FINAL
REPORT

Combined Sewer Overflow Long Term Control Plan Tier III Update

City of Portland, Maine
and Portland Water District

January 2013

CDM Smith

WRIGHT-PIERCE
Engineering a Better Environment

670 N. Commercial Street
Manchester, New Hampshire, 03101
tel: 603 .222.8300
fax: 603.628.7675

January 25, 2013

Mr. Michael Bobinsky
Director of Public Works
City of Portland
55 Portland Street
Portland, Maine 04101-2921

Subject: CSO-LTCP Tier III Final Report

Dear Michael:

Please find attached the Combined Sewer Overflow Tier III Long Term Control Plan Final Report. This final report incorporates the previously approved updates to address the State of Maine Department of Environmental Protection (MDEP) review comments and questions. Included in Appendix K is the correspondence related to MDEP review comments and CDM Smith responses.

Once again, it has been a pleasure to work with you, the City staff and all the stakeholders on this important long term control plan. Please contact me with any questions.

Very truly yours,

Daniel Bisson, P.E., BCEE
Client Service Manager
CDM Smith Inc.

cc: Kathi Earley, City of Portland
David Margolis-Pineo, City of Portland
Brad Roland, City of Portland
Nathaniel Smith, City of Portland
Ellen Sanborn, City of Portland
Scott Firmin, Portland Water District
John Gall, CDM Smith
Joe Ridge, CDM Smith
Brian Hickey, CDM Smith

Table of Contents

Executive Summary - Portland CSO LTCP Tier III Update

E.1 Summary of Tier III Recommended Plan ES-1
E.2 Purpose and Scope ES-2
E.3 Tier I/II CSO Program ES-2
E.4 Review of Remaining Tier II Projects ES-5
E.5 Recommended Tier III Program ES-7

Section 1 - Introduction

1.1 Purpose and Scope 1-1
1.2 History of Program 1-2
1.2.1 Consent Agreement 1-2
1.2.2 Approved CSO LTCP 1-2
1.2.3 Upgrades to the Pump Stations and EEWWTF 1-3
1.2.4 Tier I and II Sewer Separation 1-3
1.2.5 Typical Year Rainfall 1-4
1.2.6 Historic Annual Overflows 1-5
1.3 Climate Change Implications 1-7
1.3.1 Precipitation and Sea Level Changes 1-7
1.3.2 Climate Change Summary Related to CSOs 1-7

Section 2 - Existing System

2.1 Introduction 2-1
2.2 Collection System 2-1
2.2.1 Service Area 2-1
2.2.2 Infrastructure 2-5
2.3 East End Waste Water Treatment Facility 2-7
2.3.1 Description 2-7
2.3.2 Wet Weather Treatment 2-8

Section 3 - Monitoring Program

3.1 Introduction 3-1
3.2 Flow Monitoring 3-1
3.2.1 Collection System 3-1
3.2.2 Pump Stations and EEWWTF 3-1
3.3 Precipitation Data 3-7
3.3.1 PWD Rain Gages 3-7
3.3.2 Portland International Jetport Rain Gage 3-7
3.4 Tidal Data 3-9
3.4.1 Portland Harbor and Fore River 3-9
3.4.2 Back Cove 3-10
3.5 Recommended Monitoring Improvements 3-11

Section 4 - Collection System Modeling

4.1 Introduction 4-1
4.2 Previous Modeling Efforts 4-1
4.3 Model Updates 4-1
4.3.1 Georeferencing 4-3
4.3.2 Sewer Network 4-3
4.3.3 Outfall Properties 4-3
4.3.4 Catchment Properties 4-6
4.4 Calibration and Validation 4-8
4.4.1 Methods 4-8
4.4.2 Results 4-9
4.5 Model Improvements Needed at Regulators/Outfalls 4-11
4.6 Baseline CSO Estimates 4-11
4.6.1 Existing Conditions (Typical Year Rainfall) 4-11
4.6.2 Comparison to Previous Projections 4-12
4.7 Recommended Model Improvements 4-13

Section 5 - Pollutant Loads

5.1 Introduction 5-1
5.2 Historic Pollutant Concentrations 5-1
5.2.1 1993 Portland Average (CSO) 5-1
5.2.2 New England Averages (CSO) 5-1
5.2.3 EPA Urban Stormwater 5-2
5.3 Water Quality Monitoring Program 5-2
5.3.1 Description 5-2
5.3.2 CSO Results 5-2
5.3.3 Stormwater Results 5-5
5.3.4 In-stream Results 5-5
5.4 Baseline Loading Estimates 5-5
5.4.1 CSOs 5-5
5.4.2 Stormwater 5-8

Section 6 - Receiving Water Quality and Uses

6.1 Introduction 6-1
6.2 Classification of Receiving Waters 6-1
6.2.1 Water Quality Standards 6-1
6.2.2 Receiving Water Designated Uses 6-4
6.2.3 Impaired Waters and Total Maximum Daily Loads (TMDLs) 6-8
6.3 Receiving Waters in Portland 6-10
6.3.1 Fall Brook 6-12
6.3.2 Capisic Brook 6-12
6.3.3 Fore River 6-13
6.3.4 Back Cove 6-14
6.3.5 Portland Harbor 6-14
6.3.6 Casco Bay 6-14

6.3.7 General Estuarine and Marine waters 6-15
6.4 Sensitive Environments and Restoration Programs 6-16
6.4.1 Endangered Species and Species of Concern 6-16
6.4.2 Restoration Program 6-16
6.4.3 Vernal Pools 6-17
6.5 Summary - CSO Contributions to Impairments 6-17

Section 7 - Tier II Improvements Analysis

7.1 Introduction 7-1
7.2 Tier II Effectiveness Analysis 7-1
7.2.1 General 7-1
7.2.2 Method 7-1
7.2.3 Tier II Analysis Results 7-2
7.3 Alternatives Analysis 7-2
7.3.1 Capisic Brook Watershed 7-3
7.3.2 Fall Brook Watershed 7-3
7.4 Tier II Loading Estimates 7-5
7.4.1 CSO Loadings 7-6
7.4.2 Stormwater Loadings 7-8
7.5 Recommendations for Completing Tier II 7-9
7.5.1 Capisic Brook Recommendations 7-9
7.5.2 Fall Brook Recommendations 7-9

Section 8 - Tier III Improvements Analysis

8.1 Introduction 8-1
8.2 Tier III Analysis Approach 8-1
8.3 CSO Abatement Technologies 8-3
8.4 Source Control Measures 8-4
8.4.1 Best Management Practices 8-4
8.4.2 Green Infrastructure 8-5
8.5 Collection System Controls 8-8
8.5.1 Sewer Separation 8-8
8.5.2 System Optimization via Real-Time Controls 8-9
8.5.3 Tide Gates 8-10
8.6 Satellite Facility Consideration in Portland 8-10
8.7 Storage Technologies 8-11
8.7.1 Tunnel Storage 8-11
8.7.2 Near Surface Storage 8-11
8.8 Treatment Technologies 8-13
8.8.1 Satellite Treatment Technologies 8-13
8.8.2 East End Treatment Facility Upgrades 8-14
8.8.3 Treatment Technologies Conclusion 8-16
8.9 Cost Estimates 8-16
8.9.1 Sewer Separation Costs 8-16
8.9.2 Satellite Facility Costs 8-17

8.9.3 Storage Conduit Cost Estimates 8-17
8.10 Conclusions 8-17

Section 9 - Tier III Recommendations

9.1 Introduction 9-1
9.2 Back Cove (North) 9-4
9.3 Back Cove (West) 9-4
9.3.1 General 9-4
9.3.2 Alternatives 9-4
9.4 Back Cove (South) 9-6
9.4.1 General 9-6
9.4.2 Alternatives 9-6
9.5 Portland Harbor 9-8
9.5.1 General 9-8
9.5.2 Alternatives 9-8
9.5.3 Portland Harbor Reductions 9-10
9.6 Capisic Brook/Fore River 9-11
9.6.1 General 9-11
9.6.2 Alternatives 9-11
9.7 Tier III Pollutant Loading Reductions 9-13
9.8 Recommended Program 9-16

Section 10 - Financial Evaluation

10.1 Introduction 10-1
10.2 Major Findings 10-1
10.3 Approach 10-2
10.3.1 Data 10-2
10.3.2 Methodology 10-2
10.3.3 Assumptions 10-3
10.4 Phase One - Financial Analysis 10-4
10.4.1 City Expenses 10-4
10.4.2 Total Revenue Requirement 10-8
10.5 Phase Two - Financial Capability Factors 10-11
10.5.1 Debt Indicators 10-12
10.5.2 Socioeconomic Indicators 10-12
10.5.3 Financial Management Indicators 10-14
10.5.4 Summary of Widespread Impact Indicators 10-14
10.6 Conclusions & Recommendations 10-15
10.6.1 Residential Indicator 10-15
10.6.2 Financial Impact Indicators 10-16
10.6.3 Overall Financial Capability 10-16

Section 11 - Implementation Plan

11.1 Introduction 11-1
11.2 Components of Each Project 11-1

11.3 Program Schedule 11-1
11.4 Program Summary 11-2

List of Figures

Figure ES-1 Tier I and Tier II Program Summary ES-4
Figure ES-2 Recommended Tier III Program Summary ES-10
Figure ES-3 Program Costs and Annual CSO Volume Reduction ES-12
Figure ES-4 Projected Increase in Sewer Expenses ES-13
Figure ES-5 Program Schedule ES-14
Figure ES-6 Average Annual Sewer Bill for Portland Residents ES-15
Figure ES-7 Projected Household Burden ES-16

Figure 1-1 Historical Annual Rainfall 1-6
Figure 1-2 Historic Annual CSO Volumes to Annual Precipitation 1-6

Figure 2-1 Existing Landuse 2-2
Figure 2-2 Portland's Collection System Service Area 2-4

Figure 3-1 Meter Locations 3-2
Figure 3-2 Cumulative Rainfall During Monitoring Period 3-8
Figure 3-3 Hourly Rainfall during Calibration Period at Portland Jetport 3-9
Figure 3-4 Tidal Signals at NOAA Station Portland Harbor and Metered Tide Elevation in Back Cove 3-10
Figure 3-5 Regulator Weir Crests Relative to Tide Elevation in Back Cove 3-11

Figure 4-1 Existing Collection System Model 4-2
Figure 4-2 Updated Collection System Model – Modeled Pipes 4-4
Figure 4-3 Updated Collection System Model – Modeled Catchments 4-7
Figure 4-4 Modeled and Metered Flow at CSO007 for November 14th 2009 Storm 4-9
Figure 4-5 Modeled and Metered Depth at CSO007 for November 14th 2009 Storm 4-10
Figure 4-6 Modeled and Observed Flow at Wastewater Treatment Plant for the Calibration Period 4-10

Figure 5-1 Sampling Locations 5-3
Figure 5-2 Total Volume of CSO and Stormwater per Receiving Water Existing Conditions 5-8
Figure 5-3 Total Pollutant Loading in CSO and Stormwater per Receiving Water Existing Conditions – TSS 5-9
Figure 5-4 Total Pollutant Loading in CSO and Stormwater per Receiving Water Existing Conditions – BOD 5-9
Figure 5-5 Total Pollutant Loading in CSO and Stormwater per Receiving Water Existing Conditions – Ecoli 5-10

Figure 6-1 Receiving Waters 6-11

Figure 7-1 Total Volume of CSO and Stormwater per Receiving Water – Tier II at Completion 7-6
Figure 7-2 Total Pollutant Loading in CSO and Stormwater per Receiving Water – Tier II at Completion - TSS 7-7
Figure 7-3 Total Pollutant Loading in CSO and Stormwater per Receiving Water – Tier II at Completion - BOD 7-7
Figure 7-4 Total Pollutant Loading in CSO and Stormwater per Receiving Water – Tier II at Completion - Ecoli 7-8
Figure 7-5 Recommended Tier II Program 7-12

Figure 8-1 Tier III Focus Areas 8-2
Figure 8-2 Potential Green/Separation Projects 8-7
Figure 8-3 Conceptual Layout of a New HRC Facility at the EEWWTF 8-14

Figure 9-1 Back Cove (West) Focus Area 9-5
Figure 9-2 Back Cove (South) Focus Area 9-7
Figure 9-3 Portland Harbor Focus Area 9-9
Figure 9-4 Capisic Brook and Fore River Focus Areas 9-12
Figure 9-5 Comparison of Total Pollutant Loading in CSO and Stormwater Between Existing Conditions, Tier II, and Tier III – TSS, BOD, and E. coli 9-17
Figure 9-6 Proposed Tier II and Tier III Program 9-18

Figure 10-1 Comparison of Projected Household Bill and Residential Indicator 10-1
Figure 10-2 Anticipated Capital Spending Plan, 2010 to 2030, 2011 $ 10-5
Figure 10-3 Debt Service and Capital Expenditures 10-7
Figure 10-4 Revenue Requirements with Tier III LTCP Incremental Impact 10-9
Figure 10-5 Comparison of Projected Household Bill and Residential Indicator 10-11
Figure 10-6 Residential Indicator Comparison 10-16

Figure 11-1 Program Schedule 11-3
Figure 11-2 Program Costs and Annual CSO Volume Reductions 11-4

List of Tables

Table ES-1 Estimated Annual CSO Volume Reductions by Receiving Water ES-9

Table ES-2 Recommended Tier III Project Costs and Annual CSO Volume Reductions ES-11

Table 1-1 Climate Change Summary Related to Urban Wet Weather Flows in New England 1-9

Table 2-1 Existing Landuse 2-3
Table 2-2 Existing CSO Regulators and Outfalls 2-5
Table 2-3 Pump Stations Characteristics 2-7

Table 3-1 Meter Locations 3-3
Table 3-2 Metering Data Summary 3-5
Table 3-3 Rainfall Statistics of Principal Calibration Storms 3-9

Table 4-1 SWMM Tidal Conditions at Outfalls in Updated Model 4-5
Table 4-2 Evaporation Rate 4-8
Table 4-3 Summary of Estimated CSO Conditions for 1993 and 2009 4-12

Table 5-1 Average CSO Discharge Concentrations 5-4
Table 5-2 Average Stormwater Discharge Concentrations 5-6
Table 5-3 Average In-Stream Concentrations 5-7

Table 6-1 Summary of Designated Uses and Water Quality Criteria for All Classes of Freshwater in the State of Maine 6-2
Table 6-2 Summary of Designated Uses and Water Quality Criteria for All Classes of Marine and Estuarine Waters in the State of Maine 6-3
Table 6-3 Additional Class C and SC Water Quality Criteria 6-5
Table 6-4 Number of Advisory and Closure Days for the East End Beach 6-15

Table 7-1 Estimated Annual CSO Volume Reductions 7-2
Table 7-2 Capisic Brook Watershed – Tier II Projects 7-3
Table 7-3 Cost-effectiveness Analysis for Baxter Boulevard (North) Focus Area 7-5
Table 7-4 Fall Brook Watershed – Recommended Tier II Projects 7-9
Table 7-5 Deferred Tier II Projects 7-10

Table 8-1 Tier III Focus Areas and Remaining CSO Volume 8-1
Table 8-2 Short-listed CSO Reduction Technologies 8-4
Table 8-3 CSO Control Technologies Advantages and Disadvantages 8-5
Table 8-4 Sewer Separation Cost Assumptions 8-16

Table 9-1 Estimated Annual CSO Volume Reductions by CSO Outfall 9-2
Table 9-2 Annual CSO Loading Estimates for Existing Conditions, Tier II, and Tier III 9-14
Table 9-3 Recommended Tier III Project Costs and Annual CSO Volume Reductions 9-19
Table 9-4 Anticipated CSO Events for a Typical Year 9-20

Table 10-1 Operations and Maintenance Cost Projections 10-4
Table 10-2 Capital Spending by Category 10-5
Table 10-3 Tier Three CSO Project Schedules and Costs 10-6

Table 10-4 Debt Service and Capital Expenditures 10-6
Table 10-5 City Direct Expenses – Baseline 10-7
Table 10-6 Estimated PWD Assessment 10-8
Table 10-7 Revenue Requirement – Baseline 10-8
Table 10-8 Revenue Requirement – Tier III LTCP Incremental Impact 10-9
Table 10-9 Comparison of Projected Household Bill and Residential Indicator 10-10
Table 10-10 Comparison of Projected Bill for Commercial Customer Currently Paying $1,000 10-11
Table 10-11 Bond Rating 10-12
Table 10-12 Net Debt as Percent of Full Market Property Value 10-12
Table 10-13 Unemployment Rate 10-13
Table 10-14 Median Household Income 10-13
Table 10-15 Property Tax Revenues as a Percent of Full Market Property 10-14
Table 10-16 Tax Collection Efficiency 10-14
Table 10-17 Financial Capability Indicators 10-15
Table 10-18 Financial Capability 10-15
Table 10-19 Financial Capability Matrix 10-17

Appendices

Appendix A Consent Agreement

Appendix B NPDES Permits

Appendix C Calibration-Validation Graphs

Appendix D Example EMCs

Appendix E Water Quality Sampling Plan

Appendix F Water Quality Sampling Results

Appendix G TM No. 1

Appendix H Cost Curves

Appendix I CSO Outfall Status Memorandum

Appendix J CSO and MS4 Loading Estimates

Appendix K MDEP Review and CDM Smith Response Correspondence

Executive Summary

Portland CSO LTCP Tier III Update

E.1 Summary of Tier III Recommended Plan

The purpose of this report is to provide the City of Portland (City) and Portland Water District (PWD) with a flexible and adaptive Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) that will meet the goals established in the original 1993 LTCP as well as the terms in the current administrative consent agreement and enforcement order (agreement). The plan will be used to implement near-term as well as long-term projects in what will be Tier III of the LTCP. This section of the executive summary briefly describes the recommendations and costs of projects that will fulfill the objectives of this plan. Further discussions of the background and details of the plan are provided subsequently in this executive summary and are also described in the report.

The City, PWD, and CDM Smith engaged the various stakeholders on the project, including the water quality advocates and the business community, as well as the Maine Department of Environmental Protection (MDEP) to provide input into the CSO program. The City, PWD and CDM Smith worked closely to structure a program that is cost-effective in managing CSO discharges to best protect water quality as well as public health. This plan proposes capital improvement projects that are estimated to cost $169 million (2011 dollars) over a 15 year implementation period. These recommendations include a mix of solutions that put a high reliance on storage facilities, but include supplemental sewer separation, green infrastructure, and treatment plant upgrades.

The plan is divided into three phases over a 15 year period that ultimately reduces the volume of CSO for a typical year to 87 million gallons (MG), an 88 percent reduction in volume, and reduces the number of CSO discharges from 192 to 40. These goals were defined in the 1993 LTCP for the typical year. The three phases are as follows:

- Phase A – Construct up to 7 MG of storage facilities to capture CSOs on the west and south side of Back Cove. Also included are targeted sewer separation and green infrastructure projects to manage wet weather flows before they enter the combined system. These projects are estimated to cost $53.5 million dollars (2011 dollars).

- Phase B – Construct up to 8 MG of storage facilities at Fore River Pump Station and along the south west side of the peninsula. These projects are estimated to cost $55.5 million dollars (2011 dollars).

- Phase C – Construct wet weather upgrades at the East End Waste Water Treatment Facility (EEWWTF), including upgrades to the North East Pump Station (NEPS), and complete additional sewer separation and green infrastructure projects. These projects are estimated to cost $60 million dollars (2011 dollars).

The storage facilities are designed to capture the first flush (or first 1-inch of rainfall) during wet weather events, which contains the majority of pollutants. Capturing the first flush with storage

facilities and treating this volume at the EEWWTF significantly reduce CSO pollutants from entering receiving waters while also diverting less urban stormwater (and pollutants) to the receiving waters. Supplemental green infrastructure and targeted separation will provide the additional wet weather flow management to meet the CSO goals for Tier III of the LTCP.

A 25-year implementation period was originally recommended by City staff due to the significant costs of the facilities in this program and the challenges with phasing costs while maintaining affordable sewer rates. However, the stakeholder groups advocated for a shorter time frame. Ultimately, the City Council elected to submit this LTCP with a 15-year implementation period. The annual sewer bill for a typical household is projected to increase from $460 in FY 2011 to $1,310 by FY 2030 taking into account the recommended long term control plan, operations and maintenance of the system, and expected capital improvements to ensure the integrity of the system and regulatory compliance. This represents an average annual rate increase of 5.6 percent from 2011 to 2030. Further details are included below as well as in the body of the report and appendices.

E.2 Purpose and Scope

The purpose of this LTCP Tier III Update (report) is to describe the effectiveness of Tier I and Tier II projects to date, recommend any changes that should be made in the remaining Tier II improvements, and provide an adaptable and flexible plan for the City and PWD to use in implementing near-term as well as long-term Tier III projects.

The scope of this report includes:

- Development of baseline conditions of the CSO system (2009), which summarize the extent of the work the City has completed to date and the effect historical projects have had on CSO reduction. This task includes utilizing the City's and PWD's extensive flow monitoring database to update and recalibrate the City's collection system model.
- Analysis of the anticipated CSO reduction from the remaining Tier II sewer separation projects (which are scheduled to be completed prior to 2014). Provide recommendations to the City and PWD for any changes that will provide cost savings and improved water quality.
- Development of alternatives and recommendation of an adaptable and flexible Tier III program that will meet the goals of the 1993 LTCP and the agreement. Also included is a financial analysis, which documents the cost impacts of the proposed future projects on sewer billing rates.

This report describes the City's preferred alternative that includes projects to be implemented over the next 15 years, but also provides other options to allow the City and PWD to adapt as necessary as conditions change over the period of this plan.

E.3 Tier I/II CSO Program

In 1991, the City and PWD entered into an agreement with MDEP, which was approved by EPA, and set deadlines for the development of a CSO LTCP. In 1993, the CSO Abatement Master Plan was submitted to MDEP, which set the following goals:

- Eliminate 33 of the 39 CSOs over a 15-year period at an estimated cost of $52 million (approximately $88 million in 2011 dollars).

- Reduce the number of typical year CSO events from 192 to 40.
- Reduce the total CSO volume by 88 percent from 720 MG to 87 MG. The 1993 LTCP established an allowance of 70 MG that would be discharged to Back Cove and 17 MG to Portland Harbor.
- Eliminate CSO discharges to sensitive water bodies of Capisic Brook, Fall Brook, Fore River, and the Presumpscot River.

The 1993 LTCP recommended a program with a high reliance on sewer separation to reduce or eliminate CSOs. Along with extensive sewer separation, upgrades at major conveyance restrictions were also recommended (including the West Side Interceptor and upgrades at major pump stations and the treatment plant). The 1993 LTCP also recommended a total of 5.42 MG of storage (system wide), and storm water management measures (including flow slipping on the Peninsula) to control wet weather flows.

The City and PWD made significant improvements to the collection system after the LTCP was submitted to MDEP. From 1995 to 1997 the EEWWTF as well as the two major pump stations (North East PS and India Street PS) were upgraded to allow up to 80 MGD to be delivered and treated at the EEWWTF.

The City updated the LTCP project and implementation schedule in 1997 and 2003. The 1997 update included a 5-Year Implementation Plan (1997-2001) and emphasized improvements in the Capisic Brook watershed. The 2003 update included an 8-Year Implementation Plan (2002-2007) and emphasized improvements in Fall Brook watershed. Sewer separation projects designated in the 1993 LTCP were not originally grouped into tiers, but the projects defined in the 1997 and 2003 update reports are generally referred to as Tier I and Tier II projects, respectively (although there is some overlap in projects).

Tier I was originally defined as 45 sewer separation projects. Ultimately, 38 Tier I projects were completed, which included nine flood control projects and 29 CSO projects. Some original projects were consolidated or restructured for construction purposes and to be coordinated with other utility infrastructure improvements such as water main renewal, gas mains, telephone, and pavement projects.

Tier II was originally defined as 75 sewer separation projects. The Tier II program was initially scheduled for completion in 2011, but the City negotiated a two year extension in 2007. Ultimately, 61 Tier II projects are scheduled for completion. To date 29 projects have been completed, leaving 32 anticipated projects to be constructed by the end of Tier II.

To date eleven CSO outfalls have been closed. These include CSO 001, 003, 009, 021, 031, 035, 036, 037, 038, 040 and 041. CSO 036 was closed on December 21, 2010; this closure will be reflected in the permit after the next cycle. Of these eleven closed CSOs, six were referenced in the 1993 LTCP. Therefore, 31 CSOs are potentially active and estimated discharges are annually reported to MDEP. While the City has made considerable gains through improvements to date, substantial efforts remain to meet the level of control (LOC) established in the 1993 LTCP. Figure ES-1 illustrates the Tier I and Tier II program summary.

Riverside Street Pump Station

Falmouth

Presumpscot Estuary

Fall Brook

Arcadia Street Pump Station

Northeast PS
12 MGD
Capacity Upgrade

Casco Bay

Capisic Brook

Baxter Boulevard Pump Station

EEWWTF
20 MGD
Capacity Upgrade

Back Cove

Franklin Street Pump Station

Quebec Street
-I/I Removal
-Flow Slipping
-Separation

Westbrook

India Street PS
8 MGD
Capacity Upgrade

Fore River Pump Station

Thompson Point Pump Station

Fore River

Portland Harbor

South Portland

CDM Smith
WRIGHT-PIERCE
Engineering a Better Environment

Legend

- 007 CSO and NPDES #
- Interceptor Sewer
- Force Main Sewer
- PS Pumping Station
- Sewer Separation Areas Deferred
- Sewer Separation Areas Completed
- Tier II Sewer Separation Areas Remaining

N W E S

0 2,750 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2010

Tier I and Tier II Program Summary
Figure ES-1

The cost of projects from 1994 through 2007 (including the majority of Tier I projects) totals approximately $41 million. In 2008 the City agreed to fund an additional $61 million of Tier I and Tier II projects through 2013. This will bring the total investment on CSO-related projects to approximately $102 million since 1994 and excludes the additional costs associated with the impending Tier III program.

The estimate of annual combined sewer overflow for the typical year based on the 1993 LTCP is 720 MG. The updated and recalibrated collection system model (SWMM5) predicts a total system-wide annual CSO volume of 416 MG. This estimate indicates a 42 percent reduction in annual CSO volumes from 1993 to 2010 (based on the typical year established in the 1993 LTCP). This volume provides a baseline estimate of the current LOC of the system.

E.4 Review of Remaining Tier II Projects

An alternative analysis was conducted to determine if Tier II separation projects scheduled for completion by 2014 are cost-effective compared to other CSO abatement technologies. The volume of CSO reduction that has been achieved since the beginning of the Tier I program (in 1997) was estimated. The City provided estimates of which areas have been separated to date as part of the Tier I and II projects. The total area for separation projects completed through 2009 is estimated at 1,076 acres. The typical year was run and the collection system model predicted an annual CSO volume of 416 MG, or approximately a 42 percent reduction (from 720 MG estimated at the beginning of the program).

The City again provided estimates of the areas that are proposed for separation to complete the Tier II projects. These separation projects are located in the Fall Brook and Capisic Brook watersheds and total approximately 380 acres. This acreage was then removed from the model and the typical year was run. This post separation run produced approximately 369 MG of annual overflow, equating to only an additional 7 percent reduction (totaling 49 percent reduction from the original 720 MG of overflow). This relatively small additional reduction may not be cost-effective compared to other technologies. Therefore an analysis was undertaken to estimate if CSO technologies other than sewer separation (e.g., storage) could be more cost effective in the completion of the Tier II program.

Capisic Brook Watershed

A fundamental goal established in the LTCP is the elimination of CSO discharges from CSO 036, 042 and 043 to Capisic Brook during the typical year. Land use is predominately residential in area tributary to CSO 036 and CSOs 042 and 043 are isolated in a rural area. Technologies other than sewer separation were considered, but are not recommended due to site-specific issues. Capisic Brook is a sensitive receiving water and would not be a viable discharge source for a satellite treatment facility. Access in the vicinity of the overflows is also not ideal for siting a storage facility (wooded area south of elevated railroad tracks). Based on the extent of the progress made to date with sewer separation in this area, and the planned removal of a brook (which was completed in early 2011), sewer separation remains the preferred method of CSO control in the Capisic Brook watershed.

The West Side Interceptor (WSI) project in the Capisic Brook watershed was completed in late 2010. Therefore it is estimated that the majority of overflow from CSO 036 will be removed from Capisic Brook and transferred to the Fore River pump station. Excess flows that once discharged through CSO 036 would then discharge through CSO 033 to the Fore River. No additional overflow to Capisic Brook

is anticipated, based on the assumption that planned separation efforts will eliminate CSOs 042 and 043 in the typical year. These improvements include disconnection of a brook from the system and should thus provide a substantial reduction in wet weather flows.

Implementation of Tier II projects is recommended to continue as planned in this watershed. It is anticipated that these projects will fully eliminate discharges to the Capisic Brook during the typical year. However, a future flow monitoring program should be performed to confirm that the separation projects were successful in accomplishing the goals established in the LTCP. In the event that the separation work does not fully eliminate discharges to the Capisic Brook for the typical year, additional flow reduction techniques (e.g. sewer separation, sewer rehabilitation, storage, green infrastructure, etc.) may be required at some point during the Tier III program in this area.

Fall Brook Watershed

Further analysis also indicated that construction of the remaining Tier II projects will not fully achieve the LOC of zero overflows established in the 1993 LTCP for CSO 007. Therefore, to meet the requirements of the program, additional separation projects in the catchments tributary to CSO 007 would be required in the future Tier III program. In an effort to limit the amount of additional projects required in this area, CDM Smith evaluated the remaining 25 projects (Tier II) to identify cost-effective modifications to the recommended plan as well as consider holistic City-wide solutions that may be included in the Tier III program. Additional separation projects would have to be completed totaling approximately $35 million in addition to the costs to date for the City to meet the Tier II goals.

CDM Smith and the City identified 14 sewer separation projects (consolidated down to 6 projects for bidding purposes) to be completed in this watershed as part of Tier II, with an estimated total cost of $10.1 million dollars. The remaining 11 projects are recommended to be put on hold for consideration for future implementation.

CDM Smith also recommends redirecting a total of approximately $10 million dollars to construct a 2 MG storage conduit along Baxter Boulevard. This storage facility was sized to capture the first 1-inch of rainfall discharged from the watershed, commonly known as the “first flush”. The first flush carries the majority of pollutants into the combined system. Capturing this first flush and conveying it to the EEWWTF after a storm passes, where the flow will receive secondary treatment, will provide significant water quality benefits in Back Cove.

The proposed storage facility would extend the reduction of overflow volume beyond CSO 007 to include 005 and 006 and significantly reduce the total CSO from all three outfalls to Back Cove. This facility would collect and store combined sewage from not only from the CSO 007 catchment, but also from the other two catchments that discharge in the north portion of Back Cove. The capture of all events during the typical year for this portion of the Back Cove watershed was not a goal of the original Tier II program, which specifically only concentrates on managing CSO 007.

Implementation of a prioritized Tier II separation program and a 2 MG storage facility along Baxter Boulevard in the northern portion of Back Cove is approximately 1.5 times more cost-effective than implementing sewer separation alone. This recommended alternative provides a more cost-effective solution than simply finishing (and/or expanding) the separation program developed in 1997. It also

provides flexibility if additional storage is found to be cost-effective within the Back Cove watershed during Tier III.

E.5 Recommended Tier III Program

Strategy for Developing Alternatives

An adaptive and flexible strategy was used to develop the alternatives for Tier III. The primary metrics used to develop the program include:

- Capture First Flush – first 1" of rainfall should be captured and ultimately treated to a secondary level at the EEWWTF. The first flush typically contains approximately 80 percent of the storm volume and approximately 90 percent of the pollutants (TSS, TP, Zn, etc.) transported by the runoff according to a recent U.S. EPA report - *U.S. EPA, (2010), Stormwater Best Management Practices (BMP) Performance Analysis, Region 1, prepared by TetraTech*.

- Provide Flexibility – include 5-year updates to the LTCP and consider other regulatory drivers (e.g. potential upcoming stormwater regulations, climate change, etc.)

- Reduce volume of overflows - 87% reduction from 1993 LTCP estimates for typical year discharges

- Consider storage as a primary element of the plan – storage provides largest water quality benefit because urban wet weather flows are captured and treated at the EEWWTF (Tier II - storage replaced separation as the most cost-effective approach to managing CSOs)

- Initial Focus on Back Cove – due to most concentrated number of CSO outfalls by receiving water and high visibility to public (e.g. running trail, events, etc.)

- Integrate improvements with upgrade/replacement schedule for major facilities (e.g. pump stations, EEWWTF)

- Provide for much needed replacement of the aging infrastructure

The alternative technologies considered for the Tier III program include storage, sewer separation, treatment (both WWTP upgrades and High Rate Clarification – HRC), and green infrastructure (GI). Typically, programs of the magnitude of Tier III require a combination of these alternative technologies. Initially, a single-technology solution was evaluated. If just sewer separation were applied to meet the 87 MG goal, the program would cost approximately $525 million (2011 dollars). If just storage were applied, the program cost would be approximately $250 million. Application of just treatment (either treatment plant upgrades and/or HRC) would not be practical because of uncertainties in the regulatory climate for HRC and difficulties in operating multiple satellite facilities on an intermittent basis (only during wet weather events). The cost to use GI as a single technology was not prepared and was considered impractical because of site constraints (e.g. Portland is under laid with clay, silt, and granite which provide limited infiltration capabilities – a primary mechanism of wet weather management for GI).

Recommended Program

The City, PWD, and CDM Smith engaged the various stakeholders on the project, including the water quality advocates and the business community, as well as the Maine Department of Environmental Protection (MDEP) to provide input into the CSO program. The City, PWD and CDM Smith worked closely to structure a program that is cost-effective in managing CSO discharges to best protect water quality as well as public health. These recommendations include a mix of solutions that put a high reliance on storage facilities, but include supplemental sewer separation, green infrastructure, as well as treatment plant upgrades.

The plan is divided into three phases over a 15 year period that ultimately reduces the volume of CSO for a typical year (established in 1993 LTCP) from 720 million gallons (MG) to 87 MG, which equates to an 88 percent reduction in volume. The three phases are as follows:

- Phase A – Construct up to 7 MG of storage facilities to capture CSOs on the west and south side of Back Cove. Also included are sewer separation and green infrastructure projects to manage wet weather flows before they enter the combined system. These projects are estimated to cost $53.5 million dollars (2011 dollars).

- Phase B – Construct up to 8 MG of storage facilities at Fore River Pump Station and along the south west side of the peninsula. These projects are estimated to cost $55.5 million dollars (2011 dollars).

- Phase C – Construct wet weather upgrades at the EEWWTF, including upgrades to the North East Pump Station (NEPS), and complete additional sewer separation and green infrastructure projects. These projects are estimated to cost $60 million dollars (2011 dollars).

The storage facilities are sized to capture the first flush and thus the majority of pollutants during wet weather events. This approach will provide secondary treatment for up 17 MG (including the 2 MG Tier II storage conduit) at the EEWWTF following a storm event, while diverting less urban stormwater (and pollutants) to the receiving waters. Supplemental green infrastructure and targeted separation will provide the additional wet weather flow management to meet the CSO goals for Tier III.

Table ES-1 summarizes the annual CSO volume reductions by receiving water for the recommended program. At the completion of Tier III CSO discharge into Back Cove and the Portland Harbor will still occur during the typical year, but will be reduced to 87 MG (88 percent reduction in volume compared to 1993 discharges of 720 MG). Figure ES-2 illustrates the recommended Tier III projects across the City.

Table ES-1
Estimated Annual CSO Volume Reductions by Receiving Water

Receiving Water	CSO Outfalls[1]	LTCP 1993 CSO Volume (MG)	Existing 2009 CSO Volume (MG)	Tier II CSO Volume at Completion (MG)	Tier III CSO Volume at Completion (MG)	LTCP 1993 CSO Volume at Completion (MG)[5]
Back Cove	005-008, 010-019	416	273	175[2]	36	70
Capisic Brook	036, 042, 043	97	63	0[3]	0	0
Casco Bay	002, 004, 020	57	19	18	8	0
Fore River	030, 032, 033, 034, 039	5	3	49[3]	0	0
Portland Harbor	023-029	145	59	58	43[4]	17
Total	---	**720**	**416**	**300**	**87**	**87**

Notes:

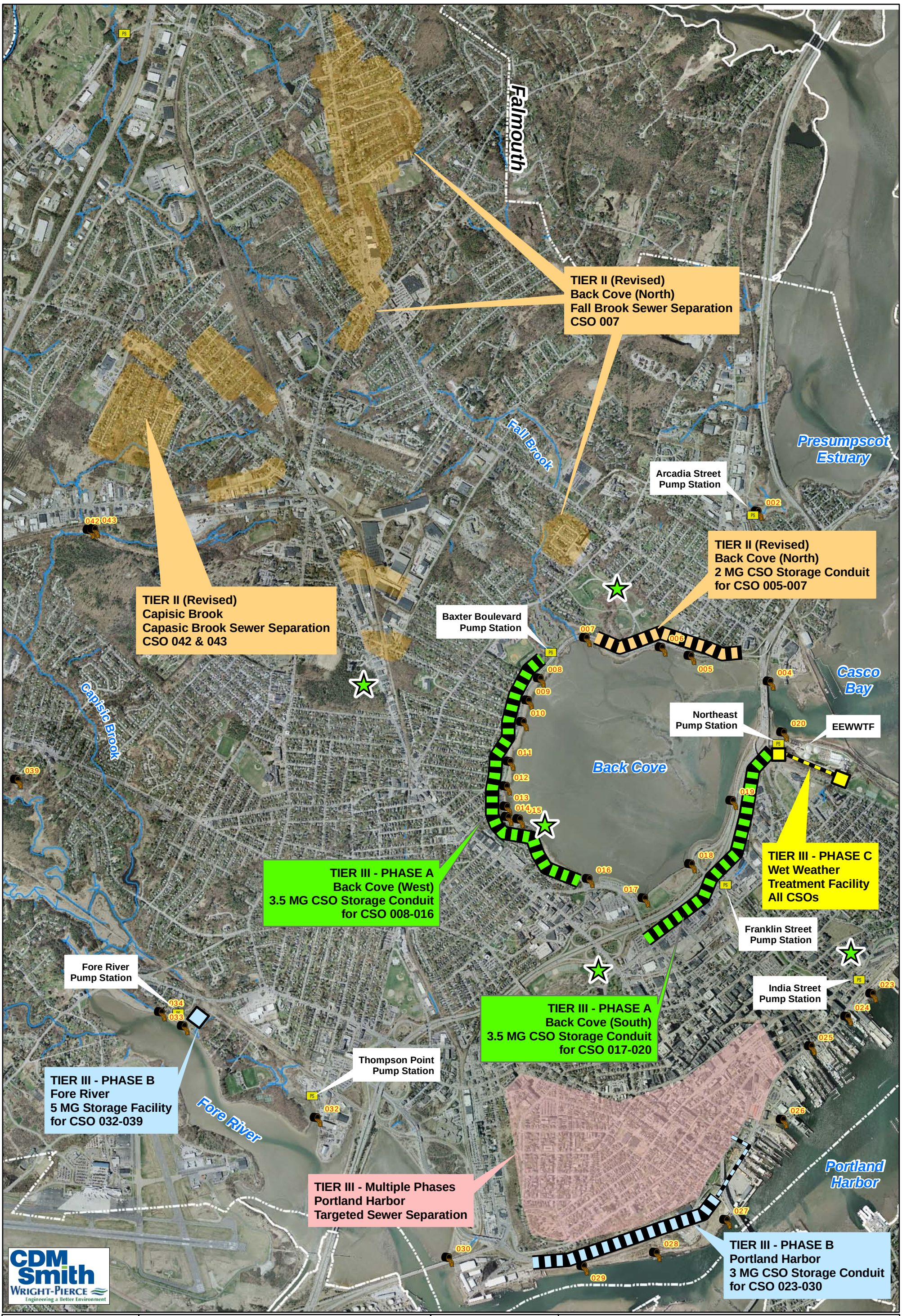
(1) CSO outfalls remaining (currently reported to DEP).

(2) Includes reduction of CSO due to existing faulty tide gate.

(3) Assumes that overflow from CSO 036 is routed to CSO 033 on Fore River and CSO's 042 and 043 will be eliminated if planned separation projects are completed by 2014.

(4) Further reduction of CSO to Portland Harbor could be realized depending on effectiveness of green infrastructure and/or sewer separation in areas draining to CSO's 023, 024, and 025.

(5) CSO Volume at Completion values obtained from 1993 LTCP.



Legend

- 007 CSO and NPDES #
- Potential Green/ Sewer Separation Project
- Tier II Targeted Separation Area
- Tier III Targeted Sewer Separation Area
- Proposed CSO Storage Facility
- Proposed CSO Storage Conduit

N W E S

0 1,850 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Proposed Revised Tier II and Tier III Plan
Figure ES-2

This plan proposes capital improvement projects that are estimated to cost $169 million (2011 dollars) over a 15 year implementation period. Table ES-2 summarizes the recommended Tier II project costs and anticipated annual CSO volume reductions for the typical year.

Table ES-2
Recommended Tier III Project Costs and Annual CSO Volume Reductions

Tier/ Phase	Project	Estimated Project Cost ($ millions)	Cumulative Tier III Program Costs ($ millions)	Annual CSO Volume (MG)(1)	Percent Volume Reduction (from 720 MG)
	Existing	---	---	416	42%
	End of Tier II - Includes Back Cove (North) Storage Conduit	---	---	300	58%
A	Back Cove (South) – 3.5 MG Storage Conduit	$21.5	$21.5	255	65%
A	Back Cove (West) – 3.5 MG Storage Conduit	$22.0	$43.5	181	75%
A	Misc. Separation and Green Projects	$10.0	$53.5	174	76%
B	Fore River – 5 MG Storage Facility	$35.5	$89.0	145	80%
B	Portland Harbor – 3 MG Storage Conduit	$20.0	$109.0	130	82%
C	EEWWTF Wet Weather Upgrades (NEPS 20 MGD upgrade, New HRC, New Outfall)	$45.0	$154.0	91	87%
C	Misc. Separation and Green Projects	$15.0	$169.0	87	88%
	1993 LTCP GOAL			**87**	**88%**

Notes:

(1)Annual CSO Volume predicted for typical year.

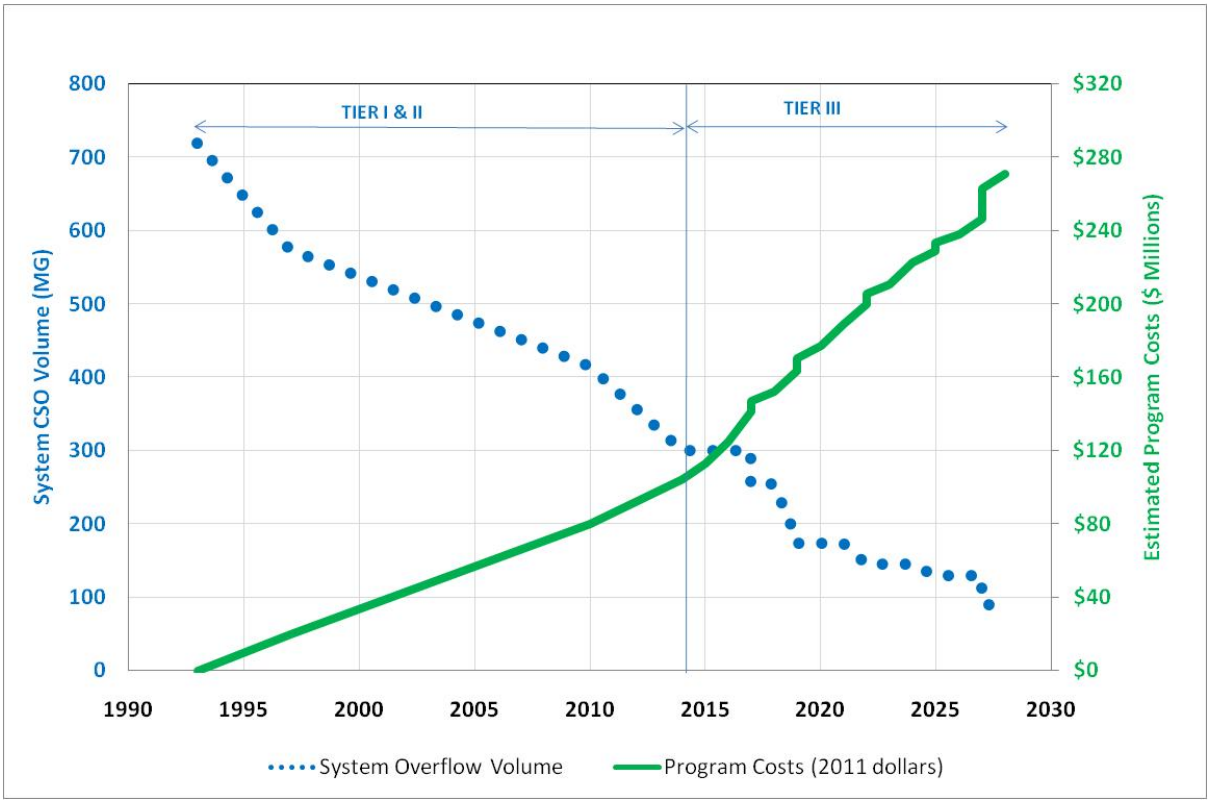
Green infrastructure (GI) plays an important role in the management of urban wet weather flows. Some examples of GI include, but are not limited to, rain gardens, permeable pavement, infiltration/bioretention basins, tree planters, vegetated buffer strips and swales. GI is by design a distributed method to capture rainfall and either infiltrate or evaporate it so that it doesn't enter into the combined or storm sewers. Low impact development (LID) techniques are also a part of GI that focuses on integrating GI into the urban landscape as it is being developed rather than retrofitting existing areas. Typically GI is designed to capture (and potentially treat) the first 1-inch of rainfall during a storm.

Stakeholders and the City are very supportive of GI and LID. The City has already begun implementing these techniques in concert with sewer separation projects. The Tier III approach affords the opportunity to integrate GI into this LTCP in a step-wise fashion, especially because the application of GI is very site specific and requires the right conditions to work effectively. Recognizing that MDEP

always requires reviews of the CSO LTCP every five years, it appears appropriate to design a plan that provides some "certain" benefits that move towards the goals of the 1993 CSO plan, while at the same time leaving open options for subsequent implementation of green and other strategies.

Figure ES-3 illustrates the estimated Tier III costs and system CSO volume reductions. This graph illustrates that the storage facilities in Phase A provide some of the largest volume reduction benefits, which is why these projects were selected for the beginning of the Tier III program.

Figure ES-3
Program Costs and Annual CSO Volume Reductions



A 15-year implementation period was chosen due to the significant costs of the facilities in this program and the challenges with phasing costs while maintaining affordable sewer rates. The timing of these projects over this implementation period is purposefully arranged to minimize excessive increases in sewer rates in any five year period. As proposed, the annual sewer bill for a typical household is projected to increase from $460 in FY 2011 to $1,310 by FY 2030. This represents an average annual rate increase of 5.6 percent from 2011 to 2030. Further details are included below as well as in the body of the report and appendices.

Financial Evaluation and Affordability

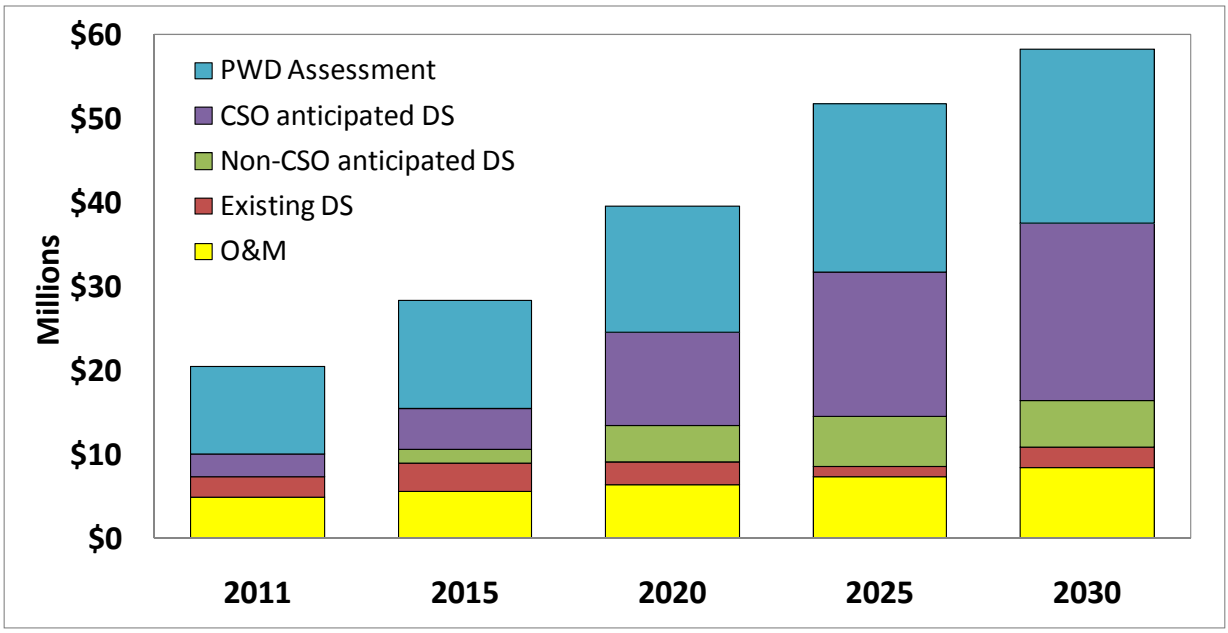
The purpose of the financial evaluation is to assess the impact of the recommended program on the City's rate payers and its affordability as established under EPA' s affordability guidance document. To undertake this assessment, we have projected the total costs of sewer for the City over the next 40 years, including the City's direct costs as well as the costs associated with conveyance, treatment and

disposal provided by the Portland Water District. These projections are then compared to the EPA's key parameters, which focus on the projected household bill relative to projected median household income. Under the EPA process, a projected sewer rate in excess of 2 percent of median household is deemed a high burden. In addition, we believe that a key parameter from the City's perspective is the rate of increase in projected household bills since more rapid increases are more burdensome.

Our projections assume the implementation of the proposed $169 million (2011 $) LTCP over 15 years. In developing these projections, a number of critical assumptions were included regarding other capital improvements that the City and PWD will need to make to ensure the integrity of the systems and compliance with existing and anticipated future regulations. These include an increased level of renewal and replacement for existing infrastructure to reflect the aging of that infrastructure as well as process upgrades at the EEWWTF to address anticipated nutrient removal requirements. Other assumptions focus on anticipated changes in customers and customer sales, inflation and the costs of financing capital improvements.

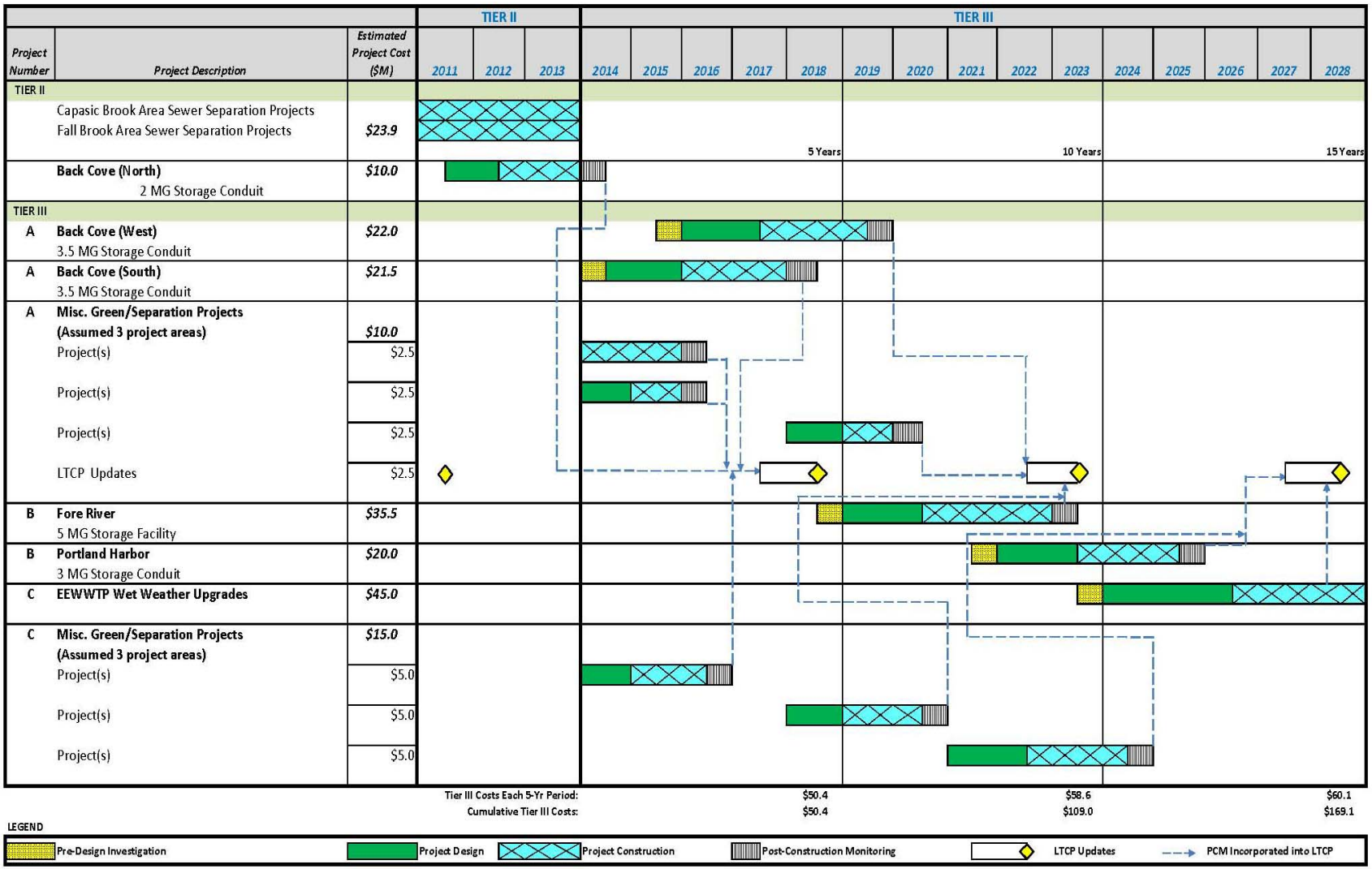
Figure ES-4 presents the projected increase in sewer expenses for the next 20 years. Sewer expenses are projected to increase from the 2011 level of approximately $20.5 million to $39.5 million in 2020, over $51.7 million in 2025, and over $58.2 million in 2030.

Figure ES-4
Projected Increase in Sewer Expenses



Note: DS = Debt Service

Figure ES-5
Program Schedule

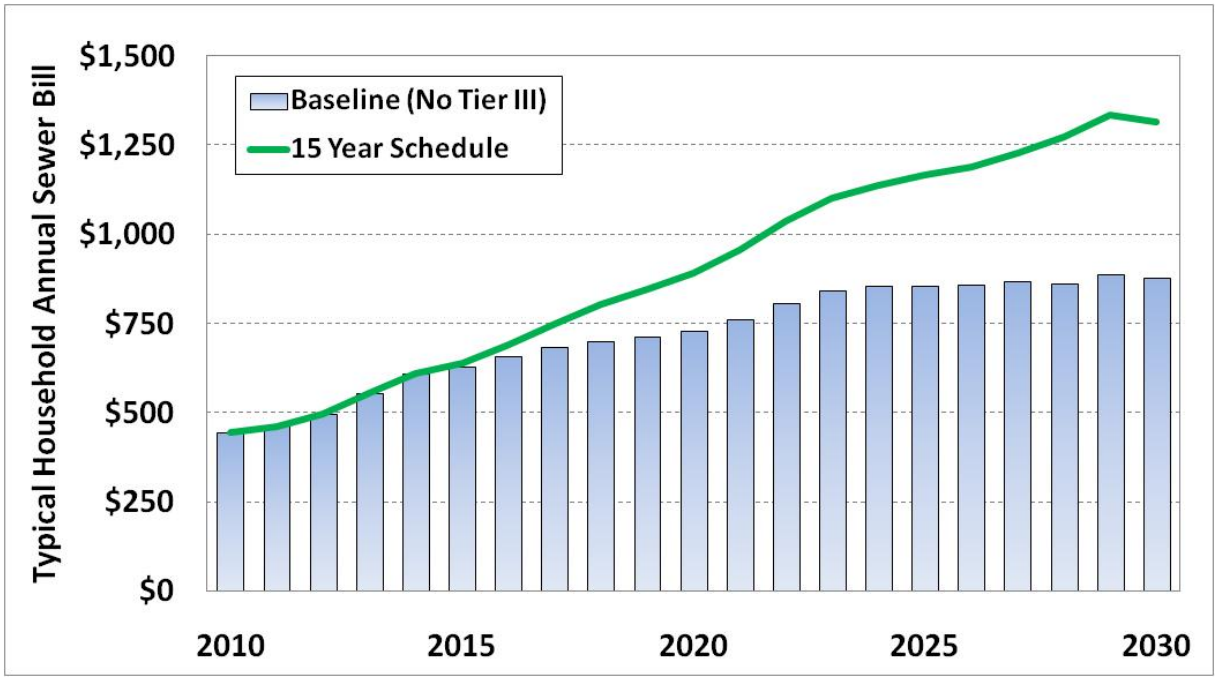


As noted earlier, a key parameter in assessing the affordability of the recommended program from the regulatory agency standpoint is the relationship of projected sewer bills to median household income (MHI). Figure ES-6 shows the projected average sewer bills for Portland's residential customers, based on a detailed assessment of the PWD's billing records. This figure compares the impact on household bills of the City's anticipated requirements with and without the $169 million Tier III program. As can be seen in the figure, the typical household bill will nearly triple from its current level of approximately $450 to approximately $1,400.

While the focus of EPA's affordability process is the impact on the household, it should be noted that business and commercial entities in the City will incur these increases as well. Through 2020, sewer customers are projected to incur cumulative rate increases of nearly 80 percent and by 2030 cumulative increases of nearly 150 percent.

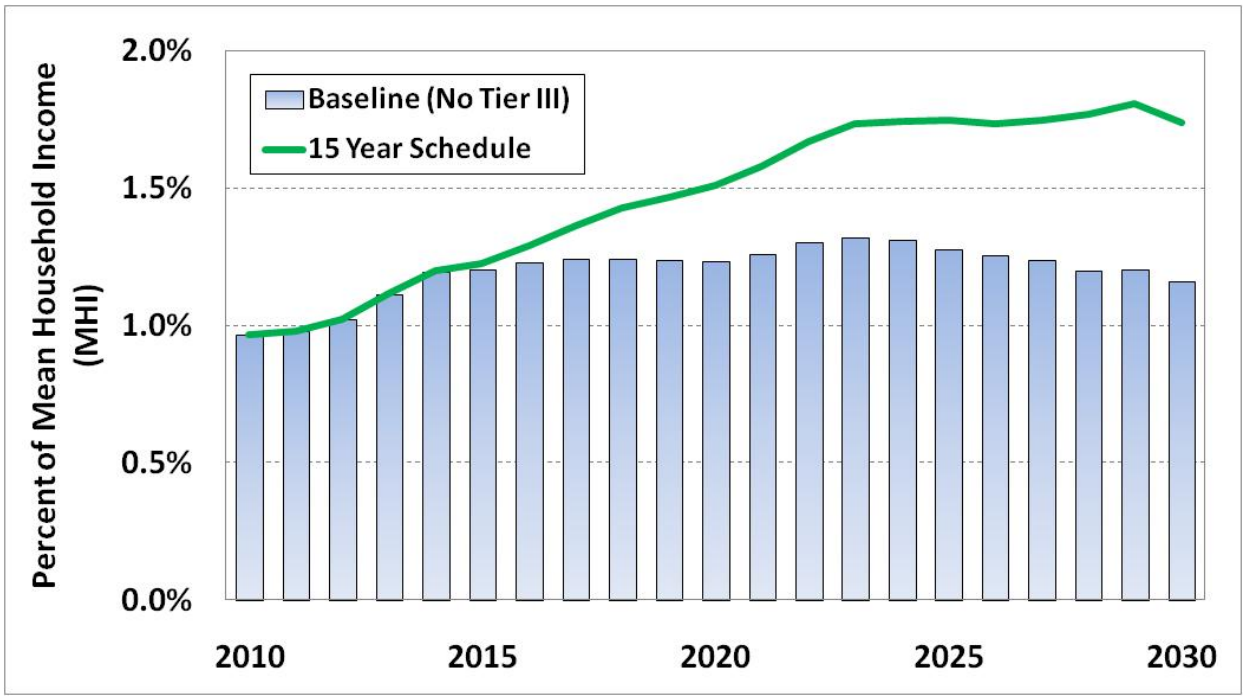
Figure ES-7 presents the projected household burden figures based on the projected household bills shown in Figure ES-6. The projected burden is expected to more than double with an increase from less than 1 percent of median household income in 2011 to a peak exceeding 1.53 percent in 2027. While this remains below EPA's threshold high burden of two percent, it represents a significant impact on the City's residential customers. Given that nearly 15.7 percent of the City's household population is estimated to be below the poverty level, the focus on the median household significantly understates the impact on the City's more vulnerable populations.

Figure ES-6
Average Annual Sewer Bill for Portland Residents



While the City's projected household burden remains below the EPA's 2 percent MHI threshold, we do believe that the magnitude of the increase and the rate of increase under the recommended 15 year implementation schedule do present significant financial and economic challenges to the City.

Figure ES-7
Projected Household Burden



The recommended 15 year implementation plan provides for a more measured approach to accomplishing the goals of the program while addressing affordability issues, than would a more aggressive and shorter implementation approach.

Section 1
Introduction

1.1 Purpose and Scope

The purpose of this report is to provide the City of Portland (City) and Portland Water District (PWD) with a flexible and adaptive Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) update that will meet the goals established in the original 1993 LTCP as well as the terms in the current Consent and Enforcement Agreement (CEA). This report describes the effectiveness of Tier I and Tier II projects to date, recommend any changes that should be made in the remaining Tier II improvements, and recommend near-term as well as long-term projects. These projects will become Tier III of the LTCP update.

The City, PWD, and CDM Smith have worked closely with environmental stakeholders on the project, including water quality advocates and the business community, and the Maine Department of Environmental Protection (MDEP) to provide input into the CSO program. The City, PWD, and CDM Smith worked closely to structure a program that is cost-effective in managing CSO discharges to best protect water quality as well as public health. This plan proposes capital improvement projects that include a mix of solutions (e.g. separation, storage, treatment, and green infrastructure) that will ultimately reduce the volume of CSO for a typical year to 87 million gallons (MG), an 88 percent reduction, and will reduce the number of CSO events from 192 to 40.

The scope of this report includes:

- Development of baseline conditions of the CSO system (2009), which summarize the extent of the work the City has completed to date and the effect historical projects have had on CSO reduction. This task includes utilizing the City's and PWD's extensive flow monitoring database to update and recalibrate the City's collection system model.

- Analysis of the anticipated CSO reduction from the remaining Tier II sewer separation projects (which are scheduled to be completed prior to 2014). Provide recommendations to the City and PWD for any changes that will provide cost savings and improved water quality.

- Development of alternatives and recommendation of an adaptable and flexible Tier III program that will meet the goals of the 1993 LTCP and the CEA. Also included is a financial analysis, which documents the cost impacts of the proposed future projects on sewer billing rates.

This report describes the City's preferred alternative that includes projects to be implemented over the next 25 years, but also provides other options to allow the City and PWD to adapt as necessary as conditions change over the period of this plan.

1.2 History of Program

This section describes the consent agreement, original CSO abatement study master plan (master plan) developed in 1993, the initial upgrades to the East End Waste Water Treatment Facility (EEWWTF) and the two major pump stations, and the development of the Tier I and Tier II sewer separation programs. This section also discusses the historic overflow activity in the City.

1.2.1 Consent Agreement

The City of Portland and Portland Water District entered into a Consent and Enforcement Agreement with the Maine Board of Environmental Protection in 1991 regarding combined sewer overflow abatement. This agreement is included in Appendix A. In 1993 the master plan was submitted to MDEP. The timing of this submittal was a year before the EPA released its official policy pertaining to CSOs (1994). Although the 1994 regulations were not in effect when the master plan was written and submitted, it was still to be judged against these regulations as a LTCP. Therefore, several revisions were needed to the initial draft report to comply with the new regulations. In 1997 the final CSO LTCP was approved initiating a formal plan and schedule for CSO reductions.

Tier I and II Implementation Plans were developed, approved and adopted jointly by the City of Portland and the MDEP. The City expended $41 million on Tier I and some Tier II CSO projects between 1994 and 2007. The City's and PWD's National Pollutant Discharge Elimination System (NPDES) permits are included in Appendix B for reference.

In 2007, the City revised its Tier II CSO implementation schedule with MDEP and agreed to expend $61 million over 6 years, with specific project milestones to be achieved, in order to maintain compliance with the original Consent Decree. The Tier II Implementation Plan calls for completion of the specified projects in 2013.

The remaining CSO abatement work required by the 1991 Consent Agreement and subsequent Master Plan is addressed in a Tier III Long Term Control Plan. This Tier III Long Term Control Plan (LTCP) development effort was initiated in 2010, and the City is submitted the completed LTCP to MDEP by July 29, 2011 (this is an amended date, original date was June 30, 2011).

1.2.2 Approved CSO LTCP

The master plan was written for the City and PWD by CH2M Hill and Dufresne-Henry in 1993 and submitted as a draft to MDEP and EPA. The master plan was approved by MDEP in 1997 and became the guiding document for management of CSOs in the City. This document will be referred to as the 1993 LTCP for the remainder of this document.

The 1993 LTCP set the following goals:

- Eliminate 33 of the 39 CSOs over a 15-year period at an estimated cost of $52 million (approximately $88 million in 2011 dollars).
- Reduce the number of CSO events from 192 to 40.
- Reduce the total CSO volume by 88 percent from 720 MG to 87 MG. The 1993 LTCP established a goal of 70 MG that would be discharged to Back Cove and 17 MG to Portland Harbor.

- Eliminate CSO discharges to sensitive water bodies of Capisic Brook, Fall Brook, Fore River, and the Presumpscot River.

The 1993 LTCP recommended a program with a high reliance on sewer separation to reduce or eliminate CSOs. Along with extensive sewer separation, upgrades at major conveyance restrictions were also recommended (including the West Side Interceptor and upgrades at major pump stations and the treatment plant). The 1993 LTCP also recommended a total of 5.42 MG of storage (system wide), and storm water management measures (including flow slipping on the Peninsula) to control wet weather flows. To date, no storage facilities have been built by the City and the flow slipping effort on the Peninsula had marginal benefits in reducing CSOs.

1.2.3 Upgrades to the Pump Stations and EEWWTF

The City and PWD made significant improvements to the collection system after the LTCP was submitted to MDEP. From 1995 to 1997 the EEWWTF as well as the two major pump stations were upgraded to allow for a significant increase in wet weather flow to be delivered and treated at the EEWWTF. The Northeast Pump Station (NEPS) pumps flow collected from the northern and eastern area of the collection system to the EEWWTF. The India Street Pump Station (ISPS) pumps flows from the southern and western area of the collection system to the EEWWTF. Other than a small service area directly tributary to the EEWWTF through a gravity sewer, the majority of flow enters the EEWWTF from these two pump stations.

PWD completed an upgrade at the India St. Pump station that included new pumps, drives, controls, and an odor control system. This upgrade focused on delivering up to 31 MGD during wet weather. During this same upgrade, the Northeast Pump Station capacity was increased from a system with 3 pumps operating during wet weather to deliver around 43 MGD to a system with 4 pumps running to deliver up to 51 MGD. The Northeast Pump Station will require continued maintenance efforts until an upgrade of the remaining pumps and systems can take place in the future. With all of the North East and India Street pumps operating, the plant has received up to 82 MGD.

The EEWWTF was also upgraded during this period to be able to treat the increase of flow from the two major pump stations. The upgrades at the EEWWTF included increasing the capacity of the preliminary treatment process train and primary clarifiers from 60 MGD to 80 MGD along with other improvements to optimize wet weather treatment. Further description of the treatment facility and pump stations are included in later sections of this report.

The pumps at the Baxter Boulevard pump station were replaced with new pumps in 2009. These pump replacements restored the original capacity of the pump station to 4.3 MGD to ensure reliable operation during wet weather.

1.2.4 Tier I and II Sewer Separation

The City updated the LTCP project and implementation schedule in 1997 and 2003. The 1997 update included a 5-Year Implementation Plan (1997-2001) and emphasized improvements in the Capisic Brook watershed. The 2003 update included an 8-Year Implementation Plan (2002-2007) and emphasized improvements in the Fall Brook watershed. Sewer separation projects designated in the 1993 LTCP were not originally grouped into tiers, but the projects defined in the 1997 and 2003

update reports are generally referred to as Tier I and Tier II projects, respectively (although there is some overlap in projects).

Tier I was originally defined as 45 sewer separation projects. Ultimately, 38 Tier I projects were completed, which included nine flood control projects and 29 CSO projects. Some original projects were consolidated or restructured for construction purposes and to be coordinated with other utility infrastructure improvements such as water main renewal, gas mains, telephone, and pavement projects.

Tier II was originally defined as 75 sewer separation projects. The Tier II program was initially scheduled for completion in 2011, but the City negotiated a two year extension in 2007. Ultimately, 61 Tier II projects are scheduled for completion. To date 29 projects have been completed, leaving 32 anticipated projects to be constructed by the end of Tier II.

To date eleven CSO outfalls have been closed. These include CSO 001, 003, 009, 021, 031, 035, 036, 037, 038, 040 and 041. CSO 036 was closed on December 21, 2010; this closure will be reflected in the permit after the next cycle. Of these ten closed CSOs, six were closed when the 1993 LTCP was completed. Therefore, 31 CSOs are potentially active and estimated discharges are annually reported to MDEP. While the City has made considerable gains through improvements to date, substantial efforts remain to meet the level of control (LOC) established in the 1993 LTCP. Figure ES-1 illustrates the Tier I and Tier II program summary.

The cost of projects from 1994 through 2007 (including the majority of Tier I projects) totals approximately $41 million. In 2008 the City agreed to fund an additional $61 million of Tier I and Tier II projects through 2013. This will bring the total investment on CSO-related projects to approximately $102 million since 1994 and excludes the additional costs associated with the impending Tier III program.

1.2.5 Typical Year Rainfall

The typical year rainfall (typical year) is a term used to define a year with precipitation statistics that provide an average annual rainfall as well as storm characteristics throughout the year that represent typical events that could be expected in the future. The typical year was established in the 1993 LTCP as the 1966 rainfall record. This typical year was the measure against which the various alternatives were developed.

The typical year is typical in the sense that it not only represents the approximate average annual precipitation, but also contains storms that could be expected over an average year (a mix of small to large storms). For example, years that have the same total rainfall might be significantly different in terms of the frequency and intensity of storms. Many low intensity storms have a different impact on overflows than do several larger ones, but the total rainfall, when added over a year, is the same.

For this LTCP, the precipitation patterns of 1966 were analyzed and compared to additional years of rainfall measured at the Portland International Jetport (PIJ). The precipitation for this year had a large storm with a total rainfall that would be expected about once every one and a half to two years, two storms that would be expected every six months and four storms that would be expected every

quarter. Additionally, there were many smaller storms. Total rainfall over the year was 40 inches, which is slightly below current average of 43 inches. But given the "typical" pattern of events over a year is still representative of a typical year of rainfall for Portland.

Recent history shows mostly higher than normal rainfall. Figure 1-1 illustrates 63 years of annual rainfall for the City. It should be noted that significant annual rainfall were also seen in the 1980's and 1950's (and regionally in the 1930's). More important than the annual rainfall totals, the pattern of events, as well as the timing within the year, influences how much runoff and thus CSO could be produced. Even with projections of the influence of climate change on precipitation patterns (which will be discussed later in this report), the typical year is still statistically significant in representing average storm conditions, and is a reasonable metric for analyzing LTCP alternatives.

1.2.6 Historic Annual Overflows

The City and PWD have made significant progress in reducing CSOs since the 1993 LTCP. Reporting of these improvements is discussed in the annual CSO report that the City and the PWD submit each year to MDEP. Improvements in the collection system and at the EEWWTF as well as separation efforts across the City have provided reductions as seen in Figure 1-2.

This figure illustrates the reported annual CSO discharges across the City from 1998 through 2010. Because rainfall is the driving element causing CSOs, the annual discharges were normalized by annual rainfall to show a simplified, but telling trend, for overflow reductions. The two trends are shown for the City as well as the combination of all other CSO communities in the state.

Both trend lines show a significant generalized reduction in CSO across the state. The City's normalized annual overflows have reduced from 34.3 million gallons of overflow per inch of precipitation to 13.9 MG/inch. Although this type of graph is a gross simplification of the complex processes that result in CSOs, this type of graph is used by MDEP to track progress of CSO reductions over time (therefore it has been included here). In the following sections of this report, a comprehensive analysis will be summarized to very specifically estimate the CSO reductions that the City and PWD have accomplished over the past years and project how further reductions will be accomplished.

Figure 1-1
Historic Annual Rainfall

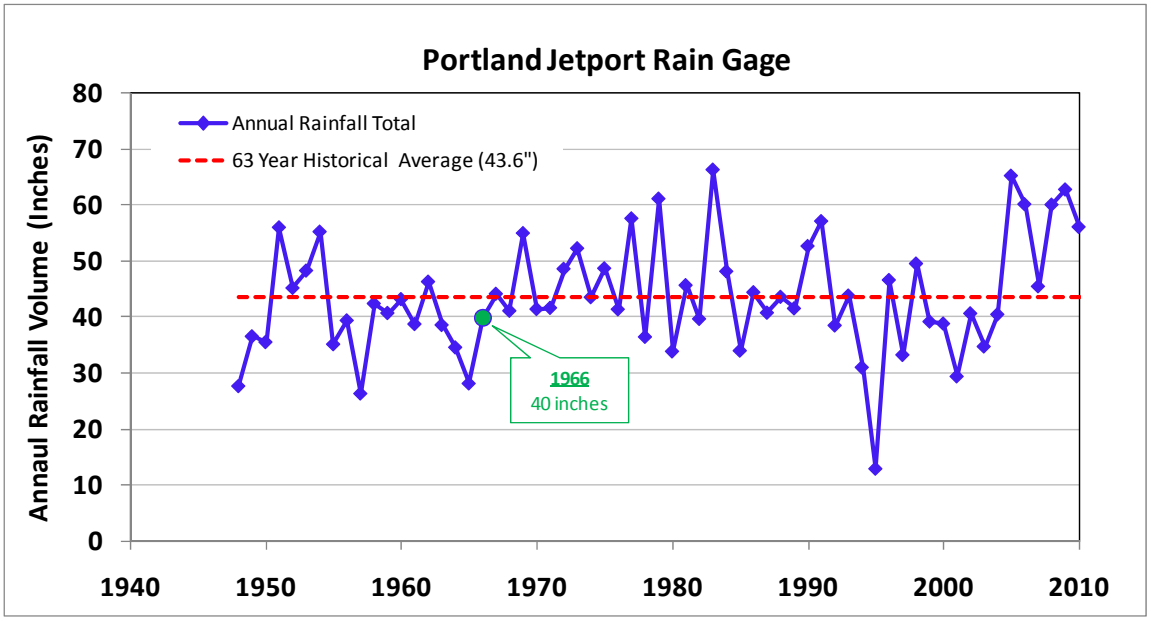
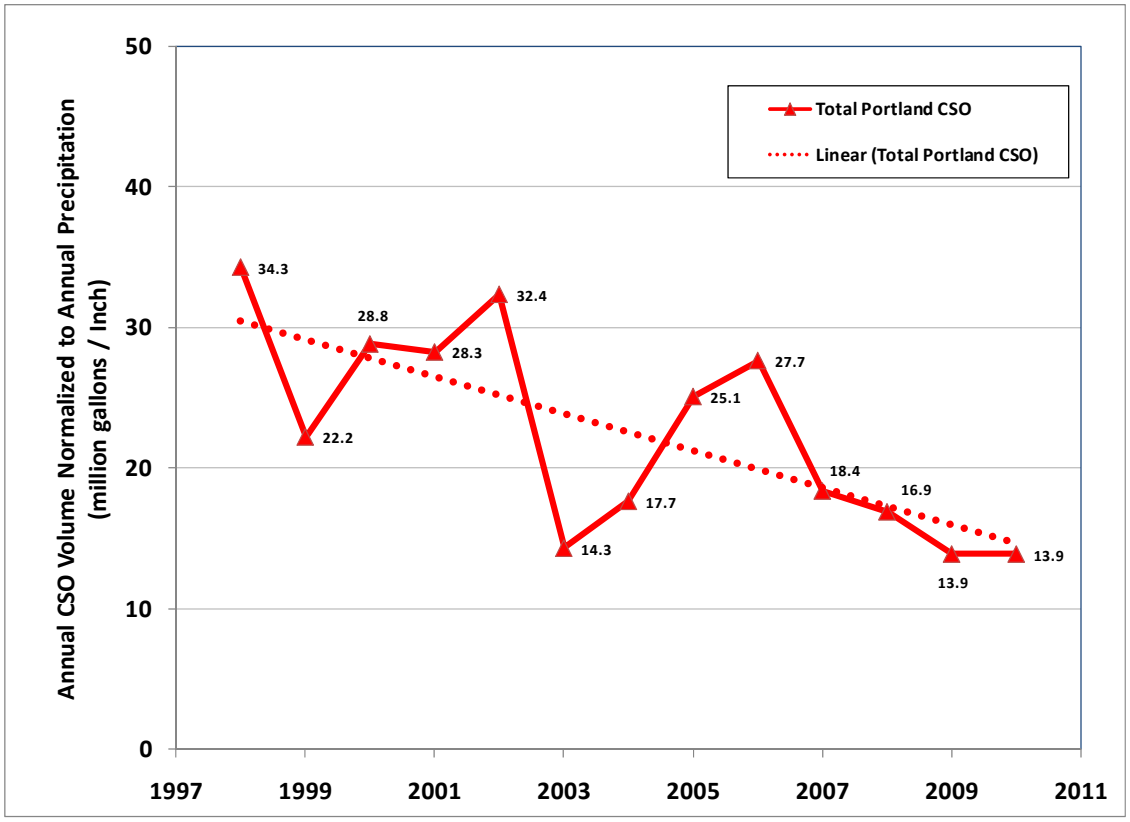


Figure 1-2
Historic Annual CSO Volumes Normalized to Annual Precipitation



1.3 Climate Change Implications

Much has been publicized in recent years regarding the potential for future climate change. Although global warming and climate change have been debated, the vast majority of the scientific community and, more recently, the military (e.g., U.S. Army Corps of Engineers) agree that it is real and must be planned for accordingly. Because investments in infrastructure tend to be long-term, capital-intensive, and, in many cases, irreversible in the short-to-medium term, it is necessary to understand that today's decisions could influence the ability of wastewater infrastructure to accommodate changes in climate for decades into the future. CSO communities are taking the first step toward understanding this complex issue, the implications of which will vary significantly in different locations and for different systems.

1.3.1 Precipitation and Sea Level Changes

There were notable changes in precipitation patterns throughout the United States during the 20th century, with more rapid variation predicted to occur during the 21st century. In New England there has been an increase in annual average precipitation of 0.4 – 0.8 inch/decade (1-2 cm/ decade) over the last century, with 5%-20% increases in annual precipitation from 1958 – 2008 (Spierre and Wake 2010, Hayhoe et al. 2007, EPA 2008). Based on climate change models there may be an increase in annual precipitation of up to 10% by the end of the century, with increases between 0.8 – 3.2 inch/year (2 – 8 cm/year) by mid century (Brekke et al. 2009, Frumhoff et al. 2007). The greatest increase in average precipitation is projected to occur in the winter, with increases between 10%-30% projected for the end of the century (Frumhoff et al., Hayhoe et al.). While more precipitation is expected in the winter, more of it is expected to fall as rain than snow, deviating from what is currently typical in the region.

In addition to there being more precipitation predicted on average each year, the intensity of storms is also predicted to increase over the next 100 years, potentially increasing the risk for flooding and combined sewer overflows (CSO). The intensity of storms in New England is projected to increase by less than 10% by mid-century, but between 10% - 20% by the end of the century (Frumhoff et al. 2007). Overall, large storms (those with greater than 2 inches of rainfall falling over 48 hours) are expected to occur more often by the end of the century, and there has already been an increase in the quantity of precipitation falling from such storms (Frumhoff et al. 2007, Hayhoe et al. 2007, EPA 2008). Due to the projected increase in storm intensities in New England along with anticipated additions of impervious area in the region the number of CSO events is expected to increase by 9% - 14% events/year between 2025 and 2050.

Increases in mean sea level of up to 14 inches have been projected, and this increase along with an increased likelihood of larger storms will likely lead to more frequent flooding in New England (EPA 2008, Frumhoff et al. 2007).

1.3.2 Climate Change Summary Related to CSOs

Table 1-1 summarizes expected changes and impacts in precipitation and sea level in New England due to climate change based on six recent industry reports. In summary, climate change is progressing but it is still very difficult to utilize models to predict the future. However, there seems to be general consensus that the annual average precipitation will increase in New England.

Annual increase in rainfall does not directly correlate to increase in CSO (as seen on Figure 1-2). CSO activity is much more controlled by individual storms and antecedent conditions. Rainfall intensity for extreme events is expected to increase over the next century but this increase is expected to be relatively small. Storms are also expected to move from the summer period to winter/spring period and the fall/winter period and with increased temperatures, some precipitation that typically fell as snow will now fall as rain.

These projections imply that summers will be dryer, which will actually benefit water quality from a CSO perspective because fewer overflows will occur during times of contact recreation. Sea level is also expected to increase by over one foot in elevation from current patterns. This will potentially increase flooding in current flood prone areas, and will regularly cause flooding in areas that currently only experience flooding in rare cases. Climate change will force communities in New England, especially those located on the coast, to plan and design future infrastructure to take into account these changing conditions to avoid costly failures in the future.

Table 1-1
Climate Change Summary Related to Urban Wet Weather Flows in New England

Reference Document	Annual Precipitation	Seasonal Variation	Extreme Events	Reported CSO Specific & Stormwater Impacts
Spierre and Wake (2010)[1]	From 1948-2007 there was a 0.73 +/- 0.27 inches/decade increase in annual precipitation.	From 1948-2007 there were seasonal increases in precipitation of: 0.26 inch/decade in the fall, 0.12 inch/decade in the spring, 0.11 inch/decade in the summer, and 0.01 inch/decade in the winter.	There has been a slight increase in the likelihood of storms exceeding 1 or 2 inches over 24 hours from 1948-2007.	N/A
Brekke et al. (2009)[2]	The 30-year mean annual precipitation in New England is expected to increase by between 2 – 8 cm/year by mid century.	N/A	Droughts and floods may become more extreme and more frequent throughout the United States under future climate conditions.	Global mean sea level rose at an average rate of about 1.7 +/- 0.5 mm/year this century, and by slightly more between 1961 and 2003. This is expected either to remain constant or accelerate leading to an increased probability of flooding and therefore CSO overflows.
EPA (2008)[3]	N/A	N/A	N/A	Hadley model suggests a 9%–14% increase in the probability of CSO overflows between 2025-2050 due to the expected increase in precipitation and impervious area.

Reference Document	Annual Precipitation	Seasonal Variation	Extreme Events	Reported CSO Specific & Stormwater Impacts
Frumhoff et al. (2007)[4]	Annual precipitation in New England is expected to increase by 10% by the end of the century (about 4 inches per year) under either higher or lower emissions scenarios.	An increase in winter precipitation between 20-30% is expected with a higher percent falling as rain than is regionally typical. Little change in summer rainfall is expected.	Increases in precipitation intensity of less than 10% are projected by mid century, and 10% - 15% by the end of the century. The number of heavy-precipitation events (more than 2 inches falling over 48 hours) is expected to increase by 8% by mid-century and 12% - 13% percent by the end of the century. In addition, 8% – 10% more rain is expected to fall in the wettest 5 days of the year by mid-century, and 20% more is expected to fall by the end of the century.	IPCC projects that global mean sea level will rise by 7 – 14 inches under the lower-emissions scenario and 10 – 14 inches under the higher emissions scenario.
Hayhoe et al. (2007)[5]	There has been an increase in precipitation over the last century in New England of approximately 10 mm/decade.	Over the last century there has been an increase in fall and spring precipitation of 9.5 +/- 2 mm/decade, an increase in summer of 1.2 +/- 0.5 mm/decade, and little change in winter precipitation. Based on climate change modeling winter precipitation is expected t0 increase by an average of 10%-15% with either a slight decrease or no change in summer precipitation.	An increase in heavy storms (greater than 2 inches of precipitation in less than 48 hours) has already been observed in New England, alluding to an intensification of the hydrological cycle. A general increase in drought frequency is projected in the future as a result of warmer summers, with potentially less rainfall.	N/A

Reference Document	Annual Precipitation	Seasonal Variation	Extreme Events	Reported CSO Specific & Stormwater Impacts
EPA (2008)[6]	From 1958 to 2008 the annual average precipitation in New England has increased by 5%-20%	Less winter precipitation is expected to fall as snow, and more is expected to fall as rain.	In the Northeast there has been a 67% increase in the amount of rainfall falling from very heavy precipitation events (defined as the heaviest 1 percent of all daily events) from 1958 to 2007. In addition, in New York City, what is currently considered a 100-year storm is projected to occur as often as once every 10 years by the end of this century.	Increases in precipitation on land have already began to pollute coastal waters with more nitrogen and phosphorous, and this will likely be exacerbated by the predicted increases in annual precipitation and storm intensity. If this trend continues further restrictions may be placed on CSO's to reduce nitrogen and phosphorous levels.

REFERENCE DOCUMENTS

(1)Spierre, S.G and Wake, C. (2010) Trends in Extreme Precipitation Events for the Northeastern United States 1948-2007, University of New Hampshire, Carbon Solutions New England, (http://www.CarbonSolutionsNE.org, and http://www.cleanair-coolplanet.org)

(2)Brekke, L.D., Kiang, J.E., Olsen, J.R., Pulwarty, R.S., Raff, D.A., Turnipseed, D.P., Webb, R.S., and White, K.D. (2009) Climate change and water resources management—A federal perspective: U.S. Geological Survey Circular 1331, 65 p. (http://pubs.usgs.gov/circ/1331/.)

(3)U.S. Environmental Protection Agency (EPA). (2008) A screening assessment of the potential impacts of climate change on combined sewer overflow (CSO) mitigation in the Great Lakes and New England regions. Global Change Research Program, National Center for Environmental Assessment, Washington, DC; EPA/600/R-07/033F. Available from the National Technical Information Service, Springfield, VA, (http://www.epa.gov/ncea)

(4)Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. (2007) Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).

(5)Hayhoe, K., C.P. Wake, T.G. Huntington, L. Luo, M. Schwartz, J. Sheffield, E. Wood, B. Anderson, J. Bradbury, A. De-Gaetano, T. Troy, and D. Wolfe. (2007) Past and future changes in climate and hydrological indicators in the U.S. Northeast. Climate Dynamics 28:381-407.

(6) U.S. Environmental Protection Agency (EPA). (2009). Global Climate Change Impacts in the United States. Global Change Research Program, National Center for Environmental Assessment, Washington, DC, (http://www.globalchange.gov)

Section 2

Existing System

2.1 Introduction

Combined sewers are pipelines that collect domestic, commercial, and industrial wastewater as well as urban stormwater from drainage areas within a City. Construction of combined sewers was typical of many early eastern cities in the United States through the early 20th century. These sewers would convey both wastewater and stormwater directly to receiving waters without any treatment. As cities grew, public health concerns over raw sewage discharges initiated the consolidation of treatment of these flows. Interceptor sewers were designed to collect these flows near the point of discharge and convey them to a centralized location where the flows and pollutants could be treated. Currently there are approximately 772 combined sewer communities in the US.

Portland, Maine, like most east coast cities, utilized combined sewers to collect sewage and control stormwater to prevent flooding. The combined sewers discharged to Back Cove, Capisic Brook, Fore River, Portland Harbor and Casco Bay (Presumpscot Estuary). Interceptor sewers were constructed in the 1970's to collect the combined sewage and transport it to a centralized location for treatment and discharge. Since these interceptor sewers could not collect all stormwater during significant rainfall events, combined sewer overflows (CSOs) were designed into the interceptors to discharge excess flows above the interceptor's capacity out of CSO outfalls to the receiving waters.

This section describes pertinent information on the collection system, including characteristics of the service area and the system infrastructure. Also included is a description of the East End Waste Water Treatment Facility (EEWWTF).

2.2 Collection System

The collection system in the City of Portland consists of a service area and infrastructure to collect and treat the combined sewerage.

2.2.1 Service Area

The City's service area has a current population of 66,194 (2010 census) and encompasses approximately 10,000 acres (15.6 square miles). The EEWWTF receives approximately 20 MGD in dry weather flow and can treat up to approximately 80 MGD during peak wet weather events. Figure 2-1 illustrates the existing land use with Portland. Table 2-1 summarizes the acreages of each land use category.

Legend

Land Use
Sources: City of Portland & State of Maine

- Recreation / Open Space / Cemetery
- Vacant
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Light Commercial
- Medium Commercial
- Industrial
- Institutions, Schools, Governmental
- Transportation
- No Data

CSO Work

- 043 CSO Outfall

CDM Smith
Wright-Pierce
Engineering a Better Environment

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
June 2011

Existing Landuse
Figure 2-1

Table 2-1
Existing Land Use

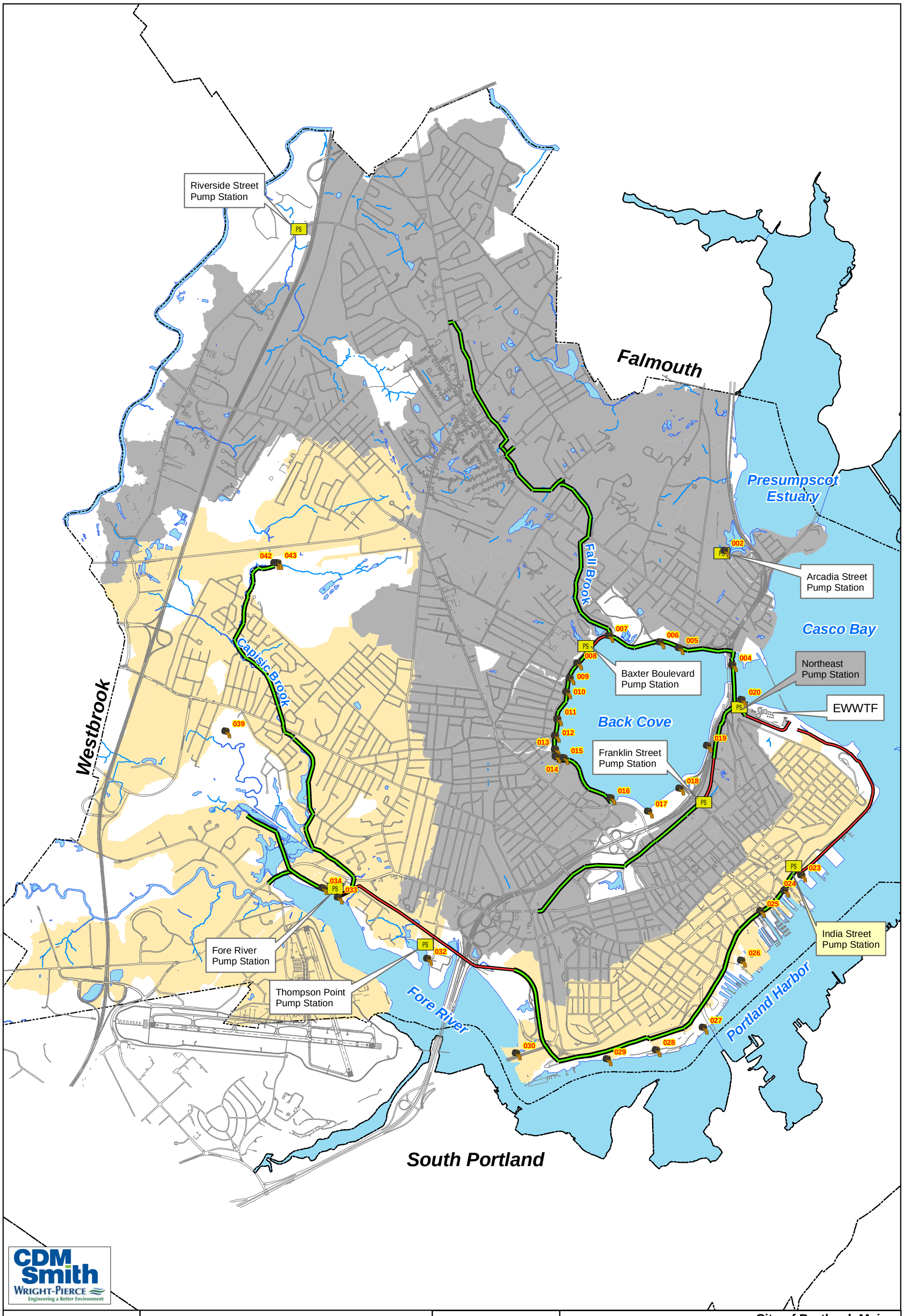
Land Use Category	Estimated Area from City GIS (Acres)
Low Density Residential	2,764
Medium Density Residential	259
High Density Residential	320
Light Commercial	837
Medium Commercial	522
Institutions, Schools, Governmental	1,514
Industrial	351
Transportation	772
Recreation / Open Space / Cemetery	1,067
Vacant	1,520
Total	**9,925**
No Data	***762***

Portland's collection system services residential, commercial and industrial customers. The collection system is predominantly combined with small areas in the outer portions of the system that were recently installed as separate sewers. The City has also been completing an extensive sewer separation plan which has decreased the combined sewer area, thus increasing the separate sewered area. The combined sewer system (CSS) services approximately 4,911 acres with the remaining 4,563 acres serviced by the separate sewer system (SSS). The municipal separate storm sewers (MS4) manage runoff in the SSS area.

Figure 2-2 illustrates the two major drainage basins within the City. The majority of the north and eastern areas of the City drain to Back Cove and Casco Bay (Presumpscot Estuary). The majority of the south and western areas of the City drain to Capisic Brook, Fore River, or Portland Harbor. Each receiving water has different capacities to assimilate the wastes from these discharges.

The two major streams in the City include Fall Brook and Capisic Brook. Fall Brook drains the northern portion of the City and discharges to Back Cove but does not have any CSOs that directly discharge into the Brook. Capisic Brook drains the western area of the City and discharges into Fore River. Capisic Brook has two remaining CSO outfalls in the upper reach (CSO 042 and 043).

Fore River drains southern portion of the service area and discharges into Portland Harbor. Portland Harbor separates Portland from South Portland and is part of Casco Bay. The Presumpscot River encircles west and northern portions of the City and drains into the Presumpscot Estuary, which is part of Casco Bay. The Presumpscot River receives only minimal MS4 flow from the City.



CDM Smith
WRIGHT-PIERCE
Engineering a Better Environment

Legend

- 007 CSO and NPDES #
- Flows to Northeast Pump Station
- Flows to India Street Pump Station
- Interceptor Sewer
- Force Main Sewer
- PS Pumping Station

N W E S

0 2,750 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Sewer Service Area
Figure 2-2

2.2.2 Infrastructure

The infrastructure that makes up the collection system includes approximately 5,800 pipes, 27 pump stations, 43 permitted CSO regulators, 33 permitted CSO outfalls, and the EEWWTF. Table 2-2 summarizes the currently permitted CSO regulators and outfalls. CSO 036 has recently been closed (December 2010), but this has yet to be reflected in the permit. This closure was possible because the sewerage from this area was routed through the new West Side Interceptor (WSI) also completed at this same time. This project removed a 60-inch diameter storm drain from the combined system, thus reducing the excess combined sewage that was tributary to CSO 036. Combined sewage from this area is now diverted through the WSI and discharges upstream of the Fore River pump station. Excess CSO, beyond the capacity of the Fore River pump station, will overflow out of CSO 033. Therefore, 32 CSOs currently exist in the system.

Two major interceptors were built along Fall and Capasic Brooks in to capture combined sewage and convey it to the East End Wastewater Treatment Facility (EEWWTF). The Fall Brook Interceptor was constructed in 1951, 1953, and 1976 and ranges in size from 36 to 42 inches in diameter and has no CSO outfalls. Capisic Brook Interceptor was constructed in 1938 – 1940, 1948, 1956, and 2010 and ranges in size from 18 to 60 inches in diameter and currently has two active overflows that discharges into the upper reaches of this brook Figure 2-2 illustrates the these two interceptors, other main interceptors in the City that have CSOs, as well as the two watersheds that drain to the two major pump stations in the system, NEPS and ISPS.

Table 2-2
Existing CSO Regulators and Outfalls

Regulator Location	Regulator Number	Regulator Owner	Outfall Number	PWD Outfall Number	Outfall Owner	Receiving Water
Acadia St.	2	PWD	002	(022)	PWD	Casco Bay @ end of Presumpscot Estuary
Tukey's Bridge Siphon	4	PWD	004	(026)	PWD	Casco Bay
Randal St.	5	PWD	005	(010)	PWD	Back Cove
Johanson St. #1 (@ Front St.)	6A	City	006	---	City	Back Cove
Johanson St. #2 (@ Front St.)	6B	City	006	---	City	Back Cove
Ocean Ave.	7	PWD	007	(011)	PWD	Back Cove
Clifton St.	8	PWD	008	(020)	PWD	Back Cove
George St.	9	PWD	009	(012)	PWD	Back Cove
Austin St.	10A	PWD	010	(014)	PWD	Back Cove
Mackworth St.	10B	PWD	010	(014)	PWD	Back Cove
Parstons St.	10C	PWD	010	(014)	PWD	Back Cove
Chenery St.	11A	PWD	011	(017)	PWD	Back Cove
Codman St.	11B	PWD	011	(017)	PWD	Back Cove
Vannah Ave	12	PWD	012	(018)	PWD	Back Cove
Belmont St.	13A	City	013	---	City	Back Cove
Forest Ave. @ Ashmont St.	13B	City	013	---	City	Back Cove
Ashmont St. @ Forest Ave.	13C	City	013	---	City	Back Cove
Forest Ave. @ Coyles Gully	14	City	014	---	City	Back Cove

Table 2-2 (Continued)
Existing CSO Regulators and Outfalls

Regulator Location	Regulator Number	Regulator Owner	Outfall Number	PWD Outfall Number	Outfall Owner	Receiving Water
Forest Ave. @ Dartmouth St.	15A	City	015	(019)	PWD	Back Cove
Dartmouth Ave. @ Baxter Blvd.	15B	PWD	015	(019)	PWD	Back Cove
Forest Ave. @Bedford St.	16A	City	016	(021)	PWD	Back Cove
Bank St.	16B	PWD	016	(021)	PWD	Back Cove
Preble St. @ Marginal Way (M W)	17	City	017	---	City	Back Cove
Franklin Arterial @ M W	18	City	018	---	City	Back Cove
Diamond @ M W (Fox @ Anderson)	19	City	019	---	City	Back Cove
Northeast P.S.	20	PWD	020	(024)	PWD	Casco Bay
India St.	23	PWD	023	(003)	PWD	Portland Harbor
Franklin Arterial @Fore St.	24A	City	024	---	City	Portland Harbor
Franklin Arterial @ Middle St.	24B	City	024	---	City	Portland Harbor
Long Wharf	25	PWD	025	(004)	PWD	Portland Harbor
Maple St. @ Commercial St.	26	City	026	---	City	Portland Harbor
Clark St.	27	PWD	027	(005)	PWD	Portland Harbor
Emery St.	28	PWD	028	(006)	PWD	Portland Harbor
West Commercial St.	29	PWD	029	(007)	PWD	Fore River
St. John St.	30	PWD	030	(008)	PWD	Fore River
Thompson Pt. P.S.	32	PWD	032	(028)	PWD	Fore River
Fore River P.S.	33	PWD	033	(009)	PWD	Fore River
Brewer St.	34	PWD	034	(025)	PWD	Fore River
Stroudwater Road	35A	PWD	035	(029)	PWD	Fore River
Capisic Pond Dam Overflow	36	City	036	---	City	Fore River
Rowe St. (Hillcrest)	39	City	039	---	City	Fore River
Warren Ave. 60”	42	City	042	---	City	Capisic Brook
Warren Ave. 24”	43	City	043	---	City	Capisic Brook

There are currently a total of 27 pump stations in the service area, of which six major stations were analyzed and are also labeled on Figure 2-2. Table 2-3 summarizes pertinent features of these pump stations including name, number of pumps, and peak capacity. As stated in Section 1, the NEPS and ISPS were upgraded between 1995 and 1997. PWD owns and operates the NEPS, ISPS, Baxter Boulevard pump station (BBPS), Fore River pump station (FRPS), Acadia Street pump station (ASPS), and Riverside Street pump station (RSPS). The Franklin Street pump station (FSPS) is owned and operated by the City. This pump station is in poor condition and in need of rehabilitation, replacement, or decommissioning (more discussion on the FSPS is included in the alternatives section of this report).

Table 2-3
Pump Stations Characteristics

Pump Station Name	Location/Description	Peak Capacity (MGD)
North East Pump Station (NEPS)	Between I-295 and Casco Bay just upstream of the EEWWTF – sewers in Back Cove watershed drain to this PS	51
India Street Pump Station (ISPS)	Off India Street Near Portland Harbor – services sewers in Capisic Brook watershed, Fore River watershed, and on the Peninsula	31
Fore River Pump Station (FRPS)	Off Congress Street near CSO 033 – services sewers in Capisic Brook, discharges upstream of ISPS	18.4
Franklin Street Pump Station (FSPS)	Off Franklin Street near Marginal Way – services sewers in Back Cove (South) on the north side of the Peninsula, discharges upstream of NEPS	9.7
Baxter Blvd Pump Station (BBPS)	Off Baxter Blvd between CSOs 007 and 008 – services sewers around Back Cove (West), upstream of CSOs 008 through 016 drain to this PS, discharges upstream of NEPS	4.3
Arcadia Street Pump Station (ASPS)	Off Arcadia Street near to Presumpscot Estuary – services sewers upstream of CSO 002	1.9

2.3 East End Waste Water Treatment Facility

The City of Portland's wastewater, which is a combination of domestic, commercial, industrial and stormwater sources, is treated at the East End Waste Water Treatment Facility (EEWWTF) located at the end of Marginal Way in Portland.

2.3.1 Description

The EEWWTF is a secondary activated sludge treatment facility owned and operated by PWD. PWD charges an annual assessment to the City for operations, maintenance and debt retirement. Aside from a small gravity contribution from the Eastern Promenade, influent to the treatment facility is largely pumped via two pump stations, Northeast (NEPS) and India Street (ISPS). The facility is currently rated for an average daily flow of 19.8 MGD with a peak secondary capacity of 36.8 MGD.

The facility's liquid train consists of: screenings and grit removal; primary clarification; aeration basins equipped with mechanical aerators; secondary clarifiers; liquid-based chemicals for disinfection and de-chlorination; chlorine contact tanks; and an outfall to Casco Bay. The solids train consists of: gravity thickeners for primary sludge concentration; gravity belt thickener for waste activated sludge concentration; sludge storage tanks; and rotary presses for dewatering of removed biosolids. Biosolids are hauled away and currently managed through landfilling and composting.

The EEWWTF was originally constructed with a secondary system bypass. The bypass is a permitted bypass and allows for flows in excess of 36.8 MGD to be bypassed around the secondary process. Under this configuration, all flows reaching the treatment facility receive a minimum of screenings removal, grit removal and primary treatment. As flows exceed the capacity of the secondary system,

remaining flows are diverted around the treatment process and disinfected and de-chlorinated before combining with secondary treated flows and released to Casco Bay.

2.3.2 Wet Weather Treatment

PWD has a license to bypass flows beyond the secondary treatment capacity of 36.8 MGD. As part of the original 1993 LTCP, the influent pump stations to the treatment facility, NEPS and ISPS, were upgraded to maximize wet weather flows to the treatment facility to deliver as much as 80 MGD to EEWWTF during wet weather events. Therefore, up to 36.8 MGD would receive secondary treatment with the remainder (up to 43.2 MGD) receiving primary treatment and disinfection.

As flow to the treatment facility increases past 36.8 MGD, an automatic bypass is initiated in the primary sedimentation basin effluent channel, downstream of the primary sedimentation basins. A butterfly valve located in the bypass line modulates to maintain 36.8 MGD to the secondary system with the remainder passing through the bypass line and into the chlorine contact tanks. The chlorine contact tank is divided into two parts. One part is dedicated to secondary treated flows and the other to bypassed flows during bypass events.

Normal operation is to run both sides of the contact tank concurrently. However, upon initialization of a bypass event, an electrically actuated gate closes in the influent channel of the tanks effectively isolating the two sides from each other thus separating the secondary treated flows from bypass flows.

Separation of the flow in the contact tanks is required by the plant license. Currently, effluent disinfection, for both secondary and bypass wastewater, is achieved through the use of sodium hypochlorite applied in the influent channel and mixed with a submersible induction mixer. After flows travel through each side of the contact tanks, residual chlorine is removed through the introduction of sodium bisulfite in the de-chlorination chambers located at the tail end of the chlorine contact tanks. Treated flows are then combined in the outlet structure and directed through the outfall pipe and released to Casco Bay.

Section 3

Monitoring Program

3.1 Introduction

Flow monitoring data, precipitation records, and tidal information were used to calibrate the collection system model. Permanent meters are installed at 34 sites throughout the system to monitor flow, depth, and velocity. Portland Water District (PWD) also has Telog meters that are located at six pump stations and at the East End Wastewater Treatment Facility (EEWWTF). The PWD also maintains three rain gages in the city. Water level data recorded at the NOAA tide gage in Portland Harbor (Station ID 8418150) was used to estimate appropriate boundary conditions at the outfalls.

3.2 Flow Monitoring

3.2.1 Collection System

During 2007 and 2009, Flow Assessment Inc. (FA) and ADS Environmental Services (ADS) installed meters at a total of 25 sites in the collection system to monitor flow conditions near regulators and outfalls. These metering sites are shown on Figure 3-1 and summarized in Table 3-1. Most meters were installed at the regulator structures or influent pipes to the regulator manhole, while others were installed directly in the overflow pipe. Depth and velocity were recorded at fifteen minute intervals at most meters, and flow was computed based on continuity. Other meters monitored only depth. Although the meters were installed at different times during 2007 and 2009, a common monitoring period was identified from September 23, 2009 to December 15, 2009 and was used for model calibration.

3.2.2 Pump Stations and EEWWTF

The PWD owns and maintains Telog meters at the Arcadia, Baxter Boulevard, Fore River, India Street, Northeast, and Thompsons Point Pump Stations and at the EEWWTF. The PWD provided flow data from these nine meters from January 2007 to December 2009 for model calibration. These sites include six pump stations, as well as the wastewater treatment plant influent, effluent, and bypass flows. CDM Smith reviewed the data quality throughout the monitoring period prior to use for model calibration. The wastewater treatment plant and pump station locations are shown on Figure 3-1.

A summary of the depth, velocity and flow data for each of the 43 meters during the period from September 23, 2009 to December 15, 2009 is provided in Table 3-2. This period was used for calibration of the collection system model (see Section 4). Metering accuracy will define how well the collection system model can be calibrated. Overall, the quality of data from these meters was very good.

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Flow Monitoring Locations
Figure 3-1

Table 3-1
Meter Locations

Outfall	Outfall Description	Meter Type	Meter Installed	Meter Location	Outfall Owner	Monitor
005	Randall Street	Depth - Velocity	Sept. 2009	Inlet pipe and Overflow pipe	PWD	ADS
007	Ocean Avenue	Depth - Velocity	Fall 2007	One in 48", one in 84" inlets	PWD	ADS
010B	Mackworth Street	Depth - Velocity	Fall 2007	Inlet pipe	PWD	ADS
012	Vannah Avenue	Depth - Velocity	Fall 2007	Inlet pipe	PWD	ADS
017	Preble St. at Marginal Way	Depth - Velocity	Fall 2007	Inlet pipe, Regulator MH	City	ADS
018	Franklin Art. at Marginal Way	Depth - Velocity	April 2009	Inlet pipe	City	ADS
020	Northeast Pump Station	Depth - Velocity	Fall 2007	Two inlet pipes	PWD	ADS
023	India Street	Depth - Velocity	May 2008	Inlet pipe	PWD	ADS
024A	Franklin Art. at Fore St.	Depth - Velocity	Feb. 2009	Inlet pipe	City	ADS
024B	Franklin Art. at Middle St.	Depth - Velocity	Feb. 2009	Inlet pipe	City	ADS
025	Long Wharf	Depth - Velocity	Fall 2007	Two inlet pipes	PWD	ADS
026	Maple St. at Commercial St.	Depth - Velocity	Feb. 2009	Inlet pipe	City	ADS
036	Capisic Pond Dam Overflow	Depth - Velocity	April 2009	Inlet pipe	City	ADS
042	Warren Avenue 60”	Depth - Velocity	April 2009	Inlet pipe	City	ADS
006A	Johansen Street #1 (at Front)	Depth	March 2009	Regulator MH	City	FA
006B	Johansen Street #2 (at Front)	Depth - Velocity	March 2009	Overflow pipe and DWF pipe	City	FA
013A	Belmont Street	Depth Only	March 2009	Inlet pipe	City	FA
013B	Forest Ave. at Ashmont St.	Depth - Velocity	March 2009	Overflow pipe (CSO 013C), Regulator MH (CSO 013B), Overflow pipe (CSO 13C and CSO 013B)	City	FA
013C	Ashmont St. at Forest Ave.	Depth Only	March 2009	Inlet pipe	City	FA
014	Forest Ave. at Coyles Gully (GLB)	Depth - Velocity	March 2009	Overflow pipe	City	FA
015A	Forest Ave. at Dartmouth St.	Depth - Velocity	March 2009	Overflow pipe (depth, velocity), Regulator MH (depth)	City	FA

Table 3-1 (Cont'd)
Meter Locations

Outfall	Outfall Description	Meter Type	Meter Installed	Meter Location	Outfall Owner	Monitor
016A	Forest Ave. at Bedford St.	Depth Only	March 2009	Inlet pipe, Regulator MH	City	FA
019	Diamond at MW (Fox at Anderson)	Depth Only	March 2009	Regulator MH	City	FA
039	Rowe Street (Hillcrest)	Depth - Velocity	March 2009	Overflow pipe (depth, velocity), Regulator MH (depth)	City	FA
043	Warren Avenue 24"	Depth - Velocity	March 2009	Overflow pipe (depth, velocity), Regulator MH (depth)	City	FA
-	-	Flow	-	EEWWTF Influent	PWD	PWD
-	-	Flow	-	EEWWTF Effluent	PWD	PWD
-	-	Flow	-	EEWWTF Bypass	PWD	PWD
-	-	Flow	-	Arcadia Pump Station	PWD	PWD
-	-	Flow	-	Baxter Blvd. Pump Station	PWD	PWD
-	-	Flow	-	Fore River Pump Station	PWD	PWD
-	-	Flow	-	India Street Pump Station	PWD	PWD
-	-	Flow	-	Northeast Pump Station	PWD	PWD
-	-	Flow	-	Thompsons Point Pump Station	PWD	PWD

Table 3-2
Metering Data Summary (September 23, 2009 to December 15, 2009)

	Depth (inches)			Velocity (ft/s)			Flow (MGD)		
Meter	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
CSO 005 Randall MP 1	2.97	106.92	6.24	0.29	3.97	2.03	0.22	9.38	0.94
CSO 005 Randall MP2	0.00	108.40	29.63	-	-	-	-	-	-
CSO 006A Front St @ Johansen	0.00	30.13	0.20	-	-	-	0.00	7.77	0.12
CSO 006B Johansen @ Front	0.00	20.95	0.20	0.00	9.50	0.11	0.00	28.98	0.10
206-15_CSO_006B	2.45	51.22	6.13	0.00	8.21	1.07	0.00	6.51	0.40
CSO 007 Ocean MP1	4.02	47.38	7.85	0.00	5.69	2.53	0.00	69.25	3.40
CSO 007 Ocean MP2	3.08	17.80	4.55	0.65	8.50	1.43	0.15	22.25	0.70
CSO 010B Mackworth	0.32	16.41	2.04	0.00	11.96	2.39	0.00	24.24	0.58
CSO 012 Vannah	1.12	103.14	7.12	0.00	10.54	1.25	0.00	21.41	0.29
CSO 013A Belmont St	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00
CSO 013B Forest @ Ahsmont	-	-	-	-	-	-	0.00	9.90	0.05
313-36 CSO 013B	-10.00	29.30	1.21	-10.14	3.72	0.02	0.00	7.69	0.01
313-42 CSO 013B	-10.00	9.34	-0.21	-0.77	5.89	0.12	-0.03	5.04	0.01
CSO 013C Ashmont @ Forest	0.00	6.29	0.01	-	-	-	0.00	2.11	0.00
CSO 014 Forest Ave @ Coyle	0.00	15.74	0.01	0.00	14.63	0.06	0.00	8.03	0.00
CSO 015A Forest @ Dartmouth	0.00	58.99	0.08	0.00	10.97	0.10	0.00	23.94	0.04
CSO 016A Forest @ Bedford	0.00	37.49	0.06	-	-	-	0.00	5.19	0.02
CSO 017 Preble St.	6.05	130.07	13.96	0.00	4.03	1.31	0.00	130.90	3.78
CSO 018 Marginal Way	0.96	141.91	6.74	0.00	3.97	2.37	0.00	36.51	0.78
CSO 019 Fox @ Anderson	0.00	8.89	0.00	-	-	-	0.00	7.96	0.00
CSO 020 Northeast PS MP1	4.91	48.00	9.11	0.00	4.37	1.37	0.00	18.04	1.72
CSO 020 Northeast PS MP2	1.95	98.22	10.30	0.46	4.81	2.87	0.10	11.43	2.82
CSO 023 India St.	0.99	56.36	4.22	0.00	5.53	0.69	0.00	50.72	0.41

Table 3-2 (Cont'd)
Metering Data Summary (September 23, 2009 to December 15, 2009)

	Depth (inches)			Velocity (ft/s)			Flow (MGD)		
Meter	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
CSO 024A Fore Street MP1	5.27	60.69	7.22	0.00	6.86	0.33	0.00	21.76	0.25
CSO 024A Fore Street MP2	7.52	70.95	9.33	0.00	1.74	0.32	0.00	1.98	0.18
CSO 024B Middle Street MP1	0.87	29.43	1.70	0.00	4.36	0.34	0.00	2.29	0.03
CSO 024B Middle Street MP2	1.83	31.31	3.02	0.18	4.90	0.61	0.02	10.81	0.14
CSO 025 Long Wharf MP1	1.45	99.87	6.20	0.00	7.23	2.50	0.00	57.64	1.11
CSO 025 Long Wharf MP2	1.23	98.07	4.33	0.00	3.50	1.78	0.00	24.98	0.33
CSO 026 Maple	2.49	97.40	4.49	0.63	8.34	3.25	0.12	27.42	0.72
CSO 036 Capisic Dam	5.06	33.71	11.13	0.22	7.12	0.52	0.24	52.28	1.42
CSO 039 Hillcrest	0.00	12.14	0.06	0.00	8.98	0.10	0.00	14.17	0.04
CSO 042 Warren 60"	1.82	43.98	6.21	0.34	4.70	1.42	0.04	44.14	1.08
CSO 043 Warren 24"	0.00	4.45	0.02	0.00	4.92	0.03	0.00	1.15	0.00
EEWWTF Influent	-	-	-	-	-	-	4.38	89.72	21.21
EEWWTF Effluent	-	-	-	-	-	-	1.48	45.68	14.90
EEWWTF Bypass	-	-	-	-	-	-	0.00	43.42	1.58
Arcadia Pump Station	-	-	-	-	-	-	0.00	1.89	0.15
Baxter Blvd. Pump Station	-	-	-	-	-	-	0.00	4.32	1.32
Fore River Pump Station	-	-	-	-	-	-	0.00	18.48	3.08
India Street Pump Station	-	-	-	-	-	-	0.33	32.17	6.09
Northeast Pump Station	-	-	-	-	-	-	3.23	50.46	14.14
Thompsons Point Pump Station	-	-	-	-	-	-	0.00	1.04	0.06

3.3 Precipitation Data

3.3.1 PWD Rain Gages

The PWD maintains three rain gages in the City of Portland. The rain gages are located at 386 Allen Avenue, Franklin Street Pump Station (FSPS), and Baxter Boulevard Pump Station, as shown on Figure 3-1. All three gages did not operate continuously over the monitoring period described above due to malfunctions or maintenance issues. Therefore the rainfall data from the three rain gages was used to create two rainfall time series for model calibration, one for the south side of the system and one for the north side.

The first rainfall time series (RG01) is primarily the rainfall data from the Allen Avenue rain gage. The second rainfall time series (RG02) is primarily the rainfall data from the FSPS rain gage. When data (for a specified period of time) from one of these sites was missing or suspect, then data from the other rain gage was used instead. If data from both RG01 and RG02 were missing, then the data from the Baxter Boulevard Pump Station rain gage was used.

The rainfall time series required adjustments during periods of snow since snowmelt is not directly modeled. This is the same method that has been used historically in the model. The rainfall data was modified to simulate snowmelt as rainfall using the following process: For those time steps where actual precipitation occurred as snowfall, zero rain was entered for that time step; a running total of snow accumulation was kept and compared to that reported by the National Weather Service for the Portland International Jetport. When there was a snow pack and temperatures were above freezing then snowmelt was added to the rainfall file. The amount of snowmelt added at each time step was based on the observed flow at the wastewater pump stations, daily temperatures, and time of day.

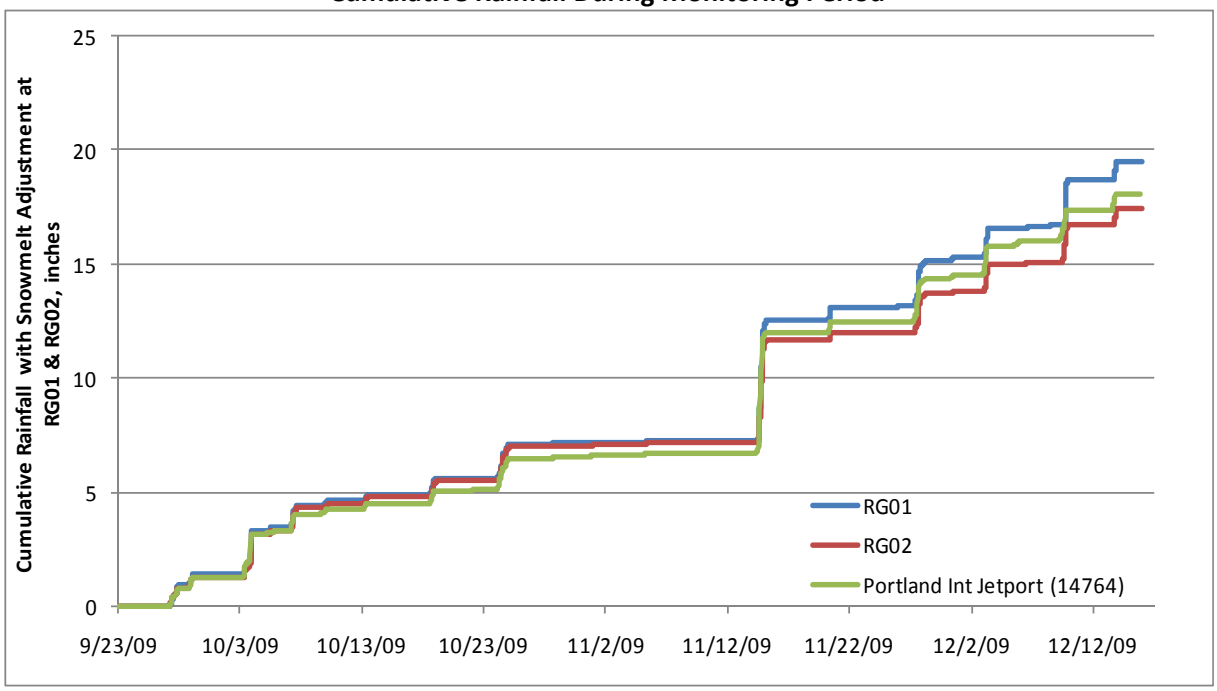
The cumulative rainfall totals (including snowmelt adjustments) for RG01 and RG02 during the calibration period are shown on Figure 3-2. The rainfall totals at both rain gages are similar for most of the calibration period but are higher at RG01 from mid-November through mid-December. The cumulative rainfall recorded at the Portland International Jetport rain gage is similar to the adjusted rainfall totals for RG01 and RG02, as shown in the Figure 3-2.

3.3.2 Portland International Jetport Rain Gage

A rain gage was also available at the Portland International Jetport (PIJ). This gage is maintained by NOAA (WBAN 14764) and has a continuous operating record from 1948 to 2010 and records rainfall at an hourly interval. From 1948 to 2009, annual total rainfall recorded at PIJ ranges from 12.93 to 66.33 inches, with an average of 43.66 inches.

A statistical analysis of the long-term hourly rainfall data from the PIJ gage was performed to identify storm events for calibration. Figure 3-3 shows the hourly rainfall during the calibration period at the Portland Jetport. Thirteen storm events with at least 0.25 inches of precipitation occurred during the calibration period (September 23, 2009 to December 15, 2009).

Figure 3-2
Cumulative Rainfall During Monitoring Period



The three storms selected as the principal calibration events include November 14th, November 27th, and December 3rd storms, as summarized in **Table 3-3**. The largest storm during the calibration period, on November 14, 2009, totaled 5.27 inches over 24 hours, which equates to a 10-year storm. The November 27th storm was greater than a 3-month storm over a 24 hour period, while the December 3rd storm was greater than a 1-month storm over a 24-hour period. Therefore, the calibration period provided an excellent range of rainfall characteristics which helps to quantify the system reaction to both small and large storm alike.

A significant storm also occurred on October 3rd, but was a short duration, high intensity event (1.13 inches over 3 hours, 1.9 inches over 17 hours). This event had a peak intensity of 0.89 inches per hour. This type of event can vary significantly over an area the size of the city and was therefore given less priority for calibration, because its potential variability could not be verified with just three gages.

The PIJ gage was also important because it recorded the rainfall that was previously identified as the typical year. The previous LTCP (1993) identified 1966 as a typical year. This year produced 40 inches of rainfall, but also had a variety of storm events that ranged up to approximately a 1.5 year event. Additional discussion of this typical year rainfall is included in Section 4.

Figure 3-3
Hourly Rainfall during Calibration Period at Portland Jetport

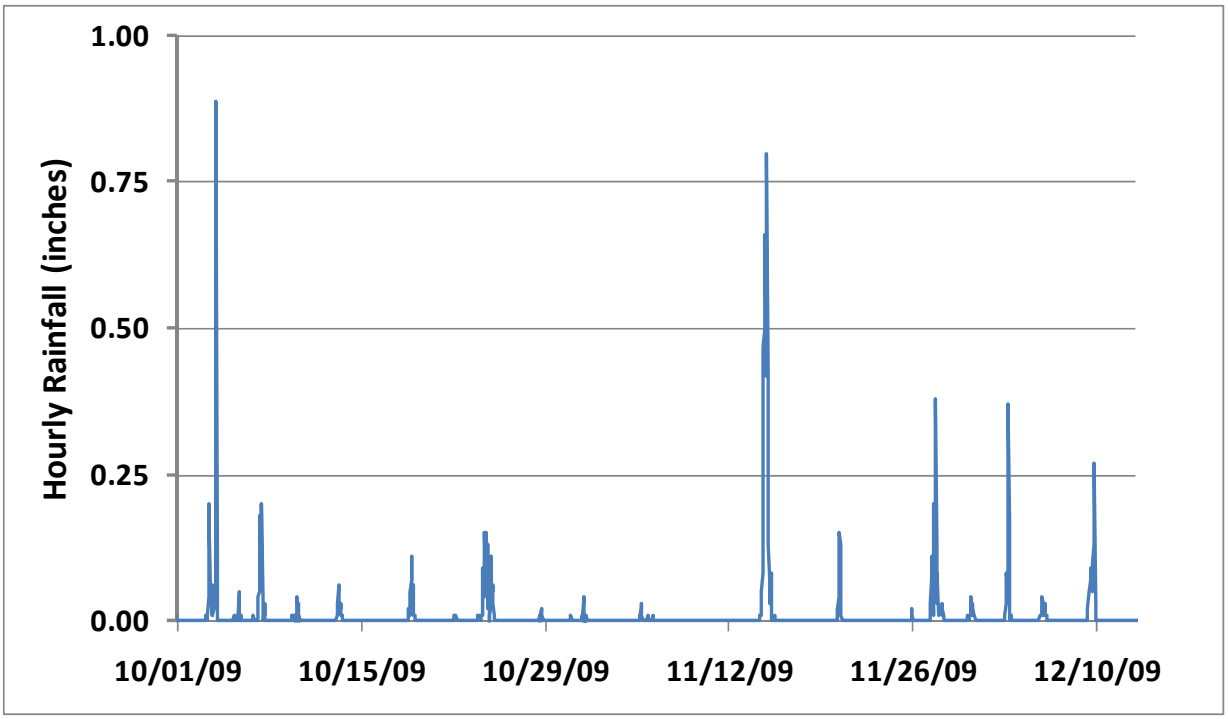


Table 3-3
Rainfall Statistics of Principal Calibration Storms

Start of Storm	Duration (hours)	Rainfall (inches)	Maxima (inches)				Storm Classification
			1-hr	3-hr	6-hr	24-hr	
11/14/2009 09:00	26	5.28	0.80	1.80	3.51	5.27	5-year at 3 hours, 2-year at 6 hours, 10-year at 24 hours
11/27/2009 07:00	25	1.86	0.38	0.86	1.27	1.85	> 3-month at 24 hours
12/03/2009 00:00	12	1.29	0.37	0.80	1.09	1.29	> 1-month at 24 hours

3.4 Tidal Data

The Portland sewer system includes several submerged outfalls that are subject to tidal fluctuations in the Portland Harbor, Fore River, and Back Cove.

3.4.1 Portland Harbor and Fore River

Stage data recorded at the NOAA tide gage in Portland Harbor (Station ID 8418150) was used as boundary conditions at outfalls discharging to the Portland Harbor and Fore River. From 1950 to 2010, the highest high tide at this station was at 9.6 feet (NGVD29) in 1978 and the lowest low tide was at -7.98 feet (NGVD29) in 1955.

3.4.2 Back Cove

A water level meter was installed in the CSO 005 overflow pipe which captured the upper half of the tidal response in the Back Cove (due to the installed elevation in the pipe). When compared to the stages recorded at the NOAA tide gage in Portland Harbor, an average of 0.53 feet of difference was evident as shown in Figure 3-4. This average difference is applied to long-term Portland Harbor tidal data to develop a long term time series of estimated tide elevations in the Back Cove. This was used as boundary conditions at the outfalls that discharge into the Back Cove. There are 26 regulators which have the potential to discharge overflows into Back Cove during storm events. Figure 3-5 demonstrates the elevation of these weirs relative to the estimated Back Cove tide. The regulators without a flap gate in the downstream overflow pipe are plotted in blue. Among them, regulator 006A, 006B, and 016B are below max tide elevation in Back Cove and are subject to salt water back flow into the sewer system.

Figure 3-4
Tidal Signals at NOAA Station (8418150) Portland Harbor and Metered Tide Elevation in Back Cove

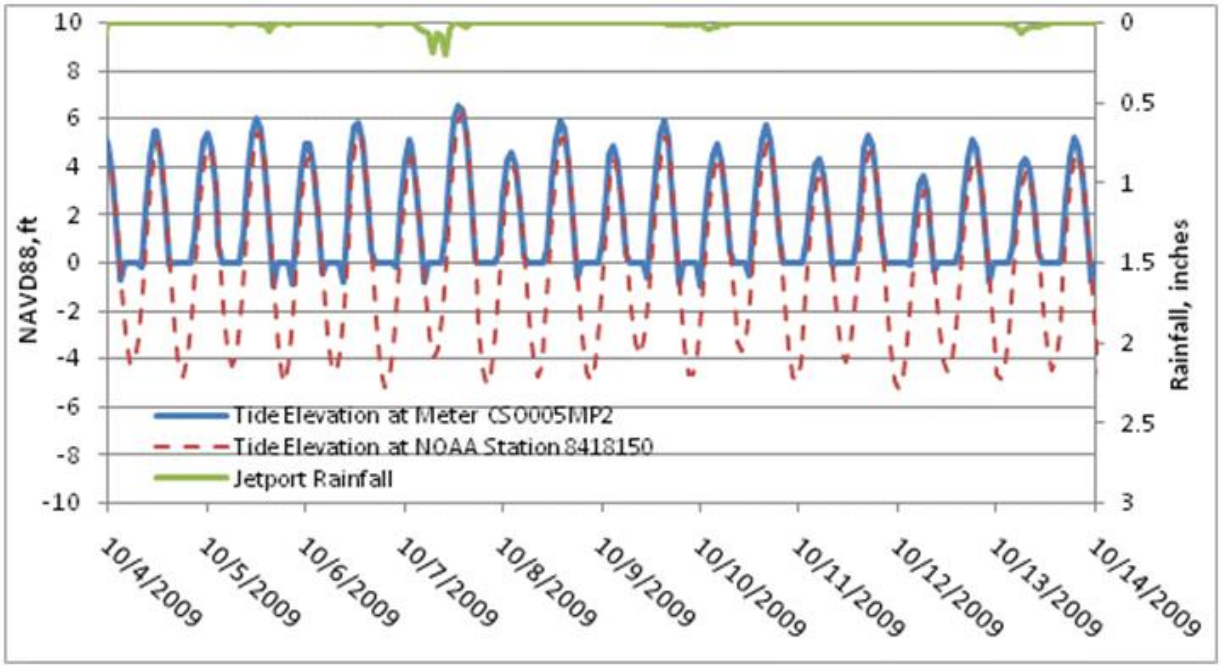
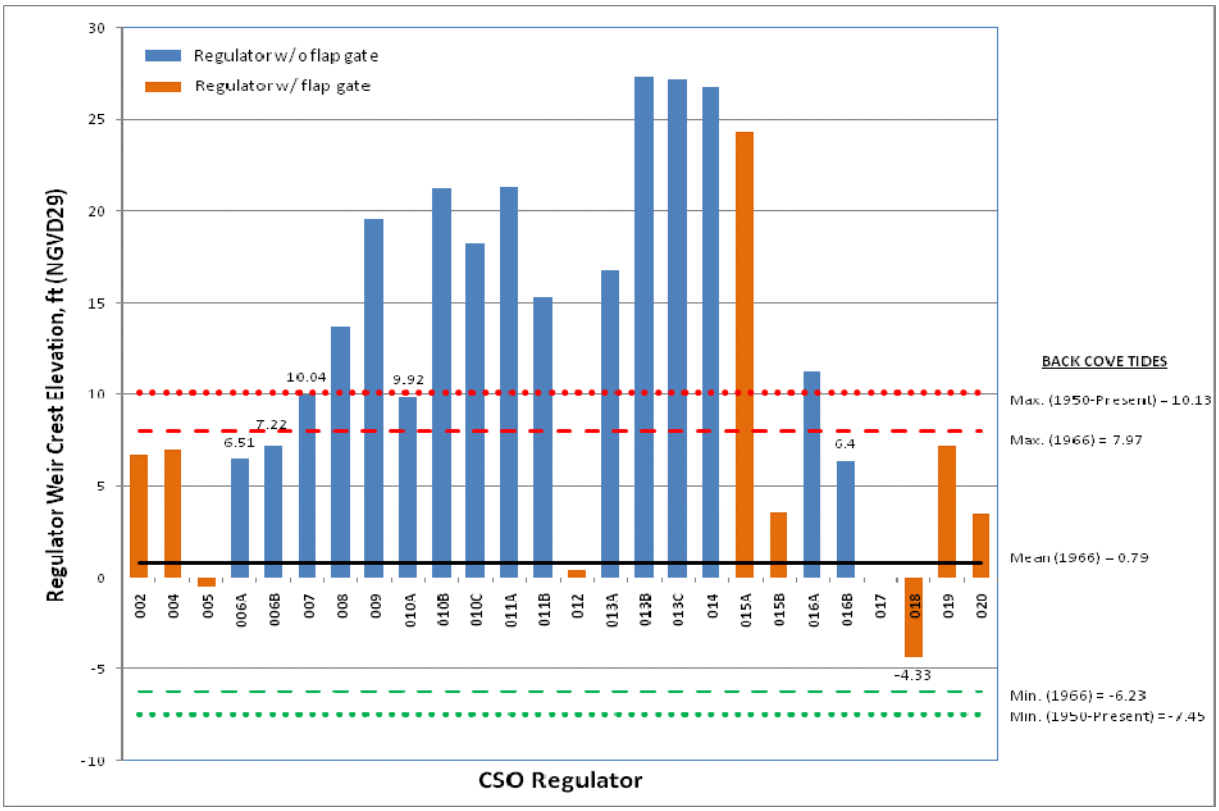


Figure 3-5
Regulator Weir Crests Relative to Tide Elevation in Back Cove



3.5 Recommended Monitoring Improvements

Among all of the meters maintained by PWD and the City, there is a good amount of quality reviewed metering data available for the entire collection system. However, temporarily augmenting the existing metering data with a few more meters at key locations is recommended. This would help the City understand the dynamics of the interceptor during wet weather. As the current metering data provides valuable information on the influent flows from major sewersheds and overflows at major CSO outfalls, it would be useful to maintain a few meters to monitor actual flow through the interceptors itself. Based on the 2010 calibration results, it is suggested to temporarily place meters at the following interceptor locations:

- Downstream of the CSO 019 regulator;
- Upstream and downstream of the regulator structure for CSO 017;
- Upstream of the CSO 025 regulator;
- West side interceptor upstream of Fore River PS;
- Upstream of the CSO 012 regulator; and
- Downstream of the CSO 005 regulator.

The suggested meter locations on the interceptors at these key locations supplement the flow data available from the other meters to add to the comprehensive understanding of the flows and depths in the collection system. Flow meters may be required in the future on a temporary basis to add additional data for further system refinements once various construction projects have been completed.

Section 4

Collection System Modeling

4.1 Introduction

The purpose of this section is to discuss the collection system modeling that was conducted as part of this study. Portland's existing sewer system model was significantly updated as part of the CSO LTCP Tier III Update project. Major improvements include updating model hydraulics and hydrology, creating a fully geo-referenced model in SWMM5, and recalibrating the model to a considerable amount of data collected from the City's and PWD's monitoring network.

In summary, the updated collection system model now provides an accurate calibration to the 2009 measured data at the majority of the metering locations and CSO outfalls. This effort calibrated to depths, velocities, and flows for four major events, plus a full year of flow data was used to verify that the model was projecting flows for a variety of storms and antecedent conditions.

The previous calibration effort only included seven CSO locations, ten flow meters, and three storms (e.g. 30 plots to develop and verify). This effort calibrated to 21 CSOs, using 41 meters, using not only flow but depth and velocity, and four storms. This equates to over 300 plots that needed to be developed and verified (10 fold more effort than previously completed). The updated model will not only provide more accurate and precise estimates of CSOs for this LTCP effort, but will also provide the City and PWD with increased confidence in projecting yearly overflow estimates for MDEP.

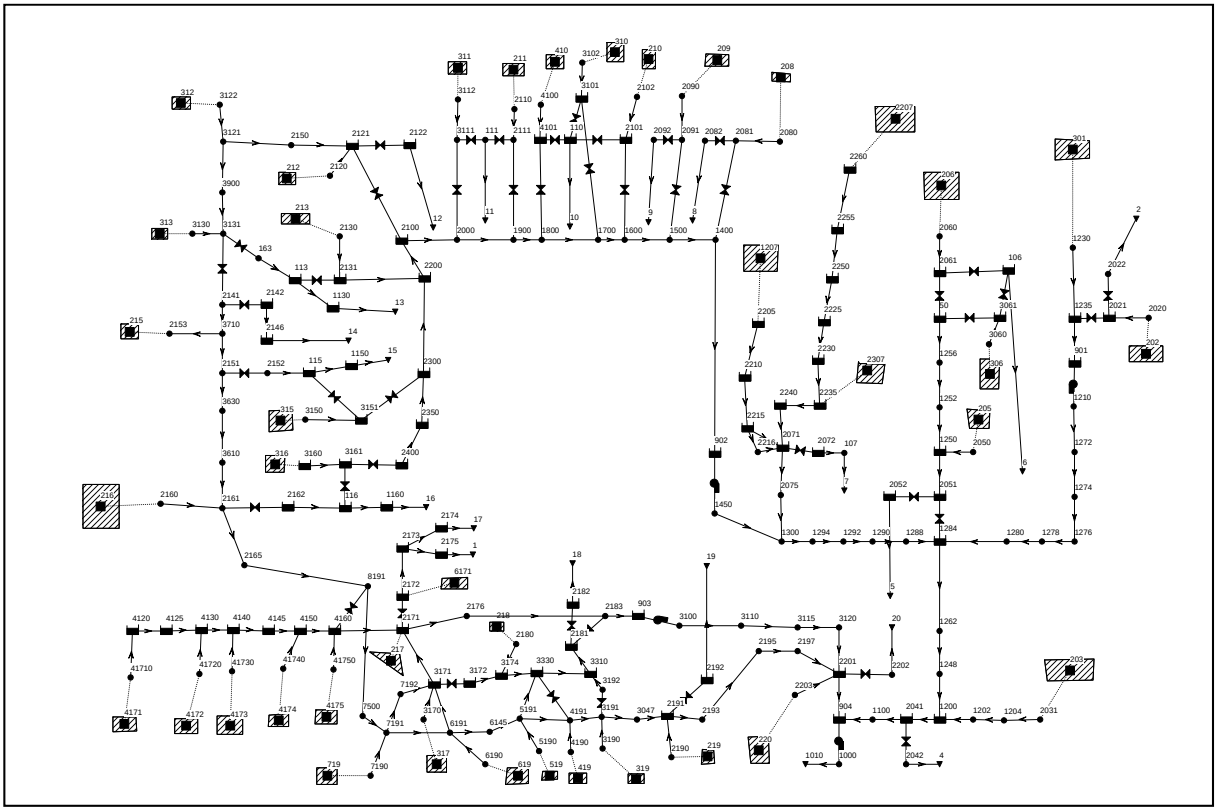
4.2 Previous Modeling Efforts

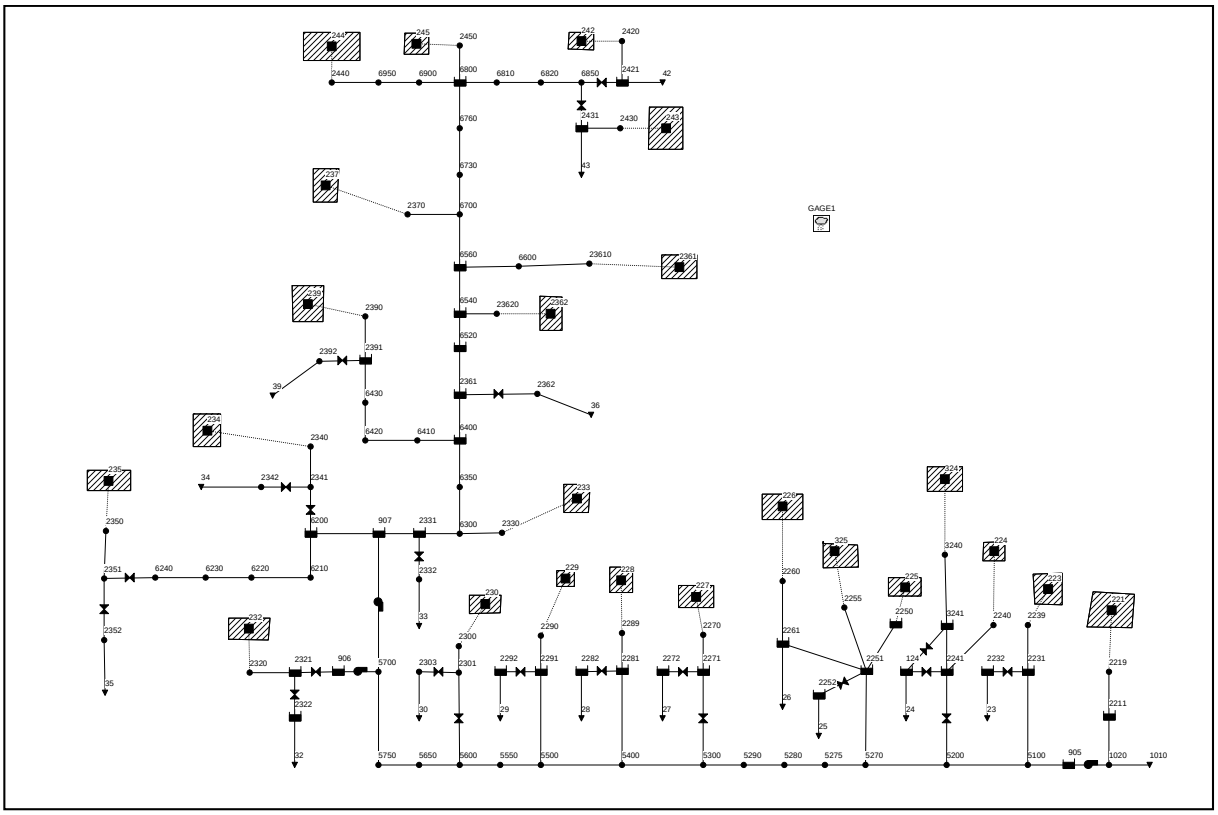
The original Portland sewer system model was developed in the early 1990s using the EPA Storm Water Management Model (SWMM) version 4. The model was originally calibrated based on overflow block data (wooden blocks placed on overflow weirs). Shortly after EPA released SWMM 5 the Portland collection system model was converted to the SWMM 5 model file format. Prior to 2009 a limited amount of model calibration occurred using depth and flow data collected at several CSO regulators within the system. As physical changes occurred within the system (e.g. the raising of overflow weirs), these changes were incorporated into the model. Since the completion of the *1993 Portland CSO Abatement Study Master Plan* the model has primarily been used to help provide annual overflow volumes and duration estimates that are part of the ongoing reporting requirements of the City's and PWD's NPDES permits.

4.3 Model Updates

The existing Portland sewer system model was developed before the prevalence of geographic information systems (GIS) and digital asset data and was not referenced to any specific geographic coordinate system. Figure 4-1 shows the two parts of the existing model, the north sewer system surrounding Back Cove and the south sewer system along Fore River and Portland Harbor, from which the flows combine at the influent channel of the wastewater treatment plant. Updates were made to the existing model including upgrading modeling software from SWMM5.9 to SWMM5.18, geo-referencing and updating the modeled network, and re-delineating model hydrology.

Figure 4-1 Existing Collection System Model





This effort focused on updating the hydrology and regulator structures in the model and the piping information was used from the existing model (pipe connectivity, inverts, sizes, roughness, *etc.*). Regulator structures in the model as well as system changes after the last model update were reviewed and adjusted as necessary based on available information. All hydrologic properties of the model were updated, including catchment boundaries and properties, soil infiltration, groundwater, and evaporation.

4.3.1 Geo-referencing

A geo-referenced model represents the modeled system spatially and can be a very useful tool during planning, preliminary design, field investigations, and daily operation. It also allows for the correct spatial delineation of tributary areas to each CSO outfall. PWD provided a digital asset database of Portland's sewer system components from the current City GIS. It defines the coordinate system of the updated model as *NAD 1983 HARN State Plane Maine West FIPS 1802 Feet*. The manholes from the two separate previous models were combined and geo-referenced using the asset network.

4.3.2 Sewer Network

Upon review of available information for the sewer system, the following updates were made to the model network:

- Additional sewer pipes installed along the existing interceptor, as part of recent sewer separation projects, upstream of CSO 036 were added;
- Weir length adjustment at regulator structure for CSO 013B (modified for metering purposes);
- Elimination of CSO 035 outfall due to closing; and
- Extension of pipes upstream of CSO 024 and CSO 013 to include metered sections.

The geo-referenced and updated model network is shown on Figure 4-2.

4.3.3 Outfall Properties

Outfall properties directly affect the timing and volume of CSO. The main factors affecting CSO estimates at outfalls are the invert of the outfall, the presence of a tide gate, and the tidal boundary condition at the outfalls.

The existing model simplified the tidal boundary condition and used either Portland Harbor tide or free outfall for all outfalls. It also assumed that all outfalls with Portland Harbor tide as boundary condition have tide gates. The existing outfall inverts in the model were checked against the most recent available information and adjusted as necessary. Historic tidal time series were also updated in the model to take into account the differences between Back Cove and Portland Harbor tide elevations (see Section 3). The presence or absence of tide gates based on recent City and PWD investigations were also updated. Table 4-1 lists tidal conditions and tide gate assumptions at each outfall for the updated model.

CDM Smith
Wright-Pierce
Engineering a Better Environment

Legend

- 007 CSO and NPDES #
- Modeled Links
- Asset Pipe
- PS Modeled Pumping Station
- Roads

N W E S

0 2,750 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
September 2010
Updated Collection System Model - Pipes and Pump Stations
Figure 4-2

Table 4-1
SWMM Tidal Conditions at Outfalls in Updated Model

Outfall	Model Tidal Condition		Modeled Tide Gate Current
	Previous	Current	
002	Portland Harbor	Portland Harbor	YES
004	Portland Harbor	Portland Harbor	YES
005	Portland Harbor	Back Cove	YES
006	Portland Harbor	Back Cove	NO
007	Portland Harbor	Back Cove	NO
008	Portland Harbor	Back Cove	NO
009	Portland Harbor	Back Cove	NO
010	Portland Harbor	Back Cove	NO
011	Portland Harbor	Back Cove	NO
012	Portland Harbor	Back Cove	YES
013	Portland Harbor	Back Cove	NO
014	Portland Harbor	Back Cove	NO
015	Portland Harbor	Back Cove	YES
016	Portland Harbor	Back Cove	NO
017	Portland Harbor	Back Cove	YES
018	Portland Harbor	Back Cove	YES
019	Portland Harbor	Back Cove	YES
020	Portland Harbor	Portland Harbor	YES
042	Free Outfall	Free Outfall	-
043	Free Outfall	Free Outfall	-
036	Free Outfall	Free Outfall	-
039	Free Outfall	Free Outfall	-
033	Portland Harbor	Portland Harbor	NO
034	Free Outfall	Portland Harbor	NO
032	Portland Harbor	Portland Harbor	YES
030	Portland Harbor	Portland Harbor	NO
029	Portland Harbor	Portland Harbor	NO
028	Portland Harbor	Portland Harbor	NO
027	Portland Harbor	Portland Harbor	NO
026	Free Outfall	Portland Harbor	NO
025	Portland Harbor	Portland Harbor	YES
024	Portland Harbor	Portland Harbor	NO
023	Portland Harbor	Portland Harbor	YES
035	Portland Harbor	Closed	-

The previous model was missing many tide gates that were active in the system. Therefore, any tidal inflow to the system for the old model was not accurate.

4.3.4 Catchment Properties

The previous model had no physical representation of the catchments, as shown on Figure 4-1. It lacked information on the actual area that the model covers and the characteristic of the catchments, such as land use, soil type, slope, etc. Moreover this does not allow easy extrapolation of the catchment properties based on implementation of different separation projects.

CDM Smith used existing asset data and information from the City and PWD to delineate catchments tributary to each CSO outfall. This process was necessary for analyzing sewer separation activities. Past sewer separation activities needed to be determined within each catchment so that an estimate could be made as to how effective the separation was in removing land area tributary to the CSO system and how much would be transferred to the separate storm sewer network.

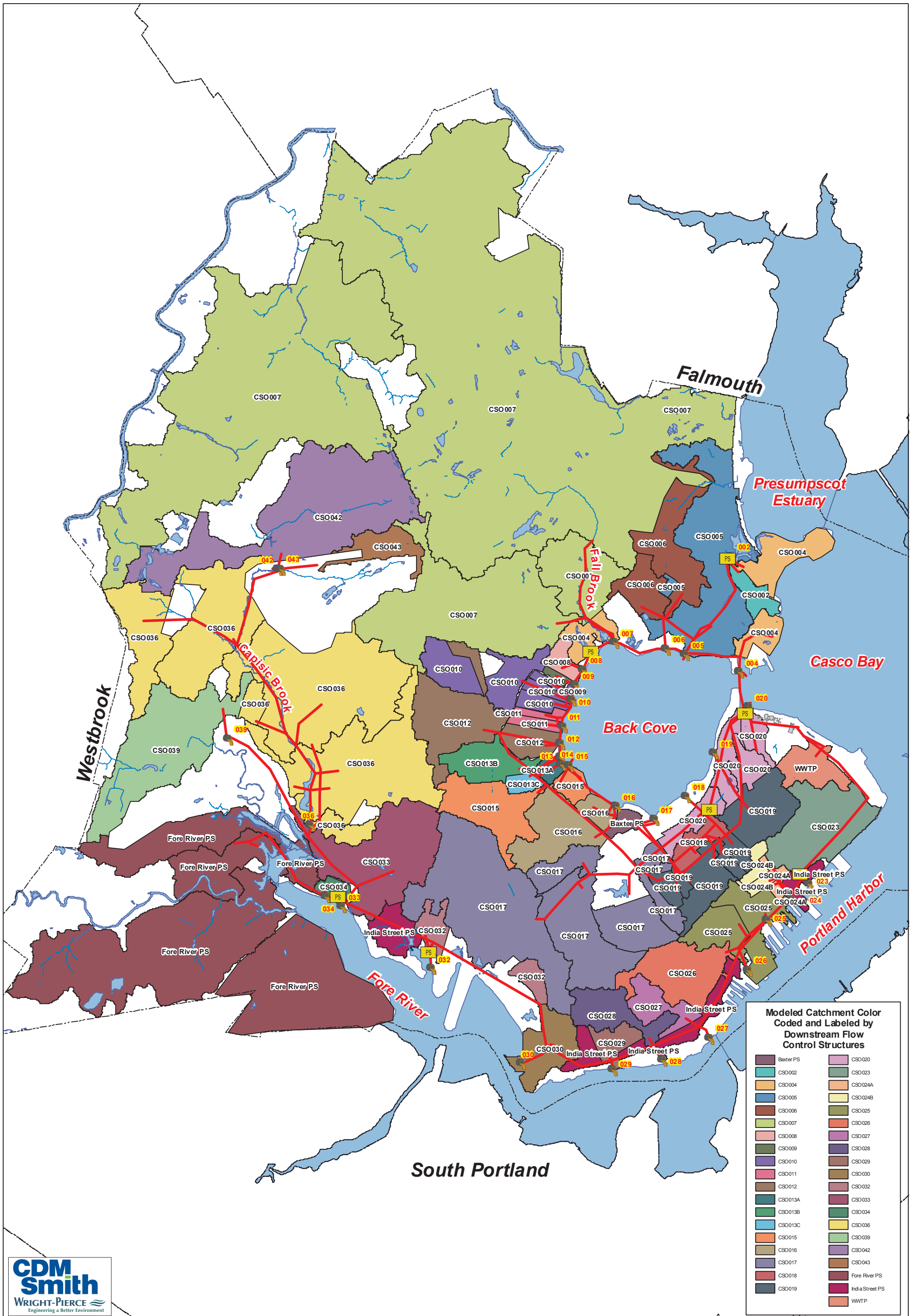
With the available Digital Elevation Model (DEM) and the sewer system asset data provided by PWD, catchment boundaries were delineated. Figure 4-3 shows the updated catchments, color coded by the outfalls to which they drain. Defining the aerial distribution of the hydrologic catchments allows for the analysis of the effect of reducing combined areas in specific catchments to estimate the effect of separation efforts on downstream overflows.

Area, Width, Percent Imperviousness, Slope

The non-linear reservoir method in SWMM was used for wet weather flow routing within a catchment. The key catchment properties required for the model are catchment area, width, percentage imperviousness, and catchment slope. The initial area of each catchment was calculated by the total combined area in that catchment subtracted by the separated areas to date in each catchment. The combined area and separated area were delineated from a 250-foot buffer around the pipes categorized as combined pipes in the asset database and the separation project pipes provided by PWD, respectively. Width was initially calculated as 300 times the square root of the catchment area and was adjusted during calibration. Percentage imperviousness of the catchment areas was downloaded from the USGS seamless website at a 30-meter resolution. This data layer was averaged over each catchment to determine one average value for percent impervious per catchment. The slope of each catchment was calculated as the average street slope within that catchment based on the DEM.

Manning's N and Depression Storage

Other catchment properties include Manning's N for pervious and impervious area, and depression storage for pervious and impervious area. The Manning's coefficients for impervious and pervious areas were fixed at 0.02 and 0.08, respectively. Depression storage for impervious and pervious areas was specified as 0.05 and 0.1 inches, respectively (ASCE, 1992, *Design & Construction of Urban Stormwater Management Systems*). These values were kept consistent throughout the model for all catchments.



City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
September 2010

Updated Collection System Model - Catchments
Figure 4-3

Soil infiltration

Soils data for Portland, ME was downloaded from the National Resources Conservation Service's Soil Survey Geographic (SSURGO) Database. The predominant soil type in the study area is sandy loam. The Horton method used in the existing model was updated to the Green-Ampt method for modeling soil infiltration. Typical Green-Ampt parameters for sandy loam were selected from SWMM guidance documents and assigned uniformly to all catchments; these include a hydraulic conductivity of 0.86 inches per hour, suction head of 4.33 inches, and initial moisture deficit of 0.25.

Groundwater and aquifer

Groundwater was explicitly modeled in the existing model. There was one aquifer modeled for each catchment. Since the aquifer parameters were identical for all catchments, they were consolidated into a single aquifer in the updated model. The parameters in the existing model were adopted initially and adjusted later during calibration.

Evaporation

The monthly evaporation rates were updated to values listed in Table 4-2. These values were extracted from long-term Portland, ME free water surface evaporation data from the NOAA Technical Report NWS 34 (1982).

Table 4-2
Evaporation Rate (inches/day)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.02	**0.03**	**0.05**	**0.08**	**0.12**	**0.14**	**0.14**	**0.12**	**0.08**	**0.06**	**0.03**	**0.02**

Reference: NOAA Technical Report NWS 34 (1982) Table 2

Dry weather flow

The dry weather flow inputs in the existing SWMM model were average flows without any diurnal patterns. To reflect the variation of sanitary flow throughout a day, diurnal patterns were delineated using metered flow at CSO 020 Northeast PS MP2, and then applied to all the modeled manholes with average dry weather flow input.

4.4 Calibration and Validation

The characteristics of a watershed or catchment are represented in a model by parameters and relationships that are used to estimate the response of the watershed. Most models have several parameters that can be directly measured or observed (e.g. area of watershed, percent imperviousness) as well as parameters that are not directly observable (i.e. parameters that define ground water flow). Parameters that are not directly observable must be estimated using indirect techniques of matching the model output to historical measured data. The process of adjusting model parameters is called calibration or parameter estimation. Verification is simply taking a calibrated model and comparing output to additional historic monitoring data to make sure the model is not biased to the data that was used for the calibration period, but can be used for a variety of conditions.

4.4.1 Methods

The model was calibrated using the two post-processed rainfall time series, flow metering data from 25 meters, permanent metering at six PWD pump stations, and permanent metering data at the influent of the wastewater treatment plant. The average dry weather flow input nodes in the existing

SWMM model were maintained in the updated model. Diurnal flow patterns were not included in the original model, so patterns were added to the updated based on those at the EEWWTF. A minimal dry weather flow calibration was performed during this update.

The model was calibrated to three principal storms during the 2009 metering period. They are November 14th, 27th, and December 3rd. Statistical analysis of these events is included in Section 3 of this report. The model was adjusted within reasonable limits to minimize differences between observed and modeled timing of peak flow, peak volume, and depth at each metered location. The primary calibration parameters were catchment width, area, and pipe Manning's coefficient. Groundwater parameters were adjusted to eliminate model instabilities. These instabilities may have been a result of version 5.18 of SWMM, but regardless, these instabilities were fixed even though ground water infiltration was minor during calibration period compared to wet weather peak flows.

4.4.2 Results

Figure 4-4 shows the comparison of modeled and metered flow at meter CSO007 MP2 for the three calibration storms. Figure 4-5 shows the comparison of depths at the same meter for the same storms. The red line indicates the crown of the pipe. The model matched the metered flow and depth well at this location. Figure 4-6 shows the modeled and observed flow at the influent of the treatment plant. The calibration plots of flow and depth at all meter locations are provided in Appendix C.

Figure 4-4
Modeled and Metered Flows at CSO007 for Calibration Storms

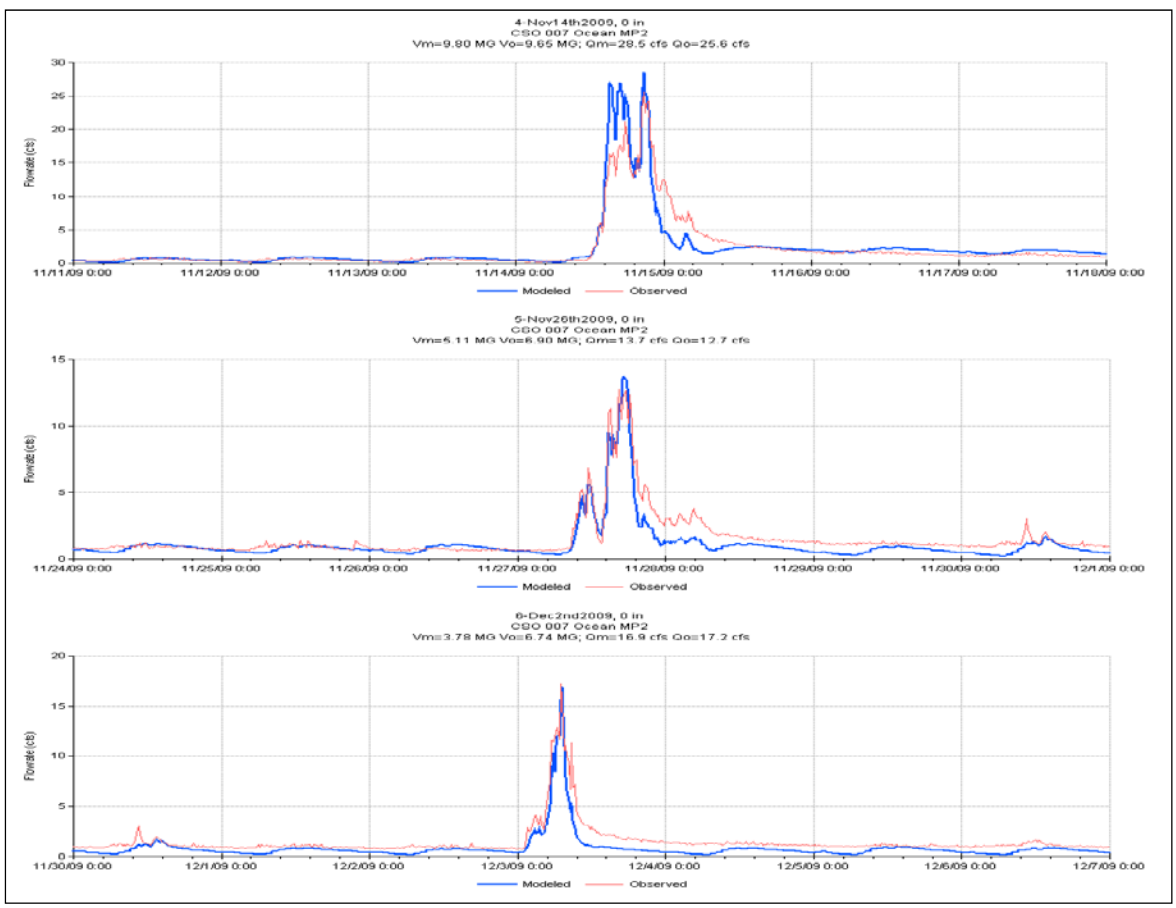


Figure 4-5
Modeled and Metered Depth at CSO007 for Calibration Storms

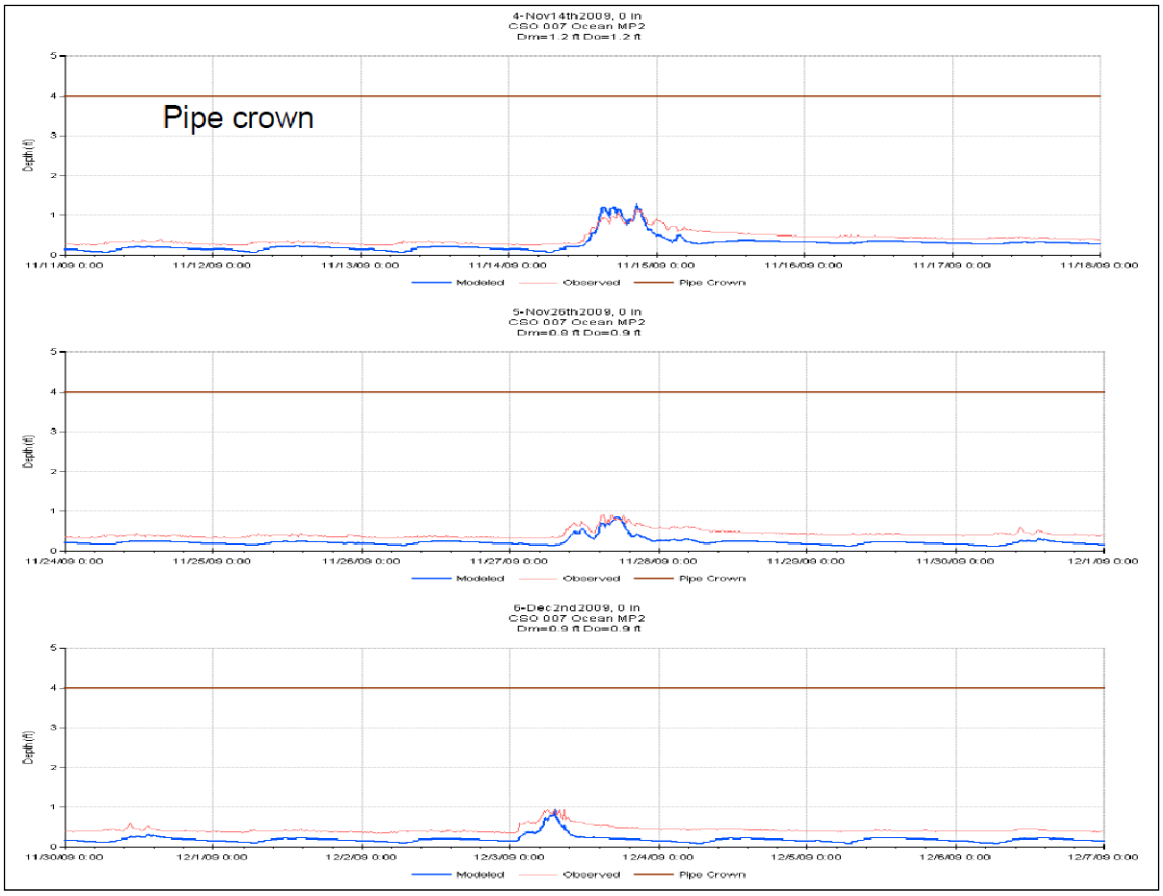
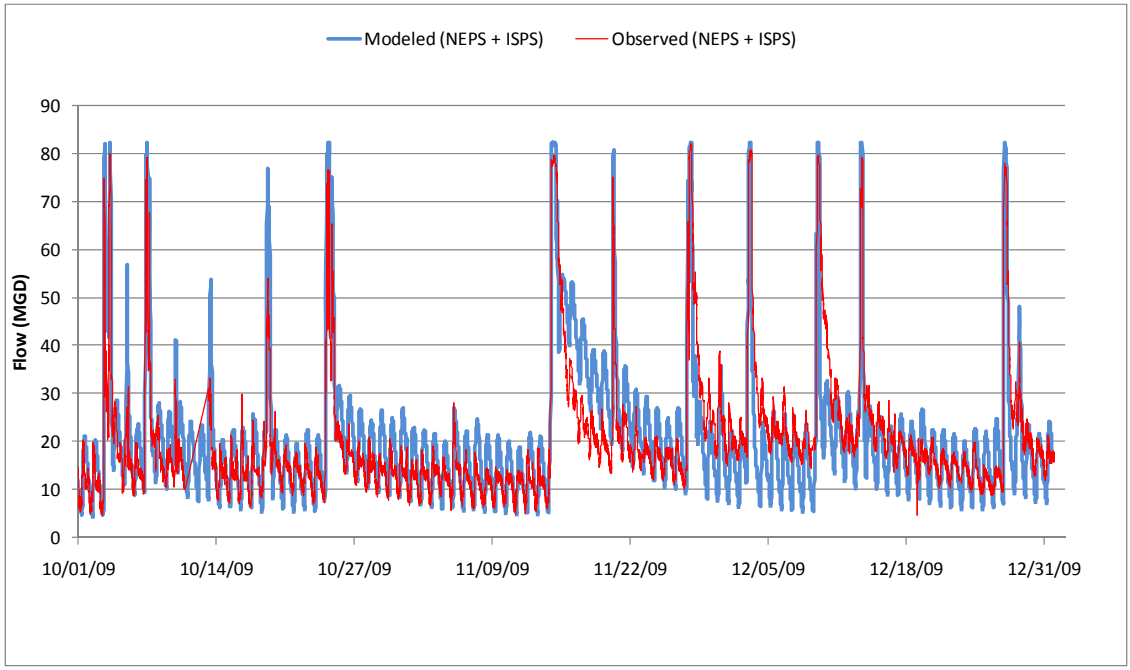


Figure 4-6
Modeled and Observed Flow at Wastewater Treatment Plant Influent for the Calibration Period



4.5 Model Improvements Needed at Regulators/Outfalls

The Portland sewer system model was updated and calibrated with the best information available to CDM Smith. The model now performs satisfactorily for LTCP purposes. Further data collection and field investigation is recommended to improve the model for use during the preliminary design of facilities.

The connectivity of the sewer system on the north side of the peninsula which drains towards CSO017, CSO018, and CSO019 is not well understood. There are multiple flow splits in this area, some of which are included in the model. These flow split structures need to be surveyed in order to improve model estimation on CSO volumes at individual outfalls among CSO017, CSO018, and CSO019. PWD recently found a pipe around the CSO019 area which might function as an overflow. This may change the configuration of CSO019 completely.

Outfall 6 and 16 are the lowest outfalls without tide gates. Both the metering data and the model showed that tide enters the sewer system from these points. This may affect the accuracy of the CSO volume estimate during the long term simulation when the tide gates are replaced.

Other areas of the modeled system were also identified for additional refinements to potentially improve the system representation and model calibration. These areas are described below and may be addressed during future modeling efforts.

- CSO 023 – The City indicated that the incoming brick pipe at the regulator for CSO 023 is in poor condition, and fallen bricks often block the flow at the regulator. This flow blockage is not represented in the model.
- CSO 024 – Sediment may exist in the 25-inch incoming pipe at the regulator located on Middle Street. The model calibration plots indicate that 3 inches of sediment in this pipe could improve the depth calibration.
- CSO 025 – The model includes two 5-foot incoming pipes and a single 19-inch outlet pipe (with flap gate) at the regulator for CSO 025. Also, near to this regulator, the interceptor sewer size changes from a 4-foot pipe to a 34-inch pipe and then back to a 4-foot pipe. These irregular pipe size restrictions should be verified and further investigated.

Despite the above limitations, the updated and calibrated model is a more accurate and effective tool for planning and evaluating system-wide improvements compared to its predecessor.

4.6 Baseline CSO Estimates

4.6.1 Existing Conditions (Typical Year Rainfall)

The calibrated collection system model was used to estimate the existing (2009) amount of CSO that could be expected based on hourly rainfall from the typical year. The precipitation records from 1966 were selected to represent typical annual rainfall in the 1993 LTCP analysis. As part of this LTCP Update, the data sets for rainfall were reviewed and this data set was determined to still be valid for this analysis. Existing conditions include sewer separation and other system improvements that had been implemented through 2009. The existing 2009 combined sewer area for the City was estimated

at 5,082 acres. This estimate was based on using the pipes included in the City's and PWD's GIS that are identified as combined sewers and calculating a 250 foot buffer on both sides of each pipe.

4.6.2 Comparison to Previous Projections

The previous estimate of combined sewer overflow from the system in the 1993 LTCP was 720 MG. Although the model was updated and recalibrated, it is assumed that this volume is still an adequate representation of the system-wide overflows for the 1966 rainfall based on the condition of the system in 1993. Therefore, this volume can be compared to existing estimates to predict the amount of CSO reduction due to improvements since 1993.

The model predicted a total system-wide annual CSO volume of 416 MG for existing conditions using hourly rainfall from the typical year. Table 4-3 provides a comparison of the predicted CSO conditions from the 1993 LTCP and existing 2009 simulations. Based on the above assumption, the estimate of 416 MG indicates a 42 percent reduction from the 720 MG estimated in 1993. This volume provides a baseline estimate of the current LOC of the system. For comparison purposes, the estimated amount of overflow from the system reported to MDEP for 2009 was higher at 873 MG; however, 2009 was a very wet year – 56 inches of rainfall compared to 40 inches in the typical year.

Table 4-3
Summary of Estimated CSO Conditions for 1993 and 2009

Outfall	LTCP 1993 CSO Conditions[1,4]		2009 CSO Conditions[1]	
	No. of Events[2]	Volume (MG)	No. of Events[3]	Volume (MG)
Casco Bay				
001	10	0.2	-	-
002	13	1.8	0	0.0
003	0	0.0	-	-
004	0	0.0	0	0.0
020	30	54.0	20	19.2
021	7	1.1	-	-
Subtotal	-	57.1	-	19.2
Back Cove				
005	34	100.0	11	5.3
006	23	1.6	31	21.2
007	24	100.0	18	40.5
008	5	4.1	1	0.1
009	0	0.0	0	0.0
010-018	44	210.0	27	205.5
019	5	0.2	1	0.2
Subtotal	-	415.9	-	272.8
Portland Harbor				
023-029	43	145.0	25	58.8

Table 4-3 (Cont'd)
Summary of Estimated CSO Conditions for 1993 and 2009

Outfall	LTCP 1993 CSO Conditions[1,4]		2009 CSO Conditions[1]	
	No. of Events[2]	Volume (MG)	No. of Events[3]	Volume (MG)
Fore River				
030	24	3.5	1	0.1
032	18	0.8	10	1.6
033	2	0.1	0	0.0
034	23	0.2	1	0.04
035	13	0.2	-	-
039	0	0.0	9	1.3
Subtotal	-	4.8	-	3.0
Capisic Brook				
036	46	68.0	24	34.5
038	14	4.4	-	-
040	0	0.0	-	-
041	4	0.4	-	-
042-043	69	24.6	19	28.2
Subtotal	-	97.4	-	62.7
Total	**-**	**720.2**		**416.4**

[1]Based on 1966 precipitation record.

[2]Number of events approximates the number of days an overflow event is occurring.

[3]Number of events based on 24 hour interevent time.

[4]Combined Sewer Overflow Abatement Study Master Plan Final Report, City of Portland, Maine, December 1993 (CH2M HILL).

4.7 Recommended Model Improvements

The updated and calibrated Portland sewer system model provides a reasonable representation of the system hydraulics and estimation of sewer overflows. The following recommendations can further improve the physical representation of the sewer system in the model, as well as the accuracy of the simulation results:

- Improve model sewer network representation with field verification of pipe connectivity, sediment accumulation, and potential blockages at specific locations in the system as identified in Section 4.5;
- Improve pump station representation in the model with more recent and accurate information regarding wet well size and configuration, actual pump curves (from pump tests), and pumping operations including pertinent SCADA controls;
- Explicitly model the snow melt process in SWMM to provide a more robust representation of precipitation runoff during the winter; and
- Improve groundwater representation in the model to better reflect the seasonality of the baseflow as well as rainfall-induced infiltration. Groundwater tends to be a small component of peak flows in a CSS, but for areas that have a SSS and high seasonal infiltration, this representation will be critical for accurate long term simulations. Accurate groundwater representation is also important for accurate simulation of storage facilities.

Section 5

Pollutant Loads

5.1 Introduction

The purpose of this section is to discuss the existing pollutant loading from CSO and stormwater discharges into various receiving waters in Portland, including Fall Brook, Capisic Brook, Fore River, Portland Harbor, Back Cove, and Casco Bay. This task is the preliminary step in determining event mean concentrations (EMCs) for CSO and stormwater pollutant loadings.

5.2 Historic Pollutant Concentrations

Prior to collecting current day pollutant leading data thought the water quality sampling program, a detailed search was completed to obtain historic pollutant concentration data from past water quality sampling programs. The following subsections present the findings of the data search.

5.2.1 1993 Portland Average (CSO)

As part of the December 1993 CSO Abatement Study Master Plan for the City of Portland, typical values for CSO pollutants parameters were developed. A summary of these typical values for Portland (in addition to several other Maine communities) was developed by the MDEP and is included in Appendix D.

5.2.2 New England Averages (CSO)

Pollutant loading data for CSO discharges was summarized for over a dozen New England communities, including:

- Maine - Portland, Bangor, Lewiston, Auburn
- Massachusetts - New Bedford, Springfield, Lowell, GLSD, Haverhill
- Connecticut - Hartford
- New Hampshire - Manchester, Nashua

Data for the New England averages was obtained from the following sources:

- MDEP compilation from:
  - CSO Abatement Study Master Plan, City of Portland, December 1993.
  - Final Draft Combined Sewer Overflow Facilities Plan for the City of Bangor, December 1993.
  - Clean Water Act Master Plan, Auburn Sewerage District & City of Lewiston, October 2000
  - New Bedford Facilities Plan, 1990 (CDM Smith study).
  - Other past CDM Smith studies.

A summary table with this data is included in Appendix D.

5.2.3 EPA Urban Stormwater

On August 26, 2004, the EPA delivered a report to Congress on the Impacts and Control of CSOs and SSOs. As part of this report, the EPA presented a characterization of CSOs and SSOs, including typical values for urban stormwater pollutant loading for BOD, TSS, TKN, Total P, and Zn. A summary table with this data is included in Appendix D.

5.3 Water Quality Monitoring Program

5.3.1 Description

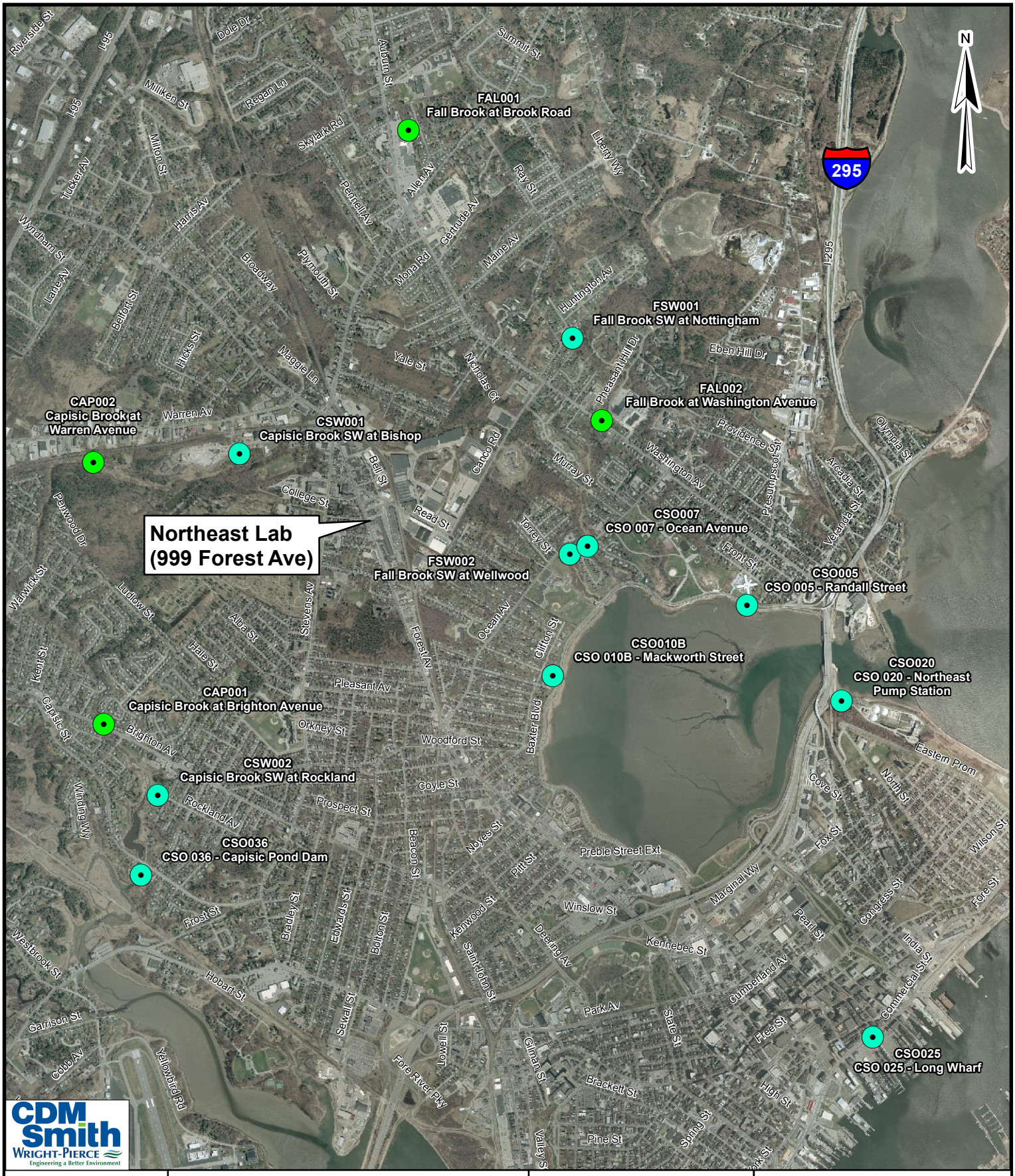
The ultimate goal of the CSO LTCP Update is to identify Tier III projects necessary to meet the requirements of the existing Consent and Enforcement Agreement. A water quality monitoring program was developed to: 1) document the baseline water quality condition of the CSO, stormwater, and receiving water system to date; 2) predict the anticipated water quality impacts the remaining Tier II sewer separation projects will have on the receiving waters; and 3) predict other alternatives that could provide the City with improved water quality. The following information is a summary of the monitoring activities.

The goal of the water quality monitoring activities was to collect water quality data for two wet weather events greater than one inch of rainfall and one dry weather event. Crews were mobilized for three wet weather events and one dry weather event. Figure 5-1 illustrates the sampling locations for the wet and dry weather events that were selected with the assistance of the City staff. Ultimately, six CSO locations, four in-stream locations, and four stormwater outfalls were chosen as sample sites for the wet weather event. The same four in-stream locations were selected for the dry weather event. Roughly 15 water quality parameters were measured for use in determining pollutant loading at the sites, most notably, BOD, TSS, and *E.coli*.

A Water Quality Monitoring Plan (WQMP) was developed to guide the field activities and is included as Appendix E. The intent of the plan was to direct the water quality sample collection procedures and to identify priority pollutants discharged at the sample sites. Topics covered in the WQMP include parameters to be sampled, roles and responsibilities, sampling locations (with site investigation sheets), sampling frequencies, sampling activities, field documentation, QA/QC, and standard operating procedures. The water quality monitoring activities and results are presented in a memorandum included in Appendix F. The following subsections present a brief summary of the water quality monitoring results.

5.3.2 CSO Results

The average pollutant concentrations for the six CSO locations are presented in Table 5.1. The averages are compared to historical data in Portland and New England. In addition, Event Mean Concentrations (EMCs) of pollutants are highlighted in the table for use during the pollutant loading calculation task. As a conservative approach, the EMCs were set equal to the highest average concentration between the event results, Portland averages, and the New England averages.



CDM Smith
Wright-Pierce
Engineering a Better Environment

Legend

Sample Sites

- Wet
- Wet and Dry

N
W E
S

0 2,500 Feet

City of Portland, Maine
CSO LTCP Tier III Update
Mar 2010

WQMP Sample Sites
Figure 5-1

Path: W:\GIS_Development\Projects\ME\Portland\11583A\Figures\Fig5-1_Portrait_8x11.mxd

Table 5-1
Average CSO Discharge Concentrations

Parameter	1993 Portland Averages	New England Averages	Event No. 1 (3/23/2010)			Event No. 2 (5/8/2010)			Event No. 3 (7/10/2010)			EMC
			Averages[1]	Range		Averages[2]	Range		Averages[3]	Range		
BOD (mg/l)	34	44	19	ND	69	69	18	130	130	11	220	130
TSS (mg/l)	217	124	37	7.2	96	120	25	200	231	33	470	231
E-coli (CFU/100ml)	430,000	556,917	>20,000	ND	>20,000	-	-	-	1,700	1,700	1,700	556,917
pH	-	-	7.1	6.4	9.5	7.3	6.9	8.2	6.5	6.2	6.8	6.5
DO (mg/l)	-	-	11.3	9.8	12.2	6.6	6.1	7.1	9.8	7.5	12.5	6.6
Conductivity (mS/cm)	-	-	0.64	0.04	8.6	0.63	0.19	1.65	0.24	0.12	0.46	0.64
Temperature (°C)	-	-	7.1	5.5	9.3	12.4	11.7	13.2	21.7	20.4	23.9	21.7
Ammonia (mg/l)	-	2.66	0.74	ND	5.1	4.0	2.3	6.2	5.5	0.59	9.7	5.5
Nitrite (mg/l)	-	0.02	0.23	ND	0.23	ND	ND	ND	ND	ND	ND	0.23
Nitrate (mg/l)	-	0.47	0.70	ND	1.10	0.88	ND	0.88	ND	ND	ND	0.88
TKN (mg/l)	5	5.82	3.5	ND	11.0	10.6	2.7	17.0	13.2	3.5	20.0	13.2
Total-P (mg/l)	0.8	0.77	0.38	ND	3.9	1.8	0.15	3.1	2.5	0.09	4.6	2.5
Ortho-P (mg/l)	-	-	0.28	ND	1.9	0.97	0.60	1.2	0.75	0.15	1.1	0.97
PAH	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zn (mg/l)	0.095	0.14	0.036	0.030	0.042	0.056	0.056	0.056	0.18	0.18	0.18	0.18

[1] Based on an average of 6 to 9 samples per site, except PAH and Zn are based on an average of 2 samples per site

[2] Based on an average of 1 to 2 samples per site

[3] Based on an average of 3 samples for one site, except PAH and Zn are based on 1 sample

In general, the Event No. 3 averages were used to establish the EMCs for CSO discharge. The exceptions are E.coli (New England average), DO (Event No. 2), Conductivity (Event No. 1), Nitrite (Event No. 1), Nitrate (Event No. 2), and Ortho-P (Event No. 2).

5.3.3 Stormwater Results

The average pollutant concentrations for the four stormwater discharge locations are presented in Table 5.2. The averages are compared to EPA-provided data on urban stormwater. In addition, EMCs of pollutants are highlighted in the table for use during the pollutant loading calculation task. As a conservative approach, the EMCs were set equal to the highest average concentration between the event results and the EPA urban stormwater data.

Event No. 3 averages were used to establish the EMCs for each of the pollutants for stormwater discharge.

5.3.4 In-stream Results

The average pollutant concentrations for the four in-stream locations are presented in Table 5.3. The averages are compared to MDEP bio-monitoring and stream TMDL monitoring data.

5.4 Baseline Loading Estimates

As discussed in Section 4, the collection system model was updated as part of this Tier III update. The model was then used to determine CSO and stormwater discharges to each receiving water under existing conditions. Figure 5.2 presents the volume of CSO and stormwater discharged to each receiving water for existing conditions for the design storm event.

As shown in Figure 5.1, roughly 80% of the discharges into the receiving waters are attributable to stormwater, while the remaining 20% are from CSO sources. It should also be noted that 60% of the CSO and stormwater discharges are received by Back Cove.

5.4.1 CSOs

The EMCs developed for the CSO discharges were used in conjunction with the existing modeled conditions for CSO discharge volumes to determine pollutant loading to each receiving water under baseline conditions. Figures 5.2 through 5.4 present the pollutant loading for TSS, BOD, and E.coli from CSOs discharged to each receiving water for existing conditions for the design storm event.

Roughly 43% of the total TSS loading is attributable to CSO sources. Roughly 39% of the total BOD loading is attributable to CSO sources. The majority (96%) of the total E.coli loading is from CSO sources. Back Cove receives 65%, 48%, and 66% of the total TSS, BOD, and E.coli loading from CSO sources under baseline conditions.

Table 5-2
Average Stormwater Discharge Concentrations

Parameter	EPA Urban Stormwater		Event No. 1 (3/23/2010)			Event No. 2 (5/8/2010)			Event No. 3 (7/10/2010)			EMC
	Range	Median	Averages[1]	Range		Averages[2]	Range		Averages[3]	Range		
BOD (mg/l)	0.4 to 370	8.6	3.5	ND	7.4	9.3	ND	14	24	3.3	61	24
TSS (mg/l)	0.5 to 4,800	58	33	ND	130	29	9.9	64	77	16	240	77
E-coli (CFU/100ml)	1 to 5,230,000	5,081	>1,385	100	>20,000	1,488	18	4,300	>5,918	750	20,000	5,918
pH	-	-	7.0	6.5	8.3	6.8	6.2	7.8	6.6	5.6	7.2	6.6
DO (mg/l)	-	-	11.2	9.4	12.6	9.2	8.5	9.6	8.0	5.0	11.5	8.0
Conductivity (mS/cm)	-	-	0.15	0.07	0.30	0.15	0.04	0.25	0.18	0.04	0.74	0.18
Temperature (°C)	-	-	5.9	4.3	6.9	12.6	11.2	14.3	23	18.5	25.3	22.5
Ammonia (mg/l)	-	-	0.31	ND	0.43	0.65	ND	1.2	1.7	0.42	6.7	1.7
Nitrite (mg/l)	-	-	ND	ND	ND	ND	ND	ND	0.20	ND	0.20	0.20
Nitrate (mg/l)	-	-	0.84	ND	1.2	0.52	ND	0.53	1.0	ND	2.1	1.0
TKN (mg/l)	0.05 to 66.4	1.4	2.1	ND	2.8	2.6	ND	3.0	5.5	3.0	11	5.5
Total-P (mg/l)	0.01 to 15.4	0.27	0.06	ND	0.09	0.08	ND	0.09	0.38	0.05	1.6	0.38
Ortho-P (mg/l)	-	-	0.07	ND	0.12	0.14	0.08	0.19	0.16	0.06	0.34	0.16
PAH	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zn (mg/l)	0.0001 to 22.5	0.117	0.05	0.03	0.10	0.09	0.05	0.13	0.24	0.17	0.31	0.24

[1] Based on an average of 8 to 9 samples per site, except Zn is based on an average of 2 samples per site

[2] Based on an average of 1 to 3 samples per site

[3] Based on an average of 3 to 4 samples per site, except PAH and Zn are based on an average of 1 sample at 2 sites.

Table 5-3
Average In-Stream Concentrations

Parameter	MDEP Biomonitoring Stream TMDL Monitoring Field	MDEP Biomonitoring Stream TMDL Monitoring Lab	MDEP Biomonitoring Stream TMDL Monitoring (Stormflow) Lab	Event No. 1 - 3/23/2010			Event No. 2 - 5/8/2010			Event No. 3 - 7/10/2010			Dry Event - 7/9/2010		
				Averages[1]	Range		Averages[2]	Range		Averages[3]	Range		Averages[4]	Range	
BOD (mg/l)	-	-	-	2.7	ND	4.5	6.4	2.0	17	26	7.4	69	10	ND	10
TSS (mg/l)	-	14	19	41	3.6	170	28	9.7	60	207	62	310	206	27	460
E-coli (CFU/100ml)	-	329	30	>6,145	ND	>20,000	338	29	1,500	>17,000	5,000	>20,000	>10,155	310	>20,000
pH	7.2	-	-	7.0	6.4	7.6	7.1	6.4	7.5	6.6	6.2	7.0	7.0	6.8	7.1
DO (mg/l)	8.7	-	-	10.7	9.4	11.6	8.1	7.0	9.5	7.4	5.8	9.9	5.0	2.8	6.3
Conductivity (mS/cm)	-	-	-	0.12	0.03	0.56	0.47	0.43	0.51	0.24	0.14	0.43	0.75	0.48	1.1
Temperature (°C)	14.48	-	-	5.4	4.1	6.0	11.9	10.9	13.1	22.4	22.0	22.9	24.2	21.7	26.4
Ammonia (mg/l)	-	0.16	-	ND	ND	ND	ND	ND	ND	1.4	0.47	4.0	0.71	ND	0.71
Nitrite (mg/l)	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate (mg/l)	-	-	-	0.66	ND	0.66	0.57	ND	0.60	0.68	ND	0.68	1.1	1.0	1.2
TKN (mg/l)	-	0.61	0.80	2.0	ND	3.1	2.8	2.8	2.8	5.6	ND	13	4.9	ND	4.9
Total-P (mg/l)	-	0.05	0.06	0.06	ND	0.08	0.09	0.07	0.10	0.78	0.15	2.1	0.92	ND	0.92
Ortho-P (mg/l)	-	-	-	0.07	ND	0.14	0.16	0.08	0.30	0.20	0.12	0.37	0.14	0.06	0.28
PAH	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zn (mg/l)	-	0.02	0.03	0.043	0.028	0.057	0.033	0.033	0.033	0.16	0.06	0.26	0.036	0.024	0.047

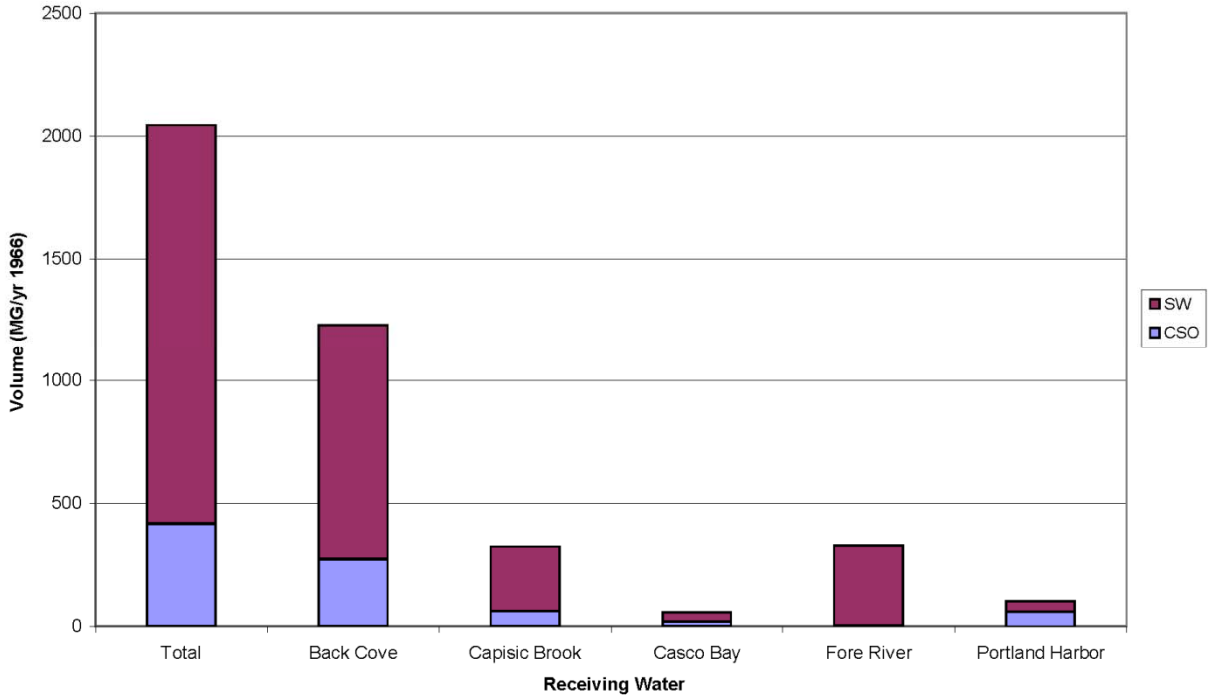
[1]Based on an average of 7 to 9 samples per site, except PAH and Zn are based on an average of 2 samples per site and Conductivity are based on 9 samples for 1 site

[2]Based on an average of 2 samples per site, except PAH and Zn are based on 1 sample for 1 site

[3]Based on an average of 3 to 4 samples for 2 sites, except PAH and Zn are based on an average of 1 sample for 2 sites

[4]Based on an average of 1 sample for three sites; except E.coli, PAH, and Zn are based on an average of 1 sample for 2 sites

Figure 5-2
Total Volume of CSO and Stormwater per Receiving Water Existing Conditions



5.4.2 Stormwater

The EMCs developed for the stormwater discharges were used in conjunction with the existing modeled conditions for stormwater discharge volumes to determine pollutant loading to each receiving water under baseline conditions. Figures 5.3 through 5.5 present the pollutant loading for TSS, BOD, and E.coli from stormwater discharged to each receiving water for existing conditions for the design storm event.

Roughly 57% of the total TSS loading is attributable to stormwater sources. Roughly 61% of the total BOD loading is attributable to stormwater sources. Only 4%of the total E.coil loading is from stormwater sources. Back Cove receives 46%, 62%, and 88% of the total TSS, BOD, and E.coli loading from stormwater sources under baseline conditions.

Figure 5-3
Total Pollutant Loading in CSO and Stormwater per Receiving Water Existing Conditions - TSS

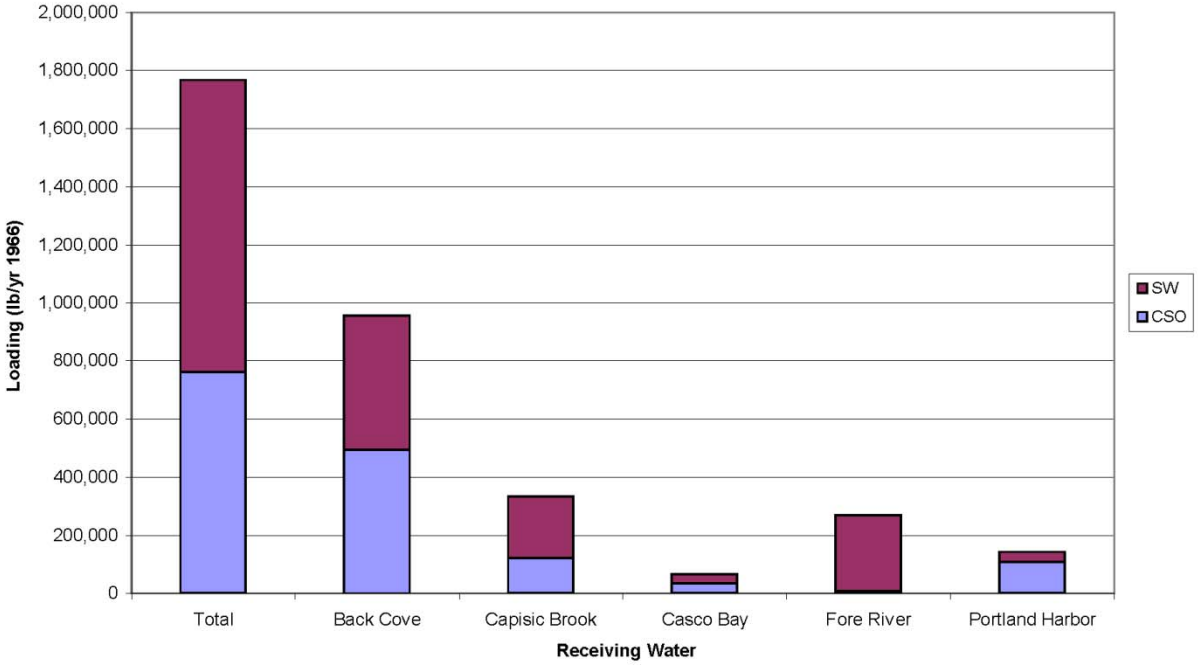


Figure 5-4
Total Pollutant Loading in CSO and Stormwater per Receiving Water Existing Conditions – BOD

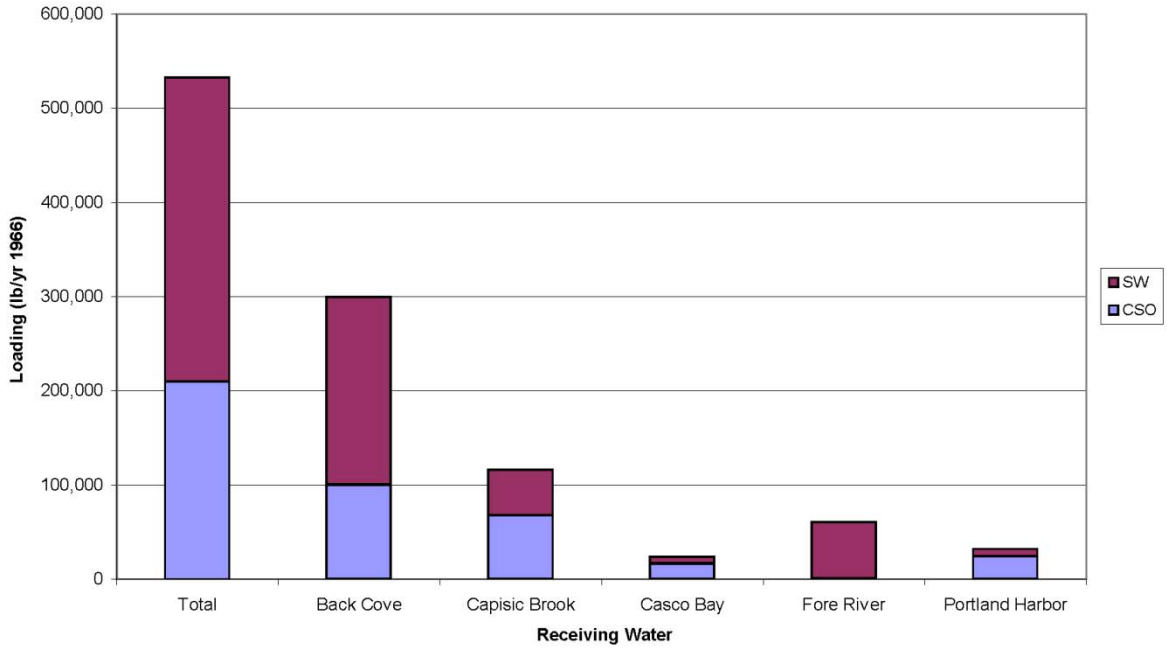
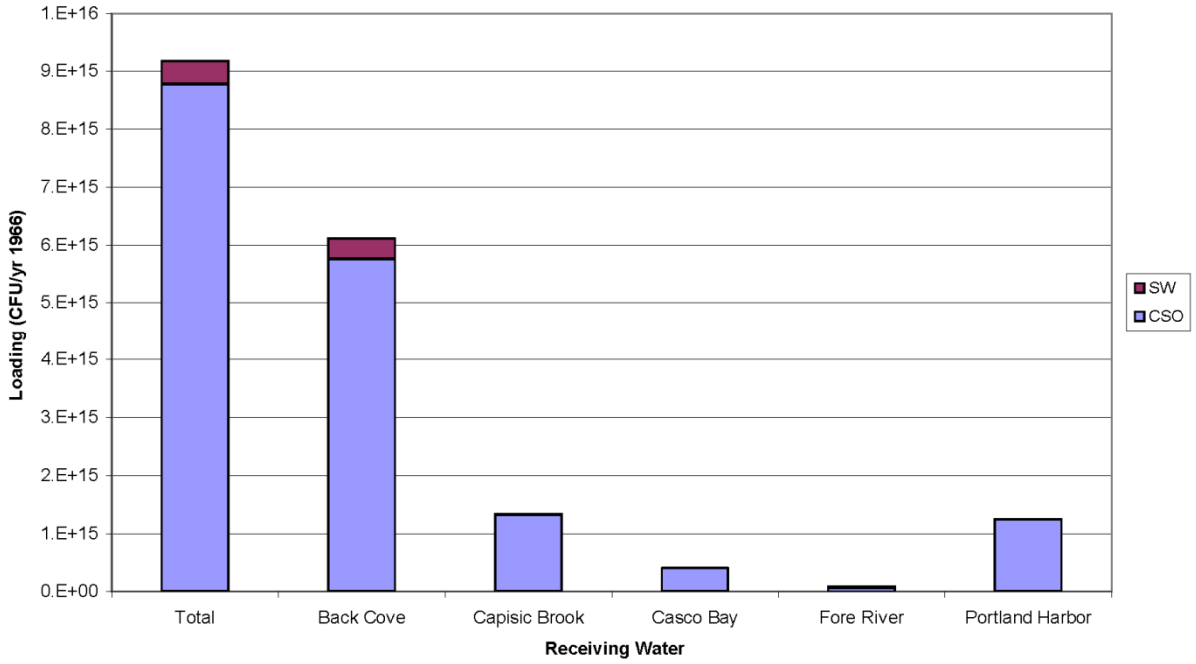


Figure 5-5
Total Pollutant Loading in CSO and Stormwater per Receiving Water Existing Conditions – E.coli



Section 6

Receiving Water Quality and Uses

6.1 Introduction

The purpose of this section is to identify the current regulatory water quality status and uses of various receiving waters in Portland, including Fall Brook, Capisic Brook, Fore River, Portland Harbor, Back Cove, and Casco Bay. The designated uses in the estuarine and marine waters of Portland that are affected by bacteria contributed by CSOs and other sources include recreation in and on the water (e.g. swimming and boating) and the propagation and harvesting of shellfish.

6.2 Classification of Receiving Waters

The state of Maine has a water classification system that establishes the water quality goals for the state. It sets the designated uses, related characteristics of the uses, criteria necessary to protect the uses, and sets specific conditions for certain activities. The state's classification system includes four classes for freshwater rivers (AA, A, B, C), three classes for marine and estuarine waters (SA, SB, SC), and one class for lakes and ponds (GPA). The classification assigned to a water body is a reflection of the water quality goals for the water body, and does not necessarily represent the actual current condition of the water body. The water quality standard is comprised of designated uses and numeric and narrative water quality criteria. The water quality criteria serve to protect a designated use. It is expected that if the water quality criteria are met, the quality of water will support and protect the designated use.

The receiving waters included in this report are considered both freshwater streams (Class C) and marine and estuarine waters (Class SC). Class C is the fourth highest classification for freshwater streams and Class SC is the fourth highest classification for marine and estuarine waters. Although both Class C and Class SC waters are the lowest classification for freshwater and marine and estuarine waters, respectively, it does not mean that they are of low quality; rather it implies that there is the least amount of restrictions on use and they have the lowest water quality criteria to attain of all the classifications.

6.2.1 Water Quality Standards

The classification system should be viewed as a hierarchy of risk rather than of quality, with the risk being the breakdown of the ecosystem and loss of designated use. The water quality standards for all classes of freshwater streams and estuarine and marine waters are summarized in Table 6-1 and Table 6-2. Since the receiving waters included in this report are either Class C or Class SC waters, the water quality standards for Class C and Class SC waters are in bold text in Tables 6-1 and 6-2 and are described in more detail below.

Table 6-1
Summary of Designated Uses and Water Quality Criteria for All Classes of Freshwater in the State of Maine

Class	Designated Use	Numeric Criteria		Narrative Criteria	
		Dissolved Oxygen	Bacteria (Escherichia coli)	Habitat	Aquatic Life (Biological)
AA	Drinking water supply after disinfection; fishing; agriculture; recreation; navigation; habitat for fish and aquatic life.	As naturally occurs.	As naturally occurs.	Free flowing and natural.	No direct discharge of pollutants; as naturally occurs.*
A	Same as Class A; plus industrial supply and hydroelectric power generation.	>7 ppm or 75% saturation, whichever is greater.	As naturally occurs.	Natural.	As naturally occurs.*
B	Drinking water supply after treatment; fishing; agriculture; recreation; industrial supply; hydroelectric power generation; navigation; habitat for fish and aquatic life.	>7 ppm or 75% saturation, whichever is greater.	From May 15 to Sept. 30, ≤64 per100 ml (g.m.**) or ≤236 per 100 ml (inst.**).	Unimpaired.	Discharges shall not cause adverse impact to aquatic life in that the receiving waters shall be sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes to the resident biological community.*
C	**Same as Class B.**	**>5 ppm or 60% saturation, whichever is greater (monthly average) at 22 and 24 °C.**	**From May 15 to Sept. 30, ≤126 per 100 ml (g.m.) or ≤236 per 100 ml (inst.).**	**Habitat for fish and other aquatic life.**	**Discharges may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community.***

1. * Numeric criteria in DEP Rule Chapter 579, Classification Attainment Evaluation using Biological Criteria for Rivers and Streams.
2. ** "g.m." means geometric mean; "inst." means instantaneous level.
3. **Bold text** indicates water standards applicable to waters included in this study.

Table 6-2
Summary of Designated Uses and Water Quality Criteria for All Classes of Marine and Estuarine Waters in the State of Maine

Class	Designated Use	Numeric Criteria		Narrative Criteria	
		Dissolved Oxygen	Bacteria	Habitat	Aquatic Life (Biological)
SA	Recreation; fishing; aquaculture; propagation and harvesting of shellfish; navigation; habitat for fish and other estuarine and marine life.	As naturally occurs.	As naturally occurs.	Free-flowing and natural.	As naturally occurs.
SB	Same as Class SA; plus industrial supply and hydroelectric power generation.	>85% saturation.	Enterococcus: ≤8 per 100 ml (g.m.*) or ≤54 per 100 ml (inst.*) from May 15 to September 30. In shellfish harvesting areas, total coliform and other specified indicator organisms, not to exceed criteria of National Shellfish Sanitation Program.	Unimpaired.	Discharges shall not cause adverse impact to estuarine and marine life in that the receiving waters shall be of sufficient quality to support all indigenous estuarine and marine species without detrimental changes in the resident biological community. No new discharge to cause closure of open shellfish areas.
SC	**Recreation; fishing; aquaculture; propagation and restricted harvesting of shellfish; industrial supply; hydroelectric power generation; navigation; and habitat for fish and other estuarine and marine life.**	**>70% saturation**	**Enterococcus ≤14 per 100 ml (g.m.) or ≤ 94 per 100 ml (inst.) from May 15 to September 30. In restricted shellfish harvesting areas, total coliform and other specified indicator organisms, not to exceed criteria of National Shellfish Sanitation Program.**	**Habitat for fish and other estuarine and marine life.**	**Discharge may cause some changes to estuarine and estuarine life provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain structure and function of the resident biological community.**

1. * "g.m." means geometric mean; "inst." means instantaneous level.
2. **Bold text** indicates water standards applicable to waters included in this study.

Class C

Class C waters must be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; navigation; and as a habitat for fish and other aquatic life (38 MRSA §465). Class C waters are managed to attain at least the swimmable-fishable goals of the federal Clean Water Act and to maintain the structure and function of the biological community (Maine DEP 2010 305(b) Report).

Class SC

Class SC waters must be of such quality that they are suitable for recreation in and on the water; fishing; aquaculture; propagation and restricted harvesting of shellfish; industrial process and cooling water supply; hydroelectric power generation; navigation; and as a habitat for fish and other estuarine and marine life (38 MRSA §465). Class SC waters are managed to be fishable and swimmable and maintain the structure and function of the biological community (Maine DEP 2010 305(b) Report).

Water Quality Criteria

The water quality criteria established by the state include both numeric criteria for dissolved oxygen and bacteria and narrative criteria for habitat and aquatic life. The water quality criteria are designed to protect the designated uses for each water classification. Water quality criteria applicable to all Class C freshwater streams are summarized in bold text in Table 6-1; those applicable to all Class SC estuarine and marine waters are summarized in bold text in Table 6-2. Additional requirements for certain activities or uses within Class C and Class SC waters are listed in Table 6-3.

CSO Classifications

The state's water classification program does include a provision for the temporary removal of designated uses (that are not existing uses) and creation of a temporary subcategory of uses for combined sewer overflows. A CSO subcategory can be created by the Board of Environmental Protection at the request of a municipality or quasi-municipality having licensed CSO discharges. There are restrictions and standards that need to be met, and a defined process that needs to be followed by the Board of Environmental Protection prior to the adoption of a CSO subcategory. Although the creation of subcategories was considered by Maine communities, the effort was abandoned. There have been no CSO subcategories created under Maine law, and no CSO subcategories exist for the city of Portland.

Outstanding Natural Resource Waters

Outstanding natural resource waters are waters that need to be preserved based on their ecological, social, scenic, and recreational importance. In Maine, all Class AA waters are considered outstanding natural resources. Direct discharges of wastewater, dams, and other significant human disturbances are prohibited (Maine 2010 305(b) Report). There are no outstanding natural resource waters in Portland.

6.2.2 Receiving Water Designated Uses

Designated uses are the desirable uses that a water body is expected to support and are part of the water quality standards for each classification. The designated uses for Class C freshwater rivers and streams are very similar to the designated uses for Class SC estuarine and marine waters. The two

classes of waters share the designated uses of fishing/fish consumption, recreation in and on the water, industrial process and cooling water supply, hydroelectric power generation, navigation, and habitat for aquatic life/estuarine and marine life. In addition, Class C waters need to support the use of drinking water supply after treatment and agriculture; whereas Class SC waters need to support shellfish propagation and restricted harvesting as well as aquaculture. The criteria for attainment described in the following subsections is based on information obtained from the Maine DEP 2010 305(b) Report, which is part of the Maine Integrated Water Quality Report.

Table 6-3
Additional Class C and SC Water Quality Criteria (38 MRSA §465)

Parameter	Criteria
Dissolved Oxygen (Class C)	In identified salmonid spawning areas where water quality is sufficient to ensure spawning, egg incubation, and survival of early life stages, that water quality shall be maintained. To provide additional protection for the growth of indigenous fish, the following apply: The 30-day average dissolved oxygen shall be 6.5 parts per million using a temperature of 22 degrees centigrade or ambient temperature of the water body, whichever is less, if: a. A licensed or water quality certificate other than a general permit was issued prior to March 16, 2004 for the water and was not based on 6.5 parts per million 30-day average dissolved oxygen criterion, or b. A discharge or a hydropower project was in existence on March 16, 2005 and required but did not have a license or water equality certificate other than a general permit for the water. This criterion for the water body applies to licenses and water quality certificate issued on or after March 16, 2004. In waters not governed by subparagraph 1, dissolved oxygen may not be less than 6.5 parts per million as a 30-day average based upon a temperature of 24 degrees centigrade or the ambient temperature of the water body, whichever is less. This criterion for the water body applies to licenses and water quality certificates issues on or after March 16, 2004. The MDEP may negotiate and enter into agreements with licensees and water quality certificate holders to provide further protection for the growth of indigenous fish. Agreements entered into under this paragraph are enforceable as DEP orders according to the provisions of sections 347-A to 349.
Total Coliform Bacteria or other Specified Indicator Organisms (Class SC)	The numbers of total coliform bacteria or other specified indicator organisms in samples representative of the waters in a restricted shellfish harvesting areas may not exceed the criteria recommended under the National Shellfish Sanitation Program, United States Food and Drug Administration.

Drinking Water Supply after Treatment - Criteria for Attainment

The designated use of drinking water supply after treatment applies to freshwater river and streams. It is assessed for attainment based on the following criteria: Ambient Water Quality Criteria set forth in Maine DEP Chapter 530.5; Maine Center for Disease Control's (MCDC's) Maximum Exposure Guidelines; and the general provisions for floating/settleable solids, pH, and radioactive substances as outlined in the water classification program (38 MRSA Section 464.4).

The public drinking water supply for the city of Portland is Sebago Lake; therefore none of the receiving waters in Portland act as a source of drinking water supply.

Fishing and Fish Consumption - Criteria for Attainment

The designated use of fishing and fish consumption applies to freshwater rivers and streams as well as estuarine and marine waters. It is assessed for attainment based on the following criteria: support of indigenous fish species; absence of a fish advisory instituted by the MCDC; and the general provisions for floating/settleable solids, pH, and radioactive substances as outlined in the water classification program (38 MRSA Section 464.4)..

Fishing and Fish Consumption - Use Assessment

The MCDC is the government agency who is responsible for recommending the warnings on eating fish and issuing fish consumption advisories. According to the Maine DEP 2010 305(b) report, waters do not attain their designated use for fishing when government agencies issue fish consumption advisories (as well as shellfish advisories for estuarine and marine waters). Common advisories for ocean fish and shellfish consumption in Maine include lobster tomalley, bluefish, and striped bass. Based on these advisories, the entire Maine coast is only in partial support of its designated use for fishing and fish consumption. In addition to marine fish and shellfish, there is a statewide fish consumption advisory for all freshwater fish because of mercury contamination. There are several freshwater rivers and streams that have additional fish consumption advisories for contaminants other than mercury. As of 2010, neither Fall Brook nor Capisic Brook was included on the MCDC Guidelines for eating freshwater fish.

Shellfish Propagation and Harvesting - Criteria for Attainment

The designated use of shellfish propagation and harvesting applies to estuarine and marine waters. It is assessed for attainment based on the National Shellfish Sanitation Program evaluated by the Department of Marine Resources (DMR); absence of a shellfish consumption advisory instituted by the MCDC; and the general provisions for floating/settleable solids, pH, and radioactive substances as outlined in the water classification program (38 MRSA Section 464.4).

Shellfish Propagation and Harvesting - Use Assessment

The DMR is the agency responsible for assessing shellfish growing areas to ensure that harvesting shellfish are safe for consumption. Shellfish areas are closed if they are found to have elevated levels of bacteria or if it is determined that the area is threatened by potential sewage pollution problems such as proximity to wastewater outfalls or intense storm events. Visual and analytical monitoring is conducted at least six times per year at each of the sampling sites along the Maine coast. The Portland area (from Cape Elizabeth to Falmouth) falls within growing area WI of Casco Bay. More specifically, it is included in pollution area 13, which was last amended on April 13, 2011. Rule DMR 95.03(I), Area No. 13, Western Casco Bay and Islands (Cape Elizabeth to Falmouth), makes it unlawful

to dig, take clams, quahogs, oysters, or mussels from the shores, flats, or waters along Portland's shoreline. This bacterial closure for shellfish harvesting applies to all marine and estuarine waters included in this study.

Agriculture and Aquaculture - Criteria for Attainment

The designated use of agriculture applies to freshwater rivers and streams, and the designated use of aquaculture applies to estuarine and marine waters. According to the EPA Water Quality Handbook, the agriculture designated use defines waters that are suitable for irrigation of crops, consumption by livestock, support of vegetation for range and grazing and other uses in support of farming and ranching, and protects livestock and crops from injury due to irrigation or other exposures. Agriculture and aquaculture uses are assessed for attainment based on the general provisions for floating/settleable solids, pH, and radioactive substances as outlined in the water classification program (38 MRSA Section 464.4). The Maine DEP did not specifically assess waters included in this study for agricultural and aquacultural use in the 2010 Maine 305(b) report.

Recreation in and on the Water - Criteria for Attainment

The designated use of recreation in and on the water applies to both freshwater rivers and streams as well as estuarine and marine waters. Recreation for both types of water are assessed for attainment based on the general provisions for floating/settleable solids, pH, and radioactive substances as outlined in the water classification program (38 MRSA Section 464.4). In addition, freshwater rivers and streams are assessed for attainment based on the geometric mean for E. coli bacteria as outlined in 38 MRSA Section 465 and water color as outlined in 38 MRSA Section 414-C, and estuarine and marine waters are assessed for attainment based on the geometric mean for Enterococcus bacteria as outlined in 38 MRSA Section 465-B.

Recreation in and on the Water - Use Assessment

Recreation in and on the water include activities that involve both primary and secondary contact with the water. Primary contact includes activities that subject the user to direct contact with or immersion in water with a high potential of ingestion. Primary contact activities include swimming, water skiing, windsurfing, etc. Secondary contact includes activities that likely result in contact with water, but immersion and ingestion are less likely. Examples of secondary contact activities include boating, wading, fishing, etc. According to the EPA Water Quality Handbook, recreation in and on the water may not be attainable for some waters that do not have sufficient amount of water, at least seasonally; however, states are encouraged to recognize and protect recreational uses that do not result in direct contact with the water, such as hiking, camping, and bird watching.

The only public beach located in Portland is the East End Beach, which is located off of the Eastern Promenade and overlooks Casco Bay. Refer to subsection *6.3.6 Casco Bay* of this report for specific use assessment information for the East End Beach. Although swimming beaches is the one type of primary recreation that is formally assessed, other forms of recreation are prevalent in Portland's receiving waters. Types of recreation include walking trails around Back Cove, sail boating in Back Cove, boating in Casco Bay, and tourism and ferry rides along Portland Harbor.

Industrial Process and Cooling Water Supply, Hydroelectric Power Generation, and Navigation - Criteria for Attainment

The designated uses of industrial process and cooling water supply, hydroelectric power generation, and navigation applies to both freshwater rivers and streams as well as estuarine and marine waters. These uses are assessed for attainment based on the general provisions for floating/settleable solids, pH, and radioactive substances as outlined in the water classification program (38 MRSA Section 464.4). Other than the general provisions, there are no other criteria used by the DEP for assessment.

Habitat for Aquatic, Estuarine, and Marine Life - Criteria for Attainment

The designated use of habitat for aquatic life applies to freshwater rivers and streams. It is assessed for attainment based on the following criteria: Biomonitoring numeric criteria established in Maine DEP Rule Chapter 579; habitat suitability and dissolved oxygen as outlined in 38 MRSA Section 464.13, 465.1-4; Ambient Water Quality Criteria set forth in Maine DEP Chapter 530.5; support of indigenous species; wetted habitat referenced in Maine DEP Chapter 581; and the general provisions for floating/settleable solids, pH, and radioactive substances as outlined in the water classification program (38 MRSA Section 464.4).

The designated use of habitat for estuarine and marine life applies to estuarine and marine waters. It is assessed for attainment based on the following criteria: Water Quality Criteria set forth in Maine DEP Chapter 530.5; dissolved oxygen and narrative biological standards outlined in 38 MRSA Section 465-B; and the general provisions for floating/settleable solids, pH, and radioactive substances as outlined in the water classification program (38 MRSA Section 464.4).

Habitat for Aquatic, Estuarine, and Marine Life - Use Assessment

The Maine DEP has established numeric criteria to assess the narrative aquatic life standards for aquatic life. In 2003, the numeric criteria were adopted in the Maine DEP rule Chapter 579 Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams. The primary method for assessment of aquatic life attainment in rivers and streams is accomplished through evaluation of the benthic macroinvertebrate community, which acts as an indicator community of the general state of the aquatic life. The Maine DEP has developed a standardized approach to the data collection and analysis for the biological monitoring, allowing for a consistent, unbiased, scientifically sound evaluation of aquatic life impacts.

According to the Maine DEP 2010 305(b) Report, generally, data from various studies and volunteer monitoring shows oxygen levels along the coast to be adequate to protect marine life. None of the estuarine or marine waters in Portland are impaired for non-attainment of water quality standards for dissolved oxygen. Refer to section *6.3 Receiving Waters in Portland* of this report for specific use assessment for individual receiving waters.

6.2.3 Impaired Waters and Total Maximum Daily Loads (TMDLs)

Under the Clean Water Act, the Maine DEP is required to submit an integrated report of the status of the state's water quality to the U.S. EPA. The Integrated Water Quality Monitoring and Assessment report is also referred to as the 305(b) report and the 303(d) list as it is required by Sections 305(b) and 303(d) of the Clean Water Act. The integrated report also serves as a biennial report to the Maine Legislature in fulfillment of the reporting requirements of 38 MRSA Section 464.3.A of the state's

Water Classification Program. The most current version of the integrated report is the 2010 report, which was submitted to the U.S. EPA on December 7, 2010.

All Maine water bodies are assigned to one of five categories or subcategories that describe their water quality status. The five main assessment categories for both freshwater and estuarine/marine waters include:

- Category 1: Fully Attaining all Designated Uses
- Category 2: Attaining Some Designated Uses - Insufficient Information for Other Uses
- Category 3: Insufficient Data or Information to Determine if Designated Uses are Attained
- Category 4: Impaired Use, TMDL Completed
- Category 5: Impaired, TMDL Required

Water bodies listed under Category 4 of the integrated report represent waters that do not require the development of a total maximum daily load (TMDL). The Category 4 subcategories include:

- Category 4-A: Impaired Use, TMDL Completed
- Category 4-B: Impaired by Pollutants - Pollution Control Requirements Reasonably Expected to Result in Attainment
- Category 4-C: Impairment not Caused by a Pollutant

It should be noted that in the Maine DEP 2010 Integrated Report, all freshwater and estuarine/marine waters previously listed under Category 5-B (and Category 5-B-2 for estuarine/marine waters impaired by bacteria from CSOs) were moved to Category 4-A based on the U.S. EPA approval of a statewide TMDL for bacteria.

Water bodies listed under Category 5 of the integrated report represent the Clean Water Act 303(d) list of impaired waters, and require the development and submission of a TMDL to the U.S. EPA. The Category 5 subcategories include:

- Category 5-A: Impaired by Pollutants Other than Those Listed in 5-B through 5-D (TMDL Required)
- Category 5-C: Impaired by Atmospheric Deposition of Mercury (inactive category due to the EPA-approved Regional Mercury TMDL)
- Category 5-B: Impaired for Bacteria Only, TMDL Required
- Category 5-D: Impaired by Legacy Pollutants

Listed Water Bodies

According to the Maine DEP, a water body is determined to be impaired if one or more of the uses assigned by its classification is not attained, as determined by the criteria assigned to that water class. A summary of the listed receiving waters as related to this study can be found in section 6.3 *Receiving Waters in Portland* of this report.

TMDL Development

There are no U.S. EPA approved TMDLs for impaired streams in Portland. A draft TMDL for Capisic Brook was developed and submitted to the U.S. EPA in 2005; a Northeast Regional Mercury TMDL was submitted to and approved by the U.S. EPA in 2007; and a Maine Statewide Bacteria TMDL was approved by the U.S. EPA in September 2009.

Northeast Regional Mercury TMDL

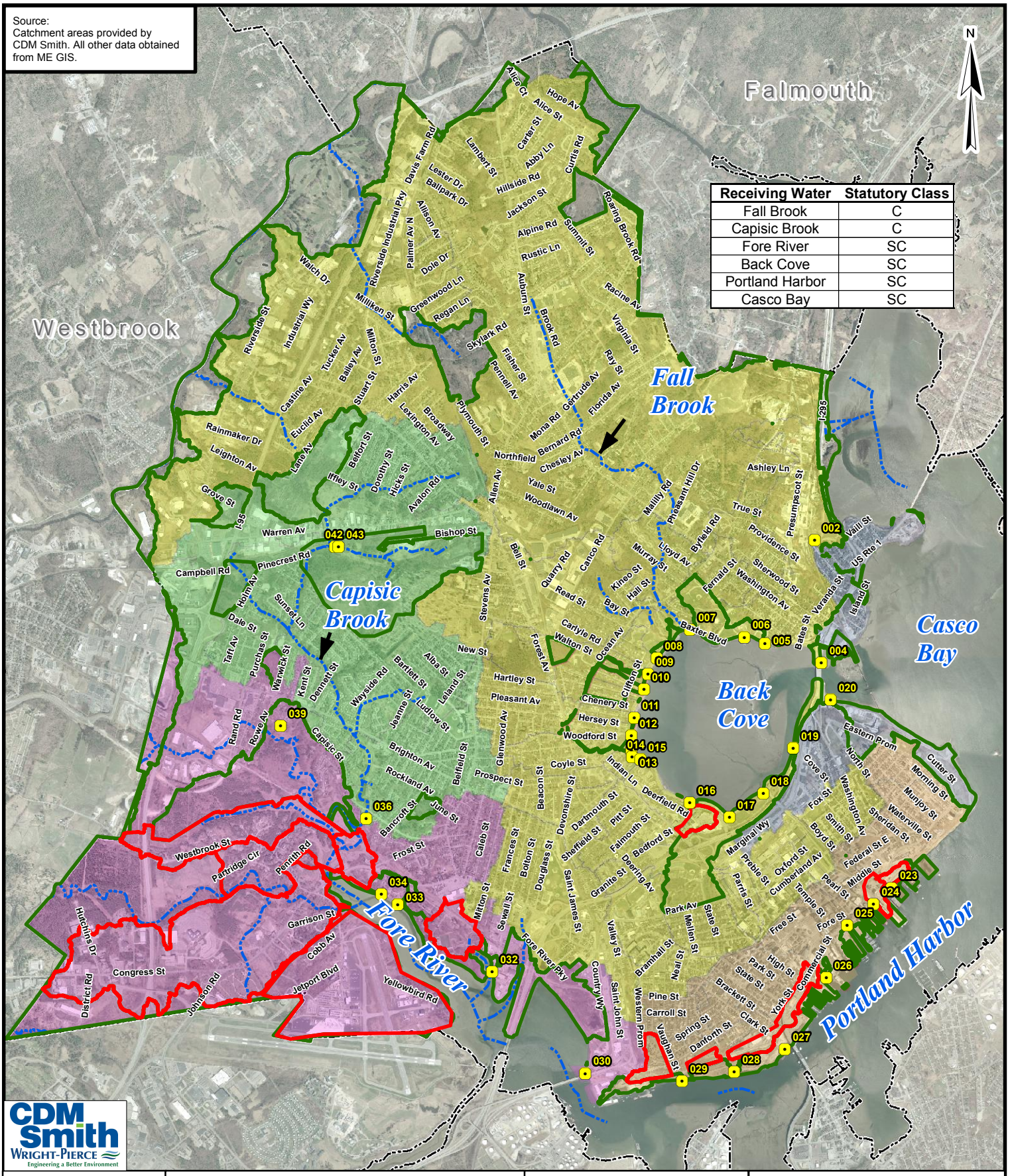
The Northeast Regional Mercury TMDL was approved by the U.S. EPA on December 20, 2007. Since Maine has a statewide advisory for fish consumption because of mercury contamination, this was the basis for listing all freshwater rivers and lakes as impaired for fish consumption due to mercury. Fish advisories are intended to be temporary, and the regional TMDL for mercury aims at reducing mercury pollution to levels that allow for safe consumption of fish. According to the Northeast Regional Mercury TMDL, it will involve reductions of mercury sources within the northeast region, states outside of the region, and global sources. The Northeast Regional Mercury TMDL is based primarily on the reduction of atmospheric deposition of mercury pollution which can be achieved through anthropogenic mercury emissions.

Maine Statewide Bacteria TMDL

A statewide TMDL for bacteria was approved by the U.S. EPA in September 2009. It includes all freshwater, marine, and estuarine waters that are impaired by bacteria and listed in the Maine 2008 303(d) list of impaired waters needing the development of a TMDL. All estuarine and marine waters in the Portland-Falmouth area are impaired by bacteria, including that from CSOs. There are no freshwater rivers or streams in Portland where the statewide bacteria TMDL applies. The purpose of the TMDL is to support action to reduce the public health risk from waterborne disease-causing organisms. Bacteria are used as indicators for the presence of pathogens in water. Maine uses the bacteria indicator of Enterococci for estuarine and marine recreational waters.

6.3 Receiving Waters in Portland

The area of study in Portland is delineated into five major watersheds based on the contributing areas that discharge to CSOs within the city. Although the Fall Brook does not have direct contributions from CSOs, it is included in this section, since it is a priority watershed for the city's water quality efforts. The receiving waters of Fall Brook, Capisic Brook, Fore River, Portland Harbor, Back Cove, and Casco Bay are identified in Figure 6-1 and discussed below.



CDM Smith
Wright-Pierce
Engineering a Better Environment

Legend

- Areas Do Not Directly Contribute to a CSO
- Open Areas Not Tributary to a CSO
- Back Cove CSO
- Casco Bay CSO
- Capisic Brook CSO
- Fore River CSO
- Portland Harbor CSO
- CSO Location

N W E S

0 3,800 Feet

City of Portland, Maine
CSO LTCP Tier III Update
Jun 2011

Stormwater Catcment Areas & Receiving Waters
Figure 6-1

Path: W:\GIS_Development\Projects\ME\Portland\11583A\Figures\Fig6-1_Portrait_8x11.mxd

6.3.1 Fall Brook

Fall Brook is located in northeastern Portland. The brook originates in the area near the Lyman Moore Middle School off of Auburn Street, and flows approximately 2.5 miles south where it discharges to Back Cove. There is multiple road crossings along Fall Brook with portions of it piped through closed pipe systems as a result of development. Although there are no direct CSOs along the length of Fall Brook, portions of the Fall Brook watershed that are combined are tributary to CSO 007. Fall Brook is classified as a Class C water and should meet the water quality requirements for Class C waters outlined in Table 6-1 and, as applicable, Table 6-3.

Fall Brook is listed under Category 5-A of Maine's 2010 303(d) list (Rivers and Streams Impaired by Pollutants other than those listed in 5-B Through 5-D), and requires a TMDL. Portions of Fall Brook are in non-attainment of the aquatic life use. According to the information provided on the 2010 303(d) list, the segment size that is impaired is 2.54 miles, the cause of listing is habitat assessment (streams), and the TMDL priority is low. A draft flow-based TMDL for Fall Brook is in the process of being developed, and is anticipated to be available in 2011. Land use in the vicinity of Fall Brook primarily consists of a mix of commercial and residential as well as some undeveloped area as shown in Section 2.

6.3.2 Capisic Brook

Capisic Brook is located in western Portland. The brook is comprised of several branches with headwaters of the main stem located within a wooded area of Evergreen Cemetery (south of the intersection of Warren Avenue and Bishop Street). The main stem is joined by the northern branch, which originates east of Forest Avenue near the intersection of Allen Avenue, just downstream of Evergreen Cemetery. The western branch, located east of the I-95 near the intersection with Warren Avenue, enters the main stem approximately half a mile downstream of the confluence of the main steam and northern branch. Capisic Brook discharges into the Capisic Brook pond which is formed by the Capisic Pond dam located below Capisic Street. Downstream of the dam, the brook enters the Fore River; however, for the purpose of this study, Capisic Brook does not include the portion downstream of the dam. There are two CSOs that discharge directly into the brook; they include CSOs 042 and 043. CSO 036, which used to discharge into the brook has been closed and the sewerage has been diverted to Fore River pump station. Capisic Brook is classified as a Class C water and should meet the water quality requirements for Class C waters outlined in Table 6-1 and, as applicable, Table 6-3. Land use in the vicinity of Capisic Brook is primarily residential; however, some portions are commercial and industrial as well as transportation related (I-95) as shown in Section 2.

Capisic Brook is listed under Category 5-A of Maine's 2010 303(d) list (Rivers and Streams Impaired by Pollutants other than those listed in 5-B Through 5-D), and requires a TMDL. Portions of Capisic Brook are in non-attainment of the aquatic life use. According to the information provided in the 303(d) list, the segment size that is impaired is 3.02 miles and the cause of listing is benthic-macroinvertebrate bioassessments (streams) and habitat assessment (streams). A draft TMDL was sent to U.S. EPA in 2005 under the bundled Urban Stream Report. The TMDL due date in the 2010 Maine 303(d) list was 2010, and was indicated as a candidate for a percent impervious cover TMDL. It is likely that Capisic Brook will be included in the Draft Maine Impervious Cover TMDL for Aquatic Life-Impaired Waters.

Draft Capisic Brook TMDL

As previously noted, the Draft Capisic Brook TMDL was submitted to the U.S. EPA in 2005 under the bundled Urban Stream Report. The Urban Streams Project was launched by the Maine DEP in 2003 to collect biological, chemical, and physical data to supplement existing data and to gain a better understanding of the stressors and sources of urban nonpoint source pollution. The Urban Streams Project focused on four urban watersheds in the state of Maine, including Capisic Brook. The Draft TMDL encompasses the impaired segment of the stream extending from the confluence of the main stem with the northern branch to Capisic Pond; approximately 1.6 miles in length (less than the 3.02 miles listed in the Maine DEP 303(d) list). The Draft Capisic Brook TMDL identifies that overall urban development is the primary factor responsible for stressors that are directly or indirectly linked to aquatic life impairments in Capisic Brook. The Draft TMDL identifies six stressors contributing to the impairment: 1) impaired in-stream habitat, 2) altered hydrology, 3) presence of toxic contaminants, 4) elevated nutrients, 5) elevated water temperature, and 6) low dissolved oxygen. The Draft TMDL uses percent impervious cover (IC) as a surrogate for a complex mixture of pollutants and stressors associated with stormwater runoff attributable to urban development.

Several of the likely sources of the stressors are related to the amount of impervious surface, including sewer discharge from CSOs. Impervious surfaces impede the ground's ability to infiltrate rainwater, and subsequently cause this water to runoff the ground surface, which contributes to increased stormwater flows to the collection system. The amount of impervious surfaces is related to sewer discharges from CSOs because CSO events occur during storm events where a combined sewer system is inundated by stormwater that exceeds the capacity of the system. Sewer discharges from CSOs were identified as a likely source for three of the six stressors in Capisic Brook. The Draft TMDL includes BMPs aimed at reducing the effects of stormwater, improving water quality, and limiting impairments. BMPs fall under the categories of general stream restoration techniques, disconnection of impervious surfaces, conversion of impervious surfaces, and separation of stormwater to eliminate CSOs.

Additional stormwater, CSO, in-stream, macroinvertebrate, algae, and wetland sampling and/or monitoring has taken place in the watershed by various entities and under various programs since the development of the 2005 Draft Capisic Brook TMDL.

6.3.3 Fore River

The Fore River is an estuarine river located in southwestern Portland, and separates Portland and South Portland. The Fore River estuary discharges into Casco Bay and is formed by the confluence of several streams including Capisic Brook, Nasons Brook, Long Creek, and the Stroudwater River. The Fore River estuary is spanned by three bridges that help define the river, including the I-295 Bridge, Veterans Bridge, and the Casco Bay Bridge. The section of the river roughly between the Casco Bay Bridge and Casco Bay is more commonly referred to as Portland Harbor. There are six CSOs that discharge directly into the estuary or a tributary of the estuary; they include CSOs 030, 032, 033, 034, and 039. It should be noted that CSOs that discharge directly into Capisic Brook and Portland Harbor are included in their respective segment descriptions. The Fore River estuary is classified as a Class SC water and should meet the water quality requirements for Class SC waters outlined in Table 6-2 and, as applicable, Table 6-3. Land use in the vicinity of Fore River is urban and varies from residential and commercial to industrial as shown in Section 2. The portion of the river located between the I-295 Bridge and Casco Bay Bridge is densely developed with industrial uses including oil and cargo transfer

terminals. Abandoned sites along the Fore River include the Portland Coal Gasification plant and Silvex/Maine Metal Finishing.

The Fore River is listed under both Category 4-A (Estuarine and Marine Waters with Impaired Use, TMDL Completed) and Category 5-A (Estuarine and Marine Waters Impaired by Pollutants other than those listed in 5-B through 5-D, TMDL Required) of Maine's 2010 303(d) list. The Fore River estuary is listed as impaired for non-attainment of the marine life use with causes of listing related to aquatic life, toxics, and elevated fecal levels. Fore River is covered under the Statewide TMDL for bacteria approved in 2009. According to the information provided in the 303(d) list, the segment size that is impaired (other than by elevated fecals) is 1.20 square miles and the cause of listing is aquatic life and toxics. The 2010 Maine 303(d) list TMDL date is scheduled for 2012. It should also be noted that portions of three tributaries of the Fore River (Nason Brook, Stroudwater River, and Long Creek) are listed as impaired for non-attainment of the aquatic life use. The cause of listing for these waters includes benthic-macroinvertebrate bioassessments, habitat assessment, and dissolved oxygen.

6.3.4 Back Cove

Back Cove is a tidal basin that is located in eastern Portland and influenced by Casco Bay. It is circular in shape, approximately one mile in diameter, and is primarily bound by Baxter Boulevard (Route 1) and Tukey's Bridge. There are fifteen CSOs that discharge directly into Back Cove; they include CSOs 005, 006, 007, 008, 009, 010, 011, 012, 013, 014, 015, 016, 017, 018, and 019. The Back Cove is classified as a Class SC water and should meet the water quality requirements for Class SC waters outlined in Table 6-2 and, as applicable, Table 6-3. Land use in the vicinity of Back Cove is heavily residential as shown in Section 2. According to the Casco Bay Estuary Partnership's State of the Bay report (2005), significant portions of Casco Bay were closed to recreation over thirty years ago because of pollution. It was reported that Back Cove was so polluted that human contact with the water was considered a health hazard. Today, walking trails are available around Back Cove, which attracts walkers, runners, cyclists, and dog walkers.

6.3.5 Portland Harbor

Portland Harbor is the outer portion of the Fore River estuary that is roughly located between the Casco Bay Bridge and Casco Bay. The harbor is sheltered with Portland to the north and South Portland to the south. There are seven CSOs that discharge directly into Portland Harbor; they include CSOs 023, 024, 025, 026, 027, 028, and 029. The Portland Harbor is classified as a Class SC water and should meet the water quality requirements for Class SC waters outlined in Table 6-2 and, as applicable, Table 6-3. Land use in the vicinity of Portland Harbor is densely urban with residential, commercial, and industrial development as shown in Section 2. Portland Harbor is a working water front with heavy industrial and commercial use including oil storage, shipyards, fishing docks, and marinas. The harbor accommodates commercial vessels and cruise ships as well as ferries and recreational boaters.

6.3.6 Casco Bay

Casco Bay is located to the east of Portland, and is an inlet of the Gulf of Maine. The portion of Casco Bay adjacent to mainland Portland, included as part of this study, is fed by the Presumpscot River estuary, Back Cove, and the Fore River estuary/Portland Harbor. There are three CSOs that discharge directly into Casco Bay; they include CSOs 002, 004, and 020. Casco Bay is classified as a Class SC

water and should meet the water quality requirements for Class SC waters outlined in Table 6-2 and, as applicable, Table 6-3. CSO 002 discharges to Casco Bay at the interface to the Presumpscot Estuary. For the purposes of this report, CSO 002's discharges are assumed to discharge directly to Casco Bay. Land use in the vicinity of this portion of Casco Bay is largely residential as shown in Section 2. In addition, the outfall from the East End wastewater treatment facility discharges to Casco Bay.

The East End Beach is the only public beach in Portland, and it is considered a swimming beach. Through the Maine Healthy Beaches (MHB) program, routine monitoring of the water quality at the East End Beach is conducted on a weekly basis between Memorial Day and Labor Day. The monitoring of the beach and providing public notification is the jurisdiction of the city of Portland. According to the Maine DEP 2008 305(b) report, beach advisories are posted based on results obtained from water quality samples for bacteria that exceed state and federal standards or if conditions indicate the possible presence of disease-causing organisms. An advisory recommends that the public avoid contact activities at the beach until further notice; a beach closure closes the beach to water contact. Beach closures are established on a risk-based assessment matrix, which takes into account bacterial count, bather numbers, time of last rainfall, and history of known problems (Maine DEP 2008 305(b) list). The MHB program maintains a database of status history for participating beaches that tracks available data as far back as 2003. The following table summarizes the number of advisory and closure days for the East End Beach between 2003 and 2010. It should be noted that continued and heavy rainfall contributed to the high number of advisory and closure days in 2009.

Table 6-4
Number of Advisory and Closure Days for the East End Beach (2003 to 2010)

Year	Advisory Days	Closure Days
2010	6	4
2009	11	12
2008	2	4
2007	0	2
2006	0	0
2005	1	0
2004	6	0
2003	0	0

6.3.7 General Estuarine and Marine waters

In addition to the information presented above regarding the individual estuarine and marine receiving waters, it should be noted that, in general, approximately 20 square miles of estuarine and marine waters in the Portland-Falmouth area are impaired by bacteria. These waters were previously listed under Category 5-B of Maine's 2010 303(d) list (waters impaired for bacteria only and require a TMDL). Additional estuarine and marine waters in Portland were also previously listed under Category 5-B-2 related to impairment caused by bacteria from CSOs. As previously noted, all estuarine and marine waters previously listed under Category 5-B and 5-B-2, were moved to Category 4-A based on U.S. EPA's approval of a statewide TMDL for bacteria. Category 4- A is for those waters with an impaired use that have a completed TMDL. As a result of impairment caused by bacteria, there is a bacterial closure for shellfish harvesting applicable to all marine and estuarine waters along Portland's

shoreline. It should also be noted that all estuarine and marine waters in the state that are capable of supporting American lobster are listed under Category 5-D (waters impaired by legacy pollutants) for only partially supporting fishing/shellfish consumption due to elevated levels of PCBs and other bio-accumulating substances in lobster tomalley.

6.4 Sensitive Environments and Restoration Programs

Sensitive environments and restoration programs were explored as related to Portland. In particular, those of endangered species and species of concern, restoration programs, and vernal pools are described below.

6.4.1 Endangered Species and Species of Concern

There are several endangered species or species of concern in the state of Maine; project specific requests can be made to various agencies to determine the presence of endangered species or species of concern. Agencies of consideration include the Maine Department of Inland Fisheries and Wildlife, the Maine Natural Areas Program, the Department of Marine Resources, the Atlantic Salmon Commission, and the United States Fish and Wildlife Service.

Based on a cursory review of the Maine Department of Inland Fisheries and Wildlife State and Federally endangered and threatened species lists, the following are the endangered and/or threatened species with known locations or range within the greater Portland and Casco Bay area:

- **Birds**: Arctic Tern, Grasshopper Sparrow, Harlequin Duck, Least Tern, Piping Plover, Roseate Tern, Sedge Wren, Upland Sandpiper
- **Fish**: Atlantic Salmon
- **Dragonflies and Damselflies**: Ringed Boghaunter
- **Mammals**: Finback Whale, Humpback Whale, Northern Right Whale, Sei Whale, Sperm Whale.
- **Snakes**: Black Racer
- **Turtles**: Atlantic Ridley, Blanding's Turtle, Leatherback, Loggerhead, Spotted Turtle

In addition, the Maine Natural Areas Programs maintains a list of rare plants and fact sheets on their website.

6.4.2 Restoration Program

The city of Portland is currently in the process of developing a watershed management plan for the Capisic Brook watershed. A project kick-off meeting was held December 10, 2009, and included representatives from the Maine DEP, Maine Turnpike Authority (MTA), Maine Department of Transportation (Maine DOT), city of Portland, and the city of Westbrook. Technical project teams, including structural stormwater retrofit strategy, planning and policy, marketing/outreach initiatives, and finance, were established to help guide the development process. A public stakeholder meeting was held January 28, 2010, and several technical project team meetings were held during 2010. A Capisic Brook Watershed webpage was developed with a link off the city of Portland Department of

Public Services webpage, and can be viewed at http://publicworks.portlandmaine.gov/capisicbrookwatershed.asp. As of the date of this report, the draft Watershed Management Plan was not available on the website.

6.4.3 Vernal Pools

Vernal pools (or "spring pools") are shallow depressions that usually contain water for only part of the year. Significant vernal pools are those with particularly valuable habitat. In general, the Maine DEP considers a vernal pool habitat to be “significant” if it has a high habitat value, either because (1) a state-listed threatened or endangered species, such as a spotted turtle, or a rare species, such as a ribbon snake, uses it to complete a critical part of its life history, or (2) there is a notable abundance of specific wildlife, such as blue spotted salamander, wood frog, or fairy shrimp. As of September 1, 2007, significant vernal pool habitat is protected under the Natural Resource Protection Act (NRPA).

According to the Maine DEP map of NRPA vernal pools, there are three identified vernal pools in Portland; however all three are considered "not significant" because they either do not meet the definition or biological criteria of a vernal pool.

6.5 Summary - CSO Contributions to Impairments

Portland is the largest city in the state of Maine, with diverse land uses including residential, commercial, and industrial. The water bodies in the study area have not escaped the pressures of development on their water quality, and they are impaired for various reasons, including CSO discharges.

According to the 2010 Maine DEP Integrated Water Quality Report, there are no freshwater rivers or streams that are impaired solely by bacteria; however, the estuarine and marine waters located in the Portland area are in non-attainment solely because of bacteria contributed by sewage treatment plant outfalls, stormwater, and non-point source pollution. The 2010 Maine DEP Integrated Water Quality Report also broadly lists Casco Bay at Portland as being impaired by bacteria from CSOs.

In addition, CSO discharges are listed as one source of impairment for the Fore River Estuary; other impairments include municipal point sources, stormwater, non-point sources caused by spills, and hazardous waste sites. Essentially the water quality of all estuarine and marine waters in Portland, which includes Back Cove, Casco Bay, Portland Harbor, and Fore River Estuary, are affected by CSOs. It should be noted that CSOs that discharge into Capisic Brook are also a likely source of the stressors that are contributing to the brook's impairment.

Section 7

Tier II Improvements Analysis

7.1 Introduction

This section describes the process used to assess the Tier II program and the development of the revised Tier II program, which has been approved by MDEP. As part of the development of this LTCP update, CDM Smith evaluated the effectiveness of the Tier II program and identified cost-effective modifications to the proposed sewer separation efforts. CDM Smith reviewed the proposed 2011, 2012, and 2013 projects and found eight projects that could be removed from the program, and identified that the addition of a 2 MG storage facility to the remaining separation projects would meet the goals of the 1993 LTCP.

7.2 Tier II Effectiveness Analysis

7.2.1 General

The calibrated collection system model described in Section 4 was used to project the existing amount of CSO that could be expected based on precipitation in a typical year. The existing combined sewer area for the City is estimated at 4,911 acres. This estimate is based on calculating a 250 foot buffer on both sides of each pipe, which is identified as a combined sewer in the City's and PWD's GIS. The total area of this buffered layer was then summed (overlapping areas were not double counted).

The estimate of combined sewer overflow from the system from the 1993 LTCP is 720 MG based on the precipitation for a typical year. Although the model has been updated and recently recalibrated, it is assumed that this volume is still an adequate representation of the system-wide overflows for the typical year based on the condition of the system in 1993. Therefore, this volume can be compared to existing estimates to predict the amount of CSO reduction due to improvements since 1993.

In Section 4, it was discussed that the model predicts a total system-wide annual CSO volume of 416 MG for existing conditions using hourly rainfall from the typical year. Based on the above assumption, this estimate indicates a 42 percent reduction from the 720 MG estimated in 1993. This volume was used as the baseline estimate of the level of control (LOC) of the system. For comparison purposes, the estimated amount of overflow from the system reported to MDEP for 2009 was 873 MG (which was a very wet year – 56 inches of rainfall compared to 40 inches in the typical year).

7.2.2 Method

A method was developed to estimate the amount of CSO reduction that has been achieved since the beginning of the Tier I program (in 1997) similar to the method described above to calculate the combined sewer area in the system. The City provided estimates of which areas have been separated to date as part of the Tier I and II projects. The total area for separation projects completed through 2009 is estimated at 1,076 acres using the above method for calculating combined area. Therefore, this area can be added to the existing combined area estimates to total approximately 5,987 acres of combined area in 1997 (pre-separation).

This additional combined sewer acreage was then added into the model and an estimate of the approximate annual CSO that would have been produced in 1997 was calculated based on the typical year precipitation (1966). For the pre-separation estimate, using these assumptions and method, the model produced 575 MG of annual overflow. This equates to a reduction of 159 MG of overflow due to the Tier I and II separation projects completed through 2009.

7.2.3 Tier II Analysis Results

This same method was used to predict the amount of CSO reduction that might be accomplished by completing the Tier II projects as outlined in the 2003 report, which listed the proposed Tier II projects through 2013. The City again provided estimates of the areas that are proposed for separation to complete the Tier II projects. These remaining projects total approximately 1,456 acres. This acreage was then removed from the model and the typical year was run. This post separation run produced approximately 369 MG of annual overflow. This equates to a reduction of 206 MG of overflow estimated for completion of Tier I and II separation projects. Therefore, an additional 47 MG could potentially be removed if proposed separation projects are completed through 2013. Table 7-1 summarizes the estimated annual CSO volume reductions based on sewer separation projects.

Table 7-1
Estimated Annual CSO Volume Reductions

Scenario	Estimated Combined Area (ac)	Estimated CSO Volume (MG)	Estimated CSO Volume Removed Since 1993 (MG)	Estimated Percent Removal Since 1993
Pre-Separation (1997)	5,987	575	145	20%
Existing (2009)	4,911	416	304	42%
Proposed Tier II Complete - Only Separation (2014)	4,531	369	351	49%

Table 7-1 also includes estimates of the total amount of overflow reduced since 1993. As discussed above, the 1993 LTCP estimate of 720 MG for annual overflow for the typical year is assumed. The pre-separation annual overflow estimate of 525 MG, when compared to the 720 MG, equates to a 145 MG reduction due to projects completed between 1993 and 1997, which is a 20 percent reduction attributed to WWTP and conveyance system upgrades. Using the same assumption and the existing estimated annual CSO, a 42 percent reduction in overflow since the beginning of the program can be concluded. An additional seven percent reduction could potentially be achieved if the remaining Tier II separation projects (only) are completed (totaling 49 percent reduction).

7.3 Alternatives Analysis

As previously discussed, the City is currently implementing a series of selective sewer separation projects in the Fall Brook watershed (FBW) and Capisic Brook watershed (CBW) as part of the Tier II CSO abatement program. The alternatives analysis included below details the process used to estimate if CSO technologies other than sewer separation (e.g., storage) could be more cost effective in the completion of the Tier II program.

7.3.1 Capisic Brook Watershed

Five Tier II projects remain in the CBW and are tentatively scheduled for construction in 2011 and 2012, as shown in Table 7-2. Estimated project costs for the remaining work is approximately $5.5 million. The combined efforts of the construction of the WSI and the remaining separation work in the CBW (focused in catchments tributary to CSOs 042 and 043) is anticipated to eliminate CSO discharges to the Capisic Brook during the typical year, which is required to achieve the LOC established in the LTCP.

Table 7-2
Capisic Brook Watershed - Tier II Projects

Project Name	Estimated Construction Complete	Estimated Project Cost	Receiving Water
Dorothy, Dibiase & Hicks	2011	$ 1,490,000	Capisic Brook
Brewer Street	2011	$ 225,000	Fore River
Commonwealth Avenue	2012	$ 1,250,000	Capisic Brook
Lexington and Broadway	2012	$ 1,600,000	Capisic Brook
Belfort Street	2012	$ 900,000	Capisic Brook
	Total	**$ 5,465,000**	

Note: Costs were provided by the City of Portland.

A fundamental goal established in the LTCP is the elimination of CSO discharges into Capisic Brook during the typical year. Land use is rural and residential in the areas tributary to CSOs 042 and 043. These two CSO outfalls are isolated in a rural area. Technologies other than sewer separation were considered, but are not recommended due to site-specific issues. Capisic Brook is a sensitive receiving water and would not be a viable discharge source for a satellite treatment facility. Access in the vicinity of the overflows is also not ideal for siting a storage facility (wooded area south of elevated railroad tracks). Based on the extent of the progress made to date with sewer separation in this area, and the planned removal of a brook, sewer separation remains the preferred method of CSO control in the CBW.

7.3.2 Fall Brook Watershed

Sewer Separation

Separation projects in the FBW were developed in 2003 by dividing the area into twelve “Focus Areas”, which were then further divided into 57 individual design projects (note that some of these projects were grouped together during the development of the implementation plan and added to the CBW projects to total 61 Tier II projects). The goal of the FBW projects was to achieve the LOC established in the LTCP, which requires elimination of CSO activity at CSO 007 during the typical year. Twelve Tier II projects remain in the FBW and are tentatively scheduled for construction in 2011-2013. Estimated project costs for the remaining work is approximately $15.5 million.

Model results indicate that construction of the remaining Tier II projects will not fully achieve the LOC of zero overflows established in the LTCP for CSO 007 during the typical year. Therefore, to meet the requirements of the program, additional separation in the CSO 007 tributary area would be required in the future Tier III program. In an effort to limit the amount of additional work required in this area,

CDM Smith evaluated the remaining Tier II projects to identify cost-effective modifications to the recommended plan as well as consider holistic City-wide solutions that may be included in the Tier III program.

Difficulty in controlling CSOs from a basin of this size (approximately 3,500 acres) is typical of CDM Smith's experience with other similar New England communities that have large combined sewer basins similar to CSO 007 (ex., Manchester, NH – Cemetery Brook CSO Basin, Lowell, MA – Warren Avenue CSO Basin, Hartford, CT – Park River CSO Basin, etc.). The wet weather response that is generated from a basin of this size is challenging to control through separation alone because it requires an aggressive private infiltration and inflow (I/I) removal program to eliminate the considerable extraneous flow generated from the private sources throughout the area.

Implementing a private I/I removal program can be difficult for a municipality because it relies on public participation in the program to conduct house-to-house investigations to locate sources of flow (i.e., roof leaders, foundation drains, yard drains, etc.) and to remove them from the collection system. Thus, in lieu of an aggressive private I/I removal program, an option is to utilize sewer separation programs coupled with downstream controls (storage and/or treatment) to meet the ultimate CSO control level. Further, it is generally preferred to conduct sewer separation as an initial program step to gauge the effectiveness of the I/I removal program and to avoid investing in overly large downstream controls.

Given that model simulations have shown that sewer separation alone will not meet the LOC established in the 1993 LTCP, downstream control measures will eventually be required. Therefore, it is in the City's best interest to prioritize the remaining separation projects and only implement those that are either determined to be cost-effective or required to achieve a secondary program benefit and reallocate the funds from the projects determined to be ineffective toward a storage facility. Examples of secondary program benefits that should be considered are:

- Sewer rehabilitation/other infrastructure improvements required (gas & water main replacement, road reconstruction, flooding control, etc.); and/or
- The project is required to realize the benefit of a previously constructed sewer separation project that currently recombines to the collection system.

Storage Analysis

CSO 007 was grouped with CSO 005 and 006 and is referred to as the Back Cove (North) Focus Area (FA). Model simulations for existing conditions indicate that approximately 53 MG of total overflow will discharge from these CSOs during the typical year.

An analysis was completed that used the model to remove separation projects to examine how much additional downstream storage would be needed to meet the LOC. This process was repeated until a result was identified to be most cost-effective. A 2 MG storage facility in combination with several proposed sewer separation projects worked out to be the primary cost-effective solution for this FA.

Table 7-3 summarizes the results of this cost-effectiveness analysis using conceptual costs for this alternative and the remaining Tier II work. Table 7-3 shows that implementation of a prioritized Tier II separation program and a downstream storage facility in this FA will cost approximately $21 million to

remove 38 MG of overflow. It is estimated to remove the same 38 MG using only separation, it would cost at least $26.6 million (38 MG x $0.70/gal). This equates to at least a $5.5 million savings to achieve the same benefit.

Table 7-3
Cost-effectiveness Analysis for Baxter Boulevard (North) Focus Area

CSO Technology	Volume of Overflow Removed (MG)	Project Cost ($M)	Effectiveness ($/gal removed)
Implement Remaining Tier II Separation Projects	22	$15.5	$0.70/gal
Prioritized Tier II Separation Projects and 2 MG Inline Storage Facility	38	$21.0	$0.55/gal

An additional benefit that storage would offer is that it is sized to sufficiently capture the CSO volume generated from the first one inch of rainfall, which is typically referred to as the "first flush", for all three outfalls. The first flush of runoff contains the highest concentrations of stormwater pollutants and represents the most significant impact on water quality to Fall Brook (from storm water flows) and Back Cove (from CSO and stormwater flows). Sewer separation techniques typically move a large portion of the first flush from the CSO system to the separate storm water system. To treat this first flush, additional best management practices (BMPs) must be applied to the stormwater. Significant BMPs are not currently part of this sewer separation program and these pollutants (bacteria, suspended solids, floatables, etc.) may be delivered directly to the receiving waters unabated.

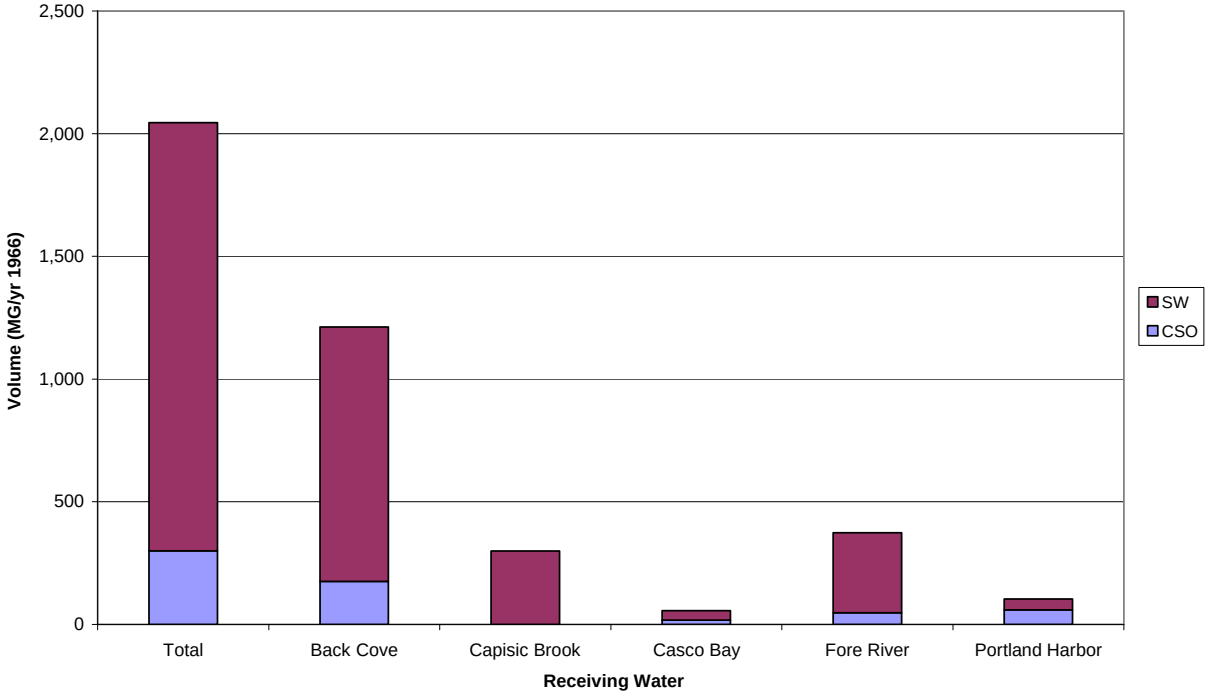
CSO captured by the storage facility would be returned to the collection system and conveyed to the WWTP to receive treatment following the storm. Thus, the proposed storage alternative would result in a considerable increase in water quality protection to Back Cove when compared to sewer separation. Further, the proposed storage will not address 100 percent of the remaining overflow and will need to be coupled with additional Tier III projects. By targeting this first flush volume as an initial program step, the City will make significant water quality gains without oversizing downstream control facilities.

This analysis assumed that six separation projects would remain in this Baxter Boulevard (North) focus area. The six projects were chosen by the City in consultation with CDM Smith and are summarized in Table 7-4. The City, also in consultation with CDM Smith, decided to put the remaining eight separation projects on hold, see Table 7-5.

7.4 Tier II Loading Estimates

The collection system SWMM model was used to determine CSO and stormwater discharges to each receiving water under conditions reflective of the completion of Tier II projects. Figure 7-1 presents the volume of CSO and stormwater predicted to discharge to each receiving water at the completion of Tier II for the typical year.

Figure 7-1
Total Volume of CSO and Stormwater per Receiving Water
Tier II at Completion



As shown in Figure 7-1, roughly 85% of the discharges into the receiving waters are attributable to stormwater, while the remaining 15% is from CSO sources. This results in a 5% increase in discharge volume attributable to stormwater and a 5% decrease in discharge volume from CSO sources from baseline conditions. Upon completion of the Tier II projects, all but Capisic Brook are anticipated to receive discharges from CSOs, with Back Cove receiving 59% of the total volume of CSO and stormwater discharges.

7.4.1 CSO Loadings

For all receiving waters, except Back Cove, the same EMCs described in Section 5 for CSO discharges were used to determine pollutant loading to each receiving water at the completion of Tier II. The EMCs for BOD, TSS, Nitrate, Total-P, and Zinc were adjusted for Back Cove under Tier II conditions to account for a reduction in pollutant loading attributed to storage of the "first flush" in Back Cove (North). Using professional judgment and pollutant removal data for stormwater dry ponds obtained from the National Pollutant Removal Performance Database (2nd Edition), the EMCs for Back Cove were reduced accordingly. The adjusted EMCs for Back Cove under Tier II conditions are included in Appendix F. Figures 7-2 through 7-4 presents the pollutant loading for TSS, BOD, and E.coli from CSO discharged to each receiving water at the completion of Tier II for the typical year.

Figure 7-2
Total Pollutant Loading in CSO and Stormwater per Receiving Water
Tier II at Completion – TSS

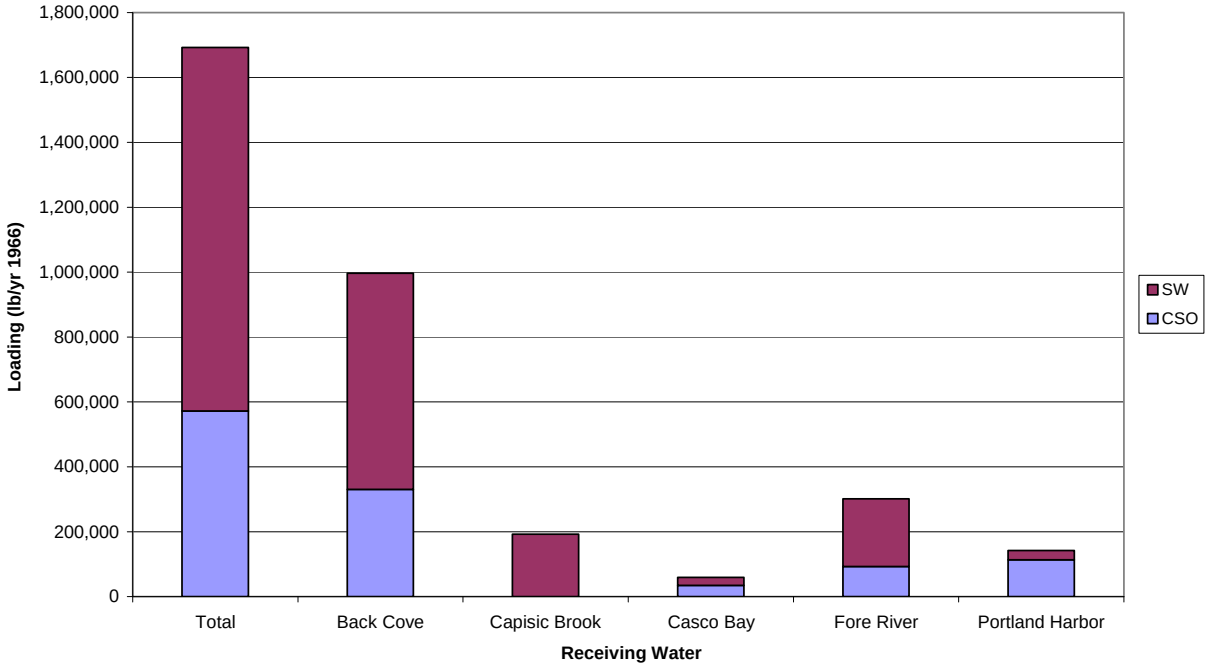


Figure 7-3
Total Pollutant Loading in CSO and Stormwater per Receiving Water
Tier II at Completion – BOD

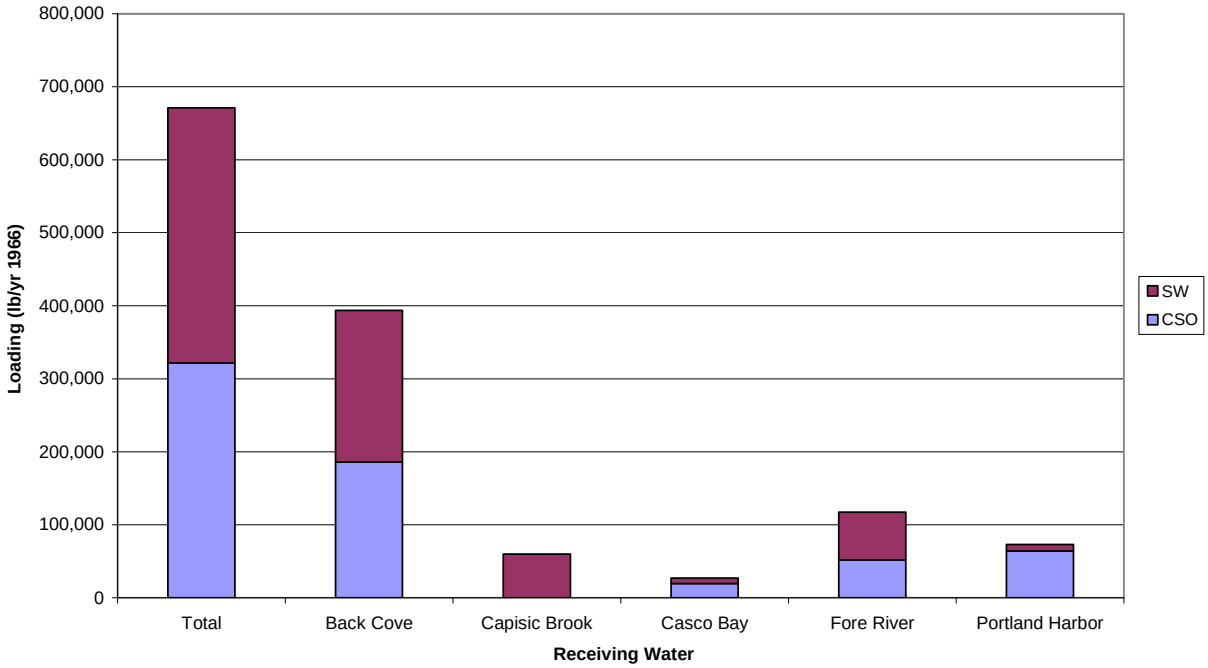
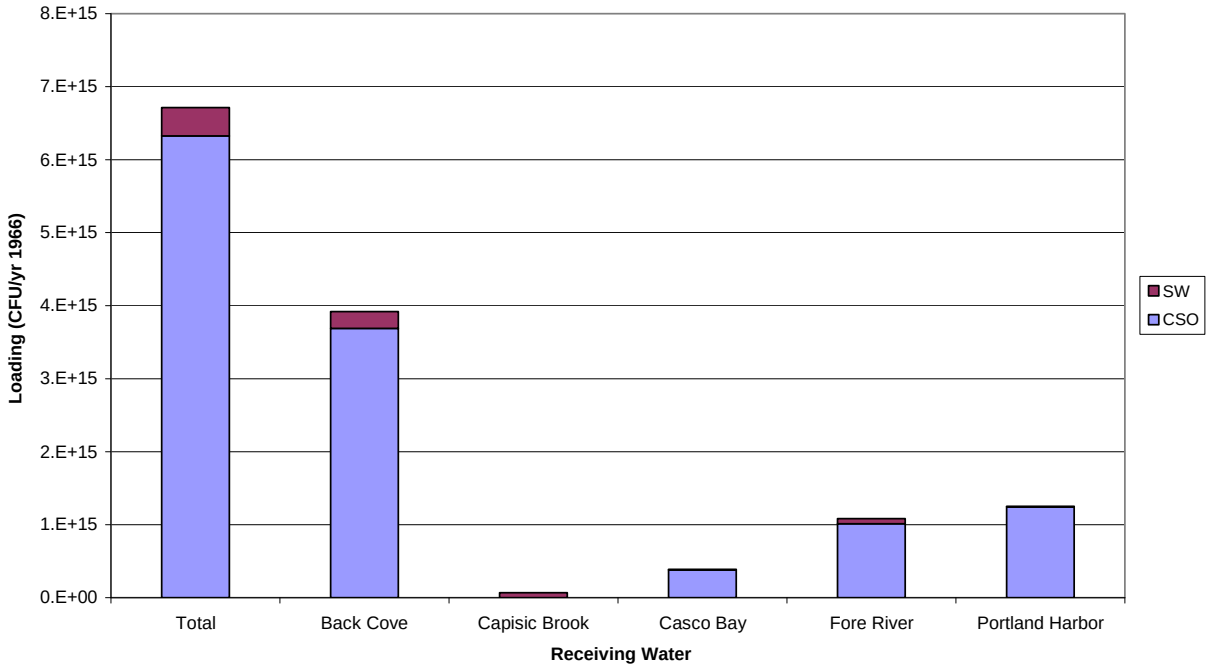


Figure 7-4
Total Pollutant Loading in CSO and Stormwater per Receiving Water
Tier II at Completion – E.coli



Roughly 34% of the total TSS loading is attributable to CSO sources, 48% of the total BOD loading is attributable to CSO sources, and 94% of the total E.coli loading is from CSO sources. This results in a 9%, 10%, and 2% reduction in TSS, BOD, and E.coli loadings from CSOs compared to baseline conditions. Upon completion of the Tier II projects, CSO discharges to Capisic Brook are anticipated to be eliminated; however this will result in an increase in pollutant loading to Fore River. In addition, moderate reductions in pollutant loadings from CSO sources will be seen in Back Cove. Under Tier II conditions, 33%, 47%, and 94% of the TSS, BOD, and E.coli loading in Back Cove is from CSO sources, which is a 13%, 14%, and 2% reduction from baseline conditions.

7.4.2 Stormwater Loadings

The same EMCs described in Section 5 for stormwater discharges were also used to determine pollutant loading to each receiving water at the completion of Tier II for stormwater sources. Figures 7-2 through 7-4 presents the pollutant loading for TSS, BOD, and E.coli from stormwater discharged to each receiving water at the completion of Tier II for the design storm event.

Roughly 66% of the total TSS loading is attributable to stormwater sources, 52% of the total BOD loading is attributable to stormwater sources, and 6% of the total E.coli loading is from stormwater sources. The decreases in pollutant loadings from CSO sources are reflected in an equal increase in pollutant loadings from stormwater; however, the total TSS, BOD, E.coli loadings at the completion of Tier II projects is reduced by 8%, 16%, and 27% compared to baseline conditions.

7.5 Recommendations for Completing Tier II

7.5.1 Capisic Brook Recommendations

Implementation of the CBW Tier II projects is recommended to continue as planned. It is anticipated that these projects will fully eliminate discharges to the Capisic Brook during the typical year. However, a future flow monitoring program should be performed to confirm that the separation projects were successful in accomplishing the goals established in the LTCP.

Additionally, in the event that the separation work does not fully eliminate discharges to the Capisic Brook for the typical year, additional flow reduction techniques (sewer separation, sewer rehabilitation, storage, green infrastructure - LID, etc.) may be required at some point during the Tier III program in this area.

7.5.2 Fall Brook Recommendations

Based on the discussion above, CDM Smith recommends prioritizing the remaining Tier II projects and implementing only those that are cost effective or required to achieve secondary program benefits. These remaining projects are:

- independent and require a new outfall;
- recommended for sewer rehabilitation; and
- connect to a previous contract or are necessary to eliminate a separated area that has drainage that recombines to the collection system.

CDM Smith and the City identified six sewer separation projects to be completed in the FBW as part of Tier II, totaling approximately $11 million. These projects are summarized in Table 7-4.

Table 7-4
Fall Brook Watershed – Recommended Tier II Projects

Project Name	Receiving Water	Estimated Construction Complete	Estimated Project Cost
Victor Road Area	Fall Brook	2012	$ 1,100,000
Auburn Street and Washington Ave	Fall Brook	2012	$ 2,200,000
(1)Ocean Avenue - Read Street to Carlyle Road	Fall Brook	2011	$ 965,000
Bartley Avenue, Fall Lane, Autumn & Martin, Melody Lane, Rustic Lane	Fall Brook	2011	$ 2,935,000
Alpine Road, Summit Park Avenue, Jackson Street, Clayton Street, Hillside Road	Fall Brook	2011	$ 2,935,000
Allen Avenue - Knight Street to Washington Avenue	Fall Brook	2011	$ 955,000
		Total	**$ 11,090,000**

Notes:
(1) Ocean Avenue separation project has recently been completed.
(2) Costs were provided by the City of Portland.

The remaining eight projects are recommended to be put on hold for consideration for future implementation. Design of some of these could proceed, in order to facilitate future implementation, if conditions (such as ARRA) warrant immediate construction. Table 7-5 lists these deferred projects that total $4.4 million.

CDM Smith also recommends redirecting a total of approximately $10 million dollars to construct an in-line storage conduit along Baxter Boulevard. The 2 MG storage facility was conceptually sized to be approximately 2,500 feet in length and a 9-ft x 12-ft (precast concrete box culvert). Alternative conduit sizing and configuration should be considered in further design analyses to optimize effectiveness while minimizing costs. This conceptual 2 MG inline storage facility is located along Baxter Boulevard to control overflows from CSOs 005, 006, and 007. These modifications bring the total cost to complete the proposed Tier II projects to approximately $21 million.

It should be noted that a Total Maximum Daily Load (TMDL) is being considered for Fall Brook based on minimum flow requirements. However, the recommended storage does not preclude the City from continuing separation and stormwater management in Tier III to meet potential future regulatory requirements. Therefore, the recommended 2 MG storage facility provides flexibility in the controlling CSOs in this FA.

Table 7-5
Deferred Tier II Projects

Project Name	Receiving Water	Estimated Construction Complete	Estimated Project Cost
Malilly Road	Fall Brook	2012	$ 300,000
Fall Brook Street	Fall Brook	2012	$ 535,000
Washington Ave @ Skylark	Fall Brook	2013	$ 135,000
Washington Ave - Greenwood to Coolidge	Fall Brook	2013	$ 1,070,000
University Street	Fall Brook	2012	$ 595,000
Woodlawn Avenue Area	Fall Brook	2012	$ 730,000
Allen Ave - East of PATHS	Fall Brook	2012	$ 260,000
Allen Ave - Harvard to Plymouth	Fall Brook	2012	$ 775,000
		Total	**$ 4,400,000**

Note: Costs were provided by the City of Portland.

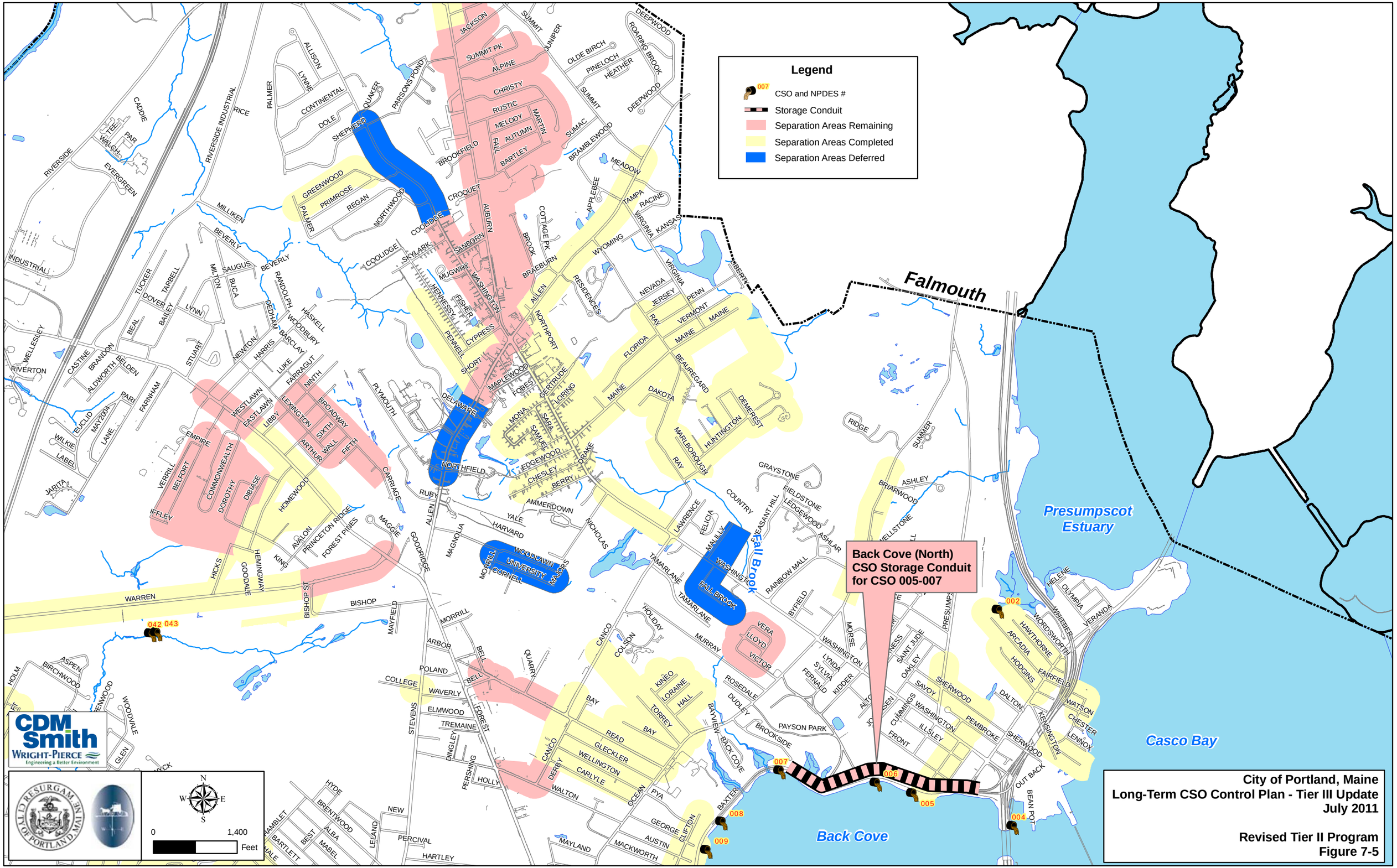
Further, it is recommended that a preliminary design study be conducted in the Back Cove (North) focus area prior to developing a final design for the proposed storage facility. Specific items recommended for inclusion in the study are:

- Conduct a siting analysis to determine optimum location of the facilities;
- Conduct a geotechnical analysis to evaluate subsurface conditions along Baxter Boulevard, which would include reviewing existing boring information as well as drilling new borings/probes. This is prudent given that the project area is located along a tidal cove and may

require special construction techniques to account for unsuitable soils and/or high groundwater conditions;

- Develop preliminary plan and profile drawings to identify any major utility conflicts with conduit sizing and alignment;
- Use the SWWM model to perform hydraulic analyses to confirm the layout and operation of the proposed conduit (necessary weirs, filling and draining, etc.); and
- Coordination with other planned improvements such as the PACTs paving schedule along Baxter Boulevard.

Figure 7-5 illustrates the recommended Tier II projects and also shows the deferred sewer separation projects previously recommended for Tier II. It should also be noted that the information included in this section supersedes the information included in *Final Technical Memorandum No.1, Tier II Recommendations and Introduction to Tier II Approach, completed by CDM Smith and Wright-Pierce, April 6, 2011*, which is included in Appendix G.


Legend
CSO and NPDES #
Storage Conduit
Separation Areas Remaining
Separation Areas Completed
Separation Areas Deferred
Falmouth
Presumpscot Estuary
Casco Bay
Back Cove
Fall Brook
Back Cove (North) CSO Storage Conduit for CSO 005-007
007
006
005
004
002
008
009
042
043
CDM Smith
Wright-Pierce
Engineering a Better Environment
City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011
Revised Tier II Program
Figure 7-5
0
1,400
Feet

Section 8

Tier III Improvements Analysis

8.1 Introduction

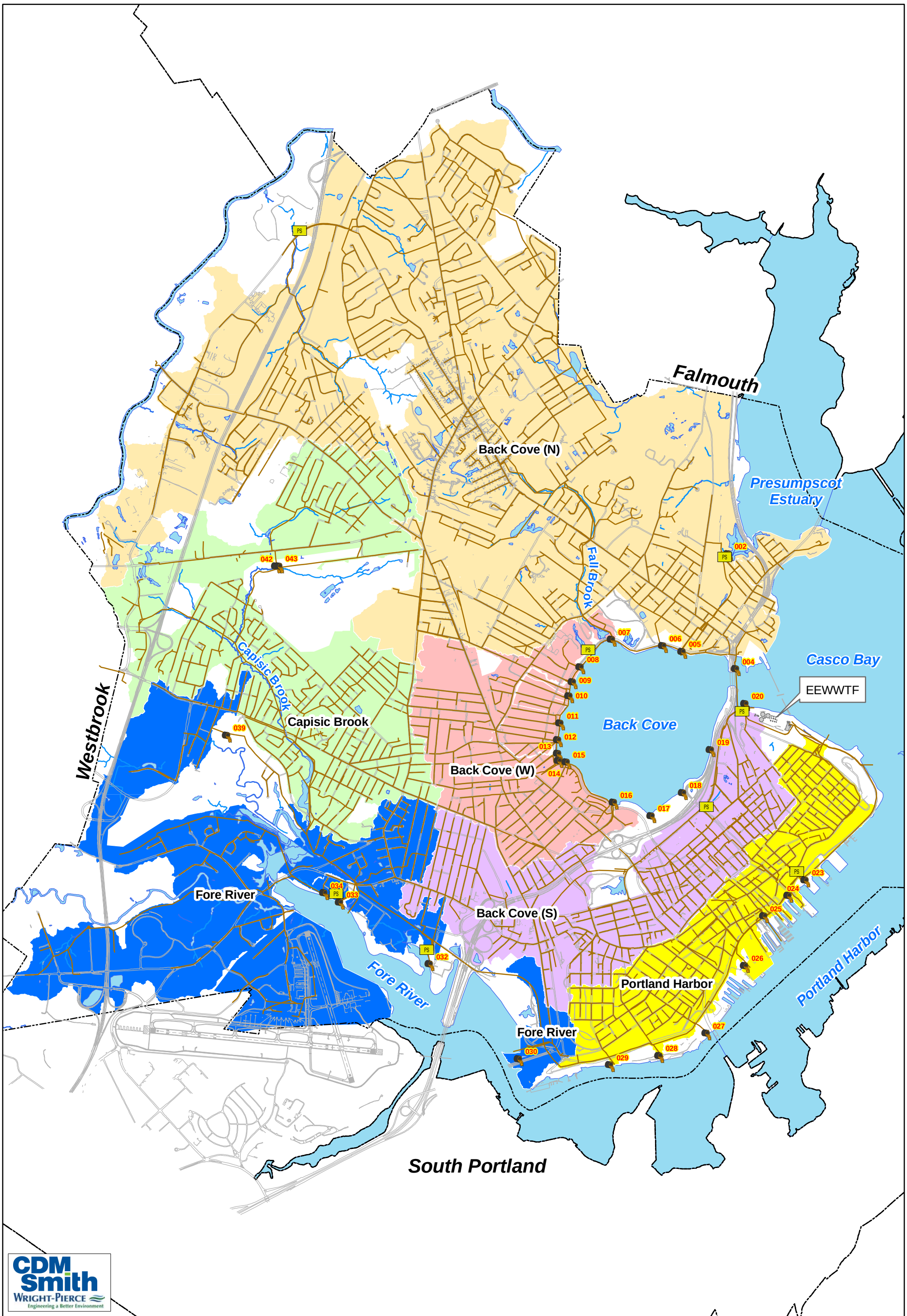
The purpose of this section is to present the process used to focus the full range of CSO control options available in Portland down to the short-listed technologies employed in the alternatives analysis presented in Section 9. The section starts by describing the approach used to strategically group and analyze the remaining CSOs in the collection system and then presents an evaluation of technologies and CSO control strategies that will be used by the City and PWD.

8.2 Tier III Analysis Approach

At the conclusion of the Tier II program 31 CSOs will remain in the system that will require implementation of control strategies to meet the goals set by the 1993 LTCP. Many of these CSOs are in close proximity to each other, do not have large tributary areas, and act in tandem to protect the interceptor network by producing overflows. Therefore, as part of the City-wide strategic solutions being considered for Tier III, CDM Smith grouped the remaining CSOs located throughout the City based on their geographic location and receiving water to develop Tier III Focus Areas, shown in Table 8-1 and on Figure 8-1. Table 8-1 lists the focus areas, active CSOs in each area, and remaining overflow volume in the typical year (at completion of Tier II).

Table 8-1
Tier III Focus Areas and Remaining CSO Volume

Tier III Focus Area	CSO Outfalls	CSO Volume (MG)
Back Cove (North)	005-007	0
Back Cove (West)	008, 010-016	46
Back Cove (South)	017-019	129
Capisic Brook	042, 043	0
Casco Bay	002, 004, 020	18
Fore River	030, 032, 033, 034, 039	49
Portland Harbor	023-029	58
TOTAL		**300**



CDM Smith
WRIGHT-PIERCE
Engineering a Better Environment

Legend

007 CSO and NPDES #

PS Pumping Station

CSO Focus Areas

- Back Cove (N)
- Back Cove (W)
- Back Cove (S)
- Portland Harbor
- Fore River
- Capisic Brook

N W E S

0 2,750 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Tier III CSO Focus Areas
Figure 8-1

This approach follows closely the approach developed for the revised Tier II program to develop a cost-effective CSO reduction alternative. Similarly, the underlying theme of the Tier III approach is to determine the most cost-effective solutions to meet the intended LOC of the initial LCTP and to modify the original plan in reaction to changes in the water quality standards/objectives that may have occurred in the eighteen years that have elapsed since the submission of the original LTCP.

For example, the revised Tier II concluded that capturing the first flush through storage and/or treatment was more beneficial to water quality than sewer separation in the Back Cove (North) focus area. Building on this success, CDM Smith used the focus areas to group the remaining CSOs and strategically approached the alternatives analysis to identify cost-effective control measures described in Section 9 of this report.

8.3 CSO Abatement Technologies

There are many alternative strategies available to control pollutants discharged from CSOs ranging from end-of-pipe treatment to complete separation of the combined sewer system into separate sanitary and stormwater systems. An initial screening-level assessment considered all the technologies presented in the EPA guidance manual to ensure that CSO technologies short-listed in the 1993 LTCP include updated and appropriate technologies for further evaluation and comparison in later sections of this report. The guidance manual divides the technologies into four general categories:

- Source Control Measures: Source control measures are generally lower cost alternatives focused on water quality protection (best management practices -BMPs) and reduction in runoff quantity (Green Infrastructure - GI - that detain and infiltrate stormwater). Examples of best management practices include: street sweeping, catch basin cleaning, snow removal and deicing practices, and fertilizer/pesticide control. Examples of green solutions include: stormwater infiltration basins, rain gardens, porous pavement, and green roofs.

- Collection System Controls: Collection system controls include modifications to the collection system, which typically require more significant capital expenditures than source control measures. Included in these controls are: sewer separation, regulator modifications, real-time control technologies, CSO consolidation and inflow control via backwater and tide gates.

- Storage Technologies: Storage technologies are designed to capture and hold overflow volumes until capacity is available in the interceptor system, at which time the tanks are dewatered back into the collection system for subsequent treatment at the WWTF. Technologies considered include near-surface storage, inline storage and tunnel storage.

- Treatment Technologies: Treatment technologies include both satellite facilities and upgrades to the existing WWTF. Satellite treatment facilities are ideally located near the CSO and are designed to remove or reduce pollutants from CSO discharges to levels consistent with water quality goals. Technologies considered include screening and disinfection, high rate clarification and WWTF upgrades.

During the Tier I and II programs, the City and PWD have utilized several abatement technologies to reduce the CSO discharges including collection system controls (e.g. sewer separation, and pump station upgrades), source control measures (e.g. flow slipping, rain gardens and collection system best

management practices), and treatment plant technologies (East End WWTF upgrades). These have provided for a significant reduction in overflow volumes but other technologies will need to be considered to cost-effectively address the remaining overflows that must be managed to meet the LOC of a typical year.

Table 8-2 presents the technologies that were short-listed in the 1993 LTCP in addition to six others (shown in italics) that have been added to the analysis based on discussions with the City and PWD. Table 8-3 summarizes key advantages and disadvantages of typical CSO control technologies.

Table 8-2
Short-listed CSO Reduction Techniques

Source Controls	Collection System Controls	Storage Technologies	Treatment Technologies
Best Management Practices	Sewer Separation/*Elimination of recombined drainage*	Closed Concrete Tanks	Vortex Separators
Stormwater Detention	Maximize Flows to WWTF	Storage Conduits	Chlorination-Dechlorination
I/I Reduction	Static Flow Control	N/A	Expand WWTF Capacity
Flow Slipping	Optimize Conveyance	N/A	*High-Rate Clarification*
Swales/Greenways	*Installation/Maintenance of Tide gates*	N/A	N/A
Stream Diversion	*Real-Time Control*	N/A	N/A
Green Infrastructure	N/A	N/A	N/A

Application of technologies was carefully assessed by CSO and focus area to identify where coordination with other City and PWD projects is possible. An alternative that has benefits beyond the CSO control program will also help in acceptance of the location and costs. As the City implements other projects, the CSO program will continually evolve to identify where coordination with CSO control projects can add value and reduce costs of large capital projects through cost sharing (e.g. bike paths, parking lots/garages, etc.).

8.4 Source Control Measures

8.4.1 Best Management Practices

As required by the Agreement, the City developed and implemented a BMP program, which focuses on proper operations and maintenance practices for the combined sewer system. Tasks include: maintenance of overflow regulators, tide/flap gates, siphons, trunk and local sewer lines, cleaning of catch basins, and street sweeping. The intent of the BMP program is to ensure the combined sewer system and WWTF function correctly and provide some level of control of CSO discharges while the LTCP is developed and implemented.

Given that the City and PWD currently have a BMP program in-place, have already upgraded the WWTF and two major pump stations (India Street PS and North East PS) to achieve maximum flow to the plant, and have been working on optimizing the plant's function, additional controls in this vein

are not expected to increase the level of CSO control or provide a water quality impact. Therefore it is recommended that the City and PWD continue to enforce their existing program and additional consideration of BMPs will not be included in this report.

Table 8-3
CSO Control Technologies Advantages and Disadvantages

Technology	Advantages	Disadvantages
Sewer Separation	▪ Decreases bacteria in receiving waters ▪ Provides new/rehabilitated infrastructure ▪ May reduce transport and treatment costs ▪ May reduce localized flooding	▪ Increases pollutants to receiving waters from separated stormwater ▪ Public separation still leaves private inflow sources (rain leaders, sump pumps, etc.) ▪ Can be disruptive in urbanized areas
Green Infrastructure	▪ Manages inflow at source ▪ Can provide treatment of stormwater ▪ May reduce transport and treatment costs ▪ May reduce localized flooding	▪ Urban settings may reduce applicability (e.g. infiltration limits, land requirements) ▪ Operation and maintenance requirements can reduce effectiveness and the O&M costs can become overwhelming ▪ Limited peak flow and volume reductions ▪ High cost per volume of CSO removed
Storage (in-line or off-line)	▪ Provides secondary treatment to captured wet weather flows ▪ May reduce transport costs ▪ Low cost per volume of CSO removed	▪ Land requirements may limit locations ▪ Operation and maintenance may be a factor
High Rate Clarification (HRC)	▪ Efficiently treats overflows with high peak rates ▪ Small footprint provides site flexibility	▪ Require remote operation if not sited at WWTF ▪ Does not provide secondary treatment ▪ Operation and maintenance may be a factor
WWTF Upgrades	▪ Provides treatment of wet weather flows ▪ Improvements may be able to be coupled with existing facilities	▪ Transport of peak of wet weather flows (e.g. new/upgraded pump stations) ▪ Land requirements may limit applicability

8.4.2 Green Infrastructure

General

Since the submission of the original LTCP, green infrastructure (GI) has progressed considerably and is currently in widespread use for management of urban wet weather flows throughout many CSO communities in the United States. GI is by design a distributed method to capture rainfall and either infiltrate or evaporate it so that it doesn't enter into the combined or storm sewers. Low impact

development (LID) techniques are also a part of GI for a City and are focused on retrofitting existing areas to integrate GI into the urban landscape as it is being redeveloped. Depending on the technology, GI can also provide some treatment of urban stormwater before it infiltrates. At a point when the rain can no longer infiltrate (e.g. soil saturation) some treatment may still be provided to the flow before eventually entering downstream urban drainage structures.

Tier III Green Infrastructure Analysis

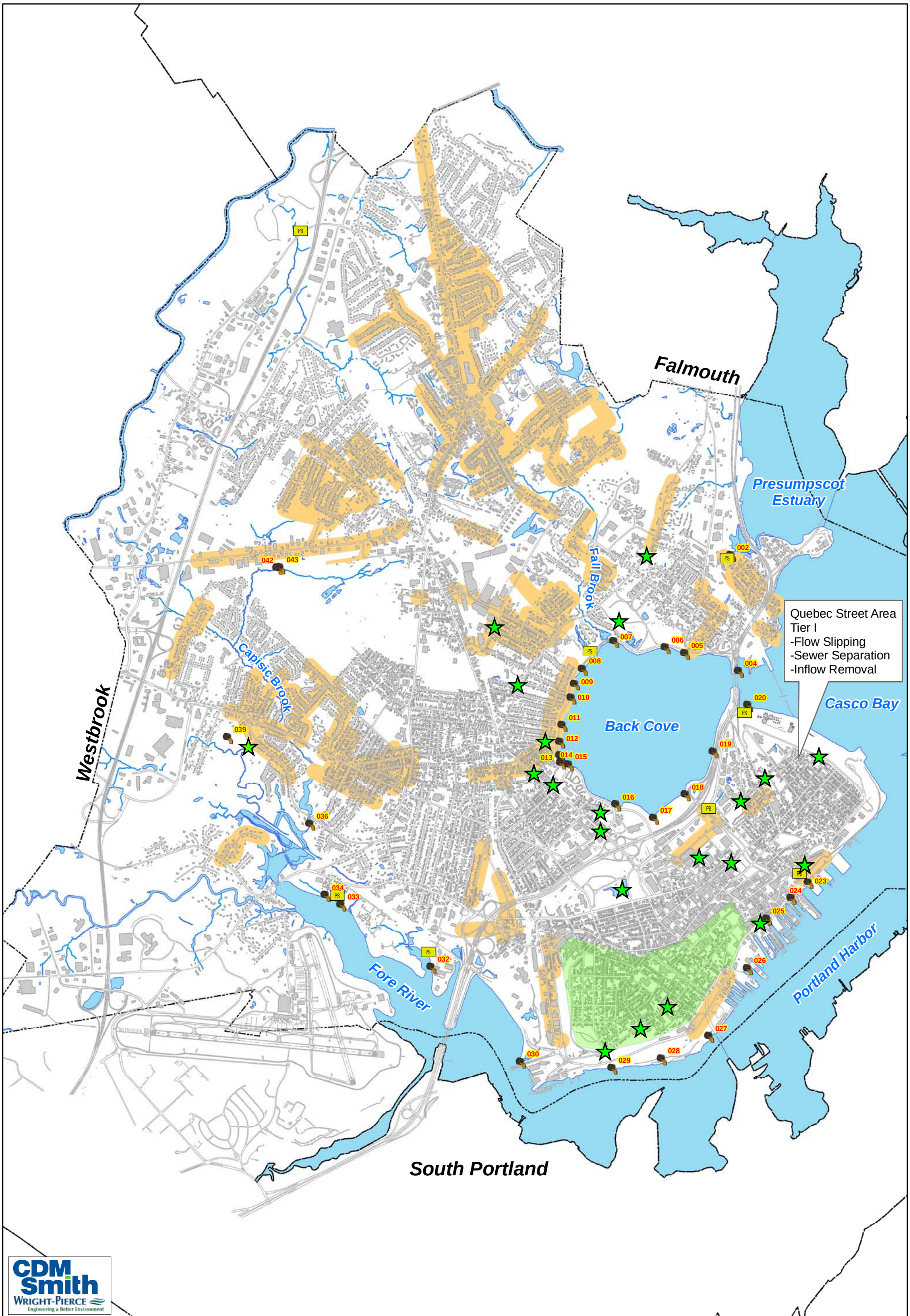
Although there are many methods of GI that have proven reliable for capturing stormwater and infiltrating it into the groundwater, implementing these in Portland could prove to be challenging because much of the City is underlain by clay, silt and rock, which provides limited infiltration capabilities. Green infrastructure solutions that include retention and detention functions verses infiltration may be more appropriate for consideration in these areas.

However, the City currently has several ongoing pilot efforts to implement or encourage GI such as:

- Construction of small scale rain gardens and other LID efforts to manage runoff in conjunction with the sewer separation program;
- Efforts to informally extend the coverage of Chapter 500 to projects of less than one acre disturbance;
- Providing support for implementation of a Stormwater Utility, which will incentivize green development;
- Development of the Capisic Brook Watershed Study, which is developing inventories of potential GI improvements; and
- Portland's selection by National Complete Streets Coalition through the U.S. Environmental Protection Agency's Sustainable Communities Building Blocks program.

Conducting a detailed analysis of the subsurface geology throughout the City and its impact on infiltration technologies was beyond the scope of this project. Consequently, predicting the effectiveness of implementation of extensive amounts of GI in the reduction of CSO volume throughout the City cannot be accomplished at this time. Nevertheless, these technologies were not excluded from the development of the Tier III plan because in some areas they remain viable as an enhancement to the various elements of the recommended plan (e.g., use of rain gardens or sidewalk tree filter boxes to infiltrate some stormwater in proposed sewer separation areas).

Hence, GI will be further evaluated in the early stages of the Tier III program and as the program progresses through preliminary engineering analyses and pilot testing to determine which projects are the most cost-effective and appropriate to implement. Those projects that provide the highest benefit for relatively low cost, low risk, and minimal maintenance requirements would be candidates for implementation in the program. Figure 8-2 shows the location of several projects that the City has already identified as potential areas for implementation of GI projects or a combination of sewer separation and green projects. Further, the City should consider encouraging the use of low-impact development (LID) techniques, which utilize GI elements to maximize infiltration with the development site, for new development and redevelopment throughout the City.



CDM Smith
WRIGHT-PIERCE
Engineering a Better Environment

Legend

- 007 CSO and NPDES #
- PS Pumping Station
- Buildings
- Proposed Targeted Sewer Separation Area
- Potential Green Infrastructure/ Sewer Separation Project
- Tier I & II Separation Areas

N W E S

0 2,750 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Potential Green/Separation Projects
Figure 8-2

8.5 Collection System Controls

8.5.1 Sewer Separation

General

Portland's combined sewers were constructed to collect both sanitary sewage and stormwater and convey these flows to the EEWWTF. Under dry weather conditions, all sewage is conveyed to the treatment facility. During wet weather, stormwater enters the collection system and combines with sewage. Combined flow can exceed pipe capacity, limit the amount of flow delivered to the treatment facility, and cause overflows. The goal of sewer separation is to have two separate pipe systems; one dedicated to sewage and the other to stormwater. Sewer separation can be achieved by either installation of a new drain (existing combined sewer remains as conveyance for sanitary flows) or a new sewer (existing combined sewer remains as conveyance for storm flows).

Tier III Sewer Separation Analysis

During Tier I and Tier II the City constructed a significant amount of sewer separation projects to achieve CSO reduction throughout the City. In areas where sewer separation could not be easily constructed, particularly along the densely developed peninsula area, catch basin modifications and flow slipping was implemented in lieu of separation. Figure 8-2 shows the approximate location of the Tier I and Tier II sewer separation and flow slipping work. During the Tier III analysis, CDM Smith performed a conceptual review of sewer separation as the primary CSO control technology to meet the ultimate objectives of the LTCP. The analysis estimated that full separation of the Portland combined system would cost approximately $525 million.

However, as discussed in Section 7 and based on the review of sewer separation effectiveness in the Fall Brook area, this rather costly expenditure may not be sufficient to meet the water quality objectives set forth in the LTCP. Therefore, it was determined that future sewer separation work in the City will need to be carefully implemented and only in areas where it is deemed cost-effective or where the work can be completed in concert with other City or utility projects to meet multiple objectives. Pre- and post- construction monitoring is also recommended to closely review the results of each project prior to constructing the subsequent project.

Recommended Tier III Sewer Separation Areas

Figure 8-2 also shows locations where the City has indicated that potential sewer separation work could be completed in the Tier III program (shown as stars on the map). Generally, the project locations indicate areas where inflow enters the system through existing separated drainage that recombines into the combined system. In each case, sewer separation, or a combination of GI and sewer separation, could be implemented to remove this extraneous flow from the combined system.

Additionally, Figure 8-2 shows a targeted sewer separation area, which displays the proposed limits of work for gas main replacement by Unitil Corporation. Within the highlighted area, the existing sewer and water infrastructure has aged beyond its useful life and is due for replacement or rehabilitation. Hence, this area has been highlighted as a potential for implementation of sewer separation projects as generating a synergy between these four pipeline projects (sewer rehabilitation, water replacement, gas replacement, and drain installation) represents a unique opportunity for the City to share the costs with other utilities and implement a cost-effective sewer separation program. Implementation of GI in this area may also present an opportunity for further cost savings.

However, it should be noted that many of the potential project locations shown on Figure 8-2 are located in congested downtown areas of the City, which may complicate the construction and escalate project costs despite the potential synergies and cost savings that could be realized. Thus, it is recommended that the City undertake a preliminary study of the areas shown early in Tier III to determine the projects that represent the greatest opportunity for cost-effective CSO reduction.

8.5.2 System Optimization via Real-Time Controls

General

System optimization is identified as a first step to reduce sewer overflows in the EPA's August 2004 report, titled "*Report to Congress, Impacts and Control of CSOs and SSOs*." Real Time Control (RTC) is a prominent technology used to achieve system optimization. Where applicable, RTC systems enhance the use of existing assets and reduce the need to build new facilities to meet regulatory requirements. Thus, use of RTC can lead to significant reductions in capital improvement costs.

Real-time controls are intended to improve the operation of flow regulating devices through automation. RTC maximizes the use of existing pipeline conveyance, storage, and treatment capacities available in the system in order to:

- Reduce overflows;
- Reduce energy costs;
- Reduce the risk of flooding and/or sewer backups; and
- Improve the balance of flows at the downstream treatment facility.

Essentially, there are several different levels of RTC, which range from local control based flow or level measurements to complicated global control that is built into the WWTF Supervisory Control and Data Acquisition (SCADA) system.

Tier III RTC Analysis

A review of RTC technology within Portland's system did not reveal any substantive opportunities for reduction in CSO overflows. This is mostly due to Tier I and Tier II improvements whereby the City increased the existing pumping capacity at the India Street and Northeast Pumping stations. These upgrades allowed the City to take full advantage of the existing collection system capacity. However, it is anticipated that the storage facility proposed in the revised Tier II program will be controlled through automated gates and incorporated into the SCADA system. RTC of this conduit will allow for a greater level of CSO control as it can be paced against the wet weather flows that are being delivered to the EEWWTF from the entire collection system in order to effectively balance the storage of overflow against conveyance to the plant when capacity is available.

In Tier III, RTC opportunities will still be available to the City and PWD and will be considered in conjunction with areas where new facilities (storage or treatment) are proposed to maximize the capacity of the facilities and the existing interceptor system.

8.5.3 Tide Gates

The Portland sewer system includes several submerged outfalls that are subject to tidal fluctuations in the Portland Harbor, Fore River, and Back Cove. Section 2 discussed that climate change may result in an increase to the tidal response throughout New England. Therefore, it will be important for the City and PWD to continue to monitor its outfalls to ensure that all tide gates are in good working order to prevent inflow from entering the system and utilizing valuable capacity in the interceptor system. As discussed in Section 3.4, the collection system model showed a tidal response at CSO 016. Based on this response, the City and PWD should consider investigating the source of this flow and consider installation of a tide gate at this location to prevent any tidal inflow from entering the system.

8.6 Satellite Facility Consideration in Portland

General

Typically, satellite facilities are most effective if they can be constructed near a regulator structure to capture overflows as they occur, and to take advantage of existing regulating structures to divert overflows to the satellite facility and minimize piping and possible pumping requirements. In Portland, the remaining CSO structures generally are located in areas that have historical significance, recreational value, and/or commercial value due to tourism (Old Port area). Portland's waterfront is highly valuable and locating large empty parcels of land for satellite CSO facilities along the water and close to the CSO structures is becoming increasingly challenging. However, the revised Tier II program showed that conduit storage in City streets is a cost-effective method to mitigate this issue and will be considered for use in other focus areas in Tier III.

Satellite Treatment versus Storage

Typically, satellite treatment technologies have lower initial capital costs than satellite storage alternatives but the required operation and maintenance (O&M) costs and level of effort associated with treatment facilities is generally higher than storage. Additionally, obtaining regulatory approval of satellite treatment facilities, which provide only primary treatment and disinfection, may be challenging given the sensitivity to discharges in Back Cove, Fore River, Portland Harbor and Casco Bay. Storage facilities may also be considered more advantageous than satellite treatment facilities from a regulatory perspective since the captured design volume is eventually conveyed to the WWTF and receives a higher level of treatment. Thus, for the purpose of the Tier III analysis a preference was given to storage technologies for all satellite facilities located upstream of the EEWWTF and satellite treatment facilities were reviewed for a cost comparison only.

However, in the vicinity of the existing treatment facility, satellite treatment facilities act more like an extension of the existing WWTF and are preferred given that operational staff are located onsite, which would promote the maximum in ease of operation and maintenance. Further, the proposed discharge outfall can be located at or near the existing permitted plant outfall, which may be useful in negotiations to obtain a new outfall for the proposed wet weather facility. Finally, siting the new facility in and around existing processes would also promote the easy disposal of settled solids and not require the use of public land currently dedicated to other purposes. Thus, the Tier III analysis assumed that satellite treatment technologies in several sites on or near the EEWWTF, are a viable option for the City and PWD to consider.

8.7 Storage Technologies

8.7.1 Tunnel Storage

General

Storage of wet weather overflows in tunnels below ground is quickly becoming a more common method of dealing with CSOs across the world. Some communities are taking advantage of existing conduits, and many are constructing new storage tunnels for the sole purpose of reducing CSO discharges. Tunnels vary in depth and diameter, but most used for CSO storage tend to be very deep rock tunnels 100 to 200-feet below grade and have fairly large diameters, typically from 12 to 28-feet or more. Tunnels are relatively common and cost-effective solution for municipalities across the U.S. with large CSO volumes. Fall River, Massachusetts; Providence, Rhode Island; Chicago, Illinois; Milwaukee, Wisconsin; Atlanta, Georgia; and Portland, Oregon all have CSO tunnels. Many others have been constructed or are planned around the country.

The construction of a new deep rock tunnel would involve excavation of large diameter vertical access shafts likely up to 100 to 200-feet below grade for lowering and raising construction equipment, and then using a large diameter tunnel boring machine to bore horizontally through bedrock. The tunnel would be lined with concrete to prevent groundwater infiltration. Consolidation drop shafts would also be constructed as portals for consolidated CSO to enter into the tunnel for storage. A dewatering pump station would be required to keep the tunnel dry between storm events so that the storage volume is available when needed. Odor control and periodic flushing of sediments that may accumulate in the tunnel should also be planned for.

Tier III Tunnel Storage Analysis

In 2006, Brown and Caldwell performed a feasibility analysis for the City and PWD to review the elimination of the Franklin Street and India Street pump stations (*Feasibility Study of the Elimination of the City of Portland Franklin Street Pump Station and Portland Water District India Street Pump Station - Brown and Caldwell, 2006).* The study concluded that tunnel storage to accomplish elimination of the two pump stations was extremely costly, ranging from approximately $60 to $150 million (June 2011 dollars). It should be noted that this cost would only provide relief for the Back Cove (South) and Portland Harbor focus areas and additional expenditures would be required to meet the requirements of the LTCP in other areas. The study also concluded that near-surface storage in conveyance conduits would have a lower unit cost than tunnel conveyance. Thus, based on the findings from this study, tunnel storage was determined to be too costly to effectively control CSOs in Portland and was eliminated from the Tier III analysis.

8.7.2 Near-Surface Storage

General

Satellite storage facilities are designed to capture and hold overflow volumes until capacity is available in the interceptor system, at which time the tanks are dewatered back into the collection system for subsequent treatment at the WWTF. Storage facilities are relatively simple in design and operation, and can effectively reduce the frequency and volume of overflows. Typically, storage provided at a satellite facility consists of a below grade tank or conduit. Flow is diverted from the CSO regulator structure to the facility. Storage tank inverts are usually set so that flow enters by gravity, and may be

dewatered to the interceptor system using small pumps. In some cases, influent pumps are required to avoid deep excavations, though this is not preferred due to the costs associated with pumping.

Since storage facilities are designed to capture a specific design storm overflow volume rather than just treating and discharging flow, they are generally larger than treatment facilities. Due to their inherent purpose of detaining peak flows, storage facilities may also provide a degree of sedimentation treatment at flows greater than the design storage volume. In some cases, screens may be installed upstream of the tanks to remove large solids and floatables prior to capture in the storage tank. For the purposes of this report, screens will not be applied to storage facilities.

Ventilation and odor control is required for tanks, wet wells, and other areas exposed to sewage gases to prevent accumulation of potentially explosive or corrosive gases and to control moisture or condensation buildup.

Tier III Storage Analysis

The MDEP program guidance on CSO facility plans explicitly states that CSO discharges to receiving waters should not contain a first flush (which contains the highest concentrations of stormwater pollutants and represents the most significant impact on water quality), and thus conveying the first flush to the treatment facility should be a high priority of any CSO abatement plan. Accordingly, CDM Smith established capture of the first flush as a primary goal of the revised Tier II and Tier III programs. This is especially notable in the Back Cove and Portland Harbor focus areas, because upon full implementation of the LTCP an estimated 87 MG of overflow will be permitted to discharge during the typical year. Therefore, it is vital to ensure that the first flush is captured and conveyed to the EEWWTF to protect these receiving waters to the greatest extent practicable. To accomplish this, it is recommended that employment of both traditional subsurface storage facilities and more site specific storage conduits (which can consolidate multiple overflows and store the captured volume in a single storage facility) be included in the Tier III program.

- Subsurface storage facilities – Both the Capisic Brook and Fore River focus areas are required to fully eliminate overflows to these sensitive receiving waters during the typical year. To ensure that this will be accomplished, a subsurface storage facility sized using the existing collection system model will be included in the Tier III program. As discussed further in Section 9, greater than 90-percent of the overflow from these two focus areas is discharged from the Fore River Pump Station (033) CSO regulator. Thus, siting a storage facility in the open area adjacent to the pump station will effectively capture the overflow from these focus areas.

- Subsurface storage conduits – As stated above, upon completion of the LTCP, overflows to the Portland Harbor and Back Cove will persist. Thus, it was critical to develop a Tier III program that cost-effectively meets the goals for volume reduction, but also has a significant water quality benefit in storms that exceed the capacity of the facilities. Therefore, similar to the revised Tier II program discussed in Section 7, the Back Cove (West), Back Cove (South), and Portland Harbor focus areas are recommended to include a storage conduit sized to capture the first flush. The proposed conduits will detain the first flush volume until the collection system has available capacity and the flow can be sent to the EEWWTF. It is important to note that through this approach the facilities will be sized to capture the first flush for all storm events, regardless of the size of the storm. Further, the use of RTC for the storage conduits will provide

the City and PWD with greater control of their collection system, which will improve operations and potentially result in even greater CSO reductions.

8.8 Treatment Technologies

8.8.1 Satellite Treatment Technologies

General

Satellite treatment facilities are designed to remove or reduce pollutants from CSO discharges to levels consistent with water quality goals. In some cases, overflow volumes may be reduced as well, due to the increased storage capacity associated with some treatment technologies. In all cases, satellite treatment facilities must be designed for reliable and effective treatment of intermittent and highly variable influent flows and pollutant concentrations characteristic of CSOs.

Open Area Near Operations Building at EEWWTF

As previously discussed, satellite treatment technologies are only considered viable in Portland at or near the existing treatment facility. However, space is limited at the EEWWTF and while the original design anticipated the potential need for sewered growth and provided space for a future fourth treatment train, future regulations on nutrient limits will likely require the need for infrastructure expansion. Therefore, it would be prudent to preserve space to accommodate a potential future nutrient removal process in close proximity to the primary clarifiers, which will limit the available area for a wet weather facility to the parking lot area in front of the Operations Building at the plant. While not optimal (significant earthwork would be required depending on the ultimate size of the facility), it strives to keep the wet weather treatment facility on the treatment plant proper. Given that space is at a premium on this site, treatment technologies that can be fit on a compact site are preferred. High-rate clarification (HRC - also known as ballasted flocculation) is an efficient treatment technology and its systems result in a much smaller footprint than traditional settling systems. Thus, the Tier III analysis assumed that HRC and disinfection would be the technology utilized by the City for wet weather treatment at the WWTF.

High Rate Clarification Operation

In the HRC process, wet weather flows are mixed with a coagulant and then introduced into a mixing chamber where flocculants and ballast, such as microsand, are added and mixed. Flow then proceeds to a clarifier where the floc and polymers attach to the ballast and settle out of the water at a very high rate. This process produces a high level of total suspended solids (TSS) removal (70-90%) as well as high biochemical oxygen demand (BOD) removal of around 60%. The settled sludge, loaded with ballast, is continuously pumped from the bottom of the clarifier and recycled through concentrators that separate the ballast from the sludge. The separated sludge is then sent to waste while the ballast is recycled back into the process. Treated effluent is then disinfected (an ultraviolet light disinfection system is assumed on the back end of the treatment system) and released. Because of limitations in capacity of the outfall pipe, an additional outfall pipe will likely be required regardless of whether the facility is located onsite or is just offsite.

Tier III HRC Analysis

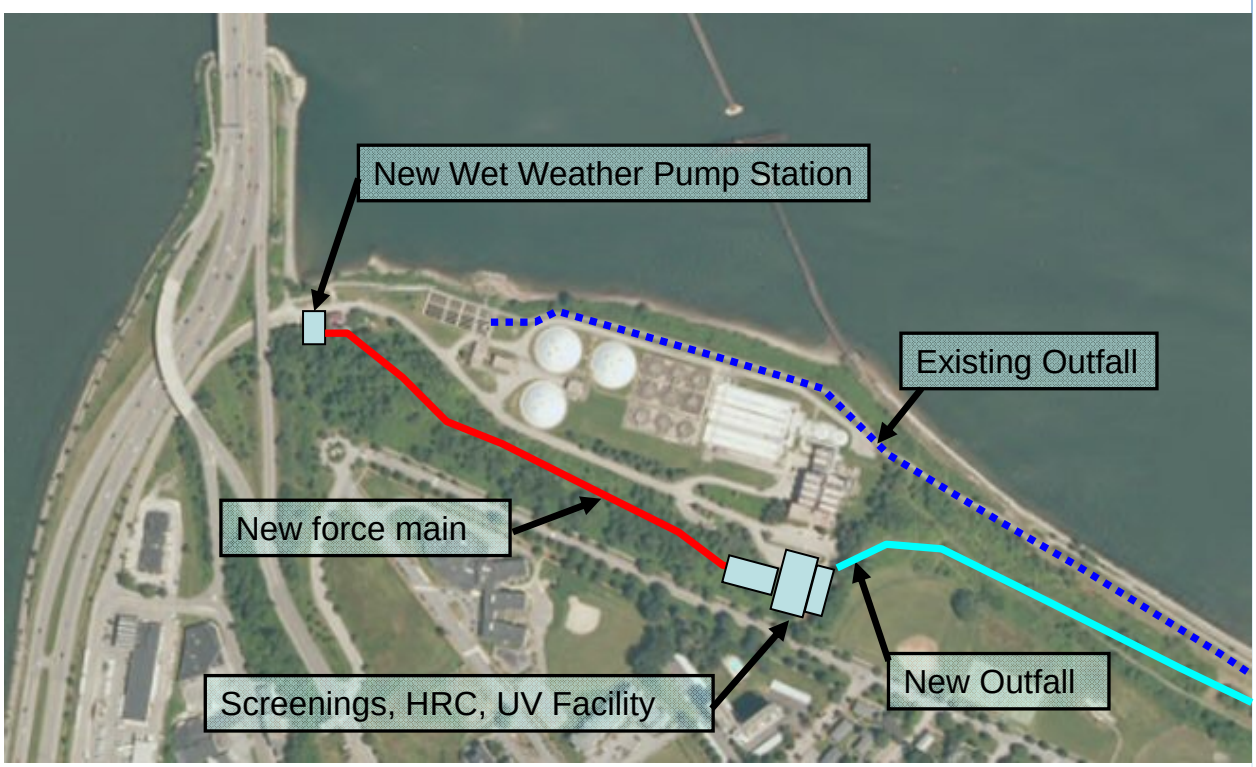
Figure 8-3 shows a schematic of the conceptual layout for a new HRC facility at the EEWWTF. To provide a benefit to all focus areas, construction of a new pump station near the Northeast pump station and upgrades to the India Street pump station (including pump upgrades, significant electrical service entrance/transformer upgrades, emergency power, and force main addition/replacement) would be required.

8.8.2 East End Treatment Facility Upgrades

General

The existing EEWWTF receives a peak wet weather flow of 80 MGD. This flow is derived from three sources: Northeast Pump Station; India Street Pump Station; and an interceptor on the Eastern Promenade. The facility currently limits secondary treatment to 36.8 MGD. Typically, for a short period of time the facility can receive up to 40 MGD before reducing secondary treated flows. The remaining flow receives primary treatment, bypasses the secondary treatment system, is chlorinated as it passes through a dedicated bypass CCT, is dechlorinated and then combined with secondary treated effluent before being discharged off the East End beach.

Figure 8-3
Conceptual Layout of a New HRC Facility at the EEWWTF



Tier III WWTF Improvements Analysis

Currently, mechanical surface aerators provide dissolved oxygen for the biological process, which is an inefficient way to meet the oxygen demands of the system, and this limits the amount of flow that can receive full secondary treatment. Upon review of the existing secondary treatment system, retrofit to fine bubble aeration and the incorporation of an anaerobic selector could increase secondary

treatment capacity to as much as 65-70 MGD. This increase in secondary treatment capacity could allow for an increase in peak wet weather flows from 80 MGD to somewhere in the range of 105-110 MGD (including bypassed flow, which receives primary treatment and disinfection) without the need for a new separate dedicated wet weather treatment system.

However, this concept has several limitations to accepting such a flow including:

- Pump station upgrades: Capacity upgrades at either the Northeast pump station, India Street pump station, or both. It should be noted that these stations were upgraded (new controls and pumps) within the last few years. Any significant upgrade to these stations could include electrical service entrance and transformers, emergency power, force main replacement and pump upgrades. Depending upon the magnitude of the upgrades, whole pump station replacement could be contemplated, considering the stations are approaching 35 years old and the constructability issues associated with extensive retrofitting.

- Headworks facility: The existing headworks facility (screenings and grit removal) could handle up to 100 MGD but would result in a loss of redundancy at high flows as all three screens would need to be operational, as would both vortex grit removal systems. Flows greater than this would require assessment of influent hydraulics and may require a new headworks/grit removal facility ahead of the existing Process Building.

- Primary clarification: The primary clarifiers currently have satisfactory surface overflow rates (SORs) at current peak flows of 80 MGD with three clarifiers online. However, flows in excess of 100 MGD will exceed typical design standards for surface overflow rate and will likely require chemically enhanced primary treatment (CEPT) to maximize removal efficiencies at these peak flows. Current practice of CEPT uses metal salts (ferric chloride and polyaluminum chloride) in combination with polymer addition, and includes the use of rapid mix and flocculation prior to the settling tank. Thus, new chemical storage and feed facilities and a flocculation chamber would be required.

- Secondary Clarification: At higher secondary treatment capacities of 65-70 MGD, SORs will approach the high end of industry standards and considerations will need to be given for possible polymer addition during peak flows to maximize settling or installation of a fourth clarifier. As previously discussed, space was provided onsite for a future fourth clarifier in the original space planning, which would make this a viable option.

- Outfall pipe: The current outfall pipe is limited in capacity during the design condition of 80 MGD discharge at the 100 year flood plain level. An increase in capacity at the plant will require a larger outfall pipe to be constructed or a second pipe parallel to the existing one. This may prove to be a challenging task from a permitting perspective given its proximity to the East End Beach.

- Nitrogen Limits: At present the facility does not have a total nitrogen limit but one is likely coming in the next 2-3 years. Adding a total nitrogen requirement to this facility will effectively reduce the capacity gains of the facility for straight BOD/TSS removals outlined above. Thus, it will be important to understand the implications of nutrient removal requirements on existing infrastructure and space limitations for new tankage. It is very possible that with a nitrogen

limitation the original maximum capacity could be held including the addition of another aeration basin. As such, it would be prudent to determine what nutrient criteria are associated with the facility.

8.8.3 Treatment Technologies Conclusion

Although potential exists to provide secondary treatment to more flow through aeration system/process configuration upgrades, with the State's directive to Maine DEP to establish nutrient criteria for Casco Bay by 2012, it is quite likely that the largest discharger to the Bay will be given a total nitrogen limit. In this event, process configuration modifications will likely not result in the ability to process more peak flow through the treatment system than presently exists. Thus, for the purpose of the Tier III analysis it is assumed that any WWTF capacity increases will be accomplished through the installation of satellite (on-site) HRC. It is estimated that 20 MGD of additional wet weather capacity will be required to meet the reduction goals of the LTCP (in conjunction with other CSO reduction components discussed in Section 9). Project cost for the HRC facility, disinfection, pump station and force main, and outfall is estimated to cost $45 million (June 2011 dollars)

8.9 Cost Estimates

8.9.1 Sewer Separation Costs

An evaluation of recent construction costs for the City's Tier I and Tier II sewer separation projects was conducted to develop a conceptual-level estimate for the Tier III analysis. Over 50 individual construction contracts were analyzed to develop a generalized construction cost for the entire City. The analysis showed that sewer separation costs range from $17,000/acre up to $430,000/acre, with an average construction cost of $125,000/acre. This value is consistent with sewer separation costs used in the development of other LTCPs in similar New England communities, and thus was used as the basis for the conceptual cost analysis of the focus areas. Table 8-4 shows the cost assumed in each of the focus areas of the City for sewer separation.

Table 8-4
Sewer Separation Cost Assumptions

Tier III Focus Area	Separation Cost ($/acre)
Back Cove (North)	$125,000
Back Cove (West)	$125,000
Back Cove (South)	$150,000
Capisic Brook	$125,000
Fore River	$125,000
Portland Harbor	$200,000

The table shows that the baseline cost was applied in four of the six focus areas, which is appropriate given the majority of the costs analyzed came from Tier II projects constructed in these areas. An additional cost factor was added to the Back Cove (South) and Portland Harbor focus areas to account for the escalated construction costs expected in these areas based on the congestion of utilities in the more urban areas of the City. However, although this general approach is a good way to estimate separation costs on a large-scale, it is expected that costs will vary throughout the City, and

construction estimates for the individual projects that were discussed in Section 8 will require a more refined cost analysis during the early stages of the Tier III program.

8.9.2 Satellite Facility Costs

Costs for satellite facilities were derived using EPA cost curves, cost data from recent CSO construction projects, and other New England LTCPs. All costs were adjusted to June 2011 dollars using ENR construction indices. An appropriate cost curve for each technology was selected based on the best fit of recent data and expected conditions in Portland. The cost curves used for this project can be found in Appendix H. Additional cost considerations/assumptions include:

- Where required, pumping costs were added to the facility costs;
- Project costs represent construction cost estimates and a 45-percent allowance for engineering and contingencies. This allowance includes design, permitting, construction oversight, survey work, geotechnical work, obtainment of easements, legal fees, bonding, and administrative needs;
- Costs for land acquisition and potential contamination issues associated with individual sites are not included in the cost estimates;
- Archeological investigations are not included in the capital costs, because it is unlikely that they will be required; and
- Annual O&M cost estimates associated with CSO facilities were not included in the assessment of cost-effective structural solutions given the City's preference for storage facilities. This was considered an acceptable approach given that O&M costs are difficult to predict because of the intermittent use of CSO treatment/storage facilities and thus would not be a key element of the alternatives analysis.

8.9.3 Storage Conduit Cost Estimates

Cost estimates for proposed storage conduits were handled differently than the traditional satellite storage facilities discussed above because it is not anticipated that the attendant facilities (access building, pumping, odor control, washing requirements, etc.) will be required for a buried concrete storage conduit. Given that concrete box culverts will be used as the basis of all storage conduits, costs were estimated based on length and a unit cost per linear foot. Unit costs were developed through review of similar recent construction projects in Maine and other New England communities.

8.10 Conclusions

The bullets below provide a brief summary of the Tier III improvements analysis and provide the basis of the recommended alternatives that are discussed in Section 9.

- BMPs - The City has an effective BMP program in place, which is in compliance with the Agreement and Maine CSO regulations. This program will continue during the implementation of the Tier III improvements and no further enhancements are recommended.

- Green Infrastructure – Widespread use of GI as a single solution to CSO control is not viable in Portland due to subsurface infiltration constraints. However, these technologies have not been dismissed and will be used selectively around the City where appropriate, particularly in conjunction with the sewer separation program.

- Sewer Separation - Sewer separation has proven to be less effective as a CSO control measure in the Back Cove (North) focus area than initially predicted. Moving forward, this control technology will be used selectively in areas of the City where it can be proven cost-effective and implemented in conjunction with other City initiatives such as sewer rehabilitation, gas main and water main replacement, and roadway reconstruction. Further, wherever possible, the use of GI will be integrated into the sewer separation program to reduce the size of new drainage infrastructure as a means to offer cost-effective savings while providing a tangible above-ground visual benefit to the rate payers.

- Satellite Facilities - Satellite facilities upstream of the EEWWTF will utilize storage technologies to limit operations and maintenance requirements and the discharge of treated overflow (that has only received primary treatment and disinfection) to the sensitive receiving waters in the City. In the vicinity of the EEWWTF, additional treatment capacity improvements will utilize HRC technologies given the high level of efficiency and limited land area required to site a facility. In general, storage facilities will be sized to effectively capture the first flush from every rain event, which will result in a significant improvement in water quality to the receiving waters.

- Storage Facilities – Storage facilities, like that recommended for Tier II, will be the primary element of Tier III improvements. Section 9 will detail the specifics of these facilities and how they integrate with other recommended improvement projects.

Section 9

Tier III Recommendations

9.1 Introduction

The purpose of this section is to provide the recommendations for the Tier III CSO Long Term Control Plan resulting from the analyses conducted during this study. The recommendations provide a plan for the City and PWD that is flexible and adaptive that will meet the goals established in the original 1993 LTCP as well as the terms in the current administrative consent agreement and enforcement order (agreement). The City, PWD, and CDM Smith engaged the various stakeholders on the project, including the water quality advocates and the business community, as well as the Maine Department of Environmental Protection (MDEP) to provide input into the CSO program. The City, PWD and CDM Smith worked closely to structure a program that is cost-effective in managing CSO discharges to best protect water quality as well as public health.

The primary metrics used to develop the program include:

- Capture First Flush – first 1" of rainfall should be captured and ultimately treated to a secondary level at the EEWWTF. The first flush typically contains approximately 80 percent of the storm volume and approximately 90 percent of the pollutants (TSS, TP, Zn, etc.) transported by the runoff according to a recent U.S. EPA report - *U.S. EPA, (2010), Stormwater Best Management Practices (BMP) Performance Analysis, Region 1, prepared by TetraTech.*

- Provide Flexibility – include 5-year updates to the LTCP and consider other regulatory drivers (e.g. potential upcoming stormwater regulations, climate change, etc.)

- Reduce volume of overflows - 88% reduction from 1993 LTCP estimates for typical year discharges

- Consider storage as a primary element of the plan – storage provides the largest water quality benefit because urban wet weather flows are captured and treated at the EEWWTF (Tier II - storage replaced separation as the most cost-effective approach to managing CSOs)

- Initial Focus on Back Cove – due to most concentrated number of CSO outfalls by receiving water and high visibility to public (e.g. running trail, events, etc.)

- Integrate improvements with upgrade/replacement schedule for major facilities (e.g. pump stations, EEWWTF)

- Provide for much needed replacement of the aging infrastructure

The alternative technologies considered for the Tier III program include storage, sewer separation, treatment (both WWTF upgrades and High Rate Clarification – HRC), and green infrastructure (GI). Typically, programs of the magnitude of Tier III require a combination of these alternative technologies, which is described further in this section.

Table 9-1 presents the individual overflows which will need to be managed under Tier III. This table details the overflow volumes and frequencies that can be expected at the end of Tier II.

Table 9-1
Estimated Annual CSO Volume Reductions by CSO Outfall

Receiving Water	CSO Outfalls[1]	LTCP 1993 CSO Volume (MG)	Existing 2009 CSO Volume (MG)	Tier II CSO Volume at Completion (MG)	Tier III CSO Volume at Completion (MG)	LTCP 1993 CSO Volume at Completion (MG)[5]
Casco Bay		***57***	***19***	***18***	***8***	***0***
	001	0.2	CLOSED			
	002	1.8	0.0	0	0	0
	004	0.0	0.0	0	0	0
	020	54.0	19.2	18.0	7.8[6]	0
	021	1.1	CLOSED			
Back Cove Total		***416***	***273***	***175[2]***	***36***	***70***
Back Cove (North)		*201.6*	*67.0*	*7*	*7*	*0*
	005	100.0	5.3	7	7	0
	006	1.6	21.2			0
	007	100.0	40.5			0
Back Cove (West)		*57.9*	*78.1*	*43.9*	*16*	---
	008	4.1	0.1	0.1	16	0
	009	0.0	0.0	0.0		0
	010	8.2	6.8	5.2		70
	011	0.6	0.2	0.2		
	012	26.0	23.2	18.8		
	013	4.6	0.2	0.1		
	014	0	0	0.0		
	015	0.4	7.9	7.9		
	016	14.0	39.7	11.6		
Back Cove (South)		*156.2*	*127.5*	*123.7*	*13*	
	017	110.0	99.2	95.8	13	
	018	46	28.1	27.6		
	019	0.2	0.2	0.3		0

Table 9-1 (Cont'd)
Estimated Annual CSO Volume Reductions by CSO Outfall

Receiving Water	CSO Outfalls[1]	LTCP 1993 CSO Volume (MG)	Existing 2009 CSO Volume (MG)	Tier II CSO Volume at Completion (MG)	Tier III CSO Volume at Completion (MG)	LTCP 1993 CSO Volume at Completion (MG)[5]
Portland Harbor		***145***	***59***	***59***	***43[4]***	***17***
	023	27.0	3.0	3.0	3.0	17
	024	1.7	8.0	8.0	8.0	
	025	79.0	42.0	42.0	17.5[7]	
	026	1.2	2.6	2.6	14.1[7]	
	027	11.0	0.2	0.2		
	028	21.0	3.0	3.0		
	029	3.9	0	0.0		
Fore River		***5***	***3***	***48[3]***	***0***	***0***
	030	3.5	0.1	0.1	0	0
	031	CLOSED				
	032	0.8	1.6	1.6	0	0
	033	0.1	0.0	45.0	0	0
	034	0.2	0.1	0.1	0	0
	035	0.2	CLOSED			
	039	0	1.3	1.3	0	0
Capisic Brook		***97***	***63***	***0[3]***	***0***	***0***
	036	68.0	45.0	CLOSED – WSI Routes Flows to CSO 033		
	037	CLOSED				
	038	4.4	CLOSED			
	040	0	CLOSED			
	041	0.4	CLOSED			
	042	19.0	18.0	0	0	0
	043	5.6	0.1	0	0	0
Total		720	416	300	87	87

Notes:

(1) CSO outfalls remaining (currently reported to DEP).

(2) Includes reduction of CSO due to existing faulty tide gate.

(3) Combined flow to CSO 036 is now routed to CSO 033 on Fore River through the new West Side Interceptor (WSI) and overflow is closed. Also assumes CSO's 042 and 043 will be eliminated if planned separation projects are completed by 2014.

(4) Further reduction of CSO to Portland Harbor could be realized depending on effectiveness of green infrastructure and/or sewer separation in areas draining to CSO's 023, 024, and 025.

(5) CSO Volume at Completion values obtained from 1993 LTCP.

(6) Entire Back Cove watershed drains to this pump station. Therefore, this overflow volume may be less than reported above depending on the operations of the three storage conduits.

(7) Operation of a new storage facility along Portland Harbor could divert more flow into the facility than just overflow from CSOs 026, 027, 028, 029, and 030 to provide additional solids capture and total overflow reductions to the Harbor. This operational strategy will decrease overflows from CSO 025 by 24.5 MG while only increasing overflows from the storage facility by 11.5 MG providing a significant net benefit.

9.2 Back Cove (North)

Much of the Tier II program focused on CSO reduction projects in the Back Cove (North) focus area, which resulted in a significant reduction in overflow volume from the 005,006, and 007 regulators. The collection system model predicts that an estimated 7 MG of overflow will remain in the typical year of rainfall, from all three regulators, upon completion of Tier II and construction of the Back Cove (North) storage conduit as discussed in Section 7. Thus, given the amount of projects that have been concentrated in this area to-date, and the analyses conducted as part of this study, it is not expected that significant cost-effective CSO reduction projects remain and it would be prudent for the City to concentrate its Tier III efforts in the Back Cove (West) and Back Cove (South) focus areas to achieve the required reduction in overflow to the Back Cove (e.g. separation of Ocean Ave at Morse Street with storm drain to Back Cove).

9.3 Back Cove (West)

9.3.1 General

As shown in Figure 9-1, the layout of the Back Cove (West) focus area is somewhat unique given that nine CSO regulators provide relief for the 24-inch Baxter Boulevard interceptor, which spans a distance of approximately one mile. The capacity of this interceptor is limiting and provides a challenge to capture the first flush volume for each of these regulators. As discussed in Section 8, this focus area will follow the approach established in the revised Tier II program for the Back Cove (North) focus area, whereby a new storage conduit will be installed to provide additional interceptor capacity, eliminate the first flush from each of the Back Cove (West) regulators (see Table 9-1), and reduce the volume of CSO discharged to the Back Cove.

9.3.2 Alternatives

Sewer Separation – A number of GI/sewer separation projects were identified in Section 8 for the Back Cove (West) focus area. However, sewer separation as a primary means of CSO control is not practical due to the limited capacity of the 24-inch Baxter Boulevard Interceptor and the Baxter Boulevard Pump Station. Model results suggest that separating the remaining 540 acres of combined area (estimated at $67.5 million) would not reduce wet weather flows enough to effectively reduce overflow volumes in keeping with the LTCP goals. Therefore, the GI/sewer separation projects identified could be completed as an enhancement to the capacity improvements to the interceptor and/or pump station to provide additional CSO reduction. Further, it is recommended that the City perform an analysis early in the Tier III program to identify which projects identified in this focus area are the most cost-effective and consider their implementation in concert with the proposed capacity improvements discussed below.

- Storage – It is recommended that approximately 5,500 feet of new 12-foot wide by 7-foot high box culvert be installed to capture overflow from the Back Cove (West) focus area at an estimated project cost of $22 million (June 2011 dollars). This conduit will provide approximately 3.5 MG of storage, which is nearly 2 MG beyond the volume required to capture the first flush for these CSOs. Further, model simulations predict that this conduit will reduce CSO volume and frequency for the nine CSOs in the focus area by almost 90-percent in the typical year, which exceeds the overall LTCP goals. It is important to note that RTC and operations of the Back Cove conduits will need to be further refined during the Tier III program to ensure optimal operation of all three conduits in concert to achieve the reductions predicted herein.

Legend

- 007 CSO and NPDES #
- PS Pumping Station
- Separated Areas

CSO Focus Areas

- Back Cove (N)
- Back Cove (W)
- Back Cove (S)
- Portland Harbor
- Fore River
- Capisic Brook

N W E S

0 750 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Back Cove (West) Focus Area
Figure 9-1

9.4 Back Cove (South)

9.4.1 General

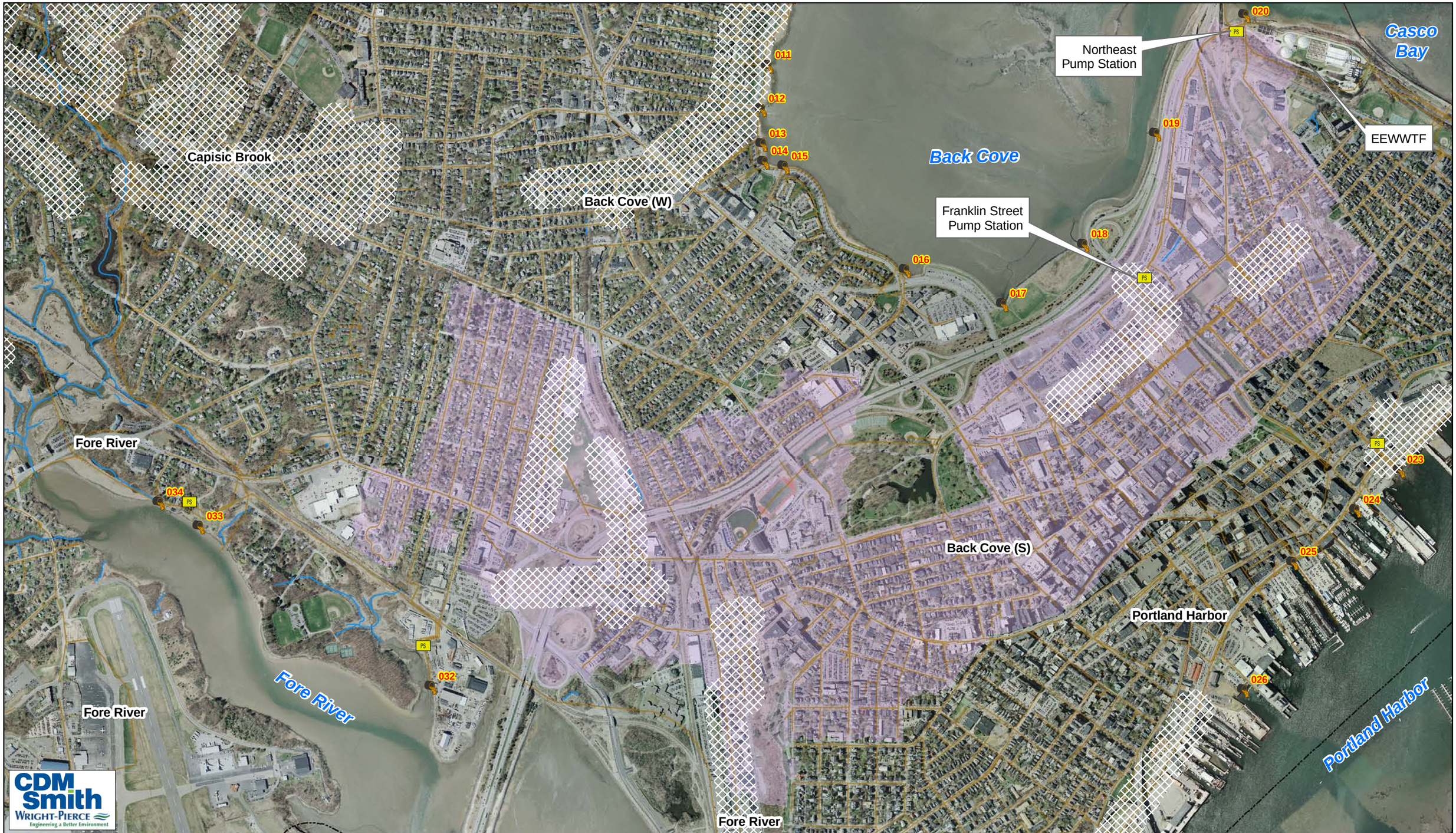
Figure 9-2 shows the limits of the Back Cove (South) focus area, sewer separation projects completed during Tier I and Tier II, and the location of the Franklin Street Pump Station, Northeast Pump Station and EEWWTF. It should be noted that improvements to this focus area will eliminate overflows from the Northeast Pump Station (020) to Casco Bay. As shown in Table 9-1, the Back Cove (South) focus area represents 41% of the remaining overflow volume in the City. Controlling this volume represents a significant challenge for the City and PWD, especially given focus on development in the Bayside area. Section 8 noted that the preferred alternative for this focus area will be a storage conduit connecting CSO 007 to 020. Installation of this conduit will likely be more challenging than other conduits recommended throughout the city because of the presence of other subsurface utilities that may be in conflict along the highly developed Marginal Way.

Although construction of the proposed storage conduit may be challenging and disruptive, it is important to note that a key advantage of the project, in addition to CSO reduction and water quality benefits, is the elimination of the Franklin Street Pump Station. This station has reached the end of its useful life and requires a significant capital investment to ensure continued reliable service. The City has expressed interest in eliminating this station, and it thus was a secondary objective of the Tier III program. This station only provides a low lift of sewage flows, and thus can be easily eliminated by installing the proposed conduit slightly lower.

9.4.2 Alternatives

- Sewer Separation – A number of GI/sewer separation projects were identified in Section 8 for the Back Cove (South) focus area. However, sewer separation as a primary means of CSO control is not considered practical due to the high cost associated with separating the remaining 670 acres of combined area (estimated at $100.5 million). Further, extensive sewer separation would represent significant disturbance in the Bayside area, which is an important commercial area for the City. Therefore, the GI/sewer separation projects identified would need to be completed as an enhancement to the storage conduit project. Additionally, it is recommended that the City perform an analysis early in the Tier III program to identify which projects identified in this focus area are the most cost-effective and consider their implementation in concert with the proposed capacity improvements discussed below.

- Storage – It is recommended that approximately 5,300 feet of new 10-foot wide by 8-foot high box culvert be installed to capture overflow from the Back Cove (South) focus area at an estimated project cost of $21.5 million (June 2011 dollars). This conduit will provide approximately 3.2 MG of storage, which model simulations predict will eliminate the first flush from this focus area and reduce overflow volume from approximately 150 MG annually to 18 MG in the typical year. This equates to a reduction of overflow volume of 88-percent, which is consistent with the overall LTCP goals. Further, as discussed previously, elimination of the Franklin Street Pump Station will be possible through the construction of the new slightly deeper storage and conveyance conduit. It is important to note that real time controls (RTC) and operations of the Back Cove conduits will need to be further refined during the Tier III program to ensure optimal operation of all three conduits in concert to achieve the reductions predicted herein.



CDM Smith
WRIGHT-PIERCE
Engineering a Better Environment

Legend

007 CSO and NPDES #
PS Pumping Station
Separated Areas

CSO Focus Areas

Back Cove (N)
Back Cove (W)
Back Cove (S)
Portland Harbor
Fore River
Capisic Brook

N W E S

0 750 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Back Cove (South) Focus Area
Figure 9-2

9.5 Portland Harbor

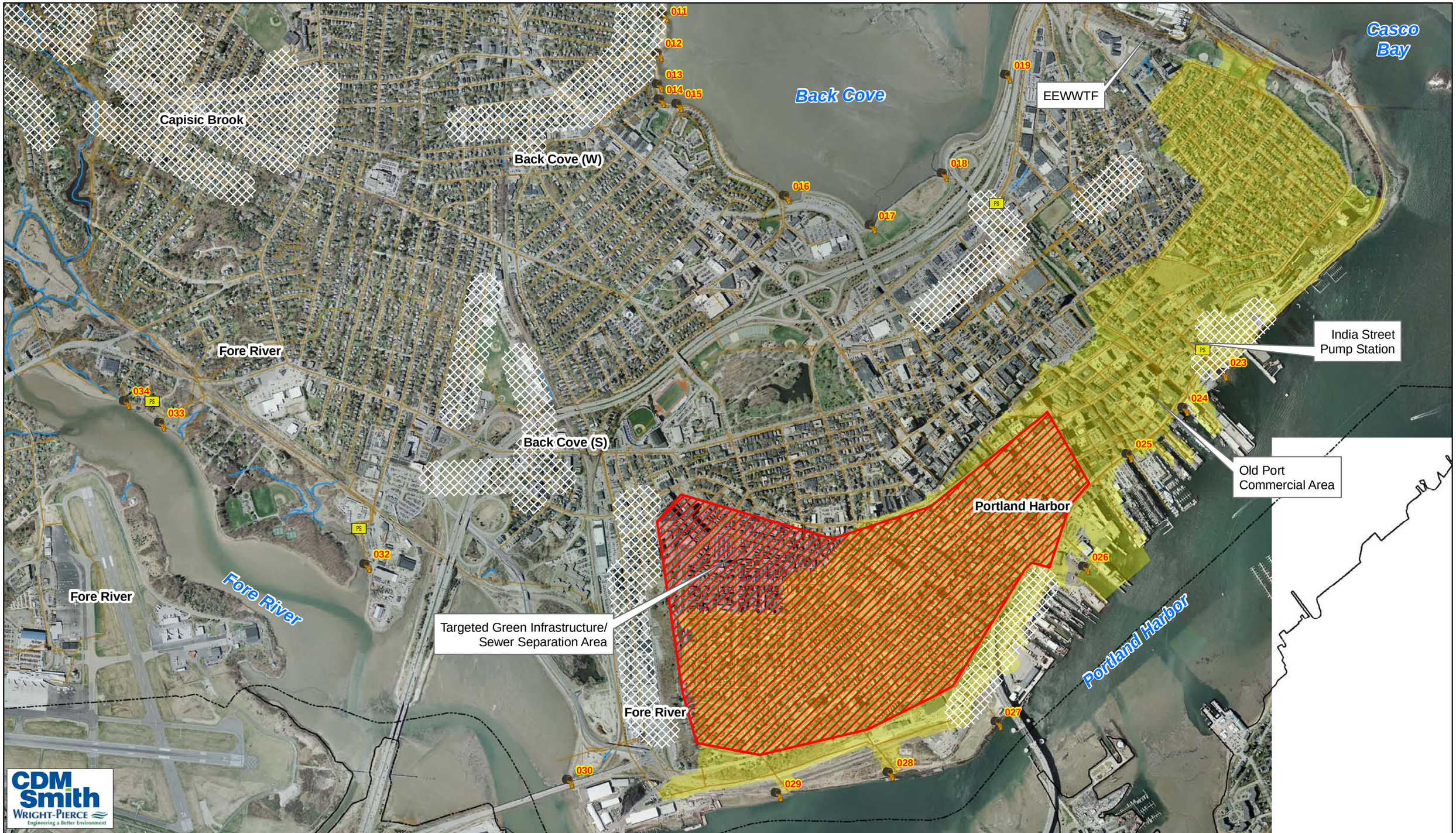
9.5.1 General

Figure 9-3 shows the limits of the Portland Harbor focus area, sewer separation projects completed during Tier I and Tier II, the location of the India Street Pump Station, and EEWWTF, and the area of proposed targeted sewer separation. Also shown on Figure 9-3 is the densely developed Old Port District, located along Portland's historic waterfront. Old Port is a vital element of the City's tourism and commerce and thus any disruption in the waterfront areas will be politically sensitive and expensive. Thus, a goal of the Tier III planning process was to develop alternatives that meet the objectives of the LTCP to the maximum extent practicable while minimizing disruptions to this critical area of the City.

Section 8 noted that the preferred alternative for this focus area will be a storage conduit extending from just west of CSO 029 to west of CSO 026. In keeping with the goal stated above, the location of the conduit is strategically placed to minimize disruption to the Old Port area. The targeted sewer separation area shown on Figure 9-3 represents the proposed limits of work for gas main replacement by Unitil Corporation. Within the highlighted area, the existing sewer and water infrastructure has aged beyond its useful life and is due for replacement or rehabilitation. Hence, this area has been highlighted as a potential for implementation of sewer separation projects in order to generate a synergy between these four pipeline projects: sewer rehabilitation, water replacement, gas replacement, and drain installation. This represents a unique opportunity for the City to share the costs of road reconstruction with other utilities and implement a cost-effective sewer separation program while minimizing the overall interruptions to the City businesses, residents, and visitors and avoiding multiple construction projects within the same streets. Implementation of GI in this area may also present an opportunity for further cost savings and provide high visibility for the City's GI initiative.

9.5.2 Alternatives

- Sewer Separation – As discussed above, several areas in the Portland Harbor focus area have been identified as candidates for sewer separation. However, sewer separation in this focus area must be approached with caution as it is not expected to be a cost-effective means of CSO control due to the densely developed urban setting and presence of bedrock near the ground surface throughout much of the peninsula. Additionally, model results suggest that separating the remaining 560 acres of combined area (estimated at $112 million) would not reduce wet weather flows enough to effectively reduce overflow volumes in keeping with the LTCP goals. Therefore, the GI/sewer separation projects identified would need to be completed as an enhancement to the conduit storage discussed below. Further, given that it is anticipated that several of the targeted sewer separation projects will be implemented in the Portland Harbor focus area early in the Tier III program, it is recommended that the effectiveness of these projects be closely monitored to refine the design of the proposed storage conduit discussed below.



CDM Smith
WRIGHT-PIERCE
Engineering a Better Environment

Legend

007 CSO and NPDES #
PS Pumping Station
Separated Areas

CSO Focus Areas

Back Cove (N)
Back Cove (W)
Back Cove (S)
Portland Harbor
Fore River
Capisic Brook

N W E S

0 1250 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Portland Harbor Focus Area
Figure 9-3

- Storage – It is recommended that approximately 5,000 feet of new 10-foot wide by 8-foot high box culvert be installed to capture overflow from the Portland Harbor focus area at an estimated project cost of $20.0 million (June 2011 dollars). This conduit will provide approximately 3.0 MG of storage, which is sized to eliminate the first flush from this focus area and reduce overflow volume to the Portland Harbor by approximately 16 MG in a typical year. RTC operations of this conduit will need to be closely analyzed in conjunction with controls for the India Street Pump Station to ensure optimal operation. Additionally, it is anticipated that implementation of a combination of green infrastructure and sewer separation projects discussed above may be necessary to effectively eliminate the first flush from all CSO regulators in the focus area. It is recommended that a detailed analysis of this focus area be completed during the design of targeted sewer separation projects that are anticipated early in the Tier III program.

9.5.3 Portland Harbor Reductions

Model simulations suggest that Tier III efforts in this area will fall short of the 17 MG goal established in the LTCP by approximately 26 MG in the typical year of rainfall. However, these simulations include conservative assumptions and do not account for two key program components, regulator modifications and sewer separation, in an effort to not over-predict the reductions expected from these controls. During the implementation of the Tier III program, the scope of these components, as described further below, will be further refined to ensure the most cost-effective projects are selected to enhance the proposed improvements in the Portland Harbor focus area and ultimately meet the requirements of the LTCP:

- The modeling analysis conservatively does not account for reductions that will be realized from the implementation of GI/sewer separation projects throughout the City, and particularly in the Portland Harbor focus area. This is because until a detailed study has been completed early in the Tier III program, the scope of work is unknown within each focus area, as only the most cost-effective projects will be implemented. Further, the effectiveness of implementing sewer separation to reduce CSO volume in the Portland Harbor focus area has not been studied to-date, and thus it is prudent to implement an initial pilot project, monitor its success, and then forecast anticipated reductions to other similar projects. Periodic reviews that will be submitted to MDEP will provide details of the program and will summarize any adaptations that may or may not be required to keep the program on-course to meet the LTCP objectives.

- Until the scope of sewer separation/GI is defined, a detailed analysis of the required adjustments of individual CSO regulators in the Portland Harbor focus area cannot be completed. Therefore, it is recommended that study of the regulators be included in the design of the Tier III Portland Harbor focus area improvements to identify cost-effective savings that may be achieved through low-cost modifications such as weir adjustments.

Intrinsic to the overall program goals to capture the first flush and reduce overflow volume by 88-percent, the Back Cove control measures are predicted to exceed the LTCP goal for that receiving water by 30 MG (40 MG discharged during the typical year of rainfall as opposed to 70 MG). When totaled with the Portland Harbor reductions, the overarching goal of no more than 87 MG of total CSO discharged to the Back Cove and Portland Harbor will be met for the typical year of rainfall. As GI, sewer separation projects and regulator modifications are incorporated and accounted for later in the

Tier III program, it is expected that ultimately the goals for the program will be exceeded as the individual goal for the Portland Harbor is achieved. As the program progresses, periodic reporting updates that will be built into the program will keep the MDEP apprised of the progress being made and will serve to inform PWD of any adjustments that may be necessary to ensure compliance.

9.6 Capisic Brook/Fore River

9.6.1 General

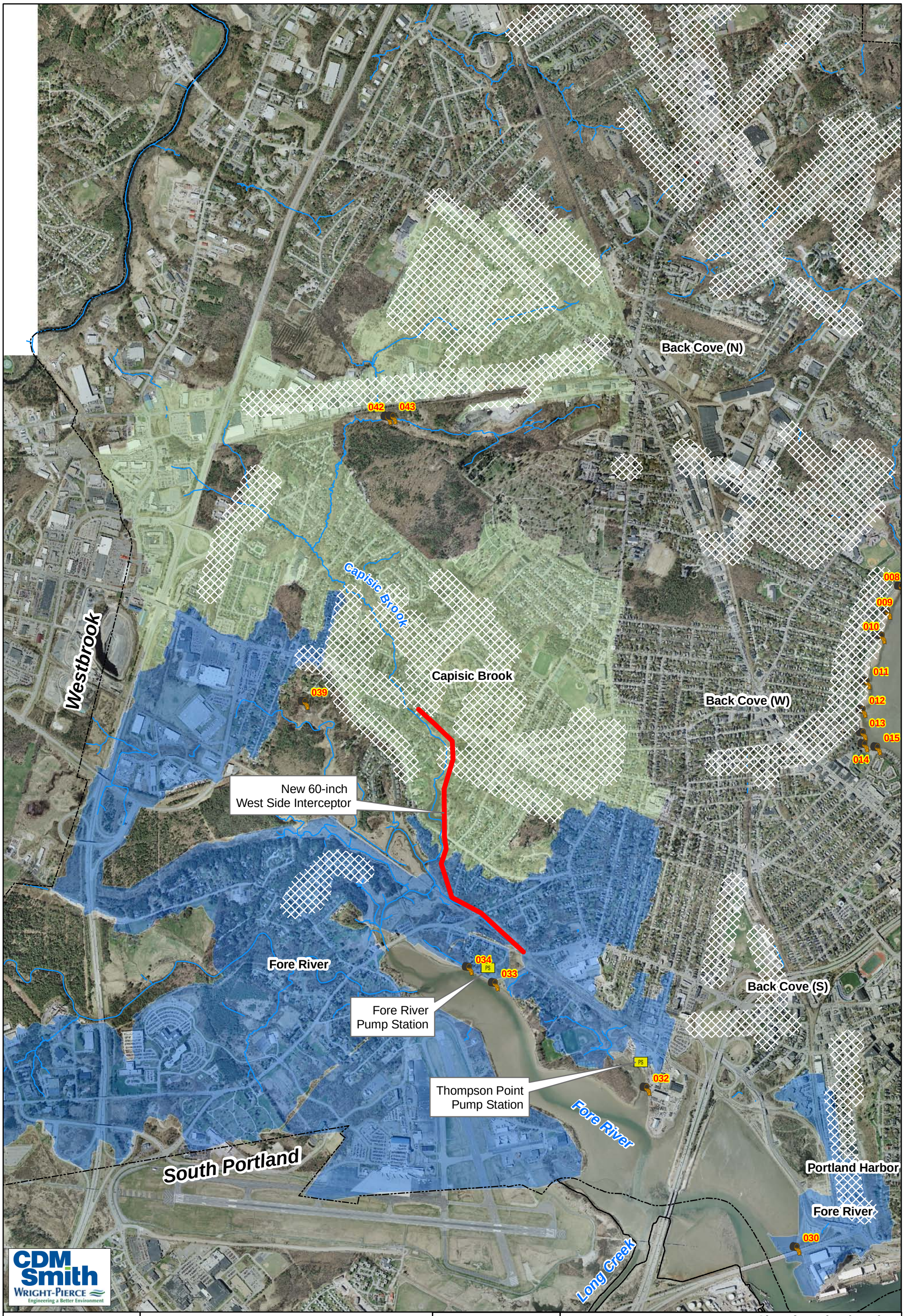
The Capisic Brook and Fore River focus areas are grouped together in this section because the West Side Interceptor project that was recently constructed essentially transfers all overflow volume from CSO 036 (Capisic Brook focus area) downstream to CSO 033 (Fore River focus area). Thus, improvements in either area will result in CSO reduction benefits for both areas. Table 9-1 displays the annual CSO discharge volumes in a typical year for each regulator in the two focus areas, and as noted previously the LTCP target is to fully eliminate CSO discharges to the Capisic Brook and Fore River areas during the typical year. Figure 9-4 shows the limits of each focus area, sewer separation projects completed during Tier I and Tier II, and the West Side Interceptor project.

9.6.2 Alternatives

- Sewer Separation – The sewer separation work conducted in Tier I and Tier II is anticipated to effectively eliminate overflow 042 and 043 in the typical year. Upon completion of the Tier II sewer separation work in this focus area, and as the Tier III program is implemented, it is recommended that these overflows be monitored to ensure that the sewer separation work achieves the requirements of the LTCP. As shown in Figure 9-4, much of the Capisic Brook focus area will be separated upon completion of Tier II and model results suggest that fully separating the remaining combined area (estimated at ~$90 million) may not fully achieve the requirements of full elimination to Capisic Brook and Fore River during the typical year. Thus, sewer separation in these focus areas will only be implemented if cost-effective combinations of GI/sewer separation projects are identified in the study of projects identified in Section 8.

- Storage – As discussed in Section 8, the LTCP goal for these focus areas is to eliminate CSO discharges during the typical year of rainfall. A traditional subsurface storage facility was selected as the preferred CSO control alternative. Model results predict that a 5 MG storage facility, located adjacent to the Fore River Pump Station, will successfully meet the objectives of the program. Estimated cost for the facility is $35.5 million.

- Regulator Modifications – The storage facility discussed above will only provide CSO control for regulators 033 and 034, which will leave 030, 032 and 039 contributing small overflow volumes during the typical year of rainfall, which will be addressed through regulator modifications during the Tier III program, discussed further below:



Legend

007 CSO and NPDES #

PS Pumping Station

Separated Areas

CSO Focus Areas

Back Cove (N)
Back Cove (W)
Back Cove (S)
Portland Harbor
Fore River
Capisic Brook

N W E S

0 1,625 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Capisic Brook and Fore River Focus Areas
Figure 9-4

- 030 (St. John Street) – This regulator shows trace amounts (0.1 MG) of overflow in the typical year. Given its proximity to the Portland Harbor focus area, and that it is located downstream of both the Fore River and Thompson Point pump stations, the St. John Street regulator is more impacted by tailwater conditions from the downstream Portland Harbor area than combined flows in the Capisic Brook and Fore River focus areas. Upstream improvements will have limited impact on overflows at this regulator and thus, it is recommended that it be studied in conjunction with the proposed Portland Harbor improvements during Tier III to identify potential modifications that may increase the level of control for this regulator.

- 032 (Thompson Point) – Model results indicate that this overflow contributes a small volume of overflow (0.8 MG) to the Fore River in the typical year. An analysis of the Thompson Point regulator revealed that the configuration of this overflow can be optimized to limit the frequency and volume of discharges. It is recommended that the City investigate weir/regulator modifications early in the Tier III program to eliminate overflows at this location during the typical year.

- 039 (Rowe Street – Hillcrest) – The model shows that that Rowe Street regulator produces 1.3 MG of annual overflow in the typical year. This area was highlighted in Section 8 as a potential GI/sewer separation project. However, the City indicated that the existing sewer downstream of this regulator is in poor condition and there currently is limited access to the manhole structures, which prevents the City from performing normal maintenance activities. Therefore, prior to implementing any upstream improvements, it is recommended that the City develop access to the downstream sewers and remove any obstructions that may exist in the pipes. Following these maintenance activities, the City should monitor the regulator to determine whether or not overflow activity will persist during the typical year. If the maintenance activity is not sufficient to eliminate the overflow, the City will need to investigate regulator modifications or limited upstream separation.

9.7 Tier III Pollutant Loading Reductions

The collection system model was used to determine CSO and stormwater discharges to each receiving water under conditions reflective of the completion of Tier III projects. The EMCs for BOD, TSS, Nitrate, Total-P, and Zinc were adjusted for Back Cove, Fore River, and Portland Harbor under Tier III conditions to account for a reduction in pollutant loading attributed to storage of the "first flush" in these watersheds. Using professional judgment and pollutant removal data for stormwater dry ponds obtained from the National Pollutant Removal Performance Database (2nd Edition), the EMCs were reduced accordingly.

The EMCs described in Section 5 for CSO discharges were used to determine pollutant loading into the other receiving waters. Table 9-2 summarizes the annual CSO loading estimates for existing conditions, Tier II, and Tier III conditions by receiving water and shows the percent reduction from existing conditions through the completion of Tier III. The existing, Tier II, and Tier III estimated annual CSO and stormwater loading by receiving water is included in Appendix I. Appendix I also provides the EMCs used for each scenario.

Table 9-2
Annual CSO Loading Estimates for Existing Conditions, Tier II, and Tier III

Receiving Water	Parameter	Units	Existing Loading	Tier II Loading[1]	Tier III Loading[1]	Percent Reduction[2]
Back Cove						
	BOD	Lbs/yr	296,198	186,073	19,530	93%
	TSS	Lbs/yr	526,321	330,637	34,702	93%
	E-coli	CFU/yr	5.75E+15	3.69E+15	7.59E+14	87%
	Ammonia	Lbs/yr	12,531	8,033	1,652	87%
	Nitrite	Lbs/yr	524	336	69	87%
	Nitrate	Lbs/yr	2,005	1,283	251	87%
	TKN	Lbs/yr	30,075	19,279	3,966	87%
	Total-P	Lbs/yr	5,696	3,629	638	89%
	Ortho-P	Lbs/yr	2,210	1,417	291	87%
	Zinc	Lbs/yr	410	260	41	90%
Capisic Brook						
	BOD	Lbs/yr	68,353	0	0	100%
	TSS	Lbs/yr	121,459	0	0	100%
	E-coli	CFU/yr	1.33E+15	0	0	100%
	Ammonia	Lbs/yr	2,892	0	0	100%
	Nitrite	Lbs/yr	121	0	0	100%
	Nitrate	Lbs/yr	463	0	0	100%
	TKN	Lbs/yr	6,940	0	0	100%
	Total-P	Lbs/yr	1,314	0	0	100%
	Ortho-P	Lbs/yr	510	0	0	100%
	Zinc	Lbs/yr	95	0	0	100%
Casco Bay						
	BOD	Lbs/yr	20,614	19,530	8,680	58%
	TSS	Lbs/yr	36,630	34,702	15,423	58%
	E-coli	CFU/yr	4.01E+14	3.79E+14	2.E+14	58%
	Ammonia	Lbs/yr	872	826	367	58%
	Nitrite	Lbs/yr	36	35	15	58%
	Nitrate	Lbs/yr	140	132	59	58%
	TKN	Lbs/yr	2,093	1,983	881	58%
	Total-P	Lbs/yr	396	376	167	58%
	Ortho-P	Lbs/yr	154	146	65	58%
	Zinc	Lbs/yr	29	27	12	58%

Table 9-2 (Cont'd)
Annual CSO Loading Estimates for Existing Conditions, Tier II, and Tier III

Receiving Water	Parameter	Units	Existing Loading	Tier II Loading[1]	Tier III Loading[1]	Percent Reduction[2]
Fore River						
	BOD	Lbs/yr	3,255	52,079	0	100%
	TSS	Lbs/yr	5,784	92,540	0	100%
	E-coli	CFU/yr	6.32E+13	1.01E+15	0	100%
	Ammonia	Lbs/yr	138	2,203	0	100%
	Nitrite	Lbs/yr	6	92	0	100%
	Nitrate	Lbs/yr	22	353	0	100%
	TKN	Lbs/yr	330	5,288	0	100%
	Total-P	Lbs/yr	63	1,002	0	100%
	Ortho-P	Lbs/yr	24	389	0	100%
	Zinc	Lbs/yr	5	72	0	100%
Portland Harbor						
	BOD	Lbs/yr	64,013	64,013	38,571	40%
	TSS	Lbs/yr	113,747	113,747	68,537	40%
	E-coli	CFU/yr	1.24E+15	1.24E+15	9.E+14	28%
	Ammonia	Lbs/yr	2,708	2,708	1,955	28%
	Nitrite	Lbs/yr	113	113	82	28%
	Nitrate	Lbs/yr	433	433	308	29%
	TKN	Lbs/yr	6,500	6,500	4,693	28%
	Total-P	Lbs/yr	1,231	1,231	845	31%
	Ortho-P	Lbs/yr	478	478	345	28%
	Zinc	Lbs/yr	89	89	59	34%
TOTAL						
	BOD	Lbs/yr	452,434	321,695	66,780	85%
	TSS	Lbs/yr	803,940	571,627	118,663	85%
	E-coli	CFU/yr	8.79E+15	6.32E+15	1.83E+15	79%
	Ammonia	Lbs/yr	19,141	13,771	3,975	79%
	Nitrite	Lbs/yr	800	576	166	79%
	Nitrate	Lbs/yr	3,063	2,201	618	80%
	TKN	Lbs/yr	45,939	33,050	9,540	79%
	Total-P	Lbs/yr	8,701	6,238	1,650	81%
	Ortho-P	Lbs/yr	3,376	2,429	701	79%
	Zinc	Lbs/yr	626	448	111	82%

Notes:
(1) Tier II and Tier III loadings are at completion.
(2) Percent reduction in loadings is relative to existing conditions through Tier III at completion.

Figure 9-5 summarizes the anticipated reductions. It can be seen that the Tier III work will result in significant reduction in pollutant discharges to the City's receiving waters. The total TSS, BOD, and E.coli loadings attributable to both CSO and stormwater discharges are predicted to be reduced by 32%, 45%, and 76% respectively, compared to baseline conditions. CSO discharges alone are predicted to be reduced by 85%, 85%, and 79% for TSS, BOD, and E.coli respectively.

9.8 Recommended Program

The plan described in the previous subsections proposes storage projects that are estimated to cost $99 million (June 2011 dollars). Section 8 discussed satellite wet weather treatment facility upgrades that are required to meet the program goals estimated at $45 million. It is also recommended that the City include a $25 million allowance for GI/sewer separation projects and LTCP updates and program monitoring to create a mix of solutions that puts a high reliance on storage facilities, but includes supplemental sewer separation, GI, and treatment plant upgrades for a total program cost of $169 million.

Further, it is recommended that the $169 million program be divided into three phases and implemented over a 15 year period to mitigate sewer rate impacts to the City's residents. Detailed financial impacts and the implementation plan are detailed in Section 10 and 11, respectively. The three phases, shown on Figure 9-6, are described below, and will ultimately reduce the volume of CSO for a typical year to 87 million gallons (MG), which equates to an 88 percent reduction in volume of CSO discharges:

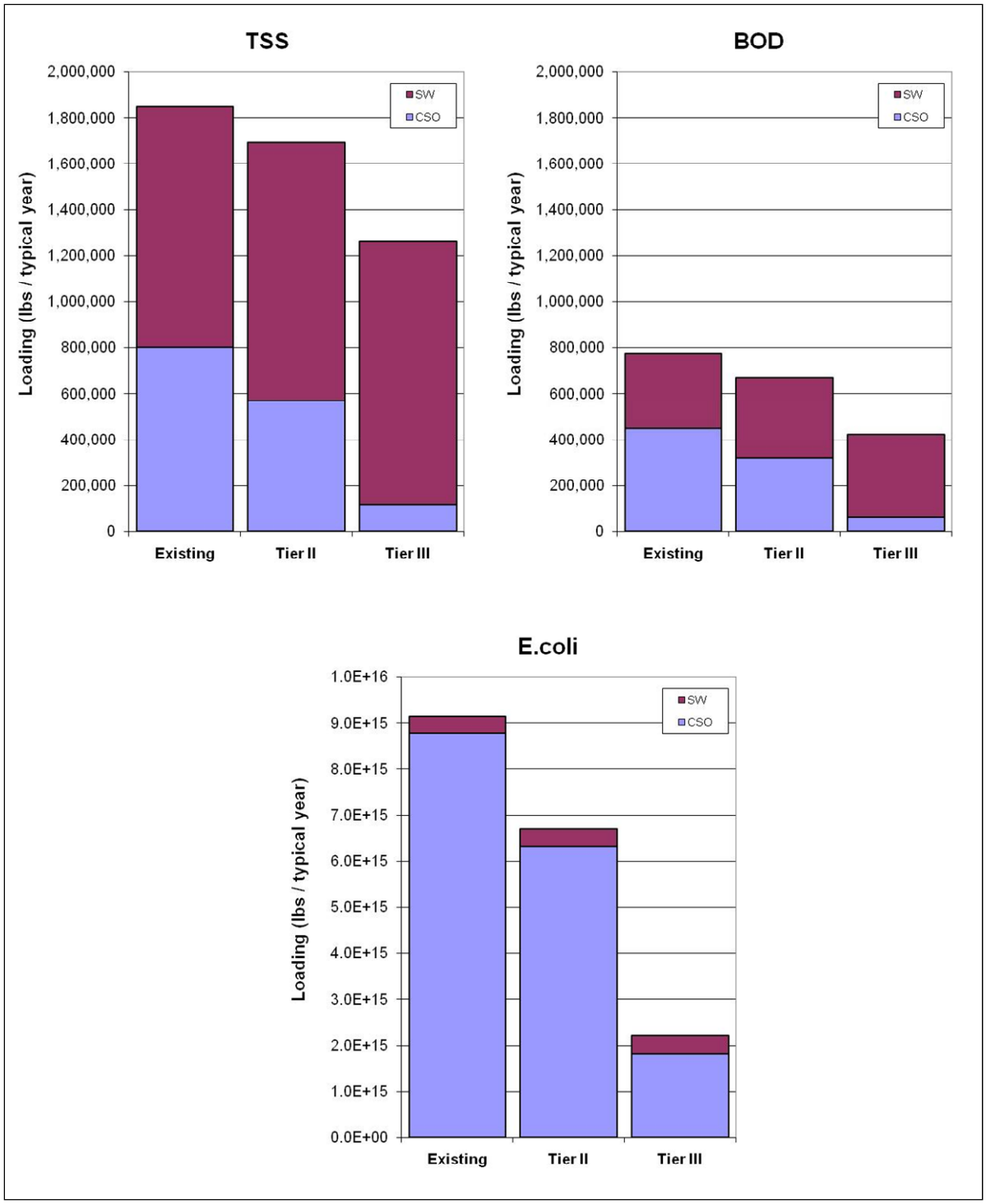
- Phase A – Construct up to 7 MG of storage facilities to capture CSOs in the Back Cove (west) and (south) focus areas. Also included are targeted sewer separation and GI projects to manage wet weather flows before they enter the combined system. These projects are estimated to cost $53.5 million dollars (June 2011 dollars).

- Phase B – Construct up to 8 MG of storage facilities at Fore River Pump Station and along the south and west sides of the peninsula for the Fore River, Capisic Brook and Portland Harbor focus areas. These projects are estimated to cost $55.5 million dollars (June 2011 dollars).

- Phase C – Construct wet weather upgrades at the EEWWTF, including upgrades to the North East Pump Station, and complete additional sewer separation and GI projects. These projects are estimated to cost $60 million dollars (2011 dollars).

The MDEP program guidance on CSO facility plans explicitly states that CSO discharges to receiving waters should not contain a first flush (which contains the highest concentrations of stormwater pollutants and represents the most significant impact on water quality), and thus conveying the first flush to the treatment facility should be a high priority of any CSO abatement plan. The storage facilities are designed to capture the first flush at a minimum and will provide secondary treatment for up to 17 MG (including the 2 MG Tier II storage conduit) at the EEWWTF following a storm event, while diverting less urban stormwater (and pollutants) to the receiving waters.

Figure 9-5
Comparison of Total Pollutant Loadings in CSO and Stormwater between Existing Conditions, Tier II, and Tier III



Legend

- 007 CSO and NPDES #
- Potential Green/ Sewer Separation Project
- Tier II Targeted Separation Area
- Tier III Targeted Sewer Separation Area
- Proposed CSO Storage Facility
- Proposed CSO Storage Conduit

N W E S

0 1,850 Feet

City of Portland, Maine
Long-Term CSO Control Plan - Tier III Update
July 2011

Proposed Revised Tier II and Tier III Plan
Figure 9-6

Supplemental GI and targeted separation will provide the additional wet weather flow management to meet the CSO goals for Tier III. Stakeholders and the City are very supportive of GI and LID. The City has already begun implementing these techniques in concert with their sewer separation projects. The Tier III approach affords the opportunity to integrate GI into this LTCP in a step-wise fashion, especially because the application of GI is very site-specific and requires the right conditions to work effectively. Recognizing that MDEP always requires periodic reviews of the CSO, it appears appropriate to design a plan that provides some "certain" benefits that move towards the goals of the 1993 CSO plan, while at the same time leaves open options for subsequent implementation of green and other strategies.

Table 9-3 summarizes the annual CSO volume reductions by receiving water for the recommended program. At the completion of Tier III, CSO discharge into Back Cove and the Portland Harbor will still occur during the typical year, but will be reduced to 87 MG (88 percent reduction in volume compared to 1993 discharges of 720 MG).

Table 9-3
Recommended Tier III Project Costs and Annual CSO Volume Reductions

Tier/ Phase	Project	Estimated Project Cost ($ millions)	Cumulative Tier III Program Costs ($ millions)	Annual CSO Volume (MG)(1)	Percent Volume Reduction (from 720 MG)
	Existing	---	---	416	42%
	End of Tier II - Includes Back Cove (North) Storage Conduit	---	---	300	58%
A	Back Cove (South) – 3.5 MG Storage Conduit	$21.5	$21.5	255	65%
A	Back Cove (West) – 3.5 MG Storage Conduit	$22.0	$43.5	181	75%
A	Misc. Separation and Green Projects	$10.0	$53.5	174	76%
B	Fore River – 5 MG Storage Facility	$35.5	$89.0	145	80%
B	Portland Harbor – 3 MG Storage Conduit	$20.0	$109.0	130	82%
C	EEWWTF Wet Weather Upgrades (NEPS 20 MGD upgrade, New HRC, New Outfall)	$45.0	$154.0	91	87%
C	Misc. Separation and Green Projects	$15.0	$169.0	87	88%
	Tier III LTCP GOAL			***87***	***88%***

Notes:

(1)Annual CSO Volume predicted for typical year.

Table 9.4 summarizes the number of anticipated CSO events to receiving waters for a typical year.

Table 9.4
Anticipated CSO Events for a Typical Year

Receiving Water	1993 Baseline	1993 Recommended Program	2025 Completion of Tier III
Back Cove	44	12	7
Capisic Brook	26	0	0
Casco Bay	30	0	8
Fore River	36	0	0
Portland Harbor	43	22	25
Presumpscot Estuary	13	0	0
Total	192	34	40

Section 10

Financial Evaluation

10.1 Introduction

The purpose of this section is to assess the financial implications of the City's recommended Combined Sewer Overflow (CSO) Tier III Long Term Control Plan (Tier III LTCP) program, and other related capital expenditures, on future wastewater costs and rates. This assessment follows the two-phase approach set forth in the United States Environmental Protection Agency's (the "EPA") *Combined Sewer Overflows — Guidance for Financial Capability Assessment and Schedule Development*. Phase I of the EPA financial capability assessment is used to determine the impact of the anticipated capital improvements on the average residential ratepayer. Phase II of the EPA financial capability assessment is an evaluation of socio-economic factors as compared to EPA benchmarks.

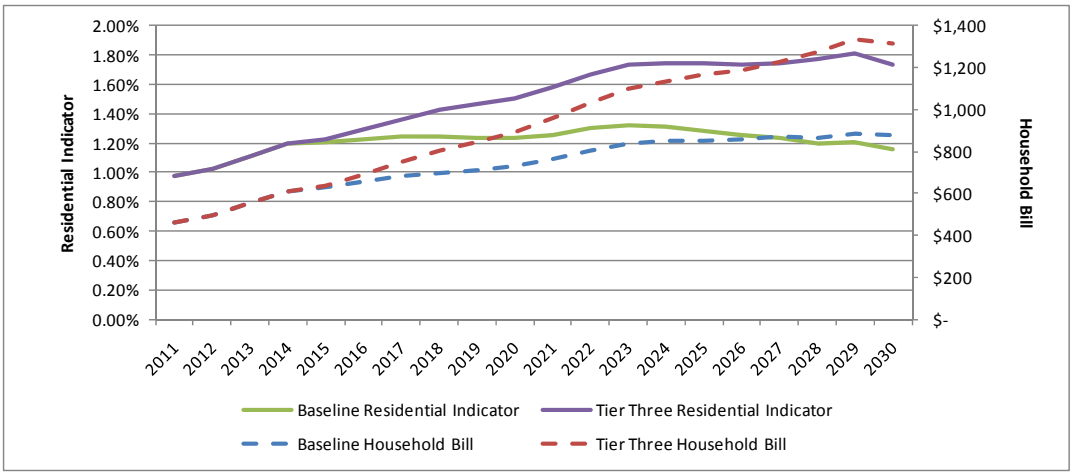
As described previously, the City will expend approximately $53 million on its Tier II program, including the proposed modifications. Tier III is estimated to cost approximately $169 million (2011 dollars) and it is recommended that it be implemented over a 15-year timeframe.

10.2 Major Findings

The results of the analysis indicate that:

- With a 15-year implementation schedule, the typical household bill is projected to grow from approximately $460 in FY 2011 to $1,310 by FY 2030. This is nearly 40 percent greater than the projected costs without Tier III. In turn, the residential indicator, which is the average household sewer bill divided by median household income, is projected to increase from 0.98 percent in FY 2011 to a peak of 1.81 percent in FY 2029 relative to a peak of 1.32 percent for the Baseline scenario. This represents a mid-range burden on households in the City.

Figure 10-1
Comparison of Projected Household Bill and Residential Indicator



- The City scored "mid-range" in two and "strong" in four of the Phase II indicators. The City's overall Phase II score is 2.67, indicating the City has a strong financial capability.

10.3 Approach

10.3.1 Data

In performing the financial capabilities assessment, CDM Smith developed a financial model, taking into account anticipated CSO related capital expenditures, to serve as the basis for making long-term affordability projections and assessing the incremental impact of the anticipated capital program. The model projects the City's sewer utility revenue requirements based on:

- Historical and projected costs to operate and maintain the systems;
- Current debt service requirements, including debt service on the Tier II LTCP (which will not be completed until 2013);
- Anticipated assessments from the Portland Water District (PWD) based on the projected annual increases in the District's revenue requirement for funds relating to the City; and
- Projected impacts of necessary non-CSO capital programs for the City, the PWD, and the proposed Tier III LTCP.

10.3.2 Methodology

This model assessed impacts of the proposed program and other projected wastewater needs on future household bills in Portland based on the City's current rate structure. The projected expenses, revenue requirements, and sewer costs have been estimated using standard industry methods while remaining consistent with the financial structures of the City and PWD. The analysis relies heavily on data and information provided by the City and the PWD and projects future sewer revenue requirements. The methodology is outlined as follows:

- Collection of relevant City and PWD financial information;
- Projections of future revenues and expenses for the City's sewer utility taking into account current obligations and anticipating additional expenses for necessary non-CSO capital improvements;
- Projections of future revenues and expenses for the PWD's funds related to Portland, and the resulting estimated annual assessment;
- Modeling the impact of the Tier III LTCP capital improvements by assessing the proposed program and its effect on the City's future sewer revenue requirements;
- Projection of annual sewer rate increases based on the percentage increase in revenue requirements of the City's sewer utility to ensure the ability to recover additional expenses; and
- Calculation of the typical residential household bill for Portland to assess the impact of the proposed Tier III LTCP on the typical household customer.

10.3.3 Assumptions

The data used in the financial capability analysis relies on the most recent data provided by the City and the PWD. Demographic data is based on a number of sources, including but not limited to US Census Bureau estimates, Maine Department of Revenue, and the Department of Labor, Bureau of Labor Statistics. The development of the financial projections requires the use a number of assumptions. CDM Smith believes these assumptions to be prudent and appropriate for this analysis. The assumptions are as follows:

- An inflation rate of 3.0 percent was used for O&M costs and this rate affects both the direct sewer O&M costs for the City's utility and PWD's O&M costs.
- It is assumed that the City's contribution for renewal and replacement (R&R) to PWD is approximately $520,000 annually until FY 2013, when it becomes $1.5M annually. This represents an estimate of ongoing R&R needs of the City.
- It is assumed the City has no miscellaneous revenue. PWD receives interest and other non-rate income, which is assumed to remain constant throughout projections.
- The City's non-CSO CIP (baseline CIP) includes a total of $90M in pipeline renewal and replacement ("R&R") and $10M in pump station R&R beginning in FY 2012. The pipeline expenditures will be spent evenly over the next 30 years while the pump station expenses are assumed to be spent evenly over 10 years. The pump station R&R is assumed to be financed entirely through bonds, while the pipeline R&R is assumed to have a combination of bonded debt with an annual ramp up of cash funding.
- The PWD CIP was provided through FY 2015. Beyond that timeframe, $1.5M annually was assumed for miscellaneous plant improvements. In addition, an allowance was made for a future nutrient removal project at the treatment plant, totaling $36M spent over 3 years beginning in FY 2020.
- Debt required to fund capital improvements is assumed to be equally split between general obligation bonds and SRF. General obligation (GO) bonds are assumed to have a 20-year amortization period with a 5.5 percent interest rate. State Revolving Fund (SRF) bonds carry a 20-year amortization period at an interest rate of 2.5 percent, with no cost of issuance.
- The City is assumed to expend approximately $53M of Tier II CSO projects in total from FY 2008 through FY 2013. Roughly $37.7M will have already been bonded through FY 2011, and $7.9M will be bonded annually in FY 2012 and FY 2013.
- Tier III LTCP spending will begin in FY 2014 and is assumed to be implemented over 15 years, with spending estimated to total approximately $169 million in 2011 dollars. All of these expenditures are assumed to be bonded. Capital inflation is set at 3.5 percent, and applies throughout the construction period.
- Median household income (MHI) for Portland in 2008 was $43,901 inflated from the Census Bureau data. The MHI figure is from the American Community Survey 3-year estimates for

2005-2007, which was the most recent figure available for Portland at the initial drafting of these projections. For the purposes of projections, MHI is inflated by 2.5 percent annually.

- Average annual sewer consumption was estimated to be 57 hundred cubic feet (HCF) per dwelling unit. This estimate was derived by using Census data to extrapolate the number of City dwelling units, then dividing total consumption by the number of dwelling units to determine the consumption per dwelling unit. Based on that analysis, and the City's sewer rates, the average household sewer bill in Portland for FY 2011 was estimated to be $460.

10.4 Phase One - Financial Analysis

This section outlines the process used to determine the City's revenue requirement projections, typical household bills, and residential indicator. The City's revenue requirement is calculated as total expenses, less non-rate revenue. This represents the amount of revenue the City will have to generate through amounts charged to its customers for the service provided to them. The growth in revenue requirement is then applied to rates. Lastly, rates are applied to typical consumption of 57 HCF, as noted in the assumptions section above, to generate typical household bills and calculate the residential indicator as set forth in EPA's guidance documentation.

10.4.1 City Expenses

Operations and Maintenance

Table 10-1 summarizes the City's projected wastewater O&M costs including capital outlay for FY 2011 to FY 2030 in 5-year increments by sewer cost category. Total O&M expenses are projected to increase from $4.9 million in FY 2011 to approximately $8.4 million in FY 2030. This average annual increase of 2.83 percent primarily reflects anticipated inflation.

Table 10-1
Operations and Maintenance Cost Projections

	2011	2015	2020	2025	2030
Operating Expenses	$3,590,042	$4,040,624	$4,684,191	$5,430,261	$6,295,161
Fringe Benefits	$980,992	$1,104,115	$1,279,971	$1,483,838	$1,720,175
Cash Funded Capital	$350,000	$350,000	$350,000	$350,000	$350,000
Total	**$4,921,034**	**$5,494,739**	**$6,314,162**	**$7,264,099**	**$8,365,336**

Anticipated Capital Improvement Plan

Total anticipated capital expenditures through FY 2030 are listed in **Table 10-2.** Total spending on the Tier III projects is $168.950 million (2011 dollars) throughout the course of the program. In addition to Tier III spending, the City and PWD are projected to spend $23.894M on remaining Tier II projects, $70.192M on renewal and replacement (R&R) work, and $71.860M on wastewater treatment plant (WWTP). The total uninflated capital spending is $334.896M. A detailed spending plan is shown in **Figure 10-2**.

Table 10-2
Capital Spending by Category, 2011 $

Spending Category	2011-2040
Tier II	$23,893,562
Tier III	$168,950,000
R&R	$70,192,884
WWTP	$71,860,000
Total	**$334,896,446**

Figure 10-2
Anticipated Capital Spending Plan, 2010 to 2030, 2011 $

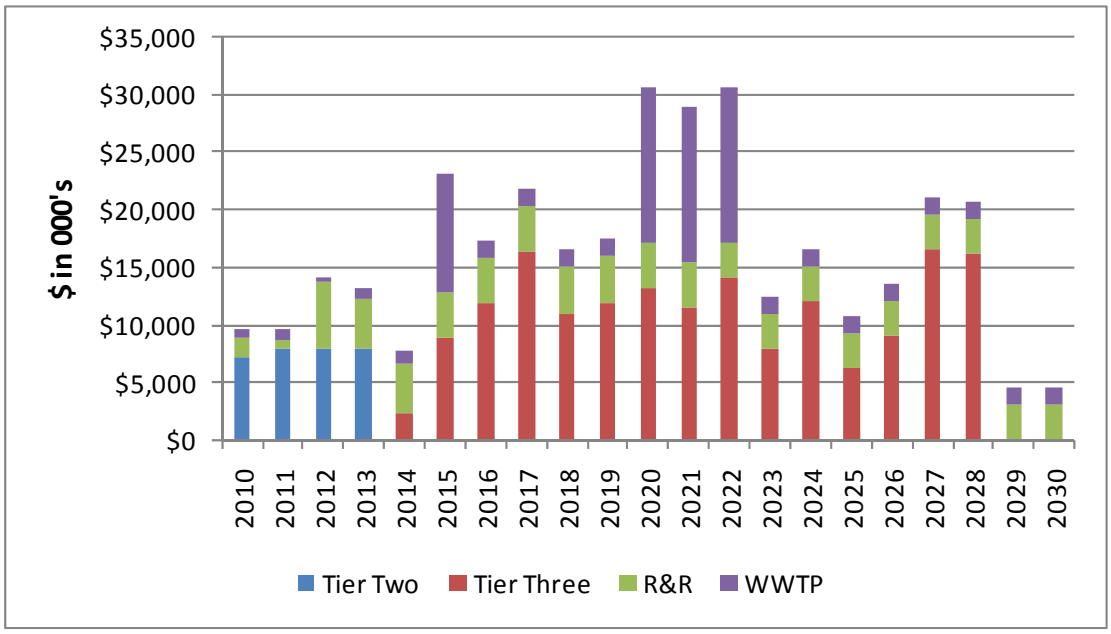


Table 10-3
Tier III LTCP CSO Project Schedules and Costs

Project Description	Begin Year	End Year	Cost (2011 $ in Millions)
Phase A			
Back Cove (West) - 3.5 MG Storage Conduit	2015	2019	$22.00
Back Cove (South) - 3.5 MG Storage Conduit	2014	2018	$21.50
Misc. Sewer Separation and Green Projects	2014	2027	$10.00
Total Phase A			**$53.50**
Phase B			
Fore River - 5 MG Storage Facility	2018	2023	$35.45
Portland Harbor - 3 MG Storage Conduit	2021	2025	$20.00
Total Phase B			**$55.45**
Phase C			
EEWTF Wet Weather Upgrades (NEPS 20 MGD upgrade, New HRC, New Outfall)	2023	2028	$45.00
Misc. Sewer Separation and Green Projects	2014	2024	$15.00
Total Phase C			**$60.00**
Total Tier III			**$168.95**

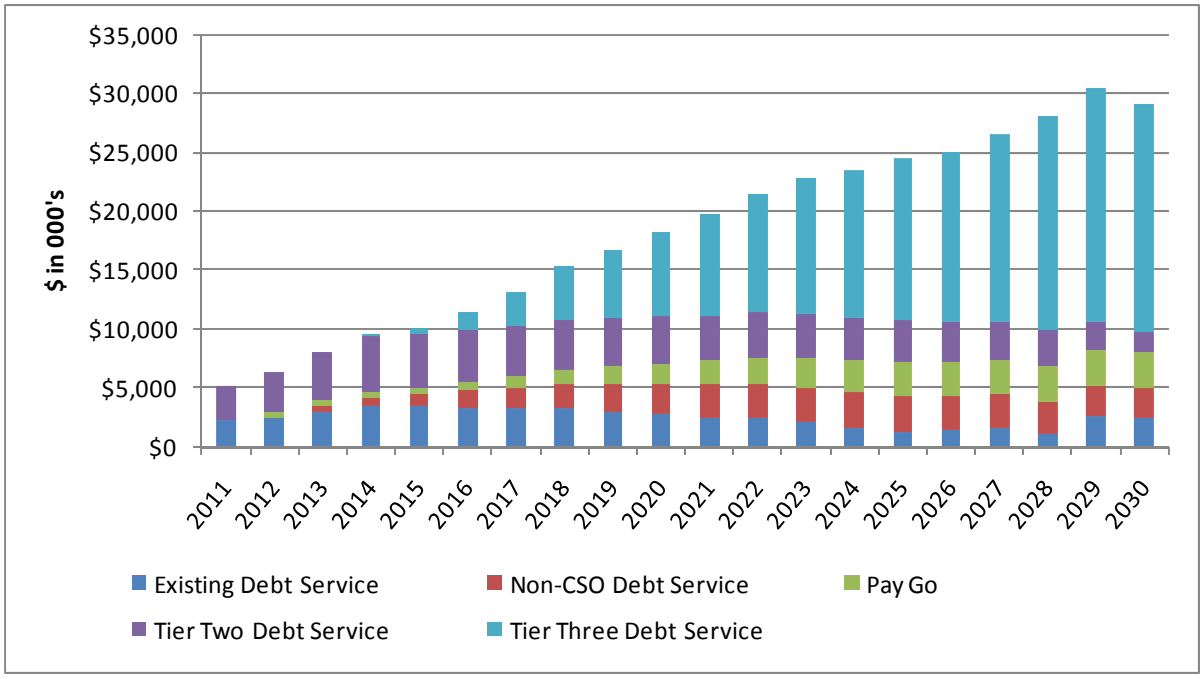
Debt Service and Pay Go

Debt service and capital expenditures are shown in five categories: Existing Debt Service, Non-CSO Debt Service, Pay Go Capital Expenditures (CapEx), Tier II Debt Service and Tier III Debt Service. With the exception of existing debt service, all debt has been projected based on the anticipated CIP. All Pay Go Capital Expenditures, which are capital projects that are cash funded, are assumed to be used to fund replacement and renewal in the system. All capital costs not funded by Pay Go are assumed to be funded evenly between SRF and GO debt. A summary of existing debt service, anticipated debt service and Pay Go expenditures for the wastewater utility CIP is shown in **Table 10-4** and **Figure 10-3**. Debt service is expected to drop off in the later years of the projections, however, that may reflect incomplete capital improvements in the future and it is possible that the total expenses will increase in the out years.

Table 10-4
Debt Service and Capital Expenditures

	2011	2015	2020	2025	2030
Existing Debt Service (less Tier II)	$2,328,853	$3,410,075	$2,706,495	$1,295,449	$2,442,898
Non-CSO Debt Service	$0	$1,109,198	$2,602,021	$2,937,641	$2,544,384
Pay Go CapEx	$0	$500,000	$1,750,000	$3,000,000	$3,000,000
Tier II Debt Service	$2,736,275	$4,537,171	$3,984,097	$3,431,024	$1,801,036
Tier III Debt Service	$0	$450,456	$7,191,999	$13,827,545	$19,311,798
Total	**$5,065,128**	**$10,006,900**	**$18,234,613**	**$24,491,658**	**$29,100,116**

Figure 10-3
Debt Service and Capital Expenditures



City Direct Expenses

The City's direct expenses (those that directly fund City expenditures as opposed to those transferred to PWD for operation and maintenance of the East End Treatment Plant, various pump stations and interceptors) are determined by adding wastewater O&M expenses with projected and existing debt service. **Table 10-5** summarizes the direct expenses for the wastewater utility under the baseline projections, which does not include Tier III capital costs. These numbers also do not include the estimated annual assessments from the PWD. Direct expenses in the City are projected to grow from roughly $9.986 million in FY 2011 to $18.153 million in FY 2030, equivalent to an average annual increase of 3.2 percent.

Table 10-5
City Direct Expenses – Baseline

	2011	2015	2020	2025	2030
O&M	$4,921,034	$5,494,739	$6,314,162	$7,264,099	$8,365,336
Debt Service and CapEx	$5,065,128	$9,556,444	$11,042,614	$10,664,113	$9,788,318
Total City Direct Expenses	**$9,986,162**	**$15,051,183**	**$17,356,776**	**$17,928,212**	**$18,153,654**

PWD Assessment

In order to determine the assessment paid by the City to the PWD, it is necessary to determine the PWD's revenue requirement. It is also necessary to adjust the revenue requirement to align with expenses during Portland's fiscal year because the PWD operates on a calendar year for its fiscal year, whereas the City operates on a July to June fiscal year.

The PWD's revenue requirement is determined by summing O&M, existing debt service, contributions to the renewal and replacement fund and anticipated debt service, and subtracting non-rate revenue. These expenses pertain specifically to Portland's expense funds and do not reflect PWD's entire budget. Additionally, since the cost of the Tier III LTCP is borne entirely by the City, the estimated PWD assessment is not affected by the CSO program and will remain the same under both the baseline and the LTCP analysis.

Using this methodology, the estimated assessment increases from $10.5 million in FY 2011 to $20.8 million in FY 2030, indicative of an average annual increase of 3.64 percent.

Table 10-6
Estimated PWD Assessment

	2011	2015	2020	2025	2030
O&M	$8,389,385	$9,442,327	$10,946,245	$12,689,698	$14,710,837
Capital Expenditures	$1,920,413	$2,499,934	$3,176,144	$6,171,668	$5,047,660
Renewal and Replacement	$520,231	$1,500,000	$1,500,000	$1,500,000	$1,500,000
Non-Rate Revenue	($336,123)	($336,123)	($336,123)	($336,123)	($336,123)
PWD Revenue Requirement	$10,493,906	$13,106,138	$15,286,266	$20,025,242	$20,922,374
PWD Assessment	**$10,531,491**	**$12,793,412**	**$14,985,427**	**$19,969,458**	**$20,780,709**

10.4.2 Total Revenue Requirement

Revenue Requirement - Baseline

As noted previously, the revenue requirement is determined by subtracting non-rate revenues from total expenses. **Table 10-6** summarizes the baseline revenue requirement for the City, which consists of the direct wastewater expenses incurred by the City, as shown in **Table 10-7**, plus the estimated PWD assessment. The baseline does not include any of the anticipated Tier III LTCP capital costs.

Table 10-7
Revenue Requirement – Baseline

	2011	2015	2020	2025	2030
O&M	$4,921,034	$5,494,739	$6,314,162	$7,264,099	$8,365,336
Debt Service and CapEx	$5,065,128	$9,556,444	$11,042,614	$10,664,113	$9,788,318
PWD Assessment	$10,531,491	$12,793,412	$14,985,427	$19,969,458	$20,780,709
Revenue Requirement	**$20,517,653**	**$27,844,595**	**$32,342,204**	**$37,897,670**	**$38,934,363**

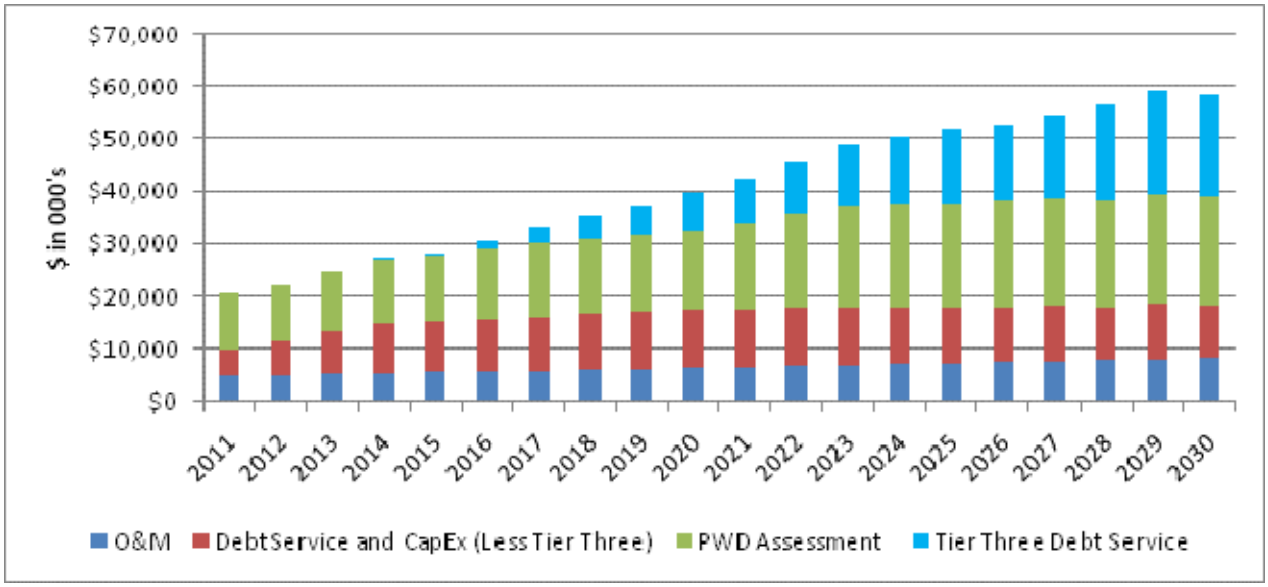
Revenue Requirement – Tier III Incremental Impact

As part of the LTCP, the City of Portland is planning $168.95 million in Tier III LTCP expenditures from FY 2014 through FY 2028, which will increase the financial impact of the CSO program on residential users. All Tier III projects are assumed to be funded through the issuance of GO and SRF debt. The incremental impact of Tier III LTCP, which increases the revenue requirement by $19.3 million in FY 2030, is shown in **Table 10-8** and **Figure 10-4**.

Table 10-8
Revenue Requirement – Tier III LTCP Incremental Impact

	2011	2015	2020	2025	2030
Baseline Revenue Requirement	$20,517,653	$27,844,595	$32,342,204	$37,897,670	$38,934,363
Tier III Debt Service	$-	$450,456	$7,191,999	$13,827,545	$19,311,798
Adjusted Revenue Requirement	**$20,517,653**	**$28,295,051**	**$39,534,203**	**$51,725,215**	**$58,246,161**

Figure 10-4
Revenue Requirement with Tier III LTCP Incremental Impact



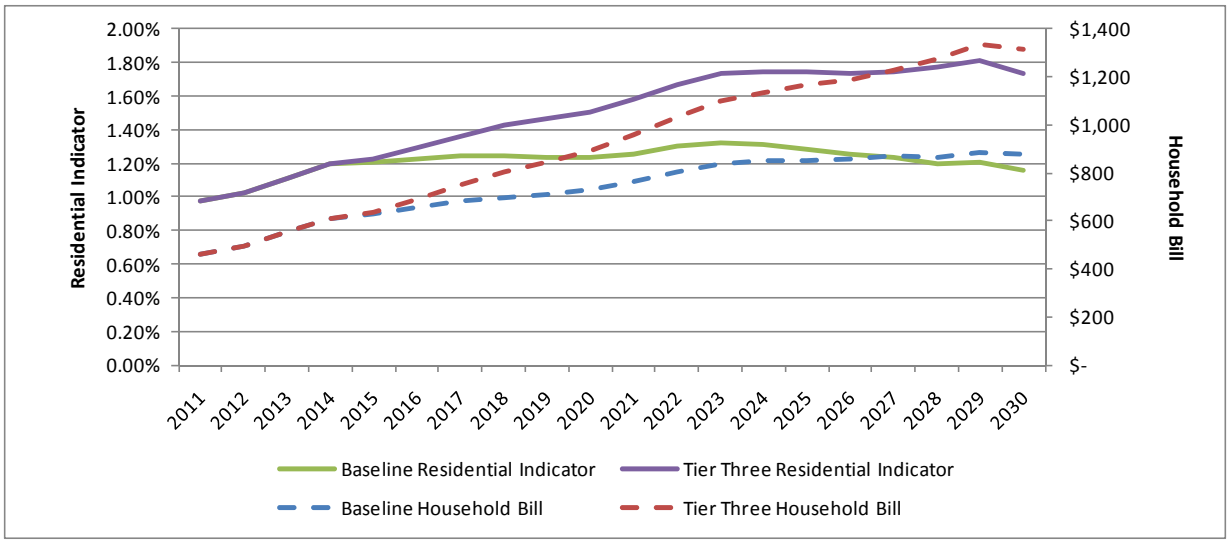
Household Bills and Residential Indicator

The primary Phase I measure of the incremental impact of the proposed CSO program, as set forth in the EPA's guidance document, is the residential indicator, which is defined as the typical household bill, as a percentage of MHI. In FY 2011 the typical household bill in the City is $460 and MHI is estimated to be $47,276. This equates to a residential indicator of 0.98 percent. Over the course of projections, annual household sewer fees will increase at a faster rate than the baseline projections. When including Tier III LTCP CSO spending, the residential indicator reaches a peak of 1.81 percent in FY 2029 in this scenario, compared with a peak of 1.32 percent in the baseline scenario. After FY 2029, the residential indicator begins to gradually decline. However, this is likely an artifact given the lack of identified CIP in the distant future. These results are summarized in **Table 10-9.**

Table 10-9
Comparison of Projected Household Bill and Residential Indicator

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline Household Bill	$462	$496	$554	$608	$628	$657	$682	$699	$713	$729	$761	$808	$841	$854	$854	$859	$869	$863	$886	$877
Tier Three Household Bill	$462	$496	$554	$609	$638	$690	$747	$802	$844	$891	$956	$1,034	$1,101	$1,137	$1,166	$1,187	$1,227	$1,273	$1,333	$1,313
Baseline Residential Indicator (%)	0.98	1.02	1.12	1.19	1.20	1.23	1.24	1.24	1.24	1.23	1.26	1.30	1.32	1.31	1.28	1.25	1.24	1.20	1.20	1.16
Tier Three Residential Indicator (%)	0.98	1.02	1.12	1.20	1.22	1.29	1.36	1.43	1.47	1.51	1.58	1.67	1.73	1.74	1.75	1.73	1.75	1.77	1.81	1.74

Figure 10-5
Comparison of Projected Household Bill and Residential Indicator



Businesses in the area will also be impacted by the increases in sewer rates as a result of the CSO program. **Table 10-10** summarizes the anticipated impact of the rate increases on a commercial customer with a current annual bill of $1,000.

Table 10-10
Comparison of Projected Bill for Commercial Customer Currently Paying $1,000

	2015	2020	2025	2030
Inflation Only—2.5%	$1,100	$1,250	$1,420	$1,600
No Tier III	$1,360	$1,580	$1,850	$1,900
25 year	$1,370	$1,770	$2,200	$2,470
15 year	$1,380	$1,930	$2,520	$2,840

10.5 Phase Two - Financial Capability Factors

This section focuses on the additional indicators, aside from the residential indicators, defined by EPA benchmarks to help assess the affordability of the Tier III LTCP capital spending plan. Since Portland's capital program is funded through rates (as opposed to property taxes, for example), these measures are not likely to change as a result of the LTCP.

These indicators evaluate any ancillary factors that may have an effect on the City's ability to fund the program that may not have been apparent in the financial affordability analysis.

This assessment identifies six benchmarks, two in each of the following subcategories:

- Debt Indicators;
- Socioeconomic Indicators; and
- Financial Management Indicators.

10.5.1 Debt Indicators

The two debt indicators are the City's bond rating and the overall net debt as a percent of full market property value in the City.

Bond Rating

The bond rating indicator is intended to address a general capacity to undertake debt. **Table 10-11** shows the most recent ratings for the City from Moody's and S&P. Based on the criteria of the EPA, this rating is considered strong, and merits a score of 3.

Table 10-11
Bond Rating

Item	Value
Rating agency	Standard & Poor's
Rating	AA
Rating Agency	Moody's Investors Service
Rating	Aa2
Financial Indicator Score	**3**

Net Debt

Net debt is the amount of tax-backed bonded debt for all taxing units that are not supported by revenue from user fees. Data for this indicator was presented in the City's FY 2011 Approved Budget, shown in **Table 10-12**. The direct debt as of June 30, 2010, for the City was $294.8M. The overlapping debt reflects the obligations from the Portland Water District, ecoMaine and Cumberland County. Since the net debt as a percent of the full market property value is between 2 and 5 percent, the City's capability for this indicator is considered mid-range.

Table 10-12
Net Debt as Percent of Full Market Property Value

Item	Value
Direct net debt (G.O. bonds)	$258,290,983
Debt of overlapping entities	$36,487,375
(Proportionate share of multi-jurisdictional debt)	
Overall net debt	$294,778,358
Market value of property	$ 9,736,867,632
Overall net debt as a percent of full market property value	3.03%
Financial capability score	2

10.5.2 Socioeconomic Indicators

Unemployment Rate

The unemployment rate ranges from a strong rating if the unemployment rate is more than 1 percentage point below the national average to a weak rating if the unemployment rate is more than 1 percentage point above the national average. The unemployment rate indicator is determined as

shown in **Table 10-13.** The City's unemployment rate as of April 2011 according to the Bureau of Labor Statistics was 7.9 percent, compared to a national rate of 9.0 percent. Based on criteria laid out in the guidance document, because local unemployment is more than one percentage point below the national unemployment rate benchmark, this indicator is considered strong according to EPA criteria.

Table 10-13
Unemployment Rate

Item	Value
Unemployment rate of permittee	7.9%
Average national unemployment rate	9.0%
Comparison of permittee with benchmark	-1.1%
Financial capability score	**3**

Household Income

The Household Income Indicator is related to the residential indicator in that both consider MHI. While the residential indicator is a value of MHI and average annual bills, this indicator focuses solely on MHI by comparing it to the national median. This benchmark then is a measurement of relative wealth or poverty of the service area.

The median household income for the City used in this analysis is shown again in **Table 10-14.** Both the City and national MHI are based on the most recent census data, which is the estimate from the 2005-2009 American Community Survey. These figures have been inflated to 2010 at a 2.5 percent annual increase.

The median household income estimates are rated strong, if MHI is more than 25 percent above the national median household income, to weak, if MHI is more than 25 percent below the national median household income. Local MHI falls 15.2 percent below the national MHI, and thus is a mid-range indicator which is assigned a value of "2" according to the EPA guidance.

Table 10-14
Median Household Income

Item	Value
MHI of permittee – 2010	$46,954
Adjusted national MHI	$55,379
Compare permittee with benchmark	-15.2%
Financial capability score	**2**

10.5.3 Financial Management Indicators

The two financial management indicators are property tax revenues and tax collection efficiency.

Property Tax Revenues as a Percent of Full Market Property

Property tax revenue as a percent of full market property value represents the property tax burden since it indicates the funding capacity available to support debt based on the wealth of the community. In the City, property tax revenues collected in FY 2010 were $129,556,626. Property value shown in **Table 10-15** below is about $9.7 billion. The property tax revenue information was obtained through the City's FY 2010 Comprehensive Annual Financial Report. The ratings range from a score of strong if the indicator is below 2 percent to a score of weak if the indicator is above 4 percent. The calculated property tax revenue indicator for the City is 1.3 percent suggesting a strong local financial capability according to the EPA benchmark.

Table 10-15
Property Tax Revenues as a Percent of Full Market Property

Item	Value
Full market value of real property	$9,736,867,632
Property tax revenue	$129,556,626
Property tax revenue as a percentage of full market property value	1.3%
Financial capability score	**3**

Tax Collection Efficiency

The last of the EPA Financial Guidance Phase Two indicators is the rate of property tax collection. The Computation of this indicator is shown in **Table 10-16**. Based on the City's 2009 Comprehensive Annual Financial Report, the 2009 property tax collection rate represents the taxes collected divided by property taxes levied. A strong rating is awarded if the collection rate is above 98 percent, whereas a weak rating is given for any rate under 94 percent. In the City, tax collection efficiency is 98.2 percent, indicative of a strong financial capability.

Table 10-16
Tax Collection Efficiency

Item	Value
Property tax revenue collected	$129,556,626
Property taxes levied	$131,995,299
Property tax revenue collection rate	98.2%
Financial capability score	**3**

10.5.4 Summary of Widespread Impact Indicators

Table 10-17 shows EPA Financial Capability Benchmarks used to evaluate the six indicators. The benchmarks are shown in the left-hand column. A value of "3", "2" or "1" is assigned to a benchmark whose value assessments are "strong", "mid-range" or "weak" respectively. The highlighted boxes in this figure indicate where the City falls within the framework of these indicators. The values and

scores of the six indicators for Portland are compared in **Table 10-18**. Overall, the un-weighted average score for the phase 2 evaluation is 2.67.

Table 10-17
Financial Capability Indicators

Indicator	Strong (3)	Mid-Range (2)	Weak (1)
Bond Rating	AAA-A (S&P) or Aaa-A (MIS)	BBB-A (S&P) or Baa-A (MIS)	BB-D (S&P) or Ba-C (MIS)
Net Debt/Property Value	Below 2%	2% - 5%	Above 5%
Unemployment Rate	>1% below National Avg.	±1% of National Avg.	>1% above National Avg.
Median Household Income	>25% above adj. Nat'l MHI	±25% of adj. Nat'l MHI	>25% below adj. Nat'l MHI
Prop. Tax/Property Value	Below 2%	2% - 4%	Above 4%
Prop. Tax Collection Rate	Above 98%	94% - 98%	Below 94%

Table 10-18
Financial Capability

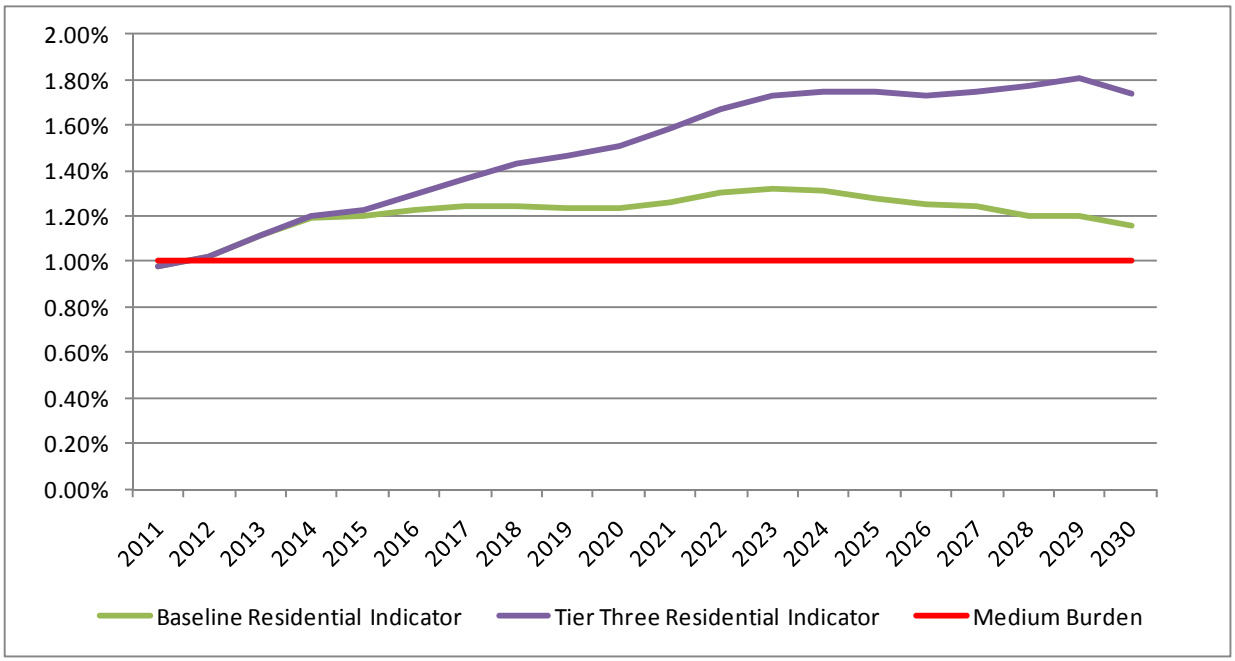
Item	Value	Score
Bond rating	AAA	3
Net debt percent of property value	3.03%	2
Unemployment rate compared with national average	-1.1%	3
Median household income compared with national average	-15.2%	2
Property tax revenue percent of property value	1.3%	3
Property tax revenue collection rate	98.2%	3
Permittee indicator score		**2.67**

10.6 Conclusions & Recommendations

10.6.1 Residential Indicator

Currently, the City's residential indicator is 0.98 percent, on the border between low- and mid-range burden categories. Without the Tier III LTCP projects, the residential indicator will reach a peak of 1.32 percent in FY 2023; including the Tier III LTCP projects under a 15-year timeline, the residential indicator will peak at 1.81 percent. Residential indicators slowly decline in both scenarios for the rest of the forecast horizon due mainly to declining debt service expenses. However, the residential indicator will be in the mid-range burden category throughout the forecast horizon due to the debt service payments associated with both the Tier II and Tier III LTCP CSO projects.

Figure 10-6
Residential Indicator Comparison



10.6.2 Financial Impact Indicators

The City of Portland has a strong financial capability according to the six indicators used in this analysis. The City has strong debt ratings and mid-range net debt as a percent of total property values. Its unemployment rate is currently below the national average, although the median household income in Portland is lower than the US average. Finally, the City's property tax revenue is low as a percentage of property values, and its collection rate is strong. The average of these values leads to a score of 2.67.

10.6.3 Overall Financial Capability

The residential indicator for the City of Portland falls between 1 and 2 percent which represents a mid-range score. Matching that factor with the appropriate financial capability score of 2.67 leads to a relatively low burden, as measured by the EPA's affordability guideline. The City of Portland possesses a relatively strong financial capability.

Table 10-19
Financial Capability Matrix

		Residential Indicator (Cost Per Household as a percentage of MHI)		
		Low Burden (below 1.0%)	Mid-Range (between 1.0 and 2.0%)	High (greater than 2.0%)
Permittee Financial Capability Indicators Score	Weak (below 1.5)	Medium Burden	High Burden	High Burden
	Mid-Range (between 1.5 and 2.5)	Low Burden	Medium Burden	High Burden
	Strong (above 2.5)	Low Burden	Low Burden	Medium Burden

Section 11

Implementation Plan

11.1 Introduction

The purpose of this section is to develop a schedule that will assist the City and PWD implement the recommended Tier III program in a cost effective and flexible manner that will spread out the costs of the significant capital improvements to minimize excessive rate increases in any multiple-year period. The length of the schedule to complete the recommended program and the sequencing of the projects have been developed to provide the greatest progress in terms of water quality benefits at the beginning of the program, while continuing the reduction of CSO discharges until the goals of the 1993 LTCP are reached.

11.2 Components of Each Project

Each recommended Tier III project has four major components that will provide for comprehensive implementation. These components include preliminary design, final design, construction, and post construction monitoring. Preliminary design is necessary to further describe the scope of each project, identify any significant impediments to completing the project on schedule and for the estimated cost, obtain necessary permits and to allow time to work with the impacted stakeholders to gain public acceptance. Final design will provide plans and specifications for each project. The construction phase includes construction oversight to manage the project and make sure the facilities are constructed according to the design intent. Post construction monitoring will consist of monitoring the performance of the constructed facilities to verify they are achieving the reductions in CSOs and providing the intended level of control. Monitoring includes flow and depth metering, water quality monitoring, and verification of overall performance through the use of the SWMM model.

The post construction monitoring of each project should be summarized in a report and then consolidated into the proposed five year LTCP updates. The projects have been phased so that post construction monitoring occurs approximately every two years in accordance with the Maine DEP guidance for CSO LTCPs. The City and PWD would continue to submit yearly reports and will continue to do so throughout the Tier III implementation period. As part of these LTCP updates, it will be important to review the results of the post monitoring programs as they contribute to a specific receiving water to allow for any adjustments to future projects and maximize the opportunities for achieving the goals of the program in the most cost-effective manner.

11.3 Program Schedule

The program schedule was developed by sequencing projects to meet the following criteria:

- Each projects completion and post monitoring period should coincide as best possible with the five year LTCP updates. This will provide timely information on the effectiveness of the project to meet program goals and allow for any necessary changes in direction if certain projects are more or less effective than estimated.

- Implement and coordinate projects that are not only necessary to meet the objectives of this LTCP but will also provide for timely upgrades (e.g. rehabilitation or replacement) of deteriorated infrastructure.

- Spread out costly projects so as to level out significant increases in rates over multi-year periods as well as over the entire program.

Figure 11-1 illustrates the proposed 15 year schedule for the Tier III LTCP. This figure also includes the schedule for the remaining Tier II projects. The costs developed in Section 9 are also summarized for each project as well as at five-year increments (e.g. incremental and cumulative costs) throughout the proposed 15 year schedule. The costs over each of the five year periods are $50.4 million for the first five years, $58.6 million for the second five years, and $60.1 million for the last five years (in 2011 dollars). The costs will vary year by year, but the average yearly cost is approximately $11.3 million, with the maximum estimated single year cost of $16.6 million (in 2011 dollars). These yearly expenditures are generally on the high side of the current expenditures for the Tier II improvements.

The schedule also shows dashed lines that connect the post construction monitoring to the LTCP updates. It will be very important to integrate the results from these monitoring programs within each LTCP update. The results of these studies could drive adjustments within projects.

Figure 11-2 illustrates the estimated Tier III costs and system CSO volume reductions. This graph illustrates that the storage facilities in Phase A provide some of the largest volume reduction benefits, which is why these projects were selected for the beginning of the Tier III program. The chosen 15-year implementation period also provides similar volume reduction rates and yearly expenditures to ultimately bring the overall CSO volume to 87 MG for a typical year in terms of rainfall by the completion of Tier III in 2028.

11.4 Program Summary

This LTCP completed for the City and Portland Water District (PWD) is adaptable and flexible and integrally supports Maine DEP's policy of capturing the first flush of pollutants. It also includes significant Green Infrastructure (GI) to manage stormwater before it enters the combined sewer system and possibly contributes to CSO. Over the past 18 years, the City and PWD has concentrated on sewer separation as the primary tool for reducing CSO to Capisic Brook, Back Cove, Portland Harbor, and Casco Bay. These efforts have reduced CSO volumes by approximately 42 percent of their current annual reduction goal of 633 MG of overflow for a typical year.

Figure 11-1
Program Schedule

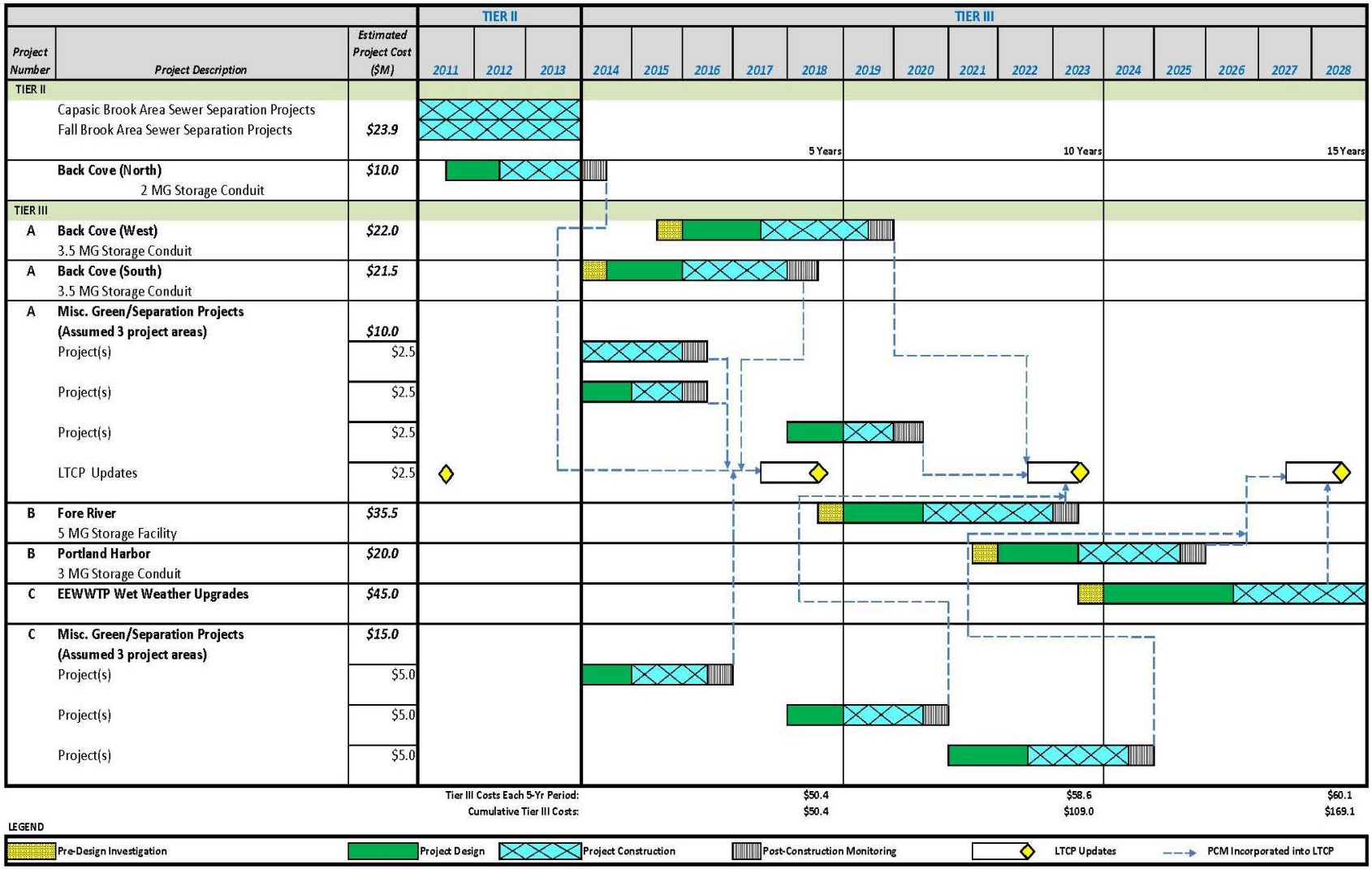
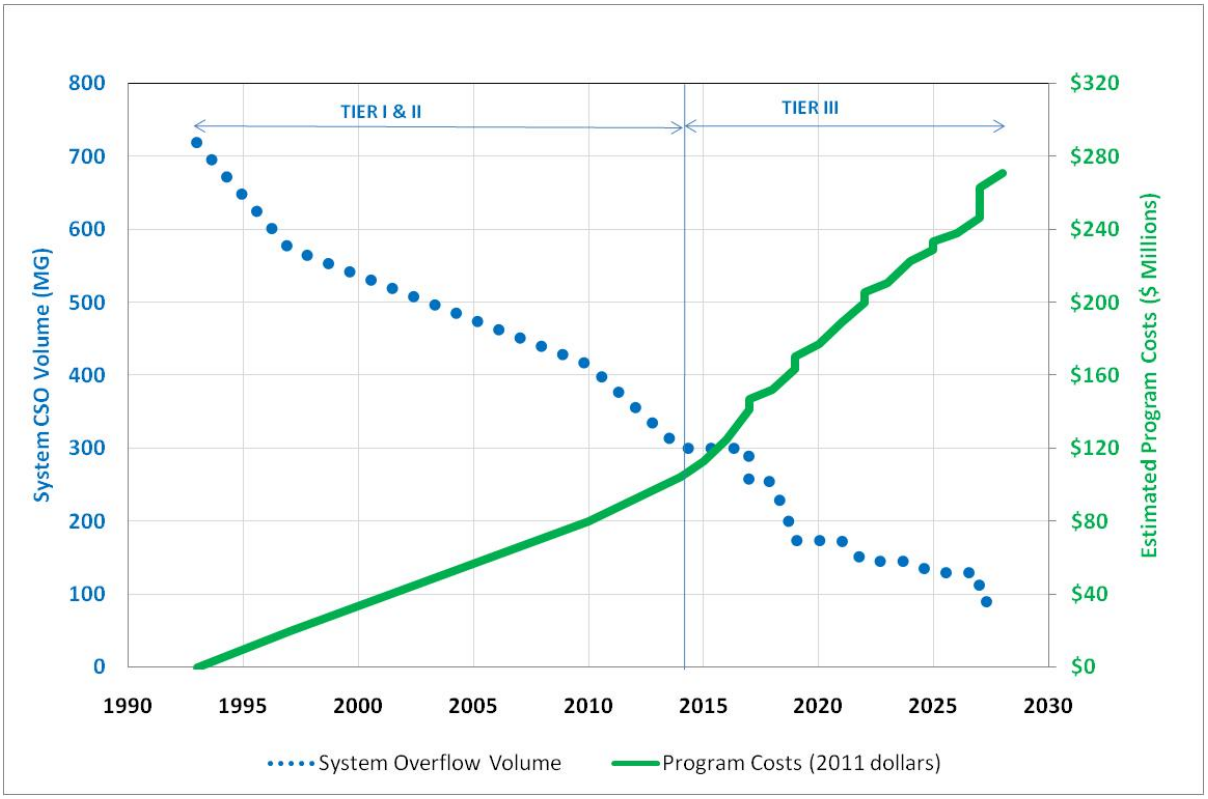


Figure 11-2
Program Costs and Annual CSO Volume Reductions



The goal for the completion of the current Tier II program (to be completed by the end of 2013) was improved by focusing remaining separation efforts, and replacing some separation projects with a storage facility to control three major CSO's that discharge to Back Cove saving the City approximately $35 million. Building on this effort, the City is planning to complete an additional 15 MG of storage facilities throughout the City to provide a major water quality benefit in capturing the first flush, and returning those flows through the East End Waste Water Treatment Facility for full secondary treatment. This approach cost-effectively avoids the transfer of urban pollutants to the separate stormwater system which would not receive treatment before being discharged to the receiving waters. Storage facilities are typically considered large "grey" projects, while GI tends to be site specific and individual projects will be identified to provide not only a significant reduction in CSO for their cost, but also work into the City's sustainability initiatives. Approximately $22.5 million has been included in the program for GI as well as complimentary sewer separation projects.

This LTCP has been complimented by the City's active working relationship with area water quality advocates including Conservation Law Foundations, Friends of Casco Bay as well as the Casco Bay Estuary Partnership. This relationship has helped the City find common ground with planned amendments to the Tier II CSO plans (storage conduit in lieu of some CSO abatement projects) and the Tier III recommendations. While City staff recommended a 25 year plan, the above stakeholder groups advocated for a 15 year plan. The City Council elected to submit a proposed 15 year plan and has begun review of financing and funding storm water maintenance needs. This working relationship with these stakeholders will be a key feature to the implementation of the LTCP over the proposed 15 year period.

CDM Smith

cdmsmith.com