KENAI RIVER HYDROCARBON ASSESSMENT

FINAL REPORT

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***Prepared for*:**
Alaska Department of Environmental Conservation
Non-Point Source Water Pollution Control Program
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Acronyms

ADEC – Alaska Department of Environmental Conservation
ADF&G – Alaska Department of Fish and Game
AWQS – Alaska Water Quality Standards (from 18 AAC 70)
BTEX – benzene, toluene, ethylbenzene and xylene
KWF – Kenai Watershed Forum
mg/L – milligrams per liter
PAH – polycyclic aromatic hydrocarbons
ppb – parts per billion (ppb=ug/L)
ppm – parts per million (ppm=mg/L)
RM – river mile
TAqH – total aqueous hydrocarbons (TAqH=BTEX+PAH)
TAH – total aromatic hydrocarbons (TAH=BTEX)
ug/L – micrograms per liter
USGS – Unites States Geological Survey
VOC – volatile organic compound

1 Executive Summary

Water samples were collected from the Kenai River in 2003 to determine potential hydrocarbon inputs. Three potential sources of hydrocarbons were the focus of the study: motorboat activity on the river, untreated stormwater outfalls and boat activity in the Kenai Harbor. Hydrocarbon inputs from motorboat activity were monitored throughout the program by sampling four transects and three representative habitat sites each Tuesday from May 20 to August 26. Additionally, two intensive sampling events took place along a transect at river mile (RM) 10. Stormwater inputs were monitored by sampling from two untreated stormwater outfalls during one spring and one fall sampling event. Boat activity in the Kenai Harbor was monitored during one spring, two summer and one fall sampling event at three sampling sites and along one transect. In addition to these three sources, potential hydrocarbon inputs from contaminated sites were also considered. There is no evidence that contaminated sites are contributing contamination as no hydrocarbons were detected when motorboats were not present on the river.

Results of the motorboat sampling program show that hydrocarbon concentrations were highest in July, the peak season of motorboat traffic on the river. Hydrocarbon concentrations increased downriver (lower river mile), with the highest detected concentrations at sampling sites below RM 10. Results of an intensive sampling event at RM 10 conducted from Sunday July 20 through Tuesday July 22 showed that hydrocarbon concentrations were associated with motorboat traffic on the river. Peaks in hydrocarbon contamination occurred throughout the day Sunday and Tuesday morning when river traffic was heavy. Only one measurable concentration was reported during the day on Monday, when motorboats are not allowed on the river for fishing and motor boat use was very light. Two exceedances of the 10 ug/L Alaska Water Quality Standard (AWQS) for total aromatic hydrocarbons (TAH) occurred at noon and 2 p.m. Sunday (10.2 ug/L and 10.76 ug/L respectively). TAH is associated with gasoline contamination.

No reportable concentrations of hydrocarbons occurred during the spring and fall sampling events in the Kenai Harbor. The two summer sampling events, conducted during an ebb and flood tide, had measurable concentrations of hydrocarbons at all the sampling sites. Concentrations increased as sites progressed towards the mouth of the river.

No measurable concentrations of hydrocarbons occurred during the spring and fall stormwater sampling events with the exception of one sample collected directly from the Soldotna Bridge outfall during the spring sampling event. Four polycyclic aromatic hydrocarbon (PAH) compounds were detected totaling 1.62 ug/L, well below the 15 ug/L AWQS for total aqueous hydrocarbons (TAqH). PAH is associated with heavier hydrocarbons such as diesel fuel, oils and lubricants.

Future research efforts studying hydrocarbon contamination on the Kenai River should focus on inputs from motorboats and boat activity in the Kenai Harbor. Research investigating motorboat inputs should be conducted on Saturdays and Sundays in July. Boat count and engine type data should be collected in conjunction with analytical samples to determine their correlation with hydrocarbon contamination. Further sampling in the Kenai Harbor should focus on commercial openers and the personal dipnet fishery. Boat count and user-type data should also be collected in the harbor (commercial vs. small motorboats) in tandem with water sampling activities.

2 Introduction

The Alaska Department of Environmental Conservation (ADEC) contracted OASIS Environmental, Inc. (OASIS) to conduct a study on the presence of hydrocarbons in the Lower Kenai River from the Soldotna Bridge to Cook Inlet in 2003. ADEC commissioned the study after several years of data collected biannually by the Kenai Watershed Forum (KWF), combined with extended screening and sampling conducted in 2002, indicated elevated petroleum levels were persistent during periods of high river usage. This study was designed to determine the sources, extent, and duration of hydrocarbon contamination on the Kenai River during times when potential contamination sources were present. Three factors were evaluated during the study: motorboat use on the river, stormwater outfalls and the level of boat activity in the Kenai Harbor. Information gained will be useful as resource managers develop long term management plans for the river.

Initial screening for the occurrence of hydrocarbons in the Kenai River has been conducted through several programs run by the Kenai Watershed Forum (KWF). These programs include the collection of grab samples twice per year at 20 sites along the river, passive hydrocarbon sampling and an intensive sampling in the summer of 2002, which included the collection of 12 samples over an eight-day period at three sites. Preliminary results from the KWF studies indicate that hydrocarbons are highest in the lower 10 miles of the river and there is an association between hydrocarbon concentrations and boat use.

This sampling program included sites selected to determine the inputs from the three possible contaminant sources. A total of 284 samples, including quality control (QC) samples, were collected over the summer. Samples were collected from May 20 to September 25, 2003.

3 Methods

All samples were collected using the same methods and in the same locations as much as possible to minimize sampling related bias. Quality control samples were also collected to verify the sampling methods were not introducing bias. Specific procedures are delineated in the following discussion.

Sample sites are shown on Figure 1. Multiple sites were sampled for each potential contamination source, including transects consisting of two sampling sites in a line perpendicular to the stream flow in the thalweg (main channel) of the river. Four transects were selected to assess motorboat impacts, three sites plus one transect were selected to assess boat activity in the Kenai Harbor, and two stormwater outfalls were sampled. In addition, three sampling sites were located in habitats representative of both fish spawning and rearing along the Kenai River.

Data collection began on May 20, 2003 and continued on every Tuesday, which is historically the highest user-day, through August 26, 2003. OASIS personnel were assisted by the Kenai Watershed Forum (KWF), the Alaska Department of Fish and Game (ADF&G), and the Alaska Department of Environmental Conservation (ADEC). All samples for laboratory analysis were collected by OASIS personnel. Volunteers provided assistance in operating the boat, collecting field parameters, and recording site conditions.

Sampling locations are depicted in Figure 1. Sampling locations were accessed using a 15 foot aluminum skiff with a 15 hp outboard engine. When conditions permitted, the skiff was anchored prior to sample collection. During periods of heavy boat traffic or strong currents which precluded anchoring at the sample site, the skiff was idled to remain in position while samples were collected from off of the bow.

All surface water samples were analyzed for total aromatic hydrocarbons (TAH) using Environmental Protection Agency (EPA) Method 624. TAH compounds are mainly associated with gasoline, which is a pollutant of concern from all sources considered in this study. Ten percent of the motorboat samples and all the samples collected from the Kenai Harbor and from the stormwater outfalls were also analyzed for polycyclic aromatic hydrocarbons (PAH) using EPA Method 610. PAH compounds are associated with diesel fuel, oils and lubricants. Samples were collected in order of volatility of the analyte; TAH samples were collected first, followed by PAH samples.

***Photo** – Susan Ives with OASIS sampling at the background transect above the Kenai Harbor. The USGS sampler is in her hands.*

All samples were collected in accordance with the detailed sampling procedures

outlined in the Kenai River Hydrocarbon Assessment Quality Assurance Project Plan (QAPP) prepared for this project (OASIS 2003). Surface water samples were collected with a Wildco® volatile organic compound (VOC) sampler at 12 inches below the surface. This sampler was designed by USGS to evacuate air and other gases from the sampler before collecting a sample. Sample bottles are flushed seven times and evacuated air is vented through the exhaust tube before the final sample is collected. The small inlet tubes (1/16 inch inside diameter) fill slowly so that the sampler can collect a representative sample and also be placed at specific depths. Where shallow surface water at the stormwater outfalls prohibited using the VOC sampler, grab samples were collected using clean 40-mL vials. Analytical laboratory services were provided by SGS Environmental Laboratories (SGS) of Anchorage, Alaska.

Multi-parameter water quality meters (Horiba U-10, Horiba U-22 or YSI 55) were used to collect the following field parameters at each site: temperature, pH, dissolved oxygen, turbidity, conductivity and salinity. GPS coordinates were taken at each sample site to record the location. Photographs were used to document site conditions, including boat use and water level. During the July intensive sampling event, photographs were taken of both the upstream and downstream reaches to record the level of boat activity in the immediate area. Field parameter measurements, photograph numbers, GPS coordinates, sampling information, and comments were recorded on Sample Data Sheets, provided as Attachment A. Photographs are provided electronically as Attachment B.

Detailed descriptions of the sampling design for each possible hydrocarbon input are described in their respective sections below. A complete list of all samples collected is provided in Table 1 at the end of this section. In the table, FY03 samples refer to the samples collected during the State's 2003 Fiscal Year, which ended on June 30, 2003. FY04 samples were collected during the State's 2004 Fiscal Year beginning July 1, 2003.

3.1 Motorboat and Representative Habitat Samples

Four transects were sampled over the summer to investigate the locations and timing of motorboat inputs of hydrocarbons to the river. The four transect locations were selected based on the reaches of highest density boat use on the river. One transect was selected above the highest density of boat use to serve as a background site. Three representative habitat sites were also selected to determine if hydrocarbon concentrations occurring in the thalweg also existed in areas that provide habitat for fish spawning and rearing. Representative habitat sites were selected through consultation with ADF&G area management biologists.

The river mile (RM) of each transect and representative habitat site and the basis for selecting them are provided below. They are listed in the order they were sampled. The background sample transect was sampled first and the sites on the lower river were sampled from the lowest point downstream moving upstream to avoid sampling the same water column

> ***RM 23.1*** – The background transect was located above the motorboat launch at Swiftwater Campground. These sites were sampled first each Tuesday morning to determine if there are background concentrations of hydrocarbon contamination above this point on the river.
>
> ***RM 8.2*** – This transect was located at the downstream end of Lower Bluffs and captures the lower reaches of the high density Chinook salmon fishery.

RM 9.7 – The first representative habitat site was located in the side channel on the right bank immediately below Beaver Creek. This sampling site is adjacent to a large gravel bar submerged during high tides and provides spawning habitat for pink salmon and other fish species and serves as an important migration area where fish can adjust to the change from salt to fresh water (Tarbox 2003).

RM 11.2 – This transect was located below Eagle Rock directly above the small feeder stream entering from the right bank. There is an extremely high density of motorboats that troll between Eagle Rock and Pillar's above this sample site. During the highest density of boat use in July, the stream of boats trolling in the thalweg continued straight past this site and down to Beaver Creek.

RM 11.4 – The second representative habitat site was located just above Eagle Rock in the side channel on the right bank between the boat launch and the main channel of the river. This side channel provides important rearing habitat for fish species.

RM 13.0 – The third representative habitat site was located at Honeymoon Cove on the right bank of the river. The thalweg of the river passes the entrance to the cove and is a popular section of the river to troll through. The cove provides excellent rearing habitat as it has a silty bottom and grasses to provide cover.

RM 15.5 – The last motorboat transect on the lower section of the river is located just upstream of Riverquest Campground at the downstream end of the vegetated island on the right bank. This sampling site was selected to capture the hydrocarbon inputs from the motorboats fishing the reaches upstream to the Soldotna Bridge.

Sampling at the four transects in areas of high motorboat use and three locations assessing conditions in areas of representative habitat occurred each Tuesday from May 20, 2003 to August 26, 2003, with the following exceptions:

- Lack of daylight and associated safety concerns prevented OASIS staff from collecting one sample at the RM 15.5 transect and both samples at the RM 23.1 transect on May 20.
- Low water levels prohibited launching the boat at Swiftwater Campground May 27 through June 17 and collecting the two samples for the RM 23.1 transect. Samples identified as MB-7 were collected from a location off of the right bank; samples were not collected from location MB-8.

In addition to the weekly monitoring, two intensive sampling events took place. The first intensive sampling event was conducted on June 24, 2003 along a transect below the Beaver Creek outlet at RM 10. From 4:00 a.m. until 8:00 p.m., samples were collected every four hours from locations ISS-1 and ISS-2. This first intensive sampling event was to evaluate potential changes in contaminant concentrations throughout the day.

The second intensive sampling event at RM 10 began at 12:01 a.m. on Sunday, July 20 and continued until midnight on Tuesday, July 22, 2003. Every two hours, one sample was collected from the thalweg of the river. This second intensive sampling event was designed to examine potential differences in contaminant concentration between days with varying motorboat activity: guided fishing trips are prohibited on Sundays, and fishing from motorboats is prohibited on Mondays.

A transect of three locations at three depths at RM 10 was sampled from 7:00 until 10:00 am on Tuesday, July 22 to assess differences in contamination with depth. The three locations are labeled ISS-1, ISS-2, and ISS-3 in Figure 1. At each location, samples were collected from three different depths:

- the sampler was lowered until the bottom was felt and raised to collect the lowest sample at 12 inches off of the bottom;
- the mid-depth sample was collected at half the depth of the deepest sample; and
- the surface sample was collected 12 inches below the surface of the river.

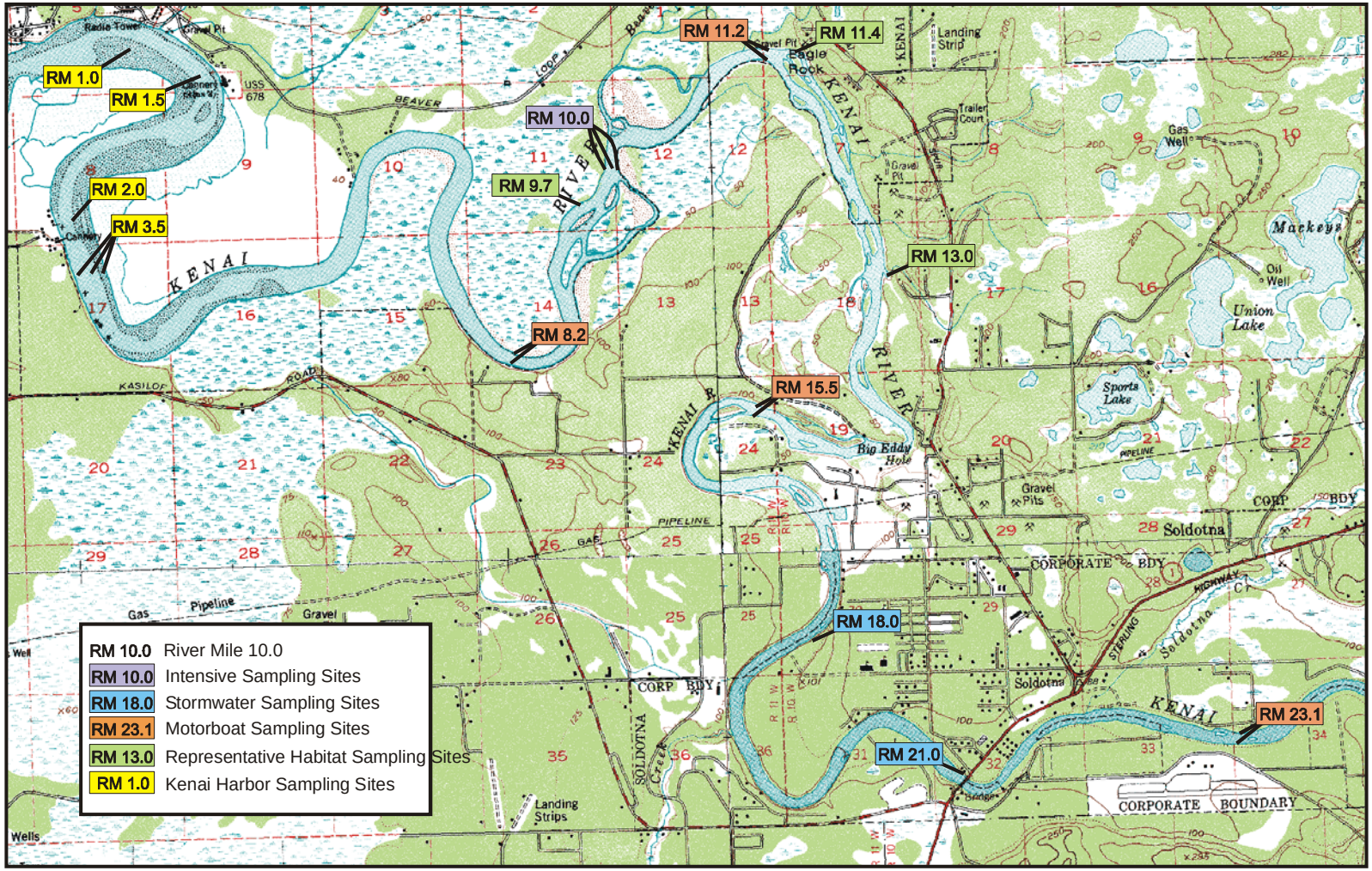


Figure 1. Sampling Sites

3.2 Kenai Harbor Samples

Samples were collected from the Kenai Harbor during the spring (May 20, 2003), summer (July 14 and 24, 2003), and fall (September 8, 2003) to evaluate potential hydrocarbon contamination associated with boat activity in the Kenai Harbor, both from commercial fishing vessels and private boats associated with the dipnet fishery.

Photo – *Sampling off of the Kenai Dock.*

With the exception of one summer sampling event, all Kenai Harbor samples were collected on an ebb tide to avoid sampling from the tidal influx of salt water. One summer sampling event (July 24, 2003) took place during a flood tide to evaluate the possibility of hydrocarbon contamination being transported upstream from boat activity in the harbor. Samples for both summer events and the fall event were collected in the evening, after the close of a commercial opener as boats were returning to the harbor. The spring event occurred on the first sampling date of the project to evaluate background conditions in the harbor. No boat activity was observed in the harbor during the spring sample event.

The original sample design called for one harbor sampling event per season. The winter sampling event was omitted to allow the collection of summer samples on both tidal stages.

3.3 Stormwater Samples

Two untreated stormwater outfalls were sampled to evaluate potential hydrocarbon inputs from stormwater runoff to the Kenai River: the Soldotna and Marydale outfalls. The Soldotna outfall is located at RM 21.0, below the Soldotna Bridge. The Marydale outfall is located off of Kobuk Street at RM 18.0. Water flowing from the Marydale outfall was partially treated, as it had come through a sediment basin.

Stormwater samples were collected the day of a significant storm event. A significant storm event is greater than 0.1 inches of rainfall that occurs at least 72-hours after the preceding measurable storm event (>0.1 inches), as defined in EPA guidance for collecting samples under their stormwater permitting program. The spring sampling event occurred on June 10 and the fall event on September 25. The spring sampling event occurred during the first significant storm event after the initiation of field activities on May 20. The summer stormwater samples were not collected due to the unavailability of OASIS field personnel at the onset of storm events during the target period of August.

The spring sample event was conducted in the afternoon after the collection of the Tuesday motorboat samples. Rainfall began that morning and a total of 0.47 inches

accumulated over the day. The fall sample event was also conducted in the afternoon. A total of 0.15 inches accumulated in the morning and rainfall had ended by the time sampling had begun.

Samples were collected from the following locations at each stormwater outfall:

- Untreated water flowing from the outfall,
- 15-feet upstream of the confluence of the river and the outfall flow, and
- 15-feet downstream of the confluence of the river and the outfall flow.

Where there was insufficient water to submerge the VOC sampler, grab samples were collected using a clean 40-mL vial.

3.4 Quality Control Samples

Quality control (QC) samples were collected throughout the program to verify that sample collection procedures did not bias results. Decontamination blanks, ambient blanks and field duplicates were all collected. Discussion of the results of the QC analysis is detailed in Section 5, Data Validation. The Kenai Watershed Forum Method Blanks are discussed in Section 4.4, Recommendations for Future Research.

3.4.1 Decontamination Blanks

Decontamination blanks were collected to verify that the VOC sampler was properly decontaminated and cross-contamination did not occur between sample sites. Decontamination blanks were collected on four dates: July 15, July 22, July 29 and August 5. Decontamination blanks were analyzed for both TAH and PAH. Decontamination blanks were collected after sampling at sites lower on the river where hydrocarbon contamination was considered most likely to be present.

3.4.2 Ambient Blanks

Strong currents and heavy boat traffic prohibited anchoring in the thalweg at certain sampling sites. When anchoring the boat was not possible, the skiff was idled at the sample site and the sample was collected off of the bow. To verify that fumes from the idling engine did not contaminated the samples three ambient blanks were collected over the course of the project. Two samples were collected on July 8 and one sample was collected on July 21. Ambient blanks were analyzed for TAH only.

3.4.3 Field Duplicates

Field duplicates were collected to assess the precision of the sample collection process and the laboratory analytical procedures. One field duplicate was collected on each of the 21 sampling dates. Two duplicates were collected on June 10, one duplicate of a motorboat sample and one duplicate of a stormwater sample. Field duplicates were submitted blind to the laboratory (*i.e.* they could not be identified by laboratory personnel as field duplicates) and analyzed for both TAH and PAH.

3.4.4 Kenai Watershed Forum Method Duplicates

Samples were collected using the sampling procedure developed by KWF to compare analytical results with those produced using the VOC sampler. A total of six KWF method duplicates were collected over the summer: one each on July 15 and July 22 and two each on July 29 and August 5. KWF method duplicates were analyzed for TAH

only. They were collected from sampling sites lower on the river where hydrocarbon contamination was most likely to be present.

Table 1. Sample Totals

Date	Stormwater		Harbor						Motorboats							Representative or Near-bank Habitats			QA/QC Samples				**TOTALS**
	Soldotna Bridge	Kobuk Street	Site #1	Site #2	Site #3	Ref. Site #1	Ref. Site #2	Ref. Site #3	Swiftwater Campground	Big Eddy	Eagle Rock	Lower Bluffs	Beaver Creek - June event	Beaver Creek - July event	Beaver Creek - July transect	Honeymoon Cove	Side Channel	Side Channel	Duplicates	Decon Blanks	KWF Method Duplicates	Ambient Blanks	
RM:	21.0	18.0	1.0	1.5	2.0	3.5	3.5	3.5	23.1	15.5	11.2	8.2	10.0	10.0	10.0	13.0	11.4	9.7	-	-	-	-	
20-May			1	1	1	1	1	1	0	1	2	2				1	1	1	1				15
27-May									1	2	2	2				1	1	1	1				11
3-Jun									1	2	2	2				1	1	1	1				11
10-Jun	3	3							1	2	2	2				1	1	1	2				18
17-Jun									1	2	2	2				1	1	1	1				11
24-Jun									2	2	2	2	10			1	1	1	1				22
1-Jul									2	2	2	2				1	1	1	1				12
8-Jul									2	2	2	2				1	1	1	1			2	14
14-Jul			1	1	1	1	1	1											1				7
15-Jul									2	2	2	2				1	1	1	1	1	1		14
20-Jul														12					1				13
21-Jul														12					1			1	14
22-Jul									2	2	2	2		12	9	1	1	1	1	1	1		35
24-Jul			1	1	1	1	1	1											1				7
29-Jul									2	2	2	2				1	1	1	1	1	2		15
5-Aug									2	2	2	2				1	1	1	1	1	2		15
12-Aug									2	2	2	2				1	1	1	1				12
19-Aug									2	2	2	2				1	1	1	1				12
26-Aug									2	2	2	2				1	1	1	1				12
9-Sep			1	1	1	1	1	1											1				7
25-Sep	3	3																	1				7
FY03 Total	3	3	1	1	1	1	1	1	6	11	12	12	10	0	0	6	6	6	7	0	0	0	**88**
FY04 Total	3	3	3	3	3	3	3	3	18	18	18	18	0	36	9	9	9	9	15	4	6	3	**196**
Total	6	6	4	4	4	4	4	4	24	29	30	30	10	36	9	15	15	15	22	4	6	3	**284**

4 Results

Analytical data from the motorboat, representative habitat, harbor, and stormwater sampling programs were entered into an Access 2002 database, provided in CD form as Attachment D. TAH and PAH analytical results for all samples collected during the program can be viewed in the database. Reports of analytical results by site and date can be produced using the "Print/View Sample Data Reports" option in the main menu. Results are presented in several graphs in the discussion section of this report.

4.1 Motorboat and Representative Habitat Sampling

4.1.1 Field Parameters

Field parameter measurements are provided in Table 2. Bold text indicates a measurement that exceeds the AWQS from 18 AAC 70. Variation in some parameters is expected because of differing climatic conditions when sampling occurred.

Only one dissolved oxygen value of 4.61 mg/L at the representative habitat site in Honeymoon Cove on July 22 was below the AWQS of 7 mg/L. Four dates had temperature measurements above the AWQS for fish spawning of 13 C° at almost every site: 7/15, 7/22, 7/29 and 8/12. The end of July was particularly warm and the 8/12 sampling event occurred after the two highest average temperature days on record for August. The only site with temperature measurements consistently above the AWQS was the representative habitat site at Honeymoon Cove, 9 of the 15 Tuesday sampling dates ranged from 13.1 to 16.9 C°. Temperatures at the intensive sampling site were above the AWQS from 2 a.m. to midnight on July 22 and only started to decrease after the 10 p.m. sample.

There were a total of 22 AWQS exceedances for pH, 8 of which were above the upper limit for pH at 8.5 pH units and 14 of which were below the lower limit for pH at 6.5 pH units. The two sampling sites at RM 23.1 had a total of ten values ranging from 5.26 to 6.48 and one value at 9.86. One site at RM 15.5 had three exceedances ranging from 8.54 to 9.34 on May 27, June 3 and July 15.

AWQS establish limits for turbidity that may not exceed 5 NTU above the natural conditions when natural conditions are 50 NTU or less or have an increase of 10% or more when natural conditions are greater than 50 NTU. Natural turbidity conditions for the Kenai River vary diurnally and seasonally due to glacial melt. An accurate comparison with AWQS cannot be made due to limited information on these variations. Turbidity values generally stayed below 100 with a few variations on several dates, May 20, June 3 and June 24.

Salinity readings are based on the conductivity measurement and do not have an AWQS. Salinity measurements were all less than 0.1% indicating minimal or no tidal influences were likely during sampling.

Table 2. 2003 Motorboat and Representative Habitat Field Parameter Results

Date	Site	Time	Conductivity (mS/cm)	Salinity (%)	DO (mg/L)	pH (pH units)	Temperature (°C)	Turbidity (NTU)
5/20/2003	RM 8.2	14:25	0.071	0	NA	7.74	9.5	226
5/20/2003	RM 8.2	14:55	0.064	0	NA	7.62	9.1	348
5/20/2003	RM 9.7	16:00	0.06	0	NA	**8.77**	10.1	173
5/20/2003	RM 11.2	16:45	0.062	0	NA	**8.72**	10.4	94
5/20/2003	RM 11.2	17:15	0.061	0	NA	**8.72**	10.2	31
5/20/2003	RM 11.4	18:00	0.105	0	NA	7.95	**18.7**	735
5/20/2003	RM 13	19:25	0.188	0	NA	7.62	**13.8**	154
5/20/2003	RM 15.5	21:00	0.045	0	NA	8.28	9.3	43
5/27/2003	RM 8.2	7:55	0.068	0	11.93	7.15	7.2	NA
5/27/2003	RM 8.2	8:40	0.063	0	12.01	7.23	7.2	NA
5/27/2003	RM 9.7	6:20	0.062	0	12.77	7.3	7.3	NA
5/27/2003	RM 11.2	10:00	0.059	0	12.97	7.67	7.3	NA
5/27/2003	RM 11.2	10:20	0.059	0	12.91	8.19	7.5	NA
5/27/2003	RM 11.4	10:45	0.069	0	12.2	7.74	9.2	NA
5/27/2003	RM 13	11:30	0.179	0	11.45	7.79	9.7	NA
5/27/2003	RM 15.5	12:15	0.54	0	13.88	7.65	7.6	NA
5/27/2003	RM 15.5	12:40	0.47	0	13.69	**8.6**	7.6	NA
5/27/2003	RM 23.1	5:35	0.067	0	13.44	**6.47**	6.8	NA
6/3/2003	RM 8.2	7:45	0.063	0	11.42	6.84	8.2	25
6/3/2003	RM 8.2	8:10	0.06	0	11.2	7.1	8.3	18
6/3/2003	RM 9.7	8:42	0.059	0	11.16	7.32	7.8	14
6/3/2003	RM 11.2	9:50	0.058	0	12.06	7.45	7.8	20
6/3/2003	RM 11.2	10:15	0.057	0	12.25	7.5	8.2	44
6/3/2003	RM 11.4	10:37	0.063	0	11.49	7.55	8.5	220
6/3/2003	RM 13	11:19	-	0	10.86	7.55	8.9	100
6/3/2003	RM 15.5	12:10	0.058	0	10.26	8.14	8.4	19
6/3/2003	RM 15.5	12:38	0.056	0	10.57	**8.54**	8.7	19
6/3/2003	RM 23.1	5:40	0.078	0	11.55	6.63	7.4	15
6/10/2003	RM 8.2	7:20	0.069	0	11.34	**5.99**	8.9	33
6/10/2003	RM 8.2	8:15	0.062	0	11.28	6.61	8.8	28
6/10/2003	RM 9.7	9:00	0.062	0	11.14	6.94	8.7	24
6/10/2003	RM 11.2	9:45	0.061	0	11.38	7.07	8.7	28
6/10/2003	RM 11.2	10:00	0.06	0	11.45	7.2	8.6	20
6/10/2003	RM 11.4	10:30	0.068	0	10.86	7.22	9.6	16
6/10/2003	RM 13	11:15	0.095	0	11.07	7.46	10.2	28
6/10/2003	RM 15.5	11:40	0.059	0	11.85	7.59	8.4	19
6/10/2003	RM 15.5	12:10	0.059	0	11.71	7.52	8.3	21
6/10/2003	RM 23.1	5:30	0.063	0	11.37	**5.59**	8.9	0
6/17/2003	RM 8.2	8:30	0.053	0	11.25	7.34	9.7	56
6/17/2003	RM 8.2	9:00	0.052	0	11.3	7.59	9.8	59
6/17/2003	RM 9.7	10:00	0.054	0	11.08	7.47	9.9	59
6/17/2003	RM 11.2	10:30	0.053	0	11.15	7.43	10	57
6/17/2003	RM 11.2	11:15	0.53	0	12.13	7.55	10.5	60
6/17/2003	RM 11.4	11:45	0.54	0	11.2	7.59	10.5	59
6/17/2003	RM 13	12:15	0.7	0	11.43	7.62	11.8	43
6/17/2003	RM 15.5	13:00	0.053	0	11.47	7.55	10.7	51
6/17/2003	RM 15.5	13:20	0.053	0	11.33	7.75	10.4	62
6/17/2003	RM 23.1	5:45	0.052	0	11.44	NA	9.8	52
6/24/2003	RM 8.2	8:30	0.056	0	10.77	7.4	10.1	27
6/24/2003	RM 8.2	9:00	0.055	0	10.74	7.37	10.1	26
6/24/2003	RM 9.7	9:40	0.056	0	11.05	7.43	10.1	26
6/24/2003	RM 10	4:10	0.057	0	10.8	7.05	10.8	93
AK Water Quality Stds.			-	-	>7 mg/L	6.5-8.5	<13°C	-

Table 2 continued.

Date	Site	Time	Conductivity (mS/cm)	Salinity (%)	DO (mg/L)	pH (pH units)	Temperature (°C)	Turbidity (NTU)
6/24/2003	RM 10	4:30	0.061	0	10.77	7.05	10.4	20
6/24/2003	RM 10	7:40	0.056	0	9.82	7.04	10	20
6/24/2003	RM 10	8:10	0.056	0	9.58	7.31	10	20
6/24/2003	RM 10	12:00	0.055	0	11.09	7.5	10.3	57
6/24/2003	RM 10	12:30	0.055	0	11.15	7.52	10.4	39
6/24/2003	RM 10	16:00	0.053	0	10.43	6.76	11.1	99
6/24/2003	RM 10	16:30	0.057	0	10.42	6.91	10.7	48
6/24/2003	RM 10	19:45	0.055	0	11.33	6.92	10.6	127
6/24/2003	RM 10	20:15	0.055	0	9.52	6.97	10.6	145
6/24/2003	RM 11.2	10:15	0.058	0	10.4	7.48	10.2	26
6/24/2003	RM 11.2	11:00	0.054	0	10.02	7.75	10.4	45
6/24/2003	RM 11.4	11:30	0.055	0	11.17	7.66	10.3	27
6/24/2003	RM 13	13:30	0.076	0	12.05	6.58	**13.1**	50
6/24/2003	RM 15.5	14:15	0.052	0	11.49	6.73	10.5	174
6/24/2003	RM 15.5	14:45	0.056	0	10.43	6.76	10.7	91
6/24/2003	RM 23.1	6:00	0.059	0	10.73	7.19	9.6	45
6/24/2003	RM 23.1	6:20	0.059	0	10.73	7.19	9.6	45
7/1/2003	RM 8.2	8:55	0.056	0	8.2	7.35	11.9	41
7/1/2003	RM 8.2	9:10	0.056	0	10.37	7.4	11.9	40
7/1/2003	RM 9.7	9:50	0.057	0	9.08	7.33	11.5	49
7/1/2003	RM 11.2	10:25	0.055	0	10.01	7.42	10.8	29
7/1/2003	RM 11.2	10:45	0.055	0	9.5	7.44	10.8	27
7/1/2003	RM 11.4	11:50	0.056	0	9.15	7.56	10.9	25
7/1/2003	RM 13	12:10	0.089	0.06	10.25	7.99	**13.1**	19
7/1/2003	RM 15.5	13:00	0.056	0	10.58	7.8	9.7	25
7/1/2003	RM 15.5	13:20	0.055	0	9.84	7.57	9.7	26
7/1/2003	RM 23.1	6:30	0.062	0	10.27	**6.46**	11	25
7/1/2003	RM 23.1	6:45	0.055	0	10.65	6.65	10.4	22
7/8/2003	RM 8.2	10:10	0.06	0	12.23	7.05	11.8	41
7/8/2003	RM 8.2	10:20	0.06	0	11.93	7.04	11.7	32.4
7/8/2003	RM 9.7	11:10	0.06	0	13.12	7.13	11.8	34.9
7/8/2003	RM 11.2	12:00	0.06	0	11.75	7.05	11.7	34.5
7/8/2003	RM 11.2	12:50	0.06	0	13.7	6.92	12.4	31.9
7/8/2003	RM 11.4	13:15	0.06	0	12.28	7.09	11.7	28.6
7/8/2003	RM 13	14:00	0.08	0	15.66	**8.61**	**14.7**	21.5
7/8/2003	RM 15.5	14:40	0.06	0	13.87	7.86	12.8	29.2
7/8/2003	RM 15.5	14:50	0.06	0	14.3	7	**13.2**	26.9
7/8/2003	RM 23.1	7:00	0.06	0	12.25	**9.86**	10.6	2.27
7/8/2003	RM 23.1	7:20	0.06	0	11.75	**6.47**	10.5	27.7
7/15/2003	RM 8.2	8:40	0.55	0	8.17	7.12	**13.8**	22
7/15/2003	RM 8.2	9:00	0.055	0	8.23	7.32	**13.8**	42
7/15/2003	RM 9.7	9:50	0.056	0	8.29	7.6	**13.6**	31
7/15/2003	RM 11.2	10:30	0.55	0	9.04	7.65	**13.4**	20
7/15/2003	RM 11.2	11:00	0.55	0	8.59	7.58	**13.6**	23
7/15/2003	RM 11.4	13:00	0.54	0	8.61	8.28	**14.3**	22
7/15/2003	RM 13	13:00	0.07	0	8	8.39	**16.9**	12
7/15/2003	RM 15.5	14:00	0.54	0	9.13	**9.34**	**15.3**	29
7/15/2003	RM 15.5	14:30	0.054	0	9	8.28	**15.4**	27
7/15/2003	RM 23.1	6:50	0.66	0	8.94	6.97	**13.2**	19
7/15/2003	RM 23.1	7:10	0.56	0	8.48	7.32	**13.1**	17
7/20/2003	RM 10	0:00	0.073	0	10.71	**6.22**	12.92	17
7/20/2003	RM 10	2:00	0.059	0	10.73	7.15	**13.07**	12.8
AK Water Quality Stds.			-	-	>7 mg/L	6.5-8.5	<13°C	-

Table 2 continued.

Date	Site	Time	Conductivity (mS/cm)	Salinity (%)	DO (mg/L)	pH (pH units)	Temperature (°C)	Turbidity (NTU)
7/20/2003	RM 10	4:00	0.06	0	10.78	7.37	**13.17**	11.2
7/20/2003	RM 10	6:00	0.06	0	11.02	7.45	12.6	11.4
7/20/2003	RM 10	8:00	0.061	0	10.83	7.37	11.82	12.1
7/20/2003	RM 10	10:00	0.062	0	11.49	7.46	11.47	24.1
7/20/2003	RM 10	12:00	0.06	0	12	7.41	11.44	39.7
7/20/2003	RM 10	14:00	0.061	0	11.7	7.57	11.7	39.1
7/20/2003	RM 10	16:00	0.061	0	12.01	7.58	12.23	13.4
7/20/2003	RM 10	18:00	0.061	0	12.53	7.65	12.78	41.5
7/20/2003	RM 10	20:00	0.07	0	10.89	**6.07**	12.78	15.6
7/20/2003	RM 10	22:00	0.065	0	10.64	6.52	12.38	10.6
7/21/2003	RM 10	0:00	0.062	0	10.75	6.74	12.15	10.9
7/21/2003	RM 10	2:00	0.061	0	10.66	7.15	12.1	11.4
7/21/2003	RM 10	4:00	0.063	0	10.41	7.33	11.96	11
7/21/2003	RM 10	6:00	0.062	0	10.61	7.42	11.7	11.2
7/21/2003	RM 10	8:00	0.065	0	11.11	7.32	11.39	11.3
7/21/2003	RM 10	10:00	0.06	0	10.57	7.46	11.3	11
7/21/2003	RM 10	12:00	0.063	0	11.46	7.43	11.91	32.9
7/21/2003	RM 10	14:00	0.062	0	11.67	7.51	12.14	25.3
7/21/2003	RM 10	16:00	0.061	0	12.04	7.39	12.75	15.4
7/21/2003	RM 10	18:00	0.061	0	10.4	7.57	**13.81**	10.7
7/21/2003	RM 10	20:00	0.061	0	12.92	**6.2**	**13.2**	13
7/21/2003	RM 10	22:00	0.061	0	10.72	6.8	12.65	10.4
7/22/2003	RM 10	0:00	0.061	0	10.44	7.17	12.96	9.7
7/22/2003	RM 10	2:00	0.061	0	10.37	7.32	**13.29**	9
7/22/2003	RM 10	4:00	0.061	0	10.34	7.43	**13.26**	9.1
7/22/2003	RM 10	6:00	0.075	0	10.27	7.16	**13.53**	6
7/22/2003	RM 10	7:10	0.063	0	10.49	7.27	**13.7**	8.7
7/22/2003	RM 10	7:30	0.063	0	10.25	7.36	**13.77**	6.5
7/22/2003	RM 10	7:45	0.063	0	10.39	7.36	**13.8**	9.7
7/22/2003	RM 10	10:00	0.063	0	10.3	7.45	**14.07**	8.2
7/22/2003	RM 10	12:00	0.063	0	10.87	7.6	**14.31**	5.3
7/22/2003	RM 10	14:00	0.064	0	10.47	7.63	**14.34**	9.9
7/22/2003	RM 10	16:00	-	-	-	**-**	**-**	-
7/22/2003	RM 10	18:00	0.063	0	11.18	7.52	**14.69**	33
7/22/2003	RM 10	20:00	0.063	0	10.62	7.52	**14.77**	12
7/23/2003	RM 10	0:00	0.063	0	10.24	7.81	**14.56**	5
7/22/2003	RM 8.2	8:00	0.062	0	8.34	8.2	**13.4**	27
7/22/2003	RM 8.2	8:00	0.06	0	8.96	8.2	**13.4**	23
7/22/2003	RM 9.7	8:50	0.057	0	8.28	8.4	**13.5**	17
7/22/2003	RM 11.2	9:10	0.057	0	9.13	8	**13.6**	17
7/22/2003	RM 11.2	9:30	0.061	0	9.3	8.2	**13.7**	49
7/22/2003	RM 11.4	10:00	0.058	0	8.07	8.4	**13.8**	20
7/22/2003	RM 13	10:20	0.075	0	**4.61**	7.9	**13.8**	12
7/22/2003	RM 15.5	10:50	0.059	0	8.94	8.2	**13.9**	16
7/22/2003	RM 15.5	11:00	0.057	0	9.75	8.4	**13.9**	17
7/22/2003	RM 23.1	6:45	0.071	0	8.92	8.4	**13.9**	16
7/22/2003	RM 23.1	7:00	0.06	0	8.95	8.4	**13.8**	17
7/29/2003	RM 8.2	8:00	0.075	0	NA	6.6	**13.2**	58
7/29/2003	RM 8.2	8:30	0.074	0	NA	6.7	**13.4**	55
7/29/2003	RM 9.7	9:00	0.075	0	NA	6.74	**13.4**	55
7/29/2003	RM 11.2	9:25	0.072	0	NA	6.73	**13.7**	47
7/29/2003	RM 11.2	9:45	0.072	0	NA	7.05	**13.4**	45
AK Water Quality Stds.			-	-	>7 mg/L	6.5-8.5	<13°C	-

Table 2 continued.

Date	Site	Time	Conductivity (mS/cm)	Salinity (%)	DO (mg/L)	pH (pH units)	Temperature (°C)	Turbidity (NTU)
7/29/2003	RM 11.4	10:00	0.072	0	NA	7.04	**13.4**	54
7/29/2003	RM 13	10:25	0.097	0	NA	6.97	**14.5**	37
7/29/2003	RM 15.5	11:00	0.07	0	NA	7.32	14	55
7/29/2003	RM 15.5	11:15	0.07	0	NA	7.02	**13.6**	49
7/29/2003	RM 23.1	6:30	0.113	0	NA	**5.83**	**13.1**	24
7/29/2003	RM 23.1	6:45	0.0648	0	NA	**6.12**	12.3	22
8/5/2003	RM 8.2	8:00	0.062	0	8.77	7.11	10.8	NA
8/5/2003	RM 8.2	8:30	0.053	0	8.32	7.38	10.9	NA
8/5/2003	RM 9.7	9:00	0.052	0	9.45	7.45	10.7	NA
8/5/2003	RM 11.2	9:45	0.052	0	9.77	7.52	10.8	NA
8/5/2003	RM 11.2	10:00	0.053	0	9.92	7.53	10.9	NA
8/5/2003	RM 11.4	10:30	0.052	0	9.85	7.59	10.9	NA
8/5/2003	RM 13	12:00	0.075	0	10.02	7.86	**14.4**	NA
8/5/2003	RM 15.5	13:00	0.052	0	9.76	7.68	12.4	NA
8/5/2003	RM 15.5	13:30	0.053	0	9.71	7.59	12.2	NA
8/5/2003	RM 23.1	6:30	0.052	0	11.14	7.14	10.2	NA
8/5/2003	RM 23.1	6:45	0.052	0	11.13	7.46	10.1	NA
8/12/2003	RM 8.2	8:44	0.075	0	9.2	7.35	**14.18**	28.4
8/12/2003	RM 8.2	9:25	0.078	0	10.7	6.94	**14.14**	30.5
8/12/2003	RM 9.7	10:25	0.076	0	8.3	7.31	**14.11**	28.3
8/12/2003	RM 11.2	11:08	0.074	0	15.5	7.44	**14.02**	61.2
8/12/2003	RM 11.2	12:10	0.073	0	11.8	6.98	**14.07**	42.9
8/12/2003	RM 11.4	12:30	0.074	0	10.1	7.33	**14.23**	30.5
8/12/2003	RM 13	13:20	0.113	0	10.2	7.39	**14.81**	21
8/12/2003	RM 15.5	13:50	0.074	0	16.1	7.34	**14.34**	66.8
8/12/2003	RM 15.5	14:00	0.073	0	14.9	7.47	**14.27**	54
8/12/2003	RM 23.1	7:00	0.107	0	13	**5.94**	**13.92**	32.6
8/12/2003	RM 23.1	7:25	0.075	0	11.5	6.57	**13.77**	31
8/19/2003	RM 8.2	8:54	0.065	0	8.4	7.06	10.59	35.5
8/19/2003	RM 8.2	9:14	0.066	0	8.2	7.2	10.66	31.6
8/19/2003	RM 9.7	9:40	0.065	0	10.1	7.35	10.6	30.9
8/19/2003	RM 11.2	10:40	0.066	0	9.8	7.33	10.69	39.2
8/19/2003	RM 11.2	11:20	0.065	0	9.4	7.23	10.7	28.1
8/19/2003	RM 11.4	11:40	0.067	0	10	7.47	10.93	30.1
8/19/2003	RM 13	13:00	0.081	0	9.9	7.41	11.52	32.6
8/19/2003	RM 15.5	13:35	0.065	0	11.2	7.42	11.42	95.8
8/19/2003	RM 15.5	13:50	0.066	0	12	7.47	11.37	75.5
8/19/2003	RM 23.1	7:04	0.099	0	11.4	**5.26**	10.33	30.6
8/19/2003	RM 23.1	7:22	0.069	0	10	**5.68**	10.31	35.5
8/26/2003	RM 8.2	9:35	0.056	0	9.4	7.52	11.3	17
8/26/2003	RM 8.2	10:00	0.056	0	9.81	7.55	11.3	16
8/26/2003	RM 9.7	10:35	0.057	0	10.35	7.56	11.3	1.8
8/26/2003	RM 11.2	11:05	0.056	0	10.51	7.6	11.3	-
8/26/2003	RM 11.2	11:55	0.056	0	10.23	7.62	11.6	20
8/26/2003	RM 11.4	12:20	0.057	0	10.3	7.7	11.7	20
8/26/2003	RM 13	13:00	0.07	0	10.29	7.49	12	15
8/26/2003	RM 15.5	13:25	0.056	0	10.09	7.62	11.9	21
8/26/2003	RM 15.5	13:50	0.056	0	9.91	7.61	12.2	19
8/26/2003	RM 23.1	7:45	0.077	0	9.51	**6.48**	11.6	17
8/26/2003	RM 23.1	8:00	0.056	0	8.95	6.58	11.5	15
AK Water Quality Stds.			-	-	>7 mg/L	6.5-8.5	<13°C	-

- measurement not recorded. Sampler error.

NA-sensor not working properly, measurements not taken.

4.1.2 Analytical Results

Concentrations of benzene, toluene and xylenes were detected in motorboat and representative habitat samples on the lower river throughout July. TAH analytes were also detected in two samples on June 10 and one sample on August 12. Ethylbenzene and PAH analytes were not detected in any of the motorboat or representative habitat samples.

Analytes in all samples collected during the intensive sampling event conducted on June 24 were ND. During the intensive sampling event in July, TAH concentrations were the highest on Sunday and Tuesday, with only one hit reported during the day on Monday (see Figure 6 in Section 5.1.2). Two samples exceeded the AWQS for TAH on Sunday July 20 at the intensive sampling site.

TAH concentrations increased as sampling sites progressed downriver. The second representative habitat site at RM 11.4 was the furthest upstream site with detections on every Tuesday in July (see Figure 5 in Section 5.1.1).

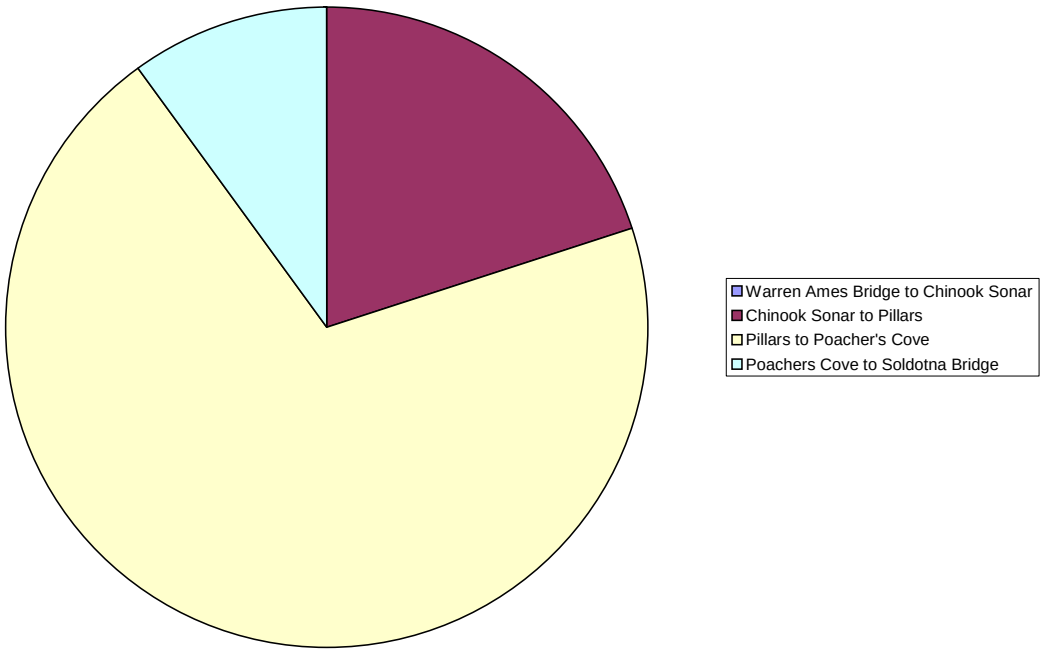
4.1.3 Boat Observations

Although boat counts were not included in the study design, qualitative observations made by sampling staff regarding the density of boats throughout the season and across the river can be provided. Boat traffic on the river was extremely low during the first two sampling events in May and increased through June. An extreme increase in boat density occurred on the July 1st opener of the bait fishing season. Traffic levels remained high on the river for all of July.

Boat concentrations during the intensive sampling event in July are based on observations made at the Beaver Creek fishing hole where sampling was performed. Traffic on Sunday, when guide boats are not allowed, was lower than on Tuesday, when all boats are allowed. On Monday, fishing from motorboats is not allowed and very few motorboats were observed. Boat traffic at the Beaver Creek hole on Sunday and Tuesday started at 5 a.m. and remained heavy throughout the day. At 6 p.m. on Tuesday, a steady stream of boats started moving upstream past the Beaver Creek hole. As illustrated in Figure 2, boat count data provided by ADFG indicate that the area around and upstream from the Beaver Creek hole is heavily used.

Boat numbers dropped significantly in August at the close of the king salmon fishing season. Some guide operations continued fishing silver salmon in August, but boat density resembled that observed in early June.

Figure 2. ADFG 2003 Boat Count Totals by Location



4.2 Harbor Sampling

4.2.1 Field Parameters

Field parameter measurements are provided in Table 3. Bold text indicates a measurement that exceeds the AWQS from 18 AAC 70.

One dissolved oxygen measurement at RM 1.0 on July 24 was 6.85 mg/L, below the AWQS for dissolved oxygen of 7.0 mg/L. Temperature in the harbor was above the AWQS for spawning areas of 13 C° at all sites on July 14, at RM 3.5 on July 24 and at RM 2.5 on September 8. There were six pH measurements below the AWQS lower limit for pH of 6.5 pH units, ranging from 6.27 to 6.44 pH units. Three were recorded during the summer ebb tide at RM 2.5 and two along the transect at RM 3.5. Three were recorded during the summer flood tide at RM 1.0, RM 1.5 and RM 2.5. One additional reading at RM 3.5 during the spring event was above the AWQS upper limit for pH of 8.5 pH units at 8.56.

AWQS establish limits for turbidity that may not exceed 5 NTU above the natural conditions when natural conditions are 50 NTU or less or have an increase of 10% or more when natural conditions are greater than 50 NTU. Natural turbidity conditions for the Kenai River vary diurnally and seasonally due to glacial melt. An accurate comparison with AWQS cannot be made due to limited information on these variations. Turbidity ranged from a low of 33 during the summer ebb tide to a high of 719 during the spring event on May 20. This corresponds with high turbidity values during the May 20

Tuesday motorboat sampling event and may result from a glacial melting event early in the summer.

Salinity readings are based on the conductivity measurement and do not have an AWQS. Salinity measurements decrease as the sampling sites progress up river. Salinity measurements from the spring and fall ebb tides are higher than the two summer events. Salinity ranged from 0 to 2.59% as sites were sampled progressively downstream during the summer event and ranged from 0.01 to 2.17% during the fall event.

Table 3. 2003 Kenai Harbor Field Parameter Results

Date	Site	Conductivity (mS/cm)	DO (mg/L)	pH (pH units)	Salinity (%)	Temperature (°C)	Turbidity (NTU)
5/20/2003	RM 1.0	41.3	NA	8.13	2.59	8.8	84
5/20/2003	RM 1.5	32.2	NA	8.22	1.95	8.9	45
5/20/2003	RM 2.0	16.2	NA	8.31	0.93	9.3	83
5/20/2003	RM 3.5	10.2	NA	8.34	0.55	9.9	232
5/20/2003	RM 3.5	6.6	NA	**8.56**	0.38	9.7	563
5/20/2003	RM 3.5	0.246	NA	8.25	0	9.1	719
7/14/2003	RM 1.0	12.9	11.36	7.01	0.73	**14.1**	33
7/14/2003	RM 1.5	0.194	NA	7.43	0	**13.8**	95
7/14/2003	RM 2.0	0.064	11.45	**6.42**	0	**14.6**	45
7/14/2003	RM 3.5	1.22	11.5	6.5	0.05	**14**	55
7/14/2003	RM 3.5	0.073	11.56	**6.44**	0	**13.8**	46
7/14/2003	RM 3.5	1.21	12.45	**6.27**	0.05	**13.7**	42
7/24/2003	RM 1.0	0.106	**6.85**	**6.41**	0	12.7	NA
7/24/2003	RM 1.5	0.069	8.04	**6.42**	0	12.7	NA
7/24/2003	RM 2.0	0.057	10.09	**6.35**	0	12.9	NA
7/24/2003	RM 3.5	0.057	10.63	7.34	0	**13.2**	NA
7/24/2003	RM 3.5	0.058	10.54	NA	0	13	NA
7/24/2003	RM 3.5	0.058	10	NA	0	13	NA
9/8/2003	RM 1.0	34.8	8.8	8.12	2.17	13	44
9/8/2003	RM 1.5	33.9	8.68	8.06	2.09	**13.1**	49
9/8/2003	RM 2.0	14.3	8.85	7.93	0.82	12.9	53
9/8/2003	RM 3.5	5.57	10.33	7.98	0.29	12.4	78
9/8/2003	RM 3.5	1.57	10.36	7.87	0.07	12.3	123
9/8/2003	RM 3.5	0.355	10.2	7.36	0.01	11.9	116
AK Water Quality Stds.		-	>7 mg/L	6.5-8.5	-	<13°C	-

NA-sensor not working properly, measurements not taken.

4.2.2 Analytical Results

No TAH or PAH analytes were detected above the reporting limit during the spring and fall ebb tide sampling events. Total aqueous hydrocarbons (TAqH), which includes benzene, toluene, ethylbenzene and xylenes (BTEX) and 16 PAH compounds, were above the reporting limit during the two summer sampling events. In general, concentrations were highest closer to the mouth and decreased as the sampling sites progress up river. This trend can be observed in Figure 3 below. On July 24, the highest TAqH concentration was reported at RM 1.0 (6.47 ug/L), followed by concentrations at RM 1.5, 2.5 and the transect at 3.5, which were less than half of the detected TAqH concentration reported at RM 1.0.

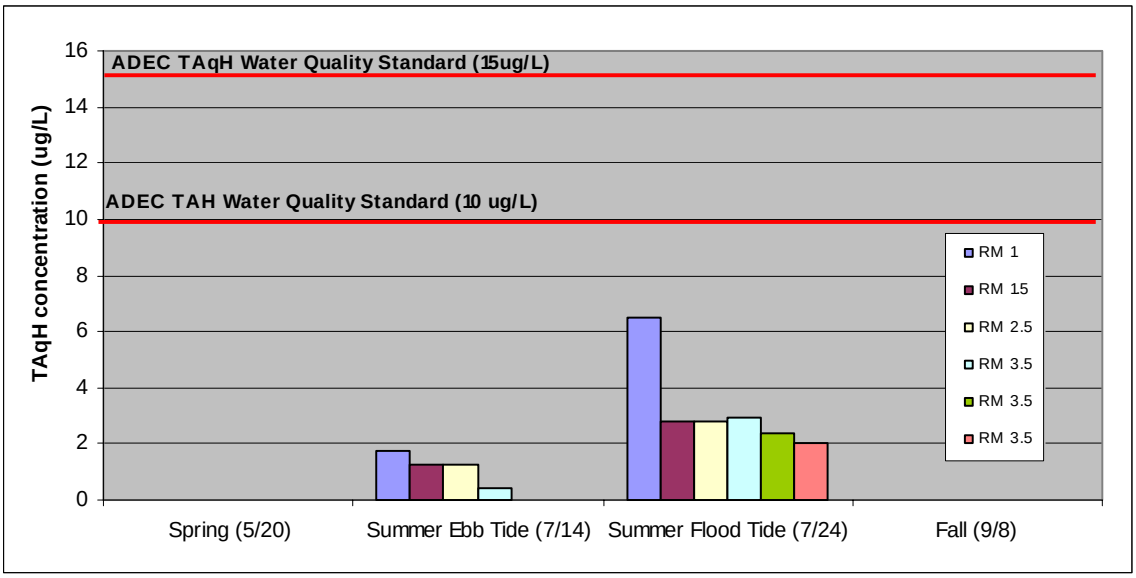


Figure 3. 2003 Kenai Harbor Sample Results

4.2.3 Boat Harbor Observations

No boats were observed in the harbor during the spring sampling event on May 20. Boat traffic was constant during the flood tide sampling event on July 14. Sampling performed on July 24 during an ebb tide was after most commercial fishing boats had returned to the harbor. Less than five boats were seen returning to the harbor during sampling activities. There were a few boats present during the fall sampling event on September 9. Less than ten boats were anchored and there was some small boat traffic.

4.3 Stormwater Sampling

4.3.1 Field Parameters

Field parameter measurements are provided in Table 4. Bold text indicates a measurement that exceeds the AWQS from 18 AAC 70.

Two measurements exceeded the AWQS upper limit for pH of 8.5 pH units at 9.1 and 9.3. Measurements were from upstream and downstream of the Soldotna outfall on September 25. The temperature measurement at the Soldotna outfall on June 10 was 13.4° C, above the AWQS of 13° C. The temperature readings at both outfalls were greater than 3° C above the river temperature on that day.

Table 4. 2003 Stormwater Field Parameter Results

Date	Outfall	Conductivity (mS/cm)	Salinity (%)	DO (mg/L)	pH (pH units)	Temperature (°C)	Turbidity (NTU)
6/10/2003	Soldotna	0.284	0.01	10.09	7.79	12.9	11
6/10/2003	Soldotna Downstream	0.06	0	12.27	7.88	8.3	20
6/10/2003	Soldotna Upstream	0.057	0	12.15	7.76	8.1	21
6/10/2003	Marydale	0.095	0	9.7	6.93	**13.4**	541
6/10/2003	Marydale Downstream	0.06	0	12.2	7.35	8.4	21
6/10/2003	Marydale Upstream	0.059	0	12.01	7.43	8.1	19
9/25/2003	Soldotna	0.247	0	14.26	8.2	7.8	33
9/25/2003	Soldotna Downstream	0.16	0	14.78	8.3	8.4	14
9/25/2003	Soldotna Upstream	0.062	0	15.68	NA	8.9	3
9/25/2003	Marydale	0.209	0	11.04	7.4	8.5	61
9/25/2003	Marydale Downstream	0.062	0	15.51	**9.3**	8.8	4
9/25/2003	Marydale Upstream	0.064	0	15.55	**9.1**	8.5	3
AK Water Quality Stds.		-	-	>7 mg/L	6.5-8.5	<13°C	-

NA-sensor not working properly, measurements not taken.

4.3.2 Analytical Results

No concentrations of TAH analytes were above the reporting limit during either of the stormwater sampling events. Four PAH analytes were above the reporting limit at the Soldotna outfall on June 10 totaling 1.62 ug/L, well below the AWQS of 15 ug/L for TAqH.

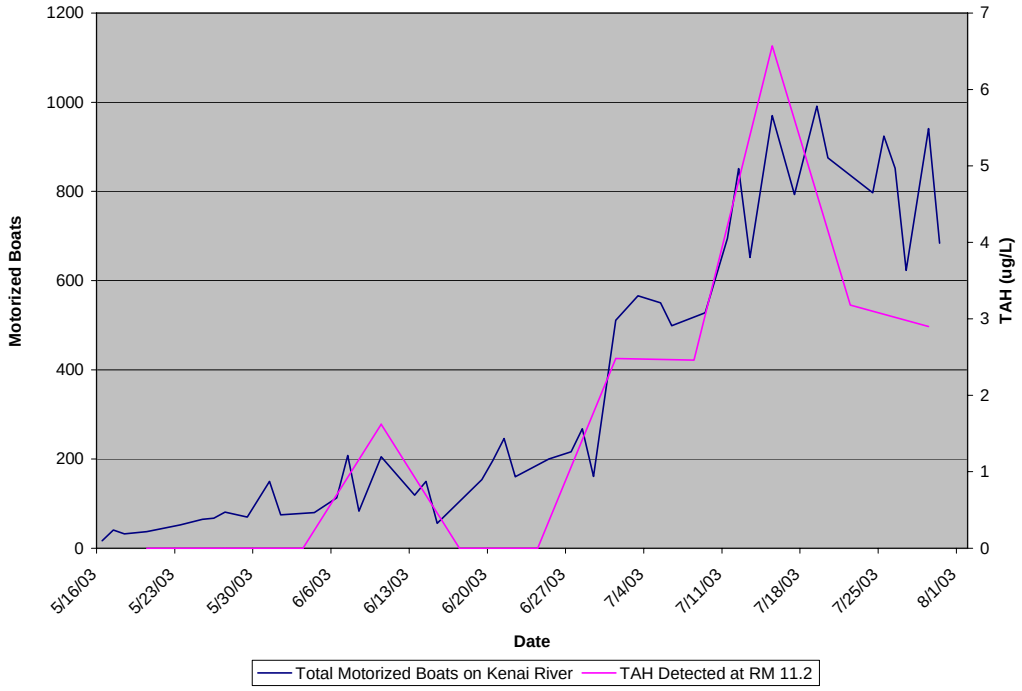
5 Conclusions

5.1 Motorboats

5.1.1 Timing

Hydrocarbon concentrations from the samples collected at the motorboat sites every Tuesday throughout the summer show that the highest concentrations occur during the month of July, during the height of the king salmon fishing season. Figure 4 couples detected concentrations of TAH at sampling location MB-4, RM 11.2 with boat count data provided by ADFG. It is apparent that increased numbers of motorized boats operating on the Kenai River are associated with increased concentrations of TAH.

Figure 4. TAH Concentration at RM 11.2 and ADFG 2003 Boat Count Totals



Isolated occurrences of hydrocarbons in the river on June 10 and August 12 were below 5 ug/L TAH. The opening of the bait fishing season on July 1st and the close of the king salmon fishery on July 31st corresponded to increased number of boats fishing on the river. Boat count data from the Kenai Watershed Forum (KWF 2003) from the mornings of July 8, 15 and 22 were 242, 291 and 379 boats respectively. There were no exceedances of the AWQS for TAH on any of the Tuesday motorboat sample events. TAH concentrations correlated to river mile for the month of July and are depicted in Figure 5.

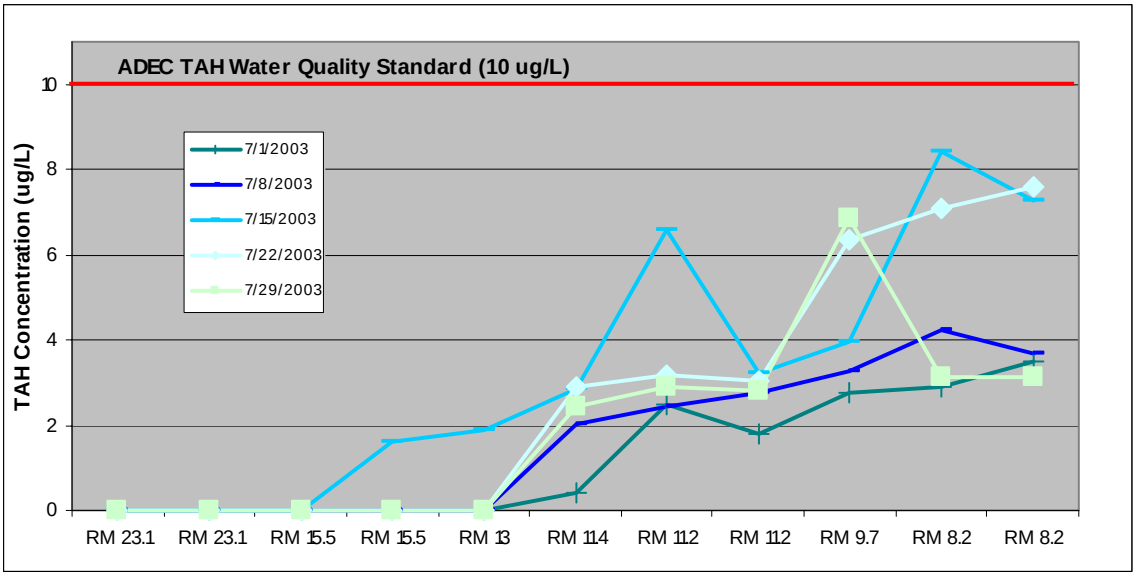


Figure 5. 2003 Motorboat and Representative Habitat July Tuesday Sample Results

The results from the intensive sampling event at RM 10 conducted from Sunday, July 20 to Tuesday, July 22 show a direct correlation between the concentration of hydrocarbons and the presence of motorboats on the river.

On Sunday,

- samples collected at noon and 2 p.m. exceeded the AWQS for TAH at 10.2 and 10.76 ug/L respectively; and
- samples collected every two hours between 8 a.m. and midnight Sunday were within 4 ug/L of the AWQS for TAH.

No guided motorboats are allowed on the river on Sundays. Kenai Watershed Forum data collected on Tuesday, July 22, 2003 (KWF 2003) on 2-stroke vs. 4-stroke motors on the river indicate that private motorboats have a higher percentage of 2-stroke motors than guided motorboats; 30% vs. 1%. ADFG boat count data for Sunday indicates that peak usage for the day occurred around 11 a.m., with a total of 285 boats between the Warren Ames Bridge and the Soldotna Bridge. As shown in Table 5, motorboat activity was high from the 6 a.m. boat count through the 4 p.m. boat count, dropping off before the 9 p.m. boat count. It cannot be determined if the higher hydrocarbon concentrations reported on Sunday are from the number of motorboats on the river or the types of engines being used.

Table 5. ADFG Boat Count Data and TAH Results

Date	Time	Mouth to Warren Ames Bridge	Warren Ames Bridge to Chinook Sonar	Chinook Sonar to Pillars	Pillars to Soldotna Bridge	All Sections	TAH Results (µg/L)
7/20/2003	6:00am	-	15	87	101	203	1.53
7/20/2003	8:00am	-	-	-	-	-	7.63
7/20/2003	10:00am	-	-	-	-	-	9.11
7/20/2003	11:00am	-	12	119	154	285	-
7/20/2003	12:00pm	-	-	-	-	-	10.2
7/20/2003	2:00pm	-	-	-	-	-	10.76
7/20/2003	4:00pm	-	21	72	154	247	9.24
7/20/2003	6:00pm	-	-	-	-	-	7.93
7/20/2003	8:00pm	-	-	-	-	-	6.74
7/20/2003	9:00pm	-	3	38	99	140	-
7/20/2003	10:00pm	-	-	-	-	-	7.86

On Monday,

- two measurable concentrations of hydrocarbons were reported in samples collected at 2 a.m. and noon.

Fishing from motorboats is not allowed on Mondays and there were very few boats observed that day. Hydrocarbon concentrations were reported on 2 a.m. both Sunday and Monday. The evening fishery continues late into the night on the weekends. Boats were observed still on the river when the sampling crew put into the river for the midnight sample collection on Saturday and until midnight Sunday. A second hydrocarbon hit was reported at noon on Monday. Some motorboats were observed on the river Monday transporting anglers to riverbank sites to fish for sockeye salmon. No boat count data is available for Monday, July 21, 2003.

On Tuesday,

- samples collected between 6 a.m. and 2 p.m. and 10 p.m. and midnight were all within 4 ug/L of the AWQS for TAH.

Approximately equal numbers of guided (70) and non-guided (60) boats were counted on the river that Tuesday morning; 15% of the total users had 2-stroke engines. The evening fishery had approximately half the number of boats compared to the morning fishery (62 vs. 130); 39% of the total users had 2-stroke engines in the evening. Although boat numbers decreased, the percentage of 2-stroke users increased in the evening fishery when hydrocarbon concentrations spiked a second time to within 4 ug/L of the AWQS. The decrease in motorboat traffic but associated increase in 2-stroke engines on the river may contribute to the high concentration of hydrocarbons reported in the evening samples. Hydrocarbon concentrations from Sunday through Tuesday are shown in Figure 6.

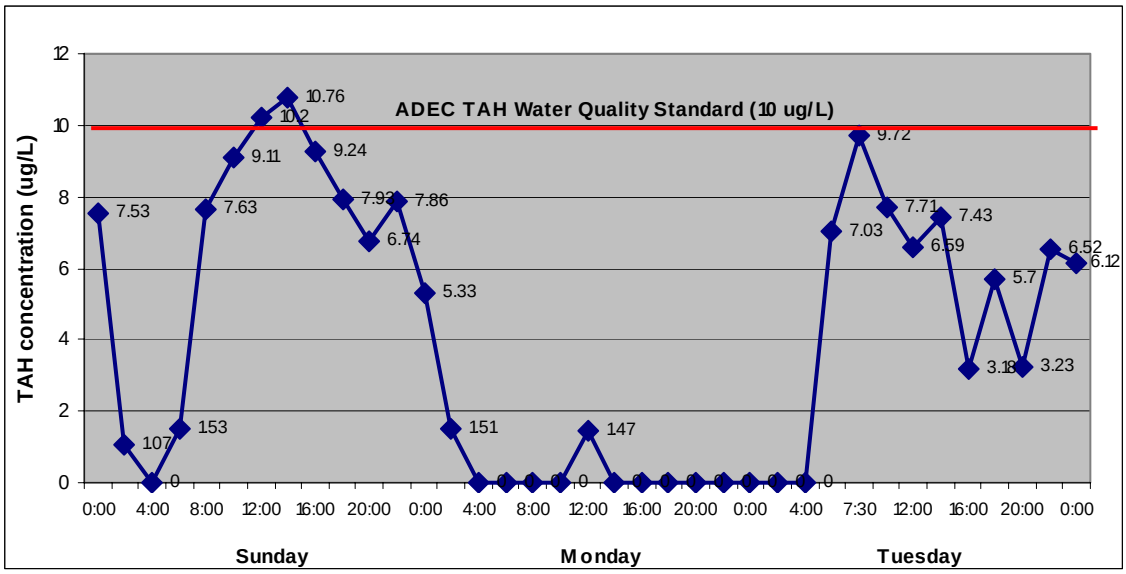


Figure 6. 2003 Motorboat July Intensive Sample Event Results

5.1.2 Location

One site along the transect at RM 8.2 had the highest average TAH concentration for the month of July, 5.15 ug/L. Averages for all sites are shown in Table 6 below. All three sites below RM 10 had average TAH concentrations greater than 4.5 ug/L. The samples collected from the transect at RM 11.2 and at the second representative habitat site at RM 11.4 also had measurable concentrations of hydrocarbons in July, greater than 2 ug/L.

Table 6. 2003 Motorboat Sampling Sites July Average TAH Concentrations

Site	Average
RM 8.2	5.15
RM 8.2	5.04
RM 9.7	4.64
RM 11.2	3.52
RM 11.2	2.74
RM 11.4	2.13
RM 13	0.38
RM 15.5	0.00
RM 15.5	0.33
RM 23.1	0.00
RM 23.1	0.00

Figure 5 shows the correlation between increasing hydrocarbon concentrations as river mile decreases. Measurable concentrations of hydrocarbons were first reported at RM 11.4, the second representative habitat site for all Tuesdays in July. Average concentrations steadily increase from 2.13 ug/L to 5.15 ug/L as sites progress downriver.

TAH concentrations from the transect during the intensive sampling event in July were essentially equal throughout the water column and across the river, as shown in Figure 7.

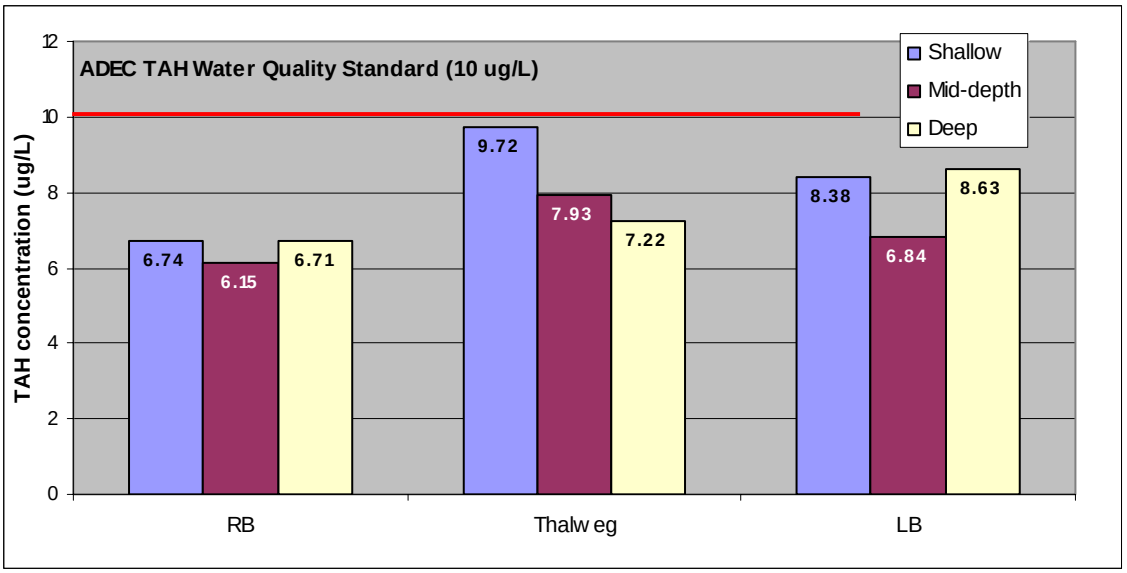


Figure 7. 2003 Hydrocarbon Profile at RM 10 on July 22

5.2 Kenai Harbor

There were no results above reporting limits for TAH or PAH analytes during the spring and fall sampling events. TAqH concentrations were higher during the summer flood tide event. The sampling design was intended to target commercial boat activity after the close of commercial fishing openers. The summer ebb tide event occurred while boats were returning to the harbor, while the summer flood tide event occurred after most boats had returned. The higher results from the flood tide may be linked to either the flood event preventing contamination from flowing out the mouth or the timing after the boats had finished refueling.

5.3 Stormwater

There was only one reportable TAqH concentration at the Soldotna outfall during the spring event. No reportable concentrations of the same PAH analytes found in the outfall sample were in either the upstream or downstream samples collected from the river. The samples collected during the stormwater program indicate that there are no inputs from stormwater outfalls that produce detections of hydrocarbons in the river.

5.4 Recommendations for Future Research

The stormwater sampling program results indicate that some hydrocarbon contamination enters the Kenai River from this source, but it is not a major contributor. Results did not exceed the AWQS for TAH or TAqH. Stormwater results did not have any reportable concentrations of TAH analytes and only one sample after a storm event in June from the Soldotna outfall had low levels of PAH analytes.

As shown in Figure 3, hydrocarbon contamination was detected during the summer in the Kenai Harbor. Future sampling should continue to focus on the commercial openers at the height of the fishing season in late July. Another possible input may be from the personal use dipnet fishery. Boat counts should be conducted in order to compare the number of commercial and small motorboats present during sample collection. The effects of tidal stage on hydrocarbon contamination are not completely understood.

Future sampling events conducted during different tidal stages after commercial openers may provide more information on this effect.

Figures 3-5 clearly depict the temporal and spatial extent of hydrocarbon contamination in the Kenai River during 2003. Further research should target the types of engines contributing the most contamination and the number of boats, based on engine type, that bring concentrations near to the AWQS. The heaviest concentration of boat traffic on the river is during the month of July. Further sampling on the river should target this period.

Tuesdays were the target of this sampling program as they are historically the highest user-day. Results from the July intensive sampling event conducted Sunday through Tuesday coupled with KWF boat count and engine type data indicate that private motorboats with a higher percentage of 2-stroke engines may contribute more hydrocarbon contamination to the river than the combination of guide boats and private boats on Tuesdays. Saturdays were not sampled as part of this study. All user-types are allowed on the river on Saturdays, which may have higher numbers of private users than either Sundays or Tuesdays. To capture the highest concentrations of contamination, future sampling should include Saturdays to determine which day of the week produces the highest levels of hydrocarbon contamination.

The sampling sites at RM 15.5 are adequate background sites as there was only one hit there during the month of July. The background sites at RM 23.1 sampled for this study do not need to be included in future research. Hydrocarbon contamination increased progressively downriver. A lower sampling site should be included in future research to determine where contamination either volatilizes out of the river or becomes diluted enough to decrease concentrations. There are some boats that troll below lower bluffs and around the bend at Cunningham Park. A lower sampling site at Cunningham Park (RM 6.5) or above the Ames Bridge (RM 5.5) could be used to determine the lower extent of contamination on the river.

No PAH compounds were detected at concentrations above reporting limits during the motorboat sampling program. Different analytical methods with lower reporting limits should be used if there is an interest in determining if engines are contributing heavier hydrocarbon contamination, such as oils and lubricants, to the river. SGS has the capability to run samples collected for PAH by a PAHSIM method; generating data with lower PQLs.

Samples collected using KWF procedures were used to compare results with those obtained using the USGS VOC sampler described in Section 3. KWF collects grab samples by filling an unpreserved 1-L plastic bottle at elbow-depth and transferring water to the 40-mL vials. Detailed procedures used for both methods are described in the QAPP 2.0 (OASIS 2003). Six samples were collected using the KWF method alongside samples collected using the VOC sampler over the course of the program. Results are presented in Table 7 below. Two pairs of samples did not have reportable concentrations of BTEX compounds. The results from the remaining four pairs of samples have varying relative percent differences; two are greater than 20%, indicating that the two methods do not produce comparable results. In three out of the four samples, the KWF method is biased low. All results were less than four times the reporting limit, so some variability may be due to the method's accuracy. ADEC should continue to use the VOC sampler for future research as it has been tested by USGS for reproducibility.

Table 7. 2003 Kenai Watershed Forum Method Blank Results

Date	Site	Method	TAH (ug/L)	RPD*
7/15/2003	RM 8.2	VOC Sampler	8.43	
		KWF Method	4.39	63%
7/22/2003	RM 10	VOC Sampler	3.18	
		KWF Method	2.68	17%
7/29/2003	RM 8.2	VOC Sampler	3.13	
		KWF Method	2.8	11%
7/29/2003	RM 11.2	VOC Sampler	2.9	
		KWF Method	5.12	55%
8/5/2003	RM 8.2	VOC Sampler	0	
		KWF Method	0	0%
8/5/2003	RM 9.7	VOC Sampler	0	
		KWF Method	0	0%

*RPD-Relative Percent Difference = ((A-B)*100)/((A+B)/2)

6 Data Validation

6.1 Field Parameters

All field water quality meters were calibrated according to manufacturer's specifications the morning of each sampling date using Autocal® solution. After calibrating, measurements were taken of the calibration solution to ensure accuracy within 5%. If accuracy was outside 5%, meters were recalibrated and checked again. Precision of the water quality meters can be determined by comparing duplicate measurements. Although duplicate readings of exact locations were not recorded, measurements taken along transects can be compared. RPDs for field parameters recorded in the same transect were <20%, which is considered acceptable.

Two separate meters were used during the July 22nd sampling event. As described above, both meters were calibrated according to manufacturer's specifications at approximately 6 a.m., and were accurate to within 5%. Consistently high temperature measurements were obtained on this day. These temperature results are considered representative and accurate because temperature probes are highly reliable, i.e. they are not prone to instrument drift, and temperature readings taken by the two meters from nearby locations at approximately 8 a.m. on July 22 are very similar, indicating that the temperature probes were working correctly (RM 8.2 and RM 10.0 read 13.4°C and 13.8°C, respectively).

Several anomalies were noted in review of the field parameters, and are discussed below.

The DO measurement taken at Honeymoon Cove, RM 13.0, on July 22 was 4.61 mg/L, well below the AWQS of 7 mg/L. As the sampling location was within a cove with only one inlet, water would not be flowing past the DO meter; lower DO values would be expected from an area with stagnant waterbody. However, it is possible the low reading was associated with instrument drift or insufficient water flow past the DO sensor. The sensor is destructive, i.e. it consumes the oxygen measured so unless there is continuous movement of either the probe or the water the oxygen reading will tend to bias low. Regardless, the low oxygen reading is an extreme condition which was not repeated; consequently, the low reading should not be considered significant other than to warrant some additional field testing in the area in future studies.

Temperature measurements were also consistently above the AWQS of 13°C at the representative habitat site in Honeymoon Cove, RM 13.0. The high temperature is believed to be attributable to the fact that Honeymoon Cove is a protected area, with only one inlet. Higher temperature measurements would be expected in a relatively stagnant waterbody of this type.

An additional high temperature measurement (18.7°C) was measured on May 20 at the representative habitat site at RM 11.4, the side channel behind Eagle Rock. At the time of sampling, water levels were extremely low creating a condition very similar to that at Honeymoon Cove: a waterbody with only one inlet. Thus, the high temperature measurement in believed to be attributable to relatively shallow, stagnant water.

A total of 22 exceedances of the AWQS for pH were measured, eight of which were above the upper limit of 8.5 pH units, with the remaining 14 below the lower limit of 6.5 pH units. As a check of instrument accuracy, the calibration solution was reread following sampling on May 27 and July 29, 2003. pH measurements were 4.32 and 4.30 pH units, respectively. These readings are within 10% of the known pH of the calibration solution (4.0 pH units). Thus, though instrument drift may occur throughout the day, it

cannot account for the variability seen throughout the sampling program. It should be noted that pH changes diurnally, increasing during the day as plants photosynthesize. A pattern is apparent on many of the sampling dates, with lower pH values occurring in the morning and increasing as sampling continues. It is believed that the pH exceedances measured are naturally occurring phenomena due to plant respiration or other factors.

6.2 Analytical Results

The analytical results for the surface water and associated laboratory quality assurance and quality control (QA/QC) samples were reviewed to determine the integrity of the reported analytical results and ensure they met the established data quality objectives.

Documentation associated with the surface water samples was reviewed to determine compliance with recommended holding times and sample preservation techniques. All samples were analyzed within their respective holding times. Several coolers were received at the lab with temperatures between 6 and 8.5°C slightly above method requirements of 4.0°C (+/- 2.0°C). Sample results associated with cooler temperatures outside the method requirements on May 27, June 10, July 1, 8, 24, 20-22 and August 24 may be affected. The data is not qualified as the potential for bias is minimal.

Trip blanks accompanied the samples, and were submitted for analysis of BTEX compounds. No analytes were detected at concentrations above the reporting limit in the trip blanks.

Ambient blanks were collected with deionized water while the motor was idling to determine if engine exhaust contaminated samples during collection. There were no detections above reporting limits in any of the three ambient blanks collected.

Decontamination blanks were collected with deionized water after decontaminating the sampling device to evaluate the possibility of cross-contamination between sampling sites. No detections were reported above the reporting limit in any of the four decontamination blanks collected.

Method blanks were analyzed in the laboratory to detect instrument and sample cross-contamination. Analytes were detected at concentrations greater than the reporting limit in method blanks associated with samples on several dates. None of these analytes were detected in any of the project samples.

Laboratory control samples and laboratory control sample duplicates (LCS/LCSD) are analyzed to confirm acceptable recovery of target analytes. Multiple analytes in the LCS and LCSD samples were slightly outside the method control limits. There are two common reasons for analytes to be reported outside of method limits. Volatile compounds may be volatilizing out of the solvent, causing the concentrations of the more volatile compounds to decrease and the semi-volatile compounds to increase. Or, the instrument may need maintenance to clean the detectors so that accuracy within the method limits can be obtained. All analytes outside of method limits were not present in the project samples and are not contaminants of concern except for benzene. Percent recovery for benzene in the LCS was slightly below method limits and affects samples collected on July 29. The associated benzene results have been flagged “J” to indicate that the results are an estimation and are possibly biased low.

Benzene recoveries in two LCS and one associated LCSD were above control limits for samples collected on August 12. All associated samples were reported non-detect for benzene except MB-8, collected from the transect at RM 23.1. Sample MB-8 was run a second time and the benzene result was confirmed (0.0006 and 0.00055). Results associated with this sample have been flagged “J” to indicate the reported results are estimated.

Matrix spikes and matrix spike duplicate (MS/MSD) samples are analyzed to evaluate possible matrix interference with analyte detection. Percent recoveries for multiple analytes in the MS and MSD samples were outside method limits. Relative percent differences for multiple analytes were also outside method limits for the MS/MSD. None of these analytes were reported in the associated project samples.

Surrogate compounds are added by the laboratory to evaluate the accuracy of individual sample analyses. Surrogate compound recoveries were slightly outside established control limits in two samples analyzed for volatile hydrocarbons. MB-9, a duplicate of MB-4 collected from the transect at RM 11.2 on July 1, was below method limits and rerun for confirmation. KH-7, a duplicate of KH-1 collected from RM 1.0 in the Kenai Harbor on July 24, had a surrogate recovery slightly above method limits. The associated analytes above the reporting limit in these samples have been flagged “J” to indicate that the results are estimated.

One field duplicate was collected on each project date for both EPA 624 and EPA 610 analyses. Relative percent differences (RPDs) between primary and duplicate results are calculated for analytes with concentrations greater than ten times the reporting limit. Analytes were not detected at concentrations greater than ten times the reporting limit, so RPDs were not calculated.

Project completeness for all field work conducted to date is 95%. This meets OASIS’ goal of 95% established for the project in the QAPP. Project completeness measures the number of samples collected divided by the number called for in the original sampling design. Project completeness for all field work is greater than 95%. One-hundred percent of samples submitted to the laboratory were analyzed and no data were rejected. The data quality objectives for the project have been satisfied.

7 References

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