FINAL REPORT
MAINE COASTAL PROGRAM
DOWNTOWN STORM WATER STUDY
BATH, MAINE

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1.0 INTRODUCTION AND BACKGROUND

1.1 Maine Coastal Program Grant

The City of Bath (City) was awarded a Maine Coastal Program Coastal Communities Grant in 2016 to complete a stormwater study for the downtown area with the goal of addressing effects of land use activity on water quality. Bath enlisted the involvement of the Kennebec Estuary Land Trust and Main Street Bath as project partners to accompany City personnel from the Public Works, Community and Economic Development, and Planning departments to sit on an Advisory Committee. Ransom Consulting, Inc. (Ransom) was contracted to complete the stormwater study, prepare conceptual designs for stormwater quality mitigation measures, and present the results to the community. The products of this work will aid the City in making decisions that consider and potentially reduce land use effects on water quality. This report summarizes the study, the results, and the conceptual designs and is meant to help Bath plan their future for stormwater management, climate adaptability and flood resilience.

1.2 Background

The City of Bath, located in Sagadahoc County on the banks of the Kennebec River, has a densely developed downtown district. Inhabitants and visitors of the region, from the Abenaki to the Vikings to Europeans to the present-day residents, have valued the access to the Kennebec River for sustenance, transportation, and beauty. From the mid-18th century to the present, shipbuilding has been the primary industry for the City. Unsurprisingly, human activity and development has clustered around the Kennebec River waterfront and with its access to deep water and straight shoreline.

As with most coastal and riverfront cities and towns, the proximity to a natural resource is a benefit to the community, while the community is not a benefit to the natural resource. Among the worst offenders are land clearing and discharges of industrial and human waste. Based on information compiled by the Kennebec Estuary Land Trust[1], the quality of the Kennebec River was significantly compromised at the turn of the 20th century by untreated discharges from saw mills, paper mills, and domestic sewage systems. Eutrophication, a process by which excess nutrients, typically from human activities, cause excessive algae growth near the surface, preventing light from penetrating further into the water column and leading to reduced dissolved oxygen levels, plagued the Kennebec River system into the 20th century.

Since the 1970s and the introduction of the Clean Water Act, aquatic resources, particularly rivers, have made remarkable recoveries. Elimination of direct discharges of untreated industrial and domestic wastewater and requirements for treatment of permitted discharges have reduced point-source pollution by orders of magnitude. However, land use and human activity that alter watershed processes still contribute to elevated levels of pollutants that can harm sensitive organisms, including humans, and reduce the water quality of natural resources. Populations of indicator organisms in the Kennebec River and estuary suggest that these water bodies have not fully recovered.

1.3 Objective

This stormwater study focused primarily on the downtown district, as it is a densely developed, predominantly impervious surface which tends to allow stormwater runoff to easily convey debris and chemicals from roads, parking lots, sidewalks, and rooftops into the Kennebec River. The goal of the study was to review existing information and generate a model to simulate the function of the existing stormwater collection system, capturing the volume and movement of stormwater within the system. The study aims to quantify the impervious surfaces throughout the downtown district and identify new treatment alternatives

[1] Moore, S., Reblin, J., "The Kennebec Estuary: Restoration Challenges and Opportunities," Kennebec Estuary Land Trust, 2010.

for polluted waters, with an emphasis on Low-Impact Development (LID) and green infrastructure design, which allow for improved stormwater retention and can reduce pollution levels. Conceptual designs of stormwater runoff reduction measures were produced and recommendations were made for implementation and incorporation of stormwater management measures in City-level regulations. In addition, the study considered effects of projected sea-level rise on the function of the existing storm drain system. The model was used to simulate a variety of precipitation events and sea level scenarios and will serve as a tool for future infrastructure project design and planning.

2.0 MODEL DEVELOPMENT

2.1 EPA Storm Water Management Model (SWMM) Background

The Storm Water Management Model (SWMM) developed by the United States Environmental Protection Agency (USEPA) is a dynamic rainfall-runoff model that can be configured to simulate single event or long-term rainfall scenarios and resulting stormwater quantity and quality characteristics. SWMM is an object-based model that uses subcatchments, nodes, and links to represent a stormwater system. Using time-series rainfall data, SWMM computes runoff and infiltration within one or multiple catchments based on a set of user-defined parameters. Modelled runoff is routed through the virtual storm drain network using a system of nodes representing structures, junctions, outfalls, and other flow regulating devices and links representing pipes, surface channels, and other flow conveyance infrastructure. Water quality characteristics are simulated through interactions between land surface pollutant build-up and wash off functions, rainfall pollutant content, and treatment measures.

The model calculated flow rates, water levels, and pollutant concentrations at each user-defined time step using conservation of mass and momentum equations. Although simplified forms of the governing equations may be used for faster simulations, the complete form of the equations were solved to account for backwater effects, pressurized pipes, flow reversal, and energy loss associated with pipe entrances and exits. The stormwater system in Bath was modelled using the “dynamic wave” analysis.

2.2 Data Sources

This study drew on data from numerous sources in an effort to represent the factors that contribute to stormwater quantity and quality in the downtown area of Bath. Data sources are identified and summarized in the sections below to provide context.

2.2.1 Bath GIS Database

The City of Bath provided Ransom with a database of sewer and storm drain infrastructure throughout the City. This database receives updates by City staff as well as an outside mapping consultant. Ransom used ArcGIS to view and process the data.

2.2.2 United States Geological Survey LiDAR

Ransom reviewed 2-foot elevation interval contours as well as raw point data acquired from the United States Geological Survey (USGS) through the National Oceanographic and Atmospheric Administration (NOAA) Digital Coast database. The LiDAR dataset that includes downtown Bath was generated in 2011.

2.2.3 National Stormwater Quality Database

The National Stormwater Quality Database (NSQD) Version 4.02 (2015) is a compilation of stormwater quality data made available by the Environmental Protection Agency (EPA). It contains event mean concentrations (EMC) for rainfall events measured by National Pollutant Discharge Elimination System communities, a Best Management Practices (BMP) database, and other select events and locations. The NSQD contains information regarding sampling methods, climatology, and land use.

2.2.4 Bath Land Use Ordinance & Zoning Maps

The study area contains areas zoned as Historic, C1, C2, Shoreland, and R1. Stormwater management for development in Bath is primarily governed by the Land Use Code, Article 10. A stormwater management plan is required when deemed necessary by the Planning Board. In the shoreland zone, parking must retain runoff onsite and prevent direct discharge from flowing directly into an adjacent water body. Stormwater drainage facilities must be designed for the 25-year or greater storm. There are few stormwater quality-specific references and performance standards in the Land Use Code, and consideration of stormwater quality is generally at the discretion of the Planning Board.

2.2.5 The Kennebec Estuary: Restoration Challenges and Opportunities

The Kennebec Estuary Land Trust commissioned a report documenting historical conditions, water quality status, and ecological conditions of the Kennebec River and Estuary systems. The report was completed in 2010 and served as a baseline for quality comparisons between urban runoff and river water for this study.

2.2.6 National Oceanographic & Atmospheric Administration Atlas 14 Storms

Historical rainfall data collected at rain gages throughout the U.S. has been analyzed to determine return period rainfall depths for events ranging from five minutes to 60 days in duration. Rainfall amounts for return periods of one, two, five, ten, 25, 50, 100, 200, 500, and 1000 years have been established using statistical analysis. Referring to predicted storm events using return period terminology is ubiquitous; however, it must be noted that, for example, the 100-year rainfall amount actually means the 1% annual chance rainfall event. That is the event that, based on historical data, is expected to have a 1% chance of occurring in a year. It is possible to have multiple 100-year events within a 100-year time frame or zero 100-year events within a 100-year time frame. Figure 2-1 illustrates ~~shows~~ the storm distribution with rainfall intensity gradually increasing during the beginning of the storm, followed by a dramatic peak in intensity, and ultimately a tail of reduced rainfall.

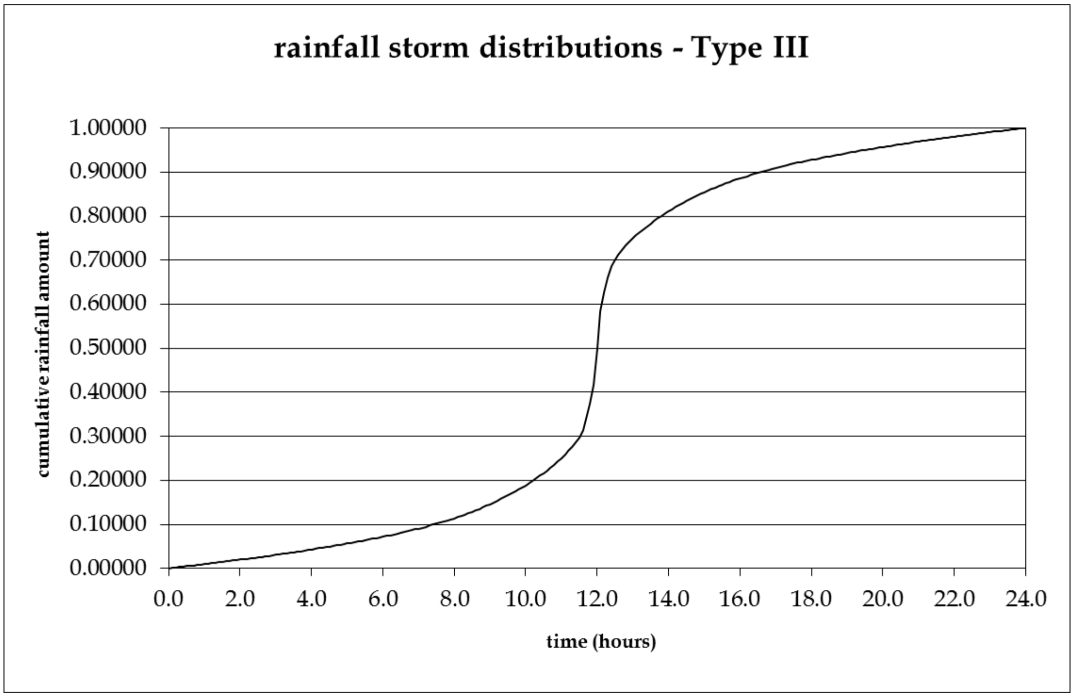

Figure 2-1: NOAA Atlas 14 rainfall intensity distribution

2.2.7 National Oceanographic & Atmospheric Administration Tidal data

NOAA publishes tidal predictions for coastal sites based on harmonic analysis of water levels at tide gage stations located along the coast. The nearest operating tide gages to the study area are in Portland and Bar Harbor. In locations where tidal predictions are desired but NOAA does not maintain a tide gauge, NOAA's practice is to collect water level data for a period of time long enough to define the harmonic constituents that characterize the tidal cycle and allow water levels to be predicted. Water levels were measured in Bath in July and August of 2005 to establish harmonic constituents for tidal predictions. Predicted tidal time series data was obtained from the NOAA Tides and Currents database for use in forcing the water levels at discharge points in the model.

2.2.8 Sea Level Rise Projections

Much of the current guidance for sea level rise planning recommends evaluating discrete sea level rise scenarios that cover a range of possible futures in order to encourage decision makers to consider multiple future conditions and identify robust solutions that will be functional for a range of highly uncertain future conditions[2,3]. Figure 2-2 shows a set of sea level rise scenarios for Portland based on recommendations from the USACE and NOAA and obtained from the USACE's online Sea-Level Change Curve Calculator (version 2017.55), http://www.corpsclimate.us/ccaceslcurves.cfm. Following this guidance, Bath should consider the possibility that, by 2050 mean sea level could rise as little as 0.39 feet to as much as 2.11 feet higher than it was in 1992; and that by 2100 sea level could be anywhere from 0.72 feet to 6.68 feet higher than it was in 1992.

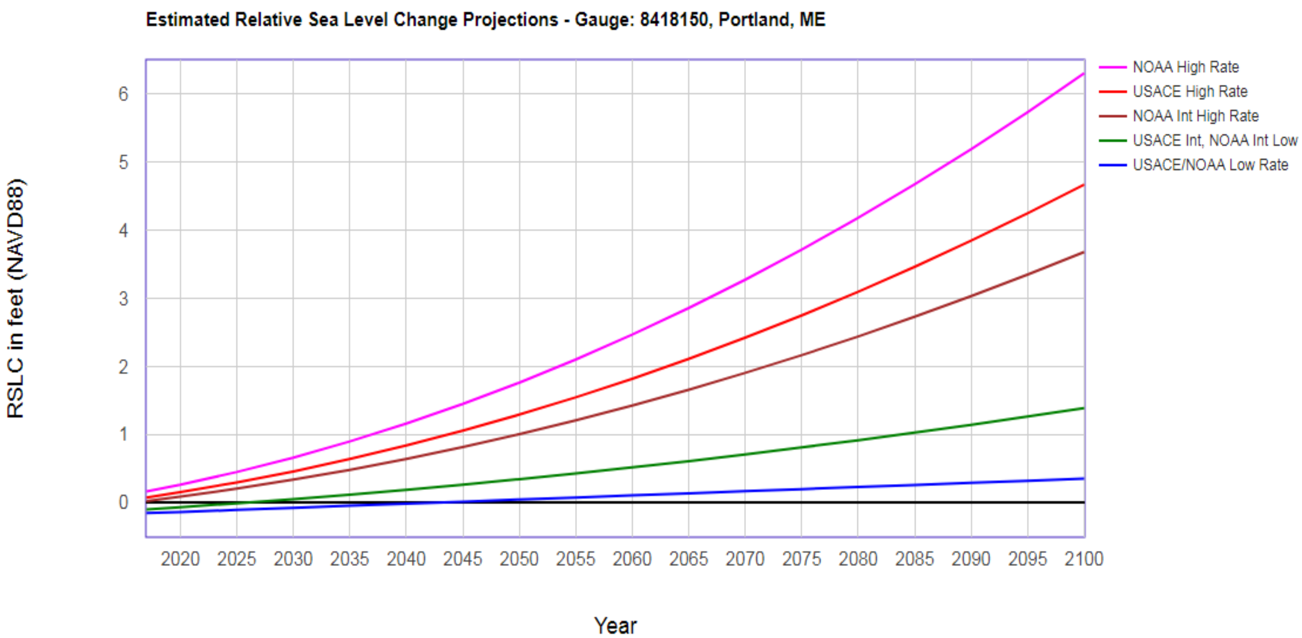

Figure 2-2: Sea Level Rise scenarios compiled by NOAA and USACE

Kopp et al. (2014)[4] provide localized actionable probabilistic information. For our study, we adopted their data to characterize probabilistic future sea level change at Portland. Their data provided cumulative probability distributions for local mean sea level at years 2030, 2050, 2100, and 2200 for three of the Representative Concentration Pathways (RCP) adopted by the Intergovernmental Panel on Climate Change (IPCC) in their fifth assessment report[5]. The

[2] Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K, Knuuti, R. Moss, J. Obeysekera, A. Sallenger, J. Weiss, 2012. Global Sea Level Rise Scenarios for the United States National Climate Assessment. National Oceanic and Atmospheric Administration Technical Report OAR CPO-1, Climate Program Office (Silver Spring, MD.
[3] USACE, 2014. Global Changes Procedures to Evaluate Sea Level Change Impacts, Responses, and Adaptation, Engineer Technical Letter No. 1100-2-1. Department of the Army, U.S. Army Corps of Engineers Washington, DC
[4] Kopp, R. E., R. M. Horton, C. M. Little, J. X. Mitrovica, M. Oppenheimer, D. J. Rasmussen, B. H. Strauss, and C. Tebaldi (2014), Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites, *Earth's Future*, *2*, 383–406, doi:10.1002/2014EF000239.
[5] Intergovernmental Panel on Climate Change (2013), Summary for policy makers, in *Climate Change 2013: The Physical Science Basis*, edited by T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. Midgley, pp. 3–29, Cambridge Univ. Press, Cambridge, U. K.

cumulative probability distributions show the probability that the future sea level will be less than the corresponding sea level rise value. Using this information, we evaluated the probability that future sea levels will be greater or less than the USACE and NOAA scenarios.

2.2.9 Federal Emergency Management Agency Flood Insurance Rate Map

Ransom reviewed the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM), effective July 16, 2015 for the study area. The base flood elevation (BFE) for downtown bath is 8 feet NAVD88.

2.2.10 Maine Geological Survey Surficial Geology Maps

Ransom reviewed the Maine Geological Survey surficial geology maps for the study area. According to maps for Sagadahoc County, two soil classifications are present. Soils are classified as made land/sanitary fill that is well drained to Hollis fine sandy loam that is somewhat excessively drained.

2.2.11 Maine Department of Environmental Protection Combined Sewer Overflow data

Combined Sewer Overflow (CSO) communities are communities which use a combined sewer and storm drain system. During precipitation events, the combined system capacity may be overwhelmed, at which point, untreated sewage is discharged through the stormdrain system. The City of Bath and the MEDEP has been tracking combined sewer overflow events since 1987, recording the number of events and total volume discharged in each community. Figure 2-3 below demonstrates the downward trend in CSO events and discharge since 1987.

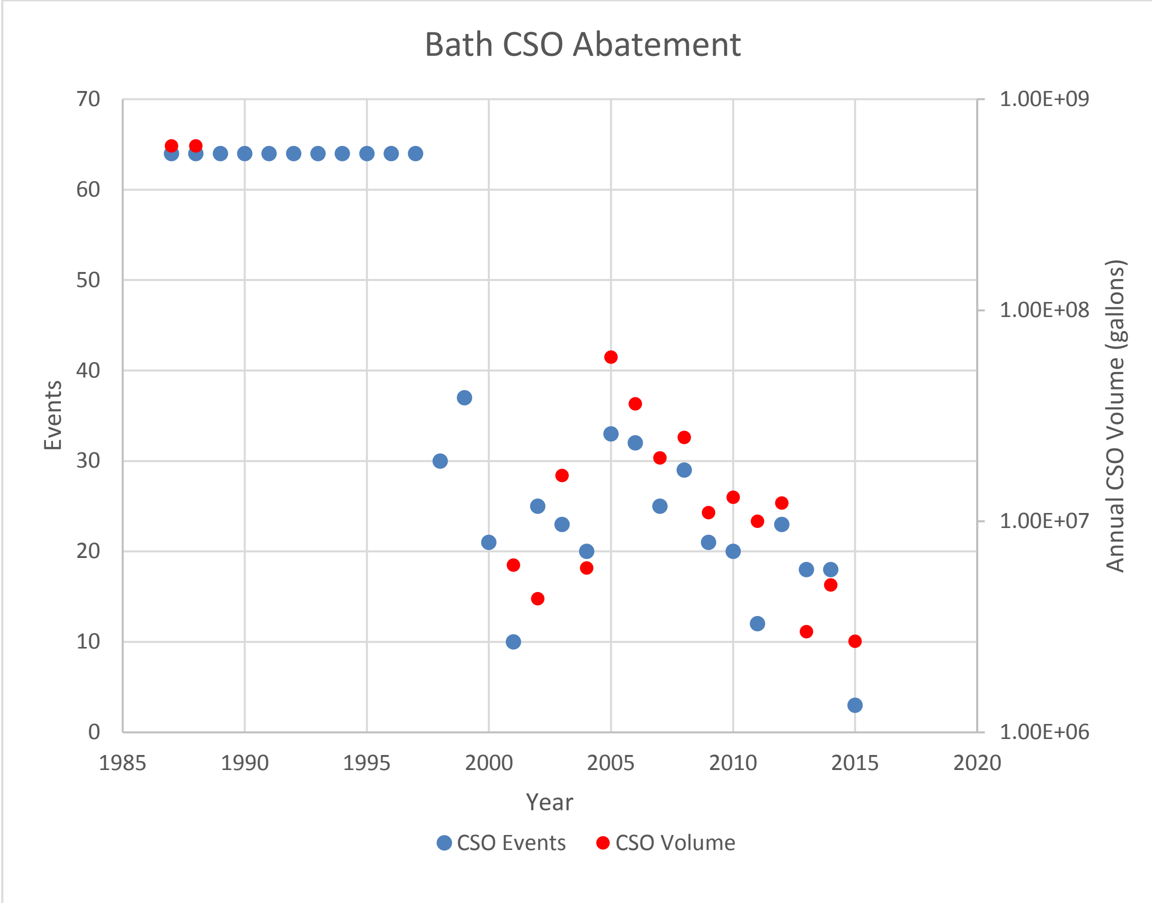

Figure 2-3: City of Bath Combined Sewer Overflow Abatement Data – Event & Flow Reduction

2.2.12 Commercial Street Outfall Engineering Plans

The primary outfall in the study area is the Commercial Street Outfall. It is located on the west bank of the Kennebec River, just south of the Route 1 bridge, adjacent to the Commercial Street sanitary sewer pump station. Ransom referred to the design drawings titled "City of Bath Commercial Street Outfall Contract No. 99-3," prepared by EER, Inc., dated April 16, 1999.

2.3 Collected Data

The primary objective of this study was to create a model of the downtown stormwater system to simulate storm events, focusing on stormwater quantity and quality and prepare conceptual design plans for stormwater quality improvement. A limited amount of data collection as described below was performed for model validation.

2.3.1 Flowmeter

Three ISCO 2150 flowmeters were deployed at strategic locations in the stormwater network for four weeks. Water level, velocity, and flowrate data were collected every 15 minutes and downloaded from the flowmeters weekly. Flowmeters were installed by Bath Public Works personnel with oversight by Ransom on June 13, 2017, and were removed on July 13, 2017. Typical rainfall totals for Bath in June and July are between three and four inches of rain each month; during the time flowmeters were deployed for this project, approximately one inch of rain was recorded, rendering the collected data minimally useful.

2.3.2 Quality samples

Two stormwater quality samples were collected by Bath Public Works personnel on October 25, 2017. Samples were analyzed for typical stormwater pollutants: total suspended solids, total nitrogen, total phosphorus, total lead, total mercury, biochemical oxygen demand, and polycyclic aromatic hydrocarbons (PAH). Samples were collected at approximately 8:30 AM on October 25; the precipitation event occurred earlier than initially forecasted; therefore, the results do not fully represent “first-flush” conditions. The results do fall within typical ranges for each pollutant based on review of select literature and NSQD information, but are expected to be lower than peak concentrations or even event mean concentrations (EMCs) due to seawater dilution and antecedent pollutant washoff. Results are tabulated in Table 2-1 in Section 2.4.4.4, and laboratory reports are available in Appendix A

2.4 Model Generation

Based on discussions with the Advisory Committee, an area of approximately 55 acres within downtown Bath was selected as the focus area for this Storm Water Study. The focus area is bounded by Route 1 and Commercial Street to the south; Washington Street to the west; Fremont Street to the north, and the Kennebec River to the east. Based on the Geographic Information System (GIS) data provided by the City of Bath, the area of interest drains to three primary storm water outfalls located in the Kennebec River. The Commercial Street outfall also drains a portion of the City outside the area of interest that is predominantly residential and has an area of approximately 52 acres. Figure 2-4 below depicts the study area in the context of Bath and the Kennebec River.

Figure 2-4: City of Bath Downtown Stormwater Study Focus Area

2.4.1 Subcatchment Delineation

The primary object in SWMM is the subcatchment. In combination with the rain gauge object, which dictates the amount and intensity of precipitation in the model, the area, slope, and relative imperviousness of the subcatchments will determine the quantity and rate of runoff entry into the storm drain system. SWMM treats subcatchments as normalized rectangular areas, independent of actual geometry. The figure below shows the LiDAR topographic data procured from the National Oceanic and Atmospheric Administration (NOAA) for the focus area.

Figure 2-5: City of Bath 2-foot LiDAR Contours (USGS 2011)

Subcatchments were delineated manually by combining storm drain network data, specifically catch basin locations, provided by the City with topographic data from NOAA and surveyed engineering plans, where available. At this time, Ransom has delineated 137 subcatchments that are included in the model. Subcatchments are shown in Figure 2-6 below.

As previously noted, the area drained by the Commercial Street outfall extends past the focus area for this study. The full drainage area must be considered to accurately represent flows; this area, shaded pink in the image ~~above~~ below, is treated as one subcatchment. Based on aerial imagery, the focus area is approximately 80% impervious, with contiguous portions greater than 12 acres that are 100% impervious. By contrast, the residential area outside the area of interest is approximately 25% impervious.

Figure 2-6: City of Bath Downtown Stormwater Study Subcatchment Delineation

2.4.2 Node and link network

Storm drain pipes and conduits are represented by links. Combining GIS information provided by the City with engineering plans where available, Ransom assigned size, material, slope, and friction coefficient attributes to storm drain conduits using ArcGIS. Figure 2-7 below depicts the layout of links used for this model.

In this model, nodes operate primarily as junctions between links. The City of Bath's storm drain system in this location does not contain pumps, storage or treatment structures; therefore, nodes were assigned based on catch basin and drain structure locations.

Figure 2-7: City of Bath Downtown Stormwater Study Subcatchment Delineation with Storm Drain Network

2.4.3 Boundary Forcing/Input

Within SWMM, stormwater quantity and circulation calculations are performed based on conservation of mass and energy and stormwater quality calculations are performed based on mass balance. Calculations are driven by stormwater input in the form of timeseries data for precipitation events, water elevation timeseries data for outfall locations, and initial pollutant mass.

Timeseries were prepared for precipitation events based on NOAA Atlas 14 return period information for Type III storm distributions as appropriate for the region of the study area. Tidal timeseries were prepared using NOAA Tides & Currents tidal prediction data and AGU sea-level rise projections for 2050 and 2100. For each event simulated, peak precipitation intensity and high tide were set to occur simultaneously.

Ransom also reviewed event specific CSO data from 2016 and 2017 to incorporate CSO flows into the model during appropriate events. CSO contributions to the stormdrain system are modelled in SWMM as rainfall dependent inflow and infiltration functions. A time and precipitation-intensity dependent function was used to approximate CSO volumes and pollutant concentrations introduced to the storm drain system during heavy precipitation events.

2.4.4 Parameter Selection

The EPA SWMM allows the user to define numerous parameters pertaining to system characteristics. For the purposes of this study, the primary parameters related to subcatchments included impervious area, slope, characteristic width, and pollutant buildup. The following sections describe the assignment of parameters throughout the model domain.

2.4.4.1 Impervious Area & Infiltration

Impervious area defines the portion of a subcatchments that does not allow precipitation to infiltrate. Impervious area includes paved roads, parking areas, sidewalks, gravel, and rooftops. Remaining area is assigned a minimum and maximum infiltration rate and flow-routing sequence that reflects whether runoff is directed from pervious area to impervious area or vice versa within a subcatchment.

2.4.4.2 Slope

The slope of the subcatchments is assigned as the elevation change over the distance of the longest flow path within the subcatchments. Flowpaths lengths were measured manually using ArcGIS. This parameter accounts somewhat for varying geometries in subcatchments.

2.4.4.3 Characteristic width

The characteristic width is the area divided by the length of the longest flowpath. The combination of the slope and characteristic width normalize the subcatchments as rectangular catchments draining to a single drainage channel. The assumptions and validations for this approach are outlined in the SWMM User's Manual.

2.4.4.4 Pollutant buildup and washoff

Buildup and washoff are inherently complicated processes and are difficult to model without extensive, site-specific data. Many factors contribute to pollutant accumulation, including frequency and timing of street sweeping, land use, vegetation, vehicular traffic, exposure to wind, time since the previous precipitation event, and other variables. The buildup and washoff functions used for this study are based on a maximum pollutant mass per acre and a precipitation-intensity and time dependent washoff function. Many factors contribute to pollutant accumulation, including frequency of street sweeping, land use, vegetation, vehicular traffic, exposure to wind, time since the previous precipitation event, and other variables.

Initial pollutant buildup values were selected using the NSQD. Ransom compiled approximately 200 data points from areas included in the NSQD located in EPA climate region 1, between 10 and 100 acres, with comparable land use and impervious areas to the study area. Using the event mean concentration (EMC), precipitation depth, and watershed area information from the NSQD, a total mass for each pollutant and precipitation event was calculated and normalized per unit area. Table 2-1 below contains the values from the

NSQD sites that are similar to the study focus area and the results of stormwater sampling conducted in October of 2017.

Pollutant	NSQD Minimum EMC (mg/L)	NSQD Maximum EMC (mg/L)	NSQD Average EMC (mg/L)	Bath SW-WFP (mg/L)	Bath SW-COMM (mg/L)
Total Suspended Solids (TSS)	6	2996	210	21	61
Total Phosphorus	0.026	8.6	0.28	0.177	0.241
Total Nitrogen	0.37	27.2	1.84	0.77	2.1
Biochemical Oxygen Demand (BOD)	1.8	49	11.5	5.9	5.1
Total Petroleum Hydrocarbons	1.06	3.03	1.626	0.6*	1.15*

Table 2-1: Comparison of NSQD to Collected Data

Pollutant buildup values calculated from the NSQD and initial pollutant buildup values used in model simulations are shown in Table 2-2 below.

Pollutant	NSQD Calculated Minimum Washoff (pounds/ acre)	NSQD Calculated Maximum Washoff (pounds/ acre)	NSQD Calculated Average Washoff (pounds/ acre)	NSQD Typical Washoff for 1-inch Rain Event (pounds/ acre)	Initial (Maximum) Mass Loading for Simulations (pounds per acre)
Total Suspended Solids (TSS)	1.63	798.5	120	80	500
Biochemical Oxygen Demand (BOD)	2.5	71.4	27	25	150
Total Nitrogen	1.79	114.6	11.4	5	30
Total Phosphorus	0.03	6.2	0.89	0.65	4

Table 2-2: NSQD Pollutant Washoff Data & Selected Buildup Concentrations

The washoff values from the NSQD are from specific rainfall events. Where precipitation and event mean concentration were available, the relationship between precipitation depth and washoff was inspected to determine a reasonable washoff mass per unit area for a 1-inch storm for calibrating the model. The initial mass loading used in the model simulations is considered a maximum (saturation value), while the mass loading calculated from the NSQD data is for individual events, and likely does not represent the maximum loading for that area.

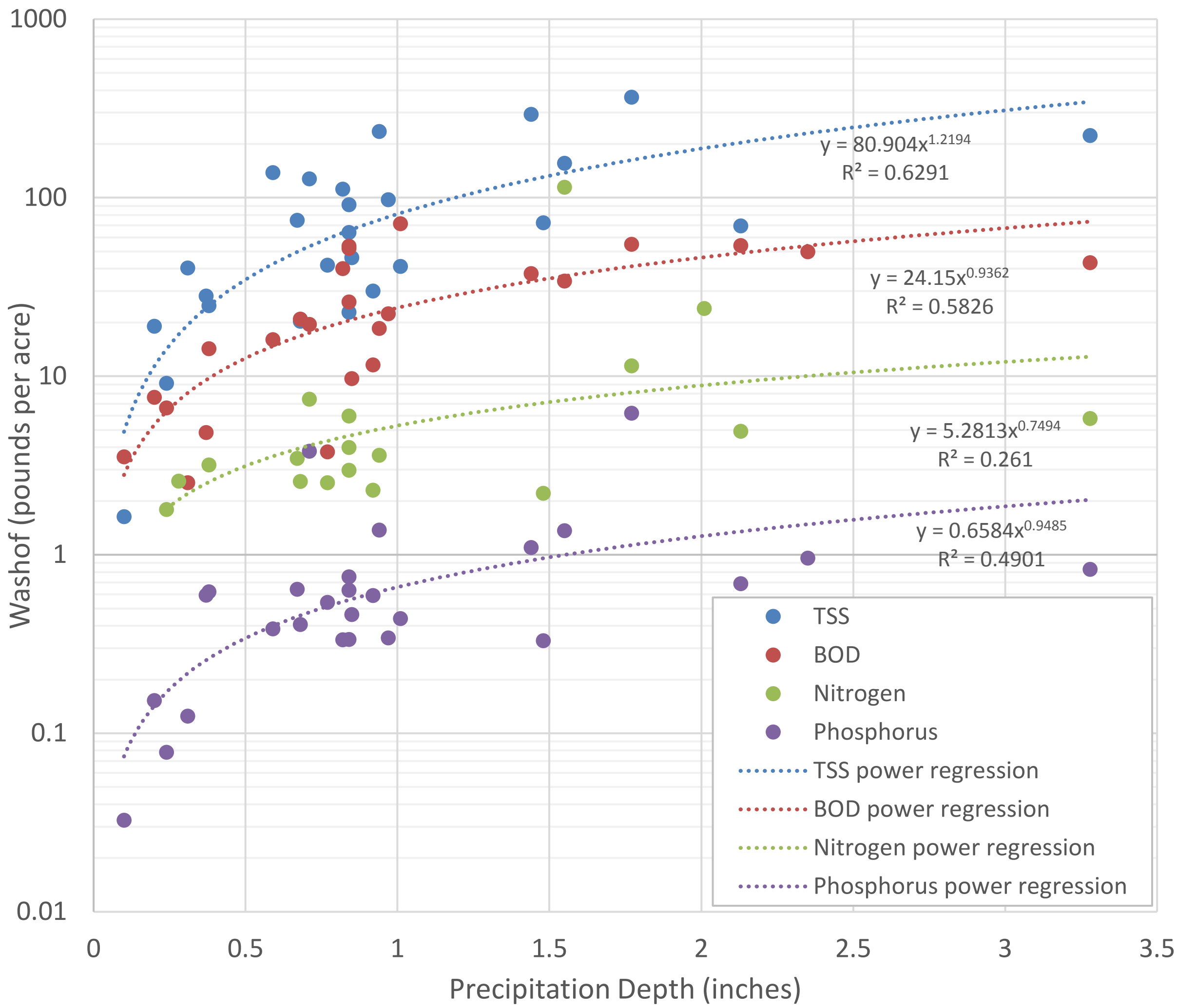

Figure 2-8: NSQD Washoff Data Used for Parameter Selection

3.0 SIMULATIONS

3.1 Scenarios Simulated

Precipitation events of 24-hour duration totaling one tenth, one quarter, one half inch, one inch, 2.59 inches (1-year storm), 3.13 inches (2-year storm), 4.01 inches (5-year storm), 4.74 inches (10-year storm), 5.74 inches (25-year storm), 6.51 inches (50-year storm), and 7.29 inches (100-year storm) were simulated. Tidal sequences were selected to represent a high tide water level equal to mean higher high water (MHHW, 5.2 feet NAVD88) at the precipitation intensity peak, with projected sea level rise for the year 2050, and with projected sea level rise for the year 2100. Sea level rise scenarios for 2050 and 2100 were selected using the probabilistic distribution compiled by Kopp et al. Based on a 90% confidence interval, meaning that there is assumed to be a 90% chance that sea level rise will not exceed this level, sea level rise values of 1.5 feet and 3.5 feet were selected for 2050 and 2100, respectively.

3.2 Results

Results of simulated scenarios occurring at high tide are tabulated in Tables 3-1 to 3-3, below. Results are reported separately for each sea-level rise scenario. The same set of storm events was simulated for each sea-level rise scenario for the purpose of comparison; however, it is likely that in 2050 and 2100, these precipitation totals will have different return periods.

The flood volume reported is calculated as the total volume of water that leaves the model domain. Once the capacity of the system is exceeded, water begins to flow out of the catchbasins. The flood volume represents the total volume of water that is in excess of the system capacity. A total flood volume of two million gallons does not necessarily mean that, at the end of the storm, there will be two million gallons of water sloshing around streets and basements. Some of that water will flow overland to the Kennebec River, some may remain in streets, and some may enter buildings or eventually drain through the storm drain as the precipitation lessens. These values are reported as a comparative measure for system capacity related to each storm.

Present Day Sea-Level						
Storm Return Period	**Precipitation Total (inches)**	**Pollutant Discharge from Outfalls (pounds)**				**Total Flood Volume (millions of gallons)**
		TSS	**BOD**	**N**	**P**	
Less than 1-year	0.1	2403	721	144	19.2	--
Less than 1-year	0.25	3591	1077	215	28.7	--
Less than 1-year	0.5	5603	1681	336	44.8	--
Less than 1-year	1.0	9275	2782	556	74.2	0.05
1-year	2.59	15957	4961	992	140.6	0.44
2-year	3.13	17553	5501	1100	157.9	0.65
5-year	4.01	20339	6436	1287	187.5	1.07
10-year	4.73	22257	7093	1419	208.9	1.52
25-year	5.74	24115	7765	1553	232.3	2.33
50-year	6.51	25060	8136	1627	246.4	3.07
100-year	7.29	25722	8422	1684	258.2	3.91

Table 3-1: Simulation Results Based on Current Sea Level

Projected 2050 Sea Level Rise (1.5 feet above 1992 mean sea level)						
Storm Return Period	**Precipitation Total (inches)**	**Pollutant Discharge from Outfalls (pounds)**				**Total Flood Volume (millions of gallons)**
		TSS	**BOD**	**N**	**P**	
Less than 1-year	0.5	5046	1514	303	40.4	0.46
Less than 1-year	1.0	7316	2195	439	58.5	0.59
1-year	2.59	12714	3977	795	113.8	1.29
2-year	3.13	14039	4428	886	128.4	1.60
5-year	4.01	16646	5292	1058	155.3	2.21
10-year	4.73	18492	5916	1183	175.3	2.79
25-year	5.74	20455	6602	1320	198.3	3.79
50-year	6.51	21419	6962	1392	211.2	4.66
100-year	7.29	22173	7256	1451	222.3	5.61

Table 3-2: Simulation Results Based on 2050 Projected Sea Level

Projected 2100 Sea Level Rise (3.5 feet above 1992 mean sea level)						
Storm Return Period	**Precipitation Total (inches)**	**Pollutant Discharge from Outfalls (pounds)**				**Total Flood Volume (millions of gallons)**
		TSS	**BOD**	**N**	**P**	
Less than 1-year	0.5	3123	937	187	25.0	11.52
Less than 1-year	1.0	3875	1163	233	31.0	11.92
1-year	2.59	6035	1857	371	51.7	13.31
2-year	3.13	6731	2076	415	58.1	13.87
5-year	4.01	7793	2410	482	67.7	14.99
10-year	4.73	8849	2743	549	77.4	15.99
25-year	5.74	10310	3201	640	90.5	17.45
50-year	6.51	11525	3580	716	101.3	18.56
100-year	7.29	12539	3901	780	110.7	19.74

Table 3-3: Simulation Results Based on 2100 Projected Sea Level

3.3 Interpretation

3.3.1 Simulated pollutant loading & flooding trends

The results included in Table 3-1 for current sea levels indicate pollutant loading and flood volume for a series of precipitation events. Pollutant discharge through the three modelled outfalls increases with precipitation intensity, but approaches a maximum; that is, the increase in pollutant loading diminishes as the return period gets longer. This is a function of the limited mass of pollutants that can accumulate on the ground surface. Flood volumes are directly correlated to rainfall intensity. Once the system capacity has been reached, all additional rainfall leaves the system as flooding.

The results included in Table 3-2 for 2050 sea level projection indicate similar trends for both pollutants and flood volume as the model simulations for current sea levels, but the 1.5-foot increase in sea level reduces the capacity of the existing system such that a 2-year precipitation event in 2050 has a comparable flooding effect to a 10-year storm event under current conditions. The pollutant mass discharged through the outfalls modeled shows a reduction for the 2050 scenario as compared to the current sea level; however, this is somewhat misleading. The total mass of pollutants washed off the surface would be comparable to the current sea level scenario. The difference in mass discharged through the outfalls is the result of flooding. The water lost during flooding carries pollutant mass with it that would not be measured at the outfalls, but may flow overland to the river or enter buildings.

The 2100 sea level rise scenario of 3.5 feet is so dire that precipitation has little meaningful effect. Looking at a high tide elevation of 8.8 feet NAVD88, nearly a foot greater than the current 1% annual chance storm surge elevation of 8 feet NAVD88, on the order of 10 million gallons of water would enter and flood the stormwater system from the Kennebec River. A similar effect is observed in the pollutant loading masses to the 2050 scenario. Much of the pollutant mass washed off the surface is not discharged through the outfalls but transported to the river via flooding.

3.3.2 Analysis considering precipitation events from 1997 to 2017

To provide context, Ransom reviewed daily precipitation totals from the Wiscasset Municipal Airport from January 1997 through November 2017. The data was obtained from the Weather Underground online meteorological database. A peaks-over-threshold analysis was done to determine the number of days with precipitation equal to or greater than 0.5 inches, 1.0 inches, 2.59 inches, 3.13 inches, 4.01 inches, 4.73 inches, 5.74 inches, 6.51 inches, and 7.29 inches. Findings are shown in Table 3-4 below, and Figure 3-1 shows a scatter plot of the precipitation events since January 1997. For clarity, days with no precipitation are not included in Figure 3-1 (leaving 3015 days with measurable precipitation).

Storm Return Period	Precipitation Total (inches)	Number of days exceeding threshold from 1997 to 2017
Less than 1-year	0.1	1611
Less than 1-year	0.25	1065
Less than 1-year	0.5	599
Less than 1-year	1.0	222
1-year	2.59	18
2-year	3.13	10
5-year	4.01	5
10-year	4.73	3
25-year	5.74	0
50-year	6.51	0
100-year	7.29	0

Table 3-4: Number of Days Exceeding Return Period Rainfall

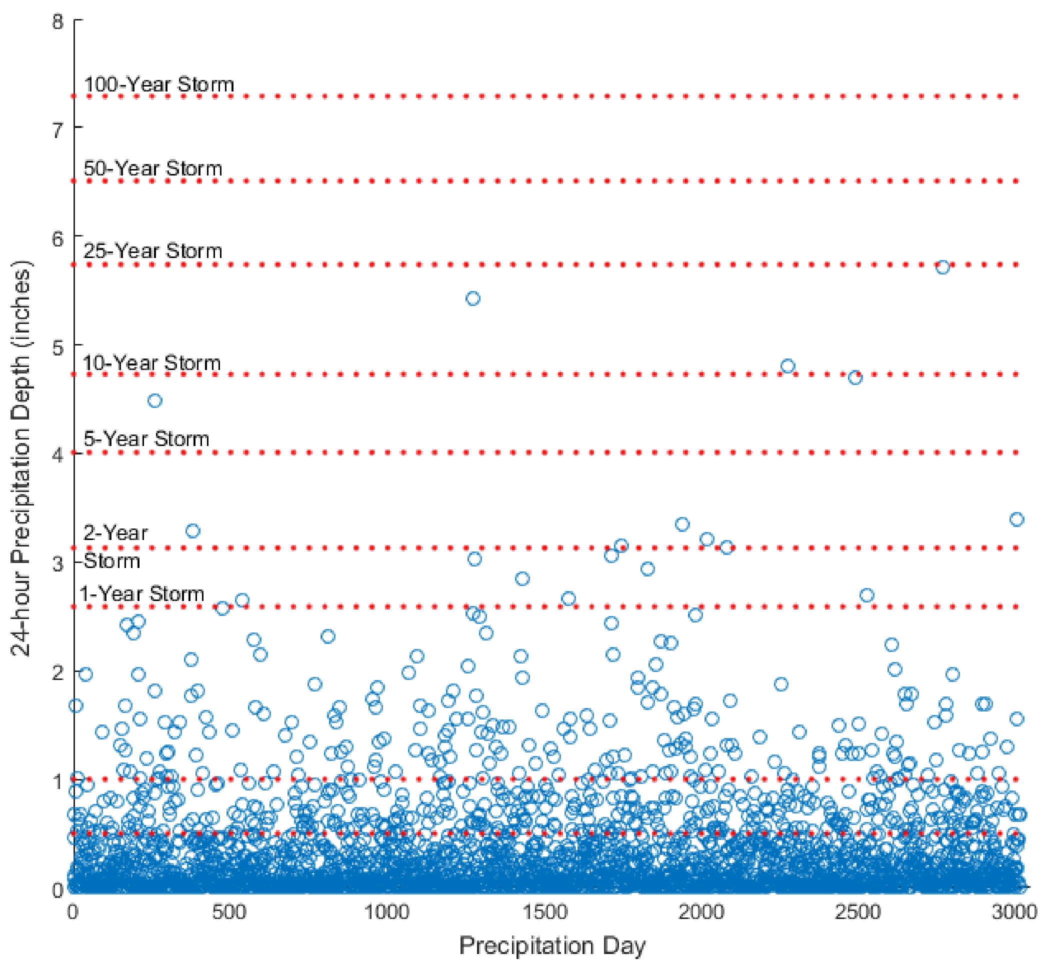

Figure 3-1: Daily Precipitation Totals Since January 1997

Looking specifically at the 24-hour precipitation depth for each synthetic storm return period, the number of events for each return period since 1997 matches the statistical model reasonably well; 18 days exceeding the 1-year value, 10 days exceeding the 2-year value, five days exceeding the 5-year value, and 3 days exceeding the 10-year value. However, it is important to consider that daily precipitation totals do not accurately represent overnight rain events, making this a conservative approach. Furthermore, two days that would be categorized as 10-year storms were only 0.03 and 0.32 inches below the 25-year return period value of 5.74 inches, well within the confidence interval of the NOAA Atlas 14 statistical analysis for a 25-year storm. Similarly, two days that would be categorized as 5-year storms, were only 0.03 and 0.25 inches below the 10-year return period value of 4.73 inches, well within the confidence interval of the NOAA Atlas 14 statistical analysis for a 10-year storm. A rigorous statistical analysis of rainfall data was outside the scope of this project; however, this data points to an increased frequency of heavy rainfall events.

Using the estimated loadings from model simulations for a range of precipitation amounts, a function relating precipitation depth to pollutant loading was assumed, and pollutant loads were calculated for each daily precipitation event recorded from 1997 to 2017. Figure 3-2 below shows the distribution of simulated pollutant loadings for each event with respect to precipitation depth.

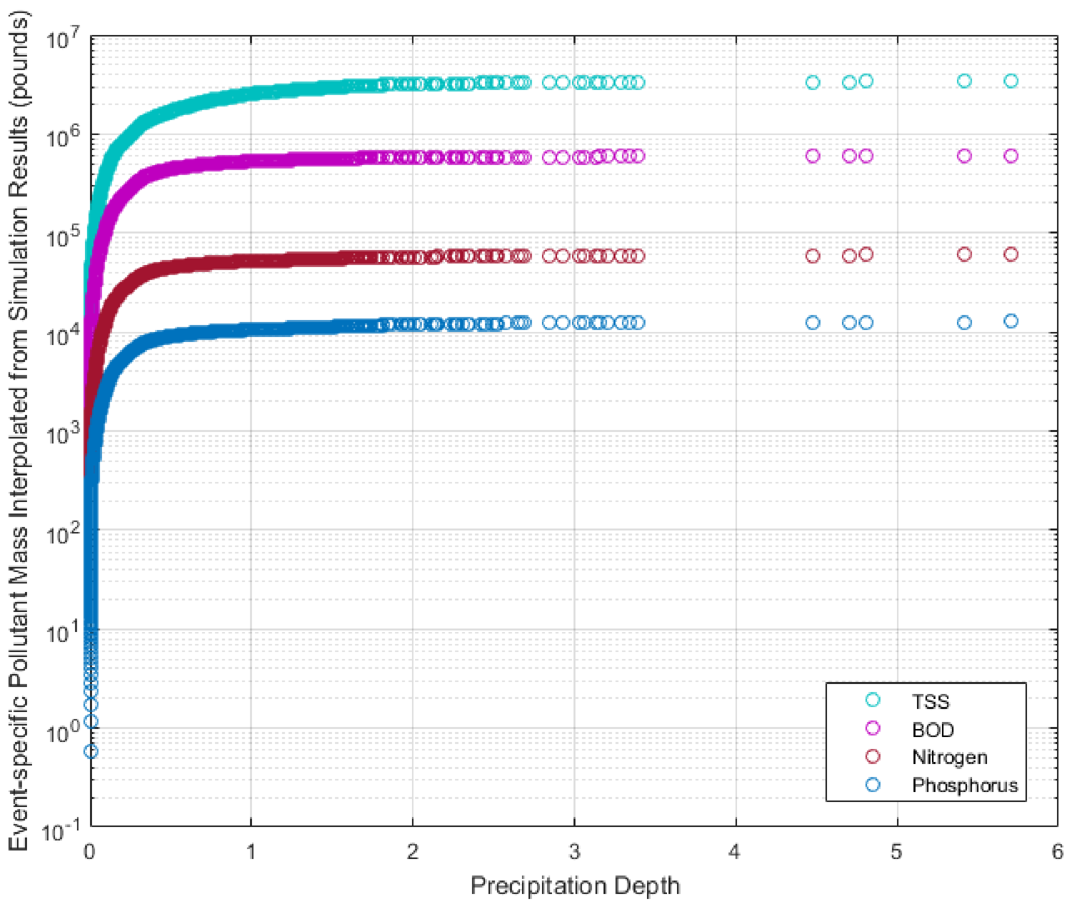

Figure 3-2: Simulated Pollutant Loading for Precipitation Events Since 1997

This analysis indicates daily rain events of one inch or less account for 75% of total TSS, BOD, total nitrogen, and total phosphorus loading. When the first inch of precipitation during heavier events is included, over 90% of the cumulative mass for each pollutant is accounted for.

3.3.3 Potential effects on Kennebec River

According to the *Kennebec Estuary: Restoration Challenges and Opportunities* report published in 2010, approximate values for TSS, nitrogen, and phosphorus concentrations at Chops point, just north of Bath, are 15 mg/L, 0.3 – 0.4 mg/L, and 0.0125 – 0.03 mg/L, respectively. Dissolved oxygen levels near the surface near Merrymeeting Bay range around 7.5 mg/L. The average flow rate at the outlet of Merrymeeting Bay is approximately six billion gallons per day, and the drainage area is approximately 6,000 square miles.

Based on the simulated results, 9,275 pounds of TSS, 2,782 pounds of BOD, 556 pounds of nitrogen, and 74 pounds of phosphorus enter the Kennebec River from the Bath stormwater system every time a 1-inch rain event occurs. Since 1997, at least 222 1-inch rain events have occurred. The effect on concentrations in the Kennebec River can be estimated using a simple mass balance approach:

$$\frac{(C_{storm} * Q_{storm}) + (C_{river} * Q_{river})}{Q_{storm} + Q_{river}}$$

Where C_{storm} is the average stormwater discharge concentration over the duration of the storm; Q_{storm} is the total volume of stormwater discharged over the course of the day; C_{river} is the concentration of the river, and Q_{river} is the daily flow rate of the river. Table 3-5 below shows the potential influence of a 1-inch storm on Kennebec River concentrations.

	C_{storm} (mg/L)	**Q_{storm} (million gallons/day)**	**C_{river} (mg/L)**	**Q_{river} (million gallons/day)**	**C_{mix} (mg/L)**	**Percent Difference**
TSS	462	2.4	15	6000	15.17	1.1% increase
BOD	139	2.4	7.5 (dissolved oxygen)	6000	7.445	0.74% reduction in dissolved oxygen
N	27.8	2.4	0.35	6000	0.36	3.1% increase
P	3.7	2.4	0.02	6000	0.215	7.4% increase

Table 3-5: Influence of Simulated 1-inch Precipitation Event on Kennebec River Quality

The magnitude of concentration changes appears relatively small, ranging from 0.74% to 7.4%; however, the study area only accounts for approximately 0.0028% of the drainage area, which illustrates the importance of stormwater management in Bath to the overall quality of the Kennebec River. Relatively small changes in concentration, particularly dissolved oxygen and nutrient concentrations, can have dramatic effects on the health of a waterbody.

4.0 IMPLEMENTATION OF LOW-IMPACT DEVELOPMENT & GREEN INFRASTRUCTURE ELEMENTS

4.1 Green Infrastructure & Low-Impact Development Background

Green infrastructure as a concept approaches the built environment from the perspective that mimicking natural systems is preferable to over-engineering systems that fight natural processes. Green infrastructure takes advantage of the natural water cycle to increase efficiency and reduce cost of water management where practical through reducing consumption of power and materials used for movement and treatment of water.

Low-impact development (LID) measures function as the implementation of green infrastructure concepts. Regarding stormwater, LID measures attempt to manage stormwater at its source, i.e., where precipitation falls. Where traditional stormwater management systems prioritize hydraulic capacity and rapid conveyance of water from a collection point to a discharge point, LID measures promote infiltration and evapotranspiration. Figure 4-1 below illustrates the differences between natural systems and densely developed urban environments.

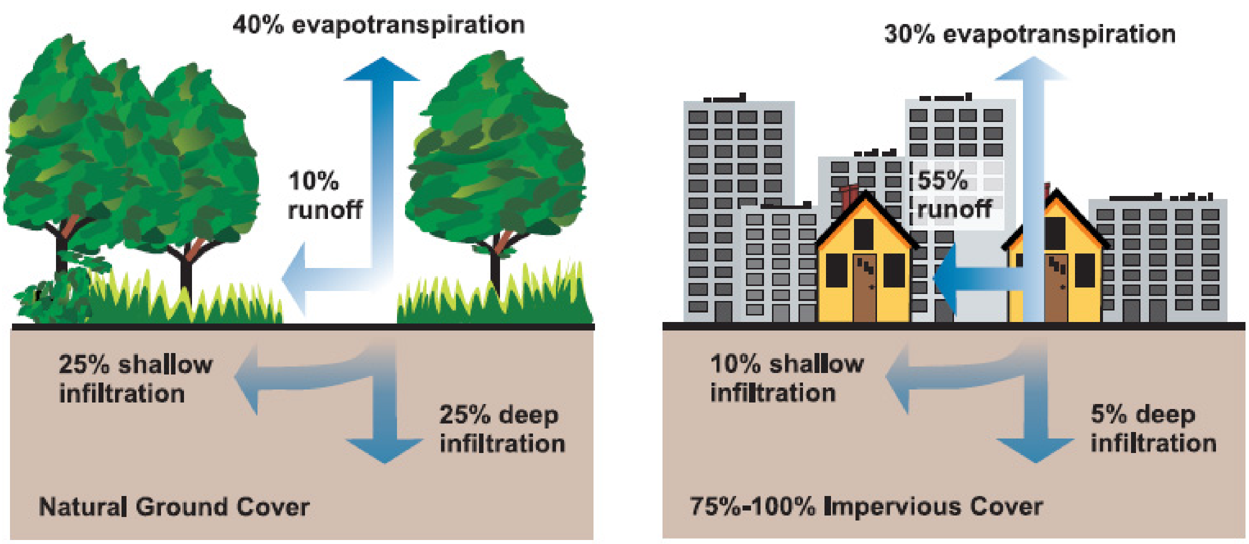

Figure 4-1: Conceptual Effect of Urbanization on Hydrologic Processes (image obtained from epa.gov)

These images are for comparative purposes only, as every system is different, but the comparison is useful. In the natural system depicted on the left, 90% of stormwater is "managed" through the combination of vegetation and infiltration. In contrast, developed urban environments must manage more than five times the runoff, and in cases of heavy precipitation in developed areas, close to 100% of precipitation must be handled as surface runoff.

4.2 Low-Impact Development Implementation for Bath

The focus area for this study is one of the most densely developed areas in Maine. Land cover is dominated by impervious buildings, roads, and parking lots. LID measures that will be the most effective in Bath must provide capacity for managing stormwater through detention, infiltration, and/or treatment, but must also not compromise the utility of existing structures or infrastructure. With space at a premium, the most effective and practical LIDs include permeable pavers, rain gardens, vegetated roofs and proprietary high rate biofilters.

Permeable pavement is constructed from porous asphalt, interlocking pavers, or pervious concrete. It allows precipitation to infiltrate close to where it falls. Runoff percolates through the pavement and through a sand media, which provides treatment through removing TSS, nutrients, and other pollutants. Typically, permeable pavement must constitute 20% of the total impervious area in order to provide effective management. It is effective at collecting and treating lower flows, and is often paired with an underdrain network that discharges to a municipal stormwater system or other receiving system in the event of heavy precipitation. Permeable pavement can be used in new construction or as a retrofit to upgrade existing infrastructure.

Rain gardens or bioretention cells treat runoff from a small to moderate contributing area by directing stormwater to a specific area where it can infiltrate. Rain gardens are typically planted with specific vegetation that can withstand frequent inundation and provide increased evapotranspiration. The soil media used in rain gardens provides treatment of stormwater, removing TSS and nutrients, and provides habitat and green space. Because soil has a limited infiltration capacity, rain gardens in urban settings are often paired with an underdrain and overflow system that handles excess water during heavy precipitation.

High rate biofilters are similar in concept to rain gardens; however, high rate biofilters take advantage of engineered soil media and drainage systems to reduce the footprint required to treat a given volume of stormwater. These systems allow higher rates of infiltration and evapotranspiration. The higher infiltration rate is sometimes accompanied by a reduction in treatment efficiency compared with a traditional rain garden, but high rate biofilters still provide significant pollutant reduction during first flush events.

4.3 Conceptual Designs

Ransom prepared conceptual designs for five sites within the study area. The intent of the designs is to demonstrate different means for managing stormwater that would be effective and minimize impact to existing facilities (e.g., roads, sidewalks, buildings, parking, etc.). Four of the conceptual designs utilize permeable pavement, rain garden, and bioretention cell approaches, which embody green infrastructure and low-impact design principles. The fifth conceptual design employs a point treatment system which demonstrates a retrofit approach that would achieve the purpose of improving stormwater quality, but does not reduce runoff volume or impervious area.

Figure 4, attached, shows the relative location of each conceptual design. Appendix B contains plan view drawings for each location, and Appendix C contains the basic construction details for each design. The following sections describe the conceptual design for each area; the anticipated stormwater management performance; and a preliminary estimate of probable construction cost (this does not include engineering or permitting, etc.). Cost estimates are based on undertaking each project individually; savings would be possible if these actions were completed during regular infrastructure maintenance or upgrades.

4.3.1 Elm Street & Water Street

The conceptual design for Elm Street and Water street utilizes a bioretention cell system to treat approximately 2,020 square-feet of impervious roadway. The system consists of a curb inlet just upstream of an existing catch basin, an energy-dissipating stone forebay, the bioretention cell area, and an underdrain and overflow system that directs excess flow to the catch basin.

This system stores, provides treatment for, and can infiltrate the first inch of precipitation. Typical bioretention cell performance reduces runoff during low intensity precipitation events by 80%, removes 99% of TSS, and removes 65% of total nitrogen and phosphorus. Use of a bioretention cell in this location has the added benefit of collecting and treating stormwater in a steep location. Runoff on steep slopes achieves a higher velocity and is more likely to pick up material deposited on the surface and carry it into the drainage network. Once in the drainage network, material can reduce the hydraulic capacity by blocking catch basins and pipes and will ultimately be discharged to the receiving water. The opinion of probable cost for this measure is $13,000.

4.3.2 Front Street & Elm Street

The conceptual design for Front Street and Elm Street utilizes a proprietary high rate biofilter system called the Focal Point produced by ACF Environmental. The biofilter can treat approximately 15,080 square feet of impervious roadway and sidewalk. The design consists of a curb inlet just upstream of an existing catch basin, an energy-dissipating stone forebay, the biofilter media area, and an underdrain and overflow system to divert high flows back into the municipal storm drain system.

This system provides treatment for and can infiltrate the first inch of precipitation. Typical bioretention cell performance reduces runoff during low intensity precipitation events by 33%, removes 80-90% of TSS, and removes 50% and 60% of total nitrogen and phosphorus, respectively. Use of a high rate biofilter cell in this location has the added benefit of collecting and treating stormwater in a steep location. Runoff on steep slopes achieves a higher velocity and is more likely to pick up material deposited on the surface and carry it into the drainage network. Once in the drainage network, material can reduce the hydraulic capacity by blocking catch basins and pipes and will ultimately be discharged to the receiving water. The opinion of probable cost for this measure is $25,000.

4.3.3 Centre Street & Water Street

The conceptual design for Center Street and Water Street calls for pervious pavers in the parking lane on each side of the street. The pervious paver system can treat runoff from approximately 14,685 square-feet of impervious roadway and sidewalk. The design consists of 6.5-foot wide strips of pervious pavers along each curb line. The pervious pavers are underlain by a 3-inch layer of fine crushed stone (3/8-inch), which is underlain by a 12-inch layer of crushed stone (3/4-inch). Below the crushed stone is an 18-inch thick filter bed of sandy mineral soil that provides treatment to the stormwater passing through. An underdrain system of drainage stone and perforated pipe lies beneath the entire system and is connected to the municipal stormdrain system to divert excess flows.

The pervious paver system provides treatment and infiltration for the first inch of precipitation. Typical performance of pervious paver systems reduces runoff during low intensity events by 45%, removes 90% of TSS, 10% of total nitrogen, and 33% of total phosphorus. Depending on the infiltration rate of the native soil underlying the entire system, a greater runoff reduction may be achieved. Pervious pavers also add visual delineation, which can be useful for directing traffic. The opinion of probable cost for this measure is $120,000.

4.3.4 Water Street Parking Lot

The conceptual design for the Water Street parking lot calls for pervious pavers in the circulation lanes through the parking lot entrance, exit, and drive aisles. The pervious paver system can treat runoff from approximately 55,885 square-feet of impervious roadway. The design consists of 6.5-foot wide strips of pervious pavers as shown in Appendix B. The pervious pavers are underlain by a 3-inch layer of fine crushed stone (3/8-inch), which is underlain by a 12-inch layer of crushed stone

(3/4-inch). Below the crushed stone is an 18-inch thick filter bed of sandy mineral soil that provides treatment to the stormwater passing through. An underdrain system of drainage stone and perforated pipe lies beneath the entire system and is connected to the municipal stormdrain system to divert excess flows.

The pervious paver system provides treatment and infiltration for the first inch of precipitation. Typical performance of pervious paver systems reduces runoff during low intensity events by 45%, removes 90% of TSS, 10% of total nitrogen, and 33% of total phosphorus. Depending on the infiltration rate of the native soil underlying the entire system, a greater runoff reduction may be achieved. Pervious pavers also add visual delineation, which can be useful for directing traffic. The opinion of probable cost for this measure is $350,000.

4.3.5 Centre Street & Washington Street

The conceptual design for treatment near the intersection of Centre Street and Washington Street calls for an in-line, point treatment measure. As discussed in previous sections, the Commercial Street Outfall drains additional area beyond the study focus area. This approximately 52-acre area outside the study focus area drains to a network of catch basins and pipes, and ultimately into the Commercial Street Outfall trunk line. The conceptual design consists of a proprietary treatment structure called the Jellyfish®, manufactured by Contech Engineered Solutions.

The Jellyfish® stormwater treatment system provides two treatment stages within one structure. Storm water is initially directed to the bottom of the structure, where solids settle. Once enough pressure head is developed, the water is forced up through membrane filters and out of the structure. This configuration allows solids to settle and fats, oils, and grease to be separated prior to filtration. The system has a maximum flow rate of 3.74 cubic feet per second (cfs), and the peak flow from a 1-inch precipitation event in this drainage area is approximately 5.8 cfs; however, the maximum flow of the Jellyfish® is only exceeded for approximately 20 minutes, based on a Type III storm event. The Jellyfish® would treat approximately 99% of the 1-inch storm event for this drainage area, with the excess being diverted through an overflow structure to the downstream collection system. This treatment system reduces TSS by 89%, total nitrogen by 51%, and total phosphorus by 59%. Because it is an in-line system that provides no opportunity for infiltration, the Jellyfish® does not reduce runoff. The estimated cost for this system is $195,000.

5.0 CONCLUSION & RECOMMENDATIONS

5.1 Study Limitations

Stormwater quality and quantity results obtained in this study are best estimates and should generally be considered comparative rather than predictive. SWMM is not topographical; flooding is volumetric but not related to inundation area. The model generally assumes all runoff from a subcatchments enters the storm drain system. In reality, flow misses catch basins due to elevation differences, bypasses plugged catchbasins, or exceeds capacity of structure inlet, and flows further downgradient, where it enters at a downstream location or contributes to surface flooding. SWMM does not account for this phenomenon.

5.2 Data Gaps

5.2.1 Long term precipitation & flowmeter data

Study area-specific data correlating precipitation with stormdrain discharge was not readily available. Due to the unpredictable nature of precipitation, data collected during this study did not provide a great deal of guidance. Longer term flow and precipitation monitoring would improve the accuracy of this model.

5.2.2 Extensive stormwater quality data collection

Stormwater quality data collected during this study was not sufficient to characterize stormwater quality during a range of precipitation events. Data from other sites provided useful guidance for producing results that are consistent with observed data, but not necessarily representative of the study focus area. Stormwater quality samples collected during a range of precipitation events and at different points during the event would improve the accuracy of this model.

5.2.3 Stormwater & sewer system GIS data collection

The stormwater and sewer system GIS data maintained by the City of Bath contains useful information regarding system component location, size, and material. However, some pipe size and structure elevation data are missing from the database. In the course of maintenance activities and improvement projects, Public Works personnel could to add and augment the system data set as they observe pipes and structures.

5.3 Recommendations for stormwater management improvements

5.3.1 Continued CSO abatement through storm drain separation

The City of Bath has made great progress in reducing the impact of CSO events on the Kennebec River. Continuing this trend with a goal of zero CSO events is crucial to improving stormwater quality and reducing potential ill-effects on the Kennebec River.

5.3.2 Establishment of a Stormwater Utility

A stormwater user fee database maintained by Western Kentucky University indicates that there were at least 1,490 stormwater utilities in the United States as of 2014. Stormwater utilities are designed based on the characteristics and needs of individual communities with the goal of funding infrastructure improvements that will improve stormwater quality and maintain or move toward compliance with applicable stormwater regulations. There are three primary bases for fee collection: Equivalent Residential Unit (ERU), Intensity of Development (ID), and Equivalent Hydraulic Area

(EHA). The ERU system bases stormwater user fees on the impervious area of a property, regardless of overall parcel size, and it is the most commonly used fee structure. The ID approach bases fees on the impervious area of a parcel as a percentage of the overall parcel size. A flat fee is often assessed in an ID system even on undeveloped land. The EHA system bases fees on the stormwater runoff generated by impervious and pervious areas of a property, weighing the impervious area much higher in the fee calculation.

The Cities of Portland, Lewiston, Bangor, and Augusta have adopted stormwater utilities, each using the ERU approach to fee structures. Fee structures are summarized in Table 5-1 below:

	Base ERU (square feet)	**Base Fee**	**Additional ERU (square feet)**	**Additional Fee**
Portland	1,200	$6.00/month	1,200	$6.00/month
Lewiston	2,900	$50.00/year	1	$0.054/year
Augusta	2,700	$8.30/month	2,700	$8.30/month
Bangor	3,000	$22/year	1,000	$11/year

Table 5-1: Comparison of Municipal Stormwater Utilities in Maine

Each stormwater utility has also developed fee reductions based on treatment measures that reduce the effective impervious area of a property. Fee reductions for treatment incentivize use of LID measures by developers in new construction and redevelopment. The collected fees should be isolated from general funds and be used to construct LID measures in public areas.

The EPA guidance breaks creation of a stormwater utility into six steps: developing a feasibility study; creating a billing system; rolling out a public information program; adopting an ordinance; providing credits and exemptions; and implementing the utility. The feasibility study identifies revenue requirements, single-family residential impervious area, and preliminary ERU billing rates to determine if a stormwater utility will achieve its designated purpose. Setting up a billing system collects parcel area data and impervious/pervious area breakdowns and establishes a system to bill users. Most utilities add the utility fee to an existing bill (as a separate item) for ease of administration. The public information program is designed to gain support from residents and business owners and inform the public of the potential benefits to water quality and flood protection. Adopting an ordinance provides the legal authority to collect fees and use the fees for stormwater improvements. The use of credits and exemptions is a powerful tool in motivating developers and homeowners to take on some of the work that would otherwise be undertaken by the municipality, thereby saving time, money, and effort on the part of the utility. Lastly, the initial implementation, i.e., first bill, must not surprise users. It is recommended that users be notified of their estimated fee several months before the first actual bill is issued. A method of public communication must also be established and maintained to respond to questions during the implementation of the fee.

5.3.3 Development of stormwater management goals

5.3.3.1 Effective impervious area

For the downtown area in particular, a stormwater management goal addressing effective impervious area would provide direction for mitigation measures. The downtown area is unlikely to become a great deal less impervious without removing or modifying roads or buildings or adding large areas of pervious pavement. The alternative to that is LID measures such as those depicted in the conceptual designs for locations 1 through 4. These measures reduce the effective impervious area by allowing infiltration of stormwater from adjacent impervious areas. An effective impervious area of 50% would reduce stormwater flows and increase green spaces.

5.3.3.2 Treatment goals

Consistent with the pollutant loading findings, the treatment goal for the study focus area, and potentially the entire City, should be treatment of the first 1 inch of precipitation. Treatment should focus on removal of TSS, nitrogen, and phosphorus. Evaluation of whether a project meets the treatment goals may be based on a tiered or scored system in which retention and infiltration of the first inch of precipitation counts fully toward the treatment goal; treatment of the first inch in accordance with the MEDEP Chapter 500 Stormwater rules counts fully toward the treatment goal; and treatment measures that don’t meet the MEDEP Chapter 500 standards are graded based on the portion of the first inch treated or the amount of nutrient and TSS removal achieved.

5.4 Recommendations for next steps

This study may be used as the basis for a combination project to assess overall feasibility of implementing a municipal stormwater utility and creating a billing system, and drafting an ordinance for review by the City Council. Model stormwater utility ordinances are available from the State of Maine Planning Office. Once an initial rate structure has been established, the approval and adoption process can move forward.

The first step toward implementation of the stormwater management goals is to incorporate stormwater management explicitly in Article 10 of the City of Bath Land Use Code. All development and redevelopment projects within the City that are subject to the Land Use Code ordinance should be required to analyze runoff and consider LID stormwater management measures that address both quantity and quality of stormwater with meeting MEDEP Chapter 500 standards as the goal. Results of analysis and a stormwater management plan, including LID measures, should be included as submittals in the City review process. In the event that LID measures are impractical, a waiver may be requested based on a technical basis (site constraints such as layout or underlying soil conditions) or economic hardship.

Requiring developers to consider stormwater quality and prepare a plan for mitigating stormwater pollutant loading without immediate utility fees, but with the clear understanding that the City intends to implement a stormwater utility, begins to introduce the stormwater review process to developers. It encourages forward thinking on the part of the developers in that consideration of capital improvements for stormwater infrastructure now may save them utility fees or retrofit costs in the future. It also provides a transition during which developers are aware of the City’s intention, but are not under a formal obligation.

RANSOM
Consulting
Engineers
and Scientists

Figure:

Figure 1

Study Area

Prepared For:

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Site:

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Legend and Notes:

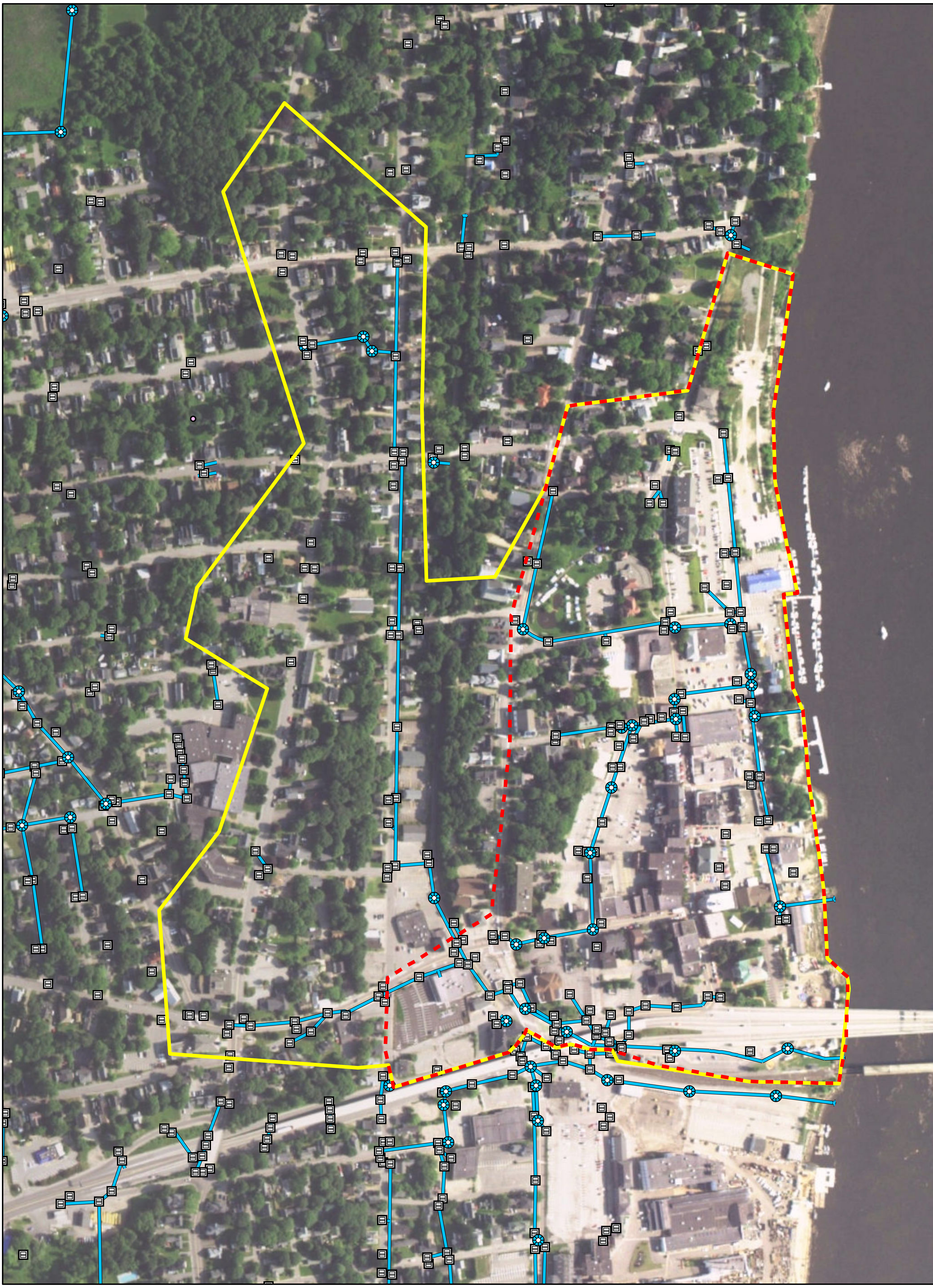
DRAFT

Notes

1. Site Plan based on National Agricultural Imagery Program Orthophotography
2. Some features are approximate in location and scale
3. This plan has been prepared for Mr. Scott Zielfelder. All other uses are not authorized unless written permission is obtained from Ransom Consulting, Inc.

0 150 300 600 FT

1 inch = 300 feet



RANSOM Consulting Engineers and Scientists

Figure:

Figure 2

Study Area with Storm Drain System

0 150 300 600 FT

1 inch = 300 feet

Prepared For:

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Site:

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Legend and Notes:

DRAFT

Notes

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RANSOM Consulting Engineers and Scientists

Figure:

Figure 3

Flowmeter Locations & Stormwater Sample Locations

0 150 300 600 FT

1 inch = 300 feet

Prepared For:

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Site:

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Legend and Notes:

Stormwater Sample

Flowmeter Locations

DRAFT

Notes

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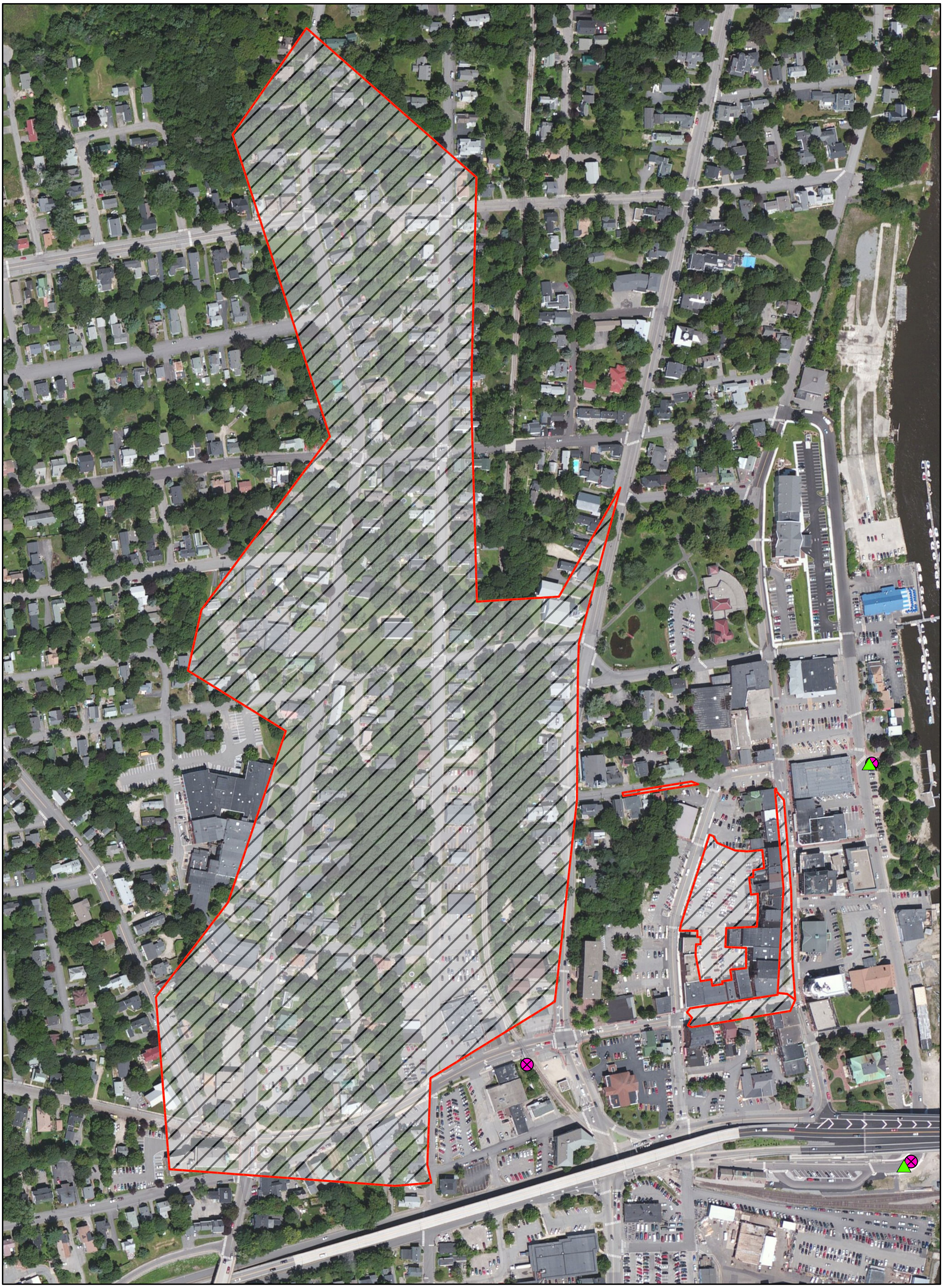

Figure:

Figure 4

Conceptual Design Locations

Prepared For:

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Site:

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0 125 250 500 FT

1 inch = 250 feet

Legend and Notes:

DRAFT

Notes

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APPENDIX A

Laboratory Analysis Results

Final Report
Maine Coastal Program
Downtown Storm Water Study
Bath, Maine

Ransom Consulting, Inc.
Project 161.06064

ANALYTICAL REPORT

Lab Number:	L1738765
Client:	Ransom Consulting, Inc. 400 Commercial Street Suite 404 Portland, ME 04101-4660
ATTN:	Steve Dyer
Phone:	(207) 772-2891
Project Name:	BATH DTSW
Project Number:	161.06064
Report Date:	11/07/17

Certifications & Approvals: MA (M-MA086), NH NELAP (2064), NJ NELAP (MA935), CT (PH-0574), IL (200077), ME (MA00086), MD (348), NY (11148), NC (25700/666), PA (68-03671), RI (LAO00065), TX (T104704476), VT (VT-0935), VA (460195), USDA (Permit #P330-14-00197).

Eight Walkup Drive, Westborough, MA 01581-1019
508-898-9220 (Fax) 508-898-9193 800-624-9220 - www.alphalab.com

Project Name: BATH DTSW
Project Number: 161.06064

Lab Number: L1738765
Report Date: 11/07/17

Alpha Sample ID	Client ID	Matrix	Sample Location	Collection Date/Time	Receive Date
L1738765-01	SW-WFP	WATER	BATH	10/25/17 08:30	10/25/17
L1738765-02	SW-COMM	WATER	BATH	10/25/17 08:30	10/25/17

Project Name: BATH DTSW **Lab Number:** L1738765
Project Number: 161.06064 **Report Date:** 11/07/17

Case Narrative

The samples were received in accordance with the Chain of Custody and no significant deviations were encountered during the preparation or analysis unless otherwise noted. Sample Receipt, Container Information, and the Chain of Custody are located at the back of the report.

Results contained within this report relate only to the samples submitted under this Alpha Lab Number and meet NELAP requirements for all NELAP accredited parameters unless otherwise noted in the following narrative. The data presented in this report is organized by parameter (i.e. VOC, SVOC, etc.). Sample specific Quality Control data (i.e. Surrogate Spike Recovery) is reported at the end of the target analyte list for each individual sample, followed by the Laboratory Batch Quality Control at the end of each parameter. Tentatively Identified Compounds (TICs), if requested, are reported for compounds identified to be present and are not part of the method/program Target Compound List, even if only a subset of the TCL are being reported. If a sample was re-analyzed or re-extracted due to a required quality control corrective action and if both sets of data are reported, the Laboratory ID of the re-analysis or re-extraction is designated with an "R" or "RE", respectively. When multiple Batch Quality Control elements are reported (e.g. more than one LCS), the associated samples for each element are noted in the grey shaded header line of each data table. Any Laboratory Batch, Sample Specific % recovery or RPD value that is outside the listed Acceptance Criteria is bolded in the report. All specific QC information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications. Soil/sediments, solids and tissues are reported on a dry weight basis unless otherwise noted. Definitions of all data qualifiers and acronyms used in this report are provided in the Glossary located at the back of the report.

In reference to questions H (CAM) or 4 (RCP) when "NO" is checked, the performance criteria for CAM and RCP methods allow for some quality control failures to occur and still be within method compliance. In these instances the specific failure is not narrated but noted in the associated QC table. The information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications.

Please see the associated ADEx data file for a comparison of laboratory reporting limits that were achieved with the regulatory Numerical Standards requested on the Chain of Custody.

HOLD POLICY
For samples submitted on hold, Alpha's policy is to hold samples (with the exception of Air canisters) free of charge for 21 calendar days from the date the project is completed. After 21 calendar days, we will dispose of all samples submitted including those put on hold unless you have contacted your Client Service Representative and made arrangements for Alpha to continue to hold the samples. Air canisters will be disposed after 3 business days from the date the project is completed.

Please contact Client Services at 800-624-9220 with any questions.

Case Narrative (continued)

Nitrogen, Nitrate/Nitrite

The WG1058200-4 MS recovery (77%), performed on L1738765-01, is outside the acceptance criteria; however, the associated LCS recovery is within criteria. No further action was taken.

I, the undersigned, attest under the pains and penalties of perjury that, to the best of my knowledge and belief and based upon my personal inquiry of those responsible for providing the information contained in this analytical report, such information is accurate and complete. This certificate of analysis is not complete unless this page accompanies any and all pages of this report.

Authorized Signature: Kara Soroko

Title: Technical Director/Representative Date: 11/07/17

ORGANICS

SEMIVOLATILES

Project Name: BATH DTSW
Lab Number: L1738765
Project Number: 161.06064
Report Date: 11/07/17

SAMPLE RESULTS

Lab ID: L1738765-01
Client ID: SW-WFP
Sample Location: BATH

Date Collected: 10/25/17 08:30
Date Received: 10/25/17
Field Prep: Not Specified
Extraction Method: EPA 3510C
Extraction Date: 11/01/17 00:13

Matrix: Water
Analytical Method: 1,8270D-SIM
Analytical Date: 11/05/17 17:15
Analyst: KL

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
PAHs by GC/MS-SIM - Westborough Lab						
Acenaphthene	ND		ug/l	0.10	--	1
2-Chloronaphthalene	ND		ug/l	0.20	--	1
Fluoranthene	0.23		ug/l	0.10	--	1
Naphthalene	ND		ug/l	0.10	--	1
Benzo(a)anthracene	ND		ug/l	0.10	--	1
Benzo(a)pyrene	0.11		ug/l	0.10	--	1
Benzo(b)fluoranthene	ND		ug/l	0.10	--	1
Benzo(k)fluoranthene	ND		ug/l	0.10	--	1
Chrysene	ND		ug/l	0.10	--	1
Acenaphthylene	ND		ug/l	0.10	--	1
Anthracene	ND		ug/l	0.10	--	1
Benzo(ghi)perylene	ND		ug/l	0.10	--	1
Fluorene	ND		ug/l	0.10	--	1
Phenanthrene	ND		ug/l	0.10	--	1
Dibenzo(a,h)anthracene	ND		ug/l	0.10	--	1
Indeno(1,2,3-cd)pyrene	0.11		ug/l	0.10	--	1
Pyrene	0.15		ug/l	0.10	--	1
1-Methylnaphthalene	ND		ug/l	0.10	--	1
2-Methylnaphthalene	ND		ug/l	0.10	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
Nitrobenzene-d5	89		23-120
2-Fluorobiphenyl	84		15-120
4-Terphenyl-d14	85		41-149

Project Name: BATH DTSW **Lab Number:** L1738765
Project Number: 161.06064 **Report Date:** 11/07/17

SAMPLE RESULTS

Lab ID: L1738765-02
Client ID: SW-COMM
Sample Location: BATH

Date Collected: 10/25/17 08:30
Date Received: 10/25/17
Field Prep: Not Specified
Extraction Method: EPA 3510C
Extraction Date: 11/01/17 00:13

Matrix: Water
Analytical Method: 1,8270D-SIM
Analytical Date: 11/05/17 17:41
Analyst: KL

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
PAHs by GC/MS-SIM - Westborough Lab						
Acenaphthene	ND		ug/l	0.10	--	1
2-Chloronaphthalene	ND		ug/l	0.20	--	1
Fluoranthene	0.20		ug/l	0.10	--	1
Naphthalene	ND		ug/l	0.10	--	1
Benzo(a)anthracene	ND		ug/l	0.10	--	1
Benzo(a)pyrene	0.17		ug/l	0.10	--	1
Benzo(b)fluoranthene	0.17		ug/l	0.10	--	1
Benzo(k)fluoranthene	ND		ug/l	0.10	--	1
Chrysene	0.13		ug/l	0.10	--	1
Acenaphthylene	ND		ug/l	0.10	--	1
Anthracene	ND		ug/l	0.10	--	1
Benzo(ghi)perylene	0.12		ug/l	0.10	--	1
Fluorene	ND		ug/l	0.10	--	1
Phenanthrene	ND		ug/l	0.10	--	1
Dibenzo(a,h)anthracene	ND		ug/l	0.10	--	1
Indeno(1,2,3-cd)pyrene	0.16		ug/l	0.10	--	1
Pyrene	0.20		ug/l	0.10	--	1
1-Methylnaphthalene	ND		ug/l	0.10	--	1
2-Methylnaphthalene	ND		ug/l	0.10	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
Nitrobenzene-d5	85		23-120
2-Fluorobiphenyl	77		15-120
4-Terphenyl-d14	69		41-149

Project Name:	BATH DTSW	**Lab Number:**	L1738765
Project Number:	161.06064	**Report Date:**	11/07/17

Method Blank Analysis
Batch Quality Control

Analytical Method:	1,8270D-SIM	Extraction Method:	EPA 3510C
Analytical Date:	11/02/17 15:36	Extraction Date:	11/01/17 00:13
Analyst:	CB		

Parameter	Result	Qualifier	Units	RL	MDL
Semivolatile Organics by GC/MS-SIM - Westborough Lab for sample(s): 01-02 Batch: WG1058258-1					
Acenaphthene	ND		ug/l	0.10	--
2-Chloronaphthalene	ND		ug/l	0.20	--
Fluoranthene	ND		ug/l	0.10	--
Naphthalene	ND		ug/l	0.10	--
Benzo(a)anthracene	ND		ug/l	0.10	--
Benzo(a)pyrene	ND		ug/l	0.10	--
Benzo(b)fluoranthene	ND		ug/l	0.10	--
Benzo(k)fluoranthene	ND		ug/l	0.10	--
Chrysene	ND		ug/l	0.10	--
Acenaphthylene	ND		ug/l	0.10	--
Anthracene	ND		ug/l	0.10	--
Benzo(ghi)perylene	ND		ug/l	0.10	--
Fluorene	ND		ug/l	0.10	--
Phenanthrene	ND		ug/l	0.10	--
Dibenzo(a,h)anthracene	ND		ug/l	0.10	--
Indeno(1,2,3-cd)pyrene	ND		ug/l	0.10	--
Pyrene	ND		ug/l	0.10	--
1-Methylnaphthalene	ND		ug/l	0.10	--
2-Methylnaphthalene	ND		ug/l	0.10	--

Surrogate	%Recovery	Qualifier	Acceptance Criteria
Nitrobenzene-d5	76		23-120
2-Fluorobiphenyl	78		15-120
4-Terphenyl-d14	86		41-149

Lab Control Sample Analysis
Batch Quality Control

Project Name: BATH DTSW **Lab Number:** L1738765
Project Number: 161.06064 **Report Date:** 11/07/17

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Semivolatile Organics by GC/MS-SIM - Westborough Lab Associated sample(s): 01-02 Batch: WG1058258-2 WG1058258-3								
Acenaphthene	70		82		37-111	16		40
2-Chloronaphthalene	65		76		40-140	16		40
Fluoranthene	69		84		40-140	20		40
Naphthalene	66		75		40-140	13		40
Benzo(a)anthracene	72		88		40-140	20		40
Benzo(a)pyrene	69		86		40-140	22		40
Benzo(b)fluoranthene	74		92		40-140	22		40
Benzo(k)fluoranthene	68		85		40-140	22		40
Chrysene	73		90		40-140	21		40
Acenaphthylene	69		82		40-140	17		40
Anthracene	72		86		40-140	18		40
Benzo(ghi)perylene	71		89		40-140	23		40
Fluorene	72		85		40-140	17		40
Phenanthrene	71		85		40-140	18		40
Dibenzo(a,h)anthracene	71		89		40-140	23		40
Indeno(1,2,3-cd)pyrene	74		92		40-140	22		40
Pyrene	67		82		26-127	20		40
1-Methylnaphthalene	67		79		40-140	16		40
2-Methylnaphthalene	66		77		40-140	15		40

Lab Control Sample Analysis
Batch Quality Control

Project Name: BATH DTSW
Project Number: 161.06064

Lab Number: L1738765
Report Date: 11/07/17

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Semivolatile Organics by GC/MS-SIM - Westborough Lab Associated sample(s): 01-02 Batch: WG1058258-2 WG1058258-3								

Surrogate	LCS %Recovery	Qual	LCSD %Recovery	Qual	Acceptance Criteria
Nitrobenzene-d5	65		74		23-120
2-Fluorobiphenyl	67		78		15-120
4-Terphenyl-d14	68		84		41-149

METALS

Project Name:	BATH DTSW	**Lab Number:**	L1738765
Project Number:	161.06064	**Report Date:**	11/07/17

SAMPLE RESULTS

Lab ID:	L1738765-01	Date Collected:	10/25/17 08:30
Client ID:	SW-WFP	Date Received:	10/25/17
Sample Location:	BATH	Field Prep:	Not Specified
Matrix:	Water		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
Total Metals - Mansfield Lab											
Lead, Total	0.00409		mg/l	0.00100	--	1	10/26/17 14:10	10/30/17 11:15	EPA 3005A	3,200.8	AM
Mercury, Total	ND		mg/l	0.00020	--	1	10/27/17 13:45	10/28/17 14:52	EPA 245.1	3,245.1	MG

Project Name:	BATH DTSW	**Lab Number:**	L1738765
Project Number:	161.06064	**Report Date:**	11/07/17

SAMPLE RESULTS

Lab ID:	L1738765-02	Date Collected:	10/25/17 08:30
Client ID:	SW-COMM	Date Received:	10/25/17
Sample Location:	BATH	Field Prep:	Not Specified
Matrix:	Water		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
Total Metals - Mansfield Lab											
Lead, Total	0.01165		mg/l	0.00100	--	1	10/26/17 14:10	10/30/17 12:43	EPA 3005A	3,200.8	AM
Mercury, Total	ND		mg/l	0.00020	--	1	10/27/17 13:45	10/28/17 14:57	EPA 245.1	3,245.1	MG

Project Name: BATH DTSW **Lab Number:** L1738765
Project Number: 161.06064 **Report Date:** 11/07/17

Method Blank Analysis
Batch Quality Control

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
Total Metals - Mansfield Lab for sample(s): 01-02 Batch: WG1056656-1										
Lead, Total	ND		mg/l	0.00100	--	1	10/26/17 14:10	10/30/17 10:59	3,200.8	AM

Prep Information

Digestion Method: EPA 3005A

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
Total Metals - Mansfield Lab for sample(s): 01-02 Batch: WG1057007-1										
Mercury, Total	ND		mg/l	0.00020	--	1	10/27/17 13:45	10/28/17 14:48	3,245.1	MG

Prep Information

Digestion Method: EPA 245.1

Lab Control Sample Analysis
Batch Quality Control

Project Name: BATH DTSW
Project Number: 161.06064

Lab Number: L1738765
Report Date: 11/07/17

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Total Metals - Mansfield Lab Associated sample(s): 01-02 Batch: WG1056656-2								
Lead, Total	107		-		85-115	-		
Total Metals - Mansfield Lab Associated sample(s): 01-02 Batch: WG1057007-2								
Mercury, Total	103		-		85-115	-		

Matrix Spike Analysis
Batch Quality Control

Project Name: BATH DTSW
Project Number: 161.06064
Lab Number: L1738765
Report Date: 11/07/17

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
Total Metals - Mansfield Lab Associated sample(s): 01-02 QC Batch ID: WG1056656-3 QC Sample: L1738765-01 Client ID: SW-WFP												
Lead, Total	0.00409	0.51	0.5440	106		-	-		70-130	-		20
Total Metals - Mansfield Lab Associated sample(s): 01-02 QC Batch ID: WG1057007-3 QC Sample: L1738765-01 Client ID: SW-WFP												
Mercury, Total	ND	0.005	0.00486	97		-	-		70-130	-		20
Total Metals - Mansfield Lab Associated sample(s): 01-02 QC Batch ID: WG1057007-5 QC Sample: L1738765-02 Client ID: SW-COMM												
Mercury, Total	ND	0.005	0.00495	99		-	-		70-130	-		20

Lab Duplicate Analysis
Batch Quality Control

Project Name: BATH DTSW
Project Number: 161.06064
Lab Number: L1738765
Report Date: 11/07/17

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
Total Metals - Mansfield Lab Associated sample(s): 01-02 QC Batch ID: WG1056656-4 QC Sample: L1738765-01 Client ID: SW-WFP						
Lead, Total	0.00409	0.00410	mg/l	0		20
Total Metals - Mansfield Lab Associated sample(s): 01-02 QC Batch ID: WG1057007-4 QC Sample: L1738765-01 Client ID: SW-WFP						
Mercury, Total	ND	ND	mg/l	NC		20
Total Metals - Mansfield Lab Associated sample(s): 01-02 QC Batch ID: WG1057007-6 QC Sample: L1738765-02 Client ID: SW-COMM						
Mercury, Total	ND	ND	mg/l	NC		20

INORGANICS
&
MISCELLANEOUS

Project Name: BATH DTSW
Project Number: 161.06064

Lab Number: L1738765
Report Date: 11/07/17

SAMPLE RESULTS

Lab ID: L1738765-01
Client ID: SW-WFP
Sample Location: BATH
Matrix: Water

Date Collected: 10/25/17 08:30
Date Received: 10/25/17
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Solids, Total Suspended	21.		mg/l	5.0	NA	1	-	10/27/17 04:30	121,2540D	VB
Nitrogen, Nitrate/Nitrite	0.22		mg/l	0.10	--	1	-	10/31/17 22:41	44,353.2	MR
Total Nitrogen	0.77		mg/l	0.30	--	1	-	11/02/17 12:36	107,-	JO
Nitrogen, Total Kjeldahl	0.553		mg/l	0.300	--	1	10/26/17 06:30	10/26/17 23:19	121,4500NH3-H	AT
Phosphorus, Total	0.177		mg/l	0.010	--	1	10/27/17 10:15	10/27/17 15:15	121,4500P-E	SD
BOD, 5 day	5.9		mg/l	2.0	NA	1	10/26/17 05:20	10/31/17 00:05	121,5210B	TE

Project Name: BATH DTSW **Lab Number:** L1738765
Project Number: 161.06064 **Report Date:** 11/07/17

SAMPLE RESULTS

Lab ID: L1738765-02
Client ID: SW-COMM
Sample Location: BATH
Matrix: Water

Date Collected: 10/25/17 08:30
Date Received: 10/25/17
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Solids, Total Suspended	61.		mg/l	5.0	NA	1	-	10/27/17 04:30	121,2540D	VB
Nitrogen, Nitrate/Nitrite	1.1		mg/l	0.10	--	1	-	10/31/17 22:49	44,353.2	MR
Total Nitrogen	2.1		mg/l	0.30	--	1	-	11/02/17 12:36	107,-	JO
Nitrogen, Total Kjeldahl	1.04		mg/l	0.300	--	1	10/26/17 06:30	10/26/17 23:20	121,4500NH3-H	AT
Phosphorus, Total	0.241		mg/l	0.010	--	1	10/27/17 10:15	10/27/17 15:17	121,4500P-E	SD
BOD, 5 day	5.1		mg/l	2.0	NA	1	10/26/17 05:20	10/31/17 00:05	121,5210B	TE

Project Name: BATH DTSW **Lab Number:** L1738765
Project Number: 161.06064 **Report Date:** 11/07/17

Method Blank Analysis
Batch Quality Control

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab for sample(s): 01-02 Batch: WG1056419-1										
Nitrogen, Total Kjeldahl	ND		mg/l	0.300	--	1	10/26/17 06:30	10/26/17 23:05	121,4500NH3-H	AT
General Chemistry - Westborough Lab for sample(s): 01-02 Batch: WG1056477-1										
BOD, 5 day	ND		mg/l	2.0	NA	1	10/26/17 05:20	10/31/17 00:05	121,5210B	TE
General Chemistry - Westborough Lab for sample(s): 01-02 Batch: WG1056803-1										
Solids, Total Suspended	ND		mg/l	5.0	NA	1	-	10/27/17 04:30	121,2540D	VB
General Chemistry - Westborough Lab for sample(s): 01-02 Batch: WG1056899-1										
Phosphorus, Total	ND		mg/l	0.010	--	1	10/27/17 10:15	10/27/17 15:01	121,4500P-E	SD
General Chemistry - Westborough Lab for sample(s): 01-02 Batch: WG1058200-1										
Nitrogen, Nitrate/Nitrite	ND		mg/l	0.10	--	1	-	10/31/17 21:59	44,353.2	MR

Lab Control Sample Analysis
Batch Quality Control

Project Name: BATH DTSW
Project Number: 161.06064
Lab Number: L1738765
Report Date: 11/07/17

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-02 Batch: WG1056419-2								
Nitrogen, Total Kjeldahl	96		-		78-122	-		
General Chemistry - Westborough Lab Associated sample(s): 01-02 Batch: WG1056477-2								
BOD, 5 day	111		-		85-115	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-02 Batch: WG1056899-2								
Phosphorus, Total	105		-		80-120	-		
General Chemistry - Westborough Lab Associated sample(s): 01-02 Batch: WG1058200-2								
Nitrogen, Nitrate/Nitrite	96		-		90-110	-		

Matrix Spike Analysis
Batch Quality Control

Project Name: BATH DTSW
Project Number: 161.06064

Lab Number: L1738765
Report Date: 11/07/17

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-02 QC Batch ID: WG1056419-4 QC Sample: L1738715-01 Client ID: MS Sample												
Nitrogen, Total Kjeldahl	0.647	8	8.30	96		-	-		77-111	-		24
General Chemistry - Westborough Lab Associated sample(s): 01-02 QC Batch ID: WG1056477-4 QC Sample: L1700010-126 Client ID: MS Sample												
BOD, 5 day	61	100	160	95		-	-		50-145	-		35
General Chemistry - Westborough Lab Associated sample(s): 01-02 QC Batch ID: WG1056899-3 QC Sample: L1738710-01 Client ID: MS Sample												
Phosphorus, Total	0.052	0.5	0.555	101		-	-		75-125	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-02 QC Batch ID: WG1058200-4 QC Sample: L1738765-01 Client ID: SW-WFP												
Nitrogen, Nitrate/Nitrite	0.22	4	3.3	**77**	Q	-	-		80-120	-		20

Lab Duplicate Analysis
Batch Quality Control

Project Name: BATH DTSW
Project Number: 161.06064

Lab Number: L1738765
Report Date: 11/07/17

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-02 QC Batch ID: WG1056419-3 QC Sample: L1738715-01 Client ID: DUP Sample						
Nitrogen, Total Kjeldahl	0.647	0.681	mg/l	5		24
General Chemistry - Westborough Lab Associated sample(s): 01-02 QC Batch ID: WG1056477-3 QC Sample: L1700010-125 Client ID: DUP Sample						
BOD, 5 day	9.4	10	mg/l	6		35
General Chemistry - Westborough Lab Associated sample(s): 01-02 QC Batch ID: WG1056803-2 QC Sample: L1739065-01 Client ID: DUP Sample						
Solids, Total Suspended	210	210	mg/l	0		29
General Chemistry - Westborough Lab Associated sample(s): 01-02 QC Batch ID: WG1056899-4 QC Sample: L1738710-01 Client ID: DUP Sample						
Phosphorus, Total	0.052	0.048	mg/l	8		20
General Chemistry - Westborough Lab Associated sample(s): 01-02 QC Batch ID: WG1058200-3 QC Sample: L1738765-01 Client ID: SW-WFP						
Nitrogen, Nitrate/Nitrite	0.22	0.24	mg/l	9		20

Project Name: BATH DTSW
Project Number: 161.06064

Lab Number: L1738765
Report Date: 11/07/17

Sample Receipt and Container Information

Were project specific reporting limits specified? YES

Cooler Information

Cooler	*Custody Seal*
A	Absent

Container Information

Container ID	*Container Type*	*Cooler*	*Initial pH*	*Final pH*	*Temp deg C*	*Pres*	*Seal*	*Frozen Date/Time*	*Analysis(*)*
L1738765-01A	Plastic 250ml HNO3 preserved	A	<2	<2	5.3	Y	Absent		HG-U(28),PB-2008T(180)
L1738765-01B	Plastic 250ml H2SO4 preserved	A	<2	<2	5.3	Y	Absent		TKN-4500(28),NO3/NO2-353(28),TPHOS-4500(28),TNITROGEN(28)
L1738765-01C	Plastic 500ml unpreserved	A	7	7	5.3	Y	Absent		ME-BOD-5210(1)
L1738765-01D	Plastic 950ml unpreserved	A	7	7	5.3	Y	Absent		TSS-2540(7)
L1738765-01E	Amber 1000ml unpreserved	A	7	7	5.3	Y	Absent		PAHTCL-SIM(7)
L1738765-01F	Amber 1000ml unpreserved	A	7	7	5.3	Y	Absent		PAHTCL-SIM(7)
L1738765-02A	Plastic 250ml HNO3 preserved	A	<2	<2	5.3	Y	Absent		HG-U(28),PB-2008T(180)
L1738765-02B	Plastic 250ml H2SO4 preserved	A	<2	<2	5.3	Y	Absent		TKN-4500(28),NO3/NO2-353(28),TPHOS-4500(28),TNITROGEN(28)
L1738765-02C	Plastic 500ml unpreserved	A	7	7	5.3	Y	Absent		ME-BOD-5210(1)
L1738765-02D	Plastic 950ml unpreserved	A	7	7	5.3	Y	Absent		TSS-2540(7)
L1738765-02E	Amber 1000ml unpreserved	A	7	7	5.3	Y	Absent		PAHTCL-SIM(7)
L1738765-02F	Amber 1000ml unpreserved	A	7	7	5.3	Y	Absent		PAHTCL-SIM(7)

*Values in parentheses indicate holding time in days

GLOSSARY

Acronyms

EDL	- Estimated Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The EDL includes any adjustments from dilutions, concentrations or moisture content, where applicable. The use of EDLs is specific to the analysis of PAHs using Solid-Phase Microextraction (SPME).
EPA	- Environmental Protection Agency.
LCS	- Laboratory Control Sample: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
LCSD	- Laboratory Control Sample Duplicate: Refer to LCS.
LFB	- Laboratory Fortified Blank: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
MDL	- Method Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The MDL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
MS	- Matrix Spike Sample: A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.
MSD	- Matrix Spike Sample Duplicate: Refer to MS.
NA	- Not Applicable.
NC	- Not Calculated: Term is utilized when one or more of the results utilized in the calculation are non-detect at the parameter's reporting unit.
NDPA/DPA	- N-Nitrosodiphenylamine/Diphenylamine.
NI	- Not Ignitable.
NP	- Non-Plastic: Term is utilized for the analysis of Atterberg Limits in soil.
RL	- Reporting Limit: The value at which an instrument can accurately measure an analyte at a specific concentration. The RL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
RPD	- Relative Percent Difference: The results from matrix and/or matrix spike duplicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD). Values which are less than five times the reporting limit for any individual parameter are evaluated by utilizing the absolute difference between the values; although the RPD value will be provided in the report.
SRM	- Standard Reference Material: A reference sample of a known or certified value that is of the same or similar matrix as the associated field samples.
STLP	- Semi-dynamic Tank Leaching Procedure per EPA Method 1315.
TIC	- Tentatively Identified Compound: A compound that has been identified to be present and is not part of the target compound list (TCL) for the method and/or program. All TICs are qualitatively identified and reported as estimated concentrations.

Footnotes

1 - The reference for this analyte should be considered modified since this analyte is absent from the target analyte list of the original method.

Terms

Analytical Method: Both the document from which the method originates and the analytical reference method. (Example: EPA 8260B is shown as 1,8260B.) The codes for the reference method documents are provided in the References section of the Addendum.

Final pH: As it pertains to Sample Receipt & Container Information section of the report, Final pH reflects pH of container determined after adjustment at the laboratory, if applicable. If no adjustment required, value reflects Initial pH.

Frozen Date/Time: With respect to Volatile Organics in soil, Frozen Date/Time reflects the date/time at which associated Reagent Water-preserved vials were initially frozen. Note: If frozen date/time is beyond 48 hours from sample collection, value will be reflected in 'bold'.

Initial pH: As it pertains to Sample Receipt & Container Information section of the report, Initial pH reflects pH of container determined upon receipt, if applicable.

Total: With respect to Organic analyses, a 'Total' result is defined as the summation of results for individual isomers or Aroclors. If a 'Total' result is requested, the results of its individual components will also be reported. This is applicable to 'Total' results for methods 8260, 8081 and 8082.

Data Qualifiers

A - Spectra identified as "Aldol Condensation Product".

B - The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For MCP-related

Project Name: BATH DTSW **Lab Number:** L1738765

Project Number: 161.06064 **Report Date:** 11/07/17

Data Qualifiers

projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For DOD-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank AND the analyte was detected above one-half the reporting limit (or above the reporting limit for common lab contaminants) in the associated method blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit. For NJ-related projects (excluding Air), flag only applies to associated field samples that have detectable concentrations of the analyte, which was detected above the reporting limit in the associated method blank or above five times the reporting limit for common lab contaminants (Phthalates, Acetone, Methylene Chloride, 2-Butanone).

C - Co-elution: The target analyte co-elutes with a known lab standard (i.e. surrogate, internal standards, etc.) for co-extracted analyses.

D - Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.

E - Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.

G - The concentration may be biased high due to matrix interferences (i.e, co-elution) with non-target compound(s). The result should be considered estimated.

H - The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.

I - The lower value for the two columns has been reported due to obvious interference.

M - Reporting Limit (RL) exceeds the MCP CAM Reporting Limit for this analyte.

NJ - Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where the identification is based on a mass spectral library search.

P - The RPD between the results for the two columns exceeds the method-specified criteria.

Q - The quality control sample exceeds the associated acceptance criteria. For DOD-related projects, LCS and/or Continuing Calibration Standard exceedences are also qualified on all associated sample results. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)

R - Analytical results are from sample re-analysis.

RE - Analytical results are from sample re-extraction.

S - Analytical results are from modified screening analysis.

J - Estimated value. This represents an estimated concentration for Tentatively Identified Compounds (TICs).

ND - Not detected at the reporting limit (RL) for the sample.

Report Format: Data Usability Report

REFERENCES

1 Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. EPA SW-846. Third Edition. Updates I - IV, 2007.

3 Methods for the Determination of Metals in Environmental Samples, Supplement I. EPA/600/R-94/111. May 1994.

44 Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, August 1993.

107 Alpha Analytical - In-house calculation method.

121 Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WEF. Standard Methods Online.

LIMITATION OF LIABILITIES

Alpha Analytical performs services with reasonable care and diligence normal to the analytical testing laboratory industry. In the event of an error, the sole and exclusive responsibility of Alpha Analytical shall be to re-perform the work at it's own expense. In no event shall Alpha Analytical be held liable for any incidental, consequential or special damages, including but not limited to, damages in any way connected with the use of, interpretation of, information or analysis provided by Alpha Analytical.

We strongly urge our clients to comply with EPA protocol regarding sample volume, preservation, cooling, containers, sampling procedures, holding time and splitting of samples in the field.

Certification Information

The following analytes are not included in our Primary NELAP Scope of Accreditation:

Westborough Facility
EPA 624: m/p-xylene, o-xylene
EPA 8260C: NPW: 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene, Azobenzene; SCM: Iodomethane (methyl iodide), Methyl methacrylate, 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene.
EPA 8270D: NPW: Dimethylnaphthalene,1,4-Diphenylhydrazine; SCM: Dimethylnaphthalene,1,4-Diphenylhydrazine.
EPA 300: DW: Bromide
EPA 6860: NPW and SCM: Perchlorate
EPA 9010: NPW and SCM: Amenable Cyanide Distillation
EPA 9012B: NPW: Total Cyanide
EPA 9050A: NPW: Specific Conductance
SM3500: NPW: Ferrous Iron
SM4500: NPW: Amenable Cyanide, Dissolved Oxygen; SCM: Total Phosphorus, TKN, NO2, NO3.
SM5310C: DW: Dissolved Organic Carbon

Mansfield Facility
SM 2540D: TSS
EPA 3005A NPW
EPA 8082A: NPW: PCB: 1, 5, 31, 87,101, 110, 141, 151, 153, 180, 183, 187.
EPA TO-15: Halothane, 2,4,4-Trimethyl-2-pentene, 2,4,4-Trimethyl-1-pentene, Thiophene, 2-Methylthiophene, 3-Methylthiophene, 2-Ethylthiophene, 1,2,3-Trimethylbenzene, Indan, Indene, 1,2,4,5-Tetramethylbenzene, Benzothiophene, 1-Methylnaphthalene.
Biological Tissue Matrix: EPA 3050B

The following analytes are included in our Massachusetts DEP Scope of Accreditation

Westborough Facility:

Drinking Water
EPA 300.0: Nitrate-N, Fluoride, Sulfate; **EPA 353.2**: Nitrate-N, Nitrite-N; **SM4500NO3-F**: Nitrate-N, Nitrite-N; **SM4500F-C, SM4500CN-CE, EPA 180.1, SM2130B, SM4500Cl-D, SM2320B, SM2540C, SM4500H-B**
EPA 332: Perchlorate; **EPA 524.2:** THMs and VOCs; **EPA 504.1:** EDB, DBCP.
Microbiology: **SM9215B; SM9223-P/A, SM9223B-Colilert-QT,SM9222D**.

Non-Potable Water
SM4500H,B, EPA 120.1, SM2510B, SM2540C, SM2320B, SM4500CL-E, SM4500F-BC, SM4500NH3-BH, **EPA 350.1**: Ammonia-N, **LACHAT 10-107-06-1-B**: Ammonia-N, **SM4500NO3-F, EPA 353.2**: Nitrate-N**, EPA 351.1, SM4500P-E, SM4500P-B, E, SM4500SO4-E, SM5220D, EPA 410.4, SM5210B, SM5310C, SM4500CL-D, EPA 1664, EPA 420.1, SM4500-CN-CE, SM2540D.**
EPA 624: Volatile Halocarbons & Aromatics,
EPA 608: Chlordane, Toxaphene, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, Dieldrin, DDD, DDE, DDT, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, PCBs
EPA 625: SVOC (Acid/Base/Neutral Extractables), **EPA 600/4-81-045**: PCB-Oil.
Microbiology: **SM9223B-Colilert-QT; Enterolert-QT, SM9221E.**

Mansfield Facility:

Drinking Water
EPA 200.7: Ba, Be, Cd, Cr, Cu, Ni, Na, Ca. **EPA 200.8:** Sb, As, Ba, Be, Cd, Cr, Cu, Pb, Ni, Se, TL. **EPA 245.1** Hg.

Non-Potable Water
EPA 200.7: Al, Sb, As, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Sr, TL, Ti, V, Zn.
EPA 200.8: Al, Sb, As, Be, Cd, Cr, Cu, Pb, Mn, Ni, Se, Ag, TL, Zn.
EPA 245.1 Hg.
SM2340B

For a complete listing of analytes and methods, please contact your Alpha Project Manager.

CHAIN OF CUSTODY

PAGE 1 OF 1

Date Rec'd in Lab: 10/25/17

ALPHA Job #: L1738765

ALPHA ANALYTICAL
8 Walkup Drive, Westboro, MA 01581, Tel: 508-898-9220
320 Forbes Blvd, Mansfield, MA 02048, Tel: 508-822-9300

Project Information

Project Name: Bath DTSW
Project Location: Bath
Project #: 161.06064
Project Manager: Steve Dyer
ALPHA Quote #:

Report Information - Data Deliverables

☑ ADEx ☑ EMAIL

Billing Information

☐ Same as Client info PO #:

Client Information

Client: Ransom Consulting, Inc.
Address: 400 Commercial St Ste 404 Portland, ME 04101
Phone: 207 772 2891
Email: kevin.trainer@ransomenv.com

Regulatory Requirements & Project Information Requirements

☐ Yes ☐ No MA MCP Analytical Methods
☐ Yes ☐ No CT RCP Analytical Methods
☐ Yes ☐ No Matrix Spike Required on this SDG? (Required for MCP Inorganics)
☐ Yes ☐ No GW1 Standards (Info Required for Metals & EPH with Targets)
☑ Yes ☐ No NPDES RGP
☐ Other State /Fed Program ______ Criteria ______

Turn-Around Time

☑ Standard ☐ RUSH (only confirmed if pre-approved!)

Date Due:

Additional Project Information:

Analysis

VOC: ☐ 8260 ☐ 624 ☐ 524.2; SVOC: ☐ ABN ☑ PAH; METALS: ☐ MCP 13 ☐ MCP 14 ☐ RCP 15; METALS: ☐ RCRA5 ☐ RCRA8 ☐ PP13; EPH: ☐ Ranges & Targets ☐ Ranges Only; VPH: ☐ Ranges & Targets ☐ Ranges Only; ☐ PCB ☐ PEST; TPH: ☐ Quant Only ☐ Fingerprint; TSS; Total Zn; Total Hg; Total Pb; BOD

SAMPLE INFO — Filtration: ☐ Field ☐ Lab to do; Preservation: ☐ Lab to do

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler Initials	PAH	TSS	Total Zn	Total Hg	Total Pb	BOD	Sample Comments	Total # Bottles
38765-01	SW-WFP	10/25	8:30	Water	MO	✓	✓	✓	✓	✓			6
-02	SW-COMM	10/25	8:30	Water	MO	✓	✓	✓	✓	✓			6

Container Type:
Preservative:

Container Type: P= Plastic, A= Amber glass, V= Vial, G= Glass, B= Bacteria cup, C= Cube, O= Other, E= Encore, D= BOD Bottle

Preservative: A= None, B= HCl, C= HNO_3, D= H_2SO_4, E= NaOH, F= MeOH, G= $NaHSO_4$, H = $Na_2S_2O_3$, I= Ascorbic Acid, J = NH_4Cl, K= Zn Acetate, O= Other

Relinquished By:	Date/Time	Received By:	Date/Time
[signature]	10/25/17 13:45	Rob Maurto AAL	10/25/17 1345
Rob Maurto AAL	10/25/17 20:20	[signature]	10/25/17 20:20

All samples submitted are subject to Alpha's Terms and Conditions. See reverse side.

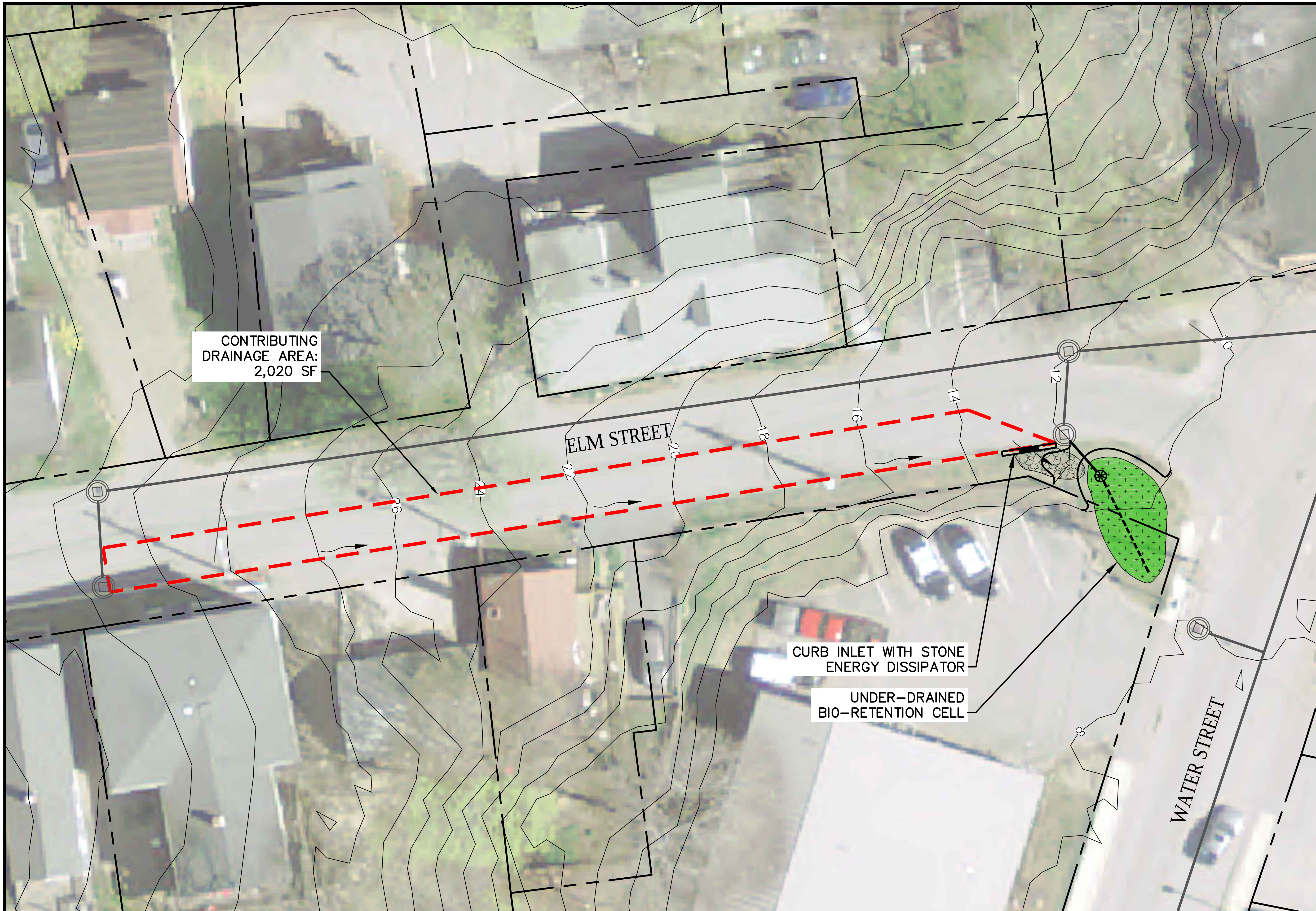
FORM NO: 01-01 (rev. 12-Mar-2012)

APPENDIX B

Conceptual Design Plans

Final Report
Maine Coastal Program
Downtown Storm Water Study
Bath, Maine

Ransom Consulting, Inc.
Project 161.06064



City of Bath Downtown Stormwater Study

Prepared for:

City of Bath
55 Front Street
Bath, ME 04530

BIORETENTION CELL

ELM STREET @ WATER STREET

N

0 10' 20'

SCALE: 1"=20'

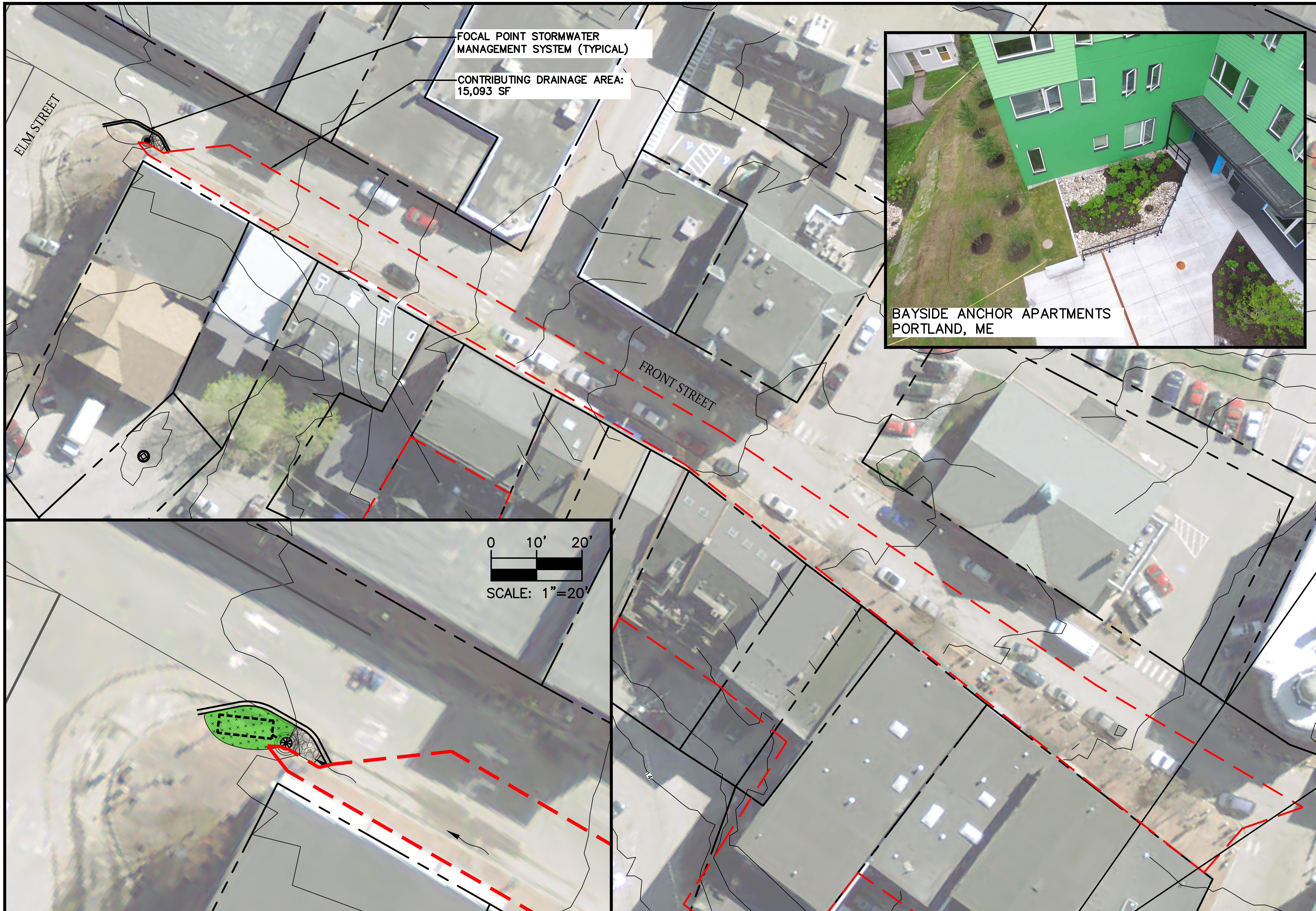
RANSOM
Consulting, Inc.

400 Commercial Street
Suite 404
Portland, Maine 04101
Tel (207) 772-2891
Fax (207) 772-3248
www.ransomenv.com

No.	Revision/Issue	Date
A	REVIEW	11-8-17

Project: 161.06064

Sheet No: 1



0 10' 20'
SCALE: 1"=40'

City of Bath Downtown Stormwater Study

Prepared for:

City of Bath
55 Front Street
Bath, ME 04530

FocalPoint HIGH RATE BIOFILTER MEDIA

FRONT STREET @ ELM STREET

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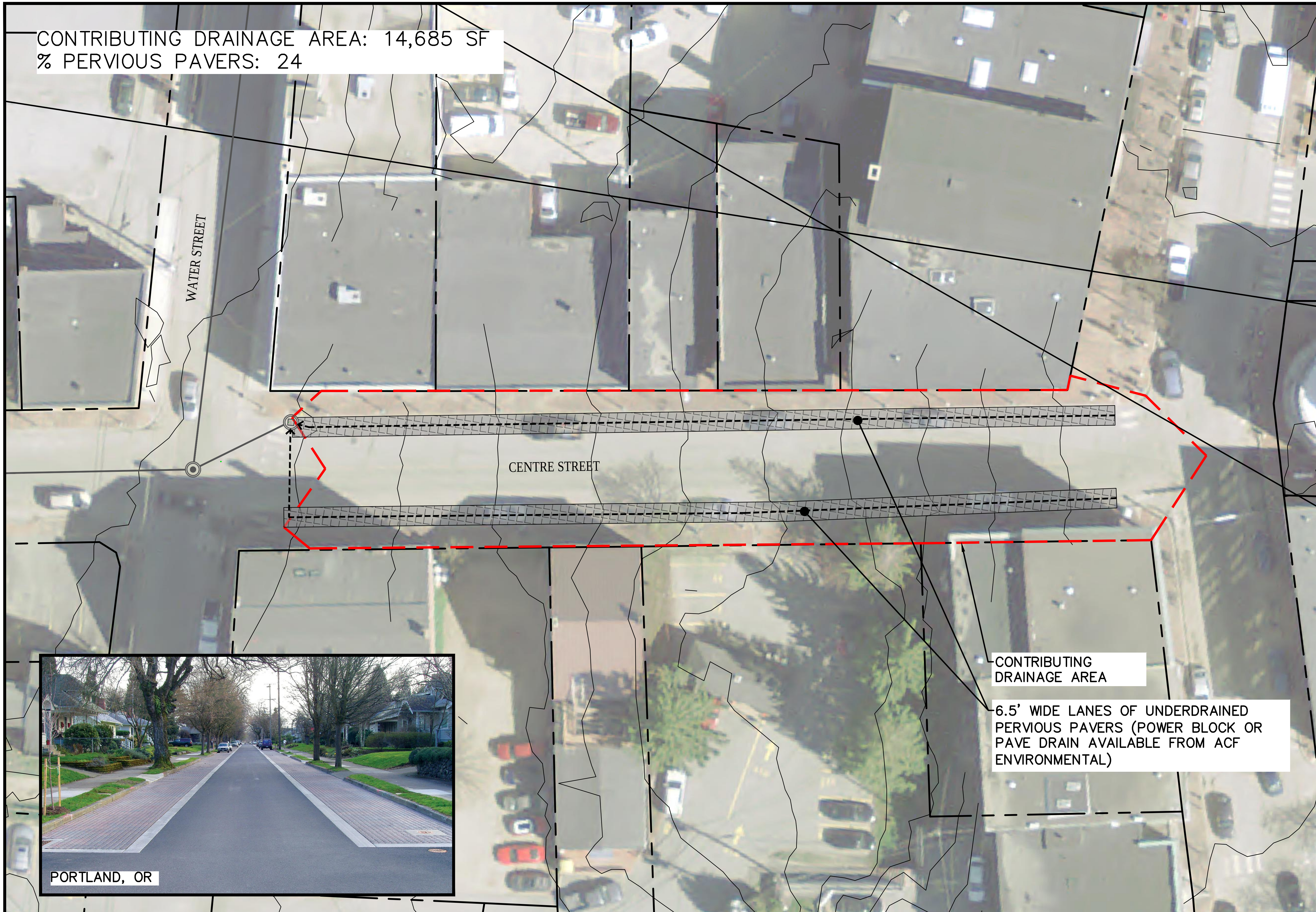
No.	Revision/Issue	Date
A	REVIEW	11-8-17

Project: 161.06064

Sheet No: 2



PORTLAND, OR

City of Bath Downtown Stormwater Study

Prepared for:

City of Bath
55 Front Street
Bath, ME 04530

RUN-ON MODULAR PERVIOUS PAVEMENT

CENTRE ST @ WATER ST

N

0 15' 30'
SCALE: 1"=30'

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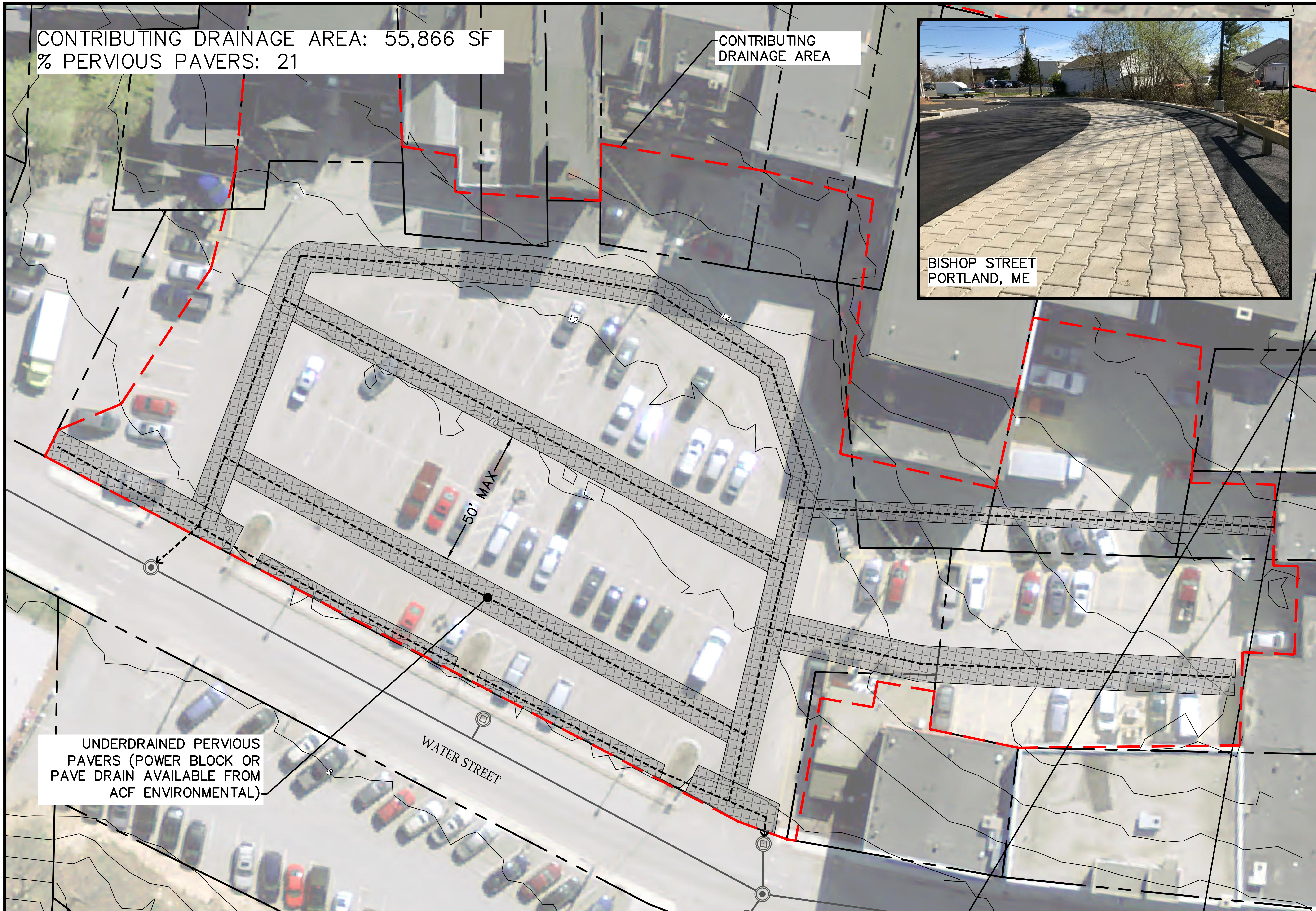
No.	Revision/Issue	Date
A	REVIEW	11-8-17

Project: 161.06064

Sheet No: 3



City of Bath Downtown Stormwater Study

Prepared for:

City of Bath
55 Front Street
Bath, ME 04530

RUN-ON MODULAR PERVIOUS PAVEMENT

WATER ST PARKING LOT

0 15' 30'
SCALE: 1"=30'

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A	REVIEW	11-8-17

Project: 161.06064

Sheet No: 4

City of Bath Downtown Stormwater Study

Prepared for:

City of Bath
55 Front Street
Bath, ME 04530

JELLYFISH Filter

N

0 200' 400'

SCALE: 1"=400'

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No.	Revision/Issue	Date
A	REVIEW	11-8-17

Project: 161.06064

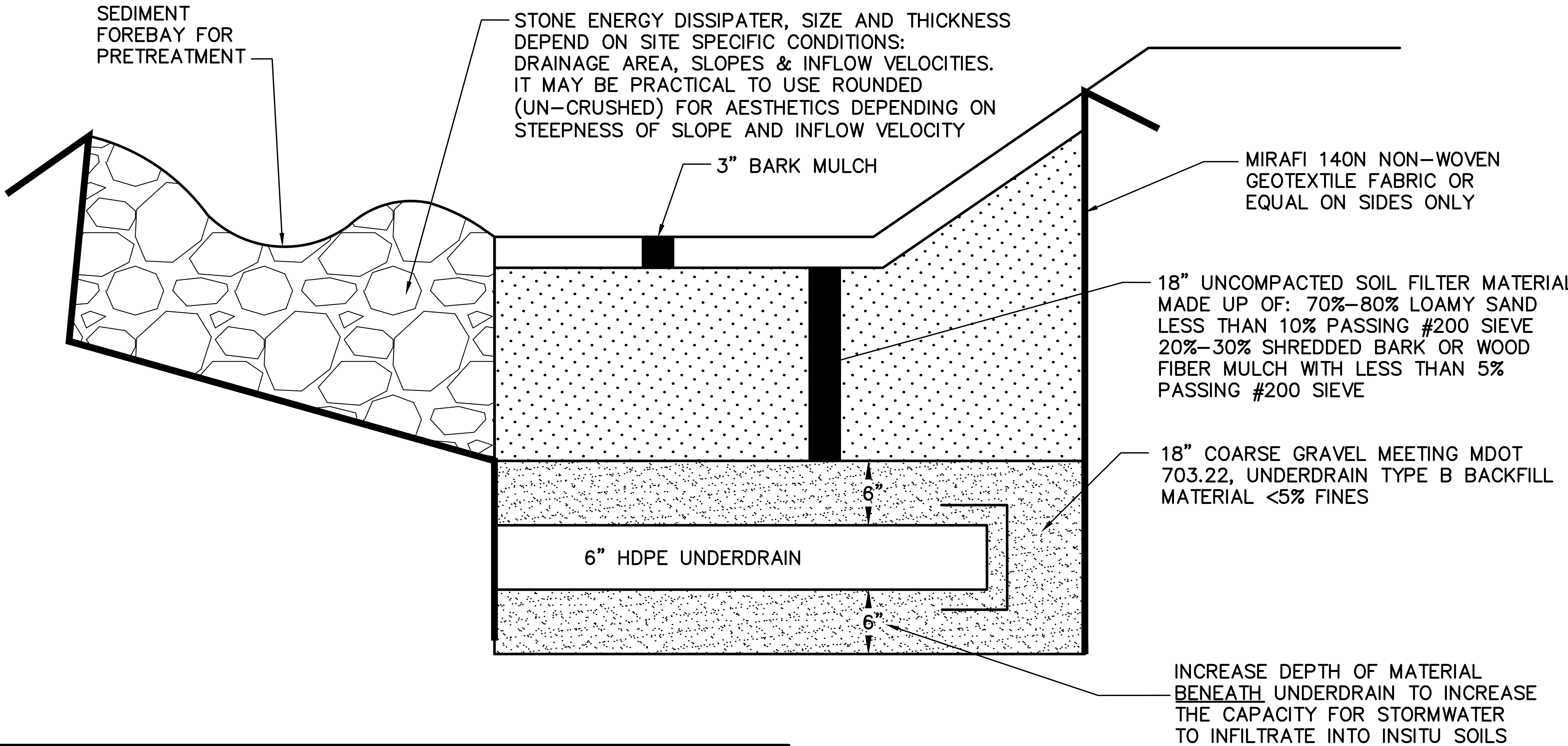
Sheet No: 6

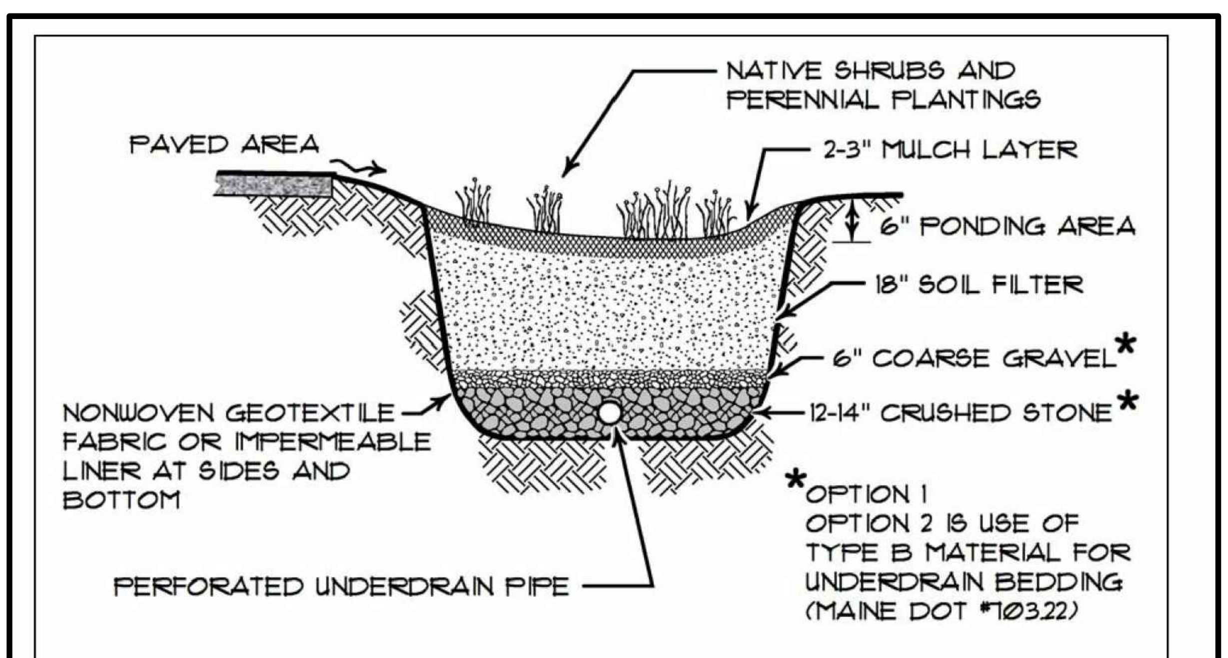
APPENDIX C

Conceptual Design Details

Final Report
Maine Coastal Program
Downtown Storm Water Study
Bath, Maine

Ransom Consulting, Inc.
Project 161.06064





City of Bath Downtown Stormwater Study

Prepared for:

City of Bath
55 Front Street
Bath, ME 04530

BIORETENTION CELL

DETAIL

RANSOM Consulting, Inc.

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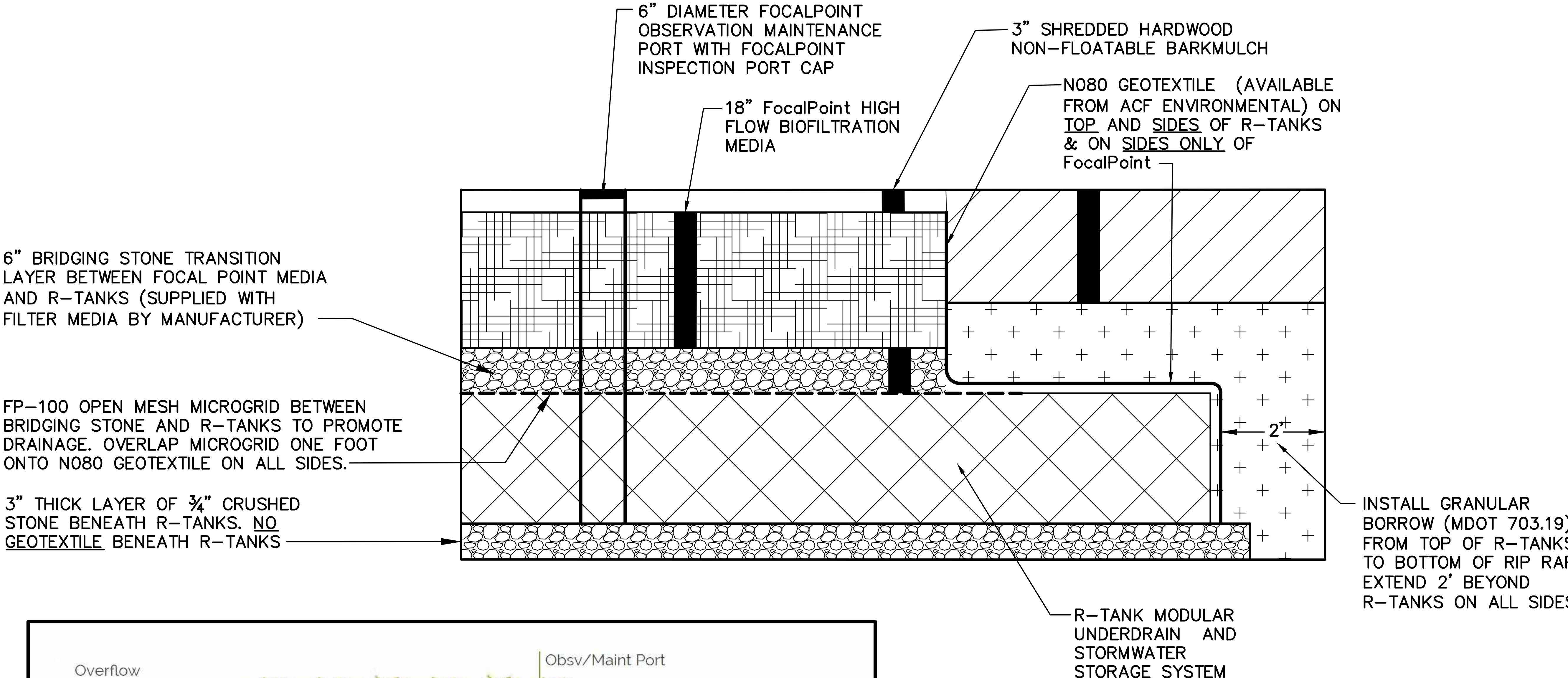
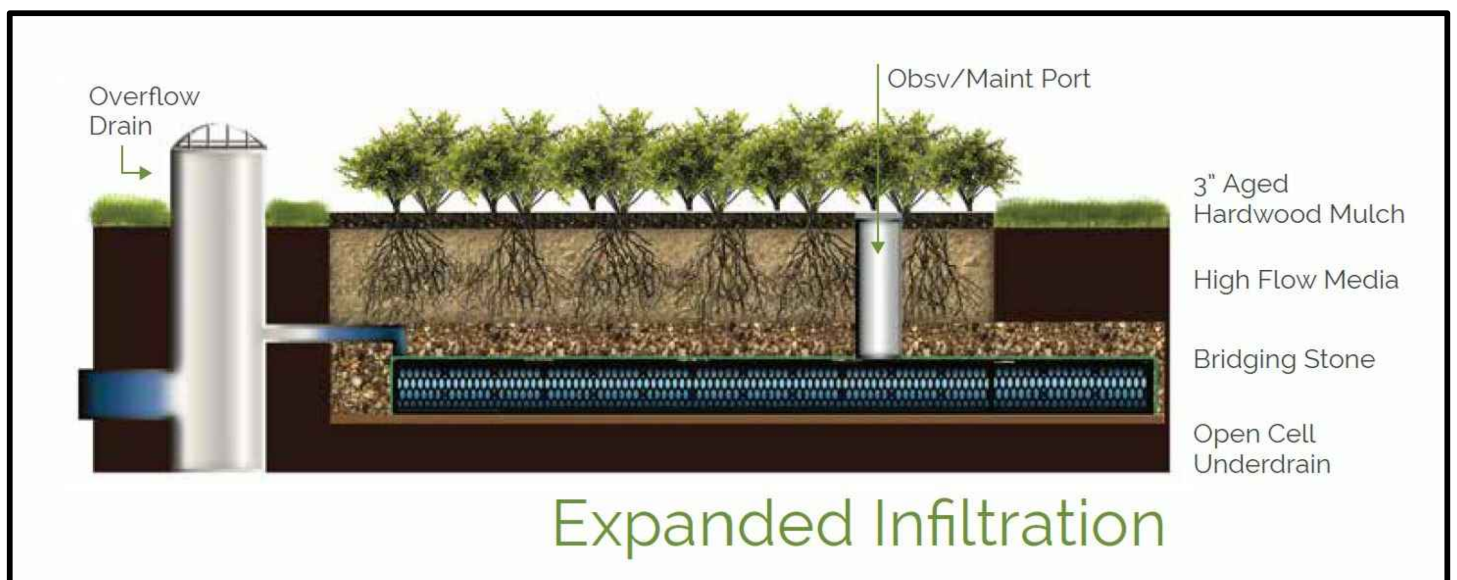
No.	Revision/Issue	Date
A	REVIEW	11-8-17

Project: 161.06064

Sheet No: 7





FOCAL POINT & R-TANK STORMWATER MANAGEMENT SYSTEM DETAIL

NOT TO SCALE

City of Bath Downtown Stormwater Study

Prepared for:

City of Bath
55 Front Street
Bath, ME 04530

FocalPoint HIGH RATE BIOFILTER MEDIA

DETAIL

RANSOM Consulting, Inc.

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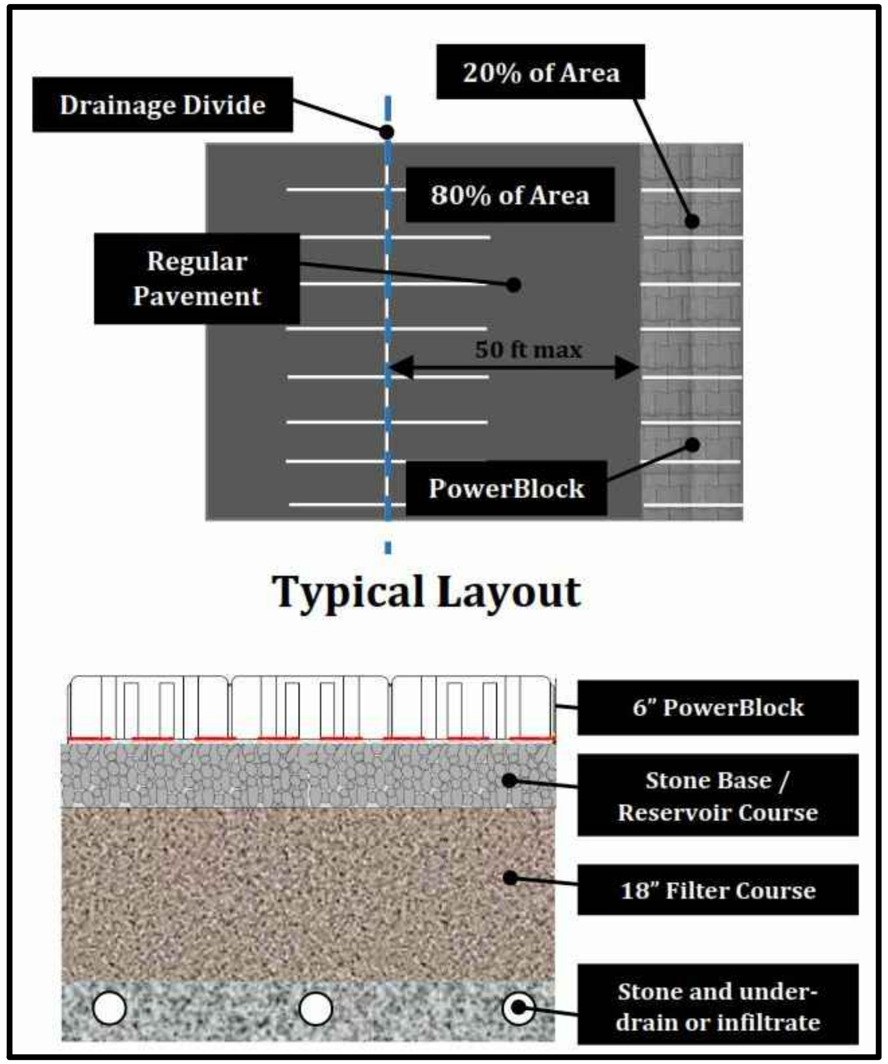
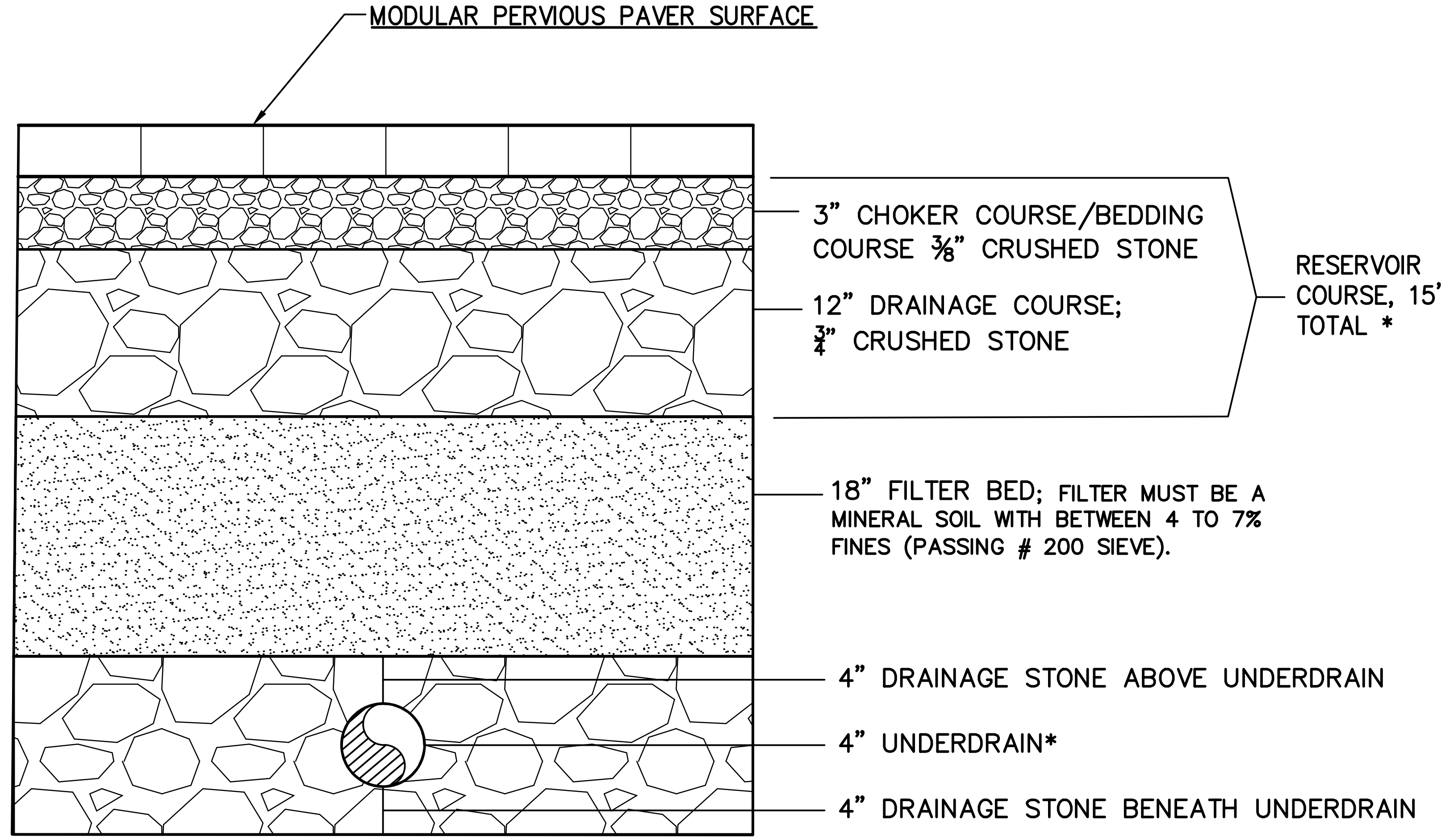
No.	Revision/Issue	Date
A	REVIEW	11-8-17

Project: 161.06064

Sheet No: 8





* THIS SECTION IS DESIGNED TO TREAT 1" RAINFALL, WITH 20% OF THE PAVED CONTRIBUTING PAVED AREA PERVIOUS. INCREASING THE PERCENTAGE OF PERVIOUS NESS WILL REDUCE THE THICKNESS REQUIREMENTS OF THE RESERVOIR AND FILTER COURSES PROPORTIONALLY

RUN-ON MODULAR PERVIOUS PAVEMENT

NOT TO SCALE

City of Bath Downtown Stormwater Study

Prepared for:

City of Bath
55 Front Street
Bath, ME 04530

RUN-ON MODULAR PERVIOUS PAVEMENT

DETAIL

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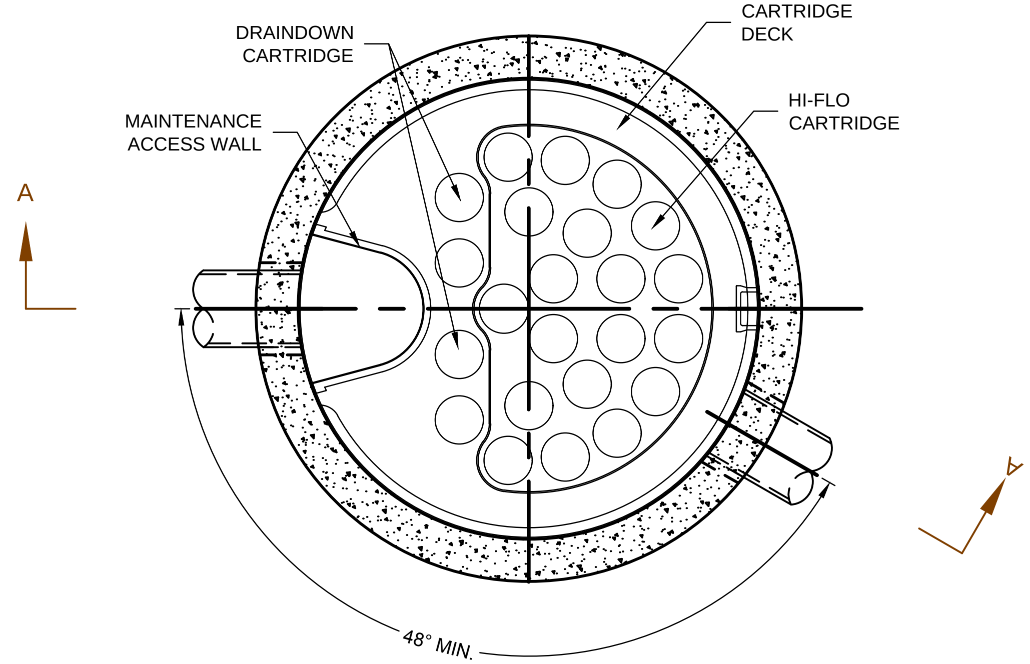
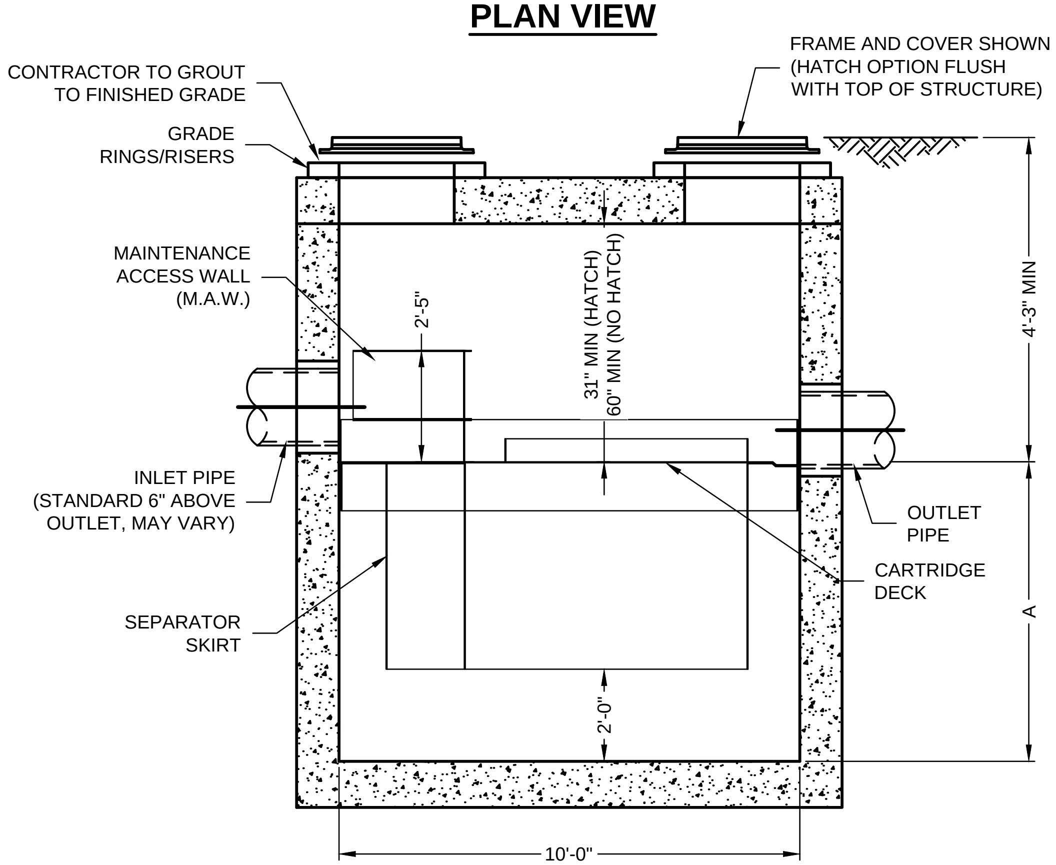
No.	Revision/Issue	Date
A	REVIEW	11-8-17

Project: 161.06064

Sheet No: 9



PLAN VIEW



SECTION A-A

JELLYFISH JF10 STANDARD DETAIL

NOT TO SCALE

JELLYFISH DESIGN NOTES

JELLYFISH TREATMENT CAPACITY IS A FUNCTION OF THE CARTRIDGE SELECTION AND THE NUMBER OF CARTRIDGES. THE STANDARD MANHOLE STYLE IS SHOWN. Ø120" MANHOLE JELLYFISH PEAK TREATMENT CAPACITY IS 3.74 CFS. IF THE SITE CONDITIONS EXCEED 3.74 CFS AN UPSTREAM BYPASS STRUCTURE IS REQUIRED.

CARTRIDGE SELECTION

CARTRIDGE DEPTH	54"	40"	27"	15"
OUTLET INVERT TO STRUCTURE INVERT (A)	6'-5"	5'-3"	4'-2"	3'-2"
FLOW RATE HIGH-FLO / DRAINDOWN (cfs) (per cart)	0.18 / 0.09	0.13 / 0.065	0.09 / 0.045	0.05 / 0.025
MAX. CARTS HIGH-FLO / DRAINDOWN	19 / 4			

SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID	*		
WATER QUALITY FLOW RATE (cfs)	*		
PEAK FLOW RATE (cfs)	*		
RETURN PERIOD OF PEAK FLOW (yrs)	*		
# OF CARTRIDGES REQUIRED (HF / DD)	* / *		
CARTRIDGE SIZE	*		
PIPE DATA:	I.E.	MATERIAL	DIAMETER
INLET PIPE #1	*	*	*
INLET PIPE #2	*	*	*
OUTLET PIPE	*	*	*
RIM ELEVATION	*		
ANTI-FLOTATION BALLAST	WIDTH	HEIGHT	
	*	*	

NOTES/SPECIAL REQUIREMENTS:

* PER ENGINEER OF RECORD

GENERAL NOTES:

1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. FOR SITE SPECIFIC DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHT, PLEASE CONTACT YOUR CONTECH ENGINEERED SOLUTIONS REPRESENTATIVE. www.ContechES.com
3. JELLYFISH WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING. CONTRACTOR TO CONFIRM STRUCTURE MEETS REQUIREMENTS OF PROJECT.
4. STRUCTURE SHALL MEET AASHTO HS-20 OR PER APPROVING JURISDICTION REQUIREMENTS, WHICHEVER IS MORE STRINGENT, ASSUMING EARTH COVER OF 0' - 3', AND GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION. CASTINGS SHALL MEET AASHTO M306 LOAD RATING AND BE CAST WITH THE CONTECH LOGO.
5. STRUCTURE SHALL BE PRECAST CONCRETE CONFORMING TO ASTM C-478 AND AASHTO LOAD FACTOR DESIGN METHOD.
6. NO PRODUCT SUBSTITUTIONS SHALL BE ACCEPTED UNLESS SUBMITTED 10 DAYS PRIOR TO PROJECT BID DATE, OR AS DIRECTED BY THE ENGINEER OF RECORD.

INSTALLATION NOTES

A. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
B. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE STRUCTURE (LIFTING CLUTCHES PROVIDED)
C. CONTRACTOR WILL INSTALL AND LEVEL THE STRUCTURE, SEALING THE JOINTS, LINE ENTRY AND EXIT POINTS (NON-SHRINK GROUT WITH APPROVED WATERSTOP OR FLEXIBLE BOOT)
D. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO PROTECT CARTRIDGES FROM CONSTRUCTION-RELATED EROSION RUNOFF.
E. CARTRIDGE INSTALLATION, BY CONTECH, SHALL OCCUR ONLY AFTER SITE HAS BEEN STABILIZED AND THE JELLYFISH UNIT IS CLEAN AND FREE OF DEBRIS. CONTACT CONTECH TO COORDINATE CARTRIDGE INSTALLATION WITH SITE STABILIZATION AT (866) 740-3318.

City of Bath Downtown Stormwater Study

Prepared for:

City of Bath
55 Front Street
Bath, ME 04530

JELLYFISH JF10

DETAIL

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