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# Penjajawoc Stream Watershed Management Plan

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A Plan for Nonpoint Source Pollution Control and  
Prevention in Penjajawoc Stream, Bangor, Maine

*August 29 2008*

Prepared for the City of Bangor

A Maine Department of Environmental Protection  
319 Nonpoint Source Pollution Control Project  
For an Urban Impaired Stream



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The following list of Stakeholders represents those present at meetings hosted by the City to provide information and gather input. The plan does not necessarily represent the views of these individuals, but rather, is a series of potential recommendations that were summarized from numerous sources including sources from outside of the Stakeholder meetings.

### Stakeholders

Edward Barrett	City of Bangor
Dan Belyea	Eastern Maine Community College
Hope Brogunier	Bangor Land Trust
Nicholas Brountas	Bangor Resident
Valerie Carter	Bangor Area Citizens Organized for Responsible Development
Tom Davis	Penjajawoc Marsh/Bangor Mall Commission
Cindy DeBeck	Penjajawoc Marsh/Bangor Mall Commission
Mary Ellen Dennis	Maine Department of Environmental Protection
Peter D'Erico	City of Bangor City Council
Norm Dube	Maine Bureau of Sea Run Fisheries
George Elliott	Penjajawoc Marsh/Bangor Mall Commission
Rae Fournier-Wren	Bangor Resident
James Gerety	Bangor Mall Management
Joyce Hedlund	Eastern Maine Community College
Jackie Hewitt	Frans Way Realty
Bobbi Hosmer	Bangor Resident
John McCormack	Webber Oil/Civil Engineering Services
Art Morgan	City of Bangor
Janet Ordway	Bangor Land Trust
Lucy Quimby	Penjajawoc Marsh/Bangor Mall Commission
Bob Quirk	Quirk Auto
Tom Quirk	Quirk Auto
Jim Ring	City of Bangor
Charles Rohn	Darling's Auto
Nathaniel Rosenblatt	City of Bangor, Planning Board
John Szarowski	Borders Books
Wendy Warren	City of Bangor

### Technical Steering Committee

Mary Ellen Dennis	Maine Department of Environmental Protection
Jeff Dennis	Maine Department of Environmental Protection
David Gould	City of Bangor
Ken Libbey	Maine Department of Environmental Protection
Ed Logue	Maine Department of Environmental Protection
Jeremy Martin	City of Bangor
Art Morgan	City of Bangor
Jim Ring	City of Bangor
Paula Thompson	Maine State Planning Office
Bobby Van Riper	Maine Department of Inland Fisheries & Wildlife
Wendy Warren	City of Bangor

The City would also like to thank Tom Valley of the Bangor Motor Inn & Conference Center for use of their conference room during public meetings.

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# **Executive Summary**

## **Background and Purpose**

This document is a watershed management plan for Penjajawoc Stream, an impaired third order, urban tributary of the Penobscot River located in the City of Bangor, Penobscot County, Maine. According to the Maine Department of Environmental Protection (DEP) 2004 and “2006 Integrated Water Quality Monitoring and Assessment Report” (2006 303(d) List), Penjajawoc Stream, and tributaries including Meadow Brook, do not currently meet Class B standards and are listed as “impaired.” The goal of the plan is to identify the steps needed to attain Class B standards and to identify and prioritize restoration and protection opportunities that will allow the water body to continue to meet those standards as development continues in the watershed.

The plan follows and is based on numerous existing studies regarding fluvial geomorphology, water quality assessment, impervious cover analysis, and structural BMP retrofit recommendations. Existing data and studies are currently under review to identify additional data requirements and explore appropriate assessment models for evaluating the stream and monitoring the impact of improvement measures. The intent of this effort is to develop a more complete understanding of the dynamics of the watershed as a whole. It is the City’s intention to assist property owners by developing a team approach to the development of a watershed management plan to improve the water quality of the stream.

## **Stakeholder Participation**

The plan was developed by the City of Bangor with the participation of the Maine Department of Environmental Protection, the Penjajawoc Stakeholder Working Group, and BSA Environmental Consulting. The Penjajawoc Stakeholder Working Group was comprised of municipal, state, residential, commercial, and conservation representatives. The Stakeholder working group met several times during the process (Fall 2007 to Spring 2008) to provide input, develop recommendations, and review the plan. The plan does not necessarily represent the individual views of these stakeholders, but rather is a series of potential recommendations that were developed from numerous sources including those outside of the Stakeholder group.

## **Existing Conditions and Impairment**

Penjajawoc Stream has a watershed area of 8.8 square miles. The watershed has three distinct sections based on land-use characteristics. The headwaters and upper portion of the watershed are composed of forestlands, cultivated lands, wetlands, and low-density residential development. The middle portion is composed of high-density development consisting of one large mall and several smaller retail commercial centers. The lower portion is primarily older, low-density residential development and a cemetery.

A Stressor Identification Analysis conducted in June, 2004 (MDEP suggests that water quality impairment in Penjajawoc is complex and that impairment is caused by multiple stressors including nonpoint source pollution and habitat impairment.

## **Restoration Toolbox**

The plan provides over 75 recommendations designed to help the Bangor community of business owners, government, conservation organizations, and citizenry improve the stream. Where appropriate, each set of recommendations also includes an estimated cost, list of partners needed to complete the task, an assigned authority, potential funding sources, and timeframe. The plan provides recommendations for education, prevention, channel and riparian restoration, retrofitting existing structural BMPs, and administration and ordinances.

## **Implementation and Monitoring**

The next major step for this plan is to obtain acceptance of the plan by Maine Department of Environmental Protection followed by the adoption of the plan by the City of Bangor City Council. The plan will be presented to the City Council within 120 days after DEP has accepted the plan, at which time the Council will consider its adoption. Assuming Council approval, the City will exercise a good faith effort to see that the recommendations are enacted in a timely manner.

It is anticipated that the plan will require up to 2 years to initiate and approximately 15-20 years to implement in its entirety. Successful implementation is dependent upon several variables including landowner cooperation, funding availability, agency cooperation, and administrative coordination.

The plan recommends the creation of a Stormwater Utility District, which, along with the Penjajawoc Compensation Fee Utilization Plan, will generate local funds to partially finance plan implementation. In addition, acceptance of the plan will improve the City's eligibility for grant funding from various sources including Nonpoint Source Water Pollution Control Grants (also known as 319 grants; see 33 U.S.C. § 1329) and Watershed Improvement Financial Assistance Partnership (WIFAP).

The plan also recommends that the City use an adaptive management approach during its annual review of plan progress and implementation. Numerous milestones and a monitoring plan are provided to help the City gauge its success toward achieving Class B standards.

## **Section 1 Introduction**

### **Purpose, Description of Stream, Report Findings, and Current Management Efforts**

#### **1.1 Purpose and Background**

The purpose of this project is to develop a Watershed Management Plan (WMP) for the Penjajawoc Stream Watershed, Bangor, Maine. The primary goals for the plan are to identify the steps needed to attain Class B standards in the stream and to identify and prioritize restoration and protection opportunities that will allow the water body, once class B is attained, to continue to meet that status as development continues in the watershed.

#### **Impaired Stream Listing**

Penjajawoc Stream is a third order stream with a watershed area of 8.8 square miles located in the City of Bangor (Figure 1.1). The upper and middle portions of the watershed drains a large wetland, the Bangor Mall, and intensely developed commercial areas on Stillwater Avenue and Hogan Road among other areas. In 1986, each Maine stream was assigned one of four categories by the Maine legislature. Penjajawoc Stream and its tributary, Meadow Brook, were designated as Class B streams. According to the Maine Department of Environmental Protection (DEP) 2004 and "2006 Integrated Water Quality Monitoring and Assessment Report" (2006 303(d) List), Penjajawoc Stream and Meadow Brook do not currently meet Class B standards and are listed as "impaired." The Penjajawoc is one of several watersheds designated by the Maine DEP as "high priority" in order to enable focusing of resources to help restore waterbodies not meeting standards.

#### **Maine Stormwater Law**

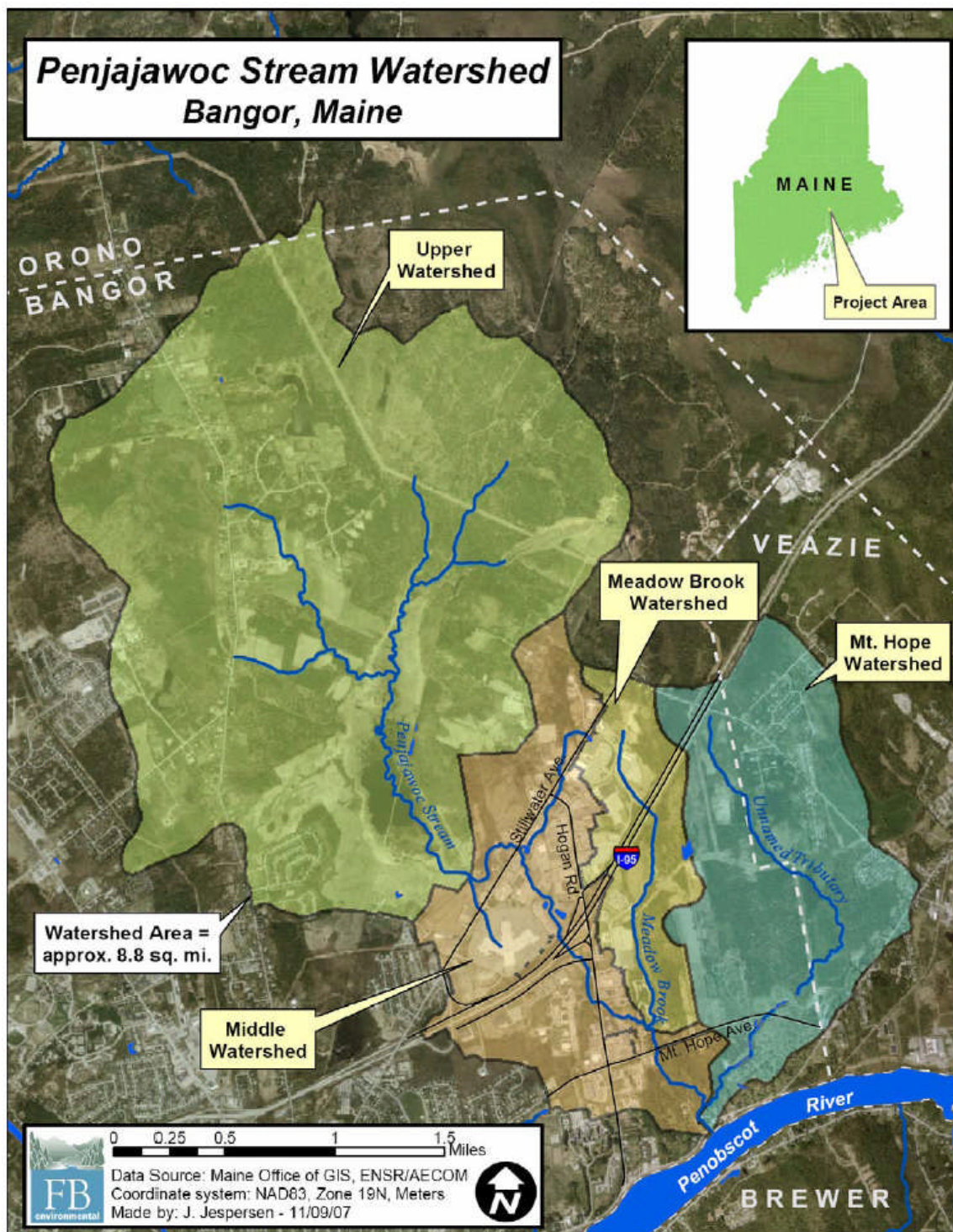
The Maine DEP's Stormwater Program works toward protecting and restoring surface and groundwater impacted by stormwater flows. Stormwater runoff from developed areas in watersheds carries pollutants, and affects the rates and volumes of flows in natural waterbodies in ways that can cause damage. Everyone has a role in reducing impacts from stormwater runoff, from the large developer constructing a new parking lot, to the homeowner using good erosion control methods and handling chemicals carefully around the house.

Maine's Stormwater Management Law provides stormwater standards for projects located in organized areas that include one acre or more of disturbed area. Title 38 § 420-D of the law states that a person may not construct, or cause to be constructed, a project that includes one acre or more of disturbed area without prior approval from the department. More information about the Stormwater Law can be found at:

<http://www.maine.gov/dep/blwq/docstand/stormwater/storm.htm>



Figure 1.1. Penjajawoc Stream Watershed (From Draft Penjajawoc Stream & Meadow Brook TMDL Report, DEP 2007).



## **Maine General Permit for Municipal Separate Storm Sewer Systems (MS4)**

This general permit authorizes the direct discharge of stormwater from or associated with a regulated small municipal separate storm sewer system (“MS4”) to an MS4 or waters of the State other than groundwater. Discharges must meet the requirements of the general permit and applicable provisions of Maine's waste discharge and water classification statutes and rules. The permit includes six minimum control measures which, implemented together, make up a stormwater management plan. Numerous elements of the MS4 Stormwater Management Plan overlap with recommendations included in this Watershed Management Plan. The goals of both plans are congruent.

## **1.2 Development of the Plan**

### **Penjajawoc Stakeholder Working Group**

The Penjajawoc Stakeholder Working Group was formed in September 2007 to provide input, develop recommendations, and review the plan. The Working Group was comprised of municipal, state, residential, commercial, and conservation representatives. (See Acknowledgments for a full listing of participants and contributors to the plan.) The Working Group met 3 times in 2007 (September 6, October 4, and November 1). During these meetings, the group discussed and developed recommendations for pollution prevention, riparian and channel restoration, retrofitting existing structural Best Management Practices (BMPs), ordinance review and modification, and water quality monitoring. The group also reviewed the draft plan and made suggestions in spring 2008.

### **Plan Description**

The U.S. Environmental Protection Agency (EPA) has identified several elements that should be included in a watershed management plan for achieving improvements in water quality. This plan is written in accordance with those EPA guidelines and includes those elements in the following sections:

- Section 1: Description of stream, plan purpose, and other background information
- Section 2: Water quality and causes of impairment
- Section 3: Plan implementation and ownership
- Sections 4 - 7: Recommendations for reducing load through education, prevention, restoration, retrofitting existing stormwater structures, and government administration
- Section 8: Milestones for monitoring and evaluating progress

It should be noted that this Plan is not an unchanging document but rather is meant to be a guide and an adaptive plan so that necessary adjustments or changes can be made in the future. “Adaptive Management” principles will be employed in order to continually improve plan implementation. (See Section 3 and Section 8 for more on Adaptive Management).

## **1.3 Stream Description**

*(Summarized primarily from Penjajawoc Watershed BMP Retrofit Design Project, WBRC 2007.)*

## **Watershed Characteristics**

The Penjajawoc Stream Watershed is a 5,486-acre watershed (Parish 2006) located primarily in the northeast section of Bangor, Maine in Penobscot County. Penjajawoc Stream is 5.2 miles long and is a third order stream. Meadow Brook and Mt. Hope Cemetery Watershed (Unnamed Stream on Figure 1.1) are the major tributaries. Although most of the watershed falls within the Bangor City limits, portions of the Mt. Hope tributary watershed lie within the town of Veazie to the northeast. The upper watershed contains a large 300-acre emergent freshwater marsh known as Penjajawoc Marsh, which is bisected by the now discontinued Veazie Railroad bed.

The stream originates at an elevation of 200 ft above sea level and flows southeasterly to an elevation of 1.81 ft where it joins the Penobscot River, which flows into the Gulf of Maine. The highest gradient is approximately 3.0% but the overall gradient is closer to 1.0%.

The headwaters and upper portion of the watershed are composed of forestlands, cultivated lands, wetlands, and low-density residential development. The middle portion below the marsh is composed of high-density development consisting of a large retail mall and numerous smaller commercial centers. The lower portion is primarily older, low-density residential development and a cemetery.

## **Headwater Characteristics**

The upper portion of the Penjajawoc watershed drains to a 300-acre marsh that lies directly upstream of the heavily developed portion of the watershed. The marsh attenuates runoff from the upper watershed and as such serves as a headwater to the middle and lower portions of the stream. During the growing season, stream flow through the marsh is often reduced by evapotranspiration, and in years with low runoff, flow is often reduced to the downstream watershed. It is part of a large system of bogs associated with nearby Caribou Bog, which formed because of the flat topography and poorly drained soil types of the surrounding area. The marsh is owned by multiple private landowners and its size has varied over time due to a variety of natural and man-made activities. It is rated as a high value Inland Waterfowl and Wading Bird Significant Wildlife Habitat (IWWH) under the Natural Resources Protection Act (Lindsay Tudor, IFW, Personal Communication, October 2007).

## **Stream Characteristics**

Penjajawoc Stream flows directly into the Penobscot River, which contributes a mild tidewater effect at the mouth of the stream. Aerial photography suggests that an alluvial deposit occurring at the confluence of the stream and the river originated from sediment transported by Penjajawoc stream. Additional inspection during June 2006 led to the tentative conclusion that the delta has been present for many years but shifts position periodically.

Flood Insurance Rate Maps suggest that many places in the watershed are susceptible to flooding. Beaver activity throughout the watershed also contributes to localized flooding.

Aerial photographs indicate that the stream has changed over the past several decades both from natural processes and from human activity. The developed area was formerly a dairy farm and some segments may have been flattened and straightened to accommodate farming needs. Also, several road crossings have been installed. More recently, development has occurred adjacent to the stream's banks, causing similar changes. Stream crossings were

installed where needed. Several tributaries have been diverted through culverts and a segment of the Penjajawoc Stream appears to have been filled to accommodate a parking lot.

### **Marine Fisheries**

Lewis N. Flagg, Director of the Anadromous Fish Division at Maine Department of Marine Resources, reports that the following fish of interest to anglers are found within the City of Bangor: Atlantic salmon, rainbow smelt, shad, alewife, and blueback herring (City of Bangor 2005). Although undocumented, it is possible that some of these species may use freshwater streams such as the Penjajawoc for refuge and/or spawning. The mouth of the Penjajawoc Stream is known as a coldwater refugia holding pool for migrating Atlantic salmon during warm summer months (R. Dill, ASC Personal Communication, 2007).

### **Freshwater Fisheries**

*(Summarized from R. VanRiper, MIFW, Personal Communication, November 2007)*

The upper reaches of the stream are supplied with water from a large wetland area dominated by emergent and shrub vegetation. This results in water temperatures that favor the presence of warm-water fish species. During human settlement and subsequent development in the watershed, there have been extensive modifications to the stream channel and riparian areas that have resulted in habitat loss and fragmentation. Currently, the effects of both habitat loss and fragmentation limit usable habitat to scattered areas in the watershed. Due to the volume and composition of inputs from human activity, many of these pocket habitats experience wide fluctuations in chemical and physical conditions. These fluctuations limit the suitability of these habitats for desired aquatic communities.

The majority of the resident fish species are those tolerant of the prevailing warm water conditions. These species include: creek chub (*Semotilus atromaculatus*), brook stickleback (*Culaea inconstans*), 3-spine stickleback (*Gasterosteus aculeatus*), black-nosed dace (*Rhynchithys atratulus*), banded killifish (*Fundulus diaphanus*) and brown bullhead (*Ameiurus nebulosus*). On occasion, the lower watershed up to the rail crossing is utilized opportunistically by brook trout (*Salvelinus fontinalis*), smallmouth bass (*Micropterus dolomieu*) and by anadromous cyprinids such as alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*). Time of residence by trout is limited to large flood events in the Penobscot River and when the fish seek temporary refuge in the Penjajawoc Stream.

## **1.4 Existing Reports**

In preparation for the development of the plan, DEP and the City of Bangor contracted several studies involving fluvial geomorphology, water quality assessment, impervious cover analysis, and structural BMP retrofit recommendations. The studies are listed below and are available at [http://www.bangormaine.gov/cs\\_financerisk\\_penjajawoc.php](http://www.bangormaine.gov/cs_financerisk_penjajawoc.php).

Preliminary Fluvial Geomorphology Study – Parish, March 2003: A preliminary fluvial geomorphology study of Penjajawoc Stream was completed and reported in March 2003.

Water Quality Monitoring- DEP, 2001-2003: Base flow and storm flow monitoring completed as part of TMDL assessment work.

Stressor Identification Field Study and Workshop – DEP, June 2004: The DEP held a Stressor Identification workshop on June 17, 2004 that included DEP Biologists, DEP Engineers, and City of Bangor Engineers to analyze the water quality and biological data, based on the Stressor Identification method developed by the Environmental Protection Agency.

Penjajawoc Stream Storm Water Management Model (SWMM) – ENSR, March 2006: A SWMM Model was completed utilizing hydrology, drainage, and land use information about the Penjajawoc. City of Bangor Engineering staff and DEP staff received training on using the model.

Penjajawoc Stream Existing Conditions – Parish, June 2006 and Penjajawoc Stream Analysis and Interpretation – Parish, June 2006: An intensive fluvial geomorphology study of both Penjajawoc Stream and Meadow Brook were completed and the reports were submitted in the summer of 2006.

Hydrocad Model and BMP Retrofit Design Recommendations – WBRC, Fall 2006: WBRC was commissioned to develop a suite of Low Impact Development (LID) recommendations that could be implemented in the watershed. They developed and utilized a Hydrocad Model to make educated projections for the results of each LID recommendation. A matrix of recommended BMPs and the areas they would target is included in the report.

Impervious Cover - Buildout Analysis – Dillon, February 2007: An Impervious Cover/Buildout Analysis was completed by Fred Dillon of FB Environmental in February 2007. The build out analysis assumes that all developable land in the watershed will be built out to the maximum allowable intensity under the then current zoning standards of the City and did not identify all undevelopable areas. Zoning and ordinances have changed since this report was completed. An updated study applying current zoning standards and identifying additional undevelopable areas and adequate maximum development intensity levels to those actually observed in existing development would be helpful.

Watershed Ordinance Review- Thomson, March 2007: A review of zoning and standards completed by Paula Thomson, State Planning Office.

TMDL Report for Penjajawoc Stream and Meadow Brook- Draft, DEP and FB Environmental, December 2007: Pollutant loading report required for impaired waters.

## **1.5 Current Stormwater Efforts in the City of Bangor**

In addition to the many studies mentioned above, the City of Bangor has also initiated several efforts to manage stormwater. The following is a brief synopsis of the recent efforts the City has made to improve stormwater quality and reduce or prevent pollution of ground and surface waters in and around the City. Some of the efforts (e.g., Item 4) also satisfy the City's permit regulations under the MS4 Program. This permit is part of the EPA National Pollutant Discharge Elimination System (NPDES) stormwater program, which requires the implementation of a stormwater management program as a means to control polluted discharges (US EPA 2005).

1. Environmental Management System (EMS) - City employees organized to focus on improving stormwater by:



- a. Becoming educated about stormwater issues relating to City operations
  - b. Recommending new practices and procedures to improve City operations
2. Birch Stream Stormwater Management Planning Committee –
- a. Organizing and preparing water quality data pertaining to impairment of the watershed
  - b. Developing a plan to improve the quality of stormwater
  - c. Built fence to prevent dumping into the stream behind Airport Mall.
3. Penjajawoc Stream Stormwater Management Technical Committee –
- a. Organizing and preparing water quality data pertaining to impairment of the watershed
  - b. Developing plan to install new stormwater filtration systems and add new procedures to improve the quality of stormwater
  - c. Guiding several studies completed for the preparation of the watershed management plan
4. Bangor Area Stormwater Group – City of Bangor Employees participate with this collaborative group to develop mutual solutions and combine resources to address stormwater management locally and regionally. Examples include:
- a. Participation in Annual Folk Festival
  - b. Standardized permit for beneficial use of catch basin waste.
  - c. Development and hosting of training sessions and workshops
  - d. Combine resources to develop and present Rubber Ducky and Think Blue media campaigns.
5. Stormwater Pollution Prevention Training of City Employees - Environmental Coordinator takes the lead in developing and presenting training to Airport, Public Works, Parks & Recreation, Fleet Maintenance, Police, Fire, etc.
6. Best Management Practices and Standard Operating Procedures within City operations being developed such as:
- a. Developed new ordinances with regard to construction
  - b. Spill kits carried on all City motor vehicles, including the Bus system.
  - c. Spill logs & reporting integrated into daily operating procedures
  - d. Spill containment measures implemented into routine work activities (hydraulic hoses, cleaning of equipment, vehicle washing)
  - e. Sand/Salt storage procedures updated
  - f. Demolition debris stockpiled procedures being updated
  - g. Street sweeping and catch basin cleaning increased
  - h. Underground and Aboveground Storage Tank inspections centralized and tracked
  - i. Oil/Water separator maintenance centralized and tracked

## Section 2 Causes of Impairment

### Stream Classification, Monitoring History, Stressor ID Analysis and Pollutant Loading

#### 2.1 Water Classification Program

The Maine Water Classification Program has four classes with different levels of environmental protection (AA, A, B, and C). For each class, the Legislature defined the desired environmental goals (designated uses). The Legislature also established narrative and numeric criteria that must be met to attain the desired environmental goals (Table 2.1). The DEP stream biomonitoring protocol provides a statistically defensible and reproducible decision-making tool for making quantitative determinations about attainment of biological water quality standards (DEP 2002).

Waters, such as Penjajawoc Stream, that do not meet the water quality criteria for its designated class are called impaired and placed on the state's list of impaired waters, also called the 303(d) List. Penjajawoc Stream does not meet Maine's Class B standards for dissolved oxygen, aquatic life, and habitat. The Clean Water Act requires that all 303(d) listed waters undergo a TMDL assessment that describes the impairments and identifies the measures needed to restore water quality. See 33 U.S.C. § 1313(d) (describing TMDL provisions). The goal is for all waterbodies to comply with the water quality standards of its assigned class.

Table 2.1. Maine Water Quality Criteria for Classification of Fresh Surface Waters (38 MRSA §465). g.m.= geometric mean; inst = instantaneous.

Class	Dissolved Oxygen	Bacteria	Habitat	Aquatic Life (Biological) Narrative Criteria
<b>Class AA</b>	As naturally occurs	As naturally occurs	Free flowing and natural	No direct discharge of pollutants; as naturally occurs
<b>Class A</b>	7 ppm; 75% saturation	As naturally occurs	Natural	As naturally occurs
<b>Class B</b>	7 ppm; 75% saturation	64/100 ml (g.m.*) or 427/100 ml (inst.*)	Unimpaired	Discharges shall NOT cause adverse impact to aquatic life
<b>Class C</b>	5 ppm; 60% saturation	142/100 ml (g.m.*) or 949/100 ml (inst.*)	Habitat for fish and other aquatic life	Discharges MAY cause some changes to aquatic life

#### 2.2 Monitoring History and Stressor Identification Analysis

The Maine DEP's Biological Monitoring (Biomonitoring) Program assesses the health of rivers, streams, and wetlands by evaluating the composition of resident aquatic benthic

macroinvertebrate and algal communities (DEP 2005). Biomonitoring was conducted in the stream in 1997, 2001, 2002, 2003, and 2006. This type of monitoring offers a number of advantages over conventional water chemistry monitoring in that it measures the direct impact of water quality and habitat on the biological community.

Water chemistry monitoring was conducted at four stations and biomonitoring was conducted at five (Figure 2.1). The monitoring included base flow and storm flow sampling for a suite of parameters including dissolved oxygen, temperature, nutrients, chlorophyll, sediment (turbidity and total suspended solids), bacteria, conductivity, total and dissolved organic carbon, and metals. For monitoring and analysis purposes, the watershed was divided into three sections based on major crossings and sources of impact. The upper watershed includes the headwaters down to the Stillwater Avenue crossing. The middle watershed extends from Stillwater Avenue downstream to below the Hogan Road crossing. The lower watershed extends from below the Hogan Road crossing to the confluence with the Penobscot River.

Table 2.2 lists the stressors that were identified during the Stressor Identification Analysis conducted in June 2004 (MDEP). The analysis suggests that water quality impairment in an urban stream such as the Penjajawoc is complex and that impairment is caused by multiple stressors. The analysis suggests that aquatic life impairment is likely due to urban nonpoint source pollution and habitat impairment. Development and increased impervious surfaces result in increases in stormwater volume that alter stream stability and cause in-stream habitat degradation: bank erosion, siltation, scour, over-widening of stream channel, and washout of biota. Impervious surfaces also prevent seepage of rainfall to local groundwater, which, in turn, reduces summer base flow and habitat availability. Furthermore, as runoff flows across developed areas, it picks up contaminants such as sediment, metals, and toxic substances.

Table 2.2. Stressor Identification Analysis Results (From *Water Quality Data Summary- Penjajawoc Stream, Bangor, Maine*, MDEP 2004)

Stressors	Watershed		
	Upper	Middle	Lower
Temperature	Yes- minor	Yes- possible	Yes
Nutrients	Yes	Yes	Yes- related to stormflow (less of a problem here)
Dissolved Oxygen	Yes- wetland main source	Yes	No (meets standards)
Conductivity	Yes	Yes- sand/silt sources	Yes- salt sources
Toxics	Yes	Yes	Yes
Sediment	No	Yes	Yes-high suspended sediment during storms (probably from Meadow Brook)
Altered Hydrology	Yes	Yes- groundwater may mitigate low baseflow syndrome	Yes- from upper reaches
Habitat	Yes	Yes	Yes- more data needed

### 2.3 Total Maximum Daily Load Study

As a consequence of being listed as “impaired” on the “2006 Integrated Water Quality Monitoring and Assessment Report” (2006 303(d) List), EPA requires that a Total Maximum



Daily Load (TMDL) study be conducted. A TMDL report describes the impairments, pollutants or pollutant surrogates, water quality targets, and the estimated loading that a waterbody can receive without exceeding water quality criteria. A Penjajawoc TMDL was in draft form at the time this plan was developed.

## 2.4 Pollutant Loading

DEP staff conducted a pollutant load analysis on the existing stormwater structures in the developed, middle portion of the watershed. As mentioned in Section 1, WBRC Architects and Engineers conducted a study titled, *Hydrocad Model and BMP Retrofit Design Recommendations*, in Fall 2006. The report identified approximately 82 subwatersheds in the watershed. Many of the subwatersheds in the developed, middle portion of the stream either have no treatment measures or drain to older stormwater structures that should be replaced or retrofitted. Therefore, the report modeled, analyzed, and made retrofit recommendations for approximately 79 subwatersheds in this middle, developed segment. (The report did not model or make recommendations for Meadow Brook, Mt Hope Watershed, Penjajawoc Marsh, or the residential areas upstream and surrounding the marsh.)

Thirty-seven of the 79 subwatersheds were determined to be high priority because they have impervious cover greater than 2.5 acres and/or are considered areas with potentially high traffic and high pollutant release, such as a fast food restaurant or gas station. (More information regarding site prioritization is found in Section 6 and Appendix B, C, and D) These thirty-seven subwatersheds represent 62% (209 acres) of the total impervious cover in the Penjajawoc Stream mainstem watershed (excluding Meadow Brook watershed). DEP conducted a pollutant load analysis on these 37 high priority subwatersheds (Appendix B, C, and D).

Current load levels from each subwatershed were estimated using the Impervious Cover Method (ENSR 2005) and the Stormwater Management Model (See Appendix B). Calculations were determined for total phosphorus (TP), copper (Cu), lead (Pb), and zinc (Zn). The current load levels for the 37 high priority subwatersheds requiring retrofitting are listed in Table 2.3. The anticipated load levels after each subwatershed is retrofitted are listed in Table 2.4. Based on TP, it is anticipated that the retrofits will generate a 44% reduction in pollutant loading (a reduction of 186.7 lbs of TP) from these subwatersheds.

Table 2.3. Estimated Current Annual Pollutant Load of 20 High Priority Sites Requiring Retrofitting.

Annual Pollutant Load Tot-P (lbs)	Annual Pollutant Load Cu (lbs)	Annual Pollutant Load Pb (lbs)	Annual Pollutant Load Zn (lbs)
427.5	33.0	35.0	291.5

Table 2.4. Estimated Annual Pollutant Load of 20 High Priority Sites After Implementation of Structural Retrofit

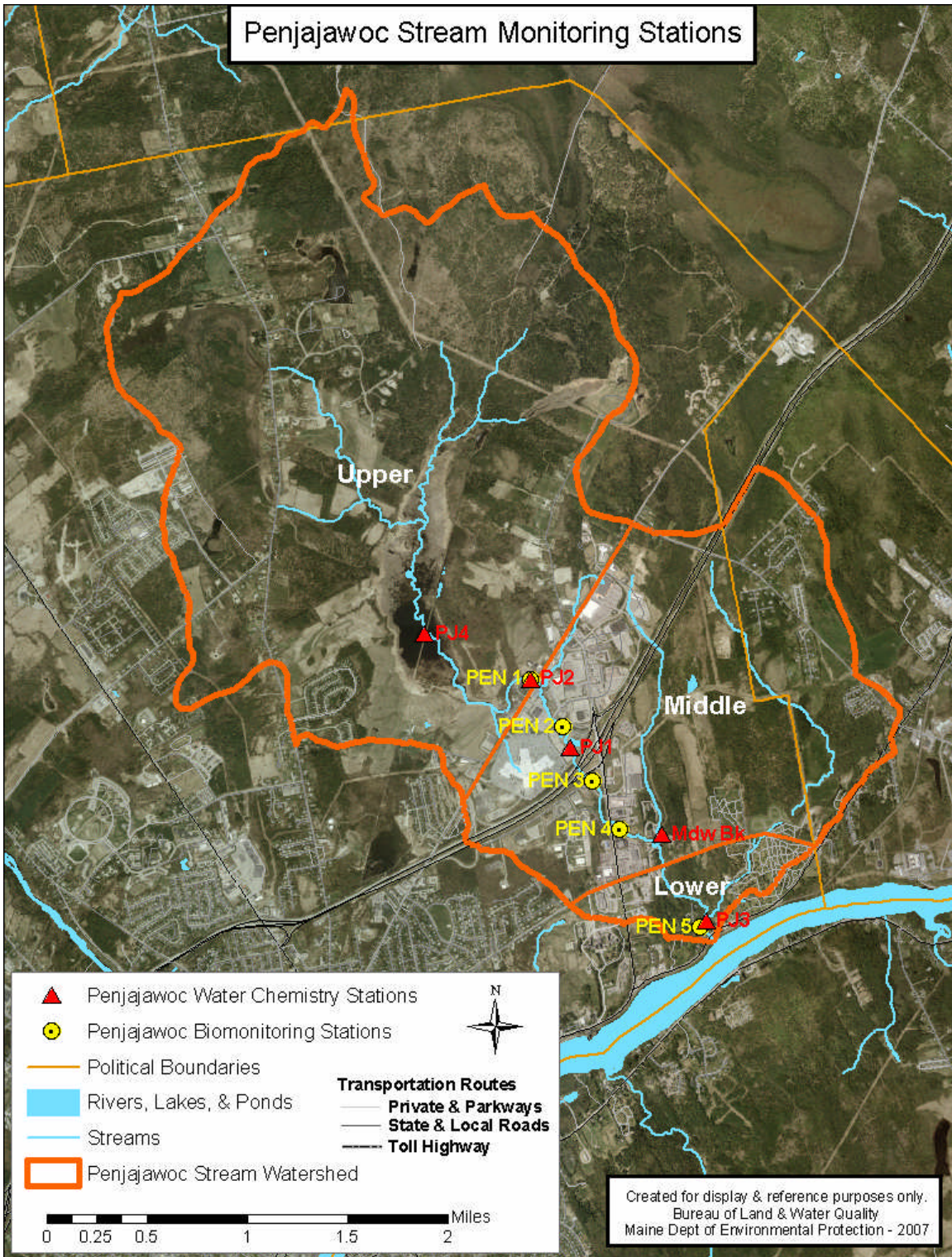
Annual Pollutant Load Tot-P (lbs) w/ retrofit	Annual Pollutant Load Cu (lbs) w/ retrofit	Annual Pollutant Load Pb (lbs) w/ retrofit	Annual Pollutant Load Zn (lbs) w/ retrofit
240.8	18.6	19.7	164.2

As noted, pollutant loads are estimated and may be refined or changed as additional information becomes available and consistent with the adaptive management model to be applied to implementation of this plan.

## 2.5 Naturally Occurring Conditions

The headwaters of the Penjajawoc Stream emerge from the Penjajawoc bog. Throughout the development of this plan, stakeholders have expressed concern that water quality conditions below the bog may be influenced by naturally occurring conditions associated with the bog. As a result of these concerns, Maine DEP has agreed to undertake additional work to quantify the effects of the bog on the quality of water entering the stream including evaluating the distance below the bog that such effects continue.

Figure 2.1. Penjajawoc Stream DEP Monitoring Stations



## **Section 3 Plan Implementation**

### **Plan Ownership, Adoption, Timing, Partners, Funding, Annual Review, and Adaptive Management**

#### **3.1 Plan Ownership, Adoption, and Implementation**

The City of Bangor, with the assistance of Maine DEP, initiated the development of this watershed management plan in July 2007. The planning process involved reviewing existing water quality data, integrating existing engineering and hydrology data, and soliciting and incorporating input from citizens, conservation organizations, state agencies, landowners, and business owners.

The plan will be presented to the City Council within 120 days after DEP has accepted it, at which time the Council will consider its adoption. Assuming Council approval, the City will exercise a good faith effort to see that the recommendations are enacted in a timely manner. Implementation may require the enactment of ordinances, changes in staff duties, and/or the hiring of additional staff.

It is anticipated that the plan will require up to 2 years to initiate and approximately 15-20 years to implement in its entirety. Successful implementation is dependent upon several variables including landowner cooperation, funding availability, agency cooperation, and administrative coordination. Implementation is also dependent upon achieving Class B standards. If Class B standards are met before implementation is complete, the City may choose to discontinue implementation since the goal of the plan (to meet Class B standards) will have been met.

The City will use the Penjajawoc Compensation Fee Utilization Plan, which is due to be accepted in 2008, to partially fund implementation of this plan. Figure 3.1 (at the end of this section) illustrates the overall process for plan implementation.

Stakeholders are aware that much work will remain to be done with regard to the specific details required for implementation after the plan is adopted. Significant decisions associated with the plan (i.e., ordinances, policies, etc.) will be made through a local legislative process that allows stakeholders to participate in the process through review and comment prior to adoption.

Furthermore, the City assures stakeholders interested in installing new BMPs that the process for authorizing them will not be lengthy and complex but rather will be efficient, effective, and cooperative.

#### **3.2 Implementation Timing**

The plan recommends over 75 tasks in four different pollution-reduction categories including education and prevention, stream restoration, retrofitting existing stormwater structures, and government administration. While Sections 4 through 7 provide detailed information on each of the tasks sorted by pollution-reduction category, Appendix A provides an "Integrated List" of all tasks sorted by 5-year time intervals. The Integrated Table is designed to guide overall

implementation of tasks from all categories and illustrates how tasks and projects from various categories may be implemented simultaneously.

The Integrated Table also takes into account the “Reach Approach” to overall implementation of stream channel and riparian improvements. The table suggests that, where possible, implementation may occur in order from upstream to downstream. For example, restoration, retrofit, and improvement projects in the Stillwater Avenue Reach could be implemented first (in the first 5-year interval), followed by the Bangor Mall Reach (second 5-year interval), followed by I-95 to Hogan Road Reach (third 5-year interval), etc.

### 3.3 Partners

The success of this plan will depend not only on the efforts and administration of the City but also on its stakeholders and partners in implementation. Although the City will take the lead in ensuring that the recommendations and tasks are initiated, partnering organizations, state agencies, and private landowners may have responsibility for actually completing some tasks. For example, the City may initiate a small business hazardous materials pick up program, but it will be up to the Chamber of Commerce or Small Business Association to actually implement and complete the task of contacting businesses, coordinating the pick up, and arranging for a disposal contract. Partnering organizations are listed in each set of recommendations in order to facilitate such partnering. Table 3.1 illustrates some examples of implementation through partnerships.

Table 3.1. Examples of Implementation Partners

Example Task	Initiating Party	Implementation Partners
Stabilize banks & improve riparian conditions by using plantings, live stakes, and root wads	City	Penobscot Co S&WCD, NRSC Landowners, Scouts, Conservation Groups,
Conduct screening level, rapid assessment for macroinvertebrates.	Stream Team	DEP, Stream Team, City
Landowners identify and assign maintenance responsibility for structural BMPs	Business Owners	City, DEP, Business owners, Chamber of Commerce

### 3.4 Funding

#### General Project Funding

Funding for tasks and projects can come from a variety of sources, and the City and its stakeholders will work together to be creative and combine several funding sources in order to complete implementation. Table 3.2 lists potential types of funding for each recommendation category. An example of a typical project budget and how to fund a project is provided in Table 3.3. Further details and suggestions for funding specific recommendations are listed in each section (Sections 4 through 7).

Table 3.2. Potential Funding Sources for Plan Projects and Tasks.

Recommendation Category	Type Of Funding
Education & Prevention	Landowner/Business Owner Sponsorship
	Pre-existing State Agency Programs
	Grant Funding such EPA and private education grants
	City Sponsorship
Stream restoration	Grant Funding such as DEP NPS Control Grants (319), NOAA, American Rivers, etc.
	City of Bangor Stormwater Utility District.
	New Development Incentive Programs
Retrofitting existing stormwater structures	Grant Funding such as MDOT Surface Water Quality Protection Program
	City of Bangor Stormwater Utility District.
	New Development Incentive Programs
Government administration	Stormwater Utility District

Table 3.3. Example of a Typical Funding Budget.

Project Type	Business In-Kind Cost Share	City Staff	Grant	State Agency Program	Total Budget
Prevention Program	\$10,000	\$10,000	\$30,000	\$10,000	\$60,000

### Stormwater Utility District

The most costly and complicated projects will be those involving stream restoration and retrofitting existing stormwater structures. Most of the retrofit projects occur in the section of the stream with retail properties and, in most cases, drain more than one property. Because of the complexity of multiple ownerships and drainages, funding the projects separately may not be feasible. If a landowner has a structural BMP that only drains his/her property, he/she may agree to pay for the upgrade or perform the upgrade at the time the property is further developed or redeveloped. The same may be true for properties with a few owners, if the owners agree to work cooperatively. However, where the BMP is treating several properties and/or treating residential as well as commercial properties, the City may want to take the lead in overseeing implementation. In order to do so:

- The City intends to evaluate a suite of alternative stormwater funding approaches.
- The City plans to hire a consultant who will perform a Stormwater Utility District Analysis and develop Stormwater Utility District Guidelines.
- Many of the implementation options may require changes in administration and ordinances (See Section 7).
- Final funding decisions will be made by the City Council after additional public proceedings.
- Two of the most significant funding options include:
  - A. Stormwater Utility District:** The City will consider establishing a Stormwater Utility District in which members of the district pay a pro-rated fee that can be used to pay for the upgrade of existing structural BMPs. The City may consider exempting residents and evaluating the creation of a Citywide or individual watershed district.



An effective stormwater utility district would provide credits for existing BMPs - especially updated stormwater treatment systems that meet Maine's most recent stormwater requirements – so that BMPs would be recognized as providing a positive impact. The City would need to establish this program in phases before it has collected enough fees to begin implementation

1. conduct utility district analysis
2. establish plan/criteria for fee structure
3. implement plan and fee notification
4. collect fees
5. establish grant program whereby individual businesses apply for implementation funds

**B. Incentive Programs:** The creation of an incentive program whereby owners of new developments (which presumably would install modern, more effective structural BMPs) would undertake one of the retrofit projects as a requirement of its new development. This method could also be used with re-development of an existing site. Mitigating one of the retrofit sites could be a condition of re-development.

### **3.5 Further Studies**

To help provide a sound basis for investment in stormwater measures, an appropriate and accurate model needs to be selected and utilized to evaluate the effectiveness of BMPs prior to their installation. Property owners in the watershed have indicated that any costs incurred should be based upon well documented, scientific, and well understood baseline data, so that, as investment is made, measurable improvements can be directly linked to those costs. After additional monitoring and assessment has occurred and an appropriate model has been selected and applied to the watershed, the list of recommended BMPs (including the retrofits) will be revised accordingly. This will take place through a collaborative review, and the plan will be amended to include the revised integrated list.

One of the first projects to be conducted by the City and its stakeholders is a Penjajawoc Stream Impairment Assessment Study conducted by the consulting firm of CH2M Hill. This study is anticipated to be completed by 2009 and will include:

- a review and summary of watershed assessment information, which will assess the basic biological, habitat, and water quality data and independently evaluate this information;
- a preliminary workplan for additional monitoring, modeling, and a watershed plan refinement process; and
- a final workplan document incorporating information from the assessment outlining the approach, schedules, and resources for developing the watershed plan.

### **3.6 Annual Review and Adaptive Management**

Frequent review of water quality monitoring results will be conducted and periodically shared with stakeholders in order to guide the implementation of BMPs and gauge whether or not additional steps must be taken. Analysis of these results and any other pertinent information will provide feedback to indicate what adaptations may be necessary for the implementation plan to meet its objectives. Adaptations may include, but are not limited to, changes in whether and when restoration and improvement projects are implemented.

The City will meet with the stakeholders at least annually to review progress on the plan. At that time, progress toward meeting milestones and any necessary changes will be discussed. The City will conduct an annual review beginning in fall 2009. The City agrees to provide a semi-annual newsletter that will include information on monitoring results, implemented BMPs, recent decisions, policies, ordinance changes, and upcoming events and meetings.

A five-year action plan for planned BMPs, as well as any amendments to the long-term implementation plan, should be revisited as necessary, and, at a minimum, at least once every five years through a stakeholder process. The five-year review will include Stakeholder involvement, review, and comment. Milestones (see Section 8) will also be considered and revised if necessary.

When reviewing and updating the plan, the City and its stakeholders will use an “Adaptive Management Approach.” Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs (Williams 2007).

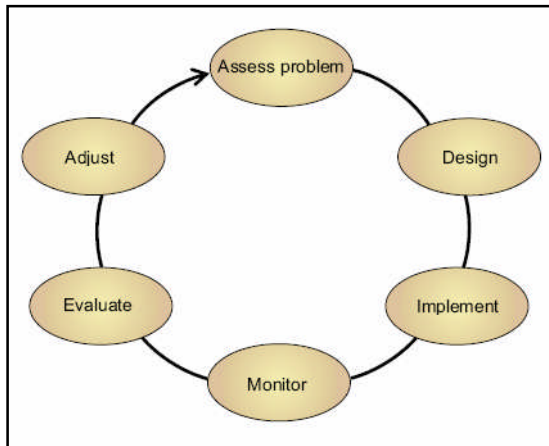
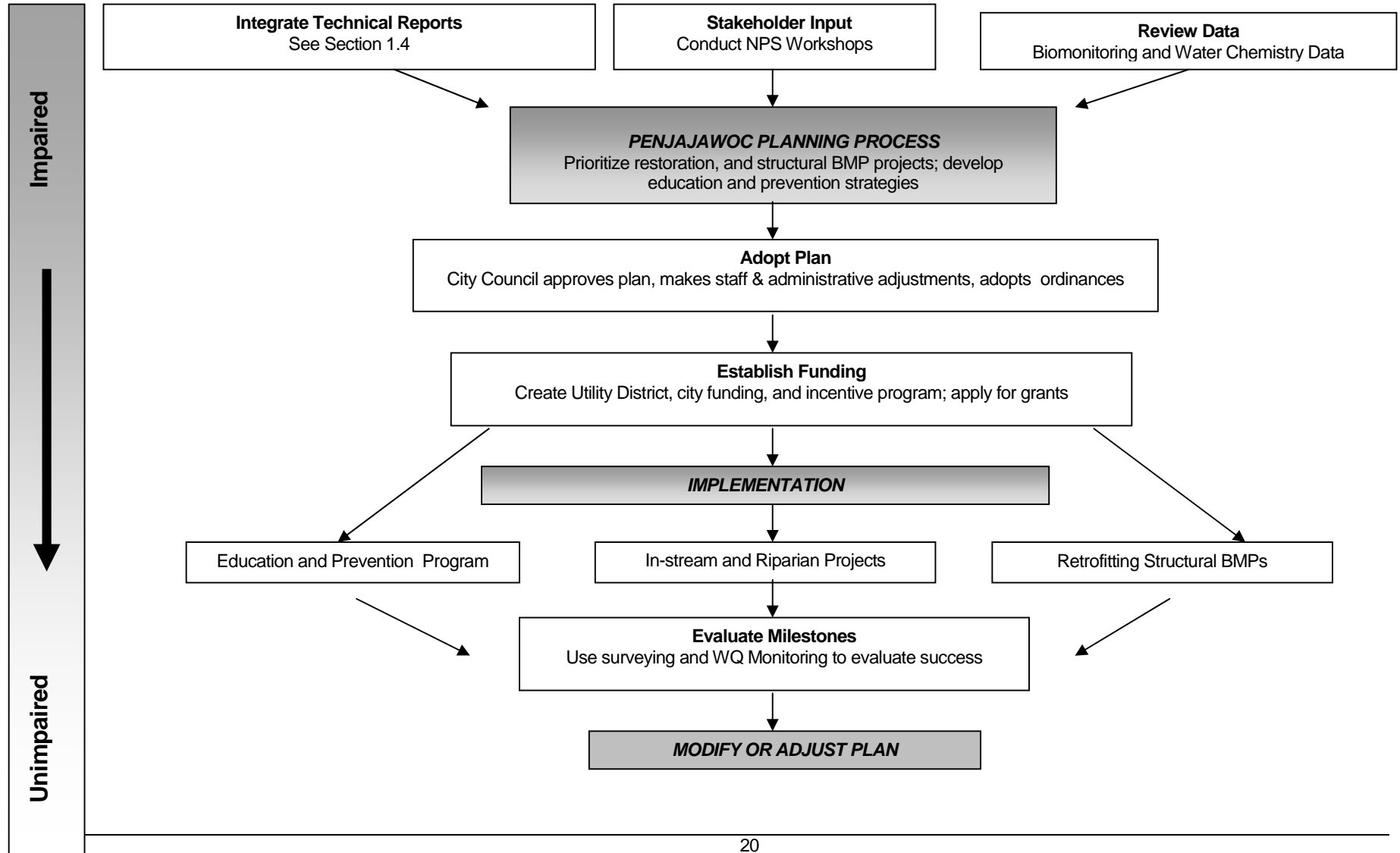


Figure 3.2 illustrates the steps in the adaptive management process. The technical reports on geomorphology, hydrology, and retrofit designs (Section 1) represent the Assess Problem phase while this plan and its recommendations and strategies represent the Design phase. The annual review process will incorporate the Adjust phase of the process. If no improvement is found after the Implementation, Monitoring, and Evaluation phases, then the problem will be reassessed and design and implementation will be adjusted.

Figure 3.2. Phases of the Adaptive Management Process



Figure 3.1. Penjajawoc Planning and Implementation Process



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## **Section 4 Restoration Toolbox: Prevention, and Housekeeping**

Public Awareness and Engagement, Sand and Salt, Fertilizers, Pesticides, Hazardous Substances, and Litter.

### **4.1 Restoration Toolbox**

Once a community becomes aware that they have an impaired stream, they have several options and resources available to them for the purposes of mitigation and restoration. These resources are called the Restoration Toolbox. The term “Restoration Toolbox” is used throughout this report in line with standard practice. It denotes a wide range of activities designed to improve water quality through reducing the amount of pollutants that reach a water body, managing stormwater appropriately, and improving impaired habitat and riparian areas. Sections 4 through 7 provide numerous recommendations from the Restoration Toolbox designed to help the business owners, government, conservation organizations, and citizenry improve the stream. Where appropriate, each set of recommendations also includes an estimated cost, list of partners needed to complete the task, an assigned authority, potential funding sources, and timeframe.

This plan provides recommendations in the following categories:

- Education (Section 4)
- Prevention and Housekeeping (Section 4)
- Channel and Riparian Restoration (Section 5)
- Retrofitting Existing Structural BMPs (Section 6)
- Administration and Ordinances (Section 7)

### **4.2 Best Management Practices**

Many of the recommendations suggested in this plan are considered Best Management Practices or BMPs. A BMP is a structure or practice designed to minimize the discharge of one or more pollutants to the land surface and their wash-off by stormwater; or to temporarily store or treat urban stormwater runoff to reduce flooding, remove pollutants, and otherwise mitigate the effects of runoff. For more information about recommended BMPs, please refer to the DEP Stormwater Management for Maine Manual (2006) at the DEP website:

<http://www.maine.gov/dep/blwq/docstand/stormwater/stormwaterbmps/index.htm>

### **4.3 Education and Awareness**

Perhaps the most effective BMP in the Restoration Toolbox is education and awareness. Table 4.1 lists several recommendations with estimated costs, timeframes, and potential partners and funding sources. The City, local businesses, county and state agencies (such as Penobscot County Soil and Water Conservation District and University of Maine and Penobscot County

Cooperative Extension), and conservation groups (such as Keep Bangor Beautiful, Bangor Land Trust, Bangor Area Citizens for Responsible Development, and the local Audubon Chapter) can work together to conduct these activities. They can be started at any time, can occur simultaneously, and are generally low cost but can go a long way to reducing the impacts from nonpoint source and stormwater runoff pollution. The Center for Watershed Protection Watershed Stewardship program provides some guidance on education, advocacy, and prevention. [http://www.cwp.org/Resource\\_Library/Restoration\\_and\\_Watershed\\_Stewardship](http://www.cwp.org/Resource_Library/Restoration_and_Watershed_Stewardship).

The overall goal of the education recommendations is to reduce pollutant loads and stormwater runoff by increasing the public's understanding of influences on the water quality of the stream. The recommendations in Table 4.1 are categorized into three objectives designed to meet this goal:

1. Increase public awareness about the stream and watershed
2. Increase knowledge and awareness about the impacts of NPS pollution and stormwater runoff in urban areas.
3. Increase public engagement in watershed issues and improving stream health.

#### **4.4 Prevention and Housekeeping**

The overall goal of preventive measures is to prevent the release of pollutants so that they are not available for mobilization by runoff. Table 4.2 lists recommendations designed to achieve this goal using objectives that address seven specific areas:

1. Ensure that sand/salt is properly stored and applied to avoid excess use and runoff.
2. Ensure that streets and parking lots are free of excess sand and salt.
3. Ensure that structural BMPs are properly designed and maintained so that they function properly (this is also required by the MS4 permit and associated post construction ordinance).
4. Reduce the amount of fertilizers and pesticides used in the watershed.
5. Reduce the amount of hazardous materials used in the watershed.
6. Reduce the amount of litter (and associated pollutants) getting into the stream.
7. Ensure that the landfill located in the upstream portion of the watershed is in compliance with applicable DEP closure requirements

Like the education and awareness recommendations, the prevention recommendations can be started at any time, can occur simultaneously, and can be completed by a variety of stakeholders in the watershed including individual landowners.

#### **4.5 Potential Funding Sources for Education and Prevention**

Education and prevention programs can be initiated, administered, and funded through a variety of mechanisms. The following are some examples of what the City can do to implement the education and prevention recommendations:

1. Landowner/Business Owner Sponsorship: Businesses, landowners, and the chamber of commerce can initiate a NPS prevention and education program.
2. Pre-existing State Agency Programs:
  - a. Cooperative Extension
  - b. Penobscot County Soil and Water Conservation District
  - c. DEP Nonpoint Source Training and Resource Center

3. Grant Funding
  - a. EPA Environmental Education Grants  
<http://www.epa.gov/enviroed/grants.html>
  - b. Watershed Protection Grant Program (for schools)  
<http://www.maine.gov/dep/blwq/docgrant/watershed/index.htm>
  - c. Project AWARE (Aquatic World Awareness, Responsibility and Education)  
<http://www.projectaware.org/americas/english/grantsasp>
  - d. Jessie B. Cox Charitable Trust  
<http://www.hemenwaybarnes.com>
  - e. New England Grassroots Environment Fund  
<http://www.grassrootsfund.org>
  
4. City Sponsorship: The City can expand their current education programs and activities to include projects such as the creation and placement of signage, sponsoring NPS Workshops, and assisting in the coordination of small business hazardous material disposal.

Table 4.1. Penjawoc Stream Education and Awareness Recommendations

<b>PENJAJAWOC EDUCATION &amp; AWARENESS RECOMMENDATIONS</b>						
<b>GOAL: Reduce pollutant loading and stormwater runoff.</b>						
	<b>Task</b>	<b>Partners (Who can work together?)</b>	<b>Authority (Who will initiate or oversee?)</b>	<b>Cost (One time unless noted otherwise)</b>	<b>Funding</b>	<b>Timeframe</b>
<b>4.1.0</b>	<b>Public Awareness</b>					
	<b>OBJECTIVE: Increase public awareness about the stream and watershed</b>					
4.1.1	Install one or more demonstration sites with interpretive signs at sites where BMPs are being installed. These can be on public lands or on private with landowner cooperation.	Penobscot SWCD, Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City	City	\$500-\$1,000/per site	City, Business Owners, Grants	2009
4.1.2	Develop a "Yardscapes" Demonstration site similar to the Back Cove site in Portland which showcases ecological landscaping with low-maintenance plants ( <a href="http://www.yardscaping.org/demo/portland.htm">http://www.yardscaping.org/demo/portland.htm</a> ).	City, Business owners, Chamber of Commerce, Cooperative Extension Service, Conservation Organizations	City	25,000	City, Business Owners, Grants	2009
<b>4.2.0</b>	<b>Education</b>					
	<b>OBJECTIVE: Increase knowledge and awareness about the impacts of NPS pollution and stormwater runoff in urban areas.</b>					
4.2.1	Initiate a commercial and residential BMP education program that encourages better housekeeping and management of:	Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City, Bangor Area Stormwater Group	City	\$5,000	City, Business Owners, Grants	2009
	a. Sand/salt					
	b. Fertilizer and pesticide					
	c. Litter					
	d. Dumpster s					
	e. Hazardous materials					

4.2.2	Increase awareness of education programs with a media campaign that includes:	Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City	City	\$5,000	City, Business Owners, Grants	2009
	a. Newspaper ads and press releases					
	b. Radio ads					
	c. Outreach through schools and community events					
<b>4.3.0</b>	<b>Public Engagement</b>					
	<b>OBJECTIVE: Increase public engagement in watershed issues and improving stream health.</b>					
4.3.1	Work with Marsh Mall Commission and DEP to develop a Penjajawoc Stream Team that will conduct water quality monitoring, habitat surveys, and NPS observations.	Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City	City	\$3,500 ongoing - \$7,000 start up	City, Business Owners, Grants	In Progress
4.3.2	Develop an "Adopt a Stream" program whereby businesses adopt their portion of the stream and/or streets that drain to the stream and are responsible for trash clean up and riparian integrity.	Chamber of Commerce, Keep Bangor Beautiful, City, Business Owners, Conservation Organizations	Chamber of Commerce	\$5,000	City, Business Owners, Grants	2009
4.3.3	Establish the "Business Friends" incentive program that generates dialogue between the City and business owners, encourages the use of Best Management Practices, and provides public acknowledgement for implementation of such programs.	Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City	City	\$5,000	City, Business Owners, Grants	2009
4.3.4	Work with state to require automobile undercarriage cleaning once per year prior to safety inspection in order to reduce leakage of automobile fluids in area parking lots.	State Department of Motor Vehicles, State Legislature	City, Chamber of Commerce	0	Not Applicable	2010



Table 4.2. Penjawoc Stream Prevention and Housekeeping Recommendations

<b>PENJAJAWOC PREVENTION RECOMMENDATIONS</b>						
<b>GOAL: Prevent the release of pollutants in stormwater runoff.</b>						
	<b>Task</b>	<b>Partners (Who can work together?)</b>	<b>Authority (Who will initiate or oversee?)</b>	<b>Cost (One time unless noted otherwise)</b>	<b>Funding</b>	<b>Timeframe</b>
<b>4.4.0</b>	<b>Sand/salt Management</b>					
	<b>OBJECTIVE: Ensure that sand/salt is properly stored and applied to avoid excess use and runoff</b>					
4.4.1	Ensure that all sand/salt storage areas comply with DEP requirements. Evaluate need for additional local regulations.	DEP, City, Landowner, Contractors	DEP, CEO	N/A	Landowner/ Business owner	Ongoing
4.4.2	Conduct annual inventory of all sand/salt storage areas.	City, Business Owners	City	\$1,000/per year	City	2009
4.4.3	Develop and conduct a sand/salt management education and training program (similar to other DEP contractor training) based on the DEP Stormwater Management BMPs. Program would include:	City, DEP, Landowners, Chamber of Commerce, Contractors	DEP, City	\$5,000	DEP	2009
	a. Developing an area s/s contractors list					2009
	b. Contractor training with certification					2009
	c. Evaluating need for sand/salt applicators' certification.					2009
4.4.4	Implement salt use restrictions near water bodies or throughout watershed (See Ordinance Recommendations)	City, DEP	City	N/A	N/A	Ongoing
4.4.5	Work with commercial entities to develop a vehicle-washing program to direct contaminated rinse water to sanitary sewers.	City, Business Owners	City	\$5,000	Business Owners	2010
<b>4.5.0</b>	<b>Street Sweeping</b>					
	<b>OBJECTIVE: Ensure that streets and parking lots are free of excess sand, salt, and other fine</b>					



	<b>particles.</b>					
4.5.1	Sweep major arterial streets twice per month especially prior to storm events when possible (during mid-winter thaws, etc).	City	City	\$150,000	City	2011
4.5.2	Work with business owners to ensure that private parking lots are cleaned regularly.	City, DEP, Business owners, Chamber of Commerce	City, Business Owners	\$1,000-\$5,000 per lot	Business Owners	2009
4.6.0	<b>Long-term BMP Maintenance</b>					
	<b>OBJECTIVE: Ensure that structural BMPs are functioning properly.</b>					
4.6.1	Ensure that all structural BMPs are easy to access, inspected annually, and maintained by certified erosion/stormwater control specialists in accordance with ordinance.	City, DEP, Business owners, Chamber of Commerce	City, Business Owners	N/A	N/A	2009
4.6.2	Ensure that those structural BMPS of unknown ownership ("orphaned") are maintained.	City, DEP, Business owners, Chamber of Commerce	City, Business Owners	N/A	City	Ongoing
4.7.0	<b>Fertilizer and Pesticide Management</b>					
	<b>OBJECTIVE: Reduce the amount of fertilizers and pesticides used in the watershed.</b>					
4.7.1	Initiate and encourage a program that works with businesses and residents and is based on Board of Pesticide Control's "Best Management Practices for the Application of Turf Pesticides and Fertilizers" ( <a href="http://www.maine.gov/agriculture/pesticides/turf_bmps/index.htm">www.maine.gov/agriculture/pesticides/turf_bmps/index.htm</a> ). (See Education Recommendations) The program should encourage:	City, DEP, Business owners, Chamber of Commerce, Conservation Organizations	City, Chamber, Business Owners	\$2,000	City, Business Owners, Grants	2009
	a. Conducting soil testing prior to application					
	b. Use of organic pesticides/fertilizers					
	c. Use of phosphorous free fertilizers					
	d. Planting low maintenance native species					
	e. Inclusion of topic in Chamber Newsletter					

	f. Chemical application					
4.7.2	Evaluate need for education and certification program for chemical applicators (commercial and facilities operators).	City, DEP, Business owners, Chamber of Commerce, Conservation Organizations	City, Chamber, Business Owners	\$5,000	City, Business Owners, Grants	2009
<b>4.8.0</b>	<b>Hazardous Materials Management</b>					
	<b>OBJECTIVE: Reduce the amount of hazardous materials used in the watershed.</b>					
4.8.1	Develop an education program based on DEP's Stormwater Management BMPs that works with businesses and residents and encourages:	City, DEP, Business owners, Chamber of Commerce, Conservation Organizations	City, Business Owners, Chamber	\$5,000	City, Business Owners, Grants	2009
	a. Use of natural/less toxic alternatives					
	b. Safe storage, handling, and disposal					
	c. Small businesses to conduct a group haz mat disposal	DEP, Penobscot Valley Council of Gov (PVCOG), Maine Resource Recovery Assoc, City, Chamber				
	d. Inclusion of topic in Chamber Newsletter					
<b>4.9.0</b>	<b>Litter Management</b>					
	<b>OBJECTIVE: Reduce the amount of litter (and associated pollutants) entering into the stream.</b>					
4.9.1	Evaluate the need to install more trash receptacles in business parking lots (receptacles can be placed in association with cart corrals, medians, etc)	Chamber of Commerce, Keep Bangor Beautiful, City, Business Owners, Conservation Organizations	Chamber of Commerce	N/A	Business Owners	2009
4.9.2	Evaluate the need to amend the dumpster/trash ordinances governing dumpster maintenance whereby businesses regularly inspect and conduct maintenance on dumpsters on their property. (See Ordinance Recommendations)	Chamber of Commerce, Keep Bangor Beautiful, City, Business Owners, Conservation Organizations	Chamber of Commerce	N/A	Business Owners	2009
<b>4.10.0</b>	<b>Landfill Management</b>					

	<b>OBJECTIVE: Ensure that the former landfill in the upstream portion of the watershed remains in compliance with applicable DEP closure requirements</b>					
4.10.1	Conduct annual inspection of landfill that includes confirmation of cap system integrity and documentation of any physical or functional site changes. Cap shall be mowed annually and be kept free of deep-rooted woody vegetation. Mowing shall be scheduled to avoid critical bird nesting periods	City	City	\$2,000	City	2009

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## Section 5 Restoration Toolbox: Channel and Riparian Restoration

Riparian Buffers, Channelization, Geomorphology, Erosion Control, and Bank Stabilization

### 5.1 Geomorphic Assessment Results

Parish Geomorphic conducted an extensive geomorphic assessment of the stream and its tributaries in 2005. The purpose of this study was to determine how watershed conditions are affecting stream stability and aquatic habitat. The study found that, in general, the Penjajawoc Stream displays “many symptoms indicative of urban development and the associated altered flow and sediment regime that occur as a result. Typically, this response includes active widening and incision as the channel expands to accommodate the increased runoff being diverted from hard, urban surfaces. Data analysis performed on Penjajawoc Stream indicated that there is an over supply of fine sediment within the system that is impacting the quality of aquatic habitat and is readily mobilized during high flow events. This sediment likely relates to past land use practices within the watershed and fine materials produced through the active erosion occurring within the channel.” (Parish 2006).

Parish’s study assessed existing conditions and makes specific recommendations for several high priority sites in the stream and Meadow Brook. The general trends found at these sites are summarized in Table 5.1. Recommendations for restoration of these sites are listed in Table 5.2.

Table 5.1. Summary of Existing Channel and Riparian Conditions of Prioritized Stream Segments (Parish 2006).

Reach	Summary of Existing Concerns.
Stillwater Avenue	Aggradation (sediment accumulation) dominates the reach
Mall Reach	Channel overly wide & low gradient causes backwater effects, aggradation of sediment, lack of riparian cover, warm summer temperatures, and lack of habitat/geomorphic diversity.
I-95 to Hogan Rd	Sediment starved, channel is eroding the bed and banks, upstream culvert is perched, high flow events are not connected to floodplain and high energy flows further incise and erode main channel.
Meadow Brook	Degradation (sediment scouring) and widening, channel is incised, steep gradient and bank erosion, high levels of sediment are being transported to the main stream and impacting aquatic habitat
Cemetery	Upstream detention ponds affect water temperature, deposition of fine material in pond causes deficit of materials downstream and causes erosion.
Rail Trestle and Rt 2 Crossing	Existing stream crossing structures pose a barrier to fish passage.
Beaver Dams	Beaver ponds cause deposition and increase water temperatures, concerns regarding fish passage

## 5.2 Restoration Recommendations and Costs

Since the recommendations suggested in the Parish study are preliminary, the actual dimensions and other specific engineering data have not been determined. Therefore, the cost for each site recommendation has also not been determined. Specific site designs will need to be developed before the City and its stakeholders can make implementation decisions. One of the leading agencies in the implementation process is the USDA Natural Resource Conservation Service and the Penobscot County Soil and water Conservation District. They have provided the following estimates for site design and cost estimation (C. Brewer, Penobscot SWCD, Personal Communication, December 2007):

- 12"-24" culverts = \$20.68/ft installed
- 36"-48" culverts = \$83/ft installed.
- Streambank Protection = \$5.13/ft
- Stream habitat improvement = \$50/ft
- Stream Rehabilitation simple structures = \$75/ea
- Stream Rehabilitation complex structures = \$3,750/ea (such as major road/train crossings)

## 5.3 Potential Funding Sources for Restoration Projects

Funding for channel and riparian restoration projects can be raised through the same mechanisms listed for education programs listed in Section 4. The City can also work with landowners to obtain easements in order to conduct restoration projects and this can be achieved separately or in conjunction with the Stormwater Utility District (Section 6.3). There are also several grant sources for which the City can apply. In some cases, the City may need to form partnerships with various agencies such as the Penobscot Soil and Water conservation District or the Natural Resource Conservation Service. Some possible grant sources include:

- **Nonpoint Source Water Pollution Control Grants (319).** Grants to prevent or reduce nonpoint source pollutant loadings entering water resources so that beneficial uses of the water resources are maintained or restored. The Maine NPS Grants Program is administered by the Maine Department of Environmental Protection (MDEP) in consultation with the U. S. Environmental Protection Agency (EPA). Grants for projects will be funded with monies provided to Maine by the U.S. Environmental Protection Agency under Section 319(h) and 604(b) of the Federal Clean Water Act. (<http://www.maine.gov/dep/blwq/docgrant/319.htm>)
- **Watershed Improvement Financial Assistance Partnership (WIFAP).** The *Watershed Improvement Financial Assistance Partnership* (WIFAP) provides financial assistance to help Maine Soil and Water Conservation Districts conduct Nonpoint Source Watershed Projects to help restore or protect lakes, streams, or coastal waters that are polluted or considered threatened. Funds for WIFAP are from the U. S. Environmental Protection Agency (\$120,000) administered by the DEP 319 Program and State of Maine general fund (\$80,000) administered by the Maine Department of Agriculture, Food, & Rural Resources (DAFRR). EPA-New England and the Maine Association of Conservation Districts are cooperating partners. Maine's 16 Districts joined together into 4 watershed regions for the partnership. Contact Norm Marcotte, DEP, 207-287-7727, [norm.g.marcotte@maine.gov](mailto:norm.g.marcotte@maine.gov).

- **American Rivers & NOAA Community-Based Restoration Program River Grants.** American Rivers and NOAA's Community-based Restoration Program provide financial and technical assistance for river restoration projects benefiting diadromous fish species in the Northeast. This funding seeks to enable environmental and economic renewal in local communities through the removal of stream barriers and realized benefits to diadromous fish species.
- **Surface Water Quality Protection Program (SWQPP)** is a cooperative endeavor that joins local, state and federal organizations in efforts to reduce the effect of polluted stormwater runoff from state highways and other MDOT transportation facilities. The SWQPP uses federal and state funds to assist in the engineering design and construction of innovative and effective stormwater management projects. The program relies on the interest and expertise of local citizens and community groups to locate and nominate these problem areas.  
(<http://www.maine.gov/mdot/environmental-office-homepage/surface-water-quality-protection.php>)



Table 5.2. In-stream and Riparian Habitat Restoration Recommendations.

<b>PENJAJAWOC RIPARIAN RESTORATION RECOMMENDATIONS</b>					
<b>GOAL: Restore ecosystem integrity of riparian areas and functionality of stream channel.</b>					
<i>The following recommendations are adapted from Penjajawoc Analysis and Interpretation, 2007, Parish Geomorphic.</i>					
	<b>Site</b>	<b>Partners (Who can work together?)</b>	<b>Authority (Who will oversee?)</b>	<b>Funding</b>	<b>Timeframe</b>
<b>5.1.0</b>	<b>Stillwater Ave</b>				
5.1.1	Investigate feasibility of decreasing cross-sectional stream area to promote velocity and sediment transport	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
5.1.2	Add native deciduous plantings to moderate stream temperature, create habitat, and stabilize banks.	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City, Landowners	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009
5.1.3	Create a "river walk" trail and natural area in the riparian zone that would attract wildlife and walkers/hikers. The "river walk" area could also be promoted as a "health walk" for shoppers and mall employees	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD	City, Landowners	Habitat Restoration & Economic Development Grants	2009-2011
<b>5.2.0</b>	<b>Mall Reach</b>				
5.2.1	Investigate feasibility of redesigning/realigning channel to reduce braiding, shorten stream length, and increase gradient	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
5.2.2	Investigate feasibility of decreasing cross-sectional area to promote velocity and sediment transport	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
5.2.3	Improve geomorphic diversity through the creation of riffles for improved DO	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011



5.2.4	Add plantings to moderate stream temperature, create habitat, and stabilize banks.	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC		Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
<b>5.3.0</b>	<b>Downstream of I-95 to Hogan Rd Crossing</b>				
5.3.1	Repair and resize perched culvert	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City, DOT	City, DOT	2009
5.3.2	Reconnect channel to floodplain by lowering bank and terracing margins	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
5.3.3	Stabilize banks & improve riparian conditions by using plantings, live stakes, and root wads.	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
5.3.4	Apply erosion controls to stabilize banks such as vegetated rip-rap, brush layering, brush wattles.	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
5.3.5	Apply grade control using step-pool morphology	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
<b>5.4.0</b>	<b>Meadow Brook</b>				
5.4.1	Redesign/realign channel	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
5.4.2	Increase length and decrease gradient by using sinuous planform	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011

5.4.3	Increase cross-sectional area to reduce velocity	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
5.4.4	Regrade banks to reduce entrenchment	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)	2009-2011
<b>5.5.0</b>	<b>Cemetery</b>				
5.5.1	Mitigate bank erosion	City, Cemetery Association	City	Landowner	2009
5.5.2	Detention Pond changes?	City, Cemetery Association	City	Landowner	2009
<b>5.6.0</b>	<b>Rail Trestle</b>				
5.6.1	Replace fish barrier with rocky ramp structures	City, Landowners, DMRBSRF (previously ASC)	City, Landowners	Landowner	2010
5.6.2	Replace and lower bridge footings	City, Landowners, DMRBSRF (previously ASC)	City, Landowners	Landowner	2010
<b>5.7.0</b>	<b>Beaver Dams</b>				
5.7.1	Work with IF&W to remove dams that cause flooding to homes and businesses	IF&W, Landowners, City	City, Landowners	IF&W	2009
5.7.2	Leave beaver dams in those areas where they are not causing damage so that they can generate natural riffles and aeration.	Landowners, City	City, Landowners	N/A	N/A

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## **Section 6 Restoration Toolbox: Retrofitting Stormwater Measures**

### Past Practices, Prioritizing Sites, and Stormwater Utility Districts

#### **6.1 Past Stormwater Management Practices and Retrofits**

In many cases, the traditional stormwater management standards that were applied in the past have been found to be either inadequate or, in some cases, to cause problems in the waters to which they drain. Many of the older standards failed to protect the stream channel and/or provided inadequate pollutant removal and inadequate shading. The current philosophy in stormwater management and the goal of each retrofit is focused on ensuring that stormwater systems meet the following four objectives (DEP 2006):

1. effective pollutant removal (reduce pollutant load),
2. cooling water temperatures,
3. channel protection, and
4. flood control.

As mentioned in Section 2, WBRC Architects and Engineers delineated 79 subwatersheds in the watershed. A matrix was developed that provides a suite of Low Impact Development (LID) and modern stormwater BMPs that could be implemented at these subwatersheds. This section of the plan attempts to prioritize the recommended retrofits for each of the subwatersheds based on a number of different variables.

#### **6.2 Prioritizing Retrofitted Sites**

##### **Retrofitting Sites on Public Property**

Table 6.1 is a list of Penjajawoc Watershed projects occurring on public property that the City of Bangor has agreed to retrofit or restore using funds from the Penjajawoc Compensation Fee Utilization Plan (City of Bangor, 2006). This list is not all encompassing as it is expected that new projects will be identified as the Watershed Management Plan is implemented and the City begins to work with stakeholders in the watershed. The projects have been chosen because they are located on public property, making them easy and efficient to implement using public funds. It is anticipated that these projects would be completed within the first 5 years of the plan.

Table 6.1. Penjawoc Compensation Fee Utilization Plan Projects on Public Land with Costs and Timeframes.

	<b>Penjawoc Compensation Fee Utilization Plan Project</b>	<b>Estimated Cost</b>	<b>Partners (Who can work together?)</b>	<b>Authority (Who will oversee?)</b>	<b>Funding</b>	<b>Timeframe</b>
6.1.1	PROJECT 1 – Design, model, and Construct Mall Area By-Pass System on City-owned right-of-way.	\$20,000	Mall Area Landowners	City of Bangor	CFUP	2009-2014
6.1.2	PROJECT 2 – Design, model, and Construct Storm Drainage Improvements at Stillwater Avenue and Other Projects.	\$100,000	Stillwater Avenue Landowners	City of Bangor	CFUP	2009-2014
6.1.3	PROJECT 3 - Design, Model, and Construct Storm Drainage Low Impact Development (LID) Improvements at Municipal Right-of-Ways near Hogan Rd. and Bangor Mall Blvd.	\$180,000	K-Mart Development Landowners	City of Bangor	CFUP	2009-2014
6.1.4	PROJECT 4 – Purchase a Super Sweeper/Vacuum Truck and implement an advanced cleaning/sweeping program,	\$250,000	All Landowners	City of Bangor	CFUP	2009-2014
6.1.5	PROJECT 5 – Enhance Riparian Corridors with Streambank Plantings.	\$48,000	Adjacent Landowners	City of Bangor	CFUP	2009-2014
	<b>TOTAL</b>	<b>\$598,000</b>				

## Retrofitting Sites on Private and Residential Property

Prioritization of subwatersheds was primarily based on the relative contribution of impervious surface within the watershed and the potential load reduction after retrofitting. The prioritization process consisted of several steps:

**Step One: Relative Impervious Cover** – Subwatersheds were preliminarily ranked based on their amount of impervious cover, existing stormwater treatment practices, and potential as high traffic and pollutant release areas. See Appendix C for the full list of subwatersheds and impervious cover data. Thirty-seven of the 79 subwatersheds were found to be high priority sites because:

- they have impervious cover greater than 2.5 acres
- stormwater treatment is limited or does not meet current standards and/or
- they are considered areas with potentially high traffic and high pollutant release such as a fast food restaurant or gas station.

**Step Two: Treatment Options** - City engineers and DEP staff grouped the thirty-seven subwatersheds by landowner and/or drainage patterns and determined the most appropriate treatment for each of 20 high priority sites. (See Appendix D for treatment details) Typical recommendations include:

- Retrofitting existing ponds to withstand more frequent stormwater events
- Installing of rain gardens, bioretention cells, filters
- Installing of oil/grit separators
- Use of “Tree Filter Boxes”
- Use of Lip-level Spreaders
- Revegetation and enhanced buffers where needed
- Increased Sweeping

**Step Three: Cost Estimates** - The City Engineer developed estimated costs for each of the retrofits at the twenty sites. (Table 6.2) The total estimated cost to retrofit all 20 sites is \$4,384,860. The cost per site ranges from \$20,000 to \$600,000 and the cost per acre of impervious area ranges from \$8,000 to \$126,000. Some retrofitted sites are more cost effective than others. For example, the total estimated cost to retrofit the 2550, 2513, 2750 subwatershed is \$540,000, but, since the retrofit will treat a large impervious area (58 ac), the cost per acre of impervious area is only \$9,259. (See costs per individual structural BMP in Appendix E)

**Step Four: Load Reductions** - DEP staff estimated the current load and load reductions for each of the 20 high priority sites (Section 2 and Table 6.2). Loads and reductions were determined for both nutrients (TP and N) and metals (Cu, Zn, and Pb). Only TP was used in prioritizing for load reduction. Potential reductions in TP range from <1 lb to 53.5 lbs depending on the effectiveness of the recommended retrofit and conditions specific to the site.

**Step Five: Evaluation Criteria** - Based on stakeholder input, the sites were evaluated and scored based on the following set of criteria (Table 6.3):

- Cost per acre treated by retrofit
- Estimated Load Reduction with retrofit
- Landowner Willingness and Participation.

**Step Six: Ranking Sites for Implementation** - The final step in the prioritization process was ranking the sites based on their evaluation scores (Table 6.4). Based on the scores, the sites were categorized into four tiers for implementation (1<sup>st</sup> through 4<sup>th</sup>). First tier sites are those that should be retrofitted first since they will have the greatest impact measured by either estimated load reduction or cost per acre impervious area. Second tier sites are generally cost effective while providing moderate benefits in terms of treated area and load reduction. Third and fourth tier sites treat smaller areas, have smaller load reductions, and/or are less cost effective. Implementation timeframes associated with this ranking are as follows:

<b>Implementation Tiers</b>	<b>Timeframe</b>
First Tier Sites	1-5 years
Second Tier Sites	5-10 years
Third Tier Sites	10-15 years
Fourth Tier Sites	15-20 years

### **6.3 Funding Retrofit Projects**

As stated in Section 3, Plan Implementation, the City intends to evaluate a suite of alternative stormwater funding approaches (Refer back to Section 3). Two of the most significant funding options include:

1. **Stormwater Utility District:** The establishment of a Stormwater Utility District in which users within the district pay a pro-rated fee which can be used to fund the upgrade of existing structural BMPs.
2. **Incentive Programs:** The creation of an incentive program whereby owners of new developments (which presumably would install modern, less polluting structural BMPs) would undertake one of the retrofit projects as a requirement of its new development. This method could also be used with re-development of an existing site. Mitigating one of the retrofits sites could be a condition of re-development

Table 6.2 Penjajawoc Stream High Priority Subwatersheds Impervious Area, Costs, and Load Reduction. Ranked by Load Reduction.

WBRC Drainage #	Total Area (Ac)	Impervious Area (Ac)	Cost/Sub Watershed	Cost/ Ac Imp Area	Estimated Pollutant Load (Lbs/yr of TP)	Estimated Load Reduction w/Retrofit(Lbs/yr of TP)	Estimated Load Reduction w/Retrofit (%)
2550, 2513, 2750	87.6	59.24	\$540,000	\$9,115.46	107.0	53.5	50%
500	123	31.4	\$344,000	\$10,955.41	63.8	35.1	55%
5000 Series	394	3.94	\$500,000	\$126,903.55	43.1	19.4	45%
1091, 1092, 1093	31.8	23	\$472,000	\$20,521.74	37.6	12.4	33%
400, 600, 800,1010, 2100, 2510, 2514	55.9	15.3	\$600,000	\$39,267.02	35.7	10.7	30%
1040, 1030	15.3	9.98	\$258,000	\$25,851.70	18.0	9.9	55%
520	28.5	8.73	\$210,000	\$24,054.98	17.2	8.6	50%
2511	9.2	6.17	\$180,000	\$29,173.42	11.1	5.0	45%
1712	12	4.08	\$67,200	\$8,000.00	8.0	4.8	60%
110	15.2	6.11	\$90,000	\$14,729.95	11.5	4.6	40%
310, 320, 321	14.3	12	\$190,000	\$15,859.77	21.9	3.5	16%
1220	4.6	3.59	\$162,900	\$45,376.04	6.4	3.2	50%
1291 & 1413	3.7	2.65	\$78,600	\$29,660.38	4.8	2.8	58%
410	6.5	5.54	\$130,000	\$23,465.70	10.0	2.5	25%
1200, 1210	6.52	3.09	\$100,000	\$32,362.50	5.7	2.1	37%
2720, 2730	2.97	2.15	\$152,000	\$70,697.68	3.8	1.5	40%
1000	6.1	1.34	\$50,000	\$37,313.43	2.8	1.4	50%
1090	2.6	2.06	\$200,000	\$97,087.38	3.7	1.3	35%
412	5.5	1.95	\$40,000	\$20,512.82	3.6	0.9	25%
1297	1.3	0.84	\$20,160	\$24,000.00	1.6	0.4	25%
<b>TOTAL</b>			<b>\$4,384,860</b>		<b>417.3</b>	<b>183.6</b>	

Table 6.3 Evaluation and Scoring Criteria for Penjajawoc Stream High Priority Retrofit Sites.

<b>Evaluation Factor</b>	<b>Cost per Acre Treated</b>	<b>Load Reduction with Retrofit (Lbs/yr of TP)</b>	<b>Landowner Participation</b>	<b>Points</b>
<b>Scoring Criteria</b>	\$100,000-127,000	<1 – 10	Little or no involvement/incentive	1
	\$75,000-99,999	11-20	Some involvement, and/or incentive to participate	2
	\$50,000-74,999	21-30	Landowner is involved in process and/or has incentive	3
	\$25,000-49,999	31-40	N/A	4
	\$1-24,999	>40	N/A	5

Highest Possible Points for any one project = 13 points. A site treatment scoring 13 points would treat a site with a low cost per acre treated, a high load reduction, and high landowner participation and willingness.



Table 6.4. Penjawoc Stream Final Retrofit Scoring, Ranking, and Prioritization. Ranked by Total Points and Implementation Tier.

WBRC Drainage #	Cost/ Ac Imp Area	Points	Load Reduction w/Retrofit	Points	Landowner Willingness Points	Total Points	Implementation Tier
2550, 2513, 2750	\$9,259.26	5	53.5	5	3	13	1st
500	\$10,955.41	5	35.1	4	3	12	1st
400, 600, 800, 1010, 2100, 2510, 2514	\$39,267.02	4	10.7	2	3	9	2nd
310, 320, 321	\$15,859.77	5	3.5	1	3	9	2nd
1091, 1092, 1093	\$20,521.74	5	12.4	2	1	8	2nd
110	\$14,729.95	5	4.6	1	2	8	2nd
1200, 1210	\$49,019.61	4	1.2	1	2	7	3rd
412	\$20,512.82	5	0.9	1	1	7	3rd
1297	\$24,000.00	5	0.4	1	1	7	3rd
410	\$23,465.70	5	2.5	1	1	7	3rd
2720, 2730	\$70,697.68	3	1.5	1	3	7	3rd
1000	\$37,313.43	4	1.4	1	2	7	3rd
520	\$24,054.98	5	8.6	1	1	7	3rd
1712	\$8,000.00	5	4.8	1	1	7	3rd
1291 & 1413	\$29,660.38	4	2.8	1	1	6	4th
2511	\$29,173.42	4	5.0	1	1	6	4th
1220	\$45,376.04	4	3.2	1	1	6	4th
1040, 1030	\$25,851.70	4	9.9	1	1	6	4th
5000 Series	\$126,903.55	1	19.4	2	2	5	4th
1090	\$97,087.38	2	1.3	1	1	4	4th

First tier sites = 1-5 years

Second tier sites = 5 -10 years

Third Tier sites = 10 -15 years

Fourth Tier = 15- 20 years



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## **Section 7 Restoration Toolbox: Ordinances and Administration**

Enacting Implementation, Easements, Staffing Needs, Future Development

### **7.1 Ordinances**

In order to implement the recommendations for education, prevention, restoration, and retrofitting existing stormwater structures, the City will need to:

1. consider enacting ordinances which enable the City to conduct implementation,
2. consider obtaining easements on properties where the City will conduct implementation,
3. evaluate and possibly amend staff duties where needed,
4. review current ordinances to ensure that they address current and future development and stormwater BMP requirements.

Once the plan is adopted, the City should work quickly to consider the ordinance changes necessary to enact implementation. Implementation of structural BMPs will require further and more specific site planning; and the City will need to establish easements and collect fees for any future work. Table 7.1 lists the recommended ordinances needed to continue with implementation. The City recognizes that an equitable approach is necessary and will consider applying all new regulations Citywide.

### **7.2 Administration**

Given the number of programs and recommendations needed to improve water quality and prevent future NPS pollution, the City may need to consider changing staff duties and/or hiring new staff in order to complete the tasks in a timely manner. For example, additional staff may be needed to implement programs, enforce ordinances, oversee construction, implement BMPs, and conduct education programs. Table 7.2 lists the administrative recommendations needed for implementation. These recommendations will be initiated, enacted, and funded by the City. Funding for administrative changes will most likely come from the City's general funds.

Table 7.1.Penjajawoc Ordinance Recommendations.

<b>PENJAJAWOC ORDINANCE RECOMMENDATIONS</b>		
<i>All of the following recommendations would be initiated and administered by the City.</i>		
	<b>Proposed Ordinance Description</b>	<b>Timeframe</b>
<b>7.1.0</b>	<b>GOAL: Establish ordinances that support the use of best management practices and other stormwater measures in all City watersheds</b>	
7.1.1	Consider the creation of an ordinance that establishes a Stormwater Utility District in which members of the district pay a pro-rated fee that can be used to pay for the upgrade of existing structural BMPs. Consider exempting residents and evaluate city-wide or by watershed district. (See Retrofit Funding and Incentives).	2009
7.1.2	Establish an ordinance requiring annual inspection and maintenance of all structural BMPs in accordance with MDEP Stormwater Manual.	2009
7.1.3	Create a dumpster maintenance ordinance whereby businesses are required to regularly inspect and conduct maintenance on dumpsters on their property. (See Prevention/Housekeeping Recommendations)	2009
7.1.4	Evaluate the need to establish ordinances based on recommended BMPs (see CWP "Better Site Design Handbook") and on the following principles:	2009
	a. Require buffers that abut the stream on commercial and residential sites for all new development (Compare with current standards).	
	b. All new and existing buffers should be composed of woody shade-bearing, native tree species.	
	c. Consider banning the use of fertilizers and pesticides in the watershed, at least temporarily.	
	d. Implement salt use restrictions/limits near waterbodies or throughout watershed	
<b>7.2.0</b>	<b>GOAL: Ensure that current ordinances address current and future development BMP needs</b>	
7.2.1	Update current impervious cover data and build-out findings to include recent land-use changes and development in order to determine what levels are acceptable and what changes, if any, are necessary for future development levels.	2010
7.2.2	Systematically review existing codes, standards, and ordinances and compare them to the "model development principles" as established in the "Better Site Design" Handbook at the Center for Watershed Protection ( <a href="http://www.cwp.org/PublicationStore/bsd.htm">http://www.cwp.org/PublicationStore/bsd.htm</a> ). Include in the discussion, the forthcoming Municipal Separate Storm Sewer Systems (MS4) rules that may apply Citywide (especially for new development). Assign to existing City committees (i.e., Marsh Mall Commission, Comprehensive Planning Committee).	2009
7.2.3	Develop a Stormwater Amendment to the City Comprehensive Plan.	2009
7.2.4	Create an incentive program where owners of new developments (which presumably would install modern, less polluting structural BMPs) would provide resources to fund one of the retrofit projects as a mitigation requirement to insure that a new	2009

development has no impact on water quality. This method could also be used with re-development of an existing site.

Table 7.2. Penjawoc Administrative Recommendations

<b>PENJAJAWOC ADMINISTRATIVE RECOMMENDATIONS</b>				
<i>All of the following would be initiated, enacted, and funded by the City.</i>				
	<b>Task</b>	<b>Partners (Who can work together?)</b>	<b>Cost</b>	<b>Timeframe</b>
<b>7.3.0</b>	<b>GOAL: Ensure that there is sufficient support staff to enact plan.</b>			
7.3.1	Develop an annual work plan (and publish it to the public) by anniversary date of approved WMP.	City, Penjawoc Stakeholder Working Group	\$1,000	2009
7.3.2	Hire required staff needed to implement programs, enforce ordinances, oversee construction, implementation of BMPs, and education program.	N/A	\$67,000	2009
<b>7.4.0</b>	<b>GOAL: Ensure that there is sufficient organizational structure to enact plan.</b>			
7.4.1	Adopt the Penjawoc Watershed Management Plan	City, Penjawoc Stakeholder Working Group	N/A	2008
7.4.2	Update the Penjawoc Compensation Fee Utilization Plan and integrate with this management plan.	City, Penjawoc Stakeholder Working Group	N/A	2009
7.4.3	Establish a City staff working group that consists of representatives from all relevant City departments that reviews all stormwater, development, and planning related issues. Where appropriate, invite stakeholder involvement.	City, Penjawoc Stakeholder Working Group	N/A	2008
7.4.4	Where necessary and appropriate, seek public easements along stream in order to increase opportunities and access for restoration and water quality improvement.	City, Penjawoc Stakeholder Working Group	\$20,000	Ongoing

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# Section 8 Milestones of Success and Monitoring for Future Evaluation

## Measurable Milestones and Water Quality Monitoring

### 8.1 Adaptive Management

As discussed in Section 3, a critical part of the plan's success will depend on additional evaluations, modeling, and monitoring. The City will meet with the stakeholders at least annually to review progress on the plan. At that time, progress toward meeting milestones and any necessary changes will be discussed. The City will conduct an annual review beginning in fall 2009. The City will also meet with the Stakeholders as necessary to review policy issues involving the implementation of this plan prior to advancing those issues through the City's formal governance process. The City agrees to provide a semi-annual newsletter that will include information on monitoring results, implemented BMPs, recent decisions, policies, ordinance changes, and upcoming events and meetings.

### 8.2 Measurable Milestones

The purpose of monitoring milestones is to evaluate the effectiveness of implementation efforts. Specifically, the milestones should measure progress toward implementation of the plan and whether the efforts are achieving load reductions over time and progressing towards attainment of Class B standards. All recommendations in the plan include a timeframe for initiating and, in some cases, completing the tasks. However, it is helpful to view the tasks in terms of milestones. Tables 8.1 through 8.4 include milestones for education and prevention, restoration, structural retrofits, and administration and ordinances that the City will incorporate into its annual review and adaptive management program.

Table 8.1. Milestones for Education and Prevention.

Education and Prevention Milestones
<b>Goal: Have education and prevention programs in place by 2012</b>
<b>Milestone</b>
• One demonstration site is established per year for the next 7-10 years
• Signage is established throughout watershed in the first 3 years
• Business Friends generates 2 new business per year for the next 7 years
• Sand/salt management training is held annually for the first 3 years and biannually for the next 5-10 years
• Education programs are in place within the first 3 years and at least 3 program activities (training, newsletter, haz mat disposal) occur every year for the next 20 years.

Table 8.2. Milestones for In-Stream and Riparian Restoration.

<b>In-Stream and Riparian Restoration Milestones</b>
<b>Goal: Restore ecosystem integrity of riparian areas and functionality of stream channel.</b>
<b>Milestone</b>
<ul style="list-style-type: none"> <li>• 1-2 restoration projects implemented per year. Restoration Projects should be completed by year 2020</li> <li>• Buffers and/or riparian areas restored @ 1 mile per year and be completed by 2020</li> <li>• Trail and/or interpretative natural area along the stream developed by 2015</li> <li>• Establish gages to monitor flow before and after restoration</li> <li>• Continue monitoring of erosion pins installed along the stream by Parish Geomorphic (PS2, PS4, PS617, PST1-2, PST2-3, PST5-4)</li> </ul>

Table 8.3 Milestones for Retrofitting Structural BMPs.

<b>Retrofit Milestones</b>
<b>Goal: Reduce pollutant and sediment loading, cool water temperatures, and reduce stormwater flow by 2025.</b>
<b>Milestone</b>
<ul style="list-style-type: none"> <li>• First and second tier retrofit sites implemented in 5 years</li> <li>• Second tier retrofit sites implemented in 10 years</li> <li>• Third tier retrofit sites implemented within 15 years</li> <li>• Fourth tier retrofit sites implemented within 20 years</li> <li>• Stormwater Utility District is established and fees are collected by 2012.</li> </ul>

Table 8.4 Milestones for Administrative and Ordinance BMPs.

<b>Administrative and Ordinance Milestones</b>
<b>Goal: Establish ordinances that support the use of best management practices and other stormwater measures in all City watersheds; ensure that current ordinances address current and future development BMP needs; ensure that there is sufficient staff and organizational structure to enact plan.</b>
<b>Milestone</b>
<ul style="list-style-type: none"> <li>• Annual work plan developed (and published to the public) by anniversary date of approved WMP.</li> <li>• Organizational structure developed and staff increased by 1 part time person within 1 year.</li> <li>• City staff working group reviews all stormwater related issues established and review of ordinances is completed within 2 years.</li> </ul>

### 8.3 Water Quality Monitoring

Every watershed management plan should incorporate a water quality monitoring component to assist managers in tracking progress toward attaining class standards. A monitoring program should be directly related to the management objectives and to the implementation schedule. The overall water quality goal for the Penjajawoc is to achieve class B standards as stated in Table 2.1. The objective of the water quality monitoring recommendations as stated in Table 8.5 is to increase water quality monitoring and habitat assessment.

The Penjajawoc Stream Team was created in fall 2007 with the assistance of DEP staff. The purpose of the Stream Team is to improve our knowledge of water quality parameters in the stream and to establish baseline data that could later be used to track progress especially after significant implementation projects are undertaken. The team's 2007-2008 regime and equipment list (Appendix F) indicates that the following parameters will be measured:

- Turbidity
- Bacteria (E. coli)
- Dissolved oxygen
- Conductivity
- Temperature
- Flow
- pH
- Nutrients
- Metals
- Cations/anions

In addition the Stream Team will conduct screening-level macroinvertebrate sampling, flow and erosion studies, and habitat assessment using the DEP Rapid Assessment Stream Walk technique. Milestones for the monitoring program are listed in Table 8.5.

Table 8.5. Milestones for the Penjajawoc Stream Team Water Quality Monitoring Program.

<b>Water Quality Monitoring Milestones</b>
<b>Goal: Establish and maintain a regular, continuous monitoring program and achieve Class B standards by 2023.</b>
<b>Milestone</b>
• Stream Team has 5 years of baseline data and is well-established by 2015
• Stream Team regularly monitors new restoration and implementation sites
• Dissolved oxygen throughout watershed is 7 ppm by 2020
• DEP will continue macroinvertebrate monitoring on rotation schedule and will follow-up on problems found by Stream Team.





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## **APPENDICES**

- Appendix A: Integrated Table of Recommendations Sorted by Timeframe.
- Appendix B: Retrofit Prioritization and Loading Analysis Method
- Appendix C: Penjajawoc Stream Prioritization, Impervious Cover, and Pollutant Load Information
- Appendix D: Penjajawoc Stream Retrofit Recommendations
- Appendix E: Penjajawoc Stream Retrofit Estimated Costs
- Appendix F: Penjajawoc Stream Team Monitoring Regime & Equipment List

## Appendix A: Integrated Table of Recommendations Sorted by Timeframe.

Tasks may be abbreviated and summarized; for more information see original tasks and tables Sections 4-7.

	Task	Partners (Who can work together?)	Authority (Who will initiate or oversee?)	Cost (One time unless noted otherwise)	Funding
	<b>Timeframe 2009-2014</b>				
	Conduct CH2M Hill Penjajawoc Stream Impairment Assessment Study	City of Bangor, Stakeholders, Business owners	City	\$25,000	Cost Share: City of Bangor; Business owners
4.1.1	Install one or more demonstration sites with interpretive signs at sites where BMPs are being installed. These can be on public lands or on private with landowner cooperation.	Penobscot SWCD, Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City	City	\$500-\$1,000/per site	City, Business Owners, Grants
4.1.2	Develop a "Yardscapes" Demonstration site similar to the Back Cove site in Portland which showcases ecological landscaping with low-maintenance plants ( <a href="http://www.yardscaping.org/demo/portland.htm">http://www.yardscaping.org/demo/portland.htm</a> ).	City, Business owners, Chamber of Commerce, Cooperative Extension Service, Conservation Organizations	City	25,000	City, Business Owners, Grants
4.2.1	Initiate a commercial and residential BMP education program that encourages better housekeeping and management of:	Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City, Bangor Area Stormwater Group	City	\$5,000	City, Business Owners, Grants
4.2.2	Increase awareness of education programs with a media campaign that includes:	Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City	City	\$5,000	City, Business Owners, Grants
4.3.1	Work with Marsh Mall Commission and DEP to develop a Penjajawoc Stream Team that will conduct water quality monitoring, habitat surveys, and NPS observations.	Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City	City	\$3,500 ongoing - \$7,000 start up	City, Business Owners, Grants

4.3.2	Develop an "Adopt a Stream" program whereby businesses adopt their portion of the stream and/or streets that drain to the stream and are responsible for trash clean up and riparian integrity.	Chamber of Commerce, Keep Bangor Beautiful, City, Business Owners, Conservation Organizations	Chamber of Commerce	\$5,000	City, Business Owners, Grants
4.3.3	Establish the "Business Friends" incentive program that generates dialogue between the City and business owners, encourages the use of Best Management Practices, and provides public acknowledgement for implementation of such programs.	Chamber of Commerce, Keep Bangor Beautiful, Cooperative Extension, City	City	\$5,000	City, Business Owners, Grants
4.3.4	Work with state to require automobile undercarriage cleaning once per year prior to safety inspection in order to reduce leakage of automobile fluids in area parking lots.	State Department of Motor Vehicles. State Legislature	City Chamber of Commerce	0	Not Applicable
4.4.1	Ensure that all sand/salt storage areas comply with DEP requirements. Evaluate need for additional local regulations.	DEP, City, Landowner, Contractors	DEP, CEO	N/A	Landowner/ Business owner
4.4.2	Conduct annual inventory of all sand/salt storage areas.	City, Business Owners	City	\$1,000/per year	City
4.4.3	Develop and conduct a sand/salt management education and training program (similar to other DEP contractor training) based on the DEP Stormwater Management BMPs.	City, DEP, Landowners, Chamber of Commerce, Contractors	DEP, City	\$5,000	DEP
4.4.4	Implement salt use restrictions near water bodies or throughout watershed (See Ordinance Recommendations)	City, DEP	City	N/A	N/A
4.5.2	Work with business owners to ensure that private parking lots are cleaned regularly.	City, DEP, Business owners, Chamber of Commerce	City, Business Owners	\$1,000-\$5,000 per lot	Business Owners
4.6.1	Ensure that all structural BMPs are easy to access, inspected annually, and maintained by certified erosion/stormwater control specialists in accordance with ordinance.	City, DEP, Business owners, Chamber of Commerce	City, Business Owners	N/A	N/A
4.6.2	Ensure that those structural BMPS of unknown ownership ("orphaned") are maintained.	City, DEP, Business owners, Chamber of Commerce	City, Business Owners	N/A	City

4.7.1	Initiate and encourage a program that works with businesses and residents and is based on Board of Pesticide Control's "Best Management Practices for the Application of Turf Pesticides and Fertilizers" ( <a href="http://www.maine.gov/agriculture/pesticides/turf_bmps/index.htm">www.maine.gov/agriculture/pesticides/turf_bmps/index.htm</a> ). (See Education Recommendations)	City, DEP, Business owners, Chamber of Commerce, Conservation Organizations	City, Chamber, Business Owners	\$2,000	City, Business Owners, Grants
4.7.2	Evaluate need for education and certification program for chemical applicators (commercial and facilities operators).	City, DEP, Business owners, Chamber of Commerce, Conservation Organizations	City, Chamber, Business Owners	\$5,000	City, Business Owners, Grants
4.8.1	Develop an education program based on DEP's Stormwater Management BMPs that works with businesses and residents and encourages:	City, DEP, Business owners, Chamber of Commerce, Conservation Organizations	City, Business Owners, Chamber	\$5,000	City, Business Owners, Grants
4.9.1	Evaluate the need to install more trash receptacles in business parking lots (receptacles can be placed in association with cart corrals, medians, etc)	Chamber of Commerce, Keep Bangor Beautiful, City, Business Owners, Conservation Organizations	Chamber of Commerce	N/A	Business Owners
4.9.2	Evaluate the need to amend the dumpster/trash ordinances governing dumpster maintenance whereby businesses regularly inspect and conduct maintenance on dumpsters on their property. (See Ordinance Recommendations)	Chamber of Commerce, Keep Bangor Beautiful, City, Business Owners, Conservation Organizations	Chamber of Commerce	N/A	Business Owners
4.10.1	Conduct annual inspection of landfill that includes confirmation of cap system integrity and documentation of any physical or functional site changes. Cap shall be mowed annually and be kept free of deep-rooted woody vegetation. Mowing shall be scheduled to avoid critical bird nesting periods	City	City	\$2,000	City
4.4.5	Work with commercial entities to develop a vehicle-washing program to direct contaminated rinse water to sanitary sewers.	City, Business Owners	City	\$5,000	Business Owners
4.5.1	Sweep major arterial streets twice per month especially prior to storm events when possible (during mid-winter thaws, etc).	City	City	\$150,000	City

6.1.1	PROJECT 1 – Design, model, and Construct Mall Area By-Pass System on City-owned drainage system.	Mall Area Landowners	City of Bangor	\$20,000	CFUP
6.1.2	PROJECT 2 – Design, model, and Construct Storm Drainage Improvements at Stillwater Avenue and Other Projects.	Stillwater Avenue Landowners	City of Bangor	\$100,000	CFUP
6.1.3	PROJECT 3 - Design, Model, and Construct Storm Drainage Low Impact Development (LID) Improvements at Municipal Right-of-Ways, Near the K-Mart Development.	K-Mart Development Landowners	City of Bangor	\$180,000	CFUP
6.1.4	PROJECT 4 – Purchase a Super Sweeper/Vacuum Truck and implement an advanced cleaning/sweeping program,	All Landowners	City of Bangor	\$250,000	CFUP
6.1.5	PROJECT 5 – Enhance Riparian Corridors with Streambank Plantings.	Adjacent Landowners	City of Bangor	\$48,000	CFUP
7.1.1	Consider the creation of an ordinance that establishes a Stormwater Utility District in which members of the district pay a pro-rated fee that can be used to pay for the upgrade of existing structural BMPs. Consider exempting residents and evaluate Citywide or by watershed district. (See Retrofit Funding and Incentives).	N/A	City	N/A	City
7.1.2	Establish an ordinance requiring annual inspection and maintenance of all structural BMPs in accordance with MDEP Stormwater Manual.	N/A	City	N/A	City
7.1.3	Create a dumpster maintenance ordinance whereby businesses are required to regularly inspect and conduct maintenance on dumpsters on their property. (See Prevention/Housekeeping Recommendations)	N/A	City	N/A	City
7.1.4	Evaluate the need to establish ordinances based on recommended BMPs (see CWP “Better Site Design Handbook”).	N/A	City	N/A	City



7.2.1	Update current impervious cover data and build-out findings to include recent land-use changes and development in order to determine what levels are acceptable and what changes if any are necessary for future development levels.	N/A	City	N/A	City
7.2.2	Systematically review existing codes, standards, and ordinances and compare them to the "model development principles" as established in the "Better Site Design" Handbook at the Center for Watershed Protection. Include in the roundtable discussion, the forthcoming Municipal Separate Storm Sewer Systems (MS4) rules that may apply Citywide (especially for new development). Assign to existing City committees (i.e., Marsh Mall Commission, Comprehensive Planning Committee).	N/A	City	N/A	City
7.2.3	Develop a Stormwater Amendment to the City Comprehensive Plan (similar to what other cities, such as York, have developed)	N/A	City	N/A	City
7.2.4	Create an incentive program where owners of new developments (which presumably would install modern, less polluting structural BMPs) would provide resources to fund one of the retrofit projects as a mitigation requirement to insure that a new development has no impact on water quality. This method could also be used with re-development of an existing site. Mitigating one of the retrofit sites could be a condition of re-development	N/A	City	N/A	City
7.3.1	Develop an annual work plan (and published to the public) by anniversary date of approved WMP.	City, Penjajawoc Stakeholder Working Group	City	\$1,000	City
7.3.2	Evaluate staffing needs to implement programs, enforce ordinances, oversee construction, implementation of BMPs, and education program.	N/A	City	\$67,000	City
7.4.1	Adopt the Penjajawoc Watershed Management Plan	City, Penjajawoc Stakeholder Working Group	City	N/A	City

7.4.2	Update the Penjajawoc Compensation Fee Utilization Plan and integrate with this management plan.	City, Penjajawoc Stakeholder Working Group	City	N/A	City
7.4.3	Establish a City staff working group that consists of representatives from all relevant City departments that reviews all stormwater, development, and planning related issues. Where appropriate, invite stakeholder involvement.	City, Penjajawoc Stakeholder Working Group	City	N/A	City
7.4.4	Where necessary and appropriate, seek public easements along stream in order to increase opportunities and access for restoration and water quality improvement.	City, Penjajawoc Stakeholder Working Group	City	\$20,000	City
<b>5.1.0 Stillwater Ave Restoration Projects</b>					
5.1.1	Investigate feasibility of decreasing cross-sectional stream area to promote velocity and sediment transport	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
5.1.2	Add native deciduous plantings to moderate stream temperature, create habitat, and stabilize banks.	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City, Landowners	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
5.1.3	Create a "river walk" trail and natural area in the riparian zone that would attract wildlife and walkers/hikers. The "river walk" area could also be promoted as a "health walk" for shoppers and mall employees	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD	City, Landowners	N/A	Habitat Restoration & Economic Development Grants
6.0	All Retrofit Projects between Stillwater Ave and the Bangor Mall (See Section 6)	City, Landowners, DEP	City, Landowner	N/A	Stormwater Utility District
<b>Timeframe: 2014-2019</b>					
<b>5.2.0 Mall Reach Restoration Projects</b>					
5.2.1	Investigate feasibility of redesigning/realigning channel to reduce braiding, shorten stream length, and increase gradient	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)

5.2.2	Investigate feasibility of decreasing cross-sectional area to promote velocity and sediment transport	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
5.2.3	Improve geomorphic diversity through the creation of riffles for improved DO	City, DEP, Landowners, Engineering Consultants, PCS&WCD, NRCS	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
5.2.4	Add plantings to moderate stream temperature, create habitat, and stabilize banks.	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC		N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
6.0	<b>All Retrofit Projects between Bangor Mall and I-95 (See Section 6)</b>	City, Landowners, DEP	City, Landowner	N/A	Stormwater Utility District
	<b>Timeframe: 2019-2024</b>				
5.3.0	<b>Downstream of I-95 to Hogan Rd Crossing Restoration Projects</b>				
5.3.1	Repair and resize perched culvert	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City, DOT	N/A	City, DOT
5.3.2	Reconnect channel to floodplain by lowering bank and terracing margins	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
5.3.3	Stabilize banks & improve riparian conditions by using plantings, live stakes, and root wads.	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
5.3.4	Apply erosion controls to stabilize banks such as vegetated rip-rap, brush layering, brush wattles.	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)

5.3.5	Apply grade control using step-pool morphology	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
<b>6.0</b>	<b>All Retrofit Projects between I-95 and Hogan Rd (See Section 6)</b>	City, Landowners, DEP	City, Landowner	N/A	Stormwater Utility District
	<b>Timeframe: 2024-2029</b>				
<b>5.4.0</b>	<b>Meadow Brook Restoration Projects</b>				
5.4.1	Redesign/realign channel	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
5.4.2	Increase length and decrease gradient by using sinuous planform	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
5.4.3	Increase cross-sectional area to reduce velocity	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
5.4.4	Regrade banks to reduce entrenchment	City, Landowners, Scouts, Conservation Groups, Cooperative Extension, PCS&WCD, NRSC	City	N/A	Habitat Restoration Grants (WIFAP, 319, NFWF, USDA, NOAA, USFWS)
6.0	All Retrofit Projects in the Meadow Brook Watershed (See Section 6)	City, Landowners, DEP	City, Landowner	N/A	Stormwater Utility District
<b>5.5.0</b>	<b>Cemetery Restoration Projects</b>				
5.5.1	Mitigate bank erosion	City, Cemetery Association	City	N/A	Landowner
5.5.2	Detention Pond changes	City, Cemetery Association	City	N/A	Landowner
<b>5.6.0</b>	<b>Rail Trestle Restoration Projects</b>				

5.6.1	Replace fish barrier with rocky ramp structures	City, Landowners, DMRBSRF (previously ASC)	City, Landowners	N/A	Landowner
5.6.2	Replace and lower bridge footings	City, Landowners, DMRBSRF (previously ASC)	City, Landowners	N/A	Landowner
<b>5.7.0</b>	<b>Beaver Dams Restoration Projects</b>				
5.7.1	Work with IF&W to remove dams that cause flooding to homes and businesses	IF&W, Landowners, City	City, Landowners	N/A	IF&W
5.7.2	Leave beaver dams in those areas where they are not causing damage so that they can generate natural riffles and aeration.	Landowners, City	City, Landowners	N/A	N/A

## **Appendix B: Retrofit Prioritization and Loading Analysis Method**

(Completed for Penjajawoc Stream Watershed Management Plan-11/28/07)

Mary-Ellen Dennis, DEP

### Step 1-Prioritize Sub-Watersheds into 3 categories

- Gather data and maps-used WBRC aerial photo with sub-watersheds map which divided watershed into 79 sub-watersheds (exclusive of Meadow Brook)
- Data for each sub-watershed includes total sub-watershed area, impervious area and % imperviousness of the sub-watershed
- Using spreadsheet from WBRC, sorted sub-watersheds by impervious area
- With City Engineer, consultant and DEP staff, took notes about each sub-watershed. Information included what the existing bmps are, existing treatment, plans for re-development, and limitations of site
- Assigned each sub-watershed high, medium, or low priority based on the following criteria:
  - High- >2.5 acres impervious and no or limited existing treatment, or hot spot
  - Medium- 1.0-2.5 acres impervious and no or limited treatment (if >2.5 acres, but has sheet flow, volume issue only or some treatment bumps it from high to medium)
  - Low- <1 acre impervious or treatment in place or low density/not connected
  - Hot spot- High traffic area and potential for toxic release (includes convenience stores, gas stations, fast food restaurants and DOT maintenance garage)

### Step 2-Recommend Retrofits for High Priority Sub-Watersheds

- City Engineer, City Environmental Manager and DEP staff reviewed each sub-watershed and made recommendations for what could be done for retrofits.
- Recommendations included implementing new bmps, enhancing existing bmps and housekeeping
- The recommendations took into account drainage, limitations of site (e.g. shallow to groundwater, little space) and site assets (e.g. large area, opportunity for sheet flow). A number of sites were looked at in the field by City Engineer and DEP staff.

### Step 3- Estimate treatment with retrofit

- For each high priority sub-watershed, DEP staff determined treatment that would be obtained with recommended retrofits:
- This was done by first estimating what percent of the sub-watershed will be treated with the recommended BMPs.
- Second, a treatment factor for the entire sub-watershed was estimated based on how much of the site will be treated and the treatment factor for the recommended BMP. For example, if 50% of the site can be treated with biocells (65% treatment factor), then assume treatment for the sub-watershed of 30-35%.

### Step 4- Calculate Existing Load and Load with Retrofit

- Estimated existing loading from each sub-watershed using Impervious Cover method<sup>1</sup>
- Estimated loading from each sub-watershed with recommended bmps in place
- Loading estimated for the following parameters: total phosphorus, TKN, TSS, Copper, lead, zinc (what was done with the Impervious Cover model).
- Loading estimated for retrofits for the following parameters: total phosphorus and metals.

<sup>1</sup> ENSR Corporation, "Pilot TMDL Applications using the Impervious Cover Method", Submitted to United States Environmental Protection Agency Region 1, October 2005.

## Appendix C: Penjajawoc Stream Prioritization, Impervious Cover, and Pollutant Load Information

### SUBWATERSHED LOADING

#	WBRC WS #	ENSR #	Area (SF) Total	Acre s- Total	SF- Imperv	Acre- Imperv	% IMP of sub- watershed	% IMP of total Wtsh	Priority *	Comments	Retrofit #	Rv-Runoff Volume Coefficient	R- Annual Runoff Volume	L-Annual Pollutant Load Tot-P (lbs)	A Po
63	2550	2550	3,238,020	74.3 3	2,527,351	58.02	78%	17%	High	Old BMPs, opportunity for retrofits, sand/salt uncovered	1	0.753	173.688	103.782	7
61	2513	2510	322,098	7.39	13,128	0.30	4%	<1%	Low	Part of mall	1	0.087	1.990	1.189	
69	2750	2550	255,567	5.87	39,806	0.91	16%	<1%	High	Part of mall	1	0.190	3.465	2.070	
16	500	500, 710, 700, 900	5,361,196	123. 08	1,367,784	31.40	26%	9%	High	Opportunity-will be expanding	2	0.280	106.855	63.848	4
26	1092	1090	530,228	12.1 7	412,934	9.48	78%	3%	High	No quantity control, no BMPs, no channel protection	3	0.751	28.381	16.958	1
25	1091	1091	432,426	9.93	260,778	5.99	60%	2%	High	Dry detention pond, no channel protection	3	0.593	18.271	10.917	
27	1093	1090	307,234	7.05	250,115	5.74	81%	2%	High	No controls	3	0.783	17.141	10.242	
7	310	310	418,537	9.61	354,744	8.14	85%	2%	High	No channel protection	4	0.813	24.250	14.490	
9	320	320	165,465	3.80	130,928	3.01	79%	1%	High	No detention, combine with other Quirk sites for retrofit & BMPs opportunity	4	0.762	8.989	5.371	
10	321	321	39,918	0.92	36,298	0.83	91%	<1%	High	New parcel, combine with other Quirk properties	4	0.868	2.471	1.476	



23	1040	1040	440,128	10.1 0	322,265	7.40	73%	2%	High	No channel protection, wet pond filled in, retrofit opportunity	5	0.709	22.243	13.291
22	1030	1030	226,190	5.19	112,340	2.58	50%	1%	High	Flood control only, pond needs maintenance	5	0.497	8.013	4.788
58	2510	2510	1,095,773	25.1 6	292,657	6.72	27%	2%	High	Receives runoff from mall, single largest outfall in WS, all of I-95 should be considered together, easy and cost-effective BMPs	6	0.290	22.680	13.552
21	1010	1010 400, 401,	446,116	10.2 4	134,155	3.08	30%	1%	High	Combine with other Freeway sub-watersheds	6	0.321	10.196	6.093
12	400	402	378,708	8.69	111,637	2.56	29%	1%	High	Combine with other Freeway sub-watersheds	6	0.315	8.512	5.086
19	800	800	283,144	6.50	87,623	2.01	31%	1%	High	Combine with other Freeway sub-watersheds	6	0.329	6.630	3.962
18	600	600	253,528	5.82	77,832	1.79	31%	1%	High	Combine with other Freeway sub-watersheds	6	0.326	5.897	3.523
55	2100	2100	216,448	4.97	59,885	1.37	28%	<1%	High	Combine with other Freeway sub-watersheds	6	0.299	4.613	2.756
62	2514	2550	140,630	3.23	13,577	0.31	10%	<1%	High	Combine with other Freeway sub-watersheds	6	0.137	1.372	0.820
59	2511	2511	401,156	9.21	268,753	6.17	67%	2%	High	No channel protection	7	0.653	18.671	11.156
4	110	110	659,829	15.1 5	266,270	6.11	40%	2%	High	MDOT Maintenance, hot spot, no BMPs, close to stream	8	0.413	19.434	11.612
53	1712	1100 5000 series,	522,935	12.0 0	177,626	4.08	34%	1%	High	Vacant, hotel going in, volume issue, opportunity for retrofits	9	0.356	13.259	7.923
	5000 series	1050, 1295	#####	394	171,632	3.94	1%	1%	High	5030 (Sam's), 5060, 5062, 5110 (Wal-Mart), 5130 (detention), 5170, Berlin City, new hotel (biocells)	10	0.059	72.181	43.130
30	1220	1220	199,735	4.59	153,361	3.52	77%	1%	High	Drains to Wendy outfall pipe (see below)	11	0.741	10.550	6.304
60	2512	2510	293,520	6.74	138,670	3.18	47%	1%	High	Part of 2510 sub-watershed	12	0.475	9.942	5.941
36	1291	1291	161,591	3.71	115,512	2.65	71%	1%	High	No treatment, hot spot	13	0.693	7.986	4.772
47	1413	1420	230,509	5.29	90,941	2.09	39%	1%	Med	No treatment, no high traffic turn around	13	0.405	6.656	3.977

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24	1090	1090	114,274	2.62	89,917	2.06	79%	1%	High	Part of K-Mart, drains to Wendy's pipe	14	0.758	6.176	3.690			
28	1200	1200	225,447	5.18	88,708	2.04	39%	1%	High	Goodyear tire, Pizza Hut, adjacent to stream, hot spot	15	0.404	6.494	3.881			
29	1210	1210	58,481	1.34	45,828	1.05	78%	<1%	High	Part of 1200 sub-watershed, hot spot	15	0.755	3.148	1.881			
15	412	410	238,609	5.48	85,124	1.95	36%	1%	High	Near Bangor Ford-Dodge, hot spot	16	0.371	6.311	3.771			
20	1000	1000	266,200	6.11	58,270	1.34	22%	<1%	High	Hot spot	17	0.247	4.687	2.801			
66	2720	2550	72,292	1.66	52,378	1.20	72%	<1%	High	No BMPs, part of mall?	17a	0.702	3.618	2.162			
67	2730	2550	49,064	1.13	41,579	0.95	85%	<1%	High	Part of mall	17a	0.813	2.842	1.698			
41	1297	1090	58,523	1.34	36,491	0.84	62%	<1%	High	Quick's oil change, hot spots	18	0.611	2.550	1.523			
13	410	410	282,912	6.49	241,494	5.54	85%	2%	High-Med	No channel protection, volume issue, car dealer not a hot spot	19	0.818	16.501	9.860			
17	520	520	1,240,020	28.4	380,348	8.73	31%	3%	High-Med	No BMPs, flows directly to lower part of stream	20	0.326	28.820	17.220			
													<b>Total</b>			<b>427.515</b>	<b>29</b>



## Appendix D: Penjajawoc Stream Retrofit Recommendations

(Recommendations for High Priority Sites in WBRC Report)

Art Morgan, Wendy Warren, Jeff Dennis, Mary Ellen Dennis  
October 25, 2007 and continued on October 31, 2007  
(Updated 11/28/07- treatment assumptions)

The following are preliminary recommendations for potential retrofits to the high priority sites identified in the WBRC Penjajawoc BMP Retrofit Design Project Report as developed by staff of the City and the Maine Department of Environmental Protection. These recommendations are subject to additional information and analysis in accordance with the adaptive management approach and modifications as detailed designs are developed for and adjusted to specific sites.

1. Sub watersheds #2550, #2513, and #2750
  - Minimum recommendations include:
    - a. Retrofit ponds for 1" or 2 yr. storm to provide for channel protection
      - Include underdrain outlets to increase base flow and decrease temperature
    - b. Maintain and if needed stabilize maintenance area
      - At maintenance area define high use areas and treat with bio-cell
    - c. Sweep parking lot twice/month
  - Optimum recommendations include:
    - a. Maximize pond storage volume
    - b. Tree box filters
      - Note that bio-retention cells, or Filtera, are likely not feasible due to high groundwater

### Treatment:

- a. Entire sub-watershed drains to ponds so can get treatment on entire site
- b. If can get tree box filters in and maximize pond volume, then can get 45% reduction
  - 50% reduction based on ponds and street sweeping
  - Shallow tree box filters may be possible, but not counting on for 50% reduction

2. Sub watershed #500
  - a. - Retrofit existing pond to provide storage and slow release for smaller storms (i.e. channel protection)
    - Make pond more efficient by increasing length to width ratio
    - Design similar to Maine Mall pond -1 pond to 2 pond system
  - b. BMPs upstream such as rain gardens or bio-cells
  - c. Improve housekeeping (e.g. street sweeping)
  - d. There are a number of parking lots and likely poorly maintained cars using them
    - Put in oil/water separators
  - e. Revegetate haul road for construction?

### Treatment:

- a. Assume that pond treats most of sub-watershed based on map and drainage
- b. If just do pond, then assume treatment of 45-50%
  - If can do more, then increase to 55% treatment (pond cannot be made much bigger)
  - Opportunity for rain gardens or biocells-provide additional treatment on 25% of site

3. Sub-watersheds #1092 , #1091, and #1093

- Volume and flood control; temperature, nutrients, conductivity and metals high
- These 3 sub-watersheds will be toughest to address, but from priority perspective are very important and should be addressed early
- Three storm drain pipes here—Hogan Road corridor, K-Mart parking, & between McDonald's and Maine Square Mall
- Possibly one storage area to attenuate sub-watersheds 1091 & 1093
  - a. - Islands in large untreated parking lot with tree box filters/bioretenion
  - b. Hogan Road
    - Bio-retention cell along with housekeeping
  - c. - High traffic small area -Tree box filtration, Filtera-on-line high flow filter
  - d. - High traffic larger area – High volume and nutrient removal- biocells
  - e. - Change the outlet structure of existing dry pond, if possible. It may not be big enough to retrofit to wet pond.
    - Housekeeping and Oil/water separators

Treatment:

- a. Sub-watershed #1091
  - Assume treatment on <50% of sub-watershed
  - No treatment on Hogan Road
  - Treatment factor at best of 65% on <50% of watershed
  - Overall treatment of 25% on entire sub-watershed
- b. Sub-watershed #1092
  - Treatment of 45% on entire sub-watershed
- c. Sub-watershed #1093
  - Conservative treatment based on realistically not being able to do much
  - Can treat small high traffic area, but may be hard to lose space for treatment
  - Overall 20% treatment on entire sub-watershed

4. Sub-watersheds #310, #320, and #321

- There are two ponds that provide flood protection and treat small portions of the sub-watersheds
  - a. Retrofit ponds to provide channel protection and cooling
    - Alter storm drain system to put flow into pond (stream protection to unattenuated areas)
    - Separate roof runoff?
    - May want to let 10 & 25 year storms go
  - b. Sub-watershed #321 may be able to sheet flow to buffer
  - c. How is car washing done- is it going to storm drain (treatment plant)?
    - May be able to let water go through vegetated buffer at back of lot
  - d. Housekeeping and oil/water separators

Treatment:

- a. Sub-watershed #310
  - Put level spreader where pond discharge is (big watershed for small area)
  - Assume 15% treatment
- b. Sub-watershed #320
  - Put sub-watershed #320 into #321 pond-no additional treatment in pond
  - Good housekeeping

- Assume 5-10% treatment
- c. Sub-watershed #321
  - Buffer treatment-assume 50% treatment for entire sub-watershed

5. Sub watershed #1040 and #1030
- These sub-watersheds drain to large wet pond
  - More important to get channel protection than permanent pool
    - a. Clean out and maintain wet pond
      - Adjust outlet structure for 2 and 10 year storms
    - b. Housekeeping-sweeping
    - c. Bio-retention cells at Toys R Us, Hampton Inn and 99 restaurant
    - d. Roof drainage to rain garden

Treatment:

- If can do all recommendations, then can get 55% treatment for entire site

6. Sub watersheds #400, #600, #800, #1010, #2100, #2510, and #2514
- a. See WBRC recommendations for berm, under drain median and ditch line
  - b. Talk to DOT about salting practices

Treatment:

- Can get at least 25% treatment and should be able to get 40%
- Realistically, use 30% treatment

7. Sub watershed #2511
- Standard flood control pond exists
    - a. Retrofit pond for channel protection and temperature
    - b. Part of parking lot may be able to be sheet flow to buffer
      - Soil imprinter may be way to increase infiltration
    - c. Bioretention cell may be possible, but would mean rearranging the parking lot
    - d. Housekeeping

Treatment:

- For bio-retention cells-can get 40% treatment
- If do not do bio-retention, then 25%
- Sub-watershed into buffer-30% treatment
- All recommendations implemented-then use 45% treatment

8. Sub watershed #110
- a. Concentrated flow to level spreaders and buffers
    - This will need to be checked on the ground-slope gradual enough for buffer
  - b. Flow splitter-low flows to level spreader along contour
  - c. Housekeeping

Treatment:

- Avoid biocells because the site is mostly gravel
- Check with Art regarding whether buffers will work there

9. Sub watershed #1712
- This is presently an abandoned manufacturing plant-likely to be redeveloped at some point

- Lots of opportunity to do bioretention cells and buffers

Treatment:

- If site gets re-developed-then can get good treatment
- Site is not currently exporting much
- If re-developed-then can get 60% treatment

10. 5000 series sub watersheds

- Much going on in this watershed as new development and redevelopment happening so should be opportunities to do retrofits and additional treatment
- Channel protection is very important here
- Make stormwater systems meet 100% Current General Standards or as close as practicable.
- Need channel protection quality treatment and flood control.
- Retrofit existing ponds, add biocells, buffer enhancement along stream.
- Improve existing wet pond system.

Treatment:

- All sites will be required to meet new standards when re-developed
- Existing developments could do bio-retention cells (parking lot to bio-retention)
- 50% removal for existing developments with retrofits
- Net removal for whole sub-watershed of 45%

11. Sub watershed #1220

- Channel Protection & Quality treatment needed.
- Install Wet Pond(?), biocell in existing parking lot (with under drain filter system).

Treatment:

- Biocell-front end sheets down to south
- North end drains the other way and missing roof
- Treatment of 50% for entire site

12. Sub watershed #2512

- Work with DOT as drainage goes to drainage ditch

Treatment:

- May be able to do bio-retention cells, although may be in DOT right of way
- Should be able to do all of site, except for access road which may be buffered
- Assume 50% treatment on entire site (assumes bio-cell treatment only)

13. Sub watershed #1413 & #1291

- High volume, small area - curb cuts to 4x8 Tree Filters (Filtera) 1 per ¼ acre (per manufacturer recommendations). Alternative is catch basin with oil & grit separator
- Add biocell or pond to existing untreated parking lot.

Treatment:

a. #1413

- Assume 50% of site may be treated-room in back for bio-cells
- 35% treatment for the entire sub-watershed

b. #1291

- Storm Treat for half of site
- Assume 30% treatment for sub-watershed

14. Sub watershed #1090

- Bioretention cell, underground storage or stormtreat, good housekeeping

Treatment:

- May not be enough head for underground storage or Storm Treat
- Can treat a large part of the parking lot-assume 35% treatment for entire site

15. Stream bank #1200 and #1210

- Stormtreat, Filtera tree filters, underground storage
- Roadway – bio-retention cell

Treatment:

a. Sub-watershed #1200

- Not much opportunity as a steep drop- ff to stream limits opportunities
- Can pick up some of the road here
- 1/4 of the site can be treated- assume 30% treatment for entire sub-watershed

b. Sub-watershed #1210

- Some of road can go into bio-retention cell
- Assume 50% treatment for entire sub-watershed

16. Sub watershed #412 –

- Ditch turn out, bio-retention cell to wet land.

Treatment:

- Should be able to treat half of site-assume 25% treatment for entire sub-watershed

17. Sub watershed #1000 –

- Curb parking lot & divert to bio-retention cell
- Better housekeeping

Treatment:

- Can get most of site treated-assume 50% treatment for site

18. Sub watershed #2720 & # 2730 –

- Rear of building, eliminate some paving – put in storage pond or bio retention cell(s)
- Front of building, remove berm and install bio-retention cells along low area along Stillwater Ave.
- Large tree box filter at where catch basin drains to Stillwater

Treatment:

- Bio-retention or Storm Treat- do what ever works at site
- Assume 40% treatment for both sub-watersheds

19. Sub watershed # 1297 –

- Filtera Tree box Filters (Look at site plan)



Treatment:

- Can not do much here- may be able to install tree box filter for part of site
- 25% treatment at best for entire sub-watershed

20. Sub watershed # 410 -

- Bio cell off Haskell Rd, Dry Swale off Hogan Rd., Underground Storage

Treatment:

- Pick up ½ of site on undersized bio-cells
- 25% treatment on entire site

21. Sub watershed #520

- bio-retention cell

Treatment:

- Should be able to treat most of site
- Assume 50% treatment for entire sub-watershed

Additional Notes:

1. All sites should have snow storage areas and management plans
2. For car washes- suggest tank (reservoir) to collect rain water for use in gray water applications (i.e., irrigation, car washing, etc.)
3. Many businesses doing away with sanding and going with straight salt treatments. How much of a problem is chloride and how we deal with this?

**Appendix E: Penjajawoc Stream Retrofit Estimated Costs**

Penjajawoc Stream Watershed Recommended Retrofits for High Priority Sites  
 Date: November 9, 2007

	Total Area	Impervious Area	Cost	Cost/ Acre Impv.
1.) Sub watersheds 2550, 2513	81.72	58.32		
a. Modify Pond ( Channel Protection)			\$100,000.00	
b. Maintenance Area Stabilize and Bio-cell			\$ 30,000.00	
c. Sweep Parking Lot 2Xmonth (Sweeper \$100,000.00)			\$160,000.00	
d. Install Under drain System			\$250,000.00	
Total Cost/Sub-area			<u>\$540,000.00</u>	\$9,259.26
2.) Sub watersheds 500, 700, 900	123.08	31.4		
a. Modify Pond ( Channel Protection)			\$ 75,000.00	
b. Rain Garden, Bio-Cell, Filters			\$100,000.00	
c. Sweep Parking Lot 2X month (Sweeper \$100,000.00)			\$124,000.00	
d. Oil-Water Separators			\$ 40,000.00	
e. Revegetate			\$ 5,000.00	
Total Cost/ Sub-area			<u>\$344,000.00</u>	\$ 10,955.41
3.) Sub watersheds 1090, 1091, 1092, 1093	31.77	23		
a. Pond adjacent to #1092			\$100,000.00	
b. #1092 parking lot improvement			\$100,000.00	
c. #1093			\$ 24,000.00	
d. #1091			\$ 36,000.00	
e. #1093			\$ 36,000.00	
f. #1091 Pond			\$ 36,000.00	
g. Sweeping 2X month			\$ 30,000.00	
h. Hogan Road			\$ 60,000.00	
j. Behind #1092, etc.			\$ 50,000.00	
Total Cost/Sub-Area			<u>\$472,000.00</u>	\$ 20,521.74
4.) Sub watersheds 310, 320, 321	14.33	11.98		
Retrofit Existing Pond			\$ 60,000.00	
Alter SD System ( to Pond)			\$100,000.00	
Separate Roof Runoff			\$ 30,000.00	
			<u>\$190,000.00</u>	

				\$ 15,859.77
	OR			
	Retrofit Existing Pond		\$ 60,000.00	
	Buffer yard Development		\$ 10,000.00	
	oil-waterseparator		\$ 10,000.00	
	Total Cost/ Sub-Area		<u>\$ 80,000.00</u>	
				\$ 6,677.80
5.)	Sub watersheds 1030, 1040	15.29	9.98	
	Cleanout & Maintain Pond		\$ 60,000.00	
	Retrofit POND Outlet		\$ 60,000.00	
	Bio-Cell Hampton Inn		\$ 30,000.00	
	Sweep 2X Month		\$108,000.00	
			<u>\$258,000.00</u>	
				\$ 25,851.70
6.)	Freeway Subwatersheds 400, 600, 800, 1010, 2100, 2510, 2514	55.92	15.28	
	Berm, underdrain, median and ditch line work		\$600,000.00	
				\$ 39,267.02
7.)	Sub watershed 2511	9.21	6.17	
	Retrofit Existing Pond		\$ 50,000.00	
	Develop Hydraulic Buffer Yard		\$ 10,000.00	
	Soil Imprinting - increase Infiltration		\$5,000	
	Bioretention cell		\$ 60,000.00	
	Sweep 2X Month		\$ 55,000.00	
			<u>\$180,000.00</u>	
				\$ 29,173.42
8.)	Sub watershed 110	15.15	6.11	
	Level Lip Spreader & Buffer		\$ 60,000.00	
	Housekeeping		\$ 30,000.00	
			<u>\$ 90,000.00</u>	
				\$ 14,729.95
9.)	Sub watershed 1712	12	4.08	
	This Site has a great potential to be Re-Develo[ped]. The City will need to see that modern BMP's are required.		\$ 67,200.00	
				\$ 8,000.00
10.)	Sub watershed 5000 series	394	3.94	

				\$500,000.00	\$126,903.55
	This area has a great potential to be Re-Developed. The City will need to see that modern BMP's are required.				
11.)	Sub watershed 1220	4.59	3.59		
	Bioretention Cells			\$ 60,000.00	
	Sweep 2X Month			\$102,900.00	
				<hr/>	
				\$162,900.00	\$ 45,376.04
12.)	Sub watershed 1291, 1413	3.71	2.65		
	Tree Box Filter &			\$ 63,600.00	
	Oil & Grit Separator			\$ 15,000.00	
	Hotel Bioretention Cell				
				<hr/>	
				\$ 78,600.00	\$ 29,660.38
13.)	Sub watershed 1090	2.62	2.06		
	Bioretention Cells			\$ 50,000.00	
	Storm Treats & Under Ground Storage			\$100,000.00	
	Tree Filter Box			\$ 50,000.00	
				<hr/>	
				\$200,000.00	\$ 97,087.38
14.)	Sub watershed 1200	5.18	2.04		
	Roadway Bioretention Cell			\$ 50,000.00	
	Tree Filter Box			\$ 50,000.00	
				<hr/>	
				\$100,000.00	\$ 49,019.61
15.)	Sub watershed 412	5.48	1.95		
	Ditch turnout			\$ 10,000.00	
	Bioretention Cell or wetland			\$ 30,000.00	
				<hr/>	
				\$ 40,000.00	\$ 20,512.82
16.)	Sub watershed 1000	6.11	1.34		
	Curb Parking Lot & Divert to Bioretention Cell			\$ 50,000.00	\$ 37,313.43
17.)	Sub watershed 2720, 2730	2.97	2.15		
	Shoe Center				

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	Bioretention Cell Stillwater			\$ 30,000.00	
	Tree Filter Box			\$ 10,000.00	
	Remove Pavement & replace with pond or Porus Pavement			\$ 60,000.00	
	Sweep 2X Month			\$ 52,000.00	
				<hr/>	
				\$152,000.00	\$ 70,697.68
18.)	Sub watershed 1297 Filtera Tree Filter Box	1.34	0.84	\$ 20,160.00	\$ 24,000.00
19.)	Sub watershed 410 Bioretention Cell off Haskell Rd Dry Swale Off Hogan Underground Storage	6.49	5.54	\$130,000.00	\$ 23,465.70
20.)	Sub watershed 520 Bioretention cells	28.47	8.73	\$210,000.00	\$ 24,054.98

## **Appendix F: Penjajawoc Stream Team Monitoring Regime & Equipment List**

Six sets of equipment are needed for 6 monitoring teams to monitor 1 x month, (Jun – Oct). Teams will monitor for turbidity, bacteria, temperature, conductivity, and dissolved oxygen. Nutrients will be monitored at only 4 sites. DEP and/or City will monitor during storm events, and DEP will conduct pH testing. The following equipment & supplies and analysis will be required for sampling:

- 1) Turbidity: Samples taken with sterile, clear, capped bottles will be brought to DEP lab where turbidity will be measured with a hand-held meter.
  - > 6 teams x 5 months = 30 bottles
  - > 8 oz. wide mouth clear bottles – 24 @ \$19.10 = \$40.00
  - > **Annual Cost Supplies = \$40.00**
  - > **DEP match - time to analyze and record data**
  - = 8 x 4 x \$75 = \$2400**
  
- 2) E coli: Six sites x 3 storm events. Samples must be taken using sterile sample baggies (**DEP to provide sampling baggies**). These must be stored on ice, in a cooler and must be delivered to DEP offices to be processed at DEP lab free of charge.
  - > **DEP match of \$12/sample + time to analyze & record data**
  - = \$85.00/sample x 6 sites x 3 = \$1530**
  
- 3) DO: Kits are \$50 each (BM pg. 437 – 4JE-100836); we need 6 kits (DEP provided kits to 2 teams already)
  - > 2 kits @ \$52.00 each = provided by **DEP (Match of \$104)**
  - > 4 kits @ \$52.00 each = **One time expense of \$208.00**
  
- 4) Hanna combo pH/Temp/Conductivity meter for 2 sites (Cemetery Brook and Jo-ann's): = \$144.00 each (BM pg 474 4-JE-89306), plus 4 conductivity meters at \$62.60 ea
  - > 4 Conductivity meters @ \$62.60 + 2 Hanna Combos @ \$144.00
  - = One time expense of \$538.40 (possible DEP match)**
  - Alternatively – 6 Conductivity: Testers (BM pg.461 – 4JE-78242 )
  - > 6 meters @ \$62.60 = One time expense of \$375.60
  
- 5) Temperature/Depth (Flow): 2 - 3 continuous loggers for Cemetery Brook, Jo-ann's, and Meadow Brook. \*City owns 4 temp/depth data loggers. Three are currently installed and recording in Birch Stream which began in 2006. 1 is not in use. The City also owns a PDA used to download data from the loggers. The price of an additional logger would be \$800 totaling \$1300 - \$1500 to purchase, install, calibrate, and generate the stream profile (in order to calculate velocity/flow). Alternatively, one logger could be removed from Birch and brought over to Penjajawoc to use with the logger that is currently not in use.
  - > 1 additional Data Logger purchased (1500) + install existing logger (800)
  - = One time expense of approx. \$2300/site**
  - > Alternatively – use the one remaining logger and add others from Birch when available.
  - Set up fee to install existing logger = \$800
  - > 6 Thermometers @ \$12.00ea = **One time expense of \$72.00**

- 6) pH: Only necessary at Jo-ann's (departure from Marsh) DEP (Mark Whiting) will conduct pH sampling  
> **DEP match of time = 5 events x \$75/hr = \$375.00**
  
- 7) Nutrients: nitrates and phosphorus: \$40/sample at Mitchell Center Lab; Need 3 samples per year at times of low flow at 4 sites CB-1, MB-1, PJS-1, PJS2. Samples must be refrigerated and delivered to DEP for transport to Mitchell Center Lab.  
> 3 samples x 4 sites x \$40.00 ea = **Annual expense of \$480.00**
  
- 8) Metals: during high flow; 3/yr x 4 sites;  
> 3 samples x 4 x \$150 = **Annual expense of \$1800.00**
  
- 9) Automatic Stormwater Samplers for high flow sampling – 6 needed: \$75 each (BM pg. 414; 4JE-111379 sampler & 4JE-111380 mounting kit);  
> 6 kits @ \$75 each = **One time expense of \$450.00**
  
- 10) Cation/anion sampling: 3 downstream sites, 3 times per year – Wherever conductivity is high – to determine what the cause of the conductivity is.  
> up to **\$1000/yr possible annual expense**
  
- 12) Other Equipment  
> Orange Safety Reflective vests - volunteers provide our own? (donation to students?)  
> Telescoping paint stick, volunteers make our own?

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TOTAL ONE TIME EXPENSE FOR EQUIPMENT - \$3496.40  
DEP may be able to match some funds (\$1000?)

TOTAL ONE TIME EXPENSE USING ALTERNATIVE - \$1905.60

TOTAL ANNUAL COST FOR SAMPLING - \$2200 - \$3320  
Alternative is bi-annual testing of metals, cations totaling  
Alternative = \$400/year  
TOTAL ONE TIME DEP MATCH FUNDS – Kits + Equip = \$604  
TOTAL ANNUAL DEP MATCHING FUNDS – In kind = \$4305

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**Notes:**

\*\* The City (Airport) owns a Water/Oil level indicator – perhaps this could be used in a test well area to measure how much oil we are getting off of large parking areas?