East End Road Construction Project
Water Quality Monitoring Report


May 2006

Prepared by

Cook Inletkeeper

For the

Homer Soil & Water Conservation District,

Alaska Department of Transportation and Public Facilities, and

Quality Asphalt Paving Inc.

Homer Soil & Water Conservation District

COOK INLETKEEPER®

Protecting Alaska's Cook Inlet Watershed and the life it sustains

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Cover Photos: Right – Rock-lined channel at Alder Creek, July, 2004.
Left – Sample collection at Mariner Creek, June, 2004

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INTRODUCTION

Beginning in October of 2003 and extending into November 2005, East End Road MP 0 to 3.75 in Homer, Alaska was reconstructed by the Alaska Department of Transportation and Public Facilities and Quality Asphalt Paving Inc. The Project included a full roadway reconstruction, utility upgrades, and drainage improvements. All of the existing culverts were replaced. The 3.75 mile construction zone contained numerous streams that would be impacted by various construction efforts. In order to assess the water quality of these streams and construction impacts to these streams, the Alaska Department of Transportation and Public Facilities and Quality Asphalt Paving Inc. contacted the Homer Soil & Water Conservation District for assistance. The District then contracted with Cook Inletkeeper to monitor a selection of these streams. Cook Inletkeeper completed a Quality Assurance Project Plan 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 goals for the East End Road Monitoring Project were to collect water quality data to better understand the effects of road construction projects on local water bodies and to document the existing water quality of streams entering and exiting the construction zone. In addition, monitoring these streams provided valuable information about the effectiveness of best management practices (BMPs) used to reduce the environmental impacts of road construction. Monitored parameters included discharge, turbidity, temperature, pH, and conductivity, which are particularly important in evaluating the effects of road construction on water quality. Comparisons of sampling sites upstream and downstream of the construction zone were used to evaluate the effectiveness of BMPs.

Figure 1. Data collection at the downstream site on Miller Creek 5/19/05.

WATER QUALITY PARAMETERS

Based on their familiarity with local hydrological conditions and an understanding of potential road construction runoff implications for surface water quality, the Homer Soil and Water Conservation District and Cook Inletkeeper recommended the following parameters for testing:

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 effects water chemistry; thus, water quality measurements should always be viewed in relation to discharge (EPA 1997 b).

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). "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). All six study streams could still be experiencing erosion resulting from a loss in riparian habitat after the flooding in 2002. 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 b).

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 b).

Conductivity is the ability of a substance to conduct an electrical current and is measured in microsiemens per centimeter (µS/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 25º 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 b).

Table 1. Water quality parameters and common natural and human impact sources (Murdoch 1999).

Parameter	Common Natural Impact Sources	Common Human Impact Sources
Discharge	Precipitation, snowmelt, groundwater	Withdrawals of stream or groundwater, impermeable surfaces
Turbidity	Discharge, natural erosion	Road building and erosion, wastewater or storm water discharges
Temperature	Solar radiation, shade, groundwater contributions	Removal of riparian vegetation
pH	Decaying wetland plants, geology	Agricultural runoff, algae blooms
Conductivity	Geology, discharge	Pollution, road and fertilizer runoff

WATER QUALITY STANDARDS

Table 2. 18 AAC 70, Water Quality Standards, as amended through June 26, 2003 (ADEC 2003).

Water Uses	Turbidity	Water Temp.	pH
(A) Water Supply (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 6.5 or greater than 8.5. May not very more than 0.5 pH units from natural conditions.
(A) Water Supply (ii) agriculture, including irrigation and stock watering	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.
(B) Water Recreation (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 30º C.	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 increase in the buffering capacity of the water.

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 East End 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 (Fafield 2002). In order to address the requirements of pollution prevention at the construction site, Quality Asphalt Paving Inc. employed a variety of BMPs to reduce soil erosion and site sediment loss. BMPs implemented include:

Silt Fence Barriers 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 (Fafield 2002).

Straw Bale Barriers 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 (Fafield 2002).

Diversion ditches, Rock-lined Channels, Slope Drains, Outlet Protection, and Silt Basins are runoff control measures that reduce erosion and sediment transport associated with stormwater and roadway runoff. Diversion ditches intercept runoff from the construction area and transport it through the proper channels away from the work zone. Rock check dams were installed in some diversion ditches to slow runoff flows. The armoring of diversion ditches, stream channels, and culvert outlets with riprap and cobble helped to prevent the scouring and gully erosion during peak flows. Slope Drains used plastic pipe to collect and transport runoff from the roadway to silt basins at the toe of embankment slopes. These measures are temporary and permanent structures to be used during and after construction activities (Fafield 2002).

Live Water Diversion is necessary when construction activities must occur within a stream channel. Streamflow is intercepted upstream of the construction area and channeled around the work zone before being deposited back into the stream channel downstream of the construction area (Fafield 2002). The diverted flow may travel around the wok zone through a constructed bypass channel or through a pump and holding tank system. Live water diversion was used on the East End Road project during the removal and replacement of culverts at stream crossings.

Vegetative Cover is the most effective measure to prevent erosion and soil loss associated with construction projects. One of the most effective methods for minimizing erosion is to only disturb areas immediately needed for construction. This allows existing vegetation to reduce the potential for sediment generation due to erosion of bare ground. Existing vegetative buffers or filter strips can also remove suspended particles from sheet flows. Quality Asphalt Paving Inc. aimed to only disturb natural vegetative cover in areas immediately needed for construction. If there is no existing vegetation, the most efficient and economical method for controlling erosion and minimizing sediment yields is to establish a vegetative cover (Fafield 2002). Vegetation can be established by lying down sod or by planting seed. Vegetative cover was established on the East End Road project by utilizing temporary and permanent seeding.

Mulches and Rolled Erosion Control Products are applied over the soil surface to reduce erosion from rainfall and wind. Mulches can provide ground cover until vegetation can be established. Mulches can also aid in the establishment of vegetation by adding soil amendments and improving soil structure. For mulches to be effective, it is important that ground coverage of 80-100% occurs (Fafield 2002). Dry mulches consisting of straw were used extensively during the East End Road project. Rolled Erosion Control Products (RECPs) were also used on this project. RECPs, also known as erosion control mats or blankets, are manufactured mulch materials used to reduce erosion and assist in establishing vegetation. They allow for increased infiltration, conserve soil moisture and help keep seed in place. RECPs made of straw matting were used on slopes and ditches for this project, these products are composed of organic materials and are subject to biodegradation and photodegradation processes.

Inspection and Maintenance of BMPs is necessary to sustain sediment and erosion control. To be effective BMPs must be inspected frequently and regularly. The minimum inspection requirements set forth by the EPA 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. BMPs should be 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. EPA minimum inspection requirements state that where construction activity has been halted due to frozen conditions, inspections are required one month before thawing is expected (Fafield 2002).

Table 3. Best Management Practices employed on the East End Road Project.

Temporary soil stabilization and sediment control BMPs	Long term erosion and sediment control BMPs
Silt Fence Barriers	Rock-lined Channels and ditches
Straw Bale Barriers	Check Dams
Live Water Diversion	Outlet Protection
Mulches	Silt Basins
Rolled Erosion Control Products (RECPs)	Establishment of Vegetative Cover
Slope Drains	

Figure 2. Examples of BMPs employed on the East End Road construction project. Upper left – straw mulching and rock-lined channel at the upstream site on Mariner Creek 9/6/05. Upper right - silt fence barriers, rolled erosion control products, and outlet protection at the downstream site on Mariner Creek 7/13/04. Lower right – straw bale barrier at the downstream site on Alder Creek 8/13/04. Lower left – seeding, silt fence barriers, and outlet protection at the downstream site on Mattox Creek 8/10/04.

SITE SELECTION

East End Road extends from Lake Street at Pioneer Avenue in Homer, northeasterly along Kachemak Bay. The terrain along the route is gently rolling, and slopes from north to south. Many small streams originate on the Homer Bench north of East End Road, and drain into Beluga Lake and Kachemak Bay to the south (ADOTPF 2000). The abundance of streams within the construction zone made it necessary to prioritize them based on certain characteristics. The streams given a high monitoring priority were those with large drainage areas and high discharge. Table 4 includes drainage basin characteristics for four of the streams that were monitored on this project. Other streams given a high monitoring priority were those with a large potential for impact from construction efforts. Five streams within the construction zone were selected for monitoring including: Mariner Creek, Mattox Drainage, Alder Creek, Palmer (Bear) Creek, and Miller Creek (Figure 3). Each of these streams was monitored outside the work zone upstream and downstream of East End Road.

For comparative purposes, a control stream was selected outside of the construction zone. The control stream was selected based on similarities to the construction area streams in terms of drainage area, flow, and general water chemistry. After on-site and laboratory analysis of four potential control streams, Waterman Creek was selected as the control for the East End Road Monitoring Project (Figure 3). Each of the possible control streams exhibited baseline water quality characteristics that were slightly different. Waterman Creek was selected because the turbidity and discharge readings were the most similar to the other study streams. The control stream was monitored in the same manner as the other five streams in the study.

Table 4. East End Road drainage basin characteristics (DOT 2000).

Watershed	Area (sq. mi.)	Precipitation (in./yr)	Elevation (ft.)
Mariner Creek (Creek at Station 0+140)	0.34	25	800
Alder Creek (Creek at Station 3+550)	0.34	25	800
Palmer (Bear) Creek	0.97	25	800
Miller Creek	0.35	25	800

Figure 3. Sampling sites for the East End Road Monitoring Project.

SAMPLE DESIGN

All samples were collected and analyzed using methods in accordance with the Quality Assurance Project Plan for the East End Road Monitoring Project. In 2004 Cook Inletkeeper staff sampled twelve sites once a week (Tuesday) from June 1- October 15. The sites included two sampling stations on each of the five streams located in the construction zone and two sampling stations on the control stream (Waterman Creek) that is located outside of the work zone. In 2005 samples were collected during spring break-up at all twelve sites one time per week (Thursday) over a four-week period (April 14- May 5). After May 5, samples were collected at eight sites once every two weeks over a 16-week period (May 19- August 23). Bi-weekly sampling included Alder Creek, Palmer (Bear) Creek, Miller Creek, and Waterman Creek (control site). One final sampling event was conducted at eight sites during spring break-up in 2006 on April 27th. On each study stream, one site was located upstream of the construction zone, and the other was downstream of the construction zone. In addition to the weekly and bi-weekly sampling, measurements were taken during 10 rain events. Six rain events were sampled in 2004 following a rainfall of 0.25 inches within a 24-hour period. Three rain events were sampled in 2005 following a rainfall of 0.50 inches in a 24-hour period. Amount of precipitation was checked using data from the National Weather Service Homer (PAHO) airport weather station. Data was extracted from The Weather Underground, Inc. history for Homer, Alaska, PAHO. Figure 4 shows the daily precipitation for the Homer (PAHO) airport weather station from 6/1/04 to 11/10/4 and from 4/13/05 to 9/10/05 (Weather Underground 2005). Also included on the graph are the regular weekly and bi-weekly sampling days as well as rain event sampling days.

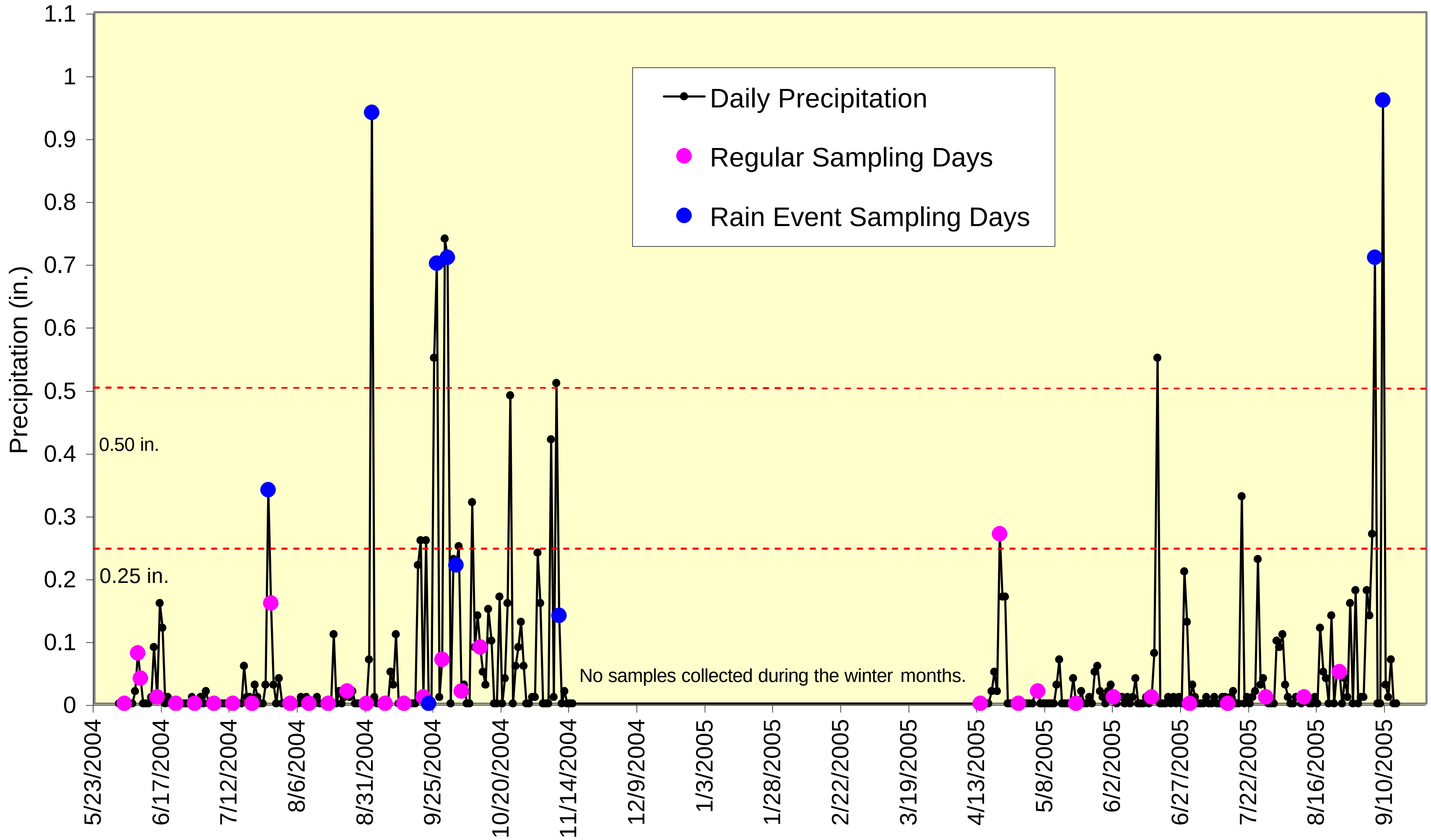

Figure 4. Daily precipitation for the Homer Airport (PAHO) weather station from 6/1/04 to 9/15/05.

METHODS

Each study stream was monitored at sites upstream and downstream of East End Road for temperature, conductivity, pH, turbidity, and discharge. Temperature, pH, and conductivity 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. In 2004, water temperature was measured at 15-minute intervals throughout the project using Stowaway Tidbit temperature loggers (Onset Computer Corp.). Temperature loggers were deployed on Palmer (Bear) Creek at both the upstream and downstream sampling sites. 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 the 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. Data quality objectives for precision are set at +/- 2% for turbidity readings of 100 NTU or less, and +/- 3% for readings 100 NTU and above. A full list of data quality objectives for parameters sampled is included in Appendix I. Each piece of equipment was calibrated on the day the measurements were taken to assure 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, providing similar documentation. The sampling sites for the project were marked using a Garmin GPS unit and are included in Appendix IX.

RESULTS

Discharge

Palmer (Bear) Creek recorded the highest discharge readings of the streams monitored. Mean discharge for Palmer (Bear) Creek from 6/3/04 to 9/9/05 was 0.95 cfs. For the other five study streams, mean discharge from 6/3/04 to 9/9/05 was between 0.21 cfs and 0.44 cfs. During regular weekly and bi-weekly sampling, discharge on the five sample streams ranged between 0.09 cfs and 0.23 cfs. During rain events and spring break-up, discharge on these five streams ranged between 0.29 cfs and 1.61 cfs. All six streams registered a higher mean discharge at the downstream site.

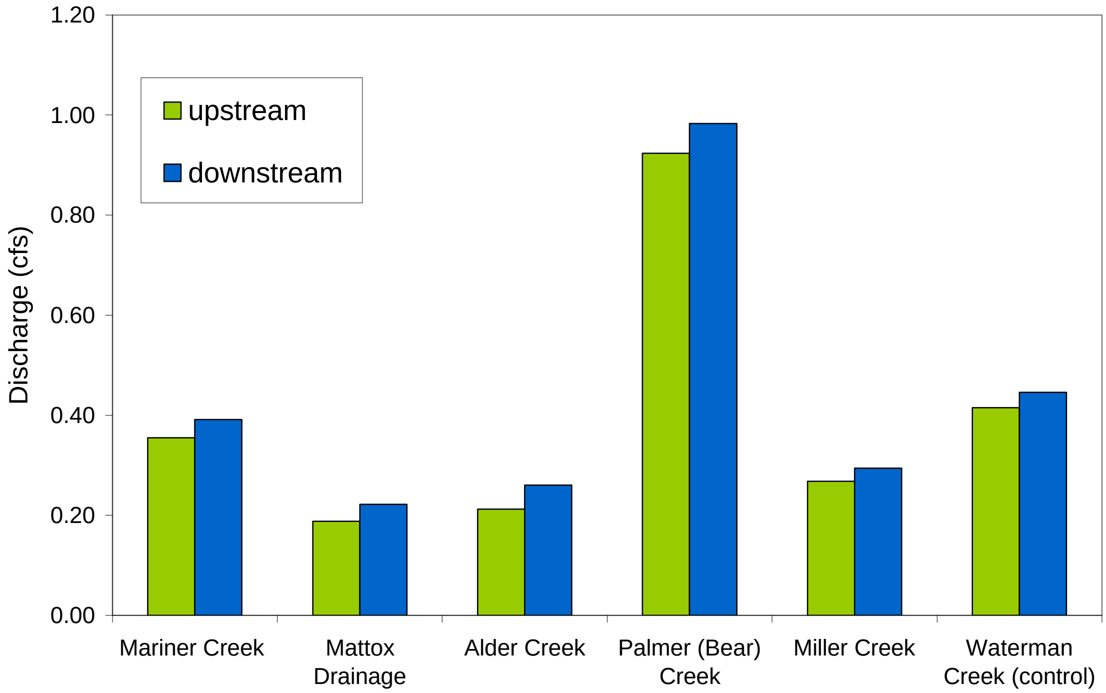

Figure 5. Mean discharge from 6/3/04 to 9/9/05 for upstream and downstream sites on six streams crossing East End Road.

Turbidity

Miller Creek recorded the highest turbidity levels of the six streams that were monitored (Figure 6). Alder Creek was the only stream that displayed an increase in turbidity of more than 5 NTUs from the upstream site to the downstream site (Figure 6). All six study streams showed an increase in turbidity as discharge increased. Mariner Creek, Miller Creek, and Waterman Creek recorded lower turbidity levels at the downstream sites (Figure 7, 11, 12). Mattox Drainage and Palmer (Bear) Creek displayed similar turbidity to discharge relationships at both the upstream and downstream sites (Figure 8, 10). Alder Creek was the only stream that showed a larger increase in turbidity at the downstream site as discharge increased (Figure 9). All six study streams showed higher turbidity levels during rain events and spring break-up than during regular weekly and bi-weekly sampling.

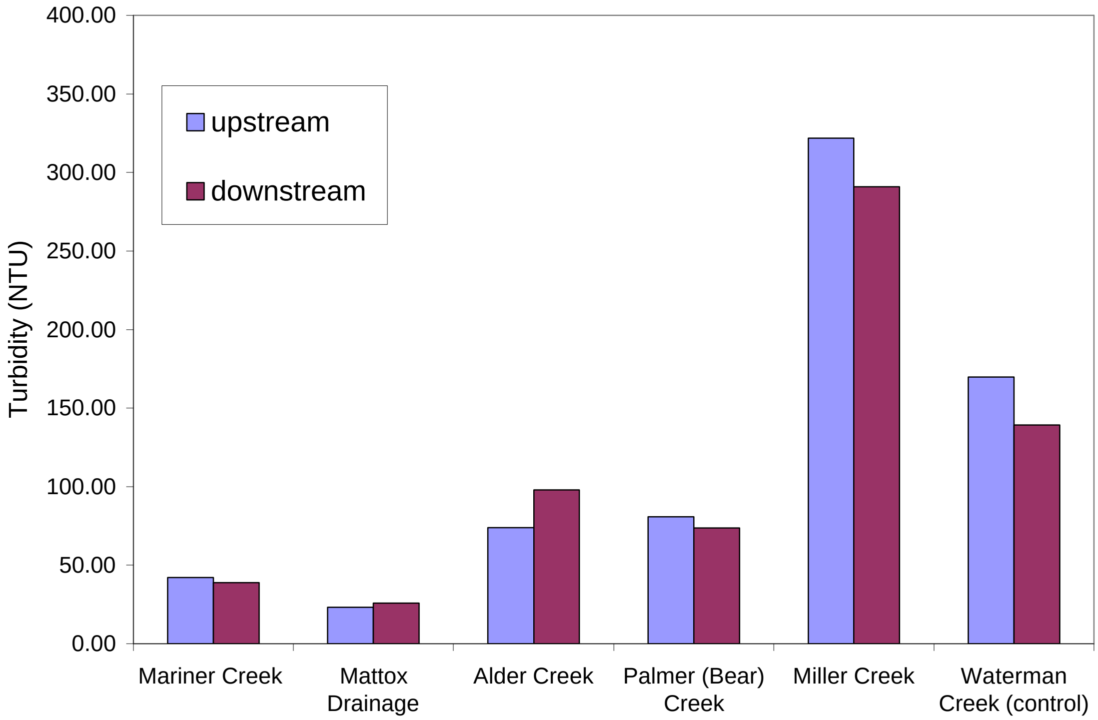

Figure 6. Mean turbidity from 6/3/04 to 9/9/05 for upstream and downstream sites on six streams crossing East End Road.

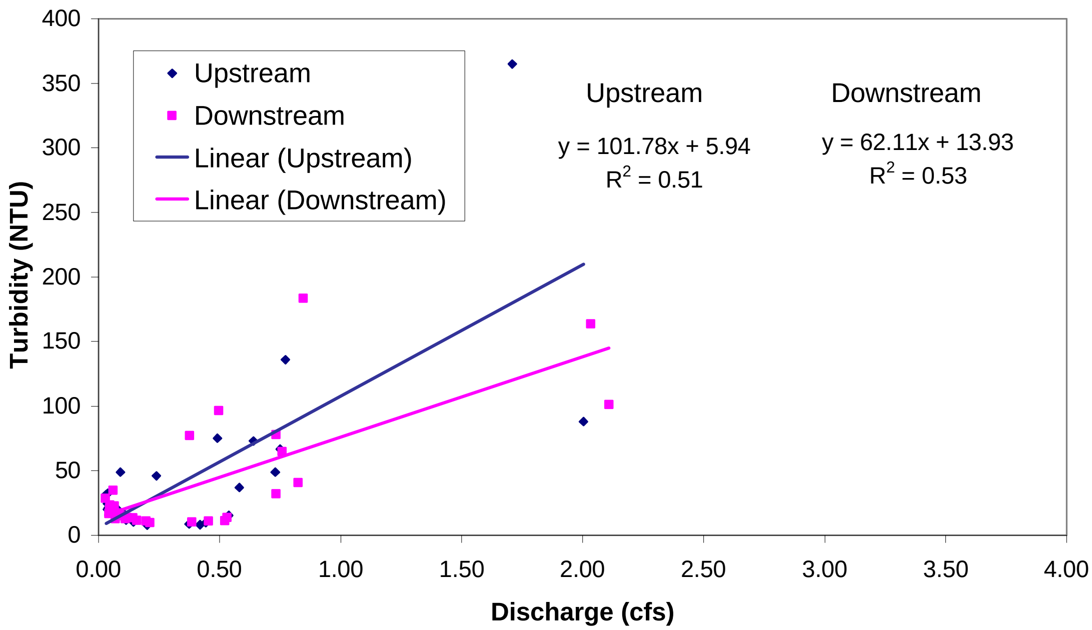

Figure 7. Relationships between discharge and turbidity at the upstream and downstream sites on Mariner Creek.

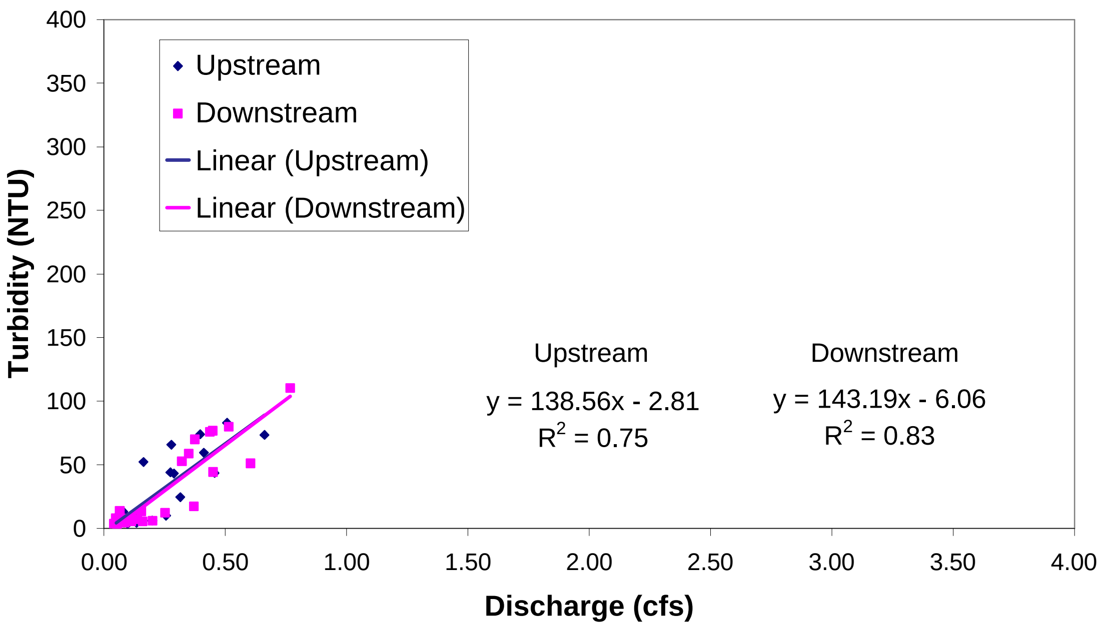

Figure 8. Relationships between discharge and turbidity at the upstream and downstream sites on Mattox Drainage.

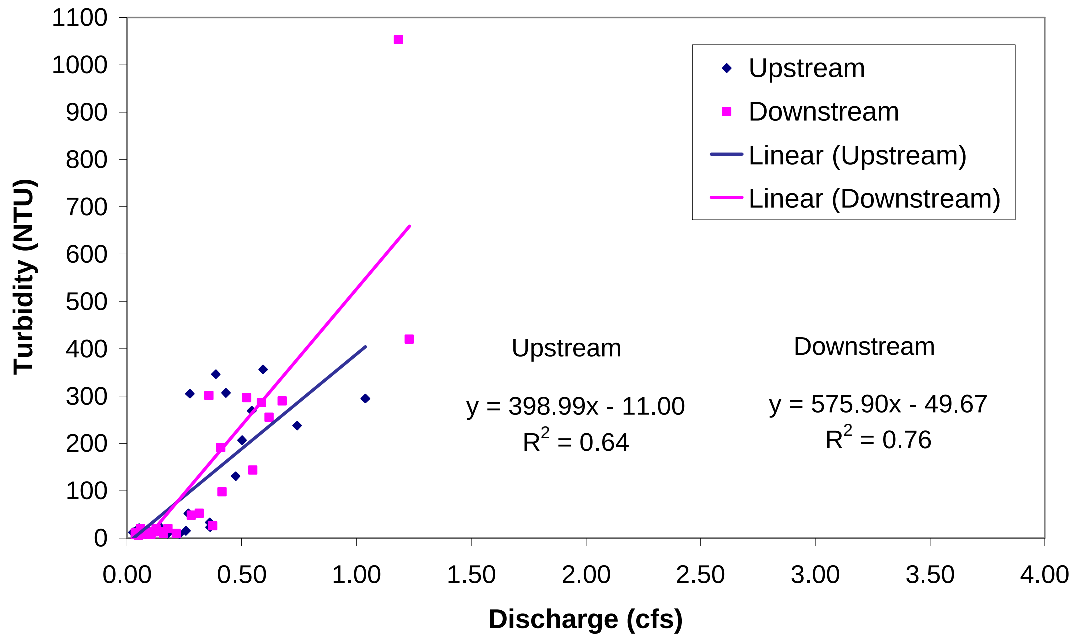

Figure 9. Relationships between discharge and turbidity at the upstream and downstream sites on Alder Creek.

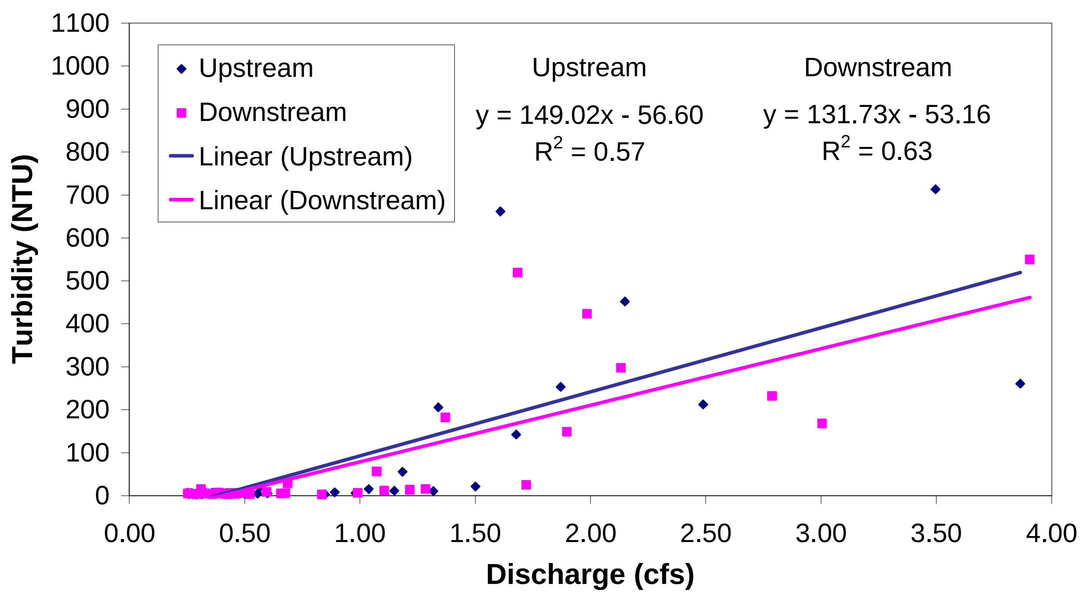

Figure 10. Relationships between discharge and turbidity at the upstream and downstream sites on Palmer (Bear) Creek.

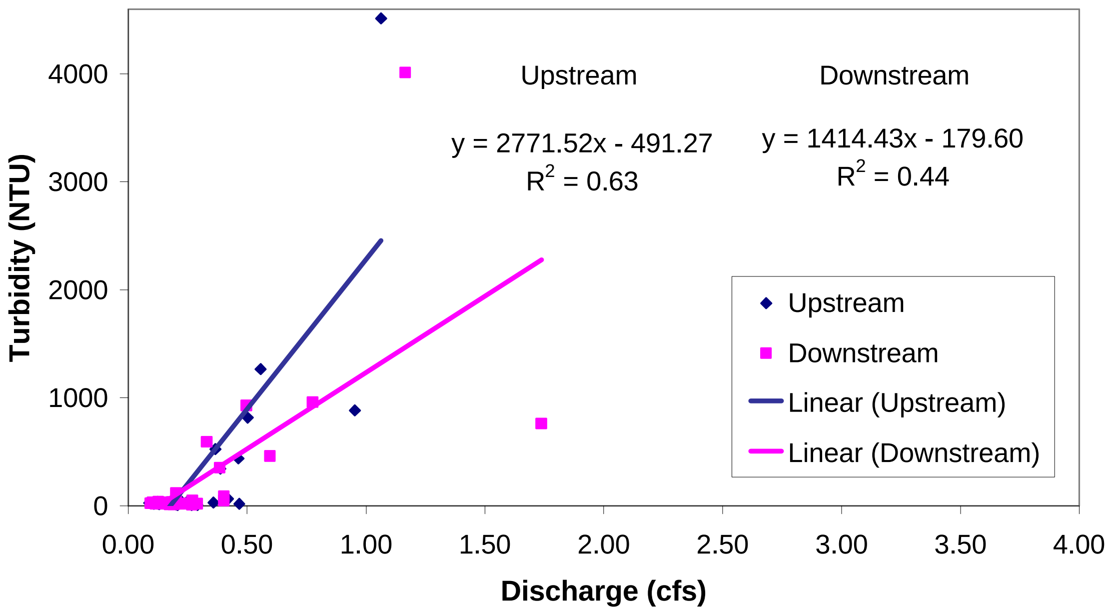

Figure 11. Relationships between discharge and turbidity at the upstream and downstream sites on Miller Creek.

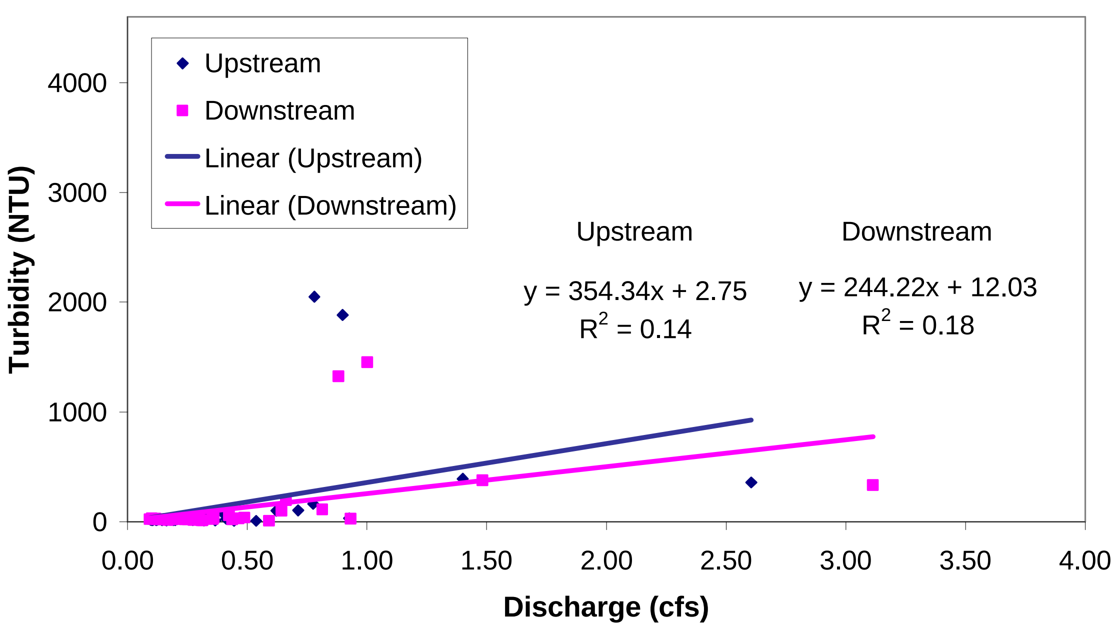

Figure 12. Relationships between discharge and turbidity at the upstream and downstream sites on Waterman Creek.

Water Temperature

On the six study streams that were monitored from 6/3/04 to 9/9/05, mean water temperature ranged from 8.3º C to 11.9º C. Water temperature readings did not vary from upstream site to downstream site by more than 0.2º C on any of the study streams. The largest upstream/downstream gradient (0.2º C) was recorded in Alder Creek. Water temperature was recorded at both the upstream and downstream sites on Palmer (Bear) Creek every 15 minutes from 6/22/04 to 10/12/04. Mean daily water temperature in Palmer (Bear) Creek did not vary from upstream site to downstream site by more than 0.1°C. Mean daily water temperature on Palmer (Bear) Creek from 6/22/04 to 10/12/04 was 11.1º C at the upstream site (Figure 13) and 11.2° C at the downstream site.

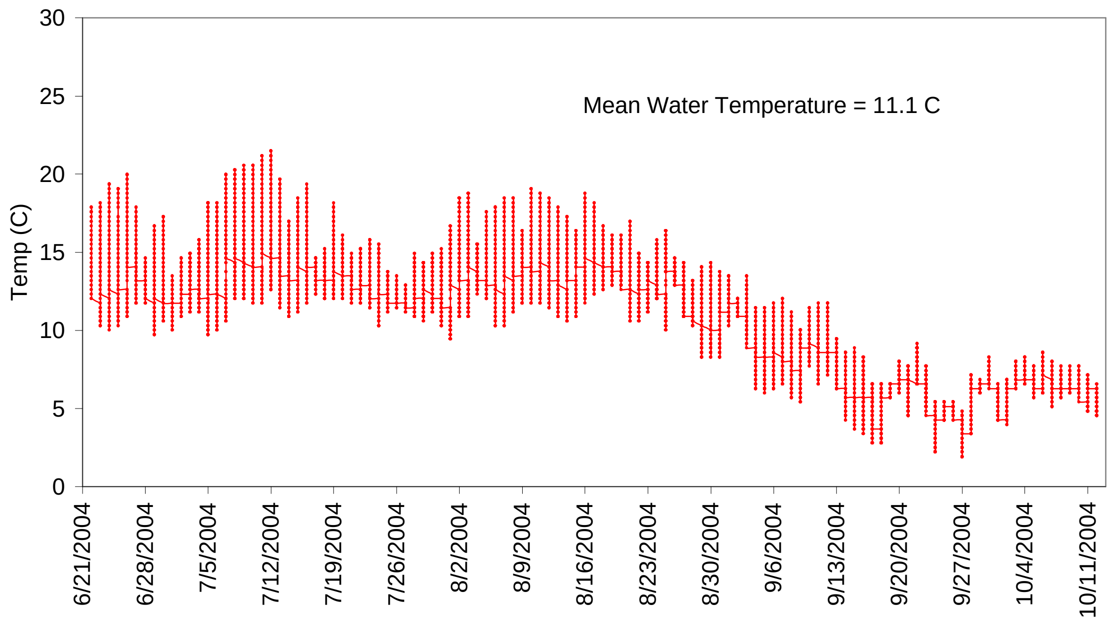

Figure 13. Water temperature at the upstream site on Palmer (Bear) Creek recorded every 15 minutes from 6/22/04 to 10/12/04.

pH:

Mean pH values for the six study streams ranged between 7.34 and 8.10 (Figure14). On four of the study streams including Mattox Drainage, Palmer (Bear) Creek, Miller Creek, and Waterman Creek, pH values did not vary by more than 0.05 from upstream site to downstream site. On Mariner Creek, mean pH was 7.45 at the upstream site and 7.34 at the downstream site. On Alder Creek, mean pH was 7.77 at the upstream site and 7.41 at the downstream site. pH values recorded in the six study streams did not exceed ADEC water quality standards for drinking water, agriculture, or contact recreation.

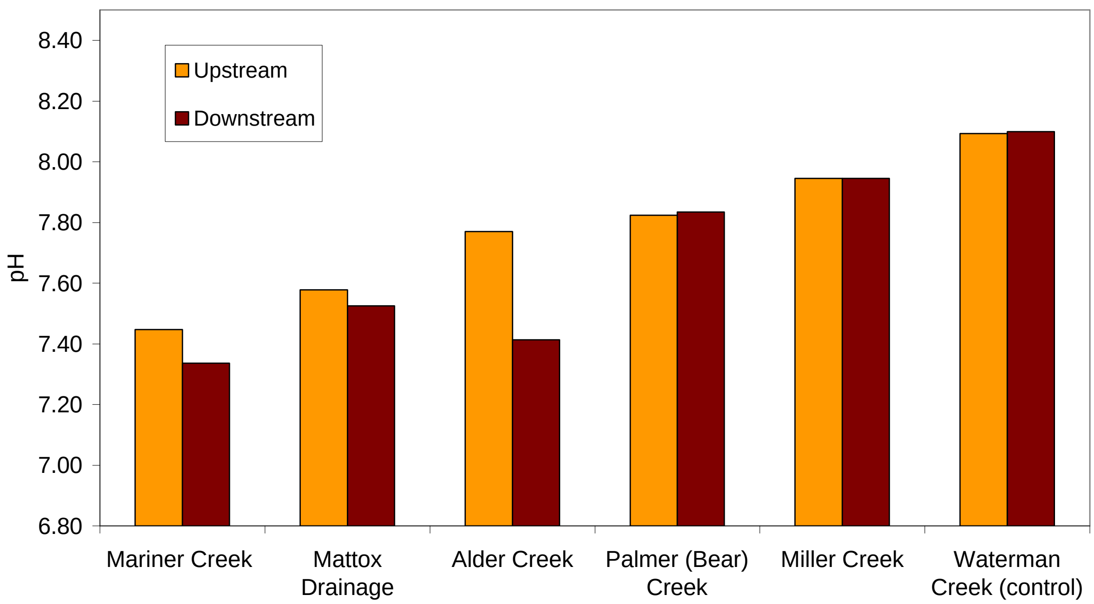

Figure 14. Mean pH values from 6/3/04 to 9/9/05 for six streams crossing East End Road.

Specific Conductance:

All six study streams recorded slightly higher specific conductance readings at the upstream site (Figure 12). The largest upstream/downstream gradient was 7.1 µS/cm recorded in Miller Creek. All six study streams recorded lower specific conductance during rain event sampling than during regular weekly sampling.

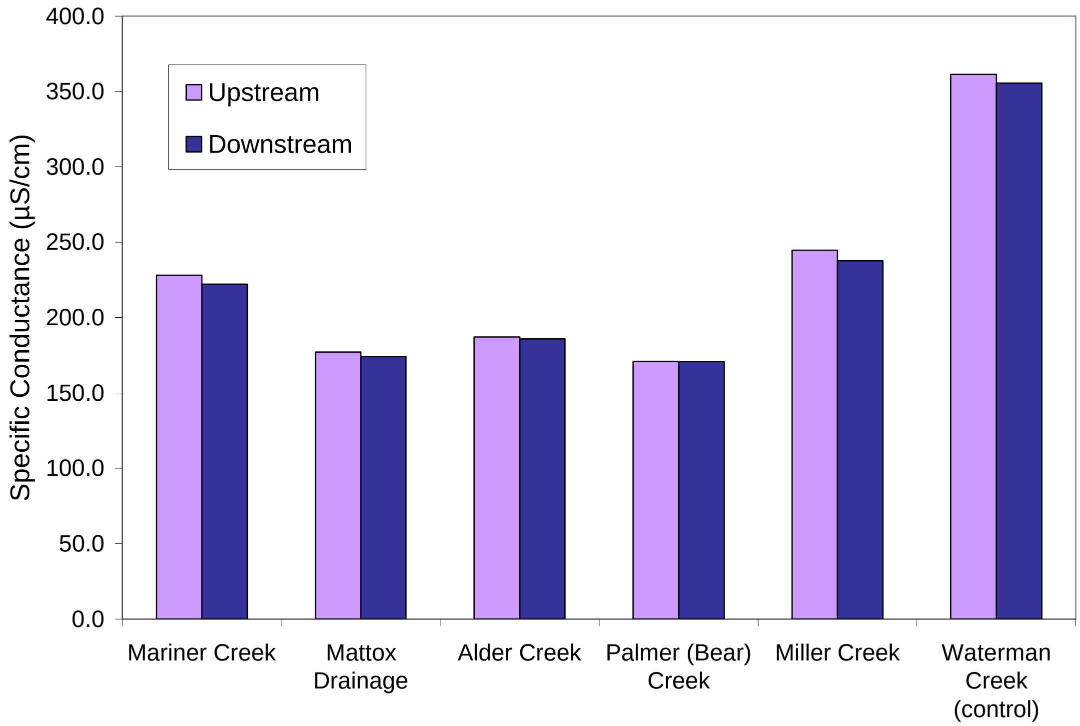

Figure 15. Mean specific conductance from 6/3/04 to 9/9/05 on six streams crossing East End Road.

Historic Data

After the large-scale flooding in October and November 2002, the downstream site on Miller Creek was monitored by volunteers participating in Cook Inletkeeper's Citizens' Environmental Monitoring Program (Table 5). The upstream site on Miller Creek was also monitored by Keeper volunteers beginning on 10/31/04 (Table 6). Historic data shows that at the downstream site on Miller Creek, from 11/1/02 to 8/29/05, mean turbidity was 188.0 NTU. A complete list of volunteer collected data for Miller Creek is located in Appendix VII.

Table 5. Historic measurements for the downstream site on Miller Creek recorded from 11/1/02 to 8/29/05 by Cook Inletkeeper's Citizens' Environmental Monitoring Program.

Site # KB-951	Turbidity NTU	WaterTemp(C)	Specific Conductance	pH
N	40	46	46	46
Mean	188.0	9.4	218.5	7.7
Median	33.0	10.2	239.5	7.7
Stan. Dev.	638.664	6.274	65.560	0.466
Range	3896.9	22.0	286.5	2.21
Minimum	9.1	0.0	9.5	6.5
Maximum	3906.0	22	296.0	8.7

Table 6. Historic measurements for the upstream site on Miller Creek recorded from 10/31/04 to 8/28/05 by Cook Inletkeeper's Citizens' Environmental Monitoring Program.

Site # KB-952	Turbidity NTU	WaterTemp(C)	Specific Conductance	pH
N	11	12	12	12
Mean	41.4	9	251.3	7.4
Median	32.2	11.5	265.5	7.5
Stan. Dev.	38.792	5.722	44.339	0.246
Range	99.7	14.3	156.5	0.8
Minimum	8.3	0.8	160.5	6.9
Maximum	108.0	15.1	317.0	7.8

DISCUSSION

Discharge

Palmer (Bear) Creek has the largest drainage area and, as expected, recorded the highest discharge readings of the six study streams. All six streams recorded lower discharge readings during regular weekly and bi-weekly sampling. Measurements recorded during weekly and bi-weekly sampling represent base flow conditions. All six study streams recorded higher discharge readings during rain event sampling and spring break-up conditions. Measurements taken during rain event sampling and spring break-up reflect the combination of base flow with event flow.

All of the study streams recorded higher discharge readings at the downstream site than at the upstream site. On most sections of East End Road there are drainage ditches that run parallel to the road. Diversion ditches intercept runoff and divert it to a stabilized area where it can be safely discharged (ADOTPF 2004). The upstream sampling sites were located above the roadside ditches and were not affected by ditch runoff. The amount of runoff after a storm is influenced by the ground's ability to absorb water (permeability). Roads and parking lots are considered 100% impervious, meaning these surfaces cannot absorb water (NOAA 2004). The increase in discharge from the upstream sites to the downstream sites could be attributed to storm runoff. This indicates that BMPs were effective in intercepting runoff and diverting it into the drainage system.

Turbidity

To measure the effect of road building on the turbidity levels in the study streams, upstream and downstream measurements were compared. For comparative purposes when looking at ADEC water quality standards, upstream measurements represent the natural conditions for the six study streams on this project. Alder Creek was the only stream to display turbidity levels that did not meet the ADEC water quality standard, "may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU" (ADEC 2003). Alder Creek experienced large scale reconstruction during the East End Road project. The roadway grade was raised approximately two meters with roadway widening and a separated pathway. Two culverts were replaced between the upstream and downstream monitoring sites on Alder Creek. One culvert passes under East End Road and the other culvert passes under Alder Lane. Also, the stream channel between the two culverts was lined with gabions (metal wire cages filled with rock). The increased turbidity at the downstream site on Alder Creek may have been due to disturbed soils from the construction zone entering the stream. Sediment could also have been transported to the stream by roadway runoff and sheet flow erosion. Another source of increased turbidity at the downstream site on Alder Creek may have been residue associated with the large volume of rock added to the stream channel. In terms of ADEC water quality standards, BMPs for soil stabilization and sediment control were highly effective on all sample streams except Alder Creek.

Four of the six study streams recorded higher mean turbidity levels at the upstream site than at the downstream site. The upstream/downstream decrease in turbidity may have resulted from the installation of temporary and long term sediment control BMPs. Waterman Creek, the control stream, also recorded higher turbidity readings at the upstream site. There were no temporary BMPs in place on Waterman Creek, but inlet and outlet protection using rubble and cobble was installed following the flooding in 2002. This indicates that without the use of temporary BMPs such as silt fences and straw bail barriers, sediment deposition still occurred in Waterman Creek upstream of East End Road.

Turbidity measurements at the downstream site on Mariner Creek and Palmer (Bear) Creek on 6/29/04 were excluded when turbidity levels were calculated because they were the result of observed point source pollution and not representative of normal conditions. Point source pollution is pollution contributed by any discernible, confined, and discrete conveyance from which pollutants are or may be discharged (EPA 1997 b). On Mariner Creek, upstream of East End Road, a culvert at Homer High School was being repaired the week of 6/29/04. There was no soil stabilization or sediment control BMPs in place during culvert repair. The high turbidity level recorded on 6/29/04 in Mariner Creek could have been associated with the culvert repair at Homer High School. The high turbidity level recorded on 6/29/04 in Palmer (Bear) Creek was the result of a high turbidity surge released by the construction crew during a live water stream diversion project. Palmer (Bear) Creek was temporarily being diverted to a storage tank while the construction crew replaced the culvert passing under East End Road. Water from the storage tank was then released back into the stream creating a high turbidity pulse. These two high turbidity recordings are examples of human impacts that negatively affect water quality. As was the case with Mariner Creek, the natural or upstream conditions of the study streams may have been affected by construction projects located outside of the work zone that were not associated with the East End Road project.

<u>Water Temperature</u>

There were no significant upstream/downstream differences in water temperature recorded in any of the streams monitored. Water temperature readings did not vary from upstream site to downstream site by more than 0.2º C. Water temperature was recorded at both the upstream and downstream sites on Palmer (Bear) Creek every 15 minutes from 6/22/04 to 10/12/04 using temperature loggers. Water temperature recorded using temperature loggers did not vary from upstream site to downstream site by more than 0.1º C. Mean water temperature recorded by temperature loggers was about 1° C lower than water temperatures recorded during manual sampling (using the YSI model 63 unit). Temperature measurements taken during manual sampling were collected between 12:45 and 4:00 pm. During the afternoon, water temperatures are generally higher than in the morning or at night (Lundquist 2002). The higher afternoon temperatures could explain the higher mean water temperature recorded during manual sampling.

pH

There were no significant upstream/downstream differences in pH recorded in any of the streams monitored.

Specific Conductance

There were no significant upstream/downstream differences in specific conductance recorded in any of the streams monitored. All six study streams recorded slightly higher specific conductance readings at the upstream site. The largest upstream/downstream gradient was 7.1 µS/cm recorded in Miller Creek. Conductivity is inversely correlated with discharge. As discharge increases, the concentration of dissolved solids decreases (Dingman 2002). The lower specific conductance measurements recorded during rain event sampling could be due to dilution associated with increased discharge.

Historic Data

Historic data on Miller Creek shows that measurements taken from 11/2/02 to 7/10/05 are similar to measurements taken during this project. The historic data was collected once or twice a month year-round, while measurements recorded during this project were collected weekly or bi-weekly and only during the spring, summer, and fall. Differences in temperature and pH could be attributed to the difference in sampling period. "Miller Creek flooded badly in November 2002, blocking traffic on East End Road for several hours. It has remained more turbid than other sites since then" (Banks 2003). Miller Creek may be still experiencing erosion associated with the flooding in 2002. The differences in turbidity and specific conductance could be due to the increase in suspended materials in the stream immediately after the flooding.

Figure 16. Cook Inletkeeper staff collected data during a rain/snow event on 12/9/05.

SUMMARY AND CONCLUSIONS

The data collected on the East End Road Project showed lower turbidity levels at the downstream sites than at the upstream sites, therefore we surmise that the temporary and long term BMPs employed to reduce soil erosion and site sediment loss were effective. Data and information collected during this study also yielded the following information:

- Temporary BMPs such as silt fences and straw bales were effective in keeping sediment out of the streams when properly installed and maintained.
- Live water diversions were effectively used to reroute streams around the work zone during culvert replacements.
- Seeding, mulching and rolled erosion control products were successfully used to create vegetative buffers.
- Roadside ditches intercepted and diverted runoff into the drainage system.
- Rock-lined channels and outlet protection were effective in armoring the stream channel and reducing erosion and sediment transport.

The BMPs employed on this project were effective in reducing the amount of sediment leaving the construction zone, but some deficiencies were observed. Temporary erosion control BMPs were not as effective during heavy rain events or during the winter freeze/thaw cycles. Observed deficiencies include:

- Temporary BMPs such as silt fences and straw bales were flanked, undermined, and blown out at some locations during increased flow levels resulting from large scale rain events in the fall of 2004.
- Temporary BMPs were not adequately inspected and maintained over the winter of 2004.
- Temporary BMPs were not repaired and refurbished prior to the 2005 spring break-up.

Temporary BMPs that had been damaged during rain events were actively revised and repaired, but only through the construction season. Inspection and maintenance of BMPs should have been conducted during the winter shut down period. Temporary BMPs were repaired and refurbished in the spring of 2005, but break-up had already begun. Sediment released during winter rain storms and at the beginning of spring break-up could have entered these streams due to the lack of BMP maintenance.

The data collected during this road construction project did not produce any detectable upstream/downstream changes in temperature, pH, or specific conductance in the streams monitored.

Alder Creek was the sampling site most affected by the road construction during the sampling period. It was the only creek to display noticeably higher turbidity levels at the downstream site. Alder Creek was subjected to large-scale construction efforts in 2004 including the replacement of two culverts and the installation of 150 ft. of gabion reinforced rock-lined channel. During construction, Alder Creek was completely rebuilt between the upstream and downstream sites and all riparian vegetation was removed. The downstream site on Alder Creek was also affected by slope runoff from large areas of exposed soil surrounding the stream. Until slope drains were added, Gravel shoulder berms from grading prohibited the controlled discharge of runoff from the roadway. The BMPs in place may have been effective in Alder Creek, but BMPs were not effective in controlling the roadway runoff coming into Alder Creek. These deficiencies were addressed by adding slope drains, rocking the fill slope above the creek, adding a rock lined ditch and silt basin above Alder Creek on the south side. Because of these major changes, Alder Creek was the stream most affected by the road construction.

Continued monitoring in the future could yield important information on BMPs. The observations collected during this project help to describe the effectiveness of the BMPs employed, but they do not identify which BMPs are most effective. To better understand the effectiveness of different BMPs, future road construction monitoring projects could include a selection of study streams where each stream is fitted with a different types of BMP. Water quality data from these streams could then be compared to determine which BMPs are most effective. Other factors to consider when comparing BMPs would be cost and the effort necessary for inspection and maintenance. To better understand the impacts of road construction on water quality, it is important to monitor before, during, and after construction and across a range of hydrologic conditions (Reed 1980). Continued monitoring after the construction has been completed will provide information on how quickly streams return to pre-construction conditions and the effectiveness of long-term BMPs.

Figure 17. Cook Inletkeeper staff measured discharge at the downstream site on Miller Creek 4/21/05.

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Appendix I. Summary of 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) 0.1 to 8 (meters per second)	fps/mps	0.1 fps 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 0 to 4999 S/cm 0 to 49.99 mS/cm 0 to 200.0 mS/cm	S/cm mS/cm	0.1 S/cm 1 S/cm 0.01 mS/cm 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 StowAway Tidbit Temperature Logger (TBI32-20+50)	-20 to 50	°C	0.3 º C at + 21.1 º C	NA	± 0.4 º C at 21.1º C	NIST Certified Thermometer	Analyze Immediately	P,G	Analyze Immediately	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 0 to 1.0 then 0.05 NTU 10 to 40 then 1 NTU 40 to 100 then 5 NTU 100 to 400 then 10 NTU 400 to 1000 then 50 NTU 1000 then 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

Appendix II. Discharge (cfs) measurements for six creeks sampled during the East End Road construction project in 2004 and 2005.

	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
Date	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
6/3/2004	0.20	0.20											
6/8/2004			0.27	0.35	0.27	0.42	1.32	1.22	0.27	0.29			
6/9/2004	0.20	0.21									0.44	0.44	
6/15/2004	0.14	0.16	0.14	0.15	0.11	0.13	0.85	0.84	0.27	0.17	0.37	0.31	
6/22/2004	0.11	0.12	0.12	0.14	0.10	0.12	0.56	0.66	0.47	0.23	0.27	0.25	
6/29/2004	0.09	0.09	0.08	0.13	0.07	0.06	0.50	1.70	0.13	0.20	0.19	0.24	
7/6/2004	0.07	0.04	0.08	0.09	0.06	0.07	0.43	0.42	0.16	0.11	0.20	0.21	
7/13/2004	0.04	0.03	0.06	0.08	0.05		0.38	0.36	0.11	0.10	0.14	0.14	Low flow, no Alder Creek downstream measurement
7/20/2004	0.06	0.05	0.05	0.06	0.06	0.06	0.32	0.43	0.13	0.14	0.14	0.12	Stream diversion on Alder Cr, downstream sample collected 250 ft. downstream from the normal sample collection site
7/26/2004	0.24	0.38											Rain Event- 0.13 inches in a three hour period
7/27/2004	0.07	0.07	0.08	0.08	0.05	0.14	0.40	0.46	0.23	0.18	0.23	0.21	
8/3/2004	0.05	0.07	0.08	0.09	0.05	0.06	0.30	0.36	0.11	0.10	0.10	0.15	
8/10/2004	0.08	0.06	0.06	0.07	0.03	0.05	0.29	0.32	0.10	0.09	0.10	0.13	
8/17/2004	0.04	0.05	0.06	0.05	0.03	0.04	0.25	0.26	0.09	0.10	0.10	0.10	
8/24/2004	0.05	0.08	0.10	0.06	0.05	0.04	0.29	0.33	0.12	0.14	0.12	0.18	
8/31/2004	0.03	0.05	0.06	0.04	0.06	0.06	0.29	0.26	0.14	0.14	0.12	0.09	
9/2/2004	0.49	0.50	0.29	0.32	0.27	0.36	1.19	1.07	0.42	0.40	0.39	0.42	Rain Event- 0.62 inches in a 24 hour period
9/7/2004	0.04	0.05	0.07	0.05	0.06	0.05	0.28	0.31	0.11	0.12	0.18	0.17	
9/14/2004	0.04	0.05	0.06	0.06	0.04	0.04	0.26	0.26	0.11	0.12	0.12	0.11	
9/21/2004	0.11	0.11	0.08	0.07	0.09	0.08	0.42	0.38	0.13	0.14	0.16	0.18	
9/23/2004	0.11	0.10	0.06	0.09	0.13	0.11	0.41	0.40	0.15	0.16	0.16	0.20	Rain Event- 0.23 in a 24 hour period. This event was sampled because it was the first precipitation following a prolonged dry spell
9/26/2004	0.77	0.85	0.28	0.45	0.43	0.52	1.34	1.37	0.37	0.33	0.62	0.64	Rain Event- 0.66 inches in a 24 hour period
9/28/2004	0.15	0.14	0.08	0.11	0.15	0.18	0.57	0.69	0.21	0.20	0.32	0.36	
9/30/2004	1.71	2.03	0.66	0.77	1.04	1.18	3.50	3.90					Rain Event- 0.65 inches in a 24 hour period. No discharge measurements were taken for Miller Cr. or Waterman Cr. Due to high concentrations of suspended material which caused the Global Flow Probe to malfunction
10/3/2004	0.54	0.53	0.26	0.25	0.36	0.32	1.04	1.28	0.25	0.27	0.43	0.49	Rain Event- 0.29 inches in a 24 hour period
10/5/2004	0.42	0.45	0.20	0.20	0.26	0.28	1.15	1.11	0.25	0.26	0.41	0.46	
10/12/2004	0.37	0.39	0.13	0.16	0.23	0.16	0.89	0.68	0.21	0.22	0.32	0.28	
11/10/2004	2.00	2.11	0.16	0.60	0.39	1.23	3.86	2.79	0.95	1.74	2.60	3.11	Rain Event- 0.51 inches in a 24 hour period

Date	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
4/14/2005	0.58	0.73	0.46	0.45	0.59	0.62	1.61	1.68	1.06	1.17	0.78	1.00	Spring Break-up
4/21/2005	0.64	0.76	0.40	0.44	0.50	0.41	2.15	1.99	0.56	0.78	0.90	0.88	Spring Break-up
4/28/2005	0.73	0.83	0.51	0.51	0.54	0.59	2.49	3.01	0.46	0.60	1.40	1.48	Spring Break-up
5/5/2005	0.44	0.52	0.31	0.37	0.36	0.38	1.50	1.72	0.36	0.40	0.93	0.93	Spring Break-up
5/19/2005					0.18	0.22	0.98	0.99	0.29	0.27	0.54	0.59	Moved to bi-weekly sampling schedule. No longer collecting samples in Mariner Creek or Mattox Creek.
6/2/2005					0.10	0.11	0.60	0.60	0.20	0.19	0.32	0.31	
6/16/2005					0.08	0.08	0.36	0.45	0.13	0.18	0.16	0.17	
6/30/2005					0.09	0.09	0.42	0.48	0.17	0.15	0.27	0.36	
7/14/2005					0.04		0.31	0.52	0.12	0.13	0.16	0.15	Not enough flow to measure discharge at the downstream site on Alder Creek.
7/28/2005					0.05	0.05	0.34	0.29	0.16	0.15	0.18	0.19	
8/11/2005					0.03	0.04	0.27	0.32	0.12	0.13	0.15	0.12	
8/24/2005					0.07	0.07	0.36	0.39	0.17	0.19	0.26	0.30	
9/6/2005	0.75	0.73	0.41	0.37	0.47	0.55	1.68	1.90	0.39	0.39	0.71	0.81	Rain event - 0.71 in. in a 24 hour period
9/9/2005					0.74	0.68	1.87	2.13	0.50	0.50	0.78	0.66	Rain event - 0.96 in. in a 24 hour period
12/9/2005					1.94	1.97	3.52	4.42	0.80	1.72	2.97	3.81	Rain/snow event - precipitation 0.22 in on existing snow.
4/27/2006					1.13	0.89	2.28	2.43	0.52	0.58	1.54	1.83	Spring Break-up

Appendix III. Turbidity (NTU) measurements for six creeks sampled during the East End Road construction project in 2004 and 2005.

Date	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
6/3/2004	9.99	10.82											
6/8/2004			44.05	58.75	52.25	97.70	11.03	13.25	13.75	17.90			
6/9/2004	7.95	9.81									8.99	17.05	
6/15/2004	10.36	11.55	8.75	13.20	11.27	18.95	3.03	2.62	8.25	10.51	10.66	12.03	
6/22/2004	12.00	13.75	8.22	7.27	13.55	13.05	4.90	4.83	17.05	18.05	13.50	16.90	
6/29/2004	48.75	1115.00	13.10	7.37	13.00	19.35	3.83	952.00	14.85	18.85	15.15	18.70	High turbidity levels recorded on Mariner Creek and Bear Creek at the downstream site. Instream construction was in progress on both streams
7/6/2004	16.85	16.70	9.35	7.83	12.50	10.19	3.90	3.07	19.15	19.85	16.45	24.65	
7/13/2004	32.60	28.45	7.85	6.17	9.95		5.06	3.26	24.40	24.75	15.40	17.15	Low flow, no Alder Creek downstream measurement
7/20/2004	21.00	19.60	6.26	5.70	12.05	7.58	3.32	3.14	17.55	19.65	15.85	18.40	Stream diversion on Alder Cr, downstream sample collected 250 ft. downstream from the normal sample collection site
7/26/2004	46.10	77.15											Rain Event- 0.13 inches in a three hour period
7/27/2004	16.30	12.90	4.72	5.03	21.75	13.60	6.71	4.21	25.25	34.30	30.20	30.25	
8/3/2004	18.65	22.60	5.15	4.31	13.95	10.76	5.25	3.97	19.60	20.75	15.05	18.30	
8/10/2004	19.85	34.90	10.97	13.55	13.80	11.10	4.03	7.47	22.25	24.05	16.55	22.45	
8/17/2004	24.35	20.40	6.34	4.96	12.00	11.01	7.35	4.77	27.20	30.25	20.05	27.90	
8/24/2004	18.10	17.20	3.62	3.45	11.55	7.21	2.66	4.73	22.95	25.55	16.65	20.30	
8/31/2004	31.55	23.35	4.33	3.54	10.31	7.41	3.87	4.38	26.15	26.50	17.95	22.80	
9/2/2004	75.20	96.60	43.00	52.75	305.50	300.50	55.65	56.70	64.95	86.15	92.50	60.15	Rain Event- 0.62 inches in a 24 hour period
9/7/2004	21.25	18.30	5.52	7.95	10.82	8.06	3.41	15.40	23.75	25.60	18.45	20.50	
9/14/2004	20.05	18.65	5.10	3.71	8.53	6.58	3.18	5.38	23.65	24.90	16.00	21.05	
9/21/2004	12.55	12.95	4.51	5.61	14.15	10.66	4.91	5.27	20.70	21.60	18.40	20.70	
9/23/2004	16.05	14.90	4.54	5.86	14.85	12.30	4.82	5.63	21.30	21.90	18.95	22.85	Rain Event- 0.23 in a 24 hour period. This event was sampled because it was the first precipitation following a prolonged dry spell
9/26/2004	136.00	183.50	65.70	76.70	306.50	296.50	205.50	182.00	523.00	593.00	97.70	99.55	Rain Event- 0.66 inches in a 24 hour period
9/28/2004	11.05	13.45	6.05	5.37	22.60	19.90	20.85	28.90	73.75	114.50	32.60	34.95	
9/30/2004	365.00	163.50	73.45	110.35	295.00	1053.00	713.00	549.50	2995.50	2362.50	925.00	841.00	Rain Event- 0.65 inches in a 24 hour period
10/3/2004	15.40	13.80	9.90	12.30	33.40	52.25	15.25	15.55	35.50	48.35	36.20	38.15	Rain Event- 0.29 inches in a 24 hour period
10/5/2004	8.23	10.97	6.02	5.94	15.30	47.55	11.20	11.45	25.85	22.50	26.65	28.45	
10/12/2004	8.82	10.33	4.33	5.41	8.95	9.53	7.84	5.28	8.78	17.85	13.30	13.95	
11/10/2004	87.95	101.25	52.25	51.10	346.50	420.00	260.50	232.00	882.50	761.00	356.50	332.00	Rain Event- 0.51 inches in a 24 hour period

Date	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
4/14/2005	36.85	32.00	43.50	44.25	356.00	255.00	661.50	519.00	4515.00	4012.00	2048.00	1451.00	Spring Break-up
4/21/2005	73.05	64.90	73.90	75.80	206.50	191.00	452.00	423.00	1266.00	958.00	1884.00	1325.00	Spring Break-up
4/28/2005	48.95	40.65	83.15	79.95	269.00	286.50	212.00	168.00	437.50	461.00	391.00	375.00	Spring Break-up
5/5/2005	9.61	11.20	24.45	17.15	23.45	25.90	21.25	25.00	31.30	48.00	28.00	26.25	Spring Break-up
5/19/2005					9.28	9.67	6.18	6.97	6.38	6.38	8.56	9.18	Moved to bi-weekly sampling schedule. No longer collecting samples in Mariner Creek or Mattox Creek.
6/2/2005					8.48	7.71	5.20	8.46	9.70	11.00	11.04	11.70	
6/16/2005					8.84	8.50	6.92	6.91	20.30	21.30	11.30	14.10	
6/30/2005					10.31	8.41	5.92	6.94	23.80	22.70	20.45	22.50	
7/14/2005					5.79	4.49	3.87	3.43	26.15	30.25	18.40	21.55	
7/28/2005					5.89	5.52	5.01	3.66	27.35	28.85	17.75	19.60	
8/11/2005					7.97	10.24	6.41	6.78	36.15	36.85	20.40	24.60	
8/24/2005					10.30	9.62	7.31	7.54	30.90	31.60	26.20	29.55	
9/6/2005	66.80	78.10	59.35	69.95	130.50	143.50	142.50	148.50	343.00	353.50	104.90	110.70	Rain Event- 0.71 inches in a 24 hour period
9/9/2005					238.00	289.50	253.00	297.50	817.00	930.50	164.00	194.50	Rain Event- 0.96 inches in a 24 hour period
12/9/2005					387.00	611.00	414.50	398.50	1957.00	1780.00	720.00	676.00	Rain/snow event - precipitation 0.22 in on existing snow.
4/27/2006					123.50	130.00	146.00	150.50	512.00	393.50	303.50	254.50	Spring Break-up

Appendix IV. Temperature (C) measurements for six creeks sampled during the East End Road construction project in 2004 and 2005.

	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
Date	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
6/3/2004	9.5	9.4											
6/8/2004			7.8	7.8	9.3	9.3	11.5	12.1	12.3	13.0			
6/9/2004	8.5	8.4									11.6	11.4	
6/15/2004	8.5	8.7	8.5	8.5	8.8	9.1	9.5	9.5	9.5	9.6	10.7	10.6	
6/22/2004	11.1	11.3	11.6	11.0	12.0	13.4	17.5	17.2	17.7	18.1	16.2	15.9	
6/29/2004	10.9	10.9	11.1	10.8	11.8	12.7	16.4	16.1	16.1	16.1	15.8	15.6	
7/6/2004	12.1	12.0	11.9	11.7	12.4	14.0	18.1	18.2	17.2	17.6	16.4	16.3	
7/13/2004	12.5	13.0	12.6	12.3	13.4		18.8	18.1	19.0	18.5	17.2	17.8	Low flow, no Alder Creek downstream measurement
7/20/2004	13.2	13.2	12.4	12.4	12.8	13.5	15.3	15.6	14.5	14.6	15.7	15.5	Stream diversion on Alder Cr, downstream sample collected 250 ft. downstream from the normal sample collection site
7/27/2004	11.4	11.6	11.0	11.0	11.4	11.8	12.4	12.4	12.4	12.4	13.5	13.5	
8/3/2004	12.3	12.4	11.9	11.6	12.9	13.0	17.9	17.3	17.6	17.3	16.8	16.3	
8/10/2004	13.5	13.6	13.4	13.1	13.6	13.8	18.8	18.6	17.9	17.9	17.1	16.7	
8/17/2004	13.6	13.9	13.4	13.4	13.9	14.3	18.1	18.3	16.4	16.1	16.5	16.2	
8/24/2004	12.8	12.8	12.1	12.1	12.6	13.0	15.2	15.2	14.5	14.3	15.2	15.0	
8/31/2004	9.9	10.0	9.7	9.3	10.6	10.6	13.3	13.1	13.1	12.6	13.4	13.2	
9/2/2004	11.2	12.1	10.8	10.8	11.2	11.3	11.6	11.6	12.0	12.0	12.7	12.7	Rain Event- 0.62 inches in a 24 hour period
9/7/2004	8.7	8.7	8.3	8.0	9.0	8.9	11.0	10.5	11.6	11.1	12.3	12.1	
9/14/2004	7.8	7.5	6.9	6.7	7.3	7.5	8.6	9.1	8.6	8.7	9.6	9.5	
9/21/2004	6.4	6.4	5.7	5.6	6.4	6.4	6.8	6.4	7.7	7.4	8.4	8.3	
9/23/2004	7.2	7.2	6.6	6.5	6.7	6.9	7.4	7.3	8.3	8.0	8.4	8.4	Rain Event- 0.23 in a 24 hour period. This event was sampled because it was the first precipitation following a prolonged dry spell
9/26/2004	6.2	6.2	5.5	5.5	5.6	5.8	5.5	5.6	5.6	5.7	6.5	6.6	Rain Event- 0.66 inches in a 24 hour period
9/28/2004	6.4	6.4	5.4	5.3	5.8	5.8	6.7	6.5	7.2	7.1	7.5	7.5	
9/30/2004	8.1	8.0	7.6	7.6	7.8	8.2	8.2	8.2	8.8	8.8	8.5	8.6	Rain Event- 0.65 inches in a 24 hour period
10/3/2004	7.8	7.7	7.2	7.2	7.3	7.4	8.0	8.0	8.3	8.4	8.1	8.1	Rain Event- 0.29 inches in a 24 hour period
10/5/2004	6.8	6.6	6.2	6.2	6.6	6.7	6.8	6.7	7.8	7.8	7.7	7.7	
10/12/2004	6.8	6.4	6.1	6.0	6.6	6.6	7.2	7.0	7.7	7.6	7.7	7.7	
11/10/2004	1.1	0.9	0.0	0.2	0.2	0.3	0.2	0.1	0.0	0.1	0.7	0.6	Rain Event- 0.51 inches in a 24 hour period
4/14/2005	1.7	1.4	1.8	1.8	3.3	3.3	4.2	4.3	5.9	6.0	3.5	3.7	Spring Break-up
4/21/2005	3.5	3.8	3.7	3.8	3.3	3.5	3.6	3.8	4.3	4.4	3.2	3.2	Spring Break-up
4/28/2005	5.4	5.1	7.1	6.8	9.0	8.8	10.5	10.3	14.5	13.9	11.2	10.7	Spring Break-up
5/5/2005	5.1	5.2	5.7	5.7	5.5	5.6	6.0	5.9	7.2	7.0	7.6	7.2	Spring Break-up

Date	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
5/19/2005					8.8	9.1	12.5	12.1	14.2	14.0	13.1	12.7	Moved to bi-weekly sampling schedule. No longer collecting samples in Mariner Creek or Mattox Creek.
6/2/2005					7.2	8.4	8.7	8.1	10.2	9.6	12.5	12.1	
6/16/2005					12.8	13.9	17.8	17.5	16.6	16.3	16.2	15.7	
6/30/2005					12.1	13.0	14.1	14.1	14.8	14.5	16.8	16.6	
7/14/2005					13.7	12.1	14.5	14.2	14.9	14.5	15.9	15.6	
7/28/2005					11.7	13.2	14.5	14.6	14.4	14.4	14.7	14.6	
8/11/2005					12.9	14.0	16.3	16.5	16.1	16.0	15.5	15.1	
8/24/2005					11.1	11.5	12.0	11.9	12.1	12.1	13.9	13.7	
9/6/2005	11.6	11.9	11.2	11.2	11.3	11.4	12.1	12.2	11.8	12.1	13.0	13.0	Rain Event- 0.71 inches in a 24 hour period
9/9/2005					10.5	10.6	10.5	10.5	10.9	10.9	11.7	11.7	Rain Event- 0.96 inches in a 24 hour period
12/9/2005					0.1	0.2	0.0	0.1	0.0	0.2	0.4	0.4	Rain/snow event - precipitation 0.22 in on existing snow.
4/27/2006					2.5	2.5	3.1	3.0	4.3	4.3	3.5	3.4	Spring Break-up

Appendix V. Specific Conductivity (µS@25°C) measurements for six creeks sampled during the East End Road construction project in 2004 and 2005.

	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
Date	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
6/3/2004	187.5	193.0											
6/8/2004			150.0	150.0	160.0	163.0	141.0	141.0	235.0	238.0			
6/9/2004	171.7	202.7									321.2	317.7	
6/15/2004	244.2	231.1	163.7	153.7	174.1	129.1	148.2	149.9	243.3	202.3	346.2	342.9	
6/22/2004	266.0	248.8	168.2	164.8	151.5	162.3	154.8	156.1	250.9	192.9	350.5	347.4	
6/29/2004	254.8	131.8	173.5	170.6	175.7	188.4	161.7	162.0	250.7	250.1	357.8	323.6	
7/6/2004	246.2	285.8	176.7	157.8	192.6	186.3	169.8	170.0	259.4	223.6	367.6	364.0	
7/13/2004	344.0	283.1	184.0	182.4	182.7		179.7	179.7	267.8	185.6	371.4	368.4	Low flow, no Alder Creek downstream measurement
7/20/2004	289.8	253.0	182.2	182.2	198.5	181.2	176.4	176.7	258.2	248.0	366.4	364.0	Stream diversion on Alder Cr, downstream sample collected 250 ft. downstream from the normal sample collection site
7/27/2004	263.9	271.9	183.1	183.5	192.0	189.8	174.9	155.3	250.4	252.5	394.6	394.8	
8/3/2004	296.7	320.8	195.3	194.6	211.4	207.8	190.8	190.6	272.6	270.4	392.3	388.5	
8/10/2004	296.1	326.7	171.5	169.0	213.1	207.3	193.7	193.5	276.6	276.9	389.2	377.0	
8/17/2004	341.6	251.5	197.5	151.2	216.6	189.8	196.9	196.4	280.1	280.2	395.1	391.2	
8/24/2004	290.4	295.3	203.7	204.2	221.9	219.9	198.7	197.4	280.2	280.9	400.7	396.9	
8/31/2004	358.5	344.5	204.2	203.0	209.5	128.8	196.5	196.2	281.0	281.0	401.0	394.6	
9/2/2004	215.9	175.3	189.2	187.3	214.0	215.0	185.9	189.1	223.3	238.2	388.5	391.6	Rain Event- 0.62 inches in a 24 hour period
9/7/2004	307.2	314.4	206.1	207.6	218.6	220.6	199.4	200.2	259.0	211.9	401.8	398.4	
9/14/2004	336.4	323.0	208.0	201.5	220.0	222.8	200.2	199.5	284.3	283.4	406.0	402.4	
9/21/2004	285.6	288.2	208.3	208.0	215.0	222.3	197.4	195.8	279.3	256.1	408.9	406.3	
9/23/2004	257.7	279.2	204.9	203.4	208.0	212.7	194.2	194.5	272.9	272.8	404.2	401.0	Rain Event- 0.23 in a 24 hour period. This event was sampled because it was the first precipitation following a prolonged dry spell
9/26/2004	172.1	172.7	173.7	173.8	171.3	175.8	173.0	172.5	206.9	205.0	371.8	368.8	Rain Event- 0.66 inches in a 24 hour period
9/28/2004	240.1	236.5	192.0	193.4	190.1	194.7	184.0	173.4	246.6	245.6	384.4	382.6	
9/30/2004	133.9	133.5	152.0	152.6	148.8	117.0	146.1	148.0	150.9	159.2	317.0	312.2	Rain Event- 0.65 inches in a 24 hour period
10/3/2004	171.8	170.2	175.8	178.4	168.0	172.5	169.3	168.0	248.4	248.0	360.5	358.9	Rain Event- 0.29 inches in a 24 hour period
10/5/2004	182.5	182.1	179.1	182.8	170.8	177.0	171.2	172.5	253.8	248.0	360.8	360.7	
10/12/2004	184.4	195.3	191.9	194.8	181.5	189.3	178.9	179.8	269.1	270.0	378.4	375.4	
11/10/2004	122.1	125.7	225.5	218.6	154.5	162.2	155.4	156.7	176.5	201.8	323.9	304.0	Rain Event- 0.51 inches in a 24 hour period
4/14/2005	80.0	74.2	71.9	73.0	137.4	147.3	133.2	134.3	134.6	150.5	269.8	264.0	Spring Break-up
4/21/2005	121.9	130.7	134.0	135.5	147.3	154.0	121.4	123.2	178.9	180.2	254.8	253.7	Spring Break-up
4/28/2005	127.8	127.8	130.7	132.0	141.8	146.8	107.5	108.6	168.0	133.1	234.1	230.1	Spring Break-up
5/5/2005	144.3	145.9	139.6	140.7	149.3	157.5	120.8	122.0	196.0	194.8	274.5	264.3	Spring Break-up

Date	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
5/19/2005					152.1	162.8	128.8	130.1	215.4	211.8	294.4	239.5	Moved to bi-weekly sampling schedule. No longer collecting samples in Mariner Creek or Mattox Creek.
6/2/2005					177.8	191.0	150.8	152.1	248.1	249.4	335.2	330.1	
6/16/2005					190.0	177.6	167.2	168.0	265.5	265.6	356.4	348.6	
6/30/2005					204.0	215.4	180.2	181.5	276.5	277.5	379.6	378.0	
7/14/2005					238.6	218.7	192.3	195.2	293.9	291.5	390.9	388.0	
7/28/2005					216.5	232.0	194.5	193.2	278.5	283.6	391.3	388.2	
8/11/2005					215.6	238.6	201.8	201.1	295.7	296.8	391.6	396.6	
8/24/2005					221.0	232.9	199.0	199.3	279.2	276.8	399.6	398.8	
9/6/2005	137.8	174.0	177.6	178.3	177.1	182.6	171.9	171.7	227.0	222.3	385.7	385.5	Rain Event- 0.71 inches in a 24 hour period
9/9/2005					168.8	171.7	162.0	162.9	210.9	209.3	365.8	363.6	Rain Event- 0.96 inches in a 24 hour period
12/9/2005					133.5	141.1	148.1	147.0	161.7	159.5	254.3	238.8	Rain/snow event - precipitation 0.22 in on existing snow.
4/27/2006					128.5	141.2	144.9	147.2	189.2	184.1	241.2	233.1	Spring Break-up

Appendix VI. pH measurements for six creeks sampled during the East End Road construction project in 2004 and 2005.

Date	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
6/3/2004	7.36	7.27											
6/8/2004			7.48	7.47	7.62	7.57	7.62	7.58	7.90	7.83			
6/9/2004	7.79	7.66									8.33	8.31	
6/15/2004	7.58	7.47	7.69	7.55	7.89	7.69	7.81	7.82	7.98	7.98	8.08	8.10	
6/22/2004	7.41	7.40	7.70	8.02	7.86	7.49	7.85	7.82	8.05	8.00	8.06	8.15	
6/29/2004	7.37	7.29	7.54	7.52	7.84	7.45	7.79	7.40	7.97	7.88	8.02	8.06	
7/6/2004	7.61	7.54	7.67	7.54	7.82	7.52	7.85	7.86	7.95	8.01	8.05	8.04	
7/13/2004	7.33	7.12	7.56	7.64	7.42	7.40	7.85	7.91	8.06	7.94	8.05	8.04	Low flow, no Alder Creek downstream measurement
7/20/2004	7.57	7.47	7.61	7.54	7.71	7.39	7.91	7.96	8.00	7.96	8.05	8.07	Stream diversion on Alder Cr, downstream sample collected 250 ft. downstream from the normal sample collection site
7/27/2004	7.46	7.41	7.60	7.58	7.79	7.29	7.79	7.80	7.91	7.89	8.04	8.01	
8/3/2004	7.44	7.28	7.59	7.53	7.76	7.29	7.89	7.90	7.99	7.96	8.03	8.04	
8/10/2004	7.55	7.16	7.56	7.51	7.76	7.37	7.89	7.97	8.08	8.00	7.98	8.06	
8/17/2004	7.48	7.17	7.50	7.56	7.76	7.27	7.95	7.98	8.11	8.00	8.04	8.06	
8/24/2004	7.48	7.39	7.59	7.56	7.81	7.41	7.91	7.95	8.06	7.99	8.03	8.06	
8/31/2004	7.47	7.34	7.63	7.44	7.78	7.31	7.89	7.96	8.03	7.98	7.95	7.97	
9/2/2004	7.51	7.34	7.64	7.61	7.82	7.59	7.81	7.79	7.88	7.88	8.05	8.06	Rain Event- 0.62 inches in a 24 hour period
9/7/2004	7.60	7.47	7.61	7.59	7.83	7.45	7.82	7.84	8.03	7.98	8.09	8.09	
9/14/2004	7.57	7.47	7.60	7.63	7.83	7.44	7.83	7.91	8.02	7.95	7.99	7.98	
9/21/2004	7.51	7.36	7.64	7.60	7.80	7.45	7.80	7.83	7.95	7.93	8.01	8.01	
9/23/2004	7.41	7.34	7.62	7.56	7.80	7.48	7.79	7.81	7.91	7.90	7.94	7.95	Rain Event- 0.23 in a 24 hour period. This event was sampled because it was the first precipitation following a prolonged dry spell
9/26/2004	7.36	7.27	7.56	7.42	7.71	7.27	7.68	7.69	7.74	7.84	8.07	8.07	Rain Event- 0.66 inches in a 24 hour period
9/28/2004	7.47	7.33	7.64	7.61	7.81	7.49	7.80	7.82	7.95	7.98	8.03	8.06	
9/30/2004	7.23	7.11	7.46	7.36	7.58	7.15	7.50	7.63	7.49	7.57	7.99	8.02	Rain Event- 0.65 inches in a 24 hour period
10/3/2004	7.36	7.29	7.60	7.39	7.74	7.35	7.66	7.73	7.93	7.92	7.97	8.01	Rain Event- 0.29 inches in a 24 hour period
10/5/2004	7.33	7.30	7.59	7.35	7.73	7.30	7.68	7.71	7.93	7.92	8.00	8.03	
10/12/2004	7.38	7.35	7.62	7.45	7.73	7.37	7.74	7.76	7.94	7.96	7.99	8.02	
11/10/2004	7.15	7.18	7.29	7.18	7.62	7.26	7.52	7.45	7.65	7.60	7.96	7.94	Rain Event- 0.51 inches in a 24 hour period
4/14/2005	7.43	7.30	7.55	7.48	7.64	7.63	7.69	7.71	7.46	7.65	7.96	7.99	Spring Break-up
4/21/2005	7.81	7.88	7.87	7.80	8.01	7.78	7.93	7.96	7.94	8.03	8.31	8.30	Spring Break-up
4/28/2005	7.28	7.15	7.44	7.43	7.55	7.48	7.46	7.49	7.52	7.67	7.92	7.81	Spring Break-up
5/5/2005	7.28	7.06	7.43	7.40	7.61	7.35	7.47	7.47	7.62	7.73	7.89	7.88	Spring Break-up

Date	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek		Comments
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
5/19/2005					7.83	7.27	7.81	7.81	8.03	8.08	8.19	8.17	Moved to bi-weekly sampling schedule. No longer collecting samples in Mariner Creek or Mattox Creek.
6/2/2005					7.67	7.23	7.87	7.76	7.97	8.03	8.23	8.19	
6/16/2005					7.97	7.23	8.00	8.02	8.07	8.07	8.15	8.15	
6/30/2005					7.67	7.44	8.11	7.98	8.16	8.18	8.36	8.35	
7/14/2005					7.85	7.44	8.13	8.14	8.22	8.11	8.28	8.24	
7/28/2005					7.97	7.46	7.97	8.11	8.19	8.20	8.34	8.34	
8/11/2005					7.78	7.18	8.22	8.25	8.26	8.24	8.32	8.34	
8/24/2005					8.00	7.40	8.10	8.14	8.14	8.10	8.32	8.34	
9/6/2005	7.36	7.31	7.52	7.50	7.67	7.47	7.75	7.79	7.75	7.84	8.17	8.20	Rain Event- 0.71 inches in a 24 hour period
9/9/2005					8.09	7.77	8.07	8.10	8.06	8.13	8.45	8.43	Rain Event- 0.96 inches in a 24 hour period
12/9/2005					7.46	7.36	7.45	7.52	7.45	7.48	7.89	7.84	Rain/snow event - precipitation 0.22 in on existing snow.
4/27/2006					7.59	7.41	7.49	7.51	7.58	7.63	7.92	7.87	Spring Break-up

Appendix VII. Historic data for Miller Creek, Oct 2002- Aug 05 collected by Cook Inletkeeper's Citizens' Environmental Monitoring Program.

Downstream

Collection Date	Turbidity (NTU)	Water Temperature (C)	Conductivity (µS @ 25 °C)	pH
24-Nov-02		4.5	62.0	6.46
29-Dec-02	48.4	0.5	192.0	7.60
01-Nov-02		6.0	85.0	6.84
26-Jan-03	165.5	1.0	192.0	7.60
23-Feb-03	699.0	2.0	148.5	7.61
30-Mar-03	100.1	1.0	171.0	7.65
27-Apr-03		12.0	199.5	7.81
11-May-03	99.5	9.0	190.0	7.77
25-May-03	36.0	16.5	240.0	8.06
08-Jun-03		11.0	261.0	8.11
29-Jun-03		16.0	271.0	8.20
28-Sep-03	24.4	10.0	275.0	8.11
26-Oct-03	12.4	5.0	242.0	7.85
31-Aug-03	29.8	14.0	272.0	8.15
30-Nov-03	16.7	3.8	267.0	7.37
10-Aug-03	34.1	18.5	296.0	8.53
27-Jul-03	45.6	16.5	285.0	8.06
13-Jul-03	35.1	22.0	290.0	8.50
25-Jan-04	25.2	0.0	262.0	7.39
29-Dec-03	209.5	1.0	135.0	7.11
29-Feb-04	43.4	2.0	227.0	7.48
09-May-04	250.0	11.0	122.0	7.40
25-Apr-04	3906.0	6.5	9.5	7.20
28-Mar-04	41.0	0.0	240.0	7.55
27-Jun-04	20.1	16.0	249.0	7.85
30-May-04	15.7	14.0	205.0	7.79
09-Jun-04	10.2	8.5	221.0	7.79
11-Jul-04	20.3	19.5	259.0	7.92
29-Aug-04	22.6	12.0	269.0	7.84
08-Aug-04	22.6	17.0	268.0	7.81
25-Jul-04	16.9	13.0	277.0	7.91
30-Jan-05	27.0	2.6	244.0	7.27
27-Feb-05	42.1	2.8	249.0	7.43
27-Mar-05	85.1	7.3	225.0	7.14
24-Apr-05		10.4	122.0	6.55
08-May-05	14.2	13.8	190.0	7.21
29-May-05	9.1	13.3	230.0	8.67
09-Jun-05	13.2	11.7	239.0	7.75
26-Jun-05	22.9	16.6	274.0	7.72
10-Jul-05		17.5	290.0	8.19
31-Jul-05	31.4	16.6	288.0	8.31
14-Aug-05	32.0	13.8	289.0	7.64
29-Aug-05	98.6			

Upstream

Collection Date	Turbidity (NTU)	Water Temperature (C)	Conductivity (µS @ 25 °C)	pH
31-Oct-04	10.7	2.4	269.0	7.50
19-Nov-04	108.0	0.8	212.0	7.60
21-Nov-04	32.2	1.9	218.0	7.24
15-Mar-05	99.2	0.8	210.0	7.05
28-Apr-05	8.6	14.4	160.5	6.92
01-Jun-05	8.3	12.5	238.0	7.51
16-Jun-05	12.8	12.1	262.0	7.41
26-Jun-05	18.3	10.5	272.0	7.51
10-Jul-05		14.0	285.0	7.52
31-Jul-05	33.4	15.1	317.0	7.65
14-Aug-05	32.2	12.5	294.0	7.75
28-Aug-05	92.1	10.9	278.0	7.55

Appendix VIII. GPS coordinates in decimal degrees for the 12 sampling sites monitored during the East End Road construction Project in 2004 and 2005.

	Mariner Creek		Mattox Creek		Alder Creek		Bear Creek		Miller Creek		Waterman Creek	
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
LAT	59.64964201	59.64877834	59.65133649	59.65079519	59.66410683	59.66369737	59.66424898	59.66349914	59.67057941	59.66980694	59.68246428	59.68217217
LONG	-151.52621602	-151.52567388	-151.51575649	-151.51574660	-151.47432458	-151.47225743	-151.46953650	-151.46965016	-151.43564385	-151.43495050	-151.40454138	-151.40441422