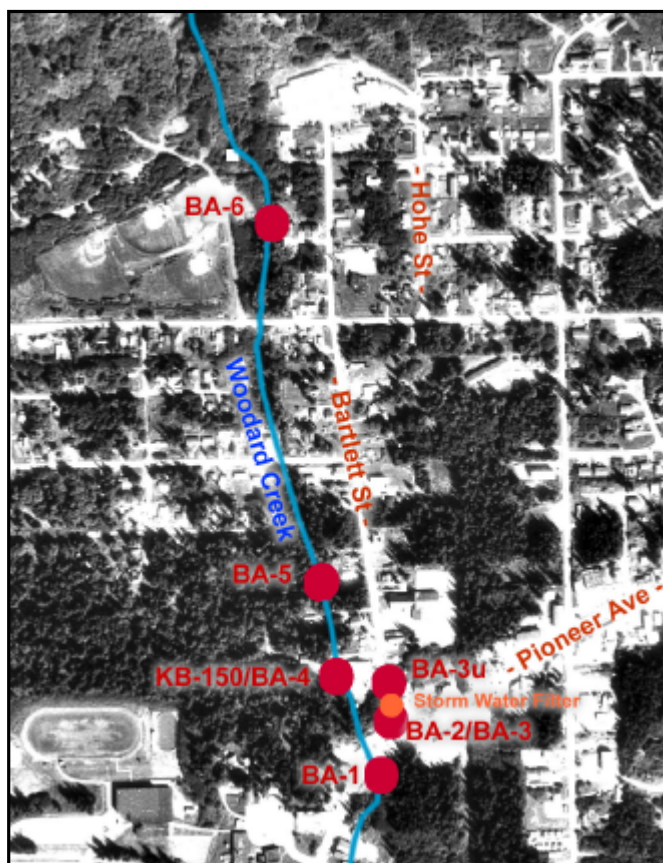
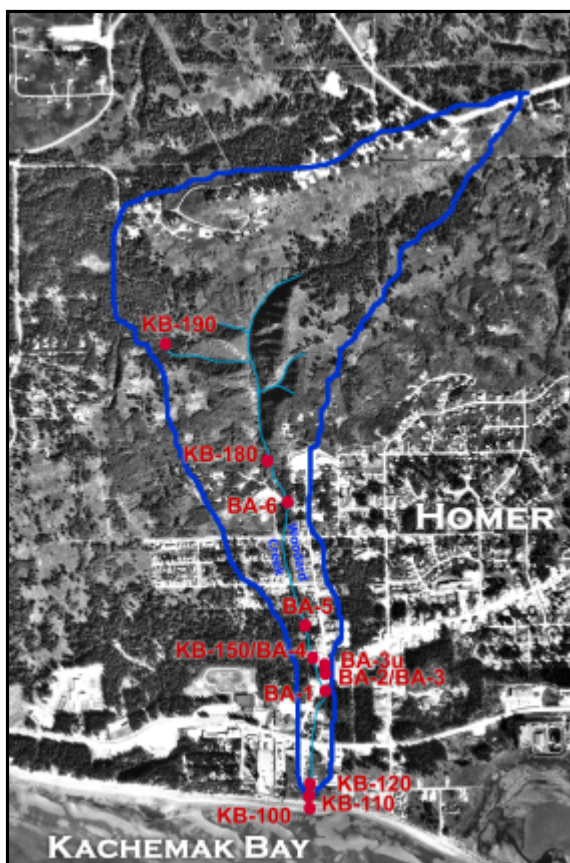


# Bartlett/Hohe Rehabilitation Project Water Quality Monitoring Report



May 2007

Prepared by  
Joel Cooper  
for

Cook Inletkeeper

Homer Soil & Water Conservation District,  
Alaska Department of Transportation and Public Facilities, and  
Zubeck Inc. General Contracting



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Cover Photos: Left – Woodard Creek Watershed in downtown Homer Alaska.  
Right– Bartlett/Hohe Construction zone and monitoring sites.

# Acknowledgements

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## INTRODUCTION

### Bartlett/Hohe Street Rehabilitation

In the spring of 2005, Homer residents saw work begin on the Bartlett/Hohe Street Rehabilitation Project. The project was completed in June 2006. The Alaska Department of Transportation and Public Facilities (ADOTPF) and Zubeck Inc. General Contracting were charged with carrying out the work. This federally funded project involved Bartlett Street from Pioneer Avenue to South Peninsula Hospital and Hohe Street reconstructed from Fairview Avenue to South Peninsula Hospital. The project included installation of water lines, sewer services, culverts, sidewalks, and a storm water filter in the Bartlett Street stormwater drainage system (ADOTPF September 2004).



**Bartlett Street on April 12, 2005. Photo Courtesy of ADOTPF**

According to ADOTPF, the project started in the early 90's and went through several project managers and designers. During this process, designers considered various pretreatment facilities that would minimize impacts from stormwater discharge. In the end, a Stormwater Management® StormFilter was installed to filter stormwater discharged into Woodard Creek. Currently the Stormwater filter installed in the Bartlett Street stormwater drainage system is only the second in the state, the other being at the Kenai River Bridge in Soldotna, Alaska (ADOTPF 2006).

In order to get an initial assessment of how well the stormwater filter works in a first flush situation, as well as to monitor erosion control best management practices used to mitigate the impacts of stormwater runoff, ADOTPF and Zubeck Inc. teamed up with the Homer Soil and Water Conservation District and Cook Inletkeeper to monitor the construction project. Cook Inletkeeper completed a Quality Assurance Project Plan for the Bartlett/Hohe Monitoring Project that was approved by the U. S. Environmental Protection Agency and the Alaska Department of Environmental Conservation. The project plan outlined appropriate methodology, data collection, and data management procedures to meet project needs.

The main goal for the Bartlett/Hohe Monitoring Project was to collect water quality data to better understand the effects of road construction on Woodard Creek and the effectiveness of best management practices (BMPs) used to reduce the environmental impacts. Monitored parameters included discharge, turbidity, temperature, pH, and conductivity, which are all important in evaluating the effects of road construction on water quality. Field inspection of BMPs and photo documentation of construction and BMPs was also conducted. In addition metals, hydrocarbons

and solids were analyzed to determine the effectiveness of the stormwater filter being installed in the Bartlett drainage system.

This report provides a summary of the monitoring results and compares some of these results to data collected by Inletkeeper's Kachemak Bay Citizens' Environmental Monitoring Program (KBCEMP) prior to the project's start. In addition it provides some background information on stormwater, Woodard Creek, the Stormwater Management® StormFilter, KBCEMP, and the East End Road Monitoring Project. It concludes with recommendations for future monitoring and stormwater management for the Kachemak Bay area.

## **Stormwater**

There have been many studies conducted that provide information showing stormwater is a problem that needs to be monitored and managed properly. Compiled below are some important findings from these studies.

- Stormwater runoff from lands modified by human activities can harm surface water resources and, in turn, cause or contribute to an exceedance of water quality standards. Stormwater runoff can change natural hydrologic patterns, accelerate stream flows, destroy aquatic habitat, and elevate pollutant concentrations and loadings. After a rain, stormwater runoff can carry these pollutants into nearby streams, rivers, lakes, estuaries, wetlands, and oceans. The highest concentrations of these contaminants often are contained in "first flush" discharges, which occur during the first major storm after an extended dry period (EPA 1992).
- The U.S. Environmental Protection Agency estimates that at least 50 percent of our nation's water pollution is caused by stormwater runoff. Stormwater runoff from urban areas and construction sites can include a variety of pollutants, such as sediment, bacteria, organic nutrients, hydrocarbons, zinc, copper, cadmium, mercury, iron, nickel, oil, and grease (EPA 1999).
- Stream quality begins to decline when impervious surfaces cover just 10 percent of a watershed (EPA February 2006). An urbanization study conducted by the U.S. Geological Survey in five watersheds in Anchorage, Alaska found much lower threshold responses at 4.4 –5.8% impervious cover (Ourso and Frenzel, 2003).
- Improperly managed stormwater runoff is also a leading cause of flooding, which can lead to property damage, cause road safety hazards, and clog catch basins and culverts with sediment and debris (EPA February 2006).
- Unlike pollution from industry or sewage treatment facilities, which is caused by a discrete number of sources, stormwater pollution is caused by the daily activities of people everywhere. Rainwater and snowmelt runoff from streets, lawns, farms, and construction and industrial sites pick up fertilizers, dirt, pesticides, oil and grease, and many other pollutants on the way to our rivers, lakes, and coastal waters. Stormwater runoff is our most common cause of water pollution. Because stormwater pollution is caused by so many different activities, traditional regulatory controls will only go so far. Education and outreach are key components to any successful stormwater program (EPA August 2006).

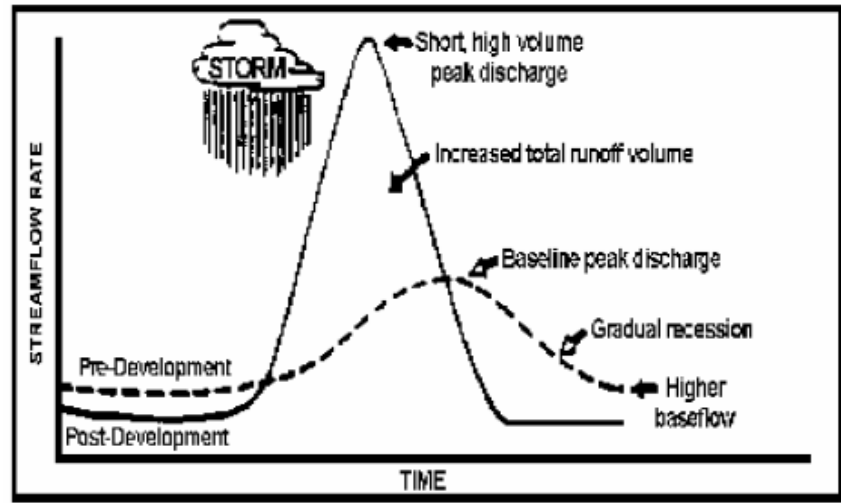


EPA provides an excellent summary of adverse impacts associated with urban runoff (Table 1).

**Table 1: Adverse Impacts Associated with Urban Runoff (EPA 1999)**

| Resource/<br>Water Use                             | Concern                                 | Potential Negative Impact on<br>Resource/Water Use  | Cause  |
|--|---|---|--|
| Ground Water                                       | Lower dry-season reserves               | Lower dry-season base flow in water courses<br>Lower drinking-water reserves  | Increased impervious catchment surface area                                    |
| Aquatic Habitat                                    | Erosion                                 | Physical destruction of habitat   | Peak discharge, high runoff volume   |
|  | Fluctuating water levels and velocities | Altered thermal and mixing characteristics<br>Reduced habitat diversity<br>Erosion  | High peak discharges and runoff volumes<br>Low dry-season groundwater reserves |
|  | Low dry-season base flow                | Elimination of spawning beds<br>Reduced habitat<br>Reduced dilution capacity  | Low dry-season groundwater reserves  |
|  | Sedimentation                           | Smothering of bottom communities and spawning beds<br>Filling of storm water impoundments<br>Transport of particulate-associated pollutants       | Erosion<br>Suspended solids  |
|  | Turbidity                               | Lower dissolved oxygen, reduced prey capture, clogging of fish gills  | Suspended solids   |
|  | Low dissolved oxygen                    | Lethal and nonlethal stress to aquatic organisms  | Biodegradable organic material   |
|  | Metals, organic contaminants, chlorides | Lethal and nonlethal stress to fish and other aquatic organisms in water column and bottom sediments  | Urban pollution  |
|  | Increased water temperature             | Lethal and nonlethal stress to sensitive cold water aquatic organisms   | Biodegradable organic material   |
|  | Bacteria                                | Diseases of aquatic organisms<br>Shellfish contamination  | Fecal contamination  |
|  | Eutrophication                          | Algae blooms and nuisance aquatic plant growth<br>Low dissolved oxygen<br>Odors   | Nutrient enrichment  |
| Public Water Supply                                | Lower dry-season reserves               | Reduced water supply  | Lower dry season groundwater reserves  |
| Wildlife Habitat                                   | Flooding and erosion                    | Physical destruction of environment<br>Dewatering and flooding of key habitat areas at critical times<br>Reduction in streambank cover vegetation | High peak discharges and runoff volumes<br>Sedimentation                       |
| Recreation and Aesthetics                          | Nature enjoyment                        | See Aquatic Habitat and Wildlife Habitat under the Resource/Water Use column  | See Aquatic Habitat and Wildlife Habitat                                       |
| Agricultural, Residential, and Industrial Land Use | Flooding and erosion                    | Public safety<br>Damage to crops and farmland<br>Damage to buildings and contents<br>Reduction of useable land area                               | High peak discharges and runoff volumes<br>Sedimentation                       |

Understanding the impacts of first flush discharges from the Bartlett Stormwater system was part of this monitoring project. This system discharges into Woodard Creek which in turn flows into Kachemak Bay. In the summer 2002, Cook Inletkeeper Intern Tracy Parsons analyzed the Woodard Creek watershed for percent impervious cover and estimated it to be 11.11% (Banks 2003). And in Laura Ballock's 2004 master's design thesis, impervious cover was estimated at 15% (Ballock 2004). Both of these figures exceed the percent of impervious cover found to be detrimental to water quality and stream health.



**Impacts of urbanization on stream flow. (EPA 2000)**

Woodard Creek has also experienced flooding in recent years. In October and November 2002, the lower Kenai Peninsula experienced flood events not seen in the last 50-100 years. Channel scour, bank erosion, and major habitat alteration reshaped stream channels and riparian habitat (Mauger 2004). In the lower course of Woodard Creek alone, there are at least eleven crossings that employ culverts and many blew out, and Woodard Creek flowed over roadways during the floods (Ballock 2004). The uppermost crossing at Fairview Avenue was rebuilt, costing taxpayers well over \$100,000 dollars (Anderson 2004).

### **Woodard Creek and Kachemak Bay**

The following is an excellent description of Woodard Creek and was written by Dr. Deland Anderson for the Pratt Museum in conjunction with a community conversation in May 2004.

*“Woodard Creek, bearing the name of some of the first settlers to the Homer area, flows only about two miles in its entire length. It drops close to 1000 feet in elevation, and passes through the heart of Homer. The land it cuts through is fragile, consisting of clay and sandstone bluffs in its upper reaches and a boggy alluvial plain in its lower half. Its course begins atop the rolling and fractured bluff above the city of Homer. These headwaters are the site of much recent residential development. The area affords stunning views and is easily accessible both from East Hill and West Hill roads, major arteries leading to the outskirts of town. As the creek trickles toward the sea, its waters gather in the short but dramatic Woodard Canyon, a largely undeveloped ravine some 300 feet deep. In its lower course, Woodard Creek passes through a heavily developed residential area with homes and businesses built on, if not in, the creek bed. Next it passes underneath the Pratt Museum’s parking lot. It emerges from time to time below that, but is often routed underground through Homer’s commercial district. After passing under the Sterling Highway, it flows through a trench for a few hundred yards, finally debouching onto*

*the gravelly beach. Woodard Creek is part creek, part ditch, part pipeline. As a creek, it's not much. Its water is not very good for drinking. Its flow rate is low, except during heavy rains (when it is terrific). Its banks are generally hidden beneath heavy undergrowth of alder, elderberry, and devil's club. Its bed is silted and scattered with coal and burnt clays (Anderson 2004)".*

Finally, Woodard Creek is one of the many small streams that empty into the estuary of Kachemak Bay. In 1999, Kachemak Bay was designated as part of the National Estuarine Research Reserve system and is one of the most productive, diverse, and intensively used estuaries in Alaska. The natural beauty and recreational opportunities of the Bay attract both residents and thousands of summer tourists. Sportfishing is by far the most popular recreational



**Woodard Creek at the Pratt Museum**

activity in the Kachemak Bay Watershed. Each year anglers come to Kachemak Bay to try their luck at halibut and salmon fishing. Homer proclaims itself as the "halibut capital of the world." And for decades, commercial fishing has been the economic mainstay for residents of Kachemak Bay (KBRR 2006).

In the Alaska's 2004 Integrated and Water Quality Monitoring Report, Woodard Creek was listed as Category 3 Waterbody – waters for which there are insufficient or no data and information to determine if any designated use is attained (ADEC 2006).

## **Road Construction Monitoring**

In the summer of 2004, a unique monitoring partnership began which now stands as a model for how agencies and private contractors can work with citizen groups to monitor public waterways and promote best management practices that protect water quality in our local streams. The Homer Soil and Water Conservation District (HSWCD), Cook Inletkeeper, ADOTPF, and Quality Asphalt Paving collaborated to monitor streams along portions of the East End Road construction project in Homer, Alaska. These collaborating efforts continued when HSWCD, DOT and Zubeck Inc. contracted with Inletkeeper to monitor Woodard Creek and the stormwater drainage system installed in the Bartlett Street construction project.

## **Citizen Monitoring**

In 1996, Cook Inletkeeper established the Kachemak Bay Citizens' Environmental Monitoring Program (KBCEMP) to actively involve citizens in collecting reliable water quality data in the Kachemak Bay and Anchor River Watersheds. KBCEMP also serves as a working template that has been adopted by other groups interested in conducting citizen-based monitoring programs.

The objectives of Citizens' Environmental Monitoring Program (CEMP) are to:

- inventory baseline water quality in the waters of Cook Inlet Basin;
- detect and report significant changes and track water quality trends;
- raise public awareness of the importance of water quality through hands-on involvement (Harrald 2006).

Woodard Creek has been monitored since CEMP's inception. In 2005 five volunteers monitored three different sites in the Woodard Creek watershed for a total of 18 observations (Harrald 2006). Many of the parameters measured by Inletkeeper staff for the Bartlett Street Project were also measured by CEMP volunteers. This existing CEMP data set is useful for comparison purposes.

### **STORMWATER POLLUTION PREVENTION PLAN**

A Stormwater Pollution Prevention Plan (SWPPP) is a document that describes the nature and extent of a construction activity and the measures that are used to ensure that sediment and other pollutants are not carried into the storm water discharges from the construction site. To control these pollutants, the contractor can use a variety of measures, referred to as Best Management Practices, or BMPs. The BMPs form the basis of the SWPPP, and the contractor must select them based on the conditions at the construction location. For a SWPPP to be effective, the contractor must properly design, construct, and maintain the BMPs during the life of the project. (ADOTPF June 2004). The department and contractor's Notice of Intent (NOI) was submitted on 2/25/05 and became effective on 3/4/05. The Notice of Termination (NOT) became effective on 12/11/2006. The SWPPP was active at the beginning of the project and was updated weekly by project and contractor staff. As the weekly inspections were performed site specific measures were taken such as straw waddles, check dams, gravel bags around inlets, temporary seeding and mulch were all used to stabilize slopes (ADOTPF 2007).

#### **Best Management Practices (BMPs)**

Best Management Practices (BMPs) are policies, practices, procedures, or structures implemented to mitigate the adverse environmental effects on surface water quality resulting from development. Construction projects are required to have BMPs in place to protect water quality, and the general contractor is responsible for installing, inspecting, and maintaining these BMPs (Fifield 2002).

The majority of BMPs implemented on the Bartlett/Hohe Road project address the problems of erosion and sedimentation. Erosion is the process by which soil particles or sediment is displaced, and sedimentation is the deposition of eroded materials. Erosion occurs when raindrops or moving water displace soil particles. When erosion occurs, soil particles become suspended in water and sediment is transported downstream away from the construction area. Sedimentation can fill in, disturb, or pollute water bodies located downstream from the work zone (Fifield 2002).

In order to address the requirements of pollution prevention at the construction site, Zubek Inc. employed a variety of temporary and permanent BMPs (noted in parenthesis) to reduce soil erosion and site sediment loss. BMPs implemented include:

Silt Fence Barriers (temporary) consist of geosynthetic material placed in a manner that controls sheet flow from disturbed lands. Silt fences do not filter sediment out of runoff waters; instead they create a small containment system to allow for the deposition of suspended particles. Silt fences act as temporary containment structures to be used while construction activities occur (Fifield 2002).



Straw Waddles (temporary), or straw rolls, are made of straw wrapped in thin mesh material. Waddles are placed around flow areas and storm drains. The straw will act like a filter to trap the soil in the water (HGTV Pro 2006).



Straw Bale Barriers (temporary) are sediment containment structures useful in limiting pollution from runoff and sheet flow. These barriers obstruct the passage of water and reduce flow velocity allowing for the deposition of suspended particles. Straw bale barriers act as temporary containment structures to be used while construction activities occur (Fifield 2002).

Diversion ditches, Rock-lined Channels, and Outlet Protection (permanent) are runoff control measures that reduce erosion and sediment transport associated with stormwater. Diversion ditches intercept runoff from the construction area and transport it through the proper channels away from the work zone. The armoring of diversion ditches, stream channels, and culvert outlets with riprap and cobble can help prevent the scouring and gully erosion that may occur during peak flows. These measures are permanent structures to be used during and after construction activities (Fifield 2002).



Additional long term BMPs (permanent) utilized on this project are the stormwater filter described below and the establishment of vegetative cover.

### **Stormwater Filter**

CONTECH Stormwater Solutions assisted with the installation of the Stormwater Management® StormFilter (permanent) in the Bartlett Street stormwater system. The filter came on line in late



September 2005. In May 2005, a 8'X18' vault with manholes, forebay, cartridge bay and exit bay was installed. To simplify installation, this configuration arrived on-site fully assembled for the contractor to place the unit, lid and risers, and then connect the inlet and outlet.



The filter contains a combination media filter known as ZPG. ZPG is a mixture of Zeolite, Perlite and GAC (granular activated carbon). It utilizes a Perlite layer on the outside with an inner layer of 90% Zeolite mixed with 10% granular activated Carbon. Perlite is naturally occurring puffed volcanic ash, effective for removing TSS, oil and grease. Zeolite is a naturally occurring mineral used to remove soluble metals, ammonium and some organics. GAC (Granular Activated Carbon) has a micro-porous structure with an extensive surface area to provide high levels of adsorption. It is primarily used to remove oil and grease and organics such as herbicides and pesticides (CONTECH 2007).



The system was sized based on flow. A design treatment flow was determined by ADOTPF to be just over 1 cfs. The system has two pipes coming off a flow-splitter manhole. One was sized at just over 1cfs to catch the first flush of the storm while the second pipe was designed to catch and bypass the excess overflow of the storm. Each cartridge has a flow rate of 0.033 cfs, and 32 cartridges were installed capable of treating 1.056 cfs.

According to CONTECH, maintenance should be determined site-specifically. Generally it is annual maintenance, but many systems go beyond 12 months with a cartridge service life of 18-24 months – depending on loading. CONTECH recommends checking the system quarterly at first to determine the site loading characteristics. In addition, this site has a separate settling manhole (72-inch diameter) between the flow-splitter manhole and the filter vault to promote additional gravity settling of the sanding materials used in winter on Bartlett. The City of Homer is charged with the maintenance of the filter and is in the process of developing a schedule once authority is handed over.

## **Inspection and Maintenance**

Inspection and maintenance of BMPs is necessary to sustain sediment and erosion control. To be effective, BMPs installed in a correct manner, inspected frequently, and maintained. BMPs that are found to no longer be functioning correctly should be repaired. In colder regions, when construction stops for the winter, it is important that BMPs be in place to provide the needed protection when spring break-up conditions result in snowmelt. The minimum inspection requirements set forth by EPA's National Pollutant Discharge Elimination System General

Permit for Discharges from Large and Small Construction Activities state that BMPs should be inspected once every 14 calendar days and within 24 hours after any storm event that is 0.5 inches or greater. The inspection frequency may be reduced to at least once every month if:

1. The entire site is temporarily stabilized,
2. Runoff is unlikely due to winter conditions (e.g., site is covered with snow, ice, or the ground is frozen), or
3. Construction is occurring during seasonal arid periods in arid areas and semi-arid areas.

A waiver of the inspection requirements is available until one month before thawing conditions are expected to result in a discharge if all of the following requirements are met:

1. The project is located in an area where frozen conditions are anticipated to continue for extended periods of time (i.e., more than one month);
2. Land disturbance activities have been suspended; and
3. The beginning and ending dates of the waiver period are documented in the SWPPP (EPA 2003).

The ADOTPF stormwater guide says that their inspectors will inspect all erosion and sediment controls as per specification at least once every seven calendar days and within 24 hours of a storm that produces 0.5 inches or more rainfall over a 24-hour period (ADOTPF June 2004). Inspections were conducted weekly, usually every Monday, and after every rainfall occurrence that exceeded ½". If a response was needed, it usually happened upon inspection unless materials need to be ordered. Although BMP maintenance was performed at the aforementioned interval it was always being scrutinized by the project staff and contractor during the week (ADOTPF 2007).

## **WATER QUALITY STANDARDS**

Comparisons between stormwater quality and water quality standards can provide valuable information for stormwater management. The relative frequency and magnitude of water quality standards exceedances within storm sewer systems can help prioritize additional investigations and/or implementation of control measures. Frequent large exceedances are a clear indication that further investigation and control measures are warranted. Marginal or occasional exceedances are more typical and more difficult to interpret (ASCE and EPA 2002).

State and Federal water quality standards that apply to the parameters above can be found in Appendix I.

## **WATER QUALITY PARAMETERS**

### **Parameters for all Sampling Events**

Discharge (streamflow) is the volume of water moving through the stream at any given point in time. Discharge is measured in cubic feet per second (cfs). The discharge of a stream can vary on a daily basis in response to precipitation, snowmelt, dry periods, and withdrawals or additions

of water by people. Water that enters streams promptly in response to individual water-input events (rain or snowmelt) is called event flow or storm flow. Event flow is distinguished from base flow, which is water that enters the stream from persistent, slowly varying sources such as ground water and maintains streamflow between water-input events (Dingman 2002). Discharge affects water chemistry; thus, water quality measurements should always be viewed in relation to discharge (EPA 1997).

Turbidity is an optical property of water that refers to the amount of light scattered or absorbed by the water. On this project, turbidity was measured in nephelometric turbidity units (NTU). Silt, clay, organic material, and colored organic compounds can all contribute to turbidity. Turbidity is influenced by discharge and erosion from natural and human impacts (EPA 1997 b). Road building may affect stream water quality by changing the natural hydrograph of these streams as well as introducing sediments to the stream channel. Sediment pollution, particularly turbidity, is the most prevalent form of pollution in Alaska (Lloyd 1987).

Water temperature is a crucial aspect of aquatic habitat. Aquatic organisms are adapted to live within a certain temperature range. Water temperature on this project was measured in degrees Celsius. Stream temperature results from inputs of solar radiation and air temperature (EPA 1997).

pH is a measure of the level of activity of hydrogen ions in a solution, resulting in the acidic or basic quality of the solution. pH ranges from 0 (acidic) to 14 (basic), with 7 being neutral. Most natural streams range from 6.5 to 8 pH units (EPA 1997).

Conductivity is the ability of a substance to conduct an electrical current and is measured in microsiemens per centimeter ( $\mu\text{S}/\text{cm}$ ). Specific conductance, also known as temperature compensated conductivity, automatically adjusts the reading to a value that would have been read if the sample had been at 25° C. The presence of ions in a sample of water gives it its ability to conduct electricity; thus conductivity is a measure of dissolved solids in a stream (EPA 1997).

### **Additional Parameters for Stormwater Filter Samples**

Chemicals of concern are generally the most toxic, mobile, persistent, and/or frequently occurring chemicals found at the site. Commonly occurring chemicals of concern in stormwater runoff include metals (cadmium, copper, lead, and zinc), polycyclic aromatic hydrocarbons (PAHs), and organo-phosphate insecticides (e.g., diazinon and chlorpyrifos) (ASCE and EPA 2002). Parameters for stormwater samples included: total suspended solids, settleable solids, oil and grease, polynuclear aromatic hydrocarbons, and the three metals-cadmium, lead, and zinc.

## **SAMPLE DESIGN**

### **Site Selection**

The sampling locations in Woodard Creek were chosen to be “representative” of the entire stream. Woodard Creek parallels the construction zone and contains 3 existing CEMP

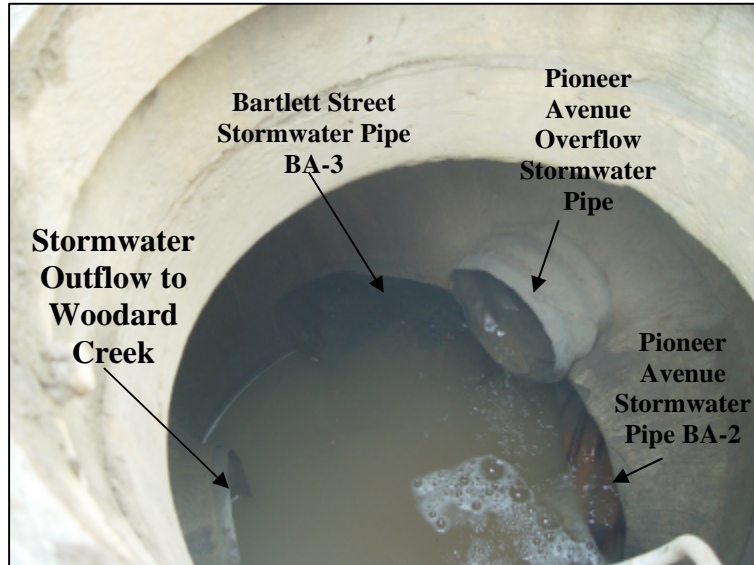


monitoring sites (Figures 1 & 2). Latitude and longitude coordinates were collected for all monitoring sites using a handheld GPS and are listed in Table 2 below.

**Table 2: Bartlett/Hohe Project (BA Site ID) and CEMP (KB Site ID) Monitoring Locations**

| Site ID                  | Site Name  | Lat       | Long       |
|--------------------------|--|-----------|------------|
| <b>KB-120</b>            | Woodard Creek @ Jenny Way  | 59.640800 | 151.550000 |
| <b>BA-1</b>              | Woodard Creek Outflow Below Pioneer  | 59.643717 | 151.546883 |
| <b>BA-2</b>              | Pioneer Ave. Stormwater Culvert in Manhole @ Pioneer Ave.                        | 59.644483 | 151.546100 |
| <b>BA-3</b>              | Bartlett St. Stormwater Culvert in Manhole @ Pioneer Ave.                        | 59.644483 | 151.546100 |
|                          | Storm Water Filter   | 59.644150 | 151.548850 |
| <b>BA-3u</b>             | Bartlett St. Stormwater Culvert in Manhole above Stormwater Filter @ Bartlett St | 59.644233 | 151.548917 |
| <b>KB-150 &amp; BA-4</b> | Woodard Creek @ Pratt Museum   | 59.645111 | 151.547667 |
| <b>BA-5</b>              | Woodard Creek @ Spruceview Ave.  | 59.646217 | 151.550333 |
| <b>BA-6</b>              | Woodard Creek Below Hospital Outflow Pipe  | 59.651783 | 151.549600 |
| <b>KB-180</b>            | Woodard Creek @ West of Hospital   | 59.653700 | 151.551500 |

Seven sampling locations were identified as monitoring sites for the project. Four sites were located in Woodard Creek: one below Pioneer Avenue and downstream from the work zone and the storm water inflow (BA-1); one located behind the Pratt Museum, at an existing CEMP site (BA-4); one at Spruceview Avenue, where a road stream crossing is to be developed (BA-5); and one located near the Bartlett Hospital parking lot and upstream from the work zone (BA-6). Two more additional monitoring sites were located within the existing storm water drainage system at the intersection of Pioneer Avenue and Bartlett Street. Site BA-2 samples were collected from the Pioneer Avenue stormwater culvert and site BA-3 samples were collected from the Bartlett Street stormwater culvert. In order to



**Looking down manhole at intersection of Bartlett Street and Pioneer Avenue where BA-2 and BA-3 samples were taken**

assess the effectiveness of the Stormwater Management® StormFilter, samples were collected in the Bartlett stormwater pipe both above (BA-3u) and below (BA-3) the filter.

## **Sample Frequency**

In 2005, sampling and field measurements took place on all six project sites once per week (Tuesday) over a four-week period (April 12- May 3). After May 3rd, sampling and field measurements took place on five sites once every two weeks over a 23-week period (May 17- October 4, 2005). Bi-weekly sampling included all sites except BA-5 (Woodard Creek @ Spruceview Ave.). Site BA-5 was established to monitor any potential effects from the scheduled construction of Spruceview Avenue, which crosses Woodard Creek. The site was dropped when work was postponed by the city of Homer. Since the Bartlett/Hohe project construction was extended into 2006, an additional 4 regular monitoring events were scheduled and sampling occurred from April 12 - June 30, 2006 while the project was being completed.

In addition to the weekly and bi-weekly sampling of the study stream and stormwater system, four rain event samples were taken over the course of the project. These samples were scheduled to be taken after a rainfall of 0.50 inches or more within a 24-hour period. The amount of precipitation was based on data from the National Weather Service Homer (PAHO) airport weather station accessed on line at [www.wunderground.com](http://www.wunderground.com) prior to the sampling event.

Initially two stormwater filter sample events were scheduled to be collected after the filter was installed. One was to be collected during a regular bi-weekly sampling event (low flow period) and the other during a rain event. A second rain event sample was added to the schedule in 2006. The criteria for sampling the stormwater sample rain events was that rain be sheeting down Bartlett Street and that samples be collected as soon as possible once the rain had started.

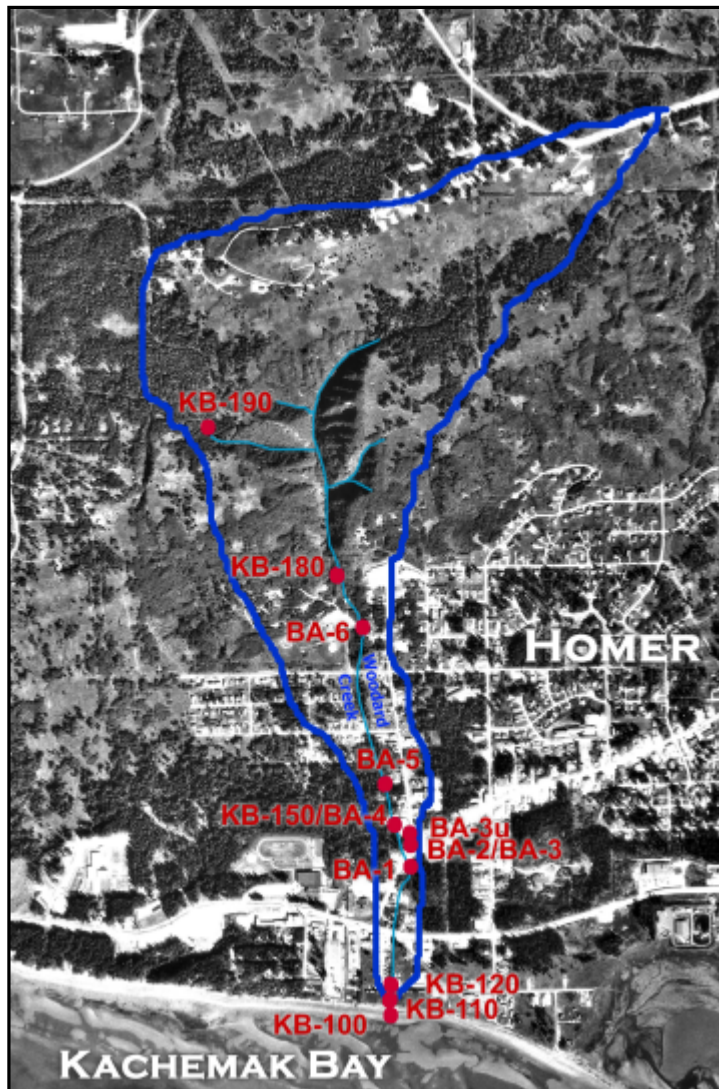


Figure 1: Project and CEMP monitoring sites in the Woodard Creek watershed.

■ Woodard Creek Watershed Boundary

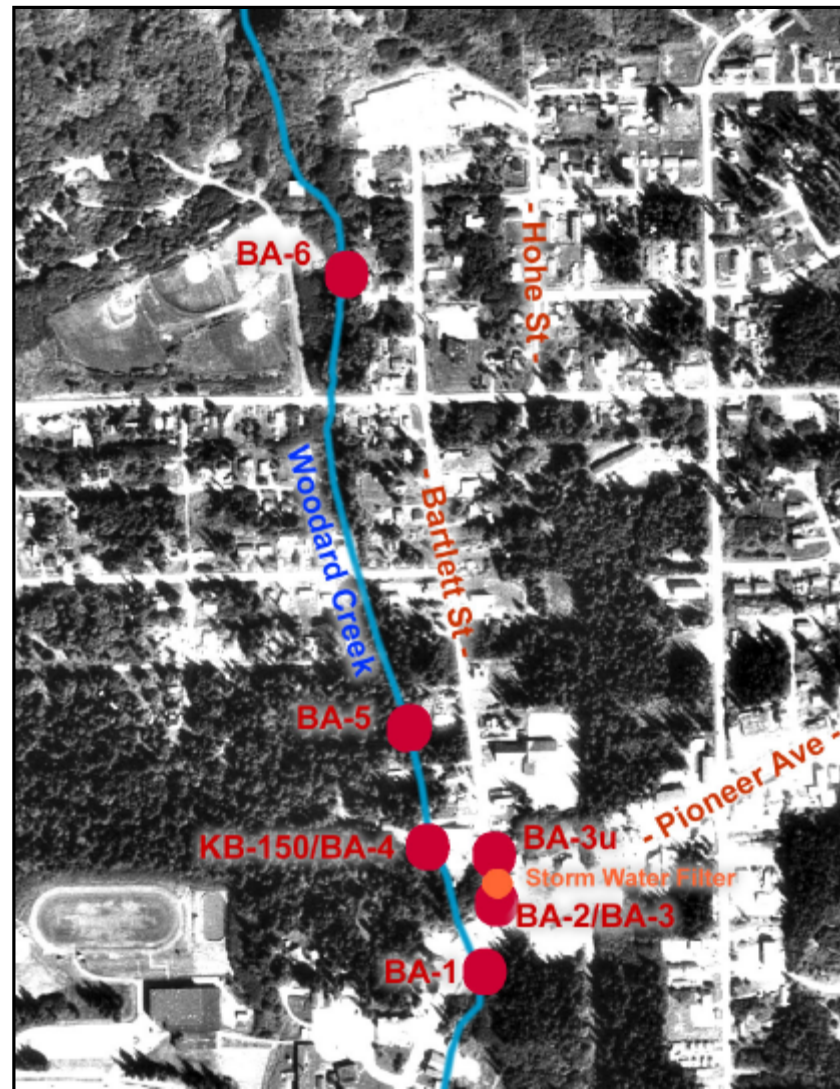


Figure 2: Project monitoring sites in Woodard Creek and the Bartlett Street Stormwater system.

## **METHODS**

### **Water Quality Samples**

At each site, temperature, specific conductance, pH, turbidity, and discharge were measured. Temperature, pH, and specific conductance were measured using a YSI model 63 unit. Measurements were taken in stream with all probes submerged. Readings were allowed to stabilize for 5 – 10 minutes. Discharge was measured using a Global Flow Probe model FP-101. Average velocities were calculated using the USGS 0.6 method (Rantz 1982), and the cross-sectional area of the stream was determined by measuring width and depth. Turbidity samples were collected mid-stream, mid-depth in acid-washed 250 ml sample bottles. Bottles were rinsed three times downstream of the collection site with water from the study stream prior to sample collection. After collection, samples were returned to Inletkeeper's Cook Inlet Community-based Water Quality Laboratory and refrigerated. Turbidity analysis was conducted within the 24-hour recommended holding time using a LaMotte 2020 Turbidimeter. Replicate readings were taken for each sample collected to assure data quality objectives are met. A full list of data quality objectives for parameters sampled is included in Appendix II. Each piece of equipment was calibrated on the day the measurements were taken to ensure accurate readings.

In addition to these measurements, ambient conditions for each site were documented. These included air temperature, wind speed and direction (using the Beaufort wind scale), precipitation, and changes in the area surrounding the sampling site. Digital photographs were collected at each sampling site to help document these conditions. Photos were used to record changes in the stream channel, water appearance, or impacts on riparian vegetation. A minimum of three pictures were taken at every site. These included photos looking downstream, upstream, and directly at the sampling site. Additional photos were taken to document BMPs as well as road and culvert construction near the sampling site. A rough sketch of the sample area was also included on the data sheet. The sampling sites for the project were marked using a Garmin GPS.

### **Stormwater Filter Samples**

Stormwater Management® StormFilter samples were collected in the Bartlett Stormwater pipe above (BA-3u) and below (BA-3) the Stormwater filter and sent to Analytica International Inc. Laboratory in Anchorage, Alaska for analysis. Table 3 shows the parameters analyzed and methods used by Analytica. Appendix III shows the data quality objectives used during each analysis. In addition, temperature, conductivity, pH, turbidity, and discharge were measured when possible, and samples for settleable solids and turbidity were taken and analyzed in the Cook Inlet Community-based Water Quality Laboratory. Turbidity samples were analyzed as described above while settleable solids were analyzed per EPA Method 160.5 – Settable Solids.

### **CEMP Samples**

Temperature, specific conductance, pH, and turbidity were also monitored by CEMP volunteers at sites KB-120, KB-150 (BA-4), and KB-180. Temperature was measured using a thermometer or thermo sensor on a Hanna meter. Specific conductance and pH were measured using a Hanna meter. Turbidity analysis was conducted using a LaMotte 2020 Turbidimeter by the Cook Inlet



Community-based Water Quality Laboratory. Detailed method and data quality objectives information for the CEMP data can be found in Inletkeeper's 2004 and 2005 *Kachemak Bay & Anchor River Citizens' Environmental Monitoring Program Annual Water Quality Status Reports*.

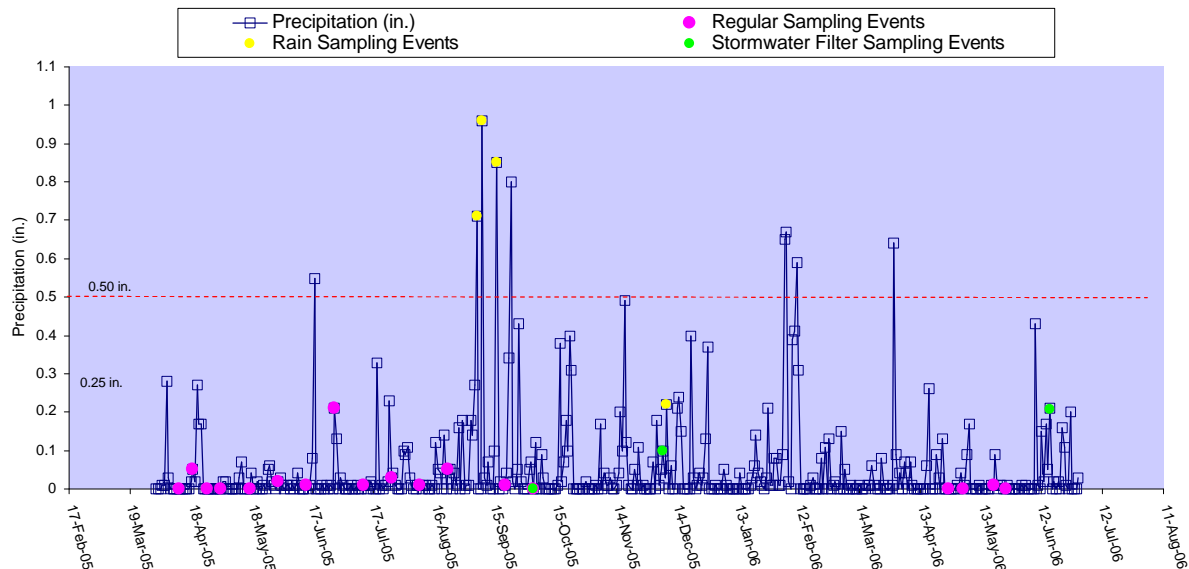
**Table 3: Stormwater Management StormFilter Samples Parameters and Methods used by Analytica Inc. Laboratory.**

| Parameter                         | Method   |
|-----------------------------------|--|
| Total Suspended Solids            | EPA Method 160.2 - Residue, Gravimetric, Non-filterable, 105°C - TSS |
| Cadmium                           | EPA Method 200.8 - Metals by ICP/MS - Total/TR                       |
| Lead                              |  |
| Zinc                              |  |
| Oil and Grease                    | EPA Method 1664 (Aqueous) - Oil & Grease                             |
| Polynuclear Aromatic Hydrocarbons | EPA Method 625 - Base-Neutrals and Acids by GC/MS-PAH                |

## RESULTS

### Discharge

Rainfall during the project and when samples were collected is shown in Figure 3. Table 4 summarizes the rainfall for rain and stormwater sampling events.



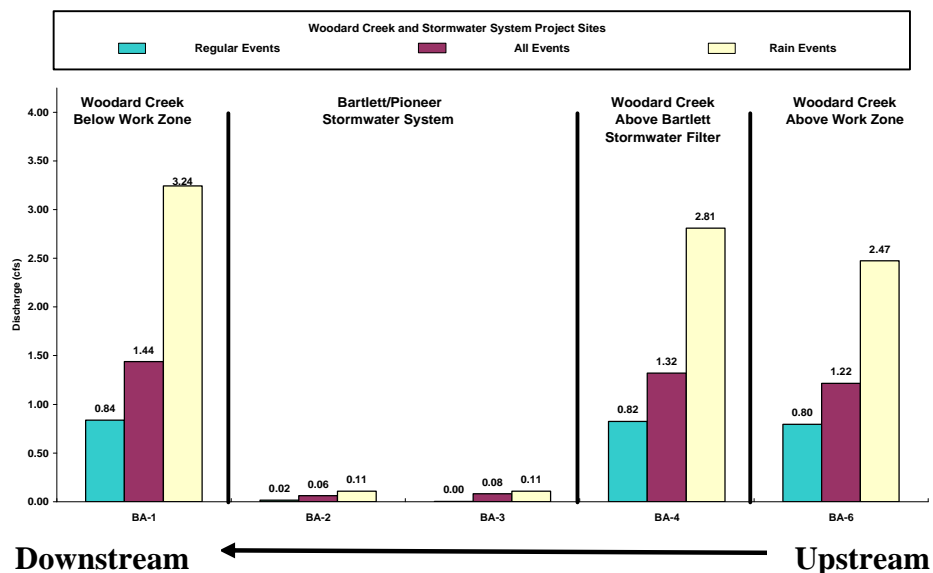
**Figure 3: Daily precipitation for the Homer Airport (PAHO) weather station from 4/1/05 to 6/30/06 and when project samples were collected.**

**Table 4: Summary of Rainfall Data for Rain and Stormwater Sample Events**

| Date    | Rainfall 24 hours Prior to sampling (Inches) | Event  | Comments                   |
|---------|--|--|----------------------------|
| 9/6/05  | 0.98   | Rain Event   |                            |
| 9/9/05  | 0.62   | Rain Event   |                            |
| 9/16/05 | 0.81   | Rain Event   |                            |
| 10/4/05 | 0.01   | Stormwater Management® StormFilter Samples Regular Event | After installation.        |
| 12/7/05 | 0.12   | Stormwater Management® StormFilter Samples Rain Event    | On existing snow.          |
| 12/9/05 | 0.21   | Rain Event   | On existing snow.          |
| 6/16/06 | 0.21   | Stormwater Management® StormFilter Samples Rain Event    | Best available conditions. |

On 12/7/05 a rain event sample was taken when rainfall was less than the established 0.5 inches. With winter conditions closing the window for getting ideal rain event conditions, a decision was made to collect samples when the combined conditions of rapid snowmelt and rain running on top of snow produced similar flow rates. Discharge on 9/16/05 for BA-1 was 5.11 cfs and on 12/9/07 it was 5.06 cfs. Stormwater Management® StormFilter rain event samples were to be collected as soon as possible if rain started sheeting down Bartlett Street. The 12/7/05 event was similar in conditions to that on 12/9/05, but with less rainfall and a flow reading of 0.14 cfs below the filter (BA-3). The 6/16/06 event was taken during less than ideal conditions because the project was to end June 30<sup>th</sup> and the forecast was not looking good for a rain event. The flow rate at BA-3 during this event was 0.11 cfs.

Calculated discharge readings ranged from 0.14 to 5.11 cfs at Woodard Creek monitoring sites. Figure 4 shows mean discharge values increasing as you move downstream at Woodard Creek



**Figure 4: Mean Discharge for Sampling Events from 4/12/05 to 6/16/06 at Woodard Creek and Stormwater System Project Sites.**

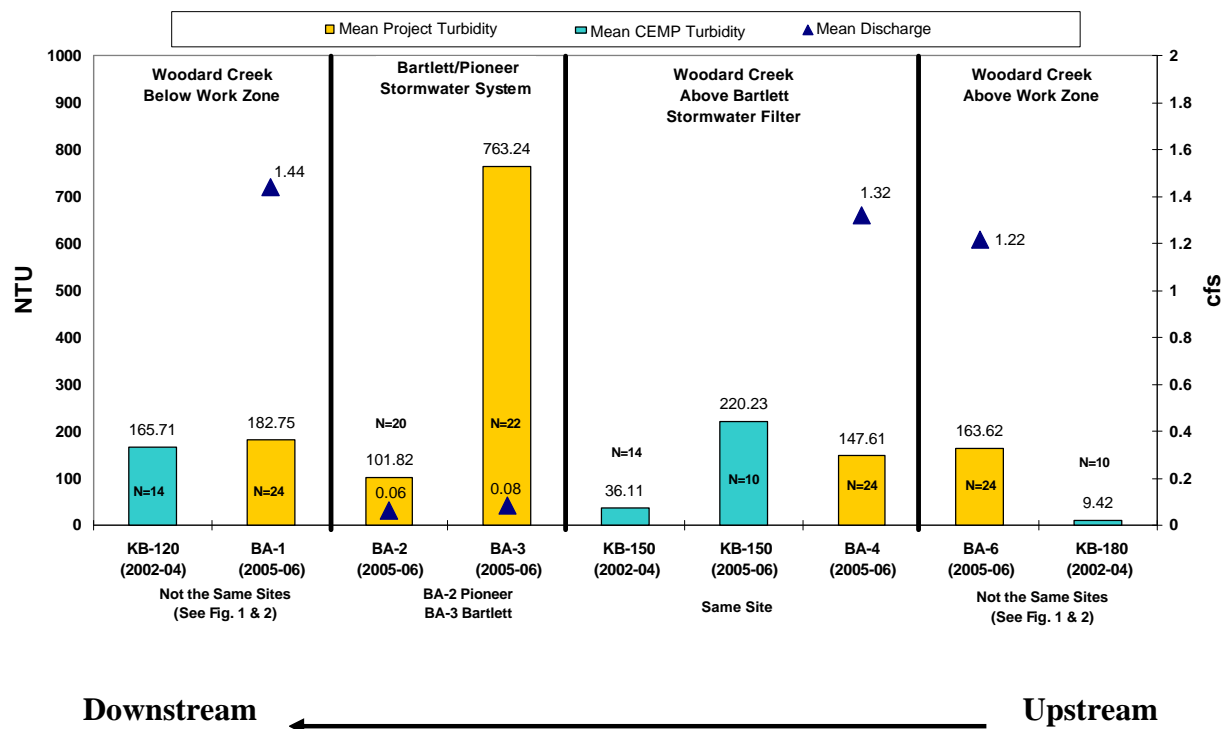
sites. The highest discharge readings were recorded on 9/16/05 when 0.82 inches of rain fell in a 24-hour period prior to sampling.

The Bartlett stormwater pipe has a slightly higher mean discharge than the Pioneer stormwater pipe, but also had four events where discharge was not measurable (not enough flow) when it was measurable on Pioneer. All calculated discharge readings taken in the Bartlett Stormwater System ranged from 0.01 to 0.23 cfs, well below the 1.056 cfs capacity of the filter. Table 5 in Appendix IV summarizes discharge data and Appendix V shows all discharge data collected for this project. There was no CEMP discharge data for comparison.

## Turbidity

Turbidity readings ranged from 1.76 to 11,175 NTU at Bartlett/Hohe Project sites. The highest was at the Bartlett Street stormwater culvert site (BA-3) on 4/26/05. CEMP sites had readings ranging from 1.57 to 2119 NTU, with the highest reading recorded at KB-150 on 4/30/06. Turbidity data for Bartlett/Hohe Project and selected CEMP sites is summarized in Table 6 in Appendix IV. Appendix VI shows all turbidity results for all project sites.

Figure 5 compares Project mean turbidity data with CEMP mean turbidity data. This figure shows Project Woodard Creek sites have higher mean turbidity readings in 2005-06 than mean turbidity in 2002-04 at CEMP sites that are the same or in close proximity, and that mean turbidity is higher in the Bartlett Stormwater System than the Pioneer Stormwater System. BA-6 show increases of 154 NTUs in 2005-06 when compared to 2002-04 data for KB-180

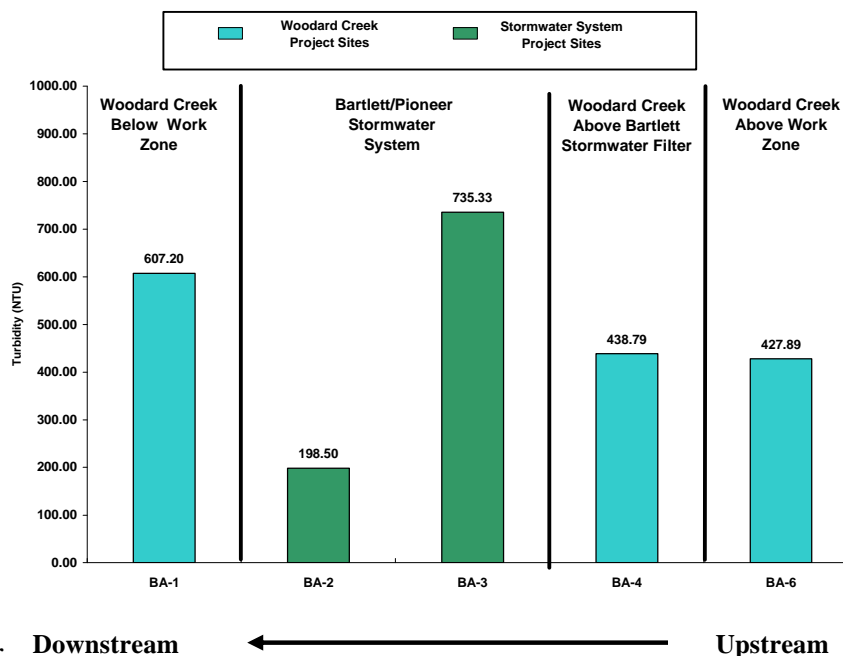


**Figure 5: Mean turbidity and discharge data collected from 4/12/05 to 6/16/06 at Project sites and mean turbidity data from 10/01/02 to 5/18/06 at CEMP sites. Note: Data sets do not include the months Jan.-Mar.**

(approximately 100 yards upstream). CEMP data for KB-150 show increases of 184 NTUs when comparing to 2002-04 data to 2005-06 data. Comparing KB-150 data for 2002-04 to BA-4 data for 2005-06 shows an increase of 111 NTUs. Mean turbidity differences in 2005-06 between CEMP data at KB-150 and project data at BA-4 is due to a CEMP sample collected on 4/30/06 (2119 NTU). Figure 5 also plots mean discharge for project sites showing high turbidity for relatively small flow rates.

Data collected during rain events shows turbidity increasing as you move downstream and that the Bartlett Street stormwater system has a significantly higher mean turbidity than the Pioneer Avenue stormwater system (Figure 6).

There was no significant change in mean turbidity at BA-1 below the stormwater filter when comparing data before (182.80 NTU; N=16) and after (182.67; N=8) filter installation.



**Figure 6: Mean rain event turbidity values at Woodward Creek and Stormwater System Project Sites.**

## Water Temperature

Temperature results collected at project sites can be found in Appendix VII. No temperature readings exceeded the state temperature standards for aquatic life (20°C) or recreational contact reading (30°C) for Woodward Creek at all sites. Temperature data for Bartlett/Hohe Project and selected CEMP sites is summarized in Appendix IV, Table 7.

## pH

All pH data collected in 2005 and 2006 at Project and CEMP sites met state water quality standards for pH. Appendix VIII shows all pH data collected at project sites. pH data for Bartlett/Hohe Project and selected CEMP sites is summarized in Table 8 in Appendix IV.

## Specific Conductance

Table 9 in Appendix IV summarizes specific conductance data at Bartlett/Hohe project sites collected from 4/12/05 to 6/16/06 and CEMP Sites KB-120, KB-150, and KB-180 collected from 7/10/97 to 5/18/06. Appendix IX shows all specific conductance data for project sites. As



expected data shows mean specific conductance increasing as you move downstream on Woodard Creek. The upper site (KB-180) has mean specific conductance of 136.02  $\mu\text{S}/\text{cm}$  and mean values gradually increase to a mean of 170.98  $\mu\text{S}/\text{cm}$  at KB-120.

Data shows Pioneer Avenue stormwater mean specific conductance is less than all Woodard Creek sites, while the Bartlett Street stormwater is greater. Pioneer Avenue stormwater has a lower mean specific conductance than Bartlett Street. As expected all sites had a mean lower specific conductance reading during rain events (Appendix IX).

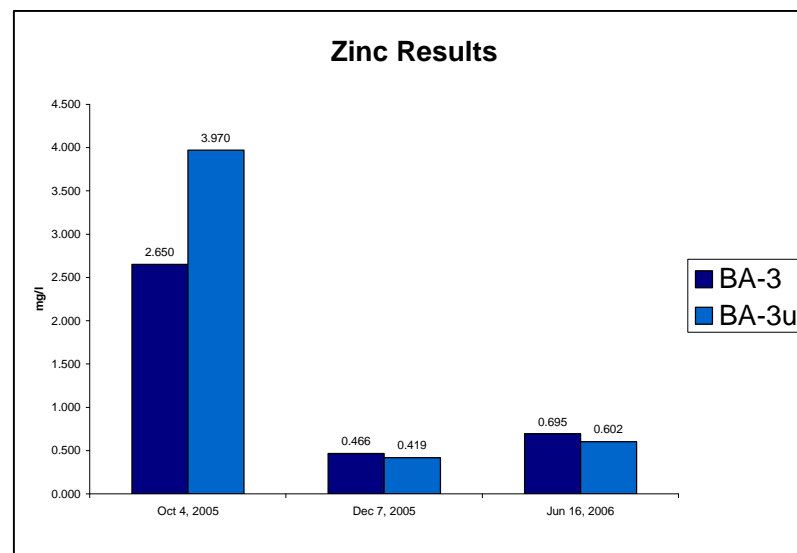
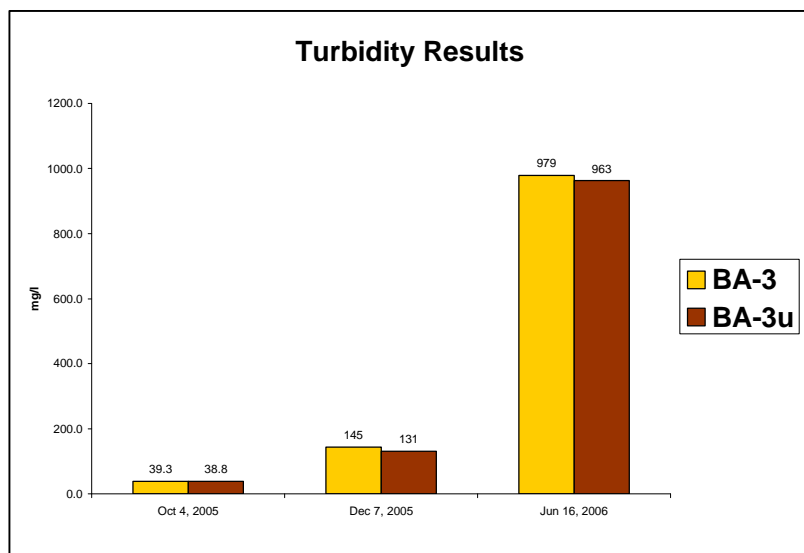
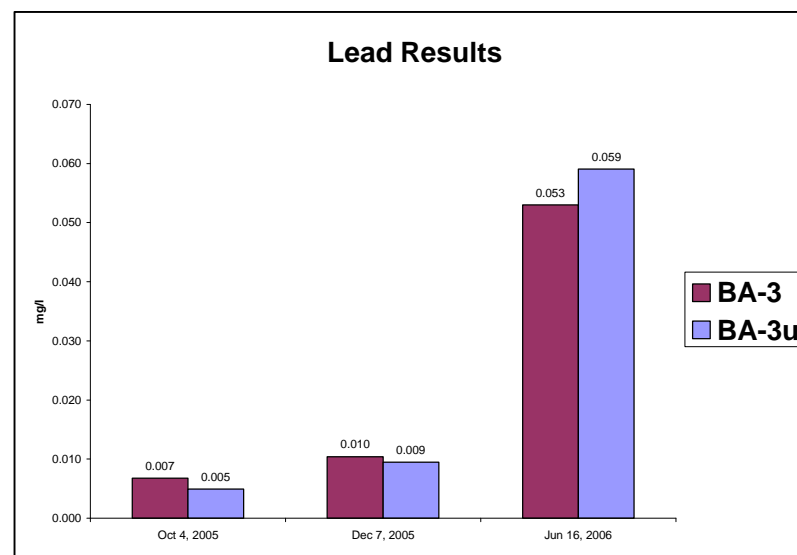
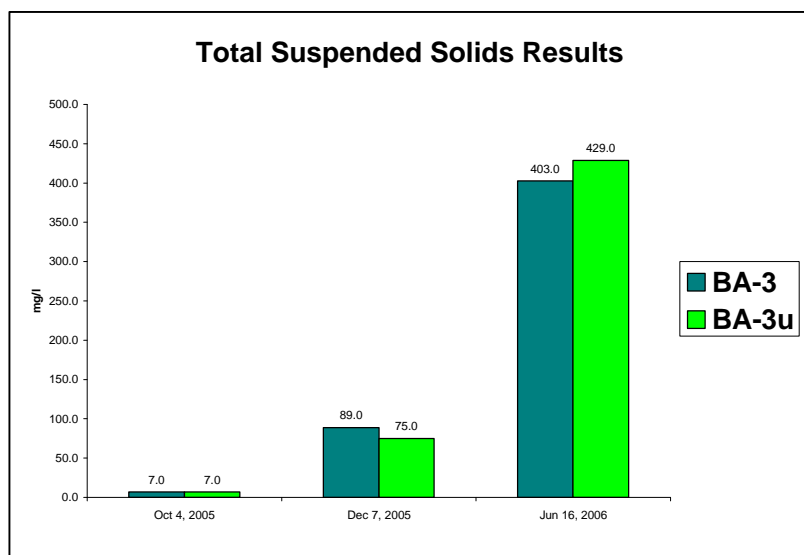
### **Stormwater Filter**

Appendix III summarizes all laboratory results for all the stormwater sampling events. Results for all three stormwater samples show that oil and grease, polynuclear aromatic hydrocarbons (all constituents), and cadmium were not detected at or below the reporting limit. All settleable solids results were  $< 0.1 \text{ ml/l}$ . Data showed only one exceedance of water standards. Zinc exceeded the standard 2.0 mg/l for stock water and irrigation water criteria at BA-3u and BA-3 on 10/04/06 (Figure 7 & Appendix I)

Figure 7 shows results for total suspended solids, turbidity, lead, and zinc. For the regular sampling event on 10/04/06, turbidity and lead had slight increases, total suspended solids stayed the same, and zinc was reduced 33% when comparing samples collected above (BA-3u) the filter with those collected below (BA-3). When comparing results for the two rain event samples on 12/07/05 and 06/16/06, we see slight increases in turbidity and zinc, while total suspended solids and lead increase slightly on 12/07/05 and decrease slightly on 6/16/06.

Result comparisons for pH, specific conductance, temperature and discharge can only be made for one event on 12/07/05. No readings exceeded water quality standards. This one sample comparison showed a pH of 6.57 at BA-3u increasing to 7.19 at BA-3; specific conductance increasing from 102.4  $\mu\text{S}/\text{cm}$  to 106.9  $\mu\text{S}/\text{cm}$ ; temperature decreasing from 11.5  $^{\circ}\text{C}$  to 11.4  $^{\circ}\text{C}$ ; and discharge decreasing from 0.16 cfs to 0.11 cfs. These results and additional readings can be found in Appendices V, VII, VIII, and IX.

The filter was inspected in late September 2006 by the CONTECH and the City of Homer Public Works and was found not to need maintenance (Meyer 2006). The City of Homer Public Works pumped the sediment clean from the stormwater sumps (manholes) on Bartlett Street and other Homer drainages (Meyer 2006).



**Figure 7: Total Suspended Solids, Turbidity, Lead, and Zinc results for samples collected above and below the Bartlett Street stormwater filter on 10/04/05, 12/07/05, and 06/16/06.**

## DISCUSSION

### Stormwater Filter Samples and Bartlett and Pioneer Stormwater

The stormwater filter in the Bartlett Street stormwater system was the second such filter installed in Alaska. It was designed to remove total suspended solids, oil and grease, soluble metals, ammonium, and some organics such as herbicides and pesticides from stormwater and was placed in the Bartlett Street Stormwater system to reduce pollutants in Woodard Creek. Only three samples were collected and thus did not provide adequate data for assessing the filter's effectiveness for inter-storm variability. In addition, the logistical challenges of catching first flush events limited the data that was collected. Data from stormwater filter samples collected here can only be used as baseline information for the 3 different types of run off events and cannot assess the effectiveness of the filter. This data will best be used if more samples are collected that span the various runoff events that would capture all pollutant runoff loads.

#### Discharge

Discharge results collected above the stormwater filter are lacking. The stormwater sampling event on 10/4/05 was meant to be a low flow event; enough water was found to collect a sample, but not enough to measure flow. The remaining stormwater sampling events were meant to be rain events, catching the initial flush of stormwater runoff, but weather conditions and logistics did not cooperate to provide for the best conditions, especially when limited to only two opportunities. Ideally capturing higher flow rates than those measured would have been preferred. Only one discharge reading was taken at the below filter site (BA-3) during first rain event and thus limits the ability to interpret results. On the second event a 0.16 cfs incoming flow was recorded and was reduced by 31% by the filter. If one were to extrapolate flow for the first event based on this reduction, there would have been an incoming flow of 0.20 cfs. These inflow rates are well below what the filter was designed to handle, 1.056 cfs, and are only 15% and 19% capacity of the incoming flow rate. More rain events with greater intensity should be measured to better understand stormwater moving through the filter. Studies in Seattle, WA using a filter with the same medium used inflow rates that were sampled were 50 percent, 100 percent, and 125 percent of the filtration capacity of the StormFilter (Milesi et al., 2006).

#### Oil and Grease, PAHs, Cadmium

More samples should be collected that span the various runoff events that would capture all pollutant runoff loads to better assess whether the filter is effectively removing pollutants from the stormwater.

#### Settable Solids

All settable solids results were  $< 0.1$  ml/l. With turbidity readings over 900 NTU, these results suggest finer material is creating high turbidity results. More samples collected at higher flow rates may help better understand results.

### Lead

The filter did not reduce lead concentrations in the stormwater and in two of the sampling events concentrations slightly increased. With the limited number of samples it is hard to draw conclusions from these results. Increases could be due to many factors, including sampling collection, handling, shipping, or laboratory analysis and not necessarily to poor filter performance. More samples need to be taken at both low flow and rain events to better interpret this data.

### Zinc

Zinc was detected above the state standard for stock water and irrigation on samples collected above and below the filter on 10/04/05, a low flow event. Rain event sampling showed the zinc concentrations dropping significantly, but also showed a similar pattern as lead where concentrations slightly increased below the filter. Again factors mentioned with the lead results could apply here. More samples need to be taken at both low flow and rain events to better interpret this data.

### Turbidity

Results for turbidity suggest that the filter is not filtering the material detected in turbidity measurements. Stormwater Management® StormFilter sampling events show turbidity readings collected below were slightly higher than those above the filter. The turbidity sample collected on 4/26/05 at BA-3 (Bartlett stormwater) had a reading of 11,175 NTUs. This shows that spring runoff has potential to produce extremely high turbidity in Bartlett stormwater. In comparison, turbidity at BA-2 (Pioneer stormwater) on the same day had a turbidity reading of 38.3 NTUs. Again more samples need to be collected to better understand these results.

### Total Suspended Solids

Suspended solid results are conflicting. The 6/16/06 results for the rain event showed the filter reducing suspended solids by 6%, but the 12/7/05 rain event showed an increase of nearly 16%. Sampling collection, handling, shipping, or laboratory analysis could have contributed, but to get a better understanding more samples will need to be taken.

### Temperature

Mean temperatures were significantly higher in the stormwater systems than Woodard Creek. During the twelve sampling events where temperature was measured in the Pioneer and Bartlett stormwater system and Woodard Creek, mean temperatures were roughly 1.5 °C higher in the Bartlett stormwater system than Woodard Creek and Pioneer was approximately 1.0 °C higher than Woodard Creek. This is likely due to the heating of the street's thermal mass that the stormwater pipes are encased and less exposure to the weather conditions above ground.

## pH

The Bartlett and Pioneer stormwater systems had neutral pH readings with no significant difference from Woodard Creek pH readings.

## Specific Conductance

Bartlett stormwater had a significantly higher specific conductance than Woodard Creek and Pioneer stormwater and Pioneer was less than Woodard Creek. Mean readings were 68  $\mu\text{S}/\text{cm}$  higher than the mean readings at BA-4 (midstream), and 50  $\mu\text{S}/\text{cm}$  higher than the downstream site (KB-120). This would suggest that Bartlett stormwater is contributing more dissolved solids into Woodard Creek beyond its natural conditions.

## **Woodard Creek**

Woodard Creek though slightly larger, has similar characteristics of the streams monitored during the East End Road Construction Project. It was also impacted by the floods of 2002, where it experienced blown culverts, bank erosion, and the creation of plunge pools (Ballock 2004). Increasing impervious cover estimates show imperviousness 5 to 10 percentage points above the thresholds where stream quality begins to decline. Woodard Creek has also been listed as a Category 3 waterbody by the Alaska Department of Environmental Conservation.

## Discharge

The readings taken during project monitoring provided the first discharge data set for Woodard Creek. Mean discharge at BA-4 was 0.34 cfs greater than mean discharge (0.98 cfs at Palmer (Bear) Creek when comparing discharge at middle sites of each the Creek.

## Turbidity

Alaska's standards for turbidity are difficult to use as they require an understanding of natural conditions which is generally lacking in the State (Mauger 2004). Data collected for this project add to the data that CEMP began collecting in 2002, but with no precedent or definition of what natural conditions are for these streams and the rapidly increasing urbanization of Woodard Creek, it is difficult to ascertain whether turbidity standards have been exceeded.

However, turbidity data collected on Woodard Creek, shows again that several of these small streams emptying into Kachemak Bay have high mean turbidities with relatively low mean flows. Woodard Creek had mean turbidity readings as high 182.75 NTU with a mean discharge of 1.44 cfs. Comparable creeks along East End road include: Bear Creek-mean turbidity 81.03 NTU, mean discharge 0.98 cfs; Miller Creek- mean turbidity 321.75 NTU, mean discharge 0.29 cfs; and Waterman Creek-mean turbidity 169.7 NTU, mean discharge 0.45 cfs (Badajos 2005). Compare this to the Anchor River where mean turbidity is 10.29 NTU and discharge ranges from 131.9 to 690 cfs (Mauger 2004).

### Temperature

There was no significant change in temperature readings taken Woodard Creek when compared to historical data.

### pH

There was no significant change in pH readings taken in Woodard Creek when compared to historical data.

### Specific Conductance

There was no significant change in specific conductance readings taken in Woodard Creek when compared to historical data.

## **Conclusion**

Considering the time, logistical constraints, and costs of stormwater monitoring, combined with the costly and time consuming deployment, monitoring and maintenance of stormwater BMPs, one must ask: is it worth it? The answer has to be a resounding yes, when we consider what is at risk-- Kachemak Bay and its many small freshwater streams.

As of 2005, Homer's population was 5,252. Since 2000, Homer has experienced a population growth of 32.83 percent (Sperling's 2006). With this growth comes more human activity, and with more human activity come more impervious cover and more stormwater runoff. As this growth continues, each large and small stream becomes a conduit for carrying stormwater pollutants to Kachemak Bay. Sediment loads are picking up more bacteria, organic nutrients, hydrocarbons, zinc, copper, cadmium, mercury, iron, nickel, oil, and grease from streets, lawns, and construction and industrial sites and carrying them to creeks like Woodard and then into Kachemak Bay. And with this runoff comes increased impairment of our local water bodies.

Given the impairment track record of our nation's estuaries, we need to get past the notion that these small water bodies are nothing more than ditches. The recent floods have alerted us to the power these streams hold. And according to the Intergovernmental Panel on Climate Change we should expect more heavy precipitation events (IPCC 2007).

The Bartlett/Hohe street project shows that we are moving in the right direction. ADOTPF had Alaska's second stormwater filter installed in the Bartlett Street stormwater system, and both temporary and long term BMPs are starting to be used on a regular basis on road and construction projects throughout the area. In addition, the Homer community finds Inletkeeper's citizens' monitoring program invaluable for collecting baseline data on local waterbodies.

But we still have a long way to go. In many ways, the road construction monitoring efforts on the East End Road and Bartlett/Hohe Street construction projects have been a shotgun approach. Planning has always been hurried and funds are not adequate to assess and monitor the projects (and in this case the stormwater filter) properly. Local, state and federal governments and non-governmental organizations should continue to work together to utilize all Best Management Practices to mitigate and reduce stormwater runoff into our streams and Kachemak Bay, and make a greater commitment to the time and financial resources necessary to make such projects successful.

With the newly installed stormwater filter, monitoring will be needed to determine whether the unit is functioning properly. With the increasing population, support and collaboration with Inletkeeper's CEMP program to assess local waterbody conditions becomes increasingly important. Monitoring is an ongoing process that provides us with the information that we need to know to answer these questions: What are the natural conditions of our local waterbodies? Are we polluting our waterbodies with our daily activities? If so, what are the pollutants of concern? What BMPs can we deploy to stop or mitigate these pollutants? Are the BMPs working? In this day and age, we should make monitoring our waterbodies a required public necessity like snowplowing and filling potholes.

As the communities of Homer and Kachemak Bay grow, so will they experience increased urban runoff. Considering the trends, it seems prudent that local, state and federal governments work together to utilize all Best Management Practices to mitigate and reduce stormwater runoff during growth, and the construction that comes with growth. We all should strive to protect a vital water resource like Kachemak Bay and we should not take little streams such as Woodard Creek for granted.

## **RECOMMENDATIONS FOR FUTURE STORMWATER MANAGEMENT**

Monitoring and managing stormwater can be challenging and expensive. Lack of equipment, time, personnel, and funds limited the ability to collect adequate data to assess the effectiveness of this newly installed filter. Studies in Seattle, WA and Portland, OR collected flow-weighted composite samples using one Isco 6700 automated sampler for the influent and two Isco 6700 automated samplers for the two effluent samples. The influent sampler and a primary effluent sampler were automatically triggered to collect samples based on flow volumes measured in the respective P-B flumes. The second effluent sampler was linked to the primary sampler using an Isco SPA 1026 cable which would trigger the second sampler to collect a sample simultaneously with the primary sampler (Milesi et al., 2006). Similar equipment needs to be used to assess the effectiveness of this and other filters installed.

Also, all storm events need to be sampled. It is recommended that this equipment and the necessary funds are put forth towards future monitoring efforts. Costs could be shared and kept down through collaboration with local, state and federal governments and local monitoring programs. Funds could be used more efficiently if these entities collaborated

to develop a Kachemak Bay Watershed Stormwater management plan. And finally adequate funds should be made available to provide for proper maintenance of the stormwater filter and stormwater systems.



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**Appendix I: 18 AAC 70, Water Quality Standards, as amended through June 26, 2003 (ADEC 2003). Note: Standards were extracted for only the parameters measured.**

| <b>Water Uses</b>   | <b>Turbidity</b>   | <b>Water Temp.</b>   | <b>pH</b>   | <b>PETROLEUM<br/>HYDROCARBONS,<br/>OILS AND<br/>GREASE</b>   | <b>TOXIC AND<br/>OTHER<br/>DELETERIOUS<br/>ORGANIC AND<br/>INORGANIC<br/>SUBSTANCES,<br/>FOR FRESH<br/>WATER USES</b>   |
|---|--|--|---|--|---|
| (A) Water Supply<br>(i) drinking, culinary, and food processing                                   | May not exceed 5 nephelometric turbidity units (NTU) above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 25 NTU. | May not exceed 15o C.  | May not be less than 6.0 or greater than 8.5.   | May not cause a visible sheen upon the surface of the water. May not exceed concentrations that individually or in combination impart odor or taste as determined by organoleptic tests.   | The concentration of substances in water may not exceed the criteria shown in Table I and in Table V, column A of the <i>Alaska Water Quality Criteria Manual</i> (see note 5). |
| (A) Water Supply<br>(ii) agriculture, including irrigation and stock watering<br>(A) Water Supply | May not cause detrimental effects on indicated use.  | May not exceed 30o C.  | May not be less than 5.0 or greater than 9.0.   | May not cause a visible sheen upon the surface of the water.   | The concentration of substances in water may not exceed the criteria shown in Table I and in Table II of the <i>Alaska Water Quality Criteria Manual</i> (see note 5).          |
| (A) Water Supply<br>(iii) aquaculture   | May not exceed 25 NTU above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.  | May not exceed 20o C at any time. The following maximum temperatures may not be exceeded, where applicable: Migration routes 15° C<br>Spawning areas 13° C<br>Rearing areas 15° C<br>Egg & fry incubation 13°C<br>For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms. | May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions. | Total aqueous hydrocarbons (TAqH) in the water column may not exceed 15 µg/l (see note 7). Total aromatic hydrocarbons (TAH) in the water column may not exceed 10 µg/l (see note 7). There may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration. | Same as (11)(C).  |
| (A) Water Supply<br>(iv) industrial   | May not cause detrimental effects on established water supply treatment levels.  | May not exceed 25o C.  | May not be less than 5.0 or greater than 9.0.   | May not make the water unfit or unsafe for the use.  | Concentrations of substances that pose hazards to worker contact may not be present.  |

|   |   |                       |   |   |  |
|---|---|-----------------------|---|---|--|
| (B) Water Recreation<br>(i) contact recreation                                  | May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU. May not exceed 5 NTU above natural turbidity for all lake waters.            | Same as (10)(A)(ii).  | May not be less than 6.5 or greater than 8.5. If the natural condition pH is outside this range, substances may not be added that cause an increase in the buffering capacity of the water. | May not cause a film, sheen, or discoloration on the surface or floor of the waterbody or adjoining shorelines. Surface waters must be virtually free from floating oils. | The concentration of substances in water may not exceed the criteria shown in Table I of the <i>Alaska Water Quality Criteria Manual</i> (see note 5).   |
| (B) Water Recreation<br>(ii) secondary recreation                               | May not exceed 10 NTU above natural conditions when natural turbidity is 50 NTU or less, and may not have more than 20% increase in turbidity when the natural turbidity is greater than 50 NTU, not to exceed a maximum increase of 15 NTU. For all lake waters, turbidity may not exceed 5 NTU above natural turbidity. | Not applicable.       | Same as (6)(A)(iv).   | Same as (5)(B)(i).  | Concentrations of substances that pose hazards to incidental human contact may not be present.   |
| (C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife | Same as (12)(A)(iii).   | Same as (10)(A)(iii). | May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.   | Same as (5)(A)(iii).  | The concentration of substances in water may not exceed the criteria shown in Table III and in Table V, column B of the <i>Alaska Water Quality Criteria Manual</i> (see note 5), or any chronic and acute criteria established in this chapter, for a toxic pollutant of concern to protect sensitive and biologically important life stages of resident species of this state. There may be no concentrations of toxic substances in water or in shoreline or bottom sediments, that, singly or in combination, cause, or reasonably can be expected to cause, adverse effects on aquatic life or produce undesirable or nuisance aquatic life, except as authorized by this chapter. Substances may not be present in concentrations that individually or in combination impart undesirable odor or taste to fish or other aquatic organisms, as determined by either bioassay or organoleptic tests. |

5. Wherever cite in this subsection, the *Alaska Water Quality Criteria Manual* means the *Alaska Water Quality Criteria for Toxic and Other Deleterious Organic and Inorganic Substances*, dated May 15, 2003, adopted by reference in this subsection.

7. Samples to determine concentrations of total aromatic hydrocarbons (TAH) and total aqueous hydrocarbons (TAqH) must be collected in marine and fresh waters below the surface and away from any observable sheen; concentrations of TAqH must be determined and summed using a combination of: (A) EPA Method 602 (plus xylenes) or EPA Method 624 to quantify monoaromatic hydrocarbons and to measure TAH; and (B) EPA Method 610 or EPA Method 625 to quantify polynuclear aromatic hydrocarbons listed in EPA Method 610; use of an alternative method requires department approval; the EPA methods referred to in this note may be found in 40 C.F.R. 136, Appendix A, as revised as of July 1, 2002 and adopted by reference.

**TABLE I. DRINKING WATER PRIMARY MAXIMUM CONTAMINANT LEVELS**

| <b>POLLUTANT<sub>1</sub></b>           | <b>CRITERIA<br/>(in mg/L unless shown otherwise)</b> |
|--|--|
| <b>Inorganic Chemical Contaminants</b> |  |
| Cadmium                                | 0.005  |
| Lead                                   | NA   |
| Zinc                                   | NA   |

**TABLE II. STOCKWATER AND IRRIGATION WATER CRITERIA**

| <b>POLLUTANT<sub>1</sub></b>           | <b>IRRIGATION WATER<sub>2</sub><br/>(for waters used continuously on all soil)<br/>(mg/L)</b> |
|--|---|
| <b>Inorganic Chemical Contaminants</b> |   |
| Cadmium                                | 0.010   |
| Lead                                   | 5.0   |
| Zinc                                   | 2.0   |

**TABLE III. AQUATIC LIFE CRITERIA FOR FRESH WATERS**Department of Environmental Conservation *Alaska Water Quality Criteria Manual for Toxic And Other Deleterious Organic and Inorganic Substances*

| <b>POLLUTANT</b><br>Calculated criteria are rounded to two significant figures. CAS number is shown under each pollutant when one is available. | <b>AQUATIC LIFE FRESH WATER ACUTE</b><br>(in µg/L unless shown otherwise)   | <b>AQUATIC LIFE FRESH WATER CHRONIC</b><br>(in µg/L unless shown otherwise)  | <b>REFERENCES</b><br>References are shown so the user can look up information on the criteria. These documents are not adopted by reference.   |
|---|---|--|--|
| 26. Lead 7439921<br>The criteria are in the dissolved form. Total recoverable criteria are shown for calculation purposes only.                 | The criterion is hardness <sup>14</sup> dependent. <sup>36</sup> The criterion formula is $e^{1.273(\ln \text{hardness})} - 1.460$ (one-hour average) <sup>6</sup> <i>total recoverable</i>   | The criterion is hardness <sup>14</sup> dependent. <sup>37</sup> The criterion formula is $e^{1.273(\ln \text{hardness})} - 4.705$ (four-day average) <sup>7</sup> <i>total recoverable</i>  | <ul style="list-style-type: none"> <li>• EPA, 1985, <i>Ambient Water Quality Criteria For Lead-1984</i>, EPA 440/5-84-027</li> <li>• National Toxics Rule2, 57 FR 60848</li> </ul>         |
| 8. Cadmium 7440439<br>The criteria are in the dissolved form. Total recoverable criteria are shown for calculation purposes only.               | The criterion is hardness <sup>14</sup> dependent. The criterion formula <sup>15</sup> is $e^{1.0166(\ln \text{hardness})} - 3.924$ (one-hour average) <sup>6</sup> <i>total recoverable</i> The conversion factor is hardness <sup>14</sup> dependent. For cadmium and lead, water hardness mediates the conversion factor. The conversion factor formula <sup>7</sup> is $1.136672 - [(\ln \text{hardness})(0.041838)]$ To calculate the dissolved criterion, multiply the total recoverable criterion by the conversion factor. <sup>18</sup> (one-hour average) <sup>6</sup> <i>dissolved</i> | The criterion is hardness <sup>14</sup> dependent. The criterion formula <sup>16</sup> is $e^{0.7409(\ln \text{hardness})} - 4.719$ (four-day average) <sup>7</sup> <i>total recoverable</i> The conversion factor is hardness <sup>14</sup> dependent. For cadmium and lead, water hardness mediates the conversion factor. The conversion factor formula <sup>19</sup> is $1.101672 - [(\ln \text{hardness})(0.041838)]$ To calculate the dissolved criterion, multiply the total recoverable criterion by the conversion factor. <sup>20</sup> (four-day average) <sup>7</sup> <i>dissolved</i> | <ul style="list-style-type: none"> <li>• EPA, 2001, <i>2001 Update of Ambient Water Quality Criteria for Cadmium</i>, EPA 822-R-01-001</li> </ul>  |
| 40. Zinc 7440666<br>The criteria are in the dissolved form. Total recoverable criteria are shown for calculation purposes only.                 | The criterion is hardness <sup>14</sup> dependent. The criterion formula <sup>35</sup> is $e^{0.8473(\ln \text{hardness})} + 0.884$ (one-hour average) <sup>6</sup> <i>total recoverable</i>  | The criterion is hardness <sup>14</sup> dependent. The criterion formula <sup>36</sup> is $e^{0.8473(\ln \text{hardness})} + 0.884$ (four-day average) <sup>7</sup> <i>total recoverable</i>   | <ul style="list-style-type: none"> <li>• EPA, 1996, 1995 Updates: <i>Water Quality Criteria Documents For The Protection Of Aquatic Life In Ambient Water</i>, EPA-820-B-96-001</li> </ul> |

**TABLE V. HUMAN HEALTH CRITERIA FOR NONCARCINOGENS**

| <b>POLLUTANT</b><br>CAS number is shown under<br>each<br>pollutant when one is available. | <b>Human Health Criteria for<br/> Consumption of:</b>        |  | <b>REFERENCES</b><br>References are shown so the user<br>can look up information on the<br>criteria. These documents are not<br>adopted by reference.   |
|---|--|--|---|
|   | <b>Water +Aquatic organisms</b><br>(µg/L)<br><b>Column A</b> | <b>Aquatic Organisms Only</b><br>(µg/L)<br><b>Column B</b> |   |
| Cadmium   | NA   | NA   |   |
| Lead  | NA   | NA   |   |
| Zinc 7440666  | 9,100  | 69,000   | <ul style="list-style-type: none"> <li>• Integrated Risk Information System, 10/01/92</li> <li>• EPA, 1999 <i>National Recommended Water Quality Criteria-Correction</i>, EPA 822-Z-99-001</li> </ul> |

## Appendix II: Data Quality Objectives

| Parameter            | Matrix         | Method   | Range   | Units                               | Method Detection Limit (Sensitivity)  | Precision  | Accuracy   | Calibration Method  | Preservation   | Minimum Volume/ Container | Maximum Storage Recommended/ Regulatory | Collection and Preservation Source     |
|----------------------|----------------|--|---|-------------------------------------|---|--|--|---|--|---------------------------|---|--|
| Flow                 | Water          | Global Flow Probe FP-101 & FP-201                        | 0.3 to 25 (feet per second)<br>0.1 to 8 (meters per second)               | fps/mps                             | 0.1 fps<br>0.1 mps  | NA   | 0.1 fps  | Computer calibration & Mechanical friction calibration of propeller bushing | NA   | NA                        | NA                                      | NA                                     |
| Habitat              | Stream Habitat | Photo Documentation using a Sony DSC-F707 Digital Camera | NA  | NA                                  | NA  | NA   | NA   | NA  | NA   | NA                        | NA                                      | NA                                     |
| pH                   | Water          | SM 4500-H+ using a YSI 63 meter                          | 0 to 14   | pH units                            | 0.01  | NA   | 0.1 unit within 10°C of calibration, +0.2 unit within 20°C | Two Buffer Calibration  | Analyze Immediately  | 50 ml/ P,G                | 2 hours/Analyze Immediately             | Standard Methods 19th Edition, 1060 B. |
| Specific Conductance | Water          | SM 2510 B using a YSI 63 meter                           | 0 to 499.9 S/cm<br>0 to 4999 S/cm<br>0 to 49.99 mS/cm<br>0 to 200.0 mS/cm | S/cm<br>mS/cm                       | 0.1 S/cm<br>1 S/cm<br>0.01 mS/cm<br>0.1 mS/cm   | NA   | ±0.5% FS of reading +0.001 mS/cm                           | Standard Solutions Method   | Refrigerate @4°C   | 500 ml/P,G                | 28 days/28 days                         | Standard Methods 19th Edition, 1060 B. |
| Temperature          | Water          | SM 2550 B using a YSI 63 meter                           | -5 to +75   | °C                                  | 0.1   | NA   | ±0.15°C ±1lsd  | NIST Certified Thermometer  | Analyze Immediately  | P,G                       | Analyze Immediately                     | Standard Methods 19th Edition, 1060 B. |
| Turbidity            | Water          | SM 2130 B LaMotte 2020 Turbidimeter                      | 0.00 to 1100  | Nephelometric Turbidity Units (NTU) | NTU Report to Nearest:<br>0 to 1.0 then<br>0.05 NTU<br>10 to 40 then<br>1 NTU<br>40 to 100 then<br>5 NTU<br>100 to 400 then<br>10 NTU<br>400 to 1000 then<br>50 NTU<br>1000 then<br>100 NTU | +2% for readings below 100 NTU ±3% above 100 NTU | +2% for readings below 100 NTU ±3% above 100 NTU           | Standard Solutions (NTU)  | Analyze same day, store in dark up to 24 hours, Refrigerate @4°C | 100 ml/ P,G               | 24 hours/ 48 hours                      | Standard Methods 19th Edition, 1060 B. |
| Settleable Solids    | Water          | APHA 2540 F  | 0.1 to 1000 ml  | ml/L                                | 0.1   | NA   | NA   | NA  |  | 1 L                       |   |  |



Appendix III: Laboratory data<sup>1</sup> summary from samples collected at BA-3 and BA-3u on 10/04/2005, 12/07/2005, and 06/16/2006.

|         |           | 160.2 - Residue, Gravimetric, Non-filterable, 105°C - TSS<br>Total Suspended Solids (mg/L) | 200.8 - Metals by ICP/MS - Total/TR |             |             | 1664- Oil and Grease<br>Extractable Material (mg/l) | 625 - Base-Neutrals and Acids by GC/MS-PAH |                       |                   |                           |                       |                             |                             |                             |                 |                               |                     |                 |                               |                    |                     |               |  |
|---------|-----------|--|-------------------------------------|-------------|-------------|---|--|-----------------------|-------------------|---------------------------|-----------------------|-----------------------------|-----------------------------|-----------------------------|-----------------|-------------------------------|---------------------|-----------------|-------------------------------|--------------------|---------------------|---------------|--|
|         |           |  |                                     |             |             |   | Results                                    |                       |                   |                           |                       |                             |                             |                             |                 |                               |                     |                 |                               |                    |                     |               |  |
|         |           |  |                                     |             |             |   |  |                       |                   |                           |                       |                             |                             |                             |                 |                               |                     |                 |                               |                    |                     |               |  |
|         |           |  | Cadmium (mg/L)                      | Lead (mg/L) | Zinc (mg/L) |   | Acenaphthene (µg/L)                        | Acenaphthylene (µg/L) | Anthracene (µg/L) | Benzo(a)anthracene (µg/L) | Benzo(a)pyrene (µg/L) | Benzo(b)fluoranthene (µg/L) | Benzo(g,h,i)perylene (µg/L) | Benzo(k)fluoranthene (µg/L) | Chrysene (µg/L) | Dibenzo(a,h)anthracene (µg/L) | Fluoranthene (µg/L) | Fluorene (µg/L) | Indeno(1,2,3-cd)pyrene (µg/L) | Naphthalene (µg/L) | Phenanthrene (µg/L) | Pyrene (µg/L) |  |
|         | MDL       | 2.50   | 0.00060                             | 0.00030     | 0.00080     | 1.0   | 0.45                                       | 0.51                  | 0.44              | 0.33                      | 0.26                  | 0.29                        | 0.39                        | 0.38                        | 0.20            | 0.34                          | 0.51                | 0.47            | 0.22                          | 0.62               | 0.43                | 0.40          |  |
|         | PQL       | 5.0  | 0.0020                              | 0.0010      | 0.0025      | 2.2   | 5.0  | 5.0                   | 5.0               | 5.0                       | 5.0                   | 5.0                         | 5.0                         | 5.0                         | 5.0             | 5.0                           | 5.0                 | 5.0             | 5.0                           | 10                 | 5.0                 | 5.0           |  |
| Site ID | Date      |  |                                     |             |             |   |  |                       |                   |                           |                       |                             |                             |                             |                 |                               |                     |                 |                               |                    |                     |               |  |
| BA-3u   | 10/4/2005 | 7.00   | ND                                  | 0.00494     | 3.97        | ND  | ND   | ND                    | ND                | ND                        | ND                    | ND                          | ND                          | ND                          | ND              | ND                            | ND                  | ND              | ND                            | ND                 | ND                  | ND            |  |
|         | MDL       | 5.0  | 0.00060                             | 0.00030     | 0.00080     | 0.95  | 0.45                                       | 0.51                  | 0.44              | 0.33                      | 0.26                  | 0.29                        | 0.39                        | 0.38                        | 0.20            | 0.34                          | 0.51                | 0.48            | 0.22                          | 0.62               | 0.43                | 0.40          |  |
|         | PQL       | 10   | 0.0020                              | 0.0010      | 0.0025      | 2.0   | 5.0  | 5.0                   | 5.0               | 5.0                       | 5.0                   | 5.0                         | 5.0                         | 5.0                         | 5.0             | 5.0                           | 5.0                 | 5.0             | 5.0                           | 10                 | 5.0                 | 5.0           |  |
| Site ID | Date      |  |                                     |             |             |   |  |                       |                   |                           |                       |                             |                             |                             |                 |                               |                     |                 |                               |                    |                     |               |  |
| BA-3u   | 12/7/2005 | 75.0   | ND                                  | 0.00947     | 0.4190      | ND  | ND   | ND                    | ND                | ND                        | ND                    | ND                          | ND                          | ND                          | ND              | ND                            | ND                  | ND              | ND                            | ND                 | ND                  | ND            |  |
|         | MDL       | 6.7  | 0.00062                             | 0.00030     | 0.00084     | 1.6   | 0.47                                       | 0.54                  | 0.46              | 0.35                      | 0.27                  | 0.30                        | 0.41                        | 0.40                        | 0.21            | 0.35                          | 0.53                | 0.50            | 0.24                          | 0.65               | 0.46                | 0.42          |  |
|         | PQL       | 13   | 0.0020                              | 0.0010      | 0.0025      | 5.4   | 5.3  | 5.3                   | 5.3               | 5.3                       | 5.3                   | 5.3                         | 5.3                         | 5.3                         | 5.3             | 5.3                           | 5.3                 | 5.3             | 5.3                           | 11                 | 5.3                 | 5.3           |  |
| Site ID | Date      |  |                                     |             |             |   |  |                       |                   |                           |                       |                             |                             |                             |                 |                               |                     |                 |                               |                    |                     |               |  |
| BA-3u   | 6/16/2006 | 429.0  | ND                                  | 0.05910     | 0.6020      | ND  | ND   | ND                    | ND                | ND                        | ND                    | ND                          | ND                          | ND                          | ND              | ND                            | ND                  | ND              | ND                            | ND                 | ND                  | ND            |  |
|         | MDL       | 2.50   | 0.00060                             | 0.00030     | 0.00080     | 1.1   | 0.50                                       | 0.57                  | 0.48              | 0.37                      | 0.29                  | 0.32                        | 0.43                        | 0.42                        | 0.22            | 0.37                          | 0.56                | 0.53            | 0.25                          | 0.69               | 0.48                | 0.44          |  |
|         | PQL       | 5.0  | 0.0020                              | 0.0010      | 0.0025      | 2.3   | 5.6  | 5.6                   | 5.6               | 5.6                       | 5.6                   | 5.6                         | 5.6                         | 5.6                         | 5.6             | 5.6                           | 5.6                 | 5.6             | 5.6                           | 11                 | 5.6                 | 5.6           |  |
| Site ID | Date      |  |                                     |             |             |   |  |                       |                   |                           |                       |                             |                             |                             |                 |                               |                     |                 |                               |                    |                     |               |  |
| BA-3    | 10/4/2005 | 7.00   | ND                                  | 0.00677     | 2.65        | ND  | ND   | ND                    | ND                | ND                        | ND                    | ND                          | ND                          | ND                          | ND              | ND                            | ND                  | ND              | ND                            | ND                 | ND                  | ND            |  |
|         | MDL       | 5.0  | 0.00060                             | 0.00030     | 0.00080     | 0.95  | 0.45                                       | 0.51                  | 0.44              | 0.33                      | 0.26                  | 0.29                        | 0.39                        | 0.38                        | 0.20            | 0.34                          | 0.51                | 0.48            | 0.22                          | 0.62               | 0.43                | 0.40          |  |
|         | PQL       | 10   | 0.0020                              | 0.0010      | 0.0025      | 2.0   | 5.0  | 5.0                   | 5.0               | 5.0                       | 5.0                   | 5.0                         | 5.0                         | 5.0                         | 5.0             | 5.0                           | 5.0                 | 5.0             | 5.0                           | 10                 | 5.0                 | 5.0           |  |
| Site ID | Date      |  |                                     |             |             |   |  |                       |                   |                           |                       |                             |                             |                             |                 |                               |                     |                 |                               |                    |                     |               |  |
| BA-3    | 12/7/2005 | 89.0   | ND                                  | 0.01040     | 0.4660      | ND  | ND   | ND                    | ND                | ND                        | ND                    | ND                          | ND                          | ND                          | ND              | ND                            | ND                  | ND              | ND                            | ND                 | ND                  | ND            |  |
|         | MDL       | 6.7  | 0.00062                             | 0.00030     | 0.00084     | 1.6   | 0.47                                       | 0.54                  | 0.46              | 0.35                      | 0.27                  | 0.30                        | 0.41                        | 0.40                        | 0.21            | 0.35                          | 0.53                | 0.50            | 0.24                          | 0.65               | 0.46                | 0.42          |  |
|         | PQL       | 13   | 0.0020                              | 0.0010      | 0.0025      | 5.4   | 5.3  | 5.3                   | 5.3               | 5.3                       | 5.3                   | 5.3                         | 5.3                         | 5.3                         | 5.3             | 5.3                           | 5.3                 | 5.3             | 5.3                           | 11                 | 5.3                 | 5.3           |  |
| Site ID | Date      |  |                                     |             |             |   |  |                       |                   |                           |                       |                             |                             |                             |                 |                               |                     |                 |                               |                    |                     |               |  |
| BA-3    | 6/16/2006 | 403.0  | ND                                  | 0.05300     | 0.6950      | ND  | ND   | ND                    | ND                | ND                        | ND                    | ND                          | ND                          | ND                          | ND              | ND                            | ND                  | ND              | ND                            | ND                 | ND                  | ND            |  |

Results

PQL = Method Quantitation Limit as defined by USACE

MDL = Method Detection Limit

ND = Not detected at or above the Reporting Limit. Reporting Limit is defined as: Limit below which results are shown as "ND". This may be the PQL, MDL, or value between. See the report conventions below.

<sup>1</sup> Samples analyzed by Analytica International, Inc. All quality assurance and quality controls measures for the sample handling, transportation and analysis were met. Detailed data reports are available upon request.

| Reporting Conventions                             |              |                                 |
|---|--------------|---------------------------------|
| Method  | # Sig. Figs. | Reporting Limit                 |
| 160.2 (Aqueous) -TSS                              | 3            | Report to PQL                   |
| 1664 (Aqueous) - Oil & Grease                     | 2            | Report to PQL                   |
| 200.8/200.8 Metals by ICP/MS (Aqueous) - Total/TR | 3            | Report to PQL                   |
| 625 (Aqueous) - PAH                               | 2            | Report to MDL, J qual below PQL |

## Appendix IV: Data Summary Tables for Discharge, Turbidity, Temperature, pH, and Specific Conductance

**Table 5: Calculated Discharge (cfs) Data Summary for All Sampling Events at Bartlett/Hohe Project Sites**

| Site       | BA-1 | BA-2 | BA-3 | BA-4 | BA-6 |
|------------|------|------|------|------|------|
| N          | 24   | 12   | 8    | 24   | 24   |
| Max        | 5.11 | 0.21 | 0.23 | 4.67 | 4.08 |
| Min        | 0.14 | 0.00 | 0.00 | 0.14 | 0.14 |
| Mean       | 1.44 | 0.06 | 0.08 | 1.32 | 1.22 |
| Median     | 0.95 | 0.03 | 0.08 | 0.92 | 0.87 |
| Stan. Dev. | 1.48 | 0.07 | 0.08 | 1.28 | 1.14 |

**Table 6: Turbidity (NTU) Data Summary for Bartlett/Hohe Project Sites collected from 4/12/05 to 6/16/06 and CEMP Sites KB-120, KB-150, and KB-180 collected from 10/01/02 to 5/18/06. Note: Data sets do not include the months Jan.-Mar.**

| Site ID    | KB-120 | BA-1   | BA-2   | BA-3    | BA-3u  | BA-4   | KB-150  | BA-6   | KB-180 |
|------------|--------|--------|--------|---------|--------|--------|---------|--------|--------|
| N          | 17     | 24     | 20     | 22      | 3      | 24     | 24      | 24     | 13     |
| Max        | 1395   | 1048   | 525.50 | 11175   | 962.50 | 732.50 | 2119.00 | 872.50 | 27.55  |
| Min        | 3.64   | 1.90   | 5.14   | 9.45    | 38.75  | 1.76   | 1.57    | 2.17   | 2.70   |
| Mean       | 139.65 | 182.75 | 101.82 | 763.24  | 377.42 | 147.61 | 112.83  | 163.62 | 9.97   |
| Median     | 8.30   | 14.78  | 39.60  | 92.10   | 131.00 | 14.53  | 6.21    | 18.20  | 5.63   |
| Stan. Dev. | 375.39 | 303.25 | 140.47 | 2359.87 | 508.79 | 228.11 | 435.73  | 263.02 | 7.88   |

**Table 7: Temperature (°C) Data Summary for Bartlett/Hohe Project Sites collected from 4/12/05 to 6/16/06 and CEMP Sites KB-120, KB-150, and KB-180 collected from 7/10/97 to 4/30/06. Note: Data sets do not include the months Jan.-Mar.**

| Site ID    | KB-120 | BA-1  | BA-2  | BA-3  | BA-4  | KB-150 | BA-6  | KB-180 |
|------------|--------|-------|-------|-------|-------|--------|-------|--------|
| N          | 41     | 24    | 12    | 12    | 24    | 49     | 24    | 52     |
| Max        | 18.50  | 14.60 | 12.40 | 12.70 | 16.00 | 18.30  | 15.00 | 14.50  |
| Min        | 0.90   | 0.30  | 0.30  | 0.80  | 0.10  | 0.50   | 0.20  | 0.00   |
| Mean       | 10.24  | 8.26  | 7.59  | 7.04  | 8.60  | 9.01   | 8.16  | 6.74   |
| Median     | 12.00  | 9.55  | 8.95  | 6.65  | 9.60  | 10.50  | 9.20  | 7.00   |
| Stan. Dev. | 4.91   | 4.36  | 4.80  | 4.79  | 4.41  | 4.93   | 4.29  | 3.89   |

**Table 8: pH Data Summary for Bartlett/Hohe Project Sites collected from 4/12/05 to 6/16/06 and CEMP Sites KB-120, KB-150, and KB-180 collected from 5/7/98 to 5/18/06. Note: Data sets do not include the months Jan.-Mar.**

| Site ID           | KB-120 | BA-1 | BA-2 | BA-3 | BA-4 | KB-150 | BA-6 | KB-180 |
|-------------------|--------|------|------|------|------|--------|------|--------|
| <b>N</b>          | 36     | 24   | 12   | 12   | 24   | 46     | 24   | 48     |
| <b>Max</b>        | 8.22   | 8.41 | 7.46 | 7.62 | 8.37 | 8.59   | 8.29 | 8.50   |
| <b>Min</b>        | 6.80   | 6.74 | 6.88 | 6.75 | 7.26 | 6.57   | 7.04 | 6.20   |
| <b>Mean</b>       | 7.54   | 7.64 | 7.22 | 7.14 | 7.76 | 7.64   | 7.74 | 7.51   |
| <b>Median</b>     | 7.57   | 7.63 | 7.24 | 7.17 | 7.72 | 7.80   | 7.68 | 7.56   |
| <b>Stan. Dev.</b> | 0.36   | 0.44 | 0.17 | 0.24 | 0.35 | 0.50   | 0.34 | 0.47   |

**Table 9: Specific Conductance ( $\mu\text{S}/\text{cm}$ )Data Summary for Bartlett/Hohe Project Sites collected from 4/12/05 to 6/16/06 and CEMP Sites KB-120, KB-150, and KB-180 collected from 7/10/97 to 5/18/06. Note: Data sets do not include the months Jan.-Mar.**

| Site ID           | KB-120 | BA-1   | BA-2   | BA-3   | BA-4   | KB-150 | BA-6   | KB-180 |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>N</b>          | 36     | 24     | 12     | 12     | 24     | 47     | 24     | 48     |
| <b>Max</b>        | 379.00 | 221.40 | 179.15 | 426.94 | 222.70 | 428.00 | 215.40 | 365.00 |
| <b>Min</b>        | 62.00  | 100.00 | 68.80  | 2.25   | 96.70  | 15.50  | 87.85  | 19.00  |
| <b>Mean</b>       | 170.98 | 157.46 | 124.48 | 223.11 | 155.21 | 158.69 | 141.50 | 136.02 |
| <b>Median</b>     | 166.00 | 144.60 | 128.54 | 247.95 | 146.13 | 149.00 | 129.08 | 127.50 |
| <b>Stan. Dev.</b> | 77.03  | 39.13  | 35.51  | 139.28 | 37.86  | 86.95  | 36.82  | 70.63  |

**Appendix V: Discharge (cfs) measurements taken at monitoring sites during the Bartlett/Hohe Street construction project in 2005 and 2006.**

|           | BA-1                                | BA-2  | BA-3  | BA-3u <sup>1</sup>  | BA-4                         | BA-5 <sup>2</sup>               | BA-6                                      |   |
|-----------|-------------------------------------|---|---|---|------------------------------|---------------------------------|---|---|
| Date      | Woodard Creek Outflow Below Pioneer | Pioneer Ave. Stormwater Culvert in Manhole @ Pioneer Ave. | Bartlett St. Stormwater Culvert in Manhole @ Pioneer Ave. | Bartlett St. Stormwater Culvert in Manhole above Stormwater Filter @ Bartlett St. | Woodard Creek @ Pratt Museum | Woodard Creek @ Spruceview Ave. | Woodard Creek Below Hospital Outflow Pipe | Comments  |
| 4/12/2005 | 1.71                                | 0.03  |   |   | 1.63                         | 1.60                            | 1.48                                      | Not enough flow in the Bartlett pipe to take a discharge measurement.   |
| 4/19/2005 | 1.81                                |   |   |   | 1.73                         | 1.71                            | 1.76                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 4/26/2005 | 1.80                                | 0.02  |   |   | 1.68                         | 1.77                            | 1.44                                      | Not enough flow in the Bartlett pipe to take a discharge measurement.   |
| 5/3/2005  | 0.86                                |   |   |   | 0.77                         | 1.01                            | 0.77                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 5/17/2005 | 0.45                                |   |   |   | 0.41                         |                                 | 0.42                                      | Manhole under construction, unable to collect samples from Bartlett of Pioneer pipes. No longer sampling at Spruceview Ave. |
| 5/31/2005 | 0.34                                |   |   |   | 0.32                         |                                 | 0.31                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 6/14/2005 | 0.35                                |   |   |   | 0.31                         |                                 | 0.23                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 6/28/2005 | 0.19                                |   |   |   | 0.17                         |                                 | 0.20                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 7/12/2005 | 0.14                                |   |   |   | 0.16                         |                                 | 0.16                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 7/26/2005 | 0.16                                |   |   |   | 0.15                         |                                 | 0.15                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 8/9/2005  | 0.15                                |   |   |   | 0.14                         |                                 | 0.14                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 8/23/2005 | 0.15                                |   |   |   | 0.18                         |                                 | 0.17                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 9/6/2005  | 2.32                                | 0.04  | 0.07  |   | 1.72                         |                                 | 1.71                                      | Rain event - precipitation 0.98 in 24-hours prior to sampling.  |
| 9/9/2005  | 4.13                                | 0.03  | 0.02  |   | 3.55                         |                                 | 2.75                                      | Rain event - precipitation 0.62 in 24-hours prior to sampling.  |
| 9/16/2005 | 5.11                                | 0.21  | 0.23  |   | 4.10                         |                                 | 3.67                                      | Rain event - precipitation 0.81 in 24-hours prior to sampling.  |
| 9/20/2005 | 0.36                                |   |   |   | 0.38                         |                                 | 0.32                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 10/4/2005 | 0.70                                |   |   |   | 0.56                         |                                 | 0.56                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a discharge measurement.                                   |
| 12/7/2005 | 1.67                                | 0.14  | 0.14  |   | 1.74                         |                                 | 1.63                                      | Rain/snow event - precipitation 0.12 in on existing snow 24-hours prior to sampling.  |
| 12/9/2005 | 5.06                                | 0.15  | 0.09  |   | 4.67                         |                                 | 4.08                                      | Rain/snow event - precipitation 0.21 in on existing snow 24-hours prior to sampling.  |
| 4/27/2006 | 1.78                                | 0.01  | 0.01  |   | 1.89                         |                                 | 1.72                                      |   |
| 5/4/2006  | 2.31                                | 0.04  | 0.00  |   | 2.30                         |                                 | 2.83                                      |   |
| 5/19/2006 | 1.04                                | 0.00  |   |   | 1.34                         |                                 | 0.97                                      | Not enough flow in the Bartlett pipe to take a discharge measurement.   |
| 5/25/2006 | 0.79                                | 0.00  |   |   | 0.71                         |                                 | 0.71                                      | Not enough flow in the Bartlett pipe to take a discharge measurement.   |
| 6/16/2006 | 1.16                                | 0.08  | 0.11  | 0.16  | 1.08                         |                                 | 1.02                                      | Rain Event - precipitation 0.21 in. 24-hours prior to sampling.   |

<sup>1</sup> Site was monitored on 10/4/2005, 12/7/2005, and 6/16/2006 only.

<sup>2</sup> Site was not monitored after 5/3/2005.

**Appendix VI: Turbidity (NTU) measurements taken at monitoring sites during the Bartlett/Hohe Street construction project in 2005 and 2006.**

| Date      | BA-1<br>Woodard<br>Creek Outflow<br>Below Pioneer | BA-2<br>Pioneer Ave.<br>Stormwater<br>Culvert in<br>Manhole @<br>Pioneer Ave. | BA-3<br>Bartlett St.<br>Stormwater<br>Culvert in<br>Manhole @<br>Pioneer Ave. | BA-3u <sup>1</sup><br>Bartlett St.<br>Stormwater<br>Culvert in<br>Manhole<br>above<br>Stormwater<br>Filter @<br>Bartlett St. | BA-4<br>Woodard<br>Creek @ Pratt<br>Museum | BA-5 <sup>2</sup><br>Woodard<br>Creek @<br>Spruceview<br>Ave. | BA-6<br>Woodard<br>Creek Below<br>Hospital<br>Outflow Pipe | Comments   |
|-----------|---|---|---|--|--|---|--|--|
| 4/12/2005 | 40.8  | 82.6  | 42.65   |  | 57.2                                       | 65.9  | 106.2  |  |
| 4/19/2005 | 145   | 244   | 117   |  | 173  | 196   | 321  |  |
| 4/26/2005 | 130   | 38.3  | 11175   |  | 74.4                                       | 75.5  | 77.0   |  |
| 5/3/2005  | 10.74   | 51.6  | 539   |  | 13.1                                       | 12.8  | 12.7   |  |
| 5/17/2005 | 4.47  |   |   |  | 3.84                                       |   | 4.24   | Manhole under construction, unable to collect samples from Bartlett of Pioneer pipes. No longer sampling at Spruceview Ave.  |
| 5/31/2005 | 2.15  | 7.75  | 9.45  |  | 1.93                                       |   | 2.45   | Unable to access the manhole on 5/31/05, samples collected from Bartlett and Pioneer pipes on 6/1/05.  |
| 6/14/2005 | 2.49  |   | 157   |  | 1.78                                       |   | 2.17   | Unable to access the manhole on 6/14/05, sample collected from the Bartlett pipe on 6/16/05. Pioneer pipe was dry, no sample collected.                                      |
| 6/28/2005 | 2.75  | 27.7  | 18.2  |  | 2.47                                       |   | 8.61   |  |
| 7/12/2005 | 2.08  |   |   |  | 2.41                                       |   | 2.41   | Not enough flow in the Bartlett pipe or the Pioneer pipe to collect a turbidity sample.  |
| 7/26/2005 | 3.32  | 33.3  | 13.2  |  | 2.35                                       |   | 2.23   |  |
| 8/9/2005  | 1.90  |   | 17.9  |  | 2.11                                       |   | 2.66   | Not enough flow in the Pioneer pipe to collect a turbidity sample.   |
| 8/23/2005 | 3.87  | 25.2  | 73.7  |  | 1.76                                       |   | 3.95   |  |
| 9/6/2005  | 645   | 116   | 1052  |  | 409  |   | 386  | Rain event - precipitation 0.98 in. 24-hours prior to sampling. The sample collected from the Bartlett pipe was out of range, sample diluted.                                |
| 9/9/2005  | 1048  | 96.6  | 1463  |  | 733  |   | 873  | Rain event - precipitation 0.62 in. 24-hours prior to sampling. The samples collected from the Bartlett pipe, Pratt Museum, and Hospital were out of range, samples diluted. |
| 9/16/2005 | 879   | 349   | 452   |  | 597  |   | 615  | Rain event - precipitation 0.81 in. 24-hours prior to sampling. The samples collected from the Bartlett pipe, Pratt Museum, and Hospital were out of range, samples diluted. |
| 9/20/2005 | 4.23  | 5.26  | 18.9  |  | 4.71                                       |   | 3.65   |  |
| 10/4/2005 | 6.68  | 7.95  | 39.3  | 38.8   | 4.03                                       |   | 3.81   |  |
| 12/7/2005 | 101.7   | 41.0  | 145   | 131  | 82.8                                       |   | 66.4   | Rain/snow event - precipitation 0.12 in on existing snow 24-hours prior to sampling.   |
| 12/9/2005 | 575   | 63.5  | 323   |  | 560  |   | 532  | Rain/snow event - precipitation 0.21 in on existing snow 24-hours prior to sampling.   |
| 4/27/2006 | 52.4  | 25.0  | 12.3  |  | 52.7                                       |   | 45.4   |  |
| 5/4/2006  | 301   | 287   | 111   |  | 484  |   | 726  |  |
| 5/19/2006 | 15.1  | 5.14  | 24.8  |  | 14.2                                       |   | 21.9   |  |
| 5/25/2006 | 14.5  | 5.42  | 12.1  |  | 14.9                                       |   | 14.6   |  |
| 6/16/2006 | 396   | 526   | 979   | 963  | 252  |   | 96.5   | Rain Event - precipitation 0.21 in. 24-hours prior to sampling.  |

<sup>1</sup> Site was monitored on 10/4/2005, 12/7/2005, and 6/16/2006 only.

<sup>2</sup> Site was not monitored after 5/3/2005.

Appendix VII: Temperature (°C) measurements taken at monitoring sites during the Bartlett/Hohe Street construction project in 2005 and 2006.

|           | BA-1                                | BA-2  | BA-3  | BA-3u <sup>1</sup>  | BA-4                         | BA-5 <sup>2</sup>               | BA-6                                      |  |
|-----------|-------------------------------------|---|---|---|------------------------------|---------------------------------|---|--|
| Date      | Woodard Creek Outflow Below Pioneer | Pioneer Ave. Stormwater Culvert in Manhole @ Pioneer Ave. | Bartlett St. Stormwater Culvert in Manhole @ Pioneer Ave. | Bartlett St. Stormwater Culvert in Manhole above Stormwater Filter @ Bartlett St. | Woodard Creek @ Pratt Museum | Woodard Creek @ Spruceview Ave. | Woodard Creek Below Hospital Outflow Pipe | Comments   |
| 4/12/2005 | 2.7                                 | 3.1   | 2.5   |   | 3.5                          | 3.9                             | 2.8                                       |  |
| 4/19/2005 | 3.9                                 | 5.1   | 4.9   |   | 4.4                          | 4.8                             | 4.5                                       |  |
| 4/26/2005 | 9.5                                 | 12.4  | 11.1  |   | 10.0                         | 10.1                            | 9.1                                       |  |
| 5/3/2005  | 6.7                                 | 9.8   | 8.4   |   | 7.3                          | 7.3                             | 6.7                                       |  |
| 5/17/2005 | 10.8                                |   |   |   | 10.7                         |                                 | 9.6                                       | Manhole under construction, unable to collect samples from Bartlett of Pioneer pipes. No longer sampling at Spruceview Ave.      |
| 5/31/2005 | 10.7                                |   |   |   | 11.6                         |                                 | 10.8                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 6/14/2005 | 12.5                                |   |   |   | 13.7                         |                                 | 13.0                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 6/28/2005 | 14.6                                |   |   |   | 16.0                         |                                 | 15.0                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 7/12/2005 | 13.0                                |   |   |   | 12.8                         |                                 | 12.4                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 7/26/2005 | 12.8                                |   |   |   | 12.9                         |                                 | 12.4                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 8/9/2005  | 13.8                                |   |   |   | 14.6                         |                                 | 14.6                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 8/23/2005 | 12.2                                |   |   |   | 12.0                         |                                 | 11.5                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 9/6/2005  | 10.7                                | 12.4  | 12.5  |   | 10.3                         |                                 | 10.2                                      | Rain event - precipitation 0.98 in 24-hours prior to sampling.   |
| 9/9/2005  | 10.9                                | 12.1  | 12.7  |   | 10.4                         |                                 | 10.0                                      | Rain event - precipitation 0.62 in 24-hours prior to sampling.   |
| 9/16/2005 | 10.3                                | 11.8  | 12.2  |   | 10.0                         |                                 | 9.6                                       | Rain event - precipitation 0.81 in 24-hours prior to sampling.   |
| 9/20/2005 | 8.7                                 |   |   |   | 9.0                          |                                 | 9.3                                       | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 10/4/2005 | 7.2                                 |   |   |   | 7.1                          |                                 | 6.9                                       | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 12/7/2005 | 0.3                                 | 0.3   | 0.8   |   | 0.1                          |                                 | 0.3                                       | Rain/snow event - precipitation 0.12 in on existing snow 24-hours prior to sampling. Temperature measurement not taken on Ba-3u. |
| 12/9/2005 | 0.4                                 | 0.8   | 1.1   |   | 0.3                          |                                 | 0.2                                       | Rain/snow event - precipitation 0.21 in on existing snow 24-hours prior to sampling.   |
| 4/27/2006 | 2.0                                 | 3.2   | 2.7   |   | 2.4                          |                                 | 2.0                                       |  |
| 5/4/2006  | 4.0                                 | 8.1   | 4.2   |   | 4.8                          |                                 | 3.9                                       |  |
| 5/19/2006 | 3.7                                 |   |   |   | 4.5                          |                                 | 4.1                                       | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 5/25/2006 | 7.3                                 |   |   |   | 8.7                          |                                 | 8.4                                       | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a water temperature measurement.                                |
| 6/16/2006 | 9.6                                 | 12.0  | 11.4  | 11.5  | 9.2                          |                                 | 8.6                                       | Rain Event - precipitation 0.21 in. from 4:30 am - 12:30 pm  |

<sup>1</sup> Site was monitored on 10/4/2005, 12/7/2005, and 6/16/2006 only.

<sup>2</sup> Site was not monitored after 5/3/2005.

**Appendix VIII: pH measurements taken at monitoring sites during the Bartlett/Hohe Street construction project in 2005 and 2006.**

|           | BA-1                                | BA-2  | BA-3  | BA-3u <sup>1</sup>  | BA-4                         | BA-5 <sup>2</sup>               | BA-6                                      |   |
|-----------|-------------------------------------|---|---|---|------------------------------|---------------------------------|---|---|
| Date      | Woodard Creek Outflow Below Pioneer | Pioneer Ave. Stormwater Culvert in Manhole @ Pioneer Ave. | Bartlett St. Stormwater Culvert in Manhole @ Pioneer Ave. | Bartlett St. Stormwater Culvert in Manhole above Stormwater Filter @ Bartlett St. | Woodard Creek @ Pratt Museum | Woodard Creek @ Spruceview Ave. | Woodard Creek Below Hospital Outflow Pipe | Comments  |
| 4/12/2005 | 7.60                                | 7.23  | 7.31  |   | 7.50                         | 7.56                            | 7.54                                      |   |
| 4/19/2005 | 7.55                                | 7.00  | 6.92  |   | 7.60                         | 7.61                            | 7.48                                      |   |
| 4/26/2005 | 7.51                                | 7.38  | 7.21  |   | 7.57                         | 7.62                            | 7.49                                      |   |
| 5/3/2005  | 7.73                                | 7.42  | 7.62  |   | 7.52                         | 7.47                            | 7.56                                      |   |
| 5/17/2005 | 7.84                                |   |   |   | 7.92                         |                                 | 7.79                                      | Manhole under construction, unable to collect samples from Bartlett of Pioneer pipes. No longer sampling at Spruceview Ave. |
| 5/31/2005 | 7.77                                |   |   |   | 8.06                         |                                 | 7.97                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 6/14/2005 | 7.98                                |   |   |   | 8.17                         |                                 | 8.12                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 6/28/2005 | 8.41                                |   |   |   | 8.37                         |                                 | 8.22                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 7/12/2005 | 8.09                                |   |   |   | 8.15                         |                                 | 8.10                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 7/26/2005 | 8.24                                |   |   |   | 8.28                         |                                 | 8.29                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 8/9/2005  | 8.19                                |   |   |   | 8.21                         |                                 | 8.20                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 8/23/2005 | 8.14                                |   |   |   | 8.16                         |                                 | 8.18                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 9/6/2005  | 7.52                                | 7.25  | 6.94  |   | 7.44                         |                                 | 7.46                                      | Rain event - precipitation 0.98 in 24-hours prior to sampling.  |
| 9/9/2005  | 7.52                                | 7.46  | 7.43  |   | 7.82                         |                                 | 7.74                                      | Rain event - precipitation 0.62 in 24-hours prior to sampling.  |
| 9/16/2005 | 7.12                                | 6.88  | 6.97  |   | 7.26                         |                                 | 7.41                                      | Rain event - precipitation 0.81 in 24-hours prior to sampling.  |
| 9/20/2005 | 8.01                                |   |   |   | 8.01                         |                                 | 8.06                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 10/4/2005 | 7.88                                |   |   |   | 7.80                         |                                 | 7.88                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 12/7/2005 | 7.14                                | 7.11  | 6.75  |   | 7.31                         |                                 | 7.38                                      | Rain/snow event - precipitation 0.12 in on existing snow 24-hours prior to sampling. pH measurement not taken on BA-3u.     |
| 12/9/2005 | 6.83                                | 7.21  | 7.03  |   | 7.34                         |                                 | 7.38                                      | Rain/snow event - precipitation 0.21 in on existing snow 24-hours prior to sampling.  |
| 4/27/2006 | 7.44                                | 7.27  | 7.16  |   | 7.66                         |                                 | 7.52                                      |   |
| 5/4/2006  | 6.74                                | 7.20  | 7.21  |   | 7.40                         |                                 | 7.04                                      |   |
| 5/19/2006 | 7.20                                |   |   |   | 7.51                         |                                 | 7.58                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 5/25/2006 | 7.39                                |   |   |   | 7.39                         |                                 | 7.63                                      | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a pH measurement.  |
| 6/16/2006 | 7.67                                | 7.28  | 7.19  | 6.57  | 7.79                         |                                 | 7.73                                      | Rain Event - precipitation 0.21 in. 24-hours prior to sampling.   |

<sup>1</sup> Site was monitored on 10/4/2005, 12/7/2005, and 6/16/2006 only.

<sup>2</sup> Site was not monitored after 5/3/2005.

Appendix IX: Specific Cond. ( $\mu\text{S}$  @ 25 °C) measurements taken at monitoring sites during the Bartlett/Hohe Street construction project in 2005 and 2006.

| Date      | BA-1<br>Woodard<br>Creek Outflow<br>Below Pioneer | BA-2<br>Pioneer Ave.<br>Stormwater<br>Culvert in<br>Manhole @<br>Pioneer Ave. | BA-3<br>Bartlett St.<br>Stormwater<br>Culvert in<br>Manhole @<br>Pioneer Ave. | BA-3u <sup>1</sup><br>Bartlett St.<br>Stormwater<br>Culvert in<br>Manhole<br>above<br>Stormwater<br>Filter @<br>Bartlett St. | BA-4<br>Woodard<br>Creek @<br>Pratt<br>Museum | BA-5 <sup>2</sup><br>Woodard<br>Creek @<br>Spruceview<br>Ave. | BA-6<br>Woodard<br>Creek Below<br>Hospital<br>Outflow Pipe | Comments  |
|-----------|---|---|---|--|---|---|--|---|
| 4/12/2005 | 124.2   | 138.8   | 241.4   |  | 120.5   | 118.4   | 106.7  |   |
| 4/19/2005 | 114.1   | 102.8   | 254.6   |  | 115.2   | 113.3   | 101.2  |   |
| 4/26/2005 | 121.1   | 123.1   | 264.5   |  | 120.8   | 119.3   | 108.7  |   |
| 5/3/2005  | 140.0   | 179.2   | 254.7   |  | 139.3   | 137.6   | 128.2  |   |
| 5/17/2005 | 149.2   |   |   |  | 149.3   |   | 138.4  | Manhole under construction, unable to collect samples from Bartlett of Pioneer pipes. No longer sampling at Spruceview Ave.       |
| 5/31/2005 | 169.3   |   |   |  | 170.0   |   | 159.6  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 6/14/2005 | 190.3   |   |   |  | 189.9   |   | 180.9  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 6/28/2005 | 190.2   |   |   |  | 155.2   |   | 173.6  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 7/12/2005 | 221.4   |   |   |  | 221.2   |   | 213.0  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 7/26/2005 | 214.3   |   |   |  | 215.1   |   | 166.3  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 8/9/2005  | 219.7   |   |   |  | 213.6   |   | 208.4  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 8/23/2005 | 219.7   |   |   |  | 222.7   |   | 215.4  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 9/6/2005  | 138.0   | 84.6  | 131.8   |  | 143.0   |   | 130.0  | Rain event - precipitation 0.98 in 24-hours prior to sampling.  |
| 9/9/2005  | 127.4   | 95.3  | 2.3   |  | 131.2   |   | 118.4  | Rain event - precipitation 0.62 in 24-hours prior to sampling.  |
| 9/16/2005 | 118.4   | 68.8  | 64.8  |  | 123.6   |   | 116.2  | Rain event - precipitation 0.81 in 24-hours prior to sampling.  |
| 9/20/2005 | 188.8   |   |   |  | 185.8   |   | 169.3  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 10/4/2005 | 165.2   |   |   |  | 164.2   |   | 149.5  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 12/7/2005 | 197.9   | 142.2   | 426.9   |  | 179.4   |   | 147.1  | Rain/snow event - precipitation 0.12 in on existing snow 24-hours prior to sampling. Conductivity measurement not taken on BA-3u. |
| 12/9/2005 | 124.3   | 134.0   | 128.8   |  | 124.9   |   | 113.8  | Rain/snow event - precipitation 0.21 in on existing snow 24-hours prior to sampling.  |
| 4/27/2006 | 128.1   | 160.5   | 413.7   |  | 124.4   |   | 117.3  |   |
| 5/4/2006  | 100.0   | 170.0   | 387.2   |  | 96.7  |   | 87.9   |   |
| 5/19/2006 | 119.1   |   |   |  | 116.7   |   | 109.4  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 5/25/2006 | 129.1   |   |   |  | 126.6   |   | 117.7  | Not enough flow in the Bartlett pipe or the Pioneer pipe to take a conductivity measurement.                                      |
| 6/16/2006 | 169.6   | 94.7  | 106.9   | 102.4  | 176.2   |   | 119.3  | Rain Event - precipitation 0.21 in. 24-hours prior to sampling.   |

<sup>1</sup> Site was monitored on 10/4/2005, 12/7/2005, and 6/16/2006 only.

<sup>2</sup> Site was not monitored after 5/3/2005.