ALASKA Department of Environmental Conservation

KENAI RIVER
2007 PETROLEUM ASSESSMENT

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oasis ENVIRONMENTAL

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ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

°C .... Degrees Celsius
µg/L .... Micrograms per liter
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 xylenes
BWS .... Below water surface
cfs.................. Cubic feet per second
DI................... Deionized
DO .... Dissolved oxygen
EPA .... U.S. Environmental Protection Agency
GPS............... Global Positioning System
KWF .... Kenai Watershed Forum
LCS/LCSD..... Laboratory control sample/laboratory control sample duplicate
mg/L .... Milligrams per liter
mS/cm .... Millisiemens per centimeter
MS/MSD........ Matrix spike/matrix spike duplicate
NTU............... Nephalometric turbidity units
OASIS .... OASIS Environmental, Inc.
ppb .... Parts per billion (ppb=µg/L)
ppm .... Parts per million (ppm=mg/L)
QA/QC........... Quality assurance and quality control
QAPP .... Quality Assurance Project Plan
RM................. River mile
RPD............... Relative percent difference
SGS............... SGS Environmental Services, Inc.
TAH .... Total aromatic hydrocarbons (TAH=BTEX)
USGS .... United States Geological Survey
YSI .... YSI 556 water quality meter

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EXECUTIVE SUMMARY

Water samples were collected from the Kenai River in July 2007 to determine concentrations of total aqueous hydrocarbons (TAH) in the river from motorboat activity. TAH compounds are associated with gasoline, which is the pollutant of concern in this study. Because historical July TAH levels annually exceeded criteria in Alaska Water Quality Standards (AWQS) for petroleum hydrocarbons, in 2006 the State listed Kenai River as an impaired Category 5 water, under the Federal Clean Water Act Section 303(d), for not meeting the State's petroleum hydrocarbon water quality criteria during the month of July. Subsequently, the State and others have taken steps to reduce the amount of petroleum entering the river. ADEC developed this project to collect information that will be used to help monitor the reduction of petroleum levels as the Kenai River recovers.

This study was similar to a 2003 ADEC study of petroleum in the Kenai River. Similar to 2003, water samples were collected at Kenai River Mile (RM) 10.1 at 2-hour intervals around the third weekend in July when motorboat use on the river historically peaks. Sampling focused on TAH, but also included standard physical and chemical parameters (pH, dissolved oxygen, conductivity, salinity, turbidity, and temperature).

In attempt to better determine the contributions from boats, counts of boats and boat motor types (two-stroke and four-stroke) were conducted from the sampling boat and by aerial surveys. Estimates of boat numbers immediately upstream of the sampling transect were obtained as samples were collected, and these estimates were compared to TAH results using a Spearman's Rank Correlation Test. The correlation test indicated that TAH results from the main current (thalweg) samples correlated with estimated boat densities. The sampling results indicate that all samples collected from the Kenai River between July 21 and July 24, 2007, complied with the AWQS petroleum criteria for TAH. The TAH concentrations generally peaked at about 6:00 to 8:00 a.m. and 6:00 to 8:00 p.m. and dropped during in the middle of the night. TAH concentrations were generally higher for the July 21 to 22 sampling event than the July 24 sampling event. The decrease in hydrocarbon concentration between the two sampling events may have been due to fewer boats or fewer boats with two-stroke engines on the river on July 24.

The maximum, minimum, and median values for the 2007 TAH results were lower than those observed in 2003, suggesting that the amount of TAH in the lower Kenai River during July 2007 may have declined from previous years. This may have occurred due to a decline in boat numbers, to fewer two-stroke motors being used on the river during the July period, or to some other factor.

Future research efforts studying hydrocarbon contamination on the Kenai River should continue to focus on determining the levels of petroleum and the contributions from different numbers of boats. As a ban was imposed in 2008 on the use of older two-stroke engines on boats during July, future boat counts do not need to focus on the types of motors used, but should focus on counting the numbers of boats that are at a distance

upstream of sampling transects that could potentially contribute to the TAH collected in samples.

Future monitoring should continue to include standard physical and chemical parameters. The field measurements generally indicated these parameters meet criteria. Although some of the field measurements were above criteria, their levels are believed to within the range of natural conditions. Specifically, temperature and turbidity should be included in future sampling to develop a better understanding of their natural conditions.

Unless background levels of parameters other than petroleum are required, future monitoring is not needed from midnight to 6 a.m. Both the 2003 and 2007 studies found little or no levels of petroleum in the river during this period, which is not anticipated to change unless motorboat usage patterns significantly change.

The results of this study suggest that a decline in TAH levels is occurring as a result of the ongoing recovery actions and that those TAH levels will be within AWQS criteria. If future monitoring shows this trend is permanent, then long-term, intensive TAH monitoring is not recommended, particularly after the Kenai River has been removed from impairment status.

1. INTRODUCTION

This report discusses results of water sampling conducted in July 2007 along a transect at River Mile (RM) 10.1 of the Kenai River. Samples were collected every 2 hours between July 21, 2007, at 12:00 a.m. and July 22, 2007, at 10 p.m. and on July 24, 2007, between 12:00 a.m. and 10 p.m.

The sampling was designed to characterize the total aqueous hydrocarbon (TAH) concentrations and other water quality parameters at the transect both vertically and horizontally during three days of heavy boat traffic. No samples were collected on Monday, July 23, as the lower Kenai River is closed to fishing from powered boats on Mondays in July.

The results are used in conjunction with the results of an aerial boat count conducted over the same period to compare TAH levels to the numbers of boats on the river. The results are also compared to the results of an intensive sampling event conducted in this area in July 2003.

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2. BACKGROUND

Previous hydrocarbon sampling in the Kenai River has been conducted by the Alaska Department of Environmental Conservation (ADEC) and other organizations. From 2000 to present, the Kenai Watershed Forum (KWF) coordinated collection of grab samples collected twice per year at 20 sites along the river, including passive hydrocarbon sampling, and in 2002 collected 12 samples over an 8-day period at three sites. The data in the 2002 assessment indicated hydrocarbons are highest in the lower 10 miles of the river. There appeared to be some correlation between hydrocarbon concentrations and boat use.

In 2003, ADEC contracted with OASIS Environmental, Inc. (OASIS) to conduct intensive sampling for petroleum and other water quality parameters in the Kenai River, focusing mainly on the lower river. The project included sites selected to determine the inputs from possible contaminant sources, along with one background site upstream from the possible contaminant sources and three representative habitat sites. The sources investigated for the 2003 project included stormwater outfalls, motorboats operating on the river, and boat activity at the Kenai River Harbor near the river mouth. The collection of background sources was designed to identify other potential sources, such as contaminated sites along the river. Stormwater samples were collected during storm events in the spring, summer, and fall. Samples from the harbor were collected once during the spring, summer, fall, and winter. Sampling for contributions from motorboats focused on summer months when motorboats operate on the river. A 24-hour sampling event targeted a weekend in June when the number of motorboats rises during sportfishing for the first run of king salmon (Chinook); another sampling event spanned 72 hours from Sunday to Tuesday the third weekend in July when motorboat numbers are at or near annual peaks during sportfishing for the second king salmon run. Final data results were analyzed to determine the hydrocarbon concentrations associated with each of the sources and the spatial and temporal extent of their inputs. The results of this assessment clearly showed that stormwater and contaminated sites were not sources of measurable amounts of petroleum in the river, but that measurable amounts of TAH were contributed by motorboat activity, and the levels varied with the amount of boat activity. The sampling showed levels of TAH occasionally exceeded the water quality standards.

Subsequent to 2003, additional TAH sampling has been conducted each year by the KWF and the Kenaitze Tribe, with project funding provided by ADEC and the U.S. Environmental Protection Agency (EPA). Results of these efforts showed that during July of every year, at least one TAH sample exceeded Alaska Water Quality Standards (AWQS). There was no trend showing the annual maximum July levels of TAH in the river were decreasing.

It is important to note the sampling conducted by ADEC in 2003 was not targeted to find the highest levels of petroleum present in the river. The 2003 sampling effort was designed to determine potential sources and levels of petroleum after mixing had occurred. Higher levels of petroleum were likely to occur in other parts of the river for these reasons:

- The July 72-hour intensive sampling was conducted immediately below where Beaver Creek enters the river. This site was chosen because it was the lowest point in the river that typically has some downstream surface current, except at high tide. However, at times other than high tide, large numbers of boats (over 100) fish below this point where samples were taken. It is expected that results would have been higher if samples were obtained below all boat activity.
- The 2003 samples were not obtained immediately downstream of motorboats, where petroleum levels are likely to be biased higher than after the petroleum has dispersed into the river.
- July sampling included sample collection on Tuesdays and a 3-day intensive sampling effort on July 20–22 (Sunday–Tuesday). The number of boats on the river was higher on some days in July when sampling did not occur. Even for those days when samples were taken, it is unlikely sampling occurred at the time and place where petroleum levels were highest.
- Sampling was conducted during a year when flows were about 10% higher than average. It is expected concentrations of TAH would have been higher if the flow was average, as less water would have been available to dilute the petroleum.
- Since 2003, there has been a significant increase in the number of boats fishing the Kenai River. It is expected that this would result in higher levels of discharges; however, it may be partially offset by more boats switching to less polluting, EPA 2006 compliant, engines.

This sampling strategy incorporated public comments received during public presentations of the 2003 Hydrocarbon Assessment. ADEC received many comments pointing out the need to collect hydrocarbon data on Saturdays, in addition to the Sunday–Tuesday period sampled in 2003, as Saturdays may have a higher number of boats, and a higher number of those boats with two-stroke motors may be participating in the July fisheries.

Because the July TAH levels have annually exceeded the AWQS for petroleum hydrocarbons and because no controls or plan were in place to reduce these levels, in December 2006, ADEC included the lower Kenai River on its biannual list of impaired waters that it submits to the EPA.

ADEC developed this monitoring project to collect information that will be used to help monitor waterbody recovery.

3. METHODS

Sampling procedures followed the ADEC-approved July 2007 Sampling and Quality Assurance Project Plan (QAPP) (OASIS 2007). All samples were collected using the same methods and at the same transect (see Figure 1) of the river to minimize sampling-related bias. The same methods and sampling stretch were also used in the 2003 study in order to enable more comparable results. Quality control samples were collected to verify the sampling methods were not introducing bias. Specific procedures are delineated in the following discussion.

Data collection began at midnight on Friday, July 20, 2007, continued every 2 hours through Sunday midnight, and resumed Monday midnight through Tuesday midnight. OASIS personnel were assisted by the KWF, the Alaska Department of Fish and Game (ADF&G), and ADEC. All samples for laboratory analysis were collected by OASIS personnel.

Samples were collected from an 18-foot, aluminum, open-hulled river boat with a 35-horsepower, two-stroke Johnson outboard motor. The boat motor was left running during the sampling due to the strong current in the river, with the bow upstream of the stern. The sampling technicians used a Wildco VOC Sampler, designed by the United States Geological Survey (USGS) and provided by ADEC for the project. The sampling protocol for this sampler is described by Shelton (1997).

The sampling strategy was to collect samples from two depths at three locations along the RM 10.1 transect. Samples were collected every 2 hours at 12 inches below water surface (BWS) and 12 inches above the riverbed from the deepest part of the river (the thalweg). The two sample depths are labeled shallow and deep in the table of results discussed in the next section. Four additional samples were collected at 6-hour intervals from the same two depths at the right and left banks of the river. Prior to each sampling event (July 21–22 and July 24), reference TAH samples were collected upstream of heavy boat traffic, at RM 18. Reference samples were collected from the thalweg at 12 inches BWS and 12 inches above the riverbed.

The samples were preserved and packaged for delivery to an ADEC-approved laboratory—SGS Environmental Services, Inc. (SGS). The samples were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX) (equivalent to TAH), using EPA Method 624. In addition to collecting TAH samples, a YSI 556 water quality meter (YSI) and a Hach 2100P turbidimeter were used to measure pH, temperature, conductivity, dissolved oxygen, and turbidity once during each 2-hour sampling interval. A peristaltic pump was used to pump the water through the YSI flow-through cell, where it collected into the sampling vessel for the turbidimeter. The end of the pump tubing was attached to the Wildco sampler to keep the tubing in place while the parameters stabilized.

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. Global Positioning System (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. Field parameter measurements, photograph numbers, GPS coordinates, sampling information, and comments were recorded on Sample Data Sheets, provided in Attachment A. Photographs are provided electronically in Attachment B.

The YSI and turbidimeter were calibrated prior to each sampling event and the calibration was checked during the two-day event. Prior to each sampling event, the Wildco sampler was decontaminated using an Alconox® and deionized (DI) water wash and a DI water rinse. The sampler was also decontaminated on July 22 at 9:20 a.m. after the motor smoked heavily before running out of gas. The crew worried that the sampler had been cross-contaminated by excess boat motor exhaust. The crew collected one rinsate sample for each sampling event. In addition, one field duplicate sample was collected per 10 project samples (every 6 hours).

In addition to water quality parameters, the crew recorded the approximate air temperature and weather conditions as well as the number of boats observed upstream during each 2-hour sampling interval.

The KWF also performed an aerial boat count over the same time period that OASIS collected the hydrocarbon samples. The length of river between the mouth and Skilak Lake was flown five times per day on July 21 and July 24 and three times on July 22 (due to weather restrictions) as follows:

July 21	July 22	July 24
05:30	05:30	05:30
08:00	08:00	08:00
13:00	13:00	13:00
17:30		17:30
20:00		20:00

The river was divided into seven section and observers in the airplane counted motorized boats in each section. In addition, observers on the bank at the Pillars public access (RM 12.5) counted the number of boats with two-stroke and four-stroke engines that passed the Pillars dock during the same time period as the aerial boat counts were conducted. The results of the aerial boat count are included in Attachment A.

4. RESULTS

The water quality parameter and laboratory analytical results are summarized in Table 1 and provided on a CD in electronic form as Attachment C. The AWQS (ADEC 2003) are included for compounds or parameters that are regulated.

4.1. Laboratory and Field Results for the Hydrocarbon Sampling

Laboratory results for all the BTEX compounds, including total BTEX (or TAH) were below the AWQS. TAH concentrations for the July 21 and July 22 sampling ranged from 0.55 to 7.4 micrograms per liter (µg/L) with a median value of 2.7 µg/L. The TAH concentrations for the July 24 sampling ranged from 0.4 to 2.6 µg/L with a median value of 1.2 µg/L.

The TAH concentrations for the deep and shallow thalweg samples are plotted against time in Figures 2 and 3. These figures show that the TAH concentrations for the first two days seem to spike up at 6:00 to 8:00 a.m. and at 6:00 to 8:00 p.m. and decrease in the middle of the night when motorboat usage declined.

TAH concentrations were lower on July 24 than on July 21 and 22. Several factors were considered as possible explanations for the difference, including changes in river flow, changes in numbers of boats and specific types of boats, and potential problems with the analytical data collection and sampling. These factors are discussed in the following subsections.

4.1.1. Comparison of TAH Concentrations in Thalweg and Near Banks

TAH concentrations measured in the thalweg were compared with those near banks, as shown in Tables 4 and 5.

All thalweg and bank samples (not including reference or duplicate samples) ranged from 0 to 7.4 µg/L with a mean of 2.26 µg/L, a median of 2.10 µg/L, and a standard deviation of 1.58 µg/L. Thalweg samples ranged from 0.39 to 7.4 µg/L with a mean of 2.35 µg/L, a median of 2.37 µg/L, and a standard deviation of 1.53 µg/L. Left bank samples ranged from 0 to 7.22 µg/L with a mean of 2.04 µg/L, a median of 1.5 µg/L, and a standard deviation of 1.70 µg/L. Right bank samples ranged from 0.40 to 6.92 µg/L with a mean of 2.23 µg/L, a median of 2.21 µg/L, and a standard deviation of 1.65 µg/L.

The maximums for each of the locations were very similar (7.4, 7.22, and 6.92 µg/L for thalweg, left bank, and right bank samples, respectively). Means were also very similar (2.35, 2.04, 2.23 µg/L, respectively) and the 0.31 µg/L difference between the low and high means is far below the ranges of the locations' standard deviations (1.53 to 1.70 µg/L). Medians had similar agreement.

A review of TAH concentrations shown in Table 1 also indicates that TAH concentrations observed at the different sections were similar for the same time periods. A statistical comparison was considered of samples collected in the thalweg with those collected at banks near the same time. However, this comparison was not made, as samples collected at each of those sites were not made simultaneously but approximately 15–30 minutes apart (the time required to move and set up the boat at each spot and decontaminate, collect, and record logs, with additional time required for duplicates).

A comparison was also made of samples collected near the water surface with those collected at depth. All ranged from 0 to 7.4 µg/L with a mean of 2.26 µg/L, a median of 2.10 µg/L and a standard deviation of 1.58 µg/L. Samples collected at depth ranged from 0 to 7.22 µg/L with a mean of 2.22 µg/L and a standard deviation of 1.68 µg/L. Samples collected near the surface ranged from 0.39 µg/L to 7.4 µg/L with a mean of 2.29 µg/L and a standard deviation of 1.5 µg/L. As with the samples collected at different sections, the minimums, maximums, means, and standard deviations were similar for the two depths.

In summary, the results indicate that the river appears to be well mixed with similar TAH concentrations at any one time between the different depths and different cross-sections of the river.

4.1.2. Comparison of TAH Concentrations with Flow

A review of river flow rates indicated that river stage at 12:00 a.m. on July 24 was approximately 0.1 feet higher than at 10:00 p.m. on July 22 and increased an additional 0.1 feet over the next 20 hours. Figures 4 and 5 present a comparison of TAH concentrations over time with these changes in river stage. The increased river flow volume between July 22 and July 24 coincides with overall lower TAH concentrations, which could partially be explained by more dilution of the petroleum loading with the increased flows. The concentrations did not continue to decrease on July 24 as the river flow volume continued to increase. This could be a result of changes in the number or types of boats operating on the river.

4.1.3. Comparison of TAH Concentrations to Boat Traffic

The aerial boat count data, included in Attachment A, were compared to the TAH concentrations at the sampling transect. The aerial boat counts were divided into seven sections of river between the mouth and the Skilak Lake outlet. The RM 10.1 sampling transect falls within the Sonar – Pillars stretch. As discussed above, TAH levels vary during the day. These variances in TAH levels coincided with the numbers of boats counted aerially. Precise correlation was not seen. This was expected, as the aerial boat count dataset was limited and accounts for a long section of river and includes counts of boats that are below the sampling transect, which would not contribute to the TAH collected in the samples. More precise correlation would be expected with more frequent counts that delineate numbers of boats and their distances upstream of the sampling transect at specific times, as discussed below.

The Kenai River's velocity is different at different discharge volumes, depths, stream slopes, meander characters, and cross-sections (e.g., bank or thalweg). As the TAH appears to be distributed through the water column, its flow velocity should be the same as the river velocity. The travel time can be estimated for discharges from nearby upstream boats to reach the sampling transect. But as the distance between boats and the sampling transect increases, it becomes increasingly difficult to determine which ones may be sources of the TAH collected at the sampling transects.

The river velocity was estimated to average slightly over 3 miles per hour. This velocity is based on comparing the July 20–24 discharge volumes of approximately 11,000 cubic feet per second (cfs) (USGS NWIS 2007) with the velocity/discharge correlations in a USGS study of Kenai River dynamics (Dorava and Moore 1997, Appendix A-2). Assuming the river flows at this average velocity over a 5-mile stretch above the sampling transect, TAH contributions would be from boats at distances upstream of the transect near times shown in Table 3. Their relative contributions depend on their motor's operating speed and discharges ongoing at the times shown in Table 3, which depend on their upstream distance from the sampling tract. Boats counted aerially in the Sonar to Pillar stretch but that were not upstream of the sampling transect would not contribute to the TAH collected and measured in the samples.

TABLE 3. FLOW DISTANCE AT DIFFERENT TIMES

Distance upstream (miles)	Time estimated for motor discharged petroleum to reach sampling transect time (minutes) at average flow velocity of 3.055 mph
0.1	2.0
0.2	3.9
0.3	5.9
0.4	7.9
0.5	9.8
0.6	11.8
0.7	13.7
0.8	15.7
0.9	17.7
1	19.6
2	39.3
3	58.9
4	78.6
5	98.2

The other boat count method relied on counts taken by the OASIS samplers at the time of sampling. The samplers recorded the approximate number of boats visible upstream of the sampling site during each 2-hour sampling event. These data have been included in Table 1 and are plotted against time alongside the TAH concentrations in Figures 2, 3, and 6–9. In comparison with the aerial boat surveys, the OASIS boat counts more closely follow TAH concentration trends with time. Spearman's Rank Correlation Tests of these two sets of data show that the TAH results for the deep and shallow thalweg samples correlate with the OASIS boat count data, but the deep and shallow sample results for the left bank and right bank did not show a correlation (at 95% quantile) under the Spearman Test (Tables 4 and 5) (Connover 1980). However, the apparent lack of correlation is likely due to lack of statistical power in the small number of samples (8) that were collected at the banks, in combination with the very low levels of TAH observed and small differences (less than 5 parts per billion [ppb]) between the samples.

The datasets for aerial boat counts and OASIS boat counts were also reviewed to determine if a relationship could be evaluated between different types of boat motors (two-stroke and four-stroke/2006 compliant two-stroke). The data indicates a difference between levels of TAH in the river with numbers of different types of motors operating in the river. For example, levels of toluene (the most prevalent hydrocarbon component observed in the TAH data) appear to increase with numbers of two stroke engines estimated to be on the river. Unfortunately, neither dataset contained sufficient specific data on different motor types to precisely quantify the differences. OASIS samplers did not distinguish the boat motor types in their counts, and the aerial boat counts provided only estimates of the percentages of different types of motors above the Warren Ames Bridge; it is unknown where boats with different motor types were operating relative to the sampling transect. As mentioned above, the accuracy of future measures of the contributions from the different motorboat types can be improved with more information on the distance and time that specific types of boats were upstream of the sampling transect.

4.2. Comparison of 2003 and 2007 TAH Results

4.2.1. Comparison of July 2003 and 2007 Average and Maximum TAH Concentrations

A comparison of the TAH concentrations measured in 2003 with the results measured in 2007 showed that the minimum, maximum, and median concentrations during the 2007 sampling event (0.5 μ/L, 7.40 μ/L, and 2.41 μ/L, respectively) are lower than those for the 2003 sampling event (1.07 μ/L, 10.76 μ/L, and 6.94 μ/L, respectively).

Several potential causes for these differences were evaluated: differences in sampling and analytical methodology or sampling/analytical errors, differences in river discharge levels, differences in boat numbers, and differences in boat motor types.

The sampling and analytical methodologies were similar in the 2003 and 2007 efforts. OASIS collected the samples in both efforts at same or similar locations, dates, and times of day with the same sampling methods. The same analytical laboratory (SGS) used the same analytical methods in both studies. Both studies also had minimal deviations from the sampling and analytical methods, and the deviations were similar. For these reasons, the differences observed between the two studies in TAH concentrations are not believed to be due to differences or errors in sampling or analytical methods.

Differences in TAH concentrations also do not appear to be due to different river discharge volumes in 2003 and 2007. River discharges ranged from 15,700–16,200 cfs during July 20–24, 2003, and ranged from 11,000–11,500 cfs during July 20–24, 2007. The higher river flows in 2003 should result in lower concentrations of TAH for the same amount of TAH loading; however higher TAH concentrations were observed.

Differences between the study years in the numbers of boats or types of boat motors may be responsible for the lower TAH concentrations observed in 2007. Unfortunately, counts of boats and motor types in 2003 were rough estimates only, so it is unclear if the differences in TAH levels may have been due to differences in numbers of boats, types of motors on the boats, or a combination of the two factors.

4.2.2. Comparison of July 2003 and 2007 Trends in TAH Concentrations

The results indicated some differences in diurnal trends of TAH concentrations between 2003 and 2007. Figure 10 shows the trends observed in 2003. Concentrations were below 2 µg/L from 2 a.m. to 4 a.m., increased rapidly to 7–8 µg/L by 7–8 a.m., ranged between 7 and 10 µg/L during the morning, dropped during the afternoon, and rose slightly in the evening. Diurnal trends were similar for Sunday, when guided boats are not allowed, and for Tuesday (guided boats allowed). TAH was not detected on Monday after 4 a.m. when motor boat fishing is banned, except for one detection at mid-day thought to be due to boats traveling and not fishing.

FIGURE 10. JULY 2003 DAILY AND DIURNAL TRENDS IN TAH CONCENTRATIONS

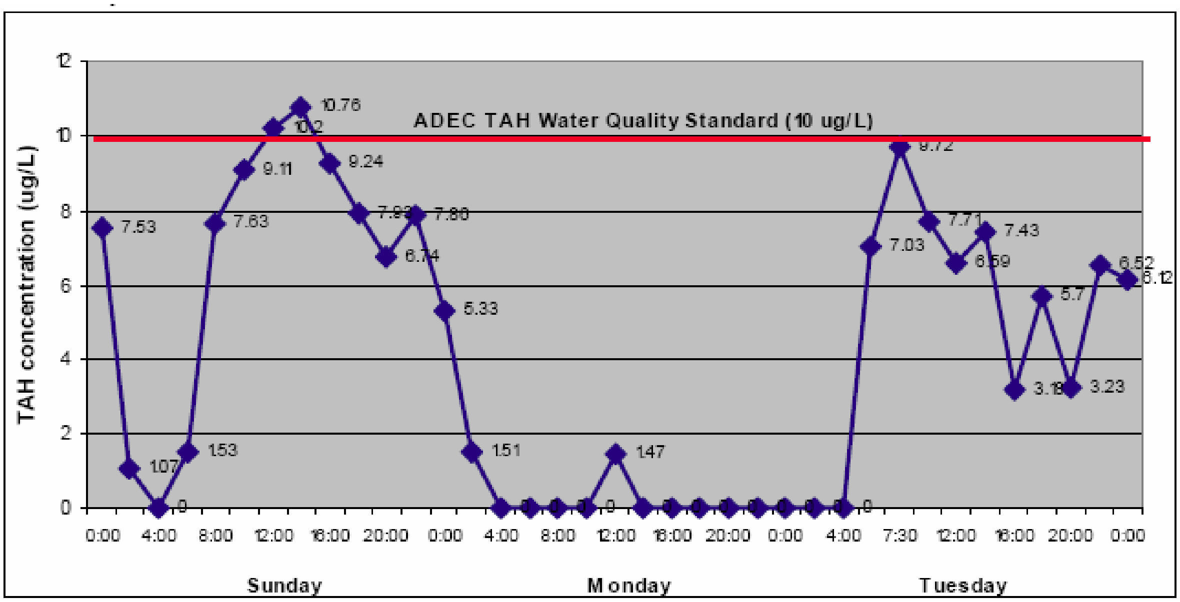
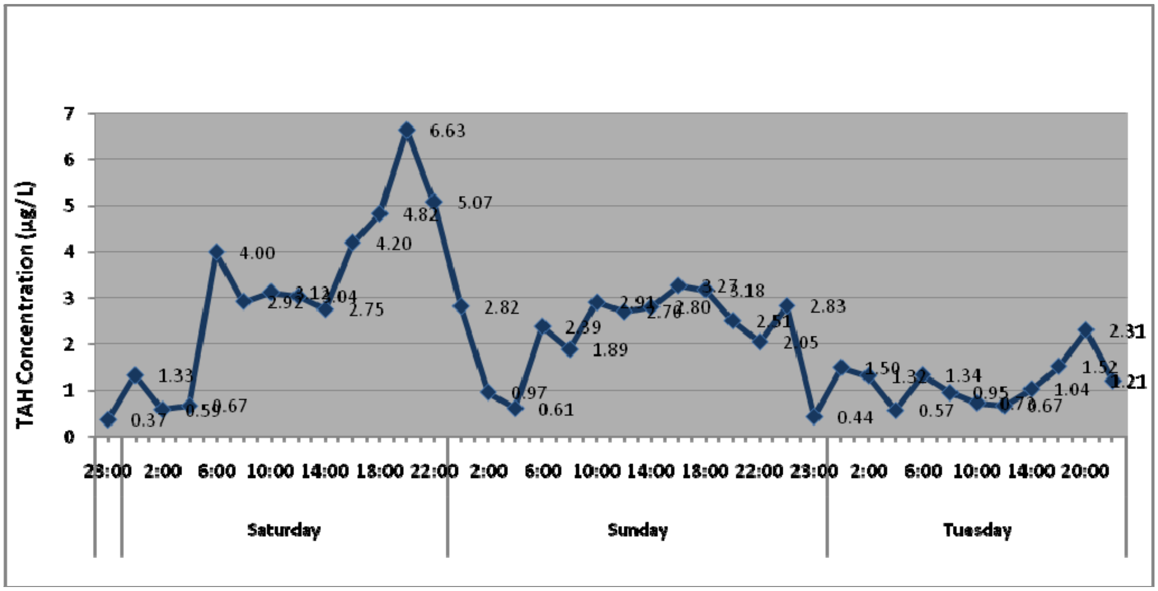


Figure 11 shows that, in contrast to 2003 trends in TAH concentrations, July 2007 TAH concentrations for Sunday and Tuesday did not exhibit as high a rise during the 6–8 a.m. time fame and also stayed lower during the remainder of the day. The results indicated a different trend pattern for Saturday, the only weekend day when fishing is allowed from both guide boats and non-guided boats. Sampling was not conducted during Saturday 2003, so a comparison for Saturdays cannot be made between 2003 and 2007. Evaluation of the 2003 results suggested that levels of TAHs may be higher on Saturdays due to estimates of higher numbers of boats with two-stroke engines. The TAH concentrations observed in the Saturday 2007 sampling appear to support this belief, as shown graphically in Figure 11.

FIGURE 11. JULY 2007 DAILY AND DIURNAL TRENDS IN TAH CONCENTRATIONS



4.2.3. Field Parameter Results

Field measurements were obtained for pH (measured as pH units), dissolved oxygen (DO, measured as milligrams per liter [mg/L]), conductivity (measured as millisiemens per centimeter [mS/cm]), salinity (calculated as %), turbidity (measured as nephalometric turbidity units [NTU]), and temperature (measured as degrees Celsius [°C]). The results for each of these parameters are discussed below.

The pH values recorded during the project ranged from 6.89 to 7.94. The pH values fell within the range acceptable by the AWQS (6.5–8.5 and cannot vary more than 0.5 from natural conditions). The pH readings were similar to those seen in 2003; however, some pH readings in 2003 were lower than 6.5 units. Readings were also similar to those from limited sampling in May 1998 conducted by the USGS near Sportsman's and Jim's Landings (Dorava and Ness 1999).

Conductivity values ranged from 0.072 to 0.075 mS/cm with one anomalous outlier at 0.65 mS/cm. Conductivity is not regulated in the AWQS. The conductivity was similar to those seen in the 2003 study and also in the 1998 USGS sampling (Dorava and Ness 1999).

Dissolved oxygen levels were similar to those observed in 2003 and ranged from 7.09 to 10.75 mg/L, with the exception of one anomaly of 18.61 mg/L. These levels were within the AWQS range of 7 to 17 mg/L. The anomalous 18.61 mg/L result is believed to be due to a meter reading or recording error, as it was significantly different than all other results, exceeds the normal DO saturation capacity of water at the temperatures observed, and no other potential cause could be identified.

Turbidity ranged from 6 to 19.4 NTU. According to the AWQS, turbidity must be less than 5 NTU over background levels. Background levels of turbidity will vary diurnally and seasonally and have not been determined for the Kenai River. Natural factors that affect turbidity levels include water source types (e.g., groundwater, surface runoff, and glacial melt), seasonal events (e.g., spring breakup), flow levels, and storm events. As turbidity baselines have not been established to account for changes in these factors, a comparison with AWQS cannot currently be made. Comparisons can be made with turbidity levels measured at the reference stretch and also with those in 2003. As seen in Figure 12, 19 of 54 measurements (35%) at the sampling transect were greater than 5 NTU over the reference stretch measurements (6 NTU on July 20, 8.5 NTU on July 23). The 2007 turbidity levels were lower than those observed in 2003, which ranged from 14 to 735, when higher flows existed (15,000 cfs in 2003, 11,000 cfs in 2007).

FIGURE 12. JULY 2007 TURBIDITY LEVELS

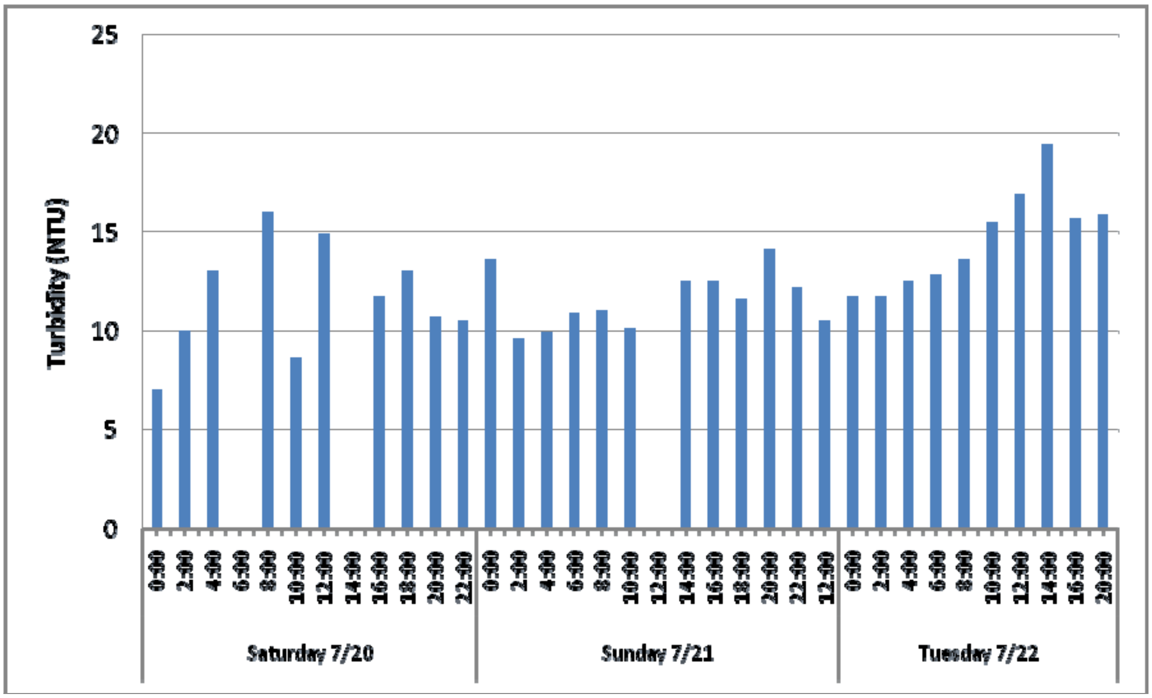


Table 1 shows the salinity levels that were determined by converting the conductivity measurements using the formula: 1 mS/Cm = 640 parts per million (ppm). This conversion provides estimates of salinity; more precise measurements require collection and evaluation of data on temperature, air pressure, and types of salts present in the water column. As in other freshwaters, Kenai River salinity levels are much lower than ocean levels (average approximately 3.5%) or in the Kenai River delta (up to 2.3%) (Bendock 1996). The salinity levels shown in Table 1 ranged from 0.0046% to 0.0058% and were similar to those calculated by converting conductivity results in the 1998 USGS study (Dorava and Ness 1999). No trends were detected for different water depths, flow rates, or tide cycles. There are AWQS for salinity criteria in marine waters but not directly for freshwaters; instead, there are AWQS for Sodium Absorption Ratio (SAR) for dissolved inorganic substances. The low salinity levels estimated from this sampling effort would not result in exceedances of those criteria.

As shown in Table 1, Kenai River water temperature measurements ranged from 12.71°C to 16.28°C. Twenty-nine of the 35 temperature measurements were above the AWQS cutoff of 13°C for spawning areas, including the two measurements recorded with the reference samples upstream. Temperature exceedances were also observed in the 2003 study, including one of 18.7 °C at a side channel near Eagle Rock.

5. CONCLUSIONS

The hydrocarbon and water quality sampling results indicate that all samples collected from the Kenai River between July 21 and July 24, 2007, complied with AWQS for TAH and pH, but not for turbidity, temperature, and DO. The TAH concentrations generally peaked from about 6:00 to 8:00 a.m. and 6:00 to 8:00 p.m. and dropped back down in the middle of the night.

The results indicate that TAH concentrations in the river were generally higher for July 21 and 22 than for July 24. Although the river stage was higher on July 24 and hydrocarbon concentrations may have been diluted by the greater water volume, the concentration did not continue to decrease during July 24, even though river stage increased over the same time period. The decrease in hydrocarbon concentration between the two sampling events may have been due to fewer boats or fewer boats with two-stroke engines upstream of the sampling transect on July 24.

The maximum, minimum, and median values for the 2007 TAH results were lower than those from the July 2003 sampling event, indicating that the hydrocarbon concentrations may have decreased over the last 4 years. Spearman's Rank Correlation Tests were used to compare the TAH results to boat counts. The tests indicated a correlation between TAH levels and boat counts. A stronger correlation was seen with counts conducted by sampling crews than with aerial counts. This difference is attributed to the more frequent counts conducted by sampling crews and to the much longer river lengths used in the aerial boat counts and corresponding decreased likelihood that numbers of boats counted in that stretch at one instant would be impacting the TAH concentrations at the transects.

As shown in Figure 11, TAH levels appeared higher on Saturday than on Sunday or Tuesday. Saturday sampling was not conducted in 2003, but was conducted in 2007 to evaluate the TAH concentrations on the only weekend day when fishing is allowed from both guided and non-guided boats. The difference may be due to differences in the numbers of boats and types of motors on boats operating on Saturday.

A comparison was also made between boat numbers and TAH levels in the thalweg and along aerial surveys. Boat numbers were counted aerially for a long stretch of river on both sides of the sampling transect and by the sampling crew for the visible stretch immediately upstream of the transect. The counts were compared with TAH results using the Spearman's Rank Correlation Test. The tests indicated that TAH results from the thalweg correlated positively with boat counts.

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6. DATA VALIDATION

6.1. Field Parameters

6.1.1. Field Measurements

The field project was designed around the July 2007 Sampling and Quality Assurance Project Plan (ADEC 2007).

All field water quality meters were calibrated according to manufacturer's specifications the morning of each sampling date using Autocal® solution. After calibration, measurements were taken of the calibration solution to ensure accuracy to 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, all pH, conductivity, and turbidity measurements were within expected ranges. One field measurement of DO was recorded as 18.61 mg/L. This is believed to be due to a meter reading or recording error, as all other DO readings were between 7.09 to 10.75 mg/L, and no other potential cause was identified.

Temperature measurements ranged from 12.71°C to 16.28°C. Twenty-nine of the 35 temperature measurements were above the AWQS cutoff of 13°C for spawning areas, including the two measurements recorded with the reference samples upstream. Temperature exceedances were also observed in the 2003 measurements.

6.1.2. Adherence to Sampling Plan

Almost all sampling occurred as outlined in the sampling plan. Though the field crew made every attempt to follow protocols in the sampling plan, there were some deviations:

- No samples were collected at 6:00 p.m. on July 24, 2007, due to problems with the boat motor.
- Salinity measurements were not recorded directly, but were calculated from the conductivity measurements using a conversion referenced in the New South Wales Department of Primary Industries – Agriculture website (NSW Agriculture 2003).
- A sampling technician forgot to record pH values during five of the 37 sampling events.

All other protocols were followed as specified in the sampling plan and QAPP, and the above deviations are not anticipated to impact results.

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 by the laboratory identified in the ADEC-approved QAPP. All Chain of Custody information was properly completed, signed and dated. There were no problems documented with broken or leaking sample bottles. All of the correct analyses were performed.

All samples were analyzed within their respective holding times. When recorded at the analytical lab, some temperature blanks were warmer than 6°C, the top range of the specified holding temperature (4.0°C +/- 2.0°C). The temperatures of coolers were generally lower; the highest cooler temperature was 6.5°C for those coolers where temperature blanks exceeded 6°C. Discussions with field and laboratory personnel and review of field logs did not indicate a cause of the temperature blank exceedances. A review of the analytical results did not indicate that samples in containers with temperature blank exceedances had lower median levels of TAH concentrations than other samples. Similar instances were observed in the 2003 sampling effort, and as concluded in that study, these minor temperature exceedances are not believed to have lowered the concentrations of TAHs in the samples. The data is not qualified, as the potential for bias is minimal.

Most samples were preserved as outlined in the sampling plan. Samples collected after 4 a.m. on July 24, 2007, were not preserved with hydrochloric acid; therefore, their holding time was shortened from 14 days to 7 days, as specified in the method. This project's sample collection method specified addition of preservative to sample vials after the water sample was collected with the Wildco sampler. Preservative was stored in small containers that were opened during each sample collection, and extra preservative was included in sampling supplies. However, some preservative was not used as the sampling crew was concerned about potential cross-contamination to opened preservative containers from volatiles in the motorboat exhaust. When it was determined that not using some of the preservative would result in an insufficient amount to complete sampling, the sampling crew consulted with the project QA officer and analytical laboratory. The solution was to collect the samples without preservative and to analyze them within 7 days, as allowed by the analysis method. This approach was followed and all samples were analyzed within holding times.

Field duplicates were collected to assess the precision of the sample collection process and the laboratory analytical procedures. Thirteen duplicates were collected at a rate of 10% of samples and were collected to represent different sampling locations, depths, and times. Field duplicates were submitted blind to the laboratory (i.e., they could not be identified by laboratory personnel as field duplicates). Relative percent differences (RPDs) between primary and duplicate results were calculated for analytes with concentrations greater than 10 times the reporting limit. Analytes were not detected at concentrations greater than 10 times the reporting limit, so RPDs were not calculated.

Decontamination blanks were not collected or analyzed. During the 2003 study, decontamination blanks were collected and no detections were made above reporting limits. This was expected, as only very low levels of TAH were encountered during deployment of sampling equipment, and the sampling equipment was rinsed in Alconox and in the river water prior to obtaining samples. As the same conditions existed and the same collection methods were used, no decontamination blanks were collected in the 2007 study.

Method blanks were analyzed in the laboratory to detect instrument and sample cross-contamination. All method blanks were below Practical Quantitation Limits.

Laboratory control samples and laboratory control sample duplicates (LCS/LCSD) are analyzed to confirm acceptable recovery of target analytes. No analytes in the LCS and LCSD samples were outside method control limits.

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. The differences are often seen with samples that are near detection limits. None of these analytes were reported in the associated project samples. Data usability was not affected.

Project completeness for all planned field sampling was approximately 98%. 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. All field samples were collected except for five pH samples and two TAH thalweg samples at 6 p.m. on July 24. 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.

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7. REFERENCES

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TABLES

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Table 1
2007 Kenai River Hydrocarbon Assessment Results
July 21 to July 24

Sample ID	Date	Time	Location	Depth	Analytical Results (µg/L)						Field Test Results						OASIS Boat Count
					Benzene	Toluene	Ethylbenzene	o-Xylene	P&M-Xylene	Total BTEX (TAH)	pH (pH units)	DO (mg/L)	Conductivity (mS/cm)	Salinity (%)	Turbidity (NTU)	Temperature (°C)	
Alaska Water Quality Standards					**5**	**1**	**0.7**	**10**		**10**	**6.5 to 8.5**	**7 to 17**	**NA**	**NA**	**<5 over background**	**<13°C**	
Reference Samples - July 20, 2007																	
RFD-072007-0900	7/20/2007	23:00	RF	Deep	ND (0.4)	0.370 J	ND (1.0)	ND (1)	ND (2)	0.37	7.73	9.77	0.076	0.004864	6	**15.42**	0
RFS-072007-0900	7/20/2007	23:00	RF	Shallow	ND (0.4)	ND (1)	ND (1.0)	ND (1)	ND (2)	<5.4	--	--	--	--	--	--	0
Assessment Samples - July 21 to 22, 2007																	
TWD-072107-0000	7/21/2007	0:00	TW	Deep	ND (0.4)	1.39	ND (1.0)	ND (1)	ND (2)	1.39	7.46	9.68	0.074	0.004736	7	**15.21**	0
TWS-072107-0000	7/21/2007	0:00	TW	Shallow	ND (0.4)	1.27	ND (1.0)	ND (1)	ND (2)	1.27	--	--	--	--	--	--	0
LBS-072107-0200	7/21/2007	2:00	LB	Shallow	ND (0.4)	0.590 J	ND (1.0)	ND (1)	ND (2)	0.59	7.66	9.42	0.074	0.004736	10	**14.57**	1
LBD-072107-0200	7/21/2007	2:00	LB	Deep	ND (0.4)	0.570 J	ND (1.0)	ND (1)	ND (2)	0.57	--	--	--	--	--	--	1
TWD-072107-0200	7/21/2007	2:00	TW	Deep	ND (0.4)	0.550 J	ND (1.0)	ND (1)	ND (2)	0.55	--	--	--	--	--	--	1
TWS-072107-0200	7/21/2007	2:00	TW	Shallow	ND (0.4)	0.650 J	ND (1.0)	ND (1)	ND (2)	0.65	--	--	--	--	--	--	1
RBS-072107-0200	7/21/2007	2:00	RB	Shallow	ND (0.4)	0.610 J	ND (1.0)	ND (1)	ND (2)	0.61	--	--	--	--	--	--	1
RBD-072107-0200	7/21/2007	2:00	RB	Deep	ND (0.4)	0.550 J	ND (1.0)	ND (1)	ND (2)	0.55	--	--	--	--	--	--	1
TWD-072107-0400	7/21/2007	4:00	TW	Deep	ND (0.4)	0.550 J	ND (1.0)	ND (1)	ND (2)	0.55	7.69	9.55	0.074	0.004736	**13**	**14.52**	8
FD-072107-0400	7/21/2007	4:00	FD	Deep	ND (0.4)	0.710 J	ND (1.0)	ND (1)	ND (2)	0.71	--	--	--	--	--	--	8
TWS-072107-0400	7/21/2007	4:00	TW	Shallow	ND (0.4)	0.750 J	ND (1.0)	ND (1)	ND (2)	0.75	--	--	--	--	--	--	8
TWD-072107-0600	7/21/2007	6:00	TW	Deep	0.73	2.08 B	ND (1.0)	ND (1)	0.700 J	3.51	7.49	9.62	0.074	0.004736	NM	**13.89**	30
TWS-072107-0600	7/21/2007	6:00	TW	Shallow	0.83	2.12 B	ND (1.0)	0.860 J	0.670 J	4.48	--	--	--	--	--	--	30
TWS-072107-0800	7/21/2007	8:00	TW	Shallow	ND (0.4)	2.24 B	ND (1.0)	ND (1)	0.670 J	2.91	--	--	--	--	--	--	40
TWD-072107-0800	7/21/2007	8:00	TW	Deep	1.07	1.16 B	0.500 J	ND (1)	ND (2)	2.73	--	--	--	--	--	--	40
RBS-072107-0800	7/21/2007	8:00	RB	Shallow	ND (0.4)	2.52 B	ND (1.0)	ND (1)	0.770 J	3.29	--	--	--	--	--	--	40
RBD-072107-0800	7/21/2007	8:00	RB	Deep	ND (0.4)	2.09 B	ND (1.0)	ND (1)	0.630 J	2.72	7.94	10.19	0.65*	--	**16**	**13.97**	40
LBD-072107-0800	7/21/2007	8:00	LB	Deep	ND (0.4)	2.25 B	ND (1.0)	ND (1)	0.680 J	2.93	--	--	--	--	--	--	40
LBS-072107-0800	7/21/2007	8:00	LB	Shallow	ND (0.4)	2.29 B	ND (1.0)	ND (1)	0.670 J	2.96	--	--	--	--	--	--	40
TWD-072107-1000	7/21/2007	10:00	TW	Deep	ND (0.4)	2.43 B	ND (1.0)	ND (1)	ND (2)	2.43	--	--	--	--	--	--	20
TWS-072107-1000	7/21/2007	10:00	TW	Shallow	ND (0.4)	2.57 B	ND (1.0)	ND (1)	0.720 J	3.29	7.85	10.66	0.074	0.004736	8.6	**14.21**	20
FD-072107-1000	7/21/2007	10:00	FD	Shallow	ND (0.4)	2.81 B	ND (1.0)	ND (1)	0.840 J	3.65	--	--	--	--	--	--	20
TWD-072107-1200	7/21/2007	12:00	TW	Deep	ND (0.4)	2.82 B	ND (1.0)	ND (1)	0.700 J	3.52	--	--	--	--	--	--	19
TWS-072107-1200	7/21/2007	12:00	TW	Shallow	ND (0.4)	2.55 B	ND (1.0)	ND (1)	ND (2)	2.55	7.56	10.18	0.074	0.004736	**14.9**	**14.45**	19
TWD-072107-1400	7/21/2007	14:00	TW	Deep	ND (0.4)	2.79 B	ND (1.0)	ND (1)	0.820 J	3.61	--	--	--	--	--	--	18
TWS-072107-1400	7/21/2007	14:00	TW	Shallow	ND (0.4)	2.43 B	ND (1.0)	ND (1)	ND (2)	2.43	--	--	--	--	--	--	18
RBD-072107-1400	7/21/2007	14:00	RB	Deep	ND (0.4)	2.49 B	ND (1.0)	ND (1)	ND (2)	2.49	--	--	--	--	--	--	18
RBS-072107-1400	7/21/2007	14:00	RB	Shallow	ND (0.4)	2.66 B	ND (1.0)	ND (1)	0.720 J	3.38	--	--	--	--	--	--	18
LBD-072107-1400	7/21/2007	14:00	LB	Deep	ND (0.4)	2.07 B	ND (1.0)	ND (1)	ND (2)	2.07	7.74	10.75	0.074	0.004736	NM	**15.47**	18
LBS-072107-1400	7/21/2007	14:00	LB	Shallow	ND (0.4)	1.84 B	ND (1.0)	ND (1)	0.690 J	2.53	--	--	--	--	--	--	18
TWD-072107-1600	7/21/2007	16:00	TW	Deep	ND (0.4)	2.92 B	0.400 J	ND (1)	1.07 J	4.39	--	--	--	--	--	--	20
TWS-072107-1600	7/21/2007	16:00	TW	Shallow	ND (0.4)	2.31 B	0.330 J	ND (1)	0.960 J	3.6	7.77	10.04	0.073	0.004672	**11.7**	**16.15**	20
FD-072107-1600	7/21/2007	16:00	FD	Shallow	ND (0.4)	3.04 B	0.420 J	ND (1)	1.14 J	4.6	--	--	--	--	--	--	20
TWD-072107-1800	7/21/2007	18:00	TW	Deep	ND (0.4)	2.78 B	0.380 J	ND (1)	0.700 J	3.86	--	10.4	0.075	0.0048	**13**	**16.18**	10
TWS-072107-1800	7/21/2007	18:00	TW	Shallow	0.200 J	3.57 B	0.460 J	ND (1)	1.55 J	5.78	--	--	--	--	--	--	10
TWD-072107-2000	7/21/2007	20:00	TW	Deep	0.54	4.12 B	0.620 J	ND (1)	1.91 J	7.19	--	--	--	--	--	--	14
TWS-072107-2000	7/21/2007	20:00	TW	Shallow	0.68	4.16 B	0.540 J	ND (1)	2.02	7.4	--	--	--	--	--	--	14
RBS-072107-2000	7/21/2007	20:00	RB	Shallow	ND (0.4)	3.16 B	0.440 J	ND (1)	1.46 J	5.06	--	--	--	--	--	--	14
RBD-072107-2000	7/21/2007	20:00	RB	Deep	0.58	3.87 B	0.540 J	ND (1)	1.93 J	6.92	--	**18.61**	0.074	0.004736	10.7	**15.88**	14
LBS-072107-2000	7/21/2007	20:00	LB	Shallow	0.230 J	3.65 B	0.480 J	ND (1)	1.62 J	5.98	--	--	--	--	--	--	14
LBD-072107-2000	7/21/2007	20:00	LB	Deep	0.62	4.06 B	0.570 J	ND (1)	1.97 J	7.22	--	--	--	--	--	--	14
TWS-072107-2200	7/21/2007	22:00	TW	Shallow	ND (0.4)	3.18 B	0.450 J	ND (1)	1.47 J	5.1	--	9.9	0.072	0.004608	10.5	**15.15**	10
TWD-072107-2200	7/21/2007	22:00	TW	Deep	ND (0.4)	3.22 B	0.430 J	ND (1)	1.54 J	5.19	--	--	--	--	--	--	10
FD-072107-2200	7/21/2007	22:00	FD	Deep	ND (0.4)	3.14 B	0.380 J	ND (1)	1.41 J	4.93	--	--	--	--	--	--	10
TWD-072207-0000	7/22/2007	0:00	TW	Deep	ND (0.4)	2.09 B	ND (1.0)	ND (1)	0.840 J	2.93	--	9.27	0.072	0.004608	**13.6**	**15.35**	0
TWS-072207-0000	7/22/2007	0:00	TW	Shallow	ND (0.4)	2.00 B	ND (1.0)	ND (1)	0.710 J	2.71	--	--	--	--	--	--	0
LBS-072207-0200	7/22/2007	2:00	LB	Shallow	ND (0.4)	0.610 JB	ND (1.0)	ND (1)	ND (2)	0.61	7.45	9.16	0.075	0.0048	9.6	**14.92**	0
LBD-072207-0200	7/22/2007	2:00	LB	Deep	ND (0.4)	0.750 JB	ND (1.0)	ND (1)	ND (2)	0.75	--	--	--	--	--	--	0
TWD-072207-0200	7/22/2007	2:00	TW	Deep	ND (0.4)	0.750 JG	ND (1.0)	ND (1)	ND (2)	0.75	--	--	--	--	--	--	0
TWS-072207-0200	7/22/2007	2:00	TW	Shallow	ND (0.4)	1.06 B	ND (1.0)	ND (1)	ND (2)	1.06	--	--	--	--	--	--	0

Table 1
2007 Kenai River Hydrocarbon Assessment Results
July 21 to July 24

Sample ID	Date	Time	Location	Depth	Analytical Results (µg/L)						Field Test Results						OASIS Boat Count
					Benzene	Toluene	Ethylbenzene	o-Xylene	P&M-Xylene	Total BTEX (TAH)	pH (pH units)	DO (mg/L)	Conductivity (mS/cm)	Salinity (%)	Turbidity (NTU)	Temperature (°C)	
Alaska Water Quality Standards					**5**	**1**	**0.7**	**10**		**10**	**6.5 to 8.5**	**7 to 17**	**NA**	**NA**	**<5 over background**	**<13°C**	
RBS-072207-0200	7/22/2007	2:00	RB	Shallow	ND (0.4)	1.42 B	ND (1.0)	ND (1)	0.630 J	2.05	--	--	--	--	--	--	0
RBD-072207-0200	7/22/2007	2:00	RB	Deep	ND (0.4)	0.570 JB	ND (1.0)	ND (1)	ND (2)	0.57	--	--	--	--	--	--	0
TWD-072207-0400	7/22/2007	4:00	TW	Deep	ND (0.4)	0.610 JB	ND (1.0)	ND (1)	ND (2)	0.61	6.89	9.04	0.073	0.004672	9.9	**15.07**	2
TWS-072207-0400	7/22/2007	4:00	TW	Shallow	ND (0.4)	0.630 JB	ND (1.0)	ND (1)	ND (2)	0.63	--	--	--	--	--	--	2
FD-072207-0400	7/22/2007	4:00	FD	Shallow	ND (0.4)	0.600 JG	ND (1.0)	ND (1)	ND (2)	0.6	--	--	--	--	--	--	2
TWD-072207-0600	7/22/2007	6:00	TW	Deep	ND (0.4)	1.81 B	ND (1.0)	ND (1)	0.640 J	2.45	--	--	--	--	--	--	14
TWS-072207-0600	7/22/2007	6:00	TW	Shallow	ND (0.4)	1.68 B	ND (1.0)	ND (1)	0.640 J	2.32	7.26	8.77	0.074	0.004736	10.9	**14.87**	14
TWS-072207-0800	7/22/2007	8:00	TW	Shallow	ND (0.4)	1.76 B	ND (1.0)	ND (1)	0.680 J	2.44	--	--	--	--	--	--	12
TWD-072207-0800	7/22/2007	8:00	TW	Deep	ND (0.4)	1.75 B	ND (1.0)	ND (1)	0.770 J	2.52	--	--	--	--	--	--	12
RBS-072207-0800	7/22/2007	8:00	RB	Shallow	ND (0.4)	1.75 B	ND (1.0)	ND (1)	0.660 J	2.41	--	--	--	--	--	--	12
RBD-072207-0800	7/22/2007	8:00	RB	Deep	ND (0.4)	1.51 B	ND (1.0)	ND (1)	ND (2)	1.51	7.25	8.66	0.074	0.004736	11	**14.65**	12
LBS-072207-0800	7/22/2007	8:00	LB	Shallow	ND (0.4)	1.42 B	ND (1.0)	ND (1)	ND (2)	1.42	--	--	--	--	--	--	12
LBD-072207-0800	7/22/2007	8:00	LB	Deep	ND (0.4)	1.05 B	ND (1.0)	ND (1)	ND (2)	1.05	--	--	--	--	--	--	12
TWS-072207-1000	7/22/2007	10:00	TW	Shallow	ND (0.4)	1.62 B	ND (1.0)	ND (1)	ND (2)	1.62	7.13	9	0.074	0.004736	10.1	**14.49**	21
TWD-072207-1000	7/22/2007	10:00	TW	Deep	0.62	3.31 B	0.340 J	ND (1)	ND (2)	4.27	--	--	--	--	--	--	21
FD-072207-1000	7/22/2007	10:00	FD	Deep	ND (0.4)	2.08 B	ND (1.0)	ND (1)	0.750 J	2.83	--	--	--	--	--	--	21
TWS-072207-1200	7/22/2007	12:00	TW	Shallow	ND (0.4)	2.08 B	ND (1.0)	ND (1)	0.620 J	2.7	--	--	--	--	--	--	22
TWD-072207-1200	7/22/2007	12:00	TW	Deep	ND (0.4)	2.18 B	ND (1.0)	ND (1)	0.650 J	2.83	7.25	9.49	0.074	0.004736	10.5	**14.02**	22
TWS-072207-1400	7/22/2007	14:00	TW	Shallow	ND (0.4)	2.32 B	ND (1.0)	ND (1)	0.630 J	2.95	--	--	--	--	--	--	18
TWD-072207-1400	7/22/2007	14:00	TW	Deep	ND (0.4)	1.70 B	ND (1.0)	ND (1)	ND (2)	1.7	--	--	--	--	--	--	18
RBS-072207-1400	7/22/2007	14:00	RB	Shallow	ND (0.4)	1.64 B	ND (1.0)	ND (1)	ND (2)	1.64	--	--	--	--	--	--	18
RBD-072207-1400	7/22/2007	14:00	RB	Deep	ND (0.4)	2.80 B	ND (1.0)	ND (1)	0.910 J	3.71	--	--	--	--	--	--	18
LBD-072207-1400	7/22/2007	14:00	LB	Deep	ND (0.4)	2.58 B	ND (1.0)	ND (1)	0.740 J	3.32	--	--	--	--	--	--	18
LBS-072207-1400	7/22/2007	14:00	LB	Shallow	ND (0.4)	2.87 B	ND (1.0)	ND (1)	0.630 J	3.5	7.41	8.95	0.074	0.004736	**12.5**	**14.11**	18
TWS-072207-1600	7/22/2007	16:00	TW	Shallow	ND (0.4)	2.37 B	ND (1.0)	ND (1)	0.720 J	3.09	7.44	8.82	0.074	0.004736	**12.5**	**14.18**	10
TWD-072207-1600	7/22/2007	16:00	TW	Deep	ND (0.4)	2.63 B	ND (1.0)	ND (1)	0.800 J	3.43	--	--	--	--	--	--	10
FD-072207-1600	7/22/2007	16:00	FD	Deep	ND (0.4)	2.53 B	ND (1.0)	ND (1)	0.760 J	3.29	--	--	--	--	--	--	10
TWD-072207-1800	7/22/2007	18:00	TW	Deep	ND (0.4)	3.15 B	ND (1.0)	ND (1)	ND (2)	3.15	7.49	9.29	0.073	0.004672	**11.6**	**14.43**	8
TWS-072207-1800	7/22/2007	18:00	TW	Shallow	ND (0.4)	2.49 B	ND (1.0)	ND (1)	0.720 J	3.21	--	--	--	--	--	--	8
RBS-072207-2000	7/22/2007	20:00	RB	Shallow	ND (0.4)	2.91 B	ND (1.0)	ND (1)	0.860 J	3.77	7.51	8.64	0.072	0.004608	**14.1**	**14.53**	9
RBD-072207-2000	7/22/2007	20:00	RB	Deep	ND (0.4)	2.55 B	ND (1.0)	ND (1)	0.770 J	3.32	--	--	--	--	--	--	9
TWD-072207-2000	7/22/2007	20:00	TW	Deep	ND (0.4)	2.32 B	ND (1.0)	ND (1)	ND (2)	2.32	--	--	--	--	--	--	9
TWS-072207-2000	7/22/2007	20:00	TW	Shallow	ND (0.4)	2.12 B	ND (1.0)	ND (1)	ND (2)	2.12	--	--	--	--	--	--	9
LBS-072207-2000	7/22/2007	20:00	LB	Shallow	ND (0.4)	2.06 B	ND (1.0)	ND (1)	ND (2)	2.06	--	--	--	--	--	--	9
LBD-072207-2000	7/22/2007	20:00	LB	Deep	ND (0.4)	1.47 B	ND (1.0)	ND (1)	ND (2)	1.47	--	--	--	--	--	--	9
TWD-072207-2200	7/22/2007	22:00	TW	Deep	ND (0.4)	1.92 B	ND (1.0)	ND (1)	ND (2)	1.92	7.43	9.01	0.072	0.004608	**12.2**	**14.43**	16
TWS-072207-2200	7/22/2007	22:00	TW	Shallow	ND (0.4)	1.91 B	ND (1.0)	ND (1)	0.770 J	2.68	--	--	--	--	--	--	16
FD-072207-2200	7/22/2007	22:00	FD	Shallow	ND (0.4)	1.56 B	ND (1.0)	ND (1)	ND (2)	1.56	--	--	--	--	--	--	16
Reference Samples - July 23, 2007																	
RFD-072307-1000	7/23/2007	23:00	RF	Deep	ND (0.4)	0.390 JB	ND (1.0)	ND (1)	ND (2)	0.39	--	--	--	--	--	--	0
RFS-072307-1000	7/23/2007	23:00	RF	Shallow	ND (0.4)	0.480 JB	ND (1.0)	ND (1)	ND (2)	0.48	7.2	10.13	0.091	0.005824	8.5	**13.37**	0
Assessment Samples - July 24, 2007																	
TWS-072407-0000	7/24/2007	0:00	TW	Shallow	0.58	0.700 JB	ND (1.0)	ND (1)	1.22 J	2.5	--	--	--	--	--	--	5
TWD-072407-0000	7/24/2007	0:00	TW	Deep	ND (0.4)	0.50 JB	ND (1.0)	ND (1)	ND (2)	0.5	7.52	8.99	0.073	0.004672	11.7	**13.42**	5
RBS-072407-0200	7/24/2007	2:00	RB	Shallow	ND (0.4)	0.440 JB	ND (1.0)	ND (1)	ND (2)	0.44	--	--	--	--	--	--	1
RBD-072407-0200	7/24/2007	2:00	RB	Deep	ND (0.4)	0.400 JB	ND (1.0)	ND (1)	ND (2)	0.4	--	--	--	--	--	--	1
TWD-072407-0200	7/24/2007	2:00	TW	Deep	ND (0.4)	0.620 JB	ND (1.0)	ND (1)	1.22 J	1.84	--	--	--	--	--	--	1
TWS-072407-0200	7/24/2007	2:00	TW	Shallow	ND (0.4)	0.640 JG	0.470 J	ND (1)	1.16 J	2.27	--	--	--	--	--	--	1
LBD-072407-0200	7/24/2007	2:00	LB	Deep	ND (0.4)	ND (1)	ND (1)	ND (1)	ND (2)	<5.4	--	--	--	--	--	--	1
LBS-072407-0200	7/24/2007	2:00	LB	Shallow	ND (0.4)	0.520 JB	ND (1)	ND (1)	1.15 J	1.67	7.43	8.86	0.074	0.004736	11.7	**13.12**	1
TWD-072407-0400	7/24/2007	4:00	TW	Deep	ND (0.4)	0.620 JB	ND (1.0)	ND (1)	ND (2)	0.62	7.06	8.54	0.075	0.0048	12.5	12.85	9
TWS-072407-0400	7/24/2007	4:00	TW	Shallow	0.390 J	ND(1)	ND(1)	ND(1)	ND(1)	0.39	--	--	--	--	--	--	9
FD-072407-0400	7/24/2007	4:00	FD	Shallow	ND (0.4)	0.520 JB	ND (1.0)	ND (1)	ND (2)	0.52	--	--	--	--	--	--	9
TWS-072407-0600	7/24/2007	6:00	TW	Shallow	ND (0.4)	1.15 B	ND (1.0)	ND (1)	ND (2)	1.15	7.45	8.56	0.074	0.004736	12.8	12.71	32

Table 1
2007 Kenai River Hydrocarbon Assessment Results
July 21 to July 24

Sample ID	Date	Time	Location	Depth	Analytical Results (µg/L) Benzene	Toluene	Ethylbenzene	o-Xylene	P&M-Xylene	Total BTEX (TAH)	Field Test Results pH (pH units)	DO (mg/L)	Conductivity (mS/cm)	Salinity (%)	Turbidity (NTU)	Temperature (°C)	OASIS Boat Count
Alaska Water Quality Standards					**5**	**1**	**0.7**	**10**		**10**	**6.5 to 8.5**	**7 to 17**	**NA**	**NA**	**<5 over background**	**<13°C**	
TWD-072407-0600	7/24/2007	6:00	TW	Deep	ND (0.4)	1.53 B	ND (1.0)	ND (1)	ND (2)	1.53	--	--	--	--	--	--	32
TWS-072407-0800	7/24/2007	8:00	TW	Shallow	ND (0.4)	1.37 B	ND (1.0)	ND (1)	ND (2)	1.37	--	--	--	--	--	--	21
TWD-072407-0800	7/24/2007	8:00	TW	Deep	ND (0.4)	1.17 B	ND (1.0)	ND (1)	ND (2)	1.17	--	--	--	--	--	--	21
RBS-072407-0800	7/24/2007	8:00	RB	Shallow	ND (0.4)	0.950 JB	ND (1.0)	ND (1)	ND (2)	0.95	--	--	--	--	--	--	21
RBD-072407-0800	7/24/2007	8:00	RB	Deep	ND (0.4)	0.700 JB	ND (1.0)	ND (1)	ND (2)	0.7	--	--	--	--	--	--	21
LBS-072407-0800	7/24/2007	8:00	LB	Shallow	ND (0.4)	0.700 JB	ND (1.0)	ND (1)	ND (2)	0.7	7.51	8.04	0.074	0.004736	**13.6**	12.97	21
LBD-072407-0800	7/24/2007	8:00	LB	Deep	ND (0.4)	0.830 JB	ND (1.0)	ND (1)	ND (2)	0.83	--	--	--	--	--	--	21
TWS-072407-1000	7/24/2007	10:00	TW	Shallow	ND (0.4)	0.920 JB	ND (1.0)	ND (1)	ND (2)	0.92	7.47	7.09	0.074	0.004736	**15.5**	12.99	17
TWD-072407-1000	7/24/2007	10:00	TW	Deep	ND (0.4)	0.870 JB	ND (1.0)	ND (1)	ND (2)	0.87	--	--	--	--	--	--	17
FD-072407-1000	7/24/2007	10:00	FD	Deep	ND (0.4)	0.410 JB	ND (1.0)	ND (1)	ND (2)	0.41	--	--	--	--	--	--	17
TWD-072407-1200	7/24/2007	12:00	TW	Deep	ND (0.4)	0.790 JB	ND (1.0)	ND (1)	ND (2)	0.79	--	--	--	--	--	--	10
TWS-072407-1200	7/24/2007	12:00	TW	Shallow	ND (0.4)	0.550 JB	ND (1.0)	ND (1)	ND (2)	0.55	7.47	7.31	0.073	0.004672	**16.9**	**13**	10
RBS-072407-1400	7/24/2007	14:00	RB	Shallow	ND (0.4)	0.940 JB	ND (1.0)	ND (1)	ND (2)	0.94	7.68	7.43	0.074	0.004736	**19.4**	**13**	16
RBD-072407-1400	7/24/2007	14:00	RB	Deep	ND (0.4)	0.670 JB	ND (1.0)	ND (1)	ND (2)	0.67				--			16
TWD-072407-1400	7/24/2007	14:00	TW	Deep	ND (0.4)	0.540 JB	ND (1.0)	ND (1)	ND (2)	0.54	--	--	--	--	--	--	16
TWS-072407-1400	7/24/2007	14:00	TW	Shallow	ND (0.4)	1.17 B	ND (1.0)	ND (1)	ND (2)	1.17	--	--	--	--	--	--	16
LBS-072407-1400	7/24/2007	14:00	LB	Shallow	ND (0.4)	1.52 B	ND (1.0)	ND (1)	ND (2)	1.52	--	--	--	--	--	--	16
LBD-072407-1400	7/24/2007	14:00	LB	Deep	ND (0.4)	1.37 B	ND (1.0)	ND (1)	ND (2)	1.37	--	--	--	--	--	--	16
TWD-072407-1600	7/24/2007	16:00	TW	Deep	ND (0.4)	1.56 B	ND (1.0)	ND (1)	ND (2)	1.56	--	7.76	0.073	0.004672	**15.7**	**13.3**	20
FD-072407-1600	7/24/2007	16:00	FD	Deep	ND (0.4)	1.47 B	ND (1.0)	ND (1)	ND (2)	1.47	--	--	--	--	--	--	20
TWS-072407-1600	7/24/2007	16:00	TW	Shallow	ND (0.4)	1.54 B	ND (1.0)	ND (1)	ND (2)	1.54	--	--	--	--	--	--	20
	7/24/2007	18:00	No samples collected due to problems with boat motor											--			
RBD-072407-2000	7/24/2007	20:00	RB	Deep	ND (0.4)	1.87 B	ND (1.0)	ND (1)	0.660 J	2.53	--	--	--	--	--	--	11
RBS-072407-2000	7/24/2007	20:00	RB	Shallow	ND (0.4)	1.82 B	ND (1.0)	ND (1)	0.660 J	2.48	--	8.91	0.074	0.004736	**15.9**	12.82	11
TWD-072407-2000	7/24/2007	20:00	TW	Deep	ND (0.4)	1.79 B	ND (1.0)	ND (1)	0.620 J	2.41	--	--	--	--	--	--	11
TWS-072407-2000	7/24/2007	20:00	TW	Shallow	ND (0.4)	1.97 B	ND (1.0)	ND (1)	0.690 J	2.66	--	--	--	--	--	--	11
LBD-072407-2000	7/24/2007	20:00	LB	Deep	ND (0.4)	1.92 B	ND (1.0)	ND (1)	0.630 J	2.55	--	--	--	--	--	--	11
LBS-072407-2000	7/24/2007	20:00	LB	Shallow	ND (0.4)	1.24 B	ND (1.0)	ND (1)	ND (2)	1.24	--	--	--	--	--	--	11
TWS-072407-2200	7/24/2007	22:00	TW	Shallow	ND (0.4)	1.35 B	ND (1.0)	ND (1)	ND (2)	1.35	7.47	8.43	0.073	0.004672	NM	12.72	7
FD-072407-2200	7/24/2007	22:00	FD	Shallow	ND (0.4)	1.34 B	ND (1.0)	ND (1)	ND (2)	1.34	--	--	--	--	--	--	7
TWD-072407-2200	7/24/2007	22:00	TW	Deep	ND (0.4)	0.940 JB	ND (1.0)	ND (1)	ND (2)	0.94	--	--	--	--	--	--	7

Notes:
Salinity has been calculated from conductivity using the following formula: salinity (%) = conductivity (mS/cm) * $640/10^4$ (NSW Agriculture, 2003)
-- Not measured
* Anomalous value
°C = Degrees Centigrade
µg/L = Micrograms per liter
DO = Dissolved oxygen
FD = Field Duplicate for sample above
J = Estimated value above method detection limit, but below practical quantitation limit.
LB = Left Bank
mg/L = Milligrams per liter
mS/cm = Millisiemens per centimeter
NTU = Nephelometric turbidity units
RB = Right Bank
RF = Reference sample
TAH = Total aqueous hydrocarbons
TW = Thalweg

Table 2 - Thalweg Spearman's Rank Correlation Tests

Thalweg Deep - TAH Concentration vs. OASIS Boat Count Correlation

TAH Concentration Rank	TAH Concentration	Boat Count Rank	Boat Count		Rank Difference	Square of Rank Difference
12	1.39	2	0		10	100
3.5	0.55	4.5	1		-1	1
3.5	0.55	9.5	8		-6	36
28	3.51	33	30		-5	25
23	2.73	35	40		-12	144
20	2.43	32	28		-12	144
29	3.52	26	19		3	9
30	3.61	24.5	18		5.5	30.25
33	4.39	27.5	20		5.5	30.25
31	3.86	14.5	10		16.5	272.25
35	7.19	19.5	14		15.5	240.25
34	5.19	14.5	10		19.5	380.25
25	2.93	2	0		23	529
7	0.75	2	0		5	25
5	0.61	6	2		-1	1
21	2.45	19.5	14		1.5	2.25
22	2.52	18	12		4	16
32	4.27	29.5	21		2.5	6.25
24	2.83	31	22		-7	49
15	1.7	24.5	18		-9.5	90.25
27	3.43	14.5	10		12.5	156.25
26	3.15	9.5	8		16.5	272.25
18	2.32	11.5	9		6.5	42.25
17	1.92	21.5	16		-4.5	20.25
1	0.5	7	5		-6	36
16	1.84	4.5	1		11.5	132.25
6	0.62	11.5	9		-5.5	30.25
13	1.53	34	32		-21	441
11	1.17	29.5	21		-18.5	342.25
9	0.87	23	17		-14	196
8	0.79	14.5	10		-6.5	42.25
2	0.54	21.5	16		-19.5	380.25
14	1.56	27.5	20		-13.5	182.25
19	2.41	17	11		2	4
10	0.94	8	7		2	4

Sum of squares = 2622

r = 0.632773109
critical r = ~0.30
result = Correlates

Thalweg Deep - TAH Concentration vs. Aerial Count Correlation

TAH Concentration Rank	TAH Concentration	Boat Count Rank	Boat Count		Rank Difference	Square of Rank Difference
8	2.73	11	210		-3	9
10	3.61	6	111		4	16
11	3.86	4	103		7	49
12	7.19	3	96		9	81
6	2.45	7	120		-1	1
7	2.52	1	13		6	36
4	1.7	5	108		-1	1
3	1.53	12	243		-9	81
2	1.17	9	165		-7	49
1	0.54	8	128		-7	49
5	2.41	2	66		3	9

Sum of squares = 381

r = -0.731818182
critical r = 0.527
result = No correlation

Table 2 - Thalweg Spearman's Rank Correlation Tests

Thalweg Shallow - TAH Concentration vs. OASIS Boat Count Correlation

TAH Concentration Rank	TAH Concentration	Boat Count Rank	Boat Count		Rank Difference	Square of Rank Difference
10	1.27	2	0		8	64
4	0.65	4.5	1		-0.5	0.25
5	0.75	8.5	8		-3.5	12.25
32	4.48	33	30		-1	1
26	2.91	35	40		-9	81
30	3.29	32	28		-2	4
21	2.55	26	19		-5	25
18	2.43	24.5	18		-6.5	42.25
31	3.6	27.5	20		3.5	12.25
34	5.78	14.5	10		19.5	380.25
35	7.4	19.5	14		15.5	240.25
33	5.1	14.5	10		18.5	342.25
25	2.71	2	0		23	529
7	1.06	2	0		5	25
3	0.63	6	2		-3	9
17	2.32	19.5	14		-2.5	6.25
19	2.44	18	12		1	1
14	1.62	29.5	21		-15.5	240.25
24	2.7	31	22		-7	49
27	2.95	24.5	18		2.5	6.25
28	3.09	14.5	10		13.5	182.25
29	3.21	8.5	8		20.5	420.25
15	2.12	11.5	9		3.5	12.25
23	2.68	21.5	16		1.5	2.25
20	2.5	7	5		13	169
16	2.27	4.5	1		11.5	132.25
1	0.52	11.5	9		-10.5	110.25
8	1.15	34	32		-26	676
12	1.37	29.5	21		-17.5	306.25
6	0.92	23	17		-17	289
2	0.55	14.5	10		-12.5	156.25
9	1.17	21.5	16		-12.5	156.25
13	1.54	27.5	20		-14.5	210.25
22	2.66	17	11		5	25
11	1.35	8	7		3	9

Sum of squares = 4927

r = 0.309943978
critical r = ~0.30
result = Correlates

Thalweg Shallow - TAH Concentration vs. Aerial Count Correlation

TAH Concentration Rank	TAH Concentration	Boat Count Rank	Boat Count		Rank Difference	Square of Rank Difference
10	4.48	10	172		0	0
9	2.91	11	210		-2	4
7	2.43	6	111		1	1
11	5.78	4	103		7	49
12	7.4	3	96		9	81
5	2.32	7	120		-2	4
6	2.41	1	13		5	25
4	1.64	5	108		-1	1
1	1.15	12	243		-11	121
3	1.37	9	165		-6	36
2	1.17	8	128		-6	36
8	2.66	2	66		6	36

Sum of squares = 394

r = -0.377622378
critical r = 0.497
result = No correlation

Table 4 - Right Bank Spearman's Rank Correlation Tests

Right Bank Deep - TAH Concentration vs. Boat Count Correlation

TAH Concentration Rank	TAH Concentration	Boat Count Rank	Boat Count		Rank Difference	Square of Rank Difference
2	0.55	2.5	1		-0.5	0.25
9	2.72	12	40		-3	9
7	2.49	9.5	18		-2.5	6.25
12	6.92	5.5	11		6.5	42.25
3	0.57	1	0		2	4
6	1.51	7	12		-1	1
11	3.71	9.5	18		1.5	2.25
10	3.32	4	7		6	36
1	0.4	2.5	1		-1.5	2.25
5	0.7	11	21		-6	36
4	0.67	8	16		-4	16
8	2.53	5.5	11		2.5	6.25

Sum of squares = 161.5

r = 0.435314685
critical r = 0.497
result = No correlation

Right Bank Deep - TAH Concentration vs. Aerial Count Correlation

TAH Concentration Rank	TAH Concentration	Aerial Boat Count Rank	Aerial Boat Count		Rank Difference	Square of Rank Difference
6	2.72	8	210		-2	4
4	2.49	5	111		-1	1
8	6.92	3	96		5	25
3	1.51	1	13		2	4
7	3.71	4	108		3	9
2	0.7	7	165		-5	25
1	0.67	6	128		-5	25
5	2.53	2	66		3	9

Sum of squares = 102

r = -0.214285714
critical r = 0.643
result = No correlation

Right Bank Shallow - TAH Concentration vs. Boat Count Correlation

TAH Concentration Rank	TAH Concentration	Boat Count Rank	Boat Count		Rank Difference	Square of Rank Difference
2	0.61	2.5	1		-0.5	0.25
9	3.29	12	40		-3	9
10	3.38	9.5	18		0.5	0.25
12	5.06	5.5	11		6.5	42.25
6	2.05	1	0		5	25
7	2.41	7	12		0	0
5	1.64	9.5	18		-4.5	20.25
11	3.77	4	7		7	49
1	0.44	2.5	1		-1.5	2.25
4	0.95	11	21		-7	49
3	0.94	8	16		-5	25
8	2.48	5.5	11		2.5	6.25

Sum of squares = 228.5

r = 0.201048951
critical r = 0.497
result = No correlation

Right Bank Shallow - TAH Concentration vs. Aerial Count Correlation

TAH Concentration Rank	TAH Concentration	Aerial Boat Count Rank	Aerial Boat Count		Rank Difference	Square of Rank Difference
6	3.29	8	210		-2	4
7	3.38	5	111		2	4
8	5.06	3	96		5	25
4	2.41	1	13		3	9
3	1.64	4	108		-1	1
1	0.7	7	165		-6	36
2	0.94	6	128		-4	16
5	2.48	2	66		3	9

Sum of squares = 104

r = -0.238095238
critical r = 0.643
result = No correlation

Table 5 - Left Bank Spearman's Rank Correlation Tests

Left Bank Deep - TAH Concentration vs. Boat Count Correlation

TAH Concentration Rank	TAH Concentration	Boat Count Rank	Boat Count		Rank Difference	Square of Rank Difference
2	0.57	2.5	1		-0.5	0.25
10	2.93	12	40		-2	4
8	2.07	9.5	18		-1.5	2.25
12	7.22	5.5	11		6.5	42.25
3	0.75	1	0		2	4
5	1.05	7	12		-2	4
11	3.32	9.5	18		1.5	2.25
7	1.47	4	7		3	9
1	0	2.5	1		-1.5	2.25
4	0.83	11	21		-7	49
6	1.37	8	16		-2	4
9	2.55	5.5	11		3.5	12.25

Sum of squares = 135.5

r = 0.526223776
critical r = 0.497
result = No correlation

Left Bank Deep - TAH Concentration vs. Aerial Count Correlation

TAH Concentration Rank	TAH Concentration	Aerial Boat Count Rank	Aerial Boat Count		Rank Difference	Square of Rank Difference
6	2.93	8	210		-2	4
4	2.07	5	111		-1	1
8	7.22	3	96		5	25
2	1.05	1	13		1	1
7	3.32	4	108		3	9
1	0.83	7	165		-6	36
3	1.37	6	128		-3	9
5	2.55	2	66		3	9

Sum of squares = 94

r = -0.119047619
critical r = 0.643
result = No correlation

Left Bank Shallow - TAH Concentration vs. Boat Count Correlation

TAH Concentration Rank	TAH Concentration	Boat Count Rank	Boat Count		Rank Difference	Square of Rank Difference
1	0.59	2.5	1		-1.5	2.25
10	2.96	12	40		-2	4
9	2.53	9.5	18		-0.5	0.25
12	5.98	5.5	11		6.5	42.25
2	0.61	1	0		1	1
5	1.42	7	12		-2	4
11	3.5	9.5	18		1.5	2.25
8	2.06	4	7		4	16
7	1.67	2.5	1		4.5	20.25
3	0.7	11	21		-8	64
6	1.52	8	16		-2	4
4	1.24	5.5	11		-1.5	2.25

Sum of squares = 162.5

r = 0.431818182
critical r = 0.497
result = No correlation

Left Bank Shallow - TAH Concentration vs. Aerial Count Correlation

TAH Concentration Rank	TAH Concentration	Aerial Boat Count Rank	Aerial Boat Count		Rank Difference	Square of Rank Difference
6	2.96	8	210		-2	4
5	2.53	5	111		0	0
8	5.98	3	96		5	25
3	1.42	1	13		2	4
7	3.5	4	108		3	9
1	0.7	7	165		-6	36
4	1.52	6	128		-2	4
2	1.24	2	66		0	0

Sum of squares = 82

r = 0.023809524
critical r = 0.643
result = No correlation

FIGURES

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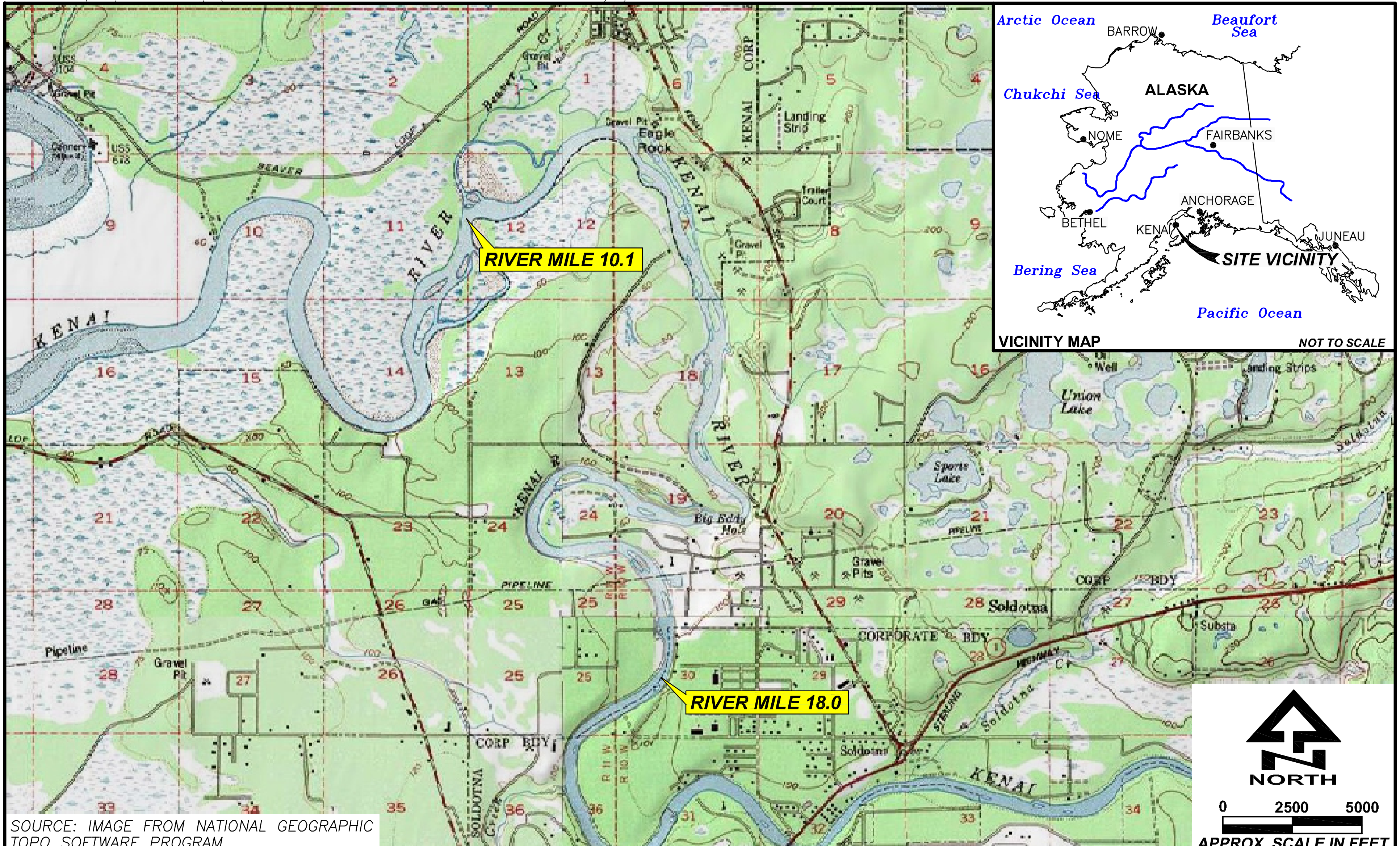

SOURCE: IMAGE FROM NATIONAL GEOGRAPHIC TOPO SOFTWARE PROGRAM.

oasis ENVIRONMENTAL

DATE: SEPT. 2007
CHKD: L.N.
DRAWN: C.E.H.
PROJ. No.: 14-109

825 W. 8th Ave., Anchorage, AK 99501, (907) 258-4880

SAMPLE LOCATION MAP

KENAI RIVER HYDROCARBON ASSESSMENT
Kenai, Alaska

FIGURE 1

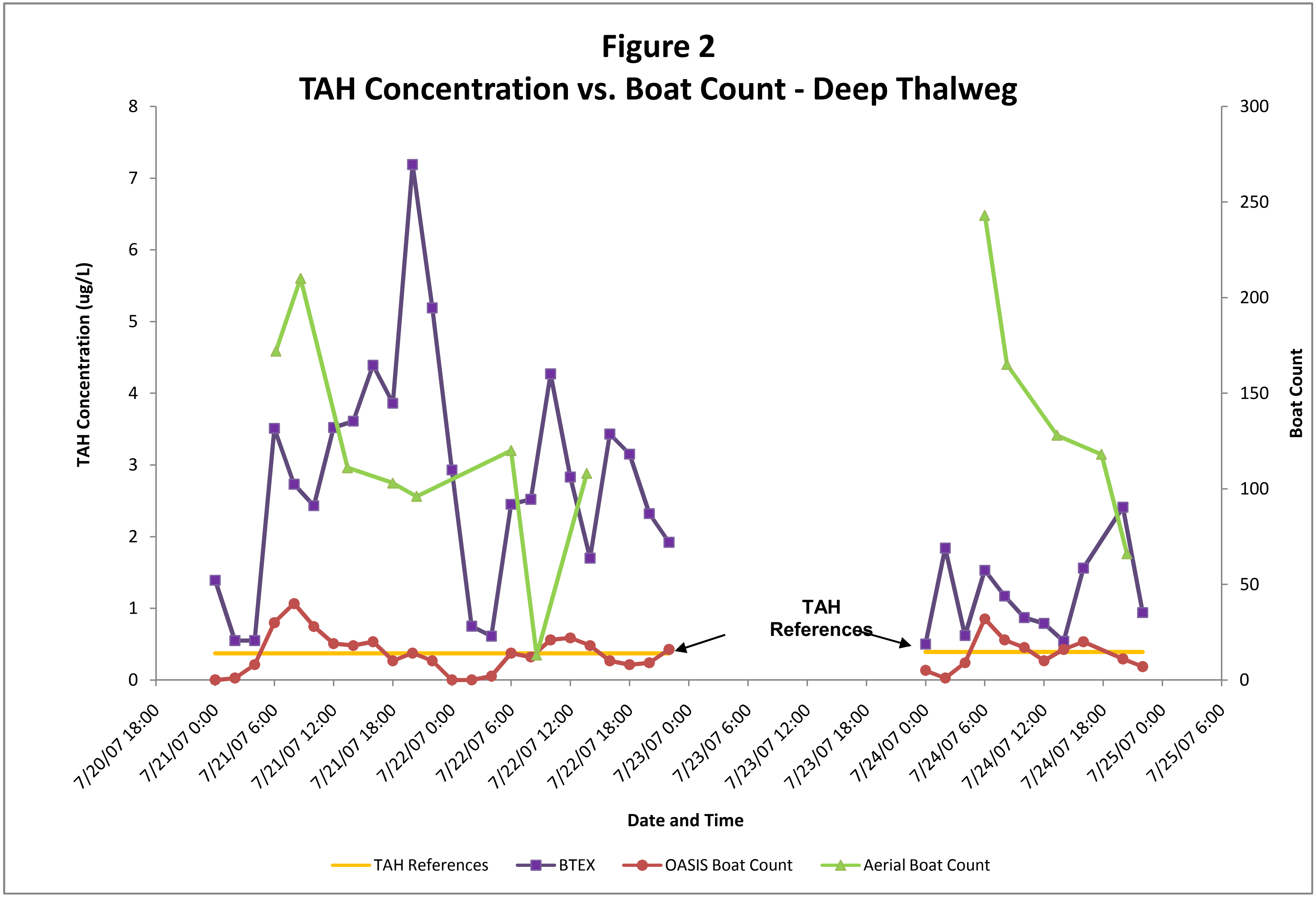
Figure 2
TAH Concentration vs. Boat Count - Deep Thalweg
TAH Concentration (ug/L)
Boat Count
0
1
2
3
4
5
6
7
8
0
50
100
150
200
250
300
TAH
References
7/20/07 18:00
7/21/07 0:00
7/21/07 6:00
7/21/07 12:00
7/21/07 18:00
7/22/07 0:00
7/22/07 6:00
7/22/07 12:00
7/22/07 18:00
7/23/07 0:00
7/23/07 6:00
7/23/07 12:00
7/23/07 18:00
7/24/07 0:00
7/24/07 6:00
7/24/07 12:00
7/24/07 18:00
7/25/07 0:00
7/25/07 6:00
Date and Time
TAH References
BTEX
OASIS Boat Count
Aerial Boat Count

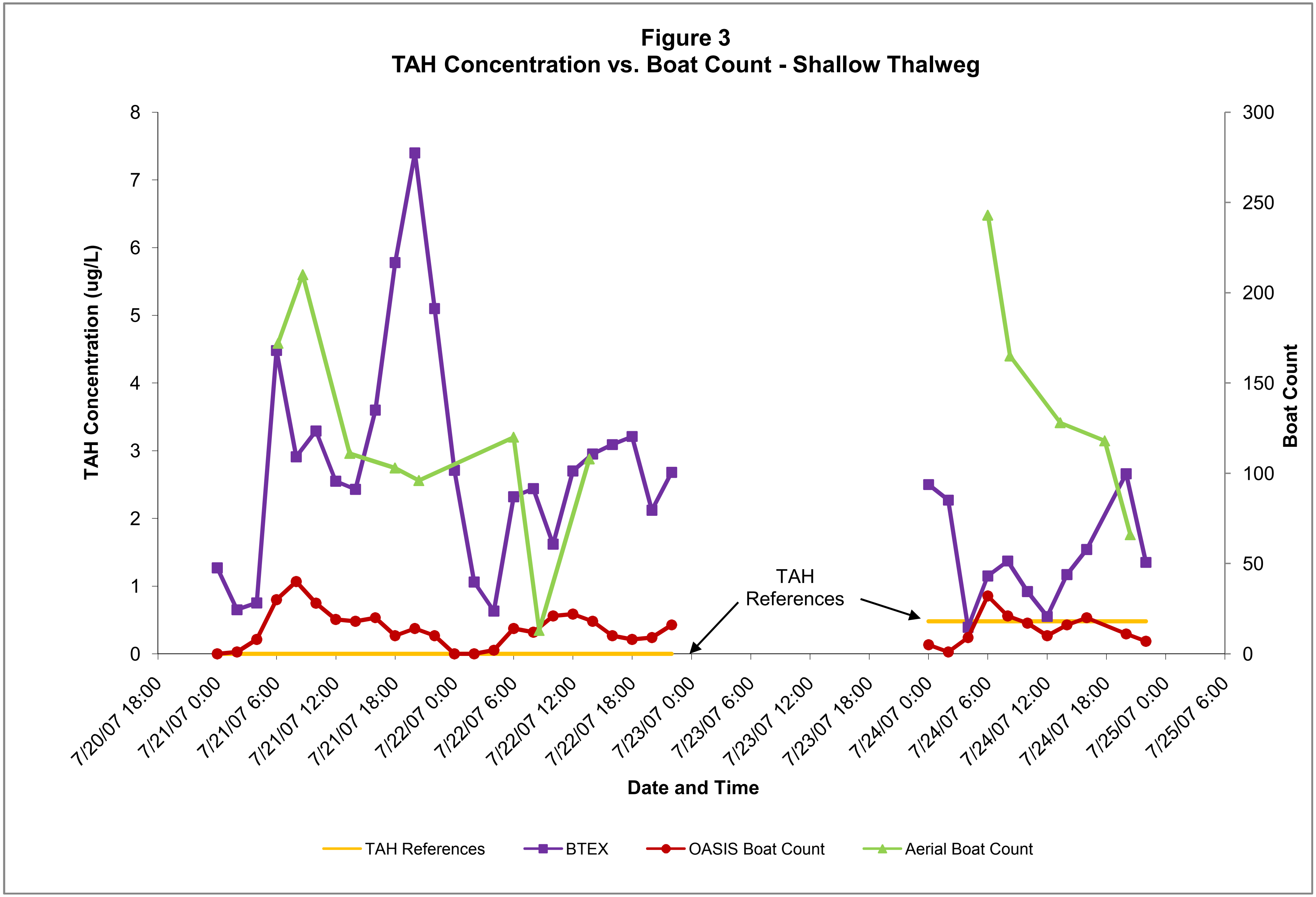
Figure 3
TAH Concentration vs. Boat Count - Shallow Thalweg
TAH Concentration (ug/L)
Boat Count
Date and Time
TAH References
TAH References
BTEX
OASIS Boat Count
Aerial Boat Count
0
1
2
3
4
5
6
7
8
0
50
100
150
200
250
300
7/20/07 18:00
7/21/07 0:00
7/21/07 6:00
7/21/07 12:00
7/21/07 18:00
7/22/07 0:00
7/22/07 6:00
7/22/07 12:00
7/22/07 18:00
7/23/07 0:00
7/23/07 6:00
7/23/07 12:00
7/23/07 18:00
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7/25/07 6:00

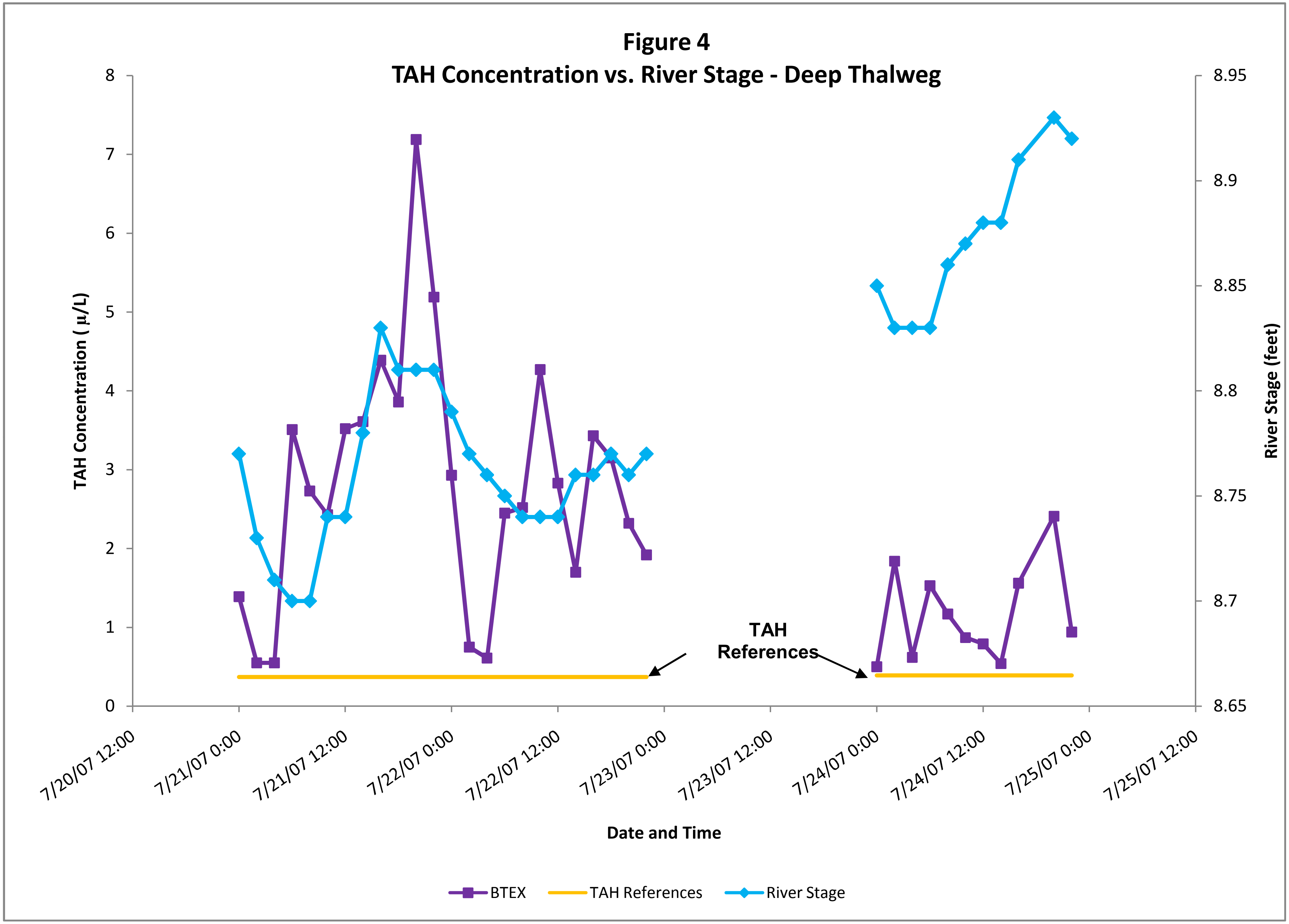


Figure 4
TAH Concentration vs. River Stage - Deep Thalweg
TAH Concentration (µ/L)
River Stage (feet)
Date and Time
TAH
References
0
1
2
3
4
5
6
7
8
8.65
8.7
8.75
8.8
8.85
8.9
8.95
7/20/07 12:00
7/21/07 0:00
7/21/07 12:00
7/22/07 0:00
7/22/07 12:00
7/23/07 0:00
7/23/07 12:00
7/24/07 0:00
7/24/07 12:00
7/25/07 0:00
7/25/07 12:00
BTEX
TAH References
River Stage

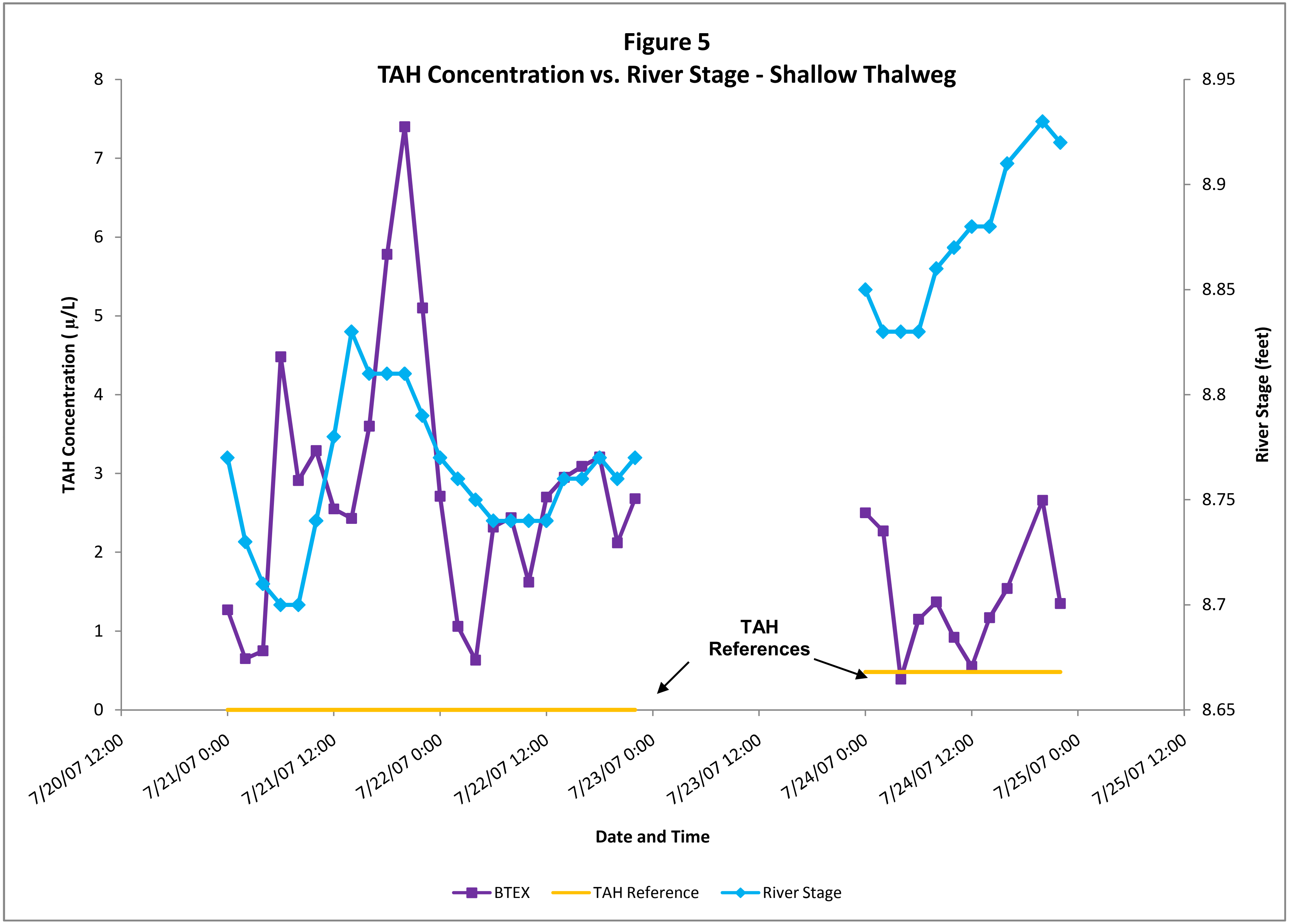
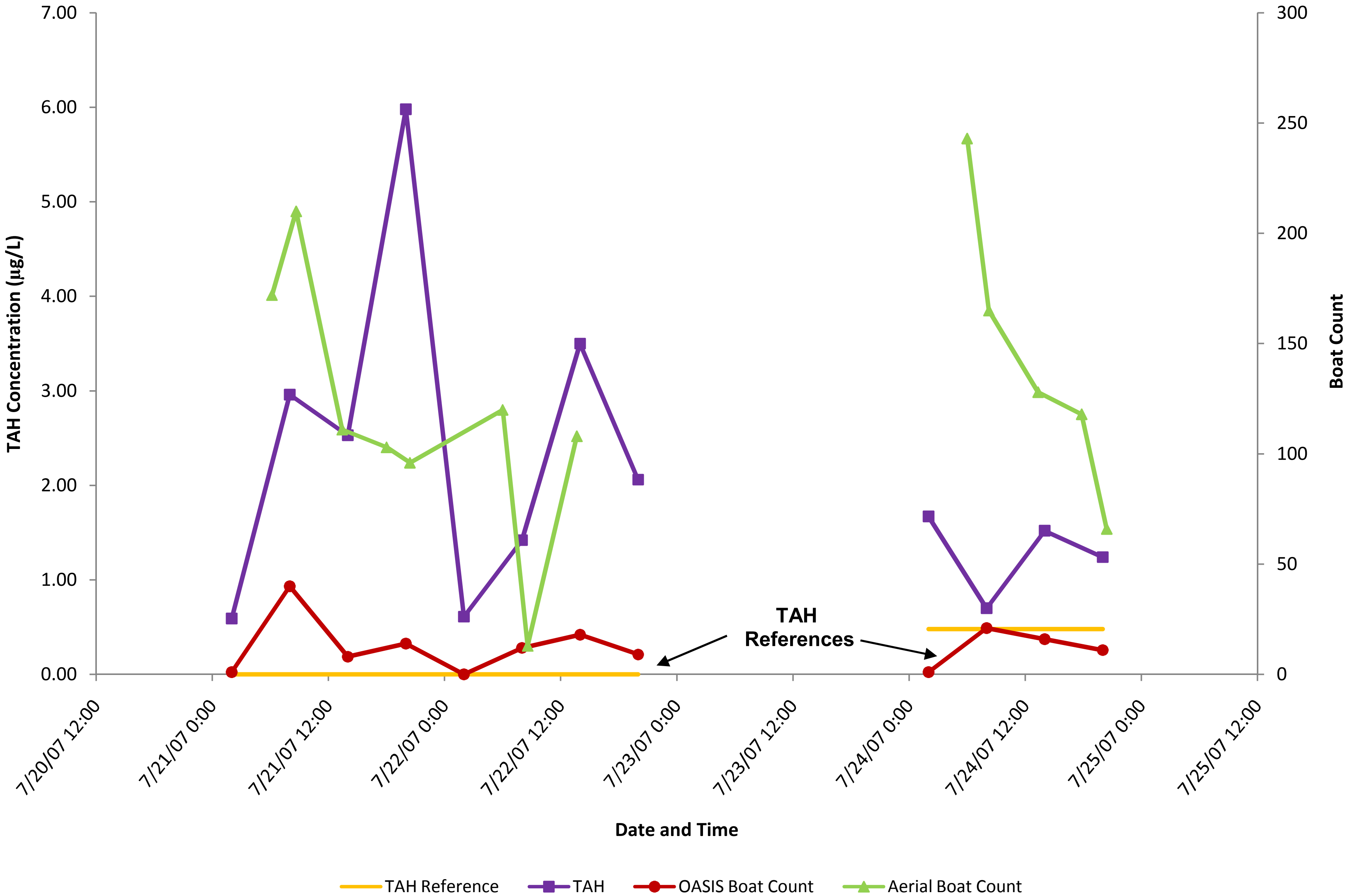


Figure 5
TAH Concentration vs. River Stage - Shallow Thalweg
TAH Concentration (µ/L)
River Stage (feet)
8
7
6
5
4
3
2
1
0
8.95
8.9
8.85
8.8
8.75
8.7
8.65
TAH
References
7/20/07 12:00
7/21/07 0:00
7/21/07 12:00
7/22/07 0:00
7/22/07 12:00
7/23/07 0:00
7/23/07 12:00
7/24/07 0:00
7/24/07 12:00
7/25/07 0:00
7/25/07 12:00
Date and Time
BTEX
TAH Reference
River Stage

Figure 6
TAH Concentration vs. Boat Count - Left Bank Shallow



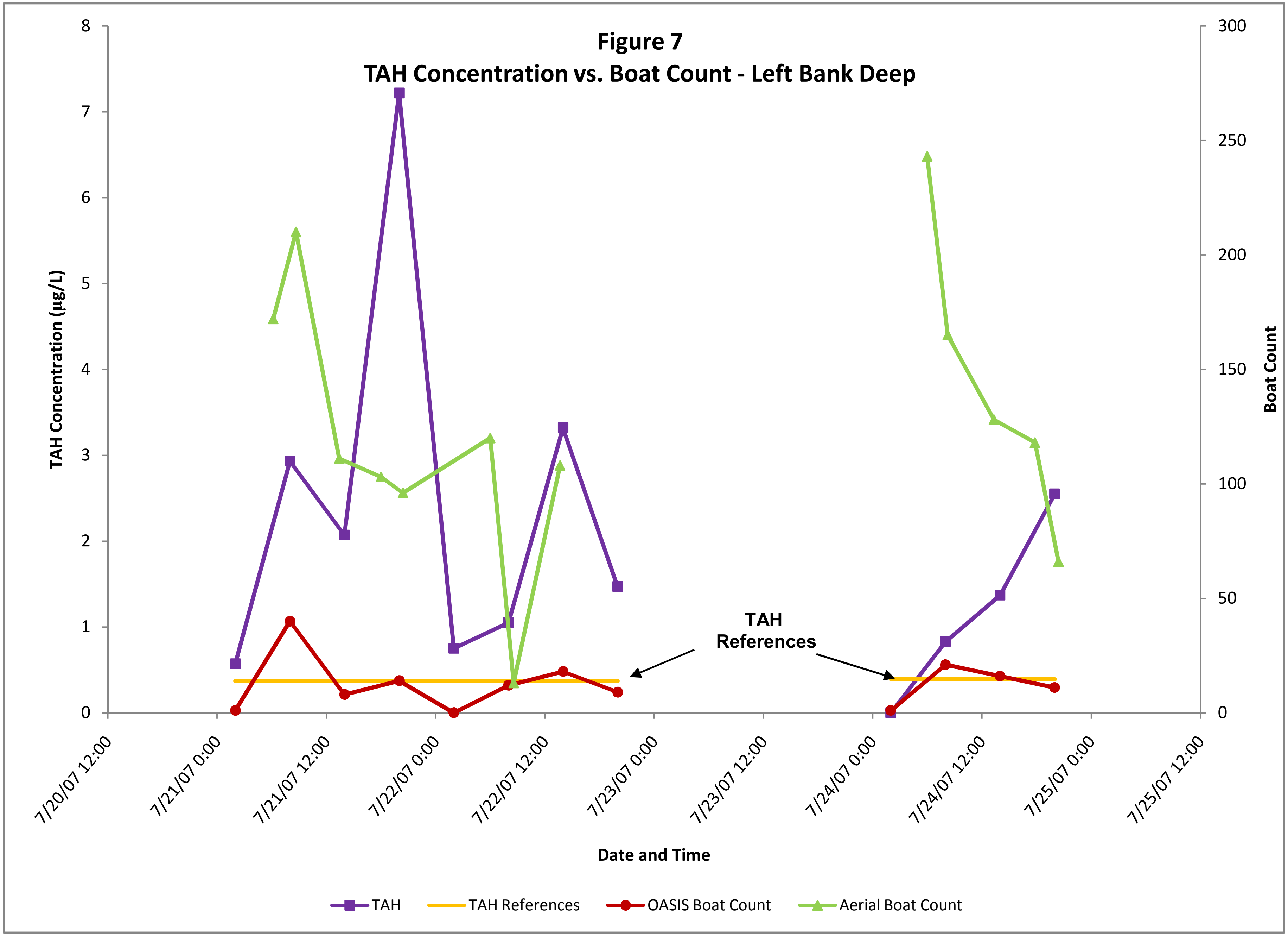


Figure 7
TAH Concentration vs. Boat Count - Left Bank Deep
TAH Concentration (µg/L)
Boat Count
Date and Time
TAH References
0
1
2
3
4
5
6
7
8
0
50
100
150
200
250
300
7/20/07 12:00
7/21/07 0:00
7/21/07 12:00
7/22/07 0:00
7/22/07 12:00
7/23/07 0:00
7/23/07 12:00
7/24/07 0:00
7/24/07 12:00
7/25/07 0:00
7/25/07 12:00
TAH
TAH References
OASIS Boat Count
Aerial Boat Count

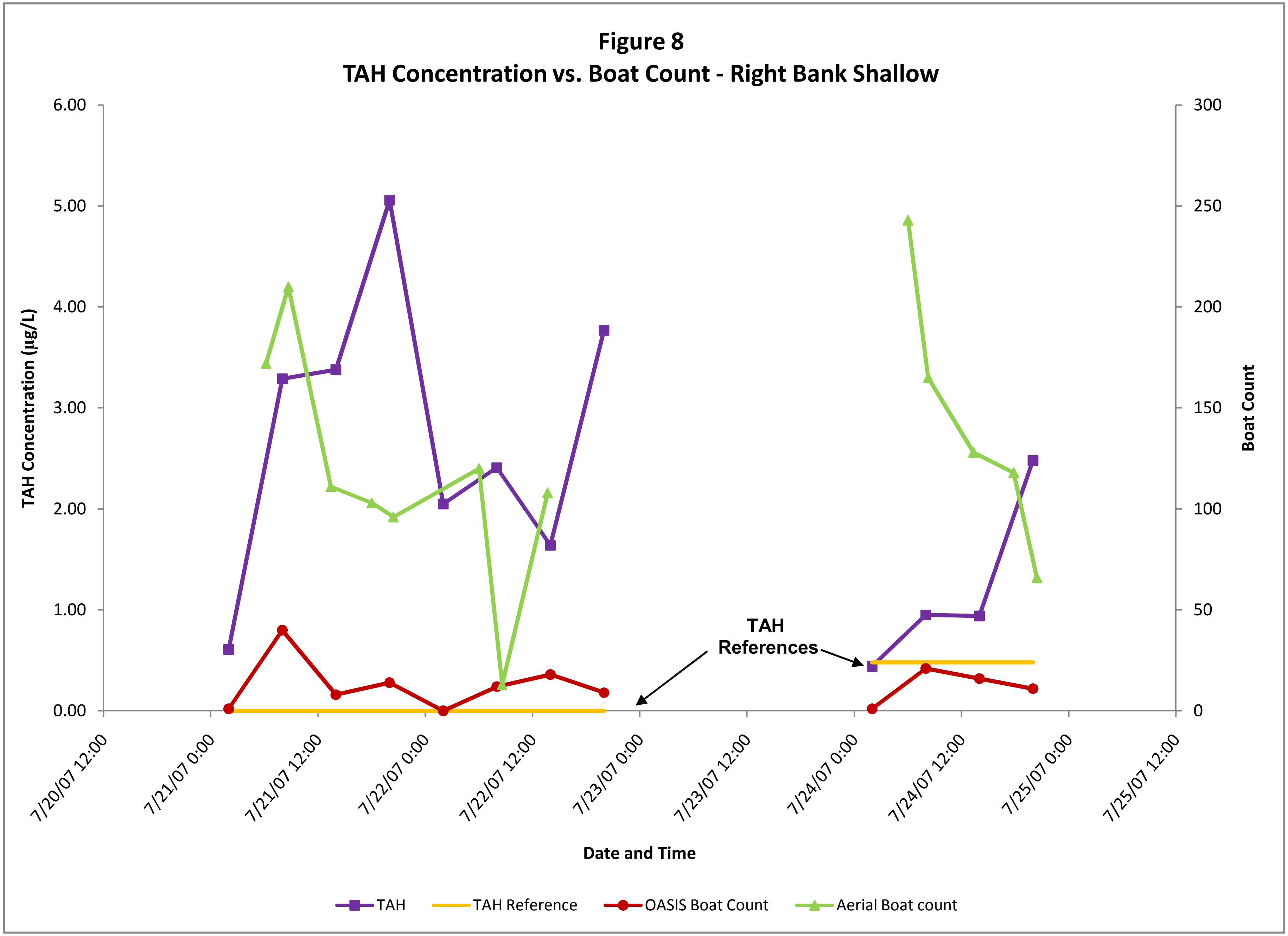


Figure 8
TAH Concentration vs. Boat Count - Right Bank Shallow
TAH Concentration (µg/L)
Boat Count
6.00
5.00
4.00
3.00
2.00
1.00
0.00
300
250
200
150
100
50
0
TAH
References
7/20/07 12:00
7/21/07 0:00
7/21/07 12:00
7/22/07 0:00
7/22/07 12:00
7/23/07 0:00
7/23/07 12:00
7/24/07 0:00
7/24/07 12:00
7/25/07 0:00
7/25/07 12:00
Date and Time
TAH
TAH Reference
OASIS Boat Count
Aerial Boat count

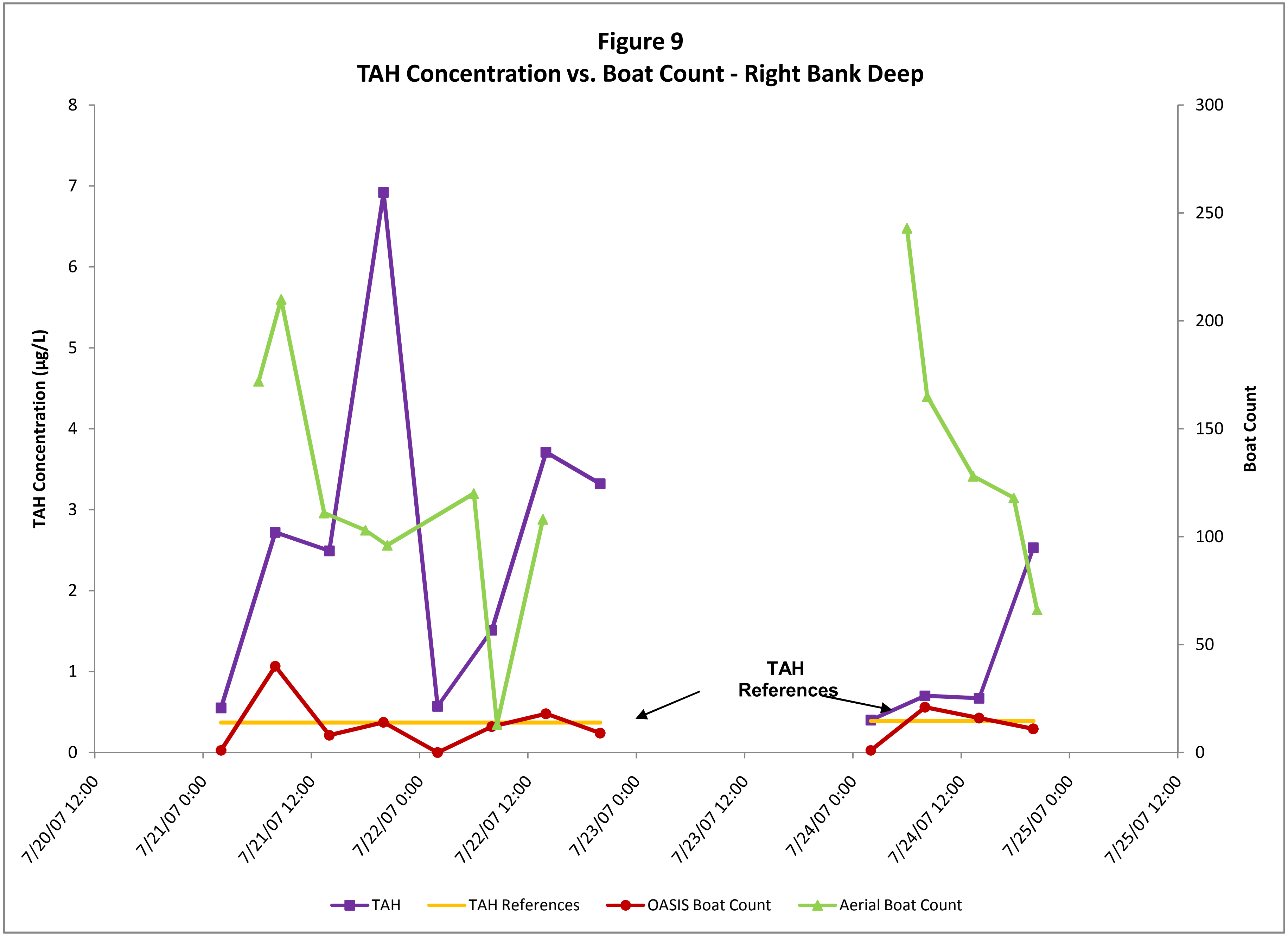


Figure 9
TAH Concentration vs. Boat Count - Right Bank Deep
TAH Concentration (µg/L)
Boat Count
0
1
2
3
4
5
6
7
8
0
50
100
150
200
250
300
7/20/07 12:00
7/21/07 0:00
7/21/07 12:00
7/22/07 0:00
7/22/07 12:00
7/23/07 0:00
7/23/07 12:00
7/24/07 0:00
7/24/07 12:00
7/25/07 0:00
7/25/07 12:00
TAH References
TAH
TAH References
OASIS Boat Count
Aerial Boat Count