gauges, for the monitoring program for the North, Scajaquada, and South Central Districts, respectively.

The field data was validated using a three-tiered approach.

- Tier One – Flow and level data were graphed against the time scale and visually inspected to ensure consistency. During Tier One validation, the raw data were organized for each flow meter into spreadsheets, missing data were identified, and periods of valid and questionable data were identified. Reasoning for questionable data was documented if available and questionable data were dropped from further validation.

- Tier Two – Valid data, as determined during the Tier One validation process, were compared to calculated flow rates based on Manning's and continuity equations, as well as to precipitation patterns to determine if the system responded to rain events as expected. Rough meter connectivity and flow balancing criteria were also checked for the Tier One valid data. At the conclusion of the Tier Two validation, periods of dry weather flows to be used to calculate diurnal flow patterns were identified as were rainfall events for potential use as calibration events during model development.

- Tier Three – The dry weather periods and wet weather events identified in the Tier Two validation were refined during Tier Three validation. The purpose of the Tier Three validation was to create a refined set of fully-validated data with the potential to be used for system-wide model calibration.

Figure 3-3 shows the overall data validation process that was used to create a fully-validated data set. At the conclusion of the flow monitoring program, a total of four wet weather events with sufficient validated data for each of the three Districts were identified for use in the system-wide model calibration effort.

Flow data for the tributary communities were provided for inclusion in the model calibration effort. Flow data for the Town of Cheektowaga, Town of West Seneca, and Erie County Sewer Districts 1 and 4, were provided by the BSA in several different formats, ranging from hardcopy circular charts to electronic data. The flow data for these four Districts were evaluated and included in the model calibration effort.

3.1.3 Water Quality Assessment Report

The goals of the 2000 Stage 1 water quality monitoring program were to:

- Support ranking of the CSOs in terms of pollutant mass loading to the project receiving water bodies.
- Assess the water quality in the receiving water bodies in terms of in-stream concentrations and pollutant mass loadings.

Collected data were used to calculate event mean concentrations (EMCs) and mass loadings for pollutants discharged by the CSOs to the project receiving water bodies. The project receiving water bodies are:

- Niagara River;
- Black Rock Canal;
- Buffalo River;
- Cazenovia Creek;
- Scajaquada Creek; and
- Erie Basin Marina.

The collected data and EMC / mass loading calculations were also used to compare the contribution of upstream sources to the receiving water bodies versus that of in-system CSO discharges.

The water quality monitoring program was conducted from May 4, 2000 through November 17, 2000. A total of 22 in-system and CSO outfall locations, as well as 13 receiving water body locations, were sampled for water quality during the program. Figure 3-4 shows the sampling locations.

The program consisted of three wet weather sampling events at all locations, and two dry weather sampling events at all receiving water body locations and at selected in-system locations. The WWTP wet wells were also sampled during wet weather events.

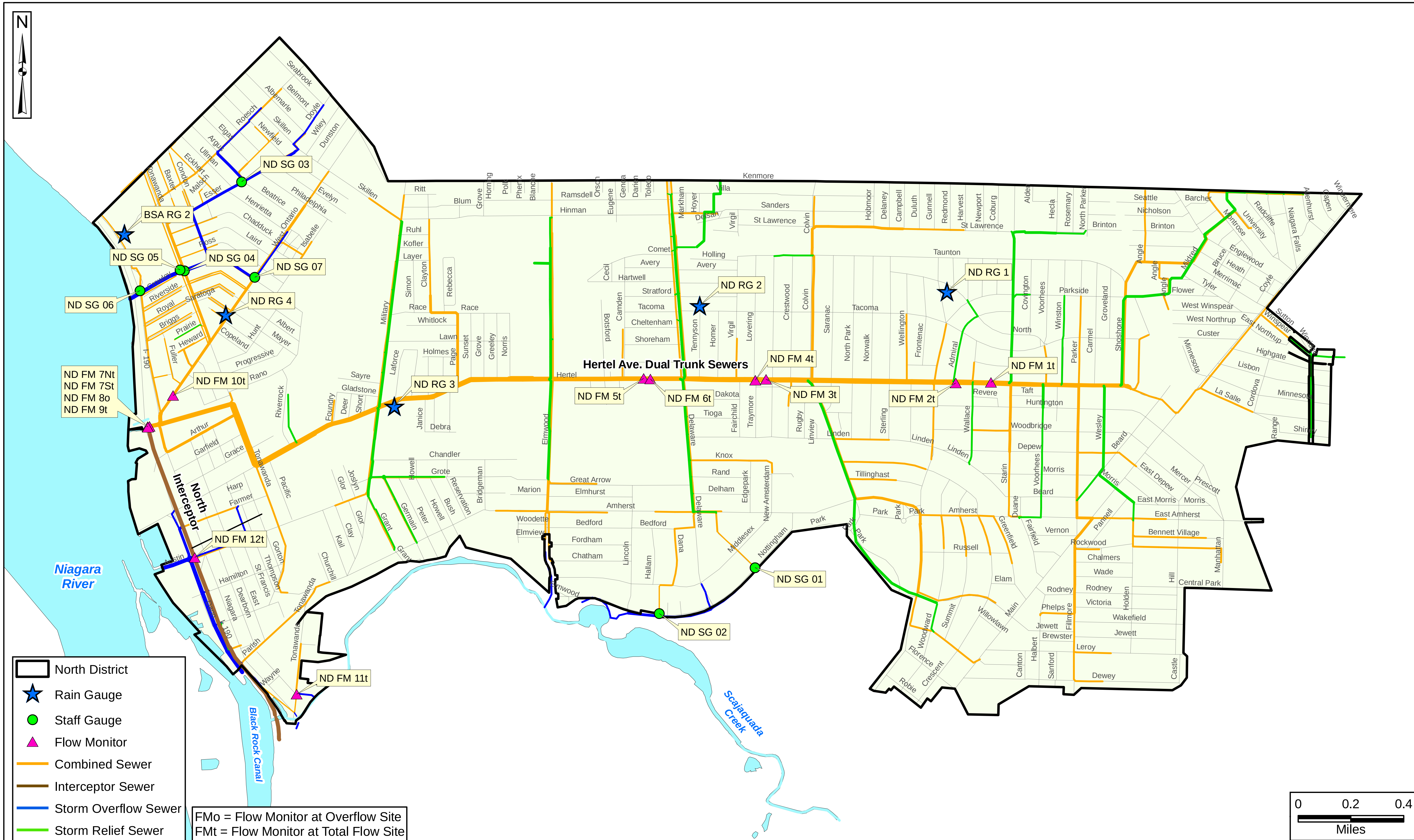

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FIGURE 3-2a

STAGE 1 FLOW MONITORING, RAIN GAUGE, AND STAFF GAUGE LOCATIONS - NORTH DISTRICT

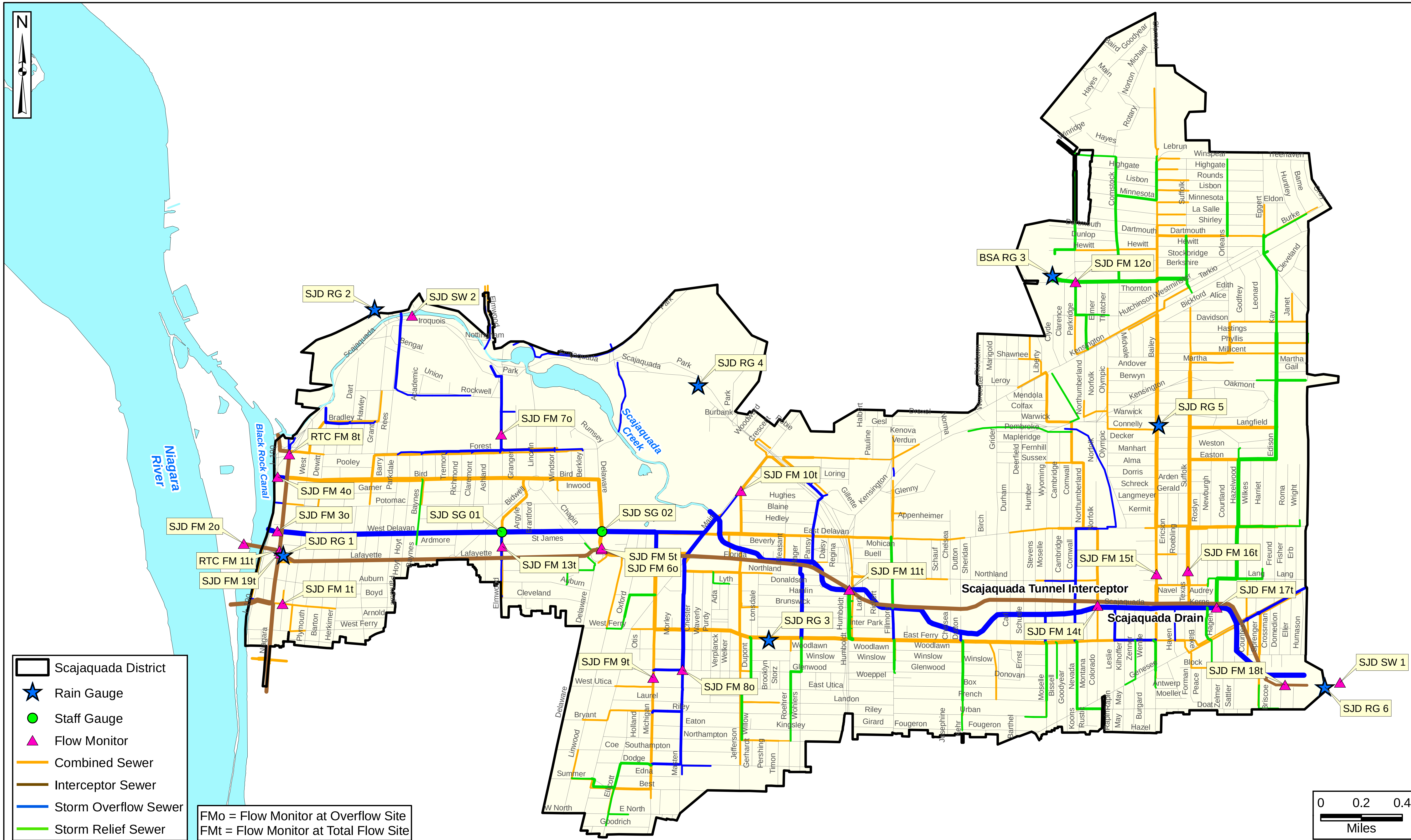

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FIGURE 3-2b

STAGE 1 FLOW MONITORING, RAIN GAUGE, AND STAFF GAUGE LOCATIONS - SCAJAQUADA DISTRICT

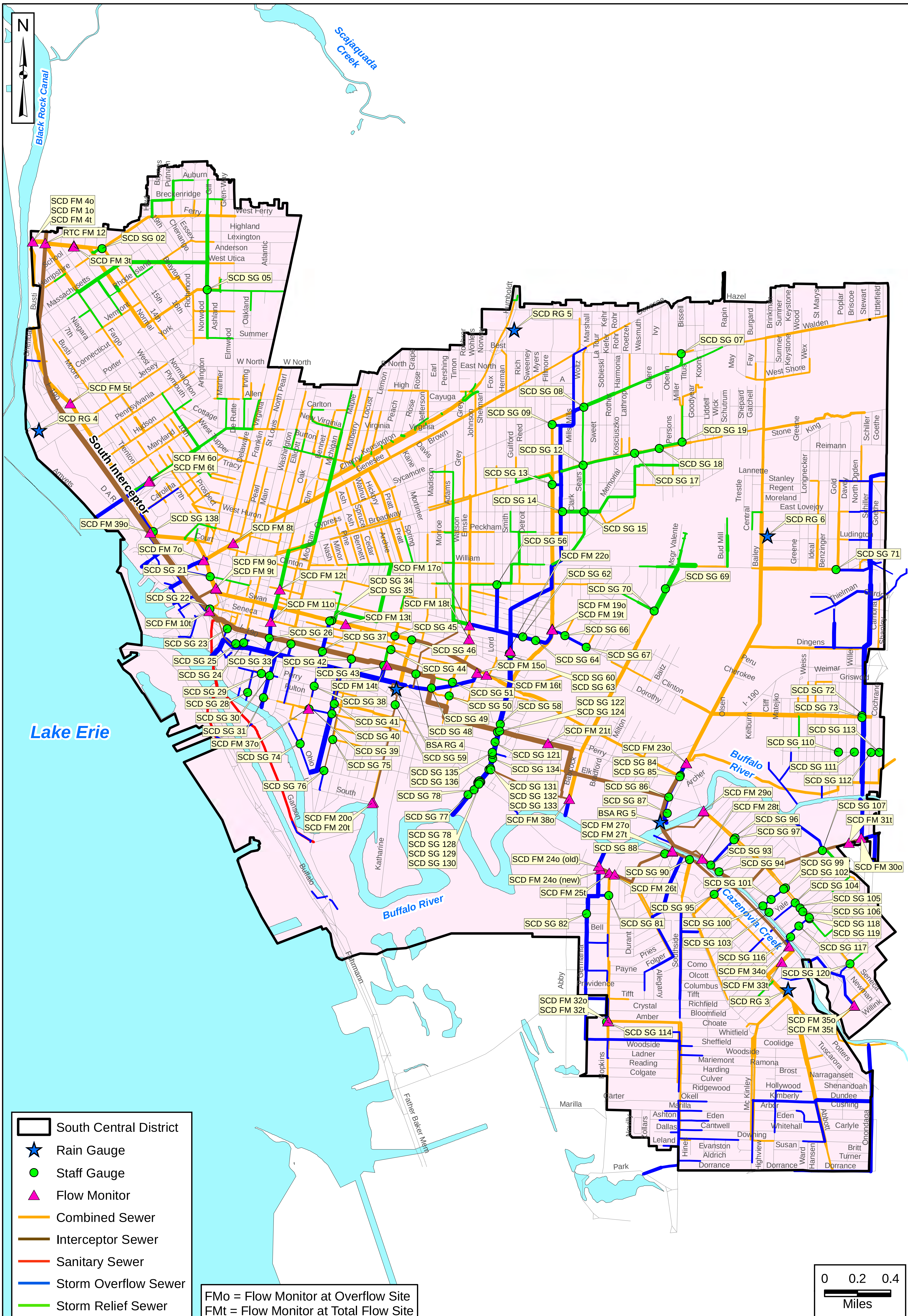

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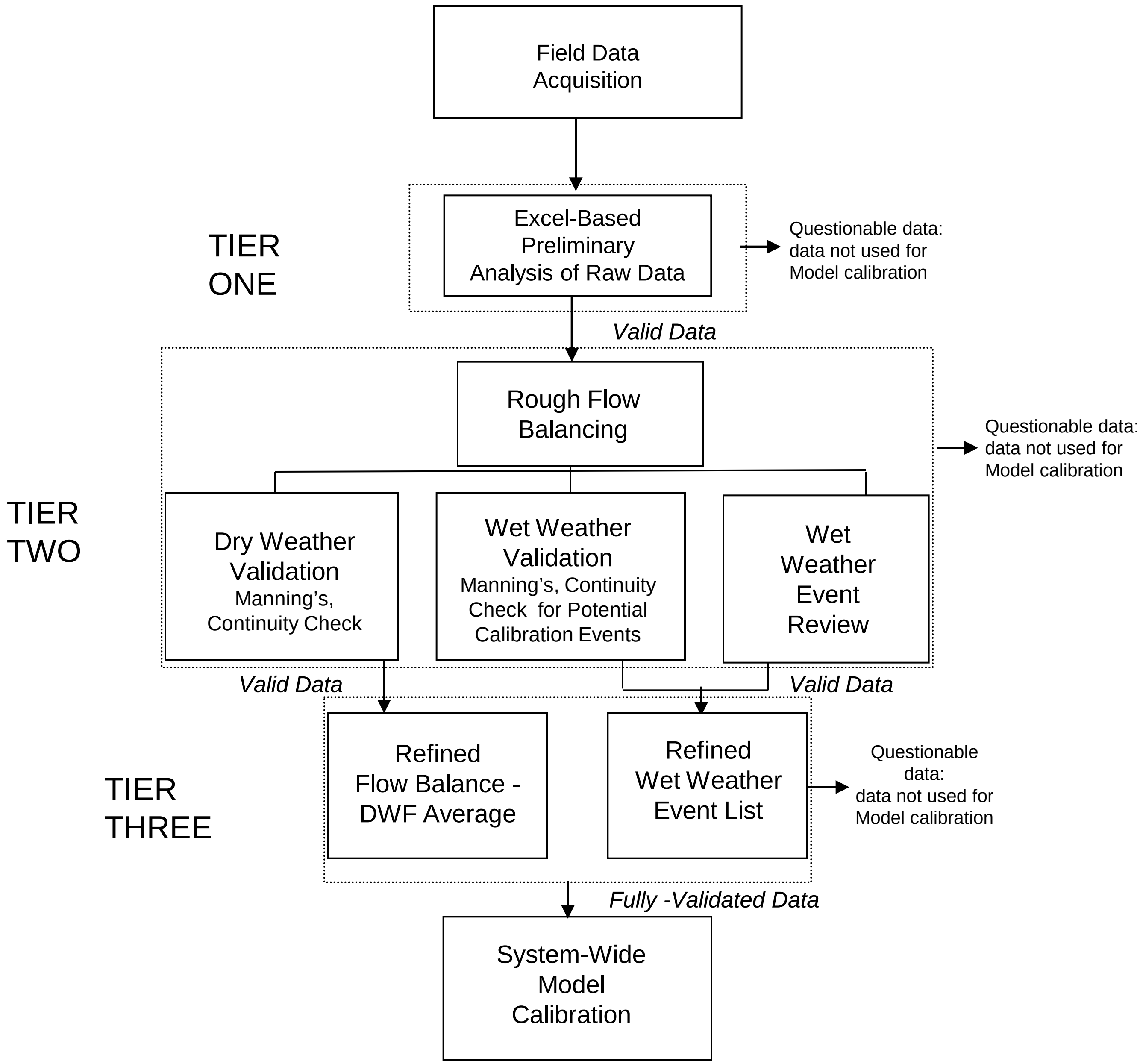
FIGURE 3-2c

STAGE 1 FLOW MONITORING, RAIN GAUGE, AND STAFF GAUGE LOCATIONS - SOUTH CENTRAL DISTRICT



MALCOLM PIRNIE / ARCADIS — The Water Division of ARCADIS 2012 — 1777-122	**BUFFALO SEWER AUTHORITY** **Long Term Control Plan Update**	**FIGURE 3-3** **DATA VALIDATION PROCESS** **(2004 LTCP DEVELOPMENT)**

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FIGURE 3-4

STAGE 1 WATER QUALITY SAMPLING LOCATIONS

All samples were analyzed for the following standard wet chemistry parameters:

- Total settleable solids;
- Total suspended solids (TSS);
- Biochemical oxygen demand (BOD);
- Ammonia-nitrogen;
- Total Kjeldahl nitrogen (TKN);
- Nitrate-nitrite; and
- Total phosphorous.

The samples were also analyzed for the following metals in both the total and dissolved phases:

- Cadmium;
- Chromium;
- Mercury;
- Copper;
- Lead;
- Nickel; and
- Zinc.

Additionally, selected samples (approximately half) were analyzed for organic parameters and cyanide. Grab samples were collected at every location for analysis of fecal coliform. At selected locations, samples were also analyzed in the field for dissolved oxygen, pH, and temperature.

The laboratory analytical data were validated for holding times, control samples, matrix spikes and matrix spike duplicates, surrogate recoveries, method/preparation blanks, and duplicate samples. The majority of the data were validated as usable, although some were qualified as estimated, and a limited amount of data was qualified as unusable.

In addition, continuous monitoring of the water column using Hydrolab Datasonde III or IV equipment was performed at selected receiving water body sites, primarily on the Buffalo River and Black Rock Canal. The Hydrolabs recorded temperature, dissolved oxygen, conductivity, pH, and turbidity.

The analytical data gathered during the water quality monitoring program was combined with the flow data gathered during the flow monitoring program (described in Section 3.1.2) to calculate the mass loadings of pollutants discharged by the CSOs to the receiving water bodies for each of the three wet-weather events sampled. The EMC for each parameter at each sampling location for each of the three wet weather events was calculated by summing the incremental mass loadings of each pollutant at each location for the whole event, and dividing by the total volume of discharge at that location for that event. The resulting EMCs were examined for outlier values that did not fall within the confidence limits of the distribution using standard statistical analysis methods. The outlier EMCs identified were removed from the data set and from further analysis.

The EMCs were then plotted against sampling event characteristics (rainfall volume, average intensity, antecedent dry time) and against the tributary basin characteristics (percent impervious and land use) to determine if temporal or spatial trends were evident. An evaluation of the EMC plots, however, revealed no relationship between sampling event or tributary basin characteristics and observed EMCs. As such, a system-wide average EMC for each parameter of concern was calculated. Table 3-1 presents the system-wide EMCs. The system-wide average EMCs were compared to published EMC values and were found to fall within a reasonable range of typical EMC values.

Table 3-1 System-Wide Event Mean Concentrations

Parameter	System-Wide Average CSO EMC (mg/L)	Published Range[(1)] (mg/L)
Mercury (Total)	1.42×10^{-4}	2.83×10^{-5} to 5.00×10^{-5}
Cadmium (Total)	9.50×10^{-4}	2.00×10^{-4} to 0.043
Chromium (Total)	8.70×10^{-3}	1.60×10^{-3} to 0.085
Copper (Total)	0.063	0.0014 to 0.46
Iron (Total)	2.79	0.21 to 12.78
Lead (Total)	0.098	1.10×10^{-3} to 1.457
Nickel (Total)	9.90×10^{-3}	0 to 0.045
Zinc (Total)	0.253	0.01 to 4.274
Total Suspended Solids	204	14 to 1021.3
BOD5	24.1	7.8 to 262
Nitrate/ Nitrite (as N)	0.524	0.543 to 0.86
Ammonia (as N)	0.681	0.08 to 28
TKN (as N)	4.41	0.12 to 13.8
Total Phosphorus (as P)	0.56	8.70×10^{-3} to 10.2
Fecal Coliform (#/100 mL)	92,500	500 to 1.20×10^{8}

Source:
For a list of sources for published EMCs see Water Quality Assessment Report, April 2001 Appendix J

To rank CSO pollutant load to the receiving water bodies, the mass loadings of pollutants from the CSOs were calculated by combining the system-wide EMC for each parameter of concern with model predictions of CSO discharge volume for planning level design rain events and a typical precipitation year. For the 2004 LTCP, a 1986 typical year was chosen for use. CSO discharge volumes for both the design events and the typical year were obtained from the results of the system-wide model simulations, further described in Section 3.1.4. To determine the typical year, thirty years of historic rainfall data for the City of Buffalo were analyzed and used to calculate rainfall statistics in terms of rainfall volume, event frequency, event duration, and intensity. Design storms were also identified from the thirty years of data to represent events with specific return periods.

Once the design storms were defined, single event design storm model simulations were used to estimate the following measures:

- Threshold rainfall condition that causes overflow at each SPP
- Peak flow rate at each modeled SPP and CSO for each design storm

- Total overflow volume at each modeled SPP and CSO for each design storm

Out of the 59 CSOs in use at the time of the development of the 2004 LTCP, 47 CSOs were modeled. The remaining CSOs were excluded from the model due to lack of hydraulic significance and negligible CSO discharge volume.

The annual mass loadings from each CSO were calculated by multiplying the CSO discharge volume predicted by the model simulations for the 1986 typical year by the system-wide average EMC. However, because system-wide average EMCs were used and did not vary by CSO, the CSOs were ranked based on the model-predicted discharge volume to determine relative importance in terms of pollutant mass load discharged. The ranking of the predicted annual total overflow discharge volume for each CSO, using the 1986 typical year, is presented in Table 3-2. On an annual basis, it was found that:

- CSO 055 (Hertel Avenue) produces the most CSO discharge volume, 20.9 percent, and also the greatest mass load of pollutants.

- CSO 006 (Delevan Drain Outfall) is the second largest, producing 16.5 percent of the total CSO discharge volume.

- CSO 017 (Hamburg Canal Drain) is the third largest, producing 10.3 percent of the total CSO discharge volume.

- CSO 026 (Smith Street CSO) is the fourth largest, producing 8.9 percent of the total CSO discharge volume.

- CSO 053 (Scajaquada Drain CSO) is the fifth largest, producing 8.4 percent of the total CSO discharge volume.

Using the 1986 typical year, these five CSOs accounted for 65 percent of the total annual CSO discharge volume to the receiving water bodies. Note that CSO 006 and CSO 053 do not include Scajaquada Creek volumes, which originate in Cheektowaga and are beyond the BSA’s control.

After ranking the CSOs in terms of pollutant mass loading to the receiving water bodies, the receiving water bodies were assessed in terms of pollutant mass loadings. The total annual mass load of each of the pollutants of concern discharged by CSOs to each receiving water body was calculated by multiplying the predicted annual volume of overflow from each CSO by the system-wide EMC, and summing the resultant mass loading for the CSOs by receiving water body. The results of these calculations are provided in Table 3-3.

Table 3-2 System-Wide CSO Ranking Based on the Water Quality Assessment Evaluation

CSO Outfall ID	Estimated Annual Total Number of Overflow Events (1)	Estimated Annual Total Overflow Duration(1) (hr)	Predicted Annual Total Overflow Volume (MG)	Percent of Total 12 Month Overflow Volume	Cumulative Percent of Total 12 Month Overflow Volume
055	44	152	814	20.9%	20.9%
006(1)	NA	2,539	642	16.5%	37.4%
017	87	2,085	401	10.3%	47.7%
026	84	2,573	345	8.9%	56.6%
053 (1)	NA	3,201	328	8.4%	65.0%
012	56	161	137	3.5%	68.6%
028	192	2,053	122	3.1%	71.7%
066	91	1,499	104	2.7%	74.4%
033	12	75	100	2.6%	76.9%
011	33	147	98	2.5%	79.5%
037	25	96	85	2.2%	81.6%
004	27	69	75	1.9%	83.6%
027	45	616	60	1.5%	85.1%
064	99	419	58	1.5%	86.6%
052	52	457	56	1.4%	88.0%
029	47	209	53	1.4%	89.4%
013	21	160	44	1.1%	90.5%
014	13	105	43	1.1%	91.6%
015	20	99	29	0.8%	92.4%
010	53	135	29	0.8%	93.2%
051	27	127	25	0.7%	93.8%
008	96	607	24	0.6%	94.4%
003	45	649	23	0.6%	95.0%
060	87	693	23	0.6%	95.6%
044	21	56	20	0.5%	96.1%
061	4	19	20	0.5%	96.6%
047	64	156	16	0.4%	97.0%
054	65	581	16	0.4%	97.4%
059	19	64	14	0.4%	97.8%
035	83	343	13	0.3%	98.1%
022	27	471	13	0.3%	98.5%
050	35	64	12	0.3%	98.8%
016	143	741	11	0.3%	99.1%
025	15	36	7.7	0.2%	99.3%
046	15	63	6.3	0.2%	99.4%
058	55	217	5.0	0.1%	99.6%
063	64	117	4.1	0.1%	99.7%
057	53	132	3.6	0.1%	99.8%
048	13	37	2.2	0.1%	99.9%
056	11	47	1.8	0.0%	99.9%
005	9	13	1.6	0.0%	100.0%
034	11	16	0.6	0.0%	100.0%
039	8	12	0.5	0.0%	100.0%
049	1	3	0.04	0.0%	100.0%
032	0	0	0	0.0%	100.0%
TOTAL	1,992	22,183	3,892	100.0%	

Notes:

(1) Volume does not include Scajaquada Creek inflow from Cheektowaga.

(2) CSO 21 was removed from BSA's SPDES permit after the release of the Water Quality Assessment report, and has therefore been removed from this table.

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Table 3-3 Pollutant Mass Loading by Receiving Water Body – Using 1986 Typical Year [(1)]

Parameter	Units	Receiving Water Body						
		Black Rock Canal	Buffalo Harbor (upstream of all CSOs)	Buffalo River	Cazenovia Creek	Erie Basin	Niagara River[(2)]	Scajaquada Creek
BOD	kg	88,300	4,020	118,000	13,400	9,150	84,200	36,400
TSS	kg	748,000	34,100	1,010,000	113,000	77,500	713,100	308,000
TKN	kg	16,200	737	21,700	2,450	1,680	15,440	6,670
Fecal Coliform	# of colonies ($x 10^{14}$)	34.0	1.55	45.7	5.15	35.2	32.37	14.0
Mercury	kg	0.5	0.02	0.70	0.08	0.05	0.50	0.21
Lead	kg	356	16.2	479	54.0	36.9	339.5	147
Copper	kg	231	10.5	311	35.0	24.0	220.3	95.2
Zinc	kg	929	42.3	1,250	141	96.3	885	383

Notes:

(1) Estimated mass loadings rounded to nearest significant figure.

(2) Includes loadings from CSO 055.

The Buffalo River and the Black Rock Canal receive significant CSO loadings. The loadings into Black Rock Canal are due mainly to CSO 004 (Bird Avenue) and CSO 006 (Delevan Drain outfall). The greatest contribution to the mass load in Scajaquada Creek is from CSO 053 (Scajaquada Drain outfall).

Finally, the mass loadings from upstream pollution sources were determined for comparison to the pollutant mass loadings from CSOs within the BSA's CSS. The upstream pollution sources are defined as the mass loadings to the following receiving water bodies at the entry point to the City of Buffalo:

- Scajaquada Creek;
- Buffalo River (includes Buffalo Creek and Cayuga Creek); and
- Cazenovia Creek.

The mass loadings from these upstream sources at the City line were calculated based on the analytical results of the water quality sampling program and Hydrolab data. Water quality samples were collected from each of the receiving water bodies at the City line. Flow data were obtained from flow monitor stations for Buffalo Creek, Cayuga Creek, and Cazenovia Creek, and from the calibrated system-wide hydraulic model for Scajaquada Creek.

Pollutant mass loadings from the upstream sources were calculated for the June 9, 2000 and August 23, 2000 wet weather events. The calculations demonstrate that the total mass loading from upstream pollution sources exceeds the total mass loading to the receiving water bodies from all the CSOs located in the BSA's CSS. The pollutant mass loadings to the Buffalo River and Scajaquada Creek from upstream drainage areas were significantly greater than the pollutant mass loadings from the BSA's CSOs to those receiving water bodies. A summary of the estimated mass loadings from upstream sources compared to the BSA CSOs is presented in Table 3-4.

3.1.4 Model Calibration Report and Updates

The goal of the Phase I, Stage 1 model development and calibration task for the 2004 LTCP was to establish a consistent system-wide analytic tool to conduct the LTCP effort and to provide an assessment of existing conditions in the collection system. The model was used to simulate District-specific alternatives by the District Consultants in Phase I, Stage 2, of the LTCP effort, and to evaluate system-wide alternatives. After the initial model calibration effort was complete, a series of four model updates were issued to address questions and topics that were raised in subsequent modeling efforts in Stage 2 by the District Consultants. However, the results presented in this report and used for the existing conditions assessment are based on Model Update #4, the latest version of the model, issued in April 2002, as updated by additional Phase II efforts in 2008 through 2010, discussed in Section 4.0.

The model consists of two layers:

- A hydraulic layer, consisting of the pipe network and CSOs, to route flows through the collection system.
- A hydrologic layer, consisting of drainage basins, to predict wet weather runoff entering the collection system during a rainfall event.

The hydraulic layer was created using the GIS mapping of the interceptor system that was developed based on record drawing information on system connectivity and sewer line attribute information as described in Section 3.1.1. Pipe connectivity and attribute information was extracted from the GIS and imported into the XP-SWMM modeling software. The hydraulic layer of the model includes the pipe network as well as flow splits at hydraulically significant regulators (SPPs) and CSOs. The regulators were built directly into the hydraulic layer of the model in XP-SWMM using hardcopy detail drawings from the BSA's vault at City Hall.

Table 3-4 Pollutant Mass Loadings from Upstream Sources

A. Total Upstream Load vs. Total BSA Modeled CSOs (metric tons)				
Parameter	Total Upstream Load		BSA Modeled CSOs	
	6/9 Event	8/23 Event	6/9 Event	8/23 Event
Total Suspended Solids	321.62	134.49	76.52	98.31
Biochemical Oxygen Demand	9.12	(2)	5.12	10.34
Total Kjeldahl Nitrogen	4.72	2.66	1.17	2.26
Fecal Coliform (1)	2.62E+14	4.24E+14	1.56E+14	5.73E+14
Mercury	3.71E-07	0	4.91E-05	6.50E-05
Copper	0.05	0.03	0.02	0.04
Lead	0.01	0.01	0.03	0.04
Zinc	0.15	0.26	0.08	0.12

B. Total Upstream Load to Buffalo River vs. Total CSO load to Buffalo River (metric tons)				
Parameter	Total Upstream Source Pollutant Mass Loading to Buffalo River		Total Pollutant Mass Loading from Modeled CSOs to Buffalo River	
	6/9 Event	8/23 Event	6/9 Event	8/23 Event
Total Suspended Solids	270.91	93.43	35.252	41.604
Biochemical Oxygen Demand	7.20	(2)	2.368	4.950
Total Kjeldahl Nitrogen	3.97	1.77	0.481	1.030
Fecal Coliform (1)	2.40E+14	3.10E+14	7.136E+13	2.445E+14
Mercury	3.71E-07	0	2.76E-05	2.84E-05
Copper	0.04	0.02	0.009	0.012
Lead	0.005	0.01	0.018	0.018
Zinc	0.11	0.15	0.035	0.045

C. Total Upstream Load to Scajaquada Creek vs. Total CSO Load to Scajaquada Creek (metric tons)				
Parameter	Total Upstream Source Pollutant Mass Loading to Scajaquada Creek		Total Pollutant Mass Loading from Modeled CSOs to Scajaquada Creek	
	6/9 Event	8/23 Event	6/9 Event	8/23 Event
Total Suspended Solids	50.71	41.06	4.230	3.167
Biochemical Oxygen Demand	1.92	1.25	0.499	0.376
Total Kjeldahl Nitrogen	0.75	0.89	0.092	0.102
Fecal Coliform (1)	2.27E+13	1.14E+14	1.922E+13	2.746E+13
Mercury	0	0	0.000003	0.000003
Copper	0.0034	0.010	0.001	0.0010
Lead	0.004	0.007	0.002	0.0014
Zinc	0.042	0.106	0.005	0.005

Notes:

(1) Represents a measure of the aggregate discharge of coliform colonies over the wet-weather condition of interest.

(2) BOD loading not determined because of suspect analytical water quality data

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The hydrologic layer was developed in two steps. First, the drainage basins were delineated based on system connectivity, topography, and land use. The basins were then characterized in terms of area (estimated in the GIS from the delineations), population (from census data), land use and percent impervious, soil type and infiltration, topography and slope, and width. Each basin was assigned a load point to the interceptors in the model; the load point is the manhole to which runoff is routed during model simulations. A maximum of five subcatchments can be assigned to each manhole.

Field data, specifically rainfall and flow data, collected during the flow and water quality monitoring programs in the early 2000's, as described in Sections 3.1.2 and 3.1.3, were used to calibrate the model. The reviewed and calibrated data were used to identify three calibration and two verification wet weather events for each District. The calibration focused on matching flow volumes and peak flow rates, with flow depths used as an ancillary check.

Following model development and calibration, the existing system hydraulic response to wet weather events was evaluated using the model to provide baseline system performance information for the development of the CSO control alternatives. The hydraulic analysis of the existing system made use of two model simulation approaches:

- Design storm simulations to estimate the response of the CSS, and each SPP and CSO, to a range of wet weather events.

- Annual simulations to estimate the response of the CSS, and each SPP and CSO, to a typical precipitation year.

The results of the design storm simulations were used to estimate the:

- Threshold rainfall condition that causes overflow at each of BSA's SPPs.

- Peak flow rate at each modeled SPP and CSO. Given a desired level of control (as measured by design storm return interval), this information is important in developing preliminary sizes of CSO control facilities that use flow rate as the design variable. These preliminary sizes were then refined with continuous simulations as appropriate.

- Total overflow volume at each modeled SPP and CSO. Given a desired level of control (as measured by design storm return interval), this information is important in developing preliminary sizes of CSO control facilities that use volume as the design variable. These preliminary sizes were then refined with continuous simulations as appropriate.

The design storm simulation results were summarized by SPP and CSO for the following quantitative measures to characterize existing conditions for a range of discrete design storms experienced by the BSA's CSS:

- Predicted design storm overflow volumes by SPP for existing conditions, detailed in Table 3-5. These are total overflow volumes at the SPP, including any overflow volume reaching the SPP from an upstream location. The only exception is for SPP 017 and SPP 170A; following BSA discussions with NYSDEC, the volume associated with Scajaquada Creek inflows from Cheektowaga is not included in the total volume for these SPPs.

- Predicted design storm peak overflow rates by SPP for existing conditions, detailed in Table 3-6.

- Predicted design storm overflow volumes by CSO for existing conditions, detailed in Table 3-7. These are total overflow volumes at the CSO, including any locally separated storm flow reaching the CSO from an upstream location. The only exceptions are for CSO 006 and CSO 053; following BSA discussions with NYSDEC, the volume associated with Scajaquada Creek inflows from Cheektowaga is not included in the total volume for these CSOs. Predicted design storm peak overflow rates by CSO for existing conditions are detailed in Table 3-8.

The annual, continuous simulation uses a 1986 typical precipitation year based on historical rainfall data to define system response for the typical precipitation year. In particular, continuous simulation serves as the basis for assessing three quantitative measures of benefit in the development of the BSA's LTCP:

- Reduction in annual overflow volume at individual SPPs, CSOs, and for the system as a whole.

- Reduction in annual number of overflow events at individual SPPs and CSOs.

- Reduction in annual number of overflow hours at individual SPPS and CSOs.

In order to document the existing baseline conditions for these measures in the 2004 LTCP, the existing condition collection system model was run in continuous mode for a 9-month period of the typical precipitation year (March through November). The 9-month period was chosen, after discussion with the NYSDEC, to avoid using the model to analyze wintertime snowfall. The results from the 9-month period were extrapolated to a full 12-month period in order to estimate the annual response measures. The extrapolation was performed by using the average of the model predictions for each of the three simulated quarters (three 3-month periods) as an estimate to represent the fourth (non-modeled) winter quarter. Later evaluations using a different typical year used the full 12-month period.

Table 3-5 Predicted Design Storm Total Overflow Volume by SPP
Sorted by Original 6-Month Design Storm Total Overflow Volume
Existing Conditions

SPP	CSO	1-Month (MG)	2-3 Month (Higher Intensity, Shorter Duration) (MG)	2-3 Month (Lower Intensity, Longer Duration) (MG)	6-Month (MG)	12-Month (MG)
1	55	28.13	48.87	44.63	89.61	147.73
170A(1)	53	13.94	37.16	28.79	72.62	121.42
17(1)	6	10.57	36.30	30.55	68.95	84.52
67	17	3.84	9.18	6.80	18.17	25.74
104	33	0.23	7.05	2.41	16.08	26.31
24	11	5.48	8.24	9.41	15.55	11.44
97	27	0.00	4.07	0.17	13.06	17.61
336B	53	4.92	7.51	7.42	13.44	17.79
296	12	2.85	7.64	5.60	12.57	10.51
13	4	1.47	6.64	3.37	11.71	17.56
122	37	0.85	4.55	2.69	10.48	16.64
317	26	1.69	4.70	4.13	10.06	13.19
337	53	2.20	5.11	3.88	8.98	15.66
339	53	2.32	5.36	4.12	9.95	11.01
206A&B	14	1.47	4.88	2.86	9.83	13.27
217	26	1.65	3.97	3.34	8.72	14.77
170B	53	2.31	5.19	4.14	8.60	13.30
281	17	1.21	3.68	2.43	7.60	13.29
332	6	2.48	4.05	3.41	7.58	9.31
340	53	2.64	4.86	4.42	8.39	15.05
23	12	0.98	4.13	2.53	6.97	6.74
126	29	0.00	0.00	0.00	0.00	0.29
106	52	0.11	1.43	1.33	3.92	4.86
304	13	0.57	3.37	1.86	6.16	12.91
180	6	1.79	3.14	2.55	5.78	7.44
338	53	1.71	5.19	3.09	9.00	14.95
326	17	0.01	2.42	0.82	5.06	13.19
341A	53	0.97	2.26	1.90	4.27	6.83
198B	26	0.11	1.21	0.71	3.82	7.10
199B	26	0.13	1.34	0.78	3.79	6.27
123A	28	0.44	1.80	1.15	3.58	6.37
179	6	0.07	1.99	0.78	3.55	7.33
330	61	1.89	3.56	1.34	9.54	14.47
307	51	0.13	0.76	0.42	1.90	3.37
35	15	0.08	1.57	0.75	3.21	8.13
254	(2)	0.95	1.69	1.54	3.00	4.86
121	44	0.30	1.41	0.85	2.81	4.86
21	10	0.94	1.61	1.42	2.70	4.49
123B	28	0.58	1.35	1.25	2.61	2.58
149	26	0.11	0.88	0.55	2.51	4.00
331	6	0.64	1.45	1.12	2.51	4.34
174	53	0.09	1.25	0.49	2.37	4.81
165B	53	1.02	1.69	1.59	2.26	2.97
197C	26	0.18	0.82	0.63	2.17	3.70
229A	53	0.00	1.06	0.33	2.11	5.09
178	53	0.15	0.58	0.30	1.11	2.10
163	53	0.22	1.12	0.72	2.01	1.47
203	53	0.05	1.20	0.53	1.99	4.00

Table 3-5 Predicted Design Storm Total Overflow Volume by SPP
Sorted by Original 6-Month Design Storm Total Overflow Volume
Existing Conditions

SPP	CSO	1-Month (MG)	2-3 Month (Higher Intensity, Shorter Duration) (MG)	2-3 Month (Lower Intensity, Longer Duration) (MG)	6-Month (MG)	12-Month (MG)
105	50	0.20	0.90	0.51	1.80	3.00
181	59	0.00	0.62	0.12	1.71	2.94
336A	53	0.58	1.31	1.00	1.66	3.00
114	47	0.51	1.17	0.97	1.65	2.02
19	8	0.46	0.94	0.78	1.53	1.97
282	17	0.00	0.80	0.10	1.86	5.45
255(1)&(2)	(2)	0.00	0.70	0.29	1.40	3.67
211	66	0.04	0.57	0.19	1.25	2.67
218	26	0.02	0.53	0.26	1.29	2.80
175	53	0.09	0.65	0.36	1.26	3.03
165	53	0.14	0.64	0.39	1.25	1.56
89	26	0.00	0.48	0.01	1.08	1.14
65	17	0.00	0.49	0.02	1.40	7.79
209	25	0.02	0.45	0.14	1.04	2.35
274	(2)	0.28	0.61	0.47	1.01	1.42
183	59	0.09	0.48	0.26	0.99	2.18
182	59	0.04	0.42	0.17	0.95	2.06
53(1)	17	0.00	0.23	0.02	0.90	1.87
132	64	0.00	0.27	0.10	0.56	1.06
107A	35	0.06	0.29	0.17	0.53	1.06
318	26	0.05	0.47	0.24	0.90	1.50
123C	28	0.21	0.47	0.41	0.90	1.53
202	53	0.00	0.42	0.13	0.94	2.24
10	3	0.22	0.54	0.43	0.85	1.48
135A	64	0.20	0.45	0.35	0.81	1.32
204	53	0.08	0.50	0.25	0.84	1.96
53(2)	17	0.00	0.21	0.02	0.80	1.66
165A	53	0.13	0.46	0.28	0.80	1.60
55	17	0.00	0.25	0.07	0.75	1.27
335B	53	0.02	0.26	0.11	0.50	2.10
164	53	0.00	0.15	0.09	0.73	0.69
200A	53	0.00	0.36	0.13	0.71	1.61
199C	26	0.00	0.13	0.02	0.65	2.11
199A	26	0.00	0.15	0.02	0.62	1.59
130	17	0.15	0.36	0.27	0.60	0.95
75	26	0.13	0.31	0.24	0.57	0.92
308	46	<0	0.12	0.03	0.32	0.50
240	60	0.05	0.39	0.21	0.56	0.79
314	26	0.12	0.32	0.23	0.54	0.93
322	66	0.00	0.00	0.00	0.51	2.94
248	26	0.00	0.09	0.00	0.51	1.42
157	53	0.00	0.22	0.08	0.49	1.18
124	28	0.43	1.41	0.95	3.12	3.48
133	64	0.02	0.26	0.12	0.44	0.73
201	53	0.00	0.06	0.01	0.39	1.66
213	58	<0	0.00	0.00	0.01	0.04
283	63	0.07	0.26	0.17	0.44	0.80
177	53	0.00	0.16	0.08	0.43	1.19
107	35	0.23	0.73	0.48	1.62	3.76

Table 3-5 Predicted Design Storm Total Overflow Volume by SPP
Sorted by Original 6-Month Design Storm Total Overflow Volume
Existing Conditions

SPP	CSO	1-Month (MG)	2-3 Month (Higher Intensity, Shorter Duration) (MG)	2-3 Month (Lower Intensity, Longer Duration) (MG)	6-Month (MG)	12-Month (MG)
88	26	0.00	0.14	0.03	0.38	0.71
5	3	0.00	0.06	0.04	0.17	0.45
345	53	0.00	0.11	0.05	0.37	1.38
4	3	0.00	0.05	0.04	0.17	0.45
36	15	0.02	0.19	0.10	0.35	0.69
94	26	0.00	0.05	0.00	0.32	0.80
128	17	0.00	0.14	0.05	0.33	0.88
91	26	0.00	0.09	0.00	0.33	0.45
129	64	0.07	0.18	0.14	0.29	0.50
39	16	0.03	0.16	0.09	0.30	0.67
195	57	0.01	0.06	0.04	0.10	0.16
342B	53	0.01	0.12	0.06	0.23	0.34
176	53	0.00	0.08	0.05	0.27	0.83
7	3	0.00	0.00	0.00	0.00	0.14
118	48	0.02	0.34	0.07	0.64	0.96
69	26	0.02	0.13	0.07	0.22	0.42
277	26	0.00	0.02	0.00	0.21	1.57
148	26	0.00	0.04	0.01	0.20	0.63
144	22	0.03	0.11	0.08	0.20	0.31
150	26	0.00	0.04	0.00	0.20	1.06
77	26	0.00	0.04	0.00	0.17	0.58
97A	27	0.04	0.11	0.08	0.19	0.36
239	60	0.00	0.06	0.05	0.19	0.41
149	26	0.00	0.02	0.00	0.19	1.15
87	26	0.00	0.04	0.00	0.19	0.49
230	60	0.00	0.11	0.05	0.19	0.34
11	3	0.02	0.08	0.06	0.14	0.24
237	60	0.00	0.08	0.05	0.19	0.37
276	(2)	0.00	0.06	0.02	0.19	0.62
291	66	0.02	0.11	0.06	0.18	0.34
51	17	0.00	0.05	0.00	0.25	0.84
138	22	0.02	0.10	0.06	0.18	0.27
90	26	0.01	0.09	0.04	0.18	0.28
84	26	0.00	0.05	0.01	0.17	0.31
166	53	0.00	0.03	0.01	0.17	0.54
235	60	0.00	0.08	0.05	0.17	0.31
309	46	0.00	0.00	0.00	0.05	0.28
145	22	0.00	0.08	0.04	0.17	0.27
238	60	0.00	0.04	0.04	0.16	0.37
131	64	0.35	0.81	0.57	1.37	1.91
92	26	0.00	0.03	0.00	0.16	0.27
335A	53	0.00	0.04	0.02	0.14	0.49
85	26	0.00	0.03	0.00	0.13	0.22
210	53	0.00	0.03	0.00	0.13	0.57
113	47	0.00	0.03	0.00	0.15	0.54
151	26	0.00	0.00	0.00	0.12	1.35
14A	5	0.00	0.03	0.01	0.11	0.55
48	17	0.00	0.01	0.00	0.11	0.86
79	26	0.00	0.06	0.02	0.11	0.28

Table 3-5 Predicted Design Storm Total Overflow Volume by SPP
Sorted by Original 6-Month Design Storm Total Overflow Volume
Existing Conditions

SPP	CSO	1-Month (MG)	2-3 Month (Higher Intensity, Shorter Duration) (MG)	2-3 Month (Lower Intensity, Longer Duration) (MG)	6-Month (MG)	12-Month (MG)
271, 272	(2)	0.02	0.06	0.04	0.10	0.19
42	16	0.00	0.02	0.00	0.13	0.53
208	28	0.00	0.05	0.01	0.10	0.33
259	(2)	0.00	0.00	0.00	0.01	0.06
261	(2)	0.00	0.05	0.02	0.12	0.29
260	(2)	0.02	0.05	0.04	0.09	0.17
232	60	0.00	0.02	0.02	0.09	0.19
50	17	0.00	0.01	0.00	0.08	1.23
293	66	0.00	0.04	0.01	0.09	0.23
125A	28	0.00	0.00	0.00	0.05	0.36
231	60	0.00	0.03	0.02	0.08	0.18
310	46	0.00	0.01	0.00	0.08	0.38
292	66	0.00	0.03	0.00	0.07	0.22
263	(2)	0.00	0.01	0.00	0.02	0.05
344	34	0.00	0.03	0.01	0.07	0.18
294	66	0.00	0.03	0.00	0.07	0.20
68	26	0.00	0.04	0.01	0.07	0.16
319	26	0.00	0.00	0.00	0.07	0.49
78	26	0.00	0.02	0.00	0.07	0.36
295	66	0.00	0.02	0.00	0.06	0.18
80	26	0.00	0.01	0.00	0.05	0.30
249	26	0.00	0.00	0.00	0.05	0.61
156	53	0.00	0.00	0.00	0.04	0.40
236	60	0.00	0.01	0.00	0.04	0.15
245	56	0.00	0.01	0.01	0.04	0.11
275	(2)	0.00	0.02	0.01	0.03	0.08
269, 270	(2)	0.00	0.02	0.01	0.03	0.07
266, 267	(2)	0.00	0.01	0.01	0.03	0.06
233	60	0.00	0.00	0.00	0.03	0.13
342A	53	0.00	0.02	0.02	0.07	0.21
311	39	0.00	0.00	0.00	0.03	0.15
74	74	0.00	0.01	0.00	0.03	0.05
262	(2)	0.00	0.01	0.00	0.02	0.05
268	(2)	0.00	0.01	0.00	0.02	0.05
265	(2)	0.00	0.00	0.00	0.01	0.04
8	3	0.00	0.00	0.00	0.02	0.08
81	26	0.00	0.00	0.00	0.02	0.09
244	56	0.00	0.00	0.00	0.00	0.10
82	26	0.00	0.00	0.00	0.00	0.10
192	54	0.00	0.00	0.00	0.00	0.01
152	26	0.00	0.00	0.00	0.00	0.42
264	(2)	0.00	0.00	0.00	0.00	0.02
234	60	0.00	0.00	0.00	0.00	0.04
200B	53	0.00	0.00	0.00	0.00	0.43
3	3	0.00	0.00	0.00	0.00	0.07
329	66	0.00	0.00	0.00	0.00	0.01
106A	52	0.00	<0	<0	<0	<0

Table 3-5 Predicted Design Storm Total Overflow Volume by SPP
Sorted by Original 6-Month Design Storm Total Overflow Volume
Existing Conditions

SPP	CSO	1-Month (MG)	2-3 Month (Higher Intensity, Shorter Duration) (MG)	2-3 Month (Lower Intensity, Longer Duration) (MG)	6-Month (MG)	12-Month (MG)
119	49	0.00	0.00	0.00	0.00	0.00
120	32	0.00	0.00	0.00	0.00	0.00
125	28	0.12	0.89	0.39	2.00	4.16
185	3	0.00	0.00	0.00	0.00	0.01
186	3	0.00	0.00	0.00	0.00	0.00
188	54	0.00	0.00	0.00	0.00	0.15
189	54	0.00	0.00	0.00	0.00	0.13
190	54	0.00	0.00	0.00	0.00	0.11
191	54	0.00	0.00	0.00	0.00	0.26
197A	26	0.00	0.00	0.00	0.00	0.01
197B	26	0.00	0.00	0.00	0.00	0.20
9	3	0.00	0.00	0.00	0.00	0.03
Old 259	(2)	0.00	0.00	0.00	0.00	0.02

Notes:

(1) Volume represents the CSO component of the mixed flow through these SPPs. It does not include Scajaquada Creek inflow from Cheektowaga.

(2) Discharge to the East Amherst Quarry Retention Pond. These overflows are stored in the Quarry facility and dewatered back into the collection system.

(3) Volumes presented in this table represent the full predicted volume at each SPP, including flows that may have been previously regulated at an upstream SPP.

(4) CSOs / SPPs that were removed from BSA's SPDES permit after the release of the Model Calibration report have not been included in this table.

(5) Volumes presented in this table represent the full predicted volume at each SPP. However, the sum of the volumes at SPPs from this table may not equal the total volume for each CSO to which the SPPs are tributary, for two reasons:

**Upstream SPPs may be configured in series, i.e., overflow from one SPP is re-regulated at a downstream SPP. Therefore, adding SPP volumes would double-account for some flows.

**Locally separated stormwater may bypass SPPs and be discharged through the formal CSO point. The separate stormwater volume is included in the CSO volume but not the tributary SPPs. Specifically, stormwater and non-BSA flows have been inlcuded in CSO volumes for 028, 054, and 066, and not in the SPPs tributary to these CSOs.

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Table 3-6 Predicted Design Storm Peak Overflow Rate by SPP
Sorted by Original 6-Month Design Storm Peak Overflow Rate
Existing Conditions

SPP	CSO	1-Month (MGD)	2-3 Month (Higher Intensity, Shorter Duration) (MGD)	2-3 Month (Lower Intensity, Longer Duration) (MGD)	6-Month (MGD)	12-Month (MGD)
1	55	288.31	563.64	468.83	740.26	1,194.81
13	4	50.78	131.49	91.36	163.18	281.23
296	12	37.40	105.84	93.51	161.69	216.69
104	33	8.77	91.56	58.12	142.21	209.09
67	17	38.25	90.26	68.18	114.94	222.08
281	17	16.43	47.01	32.92	113.64	158.44
23	12	16.36	62.08	52.73	96.10	118.05
337	53	34.81	64.94	68.18	94.16	187.66
122	37	13.70	54.42	41.30	86.36	148.70
336B	53	46.95	75.97	70.78	84.74	134.42
97	27	0	65.58	10.19	85.71	140.91
24	11	46.30	67.53	46.30	79.87	100.26
340	53	33.44	58.64	59.94	84.42	173.38
170B	53	28.96	61.69	55.78	84.42	129.87
339	53	30.32	57.40	53.70	83.77	125.45
304	13	12.86	48.77	43.57	75.32	198.05
326	17	1.37	36.56	30.52	72.73	220.78
206A&B	14	20.45	59.55	41.75	68.18	98.05
338	53	25.19	66.23	55.78	91.56	168.18
217	26	19.55	40.32	42.14	59.03	145.45
330	61	40.06	57.92	42.79	63.90	88.31
35	15	5.01	26.10	28.25	49.16	166.88
332	6	25.78	39.94	37.08	45.58	59.22
179	6	3.66	29.68	23.25	45.06	98.05
317	26	13.90	35.32	23.51	43.25	72.73
126	29	0	0	0	0.01	10.45
180	6	18.38	32.40	29.03	38.38	58.64
341A	53	11.43	25.32	23.64	36.82	89.16
123A	28	6.69	22.40	19.87	34.35	73.38
21	10	13.18	21.43	23.25	32.21	59.94
229A	53	0	16.88	10.19	29.94	70.13
163	53	4.69	18.70	18.51	29.55	16.49
174	53	1.88	18.38	13.12	29.03	60.78
203	53	2.40	19.35	18.57	29.29	60.84
121	44	4.59	21.49	17.27	28.12	64.94
331	6	10.39	19.29	20.39	27.92	55.32
282	17	0	14.16	5.19	27.73	67.53
199B	26	3.97	16.04	11.10	23.96	53.25
254	(1)	8.90	17.79	16.69	23.83	49.29

Table 3-6 Predicted Design Storm Peak Overflow Rate by SPP
Sorted by Original 6-Month Design Storm Peak Overflow Rate
Existing Conditions

SPP	CSO	1-Month (MGD)	2-3 Month (Higher Intensity, Shorter Duration) (MGD)	2-3 Month (Lower Intensity, Longer Duration) (MGD)	6-Month (MGD)	12-Month (MGD)
255(1)&(2)	(1)	0.23	12.79	12.60	22.86	78.57
198B	26	2.99	13.38	9.29	22.01	50.00
65	17	0	10.52	1.65	25.06	102.60
181	59	0.06	13.05	5.32	21.56	29.68
202	53	0	9.16	7.92	17.66	49.35
123B	28	5.20	13.38	10.65	19.16	32.21
165	53	3.00	10.58	9.87	18.77	19.22
336A	53	9.61	15.06	15.00	16.36	52.79
19	8	6.88	12.47	12.40	18.57	20.52
307	51	3.55	10.32	8.51	15.97	39.74
175	53	3.62	10.32	11.62	18.12	57.40
165B	53	12.08	16.49	16.49	16.56	17.01
105	50	3.52	11.43	9.09	16.56	33.90
211	66	1.30	8.64	4.37	14.35	29.48
164	53	0	5.76	5.40	14.55	23.51
106	52	2.36	9.42	7.40	10.65	15.13
322	66	0	0	0	13.51	35.71
209	25	0.84	7.34	5.16	12.99	29.29
114	47	7.99	16.04	16.04	14.55	15.84
218	26	0.79	7.60	7.53	12.27	33.96
149	26	1.58	8.83	5.62	12.21	27.34
200A	53	0	6.56	5.95	11.69	24.42
132	64	0	4.78	5.10	8.70	17.27
197C	26	1.76	7.73	4.89	11.62	27.27
10	3	4.37	7.66	8.90	11.62	25.00
107A	35	0.96	3.93	3.44	6.24	18.77
178	53	1.56	7.34	5.14	11.17	25.97
204	53	1.96	7.40	7.08	10.84	31.88
201	53	0	1.97	1.23	8.31	38.05
335B	53	0.66	7.14	3.12	10.45	48.51
165A	53	2.76	6.62	6.75	9.87	24.61
318	26	2.06	6.62	6.43	9.42	18.12
182	59	1.27	6.45	4.75	9.29	34.55
124	28	6.49	17.34	11.69	24.03	41.36
274	(1)	4.27	7.21	7.53	9.09	12.99
183	59	2.23	5.95	5.38	8.90	43.38
240	60	1.94	6.36	6.82	8.38	11.62
135A	64	2.88	5.38	5.50	8.05	17.53
157	53	0.03	4.14	3.84	8.25	23.64

Table 3-6 Predicted Design Storm Peak Overflow Rate by SPP
Sorted by Original 6-Month Design Storm Peak Overflow Rate
Existing Conditions

SPP	CSO	1-Month (MGD)	2-3 Month (Higher Intensity, Shorter Duration) (MGD)	2-3 Month (Lower Intensity, Longer Duration) (MGD)	6-Month (MGD)	12-Month (MGD)
177	53	0.04	3.40	3.95	7.66	25.06
345	53	0.0	2.79	2.79	7.53	35.19
53(1)	17	0.0	3.70	1.69	7.21	27.08
123C	28	2.26	4.87	4.40	7.14	17.73
199A	26	0.0	3.91	1.47	6.95	17.73
308	46	0.45	2.59	1.23	3.11	5.66
130	17	2.08	4.75	4.88	6.75	12.79
53(2)	17	0.0	3.28	1.50	6.39	24.03
199C	26	0.0	2.97	1.10	6.44	24.22
133	64	1.14	4.14	4.42	6.31	10.84
314	26	1.71	4.08	3.77	5.99	13.70
213	58	0	-0.22	0.36	0.40	1.79
248	26	0	3.08	0	5.82	15.91
128	17	0	2.66	2.96	5.75	16.43
36	15	0.69	3.39	3.26	5.57	13.05
89	26	0	4.64	1.62	5.32	8.44
277	26	0	1.43	0	5.35	24.61
75	26	1.64	3.70	3.51	5.32	12.21
5	3	0	1.36	1.62	3.07	9.87
283	63	1.04	3.64	3.18	5.45	12.47
176	53	0	1.88	2.37	5.00	18.64
4	3	0.01	1.36	1.64	3.08	10.78
210	53	0	1.49	0	4.85	17.21
55	17	0.38	2.95	2.75	4.87	20.00
131	64	5.63	9.81	9.74	12.27	20.84
118	48	0.41	5.66	1.04	6.38	9.09
342B	53	0.56	2.08	1.98	3.91	8.70
88	26	0.21	2.70	1.23	4.24	10.00
239	60	0	2.01	2.48	4.28	9.48
237	60	0	2.10	2.51	4.17	8.57
129	64	1.27	2.55	2.66	3.92	7.27
166	53	0	1.02	0.71	3.96	12.27
94	26	0	2.08	0	3.88	9.87
276	(1)	0	1.34	1.50	3.97	15.19
238	60	0	1.68	2.19	3.79	8.64
50	17	0	1.62	0	3.95	20.97
230	60	0	2.25	2.16	3.60	6.82
187	54	0	0.57	1.26	3.32	28.05
39	16	0.80	2.29	2.25	3.54	9.87

Table 3-6 Predicted Design Storm Peak Overflow Rate by SPP
Sorted by Original 6-Month Design Storm Peak Overflow Rate
Existing Conditions

SPP	CSO	1-Month (MGD)	2-3 Month (Higher Intensity, Shorter Duration) (MGD)	2-3 Month (Lower Intensity, Longer Duration) (MGD)	6-Month (MGD)	12-Month (MGD)
7	3	0	0	0	0	5.59
150	26	0	1.56	0	3.42	17.40
335A	53	0	1.23	0.91	3.39	13.31
235	60	0	1.92	2.20	3.18	6.28
87	26	0	1.56	0	3.08	7.60
69	26	0.57	1.93	1.78	2.97	6.88
151	26	0	0.45	0	3.05	19.55
113	47	0	0.84	0	3.64	12.86
51	17	0	1.69	0.33	3.05	12.14
42	16	0	0.69	0	2.93	8.70
195	57	0.56	1.10	1.27	1.56	2.92
144	22	0.71	1.74	1.81	2.62	4.73
138	22	0.52	1.76	1.82	2.60	4.11
91	26	0	1.98	0	2.53	4.84
14A	5	0	1.16	0.97	2.57	15.26
145	22	0.33	1.61	1.68	2.56	4.69
291	66	0.39	1.67	1.45	2.50	5.73
11	3	0.58	1.25	1.53	2.12	4.81
149	26	0	0.75	0	2.47	28.38
148	26	0	1.04	0.43	2.17	7.27
97A	27	0.53	1.46	1.30	2.13	5.26
232	60	0	0.98	1.21	2.14	4.53
77	26	0	1.03	0.26	2.19	8.64
79	26	0	1.21	0.94	2.05	5.87
107	35	3.35	8.51	7.08	15.26	35.32
231	60	0	0.96	1.12	1.97	4.24
84	26	0	1.23	0.39	1.90	4.32
261	(1)	0.10	1.05	1.13	2.06	6.04
125A	28	0	0.17	0.39	1.31	7.01
319	26	0	0	0	1.77	12.53
90	26	0.26	1.18	1.03	1.71	3.92
310	46	0	0.42	0.19	1.67	8.31
293	66	0	0.78	0.58	1.66	5.66
249	26	0	0.26	0	1.58	10.13
92	26	0	1.12	0	1.52	3.07
48	17	0	0.54	0	1.82	19.09
292	66	0	0.59	0.19	1.55	5.46
68	26	0	0.82	0.58	1.44	3.38
208	28	0.17	0.86	0.58	1.54	5.19

Table 3-6 Predicted Design Storm Peak Overflow Rate by SPP
Sorted by Original 6-Month Design Storm Peak Overflow Rate
Existing Conditions

SPP	CSO	1-Month (MGD)	2-3 Month (Higher Intensity, Shorter Duration) (MGD)	2-3 Month (Lower Intensity, Longer Duration) (MGD)	6-Month (MGD)	12-Month (MGD)
271, 272	(1)	0.44	0.88	0.95	1.34	2.80
156	53	0	0	0	1.31	11.69
85	26	0	0.93	0	1.29	2.64
80	26	0	0.50	0.13	1.26	5.15
294	66	0	0.61	0.32	1.29	4.22
344	34	0	0.63	0.50	1.29	3.99
309	46	0	0.20	0	1.21	6.95
295	66	0	0.58	0.32	1.21	3.84
236	60	0	0.41	0.58	1.14	3.77
233	60	0	0.23	0.39	1.14	3.22
260	(1)	0.39	0.75	0.80	1.11	2.25
259	(1)	0	0.06	0.08	0.31	1.44
78	26	0	0.52	0.32	1.10	5.80
245	56	0	0.31	0.44	0.92	2.99
263	(1)	0	0.17	0.13	0.39	0.97
342A	53	0	0.46	0.54	1.30	7.40
266, 267	(1)	0.06	0.26	0.29	0.49	1.26
311	39	0	0.06	0.06	0.57	3.95
269, 270	(1)	0.09	0.30	0.33	0.52	1.27
275	(1)	0.08	0.31	0.33	0.52	1.32
8	3	0	0	0.02	0.48	2.41
81	26	0	0.06	0	0.45	1.27
262	(1)	0	0.15	0.17	0.37	1.20
74	26	0	0.22	0.08	0.33	0.82
265	(1)	0	0.11	0	0.30	0.91
268	(1)	0	0.14	0.13	0.32	1.05
82	26	0	0	0	0.19	1.69
244	56	0	0	0	0.19	5.65
152	26	0	0	0	0.13	18.05
264	(1)	0	0	0	0.06	0.60
200B	53	0	0	0	0	14.61
234	60	0	0	0	0	0.94
197B	26	0	0	0	0	5.81
3	3	0	0	0	0	1.93
125	28	3.02	13.64	7.08	19.68	56.30
191	54	0	0	0	0	10.13
188	54	0	0	0	0	4.61
189	54	0	0	0	0	4.11

Table 3-6 Predicted Design Storm Peak Overflow Rate by SPP
Sorted by Original 6-Month Design Storm Peak Overflow Rate
Existing Conditions

SPP	CSO	1-Month (MGD)	2-3 Month (Higher Intensity, Shorter Duration) (MGD)	2-3 Month (Lower Intensity, Longer Duration) (MGD)	6-Month (MGD)	12-Month (MGD)
185	3	0	0	0	0	0.39
186	3	0	0	0	0	0
9	3	0	0	0	0	1.04
197A	26	0	0	0	0	0.42
120	32	0	0	0	0	0
119	49	0	0	0	0	0.32
190	54	0	0	0	0	7.60
329	66	0	0	0	0	0.29
Old 259	(1)	0	0	0	0	0.92
106A	52	0	0	0	0	0
170A(2)	NA	NA	NA	NA	NA	NA
17(2)	NA	NA	NA	NA	NA	NA

Notes:

(1) Discharge to the East Amherst Quarry Retention Pond. These overflows are stored in the Quarry facility and dewatered back into the collection system.

(2) The peak overflow rate resulting purely from CSO activity cannot be defined due to the Scajaquada Creek contribution to the flows through these SPPs.

(3) CSOs / SPPs that were removed from BSA's SPDES permit after the release of the Model Calibration report have not been included in this table.

Table 3-7 Predicted Design Storm Total Overflow Volume by CSO

Sorted by Original 6-Month Design Storm Total Overflow Volume

Existing Conditions

CSO	1-Month (MG)	2-3 Month (Higher Intensity, Shorter Duration) (MG)	2-3 Month (Lower Intensity, Longer Duration) (MG)	6-Month (MG)	12-Month (MG)
055	28.13	48.87	44.63	89.61	147.73
006[(2)]	10.50	36.07	30.23	68.51	83.98
017	7.32	21.73	14.72	43.71	71.46
026	4.78	17.35	12.65	42.25	75.85
053[(2)]	3.32	9.71	5.74	25.05	63.56
012	3.83	11.77	8.14	19.54	17.23
033	0.55	7.73	3.04	17.37	28.50
011	5.28	8.03	9.21	15.35	11.25
027	0.04	4.19	0.25	13.25	18.00
004[(1)]	1.77	6.98	3.65	12.36	18.03
037	0.85	4.55	2.69	10.48	16.64
028[(1),(4)]	2.87	7.86	6.24	15.62	23.65
014	1.49	4.90	2.90	9.89	13.31
066[(4)]	1.76	4.09	3.45	8.41	16.70
029	0.00	0.00	0.00	0.00	0.29
052	0.11	1.45	1.34	3.97	4.95
013	0.57	3.36	1.88	6.20	12.93
059	0.13	1.54	0.56	3.65	7.19
015	0.11	1.78	0.86	3.57	8.83
061	1.90	3.57	1.35	9.54	14.48
051	0.13	0.77	0.43	1.90	3.37
044	0.30	1.41	0.85	2.81	4.86
010	0.94	1.61	1.42	2.70	4.49
022	0.06	0.68	0.18	2.26	8.80
060	0.22	1.10	0.79	2.14	3.92
008	0.68	1.28	1.16	2.09	2.77
003	0.25	0.73	0.59	1.37	2.96
050	0.20	0.90	0.51	1.80	3.00
047[(1)]	0.51	1.20	0.97	1.80	2.56
035	0.29	1.02	0.65	2.15	4.83
064[(1)]	0.20	0.45	0.35	1.24	9.17
025	0.02	0.45	0.14	1.04	2.35
016[(1)]	0.18	0.47	0.38	0.91	1.95
046	0.01	0.20	0.08	0.56	1.40
054[(4)]	0.18	0.29	0.36	0.62	2.47
058	0.26	0.40	0.48	0.68	1.04
063	0.07	0.26	0.17	0.44	0.80
057	0.01	0.06	0.04	0.10	0.16
048	0.02	0.34	0.07	0.64	0.96
005	0.00	0.03	0.01	0.11	0.55

Table 3-7 Predicted Design Storm Total Overflow Volume by CSO

Sorted by Original 6-Month Design Storm Total Overflow Volume

Existing Conditions

CSO	1-Month (MG)	2-3 Month (Higher Intensity, Shorter Duration) (MG)	2-3 Month (Lower Intensity, Longer Duration) (MG)	6-Month (MG)	12-Month (MG)
034	0.00	0.03	0.01	0.07	0.18
056	0.00	0.01	0.01	0.04	0.21
039	0.00	0.00	0.00	0.03	0.15
032	0.00	0.00	0.00	0.00	0.00
049	0.00	0.00	0.00	0.00	0.00
Total CSO Volume(4)	79.81	219.22	163.16	445.81	717.53

Notes:

(1) Volume is calculated as sum of several outfalls in the model.

(2) Volume does not include Scajaquada Creek inflow from Cheektowaga. Estimated Creek volumes (including dry-weather creek flow) discharged through the CSOs are as follows:

	1-Month (MG)	2-3 Month (Higher Intensity, Shorter Duration) (MG)	2-3 Month (Lower Intensity, Longer Duration) (MG)	6-Month (MG)	12-Month (MG)
CSO-006	92.90	169.50	217.97	291.05	317.68
CSO-053	23.00	49.85	43.40	124.99	287.76

(3) Total CSO volumes presented in this table represent the estimated volumes discharged at the formal CSO point. These volumes will not always match the sum of incremental volumes from upstream SPPs for a combination of two reasons:

a) Upstream SPPs may be configured in series, i.e., overflow volume from one SPP is re-regulated at a downstream SPP.

b) Locally separated stormwater may bypass SPPs and be discharged through the formal CSO point. The separate stormwater volume is included in the CSO volume totals in this table.

(4) Stormwater and non-BSA flows in CSO 028, 054, and 066 discharges have been included in individual volumes and in Total CSO volume calculation.

(5) CSO 21 removed as per revised SPDES permit dated October 2, 2001.

Table 3-8 Predicted Design Storm Peak Overflow Rates by CSO
Sorted by Original 6-Month Design Storm Peak Overflow Rate
Existing Conditions

CSO	1-Month (MGD)	2-3 Month (Higher Intensity, Shorter Duration) (MGD)	2-3 Month (Lower Intensity, Longer Duration) (MGD)	6-Month (MGD)	12-Month (MGD)
055	288.29	563.59	468.79	740.20	1194.71
017	54.22	225.31	128.56	334.39	701.24
026	41.17	166.22	108.43	258.42	655.79
033	9.16	94.80	57.33	149.34	224.66
004(1)	35.84	72.01	62.59	102.52	174.92
012	27.01	84.41	71.42	128.56	193.95
037	13.70	54.41	41.30	86.36	148.69
027	0.49	65.58	10.58	85.71	145.44
011	44.67	64.80	43.96	77.27	100.12
013	12.73	47.72	42.14	74.02	196.74
014	20.00	59.02	40.32	67.53	96.75
066(3)	15.52	43.37	30.65	72.72	166.22
061	41.04	57.92	47.98	64.22	88.30
015	5.29	29.35	31.10	54.02	171.42
028(1),(3)	11.56	42.66	30.00	62.33	114.28
029	0.00	0.00	0.00	0.01	10.45
059	3.49	25.00	15.19	38.70	99.99
022	0.56	11.56	4.06	39.28	151.29
060	3.80	19.15	18.63	35.52	74.02
010	13.18	21.43	23.24	32.14	59.93
003	4.73	11.36	13.18	20.13	55.45
044	4.59	19.28	17.27	28.11	64.93
008	9.35	16.43	16.62	24.28	29.15
051	3.03	10.00	8.44	15.71	39.22
050	3.52	11.43	9.09	16.56	33.89
047(1)	0.00	0.95	0.00	3.71	12.86
052	2.00	9.48	7.27	11.23	16.56
064(1)	0.00	0.00	0.00	15.00	167.52
025	0.84	7.34	5.16	12.99	29.28
035	4.28	12.27	10.39	21.10	53.89
046	0.57	3.80	1.38	7.08	23.76
016(1)	1.58	3.43	3.27	6.95	18.18
054(3)	1.45	3.52	3.75	7.27	56.62
058	3.31	4.88	5.49	6.88	13.44
063	1.02	3.66	3.27	5.53	12.47

Table 3-8 Predicted Design Storm Peak Overflow Rates by CSO
Sorted by Original 6-Month Design Storm Peak Overflow Rate
Existing Conditions

CSO	1-Month (MGD)	2-3 Month (Higher Intensity, Shorter Duration) (MGD)	2-3 Month (Lower Intensity, Longer Duration) (MGD)	6-Month (MGD)	12-Month (MGD)
048	0.41	5.66	1.01	6.38	9.09
057	0.56	1.10	1.27	1.56	2.92
005	0.00	1.16	0.91	2.56	15.26
034	0.00	0.63	0.50	1.29	3.99
056	0.00	0.29	0.39	0.93	6.47
039	0.00	0.06	0.05	0.57	3.95
032	0.00	0.00	0.00	0.00	0.00
049	0.00	0.00	0.00	0.00	0.14
006(2)	NA	NA	NA	NA	NA
053(2)	NA	NA	NA	NA	NA

Notes:

(1) Peak Flow Rate reported is the maximum reported in one of the several outfalls in the model.

(2) The peak overflow rate due purely to CSO activity cannot be defined due to the mixed nature of the discharges from CSO 006 and 053. The estimated peak discharge rate at these two CSOs, including the impact of Scajaquada Creek flows from Cheektowaga, are as follows:

	1-Month Design Storm (MGD)	2-3 Month Design Storm (Higher Intensity, Shorter Duration) (MGD)	2-3 Month Design Storm (Lower Intensity, Longer Duration) (MGD)	6-Month Design Storm (MGD)	12-Month Design Storm (MGD)
CSO-006	473.34	870.06	870.06	909.02	999.92
CSO-053	41.30	468.15	129.86	863.57	2207.62

(3) Storm water and non-BSA flows included in this calculation.

(4) CSO 21 removed as per revised SPDES permit dated October 2, 2001.

Model results for the typical year took the form of predicted overflow hydrographs (at hourly intervals) for all SPPs and CSOs included in the model. These hydrograph results were processed to obtain baseline measures of annual overflow volume, annual number of events, and annual number of overflow hours at each regulator.

The continuous period results were summarized by SPP and CSO for the following quantitative measures to characterize existing conditions for a 1986 typical precipitation year experienced by the BSA's CSS:

- Estimated 12-month period overflow volumes by SPP for existing conditions are detailed in Table 3-9. These are total overflow volumes at the SPP, including any overflow volume reaching the SPP from an upstream location. The only exceptions are for SPP 017 and SPP 170A; following BSA discussions with the NYSDEC, the volume associated with Scajaquada Creek inflows from Cheektowaga is not included in the total volume for these SPPs.

- Estimated 12-month period number of events by SPP for existing conditions are detailed in Table 3-10.

- Estimated 12-month period number of overflow hours by SPP for existing conditions are detailed in Table 3-11.

- Estimated 12-month period overflow volumes by CSO for existing conditions are detailed in Table 3-12. These are total overflow volumes at the CSO, including any locally separated storm flow reaching the CSO from an upstream location. The only exceptions are for CSO 006 and CSO 053; following BSA discussions with the NYSDEC, the volume associated with Scajaquada Creek inflows from Cheektowaga is not included in the total volume for these CSOs.

- Estimated 12-month period number of events by CSO for existing conditions are detailed in Table 3-13.

- Estimated 12-month period number of overflow hours by CSO for existing conditions are detailed in Table 3-14.

These results represented the existing conditions assessment for the SPPs and CSOs in the BSA's system for the 2004 LTCP.

In addition to the detailed estimates of the hydraulic response at individual SPPs and CSOs, the continuous model simulation was used to estimate the existing annual percent capture of wet-weather flow in the BSA's system.

Total system-wide wet weather percent capture was estimated as the ratio of the annual wet weather volume treated at the WWTP to the sum of the annual treated wet weather volume at the WWTP and the annual system-wide CSO discharge. Annual system-wide percent capture was defined as:

$$\text{Percent Capture} = \frac{V_{TREATED}}{V_{TOTAL}}$$

where,

$V_{TREATED}$ = Volume of wet weather wastewater treated by the WWTP, defined as the WWTP influent flow when the influent flow rate is higher than the annual average flow rate

V_{TOTAL} = $V_{TREATED} + V_{OVERFLOW,}$

where,

$V_{OVERFLOW}$ = Total volume of overflows from all CSOs

In this calculation, secondary bypass at the WWTP is considered WWTP influent volume in accordance with discussions between the BSA and the NYSDEC. Additionally, Scajaquada separate storm water flow, non-BSA storm water flows, and storm water flows entering the outfall system downstream of the final SPP, were removed from CSOs 021, 028, 054, and 066 (totaling approximately 156.7 MG in the 1986 typical year). It should be noted that since the release of the Phase I, Stage 1, report, CSO 021 was removed from the BSA's SPDES permit and is no longer a CSO.

Table 3-15 summarizes the percent capture calculation using results from the model simulations for the typical year analysis using the 1986 typical year. As presented in Table 3-15, the 12-month estimate of WWTP influent during wet weather was 22,214 MG and the 12-month estimate of CSO volume was 3,899 MG. This calculation results in an estimate of approximately 85.1 percent capture of wet-weather flow over a typical 12-month period under existing conditions.

Table 3-9 Predicted 12-Month Overflow Volume by SPP

Existing Conditions

SPP	CSO	March - May (MG)	June - August (MG)	September - November (MG)	9-Month Total (MG)	9-Month Average (MG)	Predicted Annual [3] (MG)
1	55	214.38	230.16	229.56	674.10	224.70	898.80
17[1]	6	123.36	168.12	150.51	441.99	147.33	589.32
170A[1]	53	145.47	148.94	140.38	434.80	144.93	579.73
24	11	27.12	42.60	43.24	112.96	37.65	150.61
336B	53	24.32	39.67	36.92	100.92	33.64	134.56
67	17	30.83	33.97	30.15	94.95	31.65	126.60
296	12	11.75	32.15	28.99	72.89	24.30	97.19
170B	53	22.22	24.91	24.23	71.35	23.78	95.14
340	53	19.06	25.87	24.39	69.32	23.11	92.43
339	53	15.09	25.74	23.79	64.62	21.54	86.16
337	53	22.22	21.69	18.44	62.35	20.78	83.14
122	37	26.37	18.21	17.50	62.08	20.69	82.78
104	33	27.92	15.42	15.92	59.26	19.75	79.01
13	4	20.42	19.07	18.01	57.50	19.17	76.67
217	26	20.69	17.68	16.06	54.43	18.14	72.58
317	26	17.48	17.73	17.26	52.47	17.49	69.96
281	17	18.32	14.82	14.50	47.63	15.88	63.51
338	53	16.42	15.54	13.63	45.59	15.20	60.79
332	6	10.27	16.64	12.91	39.82	13.27	53.09
206A&B	14	13.46	13.73	12.32	39.51	13.17	52.68
330	61	14.87	11.50	12.90	39.27	13.09	52.36
97	27	17.04	10.08	10.59	37.71	12.57	50.29
304	13	14.98	10.36	9.46	34.80	11.60	46.41
23	12	5.87	14.43	14.02	34.31	11.44	45.75
180	6	8.79	12.65	9.99	31.43	10.48	41.91
341A	53	10.10	10.71	10.01	30.82	10.27	41.09
106	52	7.73	7.34	10.34	25.42	8.47	33.89
254	[2]	8.19	8.18	8.13	24.50	8.17	32.67
21	10	6.79	8.06	7.39	22.24	7.41	29.65
165B	53	4.92	9.40	7.73	22.05	7.35	29.40
35	15	10.11	4.96	5.27	20.35	6.78	27.13
123B	28	5.19	7.36	7.36	19.91	6.64	26.54
123A	28	7.35	6.21	5.50	19.06	6.35	25.42
179	6	9.08	4.56	4.78	18.43	6.14	24.57
198B	26	9.00	4.54	4.86	18.40	6.13	24.53
199B	26	8.01	5.14	4.86	18.01	6.00	24.01
331	6	5.56	5.95	4.99	16.50	5.50	22.00
121	44	6.11	5.02	4.61	15.74	5.25	20.99
124	28	3.49	5.54	5.47	14.49	4.83	19.33

Table 3-9 Predicted 12-Month Overflow Volume by SPP
Existing Conditions

SPP	CSO	March - May (MG)	June - August (MG)	September - November (MG)	9-Month Total (MG)	9-Month Average (MG)	Predicted Annual (3) (MG)
336A	53	3.52	5.73	4.10	13.34	4.45	17.79
107	35	6.14	3.52	3.40	13.06	4.35	17.41
114	47	3.10	5.16	3.99	12.25	4.08	16.33
174	53	5.97	3.01	3.19	12.17	4.06	16.22
229A	53	6.72	2.39	2.89	12.01	4.00	16.02
65	17	8.44	1.05	2.48	11.98	3.99	15.97
125	28	5.33	2.97	3.13	11.43	3.81	15.24
19	8	2.61	4.39	3.92	10.92	3.64	14.56
326	17	4.16	2.83	3.76	10.76	3.59	14.34
307	51	4.40	3.07	3.10	10.57	3.52	14.09
203	53	4.63	2.86	2.88	10.36	3.45	13.81
255 (1) & (2)	(2)	6.45	1.81	2.04	10.30	3.43	13.73
105	50	3.66	3.28	2.79	9.73	3.24	12.97
282	17	4.89	1.35	2.78	9.02	3.01	12.02
149	26	4.39	2.24	2.28	8.91	2.97	11.88
163	53	1.34	3.68	3.72	8.74	2.91	11.65
175	53	3.88	2.38	2.19	8.46	2.82	11.28
218	26	4.00	1.69	1.67	7.36	2.45	9.81
10	3	2.87	2.27	1.92	7.07	2.36	9.42
123C	28	2.41	2.31	2.23	6.95	2.32	9.27
204	53	4.29	1.32	1.22	6.83	2.28	9.10
197C	26	3.29	1.70	1.81	6.80	2.27	9.07
165	53	1.65	2.63	2.44	6.72	2.24	8.96
274	(2)	1.73	2.45	2.04	6.22	2.07	8.29
135A	64	2.00	2.17	1.94	6.12	2.04	8.16
211	66	3.00	1.53	1.57	6.11	2.04	8.14
131	64	1.63	2.49	1.91	6.03	2.01	8.03
178	53	2.73	1.63	1.57	5.93	1.98	7.90
202	53	3.43	1.01	1.32	5.76	1.92	7.68
209	25	2.71	1.49	1.55	5.75	1.92	7.66
335B	53	3.80	0.83	0.97	5.59	1.86	7.46
183	59	2.91	1.10	1.07	5.08	1.69	6.77
199C	26	3.23	0.67	0.90	4.80	1.60	6.40
165A	53	2.05	1.44	1.23	4.72	1.57	6.29
318	26	1.72	1.49	1.30	4.51	1.50	6.01
75	26	1.46	1.54	1.45	4.45	1.48	5.94
130	17	1.40	1.60	1.41	4.41	1.47	5.88
322	66	3.15	0.27	0.80	4.22	1.41	5.62
201	53	3.23	0.34	0.58	4.15	1.38	5.53

Table 3-9 Predicted 12-Month Overflow Volume by SPP
Existing Conditions

SPP	CSO	March - May (MG)	June - August (MG)	September - November (MG)	9-Month Total (MG)	9-Month Average (MG)	Predicted Annual (3) (MG)
107A	35	1.66	1.19	1.19	4.04	1.35	5.38
53 (1)	17	2.29	0.79	0.95	4.03	1.34	5.37
314	26	1.33	1.35	1.21	3.89	1.30	5.19
181	59	2.26	0.55	0.88	3.68	1.23	4.91
199A	26	2.08	0.69	0.88	3.64	1.21	4.86
53 (2)	17	2.02	0.70	0.85	3.57	1.19	4.76
277	26	2.69	0.26	0.55	3.51	1.17	4.67
89	26	1.15	1.09	1.11	3.35	1.12	4.47
157	53	1.95	0.62	0.74	3.31	1.10	4.41
187	54	2.31	0.35	0.60	3.26	1.09	4.35
55	17	1.73	0.76	0.76	3.25	1.08	4.33
240	60	1.06	1.16	0.99	3.22	1.07	4.29
200A	53	1.24	0.88	1.04	3.16	1.05	4.21
177	53	1.89	0.60	0.65	3.14	1.05	4.19
164	53	0.88	0.92	1.32	3.13	1.04	4.17
248	26	1.92	0.51	0.69	3.12	1.04	4.16
132	64	1.37	0.82	0.88	3.08	1.03	4.11
283	63	1.10	1.04	0.93	3.07	1.02	4.10
182	59	1.48	0.70	0.76	2.94	0.98	3.92
118	48	1.06	0.93	0.95	2.93	0.98	3.91
345	53	1.99	0.42	0.51	2.92	0.97	3.90
151	26	2.38	0.16	0.38	2.92	0.97	3.90
5	3	1.27	0.84	0.73	2.85	0.95	3.79
4	3	1.33	0.68	0.65	2.66	0.89	3.54
150	26	2.05	0.22	0.37	2.64	0.88	3.52
36	15	0.99	0.68	0.65	2.32	0.77	3.10
128	17	1.26	0.46	0.54	2.27	0.76	3.03
200B	53	2.16	0.02	0.02	2.20	0.73	2.93
129	64	0.69	0.80	0.67	2.16	0.72	2.88
176	53	1.32	0.38	0.41	2.11	0.70	2.82
50	17	1.53	0.10	0.40	2.02	0.67	2.70
133	64	0.58	0.74	0.69	2.00	0.67	2.67
7	3	0.87	0.60	0.52	1.99	0.66	2.65
39	16	0.80	0.57	0.52	1.89	0.63	2.52
48	17	1.28	0.13	0.35	1.76	0.59	2.34
88	26	0.89	0.42	0.44	1.75	0.58	2.33
276	(2)	1.06	0.22	0.29	1.58	0.53	2.11
166	53	1.05	0.19	0.31	1.55	0.52	2.07
191	54	1.45	0.02	0.06	1.53	0.51	2.05
149	26	1.19	0.09	0.20	1.48	0.49	1.98

Table 3-9 Predicted 12-Month Overflow Volume by SPP

Existing Conditions

SPP	CSO	March - May (MG)	June - August (MG)	September - November (MG)	9-Month Total (MG)	9-Month Average (MG)	Predicted Annual (3) (MG)
113	47	0.93	0.19	0.34	1.46	0.49	1.94
239	60	0.75	0.33	0.37	1.45	0.48	1.93
94	26	0.88	0.25	0.31	1.44	0.48	1.92
249	26	1.17	0.07	0.17	1.40	0.47	1.87
148	26	0.91	0.21	0.28	1.39	0.46	1.86
69	26	0.56	0.43	0.39	1.37	0.46	1.83
97A	27	0.49	0.45	0.42	1.36	0.45	1.81
11	3	0.35	0.54	0.45	1.34	0.45	1.78
14A	5	0.86	0.17	0.21	1.24	0.41	1.66
238	60	0.60	0.29	0.32	1.21	0.40	1.62
319	26	0.95	0.09	0.18	1.21	0.40	1.61
210	53	0.92	0.10	0.18	1.20	0.40	1.60
51	17	0.80	0.13	0.25	1.17	0.39	1.57
144	22	0.39	0.41	0.36	1.16	0.39	1.55
291	66	0.44	0.35	0.33	1.13	0.38	1.50
77	26	0.69	0.16	0.27	1.12	0.37	1.50
342B	53	0.35	0.38	0.40	1.12	0.37	1.50
237	60	0.39	0.34	0.37	1.09	0.36	1.46
152	26	1.04	0.00	0.02	1.06	0.35	1.42
235	60	0.46	0.30	0.30	1.05	0.35	1.40
87	26	0.61	0.18	0.25	1.03	0.34	1.38
42	16	0.66	0.09	0.26	1.01	0.34	1.35
91	26	0.48	0.25	0.24	0.98	0.33	1.31
138	22	0.34	0.33	0.30	0.97	0.32	1.29
310	46	0.69	0.09	0.16	0.94	0.31	1.25
230	60	0.30	0.29	0.32	0.92	0.31	1.22
90	26	0.34	0.27	0.27	0.88	0.29	1.17
190	54	0.87	0.00	0.00	0.87	0.29	1.16
145	22	0.36	0.25	0.26	0.87	0.29	1.16
308	46	0.43	0.17	0.26	0.86	0.29	1.15
125A	28	0.63	0.06	0.14	0.83	0.28	1.11
261	(2)	0.47	0.16	0.17	0.81	0.27	1.08
126	29	0.77	0.00	0.02	0.79	0.26	1.06
79	26	0.41	0.16	0.21	0.78	0.26	1.04
208	28	0.45	0.14	0.18	0.77	0.26	1.03
335A	53	0.19	0.22	0.31	0.73	0.24	0.98
84	26	0.38	0.16	0.17	0.71	0.24	0.95
78	26	0.43	0.07	0.17	0.68	0.23	0.90
244	56	0.61	0.02	0.04	0.67	0.22	0.89
342A	53	0.42	0.11	0.13	0.66	0.22	0.88

Table 3-9 Predicted 12-Month Overflow Volume by SPP

Existing Conditions

SPP	CSO	March - May (MG)	June - August (MG)	September - November (MG)	9-Month Total (MG)	9-Month Average (MG)	Predicted Annual (3) (MG)
245	56	0.52	0.05	0.07	0.64	0.21	0.85
260	(2)	0.23	0.22	0.18	0.64	0.21	0.85
232	60	0.33	0.13	0.16	0.63	0.21	0.83
271, 272	(2)	0.23	0.22	0.18	0.62	0.21	0.83
293	66	0.37	0.10	0.14	0.61	0.20	0.81
195	57	0.23	0.19	0.18	0.60	0.20	0.80
309	46	0.42	0.06	0.12	0.59	0.20	0.79
80	26	0.40	0.06	0.13	0.58	0.19	0.78
231	60	0.31	0.12	0.15	0.58	0.19	0.78
156	53	0.41	0.06	0.11	0.58	0.19	0.78
292	66	0.36	0.08	0.12	0.55	0.18	0.74
188	54	0.48	0.02	0.05	0.54	0.18	0.72
92	26	0.29	0.12	0.12	0.53	0.18	0.71
294	66	0.30	0.08	0.13	0.51	0.17	0.68
189	54	0.45	0.01	0.04	0.50	0.17	0.67
344	34	0.27	0.09	0.12	0.48	0.16	0.64
68	26	0.25	0.09	0.13	0.47	0.16	0.63
295	66	0.28	0.07	0.12	0.46	0.15	0.62
85	26	0.24	0.10	0.10	0.45	0.15	0.60
236	60	0.26	0.07	0.09	0.42	0.14	0.56
311	39	0.29	0.03	0.06	0.39	0.13	0.52
233	60	0.25	0.06	0.07	0.39	0.13	0.52
197B	26	0.34	0.00	0.00	0.34	0.11	0.45
8	3	0.19	0.03	0.06	0.28	0.09	0.37
275	(2)	0.12	0.05	0.05	0.22	0.07	0.29
3	3	0.19	0.00	0.02	0.20	0.07	0.27
269, 270	(2)	0.11	0.05	0.05	0.20	0.07	0.27
266, 267	(2)	0.11	0.04	0.04	0.19	0.06	0.25
234	60	0.15	0.01	0.00	0.16	0.05	0.21
213	58	0.13	0.01	0.02	0.16	0.05	0.21
82	26	0.13	0.00	0.03	0.16	0.05	0.21
263	(2)	0.10	0.02	0.03	0.15	0.05	0.20
259	(2)	0.11	0.01	0.02	0.15	0.05	0.19
81	26	0.10	0.01	0.03	0.15	0.05	0.19
262	(2)	0.09	0.02	0.03	0.14	0.05	0.19
268	(2)	0.09	0.02	0.02	0.13	0.04	0.17
74	26	0.06	0.03	0.03	0.12	0.04	0.16
9	3	0.12	0.00	0.00	0.12	0.04	0.16

Table 3-9 Predicted 12-Month Overflow Volume by SPP

Existing Conditions

SPP	CSO	March - May (MG)	June - August (MG)	September - November (MG)	9-Month Total (MG)	9-Month Average (MG)	Predicted Annual (3) (MG)
265	(2)	0.08	0.02	0.02	0.12	0.04	0.16
185	3	0.09	0.00	0.00	0.09	0.03	0.12
Old 259	(2)	0.06	0.00	0.00	0.06	0.02	0.09
264	(2)	0.05	0.00	0.00	0.05	0.02	0.07
186	3	0.04	0.00	0.00	0.04	0.01	0.06
119	49	0.03	0.00	0.00	0.03	0.01	0.04
197A	26	0.02	0.00	0.00	0.02	0.01	0.03
329	66	0.02	0.00	0.00	0.02	0.01	0.02
106A	52	0.00	0.00	0.00	0.00	0.00	0.00
120	32	0.00	0.00	0.00	0.00	0.00	0.00

Notes:

(1) Volume represents the CSO component of the mixed flow through these SPPs. It does not include Scajaquada Creek inflow from Cheektowaga.

(2) Discharge to the East Amherst Quarry Retention Pond. These overflows are stored in the Quarry facility and dewatered back into the collection system.

(3) Annual total estimated by adding the average quarterly value to the 9-month total.

(4) Volumes presented in this table represent the full predicted volume at each SPP. However, the sum of the volumes at SPPs from this table may not equal the total volume for each CSO to which the SPPs are tributary, for two reasons:

**Upstream SPPs may be configured in series, i.e., overflow from one SPP is re-regulated at a downstream SPP. Therefore, adding SPP volumes would double-account for some flows.

**Locally separated stormwater may bypass SPPs and be discharged through the formal CSO point. The separate stormwater volume is included in the CSO volume but not the tributary SPPs. Specifically, stormwater and non-BSA flows have been inlcuded in CSO volumes for 028, 054, and 066, and not in the SPPs tributary to these CSOs.

(5) CSOs / SPPs that were removed from BSA's SPDES permit after the release of the Model Calibration report have not been included in this table.

Table 3-10 Predicted 12-Month Number of Overflow Events by SPP
Existing Conditions

SPP	CSO	March - May	June - August	September - November	Annual (2)
123B	28	15	25	23	84
341A	53	14	25	20	79
75	26	15	22	20	76
107A	35	12	24	20	75
165B	53	12	24	19	73
170B	53	14	23	16	71
340	53	14	21	18	71
135A	64	13	21	19	71
130	17	13	20	18	68
283	63	11	22	18	68
123C	28	12	20	18	67
339	53	14	20	16	67
336B	53	12	18	14	59
10	3	10	18	15	57
336A	53	10	18	15	57
129	64	10	18	15	57
180	6	9	18	15	56
314	26	9	18	15	56
114	47	10	17	15	56
254	(1)	10	19	13	56
19	8	9	16	16	55
97A	27	9	16	16	55
21	10	9	16	15	53
296	12	10	15	15	53
11	3	8	17	14	52
337	53	9	15	14	51
163	53	8	17	13	51
165	53	8	17	13	51
274	(1)	8	16	14	51
260	(1)	8	16	14	51
331	6	8	15	14	49
281	17	11	13	13	49
217	26	9	15	12	48
1	55	9	13	14	48
144	22	8	15	12	47
332	6	7	12	13	43
24	11	8	12	11	41
67	17	8	12	11	41
105	50	4	13	13	40
123A	28	6	12	11	39
23	12	4	14	10	37
317	26	6	11	11	37
13	4	8	10	9	36
107	35	3	13	11	36

Table 3-10 Predicted 12-Month Number of Overflow Events by SPP
Existing Conditions

SPP	CSO	March - May	June - August	September - November	Annual (2)
307	51	5	13	9	36
271, 272	(1)	6	11	10	36
7	3	2	13	9	32
39	16	2	13	9	32
138	22	3	12	9	32
53 (2)	17	2	9	11	29
122	37	3	10	8	28
131	64	4	10	7	28
5	3	1	12	7	27
121	44	3	10	7	27
304	13	1	11	7	25
291	66	2	10	7	25
197C	26	3	8	7	24
69	26	1	10	7	24
124	28	3	9	6	24
211	66	1	10	7	24
118	48	3	8	6	23
178	53	4	8	5	23
165A	53	1	10	6	23
48	17	3	8	6	23
199B	26	1	9	6	21
338	53	1	9	6	21
36	15	1	8	6	20
318	26	1	8	6	20
308	46	3	6	6	20
183	59	1	8	6	20
4	3	1	9	4	19
149	26	2	6	6	19
125	28	3	7	4	19
106	52	3	7	4	19
206A&B	53	2	8	4	19
175	53	1	8	4	17
204	53	1	7	5	17
188	54	2	6	5	17
240	60	1	8	4	17
198B	26	1	6	5	16
90	26	2	6	4	16
35	15	1	6	4	15
145	22	1	6	4	15
209	25	1	6	4	15
335B	53	1	6	4	15
342B	53	1	6	4	15
195	57	1	6	4	15
182	59	1	6	4	15

Table 3-10 Predicted 12-Month Number of Overflow Events by SPP
Existing Conditions

SPP	CSO	March - May	June - August	September - November	Annual (2)
133	64	1	6	4	15
269, 270	(1)	1	6	4	15
275	(1)	1	6	4	15
326	17	1	6	3	13
88	26	1	5	4	13
149	26	2	6	2	13
79	26	1	5	4	13
208	28	1	5	4	13
330	61	2	4	4	13
266, 267	(1)	1	5	4	13
179	6	1	5	3	12
55	17	1	5	3	12
128	17	1	5	3	12
218	26	1	5	3	12
199C	26	1	5	3	12
199A	26	1	5	3	12
89	26	1	4	4	12
84	26	1	5	3	12
68	26	1	5	3	12
97	27	1	4	4	12
104	33	1	5	3	12
106A	52	1	3	5	12
174	53	1	5	3	12
203	53	1	5	3	12
157	53	1	5	3	12
164	53	1	5	3	12
177	53	1	5	3	12
176	53	1	5	3	12
335A	53	1	5	3	12
342A	53	1	5	3	12
245	56	1	5	3	12
239	60	1	5	3	12
238	60	1	5	3	12
237	60	1	5	3	12
235	60	1	5	3	12
230	60	1	5	3	12
232	60	1	5	3	12
231	60	1	5	3	12
132	64	1	5	3	12
255 (1) & (2)	(1)	1	5	3	12
261	(1)	1	5	3	12
148	26	1	4	3	11
229A	53	1	4	3	11
236	60	1	4	3	11

Table 3-10 Predicted 12-Month Number of Overflow Events by SPP
Existing Conditions

SPP	CSO	March - May	June - August	September - November	Annual (2)
276	(1)	1	4	3	11
263	(1)	1	4	3	11
268	(1)	1	4	3	11
14A	5	1	4	2	9
53 (1)	17	1	4	2	9
78	26	1	4	2	9
74	26	1	3	3	9
344	34	1	4	2	9
310	46	1	4	2	9
202	53	1	4	2	9
200A	53	1	4	2	9
345	53	1	4	2	9
166	53	1	4	2	9
187	54	1	4	2	9
213	58	1	4	2	9
233	60	1	4	2	9
293	66	1	4	2	9
265	(1)	1	4	2	9
262	(1)	1	4	2	9
8	3	1	3	2	8
150	26	1	3	2	8
319	26	1	3	2	8
77	26	1	3	2	8
87	26	1	3	2	8
80	26	1	3	2	8
125A	28	1	3	2	8
311	39	1	3	2	8
309	46	1	3	2	8
113	47	1	3	2	8
156	53	1	3	2	8
181	59	1	3	2	8
292	66	1	3	2	8
294	66	1	3	2	8
295	66	1	3	2	8
259	(1)	1	3	2	8
248	26	1	2	2	7
249	26	1	2	2	7
201	53	1	2	2	7
3	3	1	1	2	5
42	16	1	1	2	5
65	17	1	1	2	5
282	17	1	1	2	5
50	17	1	1	2	5
51	17	1	1	2	5

Table 3-10 Predicted 12-Month Number of Overflow Events by SPP
Existing Conditions

SPP	CSO	March - May	June - August	September - November	Annual (2)
277	26	1	1	2	5
151	26	1	1	2	5
94	26	1	1	2	5
152	26	1	1	2	5
91	26	1	1	2	5
92	26	1	1	2	5
85	26	1	1	2	5
126	29	1	1	2	5
210	53	1	1	2	5
191	54	1	1	2	5
189	54	1	1	2	5
244	56	1	1	2	5
322	66	1	1	2	5
264	(1)	1	1	2	5
9	3	1	1	1	4
81	26	1	1	1	4
200B	53	1	1	1	4
234	60	1	1	1	4
185	3	1	0	1	3
197B	26	1	0	1	3
82	26	1	0	1	3
190	54	2	0	0	3
Old 259	(1)	1	1	0	3
186	3	1	0	0	1
197A	26	1	0	0	1
119	49	1	0	0	1
329	66	1	0	0	1
120	32	0	0	0	0
17(3)	6	NA	NA	NA	NA
170A(3)	53	NA	NA	NA	NA

Notes:

(1) Discharge to the East Amherst Quarry Retention Pond. These overflows are stored in the Quarry facility and dewatered back into the collection system.

(2) Annual total estimated by adding the average quarterly value to the 9-month total.

(3) The number of overflow events resulting purely from CSO activity cannot be defined due to the Scajaquada Creek contribution to the flows through these SPPs.

(4) CSOs / SPPs that were removed from BSA's SPDES permit after the release of the Model Calibration report have not been included in this table.

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Table 3-11 Predicted 12-Month Total Overflow Duration by SPP
Existing Conditions

SPP	CSO	March - May (hr)	June - August (hr)	September - November (hr)	Annual (hr)[(2)]
254	[(1)]	216	289	257	1016
165B	53	122	170	161	604
217	26	72	94	91	343
123B	28	73	80	97	333
170B	53	69	79	91	319
340	53	66	78	92	315
341A	53	64	68	74	275
67	17	57	73	73	271
336B	53	52	60	75	249
106	52	46	58	76	240
24	11	49	59	68	235
339	53	51	56	67	232
75	26	45	46	66	209
123C	28	44	51	60	207
304	13	11	80	50	188
114	47	38	47	42	169
1	55	33	43	48	165
135A	64	33	40	47	160
317	26	32	45	42	159
180	6	31	43	43	156
107A	35	30	40	44	152
130	17	31	35	42	144
107	35	26	44	37	143
281	17	29	34	42	140
274	[(1)]	23	36	41	133
21	10	27	33	38	131
283	63	26	35	36	129
314	26	25	34	36	127
296	12	23	35	35	124
307	51	19	41	33	124
97A	27	24	29	36	119
331	6	24	31	33	117
19	8	23	31	34	117
260	[(1)]	22	31	33	115
332	6	19	32	34	113
230	60	11	46	28	113
337	53	20	30	32	109
122	37	21	33	26	107
198B	26	16	32	30	104
129	64	21	30	25	101
197C	26	17	30	25	96
218	26	12	37	21	93
123A	28	15	28	26	92

Table 3-11 Predicted 12-Month Total Overflow Duration by SPP
Existing Conditions

SPP	CSO	March - May (hr)	June - August (hr)	September - November (hr)	Annual (hr)[(2)]
124	28	13	31	25	92
23	12	9	33	25	89
10	3	16	27	22	87
336A	53	16	27	22	87
322	66	17	15	30	83
165	53	12	25	20	76
11	3	12	23	21	75
144	22	12	25	19	75
149	26	15	19	21	73
149	26	15	19	21	73
163	53	11	24	20	73
104	33	9	27	17	71
105	50	8	22	23	71
121	44	8	24	19	68
118	48	13	19	19	68
48	17	13	19	19	68
178	53	11	21	18	67
271, 272	(1)	11	20	18	65
13	4	13	19	16	64
308	46	13	15	18	61
199B	26	9	19	16	59
338	53	7	21	16	59
90	26	7	17	16	53
131	64	7	19	14	53
125	28	7	17	14	51
138	22	5	17	15	49
165A	53	5	19	13	49
39	16	5	20	11	48
89	26	7	15	14	48
206A&B	53	7	19	10	48
106A	52	12	12	11	47
204	53	6	17	11	45
7	3	4	18	11	44
97	27	6	15	12	44
291	66	4	16	13	44
211	66	5	16	11	43
5	3	4	16	11	41
255 (1) & (2)	(1)	5	16	10	41
179	6	6	15	9	40
174	53	6	15	9	40
330	61	7	11	11	39
318	26	4	14	10	37
69	26	3	16	9	37

Table 3-11 Predicted 12-Month Total Overflow Duration by SPP
Existing Conditions

SPP	CSO	March - May (hr)	June - August (hr)	September - November (hr)	Annual (hr)[(2)]
183	59	5	13	10	37
133	64	5	14	9	37
209	25	9	11	7	36
175	53	7	12	7	35
53 (2)	17	3	10	12	33
199C	26	7	10	7	32
188	54	6	10	8	32
326	17	4	11	7	29
248	26	6	8	8	29
335B	53	5	10	7	29
182	59	5	10	7	29
36	15	3	10	8	28
203	53	5	9	7	28
166	53	4	10	7	28
55	17	5	9	6	27
199A	26	6	9	5	27
277	26	7	5	8	27
88	26	4	8	8	27
148	26	6	8	6	27
4	3	3	11	5	25
74	26	4	8	7	25
208	28	4	9	6	25
237	60	4	9	6	25
275	(1)	4	9	6	25
240	60	3	10	5	24
35	15	4	8	5	23
145	22	3	9	5	23
249	26	5	6	6	23
84	26	3	8	5	21
229A	53	4	7	5	21
345	53	2	9	5	21
269, 270	(1)	4	7	5	21
53 (1)	17	4	7	4	20
79	26	3	7	5	20
157	53	4	7	4	20
342B	53	3	7	5	20
195	57	3	7	5	20
266, 267	(1)	4	6	5	20
150	26	4	6	4	19
261	(1)	4	6	4	19
77	26	3	6	4	17
87	26	3	6	4	17
91	26	4	4	5	17

Table 3-11 Predicted 12-Month Total Overflow Duration by SPP
Existing Conditions

SPP	CSO	March - May (hr)	June - August (hr)	September - November (hr)	Annual (hr)$^{(2)}$
68	26	3	6	4	17
177	53	3	6	4	17
176	53	3	6	4	17
342A	53	3	6	4	17
235	60	3	6	4	17
132	64	3	6	4	17
128	17	2	6	4	16
85	26	4	4	4	16
164	53	2	6	4	16
200A	53	3	6	3	16
335A	53	2	6	4	16
181	59	3	5	4	16
42	16	3	3	5	15
51	17	3	4	4	15
151	26	4	3	4	15
78	26	3	5	3	15
92	26	4	4	3	15
344	34	2	6	3	15
310	46	3	5	3	15
202	53	3	5	3	15
187	54	3	5	3	15
245	56	2	5	4	15
239	60	2	5	4	15
238	60	2	5	4	15
232	60	2	5	4	15
231	60	2	5	4	15
276	(1)	2	5	4	15
263	(1)	2	5	4	15
268	(1)	2	5	4	15
94	26	3	4	3	13
80	26	2	5	3	13
125A	28	3	4	3	13
309	46	3	4	3	13
236	60	2	4	4	13
293	66	2	5	3	13
265	(1)	2	5	3	13
262	(1)	2	5	3	13
14A	5	2	4	3	12
65	17	3	3	3	12
282	17	3	3	3	12
319	26	2	4	3	12
311	39	2	4	3	12
113	47	2	4	3	12

Table 3-11 Predicted 12-Month Total Overflow Duration by SPP

Existing Conditions

SPP	CSO	March - May (hr)	June - August (hr)	September - November (hr)	Annual (hr)(2)
201	53	3	3	3	12
213	58	2	4	3	12
233	60	2	4	3	12
292	66	2	4	3	12
294	66	2	4	3	12
295	66	2	4	3	12
8	3	2	3	3	11
50	17	3	2	3	11
126	29	3	2	3	11
210	53	3	2	3	11
156	53	2	3	3	11
259	(1)	2	3	3	11
81	26	3	3	1	9
3	3	2	1	2	7
152	26	2	1	2	7
200B	53	3	1	1	7
191	54	2	1	2	7
189	54	2	1	2	7
244	56	2	1	2	7
264	(1)	2	1	2	7
197B	26	3	0	1	5
9	3	1	1	1	4
185	3	2	0	1	4
82	26	2	0	1	4
190	54	3	0	0	4
234	60	1	1	1	4
Old 259	(1)	2	1	0	4
197A	26	2	0	0	3
119	49	2	0	0	3
186	3	1	0	0	1
329	66	1	0	0	1
120	32	0	0	0	0
17(3)	6	NA	NA	NA	NA
170A(3)	53	NA	NA	NA	NA

Notes:

(1) Discharge to the East Amherst Quarry Retention Pond. These overflows are stored in the Quarry facility and dewatered back into the collection system.

(2) Annual total estimated by adding the average quarterly value to the 9-month total.

(3) The number of overflow hours resulting purely from CSO activity cannot be defined due to the Scajaquada Creek contribution to the flows through these SPPs.

(4) CSOs / SPPs that were removed from BSA's SPDES permit after the release of the Model Calibration report have not been included in this table.

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Table 3-12 Predicted 12-Month Overflow Volume by CSO
Existing Conditions

CSO	March - May (MG)	June - August (MG)	September - November (MG)	Average Quarterly (MG)	Estimated Annual (MG)[1]
55	214.38	230.16	229.56	224.70	898.80
06[2]	123.20	167.75	150.15	147.03	588.13
26	109.58	76.30	76.37	87.42	349.67
17	77.04	77.49	74.95	76.50	305.98
53[2]	86.87	73.20	66.02	75.36	301.45
66[4]	57.92	46.33	50.12	51.46	205.83
28[1],[4]	49.64	52.26	51.25	51.05	204.21
11	27.12	42.60	43.24	37.65	150.61
12	17.64	46.65	43.07	35.79	143.15
37	26.37	18.21	17.50	20.69	82.78
04[1]	20.91	20.32	18.90	20.04	80.18
33	27.92	15.42	15.92	19.75	79.01
64[1]	22.57	9.51	11.09	14.39	57.56
14	13.49	13.77	12.34	13.20	52.81
61	14.88	11.52	12.93	13.11	52.44
27	17.57	10.55	11.03	13.05	52.20
13	14.98	10.36	9.46	11.60	46.41
52	7.95	7.58	10.59	8.71	34.84
15	11.14	5.67	5.94	7.58	30.34
10	6.79	8.06	7.39	7.42	29.66
08	4.81	6.92	6.56	6.10	24.39
35	7.82	4.72	4.59	5.71	22.84
03	7.44	5.12	4.44	5.67	22.66
60	6.70	5.08	5.21	5.66	22.65
44	6.11	5.02	4.61	5.25	20.99
47[1]	4.03	5.35	4.33	4.57	18.27
54[4]	7.70	2.44	2.90	4.35	17.39
59	6.68	2.35	2.71	3.91	15.65
51	4.40	3.07	3.10	3.52	14.09
50	3.66	3.28	2.79	3.24	12.97
22	6.25	1.30	2.05	3.20	12.80
58	3.09	2.91	3.10	3.04	12.15
16[1]	3.23	2.60	2.82	2.88	11.52
25	2.71	1.49	1.55	1.92	7.66
46	2.03	0.75	1.01	1.26	5.05
63	1.10	1.04	0.93	1.02	4.10
48	1.06	0.93	0.95	0.98	3.91
56	1.14	0.07	0.10	0.44	1.75

Table 3-12 Predicted 12-Month Overflow Volume by CSO
Existing Conditions

CSO	March - May (MG)	June - August (MG)	September - November (MG)	Average Quarterly (MG)	Estimated Annual (MG)(1)
05	0.86	0.17	0.21	0.41	1.66
29	0.77	0.00	0.02	0.26	1.06
57	0.23	0.19	0.18	0.20	0.80
34	0.27	0.09	0.12	0.16	0.64
39	0.29	0.03	0.06	0.13	0.52
49	0.03	0.00	0.00	0.01	0.04
32	0.00	0.00	0.00	0.00	0.00
Total CSO volume(4)	1030.37	998.66	972.16	1000.40	4001.61

Notes:

(1) Annual total estimated by adding the average quarterly value to the 9-month total.

(2) Volume does not include Scajaquada Creek inflow from Cheektowaga. Estimated Creek volumes (including dry-weather creek flow) discharged through the CSOs are as follows:

CSO	March - May (MG)	June - August (MG)	September - November (MG)	Average Quarterly (MG)	Estimated Annual (MG)(1)
CSO-006	686.14	931.07	995.04	174.15	3134.71
CSO-053	580.99	483.99	508.39	104.89	1888.05

(3) Total CSO volumes presented in this table represent the estimated volumes discharged at the formal CSO point.
These volumes will not always match the sum of incremental volumes from upstream SPPs for a combination of two reasons:
a) Upstream SPPs may be configured in series, I.e., overflow volume from one SPP is re-regulated at a downstream SPP.
b) Locally separated stormwater may bypass SPPs and be discharged through the formal CSO point. The separate stormwater volume is included in the CSO volume totals in this table.

(4) Stormwater and non-BSA flows in CSO 028, 054, and 066 discharges have been included in individual volumes and in Total CSO volume calculation.

(5) CSO 21 removed as per revised SPDES permit dated October 2, 2001.

Table 3-13 Predicted 12-Month Number of Overflow Events by CSO
Existing Conditions

CSO	March - May	June - August	September - November	Average Quarterly	Estimated Annual [1]
016	19	30	29	26	104
008	18	26	27	24	95
066	14	27	27	23	91
028	13	28	27	23	91
017	13	26	27	22	88
060	16	25	22	21	84
026	12	26	24	21	83
064	13	21	19	18	71
063	11	22	18	17	68
035	11	21	18	17	67
054	15	20	15	17	67
047	10	18	15	14	57
012	10	18	14	14	56
058	10	18	13	14	55
010	9	16	15	13	53
055	9	13	14	12	48
003	8	15	12	12	47
027	9	15	10	11	45
050	4	14	13	10	41
011	8	12	11	10	41
051	5	14	9	9	37
037	3	11	8	7	29
013	1	12	7	7	27
044	3	10	7	7	27
022	2	10	6	6	24
048	3	8	6	6	23
052	3	7	5	5	20
015	1	8	6	5	20
046	3	7	5	5	20
014	2	8	5	5	20
059	1	8	5	5	19
057	1	6	4	4	15
025	1	6	4	4	15
061	3	4	4	4	15
004	1	5	4	3	13
033	1	5	3	3	12
034	1	4	3	3	11
056	1	4	2	2	9
005	1	4	2	2	9
039	1	3	2	2	8
029	1	1	2	1	5
049	1	0	0	0	1
032	0	0	0	0	0
006[2]	NA	NA	NA	NA	NA

Table 3-13 Predicted 12-Month Number of Overflow Events by CSO
Existing Conditions

CSO	March - May	June - August	September - November	Average Quarterly	Estimated Annual [(1)]
053[(2)]	NA	NA	NA	NA	NA

Notes:

(1) Annual total estimated by adding the average quarterly value to the 9-month total.

(2) The number of overflow events due purely to CSO activity cannot be defined due to the mixed nature of the discharges from CSO 006 and 053. The estimated number of discharge events at these two CSOs, including the impact of Scajaquada Creek flows from Cheektowaga, are as follows:

CSO	March - May	June - August	September - November	Average Quarterly	Estimated Annual
CSO-006	10	21	16	16	63
CSO-053	12	25	25	21	83

(3) CSO 21 removed as per revised SPDES permit dated October 2, 2001.

Table 3-14 Predicted 12-Month Total Overflow Duration by CSO
Existing Conditions

CSO	March - May (hr)	June - August (hr)	September - November (hr)	Average Quarterly (hr)	Estimated Annual (hr)[(1)]
066	289	396	439	375	1499
017	270	384	419	358	1431
026	244	359	363	322	1288
028	172	208	235	205	820
027	106	183	168	152	609
003	77	158	135	123	493
054	108	113	117	113	451
060	89	88	110	96	383
016	82	74	104	87	347
008	85	72	99	85	341
022	19	125	84	76	304
064	33	110	83	75	301
052	48	61	77	62	248
011	49	59	68	59	235
035	49	60	61	57	227
058	44	60	59	54	217
013	11	80	50	47	188
012	33	51	47	44	175
047	38	47	42	42	169
055	33	43	48	41	165
014	19	60	38	39	156
010	30	35	44	36	145
063	26	35	36	32	129
051	19	41	33	31	124
037	21	33	26	27	107
015	8	41	25	25	99
033	9	27	17	18	71
050	8	22	23	18	71
044	8	24	19	17	68
048	13	19	19	17	68
059	9	25	16	17	67
046	13	15	17	15	60
061	11	16	16	14	57
056	7	15	12	11	45
025	9	11	7	9	36
004	4	13	9	9	35
057	3	7	5	5	20
034	2	6	4	4	16
005	2	5	3	3	13
039	2	4	3	3	12
029	3	2	3	3	11
049	2	0	0	1	3
032	0	0	0	0	0
006[(2)]	NA	NA	NA	NA	NA

Table 3-14 Predicted 12-Month Total Overflow Duration by CSO
Existing Conditions

CSO	March - May (hr)	June - August (hr)	September - November (hr)	Average Quarterly (hr)	Estimated Annual (hr)[(1)]
053[(2)]	NA	NA	NA	NA	NA

Notes:

(1) Annual total estimated by adding the average quarterly value to the 9-month total.

(2) The number of overflow hours due purely to CSO activity cannot be defined due to the mixed nature of the discharges from CSO 006 and 053. The estimated number of discharge hours at these two CSOs, including the impact of Scajaquada Creek flows from Cheektowaga, are as follows:

CSO	March - May (hr)	June - August (hr)	September - November (hr)	Average Quarterly (hr)	Estimated Annual (hr)[(1)]
CSO-006	346	556	484	462	1848
CSO-053	615	903	886	801	3205

(3) CSO 21 removed as per revised SPDES permit dated October 2, 2001.

Table 3-15: Estimated Annual Percent Capture of Wet Weather Flow Presented in 2004 LTCP (based on Modeling from Typical Year Analysis using 1986 Typical Year)

Average Daily Flow (ADF) = 233.68 cfs* — * Calculated from 9-month period simulation

Average Daily Flow (ADF) = 151.03 MGD

Period	CSO Outfall Volume (out of system, upstream of WWTP) (MGD)	WWTP Main Pump Station Bypass Volume (MGD)(1)	WWTP Grit Chamber Bypass Volume (MGD)(1)	Total Out of System Overflow Volume (MGD)	Captured Volume When WWTP Influent Above Average Daily Flow(2) (MGD)	Percent Capture(3)
	A	B	C	D = A+B+C	E	
March - May	1,000	0	24	1,024	4,342	80.9%
June - August	930	0	22	952	6,372	87.0%
September - November	902	0	46	948	5,946	86.2%
Quarterly Average (4)	*944*	*0*	*31*	*975*	*5,553*	*85.1%*
Full Year	3,776	0	123	3,899	22,214	85.1%

Notes:

(1) Volumes (B) and (C) discharge through Outfall 001a.

(2) Volume (E) represents the sum of the individual discharges through Outfalls 001x and 002.

(3) Percent Capture = (E)/(E+D)

(4) Represents arithmetic average of the three modeled quarters. The percent capture calculation's sensitivity to this assumption w as checked by using a quarterly rainfall-w eighted average for the December-February quarter. This w eighted average method resulted in the same percent capture estimate, due to offsetting changes in the calculated w et-w eather overflow and w et-w eather treated flow estimates.

(5) Scajaquada Creek inflow from Cheektow aga discharged through CSOs 006 and 053 has been excluded from the percent capture calculation.

(6) Stormw ater and non-BSA flow s in the follow ing CSOs have been excluded from the percent capture calculation: 028, 054, and 066.

3.2 Phase I, Stage 2: District-Specific Combined Sewer Overflow Planning

Phase I, Stage 2 consisted of the following efforts:

- Draft Technical Memorandum: Alternatives Screening Protocol for Phase I, Stage 2: District-Specific Planning;
- Draft Final Report LTCP for CSO Abatement North District Service Area (prepared by O'Brien & Gere Engineers, Inc,, November 2002);
- Draft Report Scajaquada District CSO LTCP (prepared by Stearns & Wheler Companies, November 2002); and
- CSO Study Draft LTCP South Central District (prepared by URS and the State University College at Buffalo, December 2002).

Each of the District-specific efforts was led by a District Consultant. Each District Consultant used the system-wide calibrated model developed in Stage 1, split the appropriate District from the system-wide model, input the necessary boundary conditions to simulate the District, and used the split model to evaluate

CSO abatement alternatives for the District. A Draft Alternative Screening Protocol was developed to provide a consistent framework for use among District Consultants in conducting the Stage 2 evaluations.

3.2.1 Draft Technical Memorandum: Alternatives Screening Protocol for Stage 2: District-Specific Planning

The Alternative Screening Protocol identified a conceptual process to be followed in screening CSO abatement alternatives during Phase I, Stage 2. The process, illustrated in Figure 3-5, consists of four steps:

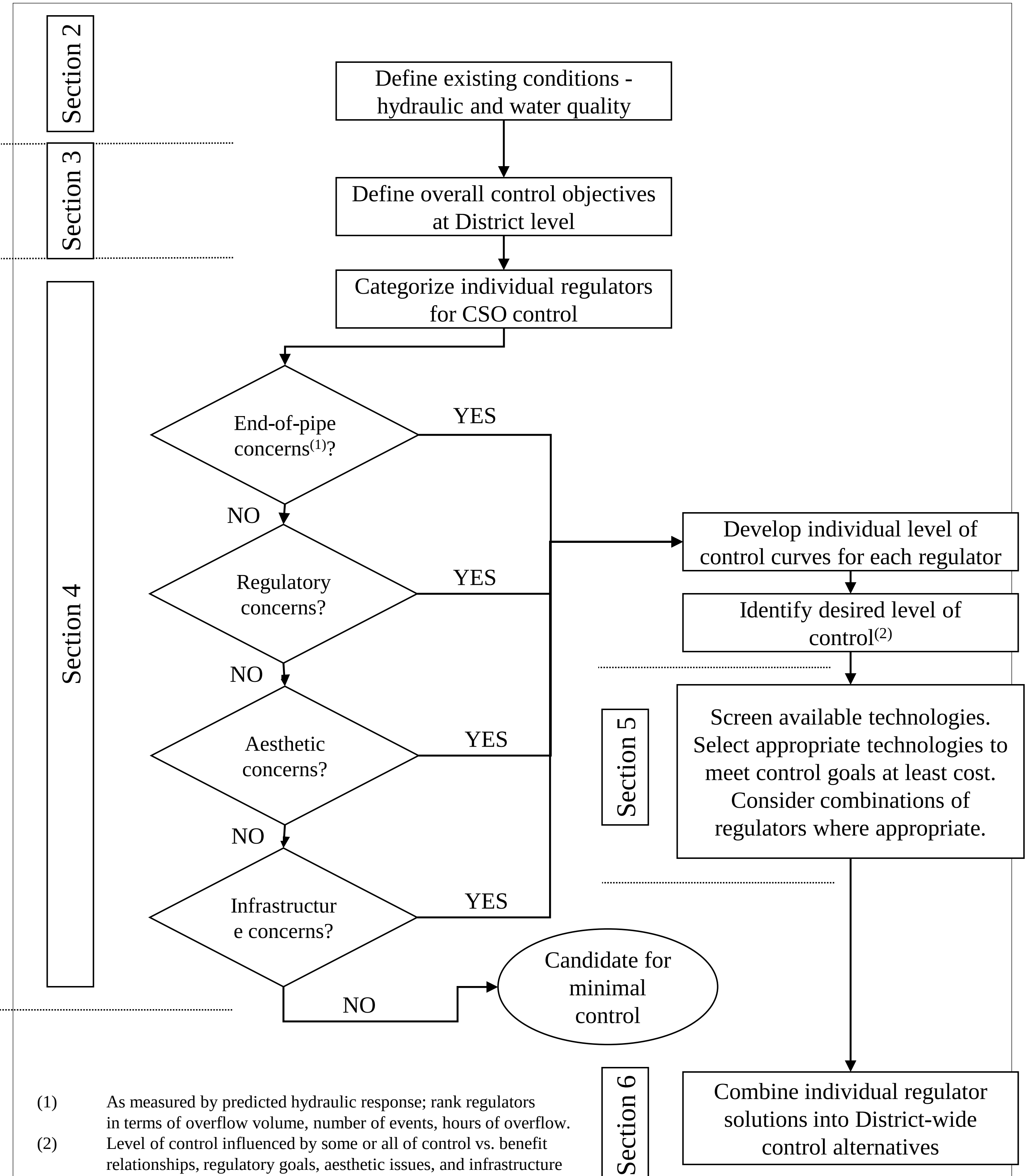
- Step 1: Define general pollutant control objectives at the District level.
- Step 2: Categorize individual regulators for CSO control.
- Step 3: Assess available technologies to meet the desired levels of control and select preferred technology at individual regulators selected for control.
- Step 4: Combine individual regulator solutions into District-wide alternatives.

This protocol was not meant to provide a rigid set of directions, but rather, was meant to serve as a consistent guide to screening alternatives among the District Consultants involved in Phase I, Stage 2. CSO control decisions do not always follow a step-wise process, and in some cases, required an iterative approach to balance multiple factors that influenced the decisions. The protocol also presented preliminary pricing guidelines for various technologies.

The Alternative Screening Protocol identified four main concerns to guide alternative selection:

- End-of pipe;
- Regulatory;
- Aesthetic; and
- Infrastructure.

The Alternative Screening Protocol was used in Phase I, Stage 3 to evaluate, choose, and discard, alternatives.



(1) As measured by predicted hydraulic response; rank regulators in terms of overflow volume, number of events, hours of overflow.

(2) Level of control influenced by some or all of control vs. benefit relationships, regulatory goals, aesthetic issues, and infrastructure needs.

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FIGURE 3-5
ALTERNATIVE SCREENING PROTOCOL

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3.2.2 Draft Final Report LTCP for CSO Abatement North District Service Area

Figure 3-6 depicts the extents of the North District. The North District consists of three main drainage basins: Ontario, Hertel, and Parish. The main interceptor trunk line runs down Hertel Avenue. Six of the BSA's CSOs are located within this District, including the largest CSO in the City (CSO 055), located at Cornelius Creek. Receiving water bodies for the North District are the Niagara River, Black Rock Canal, and Scajaquada Creek.

Three different model simulations were compared in the alternatives assessment for the North District:

- Existing conditions, based on the full-system model simulation results as developed in Phase I, Stage 1.
- Base case, consisting of changes made to the sewer system configuration based on projects either being conducted by the BSA at the time of the Phase I, Stage 2, evaluation, near-term budgeted projects, or projects considered to be easily implemented at relatively minor cost. The intent of the base case model was to represent the configuration of the collection system in the North District as it was planned to exist at the conclusion of Phase I, Stage 2, at the end of 2002.
- Recommended actions, consisting of changes made to the sewer system configuration to abate CSO discharge in the North District.

Base case changes consisted of weir adjustments, orifice plate removal, and sewer separation. These base case changes, summarized in Table 3-16, were incorporated into the first system-wide alternative evaluated during Phase I, Stage 3. Recommended actions, also summarized in Table 3-16, included floatable control and additional weir adjustments. Evaluations of alternatives in the North District were made based on comparisons of results between incorporating base case and recommended actions into the North District model.

3.2.3 Draft Report Scajaquada District CSO LTCP

The Scajaquada District is bounded to the east by the City of Buffalo limits, to the west by the Black Rock Canal, and to the south by West Ferry and Fougeron Streets, as presented in Figure 3-7. The main interceptor trunk line is the Scajaquada Tunnel Interceptor, which extends from the City border with Cheektowaga and discharges to the North Interceptor. Flows from Cheektowaga enter the BSA's collection system in the Scajaquada District, as well. Overflows from the trunk sewers tributary to the Scajaquada Tunnel Interceptor discharge to the Scajaquada Drain, which extends from the City border with Cheektowaga to the Scajaquada Creek at Forest Lawn Cemetery. Eleven of the BSA's CSOs are located within this District. The receiving water bodies for this District are Scajaquada Creek and the Black Rock Canal.

The recommendations for the Scajaquada District were organized into five Project Groups, based on a prioritization of CSOs. The main objective for CSO abatement for the Scajaquada District was identified by the District Consultant as floatables control on the Scajaquada Creek first, and then followed by construction of facilities to control CSO discharges to the Black Rock Canal.

- Project Group 1 consists of sewer separation projects for priority basins tributary to the largest CSOs in the District.

- Project Group 2 consists of finishing separation projects and implementing overflow redirection.

- Project Group 3 consists of floatable control facilities and in-line storage for the trunk sewers tributary to the upstream portions of the Scajaquada Tunnel Interceptor, which overflow to the Scajaquada Drain.

- Project Group 4 consists of finishing the floatable control facilities on the overflows to the Scajaquada Drain.

- Project Group 5 consists of in-line storage facilities and floatable control facilities along the trunk lines that overflow to the Black Rock Canal.

Table 3-17 summarizes the specific recommendations within each Project Group for the Scajaquada District.

3.2.4 CSO Study Draft LTCP South Central District

The South Central District is the largest of the three Districts and is bounded by Albany Street to the north, the City line to the east and south, and the Niagara River and Lake Erie to the west, as presented in Figure 3-8. The District can be split into two hydraulically distinct sections by the South Buffalo Pump Station, which pumps flows from the southern portion of the City to the beginning of the South Interceptor. Flows from Erie County Sewer Districts 1 and 4, as well as from West Seneca Sewer Districts 5 and 13, enter the BSA's system in the South Central District. Forty of the BSA's CSOs are located within this District. The receiving water bodies are Cazenovia Creek, the Buffalo River, Erie Basin Marina, and the Niagara River.

Alternatives for the South Central District were divided into four implementation phases, with the first two phases as follows:

- Phase 1A alternatives have a planning horizon of three to five years and are considered to be readily implemented, including weir raising, flow redirection, supplemental capacity, and floatables control.

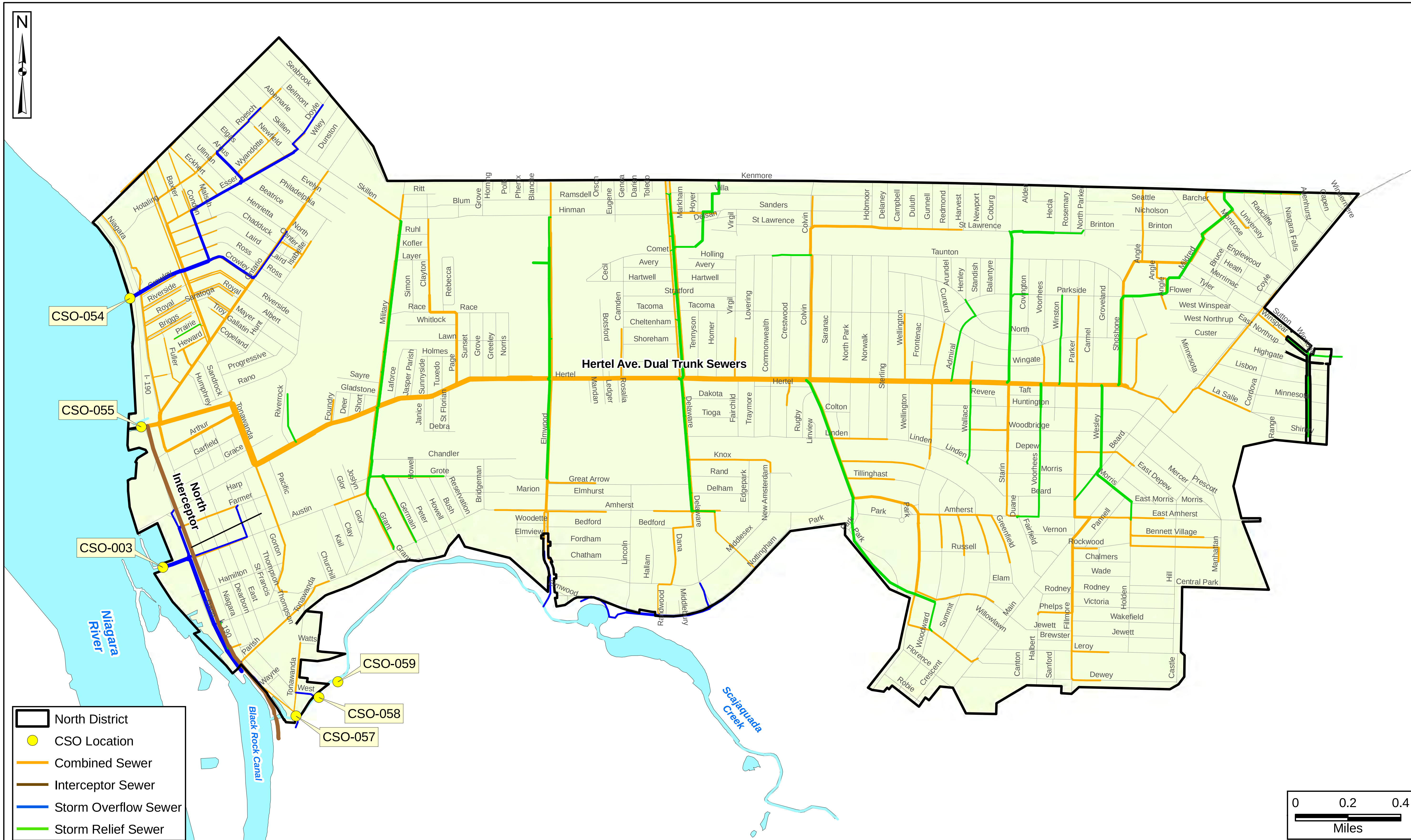

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FIGURE 3-6

NORTH DISTRICT

Table 3-16 North District-Specific Recommendations

Category	Description	Phase
Floatable Control	CSO 003 (ROMAG)	Discarded Alternative
	CSO 003 (CDS)	Recommended Action
	CSO 054: SPPs 187, 188, 189, 190, 191, 192, 193, and 280 (ROMAG)	Discarded Alternative
	CSO 054 (CDS)	Recommended Action
	CSO 055 (ROMAG and Copa)	Discarded Alternative
	CSO 055 (CDS)	Recommended Action
	CSO 056 (CDS)	Recommended Action
	CSO 057 (ROMAG)	Discarded Alternative
	CSO 057 (CDS)	Discarded Alternative
	CSO 058 (ROMAG)	Discarded Alternative
	CSO 058 (CDS)	Recommended Action
Flotable Control / Off-Line Storage	CSO 055	Discarded Alternative
Off-Line Storage	CSO 055	Discarded Alternative
	CSO 056	Discarded Alternative
Upstream Off-Line Storage	CSO 055	Discarded Alternative
Parallel Interceptor	CSO 055	Discarded Alternative
Parallel Interceptor with Storage	CSO 055	Discarded Alternative
In-Line Storage	CSO 055	Discarded Alternative
Raise Weir	CSO 003: SPPs 4, 11, and 185	Base Case
	CSO 054	Discarded Alternative
	CSO 057: SPP 195	Base Case
	CSO 057	Recommended Action
	CSO 058: SPP 213	Base Case
Orifice Plate Removal	CSO 003: SPPs 3, 4, 5, 7, and 8	Base Case
	CSO 057: SPPs 10, 11, and 195	Base Case
	CSO 058: SPP 213	Base Case
Sewer Separation	Ontario Basin	Base Case
	CSO 054 Tonawanda Street	Base Case
	CSO 055 Hertel Street	Base Case
No Action	CSO 057	Discarded Alternative
	CSO 058	Discarded Alternative

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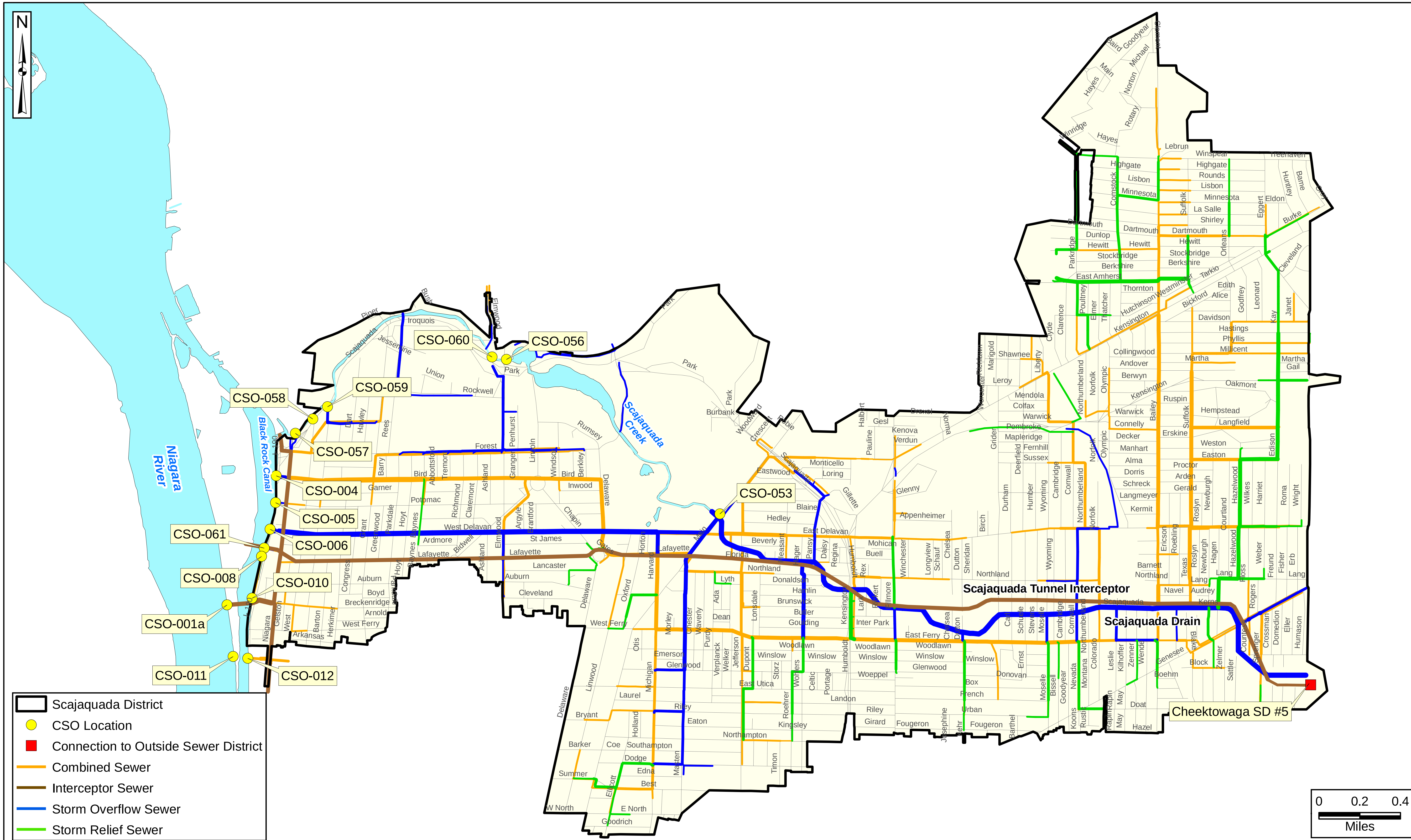

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FIGURE 3-7

SCAJAQUADA DISTRICT

Table 3-17 Scajaquada District-Specific Recommendations

Category	Description	Phase
Flotable Control	CSO 053: SPPs 336B, 170B, 341A, 341B, 165B, 336A, 229A, 203, 163, 164, 165, 204, 201, 202, 335B, 165A, 200A, 200B, 345, 166, 342A, 342B, and 157 (mechanical screens)	Project Group 4
	CSO 053: SPPs 340, 339, 337, 338	Project Group 3
	CSO 004: SPP 13 (mechanical screen)	Project Group 5
	CSO 006: SPPs 332, 180, 179, and 331 (mechanical screens)	Project Group 5
	CSO 061: SPP 330 (mechanical screen)	Project Group 4
	CSOs 053, 060, and 059 (net bag)	Discarded Alternative
	Scajaquada Drain SPPs (CDS)	Discarded Alternative
	CSOs 059 and 060 (mechanical screens)	Discarded Alternative
	Black Rock Canal basins (net bag)	Discarded Alternative
High-Rate Treatment	Scajaquada Drain basins	Discarded Alternative
In-Line Storage / RTC	Scajaquada Tunnel Interceptor	Project Group 4
	Bird Avenue Trunk Sewer	Project Group 5
	Hagen Trunk Sewer	Project Group 3
	Texas Trunk Sewer	Project Group 3
	Colorado Trunk Sewer	Project Group 3
	Bailey Trunk Sewer	Project Group 3
	Delavan Drain	Discarded Alternative
	Scajaquada Drain	Discarded Alternative
Overflow Redirection	Tie CSO 005 SPP 14A overflow into Bird Avenue Trunk Sewer	Project Group 2
	Tie CSO 008 SPP 19 overflow into Scajaquada Tunnel Interceptor	Project Group 2
	Redirect all flow from Scajaquada Drain into Scajaquada Creek	Discarded Alternative
	Redirect dry weather flow from Scajaquada Drain into Scajaquada Creek	Discarded Alternative
	Direct Cheektowaga flows into downstream Scajaquada Creek and CSO discharges to Delavan Drain	Discarded Alternative
Sewer Separation	Tie CSO 005 SPP 14A overflow into Bird Avenue Trunk Sewer	Project Group 2
	Separate sewers upstream of CSO 007	Project Group 2
	Tie CSO 008 SPP 19 overflow into Scajaquada Tunnel Interceptor	Project Group 2
	Separate sewers upstream of CSO 009	Project Group 2
	Separate sewers upstream of CSO 010: SPP 21	Project Group 2

Table 3-17 Scajaquada District-Specific Recommendations

Category	Description	Phase
	Separate sewers upstream of CSO 059: SPPs 183, 184, and 185	Project Group 1
	Separate sewers upstream of CSO 060: SPP 240	Project Group 1
	Separate sewers upstream of CSO 053: SPPs 335A, 156, 334A, 334B, 229, 247, 156A, and 156B	Project Group 1
Flow Redirection / Sewer Separation	Separate all combined sewers tributary to Scajaquada Drain and direct all flow to lower Scajaquada Creek	Discarded Alternative
	Separate all combined sewers tributary to Scajaquada Drain and direct wet weather flow to lower Scajaquada Creek	Discarded Alternative
Storage Tunnel	CSO 053 along Niagara Street	Discarded Alternative

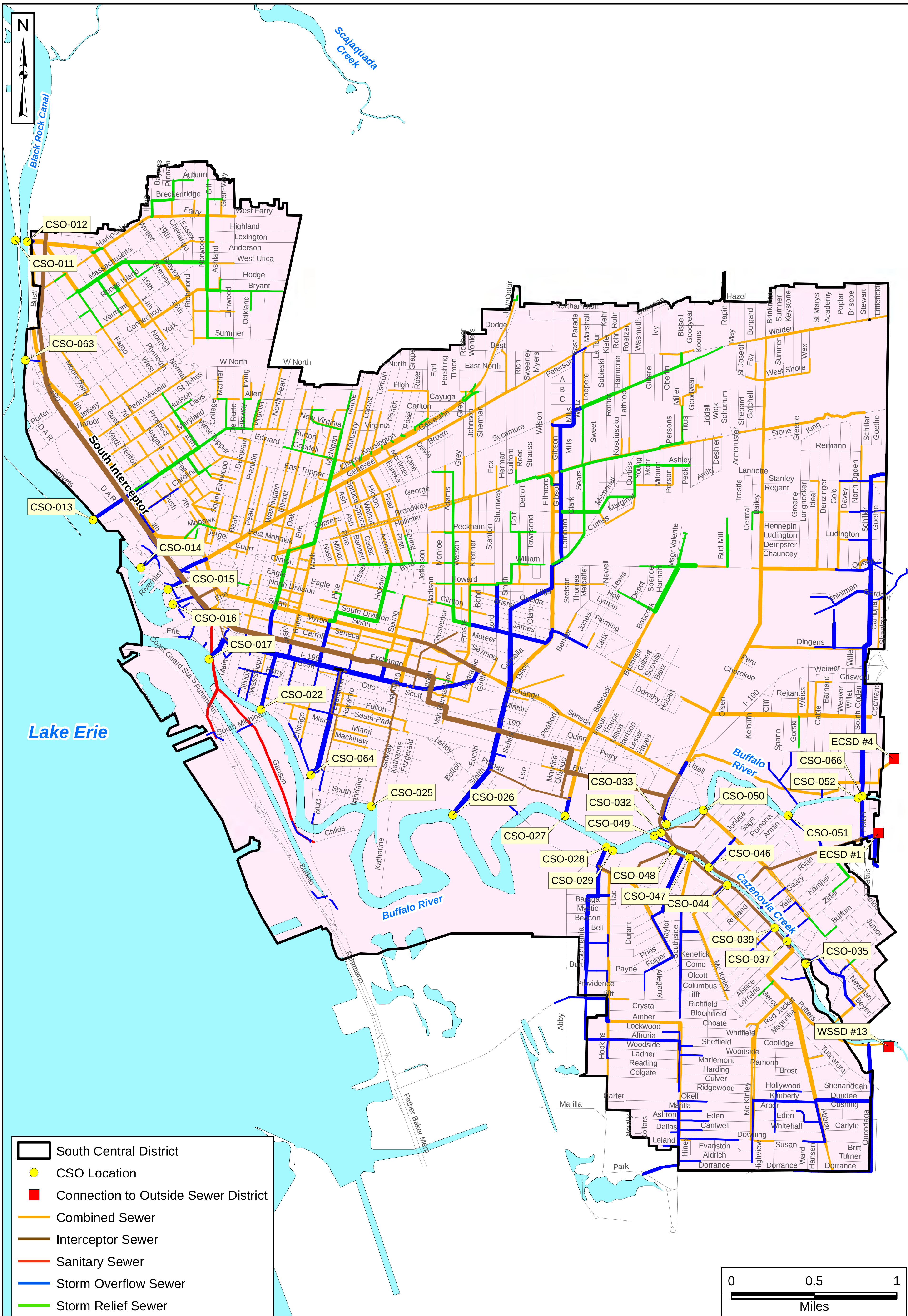

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FIGURE 3-8

SOUTH CENTRAL

- Phase 1B alternatives have a planning horizon of five to 20 years and include mostly partial sewer separation.

Table 3-18 summarizes the specific recommendations within each of these phases for the South Central District.

The last two phases of the recommendations, Phases 2 and 3, do not include specific abatement measures. Phase 2 is a flow monitoring program to be implemented to determine the effectiveness of the Phase 1A and 1B recommendations. Phase 3 consists of long term advanced control measures on a planning horizon of 20 to 40 years and would be implemented in response to stricter regulations, if promulgated in the future.

The District Consultant plans were used to identify and evaluate the alternatives described in the 2004 LTCP. Additional flow monitoring and water quality sampling conducted after the development of the 2004 LTCP are further described in Section 4.0 and subsequent sections of this LTCP.

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Table 3-18 South Central District-Specific Recommendations

Category	Description	Phase
Floatable Control	CSO 011	Phase 1A
	CSO 012	Phase 1A
	CSO 013: SPP 304	Phase 1A
	CSO 014	Phase 1A
	CSO 015	Phase 1A
	CSO 017	Phase 1A
	CSO 022	Phase 1A
	CSO 025: SPP 209	Phase 1A
	CSO 026	Phase 1A
	CSO 027	Phase 1A
	CSOs 028 and 029	Phase 1A
	CSO 033	Phase 1A
	CSO 035: SPPs 107 and 107a	Phase 1A
	CSO 037: SPP 122	Phase 1A
	CSO 044: SPP 121	Phase 1A
	CSO 046	Phase 1A
	CSO 047: SPP 114	Phase 1A
	CSO 050: SPP 105	Phase 1A
	CSO 051	Phase 1A
	CSO 052: SPP 106	Phase 1A
	CSO 063: SPP 283	Phase 1A
	CSO 064	Phase 1A
	CSO 066	Phase 1A
Raise Weir	Swan Trunk: SPPs 42, 48, 55, 65, 67, 206ab, 281, 282, 283, 304, and 326	Phase 1A
	North of Buffalo River excluding Swan Trunk: SPPs 68, 69, 74, 75, 77, 78, 79, 80, 81, 82, 84, 85, 87, 88, 89, 90, 91, 92, 94, 128, 129, 131, 132, 135a, 138, 144, 145, 149(1), 149(2), 150, 151, 197a, 197b, 197c, 198b, 199a, 199b, 199c, 248, 249, 277, 314, and 317	Phase 1A
	South Buffalo: SPPs 105, 106, 106a, 107a, 113, 114, 118, 121, 122, 125, 125a, 126, 208, 307, 308, 309, 310, 311, and downstream of 308, 309, and 310	Phase 1A
Supplemental Capacity	SPP 121	Phase 1A
	SPP 123a	Phase 1A
	SPPs 23 and 296	Discarded Alternative
	SPP 35	Discarded Alternative
Redirect Flow	SPP 42 underflow from Swan Trunk to South Interceptor	Phase 1A

Table 3-18 South Central District-Specific Recommendations

Category	Description	Phase
	SPP 304 Underflow from Swan Trunk to South Interceptor	Phase 1A
	Retain flow in Swan Trunk at Skyway and Charles Street	Phase 1A
	Oak and Smith Streets to South Interceptor	Discarded Alternative
Partial Sewer Separation	Casmir Street and South Ogden Street, south of Clinton Street (CSO 066)	Phase 1B
	Smith Street South of Route 190 to Buffalo River (CSO 026)	Phase 1B
	Smith Street and Seneca Street to Howard Street (CSO 026)	Phase 1B
	Clinton Street and Fillmore Street to Babcock Street (CSO 026)	Phase 1B
	Area tributary to Hamburg Street Pump Station (CSOs 022, 025, and 064)	Phase 1B
	South Buffalo (CSOs 035, 037, 039, 044, 046, 047, 048, 049, 050, 051, and 052	Phase 1B
	Railroad Yard (CSOs 033 and 066)	Phase 1B
	Front Park	Phase 1B
Advanced Control Measures (ACM) based on 12-month design storm		
Below-Ground Storage	CSO 011: LaSalle Park	Phase 3
	CSO 013	Phase 3
	CSO 014	Phase 3
	CSO 015	Phase 3
	CSO 017: between Hamburg and Alabama and between Oak and Chicago	Phase 3
	CSO 026	Phase 3
	CSO 027	Phase 3
	CSO 028	Phase 3
	CSO 029	Phase 3
	CSO 033	Phase 3
	CSO 035	Phase 3
	CSO 037	Phase 3
	CSO 050	Phase 3
	CSO 051	Phase 3
	CSO 052	Phase 3
	CSO 064	Phase 3
	CSO 066	Phase 3

Table 3-18 South Central District-Specific Recommendations

Category	Description	Phase
Deep Rock Tunnel	CSO 011: Albany Street	Phase 3
	CSO 012	Phase 3
	CSO 017: between Hamburg and Alabama	Phase 3
	CSO 026	Phase 3
	CSO 028	Phase 3
	CSO 029	Phase 3
	CSO 064	Phase 3
Off-line Treatment	CSO 026	Phase 3
CDS	CSO 050	Phase 3
	CSO 052	Phase 3
	CSO 066	Phase 3
None	CSO 016	Discarded Alternative
	CSO 022	Discarded Alternative
	CSO 025	Discarded Alternative
	CSO 032	Discarded Alternative
	CSO 034	Discarded Alternative
	CSO 039	Discarded Alternative
	CSO 044	Discarded Alternative
	CSO 046	Discarded Alternative
	CSO 047	Discarded Alternative
	CSO 048	Discarded Alternative
	CSO 049	Discarded Alternative
	CSO 063	Discarded Alternative

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4. Additional Monitoring and Modeling Work under Phase II LTCP Engineering

The 2004 LTCP was developed based on evaluation of the BSA's collection and conveyance system, and water quality-based assessments, conducted from 2000 through 2004, as described in Section 3.0 of this report. Based on the review of the 2004 LTCP by the NYSDEC and the USEPA, refinement of the BSA collection system model and development of receiving water quality models for waterways potentially affected by CSOs was required. Additional flow/rainfall monitoring and receiving water quality sampling activities were also necessary in support of the requested modeling work. Collectively, this additional monitoring and modeling work was referred to as Phase II LTCP activities and is summarized in the following subsections. Figure 4-1 shows the locations of the rainfall and flow monitoring points used during this effort.

4.1 Additional Combined Sewer System Monitoring Program

The collection system model refinement effort described in Section 4.2 required additional precipitation and in-system flow monitoring. As a result, the BSA prepared the *Combined Sewer System (CSS) Monitoring Program Workplan for Additional Combined Sewer System Data Collection* in April 2008 (included as Appendix 4-1) that described the approach for collecting additional system flow and rainfall data. The USEPA subsequently approved the Workplan.

The monitoring program included the installation of flow meters at 23 locations within the BSA's collection system. Fourteen of the flow meters collected flow velocity and depth measurements at five-minute intervals during both dry and wet weather conditions and computed the flow rate based on the collected data and channel geometry. At the other nine locations, all of them overflow pipes, only depth data were recorded. Twelve rain gauges were also installed at various locations around the City. To supplement the precipitation data obtained from the 12 rain gauges, the BSA also obtained and used weather radar data for the greater Buffalo area. Data were collected from April 22, 2009 to September 20, 2009.

The goal of the program was to collect flow monitoring data from three representative storm events having the following characteristics:

- Rainfall duration ranging from two hours to eight hours. A six- to eight-hour duration is representative of an average time of concentration in the City's overall collection system; therefore, shorter durations were intended to highlight the response in individual CSO service areas.

- Depths equal to or greater than 0.5 inches, which represents an approximate depth threshold for events that typically cause widespread activations at major overflows in the system.

- Rainfall distributed evenly across the entire drainage area (or use of the project rain gauge network to record non-uniform rainfall).

Following data collection, all data were checked for accuracy, data drops (i.e., periods where the data record disappears as the result of equipment failure), and unreasonable rainfall/runoff relationships.

4.2 Additional Collection System Model Validation and Refinement

Additional validation and refinement of the BSA CSS model developed as part of the 2004 LTCP efforts was conducted in accordance with the approved *Collection System Model Refinement Workplan* (April 2008, included as Appendix 4-2).

4.2.1 Model Updates

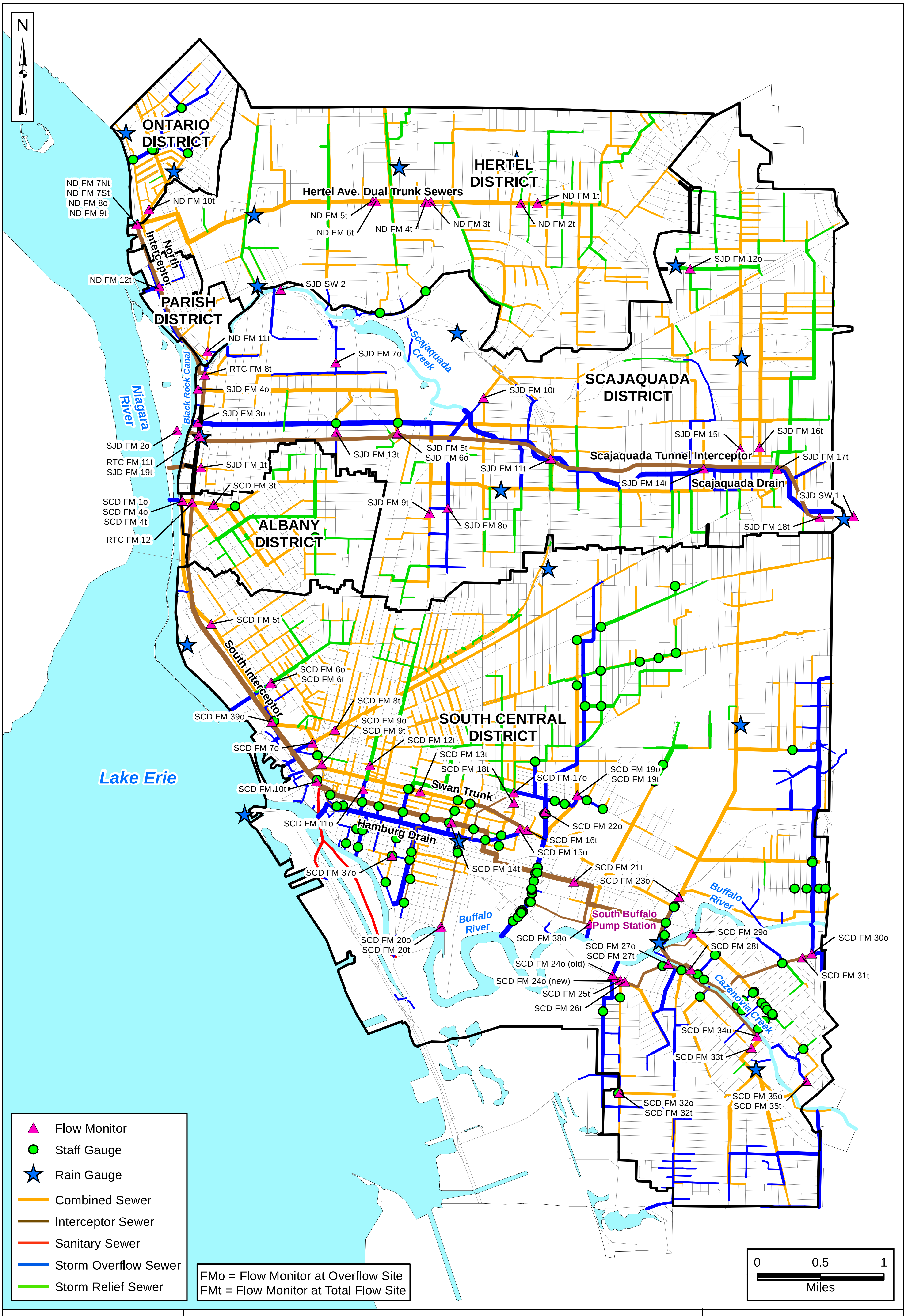
The model refinement approach included the following sequential steps:

- Update the model to incorporate physical collection system improvements implemented since the model was originally developed in 2001.
- Perform additional model validation, using new data from the Phase II flow monitoring program, and assess the validation using agreed-upon criteria, including "goodness of fit", quantitative comparison between events and identification of potential biases and outliers.
- Based on the validation results, determine if any individual sections of the system (as determined by flow monitoring locations) warrant additional model refinement, and if so, perform additional local calibration followed by a second round of independent model validation.
- Draw conclusions on overall strength of the collection system model for application to the Phase II LTCP development.

The model updates are summarized below, with additional detail provided in the *Model Validation Report* (June 2010; included as Appendix 4-3).

The following system changes were incorporated in the fall of 2008 as part of model validation to account for Phase I projects completed by the BSA:

- Removed orifice plates in 11 SPPs (003-005, 007, 008, 010, 010, 107A, 132, 195, and 213);
- Updated weir crest elevations in 14 SPPs (004, 011, 022, 089, 156A&B, 185, 187-191, 195, and 213);



BUFFALO SEWER AUTHORITY
Long Term Control Plan Update

FIGURE 4-1

RAIN GAUGES, STAFF GAUGES, & FLOW MONITORS

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- Eliminated 16 SPPs and their associated CSOs (093, 108, 110, 111, 116, 139-143, 192, 207. 325, 328, 341B, and 344); and

- Revised the imperviousness in 21 areas (totaling 70.4 acres) where sewer separation projects were completed.

The following changes were incorporated in the fall of 2009, again, to reflect changes in the system as the result of projects implemented by the BSA:

- Weir crest elevations were updated in 21 additional SPPs (068, 069, 074, 075, 077-082. 084, 085, 087, 088, 090-092, 094, 107, 135A, and 314); and

- Incorporated the CSO 035 sewer separation project.

All of the system changes implemented by the BSA that were incorporated into the model were part of the BSA's Nine Minimum Control program, and/or recommendations from the original (2004) LTCP. Further, all of these changes had the net effect of reducing storm water contribution to the combined sewer system, increasing in-line storage, increasing the capture of wet-weather flow, and/or reducing wet-weather overflow.

In addition to the system changes listed above, several other changes were made to the system since the completion of the 2009 Phase II flow monitoring program used to validate the model. Because these changes were not in place at the time of the flow monitoring program, they were not incorporated into the validation model described in this section. However; they were incorporated into the baseline model that was used for analysis going forward. These changes were as follows:

- Updated the weir elevations at 23 additional SPPs. (107A, 121, 128, 129, 131, 132, 138, 145, 149A&B, 150, 151, 197A&B&C, 198B, 199A&B&C, 248, 249, 277, 317);

- Incorporated the Mumford Street Sewer Improvements at SPP 121; and

- Incorporated the CSO 059 sewer separation improvements.

4.2.2 Model Validation

After the model was updated to represent the current system configuration, the original calibration of the model was re-validated using the 2009 Phase II monitoring data. Data obtained during the 2009 program was reviewed to identify wet-weather validation events.

The available flow data resulted in the identification of eight potential candidate validation events, and, therefore, it was decided that the model would be validated using four event periods instead of the initially-proposed two event periods. The remaining four event periods were used as independent datasets for additional validation as required. The selected validation event periods were chosen to cover a range of conditions in terms of storm volume, storm peak intensity, storm duration, and to incorporate back-to-back events.

The selected validation events were simulated using the updated model, and the results were compared with the observed data. The success of the validation was then assessed using a series of qualitative and quantitative criteria.

In addition, the more recent monitoring data, coupled with data from the WWTP, indicated that a drop in base flow had occurred between the completion of the modeling included in the 2004 LTCP and the Phase II modeling in 2009. To be able to properly validate the revised model, it was necessary to account for the drop in boundary condition base flow. This was done by post-processing the model results by comparing the average modeled 2000 base flow with the average observed 2009 base flow, and adjusting the modeled results by the calculated difference.

Based on the findings from model validation, the results showed a successful validation of the BSA's model on a system-wide basis. The flow comparison plots show a strong visual match between the modeled and observed hydrographs, satisfying the "goodness-of-fit" criterion. In addition, 70 to 80 percent of model comparisons to observed data fall within the +/- 35 percent range for both peak flow rate and flow volume. Finally, there is a strong match on activation counts at staff gauge locations, especially for larger events.

The model refinement results satisfied all agreed-upon validation criteria described in the approved 2008 *Model Refinement Workplan*, and demonstrated successful validation on a system-wide basis with exceptional comparisons at 11 of 14 locations. Additional calibration refinement was performed at the three remaining sites with successful independent validation, producing an even stronger model. Ultimately, these results indicated that the refined model is a strong planning level tool, developed appropriately during the original LTCP effort, and is suitable for the Phase II LTCP alternatives analysis. The full validation report is included as Appendix 4-3.

4.3 Additional Receiving Water Quality Sampling

A *Receiving Water Quality Sampling Workplan* was developed and submitted to the USEPA in April 2008 (included with the LTCP as Attachment A of Appendix 4-4). The USEPA subsequently approved the workplan. The sampling program was initiated in July 2008 with two dry weather samples collected in 2008. However, due to unfavorable weather conditions, no wet weather sampling events were conducted in 2008. With the concurrence of the USEPA and the NYSDEC, the wet weather sampling program was extended to

2009 with two discrete wet weather sampling events conducted in the fall of 2009. The program is described in detail in the *Receiving Water Quality Sampling Program Summary Report (January 2011)* included in Appendix 4-4 and was comprised of the following major receiving water sampling components:

- ***Discrete dry and wet weather sampling events*** comprised of manual surface sampling at locations along five transects in the Niagara River, and specific locations at the mouth of the Buffalo River, and in the Black Rock Canal and Scajaquada Creek (24 total discrete sampling locations, see Figure 4-2). Two discrete dry weather and two discrete wet weather sampling events were conducted during the Phase II program. Dry weather events included collecting one sample at each location during each event, while wet weather events were comprised of a time series of sampling during each event. Wet weather sampling followed the initiation of wet weather conditions and confirmed overflow activation in the BSA's system. The samples collected during the discrete events were analyzed for fecal coliform bacteria (at all locations) and total and soluble BOD_5 (at all locations except Niagara River transects, as fecal coliform was the only parameter of concern within the Niagara River). Dissolved oxygen, temperature, and conductivity were measured at the Scajaquada Creek sampling locations, while turbidity and pH were recorded for the Black Rock and Buffalo River sites.

- ***In-situ sediment oxygen demand (SOD) sampling/analysis*** was performed during dry weather conditions at four locations in Scajaquada Creek and the Black Rock Canal (two in each). For each of the two receiving waters, SOD sampling was conducted at a downstream and an upstream location.

- ***Continuous water quality monitoring*** was conducted to provide incremental water quality data at three locations (two in the Black Rock Canal, and one at the mouth of the Buffalo River (Figure 4-3)). This monitoring occurred during the navigable boating seasons of both 2008 and 2009. Temperature, specific conductance, DO, pH, and turbidity were sampled continuously at 15-minute intervals during each monitoring season.

- ***Water stage and velocity monitoring*** was completed using water level sensors and horizontal acoustic Doppler current profilers installed at upstream and downstream locations on Scajaquada Creek to record water levels and water velocities from July through October 2008.

- ***Rainfall monitoring*** was completed in conjunction with the collection system flow monitoring program using a total of 12 tipping-style rain gauges deployed to individual locations throughout the City (Figure 4-4). The gauges continually measured rainfall during both the 2008 and 2009 sampling seasons.

Operation of both the CSO activation monitors at select key locations within the BSA system and the rain gauges were integrated into a “remote monitoring” system that included wireless transmission of continuous monitoring data to a central data processing/storage system. These near real-time data were available to water quality sampling team members during all phases of the sampling effort to assist in decisions on sample initiation or stand-down. In total, thousands of individual data points were collected during this effort. As indicated previously, the data collection was summarized in the full *Receiving Water Quality Sampling Program Summary Report*, initially submitted in November 2010 and subsequently revised to address the USEPA comments in January 2011 (included as Appendix 4-4). The USEPA subsequently approved the Report.

4.4 Additional Water Quality Modeling

As part of the 2004 LTCP preparations and as outlined in Section 3.0, the BSA, in conjunction with the University at Buffalo, previously conducted water quality modeling to evaluate DO in the Buffalo River. The agencies involved in reviewing the 2004 LTCP suggested that the BSA conduct additional receiving water quality modeling of waterways potentially affected by CSOs. Specifically, modeling *o*f the Niagara River, the Buffalo River, and Scajaquada Creek was requested in a letter to the BSA from the NYSDEC to evaluate specific concerns regarding bacteria, BOD, and effects on DO in the Buffalo River and Scajaquada Creek. Subsequent discussions identified concerns regarding DO impacts in Black Rock Canal, as well. The updated modeling efforts build upon previous work and involved development of new receiving water models to enhance the BSA's understanding of the impacts of CSOs on these receiving waters. The modeling approach was documented in the approved *Water Quality Modeling Work Plan for Niagara River, Buffalo River, Black Rock Canal, and Scajaquada Creek (May 2008 – See Appendix 4-5)*. Discussions with the NYSDEC and USEPA defined a set of questions to be answered by the receiving water quality models:

- What is the relative contribution of the BSA's CSO discharges to the bacteria and BOD concentrations in receiving waters during and following a CSO event relative to other watershed sources, such as direct runoff, other tributary sources, and sources in the watershed outside the city?

- What are the effects of the BSA's CSO discharges on the bacteria and BOD concentrations in receiving waters in the hypothetical absence of other contributions or following potential reductions of other contributions?

- What effect will proposed CSO control projects have on receiving water quality, relative to current conditions?

More specific water quality models for each of the targeted water bodies were then developed, calibrated, and validated as described in the *Water Quality Model Development and Calibration Report for Buffalo*

MALCOLM PIRNIE / ARCADIS 2012 1777-122	**BUFFALO SEWER AUTHORITY** **Long Term Control Plan Update**	**FIGURE 4-2** **PHASE II WATER QUALITY DISCRETE SAMPLING LOCATIONS**

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FIGURE 4-3
PHASE II WATER QUALITY CONTINUOUS SAMPLING LOCATIONS

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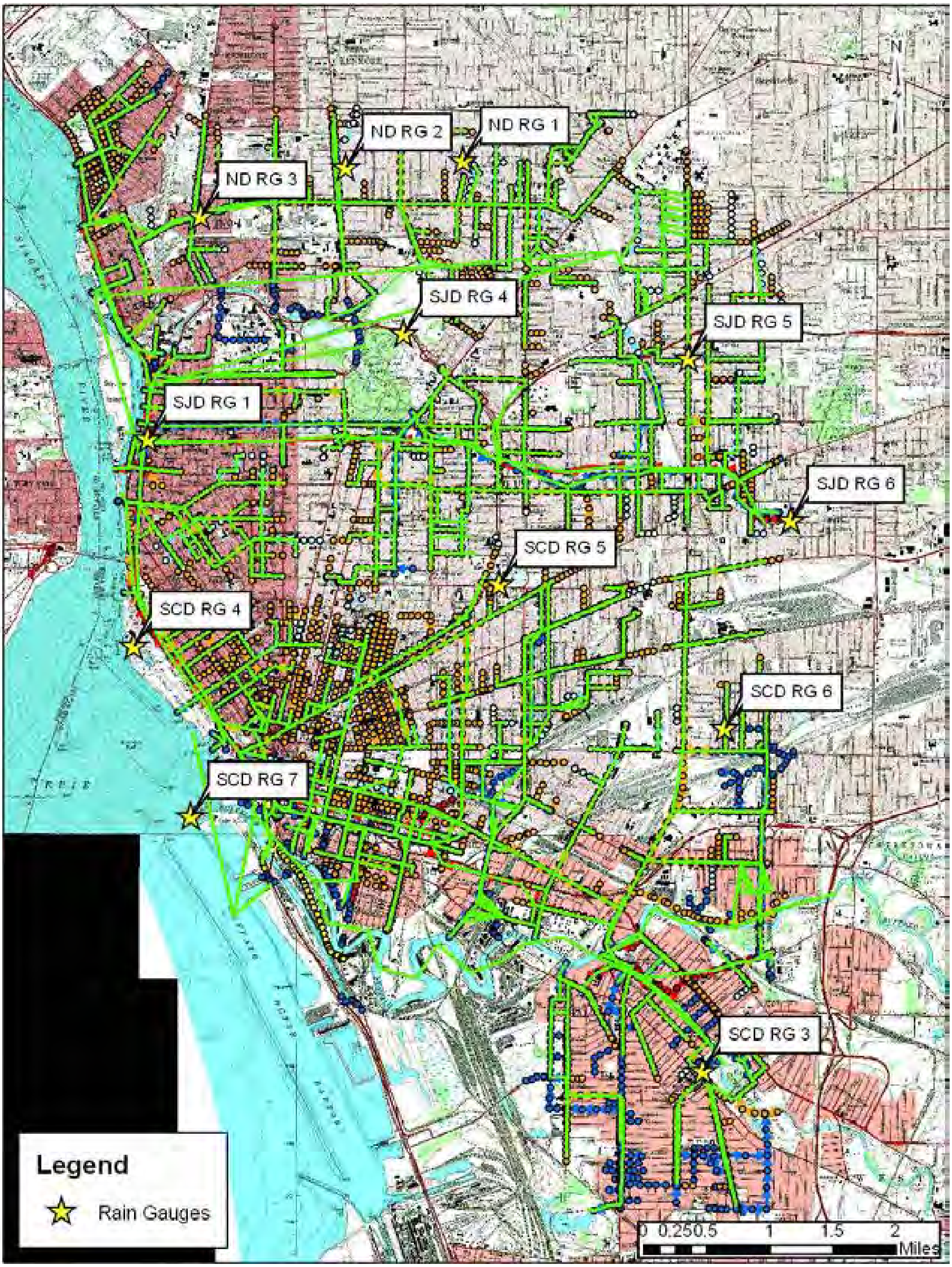

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Long Term Control Plan Update

FIGURE 4-4
PHASE II WATER QUALITY RAIN GAUGE LOCATIONS

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River, Scajaquada Creek, Niagara River, and Black Rock Canal (Limnotech, November 2010), included as Appendix 4-6. The approach outlined in this report was approved by the USEPA on January 4, 2011.

4.4.1 Buffalo River Model

The Buffalo River model was developed to simulate BOD and DO levels in the lower Buffalo River, especially during and following CSO events, and to assess the effects of the BSA's CSO discharges on bacteria to determine the impact on overall water quality. The model extends from Lake Erie upstream along the Buffalo River and Cazenovia Creek branches to approximately the Buffalo municipal boundary.

The Buffalo River model is a two-dimensional, laterally-averaged model because the lower Buffalo River has been deepened by dredging. The Buffalo River model was calibrated to wet weather water quality data collected in 2000 and 1994, as well as more recent hydrodynamic data collected in 2008.

4.4.2 Scajaquada Creek Model

A one-dimensional model of Scajaquada Creek was developed to simulate water quality in the creek and loading to Black Rock Canal. The Scajaquada Creek model was calibrated to data collected in 2009. The purpose of this model is to assess the relative contribution of the BSA's CSO discharges to the presence of bacteria and DO during and following a CSO event relative to other watershed sources. The output from the Scajaquada Creek model was used to calculate the bacterial input loads to the Black Rock Canal and Niagara River during various storm events with and without CSO controls. The Scajaquada Creek model extends from the terminus of the creek at the Black Rock Canal to the point at which the Creek exits the Scajaquada Tunnel in Delaware Park.

4.4.3 Niagara River Model

A time-variable, two-dimensional, vertically-averaged hydrodynamic and water quality model of the Niagara River was developed to simulate bacteria fate and transport and to provide hydrodynamic output for subsequent use in the Black Rock Canal DO/BOD model. The Niagara River model was calibrated to 2009 data. The Niagara River model was developed extending from the downstream end of Lake Erie to the approximate northern municipal boundary of the City of Buffalo.

4.4.4 Black Rock Canal Model

A separate, two-dimensional, laterally-averaged model of the Black Rock Canal was developed to focus specifically on DO, while bacteria fate and transport in the Black Rock Canal is addressed using the Niagara River model. The Black Rock Canal model was calibrated to 2009 data, and was used to assess the impact of CSO discharges on DO and to determine the impact of CSO controls on DO levels in the Canal. The

Black Rock Canal was modeled from the canal's southern boundary at the Lake Erie Basin Marina northward to the Black Rock Lock, and includes the segment of Scajaquada Creek downstream of the Grant Street dam.

4.4.5 Summary

Based on the Phase II calibration and verification activities performed in accordance with the USEPA-approved 2010 water quality report, the four water quality models are capable of simulating time-variable conditions on a wet weather event or continuous basis and are designed to provide reasonable spatial detail for analysis of receiving water conditions. The water quality models have been specifically designed and calibrated for use in evaluating receiving water quality effects of CSO control alternatives evaluated.

5. Implementation of Best Management Practices

The BSA's SPDES permit, issued in 2009, mandates that the BSA implement a list of combined sewer overflow (CSO)-specific Best Management Practices (BMPs). The BMPs are designed to optimize use of operation and maintenance (O&M) procedures, utilize the existing treatment facility and collection system to the maximum extent practicable, maximize pollutant capture through sewer design, replacement, and drainage planning, and minimize water quality impacts from CSOs. The 15 BMPs satisfy and go beyond the nine minimum control (NMC) measures required under the USEPA CSO Control Policy.

The CSO BMPs to be addressed, as listed in the SPDES permit, are:

1. CSO maintenance and inspection;
2. Maximize use of collection system for storage;
3. Industrial pretreatment;
4. Maximize flow to publicly-owned treatment works (POTW);
5. Wet weather operating plan;
6. Prohibition of dry weather overflow;
7. Control of floatable and settleable solids;
8. Combined sewer system replacement;
9. Combined sewer / extension;
10. Sewage backups into basements;
11. Septage and hauled waste;
12. Control of run-off;
13. Public notification;
14. Characterization and monitoring; and
15. Annual report.

The BSA has implemented the above CSO BMPs through various programs and activities performed by its personnel. This section summarizes and documents the BSA's implementation of CSO BMPs. Per Section VII of the current BSA SPDES permit, "The BMPs are equivalent to the 'Nine Minimum Control Measures' required under the USEPA National Combined Sewer Overflow policy." Also, per the last BMP, the BSA submits an annual report that summarizes the implementation of the BMPs – this report is submitted to the NYSDEC.

5.1 CSO Maintenance and Inspection

The SPDES permit stipulates that the BSA develop a written maintenance and inspection program for all of its permitted CSO regulators tributary to the CSOs. The objective of the maintenance and inspection program is to detect and prevent dry weather discharges and ensure that the maximum amount of wet weather flow is conveyed to the WWTP for treatment, consistent with hydraulic and other limitations. Inspection reports documenting regular compliance with this BMP are provided to the NYSDEC.

A schedule for routine maintenance and inspection has been implemented by the BSA, and is presented in Appendix 5-1. The BSA continuously inspects between 17 and 33 regulators a day, over a period of 11 days. For each regulator, the inspection report notes the date, weather, CSO to which the regulator is tributary, if the connection is open or closed, and if a dry weather overflow is observed. The CSO maintenance and inspection protocols ensure that each sewer regulator is inspected at least twice per month. If deficiencies are observed, a separate emergency repair crew is available to make appropriate repairs or modifications. A sample report submitted by the BSA to the NYSDEC is included in Appendix 5-2.

5.2 Maximize Use of Collection System for Storage

The BSA's SPDES permit stipulates that the BSA optimize the collection system by operating and maintaining it to minimize the discharge of pollutants from the CSOs within the conveyance and treatment limitations of the system. The intent of this CSO BMP is to maximize in-system storage capacity and flow conveyed to the WWTP without causing service backups or street flooding while minimizing CSO discharges. Compliance with this BMP is achieved through evaluating the hydraulic capacity of the system, implementing a continuous flushing/cleaning program to minimize the deposition of solids, adjusting regulators and weirs, and implementing Real Time Control (RTC) technologies to maximize in-system storage.

A hydraulic capacity evaluation of the collection system and an evaluation of maximizing storage by adjusting regulators and weirs were performed as part of the LTCP development, the results of which are presented in this report. The BSA currently has an ongoing flushing program to minimize solids deposition. Additionally as part of the Phase 3 LTCP work, the BSA undertook RTC feasibility studies by two specialized consultants, BPR CSO and EmNet. The RTC consultant recommendations are being incorporated into the CSO control alternatives presented in subsequent sections of this report. At the time of this report preparation, the BSA is in the process of implementing two RTC demonstration projects in the Bird Avenue and Hagen Street areas.

5.3 Industrial Pretreatment

The industrial pretreatment program conducts the following analyses, as applicable, for indirect discharges:

- For batch discharge industrial operations, consideration is given to the feasibility of a schedule of discharge during dry-weather conditions (i.e., when CSOs are not occurring).
- For continuous discharge industrial operations, consideration is given to the collection system capacity to maximize delivery of waste to the treatment plant.

To meet the industrial pretreatment CSO BMP requirements of its SPDES permit, the BSA:

- Submits a copy of every new significant industrial user permit to the NYSDEC Division of Water for review and approval before the permit is issued to the industry.
- To the extent possible, does not allow batch discharges during a wet weather event.
- Has informed all industrial users that are permitted by the BSA that non-contact cooling water cannot be part of that industry's process discharge.
- Has informed all industrial users that are permitted by the BSA and that require a SPDES permit to contact the NYSDEC Division of Water for further guidance.

5.4 Maximize Flow to Publicly-Owned Treatment Works

During wet weather, the BSA maximizes flow through the secondary treatment process and routes all flow up to the capacity of the secondary treatment process through the secondary treatment units. Flows in excess of the capacity of the secondary treatment process receives at least primary treatment and disinfection, before being discharged to the Niagara River, as part of the partial treatment WWTP operational mode.

Maximizing flow to the treatment plant is addressed by the evaluations conducted in the LTCP development, the results of which are presented in Section 8 of this report.

The BSA is currently completing design for modification of the primary bypass chamber to allow additional wet weather flows to be passed to the secondary treatment process train. As a result of the modifications, the WWTP will have the capability to convey flow up to the secondary process peak design flow rate of 360 MGD during the partial treatment mode of operation.

In addition, the BSA's wet weather operating plan documents procedures to be implemented to maximize flow through the secondary treatment process train during periods of wet weather. The WWTP wet weather capacity evaluation results are described in more detail in Section 8.

5.5 Wet Weather Operating Plan

The wet weather operating plan documents a set of procedures to be implemented to maximize treatment during wet weather events, while not appreciably diminishing effluent quality or destabilizing treatment upon return to dry weather operation. The wet weather operating plan was drafted and submitted to NYSDEC in June 2000, and subsequently revised in 2007, after completion of the grit removal system modifications.

5.6 Minimization of Dry Weather Overflow

The occurrence of any dry weather overflow is required to be promptly abated and reported to the NYSDEC within 24 hours. A written report is also required, to be submitted within 14 days of the time the permittee becomes aware of the occurrence.

The occurrence of dry weather overflows is checked as part of the ongoing routine CSO inspection and maintenance program. Dry weather overflow occurrences are addressed in compliance with the requirements in the SPDES permit.

5.7 Control of Floatable and Settleable Solids

This CSO BMP requires that the discharge of floating solids, oil and grease, or solids of sewage origin which cause deposition in the receiving water shall be minimized. Activities implemented to comply with CSO maintenance and inspection, maximizing use of the collection system for storage, maximizing flow to the POTW, and the wet weather operating plan (CSO BMPs 1, 2, 4, and 5) address the requirement to control floatables. Furthermore, additional floatables control technologies were evaluated in developing the LTCP.

The BSA currently implements regular ongoing catch basin and receiver cleaning as part of their collection system operations and maintenance program. Two crews clean approximately 200 receivers per working day, with each receiver being cleaned approximately twice per year. In addition, the BSA's Hamburg Drain Floatables Control Facility, currently under construction, will remove larger solids from the flow stream before they reach the Hamburg Drain outlet at the Inner Harbor area.

While the BSA staff does not perform street sweeping, the City of Buffalo Department of Public Works provides street sweeping to every city street at least three times per year. This also helps to minimize solids entering the CSS.

5.8 Combined Sewer System Replacement

The BSA's SPDES permit stipulates that replacement combined sewers shall not be designed or constructed without NYSDEC approval. If replacement of combined sewers is necessary, separate sanitary and storm sewers should be considered for installation instead of a combined sewer. When combined sewers are replaced, velocity through the pipes should be great enough to prevent deposition of organic solids during low flow conditions.

The BSA does not replace combined sewers; however, the BSA does repair combined sewers. When new developments are constructed, all sewers consist of separate storm and sanitary lines.

5.9 Combined Sewer Extension

This CSO BMP requires that combined sewer extensions, when allowed, should be accomplished using separate sanitary sewers. No new sources of storm water should be connected to any separate sanitary sewer in the collection system. Furthermore, if separate sewers are to be extended from combined sewers, the permittee shall demonstrate that the existing collection system and treatment plant can adequately convey and treat the increased dry weather flows. The NYSDEC will assess the effects of the increased flow of sanitary sewage or industrial waste on CSO concentrations, frequency, and the impacts on the receiving water bodies, using collection system and water quality modeling.

The BSA does not build combined sewer extensions.

5.10 Basement Backups

If there are documented, recurring instances of sewage backing up into houses or of raw sewage discharges to the ground surface from surcharging manholes, the BSA is required to notify the NYSDEC by letter and prohibit further connections to the system that would exacerbate the problem.

In areas where sewage back-ups are documented, the BSA has aggressively and proactively implemented sewer separation projects with the intent of mitigating the problem.

5.11 Septage and Hauled Waste

Discharge or release of septage or hauled waste upstream of a discharging CSO is prohibited. The BSA does not engage in this practice; septage and hauled waste are required to be discharged directly to the WWTP for treatment. The BSA WWTP is equipped with a dedicated receiving area for septage and hauled wastes. From this receiving area, these wastes are discharged directly to the settled wastewater wet well, where they combine with primary effluent or primary bypass flows when operating in the primary bypass or partial treatment modes, and are pumped to the aeration tanks for secondary treatment. Since this and all other waste streams influent to the Settled Wastewater Pumping Station receive full secondary treatment even during high flows, the BSA accepts septage during wet weather events.

5.12 Control of Run-Off

It is recommended that impacts from runoff in new developments served by combined or separate sewers should be reduced by implementing practices documented in NYSDEC's guidance, NYS Stormwater Management Design Manual. The BSA follows the procedures in this manual in attempting to reduce runoff.

In addition, the City is currently in the process of finalizing a Green Code, as part of the City Code, outlining requirements for capturing runoff before it reaches the collection system, for redevelopment efforts within the City limits.

5.13 Public Notification

All CSO outfalls owned and operated by the BSA are identified with signs, minimum dimensions of 18 in by 24 in, with white letters on green background, and contain standard language as noted in the SPDES permit and per comments from the NYSDEC. An example of the sign language is presented in Figure 5-1. The BSA has posted signs at all CSOs in accordance with the SPDES permit.

5.14 Characterization and Monitoring

The SPDES permit requires characterization of the CSS as well as the determination of the frequency of overflows and the impact of CSOs. This BMP is further expounded upon in other sections of this LTCP.

5.15 Annual Report

An annual report, which summarizes the implementation of each of the BMPs, is submitted to the NYSEC by January 31 of every year.

5.16 Phase I CSO Improvements Implementation

Since the development of the 2004 LTCP, several projects have been completed by the BSA as part of the CSO Phase I improvements. Descriptions of each of the projects are provided below. Additional information about these projects and their schedule for completion is provided in Section 11.2 and shown on Table 11-1.

CSO 003 SPPs 4, 11 and 185
CSO 003 SPPs 3, 4, 5, 7 and 8

These projects were completed in 2008 by BSA personnel. They consisted of raising weirs in SPPs 4, 11 and 185 and removing orifice plates in SPPs 3, 4, 5, 7 and 8. The projects were undertaken to reduce CSO discharges from CSO 003 (Austin Street) into the Black Rock Canal.

Cazenovia Creek CSO 35

This was a sewer separation project completed in the fall of 2009. This project was designed to reduce CSO discharges from CSO 35 through weir modifications to SPP's 107 and 107A.

N.Y.S. PERMITTED DISCHARGE POINT
(wet weather discharge)
SPDES PERMIT No.: NY__________

OUTFALL No. : __________

For information about this permitted discharge contact:

Permittee Name:

Permittee Contact:

Permittee Phone ( ) - ###-####

OR:

NYSDEC Division of Water Regional Office Address

NYSDEC Division of Water Regional Phone: ( ) - ###-####

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Cazenovia SPP 121

This was a supplemental capacity project designed to reduce CSO discharges from SPP 121 into Cazenovia Creek. A new 48-inch diameter sanitary sewer was built on Mumford Street in October 2009.

CSO 057 SPP 195

The weir was raised in SPP 195 by BSA personnel to reduce CSO discharges into Scajaquada Creek through CSO 057.

CSO 057 SPPs 10, 11, & 195

The orifice plates were removed by BSA personnel in SPPs 10, 11, & 195 to reduce CSO discharges into Scajaquada Creek through CSO 057.

CSO 058 SPP 213

The weir was raised in SPP 213 by BSA personnel to reduce CSO discharges into Scajaquada Creek through CSO 058.

The orifice plate was removed in SPP 213 by BSA personnel to reduce CSO discharges into Scajaquada Creek through CSO 058.

North of Buffalo River SPP Modifications

This project was completed by BSA personnel in June and July 2009. Work consisted of raising weirs in approximately 27 SPPs and was done to reduce CSO discharges into the Buffalo River.

South Buffalo SPP Modifications

This project was completed in May 2010. It consisted of raising weirs in 17 SPPs to reduce CSO discharge into the Buffalo River.

CSO 059 SPPs 181, 182, & 183

A sewer separation/new storm sewers project was completed in September 2010. The weirs were raised in SPPs 181, 182 and 183 to reduce CSO discharges into Scajaquada Creek through CSO 059.

SPP 123 A Modification

This project was bid in November 2009 and was completed in the spring of 2011. The project replaced 5,000 lineal feet of the Hopkins Street Sanitary Sewer with a larger sewer and raised the weir in SPP 123A. The increased capacity of the Hopkins Street Sewer along with the weir raising will reduce CSO discharges from SPP 123A into the Buffalo River.

CSO 009

Auburn Street, CSO 009, was completed in the summer of 2011 and consisted of raising the weir on SPP 20 and installing a separate storm sewer to reduce flows.

CSO 053 SPP 229

This project, which was completed in the summer of 2011, is a sewer separation project with a new storm sewer that was constructed in Beverly Road, which will reduce CSO discharges into Scajaquada Creek.

CSO 060 SPP 240

Originally developed as a sewer separation, this project presented an opportunity to evaluate the performance of green infrastructure technologies as an alternative to separation. Construction was substantially completed in the spring of 2013. Within this project, the BSA piloted the following green initiatives to establish metrics on these treatments to help verify performance and evaluate the potential role of green infrastructure in future projects:

1) Rain gardens/infiltration basins located along a typical residential street (Windsor and Parkdale Avenues) and a typical commercial street (Elmwood Avenue).

2) Pervious pavement along two residential streets (Clarendon Place and Claremont Avenue)

3) House downspout disconnection/rain barrels to divert roof runoff from the sewer system (throughout the study area).

This project also entailed selective sewer separation in conjunction with the green initiatives. Additionally, the BSA raised weirs in SPPs 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, and 240. This project is expected to reduce discharges into Scajaquada Creek through CSO 060 along Elmwood Avenue.

Swan Trunk Sewer Modifications – SPP 304

This project was completed in the summer of 2011. Work consisted of raising weirs in 10 SPP's to reduce CSO discharges from the Swan Trunk.

Redirect Flow from Swan Trunk to South Interceptor (Pennsylvania Street)

This project is expected to reduce CSO discharges from the Swan Trunk. The project will take advantage of an existing box culvert at Pennsylvania Street. This 8-ft. x 8-ft. culvert was originally intended to serve as a new CSO discharge into the Black Rock Canal. However, after the culvert was installed, the project was abandoned leaving approximately 2,000 ft. of the culvert in place from the Swan Trunk under the New York State Thruway. By opening the culvert where it crosses the South Interceptor, flow from the Swan Trunk will be redirected into the South Interceptor using the empty culvert as storage. This project was completed in the summer of 2013.

SPP 42 Underflow from Swan Trunk to South Interceptor (Erie Street)

This project was bid in the fall of 2012. The project will reduce flow in the Swan Trunk using available capacity in the South Interceptor and eliminate CSO discharges from SPP 42. This project was completed in the summer of 2013.

Retain Flow in Swan Trunk at Skyway & Charles Street

This project consists of installing permanent stop logs in a diversion structure on the Swan Trunk. This chamber diverted virtually all flow from the Swan Trunk to the South Interceptor and contributed significantly to sediment accumulation in the Swan Trunk. The stop logs will retain most flow in the Swan Trunk while allowing diversion of flow during extreme high flows. The increased velocity in the Swan Trunk will reduce future sedimentation. Construction of this project was completed in the summer of 2013.

SPP 55 to South Interceptor along Exchange Street

The project will reduce flow in the Swan Trunk by increasing the capacity of dry weather flow in the Exchange Street sewer. A new 27-inch diameter sewer will replace the existing 15-inch diameter sewer. The carrying capacity of the new sewer exceeds the predicted peak design storm overflow rate. The project was completed in the summer of 2013.

Hamburg Drain Floatable Control Facility

The Hamburg Drain Floatables Control Facility is currently under construction with an estimated completion date of late 2013.

Bird Avenue In-Line Storage (RTC)

This project will store flows in the existing Bird Avenue line that will be released after a storm event to be treated at the BSA WWTP. Design is complete for this Real Time Control (RTC) project. The BSA bid this project in the August 2013 with all work expected to be completed by late 2014.

Hagen / Lang Street In-Line Storage (RTC)

This $3 million project was initially conceived of to store flows in the existing Texas Street Trunk sewer line. The stored flows would then be released after storm events and conveyed to, and treated at, the BSA's WWTP. However, after further evaluating the vertical alignment of the Texas Street Trunk relative to the elevation of private service laterals in the area, implementing RTC on this street was deemed not feasible. Therefore, the RTC implementation project was moved to nearby Hagen Street, which is also tributary to CSO 053. During the design phase, the location for this RTC project was moved again to Lang Street due to constructability issues along Hagen Street. Ultimately, the reduction in overflows at CSO 053 associated with the project will be comparable to that initially estimated. The BSA bid this project in the spring of 2013, with all work expected to be completed by late 2014.

Smith St. Storage

This project is currently under design and will consist primarily of in-line and off-line storage to address overflows into the Buffalo River at CSO 026. In-line storage will use real time control to store flows at or below the level of control within the Smith Street Drain. Flows greater than the level of control will be allowed to bypass the storage and will continue to discharge from CSO 026. Following the wet weather event, stored flows will be pumped back to the South Interceptor for treatment. This project is anticipated to be bid in the spring of 2014 with construction complete by late 2014.

Green Infrastructure Initiatives

This $1 million initiative will be used for various green projects including: a downspout disconnect and rain barrel program, a vacant land management program where structures are demolished thereby reducing impervious surface and creating green space for rain gardens, urban farming, street runoff, etc., and a variety of green treatments on appropriate Department of Public Works and Community Development projects. The $1 million commitment includes the projects below.

- Carlton Street (porous asphalt)
- Ohio Street (porous asphalt and other green street technologies)
- Fillmore Avenue (porous asphalt parking lots)
- North Buffalo Ice Rink (porous asphalt parking lot)
- Ardmore Street (brick street restoration)
- Pilot project vacant property demolitions
- Genesse Street (porous asphalt)

Prior to the start of the LTCP Phase I projects, the BSA had completed various sewer separation projects designed to remove storm water from the CSS, prevent basement flooding, and reduce CSO discharges.

The major projects were:

- Riverside Sewer Separation - Consisted of thirteen (13) projects in which weirs were raised in five (5) SPPs and 1 SPP was eliminated.
- Lovejoy Sewer Separation - Total of four (4) projects.
- Kaisertown Sewer Separation - Total of four (4) projects.
- Hertel Avenue Storm Water Storage - Total of two (2) projects.
- South Park Storm Sewers - Total of four (4) projects.

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6. Control Objectives

The CSO Policy requires that each community consider a range of CSO control alternatives and their potential ability to meet identified water quality goals and associated CSO control objectives. This section outlines the process by which the BSA developed the water quality goals and associated CSO control objectives for the various receiving waters. Note that the majority of the discussions presented in Sections 6.1 through 6.4 were completed during Phase 1 of the LTCP development. Because these evaluations were instrumental in establishing control objectives for development and evaluation of the initial CSO control alternatives in the 2004 LTCP, they were left largely unchanged in this update report. The original control objectives were revised during the subsequent LTCP phases (2 and 3) based on the regulatory agencies comments and/or additional evaluations requested by the agencies. A brief summary of these revisions is as follows:

- Revised fecal coliform WQS for Class C water bodies;
- Revised typical year of precipitation;
- Additional receiving stream water quality sampling and modeling;
- Revised Sensitive Area evaluation;
- Additional Watershed Use Study; and
- Refined parameters of concern for each receiving water body.

6.1 Criteria

6.1.1 Combined Sewer Overflow Control Policy Guidance Summary

In the guidance document *Combined Sewer Overflows, Guidance for Long Term Control Plan (1995)*, the USEPA provides a list of general concepts that should be considered when developing CSO control objectives. The list includes definitions of the following:

- Water quality objectives/intended uses;
- Outfall-specific concerns;
- Sensitive areas concerns; and

- Aesthetic concerns.

According to the USEPA guidance, the development of CSO control alternatives should adhere to the following sequence of events:

- Definition of water quality goals.

- Definition of a range of CSO control objectives to meet the CSO component of the water quality goals.

- Development of control alternatives to meet the CSO control objectives.

Initial definition of CSO control objectives should be based on an identification of watershed-specific, receiving water body-specific or receiving water body segment-specific water quality goals without regard to pollution source. The guidance also states that definition of a CSO control objective based on water quality goals entails identifying a level of CSO control, which will allow attainment of the water quality goals, assuming non-CSO sources of pollution are also controlled to an appropriate level. The USEPA guidance recommends that a "reasonable range" of control objectives be identified. Once CSO control objectives are defined, CSO control alternatives, which are made up of technologies or other control measures, can be developed to meet the CSO control objectives in a manner that targets a specific CSO or group of CSOs.

6.1.2 Alternatives Screening Protocol

Following the completion of Phase 1, Stage 1, of the BSA CSO LTCP development process, an Alternatives Screening Protocol was developed and distributed to each of the District Consultants. The protocol was intended to be used by each District Consultant during Phase 1, Stage 2 to develop a range of preliminary CSO abatement alternatives specific to their districts.

The conceptual process outlined in the Alternatives Screening Protocol consisted of the following steps:

- Step 1: Define general pollutant control objectives at the District level. This encompasses the definition of water quality goals, and development of general CSO control objectives to meet those goals.

- Step 2: Categorize individual regulators for CSO control in order to meet the CSO control objectives. The process allows for this level of control to vary by regulator, if warranted.

- Step 3: Assess available technologies to meet the desired levels of control at regulators, and select the preferred technology.

- Step 4: Combine individual regulator solutions into District-wide alternatives.

The protocol, developed through review of the USEPA guidance documentation, included the following guidance to be used specifically for the definition of pollutant control objectives:

- Are there end-of-pipe concerns?
- Are there regulatory concerns?
- Are there sensitive areas?
- Are there bacteria concerns?
- Are there metals/toxics concerns potentially due to CSOs?
- Are there DO concerns potentially due to CSOs?
- Are there aesthetic concerns?
- Are there infrastructure concerns?

A graphical representation of the conceptual process outlined in the Alternatives Screening Protocol is provided as Figure 6-1.

6.2 District-Specific Conclusions Reached During the Development of the 2004 LTCP

During the development of the 2004 LTCP, each of the District Consultants developed District-specific recommendations to abate CSOs. Using guidance from the USEPA CSO Control Policy, the Alternatives Screening Protocol, and input from the BSA, the District Consultants developed a set of control objectives and CSO priorities to meet those objectives as the first steps in drafting recommendations for each district.

6.2.1 District-Specific Control Objectives – *2004 LTCP*

The district-specific control objectives guided CSO prioritization in each district by identifying potential concerns in the receiving water bodies affected by CSO discharges. The control objectives summarized in this section are those that were defined by the District Consultants, and were used in the preparation of the overall control objectives that guided the evaluations in the development of the system-wide 2004 LTCP alternatives.

6.2.1.1 North District Control Objectives – 2004 LTCP

The North District control objectives were organized into the following categories:

- Sensitive areas;
- Bacteria concerns;
- Metals and toxics concerns;
- DO concerns;
- Aesthetic concerns;
- Infrastructure concerns; and
- Resource protection (i.e., protection is required if the CSO discharges to an area used for recreation, as defined in the North District report).

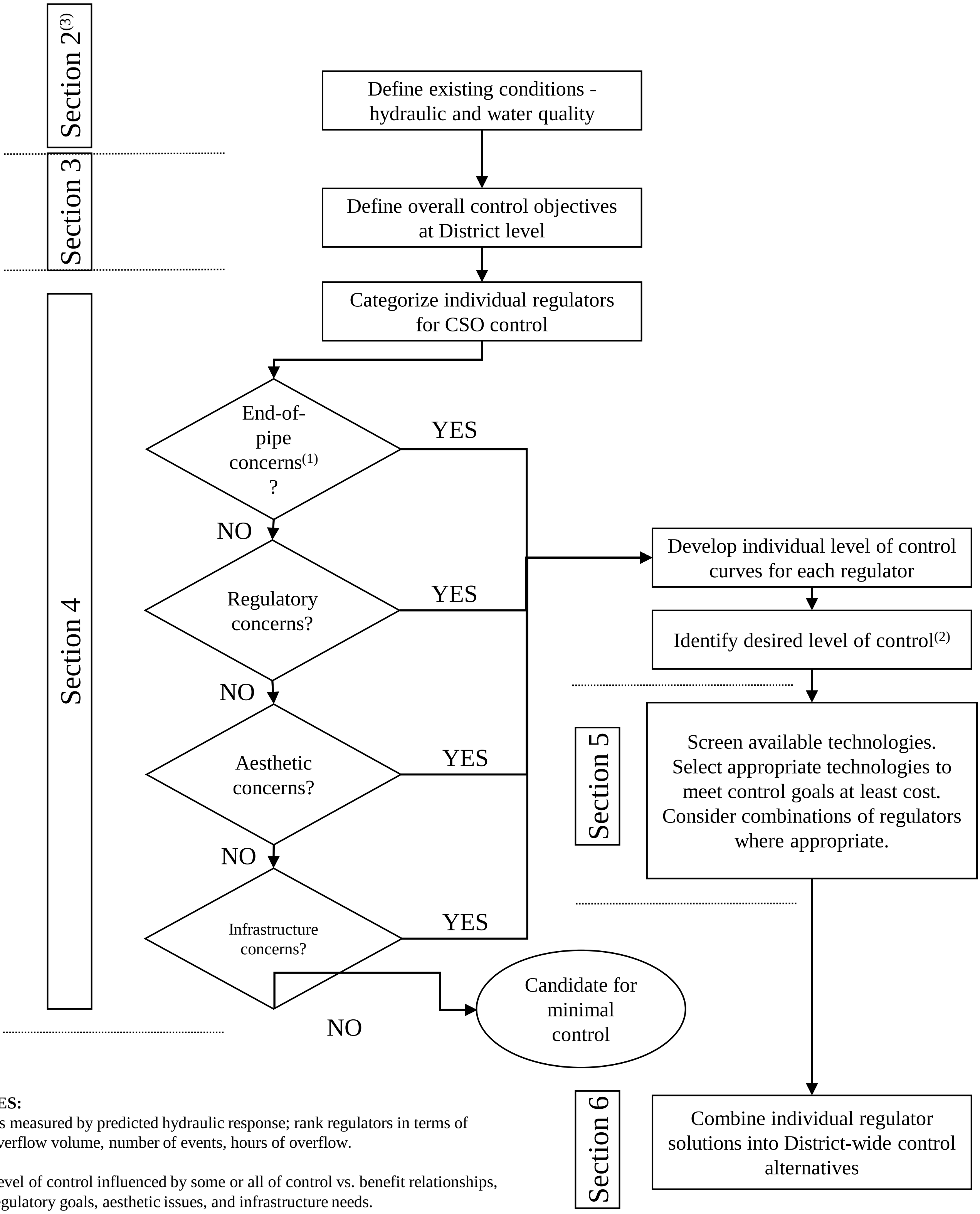
The receiving water bodies for the North District are:

- Niagara River;
- Scajaquada Creek; and
- Black Rock Canal.

No sensitive areas were identified in any of these receiving water bodies. .

Fecal coliform was identified as a bacteria concern at CSO-055 (water quality sampling location NDRBWQ1). Copper and zinc concentrations in one sample at this location were higher than receiving water standards. DO was not considered to be of significant concern at this location, due to the volume and mixing characteristics of the Niagara River.

Floatables were identified as the main aesthetic concern for the North District. CSO-055 was identified as a candidate site for floatable control technology due to high discharge volume.



NOTES:

(1) As measured by predicted hydraulic response; rank regulators in terms of overflow volume, number of events, hours of overflow.

(2) Level of control influenced by some or all of control vs. benefit relationships, regulatory goals, aesthetic issues, and infrastructure needs.

(3) Section numbers refer to sections of the *Alternatives Screening Protocol for Stage 2: District-Specific CSO Planning* (2001).

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FIGURE 6-1
Technology Screening and Alternative Selection Flow Chart

Two infrastructure projects were occurring at the same time the North District alternatives were being evaluated during the development of the 2004 LTCP: sewer separation in 1) the Ontario Basin, and 2) along Hertel Avenue. These two areas were the only infrastructure concerns identified at that time for the North District, primarily due to basement flooding.

6.2.1.2 Scajaquada District Control Objectives – 2004 LTCP

The Scajaquada District control objectives were organized into the following categories:

- End of pipe concerns;
- Discharge volume;
- Sensitive areas;
- Bacteria concentrations;
- Metals / toxics;
- DO;
- Aesthetic concerns; and
- Infrastructure concerns.

The receiving water bodies for the Scajaquada District are:

- Black Rock Canal; and
- Scajaquada Creek.

As a preliminary indicator of the impact of CSOs on water quality, the CSOs were ranked in terms of discharge volume and number of overflow events per year. CSOs 006 (West Delavan Avenue) and 053 (Scajaquada Drain) ranked 1 and 2, respectively, for both parameters. CSO-006 discharges to the Black Rock Canal and CSO-053 discharges to Scajaquada Creek. CSO-053 is unique in that it accepts the entire Scajaquada Creek flow and diverts the flow either to the downstream portion of the creek or through an overflow conduit (Delavan Drain) directly to the Black Rock Canal through CSO 006. Bacteria concerns in terms of fecal coliform were identified in both the Black Rock Canal and Scajaquada Creek. Although iron concentrations were in violation along both receiving water bodies, it was concluded that control of metals from CSO discharges would not be a priority in the Scajaquada District due to the high background concentration of iron.

DO concentrations were of concern in both receiving water bodies. For the Scajaquada Creek, DO was identified as a potential parameter of concern for LTCP development in terms of reducing CSO discharges. For the Black Rock Canal, however, it was recommended that DO be addressed as part of the post-construction compliance monitoring program. The Scajaquada District Consultant suggested that the release of more water through the locks at the downstream end of the canal would improve water circulation and DO levels. This method would require coordination with the USACE, which controls the canal lock. Discussions with the USACE confirmed that releasing more water through the locks is not feasible.

No aesthetic concerns were identified for Black Rock Canal. However, based on the results of the water quality monitoring, as well as the inclusion of the Scajaquada Creek on the NYSDEC's Priority Water Bodies list, it was recommended that control of floatables and gross solids be one of the highest water quality priorities for CSO abatement along Scajaquada Creek.

The BSA reported that no chronic flooding problems exist in the Scajaquada District, and therefore, no infrastructure concerns were identified for the district.

6.2.1.3 South Central District Control Objectives – 2004 LTCP

The South Central District control objectives were organized according to receiving water body. The receiving water bodies for the South Central District are:

- Buffalo River and Cazenovia Creek;
- Erie Basin Marina;
- Black Rock Canal; and
- Niagara River.

Impacts from CSOs on the Buffalo River and Cazenovia Creek are limited to aesthetics and fecal coliform. Therefore, the District-specific control objective for the Buffalo River and Cazenovia Creek has two components:

- Floatables reduction at major CSO discharges, with discharges ranked by annual flows or maximum capacity of the CSO discharge pipe.

- Volume reduction through the use of BMPs or retaining as much flow as possible in the system for conveyance and treatment at the WWTP.

Although DO concentrations were low in the Buffalo River, it was concluded that the hydraulics of the river, rather than CSO discharge, controlled the DO concentrations, and subsequently, CSO abatement would not improve DO conditions in the river.

For the Erie Basin Marina, control of floatables was identified as critical, and reduction of other pollutants through the implementation of BMPs to the greatest extent practical was identified as a goal for the receiving water body.

Reduction of floatables in the Black Rock Canal was identified as essential to address aesthetics of the canal. Furthermore, reduction of CSO volumes through the implementation of BMPs would be desirable to reduce the discharge of fecal coliform and to maintain water quality. In-system floatables control was recommended for this receiving water body.

Finally, it was concluded that CSO abatement in the South Central District would have negligible effect on the Niagara River water quality due to the large volume of flow through the river. Therefore, recommendation for upstream discharges was limited to floatables control and BMP implementation.

6.2.2 District-Specific CSO Prioritization – *2004 LTCP*

Based on the control objectives identified by the District Consultants and the model-predicted CSO discharge volumes generated in Phase I, Stage 1, a prioritization of CSOs was developed by each District Consultant for each District to guide in alternative development. The CSO prioritization is summarized in Table 6-1 for the North, Scajaquada, and South Central Districts, as part of the 2004 LTCP development.

The CSO prioritization, established by the District Consultants, was used in guiding the prioritization for the system-wide 2004 LTCP, as well as the development of this LTCP.

6.3 Water Quality Standards by Receiving Water Body

An integral step towards development of CSO control objectives is to compile WQS for each receiving water body and to compare measured concentrations to those WQS. The initial set of measured concentrations was obtained in 2000 during the Phase 1 water quality sampling program. This comparison was performed to determine the attainment, or non-attainment, of WQS in the receiving waters under existing conditions.

This section provides a summary of the WQS, as designated by the NYSDEC, for each of the receiving water bodies that receive CSO discharges from the BSA's CSS.

The WQS included in this evaluation are from the list of priority pollutants presented in the Water Quality Assessment Report prepared in 2000. The identified priority pollutants are as follows:

- BOD5;
- TSS;
- TKN;
- Fecal Coliform;
- Mercury;
- Lead;
- Copper; and
- Zinc.

6.3.1 Receiving Water Body Classifications

The WQS for each parameter in a given receiving water body, or portion thereof, is a function of the use classification designated by the NYSDEC. A list of the use classifications for the individual receiving water bodies in the study area is presented in Table 6-2. A description of the designated uses for each of the classifications shown in Table 6-2 is as follows:

- Class A (special) - Suitable as a source of water supply for drinking, culinary, or food processing purposes; suitable for primary and secondary recreation and fishing; suitable for fish propagation and survival; this designation can be given to international boundary waters that, if subjected to approved treatment, equal to coagulation, sedimentation, filtration, and disinfection with additional treatment, if necessary, to reduce naturally present impurities, meet or will meet NYSDOH drinking water standards and are or will be considered safe and satisfactory for drinking water purposes.

- Class A – Suitable as a source of water supply for drinking, culinary or food processing purposes; suitable for primary and secondary contact recreation and fishing; and suitable for fish, shellfish, and wildlife propagation and survival. This classification may be given to those waters that, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional

Table 6-1 CSO Prioritization by District

6-1a: North District			
Rank	CSO	Location	Receiving Water Body
1	CSO 055	Cornelius Creek	Cornelius Creek
2	CSO 056	Nottingham Terrace at Buffalo Historical Society	Scajaquada Creek
3	CSO 003	Austin Street	Black Rock Canal
4	CSO 054	Crowley Avenue and Niagara Street	Niagara River
5	CSO 057	Tonawanda Street	Scajaquada Creek
6	CSO 058	Niagara Street, Tonawanda Street, and West Avenue	Scajaquada Creek

6-1b: Scajaquada District			
Rank	CSO	Location	Receiving Water Body
1	CSO 006	West Delavan Avenue	Black Rock Canal
2	CSO 053	Scajaquada Drain outlet to Scajaquada Creek in Forest Lawn Cemetery	Scajaquada Creek
3	CSO 004	Bird Avenue	Black Rock Canal
4	CSO 061	Scajaquada Tunnel Interceptor at Lafayette Avenue	Black Rock Canal
5	CSO 059	Dewitt Street	Scajaquada Creek
6	CSO 010	Breckenridge Street	Black Rock Canal
7	CSO 060	Elmwood Avenue	Scajaquada Creek
8	CSO 008	Brace Street	Black Rock Canal
9	CSO 005	Potomac Avenue and Niagara Street	Black Rock Canal

6-1c: South Central District			
Rank	CSO	Location	Receiving Water Body
1	CSO 026	Smith Street	Buffalo River
2	CSO 017	Hamburg Canal Drain	Buffalo River
3	CSO 012	Albany Street	Black Rock Canal
4	CSO 033	Bailey Avenue	Buffalo River
5	CSO 028	Boone Street	Buffalo River
6	CSO 066	Sloan Drain at South Ogden Street	Buffalo River
7	CSO 011	Bird Island West Wall at Foot of Albany Street	Niagara River
8	CSO 027	Babcock Street	Buffalo River
9	CSO 037	Salem Street	Cazenovia Creek
10	CSO 013	Virginia Street	Buffalo Harbor
11	CSO 014	Wilkeson Street	Erie Basin Slip #3
12	CSO 015	Genesee Street	Erie Basin Slip #2
13	CSO 064	Ohio Drain on Ohio Street	Buffalo River
14	CSO 022	Clark Skinner Drain at Baltimore Street	Buffalo River
15	CSO 052	South Ogden Street	Buffalo River
16	CSO 035	North Bank Cazenovia Creek	Cazenovia Creek
17	CSO 044	Munford Avenue	Cazenovia Creek
18	CSO 047	Southside Parkway	Cazenovia Creek
19	CSO 051	Pawnee Street and Pennsylvania Railroad	Buffalo River
20	CSO 050	Seneca Street	Buffalo River
21	CSO 025	Hamburg Street	Buffalo River
22	CSO 046	Unger Avenue	Cazenovia Creek
23	CSO 016	Mechanic Street	Erie Basin Slip #1
24	CSO 048	Bailey Avenue	Cazenovia Creek
25	CSO 063	Front Park	Black Rock Canal
26	CSO 029	East Outlet at Boone Street	Buffalo River
27	CSO 034	Barnard Street	Buffalo River
28	CSO 043	Hammerschmidt Street	Cazenovia Creek
29	CSO 044	Munford Avenue	Cazenovia Creek
30	CSO 045	Riverview Drive	Cazenovia Creek

Table 6-2 Receiving Water Body Use Classifications

Receiving Water Body	Receiving Water Body Description	NYSDEC Classification
Lake Erie including Erie Basin Marina	Waters southerly of line from Buffalo Harbor Light #6 to south end of Bird Island Pier; easterly of line from south end of Bird Island Pier to north end of north breakwater; easterly of north breakwater; easterly of line from south end or north breakwater to north end of old or middle breakwater and northerly end of line from north end of old or middle breakwater to south pier light at US Coast Guard Station.	C
Lake Erie or Outer Harbor	Waters easterly of old or middle breakwater and south breakwater between line from northern end of old or middle breakwater to south pier light at US Coast Guard station and line represented by extension of Tifft Street to south end of south breakwater.	B
Niagara River (American side)	Waters from international boundary to the American shore above line due west from south end of Bird Island Pier.	A (special)
Buffalo River	Downstream of confluence with Cayuga Creek to the mouth.	C
Cazenovia Creek	Reach 1 - From the Cazenovia Street Bridge upstream to the junction of the East and West Branches of Cazenovia Creek.	B
Cazenovia Creek	Reach 2 - From the Cazenovia Street Bridge downstream to the confluence with Buffalo River.	C
Scajaquada Creek	Reach 1 - From the crossing on Main Street in the City of Buffalo upstream to “tributary 4”, which is in line with continuation of Frederick Drive, Town of Cheektowaga (underground portion).	C
Scajaquada Creek	Reach 2 - From the crossing on Main Street in the City of Buffalo downstream to mouth of Scajaquada Creek at the Niagara River.	A [1]
Black Rock Canal	Waters east of Squaw Island and Bird Island Pier between canal locks and a line from the south end of Bird Island Pier to Buffalo Harbor Light #6.	C

Source: Water Quality Regulations, Surface Water and Groundwater Classifications and Standards, New York State Codes, Rules, and Regulations, Title 6, Chapter X, Part 837, NYSDEC.
Note: 1.Listed as Class B in 2004 LTCP, the current Part 837 as of Aug 2011 indicates an upgraded class of A for this segment of Scajaquada Creek.

treatment if necessary to reduce naturally present impurities, meet or will meet NYSDOH drinking water standards and are or will be considered safe and satisfactory for drinking water purposes.

- Class B - Primary and secondary contact recreation and fishing; suitable for fish propagation and survival.

- Class C - Fishing; suitable for fish propagation and survival; suitable for primary and secondary contact and recreation; other factors may limit the use for these purposes.

A graphical representation of the information shown in Table 6-2 is provided on Figure 6-2.

6.3.2 Receiving Water Body Water Quality Standards

Table 6-3 presents a summary of the WQS for each priority pollutant for each receiving water body listed in Table 6-2. As noted in Table 6-3, TSS and TKN WQS are only provided qualitatively by the NYSDEC (*i.e.*, not based on a given quantifiable standard).

Based on correspondence with the NYSDEC during Phase 1, the fecal coliform WQS in the 2004 LTCP did not apply to receiving waters possessing a “Class C” designation unless a use for the given Class C receiving water body was specified as requiring disinfection. Therefore, Phase 1 evaluations for Class C receiving water bodies were based on this designation. Correspondence from the NYSDEC after submittal of the 2004 LTCP (July 16, 2007, see Appendix 6-1) stated that whether bacteria standards should apply for Class C receiving streams would be determined after development of a water quality model. Subsequent to that, through a January 17, 2008 filing (effective February 16, 2008), the Part 703 rule was modified to require, that for a Class C water body the monthly geometric mean, from a minimum of five examinations, shall not exceed 200 counts per 100 mL. The updated fecal coliform WQS for Class C receiving water bodies was subsequently used for the Phase 2 and 3 evaluations, including this LTCP effort.

6.3.3 Comparison of Water Quality Standards and Measured Concentrations – *2004 LTCP*

This section compares the WQS (as they were in 2004) with measured concentrations from the 2000 Water Quality Monitoring Program, conducted for the 2004 LTCP. As part of this LTCP, additional water quality sampling was performed in support of additional receiving water quality modeling that was requested by the NYSDEC and the USEPA following the submission of the 2004 LTCP document. The Phase 2 water quality sampling effort was presented in detail in Section 4 of this report.

Also, as noted in Section 6.3.2, although the fecal coliform WQS for Class C water bodies was modified by the NYSDEC, after the submission of the 2004 report, the discussions presented in the following subsections are based on the WQS in place during the 2004 LTCP effort.

6.3.3.1 Dry Weather/Baseline Condition Comparison – 2004 LTCP

The goal of this section is to compare the WQS for each water body as presented in Table 6-3 to concentrations measured in samples taken from receiving water sampling locations during dry weather sampling events. The samples were collected in the two dry weather sampling events conducted during the 2000 Water Quality Monitoring Program and represent background water quality conditions without the occurrence of CSO discharge. The dry weather portion of the Water Quality Monitoring Program included sampling at 13 discrete locations. Continuous monitoring was also conducted using Hydrolab monitors at eleven receiving water body locations to supplement the discrete sampling component. The first dry weather sampling event was conducted on May 4, 2000, while the second event was conducted on September 7, 2000.

The comparison of WQS and measured concentrations was conducted for each of the priority pollutants. This comparison was not performed for TSS and TKN because of the lack of a quantifiable WQS for these parameters. This comparison also was not performed for fecal coliform bacteria in Class C receiving water bodies in the BSA study area because they did not have designated primary contact uses requiring disinfection. Additionally, while the fecal coliform WQSs are defined on a 30-day or monthly geomean basis, for the purposes of discussion in this section, the individual sample results were compared to the geomean standards. The results of the data comparison are presented graphically on Figures 6-3 through 6-8 to show the compliance status for each sampling location for each individual priority pollutant. Each location was determined to either be within compliance with WQS for both dry weather sampling events, exceeding WQS during one of the two dry weather events, or exceeding WQS during both dry weather sampling events.

A summary of the baseline compliance status observed during this comparison is provided in Table 6-4.

As shown in Table 6-4, exceedances were observed for DO, fecal coliform bacteria, and dissolved phase zinc. Background fecal coliform bacteria counts were observed to exceed WQS at various receiving water body sampling locations included in the monitoring program. However, as previously noted, the exceedances at sampling locations in Class C receiving water bodies were not applicable for the 2004 LTCP. Only the bacteria exceedance at site SJDRBWQ02, which is located in a Class B receiving water body, was determined to be applicable. DO concentration exceedances were also observed at various Hydrolab locations. Exceedance of the zinc WQS was observed for receiving water body sampling location SJDRBWQ02 for one of the dry weather sampling events.

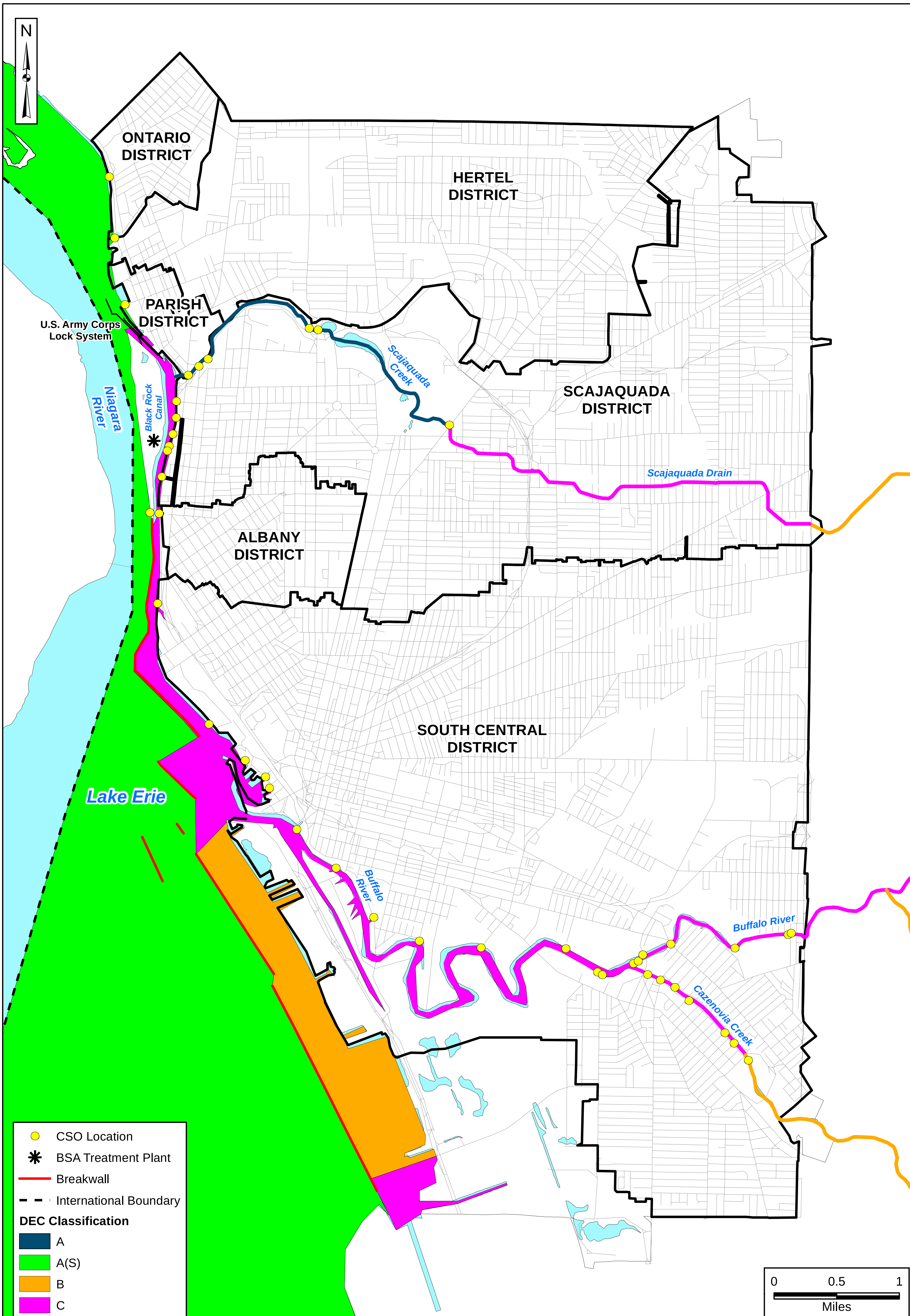

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FIGURE 6-2

NYSDEC WATER QUALITY CLASSIFICATIONS

Table 6-3 Water Quality Standards for Priority Pollutants by Receiving Water Body

Receiving Water Body	Class	Dissolved Oxygen [mg/L]	TSS [mg/L]	TKN [mg/L]	Fecal Coliform [#/100 mL]	Mercury [ug/L]	Lead [ug/L]	Copper [ug/L]	Zinc [ug/L]
Lake Erie including Erie Basin Marina	C	4.0 [1]	(a)	(b)	200 [(c),2]	0.0026 [3]	5.62 [4]	12.23 [4]	112.66 [4]
Lake Erie or Outer Harbor	B	4.0 [1]	(a)	(b)	200 [2]	0.0026 [3]	5.62 [4]	12.23 [4]	112.66 [4]
Niagara River (American side)	A (S)	6.0 [1]	(a)	(b)	200 [5]	0.0026 [3]	5.62 [4]	12.23 [4]	112.66 [4]
Buffalo River	C	4.0 [1]	(a)	(b)	200 [(c),2]	0.0026 [3]	5.62 [4]	12.23 [4]	112.66 [4]
Cazenovia Creek Reach 1	B	4.0 [1]	(a)	(b)	200 [2]	0.0026 [3]	5.62 [4]	12.23 [4]	112.66 [4]
Cazenovia Creek Reach 2	C	4.0 [1]	(a)	(b)	200 [(c),2]	0.0026 [3]	5.62 [4]	12.23 [4]	112.66 [4]
Scajaquada Creek Reach 1	C	4.0 [1]	(a)	(b)	200 [(c),2]	0.0026 [3]	5.62 [4]	12.23 [4]	112.66 [4]
Scajaquada Creek Reach 2	A	4.0 [1]	(a)	(b)	200 [2]	0.0026 [3]	5.62 [4]	12.23 [4]	112.66 [4]
Black Rock Canal	C	4.0 [1]	(a)	(b)	200 [(c),2]	0.0026 [3]	5.62 [4]	12.23 [4]	112.66 [4]

Source: *Water Quality Regulations, Surface Water and Groundwater Classifications and Standards*, New York State Codes, Rules, and Regulations, Title 6, Chapter X, Parts 700-706, NYSDEC.

Notes:
(a) – WQS written as "None from sewage, industrial wastes, or other wastes that will cause deposition or impair the waters for their best uses."
(b) – WQS written as "None in amounts that will results in growths of algae, weeds, and slimes that will impair the waters for their best uses."
(c) – Based on correspondence with the NYSDEC, the fecal coliform water quality standard in the 2004 LTCP did not apply to receiving waters possessing a "Class C" designation unless a use for the given Class C receiving water body is specified requiring disinfection. The yellow highlighted cells indicate that no fecal coliform WQS was in place for the 2004 LTCP evaluations for these receiving water bodies. However, the Part 703 rule was modified through a January 17, 2008 filing, effective February 16, 2008, indicating that for Class C, the monthly geometric mean, from a minimum of five examinations, shall not exceed 200#/100 mL. This updated rule was used for the Phase 2 and 3 evaluations of the 2011 LTCP Update.

[1]No one-time value below the standard provided.
[2]The monthly geometric mean, from a minimum of five examinations, shall not exceed 200.
[3]For wildlife
[4]Dissolved phase; WQS calculated using exponential formula presented in source document using a hardness of 114 mg/L.
[5]The geometric mean, of not less than five samples, taken over a 30-day period.

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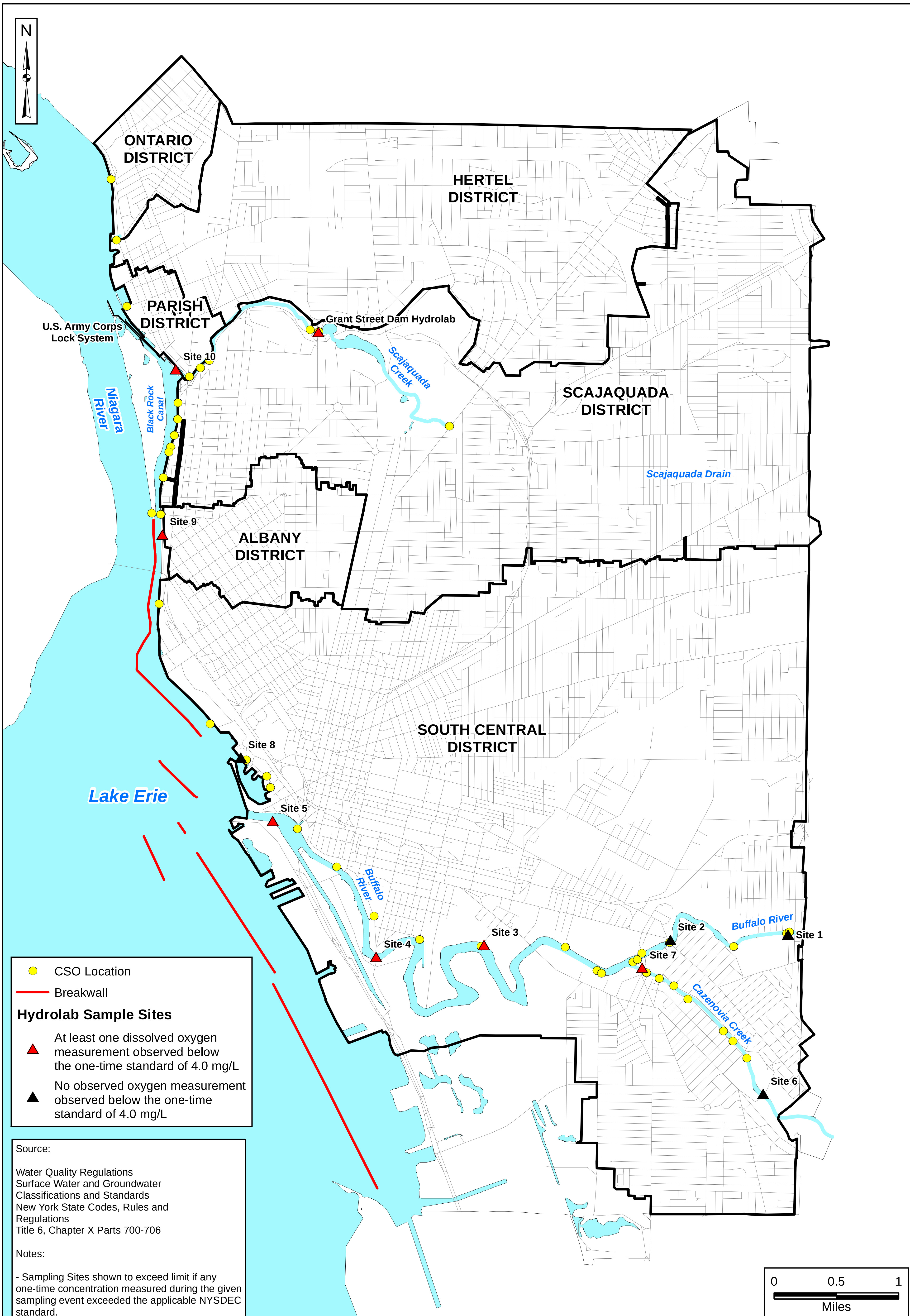
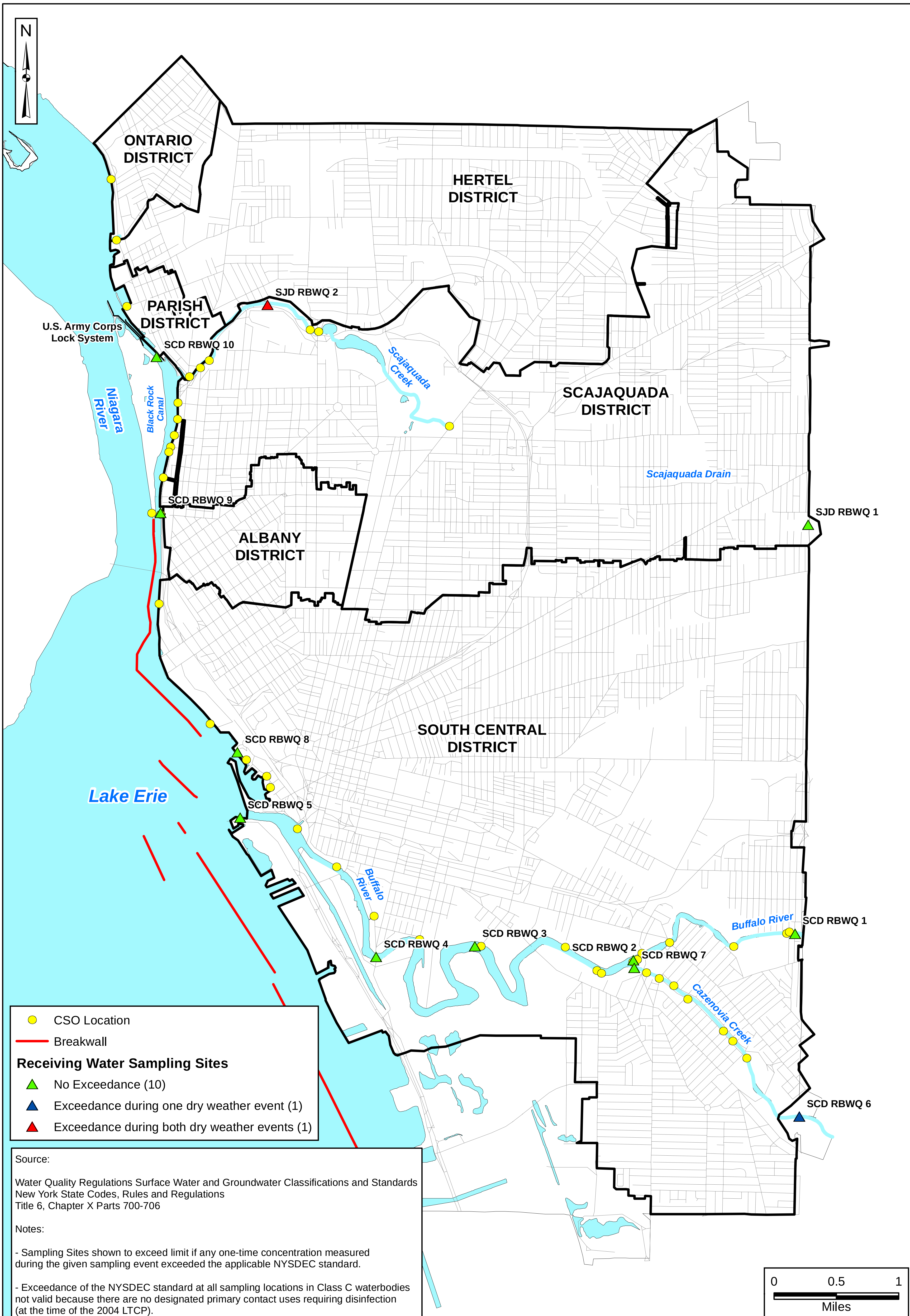


MALCOLM PIRNIE / ARCADIS — The Water Division of ARCADIS 2012 1777-122	**BUFFALO SEWER AUTHORITY** **Long Term Control Plan Update**	**FIGURE 6-3** **NYS WQ STANDARD COMPLIANCE - DISSOLVED OXYGEN** **DRY WEATHER CONDITIONS - MARCH - NOVEMBER 2000 MONITORING PERIOD**



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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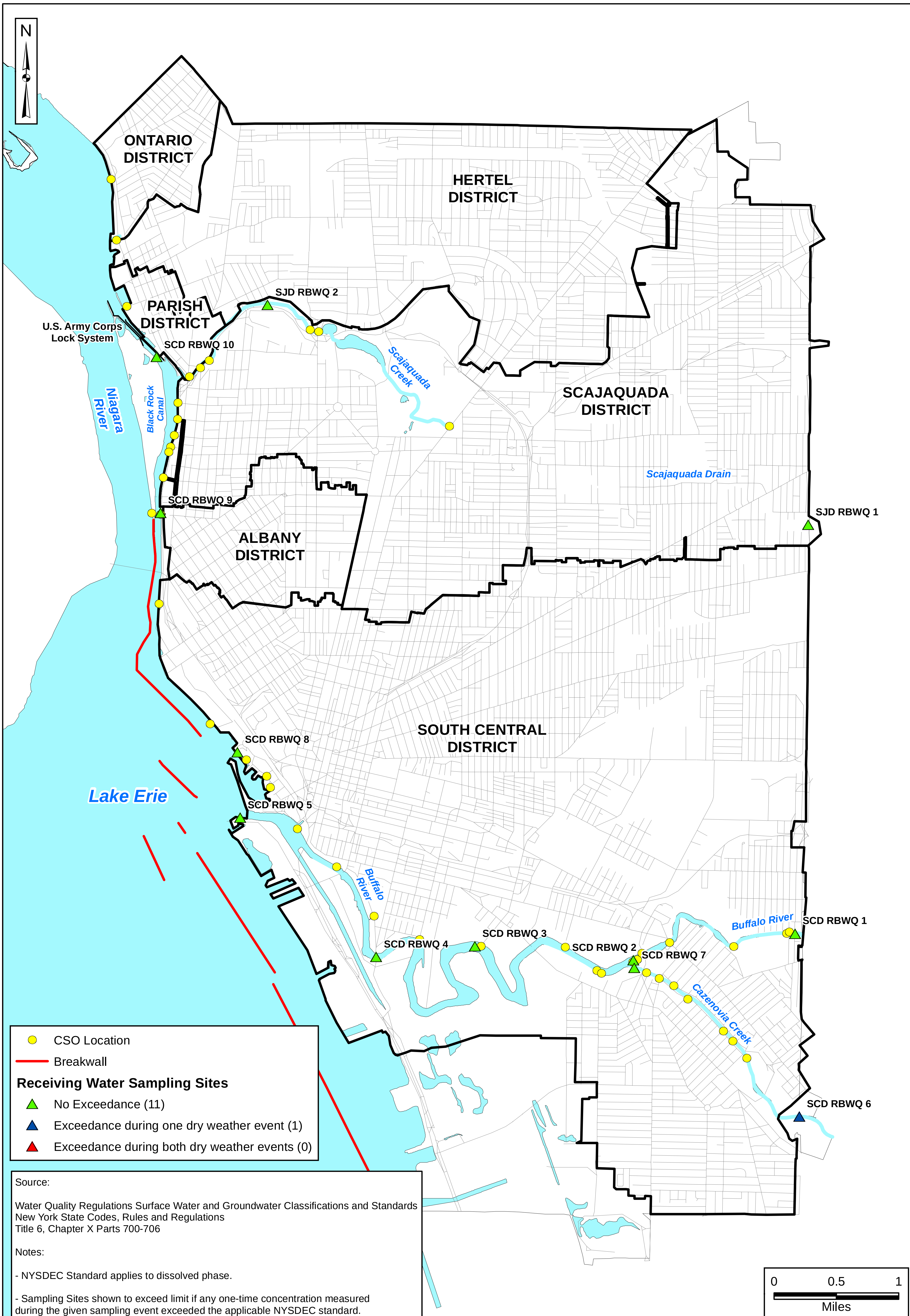
FIGURE 6-4

NYS WQ STANDARD COMPLIANCE - FECAL COLIFORM

DRY WEATHER SAMPLING EVENTS



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- NYSDEC Standard applies to dissolved phase.

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

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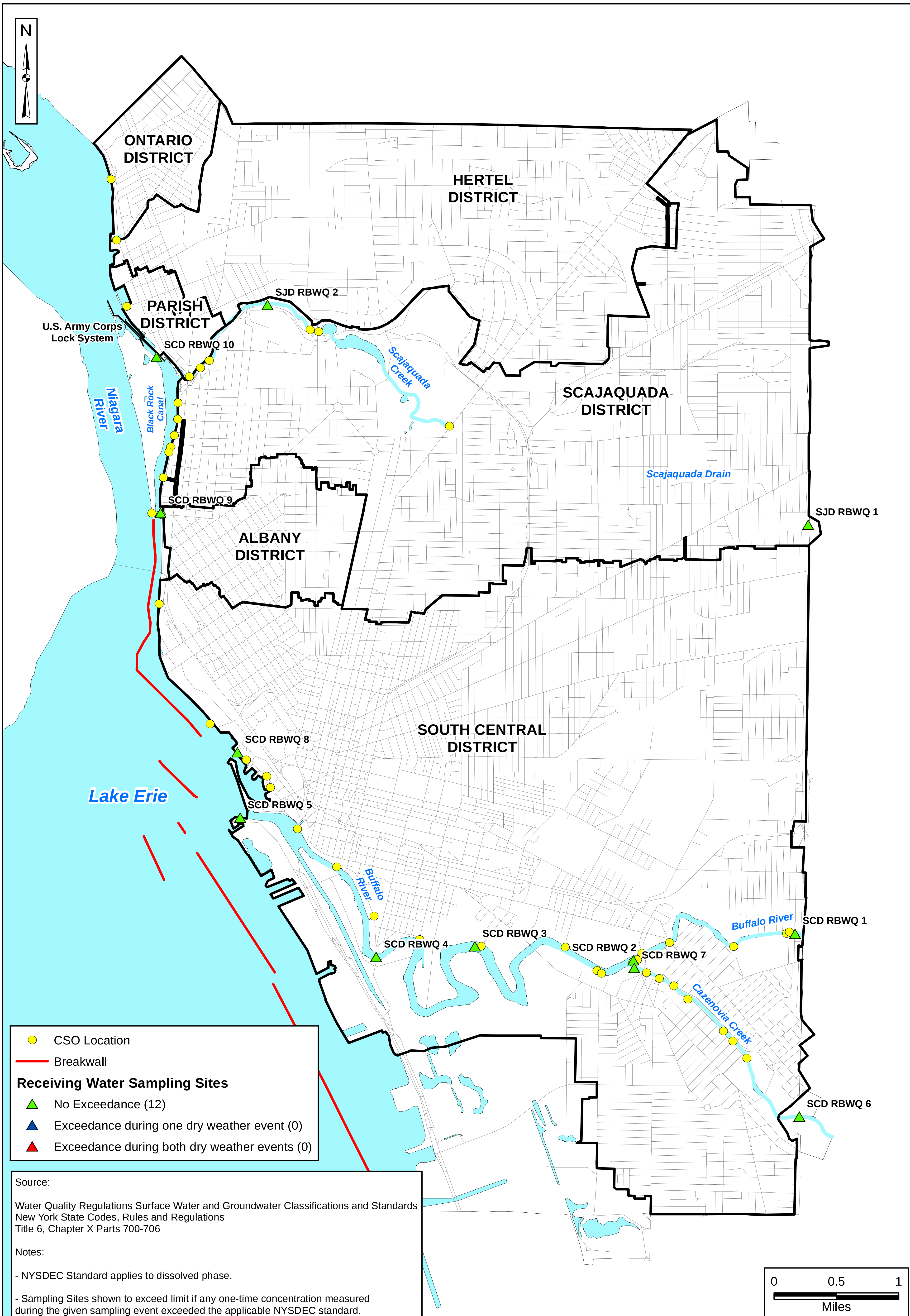
FIGURE 6-5

NYS WQ STANDARD COMPLIANCE - COPPER

DRY WEATHER SAMPLING EVENTS



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- NYSDEC Standard applies to dissolved phase.

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

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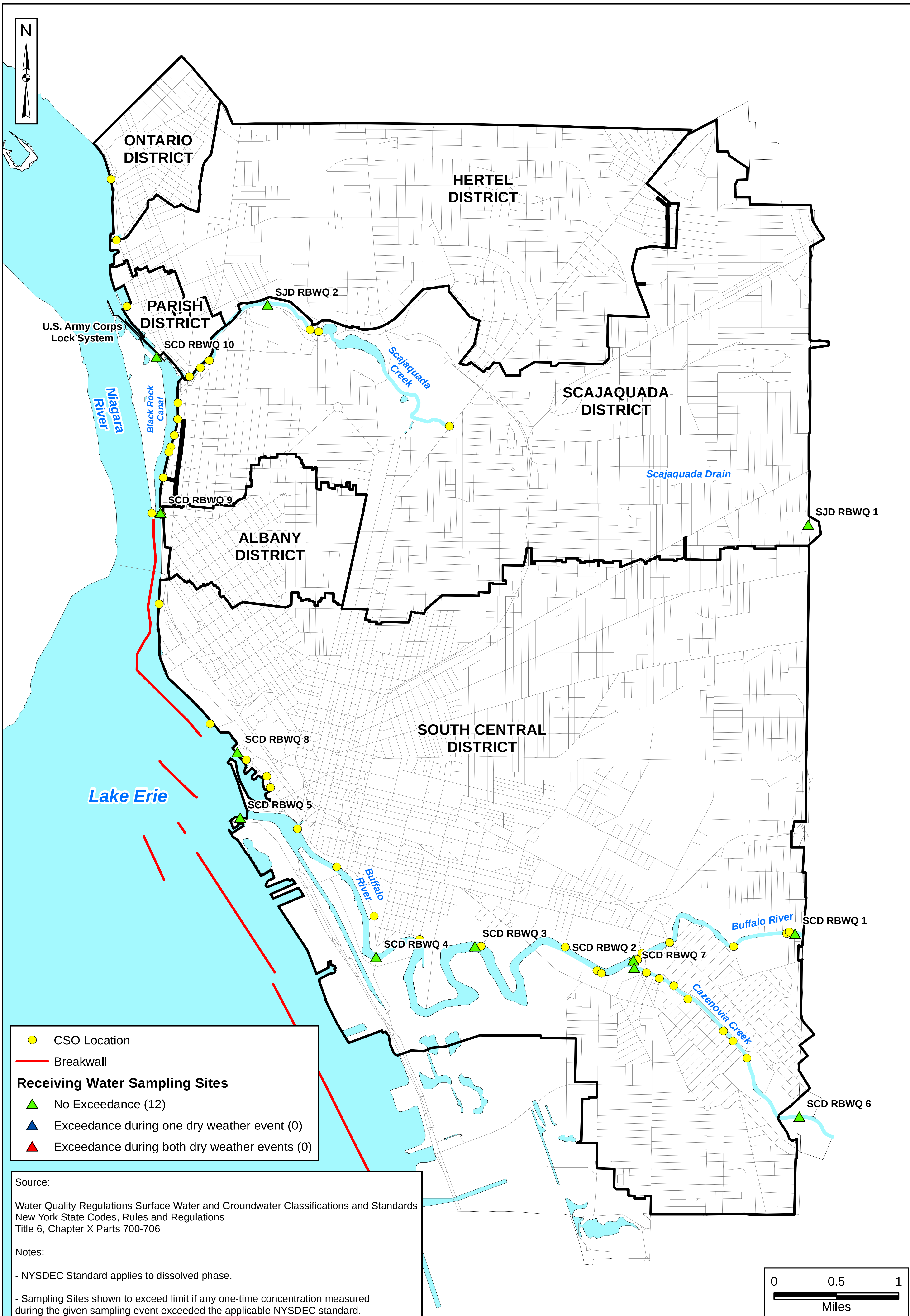
FIGURE 6-6

NYS WQ STANDARD COMPLIANCE - MERCURY

DRY WEATHER SAMPLING EVENTS



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- NYSDEC Standard applies to dissolved phase.

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

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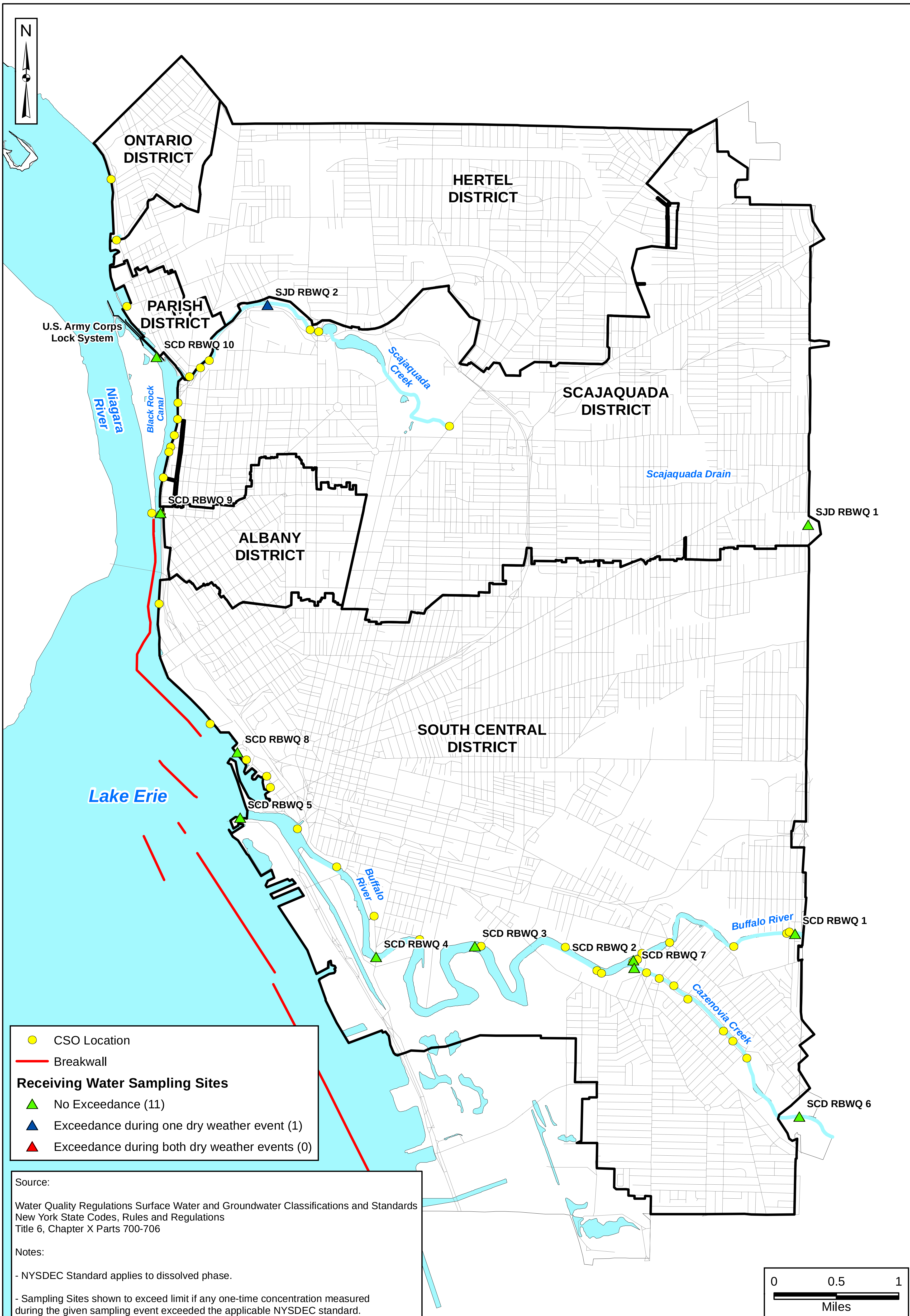
FIGURE 6-7

NYS WQ STANDARD COMPLIANCE - LEAD

DRY WEATHER SAMPLING EVENTS



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- NYSDEC Standard applies to dissolved phase.

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

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FIGURE 6-8

NYS WQ STANDARD COMPLIANCE - ZINC

DRY WEATHER SAMPLING EVENTS

Table 6-4 Water Quality Standard Exceedance Summary
During Year 2000 Dry Weather (Baseline) Water Quality Sampling Events

Parameter	Exceedance During One Dry Weather Event	Exceedance During Two Dry Weather Events
*TKN**	--	--
TSS*	--	--
Dissolved Oxygen	Hydrolab Sites 3, 4, 5, 7, 9, 10, and Grant Street Dam**	
Fecal Coliform***	--	SJDRBWQ02
Copper	None	None
Mercury	None	None
Lead	None	None
Zinc	SJDRBWQ02	None

Notes:
* Comparison not performed due to lack of quantifiable standard.
** At least one dissolved oxygen measurement observed below the WQS for the continuous monitoring period.
*** Sampling locations in receiving water bodies possessing a Class C designation excluded.

6.3.3.2 Wet Weather Condition Comparison – 2004 LTCP

The goal of this section is to compare the WQS for each water body as presented in Table 6-3, to concentrations measured in samples taken from receiving water sampling locations collected in the two wet weather sampling events conducted during the 2000 Water Quality Monitoring Program. The wet weather portion of the Water Quality Monitoring Program included sampling at 13 discrete locations. Continuous monitoring was also conducted using Hydrolab monitors at eleven receiving water body locations to supplement the discrete sampling component. The first wet weather sampling event was conducted from June 9 through June 11, 2000, while the second event was conducted between August 23 and August 25, 2000.

The comparison of WQS and measured concentrations was conducted for each of the priority pollutants. To conduct the comparison, measured concentrations from receiving water body sampling locations from the Year 2000 Water Quality Monitoring Program were plotted against the applicable WQS for each priority pollutant. Similar to the dry weather water quality data, this comparison was not performed for TSS or TKN for all of the sampling locations or for fecal coliform for sampling locations in Class C receiving water bodies. The results of the data comparison are presented graphically on Figures 6-9 through 6-20 to show the compliance status for each sampling location for each individual priority pollutant.

A summary of the observed WQS exceedances is provided in Table 6-5.

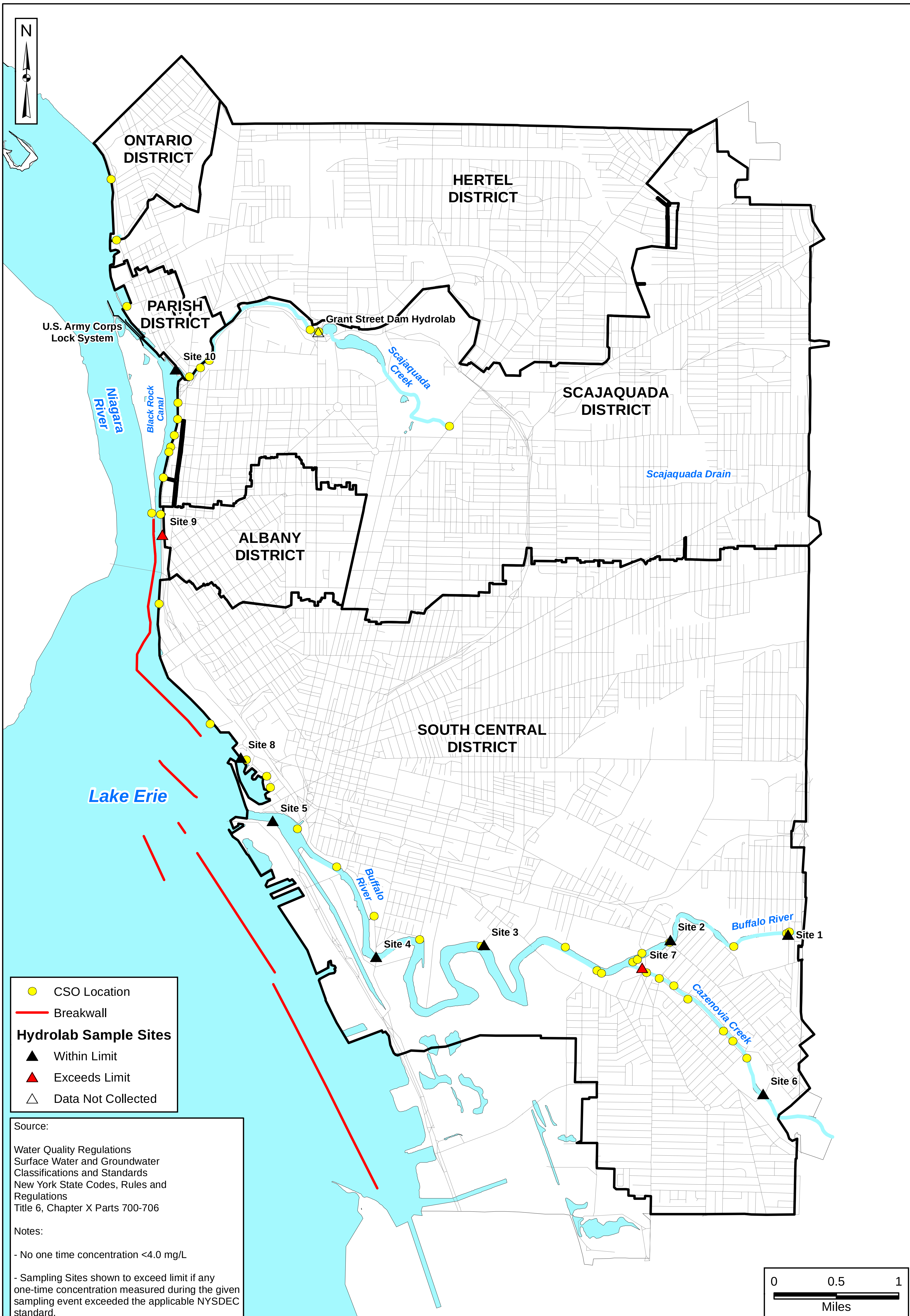
Table 6-5 Water Quality Standard Exceedance Summary
During Year 2000 Wet Weather Water Quality Sampling Events

Parameter	Wet Weather Event #1	Wet Weather Event #2
*TKN**	--	--
TSS *	--	--
Dissolved Oxygen**	Hydrolab Sites 7 and 9	Hydrolab Sites 3, 4, 5, 7, and Grant Street Dam
Fecal Coliform ***	SJDRBWQ02	SJDRBWQ02
Copper	None	None
Mercury	None	None
Lead	None	None
Zinc	None	SCDRBWQ03, SCDRBWQ05

Notes:
* Comparison not performed due to lack of quantifiable standard.
** At least one dissolved oxygen measurement observed below the WQS for the continuous monitoring period.
*** Sampling locations in receiving water bodies possessing a Class C designation excluded.

As shown in Table 6-5, exceedances were observed for DO, fecal coliform bacteria, and dissolved phase zinc. Fecal coliform bacteria counts were observed to exceed WQS for both wet weather sampling events at each of the receiving water body sampling locations included in the monitoring program. However, as previously noted, the exceedances at sampling locations in Class C receiving water bodies were not applicable at that time. Only the exceedance at site SJDRBWQ02, which is located in a Class B receiving water body, was applicable. DO concentration exceedances were also observed at various Hydrolab locations. The dissolved zinc WQS was exceeded at receiving water body sampling locations SCDRBWQ03 and SCDRBWQ05 during the August 23-25, 2000 sampling event.

Of the six locations at which DO WQS exceedances were observed during wet weather conditions, all six locations were elevated compared to WQS on at least one occasion during dry weather/baseline conditions.



Source:

Water Quality Regulations
Surface Water and Groundwater
Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- No one time concentration <4.0 mg/L

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

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FIGURE 6-9

NYS WQ STANDARD COMPLIANCE - DISSOLVED OXYGEN

WQ EVENT #1:
6/9/00 - 6/11/00

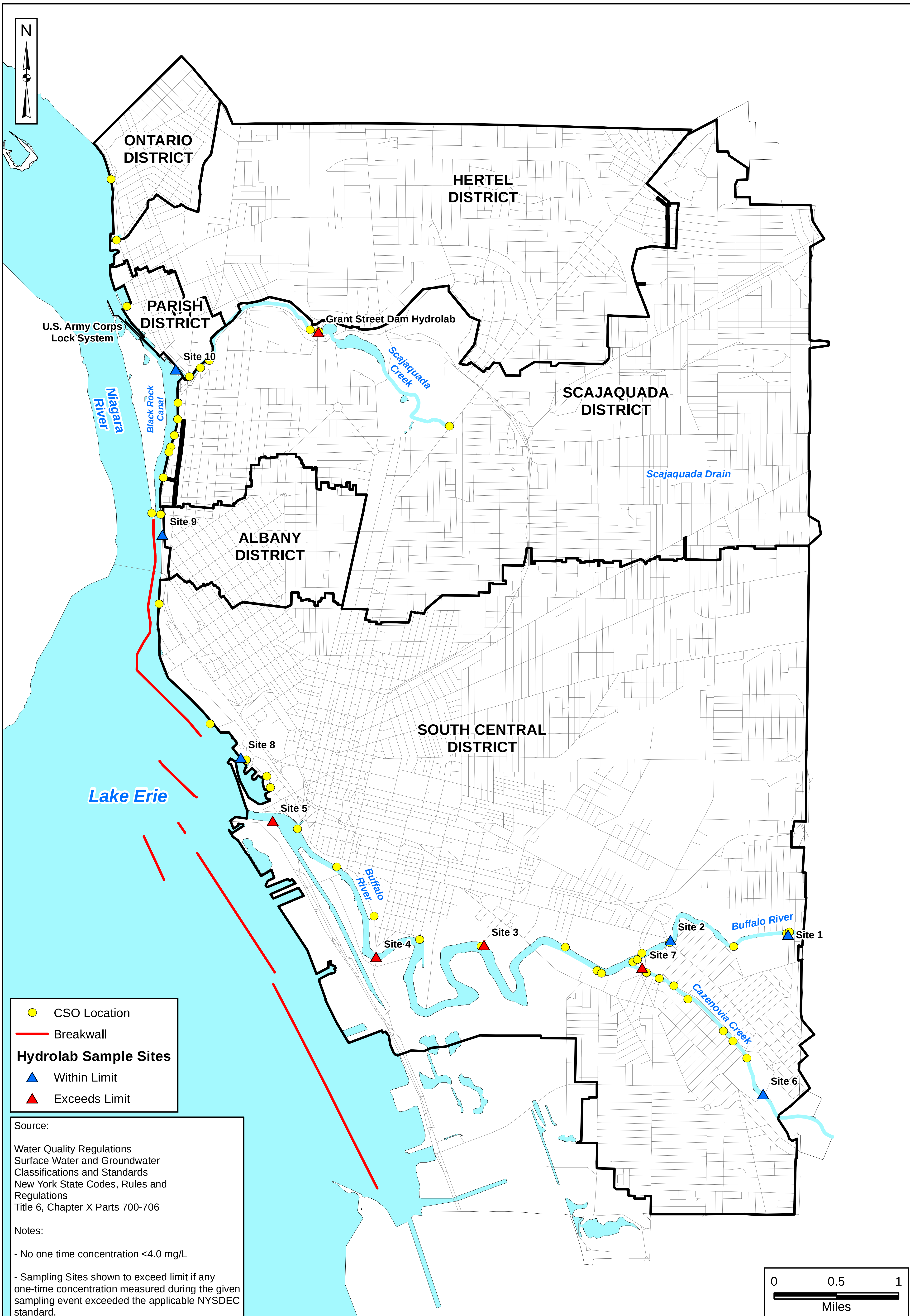

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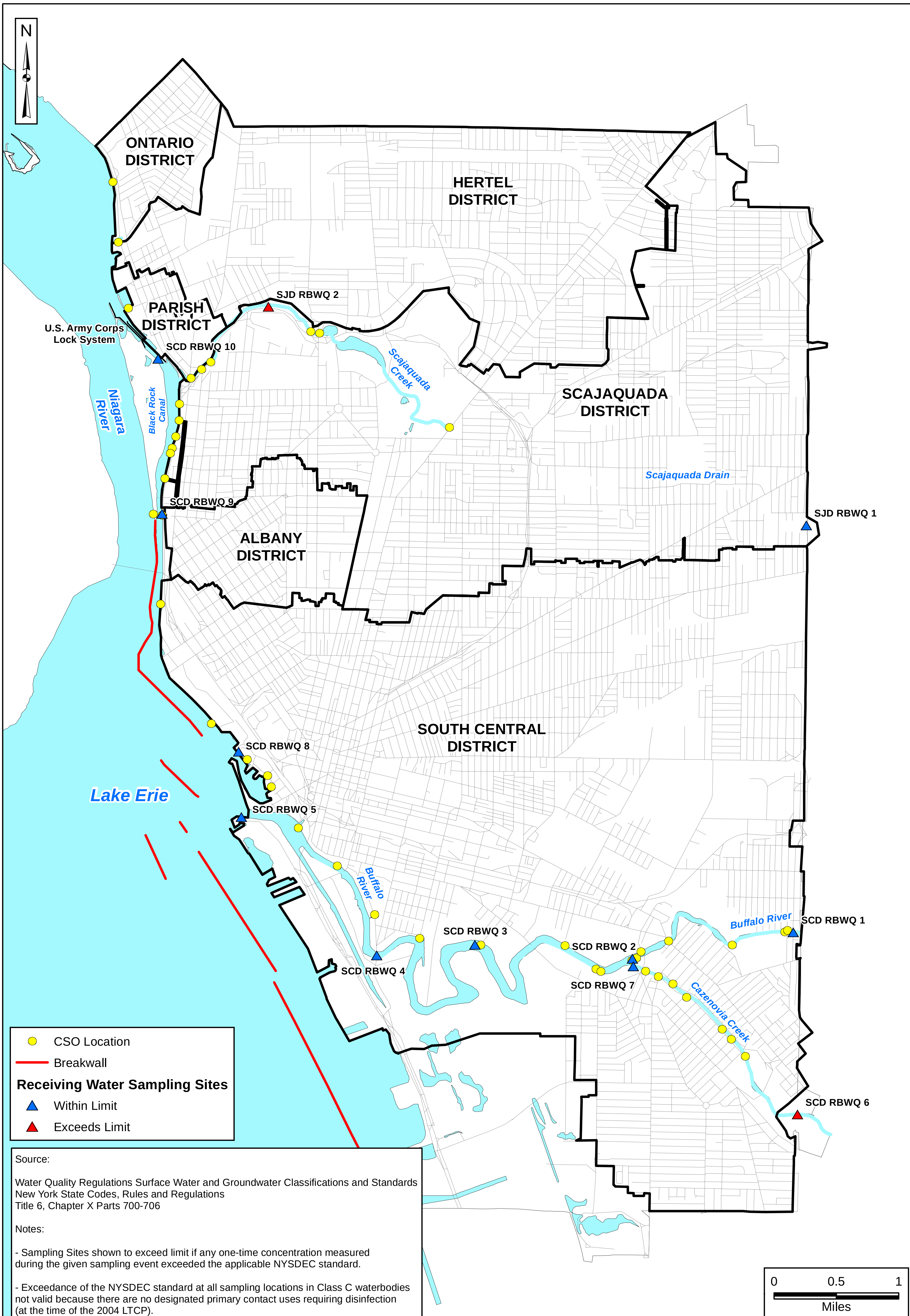
FIGURE 6-10

NYS WQ STANDARD COMPLIANCE - DISSOLVED OXYGEN

WQ EVENT #2:
8/23/00 - 8/25/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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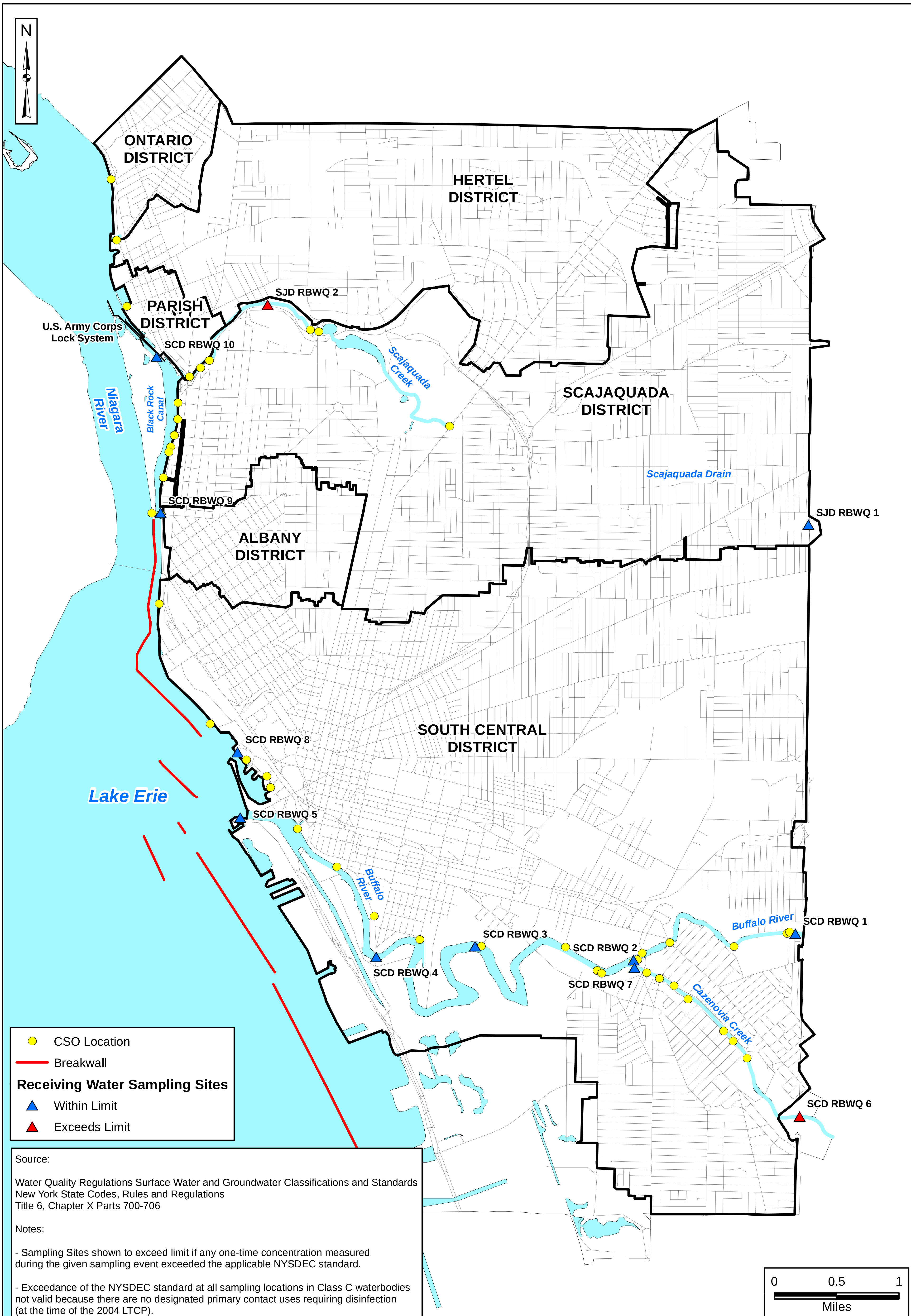
FIGURE 6-11

NYS WQ STANDARD COMPLIANCE - FECAL COLIFORM

WQ EVENT 1: 6/8/00 - 6/11/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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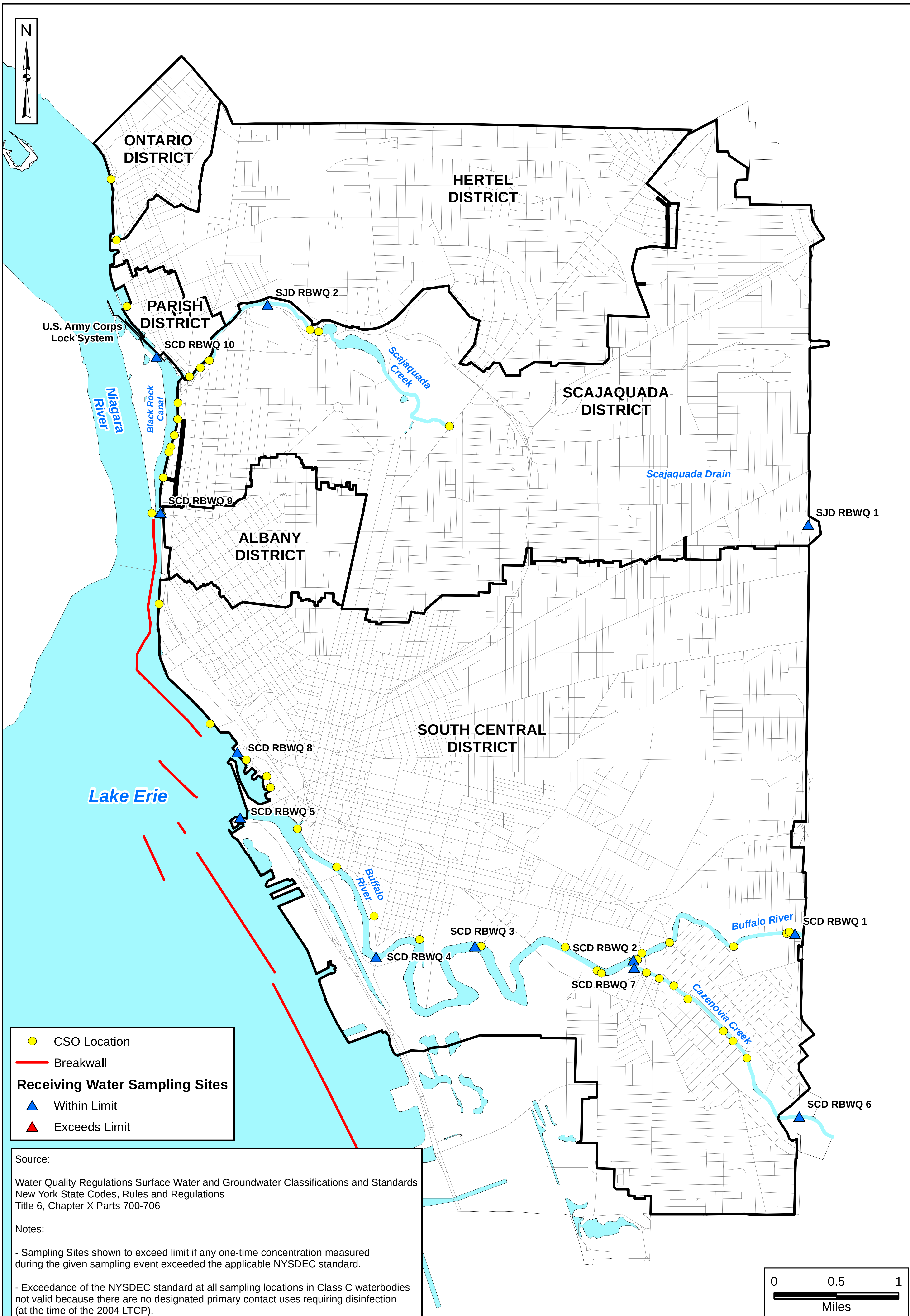
FIGURE 6-12

NYS WQ STANDARD COMPLIANCE - FECAL COLIFORM

WQ EVENT 2: 8/23/00 - 8/25/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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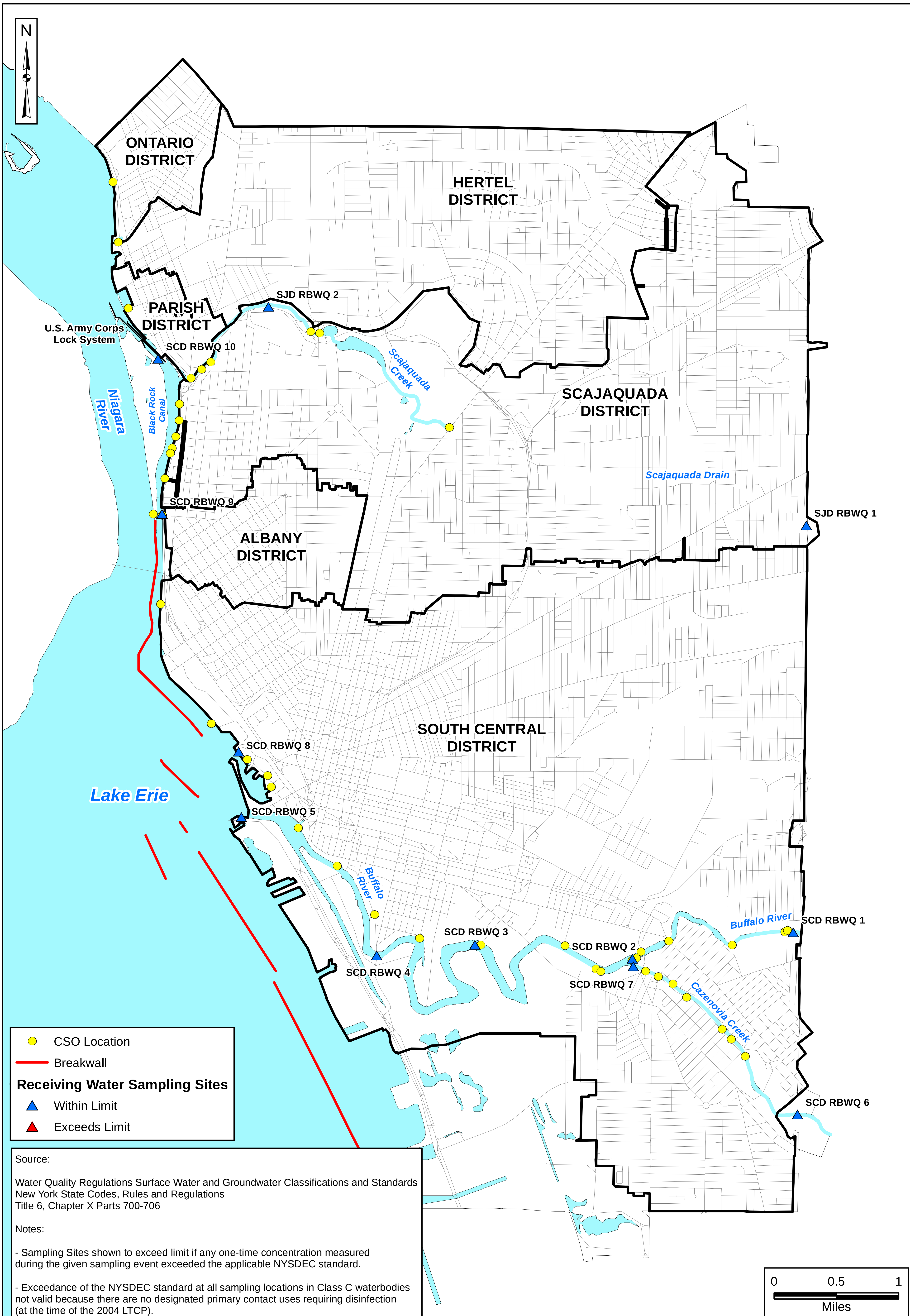
FIGURE 6-13

NYS WQ STANDARD COMPLIANCE - COPPER

WQ EVENT 1: 6/9/00 - 6/11/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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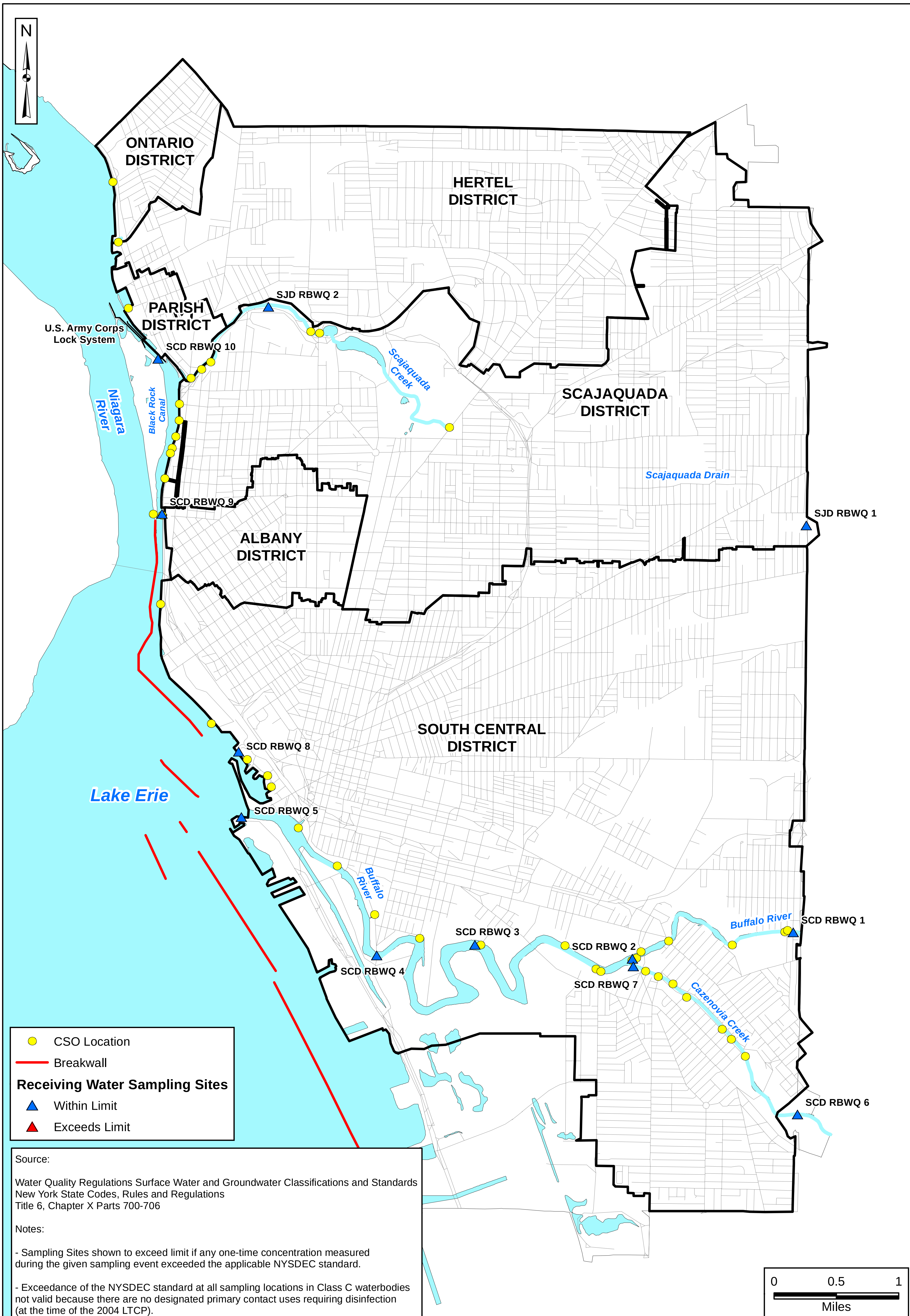
FIGURE 6-14

NYS WQ STANDARD COMPLIANCE - COPPER

WQ EVENT 2: 8/23/00 - 8/25/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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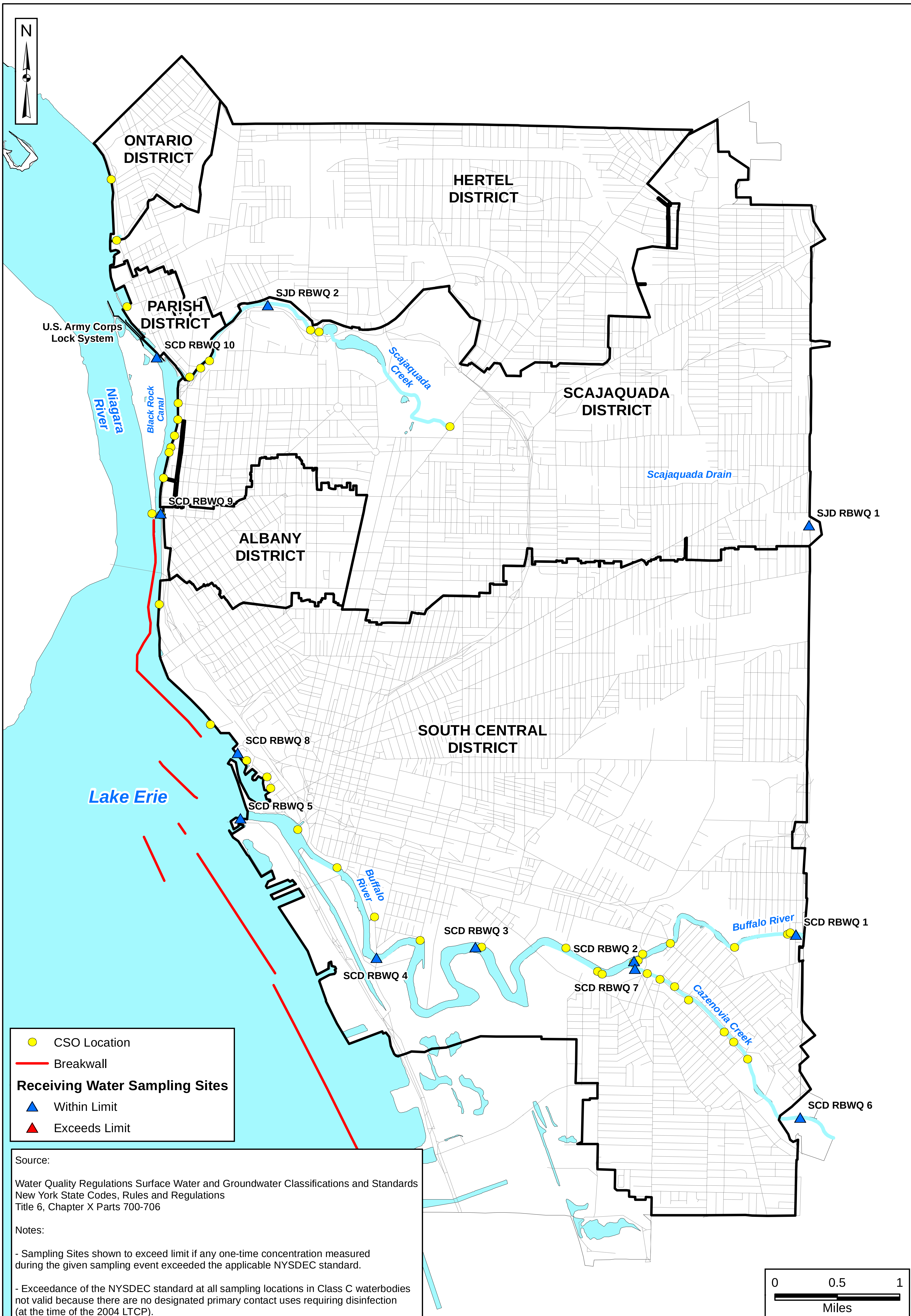
FIGURE 6-15

NYS WQ STANDARD COMPLIANCE - MERCURY

WQ EVENT 1: 6/9/00 - 6/11/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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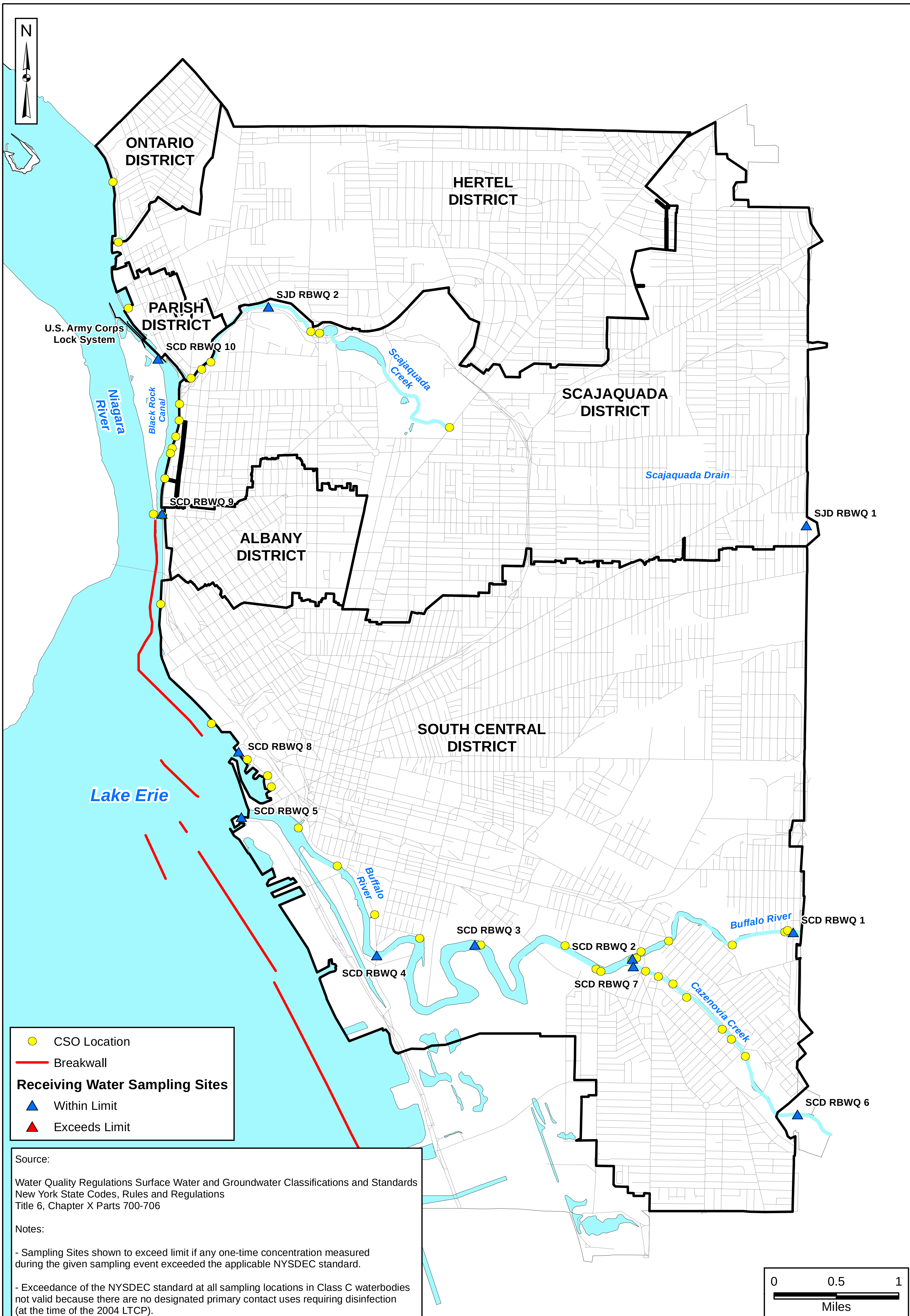
FIGURE 6-16

NYS WQ STANDARD COMPLIANCE - MERCURY

WQ EVENT 2: 8/23/00 - 8/25/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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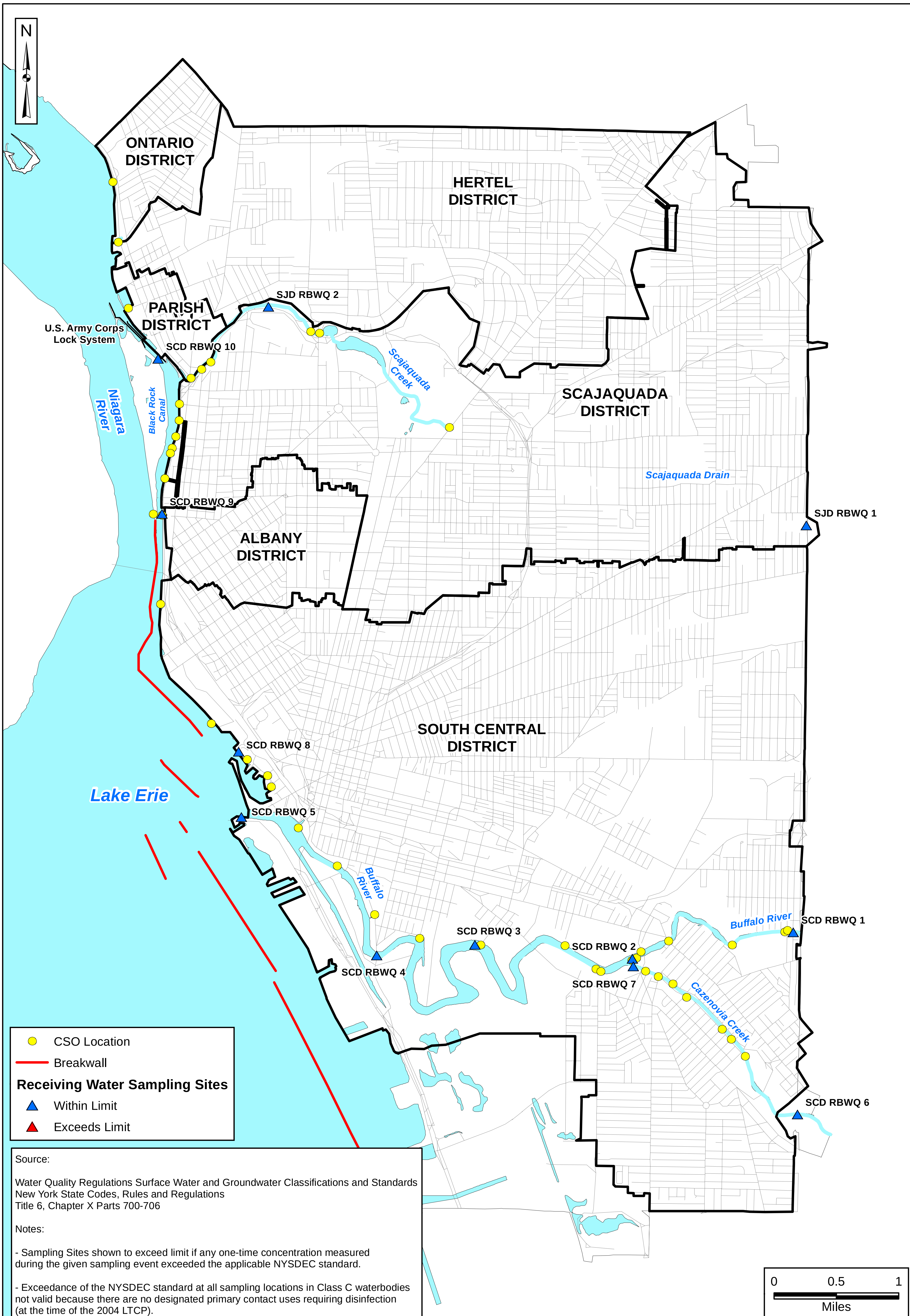
FIGURE 6-17

NYS WQ STANDARD COMPLIANCE - LEAD

WQ EVENT 1: 6/9/00 - 6/11/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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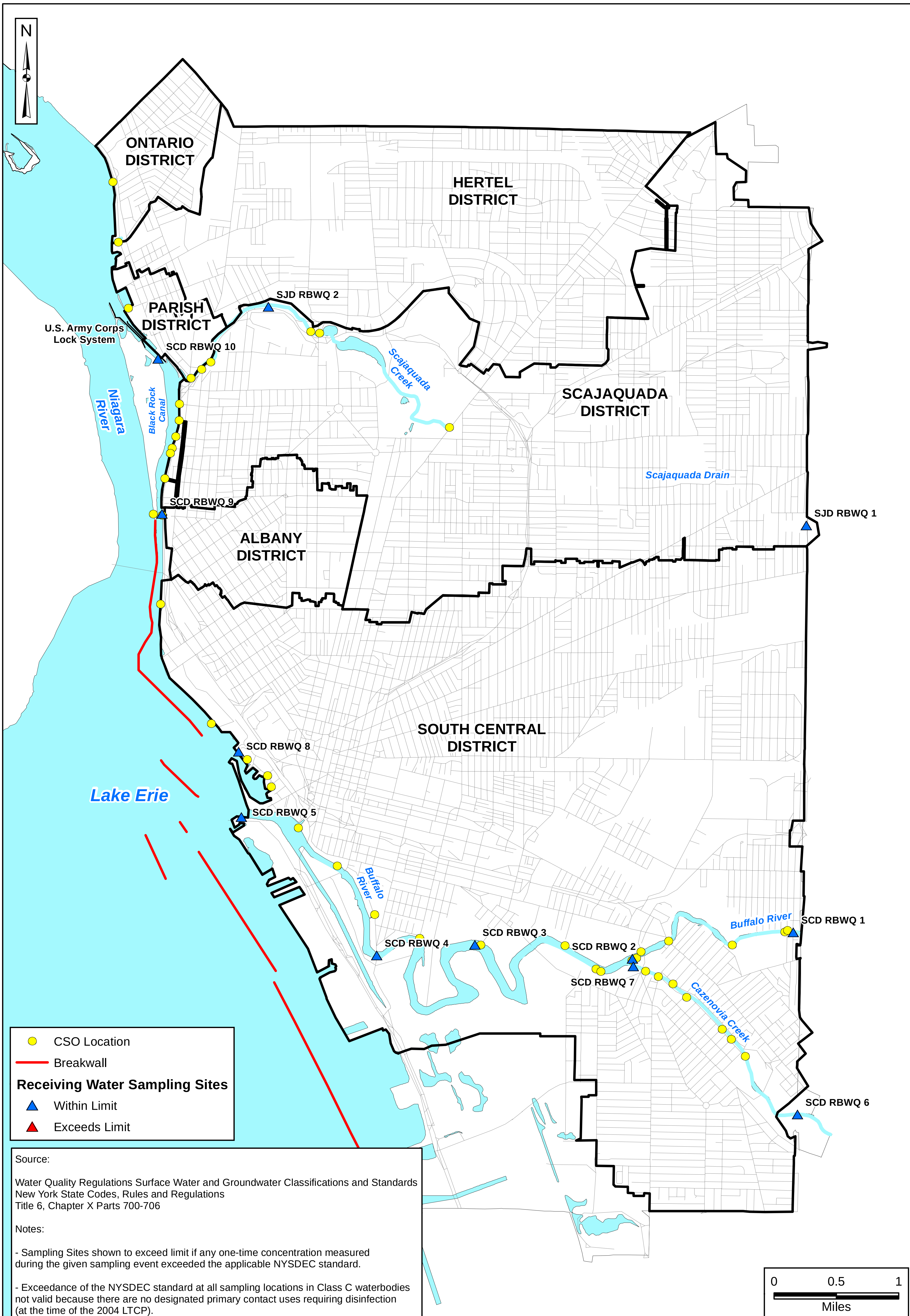
FIGURE 6-18

NYS WQ STANDARD COMPLIANCE - LEAD

WQ EVENT 2: 8/23/00 - 8/25/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

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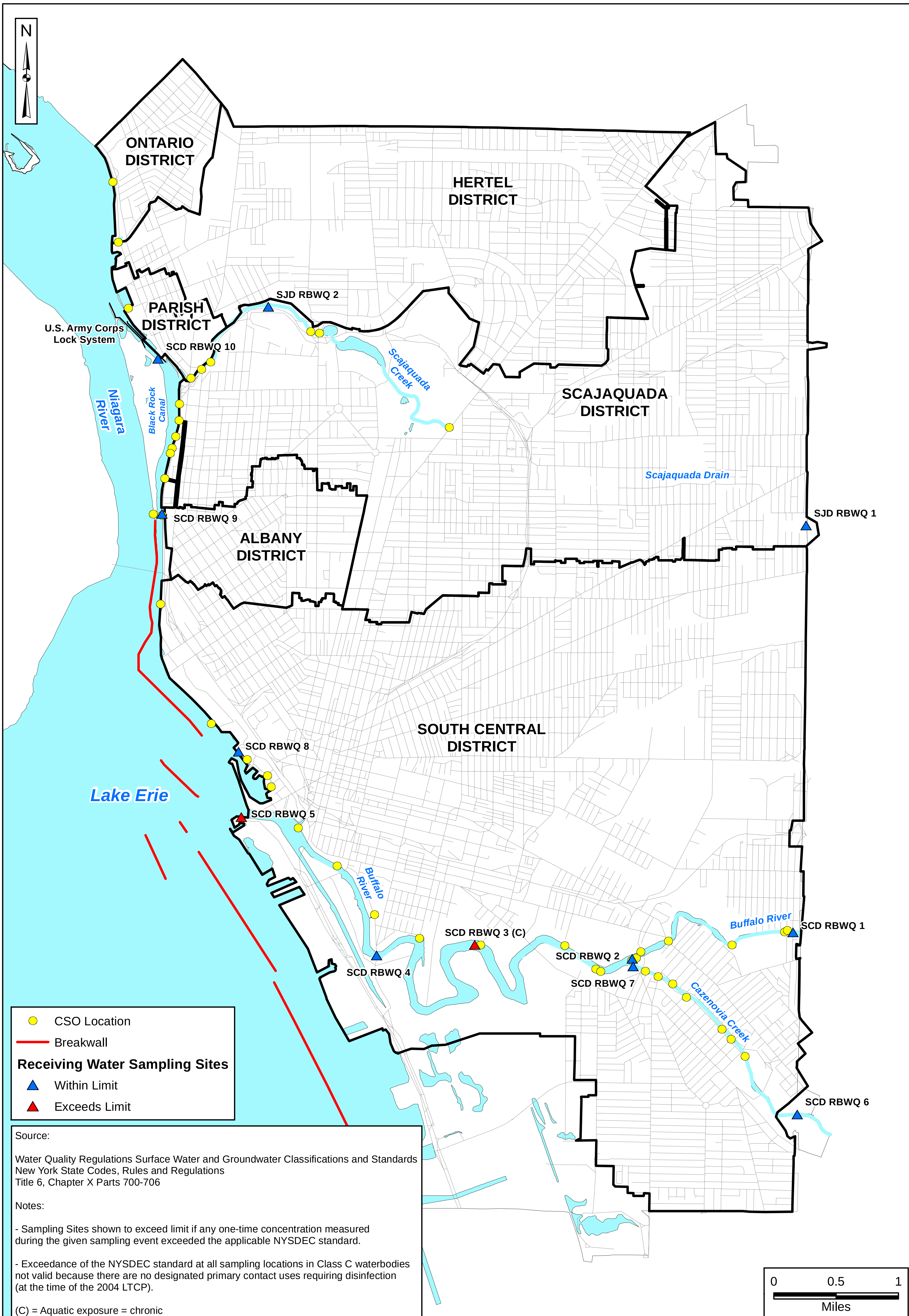
FIGURE 6-19

NYS WQ STANDARD COMPLIANCE - ZINC

WQ EVENT 1: 6/9/00 - 6/11/00



Source:

Water Quality Regulations Surface Water and Groundwater Classifications and Standards
New York State Codes, Rules and Regulations
Title 6, Chapter X Parts 700-706

Notes:

- Sampling Sites shown to exceed limit if any one-time concentration measured during the given sampling event exceeded the applicable NYSDEC standard.

- Exceedance of the NYSDEC standard at all sampling locations in Class C waterbodies not valid because there are no designated primary contact uses requiring disinfection (at the time of the 2004 LTCP).

(C) = Aquatic exposure = chronic

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FIGURE 6-20

NYS WQ STANDARD COMPLIANCE - ZINC

WQ EVENT 2: 8/23/00 - 8/25/00

Similarly, elevated fecal coliform levels were observed during wet weather conditions at sampling location SJDRBWQ02 and were also seen during dry weather/baseline conditions. This indicates that background sources likely contribute to the WQS exceedances for these two parameters during wet weather conditions.

The dissolved zinc exceedances were not observed at receiving water sampling locations SCDRBWQ03 and SCDRBWQ05 during dry weather/background conditions, while exceedances were observed at these locations during wet weather conditions. However, the source of the zinc WQS exceedances cannot be attributed solely to CSO discharges as numerous other factors such as overland flow and groundwater seepage have been shown to contribute to WQS exceedances at these two locations.

6.4 Sensitive Areas by Receiving Water Body

The USEPA CSO Control Policy requires that LTCPs give highest priority to controlling overflows which discharge into sensitive areas. Sensitive areas, as designated in the CSO Control Policy, include:

- Outstanding National Resource Waters;
- National Marine Sanctuaries;
- Waters with threatened or endangered species and their habitat;
- Waters with primary contact recreation;
- Public drinking water intakes or their designated protection areas; and
- Shellfish beds.

The CSO Control Policy indicates that for the sensitive areas identified using the criteria above, the LTCP should contain provisions to:

- Prohibit new or significantly increased flows; and
  - eliminate or relocate overflows that discharge to sensitive areas wherever physically possible and economically achievable, except where elimination or relocation would provide less environmental protection than additional treatment; or
  - where elimination or relocation is not physically possible and economically achievable, or would provide less environmental protection than additional treatment, provide the level of treatment for remaining overflows deemed necessary to meet WQS for full protection of existing and designated uses.

During this LTCP effort an additional evaluation was completed for sensitive areas to determine a final set of sensitive areas to be considered further for additional controls. In order to establish the final list, the sites identified in the 2004 LTCP document were re-evaluated based on, not only a more thorough review of the USEPA CSO Control Policy, but also on a number of other applicable documents. These documents were used to determine if the potential sensitive areas previously identified in the 2004 LTCP fell into one or more of the criteria that would more formally define them as "sensitive areas," warranting additional controls. A full list of documents reviewed during this update effort is included in Appendix 6-2.

Based on the USEPA sensitive area designation methodology, thirteen of the original potential areas were shortlisted. The thirteen areas were further grouped by geography, resulting in a total of seven shortlisted potentially sensitive areas. Table 6-6 lists the summary of the seven shortlisted potentially sensitive areas, the closest upstream CSO (and, therefore, the CSO discharge that would most likely affect the potential sensitive area), the distance to the closest CSO, the receiving water body in which the area is located, and the rationale as to why the area was or was not ultimately considered a sensitive area. These seven potential sensitive areas, shown graphically on Figures 6-21 and 6-22, were then closely evaluated using a more detailed evaluation of the six criteria contained with the CSO Control Policy.

Based on the detailed evaluation of the potential areas with respect to the six criteria outlined in the CSO Control Policy Areas, *only area 4 (Erie Basin Marina) was designated as a sensitive area* (this area is highlighted in Table 6-6 and on Figure 6-21) *because of its designation as both a water body with threatened and/or endangered species and as a water body with primary contact recreation.* The following sections provide a detailed discussion of each criterion.

6.4.1 Outstanding National Resource Waters

While there are no Outstanding National Resource Waters located in the Buffalo area, the Great Lakes Water Quality Agreement (GLWQA) of 1987 and the International Joint Commission (IJC) identified several areas of concern (AOCs) within the Buffalo area including both the lower 6.2 miles of the Buffalo River and the Niagara River. In order to make this determination, the IJC evaluated the two rivers, along with other AOCs, and rated them in terms of fourteen beneficial use impairments (BUIs). Since the original AOC designation was made in 1987, various evaluations and projects have been proposed and/or completed as part of numerous Remedial Action Plans (RAPs) intended to remove the Buffalo River and the Niagara River from their AOC listings by addressing the applicable BUIs. Table 6-7 below provides the current status of the impairments in each river.

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Table 6-6: BSA Sensitive Area Evaluation

******* **(Text in bold italics indicates "sensitive area designation"** ********

Area ID	Subareas Included within Area	Source	Nearest Upstream CSO	Distance (ft)	Distance (mi)	Receiving Water Body	Classification	Reason for Inclusion on Preliminary Pre-Screening List: Outstanding National Resource Waters OR Area of Concern	National Marine Sanctuaries	Waters with Threatened or Endangered Species and their Habitats	Waters with Primary Contact Recreation	Public Drinking Water Intakes	Shellfish Beds	Source Document	Qualification/ Disqualification Rationale
1	Erie County Water Authority Water Intake	Map of Buffalo / District Consultant	CSO-054	6,540	1.24	Niagara River - Town of Tonawanda	Water Intake					P		Public drinking water supply	Despite being downstream of all CSOs, conversations with the ECWA, Town of Tonawanda, and Erie County Health Department indicated that both have NOT observed any impacts at their intakes from CSOs. Water quality modeling also indicates CSOs do not cause non-attainment of water quality standards; therefore, this area was eliminated as a sensitive area.
	Town of Tonawanda Water Intake	Map of Buffalo / District Consultant	CSO-054	5,835	1.11	Niagara River - Town of Tonawanda	Water Intake					P		Public drinking water supply	
2	Hoyt Lake	Map of Buffalo	CSO-053	5,050	0.96	Scajaquada Creek	Potential future swimming				P			Department of Environmental Conservation's (DEC) statewide "List of Impaired Waters", Class B Water Body	Plans (to be implemented by the City of Buffalo) include flow enhancement and improving dissolved oxygen content of water body and do not include any formal plans for swimming; therefore, this area was eliminated as a sensitive area.
	Scajaquada Creek (Hoyt Lake to Niagara River)	Watershed Rec Use Study	CSO-060	1,056	0.20	Scajaquada Creek	Swimming				P			Department of Environmental Conservation's (DEC) statewide "List of Impaired Waters"; Recreational Use Survey, Class B Water Body	
3	Massachusetts Avenue Water Pump Station/ Intake	Map of Buffalo	NA	NA	NA	Black Rock Canal	Water Intake					P		Public drinking water supply	Intake currently not functioning. Could potentially be used as a second intake in the future, but would involve significant equipment rehabilitation and/or replacement to do so. Intake is separated from CSO 063 by canal breakwater and located in the Niagara River. Water quality modeling also indicates CSOs do not cause non-attainment of water quality standards; therefore, this area was eliminated as a sensitive area.
	Bird Island Pier/Broderick Park	Map of Buffalo	CSO-063	800	0.15	Black Rock Canal	Habitat			P (Black tern, common tern)				Designated Habitat: North Buffalo Harbor document, Recreational Use Survey, Department of Environmental Conservations's (DEC) statewide "List of Impaired Waters"	Only threatened or endangered species are bird species which will be minimally impacted by sporadic CSOs.
	City of Buffalo Colonel Ward Water Treatment Plant	Map of Buffalo	CSO-067	110	0.02	Black Rock Canal	Water Intake					P		Public drinking water supply	Drinking water treatment plant; but no intake located at plant site. Only intakes are in Emerald Channel and at Massachusetts Avenue Pumping Station.
	Buffalo Emerald Channel Water Intake(***note upstream of CSO)	Map of Buffalo	CSO-017	9,385	1.78	Lake Erie	Water Intake					P		Public drinking water supply	Located upstream from all CSO discharge points. Buffalo Water has not noted any adverse impact of CSOs on drinking water intake location.
4	***Erie Basin Marina, including Terminus of Buffalo River***	***Map of Buffalo***	***CSO-014***	***0.00***	***0.00***	***Lake Erie***	***Boating/ Swimming***			***P (silver chub, deepwater sculpin, lake sturgeon, mooneye, eastern sand darter)***	***P***			***NYSDEC threatened and endangered species list.***	***Primary contact with swimming as associated with boating activities, Lake Erie and Erie Basin Marina are classified as a Class B water body. Because this is part of Lake Erie, several fish species are considered threatened or endangered. Also, future development in this area may contribute to more primary contact uses. This area was designated as a sensitive area.***

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Table 6-6: BSA Sensitive Area Evaluation

******* **(Text in bold italics indicates "sensitive area designation"** ********

Area ID	Subareas Included within Area	Source	Nearest Upstream CSO	Distance (ft)	Distance (mi)	Receiving Water Body	Classification	Reason for Inclusion on Preliminary Pre-Screening List						Source Document	Qualification/ Disqualification Rationale
								Outstanding National Resource Waters OR Area of Concern	National Marine Sanctuaries	Waters with Threatened or Endangered Species and their Habitats	Waters with Primary Contact Recreation	Public Drinking Water Intakes	Shellfish Beds		
	City of Buffalo Outer Harbor	Watershed Rec Use Study	NA	NA	NA	Lake Erie	Swimming				P			Designated Habitat: North Buffalo Harbor document; Department of Environmental Conservation's (DEC) statewide "List of Impaired Waters"	Outer harbor area is located upstream of all CSOs in the City of Buffalo and was therefore, eliminated as a sensitive area.
5	Buffalo River to Confluence with Cazenovia Creek	DEC Priority Waterbodies List	Various	0.00	0.00	Buffalo River	Swimming	P						http://www.epa.gov/greatlakes/aoc/buffalo.html	This is primarily industrial area with little access to the River. Projects are currently ongoing to improve water quality. Also, studies have indicated other contaminants are present within Buffalo River that are not associated with CSO discharges and which designate it as an area of concern.
6	Seneca Bluffs Wetlands	District Consultants	CSO-051	2,600	0.49	Buffalo River	Habitat			P (black tern, common tern, upland sandpiper)				http://www.epa.gov/greatlakes/aoc/buffalo.html	Only threatened or endangered species are bird species which will be minimally impacted by sporadic CSOs. Also see Buffalo River discussion.
7	Ontario Street Boat Launch/Cornelius Creek	Watershed Rec Use Study	CSO-055	0.00	0.00	Niagara River	Swimming				P			Recreational Use Survey	Ontario Street Boat Launch is located on Niagara River, which has sufficient assimilative capacity. Also, strong currents within the Niagara River make it unamenable to swimming.

Notes:

1. Distances to the nearest CSO were determined by using the Spatial Analyst extension in ArcView to create a grid showing the distance to the nearest upstream CSO for the entire study area. Distance values for Potential Sensitive Areas were extracted as straightline distances from that grid. If upon manual inspection it was determined that the closest CSO was not upstream, the distance tool in ArcView was used to find the distance to the nearest upstream CSO. Since Spatial Analyst provided straight line distances, the measuring tool in ArcView was used to compute distances along the Buffalo River, Scajaquada Creek, and other areas where the flow does not follow a straight path.
2. No sensitive areas are listed in BSA's latest SPDES permit (effective July 1, 1999 and modified on October 2, 2001).
3. Map of Buffalo inspected from City Border to south and east, Grand Island Bridge to north, and receiving water bodies (Niagara River, Lake Erie, Black Rock Canal) to west.
4. Sources Checked:
   - USEPA CSO Control Policy and Guidance Documents
   - New York State Department of Environmental Conservation at www.dec.state.ny.us.
   - U.S. Environmental Protection Agency at www.epa.gov.
   - BSA Watershed Recreational Use Survey - September 2011
5. Reason for shortlisting 69 potential sensitive areas as listed in 2004 LTCP was that a CSO is within close proximity an area designated as one of 6 categories as noted in middle of table.
6. Reason for not including potential sensitive area in LTCP is that the area is not within close proximity to a CSO.

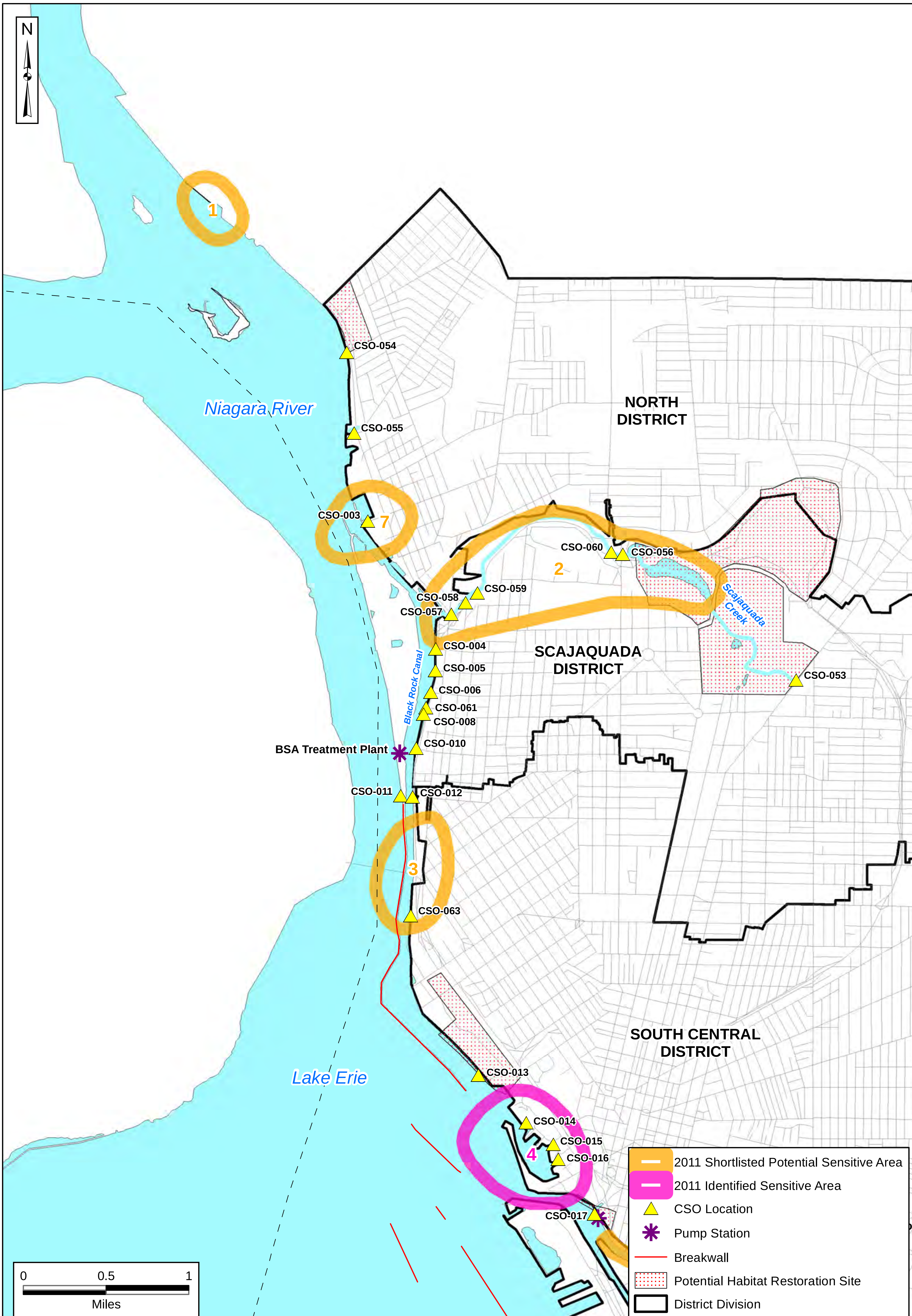

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FIGURE 6-21

POTENTIAL SENSITIVE AREAS NORTHERN PORTION OF CITY

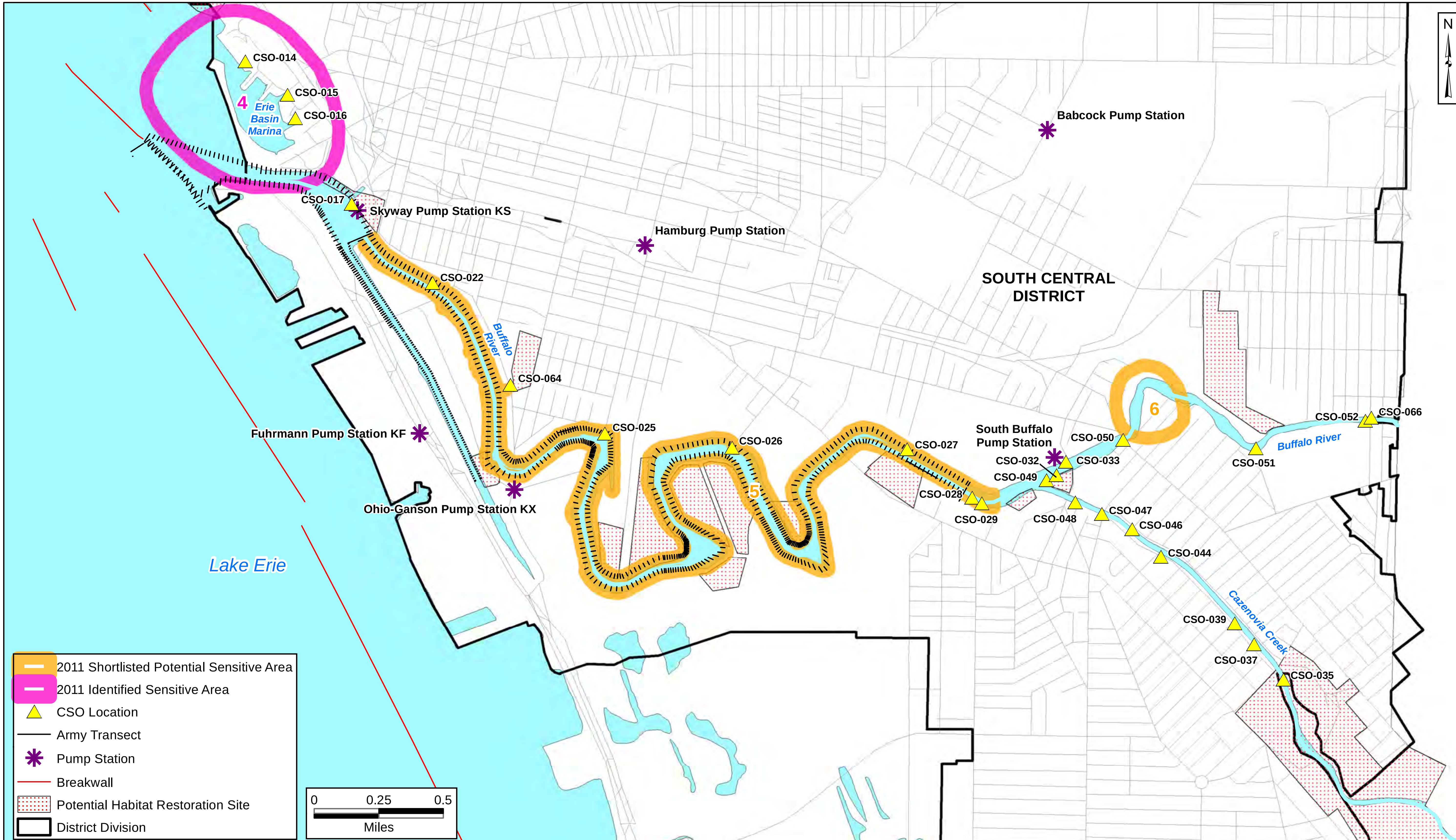

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FIGURE 6-22

POTENTIAL SENSITIVE AREAS SOUTHERN PORTION OF CITY

Table 6-7 AOC Beneficial Use Impairments (BUI) and Status for Buffalo River/Niagara River

(check marks indicate a BUI for the specific water body)

Beneficial Use Impairment	Status	Buffalo River[1]	Niagara River[2]
1. Restrictions on Fish and Wildlife Consumption	Impaired	✓	✓*
2. Tainting of Fish and Wildlife Flavor	Impaired	✓	
3. Degradation of Fish and Wildlife Populations	Impaired	✓	✓**
4. Fish Tumors or Other Deformities	Impaired	✓	
5. Bird/Animal Deformities or Reproductive Problems	Impaired	✓	
6. Degradation of Benthos	Impaired	✓	✓
7. Restrictions on Dredging Activities	Impaired	✓	
8. Eutrophication or Undesirable Algae	Impaired		✓***
9. Drinking Water Taste and Odor Problems	Impaired		
10. Beach Closings	Impaired		✓
11. Degradation of Aesthetics	Impaired	✓	
12. Added Costs to Agriculture and Industry	Impaired		
13. Degradation of Phytoplankton and Zooplankton Populations	Impaired		
14. Loss of Fish and Wildlife Habitat	Impaired	✓	✓

[1] Interim Buffalo River AOC Strategic Plan for BUI Delisting, March 2011
[2] Niagara River Remedial Action Plan – Stage 2 Update Report, December 2009
* (fish consumption only)
** (wildlife population only)
*** (undesirable algae only)

It is noted in many of the studies conducted over the past 20 to 25 years since the AOC designations were made that the designation of the Buffalo River as an AOC is not entirely attributable to CSO discharges, but more importantly to PCB and metals contamination, low DO, and high background BOD.

Note that studies have shown that low DO levels in the Buffalo River have been attributed to a combination of stratification in the river at low flows, high sediment oxygen demand, and long residence times due to system hydraulics. Modeling analysis conducted as part of the development of the LTCP update shows that the contribution of CBOD to sediments in the Buffalo River is a minor component of the overall CBOD flux to sediments and is relatively small compared to the CBOD load from upstream. As such, while reduction in CSOs may contribute to the reduction in sediment oxygen demand (SOD), it is unclear what impact this will have on SOD levels as long as upstream loading continues. The data also supports the hypothesis that the majority of bacterial contamination is generated from the upper watershed (*i.e.*, outside the City of Buffalo). Therefore, because the Buffalo River is not an Outstanding National Resource Water, the fact that other issues also contribute to its AOC designation, and that numerous projects, such as the dredging of the Buffalo River (USACE), Seneca Street Bluffs Project (Buffalo Niagara Riverkeeper), Smith Street wetlands (BSA), and the Hamburg Drain Floatables Facility (BSA) are currently underway to de-list the Buffalo River from its AOC designation, it is not identified as a sensitive area for the purposes of this LTCP.

The Niagara River is also listed as an AOC, but is not designated as an Outstanding National Resource Water. This AOC was mainly the result of BUIs related to fish habitats due to the presence of toxic chemicals in the river from industries, the majority of which are located downstream of the Buffalo CSO locations. As a result, the Niagara River is not deemed a sensitive area under the BSA's LTCP.

6.4.2 National Marine Sanctuaries

There are no National Marine Sanctuaries located in the Buffalo area.

6.4.3 Waters with Threatened or Endangered Species and Their Habitat

Of the numerous water bodies in the Buffalo area downstream of CSO outfalls, Lake Erie (and the related portions referred to as the Inner Harbor including the Erie Basin Marina and the Outer Harbor) is the only water body known to be a "water with threatened or endangered species and their habitats." These species include the silver chub, deepwater sculpin, lake sturgeon, mooneye, and the eastern sand darter, all of which are listed on New York State's List of Endangered, Threatened and Special Concern Fish & Wildlife Species. Therefore, the public areas along the Lake Erie shoreline at the Erie Basin Marina and Inner Harbor would fall under the criteria for a sensitive area in accordance with the USEPA's CSO Control Policy. It is highly likely that future development may also take place in this area to further expand public access at the Erie Basin Marina and Inner Harbor. The Outer Harbor is not included in the sensitive area designation as it is upstream of all CSOs within the City of Buffalo.

6.4.4 Waters with Primary Contact Recreation

In the summer of 2010, the BSA conducted the Watershed Recreational Use Survey for the Buffalo Sewer Authority (See Appendix 6-2). This survey examined recreational activities in Scajaquada Creek, Buffalo River, Niagara River, Lake Erie, Black Rock Canal and Cazenovia Creek. The types of recreational uses observed and available predominantly involved secondary (or incidental) contact with receiving waters and not primary contact recreation.

Significantly greater primary water contact was observed along the major shorelines of Lake Erie and the Niagara River with boating (including canoeing and kayaking) and swimming activities occurring. Because Erie Basin Marina and the Inner Harbor represent the most accessible areas for people to come in contact with the lake for recreational activities, this area was included as a sensitive area. As noted above, this area also meets the definition of a sensitive area due to the presence of threatened or endangered species. The Outer Harbor, while still bordering Lake Erie, is upstream of all CSO locations within the City of Buffalo and is considered not affected by CSO discharges. While swimming was observed at the Ontario Street Boat Launch, it is noted that the currents within the Niagara River are very strong at this location, and therefore, swimming is not recommended nor does it occur on a frequent basis.

Swimming was also observed within the Buffalo River. A Buffalo River recreational use study completed by K. Irvine of Buffalo State College in 2003 and 2004 also observed fishing, boating, and “hanging out” as predominant activities, with swimming noted at lower frequencies. While swimming was observed in the Buffalo River, most of the area surrounding the Buffalo River is industrial in nature and access to the river is limited. In addition, several projects have been, or are currently being undertaken along the Buffalo River. These projects include remediation of inactive hazardous waste sites, dredging of the bottom sediments by the USACE, Buffalo Color Peninsula grasslands restoration project (Buffalo Niagara Riverkeeper), Seneca Bluffs habitat restoration (ECDEP/Buffalo Niagara Riverkeeper), construction of Hamburg Drain floatables facility (BSA), and implementation of constructed wetlands at the foot of Smith Street (BSA). In addition, water quality modeling has shown that the Buffalo CSOs do not cause non-attainment of WQS in the Buffalo River; therefore, the Buffalo River is not designated as a sensitive area.

While swimming was not observed within Scajaquada Creek during the recreational watershed use survey, it is considered a Class B (Reach 1 – from crossing with Main Street to border with Cheektowaga) or Class A (Reach 2 – from mouth at Niagara River to crossing with Main Street) stream per 6 NYCRR Part 701 of the New York State Environmental Conservation Law. This classification indicates that the best usage of this water is for primary and secondary contact recreation and fishing. Through the Watershed Recreational Use Survey, kayaking and canoeing as a secondary contract recreational activity were frequently observed. In addition, a news release by the NYSDEC (August 25, 2010) indicated that future plans will improve water quality in Hoyt Lake and Scajaquada Creek boosting flow and oxygen levels in the lake and creek through the reactivation of an existing recirculation pumping system and fountain. It does not appear that there are any formal plans to increase the locations or frequency of primary water contact in either the Scajaquada Creek or Hoyt Lake. Therefore, this area was not considered a sensitive area.

6.4.5 Public Drinking Water Intakes or Their Designated Protection Areas

There are several public drinking water intakes proximate to CSO outfalls. Significantly, the Buffalo Water Authority has an intake, but it is located in the Emerald Channel at the bottom of Lake Erie upstream of any CSO outfalls. Therefore, this intake is not considered to be a sensitive area and does not warrant additional controls or consideration.

The City of Buffalo currently has a second intake located in the Niagara River, near the Peace Bridge, adjacent to the Massachusetts Avenue Water Pumping Station. This intake has not been used in many years and is currently reported to be out of service because of inoperability of intake gate equipment. Furthermore, water quality modeling results show that due to the level of attainment within the river, City of Buffalo CSOs have no impact on water quality in the Niagara River and, thus, even in the event that the intake were reactivated, no additional CSO controls are warranted and the area is not considered to be sensitive.

Two other public drinking water intakes are located further downstream within the Niagara River and include the intakes for the Town of Tonawanda's Water Treatment Plant and the Erie County Water Authority's Jerome D. VanDeWater Drinking Water Treatment Plant. However, despite the fact that the intakes for both plants are downstream of all of BSA's CSO locations, conversations with the Erie County Water Authority and the Town of Tonawanda have indicated that they have not observed any impacts at their intakes from CSOs (*i.e.*, no changes in the treatment of drinking water have been implemented during and following significant weather events). This was echoed by the Erie County Health Department, where the only change observed at the intakes was higher turbidity during and following wet weather events. However, higher turbidity is observed even in those areas without CSO discharges, because of the contribution of sediments associated with stormwater flows, sediment from shallow Lake Erie, and surface water runoff from areas upstream of the City of Buffalo. Again, water quality modeling of the Niagara River indicates that the Buffalo CSOs do not cause non-attainment of the WQS in the Niagara River. Therefore, the area in which these two intakes are located is not considered to be a sensitive area.

6.4.6 Shellfish Beds

There are no known shellfish beds in the Buffalo area.

6.5 Additional Watershed Use Study under Phase II LTCP Engineering

A Watershed Recreational Use Survey was conducted in the summer of 2010 for the BSA. This survey examined recreational activities in water bodies downstream of the Buffalo CSOs, including the Scajaquada Creek, Buffalo River, Niagara River, Lake Erie, Black Rock Canal and Cazenovia Creek. The study is included in its entirety in Appendix 6-2. The types of recreational uses observed and available predominantly involved secondary (or incidental) contact with receiving waters. Designated swimming areas and public beaches are typically located upstream of the City of Buffalo, or far enough downstream to effectively eliminate any impacts.

Residents of the City of Buffalo and nearby municipalities enjoy a wide variety of outdoor activities along Buffalo's waterways during the summer months. Numerous parks throughout the City encourage outdoor recreation, including walking, running, sunbathing and sports. Within the two largest City parks, Delaware Park and Cazenovia Park, most of the outdoor recreational activities observed were passive recreation involving at most minimal contact with water.

Significant water contact was observed mostly along the major shorelines of Lake Erie and the Niagara River, with boating (motorboats, sailboats, personal watercraft, kayaks, and canoes), fishing, and swimming activities. Fishing was by far the most frequently observed activity. Extensive fishing was observed along the Buffalo River, despite limited access due to large commercial/industrial sites. More limited fishing occurred along Cazenovia Creek and Scajaquada Creek.

Perceptions of water quality were mixed from those interviewed. Those pursuing passive recreational activities were more likely to rate the water quality poorer than were those people pursuing activities with increased water contact. Fisherman interviewed were more likely to rate the water quality good, as many regularly consumed the fish that they caught.

The Watershed Use Study findings are in general agreement with the sensitive area evaluation results.

6.6 Receiving Water Existing Conditions Modeling Results

In response to the NYSDEC and USEPA's request, the BSA also conducted additional water quality sampling (2008 to 2009) and used these data to support development of more detailed receiving water quality models for the Buffalo and Niagara Rivers, Scajaquada Creek, and Black Rock Canal. The additional sampling program and detailed water quality models were used to further support the control objectives for this LTCP. The detailed receiving water quality models were developed during the Phase II work and subsequently used during the Phase III evaluations. The receiving water quality models were used to evaluate existing conditions as well as to determine whether the abatement alternatives achieve attainment of WQS in each water body. A description of the receiving water quality model development is presented in Section 4.4, and the existing conditions results for water quality modeling are summarized in this section. The details of the baseline water quality modeling are attached in Appendix 6-3, *Technical Memorandum: Baseline Water Quality Modeling For Buffalo River, Scajaquada Creek, Niagara River, and Black Rock Canal.* The models were run to provide results for the following four baseline scenarios to provide a benchmark to compare different alternative levels of CSO control.

- **Baseline**: Flows and concentrations of all sources are consistent with existing conditions for the 1993 TY.

- **Baseline – Background 75% of WQS**: CSO flows and concentrations are consistent with existing conditions for the 1993 TY. Flows for background sources (storm water and upstream boundaries) are consistent with existing conditions. Water quality for background sources are reduced to a condition intended to represent future upstream improvements in water quality: 1)150 #/100 mL (bacteria), and 2) 75% of existing conditions (BOD).

- **No CSOs**: CSO flows and concentrations are set to zero. Background flows and concentrations are consistent with existing conditions for the 1993 TY.

- **No CSOs – Background 75% of WQS**: CSO flows and concentrations are set to zero. Flows for background sources (storm water and upstream boundaries) are consistent with existing conditions. Water quality for background sources are reduced to a condition of: 1) 150 #/100 mL (bacteria), and 2) 75% of existing conditions (BOD).

These fours scenarios provide the boundaries that define the range of possible results from no action to complete elimination of overflows during a typical year. The water quality models were run for each of these scenarios and the hourly model output for bacteria and dissolved oxygen were compared to current New York State WQS. The comparisons for each modeled receiving water body are presented below. It should be noted that the significant figures presented in these percentage results are intended to allow differentiation between results that rounding might obscure, and do not necessarily represent the actual level of accuracy of the models.

For the model results presented in the following subsections, the term “critical cell” is used only to refer to dissolved oxygen (DO) results for water bodies with a vertical model segmentation (Buffalo River, Black Rock Canal, Lower Scajaquada Creek). Where it applies, “critical cell” refers to the model cell in each vertical column of cells with the lowest dissolved oxygen. The DO concentration in that cell was considered to represent the water quality condition of that column of cells. The concentration of each “critical cell” was then used to determine WQ standard attainment for that cell and a spatially averaged calculation of all “critical cells” was made along the horizontal plane. Therefore, in effect, the DO results in the Buffalo River model represent the average of the lowest DO concentration at each location in the model grid. For the purposes of modeling the impacts of bacteria (fecal coliform), in model domains with multiple vertical cells (e.g., Black Rock Canal, lower end of Buffalo River), the fecal coliform concentration for the surface model cell was used to determine percent attainment.

6.6.1 Buffalo River

The results of this comparison are tabulated in Table 6-8 for the critical cells of the Buffalo River Model. The baseline results for the Buffalo River suggest that complete elimination of CSOs without addressing the background sources will have a minimal effect on attainment of recreational use (bacteria) standards. Eliminating CSOs and/or reducing the background sources will have a negligible effect on attainment of DO criteria as it appears that the physical characteristics of the stream channel are the dominant factor in oxygen depletion.

Table 6-8 Water Quality Standards Attainment for Buffalo River Critical Cells for Baseline Scenarios Averaged for Typical Year 1993

Scenario	Buffalo River Annual Percent Attainment (%) of WQS		
	Daily Average Dissolved Oxygen	Daily Minimum Dissolved Oxygen	Bacteria
1993 TY - Baseline	73.3	78.1	33.6
1993 TY - Bkgd 75% of WQS	74.3	77.7	93.1
1993 TY - No CSO	73.5	78.1	49.1
1993 TY - No CSO - Bkgd 75% of WQS	74.3	78.5	100.0

6.6.2 Scajaquada Creek

The results of the comparison are tabulated in Table 6-9 for the critical cells of the Scajaquada Creek model. The model separated the creek into upper and lower segments because of the hydraulic features of the stream. The output is separated into upper and lower sections.

Table 6-9 Water Quality Standards Attainment for Scajaquada Creek Critical Cells for Baseline Scenarios Averaged for Typical Year 1993

Scenario	Scajaquada Creek Annual Percent Attainment (%) of WQS					
	Daily Average Dissolved Oxygen		Daily Minimum Dissolved Oxygen		Bacteria	
	Upper	Lower	Upper	Lower	Upper	Lower
1993 TY - Baseline	90.1	99.6	94.6	99.8	47.6	4.6
1993 TY - Bkgd 75% of WQS	90.6	99.8	95.6	99.9	98.9	77.0
1993 TY - No CSO	91.1	99.8	97.3	100.0	49.4	8.0
1993 TY - No CSO - Bkgd 75% of WQS	91.7	99.9	98.3	100.0	100.0	100.0

Bacteria levels in both segments of the Scajaquada Creek are heavily influenced by the background sources. Elimination of CSOs provides only marginal improvements in bacteria WQS attainment in the upper Scajaquada segment and more significant, but still substantially less than background sources for the Lower Scajaquada segment. The differences gained for attainment of the DO criteria through CSO elimination and/or background source reduction are again typically very minor for both upper and lower model reaches.

6.6.3 Black Rock Canal

The modeled WQS attainment for the Black Rock Canal is presented in Table 6-10. The attainment for bacteria is presented separately for the Erie Basin at the south limit of the Canal model and the northern portions of the Canal as the attainment was significantly different in those areas.

Table 6-10 Water Quality Standards Attainment for Black Rock Canal Critical Cells for Baseline Scenarios Averaged for Typical Year 1993

Scenario	Black Rock Canal Annual Percent Attainment (%) of WQS			
	Daily Average Dissolved Oxygen	Daily Minimum Dissolved Oxygen	Bacteria	
			Northern Portion	Erie Basin
1993 TY - Baseline	98.9	99.1	84.0	100.0
1993 TY - Bkgd 75% of WQS	98.9	99.1	85.5	100.0
1993 TY - No CSO	98.9	99.2	95.2	100.0
1993 TY - No CSO - Bkgd 75% of WQS	98.9	99.2	100.0	100.0

The model does not show any significant changes in the relatively high attainment of WQS for dissolved oxygen with removal of CSOs or with reductions in background loading. For recreational use attainment, the model shows the potential for an 11 to 15% improvement of attainment for the northern portions of the Canal with the elimination of CSOs. This improvement is related to decreased loadings from CSOs both in the Canal Directly and from the discharges from Scajaquada Creek.

6.6.4 Niagara River

The sampling and the model indicates that the Niagara River WQS are not impaired for either DO criteria or for bacteria as a result of either CSO or background loadings from the Buffalo area. DO modeling for Niagara River was not necessary.

6.7 System-Wide Control Objectives

Based on the NYSDEC and USEPA's review and comments on the 2004 LTCP, as well as revisions to the WQS (discussed in Section 6.3), the pollutants of concern considered for each receiving water body were further refined for this LTCP and are presented in Table 6-11. Water quality objectives for each water body were developed based on regulatory comments, the sensitive areas evaluation, watershed recreational use study, and the results of the existing conditions water quality modeling results.

Table 6-11 Updated Water Quality Objectives for Each Receiving Water Body

Receiving Water Body	Pollutants of Concern	Water Quality Control Objectives
Cazenovia Creek / Buffalo River	DO, Fecal Coliform	Control discharge of oxygen-demanding material from CSOs through removal/capture; Control of bacteria discharges from CSOs through disinfection/capture
Erie Basin Marina	Fecal Coliform	Control of bacteria discharges from CSOs through disinfection/capture
Niagara River	Fecal Coliform	Control of bacteria discharges from CSOs through disinfection/capture
Black Rock Canal	DO, Fecal Coliform	Control discharge of oxygen-demanding material from CSOs through removal/capture; Control of bacteria discharges from CSOs through disinfection/capture
Scajaquada Creek	DO, Fecal Coliform	Control discharge of oxygen-demanding material from CSOs through removal/capture; Control of bacteria discharges from CSOs through disinfection/capture

Changes made to the 2004 LTCP objectives include adding fecal coliform for Class C water bodies and removing metals (zinc) as a pollutant of concern for the Buffalo River. While there are several significant industrial users (SIUs) adjacent to the Buffalo River in the South Central District and included in the BSA's Industrial Pretreatment Program, discussions with the BSA Industrial Pretreatment Program Coordinator indicate that none of the SIUs adjacent to the Buffalo River that are permitted/monitored for zinc have violated their permit limits in the last three years.

7. Screening of Combined Sewer Overflow Control Technologies

A wide range of technologies exist for CSO control, and the available technologies were screened for application within the BSA's CSS. This section summarizes the technology screening that was completed for the 2004 LTCP. The results of this screening were applied in this LTCP summarized in later sections of this report.

7.1 Technology Screening Criteria

The factors that drive the selection of a preferred technology are case-specific, and vary between regulators and within the three planning Districts in the BSA's system. As a result, multiple factors were considered during the initial screening process to identify technologies to be used for CSO control. Factors considered included:

- Controlling an individual regulator locally with a single identified level of control objective, versus controlling multiple regulators at a single downstream CSO location with multiple control levels. In the controlling multiple regulators scenario, it may be desirable and/or cost-effective to obtain a higher level of control at the consolidated facility than preliminary levels of control identified for individual regulators.

- Minimizing cost while maximizing achievement of an identified level of control or water quality objective.

- Minimizing O&M requirements.

- Constructability.

- Meeting overall control objectives identified in the District-specific technical memoranda and in the water quality based approach. For example, at a regulator/CSO where aesthetic control is desired, a storage technology that captures flows may be more desirable than a flow-through facility, even if they both achieve the same level of control.

- Inter-district control technologies.

- Possibility that further evaluation may be required before a single preferred technology can be selected.

7.2 Control Methodologies

7.2.1 Matrix of Technologies

A range of technologies was screened using the above criteria in the preparation of the 2004 LTCP. The technologies screened included:

- Source controls;
- Collection system controls;
- Storage;
- Treatment;
- Floatables control; and
- Non-CSO source alternatives.

Preliminary screening of improvement technologies was performed considering the BSA's goals and known characteristics of the collection system. Advantages and disadvantages of the technologies were identified. A discussion of the preliminary screening of each alternative technology is presented in this section.

7.2.2 Source Controls

Source controls are methods of reducing overflow volumes, floatables and/or BOD and suspended solids loads by controlling wet weather flows and loadings at their source. Source control methods include:

- Catch basin cleaning – This measure typically involves cleaning of catch basins by maintenance crews using a vacuum truck.
- Street cleaning – This measure involves cleaning of street litter by mechanical street cleaning. The USEPA recommends that street cleaning should be done as often as once or twice per week and after each storm. However, street sweeping performed at that frequency may not be feasible due to O&M costs incurred and logistical difficulties in large urban areas.
- Trash receptacles – This measure involves the provision of standard trash receptacles throughout major public areas within the system.

- Public education programs – This measure involves the implementation of programs to educate the public on initiatives such as litter control (with information regarding associated fines and penalties), illegal disposal, and the link between litter and CSO impacts. Public notification typically includes postings in public places, radio and television advertisements, and letter notification to residents and commercial entities.

The BSA currently incorporates such programs in implementation of the BMPs, as noted in Section 5. The primary advantage of the use of source controls is low capital cost.

The primary disadvantage of this technology is its inability to meet WQS for DO, suspended solids, and fecal coliform. Additional disadvantages include increased O&M costs required for cleaning streets and inlets and potential for street and yard flooding associated with local stormwater storage technologies.

Due to the nature of source controls, numerical estimation of their effects on collection system and receiving water body responses is not possible. Also, source control methods are typically considered to be independently insufficient for total CSO control. Due to their inability to meet WQS, source controls are not considered as an alternative for complete CSO control. Source controls typically are recommended in conjunction with other selected alternatives at discrete locations. These kinds of controls may be implemented as part of an overall program to address CSOs based upon community and regulatory perceptions, capabilities, and goals.

7.2.2.1 Green Infrastructure

The term "green infrastructure" covers a broad range of source control technologies offering the potential of reducing peak storm overflow rates, as well as the volume of stormwater generated by a site. Green infrastructure can be used to store, infiltrate, evaporate, and/or detain runoff. Common green infrastructure technologies include:

- Rain gardens/vegetated swales: Rain gardens and vegetated swales are shallow depressions, typically planted with native plants to collect, infiltrate and filter rain that falls on hard surfaces like roofs, driveways, alleys, vacant properties, or streets to reduce the flow entering the sewer system and to minimize negative impacts of excessive runoff from these surfaces on receiving water bodies.

- Downspout disconnections/rain barrels: Within CSSs, downspouts from residential and commercial properties are typically directly connected to the sewer system. Disconnection of the downspouts and redirection of the roof runoff can eliminate a major source of storm water into the combined system. In conjunction with downspout disconnection, rain barrels are often placed at the end of disconnected roof downspouts to capture and hold runoff from roofs. The water in the barrel can then be put to beneficial use to water vegetation. The barrel top typically has a protective screen to inhibit mosquitoes.

- Infiltration trenches: Excavated trenches backfilled with stone to create subsurface basins that provides storage for water and allow infiltration into soil rather than the collection system. This can be implemented either on occupied parcels, or in a City like Buffalo, there are a number of vacant properties owned by the City that can be used for the implementation of infiltration trenches, reducing the total amount of water entering the collection system.

- Blue roofs: Blue roofs are designed to collect and retain a portion of the precipitation (typically 1-inch or less) that falls on flat roofs. The collected water is then allowed to evaporate over time during dry weather. Rainfall in excess of the retained amount is allowed to discharge from the roof via the building downspouts.

- Green roofs: The practice of constructing pre-cultivated vegetation mats on rooftops to capture rainfall, reducing runoff entering the combined system.

- Permeable pavement: A type of surface material that reduces runoff to the CSS by allowing precipitation to infiltrate through the paving material and into the earth.

- Storage chambers/perforated pipes: At some parking lots, small storage areas consisting of chambers or pipes are located directly under the parking surface to collect overland flow and detain the flow during the wet weather event. Following the event, the storage area is dewatered to the CSS for conveyance to, and treatment at, the WWTP.

- Constructed wetlands: Constructed wetlands act as a combination of vegetated swales and detention ponds to reduce the amount of flow that enters the combined sewer system.

In general, green infrastructure technologies are applied over a relatively large area in order to achieve a significant reduction in runoff volume and/or flow rate to the CSS. This reduction can often be achieved at a relatively low capital cost per gallon of storm water removed, especially when coupled with other municipally funded capital projects such as street reconstruction. Green infrastructure techniques typically become even more cost-effective as part of property transfer or redevelopment activities, allowing implementation when sites have already been excavated, allowing substantial construction cost savings. In the case of rain gardens and rain barrels, significant participation and cooperation of business and private property owners is required. In some cases, implementation of green infrastructure requires revisions to the applicable building code, which can be a lengthy process. However, the City of Buffalo has already completed the draft of their “Green Code” that will become a component of the City’s Building Code. The provisions of the Green Code will be used to promote the inclusion of green infrastructure in future redevelopment efforts within the City of Buffalo. The BSA anticipates that the Green Code will be adopted by the City in 2014. Finally, through the BSA’s review of development within the City, various green infrastructure techniques are already being implemented on a case-by-case basis. Because of their potential to achieve significant reductions of storm water flows entering the BSA's CSS and therefore reducing the CSOs, green infrastructure technologies were considered for further evaluation. Further discussion on green infrastructure technologies considered for Buffalo is provided in the BSA's Green Infrastructure Master Plan presented in detail in Section 12.

7.2.3 Collection System Controls

Collection system controls are methods of reducing overflow volume and frequency by optimizing system conveyance and/or storage or increasing system capacity. Methods of collection system control include pump station modifications, regulator modifications, sewer separation, express sewers, flow diversion, and other conveyance options.

The primary advantage of the use of collection system controls is the potential for significant control of wet weather flows using in large measure, existing infrastructure. These technologies can lead to significant improvement in terms of level of control, and ultimately, attainment of WQS. Further, some of the technologies, such as flow diversions or regulator modifications, can achieve significant wet weather control for relatively little capital investment.

Some of these control technologies, such as sewer separation or express sewers, have high capital costs when compared to source control technologies. Additional disadvantages include higher O&M costs for pump stations, potential for disruption during construction, and potential for street and yard flooding associated with regulator modifications.

Because collection system controls may, in whole or in part, provide the BSA with the ability to achieve significant improvement and comply with WQS, collection system controls were considered for further evaluation.

7.2.3.1 Pump Station Modifications

Reduction in volume and frequency of overflow can be accomplished by modification of the existing hydraulic capacities and control features of pump stations, (*i.e.*, increased pump capacity, control of wet well operating elevations, etc.). These types of modifications are pump station-specific and feasible only if existing excess downstream capacity is available and the resulting hydraulic gradient upstream of the pump station can be reestablished at a safe elevation to prevent flooding or the increase of other overflows. This type of collection system control can be advantageous for pump stations with high overflow frequencies, but low volumes of discharge.

Pump station modifications were not considered for further analysis, as the pump stations contained within the BSA's collection system do not have high overflow frequencies.

7.2.3.2 Regulator Modifications – Passive

Reduction in volume and frequency of overflow at specific regulators can be accomplished by modification of the existing hydraulic control features of the regulator (*i.e.*, raising the elevation of weirs, modifications to orifice area, etc.). These types of modifications are regulator-specific and feasible only if existing excess interceptor capacity is available and the resulting hydraulic gradient upstream of the regulator can be reestablished at a safe elevation to prevent flooding or the increase of overflows at upstream locations. This type of collection system control can be advantageous for regulators with high frequencies and low discharge volumes.

7.2.3.3 Regulator Modifications – With Real Time Control (RTC)

In certain cases, the regulator modification technology can take the form of a dynamic ("real-time") regulator control (*e.g.*, adjustable weir) combined with a control system to maximize capture and minimize CSOs, street and basement flooding, and inflow peaks to the WWTP. This kind of real-time control adjusts the regulator control equipment (gates, pumps, and valves) in response to real-time system conditions. The equipment is controlled to use in-line and off-line storage assets to equalize and dampen peak flows, allowing the downstream collection system to convey the optimal amount of combined flows to the treatment facility. In addition, conveyance optimization is achieved by ensuring the collection system is fully utilized before CSOs occur upstream.

Generally, regulator modifications by themselves are not sufficient for complete CSO control. However, because they are often relatively inexpensive, regulator modifications (both passive and with real time control) were considered for further evaluation as components of system-wide alternatives for CSO control.

7.2.3.4 Sewer Separation

Sewer separation involves the installation of an additional conduit, typically to convey storm water, alongside the existing CSS. The existing lines would be left in place to convey sanitary sewage to the treatment plant, since sanitary laterals are already attached and the existing pipe goes directly to the plant. Separation can be an effective method of removing storm water flows from the sanitary sewer systems, reducing CSO volumes, and increasing equipment life and capacity at the WWTP. There are two different degrees of sewer separation: full separation and partial separation, in the form of storm water inflow removal.

Full Separation

Full separation involves the separation of the all sources of runoff from the combined sewer area tributary to any overflow point or regulator. The removal of storm water leaves the existing system with enough capacity to carry sanitary flow and reduces overflowing of the sanitary system. Only areas that have both sanitary and storm flows in a single pipe require the installation of an additional conduit. Full separation would require the installation of new storm sewers in all combined sewer areas, and the uncoupling of any storm water connections to the present combined system.

Full separation was considered for further analysis as a potential system-wide alternative for CSO control, but is a very capital-intensive solution. Because of the high capital cost involved, developing cost estimates for full sewer separation applied system-wide can establish an upper cost limit for total CSO control that serves as a benchmark against which other more feasible solutions can be compared. Another full separation approach would be constructing new separate sanitary sewers while disconnecting the existing combined sewers from sanitary service and maintaining them for stormwater drainage. This approach, however, is typically more expensive and difficult to implement than constructing new storm sewers, and therefore, was not considered further.

Partial Separation (Storm Water Inflow Removal)

Storm water inflow removal, or partial separation, is accomplished by installing new storm sewers in local, discrete areas within combined sewer subbasins to reduce direct storm water input to the existing CSS. Inflow removal is considered viable and cost-effective in areas where gravity discharge of collected storm water could be accomplished through relatively short outfalls to the receiving water or to a storm sewer with excess capacity.

As part of the BSA's on-going infrastructure improvement program, several partial separation projects have been completed as part of Phase I projects. For this reason, partial separation was considered for further evaluation as a potential component of alternatives for CSO control. For this reason, partial separation was considered for further evaluation as a potential component of the 2004 preferred for CSO control alternative carried forward for further evaluations. Due to new stormwater regulations and greater regulatory emphasis on green infrastructure technologies, for new alternatives developed under this LTCP revision effort, green infrastructure was considered in lieu of new partial separation projects.

7.2.3.5 Sanitary Express Sewers

New separate sanitary express sewers can be provided to convey flow from existing separate sanitary sewer areas in outlying, or tributary, communities directly to the treatment plant. The express sewers bypass areas of combined sewers and permit preferential treatment of separate sanitary sewer flows at the treatment plant, while removing flow from the combined parts of the system. Express sewers are typically feasible as a collection system control only if excess treatment plant capacity exists and is underutilized because of a lack of conveyance capacity within the combined portions of the collection system.

Sanitary express sewers were not considered for further evaluation as an alternative for CSO control as capacity of the existing treatment plant is not underutilized.

7.2.3.6 Flow Diversion

Flow diversion from existing overloaded parts of the collection system to parts of the system with existing excess capacity can be accomplished by the construction of new relief sewers or pump stations. These modifications are area-specific and feasible only if existing excess capacity is available elsewhere within a reasonable distance and the resulting hydraulic gradients in the receiving part of the system can be reestablished at safe elevations to prevent flooding or an increase of overflows at upstream locations.

By itself, flow diversion is generally not sufficient for complete CSO control. However, flow diversion in portions of the BSA's collection system, where appropriate, was considered for further evaluation for CSO control.

7.2.4 Storage

Total storage volume within the system (*e.g.*, in-line, tunnel, or storage/treatment basins) is typically limited by the ability of the treatment plant to accept and treat the stored flow as the storage facilities are dewatered. Generally, this stored flow would have to be treated to secondary standards. In order to avoid septicity within the storage basins and increase the likelihood that storage is available when needed, target dewatering periods are assumed to be 24 hours. The primary advantage of the use of storage controls is the potential for significant control of wet weather flows. These technologies can lead to significant improvement at the benefit-effective level of control.

As with collection system controls, the primary disadvantage of this technology is its high capital cost when compared to source control technologies. Additional disadvantages include increased O&M costs for pumping (if necessary) and cleaning, potential for disruption during construction, and siting requirements.

Because storage control may, in whole or in part, provide the BSA with the ability to achieve significant improvement and comply with WQS, storage control methods were considered for further evaluation. Storage control methods evaluated include in-line storage with real time control, satellite storage facilities, and deep rock tunnels.

7.2.4.1 In-Line Storage with Real Time Control

In-line storage can be provided in existing large diameter pipes having excess hydraulic capacity. In-line storage is typically induced by the construction of gates or inflatable dams within the existing pipe, along with a suitable control system that activates the storage and release of flow exceeding storage volume.

Typically, to develop a significant amount of in-line storage, pipe diameter and length must be the equivalent of the major intercepting sewer.

In-line storage with real time control was considered for further evaluation as an alternative for CSO control in those portions of the collection system containing trunk sewers of sufficient diameter and length.

7.2.4.2 Satellite Storage Facilities

Satellite storage facilities are typically constructed between the existing regulator and the receiving water body. Storage basins are sized to provide the storage volume associated with the selected level of control. Flows in excess of this volume are routed around the storage basin for direct discharge to the receiving water body. This discharge is considered a CSO event in the new system. The basin and settled solids are dewatered to the interceptor. As described in Section 7.2.4, it is assumed that dewatering would be accomplished with pumps capable of dewatering the basin within 24 to 48 hours, in order to avoid septicity and to increase the likelihood that storage will be available when needed. Storage basins capture all the volume associated with overflow events up to the selected level of control, and the first flush of larger events.

Detention storage basins were considered for further evaluation as a potential alternative for CSO control.

7.2.4.3 Deep Rock Tunnels

Storage is sometimes provided by the mining of storage tunnels below grade, and if possible, in bedrock. The tunnels are sized to store overflows from all captured regulators up to the selected level of control. Flows in excess of this level would be bypassed directly to the receiving water body.

There are three areas in which deep rock tunnels are evaluated as an alternative for CSO control:

- Black Rock Canal Tunnel (also known as the North-South Tunnel)
- Scajaquada Tunnel (also known as the East-West Tunnel)
- Buffalo River Tunnel

An initial review of available geological information for the City of Buffalo collection system area did not identify any potential problems that would preclude the construction of deep rock storage tunnels. Therefore, deep rock storage tunnels were considered for further evaluation as an alternative for complete CSO control.

7.2.5 Treatment

Treatment control is a method of reducing untreated overflow volume and frequency by increasing a system's treatment capacity. Treatment typically involves some form of solids (and associated BOD) removal and/or disinfection. Treatment control methods evaluated include treatment detention basins, vortex separators with disinfection, and enhanced high rate treatment (EHRT) with disinfection.

The primary advantage of the use of treatment controls is the potential for significant control of wet weather flows. These technologies can lead to significant improvement at the benefit-effective level of control.

As with collection system and storage controls, the primary disadvantage of this technology is the high capital cost when compared to source control technologies. Additional disadvantages include increased O&M costs for new mechanical equipment as well as settling and disinfection chemicals, potential for disruption during construction, and siting requirements.

Because treatment control may, in whole or in part, provide the BSA with the ability to achieve significant improvement and comply with WQS, treatment control methods were considered for further analysis.

7.2.5.1 Treatment Basins

Treatment basins are constructed between the current regulator and the receiving water. The basins are typically sized to provide 30 minutes of detention time at the peak flow rate associated with the selected level of control. When the regulator activates, flow rates up to the peak overflow rate are routed to the basin, detained for at least 30 minutes, disinfected, and then discharged to the receiving water. Flow rates above this level bypass the basin and are discharged directly to the receiving water body. The bypassed discharge would be considered a CSO event in the new system. The basin and settled solids are dewatered to the interceptor and conveyed to the treatment facility for treatment at the end of the wet weather event. It is assumed that dewatering would be accomplished with pumps capable of dewatering the basin within 24 hours. Treatment basins would treat all flow associated with overflow events up to the selected level of control, and a portion of the flow throughout the duration of larger events.

Treatment basins were considered for further evaluation as an alternative for controlling CSOs.

7.2.5.2 Vortex Separators with Disinfection

Vortex separators are typically constructed between the current regulator and the receiving water. The regulators are sized to provide 15 minutes of disinfection contact time at the selected level of control peak flow rate, or to provide a maximum loading rate of 5 gallons per minute per square foot (gpm/sq. ft.) at the selected level of control peak flow rate. Vortex separators can be covered and odor control facilities provided. Foul flow pumps would convey the concentrated underflow to the interceptor. Hatches are provided around the perimeter for washdown with hoses. A sodium hypochlorite system could be used for disinfection.

Vortex separators with disinfection were considered for further evaluation as an alternative for controlling CSOs.

7.2.5.3 Enhanced High Rate Treatment (EHRT) with Disinfection

EHRT facilities are constructed between the current regulator and the receiving water body. EHRT facilities flocculate and settle suspended solids to primary removal efficiencies so that treated CSO flows may be subsequently disinfected for the peak flow rate associated with the selected level of control. When the regulator activates, flow rates up to the peak overflow rate are routed to the EHRT, disinfected, and discharged to the receiving water body. Flow rates above this level bypass the EHRT and are discharged directly to the receiving water body. The bypassed discharge would be considered a CSO event in the new system. The settled solids are pumped to the interceptor for conveyance to the treatment plant at the end of the wet weather event. EHRT facilities would be sized to treat all flow associated with overflow events up to the level of control, and a portion of the flow throughout the duration of larger events.

EHRT facilities were considered for further evaluation as an alternative for controlling CSOs.

While there is no official definition of high-rate disinfection (HRD), wet-weather practitioners have used the term to define disinfection that occurs in a shortened period of time using a high dose of disinfection agent with intense mixing. The most common chemicals used with HRD are liquid sodium hypochlorite for disinfection and liquid sodium bisulfite as a dechlorination chemical. Other possible disinfection chemicals available include gaseous chlorine and gaseous sodium dioxide for disinfection and dechlorination, respectively. While contact times vary, five minutes is typically used for disinfection and one minute for dechlorination. HRD was considered after EHRT, before discharge of the EHRT effluent into the receiving water body.

With the use of EHRT TSS, removal rates are high enough to allow alternate disinfection systems, such as ultraviolet (UV) disinfection. UV disinfection is the most common disinfection alternative to chlorine-based chemicals with approximately 20 percent of wastewater treatment plants using this mode of disinfection. The popularity of UV disinfection is primarily due to the safety and health benefits it provides over chemical disinfectants, as UV light is a physical disinfecting agent that utilizes specific wavelengths of electromagnetic radiation. UV systems are power-intensive with medium pressure technology generally being associated with largest power requirements. Because of this, sodium hypochlorite disinfection was considered instead of UV disinfection, for sites with EHRT facilities.

7.2.6 Floatables Control

Street litter and floatables, such as plastic bottles, cups, leaves, cans, and rags, typically enter a CSS either by surface runoff generated during wet weather events or by deliberate dumping of trash into catch basins or sewers. Floatables cause aesthetic and odor problems in populated areas and contribute to the CBOD load of affected waterways. Floatables control is a means of preventing visible debris from entering waterways. The primary advantage of the use of floatables control is the ability to improve stream aesthetics at a relatively low capital cost, as compared to other control technologies. The disadvantage of floatables controls is the inability to meet WQS for DO, suspended solids, and fecal coliform, without additional controls.

Floatables control technologies screened as part of the development of the BSA's LTCP include:

- Catch basin modification;
- Underflow baffles;
- Screening devices;
- Vortex-type separators; and
- Netting systems.

This section provides information on the configuration and operational characteristics of various floatables control technologies and approaches.

7.2.6.1 Catch Basin Modification

One method of floatables control is to prevent the floatables and solids from entering the combined sewers (*i.e.*, floatables source control), through the use of a preliminary separation system. The simplest form of pre-separation that can be provided on a CSS involves catch basin modifications, such as:

- Replacement of existing castings with new castings, including coarse screens to catch larger solids and floatables.
- Installation of a catch basin trap consisting of a hood and a hanger plate. The catch basin trap is installed around the existing outflow pipe to prevent floating debris from entering the combined system.

Due to the magnitude of catch basin modifications required to effectively achieve floatables control, catch basin modifications were not considered for further evaluation in the LTCP development.

7.2.6.2 Underflow Baffles

Larger solids and floatables can be captured within the collection system with underflow baffles. Underflow baffles consist of stainless steel or aluminum plates installed in existing regulator structures. The effectiveness of the underflow baffles depends on the specific design of the diversion points for the overflows. Underflow baffles generally have lower capital and O&M costs than other solids and floatables removal devices such as screens and netting. Removal effectiveness of underflow baffles is likely to be lower, however, because of turbulence in the flow stream, which tends to entrain solids and floatables, especially those that are relatively close to neutral buoyancy. The advantages of underflow baffles include:

- The technology is well-known and understood, as noted in USEPA reports. Underflow baffles have been recommended by the USEPA as an effective means of floatables control.

- Ease of operation compared to other screening alternatives.

- Ease of construction without interfering with the current operation of existing CSOs.

The disadvantages of underflow baffles include:

- CSO regulators do not completely flush themselves clean, but instead may become clogged with solids and floatables over time. The addition of baffles are likely to make the solids and floatable accumulation problem worse, requiring more frequent cleaning of the CSO regulator.

- Performance and reliability factors are unknown, as only laboratory studies have been conducted. The Massachusetts Water Resource Authority (MWRA) conducted a study on the use of underflow baffles for CSO floatables control. Although the laboratory studies provided promising results, there is insufficient field data to prove acceptable reliability or performance. Therefore, field performance can be difficult to predict.

- Lower solids and floatables removal efficiencies are likely as compared to other technologies.

- Potential exists for clogging of interceptors with solids/floatables after wet weather events.

Due to the disadvantages summarized in this section, underflow baffles were not considered for further evaluation in LTCP development.

7.2.6.3 Screening Devices

Screening devices are used to prevent floatables from being discharged from CSOs to receiving water bodies during wet weather events. Screening of CSOs can be challenging because the quantities and loading rates of floatables and solids vary widely during the course of a wet weather event, from first flush at the initiation of the event to more dilute conditions towards the end of the event. If a period of drought is followed by a significant storm event, the quantity of floatables and solids discharged from CSOs will likely be high. However, if two storm events occur on consecutive days, the quantity of floatables and solids discharge from the CSOs from the second day's storm would be reduced. Selected screening systems for CSO control must be designed with sufficient flexibility to adapt to the fluctuations in floatables and solids loading conditions. Screening systems for floatables control in combined systems are typically installed in regulator chambers to prevent solids from being discharged from CSO outfalls.

Screening devices that were included in the technology screening process include:

- Static bar screens;
- Vertical mechanical bar screens;
- Horizontal mechanical bar screens; and
- Rotary drum screens.

Vertical, horizontal, and rotary drum screens are considered as high-level floatables control. Screening devices are typically independently insufficient for total CSO control; however, where bacteria are the only pollutant of concern, they can be coupled with chemical disinfection facilities to provide sufficient solids removal for effective disinfection. Due to the simplicity of operation, in addition to the other advantages further detailed in this section, screening devices were considered for further evaluated in LTCP development.

Static Bar Screens

Static bar screens are one of the least expensive forms of screening technologies available. A static bar screen consists of sturdy bars, aligned parallel to one another. The screens are fixed in place, trapping solids and floatable material. Static bar screens are manual, stand-alone systems without any mechanical moving parts or any automated cleaning mechanisms.

However, static bar screens have the following disadvantages:

- Periodic manual cleaning of solids and floatables from the screen is required. Maintenance crews are generally required to visit each screen during and after each storm event to ensure that screens do not become clogged, restricting flow.

- Regular visitation of bar screens increases the frequency of confined space entry by maintenance personnel.

- Static bar screens typically require significant space for installation, which potentially could limit access to the manholes in which they are installed.

- Static bar screens have the potential of clogging with solids and floatables, which may adversely affect flow patterns to CSO outfalls. Flow restrictions to the outfall pipe can also surcharge trunk sewers, leading to further problems such as basement backups and overflowing catch basins and chambers.

- Because of flow restriction limitations, use of static bar screens sometimes requires the installation of new screening chambers, which add significant costs to this approach.

Vertical Mechanical Bar Screens

Vertical mechanical bar screens are typically equipped with a vertical, inclined, static bar screen rack which remains submerged below the water surface, and a mechanical rake arm which remains above the water surface. When the bar rack requires cleaning, the mechanism periodically drives the rake arm down below the water surface and onto the bar rack, raking the bars clean. The rake arm continues to rake upward on the screen to a discharge chute, where the solids and floatables are dumped into a storage container. The advantages of vertical mechanical bar screens include:

- The technology is well-known, understood, and reliable and has been used in wastewater treatment for decades.

- The rake arm mechanism prevents the bar screen from clogging and may be programmed to activate when high water levels are detected in a chamber.

- Bar screens consist of thick, heavy-duty bars, which are more structurally sturdy during storm events when compared to other wire mesh-type screens.

- Addition of flushing water systems is possible to flush solids and floatables back to the interceptor.

- Mechanical bar screens are effective for removal of solids and floatables of 0.5 inches and greater in size depending on the bar spacing.

The disadvantages of vertical mechanical bar screens include:

- The mechanical and electrical components have more O&M requirements than other non-mechanical screening options.

- High height clearances are involved, which may present a problem at some overflow locations.

- Additional concrete or other structures are typically required to house the screening facilities, resulting in higher capital costs.

Horizontal Mechanical Bar Screens

Horizontal mechanical bar screens are a relatively new technology utilized in the United States to screen solids and floatables, though the screens have been utilized for a longer period in Europe for CSO control. The screens are rigid, weir-mounted, and constructed of narrow, corrosion resistant stainless steel bars with evenly spaced openings. The screening bars are designed in continuous runs with no intermediate supports to collect solids. The screen is activated automatically by a level sensor as storm water rises sufficiently to overflow the weir of the screen. When the screen requires cleaning, a hydraulically-driven rake assembly travels back and forth across the screen, combing away solids trapped on the screen. The combing tines carry the solids to one end of the screen for disposal back into the wastewater channel. The advantages of horizontal mechanical bar screens include:

- The rake arm assembly prevents the bar screen from clogging and may be programmed to activate when high water levels are detected in the chamber.

- Bar screens consist of thick, heavy-duty bars, which are more structurally sturdy during high storm flows than other wire mesh-type screens.

- Solids and floatables are “pushed back” into the wastewater channel to be handled at the treatment plant. Therefore, there are minimal maintenance personnel costs for screenings pickup and transportation.

- Horizontal mechanical bar screens are effective for removal of solids and floatables of 0.5 inches and greater in size depending on bar spacing.

The disadvantages of horizontal mechanical bar screens include:

- The technology is relatively new in the United States.

- The mechanical and electrical components have more O&M requirements than other non-mechanical screening systems.

Rotary Drum Screens

Rotary drum screens are used in wastewater treatment facilities for a variety of applications including municipal and industrial wastewater, food processing and pulp and paper industries, and CSOs and SSOs. The screens consist of wedge wire, which is wrapped around to form a drum screen that is open on both ends. The drum screen is mounted on a carriage of mechanical rollers, rotating around a horizontal axis parallel to the sewage flow. The screening action takes place inside the drum. Combined sewage enters through the one end of the unit and is screened as it drops through the wall of the drum. The screenings are moved to the other end of the rotating drum by a set of spiraled conveying vanes fixed on the interior wall of the drum. The screenings are discharged from the opposite end of the unit and screenings are collected in a container. The advantages of rotary drum screens include:

- The technology is well-known and well-understood.

- The rotating action and an internal spray cleaning system prevent the drum screen from clogging.

- Drum screens are effective for removal of solids and floatables of 0.5 inches and greater in size.

- Drum screens have crossbars across the wedge wire, which create smaller slot openings than mechanical bar screens.

- Drum screens have lower height clearances than bar screens.

The disadvantages of rotating drum screens include:

- The mechanical, electrical, and water spray components have more O&M requirements than mechanical bar screens and other non-mechanical screening systems.

- Additional concrete or other structures are typically required to house the screening facilities, resulting in increased capital costs.

- The wedge wires for the drums are not constructed of thick, heavy duty bars (unlike) bar screens, raising the concern of whether or not the wedge wire construction can withstand the force from the repeated high flows generated by CSOs.

- The number of mechanical components associated with this technology is greater than other screening devices, and therefore, the potential for failure of this type of device is greater.

- Maintenance personnel costs are increased due to required screenings pickup, transportation, and disposal.

7.2.6.4 Vortex-Type Separators

A vortex separator is a cylindrical unit, which uses the hydrodynamics of swirling or vortex velocities to concentrate and remove solids and grit. The unit has no moving parts. Storm flows enter the unit tangential to the cylindrical chamber to create a swirling vortex that imparts velocities beneficial to separating solids out of liquids. Vortex separation occurs when the circulating suspended solids are drawn to the center of the swirl and are directed down toward the center of the unit where the solids concentrate. This mixture of concentrated solids and wastewater is then removed from the bottom of the unit by a “foul” sewer pipe, which directs the solids flow back to the interceptor conveying flow to the treatment plant. The clarified effluent exits the top of the unit and is discharged to the receiving outfall through an outfall pipe from the vortex separator unit.

Currently, there are several types of vortex separators in use in the United States; despite variations among the different types, the principles of operation are essentially the same among the various units. The advantages of vortex separators include:

- Vortex separators are a viable CSO control technology that has been installed in several locations in the United States, Great Britain, Germany, Japan, and other countries.

- Depending on the type of vortex separator, it may be possible to pump the floatables and solids collected by the vortex separator into the interceptor with a cleanout pump, thus minimizing mechanical cleaning.

The disadvantages of vortex separators include:

- Vortex separator units for large urbanized areas may require a large footprint area for installation. In general, the spatial requirements are higher than those required for screening or netting technologies.

- More extensive construction is needed for vortex separator systems. Typical vortex separator units approach an average depth of 30 ft, which is more than three times the typical depth required for concrete chambers for screening or netting technologies.

- Performance of larger vortex separator systems has not yet been confirmed. Overall performance results of vortex separators are scattered.

- Depending on the type of vortex separator, removal of solids from the vortex units may or may not require mechanical cleaning, which would incur additional O&M costs. A vortex separator system with a cleanout pump included in the design would also incur additional O&M costs associated with pump operation and maintenance. Vortex separators without cleanout pumps would incur additional costs associated with manual cleaning and maintenance.

Vortex separators are independently insufficient for total CSO control. However, due to the advantages summarized in this section, vortex separators were considered for further evaluation in LTCP development.

7.2.6.5 Netting Systems

Two types of netting systems were identified during the development of the control alternatives:

- End-of-pipe; and

- In-line.

Because of their simplicity in capturing floatables, netting systems were considered for further evaluation in LTCP development.

End-of-Pipe Netting Systems

End-of-pipe netting systems are designed to “catch” floatable materials shortly after being discharged by CSOs. Most applications consist of simple components, such as pontoons, support columns, nylon netting, polyvinyl chloride (PVC) sheet baffles or curtains, wood beams, and concrete anchors. The standard end-of-pipe netting system consists of a floating pontoon structure that can accommodate nylon mesh bags that are positioned at a given distance into the water facing the end of the outfall pipe. The end of the outfall pipe is channeled into the mesh bags, which are each sized to capture a given volume of floatable material. The floating pontoon structure is held in place during excessive storm events by fixed and firmly anchored roller columns.

When the mesh bags are full, they are winched to shore and lifted by crane to an on-land location or picked up in the water by skimmer boats. The waste materials are usually landfilled and clean nets are replaced on the system.

The advantages of this system include:

- Construction of an on-land concrete chamber to hold screening equipment is not required.
- The system can be constructed without interfering with current operation of existing CSOs.
- End-of-pipe netting is effective for removal of solids and floatables of 0.5 inches and greater in size.
- The mesh bags provide more screening surface area per unit flow area than any other screening alternative.
- The system may be easily expanded with additional mesh bags for only minimal design and construction effort relative to other alternatives where expansion may not be economically feasible.

The disadvantages of this system include:

- Operation and personnel costs will increase due to required localized screenings pickup, transportation, and disposal, and to install new nets.
- A mobile hoisting crane is required to retrieve and remove the full nets from the water.
- Access to the nets may be difficult in some areas.
- The technology is not applicable to outfalls with shallow water depth or where outfalls do not enter the water surface with adequate submergence.
- Wetlands and stream coastal encroachment permitting will be required.

In-Line Netting Systems

In-line netting can be installed where end-of-pipe installations are not technically feasible. This system operates on the same principle as the end-of-pipe nets but consists of a concrete chamber to hold the mesh bag netting, net support guides, and access hatches, and a mesh bag net insert.

This system allows for the netting, floatables, and solids to be removed from the chamber by hoisting the nets out of the chamber with a crane, which may then be loaded on a truck for disposal. In addition to the advantages mentioned for the end-of-pipe netting system, advantages for this alternative include:

- Wetland and coastal encroachment permits may not be required.
- Personnel and equipment will be more accessible for removal and disposal of the nets than the end-of-pipe netting alternative.

Disadvantages of the in-line netting system include:

- Operation and personnel costs will increase because screenings pickup, transportation, and disposal will be required with this alternative for the manual disposal of the solids and floatables captured in the netting and for installing new nets.
- A mobile hoisting crane is required to retrieve and remove the full nets from the water.

7.2.7 Non-CSO Source Alternatives

In addition to express sewers discussed in Section 6.2.3.4, non-CSO source alternatives may include other actions to reduce wet weather inflows to the CSS from tributary separate sanitary systems, such as inflow and infiltration (I/I) removal.

The primary advantage of non-CSO source alternatives is the relatively low O&M costs of certain technologies (*i.e.*, I/I removal will typically result in a decrease in O&M). The primary disadvantages are the high capital costs associated with I/I identification and removal. Furthermore, some construction associated with I/I removal would be disruptive to local residents. In the case of the BSA service area, however, the vast majority of separate sewer systems are owned and maintained by tributary municipalities where the BSA has little control.

Non-CSO source technologies are typically used in site-specific applications. However, these methods are generally considered to be independently insufficient for total CSO control. Due to their high capital costs, non-CSO source alternatives were not evaluated as an alternative for complete control, but were considered in conjunction with other alternatives.

7.3 Level of Control Curves by Combined Sewer Overflow Developed During the 2004 LTCP

In order to develop the 2004 LTCP, CSO control levels were selected to define the performance targets for abatement alternatives. To facilitate this, level of control curves were generated for each CSO within the BSA collection system for both a generic storage and a generic treatment option.

7.3.1 Design Storm Development

The first step in the process to develop the level of control curves was to develop a set of design storms to be used to define the different levels of control. For this purpose, 6-hour duration design storms were developed for the following return periods: 1-month, 2-months, 3-months, 4-months, 6-months, and 1-year.

During Phase I, Stage 1, design storms with return periods of 1-month, 2-months, 3-months, 6-months, and 12-months were developed based on historical rainfall. However, during Stage 2, it was determined that these design storms may generate higher CSO volumes than would typically be expected at the designated return periods due to the varying durations of the design storms. Also, the Phase I, Stage 1 and 2 evaluations did not include a 4-month design storm. Therefore, a new set of design storms was developed for Phase I, Stage 3. The new set of design storms contains 6-hour duration storms, eliminating the effect of variable storm duration on generated CSO volume. A 4-month design storm was developed as an additional point of system-evaluation, as well.

The rainfall volumes for the Phase I, Stage 3 design storms were determined by extrapolating from the 6-hour duration rainfall volumes for Buffalo, New York, for return periods of 2, 5, 10, 25, 50, and 100 years as specified in the *Northeast Regional Climate Center Atlas of Precipitation Extremes for the Northeastern United States and Southeastern Canada*. In the absence of data specific to Buffalo, the rainfall volumes for the lower return periods were extrapolated by assuming that their values relative to the values for the higher return periods were similar to the relationship between rainfall volumes for different return period 6-hour storms in Cleveland, Ohio, as specified in the *Midwest Rainfall Frequency Atlas*. These rainfall volumes were distributed using a first quartile Huff distribution. This distribution is appropriate for storms with durations of six hours or less. The resulting storm hyetographs for the six design storms are shown in Figures 7-1 to 7-6. Table 7-1 compares the Phase I, Stage 1 and Stage 3 design storm parameters. All model simulations conducted under Phase I, Stage 3, use the Stage 3-developed design storms.

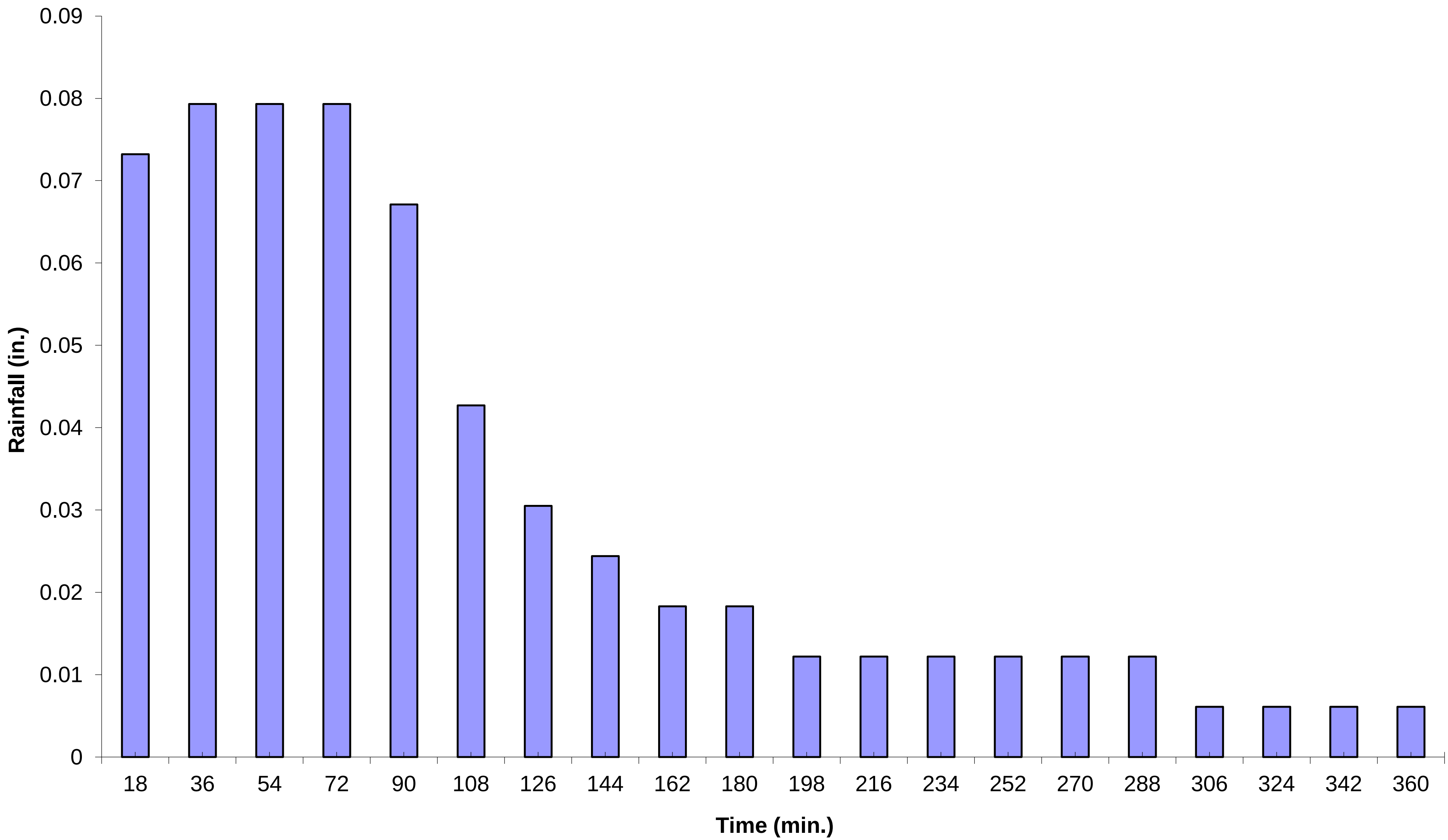

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FIGURE 7-1
1-Month Design Storm Hyetograph

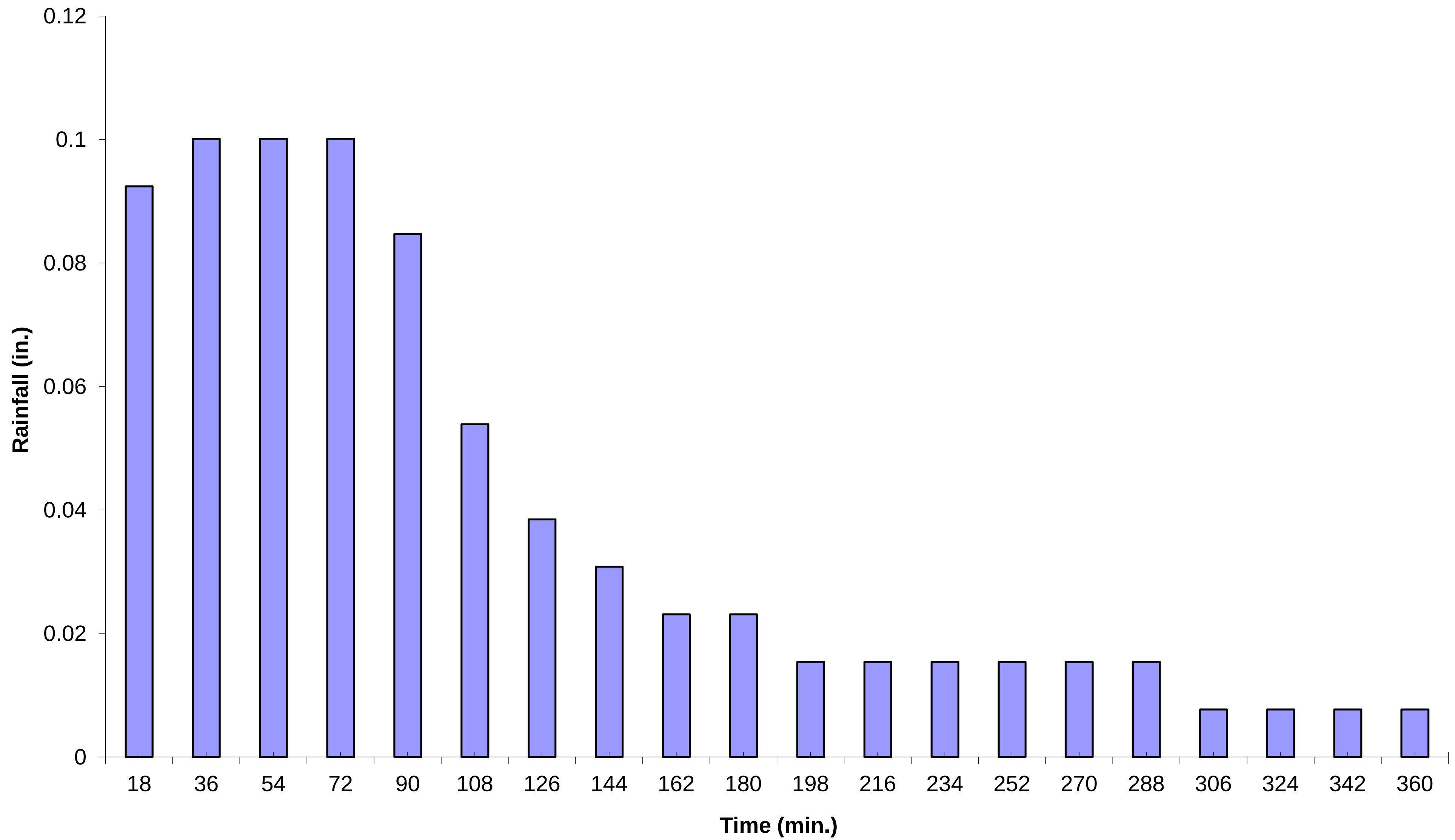

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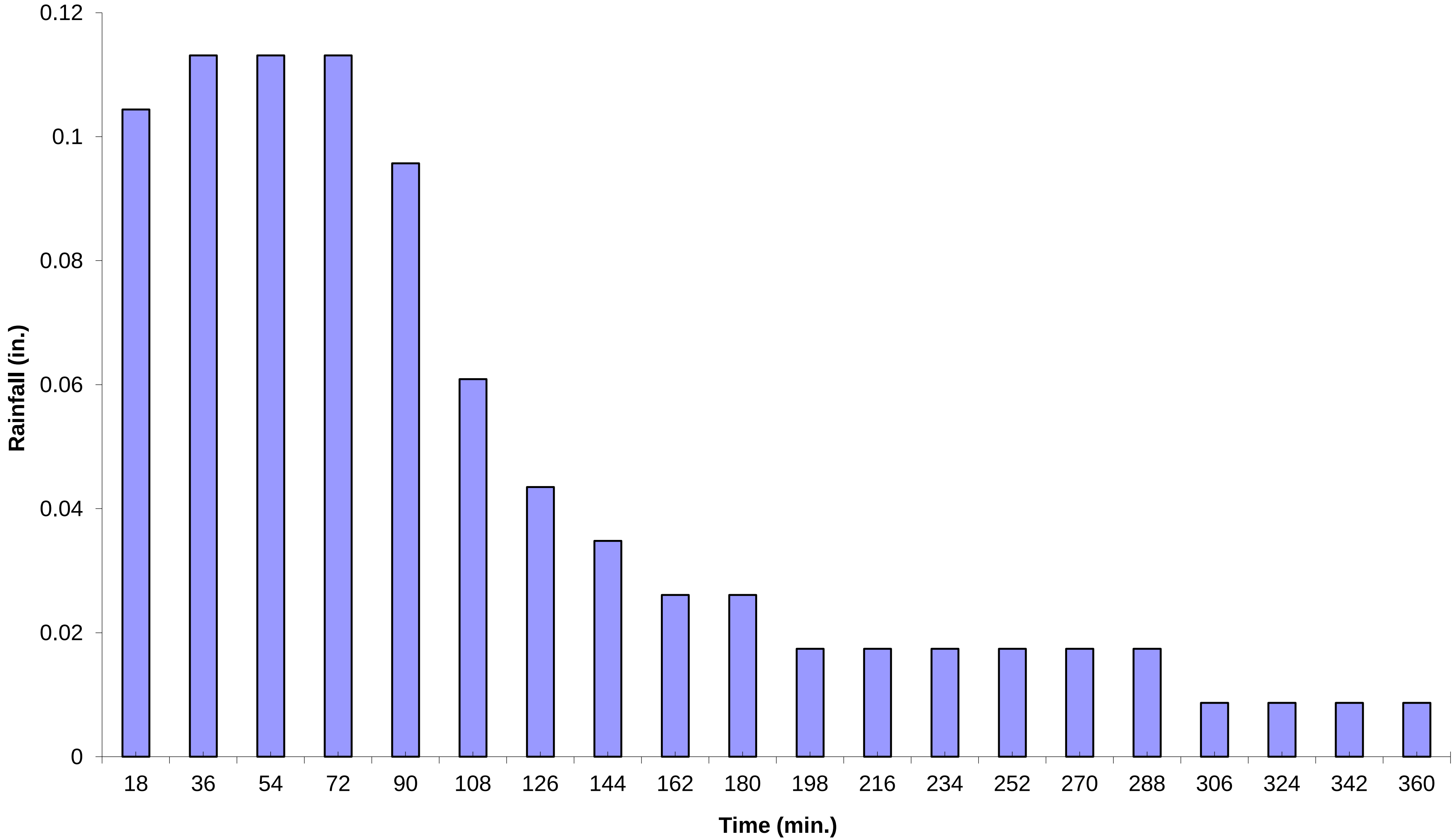
FIGURE 7-2
2-Month Design Storm Hyetograph



MALCOLM PIRNIE / ARCADIS — The Water Division of ARCADIS	**BUFFALO SEWER AUTHORITY** **Long Term Control Plan Update**	**FIGURE 7-3** **3-Month Design Storm** **Hyetograph**
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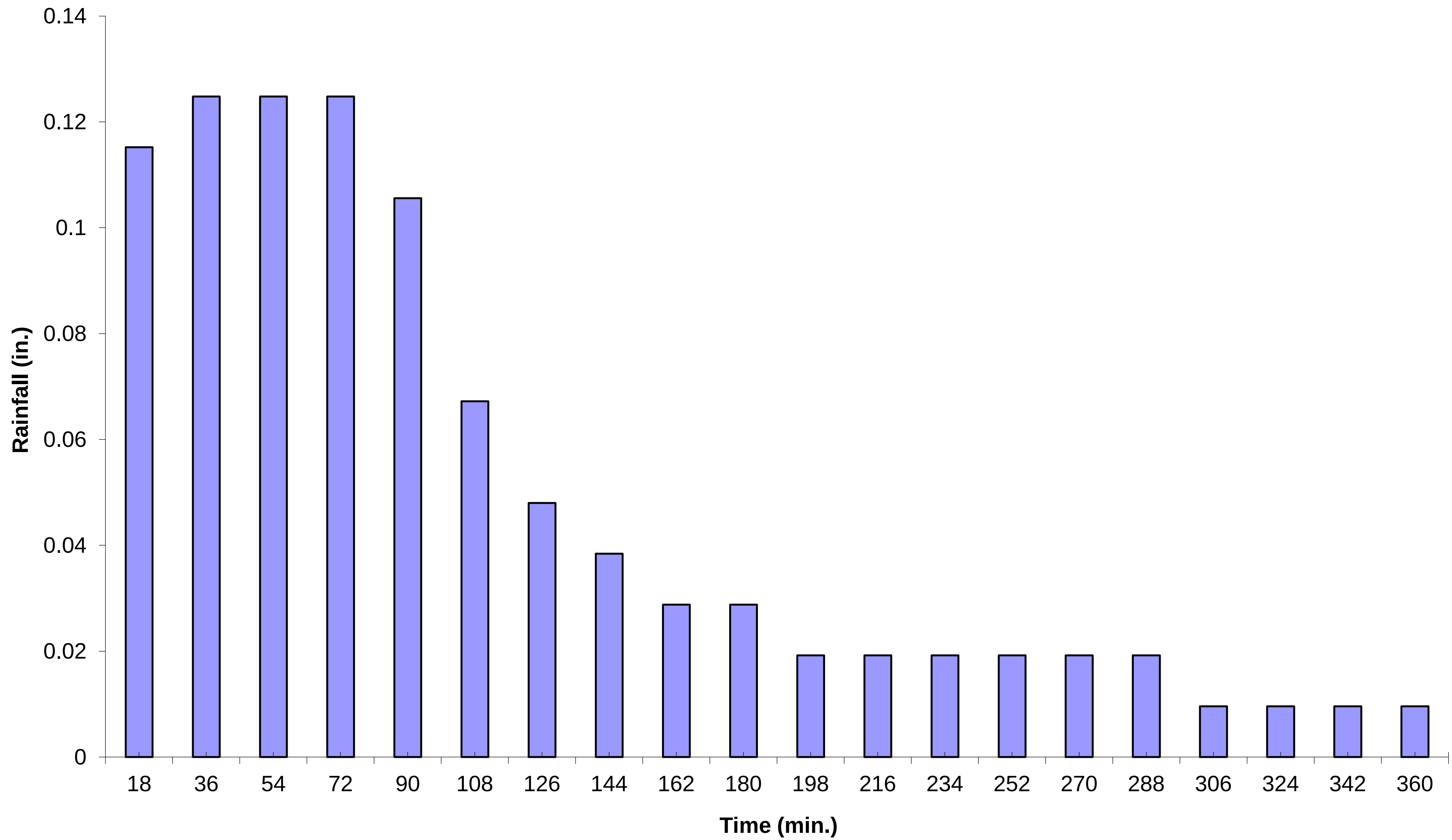

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FIGURE 7-4
4-Month Design Storm Hyetograph

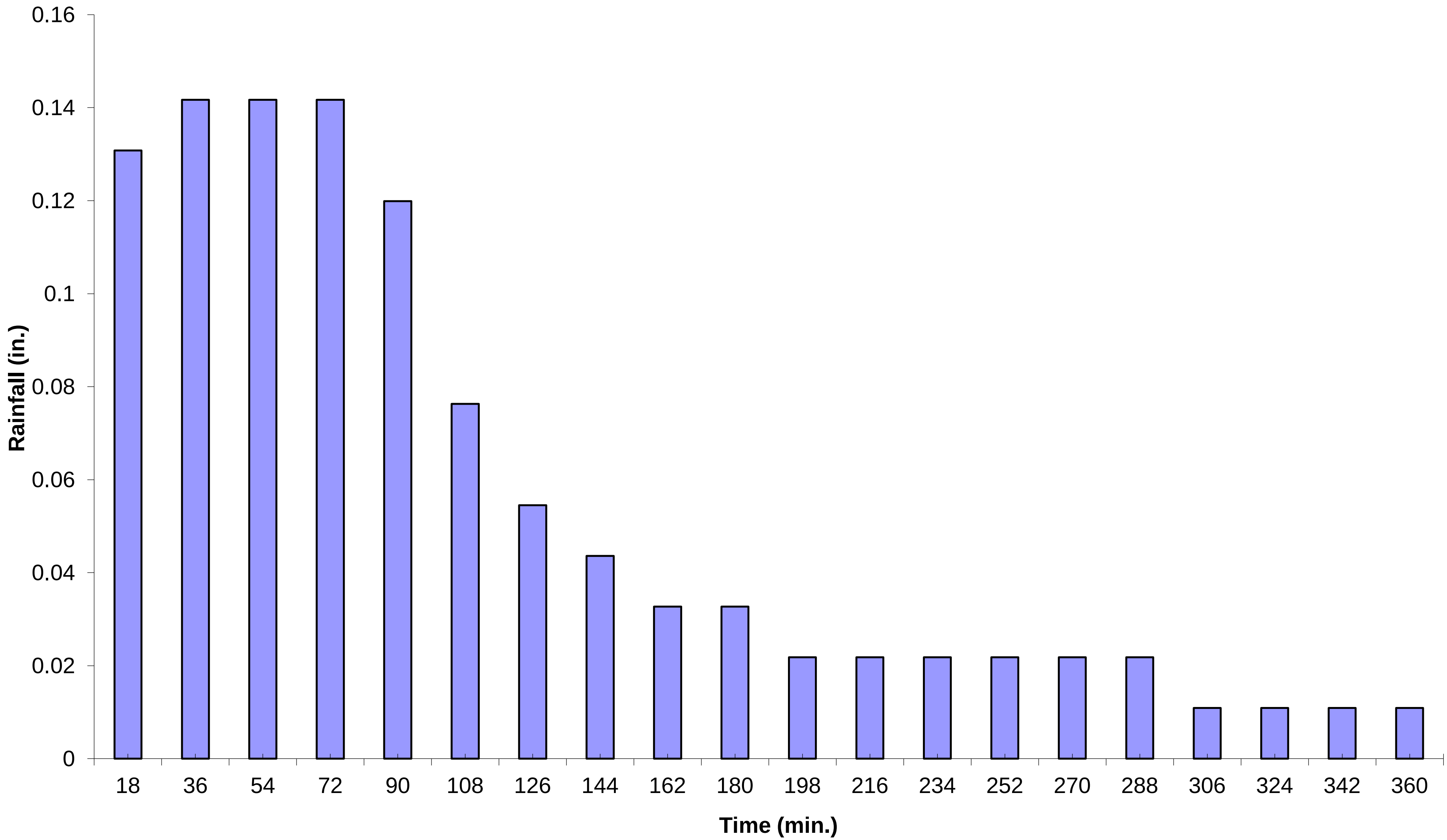

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FIGURE 7-5
6-Month Design Storm Hyetograph

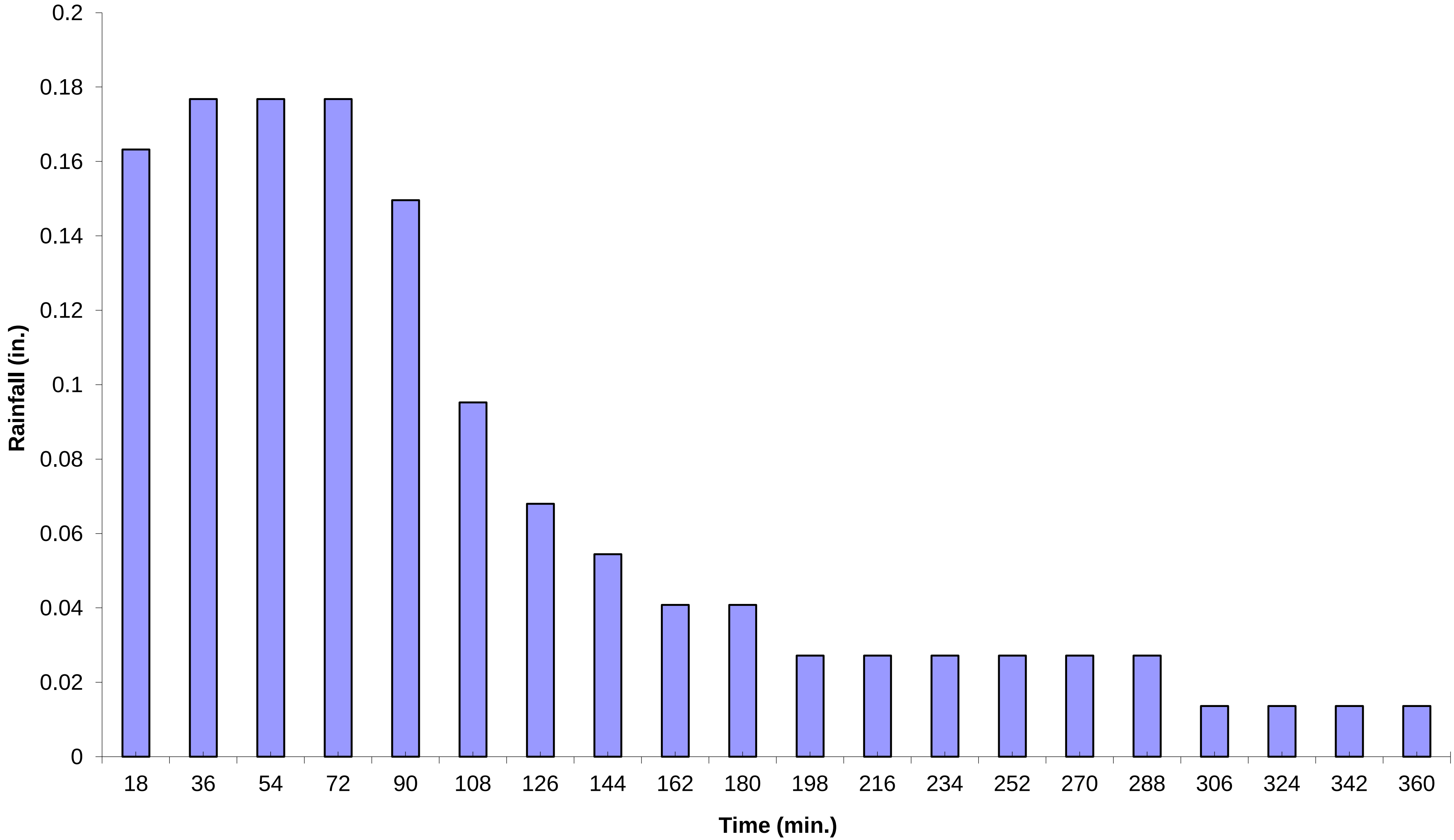

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FIGURE 7-6
1-Year Design Storm Hyetograph

Table 7-1.
Design Storm Comparison: Stage 1 to Stage 3

Design Storm	Stage 1		Stage 3	
	Duration (hrs)	Rainfall (in)	Duration (hrs)	Rainfall (in)
1-Month	4	0.81	6	0.61
2-Month	4	1.2	6	0.77
3-Month	10	1.28	6	0.87
4-Month	NA	NA	6	0.96
6-Month	7	1.89	6	1.09
12-Month	8	2.56	6	1.36

Notes:
NA = Not Applicable; A 4-month design storm was not simulated for Stage 1.

This design storm analysis, however, was not completed during the Phase III of the 2004 LTCP; therefore, the results presented in the following sections represent the Phase I (2004) model conditions and simulation periods.

7.3.2 Existing Conditions Assessment - 2004 LTCP

7.3.2.1 Existing Conditions Design Storm Simulations – 2004 LTCP

Each of the design storms listed above was run for the existing conditions model in order to determine the overflow volume and peak flow rates for each CSO within the system for each design storm. These values were then used to establish design parameter values for both the storage and treatment options. For the storage option, the storage volume for a CSO at a given level of control was set equal to the overflow volume of the corresponding design storm. For the treatment option, the design treatment rate for a CSO at a given level of control was set equal to the peak flow rate of the corresponding design storm.

7.3.2.2 Existing Conditions Continuous Simulation – 2004 LTCP

In addition to the design storms, the annual continuous simulation was run for the existing conditions system. The annual overflow statistics (i.e., overflow volume, overflow duration, and number of overflow events) were calculated for each of the CSOs in the BSA collection system. This simulation established the baseline conditions for evaluation of alternatives during Phase I LTCP efforts. Note that the evaluations presented below were performed using the 1986 typical year developed during the Phase I LTCP effort.

7.3.3 Storage Technology Option Evaluation – 2004 LTCP

7.3.3.1 Description

The storage technology option evaluation examined the impact on annual CSO overflow statistics from providing storage facilities located near the outfall of every CSO within the BSA collection system. For this evaluation, the storage facilities were sized to provide the storage volume associated with the selected design storm control level. It was assumed that flow in excess of this volume would be routed around the storage facility for discharge to the receiving water. This discharge would be considered a CSO event in the new system. After the wet weather event, the storage facility would be dewatered to the interceptor with pumps capable of dewatering the basin within 24 hours. Therefore, these storage facilities would capture all of the volume associated with overflow events up to the design storm control level, and the first flush of larger events.

7.3.3.2 Determination of CSO Overflow Statistics – 2004 LTCP

Annual continuous simulations were run for each of the six levels of control. To do this, the existing conditions model from Phase I was modified by adding representations of storage basins at each CSO. This was done by splitting the model link upstream of the CSO outfall node in two and placing a storage model node between the two links. The invert and area of this storage node were set to values such that the desired storage volume for the level of control was reached when the water level within the node reached the upstream invert of the outgoing model link. A pump link connecting the storage node with the interceptor located nearest to the CSO was also added. This pump link represented the pumps that would be used to dewater the storage basin following rainfall events with pump capacity initially set equal to the flow rate needed to dewater the total storage volume within 24 hours. The sum of the resulting dewatering rates for all of the storage basins was then calculated. This value was then compared with 187 MGD, the ultimate capacity available for dewatering of storage basins in the BSA collection system established for the 2004 LTCP (*i.e.*, the difference between BSA's theoretical secondary treatment capacity of 320 MGD and the average daily flow of 144 MGD). For those levels of control for which the sum of the dewatering rates was less than 216 MGD, the capacities of the dewatering pumps were kept at the 24-hour dewatering level. For those levels of control for which the sum of the dewatering rates was greater than 216 MGD, the capacities of the dewatering pumps were adjusted so that their sum equaled 216 MGD. After the continuous simulations were completed, the annual overflow volume, annual overflow duration, and annual overflow events were calculated for each CSO.

For this LTCP, the WWTP secondary system capacity has been revised to 320 MGD; therefore, the ultimate capacity available for dewatering of storage basins was modified to 175 MGD for Phase III evaluations.

7.3.3.3 Level of Control Curves – 2004 LTCP

Six different level of control curves were developed for each CSO evaluated for the storage option. These curves were as follows: (1) annual overflow volume vs. level of control; (2) annual overflow volume vs. storage volume; (3) annual overflow duration vs. level of control; (4) annual overflow duration vs. storage volume; (5) annual overflow events vs. level of control; and (6) annual overflow events vs. storage volume. Two system-wide level of control curves were also developed for the storage option. The first curve (Figure 7-7) plots annual system-wide overflow volume vs. level of control. The second curve (Figure 7-8) plots annual system-wide overflow volume vs. total storage volume. For both curves, the values for CSOs 006 and 053 were not included in the total because they include water from Scajaquada Creek, and, therefore are not conducive to end-of-pipe storage.

7.3.4 Treatment Option Evaluation – 2004 LTCP

7.3.4.1 Description

The treatment option evaluation consisted of looking at the impact on annual CSO overflow statistics of having end-of-pipe treatment units located near the outfall of every CSO within the BSA collection system. The treatment units were assumed to provide 30 minutes of detention time at the peak flow rate associated with the selected design storm control level. When the regulator activates, flow rates up to the peak overflow rate would be routed to the treatment unit, detained for 30 minutes with disinfection, and then discharged to the receiving water. Flow rates above this level would bypass the treatment unit and be discharged directly to the receiving water. This bypassed discharge was considered a CSO event in the new system. The treatment unit settled solids would be dewatered to the interceptor. Therefore, the treatment units would treat all of the flow associated with overflow events up to the design storm control level, and a portion of the flow throughout the duration of larger events.

7.3.4.2 Determination of CSO Overflow Statistics – 2004 LTCP

Unlike the storage option, annual continuous simulations were not conducted to assess the impact of the treatment option on the CSO overflow statistics. Instead, the CSO hydrographs from the existing conditions continuous simulation were post-processed in order to calculate the statistics. This was done by comparing the modeled flow rate with the CSOs design treatment rate for each of the specified levels of control. Whenever the modeled flow rate exceeded the design treatment rate for the CSO, it was assumed that an untreated overflow event would occur. The difference between the modeled flow rate and design treatment rate for these occasions was used to estimate the untreated overflow volume that resulted.

7.3.4.3 Level of Control Curves – 2004 LTCP

Six different level of control curves were developed for each CSO evaluated for the treatment option. These curves were as follows: (1) annual untreated overflow volume vs. level of control; (2) annual untreated overflow volume vs. treatment rate; (3) annual untreated overflow duration vs. level of control; (4) annual untreated overflow duration vs. treatment rate; (5) annual untreated overflow events vs. level of control; and (6) annual untreated overflow events vs. treatment rate. A system-wide level of control curve was also developed for the treatment option (Figure 7-9), plotting annual system-wide untreated overflow volume vs. level of control. For this curve, the values for CSOs 006 and 053 were not included in the total because they include water from Scajaquada Creek and therefore are not conducive to end-of-pipe treatment.

7.4 2004 LTCP Unit Pricing Summary

Preliminary unit price estimates were developed for each CSO control technology selected as part of the technology screening and selection process. The Draft Alternative Screening Protocol, issued in January 2001, included an initial set of unit prices for various CSO control technologies, which were then updated during development of the 2004 LTCP. The updated unit price estimates included both construction costs and annual O&M costs. This section presents the general assumptions used in developing unit pricing for the various categories of proposed technologies for CSO control for the 2004 LTCP.

The standardized cost estimating information presented in this section accommodates a wide range of potential technologies. However, there are cases where a potential technology at a particular location required special cost considerations. These special cost considerations are detailed in the alternative pricing summaries presented in Section 9 of the report.

Sources used to develop unit pricing include:

- Means Building Construction Costs Data 2003 (book);
- Construction bid tabulations from similar projects;
- Cost curves developed from construction costs of similar projects;
- Cost curves from USEPA design manuals; and
- Cost quotes from contractors.

Where required, unit prices were adjusted to current year dollar values by using the Engineering News Record Construction Cost Index (ENRCCI). The present worth of O&M costs were obtained by multiplying

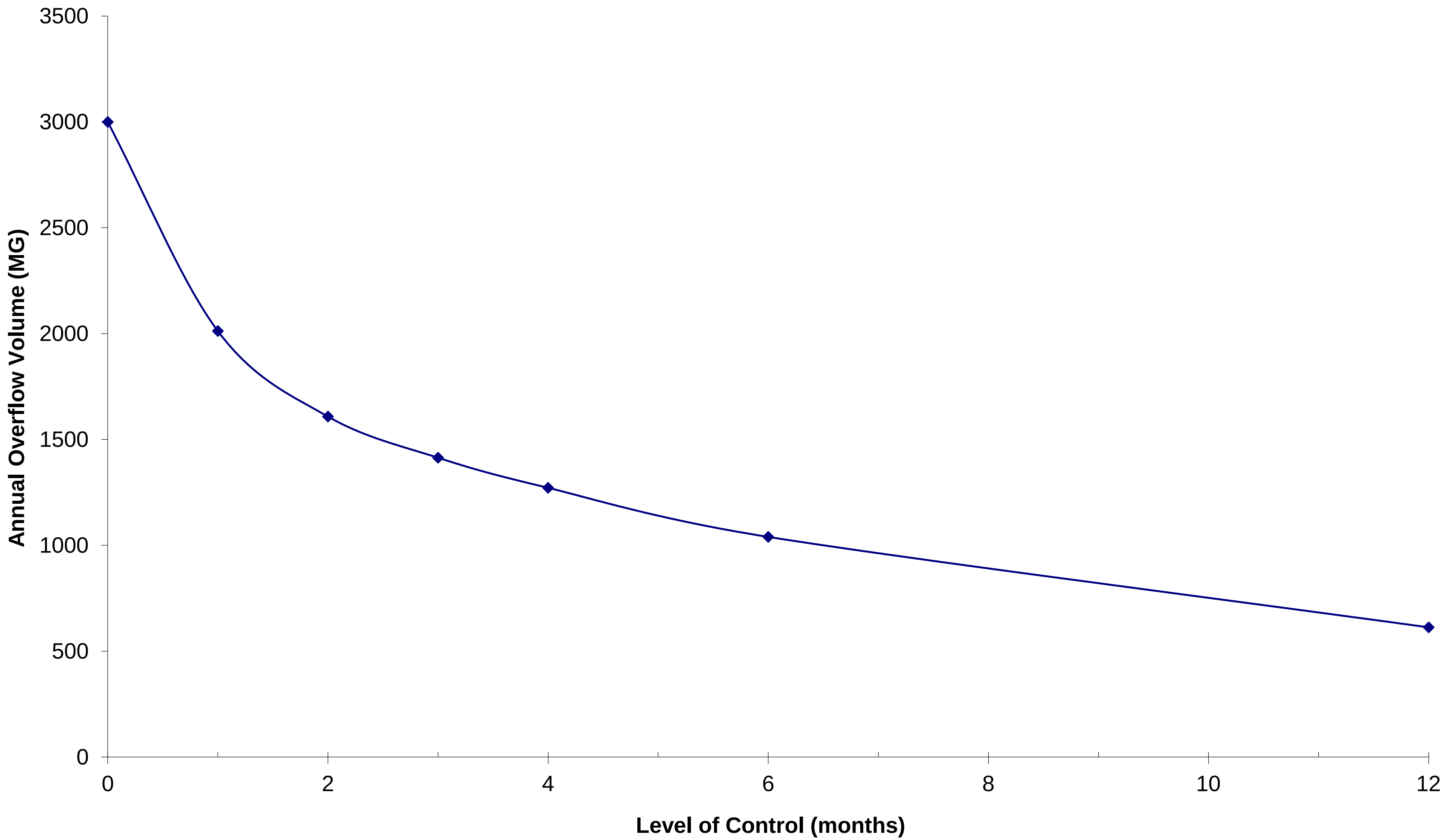

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FIGURE 7-7
System-Wide Curve: Overflow Volume vs. Storage Level of Control from 2004 LTCP

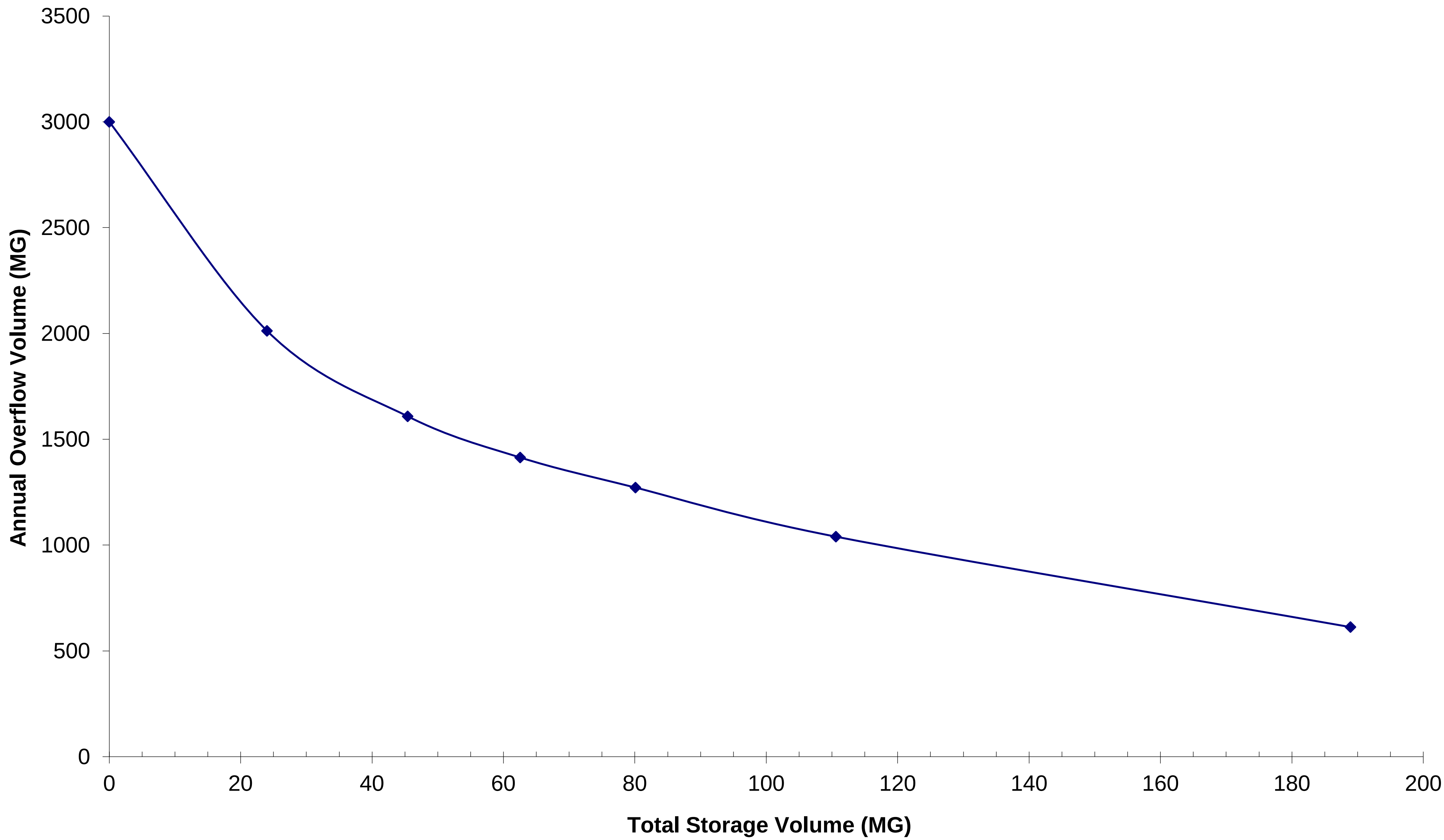

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FIGURE 7-8
System-Wide Curve: Overflow Volume vs. Total Storage Volume

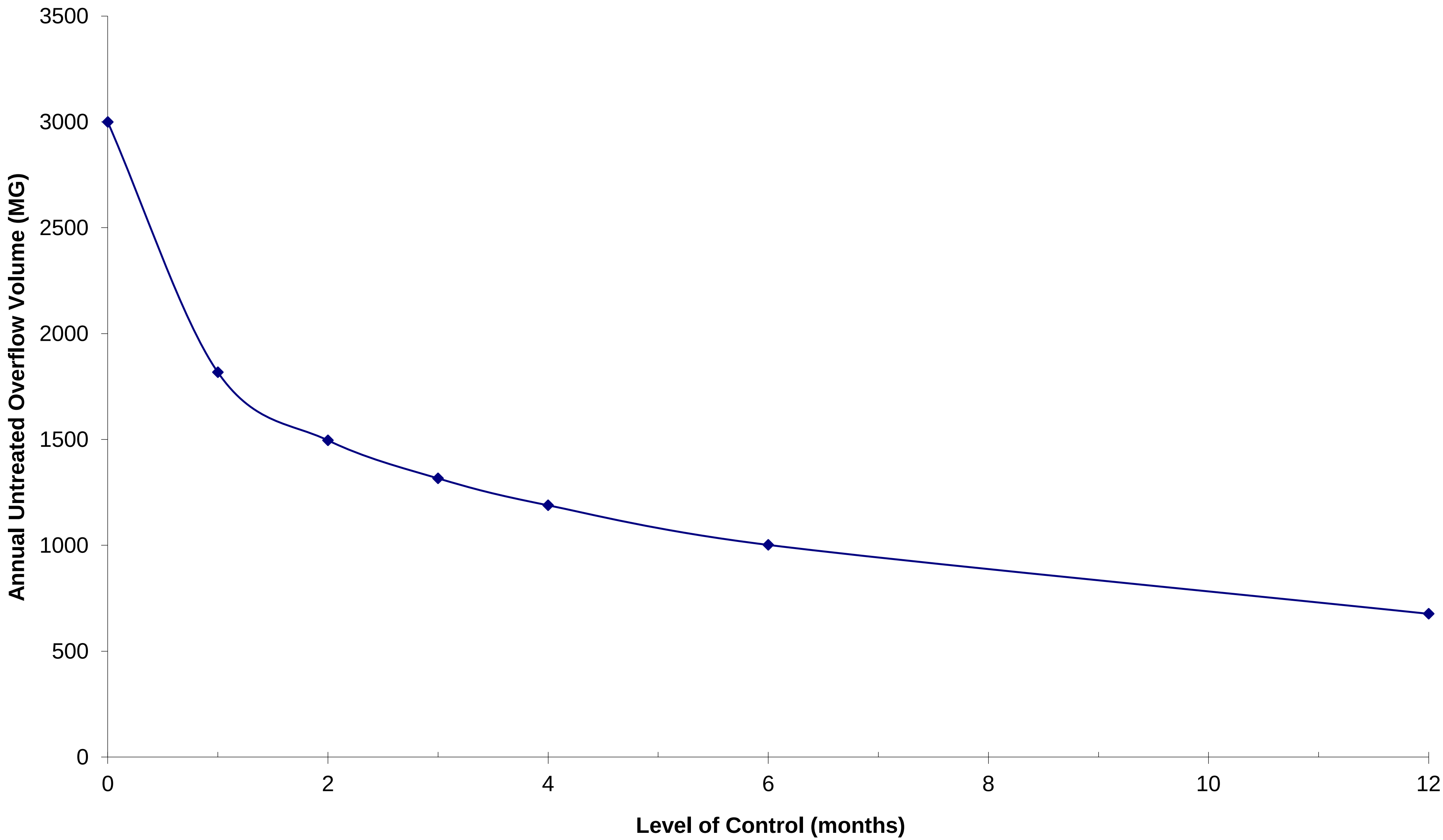

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FIGURE 7-9
System-Wide Curve: Overflow Volume vs. Treatment Level of Control

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estimated annual O&M expenses by the present worth factor. The present worth factor assumes a 20-year planning horizon, an interest rate of 5%, and an inflation rate of 2.5%. The salvage value of alternative LTCP improvements was not considered in the present worth of cost estimates because the entire capital cost of the improvements was considered to be borne by the current generation (*i.e.*, generation cost). Cost estimating backup documentation is provided in Appendix 7-1.

Generally, the unit prices for all of the various technologies included pricing for:

- Excavation, backfill, and select fill;
- Excavation sheeting;
- Excavation dewatering;
- Manholes;
- Pavement / surface restoration;
- Piping materials; and
- Land acquisition.

Items specifically excluded in the unit costs used are identified in the cost discussions, where appropriate.

Each component of each alternative evaluated was assigned a unit price. The components that were included in the alternatives evaluation, and therefore the costing, are:

- Floatables control;
- Weir modifications;
- Orifice plate modifications;
- Satellite storage facilities;
- Deep rock tunnels;
- EHRT facilities;

- Connector pipes; and
- Sewer separation.

7.4.1 Floatables Control

Floatables control units were assumed to be constructed between the current regulator and the receiving water body. The units are typically sized for screening the peak CSO flow rate associated with the selected level of control. At overflows where end-of-pipe treatment is provided by means of satellite storage facilities, deep rock tunnels, or EHRC facilities, floatables control are provided as part of the control unit. At all other overflows, floatables control will be implemented depending on accessibility, cost, CSO flow rates, volumes, and other factors.

7.4.2 Weir and Orifice Modifications

Weir modifications consist of raising weirs at SPPs, CSOs, and other non-formal regulators. Orifice modifications consist mainly of orifice plate removal. Weir and orifice modification recommendations as originally presented in the District-specific evaluations during the 2004 LTCP development were assimilated into the alternatives “as-is”. Most of the modifications to weirs and orifices in regulators were made as part of the Phase I projects implemented or initiated between the submittal of the 2004 LTCP and the submittal of this LTCP.

7.4.3 Satellite Storage Facilities

The pricing for satellite storage facilities consists of capital and O&M costs.

The unit price for the capital cost of satellite storage facilities includes:

- A satellite covered, concrete storage facility buried underground. Cover is assumed to be at-grade.
- An odor control system sized to provide six air changes per hour for two feet of headspace in the storage basin.
- A solids handling dewatering pump, capable of dewatering the basin within 24 hours.
- Bar racks to screen influent as the floatables control mechanism for treated and bypassed flow.

The volume of the basin is sized based on the desired level of control, with an assumed side water depth of 12 ft, an assumed invert depth of 15 ft, and an estimated facility land area requirement equal to four times the surface area of the basin.

Given these assumptions, the unit price for the satellite storage facility was determined using the equation below:

$$\text{Unit Price} = 220 \times V^{-0.27}$$

Where:

Unit Price	=	Unit Price per Gallon Stored	[$ / gal]
V	=	Volume	[gal]

Note that piping required to transport flows to a consolidation point is not included in the unit cost for the satellite storage facility, but is accounted for as a separate cost line item under connector pipes.

O&M costs were extrapolated from the cost curve for sedimentation basin O&M costs presented in the *USEPA Combined Sewer Overflow Control Manual* (EPA/625/R-93/007, September 1993). These annual O&M costs, as presented on the cost curve, were adjusted to present worth dollars using the ENRCCI and a present worth factor.

7.4.4 Deep Rock Tunnels

At the time of the development of the 2004 LTCP, proposed storage tunnel locations and alignments, along with depth-to-bedrock information, were provided to a local geotechnical engineering firm familiar with tunnel construction in the City of Buffalo, to obtain conceptual level cost estimates for the deep rock tunnels. On average, the depth-to-bedrock throughout the City ranges from zero to over 70 ft below grade.

Specifically, for:

- Black Rock Canal Tunnel – the depth to bedrock ranges from 5 ft below grade at the south end of the tunnel to approximately 60 ft below grade at the north end of the tunnel.

- Scajaquada Tunnel – the depth to bedrock ranges from between 3 ft and 15 ft below grade.

- Buffalo River Tunnel – the depth to bedrock varies between 10 ft to 40 ft below grade at the western end of the tunnel, 50 ft to 70 ft below grade at the central portion, and 30 ft to 60 ft below grade at the eastern end of the tunnel.

Note that these depths-to-bedrock, as presented, are approximations only to support planning-level discussions. Prior to final design, a full geotechnical investigation must be performed to determine the actual rock depth, type, and competency.

The cost information provided by the engineering firm is included in Appendix 7-1, and was subsequently updated to current dollars for use in the evaluation of alternatives,

Note that piping required to transport flows to a consolidation point is not included in the unit cost for the deep rock tunnels, but was added as a separate cost line item under connector pipes.

7.4.5 Enhanced High Rate Treatment Facilities

Unit cost estimates for package treatment units were obtained from a supplier and used for EHRT facility cost development. The cost provided assumes:

- Influent pumping is required to feed flow to the package treatment units.

- Screened influent using mechanically cleaned fine screens are required to prevent plugging of the lamella type settling plates in the clarification system, as well as bar racks to provide floatables control for bypassed flow.

- Concrete tankage for chemical addition (polymer, coagulants, and ballast sand), flash mixing, gentle mixing and sedimentation, chemical feed and pumping facilities and building, settling facilities, fencing, and access roads.

- Land acquisition, as quoted by the Director of Urban Development at the Erie County Industrial Development Agency.

The volume of each facility was sized based on the peak flow rate for the selected level of control, with a land area requirement equal to four times the footprint of the facility area. A 60% TSS and 40% CBOD removal efficiency for the selected level of control was assumed, and O&M costs were also estimated. The cost estimate information for the EHRT is included in Appendix 7-1.

Note that piping required to transport flows to a consolidation point is not included in the cost for the EHRT facility, but was added as a separate cost line item under connector pipes.

7.4.6 Connector Pipes

The connector pipe line item includes costs for all proposed piping in the system required to convey flows from CSOs to the satellite storage facilities, deep rock tunnels, or EHRT facilities. Costs are based on quotes from local contractors and Means Building Construction Costs Data (2003) estimates for concrete pipe installation, updated to current dollars. Costs were developed for a range of pipe sizes, quoted in 1-ft increments, from 2-ft diameter to 8-ft diameter installed at three depth interval ranges of 0 to10 ft, 10 ft to 20 ft, and 20 ft to 30 ft below ground surface. Rock excavation is also included under this item in addition to pipe installation costs. Costs for rock excavation are based on quotes from local contractors and updated to current dollars. No O&M costs are included in this item.

7.4.7 Sewer Separation

Two types of separation were estimated for CSO control: partial and full.

Partial separation is considered viable and potentially cost-effective in areas where gravity discharge of collected storm water could be accomplished through relatively short outfalls to the receiving water or to a storm sewer with excess capacity (assumed for cost estimation purposes to include a one-quarter mile band from the storm water source to the receiving water body/storm sewer with excess capacity). Existing combined sewers would remain in service with some residual storm water component. Elimination of this residual component is assumed to not be cost-effective. Full separation assumes a main trunk storm sewer running at the center of each subbasin with collector storm sewers draining into the main trunk from the sides.

7.5 Revised Unit Pricing

In developing this LTCP, the cost estimates used in the 2004 LTCP were updated to 2012 dollars for the following CSO control alternatives:

- Storage;
- EHRT Facilities, followed by high-rate disinfection facilities;
- Tunnel Storage and Dewatering;
- Sewer Separation;
- Conveyance Piping; and
- Green Infrastructure.

In addition to the 2004 LTCP, costing information from more recently-completed projects was gathered and compared to determine the updated unit costs. These projects include the following:

- ALCOSAN (PA) Facilities Plan cost estimating tool for CSO alternatives;
- Albany (NY) Pool LTCP cost guidelines;
- Metropolitan Sewer District of Greater Cincinnati (MSDGC) costing guidelines;
- Internal Malcolm Pirnie/ARCADIS cost estimating documents; and
- Recently completed/planned projects of a similar nature to the proposed improvements.

In some cases, the BSA did use actual project costs to develop the cost curves. However with regard to the more technically advanced types of projects, since there have been relatively few similar projects completed locally or regionally, the BSA chose to use a series of guidelines and cost estimating models that have been developed for other LTCP documents as the baseline for determining the planning level project costs. Unless otherwise noted, all costs are presented in Year 2012 dollars and used an ENR Construction Cost Index (CCI) of 9011 to escalate costs to 2012 dollars.

7.5.1 Storage

7.5.1.1 Construction Cost

Figure 7-10 below compares the construction cost as a function of the storage volume for the various cost tools evaluated. The costs from the various projects were updated to 2012 by using the ENR CCIs. It should be noted that the cost curves do not include costs for odor control or land acquisition.

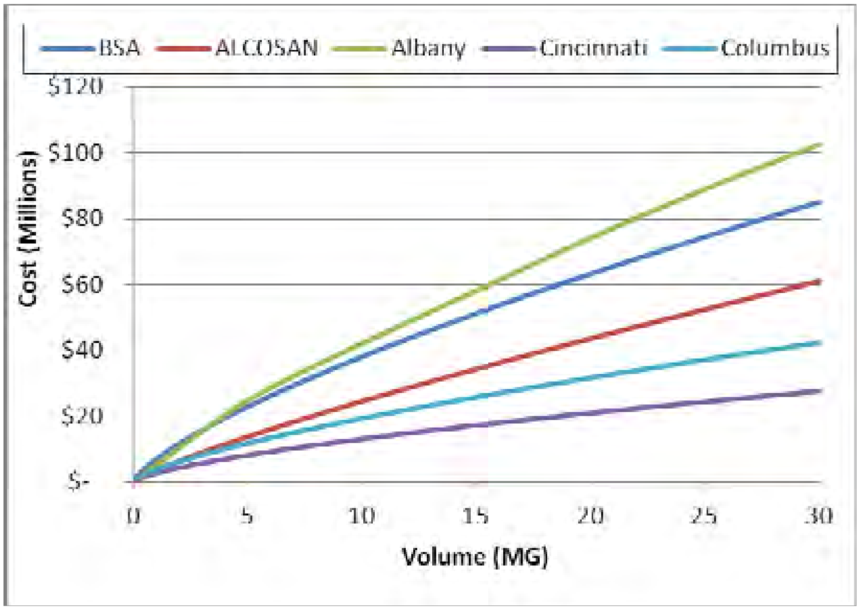


Figure 7-10: Storage Alternative Cost Curves – Construction Only

As shown on Figure 7-10, the 2004 BSA cost curves result in greater projected costs than those estimated using the ALCOSAN costing tool, while the Albany Pool project costing guidelines resulted in a cost greater than the ALCOSAN or 2004 BSA estimates. Cincinnati and Columbus cost curves were generally lower than those developed for ALCOSAN and the New York areas.

Based on the review, the ALCOSAN cost curve provides the average cost for construction of off-line storage and was used for updating the LTCP, using the equation shown below.

$$Cost\ = 3.4\ x\ Volume^{0.826}$$

7.5.1.2 O&M Cost

Two sources of information were evaluated to estimate annual O&M costs for storage facilities. The first source was derived from the ALCOSAN costing tool, and the other source was the BSA costing information from the 2004 LTCP. The ALCOSAN costing tool uses numerous variables to estimate the annual O&M, including, but not limited to, the storage tank size, maintenance supervisor and non-supervisor labor rates, operations supervisor and non-supervisor labor rates, and the number of event hours that the storage tanks are active. Also, the O&M costs were represented by different curves depending on the tank size. This method was concluded to contain too many variables and assumptions to be directly comparable to the method used in the 2004 LTCP.

The 2004 LTCP based the O&M costs on the curves provided in the *Combined Sewer Overflows, Guidance for Long Term Control Plans (USEPA, 1995)*. The storage O&M curve was digitized so that a regression line could be determined (see equation below), where Q is the dewatering capacity in units of MGD. The O&M costs in the USEPA manual were based on an ENR CCI of 4600 and were updated to 2012 dollars. The capacity in the equation below assumes that the tank volume could be completely dewatered in a single day.

$$Cost_{O\&M} = 15.174\ x\ Capacity^{0.5595}$$

7.5.2 High-Rate Treatment, or EHRT, Facilities

7.5.2.1 Construction Cost

The 2004 LTCP grouped EHRT facilities, such as Actiflo and Densadeg, with other floatables control technologies. The EHRT treatment units have considerably greater costs than other floatable control measures; therefore, cost curves specifically addressing this type of improvement were developed. Three different costing resources were compared for EHRT construction cost estimating: ALCOSAN, Albany Pool, and Cincinnati. The cost curves presented in this section do not include additional costs of land acquisition or disinfection. Figure 7-11 presents the cost curves from these sources, as well as a similar cost curve developed for the BSA as part of the 2004 LTCP (updated to 2012 costs).

Figure 7-11 also shows recent costs for three EHRT options prepared for the BSA during the development of various options for updating the LTCP. While these cost estimates fall slightly below the BSA cost curve, they represent better-defined cost estimates using actual sizes of equipment, site locations, local construction rates, vendor quotes for equipment and the like, than the conceptual planning level costs shown on the BSA cost curves. In order to compare these costs with the available cost curves, the BSA cost estimates had the force main, pump station, screens, and chemical disinfection components removed. The recently-developed BSA cost estimates agree most closely with the curve generated from the ALCOSAN CSO costing tool, and therefore, this LTCP used the following equation based on the ALCOSAN cost curve for EHRT facilities:

$$Price = 640{,}000\ x\ Capacity^{0.708}$$

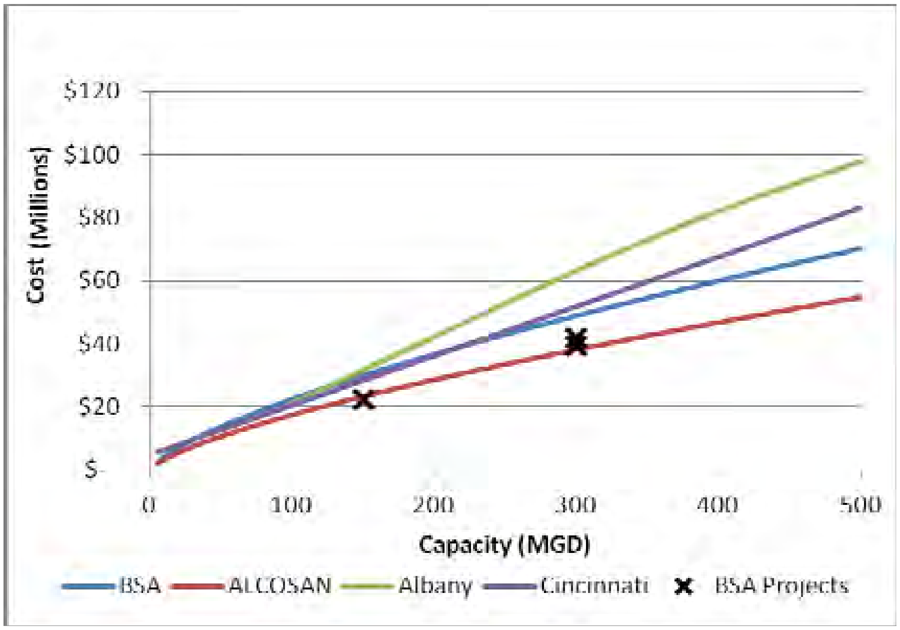


Figure 7-11: EHRT Facility Cost Curves – Construction Only

7.5.2.2 O&M Cost

Two sources of information were evaluated to estimate annual O&M costs for EHRT facilities. The first source was the ALCOSAN costing tool, and the second source was the BSA costing information used in the 2004 LTCP development. The ALCOSAN costing tool used the following formula where Q is the capacity in units of MGD:

$$Cost_{O\&M} = 98{,}251Q^{0.5920}$$

The cost formula assumes an ENR CCI of 8551, so the formula required adjustment to the current ENR CCI (9011).

No O&M cost curve for EHRT facilities was included in the 2004 LTCP; however, some costs were included for specific sizes of EHRT systems considered at that time. The documented O&M costs were compared to the capacities for each of the alternatives so that a cost curve could be developed using linear regression (Figure 7-12).

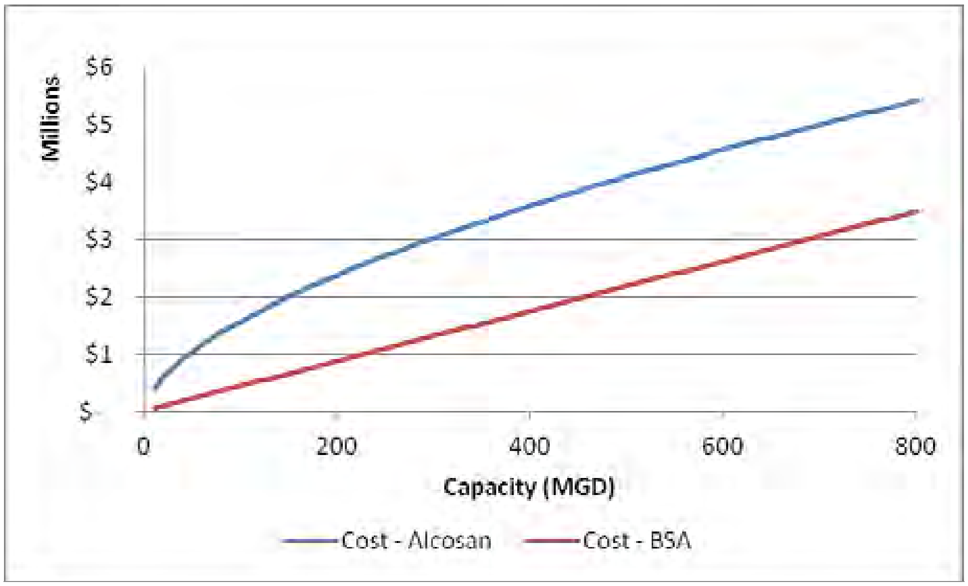


Figure 7-12: EHRT Facility Cost Curves – Annual O&M Costs

The resulting equation was adjusted to the current ENR CCI and compared to the ALCOSAN costing tool. The ALCOSAN costing tool estimated significantly greater O&M costs. Since the ALCOSAN costs reflect an economy of scale in operating costs as facility costs increase, this LTCP will use the ALCOSAN costing tool to estimate the O&M costs.

7.5.3 EHRT High Rate Disinfection

7.5.3.1 Construction Cost

It was assumed that high rate disinfection systems would be installed wherever an EHRT was installed. Capital costs for sodium hypochlorite disinfection systems were obtained from the *USEPA Combined Sewer Overflow Control Manual* (EPA/625/R-93/007, September 1993) and are represented by the equation shown below.

$$\text{Cost} = 0.121Q^{0.464} \text{ where Q is the flow in MGD (ENR CCI = 4500)}$$

This cost includes the following components:

- Chemical storage tank;

- Metering pumps;
- Dilution water supply;
- Piping and valves;
- Diffuser; and
- Chlorine Residual Analyzer.

The capital costs presented above are for the sodium hypochlorite storage and feed system components only. The high rate disinfection process would also require a contact tank sized to provide a five-minute contact time using a high disinfectant dose in accordance with industry standard practices. Since the chlorine contact tank is essentially a concrete storage tank, the total high rate disinfection system construction costs were estimated by adding the ALCOSAN cost curve for a concrete storage tank, as presented in Section 7.5.1.1.

7.5.3.2 O&M Costs

The *USEPA Combined Sewer Overflow Control Manual* also provides an estimate of O&M costs (*i.e.*, energy consumption, labor requirements, equipment maintenance, and chemical usage) for disinfection in a cost curve (included in Appendix 7-1). Regression upon this curves results in the following equation that was used to estimate annual O&M costs.

$$\text{Cost (in \$1000)} = 0.1144Q^{0.479} \text{ where Q is the flow in MGD (ENRCCI = 4500)}$$

7.5.4 Tunnel Storage

7.5.4.1 Construction Cost

A site-specific analysis was performed in the 2004 LTCP to estimate construction cost for each proposed tunnel project, not including land acquisition, with the diameter ranging from 10 ft. to 20 ft. in 5-ft. increments. These costs were plotted against the respective diameter for each tunnel, and a linear regression was performed on the resulting BSA costs to develop a cost curve. Figure 7-13 presents the Scajaquada Creek tunnel cost curve, which had a constant tunnel length of 14,200 feet for both Alternative UA3 and UA3A (discussed further in Section 11). For the Black Rock Canal tunnel, the tunnel lengths varied for the two alternatives, with 36,600 feet for Alternative UA3 (Figure 7-14) and 24,700 feet for Alternative UA3A (Figure 7-15). For each alternative, the tunnel length was held constant and only the diameter was varied. In order to confirm the reasonableness of the BSA cost curves, the cost estimating tools associated with the Albany

Pool and ALCOSAN projects were also evaluated. The ALCOSAN costing tool estimated tunnel construction costs similar to those estimated for the BSA in the 2004 LTCP, while the Albany Pool cost guidelines estimated tunnel costs that significantly exceeded the other two methods. The BSA cost estimates were used in this LTCP.

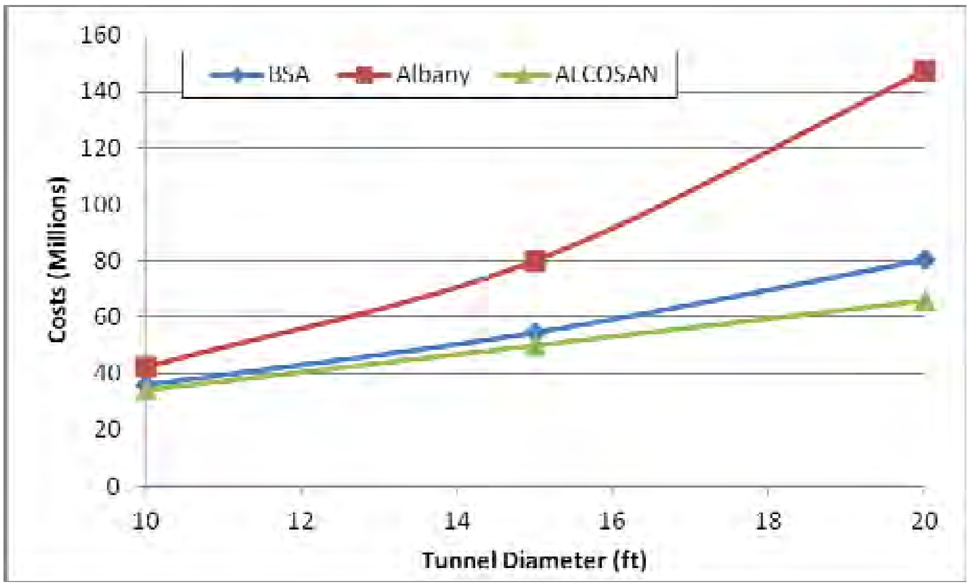


Figure 7-13: Scajaquada Tunnel Cost Curves – Construction Only (Alt UA3 and UA3A)
(Tunnel Length of 14,200 feet)

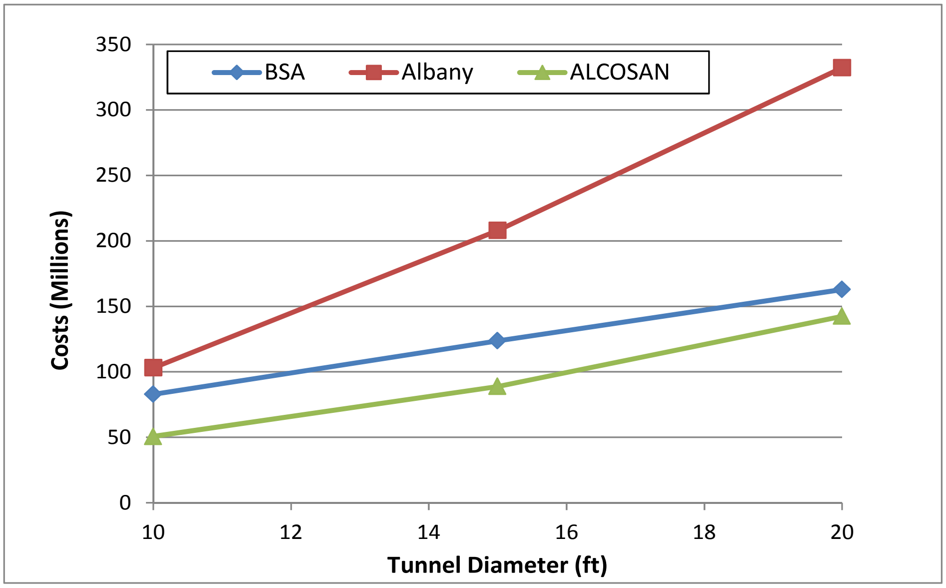


Figure 7-14: Black Rock Tunnel Cost Curves – Construction Only (Alt UA3)
(Tunnel Length of 36,600 feet)

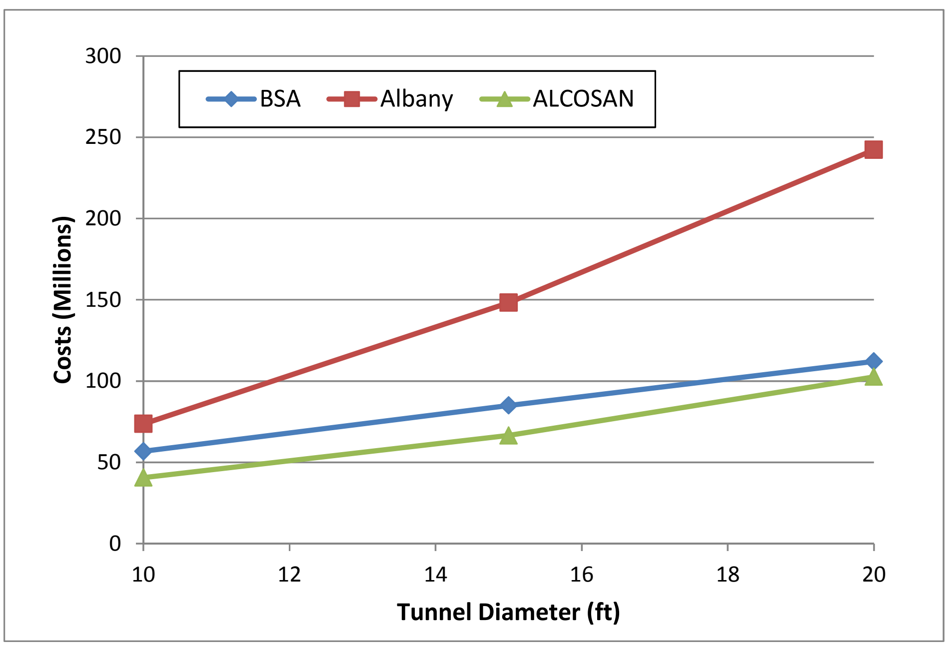


Figure 7-15: Black Rock Tunnel Cost Curves – Construction Only (Alt UA3A)
(Tunnel Length of 24,700 feet)

The cost curves in Figures 7-13 through 7-15 for the tunnels do not include costs for dewatering pump stations. The ALCOSAN costing tool has pricing information specific for tunnel dewatering pumping stations. No other resource for estimating the capital cost for tunnel dewatering pump stations was found; therefore, the ALCOSAN costing tool was selected for use in updating the LTCP. It was assumed that the dewatering pump station would drain the tunnel in 24-hours and that the treatment plant would be able to treat that amount of flow in the 24-hr timeframe. The cost curve equation for tunnel dewatering pumping station used in the ALCOSAN tool is shown below, where the capacity is the design flow rate in units of MGD. This equation was used in estimating the costs for tunnel dewatering pumping stations in this LTCP.

$$Price = 10.493 \; x \; Capacity^{0.9421}$$

7.5.4.2 O&M Cost

The annual O&M costs for storage tunnels were estimated by using the following equation, originally presented in the 2004 LTCP, where the tunnel volume is in units of MG. The costs were updated to current prices using a typical escalation factor of 3.5% per year.

$$Cost_{O\&M} = \frac{Volume}{61} \; x \; 45{,}633 \; x \; \frac{ENR\ CCI_{2003}}{ENR\ CCI_{2000}}$$

The ALCOSAN costing tool provides O&M cost information specific to tunnel dewatering pump stations. The O&M costs are comprised of three different components: energy costs, pump station maintenance materials, and labor costs. The dewatering O&M costs were updated to current prices. The equations for each of the components are given below with each having a base ENRCCI of 7939:

$$Cost_{Energy} = \frac{3.14 \; x \; Volume_{\ annual} \; x \; Head_{\ dynamic} \; x \; Cost_{\ electricity}}{Efficiency}$$

Energy costs are dependent on the annual volume pumped ($Volume_{annual}$), the dynamic head of the pump station, the cost of electricity, and the wire-to-water efficiency. For these estimates, the dynamic head was assumed to be 125 feet, the electricity cost was assumed to be \$0.10/kWhr, and the wire-to-water efficiency was assumed to be 67%. The energy costs were not adjusted with the ENRCCI since the cost of the electricity is assumed to be indicative of the current prices paid by the utility.

$$Cost_{materials} = 749.43Q + 17{,}816$$

$$Cost_{labor} = 959.78Q + 22{,}426$$

The materials cost (cost to maintain the physical components of the pump station) and the labor costs (the cost for the employees' time for repair and maintenance) are dependent on the capacity of the station (Q).

The dewatering pump station O&M costs along with the tunnel O&M costs noted above were summed to develop the total tunnel-pump station dewatering O&M costs.

7.5.5 Sewer Separation

7.5.5.1 Construction Cost

The 2004 LTCP used unit costs of $25,000/acre and $50,000/acre for partial and full sewer separation costs, respectively. These unit costs do not include land acquisition costs. The 2004 costs prices were updated to current prices using the ENRCCIs and compared to similar projects as shown in Table 7-2. The unit cost for each project was determined by dividing the actual construction cost by the total area separated. It should be noted that the costs for the Portland, Oregon, and Detroit, Michigan, projects were based on an estimate of the total construction cost. The costs presented below were updated to current dollars using a current ENRCCI of 9011.

Table 7-2
Comparison of Unit Costs for Sewer Separation Projects

Full Separation	Unit Cost ($/ac)	Partial Separation	Unit Cost ($/ac)
Albany (estimated)	$ 221,168	Albany (estimated)	$ 147,445
BSA (estimated - 2004 LTCP cost of $25,000 acre/ updated to 2012 dollars)	$ 67,296	BSA estimated - 2004 LTCP cost of $25,000 acre/ updated to 2012 dollars)	$ 33,648
St. Paul, MN	$ 33,372	ALCOSAN	$ 42,152
Portland, OR	$ 39,006	CSO No. 059 Sewer Separation	$ 24,856
Detroit, MI	$ 146,924	Beverly Rd. SS	$ 19,200
Boston, MA (Stoney Brook)	$ 85,843		
Boston, MA (South Dorchester Bay)	$ 77,182		
Boston, MA (South Point Channel)	$ 161,768		

Recently-completed partial separation projects in the BSA system show a great variation in calculated unit prices, ranging from approximately $33,400 to $161,800 per acre. This variation is also present when comparing the unit costs estimated for the Albany and BSA projects. Because the updated BSA unit cost is close to the costs for the completed projects, the updated 2004 LTCP unit costs were used for subsequent estimations for this LTCP. The same applies for the partial separation projects, as the BSA estimates are similar to those used for recently-completed partial separation projects.

7.5.5.2 O&M Costs

No O&M costs were calculated for sewer separation projects in the 2004 LTCP. The ALCOSAN costing tool estimates O&M costs based on total length installed and the number of manholes required in areas to be separated. Additional information is provided below in the conveyance piping section regarding O&M costs for sewers for this method. No information was provided in the 2004 LTCP regarding the length of sewer that needed to be constructed in order to accomplish the required separation. Therefore, no O&M cost estimating methods were applied for updating the LTCP.

7.5.6 Conveyance Piping

7.5.6.1 Construction Cost

ARCADIS publishes an internal report for use in construction cost estimating. The estimated construction costs including costs for manholes, excavation, granular fill, pipe material and placement, and surface restoration costs are provided separately for storm and sanitary sewers. These unit costs do not include cost for land acquisition or trenchless installation methods. The values reported in the ARCADIS report are based on projects in Ohio and Michigan, and it is believed that these costs are also representative of costs in the City of Buffalo.

These values were compared to the unit costs estimated for other projects, including the Albany Pool project, the ALCOSAN costing tool, and the Cincinnati costing guidelines. The ALCOSAN and Albany Pool curves yield costs significantly higher than the costs estimated in the 2004 LTCP or using the ARCADIS cost report. In addition, the City of Columbus, Ohio developed the *Livingston James Sanitary Sewer I/I Remediation Study*, where construction costs were developed for sanitary sewer replacements, including installation, bypass pumping, and lateral reconnection. The Columbus costs were generally aligned with the costs developed for the other projects. Figure 7-16 compares the unit prices from the various sources reviewed for this LTCP Update.

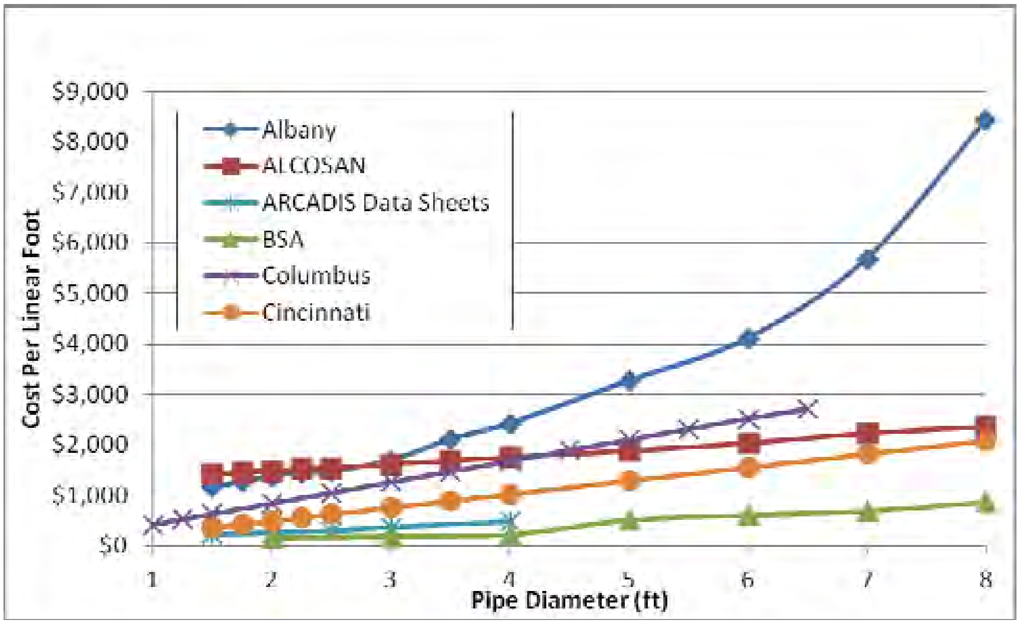


Figure 7-16: Costs per Linear Foot for Conveyance Piping

Table 7-3
Unit Prices developed for Conveyance Piping (based on ARCADIS manual)

Diameter (ft)	Unit Price ($/ft)
1.5	$221
2	$247
2.5	$289
3	$362
4	$478

Costs for two sewer projects recently bid by the BSA were used to validate the most appropriate unit cost. For the 42-in diameter sanitary sewer project (5,000 LF), the unit cost was $472/LF, and for the 15-in storm sewer project (500 LF), the unit price was $192/LF. These prices agree most closely with the ARCADIS cost curves; therefore, the ARCADIS unit costs were used in updating the costs. For the unit costs, it was assumed that all sewer conveyance piping was installed under paved areas, all piping was sanitary sewer, and when the required diameter exceeded the values listed in the ARCADIS estimating table, an extrapolation of the data was performed to determine the unit costs for larger diameter pipe. Table 7-4 summarizes the unit prices assumed in the LTCP.

Table 7-4
Unit Prices for Conveyance Piping used for the BSA LTCP

Diameter (ft)	Unit Price ($/ft)	Diameter (ft)	Unit Price ($/ft)
1.5	$221	10	$1,963
2	$247	10.5	$2,141
2.5	$289	11	$2,327
3	$362	11.5	$2,521
3.25	$391	12	$2,723
3.5	$420	12.5	$2,934
4	$478	13	$3,153
4.5	$559	13.5	$3,381
5	$645	14	$3,616
5.5	$739	14.5	$3,860
6	$842	15	$4,113
6.5	$953	15.5	$4,373
7	$1,072	16	$4,642
7.5	$1,200	16.5	$4,920
8	$1,336	17	$5,205
8.5	$1,480	17.5	$5,499
9	$1,633	18	$5,801
9.5	$1,794		

7.5.6.2 O&M Costs

No O&M costs were shown for sewer separation projects in the 2004 LTCP. The ALCOSAN costing tool estimated O&M costs based on total conduit length installed and the number of manholes required. The equation below assumes one manhole every 300 feet to estimate a per linear foot unit cost, based on the ALCOSAN model.

$$Price_{O/M} = \$4/_{LF}$$

However, to remain consistent with the 2004 LTCP, no O&M costs are presented for conveyance improvements. Given the relatively small quantities of pipe required, these costs are assumed to be negligible.

7.5.7 Green Infrastructure

Green infrastructure technologies were not considered in the 2004 LTCP. The BSA, however, has made a concerted effort to include these technologies as part of this LTCP, and have begun implementing green infrastructure as part of their current Phase I projects. Therefore, unit costs were developed for providing estimated construction costs for green infrastructure.

The Albany Pool cost estimating guide uses costs developed for Philadelphia, Pennsylvania, and based on controls installed in Chicago, Illinois, and Eugene, Oregon. These costs were updated to 2012 dollars and are presented in Table 7-5 below. These unit costs assume that the first inch of rainfall is captured via implementation of green infrastructure. Separate unit costs were developed for projects for bioretention (rain gardens), subsurface infiltration (vegetated swales), porous pavements, and installation of trees and plantings within the street right-of-way. The Albany Pool cost estimating guide also lists separate retrofit and redevelopment prices, which consider that implementation of green infrastructure during redevelopment projects usually costs less as the mobilization and restoration costs are included in other aspects of the redevelopment work.

Table 7-5
Summary of Unit Costs for Green Infrastructure Technologies

Control	Type	Minimum Cost ($/ac)	Mean Cost ($/ac)	Maximum Cost ($/ac)
Bioretention	Retrofit	$70,000	$171,000	$439,000
	Redevelopment	$47,000	$118,000	$214,000
Subsurface Infiltration	Retrofit	$70,000	$171,000	$439,000
	Redevelopment	$47,000	$118,000	$214,000
Porous Pavement	Retrofit	$70,000	$171,000	$439,000
	Redevelopment	$47,000	$118,000	$214,000
Right of Way Plantings	Retrofit	$19,000	$19,000	$19,000
	Redevelopment	$16,000	$16,000	$16,000
Average	Retrofit	$57,250	$133,000	$334,000
	Redevelopment	$39,250	$92,500	$164,500

For purposes of this LTCP, an all-inclusive cost (i.e., including engineering, legal, administration, construction) of $57,000 per acre was used. As outlined in the Green Infrastructure Master Plan, the BSA's GI program is heavily dependent upon impervious surface reduction through the City's building demolition efforts, which typically have minimal per acre cost to the BSA. Since the BSA is only responsible for a small portion of the typical building demolition cost, the $57,000 average per acre cost is likely conservative.

7.5.8 Cost Contingencies

All of the costs developed for the various alternatives included a 25% project contingency, as well as a 15% engineering and administration contingency. An additional contractor overhead and profit (OH&P) cost was specifically excluded, since the OH&P is included in the cost curves. A 10% O&M contingency was applied to the O&M costs to account for changes in labor, energy, and maintenance costs that may occur in the near future.

7.5.9 Present Worth Analysis

The LTCP assumed an interest and discount rate of 5% and 2.5%, respectively. The time horizon used for the present worth analysis was 20 years with an annual escalation rate of 3.5%. There were no salvage values assumed.

8. Bird Island Wastewater Treatment Plant

The BSA owns and operates the Bird Island WWTP located at the foot of West Ferry Street in Buffalo, New York. Figure 8-1 presents a site plan of the facility. The WWTP receives combined sewer flow from the City of Buffalo, as well as all or part of nine tributary communities. The treatment processes at the WWTP include, in general, preliminary treatment (screening and grit removal), primary clarification, aeration, secondary clarification, and disinfection.

The WWTP was designed to operate in three modes: normal, primary bypass, and partial treatment modes. The mode of operation is determined based upon influent flow rates. The WWTP discharges to the Niagara River, primarily through two permitted outfalls. The main plant outfall, Outfall 002, discharges all plant effluent flows from the secondary processes when operating in all three modes, while a second outfall (Outfall 001) handles those effluent flows from the primary process when operating in the partial treatment mode only. Additionally, the WWTP is equipped with a third permitted outfall, Outfall 01A, located upstream of the plant headworks, designed and operated in accordance with the approved BSA wet weather operating plan (Appendix 8-1) as an emergency bypass to protect the treatment plant and collection system during extreme flows exceeding the plant capacity and/or equipment or process failure.

The No Feasible Alternative (NFA) analysis was conducted as part of the Bird Island WWTP wet weather capacity analysis required by the AO and to support the preparation of the LTCP. The objective of the NFA analysis was to evaluate feasible alternatives to minimize the volume and occurrences and/or increase the level of treatment for Outfall 001 discharges during the partial treatment mode. The NFA Report is included as Appendix 8-2. This section provides a brief discussion of the current treatment plant configuration and the NFA evaluation results.

8.1 Wastewater Treatment Plant Description

The WWTP was originally constructed and placed in operation in 1938 as a primary treatment plant with secondary treatment facilities constructed in the late 1970's in response to the Clean Water Act. The WWTP, which provides primary and secondary treatment, disinfection and solids handling was designed, and is permitted, for a 12-month rolling average flow of 180 MGD. Currently the Plant treats an annual average flow of approximately 130 MGD. A process flow schematic is presented on Figure 8-2.

The headworks facility consists of the following:

- Two mechanically-cleaned coarse bar racks;
- Raw wastewater pump station (RWWPS) containing six raw wastewater pumps;

- Six mechanically-cleaned fine bar screens;

Preliminary and primary treatment equipment consists of:

- Eight vortex grit removal units; and
- Four primary sedimentation tanks.

Secondary treatment processes include:

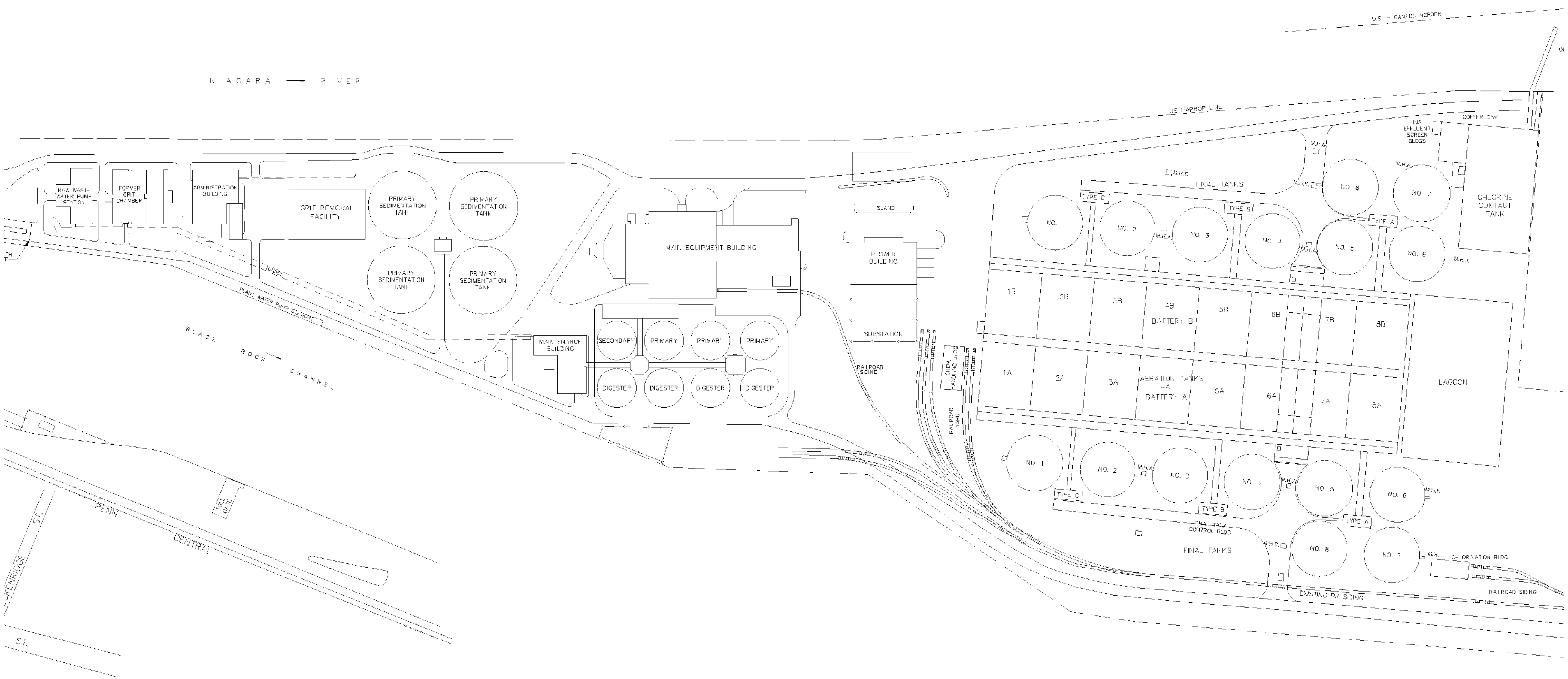
- Settled wastewater pump station (SWWPS) with five settled wastewater pumps;
- Activated sludge system consisting of sixteen four-pass aeration tanks equipped with fine bubble diffusers;
- Sixteen final sedimentation tanks;
- Four chlorine contact tanks; and
- Six return activated sludge (RAS) pumps.

The secondary treatment system is an activated sludge process originally configured to operate in the conventional plug flow, step feed, or contact stabilization modes of operation. In order to maximize flow through the secondary system, the activated sludge system currently operates in the step-feed mode. The aeration tanks and final clarifiers are arranged in two batteries ("A" and "B") with eight aeration tanks and eight final clarifiers in each battery. Wastewater flows are pumped to the aeration tanks from the SWWPS.

Disinfection of the final effluent using sodium hypochlorite occurs in the chlorine contact tanks. Treated secondary effluent is discharged to the Niagara River via Outfall 002.

The solids handling operations consist of:

- Four waste activated sludge (WAS) pumps;
- Fourteen sludge thickeners;
- Six sludge anaerobic digestion tanks;



MALCOLM PIRNIE / ARCADIS — The Water Division of ARCADIS 2013 1777-122	**BUFFALO SEWER AUTHORITY** **Long Term Control Plan Update**	**FIGURE 8-1** **WWTP SITE PLAN**

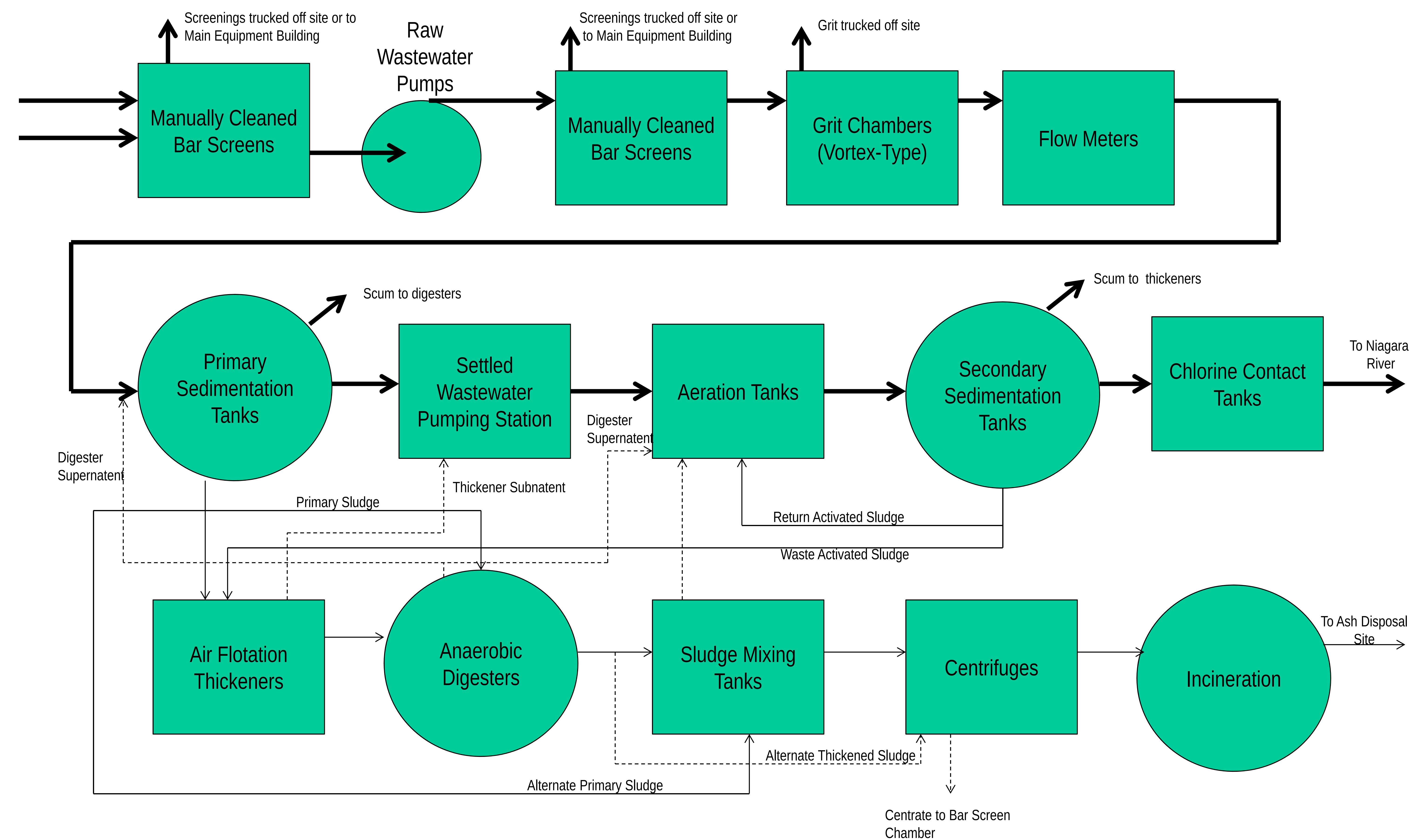


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FIGURE 8-2
WWTP PROCESS FLOW SCHEMATIC

- Two sludge mixing tanks;
- Two centrifuges for sludge dewatering; and
- Three multiple hearth incinerators.

8.2 Wastewater Treatment Plant Operating Modes

The WWTP can operate in one of three different modes (illustrated on Figure 8-3) depending on the plant influent flow:

- **Normal Mode** is used under all dry weather and some minor wet weather conditions, when the plant influent flow is less than or equal to 160 MGD. All flow receives preliminary, primary and secondary treatment, and disinfection. Plant effluent discharges through Outfall 002.

- **Primary Bypass Mode** is used under wet weather conditions when the plant influent flow exceeds 160 MGD with all units in service. The flow receives passes through the headworks and receives preliminary treatment (screening and grit removal). Flows up to 160 MGD receive primary treatment. Flows in excess of 160 MGD bypass the primary clarifiers and are conveyed along with primary effluent to the secondary treatment process. All flow receives secondary treatment and disinfection and discharges to the Niagara River via Outfall 002.

- **Partial Treatment Mode** is used under wet weather conditions when the plant influent flow exceeds the capacity of the secondary treatment system (~320 MGD). All flow receives preliminary treatment. Flows up to the secondary treatment capacity are directed to the secondary treatment process, treated, disinfected and discharged through Outfall 002. Flows in excess of the secondary treatment capacity receive primary treatment only and are disinfected and discharged via Outfall 001. In this mode, the primary clarifiers also function as chlorine contact tanks for flows not receiving secondary treatment.

The BSA Wet Weather Operating Plan, revised in August 2007, reiterates the above three operating modes and identifies the critical components of the plant that can affect or be affected by wet weather flow. Each critical component – equipment or unit process – has a wet weather operating objective and a set of guidelines for tasks to be performed prior to, during, and after a wet weather event.

8.3 Current Wet Weather Process Capacity Summary

This section summarizes the WWTP wet weather capacities for the WWTP primary and secondary systems. The evaluations are presented in detail in the NFA Report.

While the BSA currently uses all three operating modes as described above, a current hydraulic bottleneck at the primary bypass chamber upstream of the primary clarifiers currently prevents flows greater than approximately 270 MGD from reaching the secondary treatment process ***during partial treatment mode only***. Improvements to this chamber are currently being implemented which will allow sustained peak flows of up to 320 MGD (360 MGD peak instantaneous) to the secondary treatment process during partial treatment. During normal operation and when operating in the primary bypass mode, the plant can convey up to 360 MGD of flow to the secondary process through this chamber. The alternatives evaluated in the NFA assumed that these improvements have been completed.

The BSA has demonstrated through operational changes and capital improvements, both completed and ongoing, that the plant is capable of maximizing the treatment of wet weather flows using a combination of each of the three operational modes, including partial treatment once secondary treatment capacity is exceeded. Based on the original plant design, historical operations, and review of the existing treatment processes, the primary and secondary processes have the following wet weather treatment capacities during partial treatment mode.

- 240 MGD in the primary treatment process. Note however that, per the Agencies request, the BSA is willing to limit future peak flow capacity of the existing primary clarifiers to 160 MGD which equates to a flow commensurate with the most recent 10-States Standards recommended peak surface overflow rate of 2,000 gpd/sf.

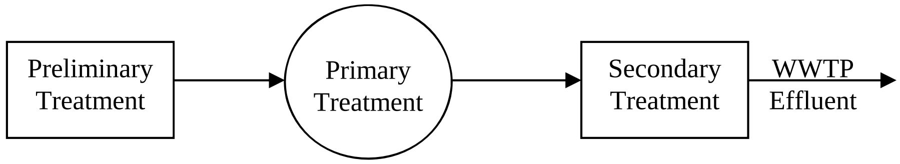
- 320 MGD sustained/360 MGD instantaneous to the secondary treatment processes following completion of the primary bypass modification project.

It was determined that a maximum flow of 560 MGD could be conveyed to the WWTP via the influent interceptors and siphon. Therefore, several alternatives were evaluated in the NFA for increasing the secondary treatment capacity, the primary treatment capacity, and a combination of the two to determine if a feasible alternative exists to minimize the volume and occurrences and/or increase the level of treatment for Outfall 001 discharges for a total flow of 560 MGD.

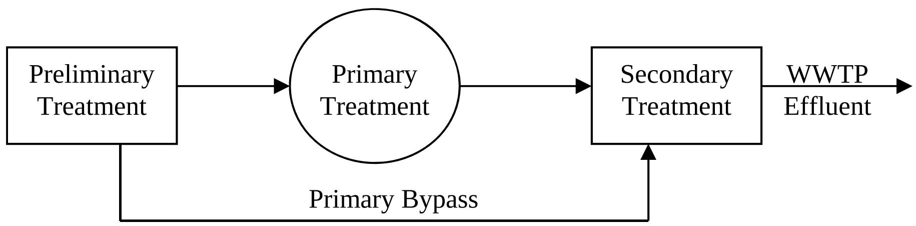
8.4 Summary of Alternatives Evaluated in the NFA Analysis

During completion of the NFA analysis, a number of alternatives were evaluated to provide treatment of plant influent flows of up to 560 MGD. Figure 8-4 below presents a summary of the evaluated alternatives.

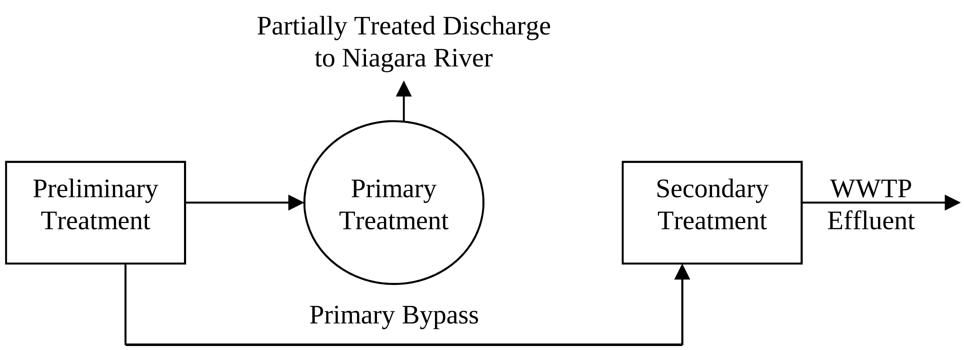
Normal Mode:



Primary Bypass Mode:



Partial Treatment Mode:



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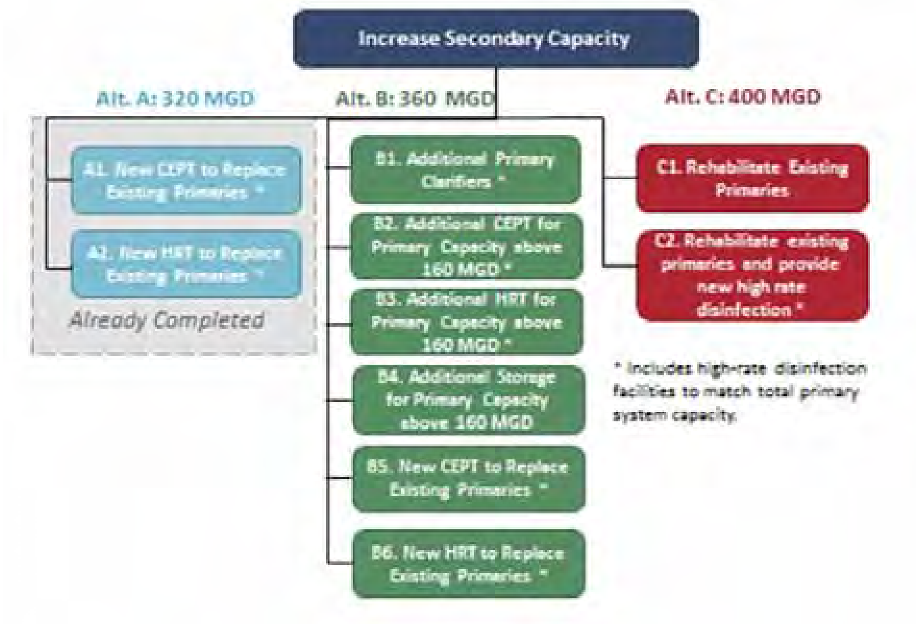

Figure 8-4: Summary of Alternatives Evaluated in the No Feasible Alternative Analysis

The NFA considered three options for secondary system capacity: maintain the current capacity of 320 MGD, increase the capacity to 360 MGD, and increase the capacity to 400 MGD. For each secondary system capacity scenario, several options for providing primary treatment to achieve a total plant influent flow of 560 MGD were considered, as shown on Figure 8-4.

Alternatives A1 and A2 considered a secondary treatment process hydraulic capacity of 320 MGD (current capacity), which would require providing 240 MGD of primary treatment capacity. Two primary treatment alternatives were evaluated as described below.

- Alternative A1 – Replace existing primary clarifiers with a new 240-MGD chemically enhanced primary treatment (CEPT) process, followed by a 240 MGD high-rate disinfection system for CEPT effluent.
- Alternative A2 – Replace existing primary clarifiers with a new 240-MGD high-rate treatment (HRT) process, followed by a 240 MGD high-rate disinfection system for HRT effluent.

Alternatives B1 through B6 considered increasing the secondary treatment sustained peak flow capacity up to 360 MGD with the remaining 200 MGD treated in the primary treatment process. To reliably convey up to 360 MGD through the secondary treatment process, it was recommended to install additional orifices in the secondary clarifier influent channels in each clarifier. The alternatives vary by the means in which 200 MGD of primary treatment capacity is achieved:

- Alternative B1 – Construct an additional 40-MGD primary clarifier to achieve a total 200 MGD of primary treatment capacity in partial treatment mode, followed by a 200-MGD high-rate disinfection system. Chlorine addition at the head of the primary clarifiers would be discontinued.
- Alternative B2 - Install a 40-MGD CEPT process to be used in parallel with the existing primary clarifiers, followed by a new 200-MGD high-rate disinfection process to treat the combined effluent from the existing primary clarifiers and new CEPT process. Chlorine addition at the head of the existing primary clarifiers would be discontinued.
- Alternative B3 - Install a 40-MGD HRT process to be used in parallel with the existing primary clarifiers, followed by a new 200-MGD high-rate disinfection process to treat the combined effluent from the existing primary clarifiers and new HRT process. Chlorine addition at the head of the existing primary clarifiers would be discontinued.
- Alternative B4 – Install a 13-MG storage tank to store influent plant flows in excess of 520 MGD and return the stored flows to the WWTP after the wet weather event subsides for full treatment. In this treatment scenario, chlorine would continue to be added at the head of the primary clarifiers for disinfection of up to 160 MGD flows discharged through Outfall 001 during partial treatment.
- Alternative B5 – Install a 200-MGD CEPT process to completely replace the existing primary clarifiers, followed by a new 200-MGD high-rate disinfection process.
- Alternative B6 – Install a 200-MGD HRT process to completely replace the existing primary clarifiers, followed by a new 200-MGD high-rate disinfection process.

Alternatives C1 and C2 considered hydraulic and process improvements to the existing secondary treatment process to treat sustained peak flows up to 400 MGD in partial treatment mode, while maintaining the existing primary treatment process capacity of 160 MGD. Two additional secondary clarifiers, expansion of the existing secondary chlorine contact tank to accommodate an additional 40 MGD of flow at a minimum 15-minute contact time, and the addition of orifices in the secondary clarifier influent channels would be required to increase the secondary treatment capacity to 400 MGD. The two alternatives are summarized below.

- Alternative C1 - Perform continued upkeep of the existing primary clarifiers to keep them in good working order for both primary settling and disinfection of up to 160 MGD.
- Alternative C2 – Implement improvements outlined as Alternative C1, but also install a new 160-MGD high-rate disinfection facility to disinfect primary effluent in partial treatment mode.

Detailed evaluations of all considered alternatives are documented in the NFA report. Table 8-1 presents a summary of the alternatives evaluated and their overall ranking score. For the purposes of ranking alternatives, the following factors were considered:

- Process performance
- Capital cost
- O&M cost
- Design complexity and constructability
- Maintenance of plant operations
- Operability

Section 5.3 of the NFA provides the detailed evaluation and ranking of alternatives.

Table 8-1: Summary of Evaluated Alternatives

Alternative		Primary Treatment Process Sizing (MGD)	Primary Effluent CCT Sizing (MGD)	Secondary Treatment Process Sizing (MGD)	Alternative Ranking Process Score[1]
A1	Primary CEPT	240	240	320	200
A2	Primary HRT	240	240	320	200
B1	Add 1 Primary Clarifier	40	200	360	180
B2	Incremental CEPT	40	200	360	230
B3	Incremental HRT	40	200	360	235
B4	Storage	200	N/A	360	185
B5	Primary CEPT	200	200	360	250
B6	Primary HRT	200	200	360	215
C1	Current + Secondary Treatment Improvements	160	N/A	400	275
C2	Current + Secondary Treatment Improvements	160	160	400	300

NOTE: (1) Refer to Table 5-4 of the NFA Report (Appendix 8-2).

8.5 Overall Recommendations from the NFA Analysis

Following the completion of the evaluation outlined in the attached NFA document, Alternative C2 was recommended as the preferred WWTP alternative for implementation. This alternative includes the following improvements that increase the capacity of the secondary treatment process to 400 MGD, while making improvements to maintain the continued performance of the existing primary clarifiers and, more importantly, to provide post-clarification disinfection of primary effluent for flows up to 160 MGD:

- Replacement of the sludge and scum collection systems in each of the four existing primary clarifiers.
- Replacement of the primary sludge pumps.
- Miscellaneous other repairs (including contract required to ensure that the primary clarifiers remain functional).
- Addition of a new chlorine contact tank and associated chemical storage and feed equipment downstream of the existing four primary clarifiers to provide a minimum 5-minute detention time for high-rate disinfection for primary effluent flows up to 160 MGD when operating in the partial treatment mode.
- Improving hydraulics through the sixteen existing secondary clarifiers by providing forty-six additional orifices in the peripheral influent channel of each secondary clarifier.
- Construction of two new secondary clarifiers; one in each secondary system battery.
- Expanding the existing chlorine contact tank following the secondary treatment process by adding a new tank to disinfect a total secondary process effluent of 400 MGD, with a contact time of 15 minutes.

Figures 8-5 and 8-6 present a schematic and layout of the recommended improvements under Alternative C2.

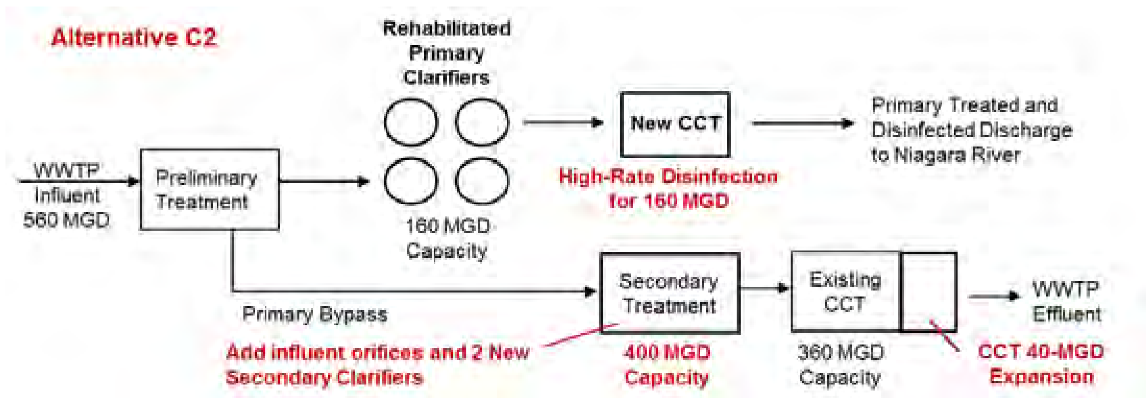

Figure 8-5: Process Flow Diagram for NFA Recommended Alternative C2 (Partial Treatment Mode)

This alternative was recommended as the most technically and financially feasible alternative to be implemented, in conjunction with the improvements recommended elsewhere in this LTCP for the combined sewer collection system. Under normal operating conditions, Alternative C2 ultimately:

- Maximizes secondary treatment of plant wet weather flows by providing secondary treatment capacity of up to 400 MGD.
- Optimizes primary effluent disinfection for flows exceeding 400 MGD (and up to 560 MGD total) by decoupling the disinfection of primary effluent with the actual clarification process.
- Offers the most appropriate life-cycle cost benefit ($40.5 million capital and $44.3 million 20-year life cycle costs).
- Involves relatively straightforward construction with minimal impact to other plant treatment processes during construction.
- Can be implemented within the limited available space on the WWTP property.
- Is similar to current treatment plant operations, providing a manageable learning curve for plant operations staff.

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BUFFALO SEWER AUTHORITY
NO FEASABLE ALTERNATIVE

PRELIMINARY LAYOUT
ALTERNATIVE C2

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Revision | C
Date | 22 JUL 2013

Figure 8-6

200 John James Audubon Parkway, Suite 101, Amherst New York 14228 USA **T** 1 716 748 6620 **F** 1 716 748 6621 **E** amhmail@ghd.com **W** www.ghd.com

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9. Development of System-Wide Improvement Alternatives (2004)

9.1 Overview

This section presents seven candidate system-wide improvement alternatives evaluated for the BSA's CSO LTCP submitted in 2004. These candidates were identified based on the results of the technology screening process and evaluation of site-specific alternatives described in Section 7. These seven improvement alternatives represent realistic, feasible combinations of control technologies applicable to the BSA collection system in 2004. Table 9-1 presents a summary of the seven candidate System-Wide Improvement Alternatives. All remaining tables and figures are presented in Appendix 9-1.

This section discusses the detailed evaluation of each of these integrated alternatives, and presents the following information:

- Background;
- Description of alternative;
- Proposed facilities and operational concepts;
- Preliminary cost estimates; and
- Cost-benefit relationship.

All results presented in this section are based on the 1986 typical year and simulations completed prior to submittal of the LTCP in 2004. All alternative costs are in 2004 dollars. This information provided the basis for the evaluation of alternatives and selection of the BSA's 2004 LTCP. Much of this information was developed with the support of the project's wet-weather modeling tools. Note that the discussion in this section refers to evaluations and cost estimates completed during the development of the 2004 LTCP and additional evaluations and revised cost estimates completed during the development of this LTCP are discussed in subsequent sections.

9.2 Alternative 1 – Foundation Plan

9.2.1 Background Information

Alternative 1 is made up of improvements that are either already planned by the BSA or were identified by the District Consultants as short-term, relatively low-cost projects. This alternative is referred to as the

"Foundation Plan". Alternatives 2, 3A, 3B, 4A, and 4B, start with the Foundation Plan and add improvements to it.

9.2.2 Description of Alternative

The Foundation Plan is made up of the following components, identified by the District Consultants for each of their respective Districts during the development of the 2004 LTCP:

- Floatables control at selected SPPs/CSOs;
- Raising selected weirs;
- Partial sewer separation;
- Increasing local capacity (limited areas); and
- Flow diversion (limited areas).

The partial sewer separation in the Foundation Plan includes improvements already planned by the BSA as part of their wet-weather control program. The components of the Foundation Plan are presented on Figure 9-1 and summarized in Table 9-2 (see Appendix 9-1).

9.2.3 Proposed Facilities and Operational Concepts

Two of the components in the Foundation Plan – floatables control and the flow diversion structure proposed for the Swan Trunk sewer – require substantive facilities and operating strategies. One of the components – partial sewer separation – does not require facilities or operating strategies, but is substantive in terms of its implementation. The remainder of the components in the Foundation Plan are relatively minor and passive, and so require little O&M activity.

9.2.3.1 Floatables Control

Operational concepts associated with floatables control technologies are presented in Section 7.2.6.

9.2.3.2 Swan Trunk Flow Diversion Structure

Currently, the Charles Street diversion structure consists of a static stop-log weir on the Swan Trunk to control the flow split between the Swan Trunk and the South Interceptor. However, this configuration does not optimize the wet-weather flow-carrying capacity of the South Interceptor under all flow conditions. The

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Table 9-1 Components of System-Wide Integrated Alternatives

Alternative	Description	End-of-Pipe Local Facilities	Centralized Facilities	Conveyance Facilities	System Separation	Floatables Control [2]
1	Foundation Plan			X	X	X
2	Consolidated District Consultant Plan	X	X	X	X	X
3A	System-Wide Storage with Partial Separation	X	X	X	X	X
3B[1]	System-Wide Storage with Partial Separation (excluding Buffalo River / Erie Basin CSOs)	X	X	X	X	X
4A	Satellite Treatment with Partial Separation	X		X	X	X
4B[1]	Satellite Treatment with Partial Separation (excluding Buffalo River / Erie Basin CSOs)	X		X	X	X
5	Complete Separation				X	

Notes:

(1) Alternatives 3B and 4B do not control Buffalo River or Erie Basin CSOs given lack of water quality objectives on these receiving water bodies.

(2) Only Alternative 1 contains newly constructed floatables control. Floatables control in Alternatives 2, 3A, 3B, 4A, and 4B, consist only of Floatables Control already included in Alternative 1.

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Foundation Plan would replace this static weir control with a dynamic control. The purpose of the dynamic control is to maintain adequate dry-weather flow in the Swan Trunk to avoid sedimentation, but allow for optimal use of both the Swan Trunk and South Interceptor during wet-weather conditions.

9.2.3.3 Partial Sewer Separation

Partial sewer separation in the combined sewer basins can reduce CSO activity by reducing the amount of wet-weather flow reaching the SPPs. Partial sewer separation is defined as the installation of new storm sewers in local, discrete areas within combined sewer basins. Existing combined sewers would remain in service. New storm sewers would be installed for local discharge to the receiving streams or routed to the existing storm sewer systems. Storm sewers would be sized to convey storm water produced by a 10-year design storm event. The local collector sewers would be a minimum of 12 inches in diameter.

Partial sewer separation projects were considered to be cost-effective, and hence feasible, in areas where gravity discharge of collected storm water could be connected to existing storm outfalls or to relatively short, newly-constructed outfalls.

Three to four inlets or catch basins would be installed at most intersections. It is anticipated that some existing inlets currently connected to the combined sewer system would be reused and connected to the new storm sewer system.

Any new storm sewer systems will be designed to meet the BSA’s Storm Sewer Design Standards.

9.2.4 Preliminary Costs

The estimated 20-year present-worth cost for Alternative 1 is approximately $165 million. A summary of the cost estimate is presented in Table 9-3 (see Appendix 9-1). Because Alternative 1 is a pure combination of components recommended in the District-specific LTCP reports, the cost estimate for the system-wide alternative is a summary of the costs as presented in the District-specific reports. The backup cost information provided by the District Consultants was included in the 2004 LTCP.

9.2.5 Description of Benefits

Figures 9-2 through 9-12 (see Appendix 9-1) present the cost-benefit curves for Alternative 1.

9.2.5.1 Benefits to Total System

Figures 9-2 and 9-3 (see Appendix 9-1) present the cost-benefit curves for Alternative 1 for the total system. Figure 9-2 presents the benefit as measured by predicted annual overflow volume. The figure demonstrates that the implementation of Alternative 1 results in a predicted reduction in annual overflow volume of approximately 14%, from 3,900 MG to 3,370 MG. Figure 9-3 presents the benefit as indicated by the percent capture value. The percent capture values for Alternative 1 and the subsequent alternatives have been normalized to existing conditions (*i.e.*, the total overflow volume for each alternative was compared to the total flow captured under existing conditions to avoid bias resulting from changes to total annual flow reaching the plant under different alternatives). Figure 9-3 demonstrates that implementation of Alternative 1 results in the predicted percent capture increasing from 85.5% to 87.7%, at an estimated 20-year present-worth cost of approximately $165 million.

9.2.5.2 Benefits to Black Rock Canal

Figure 9-4 (see Appendix 9-1) presents the cost-benefit curve for Alternative 1 for the Black Rock Canal, with the benefit measured by the predicted annual overflow volume to the Black Rock Canal. Since Scajaquada Creek flows directly into the Black Rock Canal, the overflow volume and cost values shown in Figure 9-4 and subsequent Black Rock Canal figures represent the sum of the values associated with the Black Rock Canal and Scajaquada Creek. Figure 9-4 demonstrates that for Alternative 1, a predicted reduction in annual overflow volume of 8% is achieved at an estimated 20-year present-worth cost of approximately $29 million. The components of Alternative 1 that contribute to this reduction are regulator modifications and partial sewer separation projects.

9.2.5.3 Benefits to Buffalo River

Figure 9-5 (see Appendix 9-1) presents the cost-benefit curve for Alternative 1 for the Buffalo River, with the benefit measured by the predicted annual overflow volume to the Buffalo River. The figure demonstrates that for Alternative 1, a predicted reduction in annual overflow volume of 14% is achieved at an estimated 20-year present-worth cost of approximately $87 million. The components of Alternative 1 that contribute to this reduction are regulator modifications and partial sewer separation projects.

9.2.5.4 Benefits to Cazenovia Creek

Figures 9-6 and 9-7 (see Appendix 9-1) present the cost-benefit curves for Alternative 1 for Cazenovia Creek, with the benefit measured by the predicted annual overflow volume to Cazenovia Creek. Figure 9-6 is the cost-benefit curve for the entire reach of Cazenovia Creek impacted by the BSA's collection system. The figure demonstrates that for Alternative 1, a predicted reduction in annual overflow volume of 40% is achieved at an estimated 20-year present-worth cost of approximately $36 million. Figure 9-7 further delineates the Cazenovia Creek results by examining only the portion of Cazenovia Creek with a Class B designation. As indicated in Table 5-9, this reach of Cazenovia Creek has an additional control objective for bacteria control. The figure demonstrates that for this portion of Cazenovia Creek, a predicted reduction in annual overflow volume of 35% is achieved at an estimated 20-year present-worth cost of approximately

$3.6 million. The components of Alternative 1 that contribute to these reductions are regulator modifications and partial sewer separation projects.

9.2.5.5 Benefits to Cornelius Creek

Figure 9-8 (see Appendix 9-1) presents the cost-benefit curve for Alternative 1 for Cornelius Creek, with the benefit measured by the predicted annual overflow volume to Cornelius Creek. The figure demonstrates that for Alternative 1, a predicted reduction in annual overflow volume of 15% is achieved at an estimated 20-year present-worth cost of approximately $8.8 million. The components of Alternative 1 that contribute to this reduction are proposed and on-going partial sewer separation projects. The cost of the partial sewer separation projects in the North District have not been included in the alternative cost, as they were already planned for implementation outside the development of the LTCP.

9.2.5.6 Benefits to Erie Basin Marina

Figure 9-9 (see Appendix 9-1) presents the cost-benefit curve for Alternative 1 for the Erie Basin Marina, with the benefit measured by the predicted annual overflow volume to the Erie Basin Marina. The figure demonstrates that for Alternative 1, a predicted reduction in annual overflow volume of 32% is achieved at an estimated 20-year present-worth cost of approximately $2.8 million. The alternative components that cause this reduction are regulator modifications.

9.2.5.7 Benefits to Niagara River

Figure 9-10 (see Appendix 9-1) presents the cost-benefit curve for Alternative 1 for the Niagara River, with the benefit measured by the predicted annual overflow volume to the Niagara River. This figure does not include CSO 055, which is presented in the Cornelius Creek cost-benefit curve. Figure 9-10 demonstrates that implementation of Alternative 1 for the Niagara River would result in a predicted reduction in annual overflow volume of 11% at an estimated 20-year present-worth cost of approximately $1.2 million. The components of Alternative 1 that contribute to this reduction are proposed and on-going partial sewer separation projects. The cost of the partial sewer separation projects in the North District have not been included in the alternative cost, as they were already planned for implementation outside the development of the LTCP.

9.2.5.8 Benefits to Scajaquada Creek

Figures 9-11 and 9-12 (see Appendix 9-1) present the cost-benefit curves for Alternative 1 for Scajaquada Creek. Figure 9-11 presents the benefit as measured by predicted annual overflow volume. The figure demonstrates that for Alternative 1, a predicted reduction in annual overflow volume of 5% is achieved at an estimated 20-year present-worth cost of approximately $12.6 million. The components of Alternative 1 that contribute to these reductions are regulator modifications and partial sewer separation projects. Figure 9-12 presents the benefit as measured by predicted annual bacteria exceedance hours. Bacteria exceedance hours were estimated from the annual overflow duration for the most active overflow location, as measured by overflow duration adjusted for travel time in Scajaquada Creek, and consider the impact from only the BSA's CSOs. The figure demonstrates that Alternative 1 has no impact on this value, which is explained by the fact that Alternative 1 does not contain any components that impact the most active overflow to Scajaquada Creek.

9.3 Alternative 2 – Consolidated District Consultant Plan

9.3.1 Background Information

Alternative 2 represents the selection of specific technologies evaluated by the District Consultants, into a system-wide improvement alternative. The Consolidated District Consultant Plan includes components that were recommended by the District Consultants, as well as some components that were discarded at the District-specific level, but using a system-wide perspective, were included in a system-wide alternative.

9.3.2 Description of Alternative

Alternative 2 consists of the Foundation Plan plus the following components:

- North District
  - Local storage at CSO 055; and
  - Local storage at CSO 056 (near Buffalo and Erie County Historical Society).
- Scajaquada District
  - In-line storage.
- South-Central District
  - Local storage at selected CSOs; and
  - Consolidated storage for groups of selected CSOs.

The components of Alternative 2 are presented on Figure 9-13 and are summarized in Table 9-4 (see Appendix 9-1).

9.3.3 Proposed Facilities and Operational Concepts

The following discussion summarizes the facilities and operational concepts for the local/consolidated off-line storage facilities and in-line storage facilities included in Alternative 2.

9.3.3.1 Off-Line Storage Facilities

The off-line storage facilities would operate between the current SPP and the receiving water (*i.e.*, would be constructed such that the facility would be filled from the overflow conduit). When the SPP activates, overflow would flow to the storage basin. When the basin fills, subsequent overflow from the SPP during the event would be discharged to the receiving stream. This discharge would be considered a CSO event in the new system. After the storm, the basin would be dewatered to the interceptor. Storage facilities would capture all of the volume associated with overflow events up to the selected storage control level, and the first flush of larger events.

Off-line storage facilities proposed for the BSA's system would be covered, concrete, underground tanks. The basins would include a bar screen in the influent channel to provide floatables control for the overflow. Odor control would also be included with each facility. A fan/blower system would be designed to provide six air changes per hour for the two feet of headspace in the basin, and would operate when CSO volume is present in the basin. Solids handling dewatering pumps would be used to return the contents of the basin to the interceptor after the storm event. The pumps would be sized to empty the basin volume based on the available capacity at the WWTP, with maximum dewatering times of approximately 24 hours.

9.3.3.2 In-Line Storage Facilities

In-line storage facilities would utilize available storage capacity in trunk sewers to store wet-weather flows up to a defined water surface elevation setpoint. The water surface elevation setpoint would be defined to protect the service area from flooding due to detained flows.

Operationally, the in-line storage could be activated using either adjustable weirs or inflatable dams. At the beginning of an event, the weir or dam would rise to store flow in the trunk sewer and prevent it from reaching the downstream SPP. When the water surface elevation upstream of the dam rose to the defined setpoint, the weir or dam would lower to avoid flooding. With this operating strategy, in-line storage facilities can prevent all the volume generated by selected smaller events, and some portion of that generated by larger events, from overflowing.

9.3.4 Preliminary Costs

The estimated 20-year present-worth cost for Alternative 2 is $412 million. This cost consists of $165 million for Alternative 1 and an incremental cost of approximately $247 million for the additional components of Alternative 2. A summary of the cost estimate is presented in Table 9-5 (see Appendix 9-1). Because Alternative 2 is a combination of technologies that were evaluated in the District-specific reports, the cost estimate is also based on a combination of the costs presented in the District-specific reports. The backup documentation for the Alternative 2 cost estimate was included in the 2004 LTCP.

9.3.5 Description of Benefits

Figures 9-14 through 9-24 (see Appendix 9-1) present the cost-benefit curves for Alternative 2.

9.3.5.1 Benefits to Total System

Figures 9-14 and 9-15 (see Appendix 9-1) present the cost-benefit curves for Alternative 2 for the total system. For these curves, as well as for all other total system and receiving water cost-benefit curves for Alternatives 2, 3A, 3B, 4A, and 4B, the cost values include the cost of Alternative 1 plus the incremental cost of the alternative, as Alternative 1 serves as the foundation for each of these alternatives. Figure 9-14 presents the benefit as measured by predicted annual overflow volume. The figure demonstrates that the implementation of Alternative 2 results in a predicted reduction in overflow volume of approximately 44%, from 3,900 MG to 2,190 MG. Figure 9-15 presents the benefit as indicated by the percent capture value. The figure demonstrates that implementation of Alternative 2 results in the predicted percent capture increasing from 85.5% to 91.7%, at an estimated 20-year present-worth cost of approximately $412 million.

9.3.5.2 Benefits to Black Rock Canal

Figure 9-16 (see Appendix 9-1) presents the cost-benefit curve for Alternative 2 for the Black Rock Canal, with the benefit measured by the predicted annual overflow volume to the Black Rock Canal. The figure demonstrates that for Alternative 2, a predicted reduction in overflow volume of 19% is achieved at an estimated 20-year present-worth cost of approximately $65 million. In addition to the Foundation Plan, components of Alternative 2 that contribute to this reduction are a proposed tunnel along Albany Street that collects overflow from CSO 011 and CSO 012, as well as in-line storage in several trunk sewers.

9.3.5.3 Benefits to Buffalo River

Figure 9-17 (see Appendix 9-1) presents the cost-benefit curve for Alternative 2 for the Buffalo River, with the benefit measured by the predicted annual overflow volume to the Buffalo River. The figure demonstrates that for Alternative 2, a predicted reduction in overflow volume of 49% is achieved at an estimated 20-year present-worth cost of approximately $190 million. In addition to the Foundation Plan, components of Alternative 2 that contribute to this reduction are several satellite storage facilities controlling CSOs that discharge to the Buffalo River.

9.3.5.4 Benefits to Cazenovia Creek

Figure 9-18 (see Appendix 9-1) presents the cost-benefit curve for Alternative 2 for the entire reach of Cazenovia Creek impacted by the BSA's collection system, with the benefit measured by the predicted annual overflow volume to Cazenovia Creek. The figure demonstrates that for Alternative 2, a predicted reduction in overflow volume of 45% is achieved at an estimated 20-year present-worth cost of approximately $41.7 million. Figure 9-19 (see Appendix 9-1) further delineates the Cazenovia Creek results by examining only the portion of Cazenovia Creek with a Class B designation. The figure demonstrates that for this portion of Cazenovia Creek, a predicted reduction in overflow volume of 48% is achieved at an estimated 20-year present-worth cost of approximately $5.9 million. In addition to the Foundation Plan, components of Alternative 2 that contribute to these reductions are several satellite storage facilities controlling CSOs that discharge to Cazenovia Creek.

9.3.5.5 Benefits to Cornelius Creek

Figure 9-20 (see Appendix 9-1) presents the cost-benefit curve for Alternative 2 for Cornelius Creek, with the benefit measured by the predicted annual overflow volume to Cornelius Creek. The figure demonstrates that for Alternative 2, a predicted reduction in overflow volume of 69% is achieved at an estimated 20-year present-worth cost of approximately $89 million. In addition to the Foundation Plan, the component of Alternative 2 that contributes to this reduction is a satellite storage facility controlling CSO 055 discharge to Cornelius Creek.

9.3.5.6 Benefits to Erie Basin Marina

Figure 9-21 (see Appendix 9-1) presents the cost-benefit curve for Alternative 2 for the Erie Basin Marina, with the benefit measured by the predicted annual overflow volume to the Erie Basin Marina. The figure demonstrates that for Alternative 2, a predicted reduction in overflow volume of 34% is achieved at an estimated 20-year present-worth cost of approximately $7.3 million. In addition to the Foundation Plan, components of Alternative 2 that contribute to this reduction are several satellite storage facilities controlling CSOs that discharge into the Erie Basin Marina.

9.3.5.7 Benefits to Niagara River

Figure 9-22 (see Appendix 9-1) presents the cost-benefit curve for Alternative 2 for the Niagara River, with the benefit measured by the predicted annual overflow volume to the Niagara River. The figure demonstrates that for Alternative 2, a predicted reduction in overflow volume of 78% is achieved at an estimated 20-year present-worth cost of approximately $19 million. In addition to the Foundation Plan, the component of Alternative 2 that contributes to this reduction is a proposed tunnel along Albany Street that collects overflow from CSO 011 and CSO 012.

9.3.5.8 Benefits to Scajaquada Creek

Figures 9-23 and 9-24 (see Appendix 9-1) present the cost-benefit curves for Alternative 2 for Scajaquada Creek. Figure 9-23 presents the benefit as measured by predicted annual overflow volume. The figure demonstrates that for Alternative 2, a predicted reduction in overflow volume of only 2% is achieved at an estimated 20-year present-worth cost of approximately $15 million. The components of Alternative 2 that impact Scajaquada Creek are primarily in-line storage. The Bailey, Colorado, Hagen, and Texas trunk sewer in-line storage locations help to reduce overflow to Scajaquada Creek. However, the Bird Avenue trunk sewer in-line storage location, which reduces the overflow volume to the Black Rock Canal, actually causes an increase in overflow volume to Scajaquada Creek. The increase in overflow volume to Scajaquada Creek resulting from one of the Black Rock Canal in-line storage facilities is due to the fact that the underflow lines from the CSO 059 and CSO 060 basins tie into the Bird Avenue trunk sewer. The Bird Avenue in-line storage facility as included in Alternative 2 increases the HGL in this trunk sewer. Thus, less flow can enter the Bird Avenue trunk sewer from the CSO 059 and CSO 060 basin underflow lines, increasing the overflow volume from those two CSOs. This counter-balancing of effects explains the small percent reduction in overflow volume to Scajaquada Creek under this alternative. Figure 9-24 presents the benefit as measured by predicted annual bacteria exceedance hours. The figure demonstrates that Alternative 2 has no impact on this value, which is explained by the fact that Alternative 2 contains no components that impact the most active overflow to Scajaquada Creek.

9.4 Alternative 3A – System-Wide Storage with Partial Separation

9.4.1 Background Information

Alternative 3A consists of the construction of deep-rock tunnels to provide storage for the majority of the BSA's CSOs. The mining of tunnels below grade is typically an effective method of providing off-line storage in congested urban areas. The remaining CSOs would be captured or controlled through a combination of satellite storage facilities and partial separation.

9.4.2 Description of Alternative

This alternative involves the mining of storage tunnels well below grade, and if possible, within bedrock. The tunnels would be sized to store overflows from all captured regulators up to a predetermined control level. Regulator overflow pipes would be connected to tunnel drop shafts.

Reasonable tunnel alignments allow for efficient capture of all but 14 of the BSA's CSOs. These tunnel alignments and other components (to control the remaining 14 CSOs) of Alternative 3A are presented on Figure 9-25 and in Table 9-6 (see Appendix 9-1).

9.4.3 Proposed Facilities and Operational Concepts

Facility configurations and operational concepts for the local off-line storage basins and partial separation technologies included in Alternative 3A have been presented in Sections 9.3.3.1 and 9.2.3.3, respectively. This section discusses the remaining storage tunnel component of Alternative 3A.

Storage tunnels can be used to capture wet-weather flows and attenuate peak flows during storm events, and may also provide additional dry-weather capacity for the system. When an SPP along the proposed tunnel route overflows, CSO discharges up to a predetermined control level would be directed to the tunnel for storage until the WWTP could treat the excess flows. The system would be designed to fill by gravity flow, although pumping to the interceptor or WWTP for dewatering would be required.

The storage tunnels proposed for the BSA's system would be mined at a depth between approximately 25 and 125 feet below grade using tunnel-boring machines. The design depth would depend on several factors, including the results of a geotechnical investigation to determine the depth of bedrock along the proposed route. The tunnel alignment would likely be well below ground water for its entire length.

An entrance shaft would be required to provide a platform at the tunnel invert elevation to start the advance of the tunnel. Work shafts would be constructed along the tunnel route during construction. These shafts would also provide a connection to the SPPs that would overflow to the tunnel during operation. For SPPs that are distant from the tunnel alignment, microtunnels would be constructed to connect the overflow pipes to the tunnel drop shafts. An exit shaft would then be required at the end of the tunnel.

To minimize drawdown of the groundwater table due to leakage into the entrance and exit shafts, slurry walls would be used for the sides of the entrance and exit shafts with a grout plug at the bottom of each shaft. The tunnel would be constructed with a lining system consisting of reinforced concrete, precast concrete, shotcrete, contact grout, or other materials.

The proposed tunnel would provide storage for overflow volume for the captured SPPs along its alignment up to the capacity of the selected control level for those SPPs. During a storm event, CSO discharge currently directed to a receiving stream from an SPP would flow to the tunnel up to the control level. Ventilation and odor control would be included with the facility. Solids handling dewatering pumps would be used to return the contents of the tunnel to the interceptor or the WWTP after the storm event.

9.4.4 Preliminary Costs

The estimated 20-year present-worth cost for Alternative 3A varies from $451 million for an approximately one-month level of control to $1 billion for an approximately 12-month level of control. Table 9-7 (see Appendix 9-1) summarizes the component cost breakdown (the backup documentation for the cost estimate was included in the 2004 LTCP).

9.4.5 Description of Benefits

Figures 9-26 through 9-36 (see Appendix 9-1) present the cost-benefit curves for Alternative 3A.

9.4.5.1 Benefits to Total System

Figures 9-26 and 9-27 (see Appendix 9-1) present the cost-benefit curves for Alternative 3A for the total system. Figure 9-26 presents the benefit as measured by predicted annual overflow volume. The curve represents the effect of different levels of storage within the system. The first point on the curve represents the “zero” storage level, or Alternative 1. Figure 9-26 demonstrates that the knee of the Alternative 3A benefit curve occurs at approximately $643 million.

The knee-of-the-curve represents a point of diminishing returns with respect to the incremental reduction in overflow volume resulting from an incremental increase in cost. The knee-of-the-curve is defined by a breakpoint in the slope of the cost-benefit curve where there is a significant decrease in the marginal benefit (*i.e.,* reduction in CSO volume, percent capture, water quality benefit) for a marginal increase in the level of control. The knee-of-the-curve presented in Figures 9-26 and 9-27 is the sum of the knee-of-the-curve identified for each receiving water body for Alternative 3A. This system knee-of-the-curve is different from the knee-of-the-curve based on the system curve alone, but the two points are very close. Identifying the system knee-of-the-curve based on the system curve alone ignores the uniqueness of each of the receiving water bodies. Identifying the system knee-of-the-curve by summing the knee-of-the-curve for each individual receiving water body optimizes the system at each receiving water body.

At the $643 million level of control, the figure demonstrates that the implementation of Alternative 3A results in a predicted reduction in overflow volume of approximately 63%, from 3,900 MG to 1,440 MG. Figure 9-27 presents the benefit as indicated by the percent capture value. The figure demonstrates that implementing the knee-of-the-curve level of control for Alternative 3A results in the predicted percent capture increasing from 85.5% to 94.5%.

9.4.5.2 Benefits to Black Rock Canal

Figure 9-28 (see Appendix 9-1) presents the cost-benefit curve for Alternative 3A for the Black Rock Canal, with the benefit measured by the predicted annual overflow. The figure demonstrates that for Alternative 3A, a predicted reduction in overflow volume of 57% at an estimated 20-year present-worth cost of approximately $230 million occurs at the knee-of-the-curve level of control for the Black Rock Canal. The proposed Black Rock Canal and Scajaquada deep-rock tunnels primarily contribute to this reduction.

9.4.5.3 Benefits to Buffalo River

Figure 9-29 (see Appendix 9-1) presents the cost-benefit curve for Alternative 3A for the Buffalo River, with the benefit measured by the predicted annual overflow volume to the Buffalo River. The figure demonstrates that for Alternative 3A, a predicted reduction in overflow volume of 43% at an estimated 20-year present-worth cost of approximately $200 million occurs at the knee-of-the-curve level of control for the Buffalo River. The proposed Buffalo River deep-rock tunnel primarily contributes to this reduction. Several satellite storage facilities, as well as additional partial sewer separation in targeted areas, also contribute to the reduction.

9.4.5.4 Benefits to Cazenovia Creek

Figure 9-30 (see Appendix 9-1) presents the cost-benefit curve for Alternative 3A for the entire reach of Cazenovia Creek impacted by the BSA's collection system, with the benefit measured by the predicted annual overflow volume to Cazenovia Creek. Overflow from the Cazenovia Creek CSOs is routed to the proposed Buffalo River deep-rock tunnel. None of the tunnel's seven overflows discharge to Cazenovia Creek, which means that Cazenovia Creek receives none of the tunnel's overflow volume. The end result is a 100% reduction in overflow volume to Cazenovia Creek at the knee-of-the-curve level of control for the Buffalo River, which translates into an estimated 20-year present-worth cost of approximately $46 million for the Cazenovia Creek portion of the tunnel. Figure 9-31(see Appendix 9-1) further delineates the Cazenovia Creek results by examining only the portion of Cazenovia Creek with a Class B designation. The figure demonstrates that for Alternative 3A, overflow is eliminated for this portion of Cazenovia Creek. This is a result of the configuration of the alternative. Overflow from CSO 035 is routed to the proposed Buffalo River deep-rock tunnel. None of the overflows for the tunnel discharge to this reach of Cazenovia Creek. The figure demonstrates that, as a result, Alternative 3A results in a 100% reduction in overflow volume to this reach of Cazenovia Creek at the knee-of-the-curve for the Buffalo River, which translates into an estimated 20-year present worth cost of approximately $5.2 million for the Class B Cazenovia Creek portion of the tunnel.

9.4.5.5 Benefits to Cornelius Creek

Figure 9-32 (see Appendix 9-1) presents the cost-benefit curve for Alternative 3A for Cornelius Creek, with the benefit measured by the predicted annual overflow volume to Cornelius Creek. The figure demonstrates that for Alternative 3A, a predicted reduction in overflow volume of 65% at an estimated 20-year present-worth cost of approximately $88 million occurs at the knee-of-the-curve level of control for Cornelius Creek. A satellite storage facility for CSO 055 primarily contributes to this reduction.

9.4.5.6 Benefits to Erie Basin Marina

Figure 9-33 (see Appendix 9-1) presents the cost-benefit curve for Alternative 3A for the Erie Basin Marina, with the benefit measured by the predicted annual overflow volume to the Erie Basin Marina. All overflows from the Erie Basin Marina are routed to the proposed Buffalo River deep-rock tunnel, from which no overflow discharges to the Erie Basin Marina. As a result, the figure demonstrates that for Alternative 3A, 100% reduction in overflow volume can be achieved at the knee-of-the-curve level of control for the Buffalo River, which translates into an estimated 20-year present-worth cost of approximately $10 million for the Erie Basin portion of the tunnel.

9.4.5.7 Benefits to Niagara River

Figure 9-34 (see Appendix 9-1) presents the cost-benefit curve for Alternative 3A for the Niagara River, with the benefit measured by the predicted annual overflow volume to Niagara River. The figure demonstrates that for Alternative 3A, a predicted reduction in overflow volume of 97% at an estimated 20-year present-worth cost of approximately $16 million occurs at the knee-of-the-curve level of control for the Niagara River. The component of Alternative 3A that contributes to most of this reduction is the proposed Black Rock Canal tunnel that collects overflow from CSO 011, as well as from a number of the Black Rock Canal overflows. The only other component of Alternative 3A that impacts the Niagara River is some targeted additional partial sewer separation. This sewer separation is not dependent on level of control, which explains why the benefit curve shown in Figure 9-34 becomes flat.

9.4.5.8 Benefits to Scajaquada Creek

Figures 9-35 and 9-36 (see Appendix 9-1) present the cost-benefit curves for Alternative 3A for Scajaquada Creek. Figure 9-35 presents the benefit as measured by predicted annual overflow volume. The figure demonstrates that for Alternative 3A for the knee-of-the-curve level of control for Scajaquada Creek, a predicted reduction in overflow volume of 47% is achieved at an estimated 20-year present-worth cost of approximately $48 million. Figure 9-36 presents the benefit as measured by predicted annual bacteria exceedance hours. The figure demonstrates that Alternative 3A reduces the exceedance hours from approximately 1,550 hours under existing conditions to 128 hours, at an estimated 20-year present-worth cost of approximately $48 million. The primary cause for this reduction is the proposed Scajaquada deep-rock tunnel.

9.5 Alternative 3B – System-Wide Storage with Partial Separation (Excluding Buffalo River and Erie Basin CSOs)

9.5.1 Background Information

Alternative 3B is identical in concept to Alternative 3A. However, Alternative 3B does not capture or control the CSOs along the Buffalo River or Erie Basin because, for the 2004 LTCP, there were no water quality control objectives for these receiving water bodies, as explained in Section 6.

9.5.2 Description of Alternative

Alternative 3B is identical in configuration to Alternative 3A, with the exception that it does not include controls for CSOs that discharge to the Buffalo River or Erie Basin. These controls are the portion of the Buffalo River Tunnel downstream of the confluence of the Buffalo River and Cazenovia Creek, satellite storage, and partial separation. The tunnel alignments and other components of Alternative 3B are presented on Figure 9-37 and in Table 9-8 (see Appendix 9-1).

9.5.3 Proposed Facilities and Operational Concepts

Facility configurations and operational concepts for the components of Alternative 3B are the same as those described for Alternative 3A in Section 9.4.3.

9.5.4 Preliminary Costs

The estimated 20-year present-worth cost for Alternative 3B varies from $386 million for an approximately one-month level of control to $814 million for an approximately 12-month level of control. Table 9-9 (see Appendix 9-1) summarizes the component cost breakdown (the backup documentation for the cost estimate was included in the 2004 LTCP).

9.5.5 Description of Benefits

Figures 9-38 through 9-41 (see Appendix 9-1) present the cost-benefit curves for Alternative 3B.

9.5.5.1 Benefits to Total System

Figures 9-38 and 9-39 (see Appendix 9-1) present the cost-benefit curves for Alternative 3B for the total system. Figure 9-38 presents the benefit as measured by predicted annual overflow volume. The curve represents the effect of different levels of storage within the system. The first point on the curve represents the "zero" storage level, or Alternative 1. The knee-of-the-curve presented in Figures 9-38 and 9-39 is the sum of the knee-of-the curve for each individual receiving water body, as described in Section 9.4.5.1. Figure 9-38 demonstrates that the knee of the benefit curve occurs at approximately $446 million. At this level of control, the figure demonstrates that the implementation of Alternative 3B results in a predicted reduction in overflow volume of approximately 42%, from 3,900 MG to 2,280 MG. Figure 9-39 presents the benefit as indicated by the percent capture value. The figure demonstrates that for the knee-of-the-curve level of control, implementation of Alternative 3B results in the predicted percent capture increasing from 85.5% to 91.8%.

9.5.5.2 Benefits to Black Rock Canal

The components of Alternative 3B that impact the Black Rock Canal are the same as the components of Alternative 3A that impact the Black Rock Canal. Therefore, the benefit is as described in Section 9.4.5.2 and Figure 9-28.

9.5.5.3 Benefits to Buffalo River

No additional components are present in Alternative 3B that impact the Buffalo River other than those present in Alternative 1, the Foundation Plan. Therefore, the benefit of Alternative 3B to the Buffalo River is as described in Section 9.2.5.3 and Figure 9-5.

9.5.5.4 Benefits to Cazenovia Creek

Figure 9-40 (see Appendix 9-1) presents the cost-benefit curve for Alternative 3B for the entire reach of Cazenovia Creek impacted by the BSA's collection system, with the benefit measured by the predicted annual overflow volume to Cazenovia Creek. The figure demonstrates that for Alternative 3B a predicted reduction in overflow volume of 51% is achieved at an estimated 20-year present-worth cost of approximately $58 million, corresponding to the knee-of-the-curve. This reduction is the result of the proposed Cazenovia Creek deep-rock tunnel. Figure 9-41 (see Appendix 9-1) further delineates the Cazenovia Creek results by examining only the portion of Cazenovia Creek with a Class B designation. The figure demonstrates that for Alternative 3B, overflow is eliminated for this portion of Cazenovia Creek at an estimated 20-year present-worth cost of approximately $6.4 million. This is a result of the configuration of the alternative. Overflow from CSO 035 is routed to the proposed Cazenovia Creek deep-rock tunnel. None of the overflows for the tunnel discharge to this reach of Cazenovia Creek. Therefore, under Alternative 3B, there are no longer any overflow locations for the Class B portion of Cazenovia Creek.

9.5.5.5 Benefits to Cornelius Creek

The components of Alternative 3B that impact Cornelius Creek are the same as the components of Alternative 3A that impact Cornelius Creek. Therefore, the benefit of Alternative 3B to Cornelius Creek is as described in Section 9.4.5.5 and Figure 9-32.

9.5.5.6 Benefits to Erie Basin Marina

No additional components are present in Alternative 3B that impact the Erie Basin Marina other than those present in Alternative 1, the Foundation Plan. Therefore, the benefit is as described in Section 9.2.5.6 and Figure 9-9.

9.5.5.7 Benefits to Niagara River

The components of Alternative 3B that impact Niagara River are the same as the components of Alternative 3A that impact Niagara River. Therefore, the benefit is as described in Section 9.4.5.7 and Figure 9-34.

9.5.5.8 Benefits to Scajaquada Creek

The components of Alternative 3B that impact Scajaquada Creek are the same as the components of Alternative 3A that impact Scajaquada Creek. Therefore, the benefit is as described in Section 9.4.5.8 and Figures 9-35 and 9-36.

9.6 Alternative 4A – Satellite Treatment with Partial Separation

9.6.1 Background Information

Alternative 4A consists of constructing satellite Enhanced High-Rate Clarification (EHRC) facilities at all of the BSA's CSOs. It also includes maximizing the impact of feasible partial separation to minimize the required size of the EHRC facilities.

9.6.2 Description of Alternative

This alternative involves two components:

- Additional partial separation (beyond the Foundation Plan) to reduce the amount of wet-weather flow reaching the BSA's SPPs. In order to identify these additional partial separation areas, it was assumed that partial separation was feasible in a one-quarter mile band along the receiving streams (*i.e.*, construction of gravity storm sewer outlets is feasible, in general, for areas up to one-quarter mile from the streams).

- EHRC facilities at all CSOs to treat the remaining wet-weather overflow (after partial separation).

The components of Alternative 4A are presented on Figure 9-42 and summarized in Table 9-10 (see Appendix 9-1).

9.6.3 Proposed Facilities and Operational Concepts

Concepts associated with partial separation component are as presented in Section 9.2.3.3.

The EHRC facilities would be used to flocculate and settle suspended solids to remove TSS and CBOD, and allow CSO flows to be disinfected. Pilot testing in other cities has shown that EHRC can achieve TSS removal rates comparable to those of, or exceeding, primary removal while utilizing a relatively much smaller footprint. A mechanically cleaned fine screen would need to be provided to prevent plugging of the lamella type settling plates in the clarification system.

Treated effluent from the EHRC facilities would be disinfected to meet bacteria standards. A high rate disinfection system is proposed to follow the EHRC effluent and typically includes a chlorine contact tank sized for a minimum of 5 minutes of contact time under peak flow conditions coupled with intense initial mixing. The Alternative 4A cost estimates were prepared assuming that high rate disinfection systems would be used at the satellite facilities.

The 2004 LTCP assumed that the EHRC facilities would operate between the current SPP and the receiving water (*i.e*., would be constructed in line with the overflow conduit), thereby not requiring a pumping station. When the SPP activates, overflow would flow to the facility. When the overflow rate exceeds the capacity of the EHRC facility, subsequent overflow from the SPP during the event would be discharged untreated to the receiving stream. This discharge would be considered a CSO event in the new system. The EHRC facilities would include concrete tankage for chemical (*e.g*., polymer, coagulants, and ballast sand or biochemical solids) addition, flash mixing, gentle mixing and sedimentation; chemical feed and pumping facilities and associated building; settling facilities; self-cleaning fine screens; yard piping; and electrical and instrumentation and control (I&C) equipment. The EHRC facilities would also include high rate disinfection systems, which typically consist of a concrete contact tank sized for 5-minute contact time, mixing equipment, disinfectant storage, feed and pumping facilities, piping, valves, diffuser, and chlorine residual analyzer.

9.6.4 Preliminary Costs

The estimated 20-year present-worth cost for Alternative 4A varies from $506 million for an approximately one-month level of control to $1.6 billion for an approximately 12-month level of control. Table 9-11 (see Appendix 9-1) summarizes the component cost breakdown (the backup documentation for the cost estimate was included in the 2004 LTCP).

9.6.5 Description of Benefits

Figures 9-43 through 9-53 (see Appendix 9-1) present the cost-benefit curves for Alternative 4A.

9.6.5.1 Benefits to Total System

Figures 9-43 and 9-44 (see Appendix 9-1) present the cost-benefit curves for Alternative 4A for the total system. Figure 9-43 presents the benefit as measured by predicted annual overflow volume. The curve represents the effect of different levels of treatment within the system. The first point on the curve represents the "zero" treatment level, or Alternative 1. The knee-of-the-curve presented in Figures 9-43 and 9-44 is the sum of the knee-of-the-curves for the receiving water bodies for Alternative 4A, as described in Section 9.4.5.1. Figure 9-43 demonstrates that the knee of the benefit curve for Alternative 4A occurs approximately at $658 million. At this level of control, the figure demonstrates that the implementation of Alternative 4A results in a predicted reduction in overflow volume of approximately 54%, from 3,900 MG to 1,810 MG. Figure 9-44 presents the benefit as indicated by the percent capture value. The figure demonstrates that for the knee-of-the-curve level of control, implementation of Alternative 4A results in the predicted percent capture increasing from 85.5% to 94.1%.

9.6.5.2 Benefits to Black Rock Canal

Figure 9-45 (see Appendix 9-1) presents the cost-benefit curve for Alternative 4A for the Black Rock Canal, with the benefit measured by the predicted annual overflow volume to the Black Rock Canal. The figure demonstrates that for Alternative 4A, a predicted reduction in overflow volume of 58% at an estimated 20-year present-worth cost of approximately $280 million occurs at the knee-of-the-curve level of control for the Black Rock Canal. Satellite treatment facilities primarily contribute to this reduction.

9.6.5.3 Benefits to Buffalo River

Figure 9-46 (see Appendix 9-1) presents the cost-benefit curve for Alternative 4A for the Buffalo River, with the benefit measured by the predicted annual overflow volume to the Buffalo River. The figure demonstrates that for Alternative 4A, a predicted reduction in overflow volume of 48% at an estimated 20-

year present-worth cost of approximately $155 million occurs at the knee-of-the-curve level of control for the Buffalo River. Satellite treatment facilities primarily contribute to this reduction.

9.6.5.4 Benefits to Cazenovia Creek

Figure 9-47 (see Appendix 9-1) presents the cost-benefit curve for Alternative 4A for the entire reach of Cazenovia Creek impacted by the BSA's collection system, with the benefit measured by the predicted annual overflow volume to Cazenovia Creek. The figure demonstrates that for Alternative 4A, a predicted reduction in overflow volume of 46% is achieved at an estimated 20-year present-worth cost of approximately $45 million at the knee-of-the-curve level of control for Cazenovia Creek. Figure 9-48 (see Appendix 9-1) further delineates the Cazenovia Creek results by examining only the portion of Cazenovia Creek with a Class B designation. The figure demonstrates that for this portion of Cazenovia Creek, a predicted reduction in overflow volume of 49% is achieved at an estimated 20-year present-worth cost of approximately $5.4 million. The components of Alternative 4A that primarily contribute to these reductions are satellite treatment facilities.

9.6.5.5 Benefits to Cornelius Creek

Figure 9-49 (see Appendix 9-1) presents the cost-benefit curve for Alternative 4A for Cornelius Creek, with the benefit measured by the predicted annual overflow volume to Cornelius Creek. The figure demonstrates that for Alternative 4A, a predicted reduction in overflow volume of 54% at an estimated 20-year present-worth cost of approximately $70 million occurs at the knee-of-the-curve level of control for Cornelius Creek. A satellite treatment facility for CSO 055 primarily contributes to this reduction.

9.6.5.6 Benefits to Erie Basin Marina

Figure 9-50 (see Appendix 9-1) presents the cost-benefit curve for Alternative 4A for the Erie Basin Marina, with the benefit measured by the predicted annual overflow volume to the Erie Basin Marina. The figure demonstrates that for Alternative 4A, a predicted reduction in overflow volume of 42% at an estimated 20-year present-worth cost of approximately $8 million occurs at the knee-of-the-curve level of control for Erie Basin Marina. Satellite treatment facilities primarily contribute to this reduction.

9.6.5.7 Benefits to Niagara River

Figure 9-51 (see Appendix 9-1) presents the cost-benefit curve for Alternative 4A for the Niagara River, with the benefit measured by the predicted annual overflow volume to the Niagara River. The figure demonstrates that for Alternative 4A, a predicted reduction in overflow volume of 66% at an estimated 20-year present-worth cost of approximately $25 million occurs at the knee-of-the-curve level of control for the Niagara River. Satellite treatment facilities primarily contribute to this reduction.

9.6.5.8 Benefits to Scajaquada Creek

Figures 9-52 and 9-53 (see Appendix 9-1) present the cost-benefit curves for Alternative 4A for Scajaquada Creek. Figure 9-52 presents the benefit as measured by predicted annual overflow volume. The figure demonstrates that for Alternative 4A a predicted reduction in overflow volume of 61% is achieved at an estimated 20-year present-worth cost of approximately $70 million at the knee-of-the-curve level of control for Scajaquada Creek. Figure 9-53 presents the benefit as measured by predicted annual bacteria exceedance hours. The figure demonstrates that the annual exceedance hours are reduced from approximately 1,550 hours to 164 hours for this level of control.

9.7 Alternative 4B – Satellite Treatment with Partial Separation (Excluding Buffalo River and Erie Basin CSOs)

9.7.1 Background Information

Alternative 4B is identical in concept to Alternative 4A. However, as with Alternative 3B, Alternative 4B does not capture or control CSOs along the Buffalo River or Erie Basin because, at the time of the submittal of the LTCP in 2004, there was no water quality control objective on these receiving water bodies, as explained in Section 6.

9.7.2 Description of Alternative

Alternative 4B is identical in configuration to Alternative 4A, with the exception that it does not include partial separation along the Buffalo River or construction of EHRC facilities at the Buffalo River or Erie Basin CSOs. The components of Alternative 4B are presented on Figure 9-54 and in Table 9-12 (see Appendix 9-1).

9.7.3 Proposed Facilities and Operational Concepts

Facility configurations and operational concepts for the Alternative 4B components are the same as those described for Alternative 4A in Section 9.6.3.

9.7.4 Preliminary Costs

The estimated 20-year present-worth cost for Alternative 4B varies from $459 million for an approximately one-month level of control to $1.2 billion for an approximately 12-month level of control. Table 9-13 (see Appendix 9-1) summarizes the component cost breakdown (the backup documentation for the cost estimate was included in the 2004 LTCP).

9.7.5 Description of Benefits

Figures 9-55 and 9-56 (see Appendix 9-1) present the cost-benefit curves for Alternative 4B.

9.7.5.1 Benefits to Total System

Figures 9-55 and 9-56 (see Appendix 9-1) present the cost-benefit curves for Alternative 4B for the total system. Figure 9-55 presents the benefit as measured by predicted annual overflow volume. The curve represents the effect of different levels of treatment within the system. The first point of the curve represents the "zero" treatment level, and is equivalent to Alternative 1. The knee-of-the-curve presented in Figures 9-55 and 9-56 is the sum of the knee-of-the-curve for the receiving water bodies for Alternative 4B, as described in Section 9.4.5.1. Figure 9-55 demonstrates that implementation of Alternative 4B results in a predicted reduction in overflow volume of approximately 45%, from 3,900 MG to 1,950 MG, at an estimated 20-year present-worth cost of approximately $495 million. Figure 9-56 presents the benefit as indicated by the percent capture value. The figure demonstrates that for the knee-of-the-curve level of control, implementation of Alternative 4B results in the predicted percent capture increasing from 85.5% to 92.3%.

9.7.5.2 Benefits to Black Rock Canal

The components of Alternative 4B that impact the Black Rock Canal are the same as the components of Alternative 4A that impact the Black Rock Canal. Therefore, the benefit is as described in Section 9.6.5.2 and Figure 9-45.

9.7.5.3 Benefits to Buffalo River

No additional components are present in Alternative 4B that impact the Buffalo River other than those present in Alternative 1, the Foundation Plan. Therefore, the benefit is as described in Section 9.2.5.3 and Figure 9-5.

9.7.5.4 Benefits to Cazenovia Creek

The components of Alternative 4B that impact the Cazenovia Creek are the same as the components of Alternative 4A that impact the Cazenovia Creek. Therefore, the benefit is as described in Section 9.6.5.4 and Figures 9-47 and 9-48.

9.7.5.5 Benefits to Cornelius Creek

The components of Alternative 4B that impact the Cornelius Creek are the same as the components of Alternative 4A that impact the Cornelius Creek. Therefore, the benefit is as described in Section 9.6.5.5 and Figure 9-49.

9.7.5.6 Benefits to Erie Basin Marina

No additional components are present in Alternative 4B that impact the Erie Basin Marina other than those present in Alternative 1, the Foundation Plan. Therefore, the benefit is as described in Section 9.2.5.6 and Figure 9-9.

9.7.5.7 Benefits to Niagara River

The components of Alternative 4B that impact the Niagara River are the same as the components of Alternative 4A that impact the Niagara River. Therefore, the benefit is as described in Section 9.6.5.7 and Figure 9-51.

9.7.5.8 Benefits to Scajaquada Creek

The components of Alternative 4B that impact the Scajaquada Creek are the same as the components of Alternative 4A that impact the Scajaquada Creek. Therefore, the benefit is as described in Section 9.6.5.8 and Figures 9-52 and 9-53.

9.8 Alternative 5 – Complete Separation

9.8.1 Background Information

Complete separation of a CSS converts the existing one-pipe system (one pipe carrying both sanitary and storm flows) to a two-pipe system (one pipe carrying sanitary flow, a separate pipe carrying storm flow). Complete separation is different than the CSO control technologies included in other system-wide alternatives in that it would theoretically eliminate CSO discharges, rather than controlling those discharges to a selected control level.

9.8.2 Description of Alternative

The concept behind separating combined sewers selected for the BSA is to provide new storm sewers alongside or nearby existing sewers, routing the new storm sewers to the rivers for discharge. Only sanitary sewage would then be transported to the WWTP through the existing system, without the occurrence of surcharge conditions during wet-weather events. Local storm collector sewers would be a minimum of 12-inches in diameter. Three or four inlets or catch basins would be installed at most intersections; it is anticipated that some existing inlets currently connected to the combined system would be reused and connected to the new storm sewer system.

9.8.3 Proposed Facilities and Operational Concepts

Complete separation would require the construction of new pipeline facilities, which would be no different in terms of structure or operation than existing pipeline facilities currently managed and operated by the BSA.

9.8.4 Preliminary Costs

The estimated 20-year present-worth cost for Alternative 5 is $1 billion. Table 9-14 (see Appendix 9-1) summarizes the component cost breakdown (the backup documentation for the cost estimate was included in the 2004 LTCP).

9.8.5 Description of Benefits

Figures 9-57 through 9-67 (see Appendix 9-1) present the cost-benefit curves for Alternative 5.

9.8.5.1 Benefits to Total System

Figures 9-57 and 9-58 (see Appendix 9-1) present the cost-benefit curves for the total system for Alternative 5, with the benefit measured by overflow volume and percent capture, respectively. Since Alternative 5 is a complete separation alternative, it results in the annual overflow volume being reduced to 0 MG and the percent capture being increased to 100%. The figures demonstrate that complete separation of the system can be accomplished at an estimated 20-year present-worth cost of approximately $1 billion, which is more expensive than Alternatives 1 and 2, as well as the knee-of-the-curve level of control for Alternatives 3A, 3B, 4A, and 4B.

9.8.5.2 Benefits to Black Rock Canal

Figure 9-59 (see Appendix 9-1) demonstrates that complete separation of the area tributary to the Black Rock Canal can be accomplished at an estimated 20-year present-worth cost of approximately $374 million, which is more expensive than Alternatives 1 and 2, as well as the knee-of-the-curve level of control for Alternatives 3A / 3B and 4A / 4B.

9.8.5.3 Benefits to Buffalo River

Figure 9-60 (see Appendix 9-1) demonstrates that complete separation of the area tributary to the Buffalo River can be accomplished at an estimated 20-year present-worth cost of approximately $322 million, which is more expensive than Alternatives 1 and 2, as well as the knee-of-the-curve level of control for Alternatives 3A and 4A.

9.8.5.4 Benefits to Cazenovia Creek

Figure 9-61 (see Appendix 9-1) demonstrates that complete separation of the area tributary to Cazenovia Creek can be accomplished at an estimated 20-year present-worth cost of approximately $51 million, which is more expensive than Alternatives 1 and 2, as well as the knee-of-the-curve level of control for Alternatives 3A and 4A / 4B. Alternative 5 is less expensive than the knee-of-the-curve level of control for Alternative 3B. Figure 9-62 (see Appendix 9-1) demonstrates that complete separation of the area tributary to the B Class portion of Cazenovia Creek can be accomplished at an estimated 20-year present-worth cost of approximately $4.1 million, which is only slightly more expensive than Alternative 1, and is less expensive than Alternative 2 and the knee-of-the-curve level of control for Alternatives 3A, 3B, and 4A / 4B. Complete separation, as measured by cost for the Cazenovia Creek area, is a viable CSO abatement alternative because a substantial portion of the South Buffalo area is already separated.

9.8.5.5 Benefits to Cornelius Creek

Figure 9-63 (see Appendix 9-1) demonstrates that complete separation of the area tributary to Cornelius Creek can be accomplished at an estimated 20-year present-worth cost of approximately $206 million, which is more expensive than Alternatives 1 and 2, as well as the knee-of-the-curve level of control for Alternatives 3A / 3B and 4A / 4B.

9.8.5.6 Benefits to Erie Basin Marina

Figure 9-64 (see Appendix 9-1) demonstrates that complete separation of the area tributary to the Erie Basin Marina can be accomplished at an estimated 20-year present-worth cost of approximately $26 million, which is more expensive than Alternatives 1 and 2, as well as the knee-of-the-curve level of control for Alternatives 3A and 4A.

9.8.5.7 Benefits to Niagara River

Figure 9-65 (see Appendix 9-1) demonstrates that complete separation of the area tributary to the Niagara River can be accomplished at an estimated 20-year present-worth cost of approximately $31 million, which is more expensive than Alternatives 1 and 2, as well as the knee-of-the-curve level of control for Alternatives 3A / 3B and 4A / 4B.

9.8.5.8 Benefits to Scajaquada Creek

Figures 9-66 and 9-67 (see Appendix 9-1) demonstrate that complete separation of the area tributary to Scajaquada Creek can be accomplished at an estimated 20-year present-worth cost of approximately $106 million, which is more expensive than Alternatives 1 and 2, as well as the knee-of-the-curve level of control for Alternatives 3A / 3B and 4A / 4B.

10. Re-evaluation of the 2004 Preferred System-Wide Alternative

An Alternative Screening process was used in the 2004 LTCP to develop the preferred system-wide alternative for the BSA's LTCP. The Alternative Screening process consisted of selecting criteria and then evaluating each alternative for each criterion by receiving water body using a scoring and ranking process. The preferred system-wide alternative consists of the alternatives that were ranked the highest for each receiving water body.

As presented in the 2004 LTCP, the BSA reviewed, screened and evaluated a wide range of alternatives for each receiving water body (RWB). The 2004 preferred alternatives for each RWB were selected based on a number of factors, including their ability to meet the control objectives. The NYSDEC direction, at that time, stated that no bacteria control objectives were required for Class C streams, and, as such, the preferred alternatives for Erie Basin and Buffalo River did not provide bacteria control. Table 10-1 summarizes the 2004 system-wide preferred alternative based upon that directive. Upon review of the 2004 LTCP, counter to their original position, the NYSDEC raised a concern that the 2004 LTCP preferred alternative did not provide for bacteria control in the Class C receiving waters.

Table 10-1: 2004 System-wide Preferred Alternative and Cost (2004 dollars)

Receiving Water Body	Preferred Alternative	Cost ($ M)
Black Rock Canal	3A / 3B (same)	$ 230
Buffalo River	1	$ 87
Cazenovia Creek - B	5	$ 4.1
Cazenovia Creek - C	5	$ 47
Cornelius Creek	2	$ 89
Erie Basin	1	$ 2.8
Niagara River	3A / 3B (same)	$ 16
Scajaquada Creek	3A / 3B (same)	$ 48
	System-Wide	**$ 524**

Based on the NYSDEC request, and building off the completed 2004 evaluation and ranking process, the BSA reassembled the overall 2004 preferred alternative by replacing the originally selected alternatives for Buffalo River and Erie Basin with the top-ranked alternatives that, in 2004, provided for bacteria control for these RWBs. Since the 2004 LTCP evaluated a wide range of alternatives, it contains all information necessary to review and select alternatives that will provide bacteria control for these RWBs. Much of the 2004 system-wide alternative remains viable as the backbone of the 2012 LTCP Update, as many of the original decision criteria have not changed.

This section first provides a brief overview of the alternative selection process and results from the 2004 LTCP development effort, and then summarizes a reassessment of the alternative ranking results to recommend an updated 2004 preferred alternative that meets current objectives in the Buffalo River and Erie Basin Marina. Section 6 outlines, in detail, the current control objectives for each water body.

10.1 Criteria Selection and Scoring Process (2004)

There are four criteria by which each alternative was evaluated for each receiving water body:

- Capital Cost;
- O&M Cost;
- Probability of Meeting Control Objectives; and
- Ability to Phase Components.

These criteria were selected based on the BSA's specific needs and concerns. Each criterion was then assigned a relative rank and weight based on the BSA's specific preferences at the time of the 2004 LTCP development as presented in Table 10-2.

Table 10-2: Criteria Weight

Criteria	Points
Probability of Meeting Control Objectives	100
Capital Cost	80
O&M Cost	20
Ability to Phase Components	20

The primary criteria in the selection of the preferred alternative were 1) ability to meet control objectives and 2) capital costs, in that order. Together, these criteria account for over 80% of the total weight. The O&M cost criteria was given one-fourth of the weight as capital cost because, in general, O&M cost is typically much lower than the capital cost. The O&M cost criterion also includes consideration of BSA staffing requirements, and carries the same weight as the ability to phase components criterion.

Each alternative was evaluated for each criterion on a relative scale of 0 to 10. The alternative that met the criterion completely, nearly completely, or was sufficient in achieving the desired outcome being evaluated was assigned the most points, while the alternative that did not meet the criterion, met the criterion only slightly, or was poor at providing the desired outcome being evaluated was assigned the least points.

A criteria score was calculated by multiplying the criteria weight by the assigned points. A total score for each alternative was calculated by summing the criteria scores. A normalized score for each alternative was calculated by dividing the total score by the highest total score and multiplying by 100 (thereby giving the alternative with the highest total score a normalized score of 100%). The alternatives were then ranked based on the normalized score, with a rank of 1 assigned to the alternative with the highest normalized score. The preferred alternative for each receiving water body is the alternative with the rank of 1. Ties for the highest rank were broken based on the least cost alternative.

10.2 Alternative Cost-Benefit-Effective Evaluation Point (Knee of the Curve Analysis)

Each alternative was evaluated at its cost-benefit-effective point for each of the criteria. The cost-benefit-effective point is the point at which cost expenditures for CSO controls is optimized when evaluating a plot of receiving water body benefit, such as CSO volume reduction, versus 20-year net present worth cost for CSO controls. Section 9 presents a complete listing of each 2004 alternative evaluated using this criteria.

For Alternatives 1, 2, and 5, the cost-benefit-effective point is defined as the total cost for each alternative. These alternatives do not vary with level of control. However, Alternatives 3A, 3B, 4A, and 4B do vary with level of control, and therefore, the cost-benefit-effective point was identified as the knee of the cost-benefit curve for each alternative for each receiving water body. The knee of the curve is the point where the slope of the cost-benefit curve significantly changes. For the 2004 LTCP, alternatives were not evaluated for the Buffalo River and Erie Basin because, at that time, there were no control objectives for these receiving water bodies, except for aesthetics.

Table 10-3 summarizes the cost-benefit-effective points used to re-evaluate each alternative for each criterion, by receiving water body, for the 2012 LTCP Update.

Table 10-3: Cost-Benefit-Effective Evaluation Point for Each Alternative by Receiving Water Body (2004 LTCP)

Receiving Water Body	Cost-Benefit-Effective Evaluation Point ($ M)						
	Alt. 1	Alt. 2	Alt. 3A	Alt. 3B	Alt. 4A	Alt. 4B	Alt. 5
Black Rock Canal	$ 16	$ 50	$ 230	$ 230	$ 280	$ 280	$ 270
Cazenovia Creek - B	$ 3.6	$ 5.9	$ 5.2	$ 6.4	$ 5.4	$ 5.4	$ 4.1
Cazenovia Creek - C	$ 32	$ 36	$ 46	$ 58	$ 45	$ 45	$ 47
Cornelius Creek	$ 8.8	$ 89	$ 88	$ 88	$ 70	$ 70	$ 210
Niagara River	$ 1.2	$ 9	$ 16	$ 16	$ 25	$ 5	$ 31
Scajaquada Creek	$ 13	$ 15	$ 48	$ 48	$ 70	$ 70	$ 110

10.3 Criteria Evaluation

10.3.1 Probability of Meeting Control Objectives

Because the probability of meeting control objectives increases with increasing reduction in CSO volume, each alternative was evaluated relative to the remaining alternatives for meeting this criterion. The most points were assigned to the alternative with the most reduction in CSO volume, the least points were assigned to the alternative with the least reduction in CSO volume, and the remaining alternatives were assigned points in between. Alternative 5, complete separation, was assigned 10 points because this alternative results in 100% CSO volume reduction, thereby completely meeting control objectives and achieving this criterion.

10.3.2 Capital and O&M Costs

The cost-benefit-effective evaluation point for each of the alternatives was divided into capital and O&M costs. For Alternatives 1 and 2, O&M was assumed to be 25% of the total cost as O&M costs were not identified separately in cost development. For Alternative 5, complete separation was assumed to require minimal O&M as compared to other alternatives, and therefore, the entire alternative cost was considered to be a capital cost. For Alternatives 3A, 3B, 4A, and 4B, the cost-benefit-effective point costs were further divided into capital and O&M costs by identifying the two encompassing levels of control and assuming a linear relationship in the cost. The capital and O&M costs were estimated based on a weighted average between the two encompassing levels of control. Table 10-4 summarizes the capital and O&M costs at the cost-benefit-effective point for each alternative by receiving water body.

Table 10-4: Capital and O&M Costs at the Cost-Benefit-Effective Evaluation Point

Costs	Receiving Water Body					
	Black Rock Canal	**Cazenovia Creek - B**	**Cazenovia Creek - C**	**Cornelius Creek**	**Niagara River**	**Scajaquada Creek**
Alternative 1						
Capital Cost	$ 12	$ 2.7	$ 24	$ 6.6	$ 0 .89	$ 9.5
O&M Cost	$ 4.1	$ 0.90	$ 8.0	$ 2.2	$ 0.30	$ 3.2
Total	$ 16	$ 3.6	$ 32	$ 8.8	$ 1.2	$ 13
Alternative 2						
Capital Cost	$ 38	$ 4.4	$ 27	$ 67	$ 14	$ 11
O&M Cost	$ 13	$ 1.5	$ 9.0	$ 22	$ 4.8	$ 3.8
Total	$ 50	$ 5.9	$ 36	$ 89	$ 19	$ 15
Alternative 3A						
Capital Cost	$ 219	$ 5.1	$ 45	$ 87	$ 15	$ 45
O&M Cost	$ 11	$ 0.12	$ 0.65	$ 0.53	$ 1.5	$ 2.9
Total	$ 230	$ 5.2	$ 46	$ 88	$ 16	$ 48
Alternative 3B						
Capital Cost	$ 219	$ 5.4	$ 52	$ 87	$ 15	$ 45
O&M Cost	$ 11	$ 1.0	$ 6.1	$ 0.53	$ 1.5	$ 2.9
Total	$ 230	$ 6.4	$ 58	$ 88	$ 16	$ 48
Alternative 4A						
Capital Cost	$ 242	$ 4.7	$ 43	$ 58	$ 22	$ 60
O&M Cost	$ 38	$ 0.71	$ 1.7	$ 12	$ 3.2	$ 10
Total	$ 280	$ 5.4	$ 45	$ 70	$ 25	$ 70
Alternative 4B						
Capital Cost	$ 242	$ 4.7	$ 43	$ 58	$ 22	$ 60
O&M Cost	$ 38	$ 0.71	$ 1.7	$ 12	$ 3.2	$ 10
Total	$ 280	$ 5.4	$ 45	$ 70	$ 25	$ 70
Alternative 5						
Capital Cost	$ 270	$ 4.1	$ 47	$ 210	$ 31	$ 110
O&M Cost	$ -	$ -	$ -	$ -	$ -	$ -
Total	$ 270	$ 4.1	$ 47	$ 210	$ 31	$ 110

Because BSA is under financial constraints, any monetary expenditure may be undesirable. However, given the necessity for CSO control, the cost-criteria was evaluated by ordering the costs from lowest to highest, with the lowest cost receiving the highest points.

10.3.3 Ability to Phase Components

The basic components of the system-wide alternatives include some of the following technologies:

- Floatables control;
- Regulator (weir / orifice) modifications;
- Satellite storage facilities;
- Deep rock tunnels;
- Satellite treatment facilities;
- Supplemental capacity; and
- Separation.

For the purposes of evaluating these components, a phasing period of 20 years was assumed. For any alternative that included only a tunnel, it was assumed that the alternative could not be phased over 20 years and therefore, the alternative was assigned 0 points.

For all other alternatives, it was assumed that the alternative could somewhat be phased over 20 years and was assigned 5 points. It was assumed that these alternatives could be constructed in stages, with the stand-alone facilities and separation constructed individually, and the supplemental capacity or tunnel being constructed in its entirety.

10.4 Preferred System-Wide Alternative (2004)

A matrix format was used to summarize the point distribution, scoring, and ranking of alternatives for each receiving water body. These matrices are presented in Table 10-5 for each receiving water body.

For the Black Rock Canal, Alternative 3A/3B, storage, scored and ranked the highest of all the alternatives. The total cost for Alternative 3A/3B for the Black Rock Canal is $230M with a 54% reduction in CSO volume.

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Table 10-5 Alternative Evaluation Score Sheet (2004 LTCP)

Evaluation: Black Rock Canal

Alternative	Criteria	Probability of Meeting Control Objectives	Capital Cost	O&M Cost / Staff Requirements	Ability to Phase Components	Total Score	Normalized Score (%)	Alternative Rank
	Rank	**1**	**2**	**3**	**4**			
	Weight	**100**	**80**	**20**	**20**			
1	Notes	125 MG	$12 M	$4.1 M	flt cntrl, reg mods, sep, supp cap	1,080	71%	7
	Points	1	10	4	5			
	Criteria Score	100	800	80	100			
2	Notes	275 MG	$38 M	$13 M	storage	1,100	72%	6
	Points	3	7	7	5			
	Criteria Score	300	560	140	100			
3A	Notes	750 MG	$219 M	$11 M	stor, tunnel	1,520	100%	1
	Points	8	6	7	5			
	Criteria Score	800	480	140	100			
3B	Notes	750 MG	$219 M	$11 M	stor, tunnel	1,520	100%	1
	Points	8	6	7	5			
	Criteria Score	800	480	140	100			
4A	Notes	825 MG	$242 M	$38 M	EHRC, sep	1,440	95%	4
	Points	9	5	2	5			
	Criteria Score	900	400	40	100			
4B	Notes	825 MG	$242 M	$38 M	EHRC, sep	1,440	95%	4
	Points	9	5	2	5			
	Criteria Score	900	400	40	100			
5	Notes	1,400 MG	$270 M	none	sep	1,460	96%	3
	Points	10	2	10	5			
	Criteria Score	1000	160	200	100			

Notes:

Highest Total Score 1,520

Rank	1	Most important criteria of the list for evaluating alternatives
	4	Least important criteria of the list for evaluating alternatives
Weight	Assign multiplier to each criteria to signify relative importance between criteria in evaluating alternatives.	
Points	10	Mostly meets criteria
	5	Somewhat meets criteria
	0	Does not meet criteria
Criteria Score	= Weight x Points	
Total Score	= Sum of Criteria Scores	
Normalized Score	= Total Score / Highest Total Score * 100	
Alternative Rank	1	Best Alternative (Highest Normalized Score)
	5	Worst Alternative (Lowest Normalized Score)

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Table 10-5 Alternative Evaluation Score Sheet (2004 LTCP)

Evaluation: Cazenovia Creek - B Class

Alternative	Criteria	Probability of Meeting Control Objectives	Capital Cost	O&M Cost / Staff Requirements	Ability to Phase Components	Total Score	Normalized Score (%)	Alternative Rank
	Rank	**1**	**2**	**3**	**4**			
	Weight	**100**	**80**	**20**	**20**			
1	Notes	8 MG	$2.7 M	$0.90 M	flt cntrl, reg mods, sep, supp cap	1,420	73%	3
	Points	4	10	6	5			
	Criteria Score	400	800	120	100			
2	Notes	11 MG	$4.4 M	$1.5 M	storage	1,140	59%	5
	Points	5	6	3	5			
	Criteria Score	500	480	60	100			
3A	Notes	23 MG	$5.1 M	$0.12 M	tunnel	1,500	77%	2
	Points	10	4	9	0			
	Criteria Score	1000	320	180	0			
3B	Notes	23 MG	$5.4 M	$1.0 M	storage	1,360	70%	4
	Points	10	2	5	5			
	Criteria Score	1000	160	100	100			
4A	Notes	11 MG	$4.7 M	$0.71 M	EHRC	1,140	59%	5
	Points	5	5	7	5			
	Criteria Score	500	400	140	100			
4B	Notes	11 MG	$4.7 M	$0.71 M	EHRC	1,140	59%	5
	Points	5	5	7	5			
	Criteria Score	500	400	140	100			
5	Notes	23 MG	$4.1 M	none	sep	1,940	100%	1
	Points	10	8	10	5			
	Criteria Score	1000	640	200	100			

Highest Total Score 1,940

Notes:

Rank	1	Most important criteria of the list for evaluating alternatives
	4	Least important criteria of the list for evaluating alternatives
Weight	Assign multiplier to each criteria to signify relative importance between criteria in evaluating alternatives.	
Points	10	Mostly meets criteria
	5	Somewhat meets criteria
	0	Does not meet criteria
Criteria Score	= Weight x Points	
Total Score	= Sum of Criteria Scores	
Normalized Score	= Total Score / Highest Total Score * 100	
Alternative Rank	1	Best Alternative (Highest Normalized Score)
	5	Worst Alternative (Lowest Normalized Score)

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Table 10-5 Alternative Evaluation Score Sheet (2004 LTCP)

Evaluation: Cazenovia Creek - C Class

Alternative	Criteria	Probability of Meeting Control Objectives	Capital Cost	O&M Cost / Staff Requirements	Ability to Phase Components	Total Score	Normalized Score (%)	Alternative Rank
	Rank	**1**	**2**	**3**	**4**			
	Weight	**100**	**80**	**20**	**20**			
1	Notes	65 MG	$24 M	$8.0 M	flt cntrl, reg mods, sep, supp cap	1,380	81%	5
	Points	4	10	4	5			
	Criteria Score	400	800	80	100			
2	Notes	70 MG	$27 M	$9.0 M	storage	1,380	81%	5
	Points	5	9	3	5			
	Criteria Score	500	720	60	100			
3A	Notes	160 MG	$45 M	$0.65 M	tunnel	1,640	96%	2
	Points	10	6	8	0			
	Criteria Score	1000	480	160	0			
3B	Notes	80 MG	$52 M	$6.1 M	tunnel	1,120	66%	7
	Points	7	4	5	0			
	Criteria Score	700	320	100	0			
4A	Notes	75 MG	$43 M	$1.7 M	EHRC, sep	1,400	82%	3
	Points	6	7	7	5			
	Criteria Score	600	560	140	100			
4B	Notes	75 MG	$43 M	$1.7 M	EHRC, sep	1,400	82%	3
	Points	6	7	7	5			
	Criteria Score	600	560	140	100			
5	Notes	160 MG	$47 M	none	sep	1,700	100%	1
	Points	10	5	10	5			
	Criteria Score	1000	400	200	100			

Highest Total Score 1,700

Notes:

Rank	1	Most important criteria of the list for evaluating alternatives
	4	Least important criteria of the list for evaluating alternatives
Weight	Assign multiplier to each criteria to signify relative importance between criteria in evaluating alternatives.	
Points	10	Mostly meets criteria
	5	Somewhat meets criteria
	0	Does not meet criteria
Criteria Score	= Weight x Points	
Total Score	= Sum of Criteria Scores	
Normalized Score	= Total Score / Highest Total Score * 100	
Alternative Rank	1	Best Alternative (Highest Normalized Score)
	5	Worst Alternative (Lowest Normalized Score)

Table 10-5 Alternative Evaluation Score Sheet (2004 LTCP)

Evaluation: Cornelius Creek

Alternative	Criteria	Probability of Meeting Control Objectives	Capital Cost	O&M Cost / Staff Requirements	Ability to Phase Components	Total Score	Normalized Score (%)	Alternative Rank
	Rank	**1**	**2**	**3**	**4**			
	Weight	**100**	**80**	**20**	**20**			
1	Notes	125 MG	$6.6 M	$2.2 M	flt cntrl, reg mods, sep, supp cap	1,240	82%	3
	Points	2	10	7	5			
	Criteria Score	200	800	140	100			
2	Notes	625 MG	$67 M	$22 M	storage	1,520	100%	1
	Points	8	7	3	5			
	Criteria Score	800	560	60	100			
3A	Notes	575 MG	$87 M	$0.53 M	storage	1,180	78%	4
	Points	6	4	8	5			
	Criteria Score	600	320	160	100			
3B	Notes	575 MG	$87 M	$0.53 M	storage	1,180	78%	4
	Points	6	4	8	5			
	Criteria Score	600	320	160	100			
4A	Notes	550 MG	$58 M	$12 M	EHRC, sep	1,160	76%	6
	Points	4	7	5	5			
	Criteria Score	400	560	100	100			
4B	Notes	550 MG	$58 M	$12 M	EHRC, sep	1,160	76%	6
	Points	4	7	5	5			
	Criteria Score	400	560	100	100			
5	Notes	900 MG	$210 M	none	sep	1,300	86%	2
	Points	10	0	10	5			
	Criteria Score	1000	0	200	100			

Highest Total Score 1,520

Notes:

Rank	1	Most important criteria of the list for evaluating alternatives
	4	Least important criteria of the list for evaluating alternatives
Weight	Assign multiplier to each criteria to signify relative importance between criteria in evaluating alternatives.	
Points	10	Mostly meets criteria
	5	Somewhat meets criteria
	0	Does not meet criteria
Criteria Score	= Weight x Points	
Total Score	= Sum of Criteria Scores	
Normalized Score	= Total Score / Highest Total Score * 100	
Alternative Rank	1	Best Alternative (Highest Normalized Score)
	5	Worst Alternative (Lowest Normalized Score)

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Table 10-5 Alternative Evaluation Score Sheet (2004 LTCP)

Evaluation: Niagara River

Alternative	Criteria	Probability of Meeting Control Objectives	Capital Cost	O&M Cost / Staff Requirements	Ability to Phase Components	Total Score	Normalized Score (%)	Alternative Rank
	Rank	**1**	**2**	**3**	**4**			
	Weight	**100**	**80**	**20**	**20**			
1	Notes	20 MG	$0.89 M	$0.30 M	flt cntrl, reg mods, sep, supp cap	1,380	81%	5
	Points	3	10	9	5			
	Criteria Score	300	800	180	100			
2	Notes	135 MG	$14 M	$4.8 M	storage	1,520	89%	4
	Points	7	8	4	5			
	Criteria Score	700	640	80	100			
3A	Notes	170 MG	$15 M	$1.5 M	sep	1,700	100%	1
	Points	9	7	7	5			
	Criteria Score	900	560	140	100			
3B	Notes	170 MG	$15 M	$1.5 M	sep	1,700	100%	1
	Points	9	7	7	5			
	Criteria Score	900	560	140	100			
4A	Notes	120 MG	$22 M	$3.2 M	EHRC, sep	1,120	66%	6
	Points	5	5	6	5			
	Criteria Score	500	400	120	100			
4B	Notes	120 MG	$22 M	$3.2 M	EHRC, sep	1,120	66%	6
	Points	5	5	6	5			
	Criteria Score	500	400	120	100			
5	Notes	175 MG	$31 M	none	sep	1,540	91%	3
	Points	10	3	10	5			
	Criteria Score	1000	240	200	100			

Highest Total Score 1,700

Notes:

Rank	1	Most important criteria of the list for evaluating alternatives
	4	Least important criteria of the list for evaluating alternatives
Weight	Assign multiplier to each criteria to signify relative importance between criteria in evaluating alternatives.	
Points	10	Mostly meets criteria
	5	Somewhat meets criteria
	0	Does not meet criteria
Criteria Score	= Weight x Points	
Total Score	= Sum of Criteria Scores	
Normalized Score	= Total Score / Highest Total Score * 100	
Alternative Rank	1	Best Alternative (Highest Normalized Score)
	5	Worst Alternative (Lowest Normalized Score)

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Table 10-5 Alternative Evaluation Score Sheet (2004 LTCP)

Evaluation: Scajaquada Creek

Alternative	Criteria	Probability of Meeting Control Objectives	Capital Cost	O&M Cost / Staff Requirements	Ability to Phase Components	Total Score	Normalized Score (%)	Alternative Rank
	Rank	**1**	**2**	**3**	**4**			
	Weight	**100**	**80**	**20**	**20**			
1	Notes	23 MG	$9.5 M	$3.2 M	flt cntrl, reg mods, sep, supp cap	1,420	95%	5
	Points	4	10	6	5			
	Criteria Score	400	800	120	100			
2	Notes	0 MG	$11 M	$3.8 M	storage, weir mod	920	61%	7
	Points	0	9	5	5			
	Criteria Score	0	720	100	100			
3A	Notes	173 MG	$45 M	$2.9 M	stor, tunnel	1,500	100%	1
	Points	6	8	8	5			
	Criteria Score	600	640	160	100			
3B	Notes	173 MG	$45 M	$2.9 M	stor, tunnel	1,500	100%	1
	Points	6	8	8	5			
	Criteria Score	600	640	160	100			
4A	Notes	203 MG	$60 M	$10 M	EHRC, sep	1,460	97%	3
	Points	8	6	4	5			
	Criteria Score	800	480	80	100			
4B	Notes	203 MG	$60 M	$10 M	EHRC, sep	1,460	97%	3
	Points	8	6	4	5			
	Criteria Score	800	480	80	100			
5	Notes	350 MG	$110 M	none	sep	1,380	92%	6
	Points	10	1	10	5			
	Criteria Score	1000	80	200	100			

Highest Total Score 1,500

Notes:

Rank	1	Most important criteria of the list for evaluating alternatives
	4	Least important criteria of the list for evaluating alternatives
Weight	Assign multiplier to each criteria to signify relative importance between criteria in evaluating alternatives.	
Points	10	Mostly meets criteria
	5	Somewhat meets criteria
	0	Does not meet criteria
Criteria Score	= Weight x Points	
Total Score	= Sum of Criteria Scores	
Normalized Score	= Total Score / Highest Total Score * 100	
Alternative Rank	1	Best Alternative (Highest Normalized Score)
	5	Worst Alternative (Lowest Normalized Score)

For the B-Class portion of Cazenovia Creek, Alternative 5, complete separation, scored and ranked the highest of all the alternatives. The total cost for Alternative 5 for the B-Class portion of Cazenovia Creek is $4.1M with a 100% reduction in CSO volume.

For the C-Class portion of Cazenovia Creek, Alternative 3A, deep rock tunnel, scored and ranked the highest of all the alternatives. However, the deep rock tunnel would be built mainly for the Buffalo River CSOs. As the Buffalo River will have no additional controls past Alternative 1, the preferred alternative for the C-Class portion of Cazenovia Creek becomes the second highest ranked alternative, which is Alternative 5, complete separation. The total cost for Alternative 5 for the C-Class portion of Cazenovia Creek is $47 M with a 100% reduction in CSO volume.

For Cornelius Creek, Alternative 2, satellite storage, scored and ranked the highest of all the alternatives. The total cost for Alternative 2 for Cornelius Creek is $89 M with a 70% reduction in CSO volume.

For the Niagara River, Alternative 3A / 3B, partial separation, scored and ranked the highest of all the alternatives. The components of Alternative 3A for the Niagara River are the same as those for Alternative 3B, as are the costs. The total cost for Alternative 3A / 3B for the Niagara River is $16 M with an almost 100% reduction in CSO volume.

For Scajaquada Creek, Alternative 3A / 3B, satellite storage and deep rock tunnel, scored and ranked the highest of all the alternatives. The components of Alternative 3A for Scajaquada Creek are the same as those for Alternative 3B, as are the costs. The total cost for Alternative 3A / 3B for Scajaquada Creek is $48 M with a 50% reduction in CSO volume.

Table 10-1 presented a summary of the original 2004 preferred system-wide alternative using the results of the individual receiving water body evaluations, as well as the cost. It is estimated that the 2004 preferred system-wide alternative will cost approximately $524M.

10.5 Updated 2004 Preferred System-Wide Alternative

As noted previously, upon review of the 2004 LTCP, the NYSDEC raised a concern that the 2004 LTCP preferred alternative did not provide for bacteria control in the Class C receiving waters. Therefore, each alternative was re-evaluated for the Buffalo River and Erie Basin receiving water bodies using the same criteria presented in Table 10-2 on a relative scale of 0 to 10. The alternative that met each criterion completely, nearly completely, or was sufficient in providing the desired outcome being evaluated was assigned the most points, while the alternative that did not meet the criterion, met the criterion only slightly, or was insufficient at providing the desired outcome being evaluated was assigned the least points.

Similar to the 2004 evaluation, a criterion score was calculated by multiplying the criterion weight by the assigned points. A total score for each alternative was calculated by summing the criteria scores. A normalized score for each alternative was calculated by dividing its total score by the total from the highest-scoring alternative, and multiplying by 100 (thereby giving the alternative with the highest total score a normalized score of 100%). The alternatives were then ranked based on the normalized score, with a rank of 1 assigned to the alternative with the highest normalized score. The preferred alternative for each receiving water body is the alternative with the rank of 1. Ties for the 1 rank were broken based on the least total present worth cost alternative.

Table 10-6 presents the results of the 2004 process by receiving water, updated with the criteria weights from Table 10-2, including both the Buffalo River and Erie Basin (both C-Class receiving waters).

Table 10-6: Updated Ranking of 2004 System-wide Alternatives

Receiving Water Body	Alternative Ranking							Selected Alternative
	1	2	3A	3B	4A	4B	5	
Black Rock Canal	7	6	1	1	4	4	3	3A / 3B (same)
Buffalo River	1	7	5	1	4	1	6	1
Cazenovia Creek – B	3	5	2	4	5	5	1	5
Cazenovia Creek – C	5	5	2	7	3	3	1	5
Cornelius Creek	3	1	4	4	6	6	2	2
Erie Basin	1	7	5	1	4	1	6	1
Niagara River	5	4	1	1	6	6	3	3A / 3B (same)
Scajaquada Creek	5	7	1	1	3	3	6	3A / 3B (same)

As can be seen, Alternatives 1, 3B and 4B scored and ranked the highest of all the alternatives for both the Buffalo River and Erie Basin Marina in the 2004 preferred alternative. This is expected, as the original scoring was based on the position that Class C receiving waters did not have specific water quality objectives for bacteria.

10.5.1 Re-Assessment of Buffalo River and Erie Basin Alternatives to Define the Updated 2004 Preferred System-Wide Alternative

Given the new (since the 2004 LTCP) water quality objectives required for these water bodies, the originally selected alternatives for the Buffalo River and Erie Basin Marina are now excluded as alternatives. Therefore, the preferred alternative for the C-Class Buffalo River and Erie Basin becomes the next highest ranked alternative that addresses bacteria control objectives. As can be seen in Table 10-7, the next highest ranked alternative is Alternative 4A, satellite treatment with partial separation, for both the Buffalo River and Erie Basin.

Table 10-7: Re-Assessment of Buffalo River and Erie Basin Marina Alternatives

Receiving Water Body	Alternative Ranking[1]							Selected Alternative
	1[2]	2	3A	3B[2]	4A	4B[2]	5	
Buffalo River	1	7	5	1	4	1	6	4A
Erie Basin	1	7	5	1	4	1	6	4A

Notes:

(1) Given that the original top 3 alternatives are excluded, a rank of 4 represents the top ranking

(2) Alternative excluded from consideration given post-2004 water quality objectives

It is important to note that the difference in the updated ranking between Alternative 3A (tunnel storage) and 4A (satellite treatment) for the Buffalo River and Erie Basin Marina is minimal. On a purely quantitative scoring basis, Alternative 4A has a higher ranking and so is the current recommendation for the updated preferred alternative in these two receiving water bodies. However, the scores are close enough that it is well within the BSA's discretion to choose Alternative 3A, if it is desired to maintain the tunnel concept as the backbone solution for the updated 2004 alternative throughout the system. This can be justified as a utility policy decision, made to gain the qualitative efficiencies associated with a consistent control technology, which are not directly reflected in the ranking system.

10.5.2 Updated 2004 Preferred System-Wide Alternative

Table 10-8 summarizes the updated 2004 preferred system-wide alternative by receiving water, and includes the associated NYSDEC classification for each water body. The updated 2004 preferred system-wide alternative changes only the Buffalo River and Erie Basin alternatives, while keeping the alternatives in the other receiving water bodies the same (note that this LTCP update must use the 3A alternative for receiving waters where 3A/3B was presented in 2004, as Alternative 3B is now excluded as an option).

Table 10-8: Updated 2004 Preferred System-wide Alternative for the LTCP Update

Receiving Water	NYSDEC Classific-ation	Preferred - 2004 LTCP	General Basis for 2004 LTCP	Control FC in 2004 LTCP?	Updated 2004 Preferred System-wide Alternative	Level of Control[1]				
						12	6	4	2	0
Black Rock Canal	C	3A/3B	Storage/ Separation	Y	3A	$120	$152	$168	$225	$321
Buffalo River	C	1	Floatables/ Separation	N	4A	$131	$168	$197	$280	$420
Cazenovia Creek	B	5	Separation	Y	5	$4	$4	$4	$4	$4
Cazenovia Creek	C	5	Separation	Y	5	$47	$47	$47	$47	$47
Scajaquada Creek	C	3A/3B	Storage/ Separation	Y	3A	$48	$59	$60	$73	$100
Scajaquada Creek	B	3A/3B	Storage/ Separation	Y	3A					
Niagara River	A (special)	3A/3B	Storage/ Separation	Y	3A	$16	$20	$24	$33	$48
Erie Basin	C	1	Floatables/ Separation	N	4A	$6	$8	$9	$12	$16
Cornelius Creek	NA	2	Storage	Y	2	$89	$89	$89	$89	$89
					Totals:	$461	$548	$598	$763	$1,045

[1] Levels of Control will be confirmed with updated LTCP model simulations presented in Section 11.
[2] Costs represent 2004 PW costs and will be updated to 2012 dollars (presented in Section 11).

Table 10-8 also includes the estimated cost for five levels of control, ranging from 0 to 12 overflows per year. The costs presented for each LOC are based on the 2004 analysis, which used design storm simulations to develop sizes for each control level as well as a combination of 9-month continuous simulations and post-processing of outfall hydrographs to estimate the control provided by each alternative. The costs were updated to 2012 dollars as part of the ongoing LTCP update process (see Section 11).

The benefits of the updated preferred system-wide alternative were re-evaluated using 12-month continuous simulations and explicit representation of the updated preferred alternatives in the refined baseline model as part of the ongoing LTCP update process. This updated 2004 preferred system-wide alternative formed the benchmark for the evaluation of additional alternatives identified as part of this LTCP update and as described in Section 11.

11. Additional Alternative Evaluations under Phase III Engineering

This section summarizes the updates to alternatives evaluated in the 2004 LTCP, as well as projects that were started by the BSA after submission of the 2004 LTCP. The BSA has made a lot of progress by implementing many of the Phase I projects and has incorporated the results of implementing the Phase I projects on both CSO activations and on water quality. This updated information was used to develop an updated system-wide CSO control alternative (Alternative UA2) that incorporate newer technologies such as RTC and GI as well as a North relief line and an EHRT facility that would be located in the northern portion of Bird Island. In addition, two new system-wide alternatives were developed from meetings with the USEPA and the NYSDEC in the Spring of 2011 that included system-wide tunnels (Alternative UA3) and a combination of tunnels and a North relief line and an EHRT facility that would be located in the northern portion of Bird Island (Alternative UA3A). The updated 2004 LTCP preferred system-wide alternative (Alternative UA1) described in Section 10 provided a benchmark against which these three new alternatives (Alternatives UA2, UA3, and UA3A) were compared. The evaluations in this section resulted in selecting Alternative UA2 as the basis for the Recommended Plan. Assembling, refinement and further cost/benefit evaluations of the Recommended Plan improvements are presented in Section 12.

Per the requirements of the AO, each alternative was evaluated for 5 different levels of control (LOCs) in terms of system-wide percent capture of wet weather flows (75% to 100%) and CSO activation frequency. using the 1993 modified typical year. Other regulatory metrics such as residual CSO volumes and remaining pollutant (bacteria) loadings were evaluated as well. The costs and benefits (in the form of CSO frequency, volume and pollutant reductions) for each alternative at each LOC were evaluated for each individual receiving water body. The benefits of the alternatives were evaluated using 12-month continuous simulations with the 1993 modified typical precipitation year. As agreed upon with the USEPA, water quality benefits were evaluated only for select alternatives (UA1 and UA2) because the composition of technologies for UA3 and UA3A would yield very similar water quality results for the level of control being obtained by the UA1 and UA2 alternatives. Compliance with WQS is the primary consideration for CSO levels of control (LOCs), followed by affordability and cost-effectiveness. Thus, just because a particular LOC may appear to be cost-effective, it may be neither necessary (if WQS are met short of that level of CSO control) nor affordable. Moreover, it is important to note that the data inputs to these graphs are the best available information at this time, but are still only planning level estimates.

That said, the system-wide cost-benefit curves for each alternative were compared for the different types of benefits. The cost curves for attainment of water quality standards, level of control (activations per year), residual CSO volume (million gallons), and percent capture were compared to assess the relative effectiveness of each alternative. Water quality attainment was evaluated on a receiving water body-specific basis rather than a system-wide basis. Note that all costs are presented in 2012 dollars and that the project cost estimates are consistent with an AACE Class 5 standards, which have an expected accuracy range between -30% and +50%.

The evaluations and CSO statistics presented in Sections 11.1 and 11.3 are based on the 1986 typical year (TY), which was the Agency approved typical precipitation year to be used by the BSA in updating the LTCP. Subsequent to the completion of these evaluations, the Agencies requested that the typical year be reevaluated to include all available precipitation data (1948 through 2010). Using this dataset forced the BSA to reevaluate the typical year and resulted in the selection of the modified 1993 TY for use in the alternatives evaluations moving forward. Therefore, all subsections other than 11.1 and 11.3 present CSO statistics based on the 1993 modified TY.

11.1 Updated Analytical and Reporting Approach

During the course of updating the LTCP, an evaluation of the analytical and reporting approach used for the 2004 LTCP was completed. As a result of this evaluation, three modifications to these approaches were made with the concurrence of the USEPA:

- Use of 12-month continuous simulations instead of 9-month simulations with "annualizing" of statistics (as was done for the 2004 LTCP);
- Use of 12-hour inter-event time (IET) to define CSO activations instead of a 6-hour IET; and
- Use of CSO component of end-of-pipe (EOP) discharges as a supplemental CSO statistic and evaluation metric.

Detailed discussions, including summary tables, presenting the rationale for these changes are provided in the following technical memoranda, all of which are included in Appendix 11-1:

- "Comparison of Full 12-Month vs. 9-Month Recreational Period Typical Year Results," February 18, 2011;
- "Interevent Time (IET) for use in Reporting of CSO Frequency Statistics for Ongoing LTCP Update," April 4, 2011; and
- "Reporting of CSO Statistics for Ongoing LTCP Update," March 8, 2011.

This section briefly summarizes the conclusions of these evaluations. As noted previously, the statistics presented in these evaluations and summarized in Section 11.1 are based on the 1986 typical year (TY), which at the time, was the accepted typical precipitation year for use in updating the LTCP.

11.1.1 Continuous Simulation Approach

During the 2004 LTCP effort, the 1986 precipitation year (with some modifications) was selected as the TY hyetograph to be used when assessing the performance of the system. At the time, based on discussions with the NYSDEC, it was decided that only the 9-month "Recreational Period" portion of the TY (March-November) would be simulated. The TY CSO overflow statistics (volume, activations, and durations) were then estimated through "annualizing" the 9-month results by multiplying them by 4/3. This approach was developed as a simple mechanism to address the NYSDEC's concerns with modeling snowmelt in a collection system model.

While this approach was adequate during the initial LTCP phase when the critical metrics were the CSO overflow statistics, it caused complications with the current LTCP update. The 9-month results did not provide a mechanism for extrapolation to full 12-month results for use with the water quality model simulations being performed during the current LTCP phase for the Buffalo receiving waters (Buffalo River, Scajaquada Creek, Niagara River, and Black Rock Canal). Additionally, improvements in computer processing speed and the modeling software over the last 7 years had resulted in an industry-wide shift to performing continuous annual and multi-year model simulations. Because of this, the BSA switched from the 9-month Recreational Period rainfall hyetograph to the full 12-month rainfall hyetograph for performing the TY model simulations and used the 12-month simulation and CSO statistics for evaluation of CSO control alternatives and their associated water quality benefits.

The impact of the shift to annual CSO metrics was evaluated by comparing overflow volumes and activations for the two approaches. The overflow volume comparisons showed that the volumes for the 12-month simulation (based on the 1986 TY) were lower than the annualized 9-month Recreational Period results (19% lower for the overall system overflow volume). The 12-month results also show less frequent CSO activations. These results can be explained by the lack of significant rainfall events during the non-Recreational Period of the TY used for these evaluations.

Based on these findings, the 12-month TY hyetograph was used for the current phase LTCP evaluations for the following reasons:

- The 12-month TY hyetograph supports the ongoing water quality simulations.

- Full 12-month simulations, provides a more realistic representation of TY conditions than extrapolating the 9-month results.

11.1.2 CSO Statistics Reporting Approach

During the 2004 LTCP development effort, annual overflow statistics were presented at both the SPP and the CSO outfall EOP levels in Tables 3-9 and 3-12, respectively. Using this approach for CSO discharge presentation on these tables as well as in the report Section 3 (see pp. 3-14 and 3-15), required the following explanations:

- Volumes presented by the SPPs represented the full predicted volume at each SPP. However, the sum of the volumes at the SPPs did not always equal the total volume for each CSO outfall to which the SPPs are tributary, because:
  - Upstream SPPs may be configured in series (*i.e.*, overflow from one SPP is re-regulated at a downstream SPP). Therefore, directly adding SPP volumes would double-count for some flows.
  - Locally separated storm water may bypass SPPs and be discharged through the CSO outfall. The separate storm water volume is included in the CSO outfall volume, but not the volumes noted at the tributary SPPs. Specifically, storm water and non-BSA flows have been included in CSO outfall volumes for CSO 028, CSO 054, and CSO 066, and not in the SPPs tributary to these CSO outfalls.
- Total CSO outfall volumes represented the estimated volumes discharged at the CSO outfall. These volumes did not always match the sum of incremental volumes from upstream SPPs for the reasons presented above. The separate storm water volumes are included in the CSO outfall volume totals in this table (Tables 3-9 and 3-12).

EOP metrics are reported because, by USEPA rules, the CSO measurement/compliance point (*e.g.*, for monthly DMRs) is the permitted CSO location, which for the BSA (at least as of 2004) is the EOP. The two locations where a different approach was taken were at CSOs 006 and 053, where the stream volumes from Scajaquada Creek were removed from the annual CSO statistics at these CSOs. To satisfy the USEPA EOP metric requirements for these two CSOs, the associated stream volumes were included in the footnotes for the annual CSO statistics table. Due to the above-mentioned challenges, allocation of storm water flows and CSO volumes for each EOP discharge were not done under the original 2004 LTCP, nor was it necessary, until the implementation of the Phase I projects.

The need for additional breakdown of CSO and storm water discharges became apparent while evaluating the impacts of completed Phase I projects. A comparison of the EOP volumes between the current baseline model with implemented Phase I LTCP projects and the 2004 existing conditions model showed that, for most of the CSO outfalls, the implementation of the Phase I projects translated to a reduction in overflows as defined using the EOP metrics. However, because the EOP metrics require the inclusion of storm water, there were exceptions to this. These exceptions apply to CSOs 035, 054, and 066. For each of these, the Phase I LTCP projects already implemented consisted of partial sewer separation projects where the resulting new storm sewers were tied into the existing CSO outfall line. As a result, the storm flows that were removed from the CSS still appears in the EOP metrics such that the EOP metrics remained the same or even increased –despite the fact that the CSO regulators on the CSS were less active as a result of the separation work. This may result in an unfavorable review of the effectiveness of the BSA's CSO control efforts without additional explanation.

As a result, the BSA decided to evaluate the effectiveness of CSO control alternatives using the CSO-only discharge statistics, but also present annual CSO statistics as EOP discharges for the baseline condition scenarios and for the final selected (recommended) alternative (EOP statistics for the recommended alternative are included in Appendix 12-2). This will provide a better assessment of the effect of planned and already completed separation projects on mitigating CSO discharges from the BSA's system.

For all alternatives summarized in this section, the following quantitative measures of benefit were evaluated and presented for this LTCP:

- Reduction in annual CSO-only overflow volume, at individual SPPs and CSOs, as well as for the system as a whole;
- Reduction in annual CSO-only overflow activations, at individual SPPs and CSOs;
- Reduction in pollutant (bacteria) loadings using the fecal coliform EMC of 92,500 #/100 mL; and
- System-wide annual percent capture of wet weather flows.

Annual system-wide wet weather percent capture was defined as:

$$\text{Percent Capture} = \frac{V_{TREATED}}{V_{TOTAL}}$$

where,

$V_{TREATED}$ = Volume of wet weather wastewater treated by the WWTP, defined as the WWTP influent flow when the influent flow rate is higher than the annual average flow rate

V_{TOTAL} = $V_{TREATED} + V_{OVERFLOW,}$

$V_{OVERFLOW}$ = Total volume of overflows from all CSOs

In this calculation, secondary bypass flow at the WWTP is considered WWTP influent volume in accordance with discussions between the BSA and the NYSDEC during the 2004 LTCP development. Additionally, CSO-only volumes as per discussions above were used for the calculation.

11.1.3 Inter-event Time (IET) for Reporting CSO Activations

The IET defines a period of time with no CSO discharges that separates one event from another. It is a counting mechanism for a given overflow hydrograph, and has no effect on annual overflow volumes. The BSA has historically used a 6-hour IET for defining rainfall events and CSO activations. Project documentation from the 2001 Model Calibration Report indicates that the use of a 6-hour IET dates back to the 1992 Phase 2 CSO Study.

Based on a survey of several Midwestern and Eastern utilities, IETs from 6 to 24 hours have been applied for rainfall and overflow frequency analyses. To determine the potential effect of higher IETs on the estimated frequencies in the BSA's system, overflow statistics were evaluated for baseline conditions using several IETs. CSO-only (*i.e.*, no storm water) activations for the baseline scenario, using 6-hour, 12-hour, and 24-hour IETs, were compared using the 1986 TY continuous simulations (the typical year of precipitation used for 2004 LTCP development). While CSO activations did decrease with increasing IET, in nearly all cases, the decreases are relatively small. The biggest changes were observed at CSO locations with higher numbers of activations.

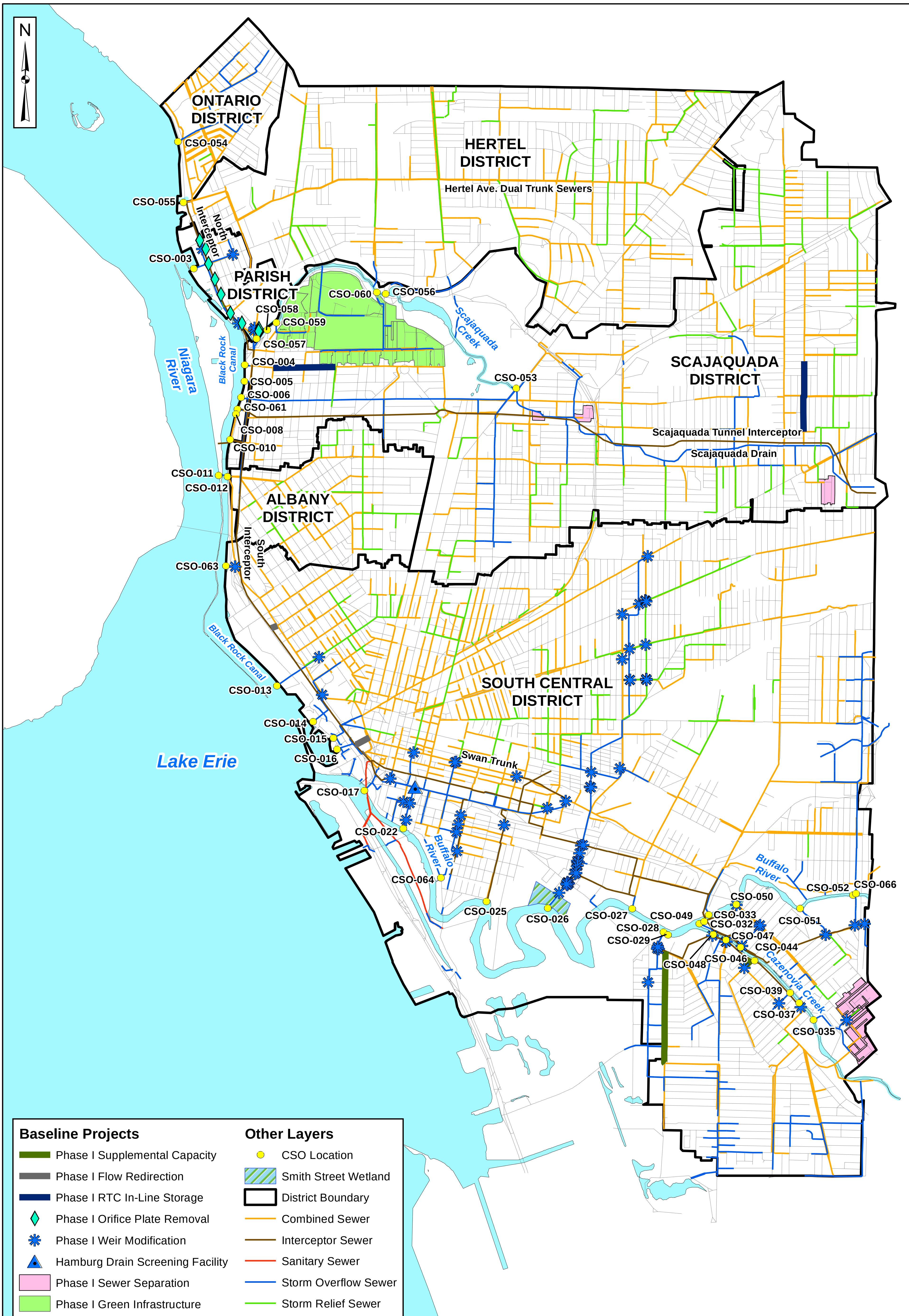
It should be noted that, for typical CSO LOCs (annual average of 0-9 activations), the only substantive effect of using longer IETs is that the existing condition (baseline) number of activations changes. For controlled conditions, where CSOs activate at most a couple of times per month, a longer IET will typically have no impact on the size of a facility required to meet a target activation level. The only time the number of activations would change for a given control facility is if two of the activations are less than 12 hours apart, which is always possible, but is not the norm given the low number of activations per year. Based on this evaluation, the BSA switched to the 12-hour IET for reporting CSO activations.

11.2 Phase I CSO Project Implementation

The 2004 LTCP generated an initial series of projects that the BSA has either already implemented, or is committed to implementing, since the 2004 LTCP was developed and submitted. These projects, termed Phase I projects, represented a mix of sewer separation, CSO regulator optimizations (raising weirs and/or removing orifice plates), and supplemental capacity projects. As the implementation of these projects evolved, several projects were modified to include RTC and GI elements. Most Phase I projects have been completed by the time of this report submittal, with the remainder to be completed by the end of 2014.

11.2.1 Description of Phase I Projects

Table 11-1 presents the list of Phase I projects, with associated project status, while Figure 11-1, presents a thematic map showing the location of these projects. A summary of the projects is provided below. All of these projects were included in the Revised Baseline model further described below.



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BUFFALO SEWER AUTHORITY
Long Term Control Plan Update

FIGURE 11-1

REVISED BASELINE CONDITIONS SYSTEM (WITH COMPLETED/ PLANNED PHASE I PROJECTS)

Table 11-1: Summary of Phase I Projects

PROJECT DESCRIPTION	STATUS	SUBSTANTIAL COMPLETION
CSO 003 SPP'S 4, 11 &185	COMPLETE	FALL 2008
CSO 003 SPP'S 3,4,5,7 & 8	COMPLETE	FALL 2008
CAZENOVIA CREEK CSO 035	COMPLETE	FALL 2009
CAZENOVIA SPP 121	COMPLETE	FALL 2009
CSO 057 SPP 195	COMPLETE	FALL 2008
CSO 058 SPP 213	COMPLETE	FALL 2008
CSO 057 SPP'S 10, 11 & 195	COMPLETE	FALL 2008
CSO 058 SPP 213	COMPLETE	FALL 2008
NORTH OF BUFFALO RIVER SPP MODIFICATIONS	COMPLETE	SUMMER 2009
SOUTH BUFFALO SPP MODIFICATIONS	COMPLETE	SPRING 2010
CSO 059 SPP'S 181, 182 & 183	COMPLETE	FALL 2010
SPP 123A MODIFICATION	COMPLETE	SPRING 2011
CSO 009 SEWER SEPARATION	COMPLETE	SUMMER 2011
CSO 053 SPP 229 (BEVERLY ST)	COMPLETE	SUMMER 2011
SWAN TRUNK SPP 304 MODIFICATIONS	COMPLETE	SUMMER 2011
CSO 060 SPP 240	COMPLETE	SPRING 2013
REDIRECT FLOW FROM SWAN TRUNK TO SOUTH INTERCEPTOR (PENNSYLVANIA ST.)	COMPLETE	SUMMER 2013
SPP 42 UNDERFLOW FROM SWAN TRUNK TO SOUTH INTERCEPTOR (ERIE ST)	COMPLETE	SUMMER 2013
RETAIN FLOW IN SWAN TRUNK AT SKYWAY & CHARLES ST.	COMPLETE	SUMMER 2013
SPP 55 TO SOUTH INTERCEPTOR ALONG EXCHANGE ST.	COMPLETE	SUMMER 2013
HAMBURG DRAIN SCREENS	WAS BID 11/09	LATE 2013
BIRD AVENUE STORAGE PROJECT (IN-LINE)	BID AUGUST 2013	LATE 2014
LANG STREET STORAGE (IN-LINE)	BID AUGUST 2013	LATE 2014
SMITH STREET STORAGE/ RTC	WILL BID SPRING 2014	LATE 2014
GREEN INFRASTRUCTURE	PART OF VARIOUS PROJECTS	LATE 2014

- CSO-003 SPPs 4, 11 and 185; CSO 003 SPPs 3, 4, 5, 7 and 8: These projects were completed in 2008 by BSA personnel. They consisted of raising weirs in SPP 4, 11, and 185 and removing orifice plates in

SPPs 3, 4, 5, 7 and 8. The projects were undertaken to reduce CSO discharges from CSO 003 into the Black Rock Canal.

- Cazenovia Creek CSO 35: This was a sewer separation project completed in the fall of 2009. This project was designed to reduce CSO discharges from CSO 035 through weir modifications to SPPs 107 and 107A.

- Cazenovia SPP 121: This was a supplemental capacity project designed to reduce CSO discharges from SPP 121 into Cazenovia Creek. A new 48-inch diameter sanitary sewer was built on Mumford Street in October 2009.

- CSO 057 SPP 195: The weir was raised in SPP 195 by BSA personnel to reduce CSO discharges into Scajaquada Creek through CSO 057.

- CSO 058 SPP 213: The weir was raised in SPP 213 by BSA personnel to reduce CSO discharges into Scajaquada Creek through CSO 058.

- CSO 057 SPPs 10, 11, & 195: The orifice plates were removed by BSA personnel in SPPs 10, 11, & 195 to reduce CSO discharges into Scajaquada Creek through CSO 057.

- CSO 058 SPP 213: The orifice plate was removed in SPP 213 by BSA personnel to reduce CSO discharges into Scajaquada Creek through CSO 058.

- North of Buffalo River SPP Modifications: This project was completed by BSA personnel in June and July 2009. Work consisted of raising weirs in approximately 27 SPPs and was done to reduce CSO discharges into the Buffalo River.

- South Buffalo SPP Modifications: This project was completed in May 2010 and consisted of raising weirs in 17 SPPs to reduce CSO discharge into the Buffalo River.

- CSO 059 SPPs 181, 182, & 183: This sewer separation/new storm sewers project was completed in September 2010. The weirs were raised in SPPs 181, 182, and 183 to reduce CSO discharges into Scajaquada Creek through CSO 059.

- SPP 123 A Modification: This project was bid in November 2009 and was completed in the spring of 2011. The project replaced 5,000 LF of the Hopkins Street Sanitary Sewer with a larger sewer and raised the weir in SPP 123A. The increased capacity of the Hopkins Street Sewer, along with the weir raising, will reduce CSO discharges from SPP123A into the Buffalo River.

- CSO 009: Auburn Street, CSO 009, was completed in the summer of 2011 and consisted of raising the weir in SPP 020 and installing a separate storm sewer to reduce flows.

- CSO 053 SPP 229: This project, which was completed in the summer of 2011, is a sewer separation project with a new storm sewer constructed on Beverly Road, which will reduce CSO discharges into the Scajaquada Creek.

- Swan Trunk Sewer Modifications – SPP 304: This project was completed in summer of 2011 and consisted of raising weirs in 10 SPPs to reduce CSO discharges from the Swan Trunk sewer.

- CSO 060 SPP 240: This project, which was bid on October 20, 2011 and completed in spring 2013, presented an opportunity to evaluate GI technologies as an alternative to sewer separation, which was the original intent of this project. The BSA piloted the following green initiatives to establish metrics on these treatments to determine the role of GI in future projects:

  - Rain gardens/infiltration basins located along a typical residential street and a typical commercial street;
  - Pervious pavement along two residential streets; and
  - House downspout disconnection/rain barrels to divert roof runoff from the sewer system.

  This project also entailed selective separation in conjunction with the green initiatives. Additionally, weirs were raised in SPPs 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, and 240. This will reduce CSO discharges into the Scajaquada Creek through CSO 060. Post-construction monitoring commenced in December 2012 and consists of monitoring the control and study areas, including monthly inspections, flow monitoring at six locations (upstream and downstream on Granger Place, downstream on remaining streets), and monthly stormwater water quality sampling.

- Redirect Flow from Swan Trunk to South Interceptor (Pennsylvania Street): This project is expected to reduce CSO discharges from the Swan Trunk sewer. The project was completed in summer 2013 and took advantage of an existing box culvert at Pennsylvania Street. This 8 ft. x 8-ft. culvert was intended to serve as a new CSO discharge into the Black Rock Canal. However, after the culvert was installed, the project was abandoned leaving approximately 2,000 ft. of the culvert in place from the Swan Trunk sewer under the New York State Thruway. By opening the culvert where it crosses the South Interceptor, flow from the Swan Trunk sewer will be redirected into the South Interceptor, using the empty culvert as storage.

- SPP 42 Underflow from Swan Trunk sewer to South Interceptor (Erie Street): This project, completed in summer 2013, will reduce flow in the Swan Trunk sewer using available capacity in the South Interceptor and reduce CSO discharges from SPP 42.

- Retain Flow in Swan Trunk at Skyway & Charles Street: This project, completed in summer 2013, consisted of installing permanent stop logs into a diversion structure on the Swan Trunk sewer. This chamber diverted virtually all flow from the Swan Trunk sewer to the South Interceptor and contributed significantly to sediment accumulation in the Swan Trunk sewer. The stop logs will retain most flow in the Swan Trunk sewer while allowing the diversion of flow during extreme high flows. The increased velocity in the Swan Trunk sewer will reduce future sedimentation.

- SPP 055 to South Interceptor along Exchange St.: The project, completed in summer 2013, will reduce flow in the Swan Trunk 27-in. diameter sewer by increasing the capacity of dry weather flow in the Exchange Street sewer. A new sewer replaced the existing 15-in. diameter sewer. The carrying capacity of the new sewer exceeds the predicted peak design storm overflow rate.

- Hamburg Drain Floatable Control Facility: The Hamburg Drain Floatables Control Facility is currently under construction with an estimated completion date of late 2013.

- Bird Avenue In-Line Storage (RTC): This project will store flows in the existing Bird Avenue line and flows will be released after a storm event for subsequent treatment at the WWTP. Design services are complete for the RTC functionality, and the BSA bid this project in August 2013, with all work expected to be completed by late 2014.

- Hagen Street In-Line Storage (RTC): This project will store flows in the existing line and flows will be released after a storm event for subsequent treatment at the WWTP. Note that during the design phase, the location for this RTC project was moved to Lang Street due to constructability issues. Design services are complete for the RTC functionality, and the BSA bid this project in August 2013, with all work expected to be completed by late 2014.

- Smith St. Storage: This project will consist of a combination of in-line and off-line storage to address overflows into the Buffalo River at CSO 026. In-line storage will use RTC to store flows and then, at a certain level, convey flows to an off-line equalization/storage basin, to further control additional flows. This project is anticipated to be bid in the spring of 2014, with construction complete by the end of 2014.

- Green Infrastructure Initiatives: A $1 million budget will be used for various green initiatives including: a downspout disconnect and rain barrel pilot program, a vacant land management program where structures are demolished thereby reducing impervious surface and creating green space for rain gardens, street run-off, etc., and a variety of green treatments on appropriate Department of Public Works and Community Development projects. The $1 million commitment includes the projects below. Please note that the impervious surface area controlled with these projects will be applied towards the green infrastructure target acreage.

  - Carlton Street (porous asphalt)

- Ohio Street (porous asphalt and other green street technologies)
- Fillmore Avenue (porous asphalt parking lots)
- North Buffalo Ice Rink (porous asphalt parking lot)
- Ardmore Street (brick street restoration)
- Pilot project vacant property demolitions
- Genesse Street (porous asphalt)

11.2.2 Description of Benefits (Reduction in CSO Volumes/Frequencies and Increase in Percent Capture)

The projects described above were incorporated into the existing conditions for the 2004 system model to develop the revised baseline conditions model. In order to document the effect of these projects on CSO activations and volumes and system-wide percent capture, both the existing (2004) conditions system and the revised baseline were run in a continuous model using the modified 1993 TY (as described in Section 2). Table 11-2 presents a summary of the predicted frequencies, residual CSO volumes, and percent capture for both existing and revised baseline conditions. Residual volumes and remaining overflows are presented for each receiving water body, while percent capture is presented on a system-wide basis (not for each receiving water).

Table 11-2: Predicted Annual CSO-Only (Excluding Storm water and Stream Inflows) Volumes and Frequencies by Receiving Water for Existing and Revised Baseline Conditions (Modified 1993 TY)

	Projected Activations (LOC)		Residual CSO Volume (MG)	
Receiving Water Body	**Existing Conditions**	**Revised Baseline**	**Existing Conditions**	**Revised Baseline**
Black Rock Canal	7 – 65	4 – 65	338.7	319.3
Buffalo River	5 – 69	4 – 69	442.9	379.7
Cazenovia Cr.-B	5	0	4.8	0.0
Cazenovia Cr.-C	2 – 47	1 – 44	40.7	35.6
Erie Basin	3 – 17	0 – 12	31.6	10.3
Niagara River (incl. CSO 055)	4 – 41	0 – 41	743.9	735.5
Scajaquada Creek	2 – 65	0 – 65	283.4	268.7
Totals	NA	NA	1,886.1	1,749.1
Percent Capture	NA	NA	90.7%	91.3%

The continuous period simulation results were also summarized by SPP and CSO location for the following quantitative measures to characterize existing conditions for a 1993 TY experienced by the BSA's CSS:

- Table 11-3: Projected annual CSO-only (excluding storm water and stream inflows) volumes, frequencies and durations for both 2004 and revised baseline conditions. These are CSO-only overflow volumes at the CSO, excluding any locally separated storm flow reaching the CSO from an upstream location, as well as the volume associated with Scajaquada Creek inflows from Cheektowaga.

- Table 11-4: Projected annual end-of-pipe (including storm water and stream inflows) volumes, frequencies and durations for both 2004 and revised baseline conditions. These are total overflow volumes at the CSO, including any locally separated storm flow reaching the CSO from an upstream location. The only exceptions are for CSO 006 and CSO 053; following BSA discussions with the NYSDEC, the volume associated with Scajaquada Creek inflows from Cheektowaga is not included in the total volume for these CSOs.

Appendix 11-2 presents the projected annual CSO-only (excluding storm water and stream inflows) volumes, frequencies, and durations by SPP for both 2004 and revised baseline conditions. Because these are total overflow volumes at the SPP, they include any overflow volume reaching the SPP from an upstream location.

As can be seen, implementation of the Phase I projects results in measurable system-wide CSO volume and frequency reductions. The Phase I projects reduced CSO volumes by just over 7%, and the resulting percent capture increases from 90.7% to 91.3%. There are significant reductions at several CSOs: CSOs 057, 058, and 059 are projected to have no discharges as a result of the Phase I projects and CSO 003 activations are projected to be reduced from 27 to 6 per year.

The revised baseline results represent the existing conditions assessment for the SPPs and CSOs in the BSA's system and form the basis for comparison of all subsequent alternative evaluation results.

11.3 Real-Time Control (RTC) Evaluation

RTC for CSO control utilizes existing collection system capacity to maximize conveyance to treatment and to take advantage of larger sewers to provide temporary storage during wet weather events. RTC can be more effective than static controls at reducing the frequency and volume of overflows by maximizing storage in the collection system or distributing flow between areas of the system. This section describes the evaluation of RTC for the BSA system and the development of recommended RTC projects to be carried forward in this LTCP.

11.3.1 Description of Alternative

To assess the potential effectiveness of RTCs at controlling CSOs within the BSA system, a side-by-side desktop analysis was conducted by two RTC specialty firms: EmNet, LLC; and BPR CSO. Table 11-5

Table 11-3: Predicted Annual CSO Only (Excluding Stormwater and Stream Inflows) Volumes, Frequencies and Durations by CSO

CSO Outfall	District	Receiving Water	CSO-only Volume (Million Gallons)		CSO-only Frequency		CSO-only Durations (hours)	
			Existing (2004)	Revised Baseline	Existing (2004)	Revised Baseline	Existing (2004)	Revised Baseline
004	Scajaquada	Black Rock Canal	16.2	11.2	7	5	12	8
005	Scajaquada	Black Rock Canal	0.1	0.1	0	4	5	5
006	Scajaquada	Black Rock Canal	201.4	198.9	65	65	322	344
008	Scajaquada	Black Rock Canal	8.2	6.1	42	39	105	90
010	Scajaquada	Black Rock Canal	11.8	11.9	44	44	103	103
012	Albany	Black Rock Canal	52.0	52.5	42	42	111	111
013	South Central	Black Rock Canal	13.6	6.8	14	7	58	25
061	Scajaquada	Black Rock Canal	33.8	31.2	10	10	31	29
063	South Central	Black Rock Canal	1.5	0.6	50	13	110	19
017	South Central	Buffalo River	101.6	71.3	55	49	166	124
022	South Central	Buffalo River	42.7	29.8	55	49	166	124
025	South Central	Buffalo River	1.4	1.4	11	11	17	17
026	South Central	Buffalo River	146.5	124.2	61	63	232	247
027	South Central	Buffalo River	19.4	31.7	36	34	127	121
028	South Central	Buffalo River	44.4	45.5	69	69	328	328
029	South Central	Buffalo River	0.0	0.0	0	0	0	0
032	South Central	Buffalo River	0.0	0.0	0	0	0	0
033	South Central	Buffalo River	35.7	37.8	8	9	20	21
034	South Central	Buffalo River	0.1	Closed	5	Closed	8	Closed
049	South Central	Buffalo River	0.0	0.0	0	0	0	0
050	South Central	Buffalo River	4.1	3.2	22	14	47	22
051	South Central	Buffalo River	3.7	1.2	16	4	56	14
052	South Central	Buffalo River	13.6	10.9	11	10	112	70
064	South Central	Buffalo River	27.2	21.1	55	56	166	181
066	South Central	Buffalo River	2.5	1.7	16	10	26	17
035	South Central	Cazenovia Creek - B	4.8	0.0	29	0	55	9
037	South Central	Cazenovia Creek - C	21.2	23.3	14	13	42	40
039	South Central	Cazenovia Creek - C	0.0	0.0	2	0	2	0
044	South Central	Cazenovia Creek - C	6.5	2.3	15	7	37	12
046	South Central	Cazenovia Creek - C	1.1	1.3	9	1	37	1
047	South Central	Cazenovia Creek - C	10.4	8.7	47	44	108	94
048	South Central	Cazenovia Creek - C	1.5	0.0	12	0	42	0
055	Hertel	Niagara River	613.6	601.1	40	41	184	174
014	South Central	Erie Basin	25.9	4.2	17	4	61	15
015	South Central	Erie Basin	5.7	6.1	12	12	43	43
016	South Central	Erie Basin	0.0	0.0	3	0	4	0
003	Parish	Niagara River	4.5	0.1	27	6	224	32
011	Albany	Niagara River	125.7	134.3	41	41	240	243
054	Ontario	Niagara River	0.1	0.0	4	0	4	0
053	Scajaquada	Scajaquada Creek	275.0	268.0	65	65	322	344
056	Hertel	Scajaquada Creek	0.0	0.0	5	5	8	8
057	Parish	Scajaquada Creek	0.3	0.0	11	0	15	0
058	Parish	Scajaquada Creek	0.0	0.0	2	0	2	0
059	Scajaquada	Scajaquada Creek	5.1	0.0	17	0	45	0
060	Scajaquada	Scajaquada Creek	2.9	0.7	11	5	25	11
		TOTAL	**1,886.1**	**1,749.1**				

Table 11-4: Predicted Annual End-of-Pipe (Including Stormwater and Stream Inflows) Volumes, Frequencies and Durations by CSO

CSO Outfall	District	Receiving Water	End-of-Pipe Volume (Million Gallons)		End-of-Pipe Frequency		End-of-Pipe Durations (hours)	
			Existing (2004)	Revised Baseline	Existing (2004)	Revised Baseline	Existing (2004)	Revised Baseline
004	Scajaquada	Black Rock Canal	16.2	11.2	7	5	12	8
005	Scajaquada	Black Rock Canal	0.1	0.1	4	4	5	5
006	Scajaquada	Black Rock Canal	850.9	852.0	N/A	N/A	N/A	N/A
008	Scajaquada	Black Rock Canal	16.9	14.8	91	86	672	609
010	Scajaquada	Black Rock Canal	11.8	11.9	44	42	103	96
012	Albany	Black Rock Canal	52.0	52.5	42	40	111	104
013	South Central	Black Rock Canal	13.6	6.8	14	6	58	23
061	Scajaquada	Black Rock Canal	33.8	31.2	10	9	31	24
063	South Central	Black Rock Canal	1.5	0.6	50	12	110	18
017	South Central	Buffalo River	133.2	102.9	100	95	971	841
022	South Central	Buffalo River	42.7	29.8	99	89	600	493
025	South Central	Buffalo River	1.4	1.4	11	10	17	16
026	South Central	Buffalo River	154.3	132.0	97	91	910	835
027	South Central	Buffalo River	19.4	31.7	36	34	127	121
028	South Central	Buffalo River	87.8	89.0	95	91	980	902
029	South Central	Buffalo River	0.0	0.0	0	0	0	0
032	South Central	Buffalo River	0.0	0.0	0	0	0	0
033	South Central	Buffalo River	35.7	37.8	8	9	20	21
034	South Central	Buffalo River	0.1	Closed	5	Closed	8	Closed
049	South Central	Buffalo River	0.0	0.0	0	0	0	0
050	South Central	Buffalo River	4.1	3.2	22	13	47	21
051	South Central	Buffalo River	3.7	1.2	16	4	56	14
052	South Central	Buffalo River	14.4	11.6	16	14	131	91
064	South Central	Buffalo River	27.2	21.1	91	82	392	367
066	South Central	Buffalo River	76.0	78.6	87	81	1437	1388
035	South Central	Cazenovia Creek - B	6.3	11.9	51	89	164	544
037	South Central	Cazenovia Creek - C	21.2	23.3	14	12	42	35
039	South Central	Cazenovia Creek - C	0.0	0.0	2	0	2	0
044	South Central	Cazenovia Creek - C	6.5	2.3	15	7	37	12
046	South Central	Cazenovia Creek - C	1.1	1.3	9	1	37	1
047	South Central	Cazenovia Creek - C	10.4	8.7	47	42	108	87
048	South Central	Cazenovia Creek - C	1.5	0.0	12	0	42	0
055	Hertel	Niagara River	613.6	601.1	40	39	184	164
014	South Central	Erie Basin	25.9	4.2	17	4	61	15
015	South Central	Erie Basin	5.7	6.1	12	11	43	40
016	South Central	Erie Basin	6.2	6.1	12	94	483	457
003	Parish	Niagara River	4.5	0.1	27	6	224	32
011	Albany	Niagara River	125.7	134.3	41	39	240	230
054	Ontario	Niagara River	7.3	17.5	62	69	520	679
053	Scajaquada	Scajaquada Creek	1,385.4	1,381.1	N/A	N/A	N/A	N/A
056	Hertel	Scajaquada Creek	0.0	0.0	5	5	8	8
057	Parish	Scajaquada Creek	0.3	0.0	11	0	15	0
058	Parish	Scajaquada Creek	10.4	10.6	84	79	621	560
059	Scajaquada	Scajaquada Creek	5.1	20.1	17	82	45	853
060	Scajaquada	Scajaquada Creek	9.6	31.5	85	78	438	737
		Totals	3,843.6	3,781.5	N/A	N/A	N/A	N/A

Table 11-5: Potential Real Time Control Projects Identified in the RTC Evaluation Study

District	Affected CSO ID	Type	BPR Project	BPR Site Location	EmNet Project	EmNetSite Location	Recommended for Implementation	If No, Reason for Excluding
North	055	In-Line storage	Hertel - Military	Hertel between Military and Delaware	Hertel Northwest Hertel South	Hertel btw Norris & Colvin. Hertel btw Foundry & Colvin	Yes	
	055	In-Line storage	Hertel - Delaware	Hertel between Delaware and Parkside	Hertel Northeast	Hertel between Colvin and Shoshone	Yes	
Scajaquada	053, 006, 061	RTC Interception	SPP 336B	SPP 336B: Kensington Expy, north of East Ferry	-	-	No	These RTC interception projects are not required since in-line storage projects are being recommended in the same areas.
	053, 006, 061	RTC Interception	SPP 337	SPP 337: Colorado & Scajaquada	-	-	No	
	053, 006, 061	RTC Interception	SPP 339	SPP 339: Texas & Kerns	-	-	No	
	053, 006, 061	RTC Interception	SPP 340	SPP 340: Hagen & Kerns	-	-	No	
	004	In-Line storage	Bird Trunk	Bird & Dewitt to Delaware & Saybrook	Bird East Bird West	Bird & Baynes to Delaware & W. Delavan Bird from Dewitt to Baynes	Yes	
	053, 006, 061	In-Line storage	East Ferry	Kensington Expy & East Ferry to East Ferry & Cornwall	-	-	Yes	
	053, 006, 061	In-Line storage	Colorado	Scajaquada & Colorado to East Delavan & Northumberland	-	-	Yes	
	053, 006, 061 053, 006, 061	In-Line storage	Bailey	Bailey & East Delavan to Bailey & Oakmont	North Bailey South Bailey	North Bailey from E. Amherst to Dorris South Bailey from Dorris to Scajaquada	Yes	
	053, 006, 061	In-Line storage	Texas	Texas & Lang to Suffolk & Langfield	Roslyn	Texas & Lang to Suffolk & Proctor	Yes	
	053, 006, 061	In-Line storage	Hazelwood (Hagen)	Hazelwood & East Delavan to Edison & Kensington	Kay	Kay & Millicent to Hazelwood & Easton	Yes	
	053, 006, 061	In-Line storage	Hagen	Hagen & Kerns to Hazelwood & East Delavan	Floss	Hazelwood & Easton to Hagen & Lang	Yes	
	053, 006, 061	Off-line storage	Amherst Quarry	Bailey & Amherst	East Amherst Quarry	East Amherst and Clarence	Yes	
South-Central	011	RTC Interception	SPP 024	I-190 & Albany	-	-	No	Albany Street RTC interception projects aren't viable, as they would require an upgrade in the plant capacity (the South Interceptor regularly backs up into this line) and an upsizing of the trunk sewer (the capacity of the existing sewer is insufficient to handle the additional flow), which is located in a difficult area construction-wise
	012	RTC Interception	SPP 023 and SPP 296	I-190 & Albany	-	-	No	
	017	RTC Interception	SPP 281	Pine & Swan	-	-	No	Impacts SPP whose flow is being picked up by Hamburg Drain storage
	026	RTC Interception	SPP 217	Emslie & Eagle	-	-	No	A review of the model results indicated that this caused flooding to ground at the SPP for even a fairly small event
	026	RTC Interception	SPP 317	Fillmore & Clinton	-	-	No	Fillmore North In-Line storage project addresses this SPP
	026	In-line storage	-	-	Fillmore North	Fillmore from Sienkiewicz to William	Yes	
	026	In-line storage	-	-	Fillmore South	Fillmore from Broadway to Howard	No	Doesn't impact any particular SPP where we are having activation issues; Since it impacts flow routed to Swan Trunk, may indirectly impact SPP 67, but this SPP is picked up by Hamburg Drain storage
	027	In-line storage	-	-	Genesee	Kensington Exp from High to East Tupper	No	Impacts SPP whose activations are already in the single digits
	017	In-line storage	-	-	Michigan	Kensington Exp & East Tupper to Michigan & West Swan	No	Impacts SPP whose activations are already in the single digits
	026	CSO Line Storage			Gibson	Gibson from Stanislaus to Sienkiewicz	Yes	
	026	CSO Line Storage	-	-	Montgomery	Fillmore & Eagle to Smith & Peckham	Yes	
	026	CSO Line Storage	-	-	Smith	Smith from Eagle to Perry	Yes	
	064	CSO Line Storage	-	-	Louisiana	Louisiana from I-90 to South Park	No	Excluded due to constructability/implementation concerns

summarizes the locations and control strategies identified by both firms, and the full reports from each firm are included in Appendix 11-7. The identified locations, analyzed RTC concepts, and overall benefit conclusions are essentially the same between the two studies:

- Major storage opportunities were identified in the North and Scajaquada Districts.
- There were limited major inline storage opportunities upstream of regulators in the South Central District, although four low-volume storage opportunities were identified in this district.
- Only local reactive control was examined in this study
- Overall, it was concluded that local reactive control could provide an approximately 15-20% reduction in annual overflow volumes (based on the 1986 TY).

These proposed projects were reviewed for constructability issues and a sensitivity analysis was conducted to determine where these projects would be most effective. In addition, model results were evaluated to make sure there were no localized adverse affects from these projects, such as manhole flooding or excessive surcharge. The following sections describe the results of these evaluations.

11.3.2 Proposed Facilities and Operational Concepts

The RTC alternatives carried forward were identified from the sensitivity analysis conducted in the spring of 2011, before the USEPA requested that the BSA reevaluate its typical year from the 1986 TY that was being used at that time. Table 11-5 summarizes all the potential RTC projects identified as part of this initial evaluation. Table 11-5 also notes which projects are recommended to be carried forward as part of the BSA's RTC program and included with all new alternatives under this LTCP. Several projects from the initial list were eliminated because of constructability issues, while others were eliminated because they were recommended upstream of SPPs that were already discharging very infrequently. Note that the RTC program was not considered in the updated 2004 preferred alternative UA1.

Figure 11-2 presents the RTC program projects within the BSA system. The recommended RTC projects will utilize local reactive controls, which are the simplest form of control. Local reactive controls consist mainly of controlling flows based on local hydraulic parameters, such as level or flows. Ultimately, the BSA may implement a broader system or sewershed-wide control scheme to further enhance the effectiveness of the RTC program by allowing for a wider view of conditions within the system. Local reactive controls will be implemented to provide CSO control in three general categories:

- Off-Line Storage: The rules implemented for off-line storage areas are directed to maximize the utilization of the available storage when CSO regulators are close to activation. In a local reactive system, an off-line storage facility starts storing water when the flow at the diversion point is greater than the regular dry weather flow. Dewatering strategies are aimed at conveying water to the collection system as quickly as possible without creating additional overflows. Water levels at the nearest large downstream conveyance system are used to determine if it is safe to release water. The storage available within the existing Amherst Quarry is the only off-line storage RTC project included in the RTC program.

- In-Line Storage: In-line storage utilizes unused sewer pipe capacity upstream of a regulator or SPP. Similar to off-line storage, in-line storage locations must time storage and dewatering actions to maximize the performance of the RTC system. These structures must be able to simultaneously store and convey flow to prevent basement and surface flooding. A local reactive in-line storage system will not store water until it detects that the flow is above the normal dry weather flow. Upon detecting the presence of significant wet weather flows, and as long as water levels do not exceed maximum surcharge levels, the structure will only allow flow approximately equivalent to dry weather conditions to be conveyed. The balance of the flow will be stored in the available space in the collection system. If the maximum surcharge level is reached, the system will allow flow to pass the RTC chamber to prevent exceeding the maximum surcharge level. This action produces flows that are essentially equivalent to flows seen without the RTC structure, but at that point, the structure would have captured and stored its target volume. Once the wet weather event passes and flows in the collection system return to normal levels, the structure will dewater at a rate equivalent to dry weather flow. The majority of the projects included in the RTC program are in-line storage projects.

- CSO Line Storage: The objective of CSO line storage is to store excess combined stormwater and sanitary flows before the release point to the environment. CSO line storage utilizes the capacity of the CSO pipe downstream of the regulator or SPP, but before the discharge point or outfall. They behave similarly to in-line storage locations in the sense that they are required to convey water if the water level threatens to cause surface flooding. Additionally, the level must be kept below the lowest weir crest upstream from the control structure. This prevents overflows from weirs with higher crest elevations from reentering the system through weirs with lower crest elevations. CSO line storage facilities also behave like off-line storage in the sense that once the storm event has subsided, they are not designed to continue conveying water, but instead, they must be dewatered back into the combined system typically through a pumping station. The dewatering rate is controlled so that it will not cause problems (i.e.; basement flooding or CSO activations) downstream from the control structure. Three CSO line storage projects in the Smith Street (CSO 026) basin are included in the RTC program.

As part of the LTCP implementation, the BSA has selected two sites for implementation as demonstration projects. The intent is to assess all aspects of RTC implementation—design, construction, and operations—and then assess the projects to determine the effectiveness of these RTC concepts at reducing overflow frequencies and volumes. These demonstration projects are not for evaluating the feasibility of the RTC

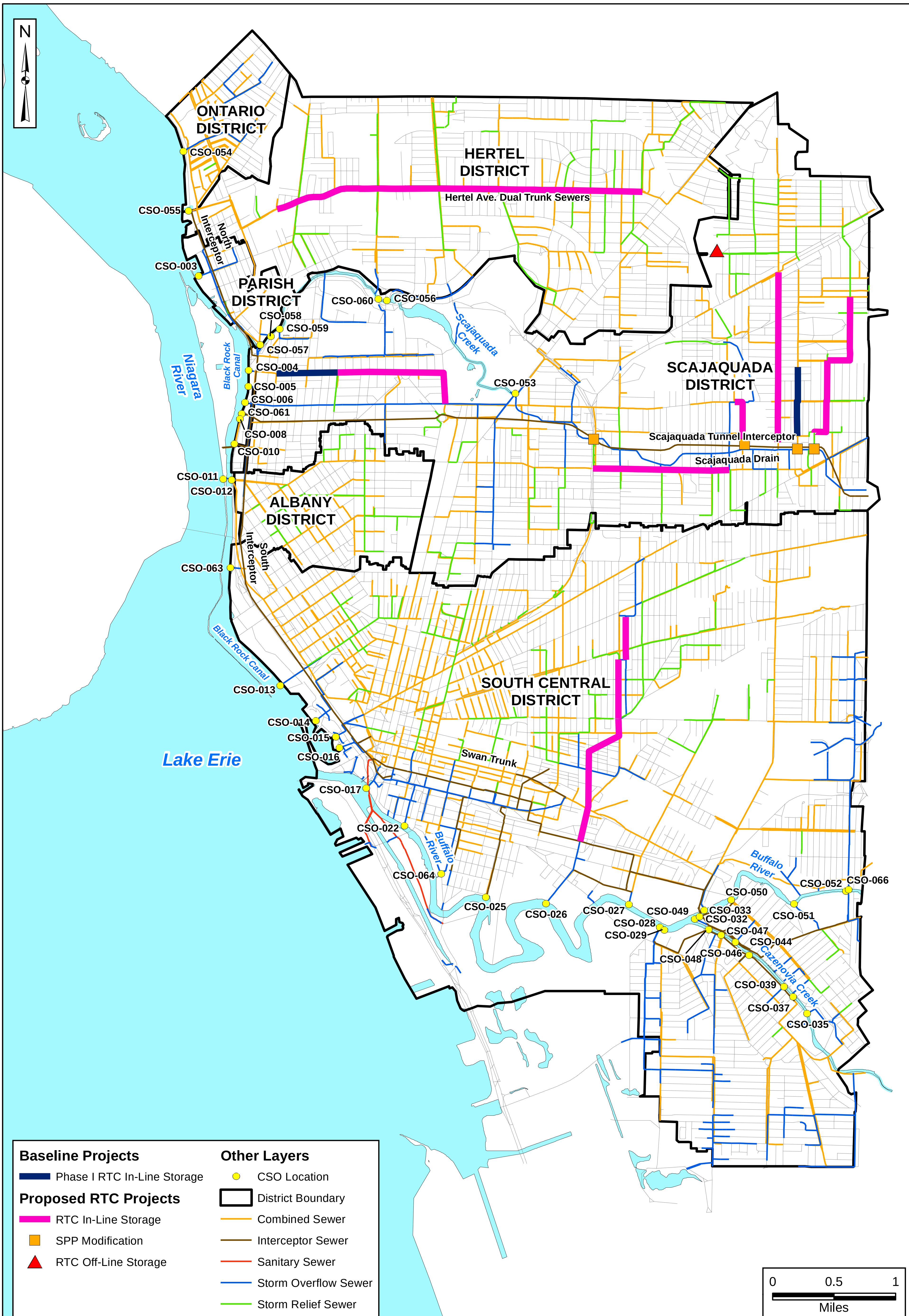

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FIGURE 11-2

PROPOSED RTC PROJECTS FOR INCLUSION IN LTCP

strategy, but rather to give the BSA staff a sense of the effort it will take to effectively operate and maintain these types of facilities before embarking on the system-wide program. Two projects from those listed on Table 11-5 were selected for pilot implementation as part of the Phase I projects and were incorporated in the revised baseline condition model discussed above:

- Bird Avenue In-Line Storage: This project will provide in-line storage of combined sewer flows in the existing Bird Avenue line that will be released after a storm event for subsequent treatment at the WWTP.

- Hagen Street In-Line Storage: This project will provide in-line storage of combined sewer flows in the existing street line that will be released after a storm event for subsequent treatment at the WWTP. Note that during the design phase, this location was moved to nearby Lang Street due to constructability issues previously identified on Hagen Street.

An RFP was developed and advertised to provide design services for the RTC functionality. Design is now complete and the BSA bid the two projects in August 2013, with all work expected to be completed by late 2014. The BSA will assess the effectiveness of RTCs based on the post-construction monitoring results of these two projects as well as evaluate the operations and maintenance requirements, and will decide then on how the remaining RTC projects will be implemented throughout the remainder of the LTCP period.

11.3.3 Preliminary Project Costs

Table 11-6 summarizes the preliminary capital costs for the RTC program to be considered as part of the new system-wide alternatives. Preliminary costs were developed by evaluating the costs provided by the RTC consultants, with additional considerations of constructability of the recommended projects, as well as evaluating the controls and site requirements. Approximately $40 million of RTC projects (project costs without O&M) are included in the program, though the full extent of the RTC implementation will be dependent upon the results of the demonstration projects. The BSA fully intends to construct all 17 RTC projects listed in Table 11-6, although the full RTC program may be reduced to account for the interaction of other RTC locations as well as increased GI projects. The overall CSO reduction associated with the RTC program however will not change.

Table 11-6: Recommended Real Time Control Projects with Estimated Costs

Project Name	Type	Project Status	Total Estimated Cost
Hertel Northwest In-Line Storage	In-Line Storage	Proposed	$ 2,185,000
Hertel South In-Line Storage	In-Line Storage	Proposed	$ 4,095,000
Hertel Northeast In-Line Storage	In-Line Storage	Proposed	$ 2,185,000
Bird East In-Line Storage	In-Line Storage	Proposed	$ 2,025,000
Bird West In-Line Storage	In-Line Storage	Demonstration Project in Construction	$ 1,595,000
East Ferry In-Line Storage	In-Line Storage	Proposed	$ 2,040,000
Colorado In-Line Storage	In-Line Storage	Proposed	$ 2,025,000
North Bailey In-Line Storage	In-Line Storage	Proposed	$ 2,025,000
South Bailey In-Line Storage	In-Line Storage	Proposed	$ 2,025,000
Roslyn In-Line Storage	In-Line Storage	Proposed	$ 2,170,000
Kay In-Line Storage	In-Line Storage	Proposed	$ 2,015,000
Hagen In-Line Storage (moved to Lang Street)	In-Line Storage	Demonstration Project in Construction	$ 4,085,000
Amherst Quarry Off-Line Storage	Off-Line Storage	Proposed	$ 2,875,000
Fillmore North In-Line Storage	In-Line Storage	Proposed	$ 2,015,000
Gibson CSO Line Storage	CSO Line Storage	Proposed	$ 2,015,000
Montgomery CSO Line Storage	CSO Line Storage	Proposed	$ 2,015,000
Smith CSO Line Storage	CSO Line Storage	Under Design	$ 2,015,000
		TOTAL	***$ 39,405,000***

11.3.4 Description of Benefits (Reduction in CSO Volumes/Frequencies)

Based on the BSA's commitment to implementing RTC as part of the overall LTCP program, the projects described above (with the exception of the two projects already included in Phase 1 projects) were incorporated into the revised baseline conditions model in order to evaluate the potential volume reductions and cost-effectiveness. In order to document the effect of these projects on CSO activations and volumes, the revised baseline model with the proposed RTC projects was run in continuous mode for the typical year (1986 TY). Because this analysis was conducted prior to the USEPA requesting the revision of the TY, the results reflect the use of the original 1986 TY. The continuous period simulation results were summarized only for the specific SPPs and CSOs that were affected by the proposed RTC projects. Table 11-7 summarizes the CSO-only volume and frequency reductions compared to the revised baseline conditions. The sensitivity analysis indicated an up to 30% reduction in annual CSO volumes at the affected SPPs/CSOs as a result of the recommended RTC projects. In addition, significant reductions in CSO activations were predicted at many of the affected SPPs. The largest reductions were predicted for SPPs 339 and 340 in the Scajaquada (CSO 053) basin, where the model predicted frequencies decreasing from 60 to less than 10 events per year at both SPPs (for the 1986 TY conditions).

Table 11-7: Real Time Control Projects Cost-Benefit Analysis (1986 TY)

Affected CSO/SPP	RTC Projects	Total Cost ($M)	Baseline OF Vol. (MG)[1]	Baseline + RTC OF Vol. (MG)[1]	Difference (MG)	Baseline OF Events	Baseline + RTC OF Events	Reduction in Events
CSO 004	Bird In-Line Storage	3.056	43.1	33.7	-9.4	9	7	-2
CSO 026	Fillmore North In-Line Storage Gibson CSO Line Storage Montgomery CSO Line Storage Smith CSO Line Storage	4.223	252.4	156.4	-96	63	63	0
CSO 055	Hertel In-Line Storage	7.15	824.9	719.0	-105.9	39	30	-9
SPP336B	SPP336B RTC Interception East Ferry In-Line Storage	4.147	121.3	81.7	-39.56	52	25	-27
SPP337	SPP337 RTC Interception Colorado In-Line Storage	4.133	61.7	39.4	-22.32	38	16	-22
SPP338	Amherst Quarry Off-Line Storage North Bailey In-Line Storage South Bailey In-Line Storage	4.454	47.7	19.8	-27.94	17	5	-12
SPP339	SPP339 RTC Interception Roslyn In-Line Storage	4.254	86.5	22.1	-64.37	60	5	-55
SPP340	SPP340 RTC Interception Floss In-Line Storage Kay In-Line Storage	4.627	89.6	31.5	-58.1	59	9	-50
Total			**1,527.2**	**1,103.6**	**-423.6**			

Note:
[1] Annual volumes presented on this table are based on the original 1986 typical year.

11.4 System-wide Green Infrastructure (GI)

The volume and rate of overflow from CSO discharges is directly affected by the hydrologic characteristics of the area served by the CSS. As such, changes to the tributary areas that reduce the amount of runoff, or delay the rate of runoff, can be an important component of the control of CSO discharges. These approaches have been implemented in CSO control programs for years and have recently become major components in the CSO control programs of New York City, Philadelphia, and Kansas City, among others. This section describes the sensitivity analysis conducted and used by the BSA to develop their approach to incorporating green technologies into some of the system-wide alternatives in this LTCP.

11.4.1 Description of Program

The GI program presented in this section represents a conservative approach to coordinating GI implementation with gray technologies. The outline of the GI program proposed by the BSA and described in Section 11.4.2 was developed to provide an initial set of goals and impervious surface control targets for integrating GI into the LTCP, and is similar to the approach taken by other CSO communities that are implementing GI as part of CSO CD programs. New York City, Philadelphia, and the Northeast Ohio Regional Sewer District (NEORSD in Cleveland) all presented planned approaches in their LTCPs that did not go into specifics and proposed to develop a detailed implementation plan as part of the LTCP implementation. The initial impervious surface control targets described in this section were used to refine the alternative evaluation presented in the remainder of this section and set preliminary cost and impervious surface control targets.

In response to Agency comments on this approach, however, the BSA developed a more detailed GI Master Plan. As presented in Section 12, the GI Master Plan incorporated a SPP level analysis to refine the final impervious surface control acreage goals. The BSA GI Master Plan details specific GI projects that will be implemented during the first five years, including project location, proposed GI technologies, and CSO reduction projections. It further establishes criteria to build upon the first phase of GI projects and to complete the overall program during the remaining 15 years of the LTCP implementation schedule. The impact of this more refined and detailed GI plan was evaluated on the Recommended Alternative, the results of which are summarized in Section 12.

This phased approach to GI implementation will allow the BSA to analyze the effectiveness of GI technologies at controlling CSOs prior to embarking on the design and construction of their recommended gray facilities. Already, the BSA is implementing a rain barrel pilot program in the Hamlin Park area and a green streets program in the CSO 060 basin. The BSA has further worked with the Buffalo-Niagara Riverkeepers (BNRK) to begin looking for additional specific opportunities in many of the CSO basins. These projects, along with additional pilot projects, will provide the BSA with critical information about GI effectiveness, allowing the BSA to refine and tailor its approach to achieve maximum sustainable controls.

11.4.2 Recommended Areas for GI

To develop the initial system-wide GI approach, land use statistics were reviewed for a sample of residential and commercial basins throughout the City. Impervious surfaces were summarized and broken down into total impervious area, publicly controllable impervious areas (*e.g.*, streets/roads, sidewalks) and typical privately controlled land uses where GI technologies could be easily implemented. The intent of this exercise was to identify a reasonable, achievable level of impervious surface control that the BSA could use as a goal for their GI program. To estimate the sensitivity of CSO discharges to GI application, 10% impervious surface control, 20% impervious surface control, and 60% impervious surface control were evaluated to determine what those control levels would mean in terms of acreage. Using six sample areas with different zoning requirements and land uses, the estimated total impervious acres at each level were calculated and compared to the available impervious surfaces that are within public control. For ease of interpretation, only roads and sidewalks were considered publicly owned. Public buildings, parking lots and privately owned impervious surfaces were not included in this analysis.

Table 11-8 summarizes this analysis for the sample areas. The general boundaries of the sample areas are as follows:

- **Residential 1:** Jefferson Avenue to the west , Hughes Avenue to the north, East Delavan Avenue to the south and Oakgrove Avenue to the east
- **Residential 2:** Lonsdale Avenue to the west, Hamlin Street to the north, Butler Street to the south and Wohlers Avenue to the east
- **Residential 3:** Carl Street to the west, Northland Avenue to the north, East Ferry Street to the south and Schuele Avenue to the east
- **Commercial 1:** Elmwood Avenue to the west, West Tupper Street to the north, West Chippewa Street to the south, and Franklin Street to the east
- **Commercial 2:** Elmwood Avenue between Hinman Avenue and Hertel Avenue
- **Commercial 3:** Hertel Avenue between Rosalia Street and Delaware Avenue, and Delaware Avenue between Hertel Avenue and Cheltenham Drive

As shown in Table 11-8, in all but one case, Commercial (2), there is adequate available publicly controlled impervious surface to support the 20% level of GI control. Based on this analysis, the BSA selected a target percentage control of up to 20% of the impervious surface for GI implementation through reasonable measures by the BSA or the City.

Table 11-8: Analysis of Land Uses for GI Control in Sample Areas

Area	Residential (1)		Residential (2)		Residential (3)		Commercial (1)		Commercial (2)		Commercial (3)	
	Acreage	%	Acreage	%	Acreage	%	Acreage	%	Acreage	%	Acreage	%
Total Area	22.1	NA	24.1	NA	23.7	NA	24.0	NA	28.8	NA	24.4	NA
Other/Pervious	9.7	43.9	6.9	28.6	11.2	47.3	1.7	7.1	2.9	10.1	2.1	8.6
Roof	6.7	30.2	8.2	34.1	4.8	20.1	6.8	28.3	7.2	25.0	5.2	21.4
Road	2.0	9.0	3.1	12.7	2.7	11.4	4.4	18.1	0.9	3.0	3.0	12.1
Sidewalk	1.3	5.7	1.3	5.4	1.1	4.6	2.7	11.1	0.8	2.9	1.7	6.8
Driveway/Parking	2.4	10.8	4.6	19.0	3.9	16.6	8.4	34.9	17.0	59.3	12.4	50.9
Total Impervious Surface Area	12.4	56.1	17.2	71.4	12.5	52.7	22.3	92.9	25.9	89.9	22.3	91.4
Total Available Publicly Owned Impervious Area*	**3.3**	**26.6**	**4.4**	**25.6**	**3.8**	**30.4**	**7.1**	**31.8**	**1.7**	**6.6**	**4.7**	**21.1**
Impervious Acreage Needed to be Controlled												
At 60% Impervious Surface Control	7.4		10.3		7.5		13.3		15.6		13.4	
At 20% Impervious Surface Control	2.5		3.4		2.5		4.4		5.2		4.5	
At 10% Impervious Surface Control	1.2		1.7		1.3		2.2		2.6		2.2	

Note * Publicly Owned Impervious Area assumed to be the sum of roads and sidewalks.

To develop impervious surface targets specific to each CSO basin, the BSA reviewed the predicted CSO activations from the revised baseline presented in Table 11-3 in Section 11.2.2. CSO basins in receiving water bodies that are critical from a water quality perspective, the Erie Basin sensitive area, or are generally discharging at higher annual frequencies (greater than 10 to 12 overflows per year) were targeted for the maximum 20% impervious surface control. For less active CSOs, those basins were targeted for 10% impervious surface control. All CSO basins were targeted for some impervious surface control between 10 to 20%, as shown on Figure 11-3. This analysis resulted in a target impervious surface control of approximately 1,600 acres for GI implementation through reasonable measures by the BSA or the City. Note that the system-wide GI at these target impervious control percentages was included as part of only one CSO control alternative evaluated further in this section - Alternative UA2.

The next step was to evaluate the land uses and impervious surface statistics within each CSO basin to develop a targeted control acreage and to determine what technologies would be most appropriate for application. For example, highly commercial basins with little vacant properties and no residential buildings would not be candidates for downspout disconnection (though rain barrels or cisterns on commercial properties could be explored); however, other GI technologies such as green and blue roofs may be more applicable. This analysis provided the BSA with additional information specific to each basin, and identified

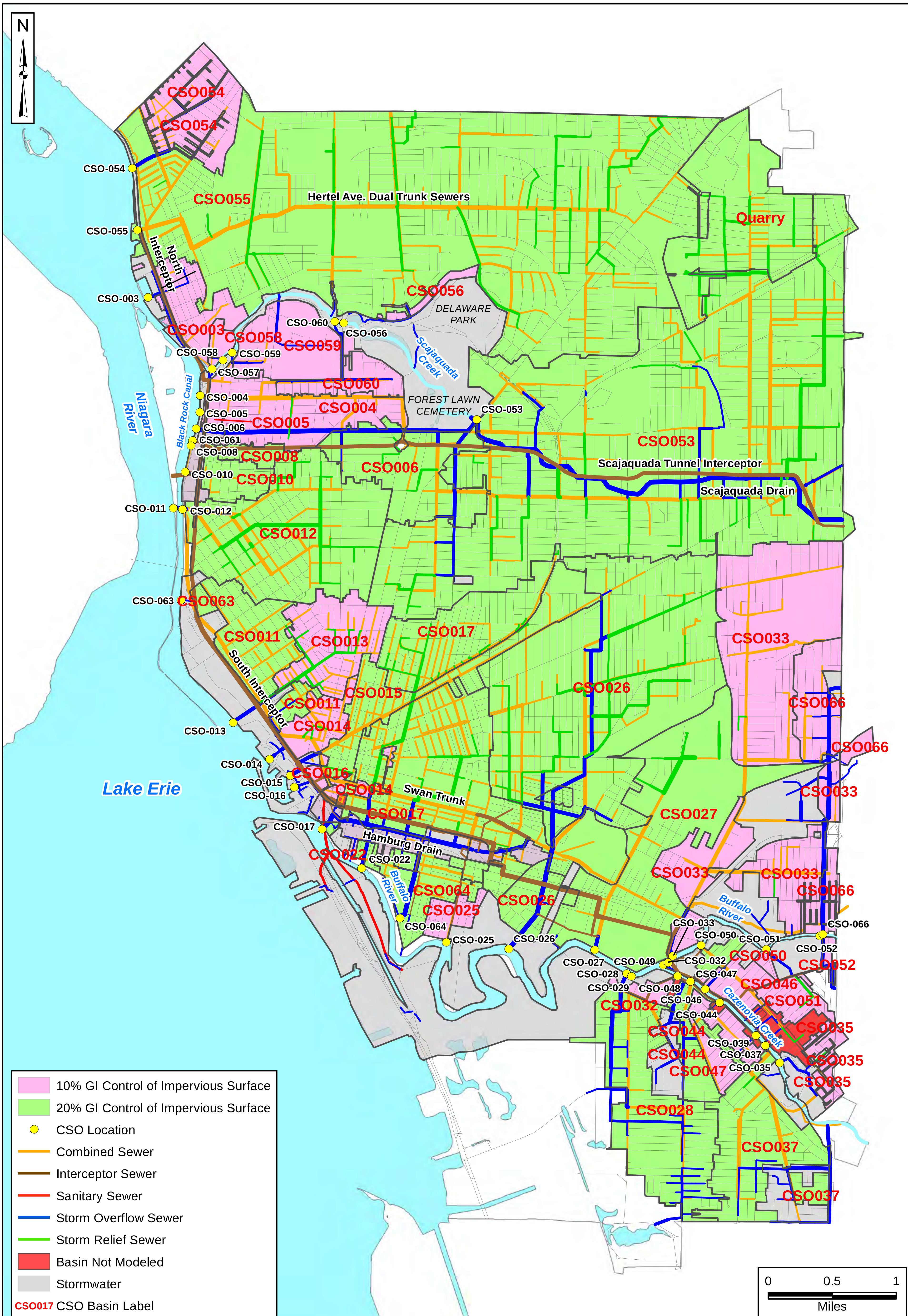

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FIGURE 11-3

RECOMMENDED SYSTEM-WIDE GI CONTROL LEVELS

publicly-held properties (where implementation would be easier since the properties are within the BSA's or the City's control), street areas where right-of-way technologies can be implemented, and vacant properties where impervious surfaces converted to pervious or GI storage (*e.g.*, rain gardens) could be constructed. Figure 11-4 presents an example of this analysis for the CSO 012 basin; similar figures for each CSO basin are provided in Appendix 11-8.

This analysis provided the BSA with a better understanding of the potential acreage for GI control in each basin. By targeting impervious surface control primarily within publicly-owned property at earlier stages of the program, the BSA's program will have a higher chance for successful implementation of GI technologies. In addition, the BSA is currently working with the City to make reasonable modifications to development code that will promote GI and low-impact development (LID) technologies whenever land is redeveloped throughout the City. Again, private property programs like downspout disconnections (with or without rain barrels) will also be explored to address those sources of runoff. A list of potential GI technologies based on type of impervious surface and property type are shown below.

- Public Right-of-Ways (Public Property): Rain gardens/bioswales, pervious curb and gutter, porous pavement
- Parking Lots (Public/Private Property): Rain gardens/bioswales, porous pavement
- Roofs (Private Residential Property): Downspout disconnection, rain barrels
- Roofs (Public and Private Commercial Property): Blue roofs, green roofs
- Vacant Properties (Public Property): Retention, infiltration

11.4.3 Preliminary Costs

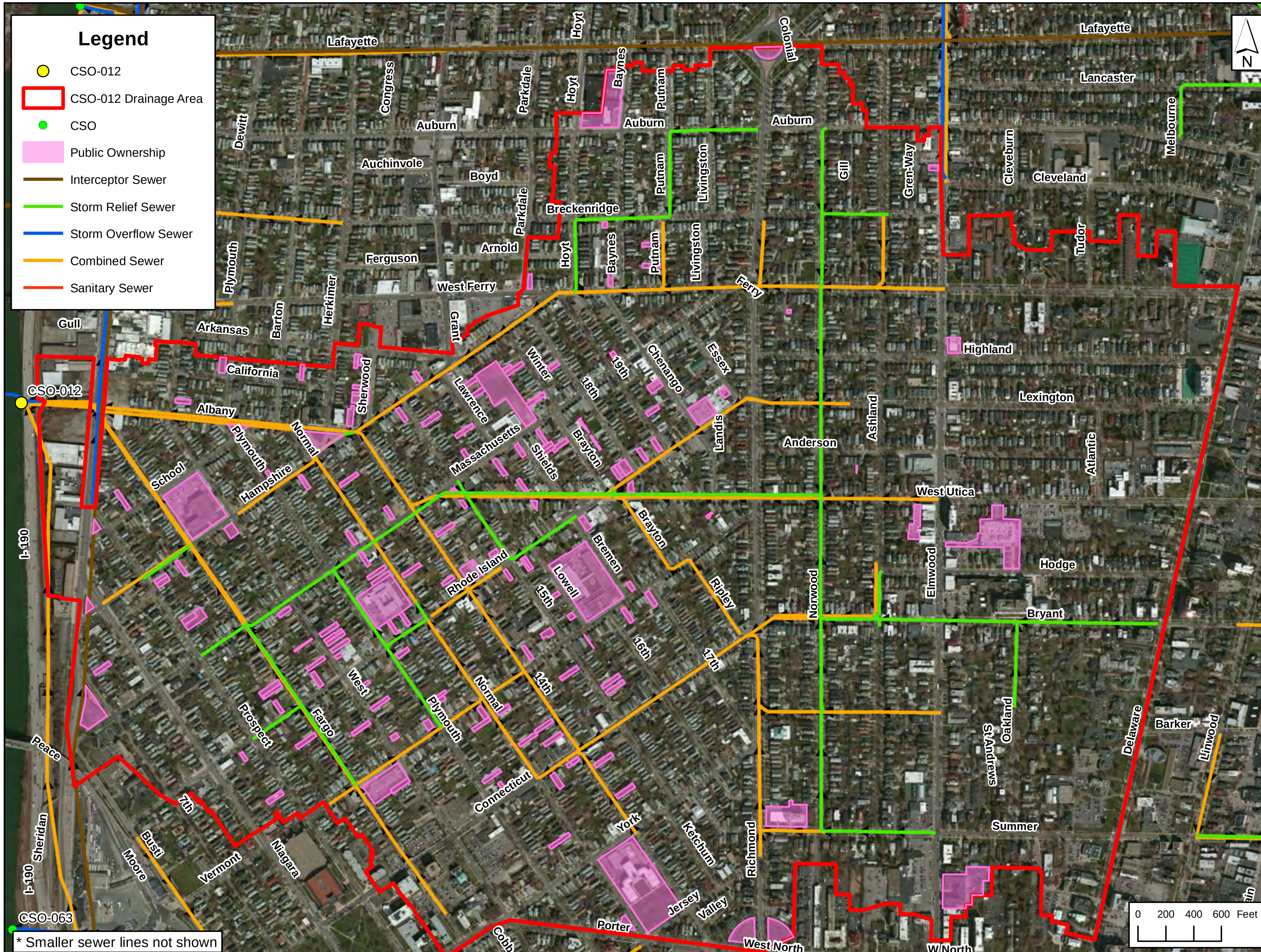
To develop project (construction) costs for GI technologies, cost information from programs across the country were reviewed. Table 11-9 summarizes typical GI technology costs presented in *Financing Storm Water Retrofits in Philadelphia and Beyond* (NRDC, February 2012). These costs include engineering, design, materials & installation. The average per acre cost from this table, excluding green roofs, was $70,000 per acre. Average costs assumed for other cities, in dollars per acre controlled by GI, developed from program summaries, include:

- Kansas City: $54,000
- Albany (redevelopment): $40,000
- Albany (retrofit): $57,000

Table 11-9: Example Stormwater GI Technologies and Approximate Costs

Stormwater Management Practice Cost Ranges (per square foot of impervious area managed)	$ / acre
Basins or Ponds $0.17 – $0.37	$7,405
Created Wetlands $0.25 – $0.50	$10,890
Reducing impervious (hard) surfaces $0.62	$27,007
Swales (broad, shallow vegetated channels designed to	
convey, filter, and infiltrate storm water runoff)	$47,045
Trees planted near pavement $1.09	$47,480
Rain gardens $1.42 – $1.45	$61,855
Underground projects (subsurface infiltration) $1.16 – $2.24	$50,530
Rainwater harvest & reuse $2.95	$128,502
Flow-through planters $5.30	$230,868
Porous pavements $2.10 – $20.96	$91,476
Green roofs $31.43	$1,369,091
Source: *Financing Storm Water Retrofits in Philadelphia and Beyond*, NRDC, Feb 2012 Adapted from the PWD Green Guide for Property Management, p. 20, accessed at www.phila.gov/water/Stormwater/pdfs/PWD_GreenGuide.pdf.	

Based on these program costs, the BSA LTCP applied a planning level project cost of $57,000 per acre, including engineering and contingencies. This cost was based on the average per acre costs from Philadelphia ($70,000) adjusted to reflect the Buffalo region. Table 11-10 presents the projected GI program project costs (excluding O&M) carried forward in the LTCP evaluation. These costs were applied to the acreages controlled within each basin developed through the analysis presented in the previous section (up to 20% control of impervious surface system-wide, for a total of 1,620 impervious acres controlled).



CSO-012 (867.9 acres)

Imperviousness: 34.5%

Total Impervious Area: 299.5 acres

Land Use:

Residential:	376.1 acres	43.5%
Transportation:	227.1 acres	26.2%
Commercial:	127.3 acres	14.7%
Community Service:	60.3 acres	7%
Vacant:	47.1 acres	5.4%
No Data:	11.3 acres	1.3%
Industrial:	8.6 acres	1%
Recreational:	2.9 acres	0.3%
Public Service:	2.7 acres	0.3%
Conservation Areas / Parks:	2.2 acres	0.3%

Target Green Infrastructure Control:

20% = 59.9 acres

<u>Green Infrastructure Opportunities</u>

Streets and Right of Way:	**227.1 acres**
Public Parcels:	**35.6 acres**
Residential Roof Surfaces:	**112.8 acres**
Public Parcels (Vacant):	**8.6 acres**

Potential Green Infrastructure Technologies:

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FIGURE 11-4

CSO 012 GI OPPORTUNITIES

Table 11-10: Projected Construction Costs for System-wide Green Infrastructure Program (Acreage Assumes Up to 20% Impervious Surface Control)

Receiving Water	Area Managed by GI (ac)	Cost ($M)
Black Rock Canal	168	$9.6
Buffalo River	418	$23.8
Cazenovia Creek - B	3	$0.2
Cazenovia Creek - C	60	$3.4
Erie Basin	49	$2.8
Niagara River	412	$23.5
Scajaquada Creek	510	$29.1
Total	***1,620***	***$92.3***

11.4.4 Description of Benefits (Reduction in CSO Volumes/Frequencies)

The benefits of the system-wide application of green infrastructure to control up to 20% of the impervious surface application were evaluated as part of the Revised Foundation Plan evaluation presented in Section 11.5. As noted earlier in this section, a more detailed GI Master Plan is presented in Section 12.

11.5 Revised Foundation Plan

The Revised Foundation Plan represents a substantial update of the original Foundation Plan implemented after the submittal of the 2004 LTCP. The Revised Foundation Plan represents a shift in management philosophy by the BSA away from sewer separation as a primary control technology to a combination of low-cost system optimizations and cost-effective RTC projects identified in Section 11.3. While some sewer separation projects are carried forward in this Revised Foundation Plan, the extent of these areas has been reduced and replaced in favor of additional technologies. Alternatives UA2, UA3, and UA3A all start with the Revised Foundation Plan and add improvements to it. Alternative UA1 (Updated Preferred 2004 alternative) uses the original Foundation Plan as recommended in the 2004 LTCP.

11.5.1 Description of Alternative

The Revised Foundation Plan is made up of the following core components:

- Phase I Projects: Includes all Phase I projects described in Section 11.2.

- Previously Completed Non-Phase 1 Projects: These projects are primarily sewer separation projects carried over from the original Foundation Plan and completed prior to the Phase I projects. These projects were also described in Section 11.2.

- RTC Program: 16 RTC projects (including the two listed under Phase I) that were selected after the evaluation described in Section 11.3.

- Additional SPP Optimizations: 20 additional optimization projects were identified as part of the alternatives evaluations conducted for this LTCP. These modifications include optimizing weir elevations and orifice plate openings, increasing underflow pipe capacity, and flow redirection at a limited number of locations.

- Additional Storage Projects: Three projects to increase capture of CSO flows have been identified and are currently in various stages of design by the BSA.

Table 11-11 presents the components of the Revised Foundation Plan, and Figure 11-5 shows the locations of these projects.

11.5.2 Proposed Facilities and Operational Concepts

All Phase I and non-Phase I projects included in the Revised Foundation Plan were described in detail in Section 11.2. All of the RTC projects and operational concepts included in the Revised Foundation Plan were described in detail in Section 11.3. The additional optimization projects are included on Table 11-11, with details of the improvements provided.

During the preparation of the LTCP submitted in April 2012, three additional storage projects were included in the Revised Foundation Plan as follows:

- Hamburg Drain Storage: This project included the construction of an approximately 6.5 million gallon off-line storage tank to be located adjacent to the Hamburg Drain. This storage facility was intended to control CSOs that discharge through CSO 017, 022 (Clark-Skinner), and 064 (Ohio). The Hamburg Drain was to be functionally disconnected from the Clark-Skinner and Ohio Drains, and the gates would remain closed on the Hamburg Drain at the new Floatables Control Facility to isolate the facility from the Buffalo River and divert flows into the storage tank. Once the WWTP has sufficient capacity, the tank would be dewatered within 24-hours into the South Interceptor. The original 6.5 million gallon storage tank size was selected by the BSA prior to completion of the LTCP evaluations to provide control up to 4 OF/year at CSO 017, which is beyond that required to address CSO-related WQ issues in the Buffalo River.

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Table 11-11 Revised Foundation Alternative Projects

Sub-Group	Project Name	Type	Description	Project Status	Total Estimated Cost
Phase I Projects	CSO 003 SPPs 4, 11, & 185	Weir Modification	See Section 11.2 for detailed description	Complete	$ 15,000
	CSO 003 SPPs 3, 4, 5, 7, & 8	Orifice Plate Removal		Complete	$ 15,000
	CSO 009 Sewer Separation	Sewer Separation		Complete	$ 200,000
	CSO 010 (SPP 21) Sewer Separation	Sewer Separation	Substituted for optimizations listed in Table 12-8 and various green projects	Ongoing	$ 1,000,000
	CSO 053 SPPs 335a, 156, 334a, 247, 156a, 156b	Sewer Separation	Substituted for various green projects		
	Pennsylvania Street Flow Redirection	Flow Redirection	See Section 11.2 for detailed description	Complete[1]	$ 200,000
	Hamburg Drain Screens	Floatables Control		Complete[1]	$ 16,885,000
	North of Buffalo River SPP Modifications	Weir Modification		Complete	$ 470,000
	SPP 123a Modification	Supplemental Capacity		Complete	$ 1,875,000
	South Buffalo SPPs Modifications	Weir Modification		Complete	$ 225,000
	Swan Trunk SPPs Modifications	Weir Modification		Complete	$ 120,000
	SPP 42 Underflow from Swan Trunk to South Interceptor	Flow Redirection		Complete[1]	$ 10,000
	Retain flow in Swan Trunk at Skyway & Charles St.	Flow Redirection		Complete[1]	$ 65,000
	Cazenovia Creek - B (CSO 035) Sewer Separation	Sewer Separation		Complete	$ 4,055,000
	Cazenovia SPP 121	Supplemental Capacity		Complete	$ 495,000
	CSO 057 SPP 195	Weir Modification		Complete	$ 5,000
	CSO 058 SPP 213	Weir Modification		Complete	$ 5,000
	CSO 057 SPPs 10, 11, 195	Orifice Plate Removal		Complete	$ 9,000
	CSO 058 SPP 213	Orifice Plate Removal		Complete	$ 5,000
	CSO 059 SPPs 181, 182, 183	Sewer Separation		Complete	$ 1,120,000
	CSO 060 SPP 240	Sewer Separation		Complete[1]	$ 5,065,000
	CSO 053 SPPs 229	Sewer Separation		Complete	$ 95,000
					$ 31,934,000
Non-Phase I Projects from Original Foundation Alternative	Ontario Basin Sewer Separation	Sewer Separation	Includes BSA In Kind Services[2]	Complete	$ 3,100,000
	Hertel Avenue Sewer Separation	Sewer Separation	Includes BSA In Kind Services[2]	Complete	$ 3,400,000
	Casimir/South Ogden Sewer Separation	Sewer Separation	Includes BSA In Kind Services[2]	Complete	$ 1,500,000
	Lovejoy Sewer Separation	Sewer Separation	Includes BSA In Kind Services[2]	Complete	$ 1,100,000
	South Park Storm Sewers	Sewer Separation	Includes BSA In Kind Services[2]	Complete	$ 3,400,000
					$ 12,500,000
Real Time Control	Hertel Northwest In-Line Storage	In-Line Storage		Proposed	$ 2,185,000
	Hertel South In-Line Storage	In-Line Storage		Proposed	$ 4,095,000
	Hertel Northeast In-Line Storage	In-Line Storage		Proposed	$ 2,185,000
	SPP336B RTC Interception	RTC Interception	Not Necessary for Local Reactive Approach	Proposed	$ -
	SPP337 RTC Interception	RTC Interception	Not Necessary for Local Reactive Approach	Proposed	$ -
	SPP339 RTC Interception	RTC Interception	Not Necessary for Local Reactive Approach	Proposed	$ -
	SPP340 RTC Interception	RTC Interception	Not Necessary for Local Reactive Approach	Proposed	$ -
	Bird East In-Line Storage	In-Line Storage		Proposed	$ 2,025,000
	Bird West In-Line Storage	In-Line Storage	Was bid, anticipated construction completion end of 2014	Bid[3]	$ 1,595,000
	East Ferry In-Line Storage	In-Line Storage		Proposed	$ 2,040,000
	Colorado In-Line Storage	In-Line Storage		Proposed	$ 2,025,000
	North Bailey In-Line Storage	In-Line Storage		Proposed	$ 2,025,000
	South Bailey In-Line Storage	In-Line Storage		Proposed	$ 2,025,000
	Texas (Roslyn) In-Line Storage	In-Line Storage		Proposed	$ 2,170,000
	Kay In-Line Storage	In-Line Storage		Proposed	$ 2,015,000
	Hagen In-Line Storage	In-Line Storage	Relocated to Lang Street; Was bid, anticipated construction completion end of 2014	Bid[3]	$ 4,085,000
	Amherst Quarry Off-Line Storage	Off-Line Storage		Proposed	$ 2,875,000
	Fillmore North In-Line Storage	In-Line Storage		Proposed	$ 2,015,000
	Gibson CSO Line Storage	In-Line Storage		Proposed	$ 2,015,000
	Montgomery CSO Line Storage	In-Line Storage		Proposed	$ 2,015,000
	Smith CSO Line Storage	In-Line Storage		Proposed	$ 2,015,000
					$ 39,405,000

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Table 11-11 Revised Foundation Alternative Projects

Sub-Group	Project Name	Type	Description	Project Status	Total Estimated Cost
Additional SPP Optimization	SPP180 Optimization	Weir Modification	Raised weir of SPP180 by 2-ft.	Complete[1]	$ 20,000
	SPP331 Optimization	Flow Redirection	Redirected SPP331's underflow to the Bird Avenue trunk sewer (instead of the Scajaquada Tunnel Interceptor) using a 1700' long D=30" sewer	Proposed	$ 3,235,000
		Supplemental Capacity		Proposed	
		Orifice Modification	Increased the area of the underflow orifice by 100% to 2.5 ft^2	Proposed	$ 5,000
	SPP36 Optimization	Orifice Modification	Increased the area of the underflow orifice to 1.8 ft^2	Proposed	$ 5,000
	SPP75 Optimization	Orifice Modification	Removed underflow orifice	Proposed	$ 5,000
		Supplemental Capacity	Upsized the underflow pipe to have a capacity of 3.5 cfs (L=10 feet) - slope of existing underflow pipe not available, so required diameter TBD	Proposed	$ 95,000
	SPP217 Optimization	Orifice Modification	Increased the area of the underflow orifices to 12.6 ft^2 (D=4')	Proposed	$ 5,000
	SPP318 Optimization	Orifice Modification	Increased the area of the underflow orifice by 30% to 1.8 ft^2	Proposed	$ 5,000
	SPP97A Optimization	Supplemental Capacity	Upsized the underflow pipe to have a capacity of 1.25 cfs (L=10') - slope of existing underflow pipe not available, so required diameter TBD	Proposed	$ 100,000
	SPP122 Optimization	Weir Modification	Raised weir of SPP122 by 0.5-ft.	Complete[1]	$ 20,000
	SPP163 Optimization	Weir Modification	Raised weir of SPP163 by 0.75-ft, and increased weir length to 10-ft	Proposed	$ 185,000
	SPP165 Optimization	Weir Modification	Raised weir of SPP165 by 0.5-ft	Complete[1]	$ 20,000
	SPP165A Optimization	Supplemental Capacity	Upsized the existing underflow pipe between nodes 4228 and 12072 to 18 inches (L=550 feet)	Proposed	$ 805,000
		Weir Modification	Raised weir of SPP165A by 0.75-ft, and increased weir length to 10 feet	Proposed	
	SPP178 Optimization	Weir Modification	Raised weir of SPP178 by 0.5-ft	Complete[1]	$ 20,000
	SPP335B Optimization	Weir Modification	Raised weir of SPP335B by 1-ft	Complete[1]	$ 20,000
	SPP336A Optimization	Orifice Modification	Increased the area of the underflow orifices to 4.9 ft^2 (D=2.5 feet)	Proposed	$ 5,000
		Supplemental Capacity	Upsized the existing underflow pipe to D=30 inches (L=28 feet)	Proposed	$ 125,000
	SPP341A Optimization	Orifice Modification	Increased the area of the underflow orifices to 7.1 ft^2 (D=3 feet)	Proposed	$ 190,000
		Supplemental Capacity	Upsized the existing underflow pipe to D=36 inches (L=74.5 feet)	Proposed	
	SPP342B Optimization	Weir Modification	Raised weir of SPP342B by 1-ft	Complete[1]	$ 20,000
	SPP1 Optimization	Weir Modification	Raised weir of SPP1 by 1-ft	Proposed	$ 230,000
	SPP183 Optimization	Weir Modification	Raised weir of SPP183 by 0.5-ft	Complete[1]	$ 20,000
	SPP283 Optimization	Orifice Modification	Increased the area of the underflow orifice by 20% to 0.5 ft^2	Complete[1]	$ 5,000
	SPP211 Optimization	Weir Modification	Added a weir at SPP211 with a crest elevation of 584 feet (currently, overflow is an elevated pipe)	Complete[1]	$ 20,000
					$ 5,160,000
Other	Hamburg Drain Storage	Off-Line Storage	6.5 MG of Storage	Proposed	$ 19,960,000
	Smith Street Storage	In-Line/Off-line Storage	Minimum 0.5 MG of Storage; Actual storage size will depend upon GI performance and construction of upstream RTC projects in basin	Proposed	$ 14,520,000
	CSO 016 Storage	Storage	0.06 MG of Storage	Complete[1]	$ 375,000
					$ 34,855,000
				Total Estimated Construction Cost	***$ 123,854,000***

NOTES:

1. Completed following submission of the April 2012 LTCP.
2. "BSA In Kind Services" represent costs of engineering and constructon inspection services performed by BSA staff during implementation of projects.
3. Project has been bid since submission of the April 2012 LTCP.

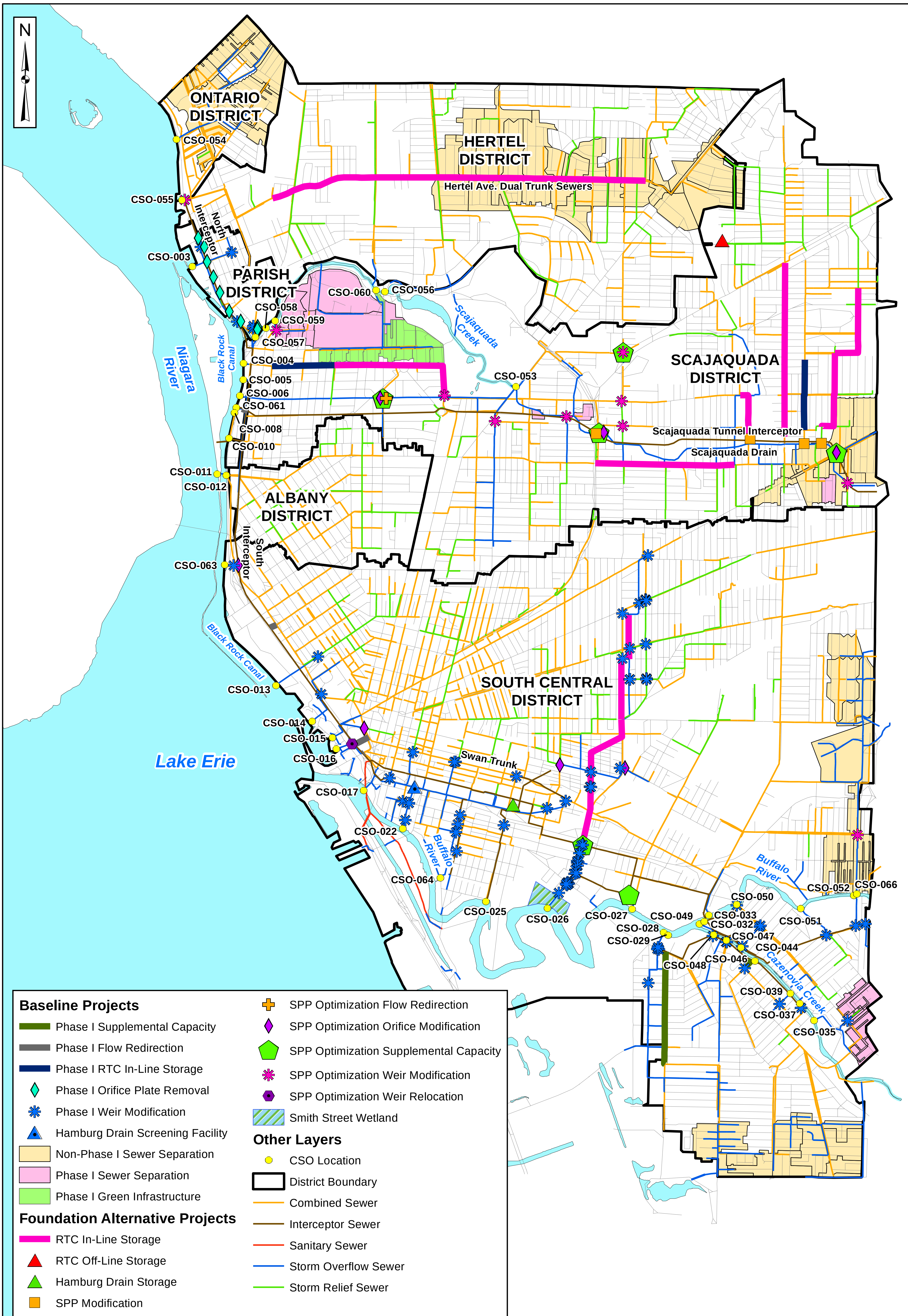

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FIGURE 11-5

REVISED FOUNDATION PLAN COMPONENTS

- Smith Street Storage: For this project, CSO discharges will be diverted from the CSO 026 outfall into a 500,000 gallon storage tank. The initial concept suggested that when the tank was full, it would overflow to a constructed wetland for further treatment prior to discharge to the Buffalo River. The storage, as initially conceived, was anticipated to provide control up to and including approximately the 5th largest storm event in the TY. This level of control assumed implementation of upstream RTC projects identified in the Revised Foundation Plan and approximately 20% impervious surface control by GI projects in the Smith Street contributing area.

- CSO 016 Storage: CSO 016 discharges into the Buffalo Harbor where the Black Rock Canal begins. For this location, the SPP chamber will be relocated and additional storage in the new chamber will be provided (approximately 60,000 gallons).

As the BSA moves forward with the implementation of the LTCP, facility planning will be completed for all major projects. The results of the facility planning processes may result in changes to the initial concepts based on more specific site condition information or on optimized approaches for CSO control. Regardless of the specifics of these projects, the BSA commits to achieving the target LOC for each receiving water body.

11.5.3 Preliminary Costs

Table 11-11 also presents the estimated project costs for all elements of the Revised Foundation Plan. The total estimated costs, including Phase I projects, is approximately $124 million. Note that the Phase I and Non-Phase I projects listed on Table 11-11 have all been completed or are in the design phase. The effects of these projects on CSO discharges are already included in the revised baseline conditions model described in Section 11.2. Therefore, the costs presented for the three new CSO alternatives (UA2, UA3 and UA3A) will reflect only the costs for projects considered in future phases of this LTCP, estimated at approximately $84.5 million.

11.5.4 Description of Benefits (Reduction in CSO Volumes/Frequencies)

As mentioned above, Phase I and non-Phase I projects have been already incorporated into the revised baseline conditions model and their benefits have already been accounted for in the revised baseline conditions. The revised baseline conditions model was modified to incorporate the projects recommended as part of the Revised Foundation Plan. In order to develop the platform for the various system-wide alternatives, two Revised Foundation Plan models were developed:

- Revised Foundation: This model includes only the projects described in this section that comprise the Revised Foundation Plan. This model forms the basis for the system-wide alternatives UA3 (described in detail in Section 11.6.3) and UA3A (described in detail in Section 11.6.4).

- Revised Foundation with GI: This model includes the projects described in this section that comprise the Revised Foundation Plan as well as the targeted GI control levels described in Section 11.4. This model forms the basis for the system-wide alternative UA2 (described in detail in Section 11.6.2).

In order to document the effect of GI on CSO activations and volumes, the typical year rainfall pattern was adjusted to assume that the GI technologies controlled one-inch of rainfall over the impervious surface controlled. The model subcatchments were then split into the areas controlled by GI (using either 10% or 20%, as outlined in Section 11.4.2), where the adjusted rainfall pattern was applied; and the "uncontrolled" areas where the unadjusted typical year rainfall pattern was applied.

The Revised Foundation Plan (with and without GI) was evaluated for each RWB in terms of targeted CSO LOC, reduction in CSO volumes, and percent capture for the modified 1993 TY. Table 11-12 presents a summary of the predicted frequencies, residual CSO volumes, and percent capture for the Revised Foundation Plan with and without GI. Residual volumes and remaining overflows are presented for each RWB while percent capture is presented on a system-wide basis. Note that the performance measure for the BSA LTCP will be receiving waterbody specific frequency of activation. Waterbody specific and system-wide residual volumes and percent capture values are presented for informational purposes only.

Table 11-12: Predicted TY Annual CSO Only (Excluding Storm water and Stream Inflows) Volumes, Frequencies and Durations by CSO for Revised Foundation and Revised Foundation with GI (Modified 1993 TY)

	Projected Activations (LOC)			Residual CSO Volume (MG)		
Receiving Water Body	**Revised Baseline**	**Revised Foundation**	**Revised Foundation with GI**	**Revised Baseline**	**Revised Foundation**	**Revised Foundation with GI**
Black Rock Canal	4 – 65	4 – 65	4 – 59	319.3	241.5	163.5
Buffalo River	4 – 69	4 – 69	4 – 63	379.7	223.1	173.4
Cazenovia Cr.-B	5	0	0	0.0	0.0	0.0
Cazenovia Cr.-C	1 – 44	1 – 44	0 – 36	35.6	34.1	21.0
Erie Basin	4 – 12	4 – 10	4 – 6	10.3	10.2	5.8
Niagara River (incl. CSO 055)	6 – 41	6 – 41	4 – 33	735.5	576.3	387.9
Scajaquada Creek	5 – 65	5 – 65	4 – 59	268.0	147.2	100.3
Totals	NA	NA	NA	1,748.4	1,232.3	852.0
Percent Capture	NA	NA	NA	91.3%	93.6%	95.6%

The continuous period simulation results were summarized by SPP and CSO for the following quantitative measures to characterize existing conditions for the 1993 TY applied to the BSA's CSS:

- Table 11-13: Projected annual CSO-only (excluding storm water and stream inflows) volumes, frequencies, and durations for existing (2004 LTCP), revised baseline, and the two Revised Foundation Plan conditions. These are CSO-only overflow volumes at the CSO, excluding any locally separated storm flow reaching the CSO from an upstream location, as well as the volume associated with Scajaquada Creek inflows from Cheektowaga.

- Table 11-14: Projected annual EOP (including storm water and stream inflows) volumes, frequencies and durations for existing (2004 LTCP), revised baseline and the two Revised Foundation Plan conditions. These are total overflow volumes at the CSO, including any locally separated storm flow reaching the CSO from an upstream location. The only exceptions are CSO 006 and CSO 053; following BSA discussions with the NYSDEC, the volume associated with Scajaquada Creek inflows from Cheektowaga is not included in the total volume for these CSOs.

As can be seen, implementation of the recommended Revised Foundation Plan projects results in significant system-wide CSO volume and frequency reductions. The Revised Foundation Plan projects are projected to reduce CSO volumes by approximately 30%, and the resulting percent capture increases from 91.3% to 93.6% compared to Revised Baseline Conditions. There are significant reductions at several CSOs. CSOs 017 and 026 will be controlled down to approximately 4 OF/ TY with the implementation of the storage projects. While it is not evident from the CSO statistics, activations at several SPPs in the Scajaquada Creek basin are reduced to single digits from well over 50 as a result of the Revised Foundation Plan implementation.

The addition of the system-wide GI program on top of the Revised Foundation Plan results in further significant reductions in CSO volumes. System-wide GI application is projected to reduce annual CSO volumes by just over 30% compared to the Revised Foundation Plan, and percent capture increases from 93.6% to 95.6%. Overall, the combined implementation of the Revised Foundation Plan along with system-wide GI results in a reduction of over 50% in average annual CSO volumes for the 1993 typical year conditions.

Note that system-wide CSO control alternative benefits presented in the remainder of this section are based on CSO-only (excluding storm water and stream inflows) model statistics. Projected annual EOP (including storm water and stream inflows) statistics in addition to the CSO-only statistics have been developed for the Recommended Plan only and are presented in Appendix 12-2.

11.6 Additional System-Wide Alternative Evaluations

Three new system-wide alternatives were identified and evaluated in this LTCP along with the updated 2004 preferred alternative. Table 11-15 outlines the overall framework for the additional alternatives evaluated. The updated 2004 LTCP preferred alternative UA1 included the original Foundation Plan. All new alternatives (UA2, UA3 and UA3A) include the Phase I projects (proposed and completed as of 2010) and the remaining projects outlined in the Revised Foundation Plan in Section 11.5. These projects consist primarily of SPP optimizations and weir modifications, and selected RTC projects. The GI program discussed in Section 11.4 is included in Alternative UA2 only. The sections below present general technologies applied for the alternatives listed on Table 11-15.

Table 11-15: Proposed Components of Additional Alternatives for Evaluation in the LTCP

Alternative	Description	RTC	GI	Satellite Treatment	Satellite Storage	Tunnel	North Relief	Partial System Separation
UA1	Updated 2004 Preferred System-wide Alternative with Original Foundation			X	X	X		X
UA2[1]	RTC + GI + North Relief + Revised Foundation + Selected Elements of UA1	X	X	X	X	X		
UA3	System-wide Tunnel + Revised Foundation	X			X	X		
UA3A[1]	System-wide Tunnel + Revised Foundation + North Relief	X		X	X	X	X	

Notes: [1] For alternatives UA2 and UA3A, HRT will be required for higher levels of control but not universally.

Costs and benefits (in the form of WQS attainment and CSO frequency and volume reductions) were evaluated in detail and are presented in this section. The benefits of the alternatives described were evaluated using 12-month continuous simulations with the 1993 modified TY (as described in Section 2). As agreed upon with the USEPA, water quality benefits were evaluated only for select alternatives (UA1 and UA2) because the composition of technologies for Alternatives UA3 and UA3A would yield very similar water quality results for a given LOC. While the recommended WWTP improvements in Section 8 (NFA) would be considered as part of each of the collection system alternatives, the associated costs for such improvements were not included in the system-wide evaluations in this section.

Based on the logical progression of engineering evaluations, each system-wide alternative was sized for a range of "sizes" using the activation frequency (0, 2, 4, 6 and 12 events per year) as a convenient target to establish the initial facility sizes. Then each "sizing" of each system-wide alternative was run through a typical year simulation model to establish important level of control metrics such as remaining CSO volume, system-wide percent capture and annual activation frequency. For convenience purposes only, each "sizing" is referred to the LOC associated with the initial activation frequency targets used for the initial alternative setup. However, predicted benefits for each alternative sizing benefits are expressed with a number of metrics including the system-wide percent capture, residual overflow volumes and activation frequency. As discussed elsewhere in this report, the Agencies suggested that the BSA use activation frequency as the primary performance metric for the Recommended Plan.

Table 11-13: Predicted Annual CSO Only (Excluding Stormwater and Stream Inflows) Volumes, Frequencies and Durations by CSO for Revised Baseline, Revised Foundation, and Revised Foundation w/ GI (Modified 1993 TY)

CSO Outfall	District	Receiving Water	CSO-only Volume (Million Gallons)			CSO-only Frequency			CSO-only Durations (hours)		
			Revised Baseline	Revised Foundation	Revised Foundation w/ GI	Revised Baseline	Revised Foundation	Revised Foundation w/ GI	Revised Baseline	Revised Foundation	Revised Foundation w/ GI
004	Scajaquada	Black Rock Canal	11.2	21.9	16.8	5	7	4	8	13	9
005	Scajaquada	Black Rock Canal	0.1	0.1	0.1	4	4	4	5	5	4
006	Scajaquada	Black Rock Canal	198.9	86.8	55.3	65	65	59	344	319	269
008	Scajaquada	Black Rock Canal	6.1	8.2	4.4	39	39	30	90	90	64
010	Scajaquada	Black Rock Canal	11.9	11.8	7.8	44	44	38	103	103	78
012	Albany	Black Rock Canal	52.5	52.7	37.7	42	42	29	111	110	77
013	South Central	Black Rock Canal	6.8	6.8	5.2	7	7	6	25	25	22
061	Scajaquada	Black Rock Canal	31.2	52.8	35.8	10	12	10	29	45	31
063	South Central	Black Rock Canal	0.6	0.5	0.3	13	11	7	19	16	11
017	South Central	Buffalo River	71.3	43.7	33.1	49	4	3	124	7	4
022	South Central	Buffalo River	29.8	2.2	1.6	49	20	14	124	33	23
025	South Central	Buffalo River	1.4	1.5	1.2	11	11	6	17	17	12
026	South Central	Buffalo River	124.2	32.6	27.0	63	4	4	247	20	31
027	South Central	Buffalo River	31.7	34.0	25.3	36	9	6	131	45	32
028	South Central	Buffalo River	45.5	45.7	34.5	69	69	63	328	328	288
029	South Central	Buffalo River	0.0	0.0	0.0	0	0	0	0	0	0
032	South Central	Buffalo River	0.0	0.0	0.0	0	0	0	0	0	0
033	South Central	Buffalo River	37.8	38.8	32.7	9	9	7	21	21	18
034	South Central	Buffalo River	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
049	South Central	Buffalo River	0.0	0.0	0.0	0	0	0	0	0	0
050	South Central	Buffalo River	3.2	3.2	2.5	14	14	11	22	22	17
051	South Central	Buffalo River	1.2	1.2	1.0	4	4	4	14	14	13
052	South Central	Buffalo River	10.9	10.9	9.0	10	10	9	70	70	60
064	South Central	Buffalo River	21.1	8.3	5.1	56	56	47	181	182	130
066	South Central	Buffalo River	1.7	0.9	0.4	10	5	4	17	11	9
035	South Central	Cazenovia Creek - B	0.0	0.0	0.0	0	0	0	9	9	8
037	South Central	Cazenovia Creek - C	23.3	21.5	11.8	13	13	8	40	35	19
039	South Central	Cazenovia Creek - C	0.0	0.0	0.0	0	0	0	0	0	0
044	South Central	Cazenovia Creek - C	2.3	2.6	1.9	7	7	5	12	12	10
046	South Central	Cazenovia Creek - C	1.3	1.3	1.2	1	1	0	1	1	0
047	South Central	Cazenovia Creek - C	8.7	8.7	6.1	44	44	36	94	95	69
048	South Central	Cazenovia Creek - C	0.0	0.0	0.0	0	0	0	0	0	0
055	Hertel	Niagara River	601.1	438.7	288.5	41	28	18	174	117	76
014	South Central	Erie Basin	4.2	4.6	2.9	4	4	4	15	15	12
015	South Central	Erie Basin	6.1	5.6	2.9	12	10	6	43	35	24
016	South Central	Erie Basin	0.0	0.0	0.0	0	0	0	0	0	0
003	Parish	Niagara River	0.1	0.1	0.1	6	6	4	32	34	23
011	Albany	Niagara River	134.3	137.4	99.3	41	41	33	243	243	182
054	Ontario	Niagara River	0.0	0.0	0.0	0	0	0	0	0	0
053	Scajaquada	Scajaquada Creek	268.0	147.1	100.3	65	65	59	344	319	269
056	Hertel	Scajaquada Creek	0.0	0.0	0.0	5	5	4	8	8	4
057	Parish	Scajaquada Creek	0.0	0.0	0.0	0	0	0	0	0	0
058	Parish	Scajaquada Creek	0.0	0.0	0.0	0	0	0	0	10	7
059	Scajaquada	Scajaquada Creek	0.0	0.0	0.0	0	0	0	0	20	20
060	Scajaquada	Scajaquada Creek	0.7	0.7	0.5	5	0	0	11	11	9
		TOTAL	1749.1	1233.0	852.5						

Table 11-14: Predicted Annual End-of-Pipe (Including Stormwater and Stream Inflows) Volumes, Frequencies and Durations by CSO for Revised Baseline, Revised Foundation, and Revised Foundation w/ GI (Modified 1993 TY)

CSO Outfall	District	Receiving Water	End-of-Pipe Volume (Million Gallons)			End-of-Pipe Frequency			End-of-Pipe Duration (hrs)		
			Revised Baseline	Revised Foundation	Revised Foundation w/ GI	Revised Baseline	Revised Foundation	Revised Foundation w/ GI	Revised Baseline	Revised Foundation	Revised Foundation w/ GI
004	Scajaquada	Black Rock Canal	11.2	21.9	16.8	5	7	4	8	13	9
005	Scajaquada	Black Rock Canal	0.1	0.1	0.1	4	4	4	5	5	4
006	Scajaquada	Black Rock Canal	852.0	669.2	611.8	N/A	N/A	N/A	N/A	N/A	N/A
008	Scajaquada	Black Rock Canal	14.8	14.8	11.4	86	86	86	609	609	609
010	Scajaquada	Black Rock Canal	11.9	11.9	7.8	42	42	38	96	96	78
012	Albany	Black Rock Canal	52.5	52.5	37.7	40	40	29	104	104	77
013	South Central	Black Rock Canal	6.8	6.8	5.2	6	6	6	23	23	22
061	Scajaquada	Black Rock Canal	31.2	52.8	35.8	9	12	10	24	45	31
063	South Central	Black Rock Canal	0.6	0.5	0.3	12	11	7	18	16	11
017	South Central	Buffalo River	102.9	45.4	34.5	95	95	95	841	665	636
022	South Central	Buffalo River	29.8	2.2	1.6	89	16	11	493	26	18
025	South Central	Buffalo River	1.4	1.4	1.2	10	10	6	16	16	12
026	South Central	Buffalo River	132.0	32.6	32.6	91	91	91	835	459	395
027	South Central	Buffalo River	31.7	34.0	25.3	34	9	6	121	45	32
028	South Central	Buffalo River	89.0	89.0	70.2	91	91	84	902	902	820
029	South Central	Buffalo River	0.0	0.0	0.0	0	0	0	0	0	0
032	South Central	Buffalo River	0.0	0.0	0.0	0	0	0	0	0	0
033	South Central	Buffalo River	37.8	37.8	32.7	9	9	7	21	21	18
034	South Central	Buffalo River	Closed	Closed	Closed	Closed	Closed	0	Closed	Closed	Closed
049	South Central	Buffalo River	0.0	0.0	0.0	0	0	0	0	0	0
050	South Central	Buffalo River	3.2	3.2	2.5	13	13	11	21	21	17
051	South Central	Buffalo River	1.2	1.2	1.0	4	4	4	14	14	13
052	South Central	Buffalo River	11.6	11.7	9.7	14	16	15	91	101	85
064	South Central	Buffalo River	21.1	8.3	5.1	82	56	47	367	182	130
066	South Central	Buffalo River	78.6	77.8	70.3	81	81	75	1388	1388	1380
035	South Central	Cazenovia Creek - B	11.9	11.9	10.7	89	89	88	544	544	540
037	South Central	Cazenovia Creek - C	23.3	21.5	11.8	12	13	8	35	35	19
039	South Central	Cazenovia Creek - C	0.0	0.0	0.0	0	0	0	0	0	0
044	South Central	Cazenovia Creek - C	2.3	2.6	1.9	7	7	5	12	12	10
046	South Central	Cazenovia Creek - C	1.3	1.3	1.2	1	1	0	1	1	0
047	South Central	Cazenovia Creek - C	8.7	8.7	6.1	42	44	36	87	95	69
048	South Central	Cazenovia Creek - C	0.0	0.0	0.0	0	0	0	0	0	0
055	Hertel	Niagara River	601.1	438.7	288.5	39	28	18	164	117	76
014	South Central	Erie Basin	4.2	4.6	2.9	4	4	4	15	15	12
015	South Central	Erie Basin	6.1	5.6	2.9	11	10	6	40	35	24
016	South Central	Erie Basin	6.1	6.1	5.6	94	103	99	457	483	469
003	Parish	Niagara River	0.1	0.1	0.1	6	6	4	32	34	23
011	Albany	Niagara River	134.3	137.4	99.3	39	41	33	230	243	182
054	Ontario	Niagara River	17.5	17.5	15.8	69	69	69	679	679	675
053	Scajaquada	Scajaquada Creek	1,381.1	1,323.7	1,297.7	N/A	N/A	N/A	N/A	N/A	N/A
056	Hertel	Scajaquada Creek	0.0	0.0	0.0	5	5	4	8	8	4
057	Parish	Scajaquada Creek	0.0	0.0	0.0	0	0	0	0	0	0
058	Parish	Scajaquada Creek	10.6	10.6	9.5	79	84	84	560	621	617
059	Scajaquada	Scajaquada Creek	20.1	19.3	17.5	82	82	82	853	853	850
060	Scajaquada	Scajaquada Creek	31.5	31.5	28.1	78	78	78	737	737	730
		Totals	3,781.5	3,216.2	2,813.4	N/A	N/A	N/A	N/A	N/A	N/A

11.6.1 Alternative UA1-Updated 2004 Preferred System-wide Alternative (with Original Foundation Plan)

Alternative UA1 consists of the 2004 Preferred System-wide Alternative modified to provide better control of bacteria for the Buffalo River and Erie Basin RWBs. Unlike the other system-wide alternatives evaluated in the LTCP, Alternative UA1 was built upon the Original Foundation Plan. The Original Foundation Plan consisted primarily of weir modifications and partial sewer separation projects. No RTC or GI projects were evaluated as part of this alternative. Alternative UA1 is intended to provide a benchmark system-wide gray alternative (with no emerging technologies or sustainability elements) against which all other alternatives will be evaluated.

11.6.1.1 Description of Alternative

The 2004 LTCP preferred alternatives for each RWB were selected from the five alternatives described in Section 9 based on a number of factors, including their ability to meet the control objectives. The NYSDEC direction, at that time, stated that no bacteria control objectives were required for Class C streams, and, as such, the preferred alternatives for Erie Basin and Buffalo River did not provide bacteria control. Based on the NYSDEC request, and building off the completed 2004 LTCP evaluation and ranking process, the BSA reassembled the overall 2004 preferred alternative by replacing the originally selected alternatives for Buffalo River and Erie Basin with the top-ranked alternatives that, in 2004, provided for bacteria control for these RWBs. As shown in Table 10-8, the updated 2004 LTCP preferred system-wide alternative changes only the Buffalo River and Erie Basin alternatives, while keeping the alternatives in the other RWBs the same. Table 11-16 summarizes Alternative UA1 (Updated 2004 Preferred System-wide Alternative; modified from Table 10-8).

Table 11-16: Alternative UA1 – Updated 2004 Preferred System-wide Alternative by Receiving Water Body (Modified from Table 10-8)

Receiving Water	NYSDEC Classific-ation	Preferred 2004 LTCP	General Basis for 2004 LTCP	Control FC in 2004 LTCP?	Updated 2004 Preferred System-wide Alternative
Black Rock Canal	C	3A/3B	Storage/ Separation	Y	3A
Buffalo River	C	1	Floatables/ Separation	N	4A
Cazenovia Creek	B	5	Separation	Y	5
Cazenovia Creek	C	5	Separation	Y	5
Scajaquada Creek	C	3A/3B	Storage/ Separation	Y	3A

Receiving Water	NYSDEC Classific-ation	Preferred 2004 LTCP	General Basis for 2004 LTCP	Control FC in 2004 LTCP?	Updated 2004 Preferred System-wide Alternative
Scajaquada Creek	B	3A/3B	Storage/ Separation	Y	3A
Niagara River	A (special)	3A/3B	Storage/ Separation	Y	3A
Erie Basin	C	1	Floatables/ Separation	N	4A
Niagara River (CSO 055)	NA	2	Storage	Y	2

11.6.1.2 Proposed Facilities and Operational Concepts

The proposed facilities and operational concepts for this plan were described in detail in Section 9. Figure 11-6 presents the specific control technologies for each CSO that are part of Alternative UA1. Table 11-17 summarizes the specific technologies and sizes by RWB for Alternative UA1.

11.6.1.3 Preliminary Costs

Costs for Alternative UA1 were developed based on the unit cost curves presented in Section 7, updated to reflect 2012 dollars. Costs presented here include capital costs for all facilities, collector pipes, and associated dewatering pumps and appurtenances. Alternative UA1 costs also assume implementation of the Original (2004 LTCP) Foundation Plan, which included significant partial sewer separation throughout the system. The estimated present worth project cost in 2012 dollars for Alternative UA1 varies from $576 million for the 12 OF/ TY LOC to almost $1.6 billion for the 0 OF/ TY LOC. Table 11-18 summarizes the cost breakdown by receiving water for each LOC and Appendix 11-3 presents the back-up documentation for the cost estimate.

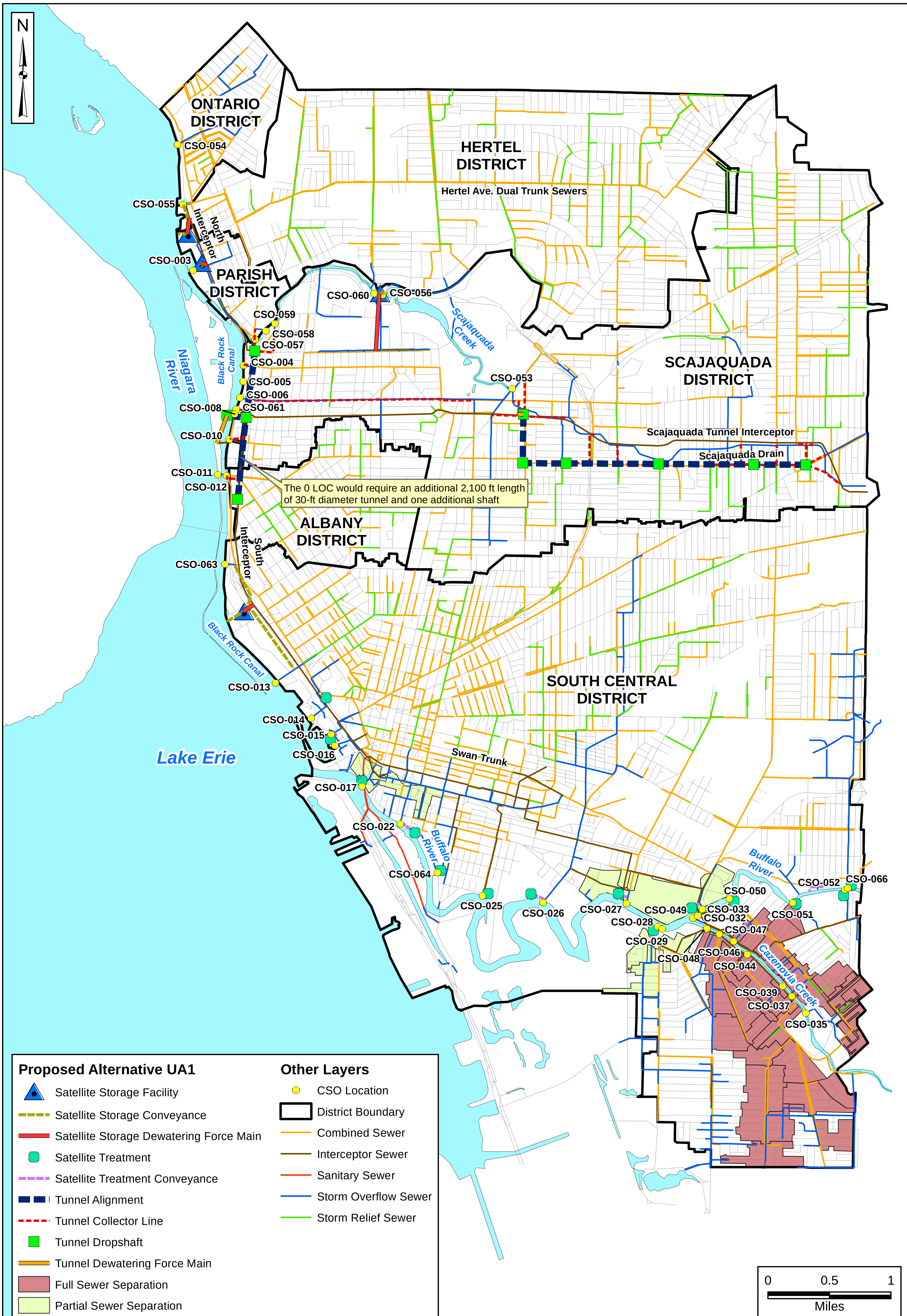

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FIGURE 11-6

RECOMMENDED FACILITIES FOR ALTERNATIVE UA1

Table 11-17: Components of ALTERNATIVE UA1 (Updated 2004 Preferred System-wide Alternative)

Storage

	Receiving Basin	Volume (MG)				
		0 OF	2 OF	4 OF	6 OF	12 OF
CSO-003	Niagara River	0.05	0.00	0.00	0.00	0.00
CSO-013/063	Black Rock Canal	2.30	1.61	0.44	0.00	0.00
CSO-055	Niagara River	69.02	53.48	35.53	26.93	14.96
CSO-056/060	Scajaquada Creek	0.42	0.30	0.14	0.00	0.00
Total		**71.8**	**55.4**	**36.1**	**26.9**	**15.0**

High Rate Treatment

	Receiving Basin	Peak Flow (mgd)				
		0 OF	2 OF	4 OF	6 OF	12 OF
CSO-014	Erie Basin	25.9	18.1	0.0	0.0	0.0
CSO-015	Erie Basin	54.9	25.9	18.1	4.4	0.1
CSO-017	Buffalo River	113.1	58.2	25.9	6.5	3.2
CSO-022	Buffalo River	1.3	1.0	0.2	0.2	0.2
CSO-025	Buffalo River	3.1	2.8	1.6	0.0	0.0
CSO-026	Buffalo River	103.4	100.2	58.2	37.5	15.7
CSO-027	Buffalo River	32.3	19.4	3.9	1.3	0.1
CSO-028	Buffalo River	74.3	64.6	42.0	22.6	12.9
CSO-033	Buffalo River	84.0	67.9	22.6	6.5	1.6
CSO-050	Buffalo River	0.8	0.0	0.0	0.0	0.0
CSO-051	Buffalo River	3.2	0.9	0.0	0.0	0.0
CSO-052	Buffalo River	7.1	6.1	1.9	0.0	0.0
CSO-064	Buffalo River	38.8	12.9	2.6	1.3	0.1
CSO-066	Buffalo River	43.3	29.1	23.3	15.5	8.4
Total		**586**	**407**	**200**	**96**	**42**

Sewer Separation

Receiving Basin	Area (ac)				
	Partial Sewer Separation	Full Sewer Separation	Proposed Foundation Partial Separation	Full Separation	Total
Buffalo River	*261*	*0*	0	0	*261*
Cazenovia Creek - B	*0*	*82*	0	82	*82*
Cazenovia Creek - C	*0*	*932*	739	193	*932*
Total	***261***	***1,014***	***739***	276	***1,276***

Tunnel Storage

	Receiving Basin	Volume (MG) / Dewatering (MGD): Top Row; Diameter (ft): Bottom Row					Length (ft)
		0 OF	2 OF	4 OF	6 OF	12 OF	
North-South Volume	Black Rock Canal	49.6	31.4	18.9	11.8	4.5	7400 (9,500 ft for the 0 LOC)
North-South Diameter		30	27	21	16	10	
East-West Volume	Scajaquada Creek	49.44	43.38	23.94	14.39	8.98	14,200
East-West Diameter		24	23	17	13	10	
Total Volume Stored (MG)		**99.0**	**74.8**	**42.9**	**26.2**	**13.5**	**21,600**

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Table 11-18: Estimated Present Worth Project Costs for System-Wide Alternative UA1 (2012 Dollars; O&M Included)

Receiving Basin	Original (2004) Foundation Alternative	Estimated Present Worth Project Cost ($M)				
		0 OF	2 OF	4 OF	6 OF	12 OF
Black Rock Canal	$9.4	$238.4	$186.2	$142.5	$97.2	$63.1
Buffalo River	$76.7	$574.7	$447.9	$272.7	$167.1	$105.8
Cazenovia Creek – B	$17.2	$8.0	$8.0	$8.0	$8.0	$8.0
Cazenovia Creek – C	$17.6	$54.4	$54.4	$54.4	$54.4	$54.4
Erie Basin	$1.2	$99.3	$65.1	$28.7	$11.3	$2.0
Niagara River (includes CSO 055)	$0.0	$194.2	$159.9	$119.3	$98.6	$67.6
Scajaquada Creek	$2.2	$291.1	$277.8	$217.8	$177.4	$151.0
Sub-Total	**$124.3**	**$1,456.0**	**$1,199.3**	**$843.4**	**$614.1**	**$451.9**
Total (with 2004 Foundation Alternative)		**$1584.22**	**$1,323.5**	**$967.7**	**$738.4**	**$576.2**

11.6.1.4 Description of Benefits

The benefits of Alternative UA1 were evaluated for each RWB for five LOCs in terms of system-wide percent capture, residual pollutant loadings (bacteria only), NYS bacteria WQS compliance, CSO frequency of activation, and residual CSO volumes using the 1993 modified typical year. This section summarizes these evaluations.

11.6.1.4.1 CSO Frequency, Volume and Percent Capture

Table 11-19 presents a summary of the percent capture, predicted frequencies, and residual CSO volumes for Alternative UA1. Specific activation and volume results for each CSO are presented in Appendix 11-3. Figures 11-7 through 11-11 provides cost-benefit curves for NYS bacteria WQS compliance for each receiving water body. The cost-benefit charts for Alternative UA1 for the each RWB based on activation frequency and remaining CSO volume are also included in Appendix 11-3. Figure 11-12 presents the cost-benefit curve for the total system-wide costs based on activation frequency, Figure 11-13 presents the benefits as measured by predicted remaining annual overflow volume and Figure 11-14 presents the benefits as measured by percent capture. Note that the costs presented on Table 11-18 and on these cost-benefit curves represent planning level present worth project costs, as described in Section 7. Therefore, the cost curves also present the -30% to +50% range in the individual LOC cost estimate.

Table 11-19: Predicted Annual CSO Only (Excluding Storm water and Stream Inflows) Volumes and Frequencies for Alternative UA1 by Receiving Water Body (Modified 1993 TY)

	Projected Activations (Events/Year)					Residual CSO Volume (MG)				
Receiving Water Body	**Revised Baseline**	**12 OF**	**6 OF**	**4 OF**	**2 OF**	**Revised Baseline**	**12 OF**	**6 OF**	**4 OF**	**2 OF**
Black Rock Canal	4 - 65	0 - 7	0 - 6	0 – 4	0 - 2	319.3	7.0	6.8	4.7	0.9
Buffalo River	4 - 69	1 - 12	1 - 6	1 – 4	1 - 2	379.7	156.6	117.5	60.6	17.4
Cazenovia Cr.-B	0	0	0	0	0	0.9	0.0	0.0	0.0	0.0
Cazenovia Cr.-C	1 - 44	0	0	0	0	35.6	0.0	0.0	0.0	0.0
Erie Basin	0 - 12	0 - 9	0 - 6	0 – 4	0 - 2	10.3	9.6	7.7	4.7	0.9
Niagara River (incl. CSO 055)	0 - 41	0 - 12	0 - 6	0 – 4	0 - 2	735.4	363.2	190.2	116.7	50.6
Scajaquada Creek	0 - 65	0 - 11	0 - 6	0 – 3	0 - 2	268.7	180.9	118.1	59.6	5.8
Totals	NA	NA	NA	NA	NA	1,749.9	717.4	440.4	246.2	75.6
Percent Capture	NA	NA	NA	NA	NA	**91.3%**	**96.6%**	**97.8%**	**98.8%**	**99.6%**

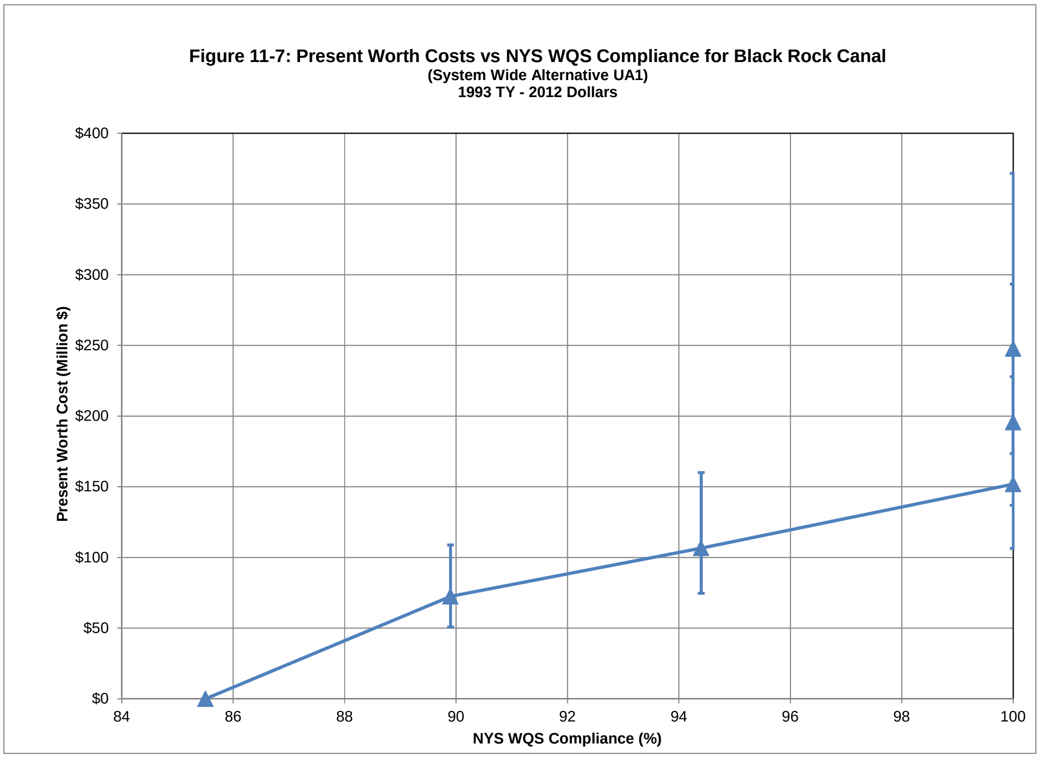
Figure 11-7: Present Worth Costs vs NYS WQS Compliance for Black Rock Canal
(System Wide Alternative UA1)
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$0
$50
$100
$150
$200
$250
$300
$350
$400
84
86
88
90
92
94
96
98
100
NYS WQS Compliance (%)

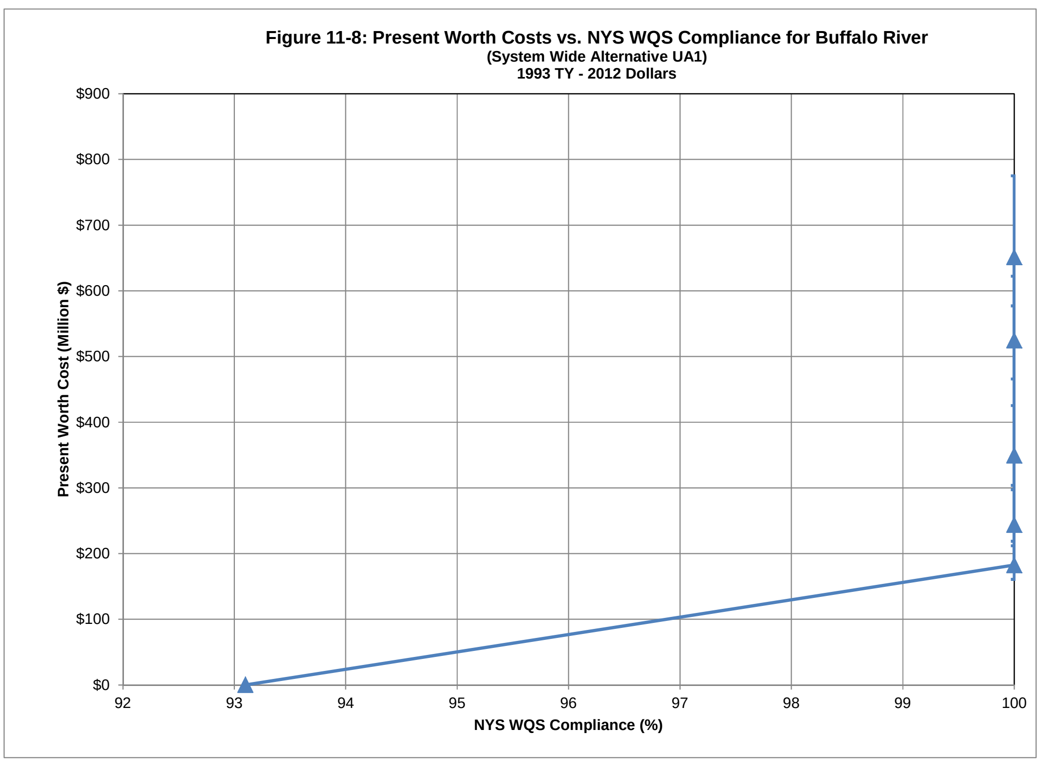
Figure 11-8: Present Worth Costs vs. NYS WQS Compliance for Buffalo River
(System Wide Alternative UA1)
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$0
$100
$200
$300
$400
$500
$600
$700
$800
$900
92
93
94
95
96
97
98
99
100
NYS WQS Compliance (%)

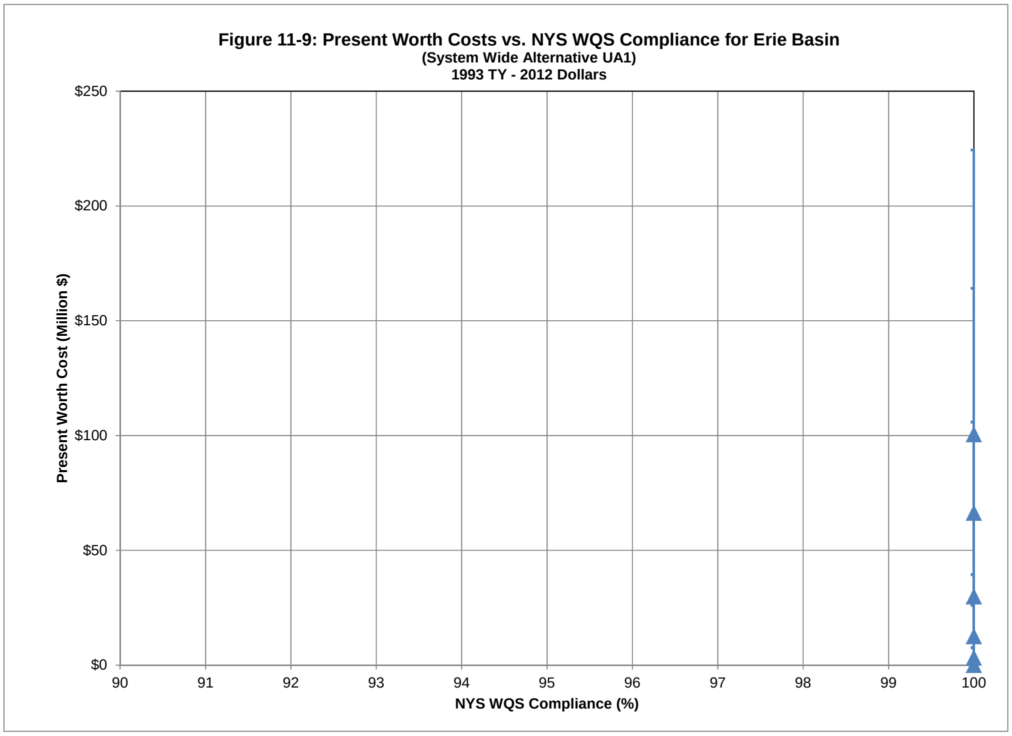
Figure 11-9: Present Worth Costs vs. NYS WQS Compliance for Erie Basin
(System Wide Alternative UA1)
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$250
$200
$150
$100
$50
$0
90
91
92
93
94
95
96
97
98
99
100
NYS WQS Compliance (%)

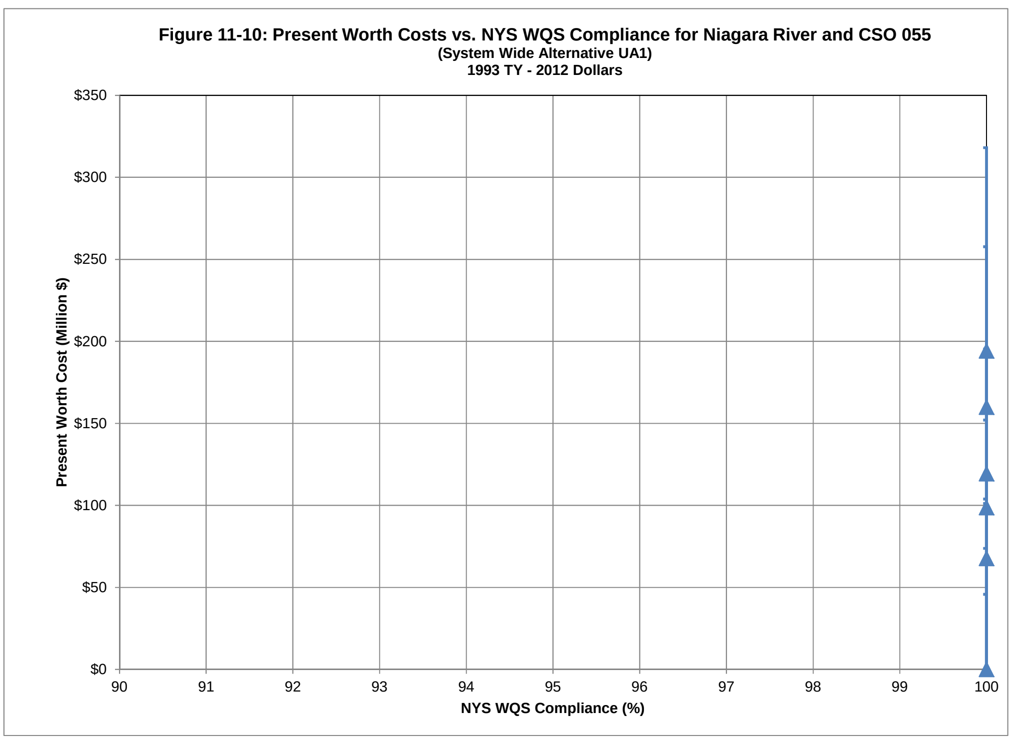
Figure 11-10: Present Worth Costs vs. NYS WQS Compliance for Niagara River and CSO 055
(System Wide Alternative UA1)
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$350
$300
$250
$200
$150
$100
$50
$0
90
91
92
93
94
95
96
97
98
99
100
NYS WQS Compliance (%)

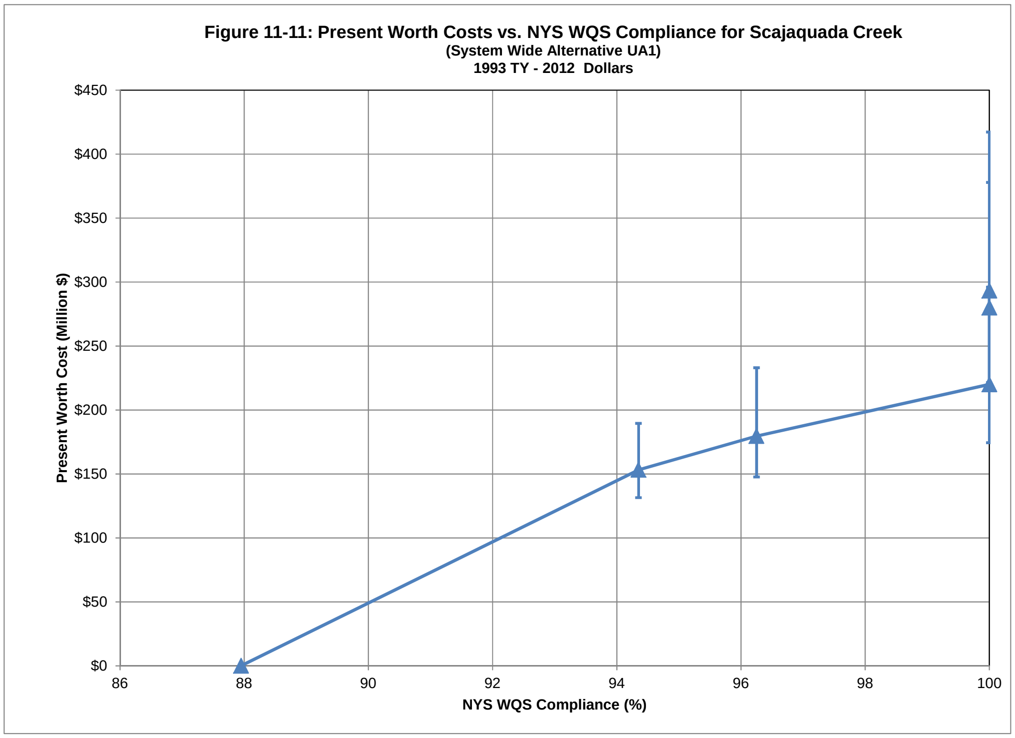
Figure 11-11: Present Worth Costs vs. NYS WQS Compliance for Scajaquada Creek
(System Wide Alternative UA1)
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$450
$400
$350
$300
$250
$200
$150
$100
$50
$0
86
88
90
92
94
96
98
100
NYS WQS Compliance (%)

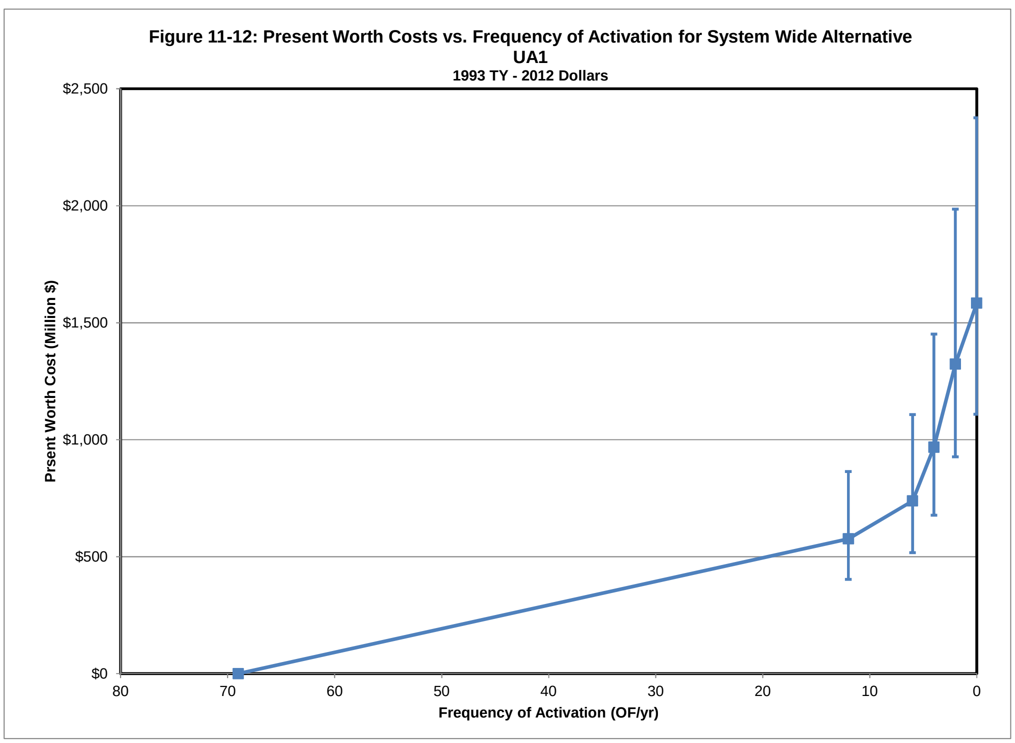
Figure 11-12: Present Worth Costs vs. Frequency of Activation for System Wide Alternative UA1
1993 TY - 2012 Dollars
Prsent Worth Cost (Million $)
$2,500
$2,000
$1,500
$1,000
$500
$0
80
70
60
50
40
30
20
10
0
Frequency of Activation (OF/yr)

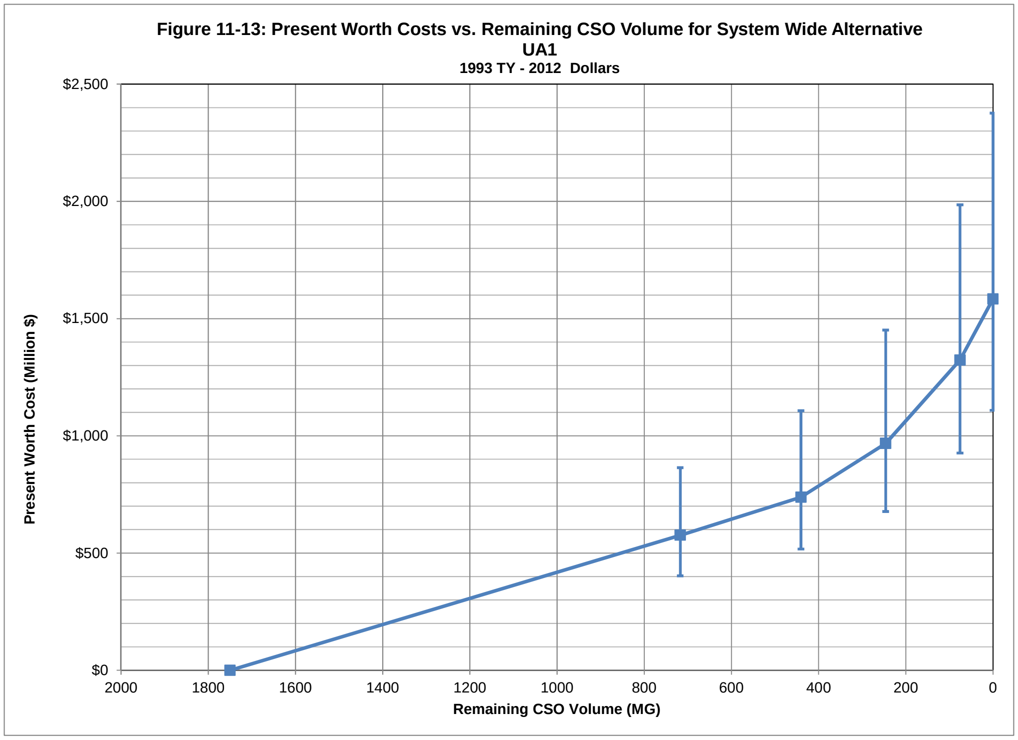
Figure 11-13: Present Worth Costs vs. Remaining CSO Volume for System Wide Alternative UA1
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$2,500
$2,000
$1,500
$1,000
$500
$0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Remaining CSO Volume (MG)

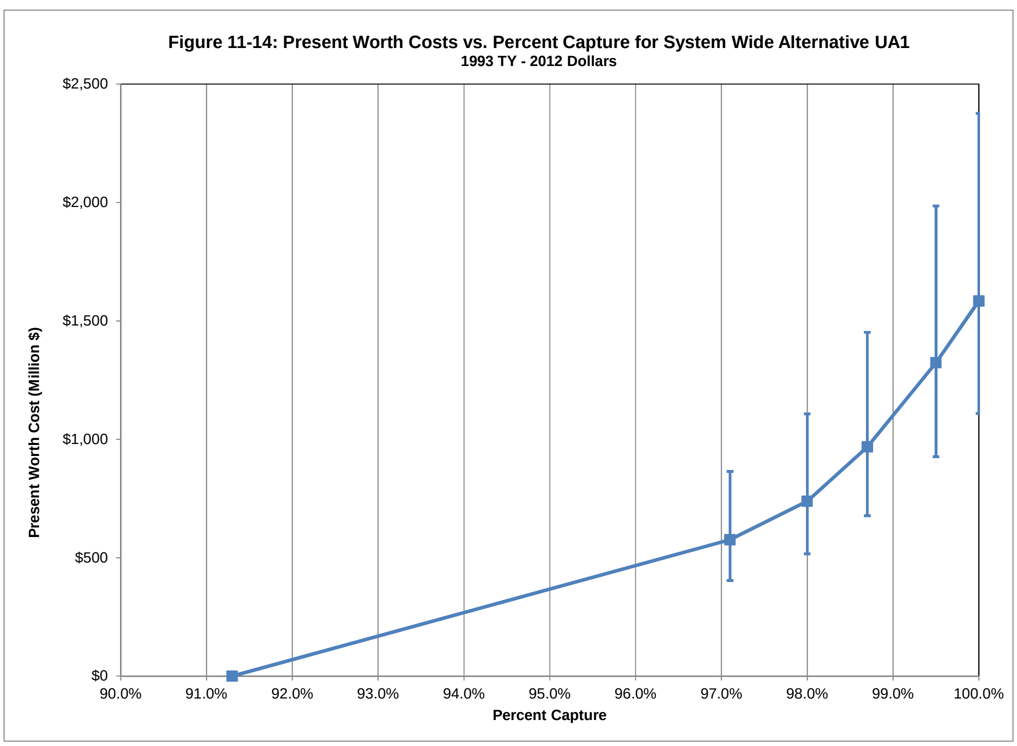
Figure 11-14: Present Worth Costs vs. Percent Capture for System Wide Alternative UA1
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$2,500
$2,000
$1,500
$1,000
$500
$0
90.0%
91.0%
92.0%
93.0%
94.0%
95.0%
96.0%
97.0%
98.0%
99.0%
100.0%
Percent Capture

- *System-wide Benefits:* Figures 11-7 through Figure 11-11 show that 100% compliance with WQS is achieved in all RWBs modeled with improvements made to the CSS, except for Black Rock Canal and Scajaquada Creek. Black Rock Canal and Scajaquada Creek do achieve 100% WQS compliance at 4 OF/year or less. The system-wide curves presented on Figure 11-12 through Figure 11-14 represent the CSO control benefits of different LOCs, with the first point on the charts representing baseline conditions (i.e., no CSO controls beyond the already implemented Phase I projects). Considerable costs are required to achieve moderate improvement in the frequency of activation and volume reduction, as well as percent capture.

- Black Rock Canal: The proposed Alternative UA1 improvements will provide significant benefits to the Black Rock Canal. CSO volumes are projected to be reduced from over 300 MG under Revised Baseline conditions to less than 1 MG at the 2 LOC. As shown on the figures in Appendix 11-3, present worth project costs (including the 2004 Foundation Plan costs) for this water body range from $72M for the 12 OF LOC to almost $248M for the 0 OF LOC. The knee of the Alternative UA1 benefit curve based on activation frequency and volume occurs at 6 OF/yr, at approximately $105 million. At that level, the residual CSO volume would be less than 7 MG. This represents a reduction in annual CSO volume of nearly 98%. Receiving water body specific percent captures were not calculated. The knee of the curve for water quality compliance in the Black Rock Canal is at 4 OF LOC, where the model indicates the Alternative UA1 improvements would bring Black Rock Canal into 100% compliance with NYS bacteria WQS (assuming reduced background conditions).

- Buffalo River: The proposed Alternative UA1 improvements will provide significant benefits to the Buffalo River. CSO volumes are projected to be reduced from over 375 MG under Revised Baseline conditions to less than 18 MG at the 2 LOC. As shown on in the graphs in Appendix 11-3, present worth project costs (including the 2004 Foundation Plan costs) for this water body range from $182M for the 12 OF LOC to $650M for the 0 OF LOC. The knee of the Alternative UA1 benefit curve, based on activation frequency and volume, occurs somewhere between 12 and 6 OF/yr, at approximately $200 million. At that level, the residual CSO volume would be less than 150 MG. This represents a reduction in baseline annual CSO volume of nearly 65%. Receiving water body specific percent captures were not calculated. Water quality simulations were run and the knee of the water quality compliance curve for Buffalo River is at 12 OF LOC, where the model indicates the UA1 improvements would bring Buffalo River into 100% compliance with NYS bacteria WQS (assuming reduced background conditions).

- Cazenovia Creek: The proposed Alternative UA1 improvements will provide significant benefits to the Cazenovia Creek (both the B and C class portions). CSO volumes are projected to be eliminated (from over 35 MG under Revised Baseline conditions) for all LOCs. As shown in Table 11-18, costs (including the 2004 Foundation Plan costs) for this alternative is $97M for all LOCs. Water quality simulations for Cazenovia Creek were run as part of the Buffalo River analysis.

- *Erie Basin:* The proposed Alternative UA1 improvements will provide significant benefits to the Erie Basin. CSO volumes are projected to be reduced from over 10 MG under Revised Baseline conditions to less than 1 MG at the 2 LOC. As shown on the graphs in Appendix 11-3, present worth project costs (including the 2004 Foundation Plan costs) for this RWB range from $3M for the 12 OF LOC to $100M for the 0 OF LOC. The knee of the Alternative UA1 benefit curve, based on activation frequency and volume, occurs around the 6 OF/yr, at approximately $13 million. At that level, the residual CSO volume would be less than 8 MG. This represents a reduction in annual CSO volume of nearly 25% from the current baseline. Receiving water body specific percent captures were not calculated. Water quality simulations were run and the model indicates that the Erie Basin is100% compliant with NYS bacteria WQS (assuming reduced background conditions) for all LOCs.

- Niagara River (including CSO 055): The proposed Alternative UA1 improvements will provide significant benefits to the Niagara River. CSO volumes are projected to be reduced from over 735 MG under Revised Baseline conditions to approximately 50 MG at the 2 LOC. As shown on of the graphs in Appendix 11-3, present worth project costs (including the 2004 Foundation Plan costs) for this RWB range from $68M for the 12 OF LOC to almost $194M for the 0 OF LOC. The knee of the Alternative UA1 benefit curve, based on activation frequency and volume, occurs at about 6 OF/yr, at approximately $100 million. At that level, the residual CSO volume would be about 190 MG. This represents a reduction in annual CSO volume of nearly 90%. Receiving water body specific percent captures were not calculated. Water quality simulations were run and the model indicates that the Niagara River is100% compliant with NYS bacteria WQS (assuming reduced background conditions) for all LOCs.

- Scajaquada Creek: The proposed Alternative UA1 improvements will provide significant benefits to Scajaquada Creek. The CSO volumes are projected to be reduced from over 265 MG under Revised Baseline conditions to less than 6 MG at the 2 LOC. As shown on in the graphs in Appendix 11-3, costs (including the 2004 Foundation Plan costs) for this water body range from $153M for the 12 OF LOC to $293M for the 0 OF LOC. The knee of the Alternative UA1 benefit curve based on activation frequency and volume occurs around 6 OF/yr, at approximately $180 million. At that level, the residual CSO volume would be less than 120 MG. This represents a reduction in annual CSO volume of nearly 55%. Receiving water body specific percent captures were not calculated. Water quality simulations were run and the knee of the water quality curve for Scajaquada Creek is at 4 OF LOC, where the model indicates the Alternative UA1 improvements would bring Scajaquada Creek into 100% compliance with NYS bacteria WQS (assuming reduced background conditions).

11.6.1.4.2 Water Quality Compliance

Alternative UA1 was evaluated for each receiving water body in terms of remaining pollutant loads and water quality compliance (bacteria only) for each receiving water body. For purposes of evaluating water quality compliance of Alternative UA1, a baseline scenario representing improved upstream water quality was chosen. This baseline scenario was previously documented in *Technical Memorandum: Baseline Water Quality Modeling For Buffalo River, Scajaquada Creek, Niagara River, and Black Rock Canal* (LimnoTech, March 30, 2012) and presented in Appendix 6-3. This baseline scenario incorporates upstream water quality conditions set at 75% of the WQS (cBOD has no WQS, so it was set to 75% of the existing conditions upstream concentration). These modified upstream boundary conditions were identical for both the Baseline scenario used in this report and Alternative UA1.

To represent the satellite treatment discharges, bacteria concentrations for treated CSO flows were set to 400 #/100 mL for the first hour and 200 #/100 mL for the remainder of each event. This represents 50% cBOD removal relative to untreated CSO discharges.

Attainment of the bacteria WQS for each water body under Alternative UA1 was calculated from model output and compared to the bacteria WQS attainment for the Baseline condition. Table 11-20 provides a summary of annual percent attainment of bacteria WQS for all modeled water bodies under these two scenarios. Attainment was first calculated for each model segment and then spatially averaged across each water body.

All water bodies demonstrated 100% attainment of the bacteria WQS under the Alternative UA1 scenario for the higher levels of control (0 and 2 OF/yr). The greatest improvement was seen for Lower Scajaquada Creek, where attainment increased from 77% in the Baseline (Background 75% of WQS) scenario to 100% in the Alternative UA1 scenario for the 0 and 2 OF/yr LOCs. Additionally, bacteria WQS attainment increased from 85.5% to 100% for Black Rock Canal, from 93.1% to 100% for the Buffalo River, and from 98.9% to 100% for Upper Scajaquada Creek at the higher LOCs. Upper Scajaquada and Buffalo River both saw improvement to 100% WQS attainment for the 12 OF/yr LOC, and Erie Basin and the Niagara River remained unchanged at 100% attainment for Baseline conditions and all LOCs. Additional results for each water body can be found in Appendix 11-3.

Table 11-20: Water Quality Standards Attainment for Bacteria Comparison of Baseline Scenario with Alternative UA1 (1993 Typical Year; Averaged across Water Body and Typical Year)

Scenario	Bacteria: Annual Percent Attainment (%) of WQS					
	Upper Scajaquada Creek	Lower Scajaquada Creek	Buffalo River	Black Rock Canal	Erie Basin	Niagara River (incl. CSO 055)
Baseline (Bkgd 75% of WQS)	98.9	77.0	93.1	85.5	100.0	100.0
12 OF/yr	100.0	88.7	100.0	89.9	100.0	100.0
6 OF/yr	100.0	92.5	100.0	94.4	100.0	100.0
4 OF/yr	100.0	100.0	100.0	100.0	100.0	100.0
2 OF/yr	100.0	100.0	100.0	100.0	100.0	100.0
0 OF/yr	100.0	100.0	100.0	100.0	100.0	100.0

In addition to evaluating bacteria water quality compliance, residual bacteria loadings were also calculated for each RWB and LOC. Because the pollutant loadings were calculated using an assumed event mean concentration that was applied to the remaining CSO volumes, the cost-benefit curves for residual bacteria loadings look very similar to the cost benefit curves for residual CSO volumes (Appendix 11-3).

11.6.2 Alternative UA2-RTC/GI/ North Relief at Plant & Selected Elements of UA1

Alternative UA2 consists of some elements of Alternative UA1 (updated 2004 preferred system-wide alternative) plus a North interceptor relief sewer that will convey additional flows to the siphon across Black Rock Canal and into the headworks of the Bird Island WWTP. Additionally, under greater levels of control, a new pump station will be constructed to pump flows to a new EHRT facility located on the north side of the WWTP. Unlike Alternative UA1, however, Alternative UA2 builds upon the Revised Foundation Plan with GI, which includes SPP optimizations and weir modifications as well as selected RTC projects (primarily in-line storage) plus the recommended range of GI control of impervious surface from 10% to 20% system-wide.

11.6.2.1 Description of Alternative

The alternatives selected for UA2 for each RWB were initially developed from the Updated 2004 Preferred System-wide alternative (UA1) described in Section 11.6.1, plus the North relief line and an EHRT at the north side of the Bird Island (for higher LOCs). Additionally, Alternative UA2 includes the Revised Foundation Plan with the initial green infrastructure control of up to 20% of the impervious surface system-wide to offset the required sizes of proposed gray technologies and to acknowledge the nationwide emphasis on sustainability supported by the USEPA.

The specific technologies applied for each RWB and LOC, then, were based on remaining CSO activations and volumes that would need to be controlled after the Revised Foundation Plan with GI has been implemented. Table 11-21 summarizes the technologies for each RWB and LOC for Alternative UA2. Figures 11-15 through Figure 11-19 present the specific technologies applied to the CSOs for each LOC.

Table 11-21: Selected Technologies for Alternative UA2 by Receiving Water Body[1, 2]

Receiving Water Body	12 OF	6 OF	4 OF	2 OF	0 OF
Black Rock Canal	North Relief	North Relief	North Relief / Satellite Storage	North Relief & HRT / Satellite Storage	North Relief & HRT / Satellite Storage
Buffalo River	Satellite Storage	Satellite Storage	Satellite Treatment	Satellite Treatment	Satellite Treatment
Cazenovia Creek - B	-	-	-	-	-
Cazenovia Creek - C	-	-	Satellite Storage / Treatment	Satellite Treatment	Satellite Treatment
Erie Basin	-	-	Satellite Storage	Satellite Storage	Satellite Storage
Niagara River (includes CSO 055)	North Relief / Satellite Storage	North Relief / Satellite Storage	North Relief / Satellite Storage	North Relief & HRT / Satellite Storage	North Relief & HRT / Satellite Storage
Scajaquada Creek	Satellite Storage	Satellite Storage	Satellite Storage	Tunnel / Satellite Storage	Tunnel / Satellite Storage

[1] Alternative UA2 includes the Revised Foundation Plan (primarily RTCs and SPP optimizations) and GI control of up to 20% of the impervious surfaces. This plan affects all RWBs and CSOs.
[2] Where no technology is listed, the CSO controls will be those listed in the Revised Foundation Plan and will include GI control of up to 20% of the impervious surfaces.

11.6.2.2 Proposed Facilities and Operational Concepts

As noted previously, the proposed facilities and operational concepts will vary among RWBs and LOCs for Alternative UA2. Table 11-22 presents the proposed facilities and sizes for all LOCs for this alternative.

11.6.2.2.1 Black Rock Canal and Niagara River

Most of the CSOs that discharge along Black Rock Canal and CSO 011 that discharges to the Niagara River can be controlled using a combination of underflow pipe upsizing (to maximize flow to the interceptors) and a relief sewer that runs parallel to the Black Rock Canal between CSO 004 and CSO 011/012. To control to 12 and 6 OF/yr, a shorter relief sewer, approximately 2,500 feet long, between CSO 011/012 and the siphon crossing, to Bird Island would be required. For higher levels of control, however, additional parallel relief sewer would be required from CSO 004 to the siphon crossing. Sizes for the relief sewer range from 2.5 ft. diameter for the 12 OF LOC to 10-ft. diameter for the short reach of sewer from the junction of the new relief line to the siphon crossing (for 0 OF LOC).

For the 2 and 0 OF/yr LOCs, an enhanced high-rate treatment (EHRT) facility would be required to treat excess flows and maintain the parallel relief sewer at a reasonable size. For these LOCs, a pump station and force main would be required to take excess flows from near the siphon crossing to the proposed EHRT facility on the north side of the WWTP. The EHRT facility would be used to flocculate and settle suspended solids to remove TSS and cBOD, and allow CSO flows to be disinfected. Treated effluent from this facility would be disinfected in a new high-rate chlorination basin to meet bacteria standards prior to discharge to the Niagara River.

Additional control of discharges to the Niagara River would be provided through a satellite storage facility at CSO 055, and a small satellite facility to control discharges from CSO 013 to the Black Rock Canal. At CSO 013, the satellite storage facility would operate between the current SPP and the receiving water (*i.e.*, would be constructed such that the facility would be filled from the overflow conduit). When the SPP activates, overflow would flow to the storage basin. When the basin fills, the inlet gate to the storage facility would close and subsequent overflow from the SPP during the event would bypass the storage basin and then be discharged to the receiving stream through the existing CSO outfall. This discharge would be considered a CSO event in the new system. After the storm when the interceptor and plant capacity become available, the basin would be dewatered to the interceptor via a pump station sized to empty the basin within 24 to 48 hours (based on the 1993 modified typical year precipitation storm patterns).

For CSO 055, the proposed storage facility would be located upstream of the regulator, near Military Road. At this location, an offline facility would be constructed and flows above 26 MGD would be diverted from the South Hertel Truck sewer into the 7.5 MG storage facility. Flows in excess of the storage capacity would be conveyed down to the existing CSO 055 regulator structure and discharge through the existing outfall. After the storm when the conveyance and plant capacity become available, the basin would be dewatered into the Hertel Avenue combined sewer via a pump station sized to empty the basin within 24 to 48 hours (based on the 1993 modified typical year precipitation storm patterns).

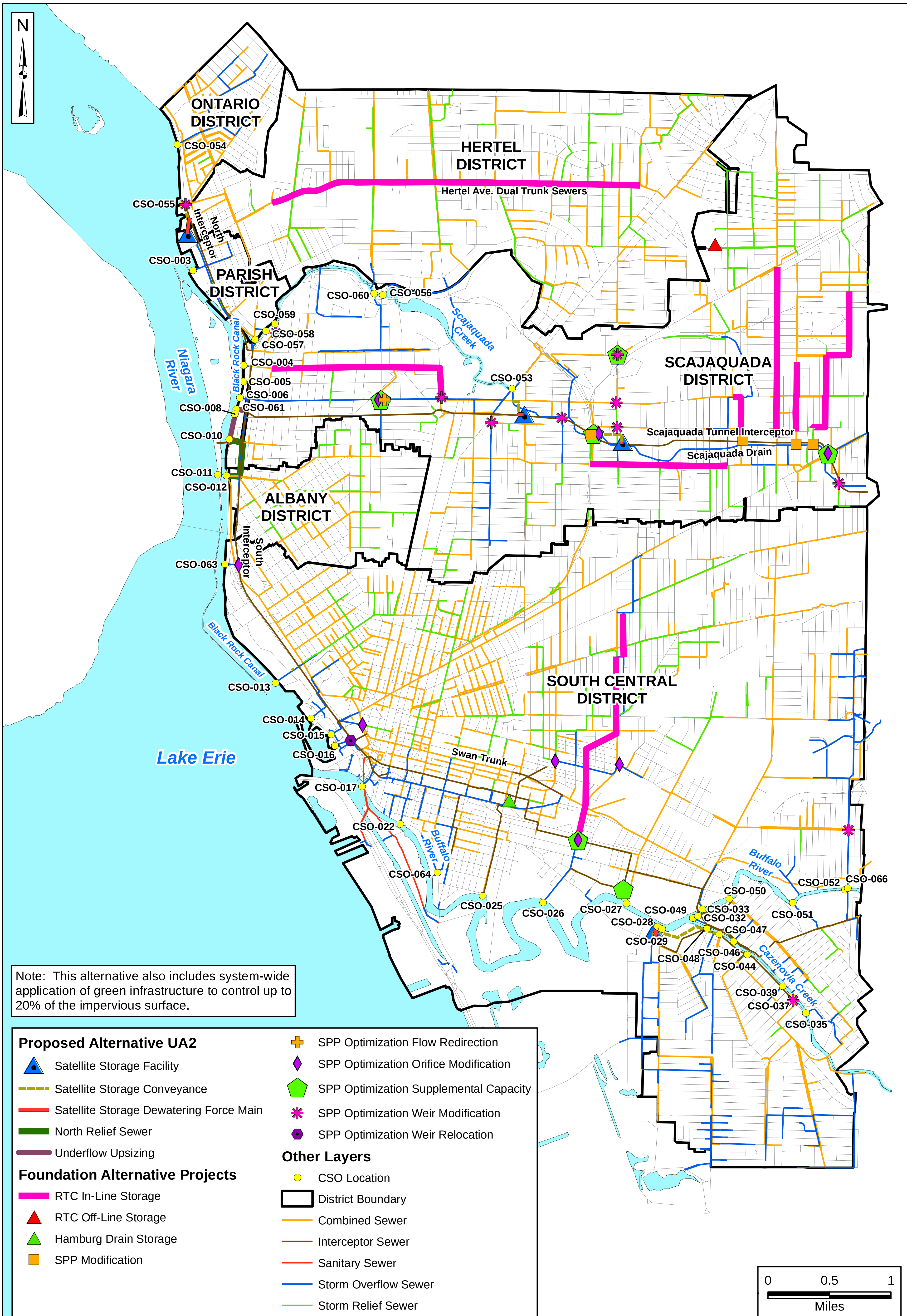

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FIGURE 11-15

RECOMMENDED FACILITIES FOR ALTERNATIVE UA2 12 OF LEVEL OF CONTROL

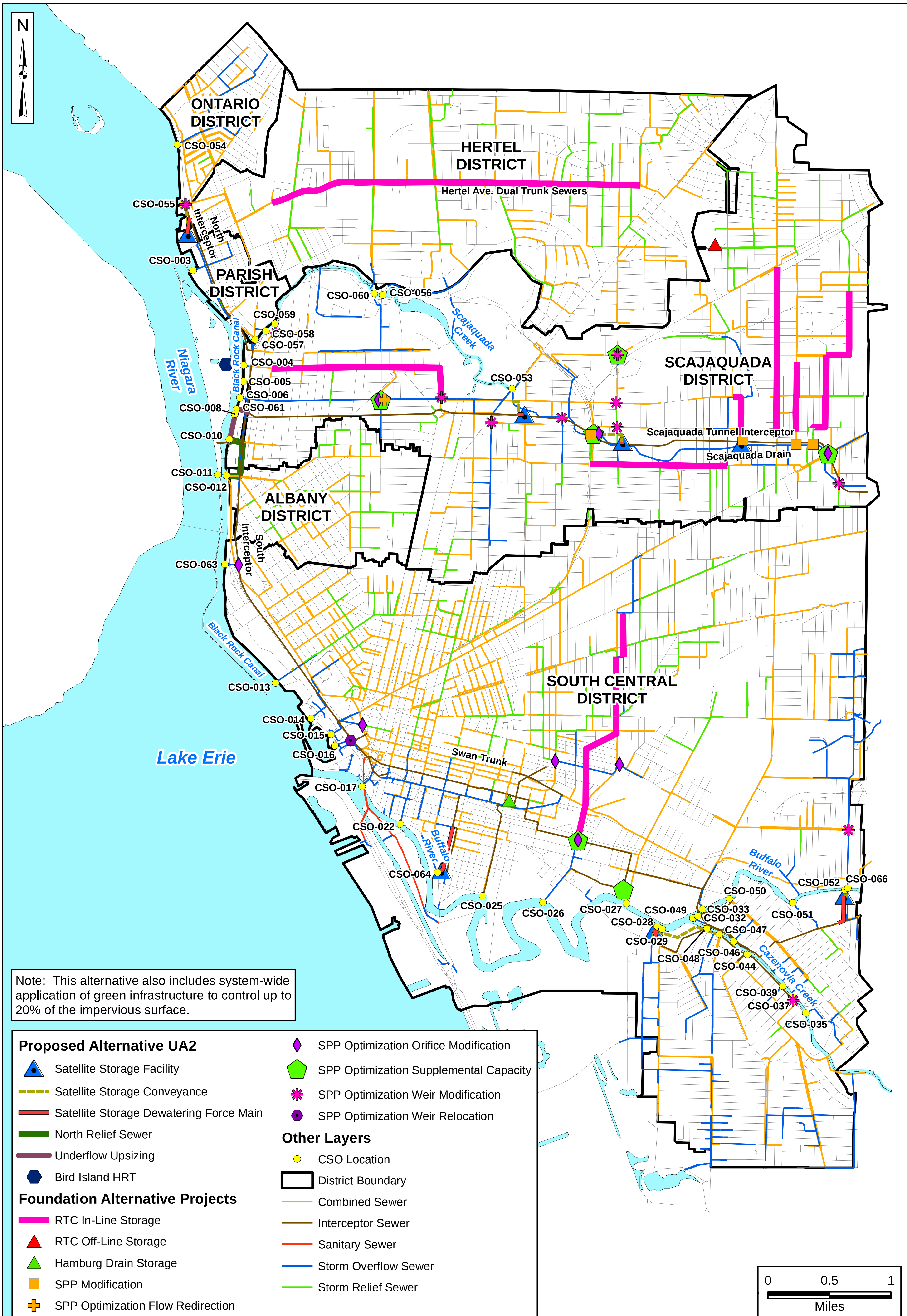

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FIGURE 11-16

RECOMMENDED FACILITIES FOR ALTERNATIVE UA2 6 OF LEVEL OF CONTROL

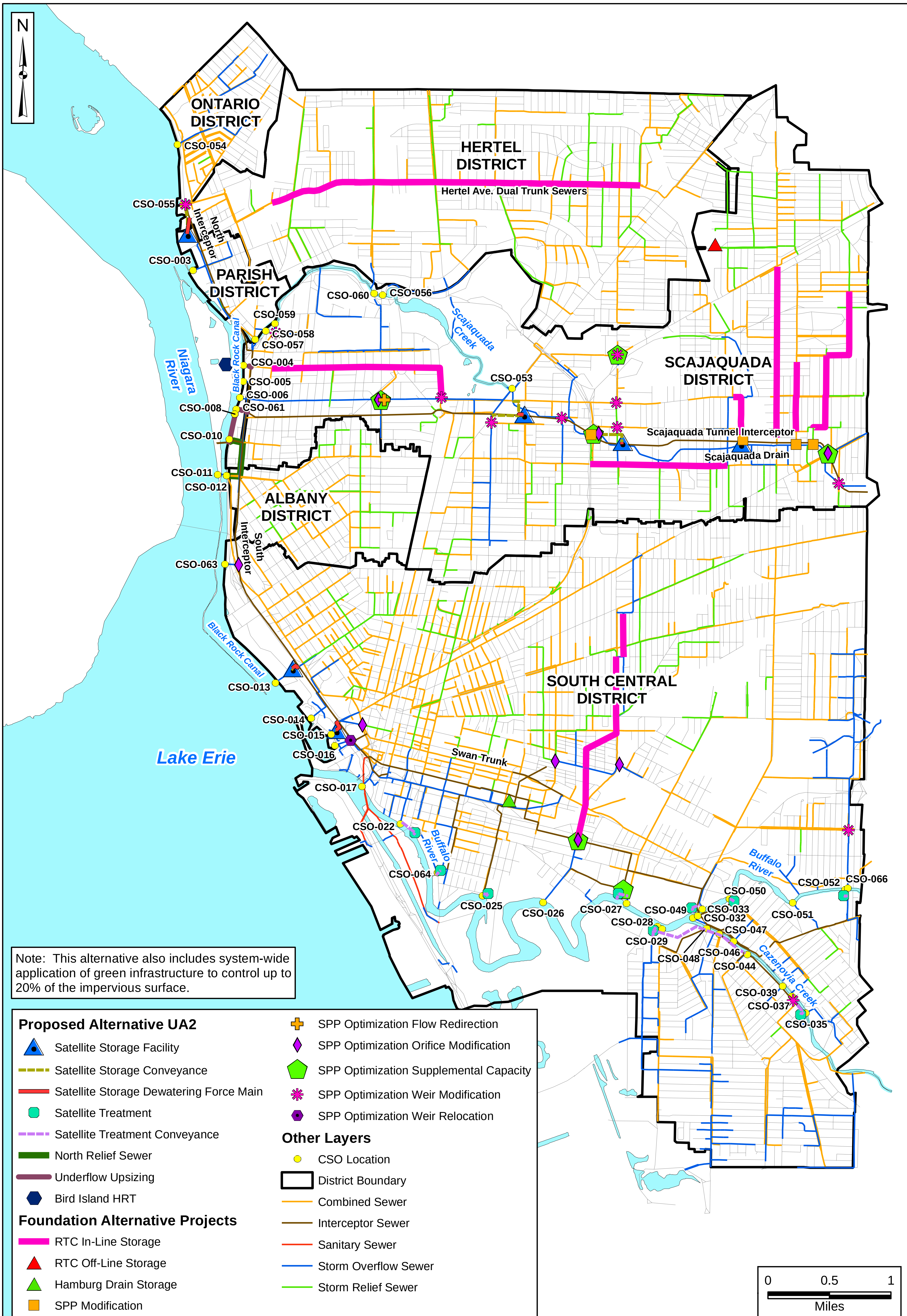

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FIGURE 11-17

RECOMMENDED FACILITIES FOR ALTERNATIVE UA2 4 OF LEVEL OF CONTROL

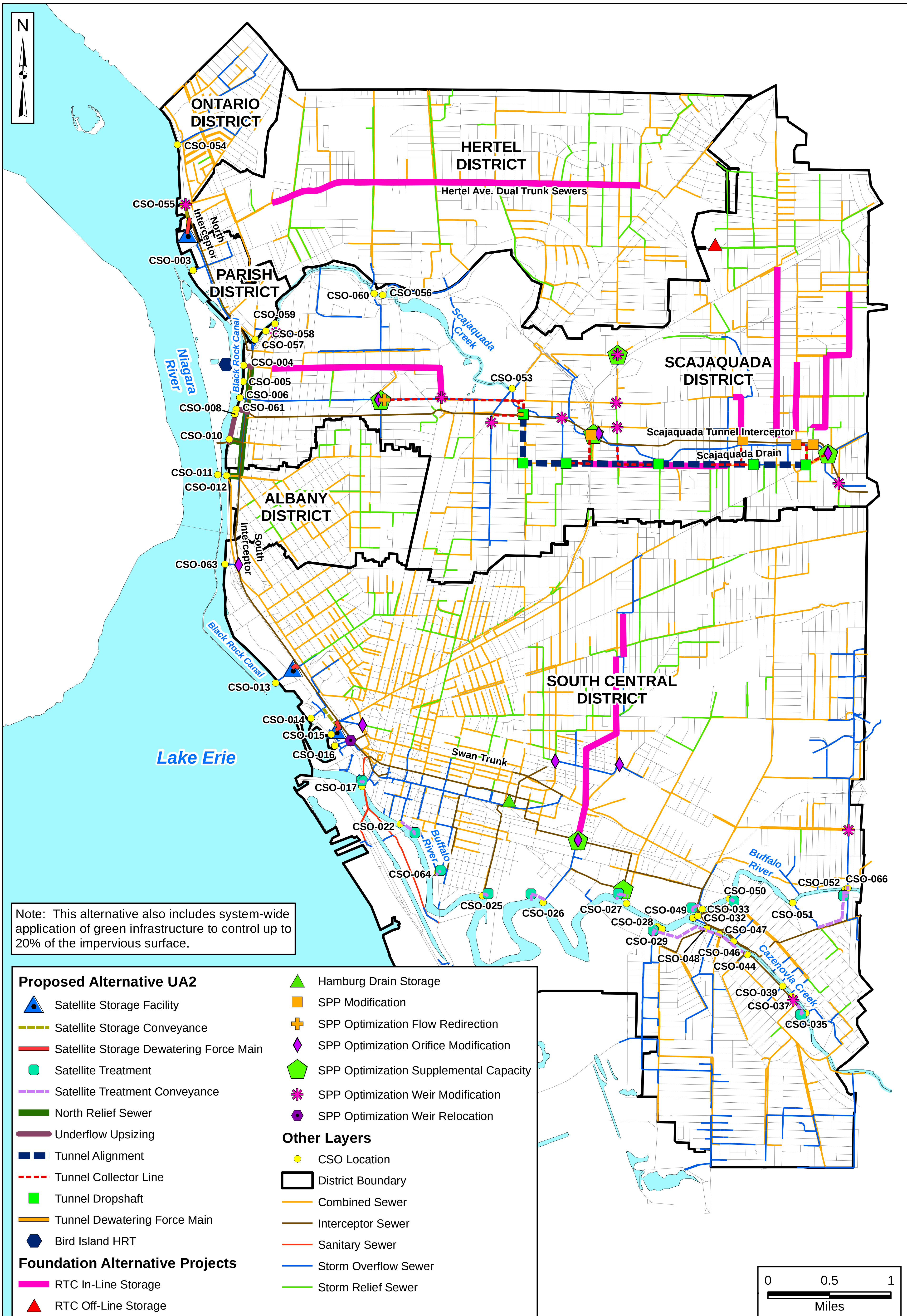

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FIGURE 11-18

RECOMMENDED FACILITIES FOR ALTERNATIVE UA2 2 OF LEVEL OF CONTROL

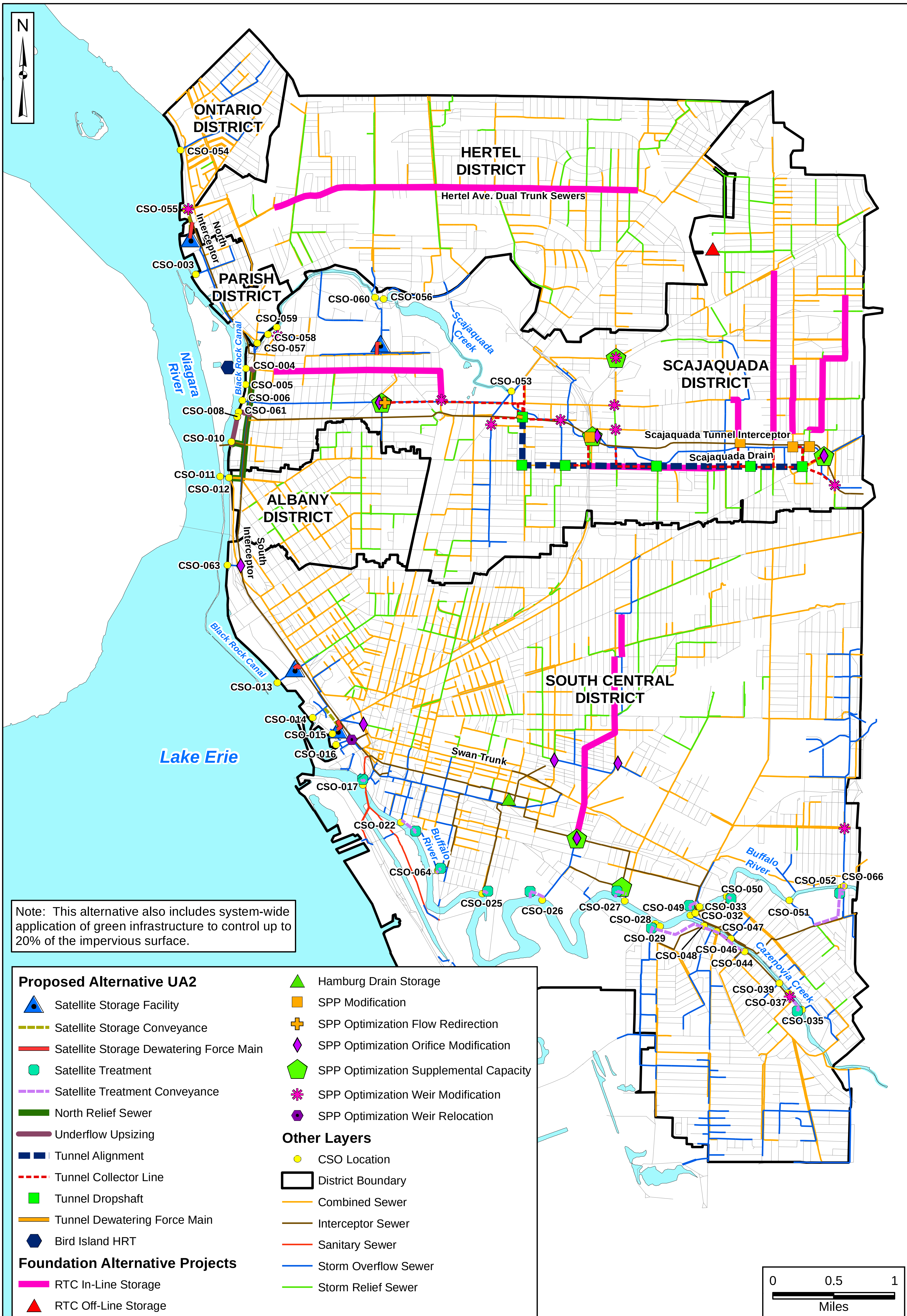

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FIGURE 11-19

RECOMMENDED FACILITIES FOR ALTERNATIVE UA2 0 OF LEVEL OF CONTROL

Table 11-22 Components of System-wide Alternative UA2 (Real Time Control/Green Infrastructure, HRT at Plant, and Revised Foundation)

Storage

	Receiving Basin	Volume (MG)				
		0 OF	2 OF	4 OF	6 OF	12 OF
CSO-013	Black Rock Canal	2.25	1.20	0.27	0	0
CSO-028/044/047	Buffalo River	0.0	0	0	2.32	0.62
CSO-052	Buffalo River	0.0	0	0	0.6	0
CSO-064	Buffalo River	0.0	0	0	0.1	0
CSO-055	Niagara River	71.16	36.00	25.00	17.50	5.00
CSO-014/015	Erie Basin	3.55	0.83	0.25	0	0
CSO-060	Scajaquada Creek	0.42	0	0	0	0
SPP337	Scajaquada Creek	0.0	0	0.70	0.45	0
Jefferson & Florida (SPP170B)	Scajaquada Creek	0.0	0	2.60	1.70	0.83
SPP165A, SPP165B, SPP336A, SPP336B	Scajaquada Creek	0.0	0	4.10	2.55	0.77
Total		**77.38**	**38.03**	**32.92**	**25.22**	**7.22**

High Rate Treatment

	Receiving Basin	Peak Flow (mgd)				
		0 OF	2 OF	4 OF	6 OF	12 OF
CSO-017	Buffalo River	75.0	40.8	0.0	0.0	0.0
CSO-022	Buffalo River	11.3	5.7	4.0	0.0	0.0
CSO-025	Buffalo River	9.1	4.2	1.0	0.0	0.0
CSO-026	Buffalo River	118.7	27.2	0.0	0.0	0.0
CSO-027	Buffalo River	88.2	36.6	10.0	0.0	0.0
CSO-028/044/047	Buffalo River	100.1	71.2	46.5	0.0	0.0
CSO-033	Buffalo River	85.9	66.1	26.0	0.0	0.0
CSO-050	Buffalo River	12.1	7.2	3.3	0.0	0.0
CSO-051/052/066	Buffalo River	44.6	20.0	4.8	0.0	0.0
CSO-064	Buffalo River	14.2	4.5	4.0	0.0	0.0
CSO-037	Cazenovia Creek - C	46.3	29.2	16.1	0.0	0.0
Bird Island	Black Rock Canal	370.0	260.0	0.0	0.0	0.0
Total		**975**	**573**	**116**	**0**	**0**

Tunnel Storage

	Receiving Basin	Volume (MG) / Dewatering (MGD): Top Row; Diameter (ft): Bottom Row					Length (ft)
		0 OF	2 OF	4 OF	6 OF	12 OF	
East-West Volume	Scajaquada Creek	44.14	18.77	0.00	0.00	0.00	14,200
East-West Diameter		23.00	15.00	0.00	0.00	0.00	
Total		**44.14**	**18.77**	**0.00**	**0.00**	**0.00**	**14,200**

Existing CSO Underflow Capacity Increase

	Receiving Basin	Length	Outlet Diameter (ft)				
			0 OF	2 OF	4 OF	6 OF	12 OF
CSO 010	Black Rock Canal	67	4.5	4.0	4.0	4.0	4.0
CSO 008/010	Black Rock Canal	84	5.5	5.0	5.0	5.0	5.0
CSO 008	Black Rock Canal	1,646	3.0	3.0	3.0	3.0	3.0
CSO 061	Black Rock Canal	46	6.5	5.0	6.0	5.0	0.0
CSO 004	Black Rock Canal	112	8.0	7.0	6.0	0.0	0.0
Total		**1,955**					

Black Rock Canal Relief Sewer

Receiving Basin	Length	Diameter (ft)				
		0 OF	2 OF	4 OF	6 OF	12 OF
Black Rock Canal	2,045	8.0	5.5	7.5	4.0	2.5
Black Rock Canal	571	10.0	8.0	10.0	5.0	2.5
Black Rock Canal	3,265	8.0	5.5	8.0	0.0	0.0
Black Rock Canal	1,185	0.0	0.0	0.0	3.0	0.0
Total	**7,065**					

Green Infrastructure

Receiving Water	Area Managed by GI (ac)
Black Rock Canal	168
Buffalo River	418
Cazenovia Creek - B	3
Cazenovia Creek - C	60
Erie Basin	49
Niagara River	412
Scajaquada Creek	510
Total	**1,620**

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Storage facilities would capture all of the volume associated with overflow events up to the selected storage control level, and the first flush of larger events.

11.6.2.2.2 Scajaquada Creek

CSO control for Scajaquada Creek will be provided primarily through satellite storage facilities. Storage facilities are proposed at the following locations and for the listed LOCs:

- SPP 337: Up to 700,000 gallons required for the 6 and 4 OF LOCs. No storage is required at this SPP for the 12 OF LOC, and for the 2 and 0 LOCs storage requirements are too high to be controlled through satellite storage (primarily because adequate land would not be available). The tunnel described below would be required for these LOCs.

- Jefferson & Florida: SPP 170B would be controlled through a storage facility ranging from 0.8 MG for 12 OF/yr to 2.6 MG for 4 OF/yr. For 2 and 0 OF/yr, CSO discharges would be handled by the tunnel described below.

- Fillmore & Northland: SPPs 165A, 165B, 336A and 336B would be controlled by a storage facility located near this intersection. Required storage volumes range from 0.7 MG for 12 OF/yr up to 4.1 MG for 4 OF/yr. For 2 and 0 OF/yr, CSO discharges would be handled by the tunnel described below.

For the highest levels of control (2 and 0 OF/yr), an offline storage tunnel would be required to control all CSO discharges upstream of where the Scajaquada Drain daylights at Forest Lawn Cemetery. This tunnel would follow the Scajaquada Drain and terminate near SPP 170. A 15-ft. diameter tunnel would be required for 2 OF/yr and a 23-ft. diameter tunnel for 0 OF/yr. Six tunnel shafts would be constructed, and SPPs along the Drain would be consolidated to the nearest tunnel shaft. Flows in excess of the selected level of control, or that occur when the tunnel is full, would bypass the consolidation lines and discharge into the Scajaquada Drain through the existing SPP connections. A tunnel dewatering pump station will be located at the downstream end of the tunnel and will be sized to dewater the tunnel contents to the Scajaquada Interceptor after the storm event within 24 to 48 hours (based on the 1993 modified typical year precipitation storm patterns).

In lower Scajaquada Creek, the remaining CSOs (056, 057, 058, 059, and 060) will activate very infrequently after the implementation of the Phase I projects, the Revised Foundation Plan, and the proposed GI control of impervious surfaces. For CSO 057, 058, and 059, Phase I projects are currently providing a high level of control and the BSA is in a post-construction monitoring phase to document the current activity from these CSO outfalls. For this reason, no controls are provided in the UA2 alternative, except for the 0 OF/typical yr LOC at CSO 060 where the model predicts additional CSO volumes for control. A 400,000 gallon satellite storage facility is proposed for this LOC near CSO 060.

11.6.2.2.3 Buffalo River (including Cazenovia Creek Class B and C portions)

The Revised Foundation Plan, assuming the implementation of GI controls, provides a high LOC for most CSOs in the Buffalo River and Cazenovia Creek basins. The primary control facilities include storage along Hamburg Drain to control CSOs 017, 022 and 064, and storage at Smith Street (CSO 026). These facilities bring the frequency of activation of CSO 017 and 026 down to 4 OF/yr. Therefore, the remaining CSOs are addressed through either satellite storage or treatment facilities, depending on size requirements and space availability.

For Alternative UA1, HRTs and partial sewer separation were the selected control technologies for the Buffalo River and Cazenovia Creek at all levels of control. Because Alternative UA2 built upon the components of Alternative UA1, HRT remained the preferred control technology in the Buffalo River and Cazenovia Creek. However, due to additional GI improvements included in UA2, CSO flows and volumes tributary to the Buffalo River under some lower LOCs were substantially lower as compared to UA1. This presented an opportunity to eliminate HRTs altogether or replace HRTs with storage tanks, which are typically less costly to construct and operate yet equally effective at controlling CSO discharges. The BSA staff is also more familiar with operation and maintenance requirements for smaller storage tanks as they are currently being implemented at a few other CSO locations. A summary of CSO locations within the Buffalo River where HRT facilities were replaced with storage tanks at lower LOCs is presented below.

Location	0 OF HRT (MGD)	2 OF HRT (MGD)	4 OF HRT (MGD)	6 OF Storage (MG)	12 OF Storage (MG)
CSO-028/044/047	100.1	71.2	46.5	2.3	0.6
CSO-051/052/066	44.6	20.0	4.8	0.6 (CSO 052 only)	0.0
CSO-064	14.2	4.5	4.0	0.1	0.0

The development of these alternatives was completed at a general planning level; therefore, it did not include a detailed site selection process for any CSO. However, the BSA did complete an example comparison of potential facility footprints and land requirements for both HRT and storage tank technologies, at all levels of control for the CSO 028/044/047 location. This comparison is presented graphically in Appendix 11-9. The figures in Appendix 11-9 show that in addition to cost, footprint constraints can and likely will become a factor during final site planning and design.

CSO 035 in the Class B portion of Cazenovia Creek has been eliminated through previously completed projects. However, the BSA will implement GI technologies in this basin to provide additional control of stormwater discharges. The remaining CSOs along the Class C portion of Cazenovia Creek generally are consolidated down to storage or treatment facilities (depending on the LOC) at CSO 028. Table 11-22 provides the proposed sizes for the storage or treatment facility at CSO 028.

The off-line (satellite) storage facilities would operate between the current SPP and the receiving water (*i.e.*, would be constructed such that the facility would be filled from the overflow conduit by gravity). When the SPP activates, overflow would flow to the storage basin. When the basin fills, subsequent overflow from the SPP during the event would bypass the storage and discharge to the receiving stream through the existing CSO outfalls. This discharge would be considered a CSO event in the new system. After the storm when the conveyance and plant capacity become available, the basin would be dewatered to the interceptor via a pump station sized to empty the basin within 24 hours (based on the 1993 modified typical year precipitation storm patterns). Storage facilities would capture all of the volume associated with overflow events up to the selected storage control level, and the first flush of larger events.

Off-line storage facilities proposed for the BSA's system would be covered, concrete, underground tanks. The basins would include a bar screen in the influent channel to provide floatables control for the overflow. Odor control would also be included with each facility.

The satellite treatment facilities (EHRTs) would be used to flocculate and settle suspended solids to remove TSS and cBOD, and allow CSO flows to be disinfected. A mechanically cleaned fine screen would need to be provided to prevent plugging of the lamella-type settling plates in the clarification system. Treated effluent from the EHRT facilities would be disinfected in a high-rate chlorination tank to meet bacteria standards.

The treatment facilities are assumed to operate between the current SPP and the receiving water (*i.e*., would be constructed in line with the overflow conduit), but would require an influent pumping station to convey flows to the facilities. When the SPP activates, overflow would flow to the facility. When the overflow rate exceeds the capacity of the EHRT facility, additional overflow from the SPP during the event would be discharged untreated to the receiving stream through the existing CSO outfall. This discharge would be considered a CSO event in the new system. Since EHRT systems are flow through rather than storage based, mechanisms to differentiate treated flows from bypass flows (CSO flows) will be incorporated. The EHRT facilities would include tankage for chemical (*e.g*., polymer, coagulants, and ballast sand or biochemical solids) addition, flash mixing, gentle mixing and sedimentation; chemical feed and pumping facilities and associated building; settling facilities; chlorine contact tanks; self-cleaning fine screens; yard piping; and electrical and instrumentation and control (I&C) equipment.

11.6.2.2.4 Erie Basin

The Revised Foundation Plan, with GI implementation, provides a high level of control for the CSO outfalls discharging to the Erie Basin (CSO 014 and 015). CSO 016 was eliminated for the typical year through the optimization of an upstream SPP that was part of a Phase I project completed after the 2004 LTCP was submitted. For Alternative UA2, a satellite storage facility is proposed to control the remaining overflows from CSOs 014 and 015 for the 4, 2 and 0 OF/yr LOCs. Storage facility sizes would range from 250,000 gallons for the 4 OF LOC up to 3.6 MG for the 0 OF LOC. No controls are required for the 12 and 6 OF/yr LOCs. CSO 014 discharges would be consolidated to the storage facility located near CSO 015. This storage facility would operate in the same manner as described in the previous sections.

11.6.2.3 Preliminary Costs

Costs for Alternative UA2 were developed based on the unit cost curves presented in Section 7. Costs presented here include capital costs for all facilities, collector pipes, and associated dewatering pumps and appurtenances. Alternative UA2 costs also assume implementation of the Revised Foundation Plan, which includes selected RTC projects, as well as GI projects to control up to 20% of the impervious surfaces system-wide. Present worth operations and maintenance (O&M) costs are also included. The estimated present worth project cost in 2012 dollars for Alternative UA2 varies from $220 million for the 12 OF/yr LOC to $1.5 billion for the 0 OF/yr LOC. Table 11-23 summarizes the cost breakdown by RWB for each LOC and Appendix 11-4 presents the back-up documentation for the cost estimate.

11.6.2.4 Description of Benefits (CSO Reductions and Water Quality Modeling Results)

The benefits of Alternative UA2 were evaluated for each receiving water body and on a system-wide basis in terms of activation frequency, reduction in CSO volumes, and percent capture (system-wide basis only). In addition, the benefits provided by Alternative UA2 in terms of NYS bacteria WQS compliance for each RWB were also evaluated. This section summarizes these evaluations.

Table 11-23: Estimated Present Worth Project Costs for System-Wide Alternative UA2 (2012 Dollars; O&M Included)

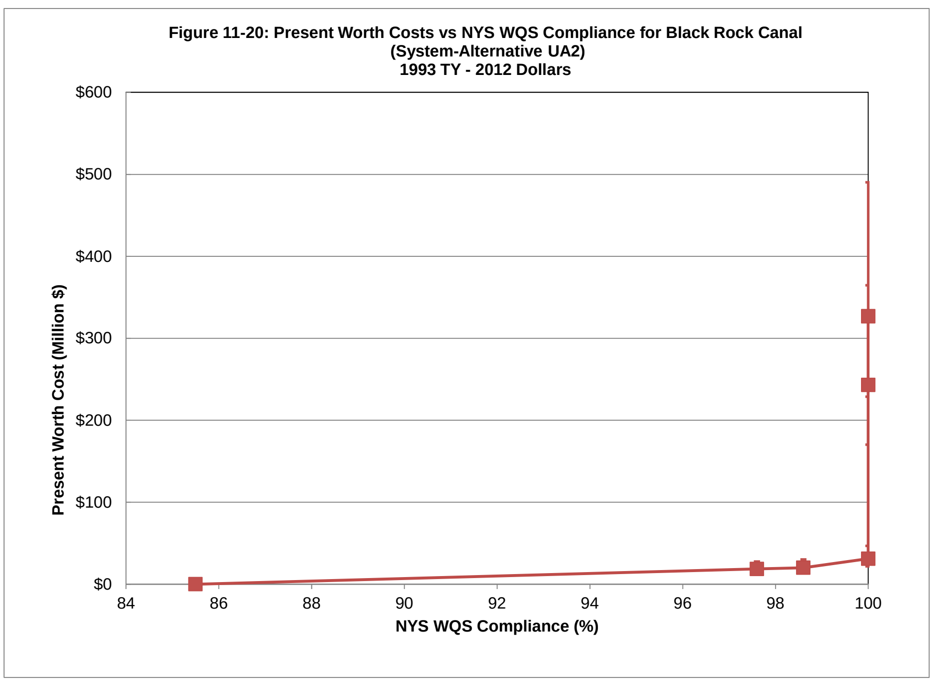
Receiving Basin	Revised Foundation Plan	Estimated Present Worth Project Cost ($Million)				
		0 OF	2 OF	4 OF	6 OF	12 OF
Black Rock Canal	$6.9	$319.9	$236.2	$24.2	$13.1	$11.6
Buffalo River	$41.1	$623.2	$388.3	$182.5	$42.0	$29.9
Cazenovia Creek - B	$0.0	$0.2	$0.2	$0.2	$0.2	$0.2
Cazenovia Creek - C	$0.0	$58.5	$43.0	$29.6	$3.4	$3.4
Erie Basin	$0.0	$19.4	$8.6	$4.7	$2.8	$2.8
Niagara River (includes CSO 055)	$8.7	$206.4	$129.5	$103.0	$83.7	$47.1
Scajaquada Creek	$27.8	$235.5	$154.7	$66.3	$55.1	$41.0
Sub-Total	**$84.5**	**$1,463.0**	**$960.4**	**$410.5**	**$200.3**	**$136.1**
Total (with Revised Foundation Plan)		**$1,547.5**	**$1,044.9**	**$495.0**	**$284.8**	**$220.6**

11.6.2.4.1 CSO Frequency, Volume and Percent Capture

Table 11-24 presents a summary of the percent capture, predicted frequencies, and residual CSO volumes for Alternative UA2. Specific activation and volume results for each CSO are presented in Appendix 11-4. Figures 11-20 through 11-24 provides cost-benefit curves for NYS bacteria WQS compliance for each receiving water body. The cost-benefit charts for Alternative UA2 for the each RWB based on activation frequency and remaining CSO volume are also included in Appendix 11-4. Figure 11-25 presents the cost-benefit curve for the total system-wide costs based on activation frequency, Figure 11-26 presents the benefits as measured by predicted remaining annual overflow volume and Figure 11-27 presents the benefits as measured by percent capture. Note that the costs presented on Table 11-23 and on these cost-benefit curves represent planning level present worth project costs, as described in Section 7. Therefore, the cost curves also present the -30% to +50% range in the individual LOC cost estimate.

Table 11-24: Predicted Annual CSO Only (Excluding Storm water and Stream Inflows) Volumes and Frequencies for Alternative UA2 by Receiving Water Body (Modified 1993 TY)

	Projected Activations (Events/Year)					Residual CSO Volume (MG)				
Receiving Water Body	**Revised Baseline**	**12 OF**	**6 OF**	**4 OF**	**2 OF**	**Revised Baseline**	**12 OF**	**6 OF**	**4 OF**	**2 OF**
Black Rock Canal	4 - 65	0 - 12	0 - 6	0 - 4	0 - 2	319.3	97.0	58.1	45.2	14.2
Buffalo River	4 - 69	3 - 12	2 - 6	1 - 4	1 - 2	379.7	172.3	158.3	94.4	29.2
Cazenovia Cr.-B	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Cazenovia Cr.-C	1 - 44	0 - 7	0 - 5	0 - 4	0 - 2	35.6	16.9	15.0	5.9	2.2
Erie Basin	0 - 12	0 - 6	0 - 6	0 - 4	0 - 2	10.3	5.4	4.8	3.3	0.8
Niagara River (incl. CSO 055)	0 - 41	0 - 10	0 - 6	0 - 4	0 - 2	735.5	186.5	76.6	49.7	19.9
Scajaquada Creek	0 - 65	0 - 12	0 - 6	0 - 4	1 - 2	268.7	69.4	53.0	42.5	17.5
Totals	NA	NA	NA	NA	NA	1,749.1	547.4	365.9	241.0	83.8
Percent Capture	NA	NA	NA	NA	NA	91.3%	97.1%	98.0%	98.7%	99.5%



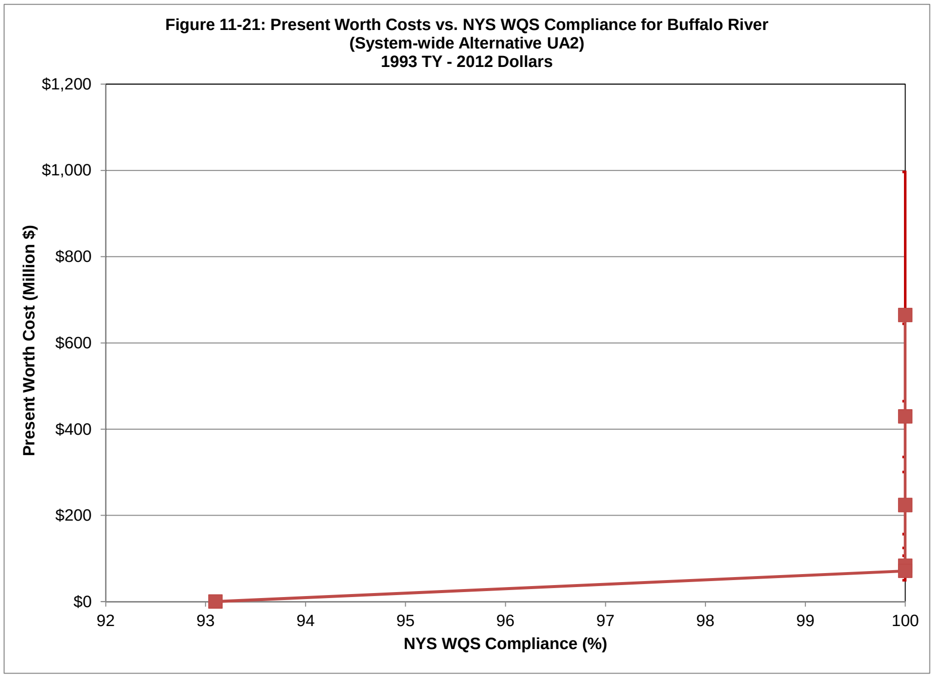


Figure 11-21: Present Worth Costs vs. NYS WQS Compliance for Buffalo River
(System-wide Alternative UA2)
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$0
$200
$400
$600
$800
$1,000
$1,200
92
93
94
95
96
97
98
99
100
NYS WQS Compliance (%)

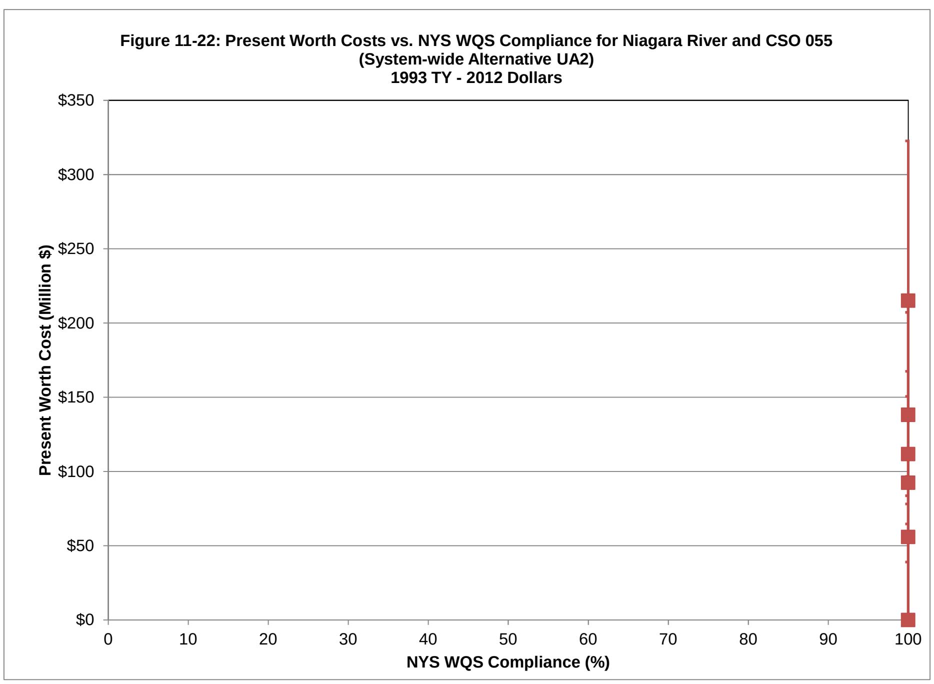


Figure 11-22: Present Worth Costs vs. NYS WQS Compliance for Niagara River and CSO 055
(System-wide Alternative UA2)
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$0
$50
$100
$150
$200
$250
$300
$350
0
10
20
30
40
50
60
70
80
90
100
NYS WQS Compliance (%)

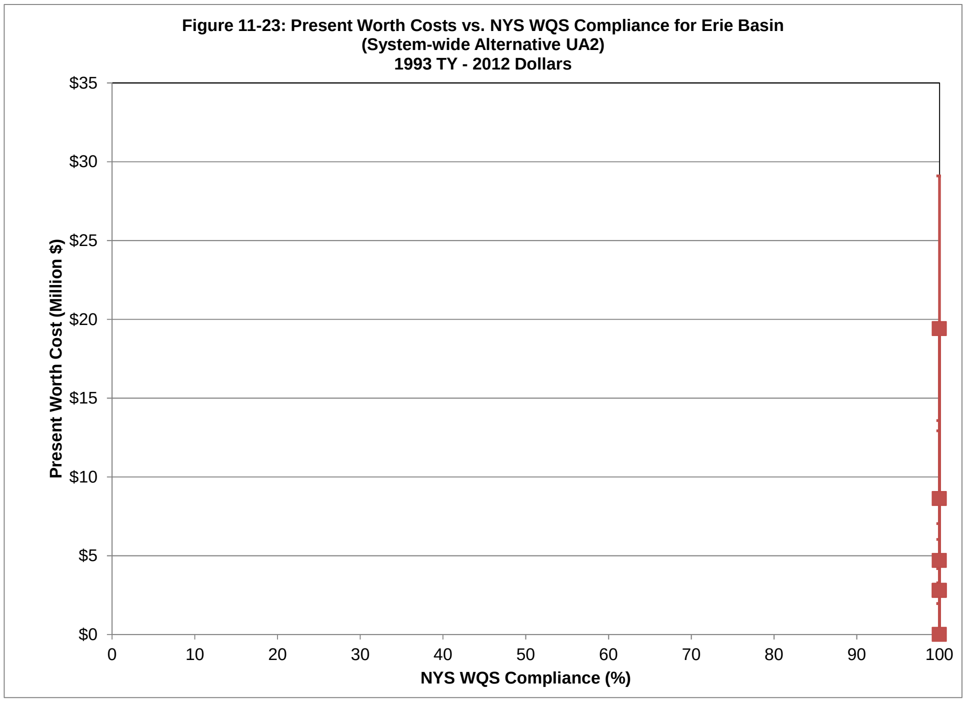


Figure 11-23: Present Worth Costs vs. NYS WQS Compliance for Erie Basin
(System-wide Alternative UA2)
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$35
$30
$25
$20
$15
$10
$5
$0
0
10
20
30
40
50
60
70
80
90
100
NYS WQS Compliance (%)

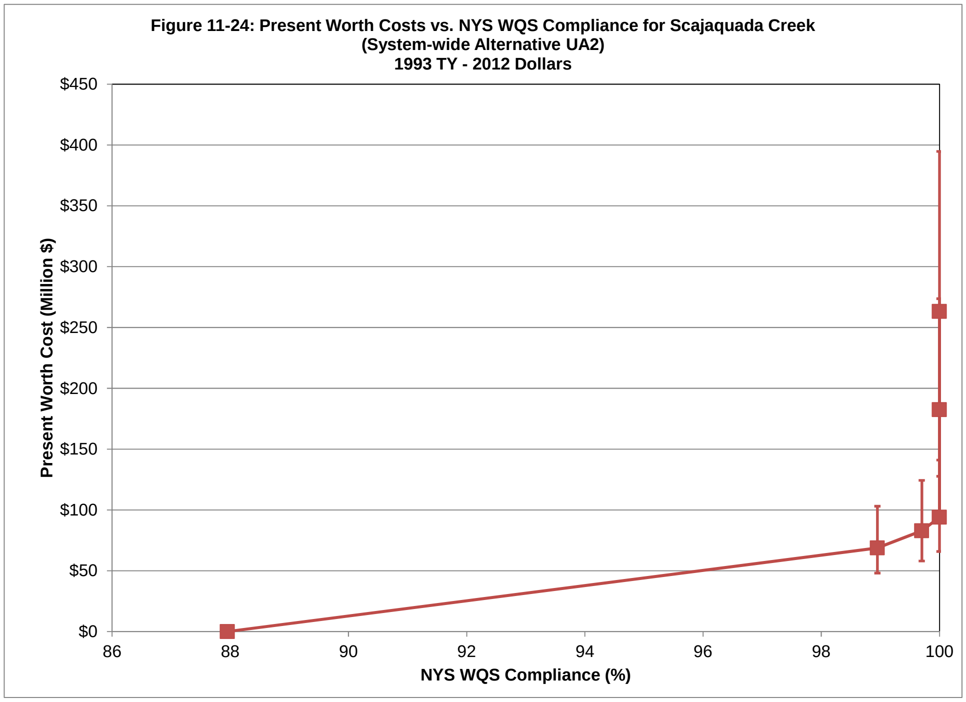


Figure 11-24: Present Worth Costs vs. NYS WQS Compliance for Scajaquada Creek
(System-wide Alternative UA2)
1993 TY - 2012 Dollars
Present Worth Cost (Million $)
$450
$400
$350
$300
$250
$200
$150
$100
$50
$0
86
88
90
92
94
96
98
100
NYS WQS Compliance (%)

- *System-wide Benefits:* The system-wide curves presented on Figure 11-25 through Figure 11-27 represent the cost and benefit of Alternative UA2 improvements at different LOCs, with the first point on the representing baseline conditions (no CSO controls beyond the already implemented Phase I and Non-Phase 1 projects). Figure 11-25 demonstrates that the knee of the Alternative UA2 benefit curve occurs at 6 OF/yr, at approximately $285 million. At that level, the residual CSO volume is approximately 360 MG and the percent capture is 98%. This represents a reduction in annual CSO volume of nearly 80%. The knee of the curve for each individual water body will likely be different given the specific conditions and responses within each basin.

- *Black Rock Canal:* The proposed Alternative UA2 improvements will provide significant benefits to the Black Rock Canal. The CSO volumes are projected to be reduced from over 300 MG under Revised Baseline conditions to less than 15 MG at the 2 LOC. As shown on the figures in Appendix 11-4, present worth project costs (including the Revised Foundation Plan and GI costs) for this alternative range from $19M for the 12 OF LOC to almost $327M for the 0 OF LOC. The knee of the Alternative UA2 benefit curve based on activation frequency and volume occurs at 4 OF/yr, at approximately $31 million. At that level, the residual CSO volume would be less than 45 MG. This represents a reduction in annual CSO volume of nearly 86%. Water quality simulations were run and the knee of the curve for Black Rock Canal is 4 OF LOC, where the model indicates the Alternative UA2 improvements would bring Black Rock Canal into 100% compliance with NYS bacteria WQS (assuming reduced background conditions).

- *Buffalo River:* The proposed Alternative UA2 improvements will provide significant benefits to Buffalo River. CSO volumes are projected to be reduced from over 380 MG under Revised Baseline conditions to less than 29 MG at the 2 LOC. As shown on the graphs in Appendix 11-4, present worth project costs (including the Revised Foundation Plan and GI costs) for this alternative range from $71M for the 12 OF LOC to almost $665M for the 0 OF LOC. The knee of the Alternative UA2 benefit curve based on activation frequency and volume occurs at 6 OF/yr, at approximately $83 million. At that level, the residual CSO volume would be less than 160 MG. This represents a reduction in annual CSO volume of nearly 60%. Water quality simulations were run and the knee of the curve for Buffalo River is at 12 OF LOC, where the model indicates the Alternative UA2 improvements would bring Buffalo River into 100% compliance with NYS bacteria WQS (assuming reduced background conditions).

- *Cazenovia Creek:* The proposed Alternative UA2 improvements will provide significant benefits to Cazenovia Creek. CSO volumes are projected to be reduced from over 35 MG under Revised Baseline conditions to less than 2.5 MG at the 12 LOC. As shown in Appendix 11-4 and Table 11-23, present worth project costs (including the Revised Foundation Plan and GI costs) for this alternative range from $4M for the 12 OF LOC to almost $59M for the 0 OF LOC. The knee of the Alternative UA2 benefit curve based on activation frequency and volume occurs at 6 OF/yr, at approximately $3.5 million. At this level of control, the residual CSO volume would be approximately 15 MG. This represents a reduction in annual CSO volume of 57%. Water quality simulations for Cazenovia Creek were run as part of the Buffalo River analysis.

- *Erie Basin:* The proposed Alternative UA2 improvements will provide significant benefits to Erie Basin. CSO volumes are projected to be reduced from over 10 MG under Revised Baseline conditions to less than 1 MG at the 2 LOC. As shown on the graphs in Appendix 11-4 and in Table 11-23, present worth project costs (including the Revised Foundation Plan and GI costs) for this alternative range from $3M for the 12 OF LOC to almost $20M for the 0 OF LOC. The knee of the Alternative UA2 benefit curve based on activation frequency and volume occurs at 6 OF/yr, at approximately $2.8 million. At that level, the residual CSO volume would be less than 5 MG (around 4.8 MG). This represents a reduction in annual CSO volume of over 50%. Water quality simulations were run and the model indicates that the Erie Basin is 100% compliant with NYS bacteria WQS (assuming reduced background conditions) for all levels of control.

- *Niagara River (including CSO 055):* The proposed Alternative UA2 improvements will provide significant benefits to Niagara River. CSO volumes are projected to be reduced from over 735 MG under Revised Baseline conditions to approximately 20 MG at the 2 LOC. As shown on the graphs in Appendix 11-4 and in Table 11-23, present worth project costs (including the Revised Foundation Plan and GI costs) for this alternative range from $56M for the 12 OF LOC to almost $215M for the 0 OF LOC. The knee of the Alternative UA2 benefit curve based on activation frequency and volume occurs between the 12 and 6 OF/yr, at approximately $80 million. At that level, the residual CSO volume would be 100 MG. This represents a reduction in annual CSO volume of nearly 86%. Water quality simulations were run and the model indicates that the Niagara River is100% compliant with NYS bacteria WQS (assuming reduced background conditions) for all levels of control.

- *Scajaquada Creek:* The proposed Alternative UA2 improvements will provide significant benefits to Scajaquada Creek. CSO volumes are projected to be reduced from over 270 MG under Revised Baseline conditions to less than 18 MG at the 2 LOC. As shown on the graphs in Appendix 11-4 and Table 11-23, present worth project costs (including the Revised Foundation Plan and GI costs) for this alternative range from $68M for the 12 OF LOC to $263M for the 0 OF LOC. The knee of the Alternative UA2 benefit curve based on activation frequency and volume occurs at 4 OF/yr, at approximately $95 million. At that level, the residual CSO volume would be less than 43 MG. This represents a reduction in annual CSO volume of nearly 84%. Water quality simulations were run and the knee of the curve for Scajaquada Creek is at 4 OF LOC, where the model indicates the Alternative UA2 improvements would bring Scajaquada Creek into 100% compliance with NYS bacteria WQS (assuming reduced background conditions).

Figure 11-25: Present Worth Costs vs. Frequency of Activation for System-wide Alternative UA2 1993 TY - 2012 Dollars

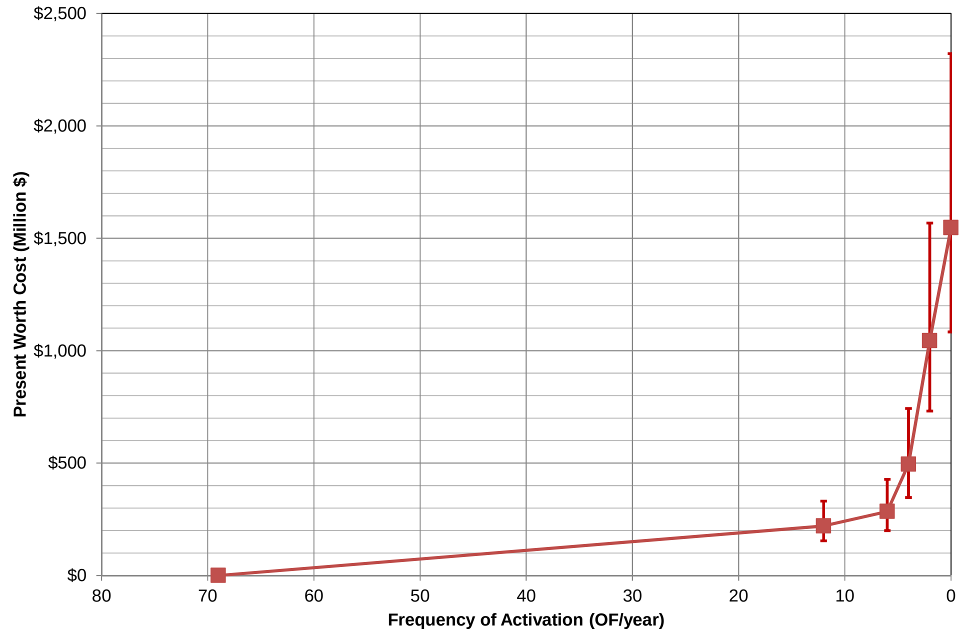
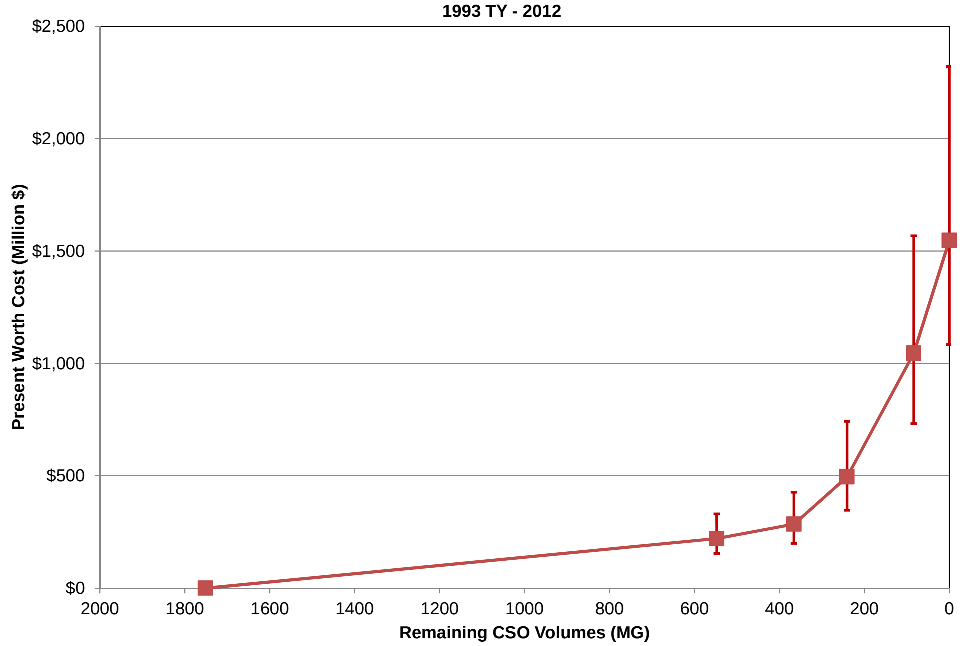
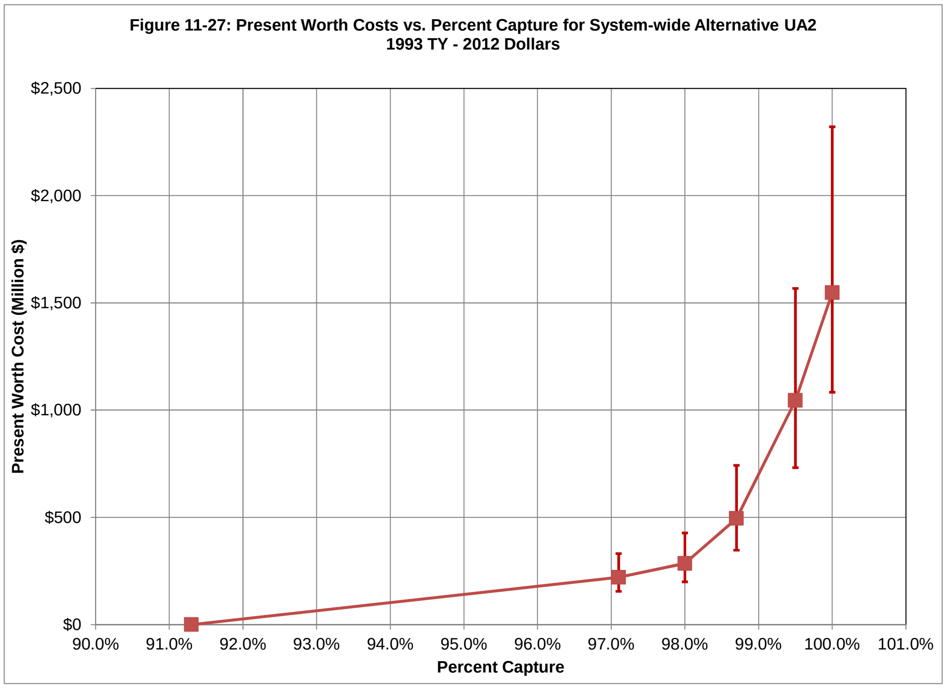


Figure 11-26: Present Worth Costs vs. Remaining CSO Volumes for System-wide Alternative UA2 1993 TY - 2012





11.6.2.4.2 Water Quality Compliance

Alternative UA2 was evaluated for each receiving water body in terms of remaining pollutant loads and NYS water quality standards compliance (bacteria only) for each receiving water body. For purposes of evaluating water quality compliance of Alternative UA2, a baseline scenario representing improved upstream water quality was chosen. This baseline scenario was previously documented in *Technical Memorandum: Baseline Water Quality Modeling For Buffalo River, Scajaquada Creek, Niagara River, and Black Rock Canal* (LimnoTech, March 30, 2012) and presented in Appendix 6-3. This baseline scenario incorporates upstream water quality conditions set at 75% of the WQS (CBOD has no WQS, so it was set to 75% of the existing conditions upstream concentration). These modified upstream boundary conditions were identical for both the Baseline scenario used in this report and Alternative UA2.

To represent the satellite treatment discharges, bacteria concentrations for treated CSO flows were set to 400 #/100 mL for the first hour and 200 #/100 mL for the remainder of each event. This represents 50% BOD removal relative to untreated CSO discharges. Storm water and upstream bacteria concentrations were set to 150 #/100 mL, and BOD concentrations set to 75% existing conditions.

Attainment of the bacteria WQS for each water body under Alternative UA2 was calculated from model output and compared to the bacteria WQS attainment for the baseline condition. Table 11-25 provides a summary of annual percent attainment of bacteria water quality standards for all modeled water bodies under these two scenarios. Attainment was first calculated for each model segment and then spatially averaged across each water body.

All water bodies demonstrated 100% attainment of the bacteria WQS under the Alternative UA1 scenario for the higher levels of control (0, 2 and 4 OF/yr). The greatest improvement was observed for Lower Scajaquada Creek, where attainment increased from 77% in the Baseline (Background 75% of WQS) scenario to 100% in the Alternative UA2 scenario for the 0, 2 and 4 OF/yr LOCs. Additionally, bacteria WQS attainment increased from 85.5% to 100% for Black Rock Canal, from 93.1% to 100% for the Buffalo River, and from 98.9% to 100% for Upper Scajaquada Creek at the higher levels of control (0, 2 and 4 OF/yr). Upper Scajaquada and Buffalo River both saw improvement to 100% WQS attainment for all LOCs, including the 12 OF/yr LOC, and Erie Basin and the Niagara River remained unchanged at 100% attainment for Baseline conditions and all LOCs. Additional results for each water body can be found in Appendix 11-4 for all RWBs.

Table 11-25: Water Quality Standards Attainment for Bacteria Comparison of Baseline Scenario with Alternative UA2 (1993 Typical Year; Averaged across Water Body and Typical Year)

Scenario	Bacteria: Annual Percent Attainment (%) of WQS					
	Upper Scajaquada Creek	Lower Scajaquada Creek	Buffalo River	Black Rock Canal	Erie Basin	Niagara River (incl. CSO 055)
Baseline (Bkgd 75% of WQS)	98.9	77.0	93.1	85.5	100.0	100.0
12 OF/yr	100.0	97.9	100.0	97.6	100.0	100.0
6 OF/yr	100.0	99.4	100.0	98.6	100.0	100.0
4 OF/yr	100.0	100.0	100.0	100.0	100.0	100.0
2 OF/yr	100.0	100.0	100.0	100.0	100.0	100.0
0 OF/yr	100.0	100.0	100.0	100.0	100.0	100.0

In addition to evaluating bacteria water quality compliance, residual bacteria loadings were also calculated for each RWB and LOC. Because the pollutant loadings were calculated using an assumed event mean concentration that was applied to the remaining CSO volumes, the cost-benefit curves for pollutant loadings look very similar to the cost benefit curves for residual CSO volumes (Appendix 11-4). Therefore, pollutant loading curves for each RWB are also presented in Appendix 11-4. Water quality compliance was not calculated on a system-wide basis.

11.6.3 Alternative UA3 – System-wide Tunnel

Alternative UA3 consists of the construction of deep-rock tunnels to provide storage for the majority of the BSA's CSOs. The mining of tunnels below grade is typically an effective method of providing off-line storage in congested urban areas. Seven remaining CSOs not controlled by the system-wide tunnels (CSO 003, 051, 052, 055, 056, 060, and 066) would be captured or controlled through satellite storage facilities.

11.6.3.1 Description of Alternative

Alternative UA3 builds upon the Revised Foundation Alternative, and does not include GI as part of the alternative technologies. This alternative involves the boring of storage tunnels well below grade, and if possible, within bedrock. The tunnels would be sized to store overflows from all captured regulators up to a predetermined control level. Regulator overflow pipes would be connected to tunnel drop shafts. This system-wide tunnel alternative contains two tunnels:

- East-West Tunnel: Follows the Scajaquada Drain and terminates near SPP 170.
- North-South Tunnel: Follows the Buffalo River to near the Erie Basin Marina, then turns north and follows Black Rock Canal to the WWTP.

Table 11-26 provides the technologies and sizes for each level of control applied in Alternative UA3 for each receiving water. Reasonable tunnel alignments allow for efficient capture of all but seven of the BSA's CSOs. These tunnel alignments and other components (to control the remaining seven CSOs) of Alternative UA3 are presented on Figure 11-28.

11.6.3.2 Proposed Facilities and Operational Concepts

Facility configurations and operational concepts for the local off-line storage basins included in Alternative UA3 and located in the Buffalo River, Niagara River, and Scajaquada Creek basins have been presented in Sections 11.6.2.1 and 11.6.2.2, respectively. Four satellite storage facilities will be required to control CSO discharges from seven CSOs in these basins. At the 12 OF LOC, only one facility is required at CSO 055. The other six CSOs do not need control at that level. CSO 003 would need additional storage only at the 0 OF LOC.

Storage facilities at CSO 055 and 003 would control discharges only for those CSOs. In both cases, the satellite storage facility would operate between the current SPP and the receiving water (*i.e.*, would be constructed such that the facility would be filled from the overflow conduit by gravity). When the SPP activates, overflow would flow to the storage basin. When the basin fills, subsequent overflow from the SPP during the event would bypass the facility and be discharged to the receiving stream. This discharge would

Table 11-26: Components of System-wide Alternative UA3 (System-wide Tunnel and Revised Foundation)

Storage

	Receiving Basin	Volume (MG)				
		0 OF	2 OF	4 OF	6 OF	12 OF
CSO 003	Niagara River	0.12	0	0	0	0
CSO 051/052/066	Buffalo River	15	3.8	2.75	2.5	0
CSO 056/060	Scajaquada Creek	0.5	0.25	0.14	0	0
CSO 055	Niagara River	76.2	54.1	37	28	13.3
Total		**91.82**	**58.15**	**39.89**	**30.50**	**13.30**

Tunnel Storage

	Receiving Basin	Volume (MG) / Dewatering (MGD): Top Row; Diameter (ft): Bottom Row					Length (ft)
		0 OF	2 OF	4 OF	6 OF	12 OF	
North-South Volume	Black Rock Canal	157.2	70	36	29	7.9	36,600
North-South Diameter		27	18	13	12	7	
East-West Volume	Scajaquada Creek	53.6	30	16	7.4	3.2	14,200
East-West Diameter		25	19	14	9	7	
Total		**210.8**	**100.0**	**52.0**	**36.4**	**11.1**	**50,800**

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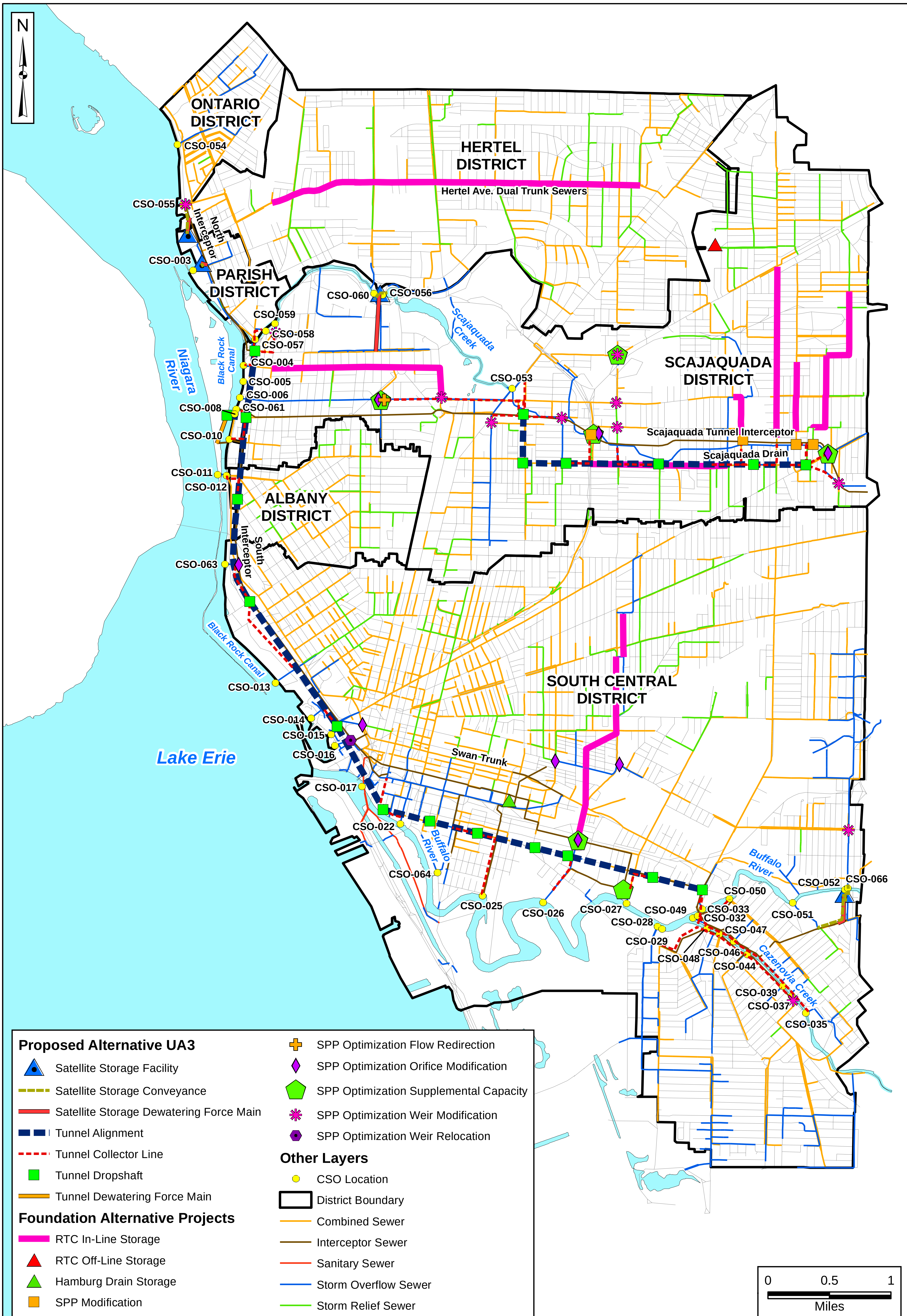

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BUFFALO SEWER AUTHORITY
Long Term Control Plan Update

FIGURE 11-28

ALTERNATIVE UA3
SYSTEM-WIDE TUNNEL

be considered a CSO event in the new system. After the storm when the conveyance and plant capacity become available, the basin would be dewatered to the interceptor via a pump station sized to empty the basin within 24 to 48 hours (based on the 1993 modified typical year precipitation storm patterns). Storage facilities would capture all of the volume associated with overflow events up to the selected storage control level, and the first flush of larger events.

For the other two proposed storage facilities, CSOs would be consolidated to the storage facility. One facility would be used to control both CSO 056 and 060, and one facility would be required to control CSOs 051, 052, and 066. In either case, the SPPs would remain the primary discharge point, where flows in excess of the LOC would bypass these facilities and discharge to the receiving water through the existing CSO outfalls. After the storm when the conveyance and plant capacity become available, the basins would be dewatered to the interceptor via a pump station sized to empty the basin within 24 to 48 hours (based on the 1993 modified typical year precipitation storm patterns). Storage facilities would capture all of the volume associated with overflow events up to the selected storage control level, and the first flush of larger events.

Storage tunnels can be used to capture wet-weather flows, attenuate peak flows during storm events, and may also provide additional dry-weather capacity for the system. When an SPP or CSO along the proposed tunnel route overflows, CSO discharges up to a predetermined control level would be directed to the tunnel for storage until the WWTP could treat the excess flows. Flows above the control level or flows that occur when the tunnel is full would bypass the tunnel and discharge through the existing SPP or CSO outfall. The system would be designed to fill by gravity flow, although pumping to the interceptor or WWTP for dewatering would be required.

The storage tunnels proposed for the BSA’s system are assumed to be constructed at a depth of approximately 125 feet below grade using tunnel-boring machines. The actual design depth would depend on several factors, including the results of a geotechnical investigation to determine the depth of bedrock along the proposed route. The tunnel alignment would likely be well below ground water for its entire length.

Tunnel construction typically requires entrance and exit shafts and, depending on the length and alignment, additional work shafts. These shafts could also provide connections to SPPs or consolidation piping from SPPs for conveying CSO flows to the tunnel during the operation. Additional drop shafts may be required in some cases to optimize the consolidation piping and the overall alternative costs. Ventilation and odor control would also be included with the facility. The proposed tunnels would provide storage for overflow volume for the captured SPPs along their alignment up to the capacity of the selected control level for those SPPs. During a storm event, CSO discharge currently directed to a receiving stream from an SPP would flow to the tunnel up to the control level. Once the tunnel is filled, the CSOs would discharge to the receiving streams through the existing outfalls.

In general, the tunnels in Alternative UA3 would discharge either to the WWTP (in the case of the North-South tunnel from Buffalo River up to the Black Rock Canal) or back into the Scajaquada Interceptor (in the case of the East-West Tunnel). The SPPs discharging to the tunnels will remain active and function as the overflow points (as they do during existing conditions). Tunnel dewatering pumps would be used to return the contents of the tunnel to the interceptor or the WWTP after the storm event. The pumps would be sized to empty the tunnel volume based on the available conveyance system and treatment capacity, with dewatering times targeted for 24 to 48 hours based on the 1993 modified typical year precipitation storm patterns. However, actual dewatering time would depend upon the actual precipitation patterns as they may affect the available conveyance and WWTP capacity.

11.6.3.3 Preliminary Costs

Costs for Alternative UA3 were developed based on the unit cost curves presented in Section 7. Costs presented here include capital costs for all facilities, collector pipes, and associated dewatering pumps and appurtenances. The estimated present worth project cost in 2012 dollars for Alternative UA3 varies from approximately $340 million for the 12 OF/yr level of control (LOC) to just over $1.2 billion for the 0 OF/yr level of control. Table 11-27 summarizes the cost breakdown by receiving water for each LOC and Appendix 11-5 presents the back-up documentation for the cost estimate.

Table 11-27: Estimated Present Worth Project Costs for System-Wide Alternative UA3 (2012 Dollars; O&M Included)

Receiving Basin	Revised Foundation Plan	Estimated Present Worth Project Costs ($M)				
		0 OF	2 OF	4 OF	6 OF	12 OF
Black Rock Canal	$6.9	$633.3	$390.8	$271.1	$246.2	$130.0
Buffalo River	$41.1	$67.8	$33.9	$25.2	$24.2	$6.9
Cazenovia Creek - B	$0.0	$1.8	$1.8	$1.8	$0.0	$0.0
Cazenovia Creek - C	$0.02	$7.8	$7.8	$7.8	$7.0	$7.0
Erie Basin	$0.00	$0.9	$0.9	$0.1	$0.1	$0.0
Niagara River (includes CSO 055)	$8.7	$198.9	$151.1	$112.6	$91.1	$52.8
Scajaquada Creek	$27.8	$231.5	$168.8	$120.6	$75.9	$56.3
Sub-Total	**$84.5**	**$1,142.0**	**$755.1**	**$539.2**	**$444.6**	**$253.1**
Total (with Revised Foundation Plan)		**$1,226.5**	**$839.6**	**$623.7**	**$529.1**	**$337.6**

11.6.3.4 Description of Benefits (Reduction in CSO Volumes/Frequencies)

Alternative UA3 was evaluated for each receiving water body and for 5 LOCs in terms of CSO activations, reduction in CSO volumes, and system-wide percent capture. Residual volumes and remaining overflows are presented for each receiving water body, while percent capture is presented on a system-wide basis and not for each receiving water). Table 11-28 presents a summary of the predicted frequencies, residual CSO volumes, and percent capture for this alternative. Specific activation and volume results for each CSO are presented in Appendix 11-5. Figures 11-29 through 11-31 present the cost-benefit charts for the Alternative UA3 activation frequency, remaining CSO volumes, and percent capture, respectively. The cost-benefit curves for individual RWBs are included in Appendix 11-5.

In addition to evaluating bacteria water quality compliance, residual bacteria loadings were also calculated for each RWB and LOC. Because the pollutant loadings were calculated using an assumed event mean concentration that was applied to the remaining CSO volumes, the cost-benefit curves for residual bacteria loadings look very similar to the cost benefit curves for residual CSO volumes (Appendix 11-5).

Table 11-28: Predicted Annual CSO Only (Excluding Storm water and Stream Inflows) Volumes and Frequencies for Alternative UA3 by Receiving Water Body (Modified 1993 TY)

	Projected Activations (Events/Year)					Residual CSO Volume (MG)				
Receiving Water Body	**Revised Baseline**	**12 OF**	**6 OF**	**4 OF**	**2 OF**	**Revised Baseline**	**12 OF**	**6 OF**	**4 OF**	**2 OF**
Black Rock Canal	4 - 65	1 - 9	0 - 6	0 - 4	0 - 2	319.3	127.8	68.3	49.3	21.9
Buffalo River	4 - 69	1 - 10	2 - 6	2 - 4	0 - 2	379.7	170.8	132.9	126.1	81.5
Cazenovia Cr.-B	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Cazenovia Cr.-C	1 - 44	0 - 9	0 - 3	0 - 3	0 - 2	35.6	18.8	10.3	9.3	5.2
Erie Basin	0 - 12	0 - 4	0 - 2	0 - 2	0	10.3	5.5	2.3	1.7	0.0
Niagara River (incl. CSO 055)	0 - 41	0 - 10	0 - 6	0 - 4	0 - 2	735.5	289.6	138.3	95.1	52.1
Scajaquada Creek	0 - 65	0 - 8	0 - 6	0 - 4	0 - 2	268.7	75.0	68.6	46.0	29.2
Totals	NA	NA	NA	NA	NA	1,749.1	687.5	420.8	327.4	190.0
Percent Capture	NA	NA	NA	NA	NA	91.3%	96.8%	98.0%	98.5%	99.1%

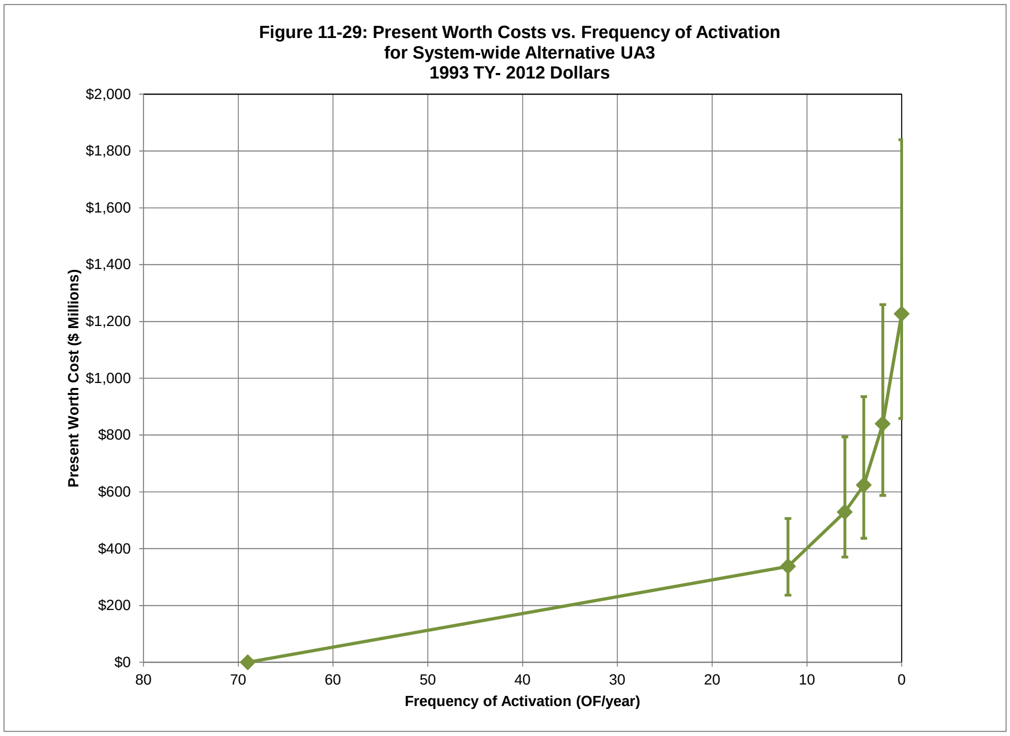


Figure 11-29: Present Worth Costs vs. Frequency of Activation
for System-wide Alternative UA3
1993 TY- 2012 Dollars
Present Worth Cost ($ Millions)
$2,000
$1,800
$1,600
$1,400
$1,200
$1,000
$800
$600
$400
$200
$0
80
70
60
50
40
30
20
10
0
Frequency of Activation (OF/year)

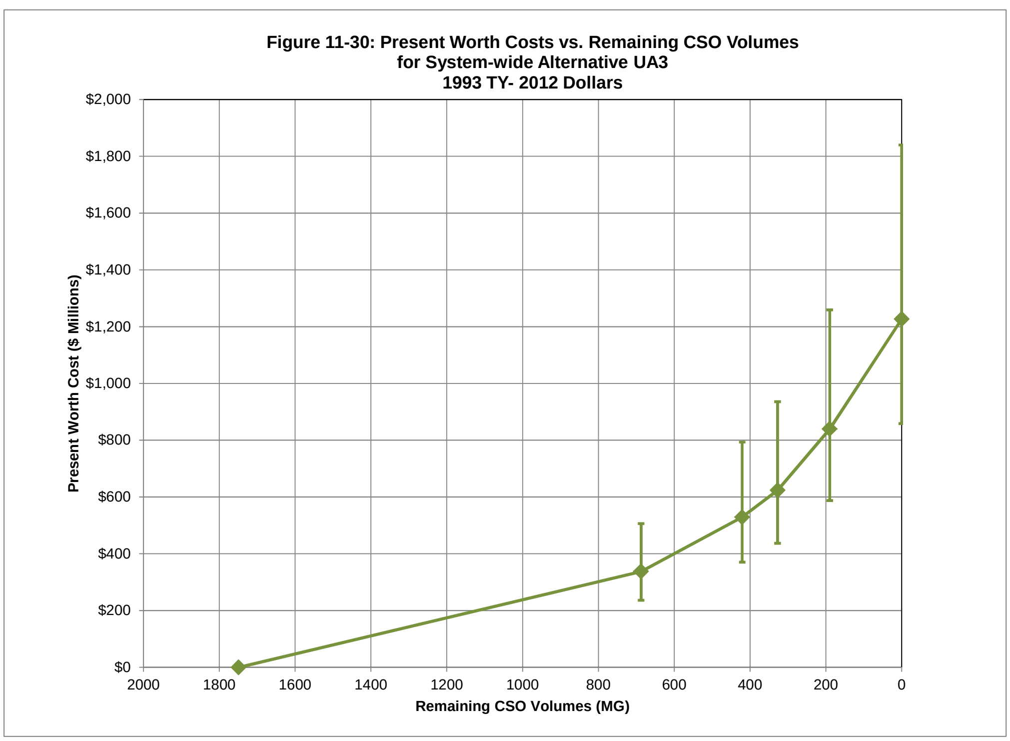
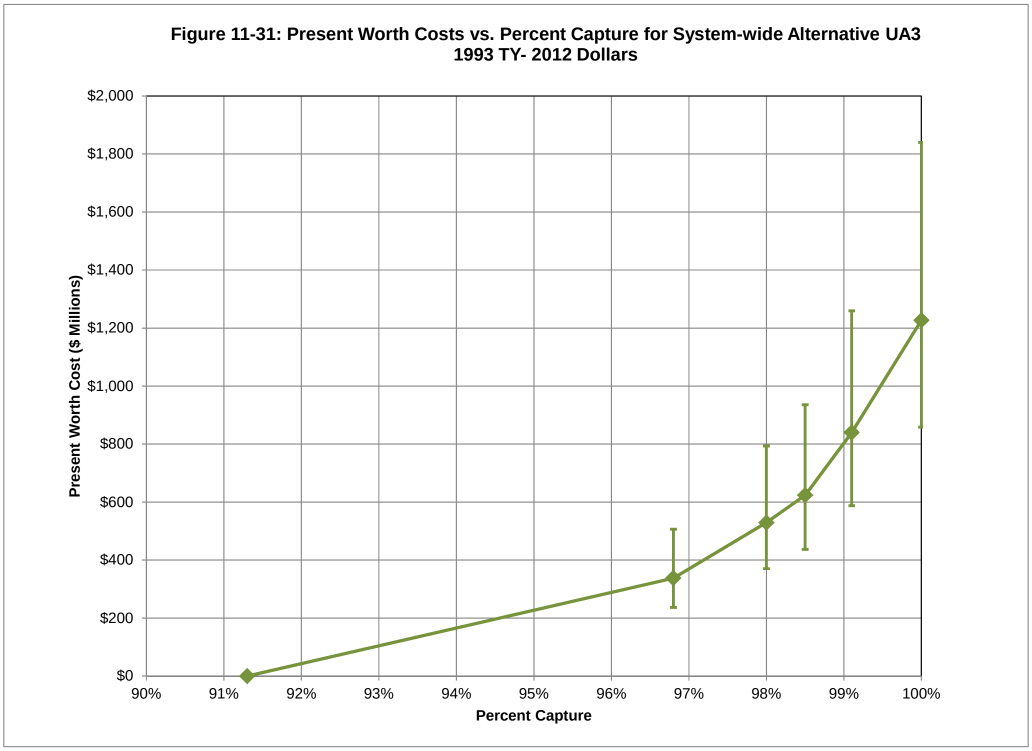


Figure 11-30: Present Worth Costs vs. Remaining CSO Volumes
for System-wide Alternative UA3
1993 TY- 2012 Dollars
Present Worth Cost ($ Millions)
$2,000
$1,800
$1,600
$1,400
$1,200
$1,000
$800
$600
$400
$200
$0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Remaining CSO Volumes (MG)



As can be seen, implementation of the UA3 improvements results in significant system-wide CSO volume and frequency reductions. The Alternative UA3 projects are projected to reduce CSO volumes from 60 percent for the 12 OF LOC to 90 percent for the 2 OF LOC, compared to Revised Baseline conditions. The percent capture increases from 91.3% for the Revised Baseline Conditions to 98.5% for the 2 OF LOC.

- *System-wide Benefits:* The system-wide curves presented on Figures 11-29 through 11-31 represent the costs and benefits of Alternative UA3 improvements for different LOCs, with the first point on the representing baseline conditions (*i.e.*, no CSO controls beyond the already implemented Phase I projects). Figure 11-29 demonstrates that the knee of the Alternative UA3 benefit curve occurs at 12 OF/yr, at approximately $340 million. At that level, the residual CSO volume would be around 700 MG and the percent capture would be nearly 97%. This represents a reduction in annual CSO volume of nearly 89%. The knee of the curve for each individual water body will likely be different given the specific conditions and responses within each basin.

- *Black Rock Canal:* The proposed Alternative UA3 improvements will provide significant benefits to the Black Rock Canal. CSO volumes are projected to be reduced from over 300 MG under Revised Baseline conditions to less than 25 MG at the 2 LOC. As shown on the figures in Appendix 11-5 and

Table 11-27, costs (including O&M) for this alternative range from $137M for the 12 OF LOC to $640M for the 0 OF LOC. The knee of the Alternative UA3 benefit curve based on activation frequency and volume occurs at 12 OF/yr, at approximately $137 million. At that level, the residual CSO volume would be less than 130 MG. This represents a reduction in annual CSO volume of nearly 60%. Water quality simulations were not run for Alternative UA3.

- *Buffalo River:* The proposed Alternative UA3 improvements will provide significant benefits to Buffalo River. CSO volumes are projected to be reduced from over 380 MG under Revised Baseline conditions to less than 82 MG at the 2 LOC. As shown on the graphs in Appendix 11-5 and Table 11-27, costs (including O&M) for this alternative range from $48M for the 12 OF LOC to almost $109M for the 0 OF LOC. The knee of the Alternative UA3 benefit curve based on activation frequency and volume occurs at 4 OF/yr, at approximately $67 million. At that level, the residual CSO volume would be less than 130 MG. This represents a reduction in annual CSO volume of nearly 66%. Water quality simulations were not run for Alternative UA3.

- *Cazenovia Creek:* The proposed Alternative UA3 improvements will provide significant benefits to Cazenovia Creek. CSO volumes are projected to be reduced from over 35 MG under Revised Baseline conditions to less than 6 MG at the 2 LOC. As shown on the graphs in Appendix 11-5 and Table 11-27, costs (including O&M) for this alternative for this alternative range from $7.1M for the 12 OF LOC to almost $9.6M for the 0 OF LOC. The Alternative UA3 benefit curve is flat, based on activation frequency and volume, with a cost ranging from $7.1M to $9.6M. For the 0 OF/year level of control, the residual CSO volume would be 0 MG. This represents a reduction in annual CSO volume of nearly 100%. Water quality simulations were not run for Alternative UA3.

- *Erie Basin:* The proposed Alternative UA3 improvements will provide significant benefits to Erie Basin. CSO volumes are projected to be reduced from over 10 MG under Revised Baseline conditions to less than 2 MG at the 2 LOC. As shown on the graphs in Appendix 11-5 and Table 11-27, costs (including O&M) for this alternative range from $0.01M for the 12 OF LOC to almost $0.90M for the 0 OF LOC. The knee of the Alternative UA3 benefit curve based on activation frequency and volume occurs at 2 OF/yr, at approximately $0.13 million. At that level, the residual CSO volume would be less than 2MG (around 1.7 MG). This represents a reduction in annual CSO volume of nearly 84%. Water quality simulations were not run for Alternative UA3.

- *Niagara River (including CSO 055):* The proposed Alternative UA3 improvements will provide significant benefits to Niagara River. CSO volumes are projected to be reduced from over 735 MG under Revised Baseline conditions to approximately 52 MG at the 2 LOC. As shown on the figures in Appendix 11-5 and Table 11-27, costs (including O&M) for this alternative range from $61M for the 12 OF LOC to almost $210M for the 0 OF LOC. The knee of the Alternative UA3 benefit curve, based on activation frequency and volume, occurs at 4 OF/yr, at approximately $120 million. At that level, the residual CSO volume would be 95 MG. This represents a reduction in annual CSO volume of nearly 87%. Water quality simulations were not run for Alternative UA3.

- *Scajaquada Creek::* The proposed Alternative UA3 improvements will provide significant benefits to Scajaquada Creek. CSO volumes are projected to be reduced from over 265 MG under Revised Baseline conditions to less than 30 MG at the 2 LOC. As shown on the figures in Appendix 11-5 and Table 11-27, costs (including O&M) for this alternative range from $85M for the 12 OF LOC to $260M for the 0 OF LOC. The knee of the Alternative UA3 benefit curve, based on activation frequency and volume occurs at 6 OF/yr, at approximately $105 million. At that level, the residual CSO volume would be less than 69 MG. This represents a reduction in annual CSO volume of nearly 74%. Water quality simulations were not run for Alternative UA3.

11.6.4 *Alternative UA3A* – System-wide Tunnel with North Relief/HRT at the Plant

Alternative UA3A consists of the construction of deep-rock tunnels to provide storage for the majority of BSA's CSOs, as described in Section 11.6.3, with the exception of the tunnel along Black Rock Canal. There, the leg of the North-South Tunnel that runs from CSO 004 along Black Rock Canal down to CSOs 011/012 is replaced with a relief sewer that will convey excess flows to the siphon across Black Rock Canal and into the headworks of the WWTP. In addition, a new pump station will be constructed near the siphon crossing to pump flows to a new EHRT located on the north side of the WWTP. As with Alternative UA3, any remaining CSOs not captured by the tunnels/relief sewer would be captured or controlled through a combination of satellite storage facilities and the Revised Foundation Alternative. This alternative, as with Alternative UA3, does not include any GI as part of the control technologies.

11.6.4.1 Description of Alternative

Alternative UA3A builds upon the Revised Foundation Alternative, and does not include GI as part of the alternative technologies. This alternative maintains nearly all of the tunnels proposed in Alternative UA3, but incorporates alternative technologies for the Black Rock Canal CSOs and for CSO 011. This system-wide tunnel alternative contains two tunnels:

- East-West Tunnel: Follows the Scajaquada Drain and terminates near SPP 170.

- North-South Tunnel: Follows the Buffalo River to near the Erie Basin Marina, then turns north and follows Black Rock Canal to approximately CSO 013.

- North Relief Sewer: Replaces the portion of the North-South tunnel in UA3 with the relief sewer alternative that is part of UA2. For higher levels of control (2 OF and 0 OF LOCs), additional controls in the form of a high-rate treatment facility would be required at the WWTP.

Table 11-29 provides the technologies and sizes for each LOC applied in Alternative UA3A for each RWB. As with Alternative UA3, the tunnel and relief sewer alignments allow for efficient capture of all but seven of the BSA's CSOs (CSO 003, 051, 052, 055, 056, 060 and 066). These tunnel alignments and other components (to control the remaining seven CSOs) of Alternative UA3A are presented in Figure 11-32.

11.6.4.2 Proposed Facilities and Operational Concepts

Facility configurations and operational concepts for the tunnel portions of this alternative are described as part of the UA3 discussions in Section 11.6.3, while the relief sewer components are described in the UA2 discussions in Section 11.6.2.

11.6.4.3 Preliminary Costs

Costs for Alternative UA3A were developed based on the unit cost curves presented in Section 7. Costs presented here include capital costs for all facilities, collector pipes, and associated dewatering pumps and appurtenances. Operations and maintenance (O&M) costs are not summarized in this phase of the alternative evaluation. The estimated present worth project cost in 2012 dollars for Alternative UA3A varies from approximately $300 million for the 12 OF/yr level of control (LOC) to just over $1.3 billion for the 0 OF/yr level of control. Table 11-30 summarizes the cost breakdown by receiving water for each LOC and Appendix 11-6 presents the back-up documentation for the cost estimate.

Table 11-30: Estimated Present Worth Project Costs for System-Wide Alternative UA3A (2012 Dollars; O&M Included)

Receiving Basin	Revised Foundation Plan	Estimated Present Worth Project Costs ($M)				
		0 OF	2 OF	4 OF	6 OF	12 OF
Black Rock Canal	$6.9	$763.5	$463.7	$158.5	$103.4	$94.9
Buffalo River	$41.1	$67.8	$33.9	$25.2	$22.9	$6.1
Cazenovia Creek - B	$0.0	$1.8	$1.8	$1.8	$0.0	$0.0
Cazenovia Creek - C	$0.02	$7.8	$7.8	$7.8	$6.6	$6.6
Erie Basin	$0.01	$0.9	$0.9	$0.9	$0.1	$0.0
Niagara River (includes CSO 055)	$8.7	$200.2	$147.5	$109.0	$87.5	$49.3
Scajaquada Creek	$27.8	$231.5	$167.7	$117.9	$72.8	$54.9
Sub-Total	**$84.5**	**$1,273.6**	**$823.4**	**$421.1**	**$293.3**	**$211.8**
Total (with Revised Foundation Plan)		**$1,358.1**	**$907.9**	**$505.6**	**$377.8**	**$296.3**

Table 11-29: Components of System-wide Alternative UA3A (System-wide Storage Tunnel with North Relief, HRT at Plant, and Revised Foundation)

Storage

	Receiving Basin	Volume (MG)				
		0 OF	2 OF	4 OF	6 OF	12 OF
CSO 003	Niagara River	0.12	0.00	0.00	0.00	0.00
CSO 051/052/066	Buffalo River	15.00	3.80	2.75	2.50	0.00
CSO 056/060	Scajaquada Creek	0.50	0.25	0.14	0.00	0.00
CSO 055	Niagara River	78.60	54.10	37.00	28.00	13.30
Total		**94.22**	**58.15**	**39.89**	**30.50**	**13.30**

High Rate Treatment

	Receiving Basin	Peak Flow (mgd)				
		0 OF	2 OF	4 OF	6 OF	12 OF
North Relief	Black Rock Canal	466.0	316.7	0.0	0.0	0.0
Total		**466.0**	**316.7**	**0.0**	**0.0**	**0.0**

Tunnel Storage

	Receiving Basin	Volume (MG) / Dewatering (MGD): Top Row; Diameter (ft): Bottom Row					Length (ft)
		0 OF	2 OF	4 OF	6 OF	12 OF	
North-South Volume	Black Rock Canal	105.74	32.64	14.51	7.11	7.11	24,700
North-South Diameter		27	15	10	7	7	
East-West Volume	Scajaquada Creek	53.6	30	16	7.4	3.2	14,200
East-West Diameter		25	19	14	9	7	
Total		**159.3**	**62.6**	**30.5**	**14.5**	**10.3**	**38,900**

Relief Piping

Receiving Basin	Length	Nominal Diameter (ft)				
		0 OF	2 OF	4 OF	6 OF	12 OF
Black Rock Canal	3,256	8	6	8.5	3	0
Black Rock Canal	2,066	8	9.5	8.5	7	4
Black Rock Canal	500	10	10	11	8	4
Total	**5,822**	**NA**	**NA**	**NA**	**NA**	**NA**

Underflow Piping

	Receiving Basin	Length (LF)					Nominal Diameter (ft)				
		0 OF	2 OF	4 OF	6 OF	12 OF	0 OF	2 OF	4 OF	6 OF	12 OF
CSO-04	Black Rock Canal	123	123	123	13	13	6	5	4.5	2.5	2.5
CSO-04	Black Rock Canal	0	0	0	110	110	0	0	O	0	0
CSO-08	Black Rock Canal	243	243	1,042	243	243	2.5	2	2	1.5	1
CSO-08	Black Rock Canal	799	799	577	799	799	3	2.5	2.5	2	0
CSO-08	Black Rock Canal	577	577	67	577	577	3.5	3	3	2.5	0
CSO-08	Black Rock Canal	67	67	0	67	67	4	3.5	0	3	0
CSO-10	Black Rock Canal	40	40	40	40	40	3.5	2.5	2	2	0
CSO-11	Black Rock Canal	0	0	0	0	0	0	0	0	0	0
CSO-12	Black Rock Canal	0	0	0	0	0	0	0	0	0	0
CSO-61	Black Rock Canal	50	50	50	50	50	6	5	6	6	0
	Total	**1,899**	**1,899**	**1,899**	**1,899**	**1,899**	**NA**	**NA**	**NA**	**NA**	**NA**

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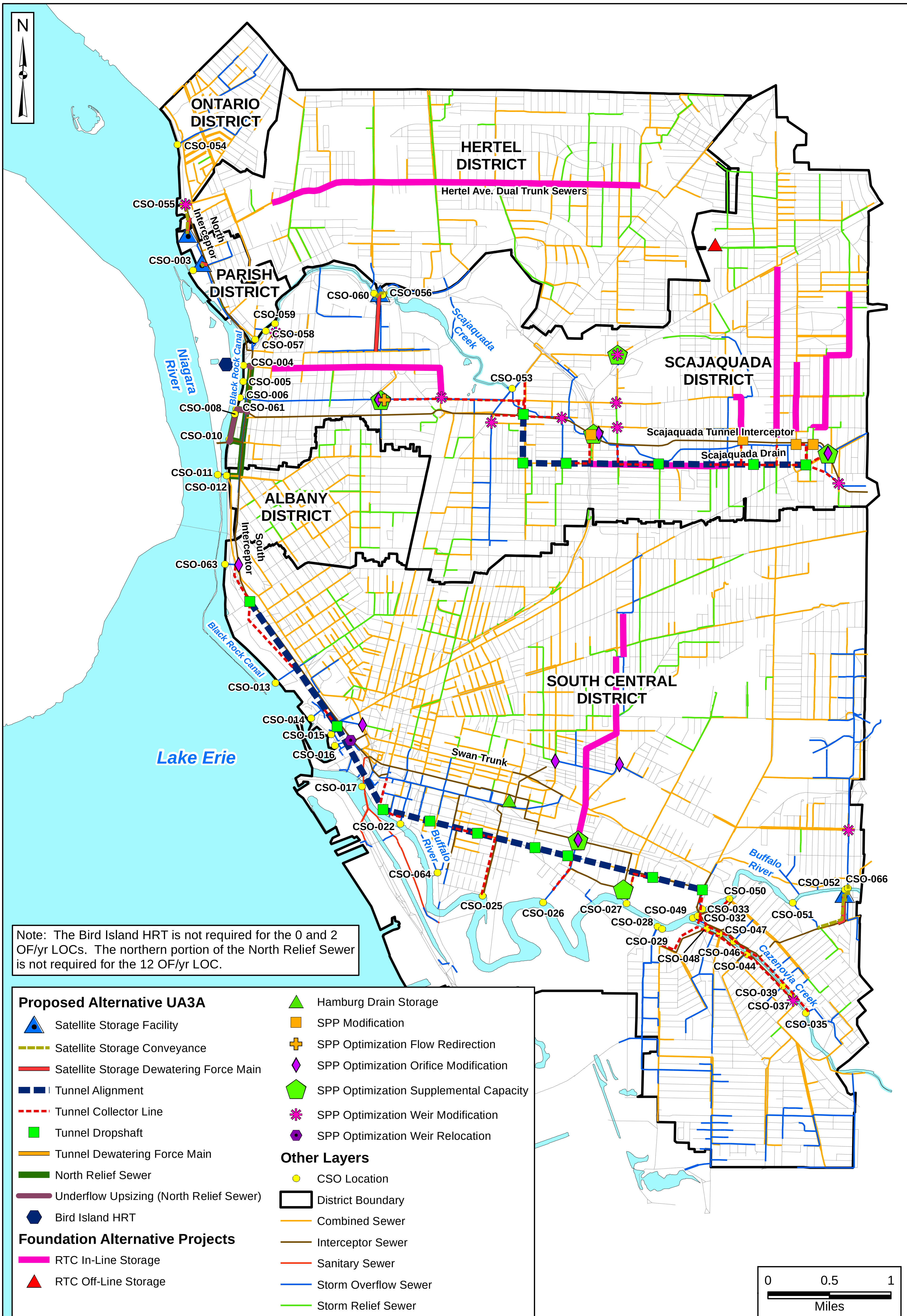

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FIGURE 11-32

ALTERNATIVE UA3A

11.6.4.4 Description of Benefits

Alternative UA3A was evaluated for each receiving water body for five LOCs in terms of CSO activations, reduction in CSO volumes, and system-wide percent capture. Residual volumes and remaining overflows are presented for each receiving water body while percent capture is presented on a system-wide basis (not for each receiving water). Table 11-31 presents a summary of the predicted frequencies, residual CSO volumes and percent capture for this alternative. Specific activation and volume results for each CSO are presented in Appendix 11-6. Figures 11-33 through 11-35 present the cost-benefit charts for Alternative UA3A for LOC, remaining CSO volumes, and percent capture, respectively. Appendix 11-6 provides similar cost-benefit curves for each RWB.

In addition to evaluating bacteria water quality compliance, residual bacteria loadings were also calculated for each RWB and LOC. Because the pollutant loadings were calculated using an assumed event mean concentration that was applied to the remaining CSO volumes, the cost-benefit curves for residual bacteria loadings look very similar to the cost benefit curves for residual CSO volumes (Appendix 11-6).

Table 11-31: Predicted Annual CSO Only (Excluding Storm water and Stream Inflows) Volumes and Frequencies for Alternative UA3A by Receiving Water Body (Modified 1993 TY)

	Projected Activations (Events/Year)					Residual CSO Volume (MG)				
Receiving Water Body	**Revised Baseline**	**12 OF**	**6 OF**	**4 OF**	**2 OF**	**Revised Baseline**	**12 OF**	**6 OF**	**4 OF**	**2 OF**
Black Rock Canal	4 - 65	1 - 9	1 - 6	0 - 4	0 - 2	319.3	97.9	74.8	34.1	7.6
Buffalo River	4 - 69	0 - 10	0 - 6	0 - 4	0 - 2	379.7	170.2	170.2	154.6	91.1
Cazenovia Cr.-B	0	0	0	0	0	0	0	0	0	0
Cazenovia Cr.-C	1 - 44	0 - 6	0 - 6	0 - 4	0 - 2	35.6	16.5	16.5	11.5	5.4
Erie Basin	0 - 12	0 - 4	0 - 4	0 - 2	0 - 2	10.3	4.9	4.9	4.8	<0.1
Niagara River (incl. CSO 055)	0 - 41	0 - 10	0 - 6	0 - 4	0 - 2	735.5	247.5	119.2	75.3	35.2
Scajaquada Creek	0 - 65	0 - 8	0 - 6	0 - 4	0 - 2	268.7	76.5	70.1	47.5	30.7
Totals	NA	NA	NA	NA	NA	1,749.1	613.5	455.7	327.8	170.0
Percent Capture	NA	NA	NA	NA	NA	91.3%	96.6%	97.5%	98.2%	99.0%

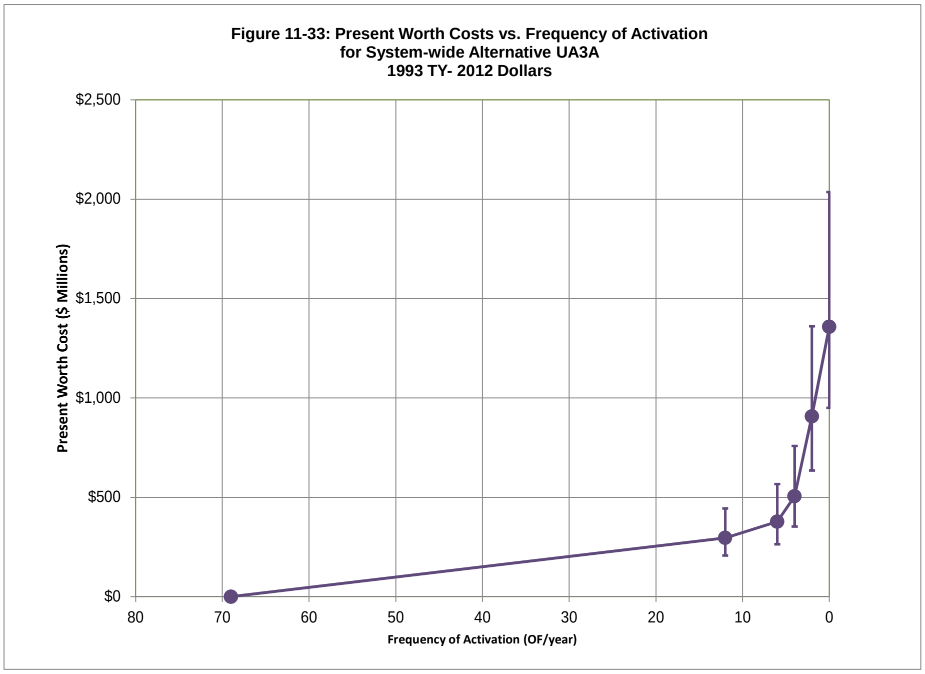


Figure 11-33: Present Worth Costs vs. Frequency of Activation
for System-wide Alternative UA3A
1993 TY- 2012 Dollars
Present Worth Cost ($ Millions)
$2,500
$2,000
$1,500
$1,000
$500
$0
80
70
60
50
40
30
20
10
0
Frequency of Activation (OF/year)

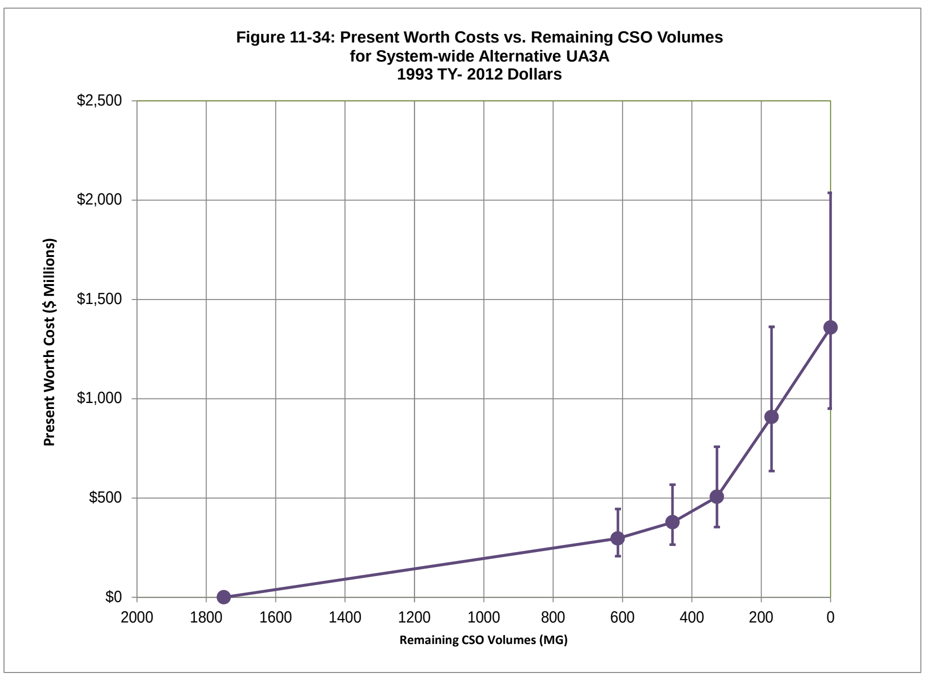
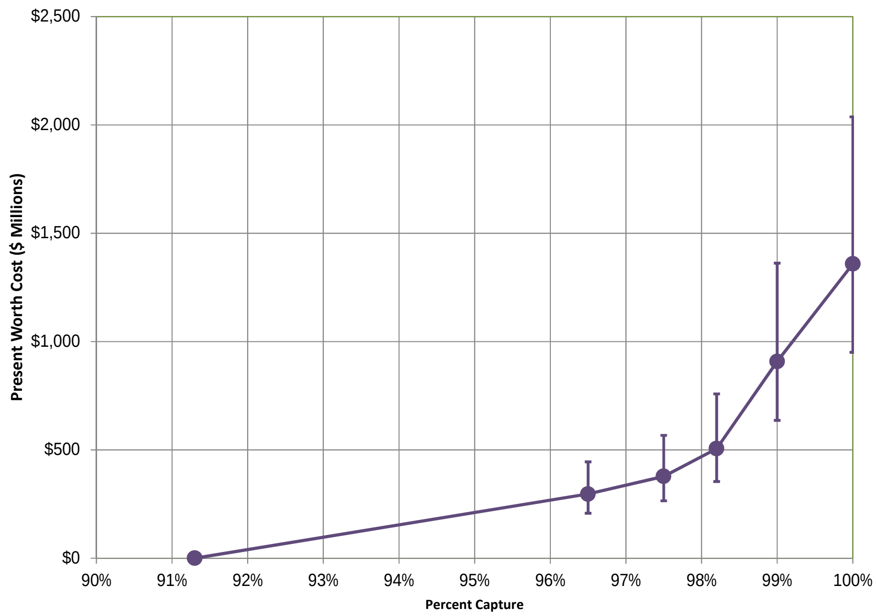


Figure 11-34: Present Worth Costs vs. Remaining CSO Volumes
for System-wide Alternative UA3A
1993 TY- 2012 Dollars
Present Worth Cost ($ Millions)
$2,500
$2,000
$1,500
$1,000
$500
$0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Remaining CSO Volumes (MG)

Figure 11-35: Present Worth Costs vs. Percent Capture for System-wide Alternative UA3A
1993 TY- 2012 Dollars



- *System-wide Benefits:* The system-wide curves presented on Figure 11-33 through Figure 11-35 represent the costs and benefits of Alternative UA3A improvements for different levels of control, with the first point on the representing baseline conditions (i.e., no CSO controls beyond the already implemented Phase I and Non-Phase 1 projects). Figure 11-33 demonstrates that the knee of the Alternative UA3A benefit curve occurs at 6 OF/yr, at approximately $380 million. At that level, the residual CSO volume would be around 456 MG and the percent capture would be 97.5%. This represents a reduction in annual CSO volume of nearly 74%. The knee of the curve for each individual water body will likely be different given the specific conditions and responses within each basin.

- *Black Rock Canal:* The proposed UA3A improvements will provide significant benefits to Black Rock Canal. CSO volumes are projected to be reduced from over 300 MG under Revised Baseline conditions to less than 10 MG at the 2 LOC. As shown on the graphs in Appendix 11-6 and Table 11-30, present worth project costs (including the Revised Foundation Plan) for this alternative range from $101M for the 12 OF LOC to $770M for the 0 OF LOC. The figures in Appendix 11-6 demonstrate that the knee of the Alternative UA3A benefit curve based on activation frequency and volume occurs at 6 OF/yr, at approximately $110 million. At that level, the residual CSO volume would be less than 75 MG. This represents a reduction in annual CSO volume of nearly 77%. Water quality simulations were not conducted for this alternative.

- *Buffalo River:* The proposed UA3A improvements will provide significant benefits to Buffalo River. CSO volumes are projected to be reduced from over 380 MG under Revised Baseline conditions to less than 100 MG at the 2 LOC. As shown on the figures in Appendix 11-6 and Table 11-30, present worth project costs (including the Revised Foundation Plan) for this alternative range from $47M for the 12 OF LOC to almost $110M for the 0 OF LOC. The figures in Appendix 11-6 demonstrate that the knee of the Alternative UA3A benefit curve based on activation frequency and volume occurs at 12 OF/yr, at approximately $50 million. At that level, the residual CSO volume would be about 170 MG. This represents a reduction in annual CSO volume of nearly 55%. Note that residual volumes for the Buffalo River CSOs are the same for both the 12 and 6 LOCs because the size for the storage tunnel is the same due to minimum tunnel diameter requirements. Water quality simulations were run not conducted for this alternative.

- *Cazenovia Creek:* The proposed UA3A improvements will provide significant benefits to Cazenovia Creek. CSO volumes are projected to be reduced from over 35 MG under Revised Baseline conditions to nearly 5 MG at the 12 LOC. As shown on the figures in Appendix 11-6 and Table 11-30, present worth project costs (including the Revised Foundation Plan) for this alternative for this alternative range from less than $7M for the 12 OF LOC to almost $10M for the 0 OF LOC. The figures in Appendix 11-6 demonstrate that the knee of the Alternative UA3A benefit curve based on activation frequency and volume occurs at 6 OF/yr, at approximately $7 million. At this level of control, the residual CSO volume would be approximately 17 MG. This represents a reduction in annual CSO volume of 54%. Note that residual volumes for the Cazenovia Creek CSOs are the same for both the 12 and 6 LOCs because the size for the storage tunnel is the same due to minimum tunnel diameter requirements. Water quality simulations were run not conducted for this alternative.

- *Erie Basin:* The proposed UA3A improvements will provide significant benefits to Erie Basin. CSO volumes are projected to be reduced from over 10 MG under Revised Baseline conditions to less than 0.1 MG at the 2 LOC. As shown on the figures in Appendix 11-6 and Table 11-30, present worth project costs (including the Revised Foundation Plan) for this alternative range from less than $0.1M for the 12 OF LOC to almost $1M for the 0 OF LOC. These cost represent consolidation to the tunnel drop shafts; costs of the tunnel are included in the Black Rock Canal costs. The figures in Appendix 11-6 demonstrate that the knee of the Alternative UA3A benefit curve based on activation frequency and volume occurs at 6 OF/yr, at approximately $0.1 million. At that level, the residual CSO volume would be less than 5 MG. This represents a reduction in annual CSO volume of over 50%. Note that residual volumes for the Erie Basin CSOs are the same for both the 12 and 6 LOCs because the size for the storage tunnel is the same due to minimum tunnel diameter requirements. Water quality simulations were run not conducted for this alternative.

- *Niagara River (including CSO 055):* The proposed UA3A improvements will provide significant benefits to Niagara River. CSO volumes are projected to be reduced from over 735 MG under Revised Baseline conditions to approximately 35 MG at the 2 LOC. As shown on the figures in Appendix 11-6 and Table 11-30, present worth project costs (including the Revised Foundation Plan) for this alternative range from nearly $60M for the 12 OF LOC to almost $210M for the 0 OF LOC. The figures in Appendix 11-6 demonstrate that the knee of the Alternative UA3A benefit curve based on activation frequency and volume occurs at 6 OF/yr, at approximately $96 million. At that level, the residual CSO volume would be 120 MG. This represents a reduction in annual CSO volume of nearly 84%. Water quality simulations were run not conducted for this alternative.

- *Scajaquada Creek:* The proposed UA3A improvements will provide significant benefits to Scajaquada Creek. CSO volumes are projected to be reduced from over 270 MG under Revised Baseline conditions to less than 35 MG at the 2 LOC. As shown on the figures in Appendix 11-6 and Table 11-30, present worth project costs (including the Revised Foundation Plan) for this alternative range from $83M for the 12 OF LOC to $260M for the 0 OF LOC. The figures in Appendix 11-6 demonstrate that the knee of the Alternative UA3A benefit curve based on activation frequency and volume occurs at 6 OF/yr, at approximately $100 million. At that level, the residual CSO volume would be about 70 MG. This represents a reduction in annual CSO volume of nearly 74%. Water quality simulations were run not conducted for this alternative.

11.7 Cost-Benefit Evaluation of LTCP System-Wide Alternatives

To evaluate the system-wide alternatives presented in this section, the system-wide cost-benefit curves for each alternative (based on Modified 1993 TY) were compared for the different types of benefits. The cost curves for activations per year, residual CSO volume (million gallons) and percent capture were compared to assess the relative effectiveness of each alternative. Water quality attainment was not evaluated on a system-wide basis.

Figure 11-36 presents a comparison of the system-wide cost curves based on CSO level of control. This figure compares the costs for each LOC and each system-wide alternative. As can be seen, Alternative UA1 (Updated 2004 Preferred Alternative) is the highest cost for all LOCs. This is due in part to the Original Foundation Plan that is the basis of this alternative and that includes significant sewer separation projects. Alternative UA3 is somewhat higher at lower levels of control but becomes the most cost-effective at the 2 and 0 LOCs. This is because tunnels are typically more cost effective than distributed storage and other technologies at higher LOCs. Alternative UA2 does also require tunnel storage for Scajaquada Creek at the 2 and 0 OF LOCs but also includes an EHRT facility, which likely drives the costs higher. The KOC for all alternatives falls approximately at the activation frequency equivalent to 6 OFs per year LOC with Alternative UA2 having the lowest costs at the KOC.

Figure 11-37 presents a comparison of the system-wide cost curves based on remaining CSO volume. This figure compares the costs for each LOC and each system-wide alternative. As with the LOC comparisons, Alternative UA1 is the highest cost for all LOCs. Alternatives UA3 and UA3A are also higher at nearly all volume levels compared to UA2, except for the remaining volumes at the 2 and 0 LOCs. While the LOC curves crossed at higher levels of control (closer to 4 OF/yr), Alternative UA2 appears to control higher volumes for a given target LOC compared to Alternative UA3 and Alternative UA3A, at a lower cost than both of those alternatives. The KOC for all alternatives falls approximately between 366MG residual volume (equivalent to 6 OFs per year LOC)and 241MG residual volume (Equivalent to 4 OFs per year LOC), with Alternative UA2 having the lowest costs at the KOC.

Figure 11-38 presents a comparison of the system-wide cost curves based on system-wide percent capture. This figure compares the costs for each LOC and each system-wide alternative. Again, Alternative UA1 is the highest cost for all LOCs. Alternative UA2 appears to provide better percent capture for a given LOC when compared to the other alternatives, at a much lower cost as well. While the LOC curves crossed at higher levels of control (closer to 4 OF/yr), Alternative UA2 appears to provide higher system-wide percent captures for a given target LOC compared to the other alternatives. The KOC for all alternatives falls approximately between 98.0 capture (equivalent to 6 OFs per year LOC) and 98.7 capture (equivalent to 4 OFs per year LOC), with Alternative UA2 having the lowest costs at the KOC.

Based on this evaluation, Alternative UA2 was selected as the basis for the Preferred LCTP alternative. In addition to being the most cost-effective alternative, UA2 represents a significant update of UA1 and incorporates emerging technologies such as real-time controls to better utilize the existing infrastructure, and also supports the USEPA's broader national sustainability objectives by including an substantial (but achievable) GI component.

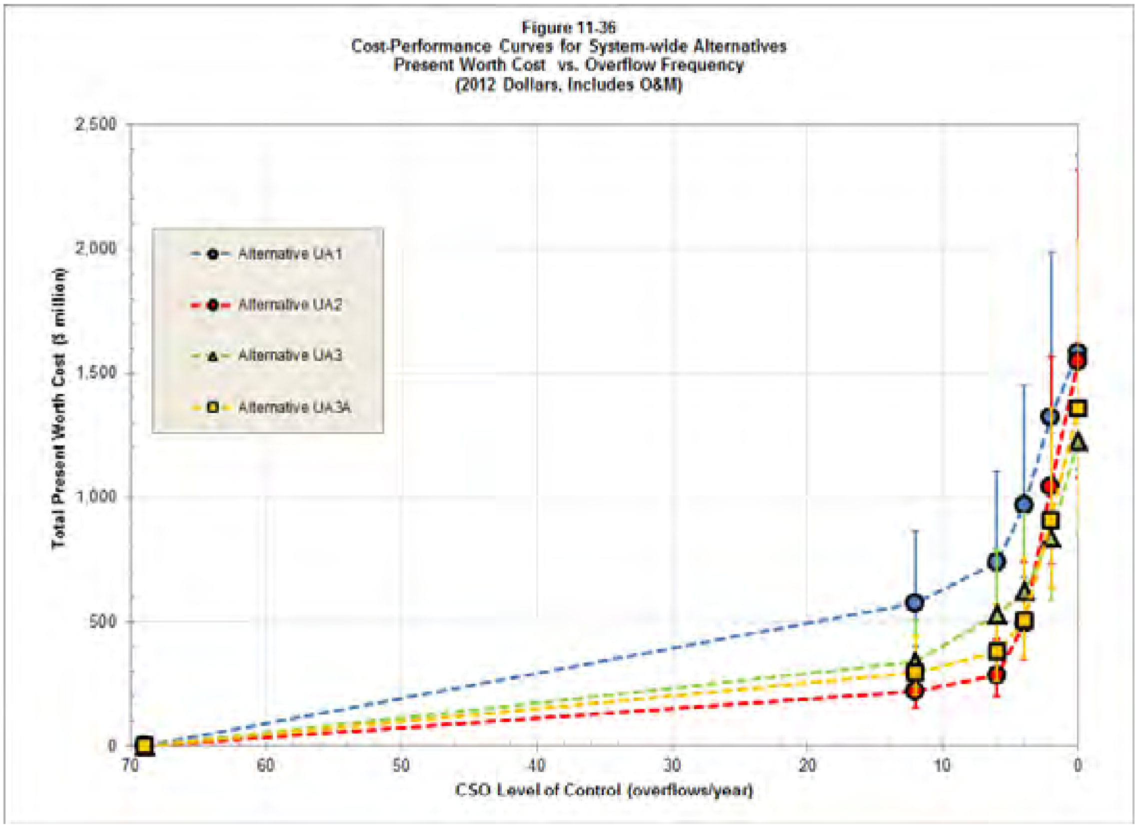


Figure 11-36
Cost-Performance Curves for System-wide Alternatives
Present Worth Cost vs. Overflow Frequency
(2012 Dollars, Includes O&M)
Alternative UA1
Alternative UA2
Alternative UA3
Alternative UA3A
Total Present Worth Cost ($ million)
2,500
2,000
1,500
1,000
500
0
70
60
50
40
30
20
10
0
CSO Level of Control (overflows/year)

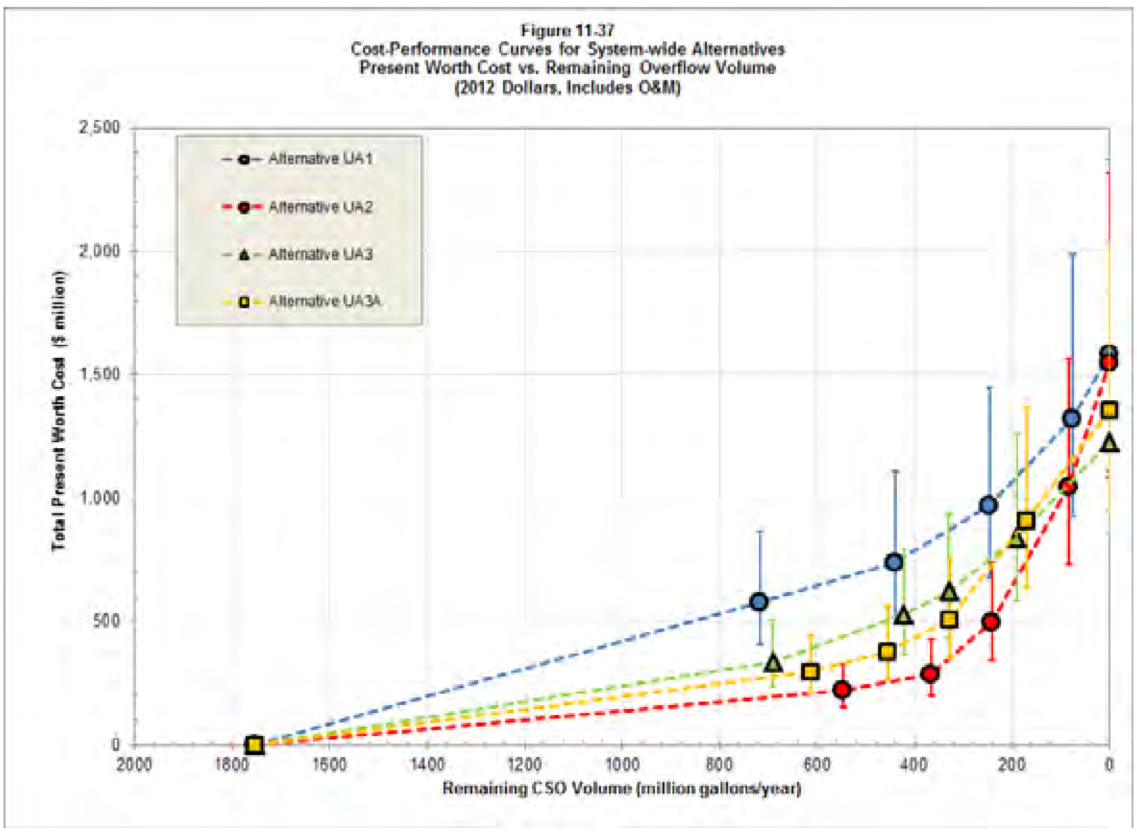


Figure 11-37
Cost-Performance Curves for System-wide Alternatives
Present Worth Cost vs. Remaining Overflow Volume
(2012 Dollars, Includes O&M)
Alternative UA1
Alternative UA2
Alternative UA3
Alternative UA3A
Total Present Worth Cost ($ million)
2,500
2,000
1,500
1,000
500
0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Remaining CSO Volume (million gallons/year)

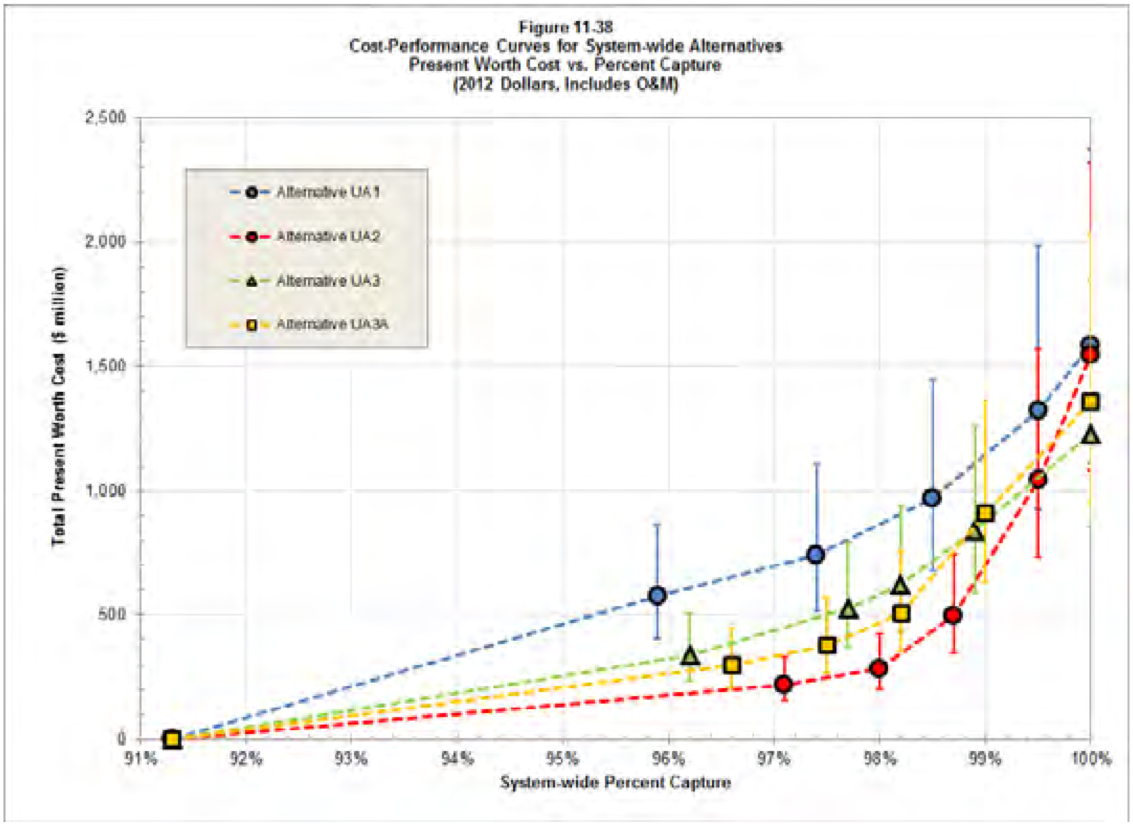


Figure 11-38
Cost-Performance Curves for System-wide Alternatives
Present Worth Cost vs. Percent Capture
(2012 Dollars, Includes O&M)
Total Present Worth Cost ($ million)
2,500
2,000
1,500
1,000
500
0
91%
92%
93%
94%
95%
96%
97%
98%
99%
100%
System-wide Percent Capture
Alternative UA1
Alternative UA2
Alternative UA3
Alternative UA3A

12. Recommended Plan

This section discusses the Recommended Plan for the BSA's LTCP implementation that addresses the requirements of the USEPA's CSO Control Policy and the BSA's Administrative Order with the USEPA. This section reflects the revisions developed by the BSA in response to Agencies' December 2012 comments and agreed to by the Agencies in October 2013. The BSA response included development of a Green Infrastructure Master Plan (summarized in Section 12.2) and updates to the No Feasible Alternatives Analysis (summarized in Section 8). The Recommended Plan is based on defining the most efficient solution for satisfying the receiving water body control objectives, consistent with the CSO Policy. Reference to the Recommended Plan refers only to the costs and benefits for projects related to the collection system, while the WWTP upgrades are referred to independently to reflect the scope of the entire 20-year program.

12.1 Recommended Plan Description

Sections 9 through 11 summarized the 2004 LTCP alternatives and provided an evaluation of additional alternative refinements. Four new system-wide CSO control alternatives were evaluated during this LTCP effort as presented in Section 11 of the report. Each alternative was evaluated for five levels of control (LOCs) in terms of estimated CSO activation frequency (0, 2, 4, 6 and 12 events per year) using the 1993 modified typical year. The system-wide percent capture, residual CSO volumes and remaining pollutant (bacteria) loadings were also estimated for informational purposes. The costs and benefits for each alternative at each LOC were evaluated not only on a system-wide basis, but also for each individual receiving water body.

Based on the economic evaluation of the alternatives, Alternative UA2 was shown to be the least expensive alternative at the knee of the curve for all receiving water bodies and, as such, was originally used as a basis for assembling a preferred system-wide alternative. However, a careful analysis of detailed receiving stream water quality modeling results revealed that a uniform level of CSO control for all BSA receiving water bodies is neither cost effective nor necessary to meet the applicable water quality standards (WQS) in each water body. The modeling revealed that each receiving water body has a unique combination of the current WQS attainment status, impacts from CSOs versus background sources, regulatory status (sensitive area), and CSO control costs. Furthermore, the evaluation results show that the knee of the curve points for Alternative UA2 for each receiving water body already provide 100% attainment of the New York State (NYS) recreational (bacteria) WQS. Therefore, the BSA's Recommended Plan was assembled with a primary focus on providing a cost-effective attainment of the current NYS bacteria WQS in each water body and the associated frequency of activation necessary to accomplish those WQS. As presented further in this section, the BSA has selected a water body-specific activation frequency as the compliance strategy and primary performance criterion, although percent capture and residual volumes are presented for informational purposes and can be used as a secondary demonstration of compliance with the CSO Policy.

The frequency of activation performance measure targets the USEPA CSO Control Policy presumption approach criterion of 4 to 6 overflow events per year. Following implementation of the Recommended Plan, all water bodies in the BSA system will meet the 4 to 6 events per typical year level of control, with the following clarifications:

- **Erie Basin -** The Erie Basin was identified as a sensitive area, and as such, has the highest selected cost-effective target LOC of 2 events per typical year. While water quality modeling reveals that the WQS are met under existing conditions in the Erie Basin, the BSA has elected to target the higher LOC as part of the Recommended Plan.

- **Buffalo River -** Based on the water quality modeling results, the Buffalo River would achieve 100% compliance with water quality standards at the lowest evaluated LOC of 12 events per typical year (provided that the USEPA and NYSDEC reasonably address upstream sources of pollutants by other parties); however, the BSA has targeted a higher level of control, 6 events per year, based on the activation frequency versus project present worth costs knee of the curve for this receiving water body.

- **Niagara River -** Water quality modeling results also reveal that the Niagara River already meets the current NYS bacteria WQS under the baseline conditions with 100% attainment. At the same time, the activation frequency versus project present worth costs knee of the curve for the Niagara River fell at approximately 8 to 10 events per year. Increased LOCs for the Niagara River provided marginal benefits in terms of CSO volume reduction and no additional benefits in terms of WQS attainment. Therefore, the BSA selected a cost-effective LOC of approximately 9 events per typical year for the Niagara River.

A summary of the basis for the selected target LOCs is presented in Table 12-1. The recommended plan features target activation frequencies of 4 to 6 events or less in the typical year, except as noted above for the Niagara River.

Table 12-1: Summary of Recommended Plan LOC Selection

Receiving Water Body	Basis for Selection of Level of Control	Target LOC Typical Year Activations
Black Rock Canal	WQS attainment KOC	4
Buffalo River	LOC and Remaining Volume KOC	6
Cazenovia Cr.-B	LOC and Remaining Volume KOC	4
Cazenovia Cr.-C	LOC and Remaining Volume KOC	6
Erie Basin	Designation as a Sensitive Area	2
Niagara River (incl. CSO 055)	LOC and Remaining Volume KOC	9
Scajaquada Creek	WQS attainment KOC	4

12.2 **Green Infrastructure Master Plan Summary**

In response to the Agencies' December 2012 comments on the April 2012 LTCP submission, the BSA provided additional detail on their green infrastructure (GI) program by developing a Green Infrastructure Master Plan (GI Master Plan), which was submitted to the Agencies in August 2013 and revised based on subsequent discussions and comments. The GI Master Plan, included in its entirety in Appendix 12-3, provided the following:

- Further refinement of the GI impervious surface control targets presented in the April 2012 LTCP document to determine, on the SPP level, where the system would most benefit from GI technologies.
- Background information on the environmental and land use conditions in Buffalo that will impact GI technology and site selection.
- An overview of GI technologies.
- A program level screening of GI for the BSA.
- Details on the Phase 1 GI projects to be implemented over the first five-year period.

- Details of the Phase 1 GI projects performance evaluation using a combination of modeling techniques implemented in the system-wide model, including a summary of the model results.

- An overview of a post-construction monitoring plan for the Phase 1 GI projects (a detailed plan will be developed as part of the overall LTCP PCM plan due to the Agencies within one year after the LTCP approval).

Relevant components from the GI Master Plan are presented in the following subsections.

12.2.1 Refinement of System-wide GI Impervious Surface Control Acreage

The GI control targets presented in Section 11 were further refined within the GI Master Plan to determine the SPP level where the system would most benefit from GI technologies. The SPP activation statistics for the revised Foundation Alternative were reviewed along with the recommended activation frequency (level of control) for each receiving water body (RWB). The target GI control level was then modified using the same general rationale that was applied at the CSO outfall level in Section 11. The following GI control of impervious acreage targets were applied at the SPP level:

- Applied 0 percent (no GI control) to any SPP with predicted activations less than or equal to the RWB target LOC.

- Applied 20 percent impervious surface control to SPPs with activations greater than the RWB target LOC.

- Applied 0 percent to stormwater only basins and any SPP basins that do not discharge directly to RWBs (e.g., Amherst Quarry SPPs).

The revised impervious surface control target percentages for GI are shown on Figure 12-1. Note Figure 12-1 presents an average percent impervious surface control for the CSOs, based upon the SPP-level evaluations described below. A summary of the revised impervious acreage to be controlled by GI for each receiving water body, as well as the original acreage recommended to be managed by GI from Section 11 is presented in Table 12-2. Overall, there is a decrease in the impervious acres to be controlled by GI due to the refinement at the SPP level. Refining the impervious control acreage to the SPP level allowed for better identification of SPPs (and by extension CSO outfalls) that would benefit most from implementing GI technologies, and also for determining which SPPs would not benefit because they were already at or below the recommended RWB LOC or do not discharge directly to a RWB. This result is consistent with the intentionally conservative estimates used in Section 11.

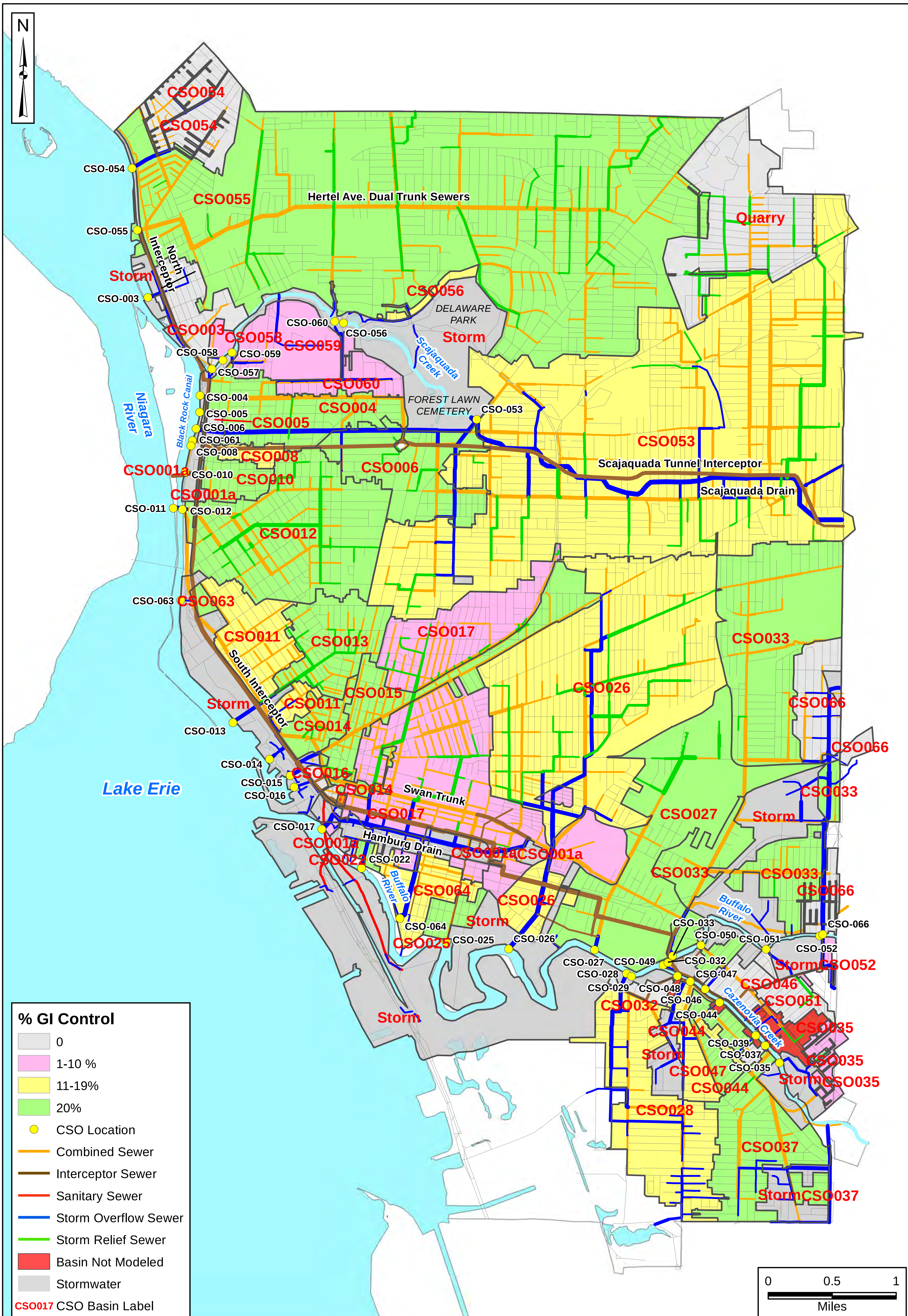


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FIGURE 12-1

Refined System-wide GI Control Levels (Based on SPP Refinement)

Table 12-2: Updated Impervious Area Target for Control by GI

Receiving Water	Area Managed (acres) by GI Based on CSO Level from Section 11	Updated Area Managed (acres) by GI Based on SPP Level
Black Rock Canal	168	198
Buffalo River	418	319
Cazenovia Creek - B	3	3
Cazenovia Creek - C	60	58
Erie Basin	49	53
Niagara River	412	378
Scajaquada Creek	510	305
Total	**1,620**	**1,315**

As shown in Table 12-2, this refinement resulted in minimal to moderate changes in controlled acreage on a receiving water body basis. Recommended acreages increased in the Black Rock Canal and Erie Basin, and decreased in the Cazenovia Creek –C, Buffalo River, Niagara River, and Scajaquada Creek. The most notable decrease occurred in the Scajaquada Creek basin, mainly due to the Amherst Quarry modifications. The Amherst Quarry is a storage basin that stores excess flows during wet weather events, and then drains combined wastewater and stormwater back to the collection system for subsequent conveyance and treatment after wet weather flows subside. Because of this, it was determined that there would be no CSO reduction benefit with application of GI technologies in areas tributary to the Quarry.

Because the SPP level GI allocation provides a more refined and cost-effective approach, the BSA will work towards a 1,315-acre total green infrastructure program effort. However, the BSA will utilize modeling and post-construction monitoring of the first three phases of GI projects to confirm that the 1,315 target acres will be sufficient to meet the level of control objectives. If needed, the acreage target for the fourth phase of GI projects will be adjusted to achieve the CSO outfall typical year frequency of activation requirements.

12.2.2 GI Refinement Model Results

The Recommended Plan with the refined impervious surface control acreages was evaluated for each receiving water body in terms of targeted reduction in CSO activations and volumes. Table 12-3 presents a comparison of model results for the SPP-refined GI control with the Recommended Plan. Projected residual volumes are presented for each CSO and receiving water body, as well as the remaining frequency of activation. As shown in Table12-3, with the exception of CSOs 022, 047, and 050, the residual activations in any given receiving water body remained the same or decreased. For the CSOs that showed an increase in activations, the resulting activations remained within the targeted typical year LOCs for each receiving water body. The total system-wide CSO volume remaining increased slightly (approximately 4 percent); however, the projected increase in residual volume is within the uncertainty of the modeling tools and, accordingly, is insignificant, particularly in light of the conservative factors used elsewhere in the GI program and LTCP.

Table 12-3: Model Projected Frequency and CSO-Only Volume Results for SPP-based Refinement

		CSO-only Frequency			CSO-only Volume (Million Gallons)		
CSO Outfall	**Receiving Water**	**Revised Baseline[1]**	**Recommended Plan[2]**	**Recommended Plan + Updated GI Control[3]**	**Revised Baseline[1]**	**Recommended Plan[2]**	**Recommended Plan + Updated GI Control[3]**
003	Niagara River	6	5	5	0.1	0.7	0.8
004	Black Rock Canal	5	4	3	11.2	9.2	8.7
005	Black Rock Canal	4	4	4	0.1	0.1	0.1
006	Black Rock Canal	65	4	4	198.9	18.1	21.7
008	Black Rock Canal	39	0	0	6.1	0.0	0.0
010	Black Rock Canal	44	1	1	11.9	0.0	0.0
011	Niagara River	41	4	4	134.3	10.9	11.7
012	Black Rock Canal	42	2	2	52.5	0.9	0.9
013	Black Rock Canal	7	4	4	6.8	3.4	2.7
014	Erie Basin	4	2	2	4.2	2.8	3.1
015	Erie Basin	12	1	1	6.1	0.4	0.6
016	Erie Basin	0	0	0	0.0	0.0	0.0
017	Buffalo River	49	4	4	71.3	41.4	34.8
022	Buffalo River	49	4	5	29.8	1.7	2.0
025	Buffalo River	11	6	6	1.4	1.2	1.2
026	Buffalo River	63	3	3	124.2	27.0	29.6

		CSO-only Frequency			CSO-only Volume (Million Gallons)		
CSO Outfall	**Receiving Water**	**Revised Baseline[1]**	**Recommended Plan[2]**	**Recommended Plan + Updated GI Control[3]**	**Revised Baseline[1]**	**Recommended Plan[2]**	**Recommended Plan + Updated GI Control[3]**
027	Buffalo River	36	6	6	31.7	37.6	39.1
028	Buffalo River	69	6	6	45.5	20.6	22.7
029	Buffalo River	0	0	0	0.0	0.0	0.0
032	Buffalo River	0	0	0	0.0	0.0	0.0
033	Buffalo River	9	6	5	37.8	35.2	31.8
034	Buffalo River	0	0	0	0.0	0.0	0.0
035	Cazenovia Creek - B	0	0	0	0.0	0.0	0.0
037	Cazenovia Creek - C	13	6	6	23.3	11.8	11.9
039	Cazenovia Creek - C	0	0	0	0.0	0.0	0.0
044	Cazenovia Creek - C	7	2	2	2.3	0.7	0.7
046	Cazenovia Creek - C	1	1	0	1.3	1.2	1.3
047	Cazenovia Creek - C	44	2	3	8.7	1.3	1.5
048	Cazenovia Creek - C	0	0	0	0.0	0.0	0.0
049	Buffalo River	0	0	0	0.0	0.0	0.0
050	Buffalo River	14	4	5	3.2	2.5	2.8
051	Buffalo River	4	4	4	1.2	1.0	1.2
052	Buffalo River	10	3	3	10.9	6.2	6.3
053	Scajaquada Creek	65	4	4	268.0	44.5	52.1
054	Niagara River	0	0	0	0.0	0.0	0.0
055	Cornelius Creek	41	9	9	601.1	196.3	206.2
056	Scajaquada Creek	5	4	3	0.0	0.0	0.0
057	Scajaquada Creek	0	0	0	0.0	0.0	0.0

		CSO-only Frequency			CSO-only Volume (Million Gallons)		
CSO Outfall	Receiving Water	Revised Baseline[1]	Recommended Plan[2]	Recommended Plan + Updated GI Control[3]	Revised Baseline[1]	Recommended Plan[2]	Recommended Plan + Updated GI Control[3]
058	Scajaquada Creek	0	0	0	0.0	0.0	0.0
059	Scajaquada Creek	0	0	0	0.0	0.0	0.0
060	Scajaquada Creek	5	0	0	0.7	0.0	0.0
061	Black Rock Canal	10	2	2	31.2	1.1	1.2
063	Black Rock Canal	13	4	4	0.6	0.3	0.3
064	Buffalo River	56	2	3	21.1	6.1	6.9
066	Buffalo River	10	4	4	1.7	0.5	0.4
Total					**1,749.1**	**485.1**	**504.3**

Notes:

(1) Revised Baseline results from Table 11-3.

(2) Recommended Plan results from Appendix 12-2 of the BSA's April 2012 LTCP.

(3) Results for Recommended Plan with Updated GI Control (refined by SPP).

12.2.3 Phase 1 GI Projects

Several factors were evaluated to determine the Phase 1 GI projects for the first five-year implementation period, including:

- Capitalize upon the City's substantial investment in demolition of vacant properties from the time the CSS model was developed through the end of Phase 1;
- Support the City's green street agenda; and
- Capture the impacts of the Environmental Facilities Corporation investment in the PUSH Blue project.

As a result of these evaluations and the opportunities available within the City, the BSA Phase 1 GI projects, summarized in Table 12-4, rely upon demolition/vacant lot management, as well as runoff reduction from seven green streets projects to achieve the impervious surface management goal. While the BSA is accounting for Phase 1 GI projects in all sub-catchments in the model, some of these projects may be located in a sub-catchment that is not targeted for impervious surface control. For the purpose of determining the green infrastructure implementation acreage towards target goals, the projects (primarily building demolitions) outside of the refined target areas were removed. Table 12-4 presents both the total impervious acreage controlled and the impervious acreage that would be applied to the proposed GI target acreage. The Phase 1 GI projects will control 448 acres of impervious area, of which 267 acres will be applied to the SPP-based GI acreage targets.

Table 12-4: BSA's Phase 1 Green Infrastructure Program Summary

Project Group	Sub Group	Impervious surface controlled (acres)	Impervious Acreage Applied to SPP-based Target CSO Control (acres)
Demolitions and Vacant Lot Management	2001 – 2013 Demolitions (excl. 2001-2009 demos in CSO 12)	354	210
	CSO 53 Pilot Project and 2014-2018 Demolitions	50	31
	Fillmore Ave green lots	0	0
	PUSH Blue Projects	1.0	1.0
Green Streets	Carlton Street porous asphalt	1.0	0
	Fillmore Ave porous parking lots	0.4	0.4
	Ohio Street	6.1	2.1
	Kenmore Ave(1)	4.1	4.1
	Kensington Ave(1)	5.5	2.5
	Allen Street(1)	2.5	2.5
	Niagara Street(1)	23	14.3
	TOTAL	448	267

Note: (1) Specific designs are not available for these projects at this time. The impervious acreage controlled was estimated based on the assumptions provided in Section 8 of the GI Master Plan.

12.2.4 GI Implementation Phases

Table 12-5 presents a comparison of the target control acres, by implementation phase, based on CSO-level targets presented in Section 11 and the SPP-refined targets. The more detailed, SPP-level modeling discussed above indicates that the same level of control may be achieved through 1,315 acres of impervious surface runoff control.

Table 12-5: Proposed GI Target Acres Based on Implementation Phase

Implementation Phase	Target (acres) Based on CSO Level	Target (acres) Based on SPP Refinement
Green 1	145	267
Green 2	320	410
Green 3	485	375
Green 4	670	263
Total	**1,620**	**1,315**

Because the SPP-level-based GI allocation provides a more refined and cost-effective approach, the BSA will work towards a 1,315-acre total green infrastructure program effort. However, the BSA will utilize modeling and post-construction monitoring during the first three phases to confirm that the 1,315 target acres will be sufficient to meet the performance criteria. If needed, the Phase 4 GI acreage target will be adjusted to achieve the level of control. Any necessary acreage adjustments will be proposed with the submission of the Green 4 plan in program year 13.

In response to public comment on the April 2012 submission, the BSA remains committed to evaluating opportunities to maximize the use of additional cost-effective green infrastructure approaches. The target acreage above is a minimum program commitment. Any additional green infrastructure acreage proposed in conjunction with the optimization of gray projects would be in addition to the acreage above. This approach allows the BSA to adaptively manage the green infrastructure program to incorporate lessons learned in each five year program and take advantage of land use and infrastructure investments projected for each period to deliver the maximum public benefits at the lowest cost.

12.3 **Proposed Facilities and Operational Concepts**

A summary of main component projects of the Recommended Plan is presented in Table 12-6. As described above, this alternative is based on Alternative UA2 concepts (optimized for cost effective levels of control in each receiving stream) and, as such, includes all Revised Foundation Plan projects, refined GI projects to control up to 20% of the impervious area, and selected gray infrastructure projects. Additional optimization of the gray infrastructure facility sizes was done to meet the target performance criteria presented in Section 12.1. Note that all facility sizes presented are concept-level approximations and are subject to revision during facility planning and/or final design activities.

Table 12-6: Summary of Recommended Plan Projects

Project Grouping	Specific Projects (Concept Level Approximate Sizing)

Revised Foundation Projects: Focus is on combination of low-cost system optimizations, pilot GI projects and cost-effective RTC projects	• Phase 1 Projects: Includes all Phase 1 projects described in Section 11.2.
	• Non-Phase 1 Projects: These projects are primarily sewer separation projects carried over from the original Foundation Plan and completed prior to the Phase 1 projects. These were also described in Section 11.2.
	• Real Time Control: 16 real-time control (RTC) projects that were selected after the evaluation described in Section 11.3
	• Green Infrastructure Pilot Projects
	  o CSO 060 – Combination of pervious pavements, rain gardens and downspout disconnections/rain barrel installations
	  o Downspout disconnect/rain barrel pilot projects in the Old First Ward and Hamlin Park neighborhoods
	• Additional SPP Optimizations: 20 additional optimization projects were identified as part of the alternatives evaluations conducted for this LTCP update. These modifications include optimizing weir elevations and orifice plate openings, increasing underflow pipe capacity, and flow redirection at a limited number of locations. Details on these SPP optimization projects are presented in Section 11.4
	• Additional Storage Projects: Three projects designed to increase capture of CSO flows have been identified and are currently in various stages of design by BSA.
	  o Hamburg Drain Storage - 5 MG offline storage facility
	  o Smith Street Storage - 0.5 MG offline storage facility
	  o CSO-016 Storage - 60,000 gallon inline storage

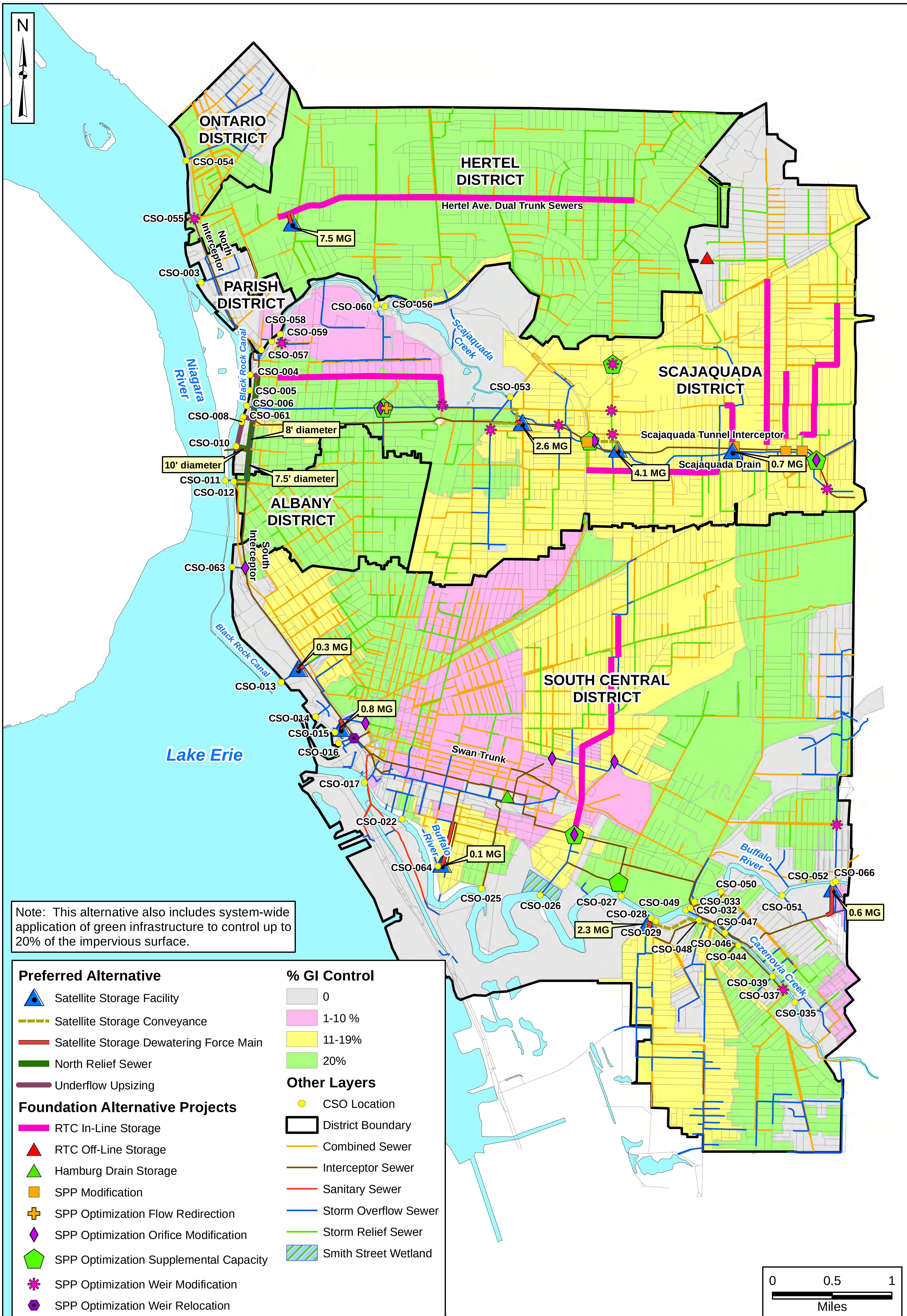
Gray Infrastructure Projects	• Black Rock Canal and Niagara River
	  o Underflow pipe upsizing (to maximize flow to the existing interceptors)
	  o New Northern Relief Sewer that runs parallel to the Black Rock Canal between CSO 004 and CSO 011/012 with an additional parallel relief sewer from CSO 004 to the existing siphon crossing at the WWTP influent. Northern Relief consists of the following components:
	    ▪ 5,310 feet of 96-inch pipe
	    ▪ 571 feet of 120-inch pipe
	  o CSO 055 – 7.5 MG offline storage facility
	  o CSO 013 – 0.3 MG offline storage facility
	• Scajaquada Creek
	  o SPP 337: 0.7 MG offline storage facility
	  o Jefferson Avenue & Florida Street: 2.6 MG offline storage facility
	  o SPP 336 a & b: 4.2 MG offline storage facility
	• Buffalo River and Cazenovia Creek:

Project Grouping	Specific Projects (Concept Level Approximate Sizing)
	o CSOs 028, 044 and 047: 2.3 MG offline storage facility o CSO 052: 0.6 MG offline storage facility o CSO 064: 0.1 MG offline storage facility • Erie Basin o CSO 014 and 015 – 0.8 MG offline storage facility
Green Infrastructure Projects	Green Infrastructure projects will include a mixture of the following techniques based upon the results of pilot studies undertaken during the early years of the LTCP implementation schedule and will be focused primarily on publicly-owned properties. • Vacant property demolitions • Modifications to vacant lots to store and infiltrate street runoff • Pervious pavements (public streets and parking lots) • Rain gardens • Downspout disconnections/rain barrels Green Infrastructure technology implementation will be based upon the control of up to 20% of the impervious surfaces (publically owned) within selected sewersheds as follows based on the SPP-level refinement outlined in the GI Master Plan: • Black Rock Canal – 198 acres • Buffalo River – 319 acres • Cazenovia Creek (Class B section) – 3 acres • Cazenovia Creek (Class C section) – 58 acres • Erie Basin – 53 acres • Niagara River – 378 acres • Scajaquada Creek – 305 acres Total controlled acreage – 1,315 acres

Figure 12-2 shows the conceptual layout of the BSA's Recommended Plan throughout the City of Buffalo. The recommended percent of impervious surface for control using GI technologies, based on the SPP refinement, is also presented on Figure 12-2. As noted previously, the proposed facilities and operational concepts will vary among CSO receiving waters and LOCs for the Recommended Plan. The following sections present the proposed operational concepts (all approximate sizing) by receiving water.

12.3.1 Black Rock Canal and Niagara River

All of the CSOs that discharge along Black Rock Canal plus CSO 011, which discharges to the Niagara River, will be controlled using a combination of underflow pipe upsizing (to maximize flow to the interceptors) and a relief sewer that runs parallel to the Black Rock Canal between CSO 004 and CSO 011/012. CSO volumes (and associated activations) under larger (*i.e.*, larger than the proposed LOC) precipitation events will be regulated by modified regulators at the existing SPPs or by the new relief pipe. Any CSO discharges greater than the selected level of control will discharge through the existing outfalls.



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BUFFALO SEWER AUTHORITY
Long Term Control Plan Update

FIGURE 12-2

RECOMMENDED PLAN WITH APPROXIMATE GI 2 - 9 OF/yr

Additional control of discharges to the Niagara River would be provided through a large satellite storage facility at CSO 055. In addition, a small satellite storage facility would be required to control discharges from CSO 013 to the Black Rock Canal. At CSO 013, the satellite storage facility would operate between the current SPP and the receiving water (*i.e.*, would be constructed such that the facility would be filled from the overflow conduit). When the SPP activates, overflow would flow by gravity to the storage basin. When the basin fills, the inlet gate to the storage facility would close and subsequent overflow from the SPP during the event would bypass the storage basin and then be discharged to the receiving stream through the existing CSO outfall. This discharge would be considered a CSO event in the new system. After the storm when the interceptor and plant capacity become available, the basin would be dewatered to the interceptor via a pump station sized to empty the basin within 24 hours (based on the 1993 modified typical year precipitation storm patterns).

For CSO O55, the proposed storage facility would be located upstream of the regulator, near Military Road. At this location, an offline facility would be constructed and flows above 26 MGD (instantaneous peak) would be diverted from the South Hertel Trunk sewer into the 7.5 MG storage facility. Flows in excess of the storage capacity would be conveyed down to the existing CSO 055 regulator structure and discharged through the existing outfall. After the storm when the conveyance and plant capacity become available, the basin would be dewatered into the Hertel Avenue combined sewer via a pump station sized to empty the basin within 24 hours (based on the 1993 modified typical year precipitation storm patterns).

All off-line storage facilities proposed for the BSA's system are assumed to be covered concrete, underground tanks. The basins would include a bar screen in the influent channel to provide floatables control for the overflow. Odor control would also be included with each facility. Solids handling dewatering pumps would be used to return the contents of the basin to the interceptor after the storm event. The pumps would be sized to empty the basin volume based on the available conveyance system and treatment capacity, with dewatering times targeted for 24 to 48 hours based on the 1993 modified typical year precipitation storm patterns. However, actual dewatering time would depend upon the actual precipitation patterns as they may affect the available conveyance and WWTP capacity.

12.3.2 Scajaquada Creek

CSO control for Scajaquada Creek will be provided primarily through satellite storage facilities. Storage facilities are proposed at the following locations:

- SPP 337: 0.7 MG offline storage facility
- Jefferson Avenue & Florida Street: 2.6 MG offline storage facility
- SPP 336 a & b: 4.2 MG offline storage facility

The operation concepts for these storage facilities will mimic those described above for the Black Rock Canal and the Niagara River. In lower Scajaquada Creek, the remaining CSOs (056, 057, 058, 059, and 060) will discharger infrequently after implementation of the Phase I projects, the Revised Foundation Plan, and the proposed GI control of impervious surfaces. For CSOs 056, 057, 058, and 059, Phase I projects are currently providing a high level of CSO capture and the BSA is in a post-construction monitoring phase to document the frequency of activation for these CSOs. Accordingly, no additional controls are provided in the Recommended Plan for these remaining CSOs.

12.3.3 Buffalo River (including Cazenovia Creek Class B and C portions)

The Revised Foundation Plan, assuming the implementation of GI controls, provides a high LOC for most CSOs in the Buffalo River and Cazenovia Creek basins. SPP-optimizations, storage in the Hamburg Drain system to control CSOs 017, 022 and 064 and RTC/ storage facilities at Smith Street (CSO 026) are included within the Revised Foundation Plan. These facilities will be designed to reduce the CSO events to up to 6 overflows in a typical year. The remaining CSO volumes are addressed through satellite storage facilities as follows:

- CSOs 028: 044 and 047: 2.3 MG offline storage facility
- CSO 052: 0.6 MG offline storage facility
- CSO 064: 0.1 MG offline storage facility

CSO 035 in the Class B portion of Cazenovia Creek has been eliminated through previously completed projects. Therefore, the control plan for this receiving water is implementation of GI to provide additional treatment for stormwater discharges. The remaining CSOs along the Class C portion of Cazenovia Creek are consolidated down to storage facilities at CSO 028 with the consolidation piping sized for the largest storm in the 1993 modified typical year.

The operation concepts for these storage facilities will mimic those described above for the Black Rock Canal, Niagara River, and Scajaquada Creek.

12.3.4 Erie Basin

The Revised Foundation Plan, with GI implementation, provides a high level of control for the three CSOs discharging to the Erie Basin (014, 015 and 016). CSO 016 discharges will be eliminated for the 1993 modified typical year through a combination of the optimization of an upstream SPP that was part of a Phase I project, completed after the 2004 LTCP was submitted, and a small in-line storage project to be completed under the Revised Foundation Plan. Because the Erie Basin has been designated as a sensitive area, a

LOC of 2 events per typical year was considered. As discussed in Section 11 (Alternative UA2), satellite storage facilities are proposed to control the remaining overflows from CSOs 014 and 015 with a small consolidation sewer also required. These storage facilities would operate in the same manner as described in the previous subsections. Alternatively, during the subsequent facility planning efforts, the BSA may optimize the storage concept by considering a Bangor, Maine-type inline pre-cast underground storage facility with similar nominal storage capacity and receiving stream benefits. We understand that a similar pre-cast storage program is being implemented in Scranton, Pennsylvania.

12.4 Additional LTCP Program Refinement

Following submission of the April 2012 LTCP, the BSA continued to refine the LTCP to address actual conditions in the City of Buffalo as well as to improve upon the projected impacts of the entire program.

- **Green Infrastructure:** As outlined in the GI Master Plan, the City of Buffalo has undertaken an extensive program to demolish vacant properties citywide. These building demolitions resulted in a significant reduction in impervious surface from that originally modeled. Consequently, the BSA has and will continue to take advantage of this impervious surface reduction, a large portion of which was not accounted for in the hydraulic and water quality models used in this LTCP, making both even more conservative. As further detailed in the GI Master Plan, building demolitions, as they occur will be incorporated into the model and their performance verified during the post-construction monitoring program. This process will be used to further refine the overall LTCP.

- **Gray Infrastructure:** As the BSA moves forward with the implementation of major gray infrastructure projects, project-specific facility planning will be completed. The results of the facility planning processes, in conjunction with GI performance, will likely result in changes to the initial concepts based on post-construction monitoring results, more specific site condition information and/or through the development of optimized approaches for CSO control. For example, following submission of the April 2012 LTCP, the BSA commissioned preliminary design services for both the Hamburg Drain storage and Smith Street RTC/storage projects. Based on the results of facility planning efforts, the BSA identified opportunities to optimize both projects while still meeting the target LOCs for the Buffalo River. The following provides potential revised concepts for each project:

    - Hamburg Drain Storage (CSOs 017, 022 and 064): In lieu of constructing a single large storage facility, the BSA is evaluating a number of in-system optimizations that may ultimately reduce the overflow events at a number of upstream SPPs. Note, however, that should hydraulic modeling and/or post-construction modeling suggest that optimizations alone will not achieve target LOCs, the BSA may still consider the construction of off-line storage capacity.

- o Smith Street Storage (CSO 026): As presented in Table 12-6, the BSA initially considered off-line storage to control CSOs in the Smith Street basin. After completing additional evaluations and considering the use of upstream RTC and enhanced GI, storage capacity was identified within the Smith Street Drain that could potentially be used to eliminate or reduce the size of the off-line storage tank while meeting target LOCs for the Buffalo River. Preliminary facility planning is ongoing that will determine the feasibility of enhancing in-line storage for CSO 026.

While pursuing ongoing optimization and refinement of the Recommended Plan project concepts, the BSA remains committed to achieving the target LOC for each receiving water body as presented in Section 12.1. In the event that any recommended plan LTCP project is proposed to be modified, the BSA will inform the Agencies on an ongoing basis as warranted and via the semi-annual status reporting process.

12.5 **Planning Level Costs**

A two-step approach was used for developing planning level project costs for the Recommended Plan. The first step included assembling the costs using the technology cost curves described in Section 7 and used for evaluation of CSO control alternatives in Sections 9 and 11. The probable construction cost for the Recommended Plan under this methodology was estimated at $273.3 million including all future capital costs.

A summary of probable capital costs using the cost curve methodology is presented in Table 12-7 below. Please note that while the refinement of the GI control acreage at the SPP level reduced the target control acreage to 1,315 acres, the GI cost was conservatively held at the initial $92.6 million estimate (based on $57,000/acre using the initial 1,620 acres impervious surface control) to reflect the BSA's commitment to increasing GI if necessary in future and in response to the Agencies' view that GI costs were not conservative enough.

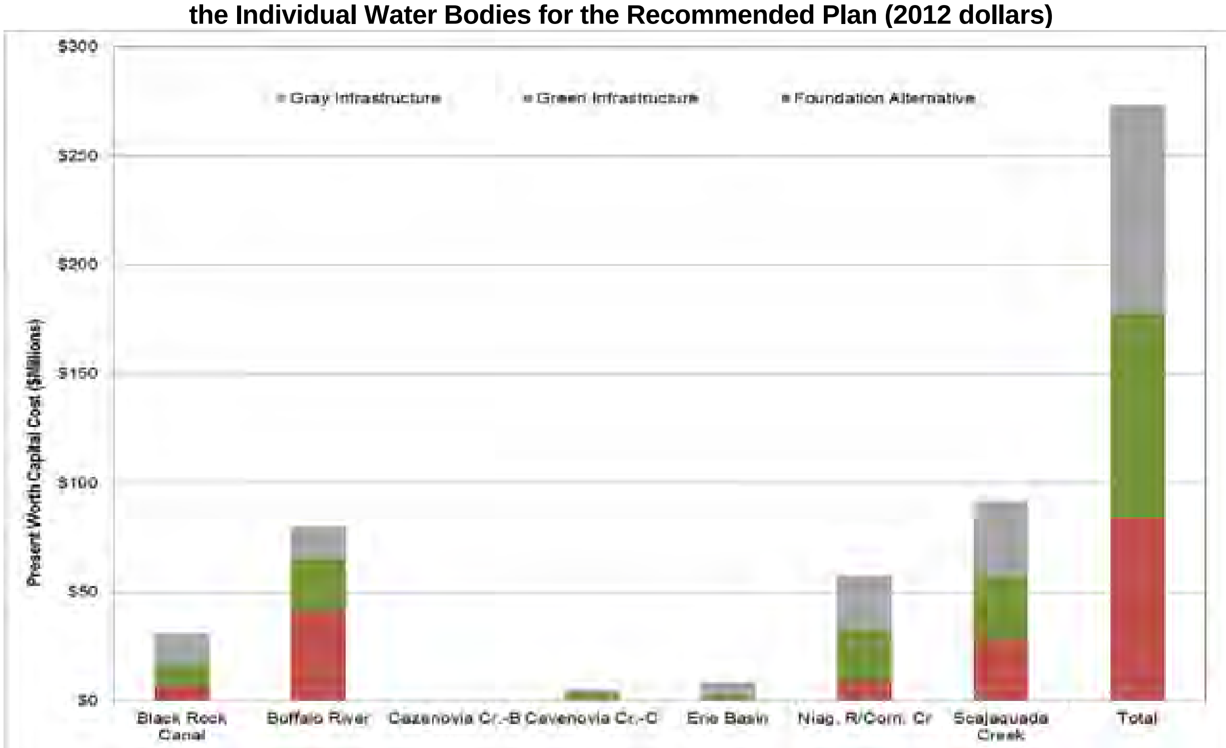
A cost breakdown (using present worth costs) by each receiving stream and general technology is shown on Figure 12-3. The estimated annual O&M cost associated with the Recommended Plan is approximately $350,000, resulting in a total 20-year Present Worth project cost (including O&M) of approximately $278 million.

Table 12-7: Summary of Recommended Plan Project Costs
(Cost Curve Methodology; not including O&M; 2012 dollars, Million dollars)

Receiving Water Body	Green Infrastructure[1]	Gray Infrastructure	Foundation	Total Construction Cost
Black Rock Canal	$9.51	$14.41	$6.89	$30.80
Buffalo River	$23.83	$15.15	$41.13	$80.11
Cazenovia Cr.-B	$0.17	$0.00	$0.00	$0.17
Cazenovia Cr.-C	$3.42	$1.85	$0.02	$5.28
Erie Basin	$2.87	$5.43	$0.01	$8.30
Niagara River (includes CSO-055 Cornelius Creek)	$23.50	$25.01	$8.70	$57.20
Scajaquada Creek	$29.32	$34.33	$27.75	$91.40
Total	**$92.61**	**$96.18**	**$84.49**	**$273.27**

NOTE: [1]GI cost based on initial target control of 1,620 acres as a conservative estimate.

Figure 12-3: Distribution of Gray, Green, and Foundation Alternative Present Worth Project Costs in the Individual Water Bodies for the Recommended Plan (2012 dollars)



NOTE: GI cost based on initial target control of 1,620 acres as a conservative estimate.

The next step was to develop a more detailed, yet still planning level, opinion of probable project costs. This cost was developed using more specific information such as conceptual facility layouts, local knowledge of construction costs, costs for similar projects constructed elsewhere, etc. The probable project cost for the Recommended Plan under this methodology was estimated at $340 million, including all future capital costs. In addition to the Recommended Plan cost, the costs for upgrades at the WWTP as outlined in Section 8 and the NFA Report (Alternative C2) have been added to reflect the overall expense for improvements across the BSA system ($380 million). For the purposes of this document, the O&M costs for all CSO-related construction projects are considered to be the same as presented above. However, the additional O&M cost for the NFA-related projects was estimated at $282,000 per year. A summary of the more detailed estimated project costs is provided in Table 12-8. It should be noted that while more detailed and refined, this cost estimate is still considered, at most, AACE Class 3 in that the costs are still based upon very limited design concepts. Backup estimating documentation is included in Appendix 12-1 (Recommended Plan) and Appendix 8-2 (WWTP upgrades). The refined system-wide project cost estimate of $380 million was used as a conservative value cost for the affordability evaluations and initial project budgeting and scheduling.

Table 12-8: Summary of System-Wide Estimated Project Costs

Receiving Water Body / Project	Project Cost (1,2,3)
Black Rock Canal	
CSO 013 (300,000 gallons)	$3,000,000
North Relief Sewer	$36,000,000
CSO 008/010, 061, 004 Underflow Upsizing	$500,000
Erie Basin Marina	
CSO 014/015 (800,000 gallons)	$6,700,000
Cazenovia Creek – C	
CSO 028/044/047 (2,300,000 gallons)	$12,200,000
Buffalo River	
CSO 052 (600,000 gallons)	$3,900,000
CSO 064 (100,000 gallons)	$2,000,000
Scajaquada Creek	
Jefferson Avenue & Florida Street (SPP 170B) (2,600,000 gallons)	$9,500,000
SPP 336 a/b (SPP165A, SPP165B, SPP 336A, SPP336B) (4,200,000 gallons)	$11,500,000
SPP 337 (700,000 gallons)	$4,000,000
Niagara River (Cornelius Creek)	
CSO 055 (7,500,000 gallons)	$18,500,000
Subtotal	*$107,800,000*
Contingency (20%)	$21,500,000
Probable Construction Cost	*$129,300,000*
Administrative and Legal (5%)	$6,500,000
Engineering (20%)	$26,000,000
Total Recommended Plan Cost	**$161,800,000**
Revised Foundation Plan Cost (for projects not already completed, see Table 11-11)	*$85,000,000*
Green Infrastructure (system wide)[5]	*$92,600,000*
Revised Foundation Plan + Recommended Plan	**$339,400,000**
NFA Alternative C2 at WWTP	*$41,000,000*
System-Wide Improvements	***$380,400,000***

NOTES:
[1] Year 2012 dollars.
[2] All Costs Rounded.
[3] Planning Level Estimate.
[4] Right-of-Way and/or land acquisition not included.
[5] GI cost based on initial target control of 1,620 acres.

12.6 **Summary of Benefits**

The Recommended Plan offers significant benefits by focusing efforts, and associated costs, to tailor CSO improvements to achieve receiving water in-stream improvements.

12.6.1 Description of Benefits (CSO Reductions and Water Quality Modeling Results)

The benefits of the Recommended Plan were evaluated for each receiving water body in terms of reduction in CSO volumes, system-wide percent capture and anticipated frequencies of activations in a typical year. The proposed performance measure at this time is the activation frequency criterion consistent with the presumption approach as provided in the CSO Policy. The following sections summarize these evaluations.

12.6.1.1 CSO Volume, Percent Capture, and Frequency of Activation

The Recommended Plan was evaluated for each receiving water body in terms of targeted reduction in CSO frequency of activation. CSO volumes and system-wide percent capture estimates are provided for informational purposes and not used in establishing the performance measures. Residual volumes are presented for each CSO receiving water, while percent capture is presented on a system-wide basis. Table 12-9 presents a summary of the predicted frequencies, residual CSO volumes and percent capture for the Recommended Plan. Moreover, estimated residual activations and volume results for each CSO are presented in Appendix 12-2.

Table 12-9: Summary of Recommended Plan Benefits

Receiving Water Body	CSO	Baseline Activations	Baseline CSO Volume (MG)	Projected Activations (LOC)	Residual CSO Volume (MG)	Remaining Fecal Coliform Annual Loadings (MPN)
Black Rock Canal	004	5	11.2	3	8.7	1.25E+14
	005	4	0.1	4	0.1	
	006	65	198.9	4	21.7	
	008	39	6.1	0	0.0	
	010	44	11.9	1	0.0	
	012	42	52.5	2	0.9	
	013	7	6.8	4	2.7	
	061	10	31.2	2	1.2	
	063	13	0.6	4	0.3	
	Total	**≤65**	**319.3**	**0 – 4**	**35.6**	

Receiving Water Body	CSO	Baseline Activations	Baseline CSO Volume (MG)	Projected Activations (LOC)	Residual CSO Volume (MG)	Remaining Fecal Coliform Annual Loadings (MPN)
Buffalo River	017	49	71.3	4	34.8	6.26E+14
	022	49	29.8	5	2.0	
	025	11	1.4	6	1.2	
	026	63	124.2	3	29.6	
	027	36	31.7	6	39.1	
	028	69	45.5	6	22.7	
	029	0	0.0	0	0.0	
	032	0	0.0	0	0.0	
	033	9	37.8	5	31.8	
	034	Closed	Closed	0	Closed	
	049	0	0.0	0	0.0	
	050	14	3.2	5	2.8	
	051	4	1.2	4	1.2	
	052	10	10.9	3	6.3	
	064	56	21.1	3	6.9	
	066	10	1.7	4	0.4	
	Total	≤69	**379.7**	**2 – 6**	**178.8**	
Cazenovia Cr.-B	035	0	0	0	0	0.00E+00
Cazenovia Cr.-C	037	13	23.3	6	11.9	5.38E+13
	039	0	0.0	0	0.0	
	044	7	2.3	2	0.7	
	046	1	1.3	0	1.3	
	047	44	8.7	3	1.5	
	048	0	0.0	0	0.0	
	Total	≤44	**35.6**	**0 – 6**	**15.4**	
Erie Basin	014	4	4.2	2	3.1	1.30E+13
	015	12	6.1	1	0.6	
	016	0	0.0	0	0.0	
	Total	≤12	**10.3**	**0 - 2**	**3.7**	
Niagara River (incl. CSO 055)	055	41	601.1	9	206.2	7.66E+14
	003	6	0.1	5	0.8	

Receiving Water Body	CSO	Baseline Activations	Baseline CSO Volume (MG)	Projected Activations (LOC)	Residual CSO Volume (MG)	Remaining Fecal Coliform Annual Loadings (MPN)
	011	41	134.3	4	11.7	
	054	0	0.0	0	0.0	
	Total	≤41	**735.5**	**4 - 9**	**218.7**	
Scajaquada Creek	053	65	268.0	4	52.1	1.82E+14
	056	5	0.0	3	0.0	
	057	0	0.0	0	0.0	
	058	0	0.0	0	0.0	
	059	0	0.0	0	0.0	
	060	5	0.7	0	0.0	
	Total	≤65	**268.7**	**0 - 4**	**52.1**	
Totals		**NA**	**1749.1**	**NA**	**504.3**	**1.77E+15**
Percent Capture		**NA**	**91.3%**	**NA**	**97.2%**	**NA**

12.6.1.2 Water Quality Compliance

The Recommended Plan was evaluated for each receiving water body in terms of remaining pollutant loads and water quality compliance (for the pollutant of concern, bacteria). The water quality compliance evaluations were performed consistent with the baseline scenario documented in the BSA's *Technical Memorandum: Water Quality Modeling For the Preferred CSO Control Alternative In Buffalo River, Scajaquada Creek, Niagara River, and Black Rock Canal* (LimnoTech, April 5, 2012) included as Appendix 12-2. Based on the SPP-level refinement of GI discussed in Section 12.2, the BSA re-ran the WQ models and the results are also included in Appendix 12-2. This baseline scenario incorporates upstream water quality conditions (i.e., bacteria) set at 75% of the WQS (cBOD has no WQS, so it was set to 75% of the existing conditions upstream concentration). These modified upstream boundary conditions were identical for both the Baseline scenario used in this report and for the Recommended Plan.

Attainment of the bacteria WQS for each water body under the Recommended Plan was calculated from model output and compared to the bacteria WQS attainment for the Baseline condition. Table 12-10 provides a summary of annual percent attainment of bacteria water quality standards for all modeled water bodies under these two scenarios. Attainment was first calculated for each model segment and then spatially averaged across each water body.

Table 12-10: Water Quality Standards Attainment for Bacteria Comparison of Baseline Scenario (Background 75% of WQS)

Scenario	Bacteria: Annual Percent Attainment (%) of WQS					
	Upper Scajaquada Creek	Lower Scajaquada Creek	Buffalo River	Black Rock Canal	Erie Basin	Niagara River (incl. CSO 055)
Baseline (Background 75% of WQS)	99	77	93	86	100	100
Recommended Plan	100	100	100	100	100	100

All water bodies demonstrated 100% attainment of the bacteria WQS under the Recommended Plan for the targeted levels of control described in Section 12.1 above (note that Black Rock Canal was rounded from 99.9% to 100%). The greatest improvement was seen for Lower Scajaquada Creek, where attainment increased from 77% in the Baseline (Background 75% of WQS) scenario to 100%. Additionally, bacteria WQS attainment increased from 86% to 100% in the Black Rock Canal, 93% to 100% for the Buffalo River, and from 99% to 100% for the Upper Scajaquada Creek. Bacteria WQS attainment in the Erie Basin and the Niagara River remained unchanged at 100% attainment for baseline conditions. Additional results for each water body can be found in Appendix 12-2. In addition to evaluating bacteria water quality compliance, residual bacteria loadings were also calculated and are presented in Table 12-9 above.

12.7 GI Sensitivity Evaluations

As described above, the Recommended Plan has an important and reasonable GI component with a number of the sewersheds within the BSA CSS targeted for up to 20% of impervious area control by GI projects. Figure 12-1 presented the conceptual level GI coverage for the CSS sewersheds City-wide.

GI has gained strong public and regulatory support over the past decade; while many GI technologies are still maturing communities nationwide and documenting their long term performance. That said, GI performance in colder climates, such as the City of Buffalo, may require additional time to validate. Finally, the ultimate effectiveness of a GI program in the longer term is heavily dependent upon community acceptance. These factors are why the BSA plans on conducting GI pilot projects prior to being able to define a system-wide GI implementation program. The BSA has constructed a demonstration project tributary to CSO 060, which is currently in the post-construction monitoring phase. This project includes a number of different GI techniques to provide a database of community-specific performance metrics. Additional GI pilot projects are considered for the early years of the LTCP implementation as discussed in the GI Master Plan (Appendix 12-3) and further presented in Section 14.

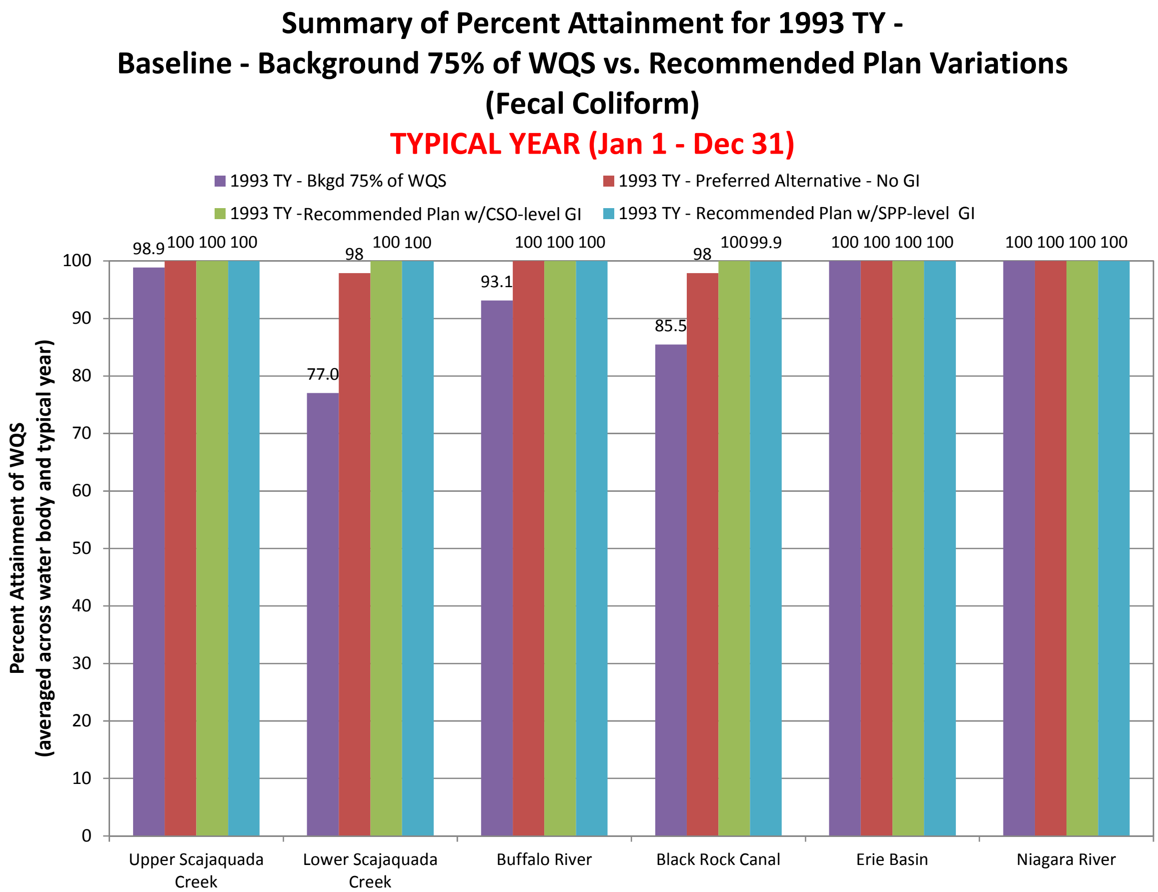
In order to evaluate the sensitivity of the program to GI effectiveness, the typical year precipitation simulation model was run incorporating only the gray components of the Recommended Plan. This run was intended to determine how the system would react in the event that in the worst case, GI proved to be ineffective. The sensitivity evaluation results are presented in Table 12-11 below. The SPP-level GI scenario represents the impervious surface area control associated with the SPP-level refinement discussed in Section 12.2. As can be seen from Table 12-11, with no GI assumed, the effect on projected activations is relatively minor; however, the implementation of GI results in an annual CSO volume reduction of approximately 210 MG. This evaluation demonstrates that even if the GI program falls significantly short of the established goals, the resulting reduction in system performance will be negligible given the significant progress and high LOC achieved to date.

Table 12-11: Green Infrastructure Sensitivity Analysis Results

	Projected Activations (LOC)		**Residual CSO Volume (MG)**	
Receiving Water Body	**GI (SPP-level)**	**No GI**	**GI (SPP-level)**	**No GI**
Black Rock Canal	0 – 4	0 - 7	35.6	57.3
Buffalo River	2 – 6	3 - 10	178.8	233.9
Cazenovia Cr.-B	0	0	0.0	0.0
Cazenovia Cr.-C	0 - 6	0 - 8	15.4	20.6
Erie Basin	0 - 2	0 - 2	3.7	6.8
Niagara River (incl. CSO 055)	4 - 9	6 - 12	218.7	321.2
Scajaquada Creek	0 - 4	0 - 7	52.1	74.2
Totals	**NA**	**NA**	**504.3**	**713.9**
Percent Capture	**NA**	**NA**	**97.2%**	**96.5%**

In addition to the hydraulic modeling comparison discussed above, the BSA also evaluated the water quality impact of no GI. Figure 12-4 shows a graphical comparison of the resulting water quality impacts.

Figure 12-4



NOTE: The 99.9 percent capture in Black Rock Canal for the “Recommended Plan – Updated GI” scenario was rounded to 100 percent.

The WQ modeling results indicate that the Recommended Plan components with no GI will result in 100% attainment of the current NYS bacteria WQS in in all receiving water bodies, except for the Lower Scajaquada Creek and Black Rock Canal (both at approximately 98%). Further, as the figure shows, and as discussed previously, the Erie Basin and Niagara River already reflect a 100% attainment of the current NYS bacteria WQS under the baseline conditions and are thus not impacted by reductions in GI. This suggests that much of the system will not be affected appreciably by reductions in GI.

12.8 Performance Criteria and Designated Uses

The BSA reserves the right to petition the NYSDEC to perform a use attainability analysis (UAA) should the NYSDEC (or USEPA) conclude in the future that the applicable WQS are not attained after achieving the LTCP performance criteria recommended in this plan for each RWB. In addition, after achieving an extraordinarily high level of CSO control, the BSA expects that the NYSDEC would prepare a Total Maximum Daily Load (TMDL) to allocate loadings among all sources, particularly upstream sources that will not have achieved anywhere near the reductions that the BSA has achieved. The CSO Policy expressly calls for a TMDL and/or use attainability analysis where other sources than CSOs cause or contribute to water quality standards excursions.

13. BSA Financial Capability Assessment

This section evaluates the ability of the Buffalo Sewer Authority's ("BSA") ratepayers to implement the Recommended Plan within the 20-year implementation schedule. It concludes that the program will impose a heavy financial burden. Despite the burden, BSA believes it can implement the Recommended Plan in the 20 year time frame. However, any change to either the proposed level of control or schedule will necessitate a reevaluation of the affordability of the program and likely the need for a use attainability analysis based upon financial infeasibility and other factors.

13.1 Background

The BSA, as part of the development of the April 2012 LTCP, updated and replaced the Financial Capability Assessment (FCA) originally submitted as part of the 2004 Draft LTCP. The April 2012 updated FCA was prepared in 2010 (revised in 2011) in accordance with the U.S. Environmental Protection Agency's *Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development, 1997* (the "Guidance").

The updated FCA demonstrated that the economic burden on BSA ratepayers would in fact be HIGH should BSA implement the "Preferred System-Wide Alternative" LTCP alternative as defined in the 2004 LTCP submittal. The revised calculation of the Residential Indicator (RI) and Financial Capability Indicator (FCI), as prescribed by the Guidance, resulted in scores of *HIGH* and *WEAK*, respectively, and yielded a HIGH burden determination within the Financial Capability Matrix.

Because the FCA demonstrates that the BSA will be heavily burdened even when using the limited criteria of the EPA's Guidance, the BSA did not go further to address the many additional local factors that would impact affordability. We believe, an analysis of such local factors would further demonstrate the heavy burden BSA will face to implement the program. However, the BSA reserves its right to include such local factors and considerations, as well as seek schedule relief if the Recommended Plan and schedule are not approved as submitted. The full FCA submitted in April 2012 can be found in Appendix 13-1.

Subsequent to the submission of the April 2012 LTCP, the Regulatory Agencies provided comments that led to revisions and resubmission of the LTCP. Some of these comments and associated revisions have driven changes to the economics originally anticipated for the LTCP. In particular, the Agencies requested that the BSA revise the No Feasible Alternative (NFA) analysis and incorporate significant treatment plant upgrades into the Recommended Plan and LTCP implementation schedule. Prior to this, no treatment plant capital projects were formally included in the FCA. This change increased the costs of the Recommended Plan from an estimated $340 million to $380 million. Also, the implementation schedule was changed from 19 to 20 years. However, the schedule extension does not offset the program cost increase so the effective financial burden on the ratepayers will have increased somewhat from the already high level demonstrated in the April 2012 FCA.

While the previously submitted FCA (Appendix 13-1) has not been modified, the following sections document the impact of the recommended LTCP revisions on the program affordability and the FCA.

13.2 Summary of Burden Impact from the Recommended Plan Cost Estimates

Based on the components of the Recommended Plan, which includes approximately $380 million in capital improvements with a 20-year implementation period, the BSA is providing this summary description of impacts to the previously completed FCA. The BSA is not replacing or revising the FCA, but is providing this summary to confirm that the implementation of the Recommended Plan does not change the BSA's previous determination of HIGH burden.

The primary differences between the assumptions used in 2010/2011 FCA and the Recommended Plan relate to the implementation schedule and the amount of estimated capital investment. Thus, only the Residential Indicator (RI) was reexamined. The Financial Capability Indicator (FCI) would not be impacted by the proposed change of schedule or estimated cost, and thus remains WEAK as previously determined.

To re-evaluate the RI based on the proposed Recommended Plan and 20 year implementation schedule, updated capital investment figures and a revised financing schedule were used. In addition, the Operation and Maintenance (O&M) estimates were updated based on the revised capital estimates. Table 13-1 shows the revised calculation of the Cost Per Household (CPH) based on the updated capital investment of $380M. This table compares with Table No.5.4 in the FCA (Appendix 13-1).

Table 13-1 Revised Cost Per Household

Description	$380 Million LTCP: City Service Area	$380 Million LTCP: Including Wholesale Customers
Current WWT Costs		
Annual O&M	$ 40,215,261	$ 40,215,261
Annual Debt Service	$ 16,049,834	$ 16,049,834
Cheektowaga		$ 10,814,559
West Seneca		$ 8,029,684
Erie Co. Sewer District 1 & 4		$ 12,753,847
Wholesale Debt Service		$ 2,408,464
Wholesale Revenues	$ (11,246,101)	$ (11,246,101)
Subtotal	**$ 45,018,994**	**$ 79,025,548**
Projected WWT & CSO Costs		
(Current Dollars)		
O&M - CSO	$ 2,394,000	$ 2,394,000
Debt Service		
Non-CSO Related Projects	$ 51,520,309	$ 51,520,309
CSO Projects	$ 37,546,898	$ 37,546,898
Cash Funded		
Non-CSO Related Projects	$ -	
CSO Projects	$ -	
Wholesale Community Capital Costs		
Cheektowaga		$ 4,414,693
West Seneca		$ 1,852,693
Erie County Sewer District		$ 6,845,761
Wholesale Community LTCP		
Cheektowaga		$ 4,395,966
West Seneca		$ 4,631,732
Erie County Sewer District		$ -
Additional O&M		$ 577,030
Future Costs Allocated to Wholesale	(25,609,138)	
Subtotal	$ 65,852,069	$ 114,179,081
Total Current & Projected Costs	$ 110,871,063	$ 193,204,629
Residential Flow	72%	75%
Residential Share of Costs	$ 79,873,748	$ 145,821,586
Number of Households in Service Area	108,387	178,769
Cost Per Household (CPH)	**$ 737**	**$ 816**

Prepared by Conestoga-Rovers & Associates, December 2013

Once the revised CPH was determined, the ratio between the CPH and the City's Median Household Income (MHI) was evaluated to establish the new RI as shown in Table 13-2. This table compares with Table No. 5.5 of the FCA and shows that the RI remains above 2% (HIGH) for the City Service Area at the new proposed LTCP investment levels.

It is important to point out again (as previously noted in the FCA), that some anticipated regulatory compliance and operational costs within the wholesale service area are currently undetermined, and thus have not been included in the calculation. Specifically, no future regulatory compliance costs (either capital or O&M) were included for the Erie County Sewer District (ECSD). In addition, the Consent Order costs for the Town of West Seneca and the Villages of Lancaster and Depew (both Villages are in the ECSD) were also not included within the CPH calculation in Table 13-1. It is anticipated that such future compliance costs will be substantial and will therefore significantly increase the RI of the wholesale communities. Furthermore, the 2010 census data, which were not available when the FCA was last revised in 2011, shows a decline in MHI relative to the figures used in the FCA – and thus the RI would increase if new data were used. Consequently, it is anticipated that even when the wholesale customers are included, the RI will continue to exceed 2% of MHI (HIGH burden). Ultimately, however, due to the BSA's WEAK FCI score and an RI greater than 1%, (under all alternative scenarios) implementing the Recommended Plan during a 20 year period will impose a HIGH burden for both the City and Wholesale Service Areas.

Table 13-2 Residential Indicator*

Description	*$380 Million LTCP*	
	City Service Area	*Including Wholesale Customers*
Census Data Year	2008	1999
Census Year MHI	$29,973	$30,931
MHI Adjustment Factor	2.59%	2.59%
Adjusted MHI	$31,545	$40,974
Cost Per Household	**$737**	**$816**
Residential Indicator (RI)	**2.34**	**1.99**

Prepared by Conestoga-Rovers & Associates, December 2013

*Residential Indicator does not factor in the recent decline in MHI nor all of the anticipated but presently undetermined regulatory compliance costs within the wholesale communities

13.3 FCA Conclusions with Recommended Plan Capital Estimates

It is important to note that due to the BSA's *WEAK* FCI, ratepayers already fall within the HIGH burden category as defined by the Guidance. Based on the 2010 Census data and without consideration of any future LTCP expenses, the CPH is approximately 1.3% of the current MHI. Per the Guidance, BSA's WEAK FCI and the current CPH in excess of 1%, results in a *HIGH* burden today, before any additional LTCP monies are expended.

Unfortunately, the CPH is expected to increase in future years regardless of what the LTCP expenses may be, due to the relentless decline in service area population. These distressing financial circumstances support the conclusion that the Recommended Plan and accompanying implementation schedule represent the maximum commitment the BSA can make to address sewer overflows. Any proposed additional requirements or reduction in the implementation schedule will warrant a use attainability analysis.

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14. Implementation Schedule

The following discussion presents the proposed implementation schedule for the BSA's LTCP. The BSA has developed this 20-year implementation schedule as agreed to by the Regulatory Agencies in their correspondence dated October 23, 2013. As allowed by the CSO Policy, the schedule is staged to both account for affordability and the fact that simultaneous construction of all improvements identified within the preferred LTCP would not be practical. Finally, staging of the improvements allows for adjustments to the program based upon the effectiveness of completed projects. This section presents a recommended sequence for implementing the improvements based on the benefit of reducing CSO frequencies and volumes as well as the availability of funding sources.

The schedule was developed based on the following general assumptions:

- Completion of Phase I projects by the end of 2014, would be the first priority. While many of the Phase I projects have been completed, there are still a few projects (*i.e.*, the RTC demonstration projects) that are currently under construction.

- Real-time control projects, which optimize the use of regulators at the SPPs and CSO chambers, are scheduled early on within the implementation schedule as these improvements would offer significant benefit for relatively little cost. Two RTC demonstration projects are included in Phase I projects and will serve to refine the RTC technology used in the BSA system and associated benefits.

- The schedule offers a distribution of green infrastructure projects that would be constructed in stages throughout the implementation duration, as discussed in the GI Master Plan (Appendix 11-3). Green infrastructure pilots have been scheduled early on within the implementation schedule, to allow for the development of performance matrices through feedback from post-construction monitoring. These matrices will be used to tailor the techniques to be considered in future phases of implementation of green infrastructure projects. The target total amount of green infrastructure coverage to be implemented will be a range of impervious area control of between 1,315 and 1,620 acres. The 1,315 acres represents the minimum target control acreage using the SPP-level refinement for GI control; however, the BSA will utilize modeling and post construction monitoring of the first three phases of GI projects to confirm that the 1,315 target acres will be sufficient to meet the target level of control objectives. If needed, the acreage target for the fourth phase of GI projects will be adjusted to ensure the level of control is achieved.

- Projects impacting CSOs in the identified sensitive area (Erie Basin Marina) are implemented early on in the schedule. This project is relatively independent from the GI performance and includes the construction of in-line and satellite storage facilities and appurtenances and associated conveyance system improvements.

- Because Black Rock Canal and Scajaquada Creek basins are more sensitive to GI performance, gray projects in these basins are scheduled upon completion of the post-construction monitoring of the pilot GI projects.

- Projects that reduce the frequency and volumes of CSO activations upstream of and into the Black Rock Canal (near CSO 013, 008, and 010) are implemented early on in the schedule (but still upon confirmation of GI pilot project performance), as this receiving water body is considered to be the most sensitive to CSOs in terms of water quality. In addition to satellite storage, these projects include underflow capacity upsizing and the installation of the Northern Relief Interceptor.

- Model estimated water quality impacts from the BSA CSOs on each receiving stream were evaluated to prioritize the improvements schedule since the BSA CSO receiving streams have very different assimilative capacities and the estimated impacts from the CSOs on the receiving stream are not proportional to the pollutant loads. Improvements to CSOs tributary to receiving streams where model estimated water quality impacts from these CSOs were greater were scheduled for earlier phases of the program and typically included gray infrastructure projects that can be constructed more quickly

- The schedule has been developed to reflect the anticipated timeframes to complete the usual steps required for planning and engineering of a typical gray infrastructure type project, including:

  - Facility planning
  - Design
  - Permitting/SEQRA/Public Notice
  - Regulatory approval
  - Land/easement acquisition
  - Funding
  - Bidding/Award

  While the BSA has included estimated durations for the Permitting/SEQRA/Public Notice, Regulatory approval, and Land/easement acquisition steps, these durations are not typically within total control of the BSA, and can be highly variable.

- The BSA reserves the right to substitute projects within the same general timeframe as the projects listed in the schedule, either by implementing one or more projects of equal cost value or that achieves the same benefit as the original project.

In addition to numerous projects completed in the past, the BSA has decided to continue implementation of collection system improvements, within the Phase I and Foundation alternatives. These collection system improvements, although less extensive than the full LTCP, represent a significant investment by the BSA for abatement of CSO discharges within the City of Buffalo. In fact, projects completed to date in the system have led to the elimination of thirteen CSOs.

14.1 Implementation of the BSA Preferred Alternative

Figure 14-1 shows the implementation of the BSA's preferred plan over the course of 20 years, resulting in a substantial reduction in annual CSO activation frequencies and volumes. As discussed previously, remaining Phase I and Foundation Plan projects are scheduled to be implemented first, with the next priority given to Erie Basin Marina (sensitive area) and Black Rock Canal (most affected by wet weather discharges). Storage and conveyance projects in the Scajaquada Creek, Buffalo River (with the exception of Smith Street project), and Niagara River sewersheds would primary be implemented starting about halfway through the overall 20-year implementation, after evaluating the GI pilot project performance.

Most notably, the preferred LTCP has a significant (but reasonable and realistic) green component, with a commitment to control a range of between 1,315 and 1,620 acres of impervious surface city-wide through the use of GI. These areas are distributed by receiving water body as shown in Table 14-1.

Table 14-1: Proposed Minimum Green Infrastructure Control Acreage by Receiving Water Body

Receiving Water	Area Managed by GI (acres)
Black Rock Canal	198
Buffalo River	319
Cazenovia Creek - B	3
Cazenovia Creek - C	58
Erie Basin	53
Niagara River	378
Scajaquada Creek	305
Total	**1,315**

Because of the need for post construction monitoring to evaluate the effectiveness of GI technologies, the minimum impervious surface control implementation is phased throughout the 20-years as follows:

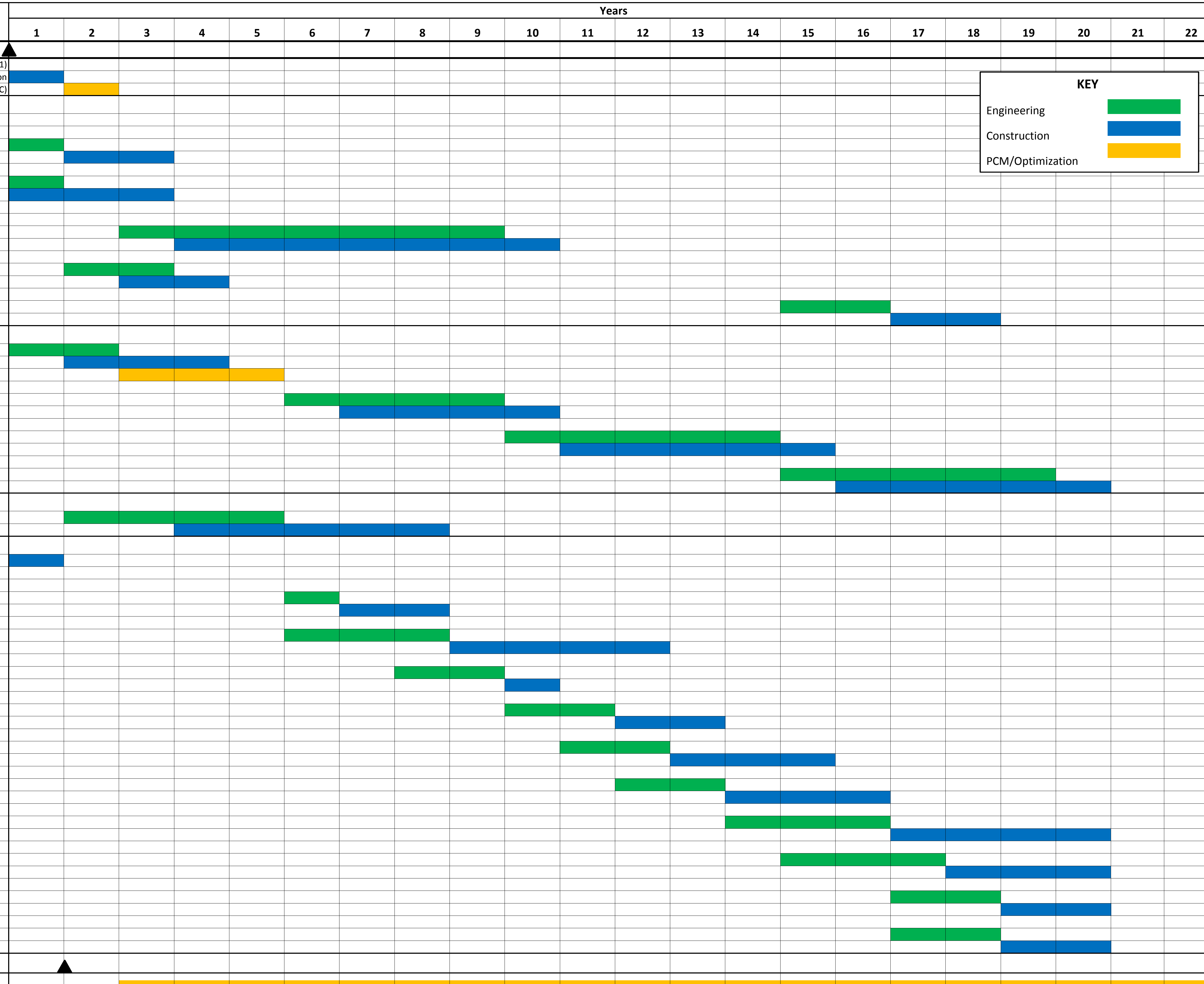
- 267-acres controlled in Years 1-5 (20% of total GI, *i.e.*, 1,315-acres)
- 410-acres controlled in Years 6-10 (~30% of total GI)
- 375-acres controlled in Years 11-15 (~30% of total GI)
- 263-acres controlled in Years 16-19 (20% of total GI)

This scheduling allows for the upfront construction of gray technologies required to capture a significant amount of wet weather flow in strategic areas and those that are relatively independent from the GI performance, while allowing the BSA adequate time to evaluate the effectiveness of the GI technologies implemented within the first five years.

Consistent with the CSO Control Policy, the BSA will conduct post-construction monitoring (PCM) to verify the effectiveness of the CSO controls to meet the performance criteria specified in this LTCP, including for GI projects. The performance feedback received from the GI projects during the post-construction monitoring will assist the BSA in rightsizing the subsequent gray projects and more accurately determining the types of GI technologies to be used in subsequent implementation periods, as well as to make adjustments to the amount of GI constructed. Should the PCM results for the GI projects indicate that the specific performance criteria are not being met or are being out performed; the BSA will propose alternative projects (green or gray) designed to achieve the performance criteria. Depending on the specific project area, this may include additional impervious surface acreage controlled by GI, rightsizing an already proposed gray project or designing an entirely new project. The BSA will use the GI performance data collected, as well as the models to fine-tune the gray infrastructure facilities to meet the specific performance criteria, whether the facilities need to be smaller or larger sized than what is included in this LTCP. Further discussions on the GI PCM are provided in the GI Master Plan (Appendix 11-3). Since the gray projects included in this LTCP are based on planning level information, the BSA will refine the size of such facilities during the facility planning and preliminary design phases of each project.

Figure 14-1: BSA CSO LTCP
Implementation Schedule - Recommended Plan

Project	Receiving Water	Description
LTCP Regulatory Approval		
Phase 1 Projects	Varies	Bird/Lang RTC Projects (see Table 11-11)
		Construction
		Operations/Optimization (RTC)
Foundation Projects		
CSO 016 Storage	Erie Basin	*Completed (In-Line Storage see Table 11-11)*
Foundation 1	Buffalo River	Smith St Storage
		(see Table 11-11)
Foundation 2	Varies	SPP Optimization (see Table 11-11)
		(20 projects)
		(conveyance facilities)
Foundation 3	Varies	Remaining RTC (see Table 11-11)
		(14 sites)
Foundation 4	Buffalo River	Hamburg Drain Optimizations
		(see Table 11-11)
	Buffalo River	Hamburg Drain Storage
		(see Table 11-11)
Green Projects		
Green Pilot Projects	Varies	267-acres of GI control (See GI Master Plan)
		Construction
		PCM
Green 2	Varies	410-acres of GI control
Green 3	Varies	375-acres of GI control
Green 4	Varies	263-acres of GI control
WWTP		
NFA Project	Niagara River	Alternative C2 from NFA
Gray Projects		
014/015	Erie Basin	In-line storage and optimization
		(see Section 12.3)
013	Black Rock Canal	Satellite storage, conveyance, FM & PS
		(see Section 12.3)
North Relief	Black Rock Canal	Interceptor (see Section 12.3)
010, 008/010, 061, 004	Black Rock Canal	Underflow capacity upsizing
		(see Section 12.3)
SPP 337 (053)	Scajaquada Creek	Satellite storage, conveyance, FM & PS
		(see Section 12.3)
SPP 336 a + b (053)	Scajaquada Creek	Satellite storage, conveyance, FM & PS
		(see Section 12.3)
Jefferson & Florida (SPP 170B - CSO 053)	Scajaquada Creek	Satellite storage, convey & FM
		(see Section 12.3)
055	Niagara River	Satellite storage, conveyance, FM & PS
		(see Section 12.3)
028/044/047	Buffalo River/ Cazenovia Creek-C	Satellite storage, conveyance, FM & PS
		(storage at Tops from CSO 47 west)
		(see Section 12.3)
052	Buffalo River	Satellite storage, conveyance, FM & PS
		(see Section 12.3)
064	Buffalo River	Satellite storage, conveyance, FM & PS
		(see Section 12.3)
Submit PCM Plan		
Overall PCM		



NOTE: The BSA reserves the right to substitute projects within the same general timeframe as the projects listed in the schedule, either by implementing a project of equal cost value or one that achieves the same benefit as the original project.

15. Post-Construction Monitoring Program

The USEPA recommends in the CSO Control Policy that a post-construction monitoring program (PCMP) be conducted during and after LTCP implementation to help determine the effectiveness of the CSO controls in meeting their intended purpose and achieving local water quality goals. Monitoring during and after LTCP implementation will include in-system and receiving stream data collection as necessary to determine the effectiveness of CSO controls. Post-construction monitoring can also be used to increase public awareness of the effectiveness of CSO controls. Data gathered during, and after, LTCP implementation would be compared to baseline data gathered during the system characterization phase of the LTCP development to determine effectiveness of CSO controls. The PCMP resources include the USEPA *Combined Sewer Overflows Guidance for Long Term Control Plan* dated August 1995 and the recently released USEPA CSO Post Construction Compliance Monitoring Guidance (May 2012).

A properly developed PCMP outlines specific efforts to be undertaken to evaluate the effectiveness of each project (or a group of projects) and within each water body. As required by the USEPA AO, the BSA commits to the development of a detailed PCMP within one calendar year of approval of the LTCP program. At this point, however, the BSA can, in general terms, describe concepts for monitoring the implementation and effectiveness of the projects. The concepts outlined below are based on previously approved LTCPs for similar municipalities. When implemented, the BSA's CSO controls are expected to improve water quality through a reduction of the CSO activation frequency in the various receiving water bodies and the PCMP will allow the BSA to track progress by individual receiving streams where controls are implemented.

The final PCMP is expected to include the following general elements:

- Actions to document that the BSA has built the CSO control measures required under the recommended LTCP;
- Actions to confirm that the control measures have achieved the Performance Criteria in the approved LTCP for each water body (based on the modified 1993 Typical Year);
- Actions to monitor the benefits of the CSO control measures, such as in-stream water quality improvements and reductions in CSO volume, frequency and duration when compared to baseline conditions; and,
- Progress reporting to the USEPA and the NYSDEC.

As stated in the *Combined Sewer Overflows, Guidance for Long Term Control Plan,* the USEPA recommends that CSO communities conduct a post-construction monitoring program during and after LTCP implementation *"to help determine the effectiveness of the overall program in meeting [Clean Water Act] requirements and achieving local water quality goals."* Accordingly, the BSA's PCMP will collect data that evaluates the effectiveness of CSO controls and their impacts on water quality. Where possible, the program will use existing monitoring locations that are used in the Nine Minimum Controls (NMC) Monitoring Plan and/or the LTCP development in order to compare results to historical conditions before controls were put in place. The program will ultimately include a map of monitoring locations, a record of data collection frequency at each location, a list of other data to be collected, and quality control procedures. Given the complexity and size of the BSA's combined sewer system, monitoring all CSO or SPP locations will not be feasible and, as such, the BSA will use sound engineering judgment and best industry practices in using the collection system model to determine whether the BSA has achieved compliance with the Performance Criteria established in the approved LTCP for each water body. As warranted, the BSA will update the model following a detailed step-wise process including data collection, completion of model updates, CSO frequency activation, model re-calibration, if necessary and full model Typical Year simulations.

Additionally, in the USEPA's December 2001 *Report to Congress: Implementation and Enforcement of the Combined Sewer Overflow Control Policy*, the agency noted the difficulty of establishing a monitoring and tracking program for CSO control programs. *"Monitoring programs need to be targeted and implemented in a consistent manner from year to year to be able to establish pre-control baseline conditions and to identify meaningful trends over time as CSO controls are implemented,*" the report said. *"In practice, it is often difficult, and in some instances impossible, to link environmental conditions or results to a single source of pollution, such as CSOs. In most instances, water quality is impacted by multiple sources, and trends over time reflect the change in loadings on a watershed scale from a variety of environmental programs.*" The report also noted that weather conditions and rainfall totals vary significantly from storm to storm and year to year, making comparisons difficult. Therefore, the PCMP will likely focus on documenting reductions in CSO activations and volumes on a Typical Year basis. The BSA will use the receiving stream water quality models for projecting resulting water quality impacts of the remaining CSO volumes and activations on the receiving streams. The current water quality models have been developed under the LTCP efforts and approved by the USEPA. The models will be updated as necessary during the LTCP implementation period.

It is expected that the PCMP will extend for at least two years after completion of the recommended LTCP improvements and will conclude with the preparation of the Final Post Construction Monitoring Report. The exact PCMP period will be dependent on the extent of field monitoring, sampling and desktop evaluations agreed upon in the approved PCMP as well as weather conditions during the program. Further discussions on the PCMP duration will take place during the development of the detailed work plan, which will be submitted within one year of the Agencies' approval of this LTCP in accordance with the USEPA's Administrative Order.

The Final Post-Construction Monitoring Report will evaluate whether CSO Control Measures are meeting the performance criteria in the approved LTCP. The BSA will use CSO activation frequency as predicted by the updated collection system model to evaluate Typical Year performance and whether the LTCP has achieved the Performance Criteria. In the Final Post-Construction Monitoring Report, the BSA also will use the water quality model to predict the conditions in CSO receiving streams to compare to baseline conditions. If necessary, the Final Post-Construction Monitoring Report will include a description of additional facilities, processes or operating strategies necessary to meet the Performance Criteria.