KENAI BEACH SAMPLING ASSESSMENT 2010 – 2014

KENAI WATERSHED FORUM

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The Kenai Watershed Forum (KWF) is a 501(c)(3) non-profit and is recognized as the regional watershed organization of the Kenai Peninsula, successfully identifying and addressing the environmental needs of the region by providing high quality education, restoration and research programs. KWF is a dynamic organization dedicated to protecting the streams, rivers, and surrounding communities on the Kenai Peninsula.

CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

The Kenai Watershed Forum (KWF) monitored Fecal Coliform and *Enterococcus* bacteria levels at Kenai, Alaska public beaches each summer from 2010 through 2014. Samples were collected in order to supply the Alaska Department of Environmental Conservation (ADEC) with important data related to public use of these beaches during the high-traffic Kenai River Personal Use Fishery.

This report provides an analytical summary of data collected over the course of five summers. Data is not currently sufficient for establishing definitive relationships between all identified influencing factors and bacteria levels. However, based on MST analysis, it is clear that gull-sourced fecal bacteria makes a large contribution to overall fecal pollution at Kenai public use beaches. In addition, there is a noteworthy relationship between yearly average bird counts and bacteria levels. Gulls are believed to be attracted to North and South Kenai Beach by unnaturally large quantities of fish waste present during the fishery.

Most importantly, data from 2010 through 2014 demonstrates that Kenai public use beaches regularly exceed relevant water quality standards for single-sample and 30-day geometric mean values of fecal coliform and enterococci. The fishery continues to grow each year, meaning more people may be exposed to potentially harmful levels of fecal bacteria. For this reason, it would be beneficial from a public health, environmental, and economic standpoint to revisit fish waste management policies, continue monitoring bacteria levels, and to consider the formation of an inter-agency advisory group for the fishery's management.

INTRODUCTION

Open from July 10th through July 31st each year, the Kenai River Personal Use Fishery attracts fishermen from around the state of Alaska to North and South Kenai Beach. The fishery provides resident families with the opportunity to catch fish for consumption throughout the year. While it is an important economic stimulus for these families and for the City of Kenai (COK), this period of high-traffic on Kenai's recreational-use beaches presents a unique challenge for state environmental regulators, fishery management personnel, and the COK.

The COK, ADEC and Alaska Department of Fish & Game (ADF&G) have made a strong effort to balance the needs of fishery users and the delicate ecosystems that surround them. However, the combination of thousands of personal use participants, unnaturally high concentration of fish waste, and large flocks of gulls (primarily *Laridae,* Figure 1) creates the potential for environmental impacts as well as water-borne illness through fecal contamination. In order to assess the safety of water recreation and potential water consumption during the fishery's open season, the

FIGURE 1: GULLS GATHERED ON NORTH KENAI BEACH

ADEC began monitoring water-borne bacteria levels at Kenai public beaches in the summer of 2010. Starting in 2011, bacteria monitoring was contracted to the Kenai Watershed Forum (KWF) through an Environmental Protection Agency (EPA) Beach Environmental Assessment and Coastal Health (BEACH) grant. KWF scientists collected water samples for fecal coliform and enterococci analysis during the months of June, July and August from 2011 through 2014, allowing the ADEC to make important decisions regarding public safety at local recreational-use beaches.

FIGURE 2: KENAI BEACH SAMPLING LOCATIONS

Following procedures outlined by an ADEC approved Quality Assurance Project Plan (QAPP) (see Methods section), water samples were collected from multiple locations on North and South Kenai Beach (Figure 2) each year. Sampling was typically conducted twice weekly in June, July, and August. In addition, samples were collected each year from a location upstream of the fishery boundary at the Warren Ames Bridge (Figure 3), and in 2014 at two locations adjacent to a large gull rookery. At times, sampling was scheduled in order to examine the effect of variables that could potentially affect bacteria levels (e.g. tide and human activity level). In 2011 and 2014 Microbial Source Tracking (MST) was utilized to trace fecal indicator bacteria to its origin.

FIGURE 3: WARREN AMES BRIDGE SAMPLING LOCATION

Each year, bacteria monitoring data from the Kenai public beaches were compiled, analyzed, and reported on by KWF and ADEC. Yearly reports can be found on the ADEC website at dec.alaska.gov/water/wqsar/wqs/beachprogram.htm. While the data has been evaluated on a year-by-year basis, this report aims to summarize and evaluate all data collected from 2010 through 2014.

METHODS

Prior to each yearly sampling period, the ADEC BEACH Water Quality Monitoring and Pathogen Detection Quality Assurance Project Plan (QAPP) was revised. While many elements of the QAPP were consistent throughout the four years of monitoring, small variations were added each year to account for specific sampling schedules and approaches unique to each grant agreement. The general BEACH QAPP can be found at:

> https://dec.alaska.gov/water/wqsar/wqs/pdfs/Generic%20BEACH%20Water%20Quality%20Monitoring%20QAPP%20(20110609,%20FINAL).pdf

Sampling Design

From 2010 through 2014, sample collection commenced in late June or early July and continued through early August. A typical sampling event involved the collection of 100mL water samples from multiple locations on North and South Kenai Beach, as well as from the Warren Ames Bridge. In 2014, in an attempt to examine the impact of a nearby gull rookery on bacteria levels, two additional sites were added upstream of the river mouth. A minimum of one replicate or one duplicate sample per event was collected from the different beach locations on a rotating basis. Samples were typically collected in the morning, and shipped via commercial air carrier to Analytica Group (now ARS Aleut Analytical, LLC), an ADEC certified laboratory in Anchorage. Analytica Group provided results to KWF and ADEC within 24 to 48 hours of sample arrival.

In addition to water sampling, a cursory sanitary survey was conducted at each location to document potential sources of bacteria present during the collection of each sample. Instantaneous readings for specific conductance, pH, water temperature, and turbidity were recorded using a Hydrolab MS5. Weather, tide activity, bird presence and any unusual conditions were also noted on field data sheets.

In 2011 and 2014, 200mL samples were split at each site to provide sample water necessary for Analytica testing as well as MST analysis. One 100mL bottle from each site was sent to Analytica, while the other was filtered, stored, and shipped by KWF staff in accordance with specifications provided by the contracted MST analysis lab, Source Molecular Corporation (Miami, FL).

Monitoring Parameters

Each monitoring plan included the analysis of water samples for two types of bacteria typically used as indicators of fecal contamination: fecal coliforms and *Enterococcus*. Fecal coliforms were measured with analytical method ID SM9222-D Fecal Coliform Membrane Filtration and reported in colony-forming units (CFU) per 100mL. Enterococci were measured with analytical method ID ASTMD-6503-99 Enterococci by Most Probable Number (MPN) and reported in MPN per 100mL.

MST analysis samples were tested against five established bacteria markers for human, dog, general bird, gull, and ruminant sources. This analysis was performed in order to determine which species contribute most to elevated bacteria levels at Kenai public use beaches during the Personal Use Fishery.

Water Quality Standards

According to Alaska Water Quality Standards (AWQS), the 30-day geometric mean for fecal coliform bacteria in recreation waters is not to exceed 100 cfu/100mL. In addition, no individual sample is to exceed 200 CFU/100mL.

Environmental Protection Agency (EPA) Standards state that enterococci single sample maximum allowable density may not exceed 276 MPN/100mL. In addition, the steady state geometric mean indicator density should not exceed 35 MPN/100mL.

These standards are summarized in Table 1.

TABLE 1: WATER QUALITY STANDARDS FOR FECAL INDICATOR ORGANISMS

MARINE WATER QUALITY INDICATOR STANDARDS	
Fecal Coliform Standard (Alaska's Limit)	
Single-sample	Not more than 10% of samples may exceed 200 fecal coliforms per 100 mL
Geometric mean (average) of 5 samples within 30 days	100 fecal coliforms per 100 mL
Enterococcus Standard[1] *(EPA's Limit)*	
Single-sample	No sample may exceed 276 enterococci per 100 mL
Geometric mean (average) of 5 samples within 30 days	35 enterococci per 100 mL

DATA PROCESSING AND ANALYSIS

After each sampling event, field observation data was entered into a Microsoft Excel spreadsheet (a template provided by ADEC), field forms were scanned, and relevant information was delivered to ADEC. When lab results were received, all were checked for adherence with the BEACH QAPP. This data was then transferred to the ADEC template and submitted to EPA's STORET database. All data can be found at http://dec.alaska.gov/das/GIS/apps.htm.

Analysis was performed by KWF on compiled data at the end of each yearly sampling period. A report was produced and delivered to ADEC at the end of each grant cycle. Yearly reports addressed bacteria levels recorded before, during, and after each respective fishery season, and highlighted exceedances of AWQS for individual samples as well as 30-day geometric mean standards.

For this report, yearly bacteria monitoring data from 2010 through 2014 was compiled in order to provide an overall assessment of bacteria levels at the Kenai public use beaches during this time period. In addition to the standard comparisons of bacteria levels with the relevant water quality standards, several other relationships between the datasets were examined. This assessment was carried out with the goal of determining what, if any, correlation exists between bacteria levels and various dynamics in and around the Kenai River mouth.

Previous Report Data Summary

Included in Appendix A are charts detailing results from sampling events conducted starting in 2010 and ending in 2014. Summarized in table format on the next several pages are the exceeding samples and results of geometric mean analyses for each sampling year.

As shown in Table 2 and Table 3, there were a total of seven single sample exceedances for fecal coliform, and four single sample exceedances for enterococci at the Kenai public use beaches during the 2014 sampling period. South Kenai Beach exceeded the AWQS 30-day geometric mean limit for fecal coliform, while both North Kenai Beach and South Kenai beach exceeded the EPA 30-day geometric mean limit for enterococci. The gull rookery and bridge sampling locations did not result in single sample exceedances nor an exceedance of the 30-day geometric mean limit for fecal coliform or enterococci.

Table 4 and Table 5 summarize results from the 2013 sampling period. In total, there were eight single sample exceedances at Kenai public use beaches for fecal coliform, and South Kenai Beach samples exceeded the AWQS 30-day fecal coliform geometric mean limit for all three periods analyzed. Five samples exceeded the EPA single sample limit for enterococci. North Kenai Beach exceeded the EPA 30-day geometric mean limit for enterococci during two of the three 30-day periods analyzed. Again, South Kenai Beach exceeded for enterococci in all three 30-day periods analyzed. The sampling location adjacent to the Warren Ames Bridge did not result in exceedances for either fecal coliform or enterococci.

2012 sampling results are organized in Table 6 and Table 7. There were a total of two single sample exceedances for fecal coliform, and two single sample exceedances for enterococci. North Kenai Beach exceeded the EPA enterococci 30-day geometric mean limit. The sampling location adjacent to the Warren Ames Bridge did not result in exceedances for either fecal coliform or enterococci.

In 2011, as shown in Table 8 and Table 9, there were nine single sample exceedances for both fecal coliform and enterococci. Both North and South Kenai Beach exceeded the EPA 30-day geometric mean limit for enterococci. South Kenai Beach also exceeded the AWQS the 30-day geometric mean limit for fecal coliform. The sampling location adjacent to the Warren Ames Bridge did not result in exceedances for either fecal coliform or enterococci.

Finally, 2010 fecal coliform and enterococci sampling results are displayed in Table 10 and Table 11. At North Kenai Beach, there was one single-sample exceedance for fecal coliform bacteria. At South Kenai Beach there were four exceedances for fecal coliform, as well as for enterococci. The EPA for 30-day enterococci geometric mean was exceeded at South Kenai Beach. Warren Ames Bridge samples did not result in exceedances for fecal coliform or enterococci.

TABLE 2: 2014 FECAL COLIFORM RESULTS SUMMARY

2014 Fecal Coliform Results Summary				
	Single Sample Standard: 200 CFU/100mL		30-Day Geometric Mean Standard: 100 CFU/100mL	
Site	**Number of Single Sample Exceedances**	**Single Sample Exceedance Value(s) (CFU/100mL)**	**Geometric Mean Value (CFU/100mL)**	**Exceedance? Y/N**
North Kenai Beach	1	270	35.9	N
South Kenai Beach	6	220, 220, 280, 550, 1100, 2000	142.1	Y
Gull Rookery	0	-	35.7	N
Warren Ames Bridge	0	-	18.5	N

TABLE 3: 2014 KENAI ENTEROCOCCI RESULTS SUMMARY

2014 Enterococci Results Summary				
	Single Sample Standard: 276 MPN/100mL		30-Day Geometric Mean Standard: 35 MPN/100mL	
Site	**Number of Single Sample Exceedances**	**Single Sample Exceedance Value(s) (MPN/100mL)**	**Geometric Mean Value (MPN/100mL)**	**Exceedance? Y/N**
North Kenai Beach	1	540	47.1	Y
South Kenai Beach	3	390, 620, 5500	103.5	Y
Gull Rookery	0	-	21.3	N
Warren Ames Bridge	0	-	25.6	N

TABLE 4: 2013 FECAL COLIFORM RESULTS SUMMARY

2013 Fecal Coliform Results Summary						
	Single Sample Standard: 200 CFU/100mL		30 Day Geometric Mean Standard: 100 CFU/100mL			
Site	Number of Single Sample Exceedances	Single Sample Exceedances Value(s) (CFU/100mL)	Geometric Mean Value (6/19/13-7/16/13) CFU/100mL	Geometric Mean Value (7/14/13-8/11/13) CFU/100mL	Geometric Mean Value (7/7/13-7/31/13) CFU/100mL	Exceedance? Y/N
North Kenai Beach	2	500, 660	17.2	30.5	27.1	N
South Kenai Beach	6	260, 320, 330, 370, 470, 1200	120.3	123.8	129.9	Y
Warren Ames Bridge	0	-	17.2	20.9	20.5	N

TABLE 5: 2013 ENTEROCOCCI RESULTS SUMMARY

2013 Enterococci Results Summary						
	Single Sample Standard: 276 MPN/100mL		30 Day Geometric Mean Standard: 35 MPN/100mL			
Site	Number of Single Sample Exceedances	Single Sample Exceedances Value(s) (MPN/100mL)	Geometric Mean Value (6/19/13-7/16/13) MPN/100mL	Geometric Mean Value (7/14/13-8/11/13) MPN/100mL	Geometric Mean Value (7/7/13-7/31/13) MPN/100mL	Exceedance? Y/N
North Kenai Beach	2	4100, 4400	22.5	96.4	70.5	Y
South Kenai Beach	3	320, 340, 620	85.2	115.8	115.6	Y
Warren Ames Bridge	0	-	10	17.3	13.3	N

TABLE 6: 2012 FECAL COLIFORM RESULTS SUMMARY

2012 Fecal Coliform Results Summary				
	Single Sample Standard: 200 CFU/100mL		30 Day Geometric Mean Standard: 100 CFU/100mL	
Site	**Number of Single Sample Exceedances**	**Single Sample Exceedance Value(s) (CFU/100mL)**	**Geometric Mean Value (CFU/100mL)**	**Exceedance? Y/N**
North Kenai Beach	0	NA	9.4	N
South Kenai Beach	2	290, 230	75.9	N
Warren Ames Bridge	0	-	10.8	N

TABLE 7: 2012 ENTEROCOCCI COLIFORM RESULTS SUMMARY

2012 Enterococci Results Summary				
	Single Sample Standard: 276 MPN/100mL		30 Day Geometric Mean Standard: 35 MPN/100mL	
Site	**Number of Single Sample Exceedances**	**Single Sample Exceedance Value(s) (MPN/100mL)**	**Geometric Mean Value (MPN/100mL)**	**Exceedance? Y/N**
North Kenai Beach	1	3800	51	Y
South Kenai Beach	1	330	10.8	N
Warren Ames Bridge	0	-	10	N

TABLE 8: 2011 FECAL COLIFORM RESULTS SUMMARY

2011 Fecal Coliform Results Summary				
	Single Sample Standard: 200 CFU/100mL		30 Day Geometric Mean Standard: 100CFU/100mL	
Site	**Number of Single Sample Exceedances**	**Single Sample Exceedances Value(s) (CFU/100mL)**	**Geometric Mean Value (CFU/100mL)**	**Exceedance? Y/N**
North Kenai Beach	1	250	49.69	N
South Kenai Beach	8	290, 500, 450, 320, 290, 510, 800, 730, 1200	153.79	Y
Warren Ames Bridge	0	-	22.65	N

TABLE 9: 2011 ENTEROCOCCI RESULTS SUMMARY

2011 Enterococci Results Summary				
	Single Sample Standard: 276 MPN/100mL		30 Day Geometric Mean Standard: 35 MPN/100mL	
Site	**Number of Single Sample Exceedances**	**Single Sample Exceedances Value(s) (MPN/100mL)**	**Geometric Mean Value (CFU/100mL)**	**Exceedance? Y/N**
North Kenai Beach	4	780, 660, 360, 310	75.27	Y
South Kenai Beach	5	330, 560, 530, 1200, 980	179.07	Y
Warren Ames Bridge	0	-	14.19	N

TABLE 10: 2010 FECAL COLIFORM RESULTS SUMMARY

2010 Kenai Fecal Coliform Results Summary				
	Single Sample Standard: 200 CFU/100mL		30-Day Geometric Mean Standard: 100 CFU/100mL	
Site	**Number of Single Sample Exceedances**	**Exceedance Value(s) (cfu/100mL)**	**Geometric Mean Value (cfu/100mL)**	**Exceedance? Y/N**
North Kenai Beach	1	220	48	N
South Kenai Beach	4	220, 240, 240, 590	58.4	N
Warren Ames Bridge	0	-	16.1	N

TABLE 11: 2010 ENTEROCOCCI RESULTS SUMMARY

2010 Kenai Enterococci Results Summary				
	Single Sample Standard: 276 MPN/100mL		30-Day Geometric Mean Standard: 35 MPN/100mL	
Site	**Number of Single Sample Exceedances**	**Exceedance Value(s) (MPN/100mL)**	**Geometric Mean Value (MPN/100mL)**	**Exceedance? Y/N**
North Kenai Beach	0	-	50.2	N
South Kenai Beach	4	320, 320, 610, 640	100.1	Y
Warren Ames Bridge	0	-	13.5	N

Comprehensive Analysis

While the preceding data have already been analyzed individually in yearly reports delivered to the ADEC, it is important to reassess the year-by-year results as they relate to each other. Through such a comparative analysis, trends in and relationships between collected data can be evaluated.

Shown below are graphs of fecal coliform and enterococci bacteria sample results from Kenai public use beaches for each sampling year (Figure 4, Figure 5, Figure 6, Figure 7). In order to combine data from each year into this presentable format, data was processed in the following ways:

- The highest values of duplicate samples (samples taken at the same site and time) were kept, while lower duplicate sample values were omitted. This was done in accordance with past duplicate sample processing as outlined by ADEC.
- Where results were reported as nondetect, values were input as half of the relevant Method Detection Limit.
- Sample values taken from the same beach (North Kenai Beach or South Kenai Beach) were averaged in order to generate a representative bacteria level on each beach for the given sampling event.
- Inner and outer fence values for outlier data were calculated (calculations in Appendix B) for each indicator bacteria on a yearly basis. Any sample results greater than 1000 CFU/100mL or 1000 MPN/100mL that fell outside the outer fence were omitted. Although these data are significant individually, their removal made it possible to view remaining data on the same scale, and to observe overall trends that were not otherwise visible.

Figure 4 through Figure 7 highlight a few important characteristics of the processed data. First, it appears that spikes in bacteria levels at North Kenai Beach generally occur in late July. Conversely, spikes in bacteria levels at South Kenai Beach appear to be more random. This may indicate that there are different factors influencing bacteria levels at the two beaches, or that the same factors have different levels of influence.

It is worth noting that the year 2011 produced the highest representative bacteria level in every case except that of fecal coliform at North Kenai Beach. In addition, as the graphs for each beach are plotted on the same scale for their respective indicator bacteria, it can be seen that South Kenai Beach consistently resulted in higher bacteria levels than did North Kenai Beach.

In order to better display year-to-year bacteria level differences, the data shown in Figure 4 through Figure 7 were used to calculate an average yearly value for each indicator bacteria at North and South Kenai Beach. This information was then organized into column charts (Figure 8 and Figure 9). These charts present clear evidence that South Kenai Beach consistently resulted in higher fecal coliform and enterococci bacteria levels than those of North Kenai Beach. In most cases, this difference is quite substantial. Again, it can be seen that 2011 resulted in very high bacteria levels relative to all other years, especially at South Kenai Beach.

Trend lines added to Figure 8 do not display any significant increase or decrease in average fecal coliform bacteria levels at either beach. While trend lines for Figure 9 appear to show a slight decrease in enterococci bacteria levels since 2010, most notably at South Kenai Beach, the trend's fit value is not significant. Additional data would be necessary to substantiate this pattern.

It is clear that bacteria levels fluctuate on a year-to-year basis, and it is likely that there are multiple factors that cause bacteria levels at North and South Kenai Beach to exceed AWQS and EPA standards on a regular basis. The subsequent sections will address and aim to answer the following questions:

- What are the factors that influence bacteria levels at the Kenai River mouth during the Kenai River Personal Use Fishery, and are these factors dependent on one another?
- What caused relatively high bacteria levels in 2011?
- Why were bacteria levels comparably low in 2012?
- What causes bacteria levels at South Kenai Beach to be consistently higher than those at North Kenai Beach?

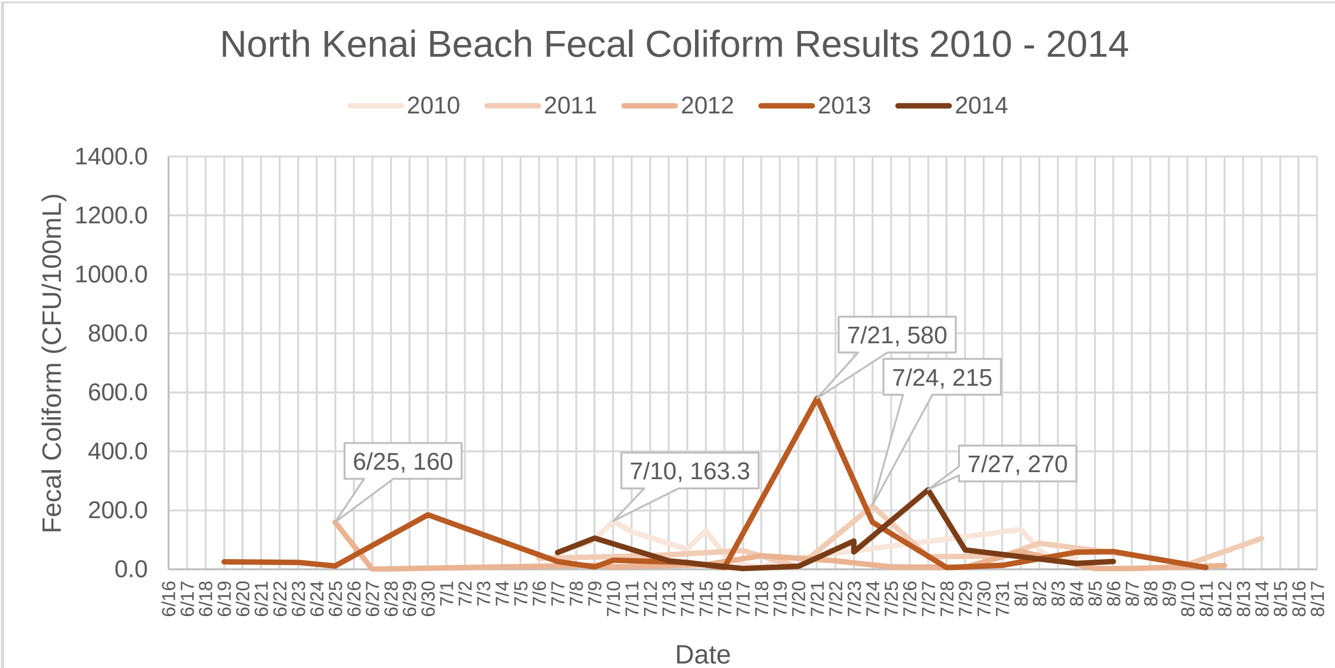

FIGURE 4: NORTH KENAI BEACH FECAL COLIFORM RESULTS 2010 – 2014

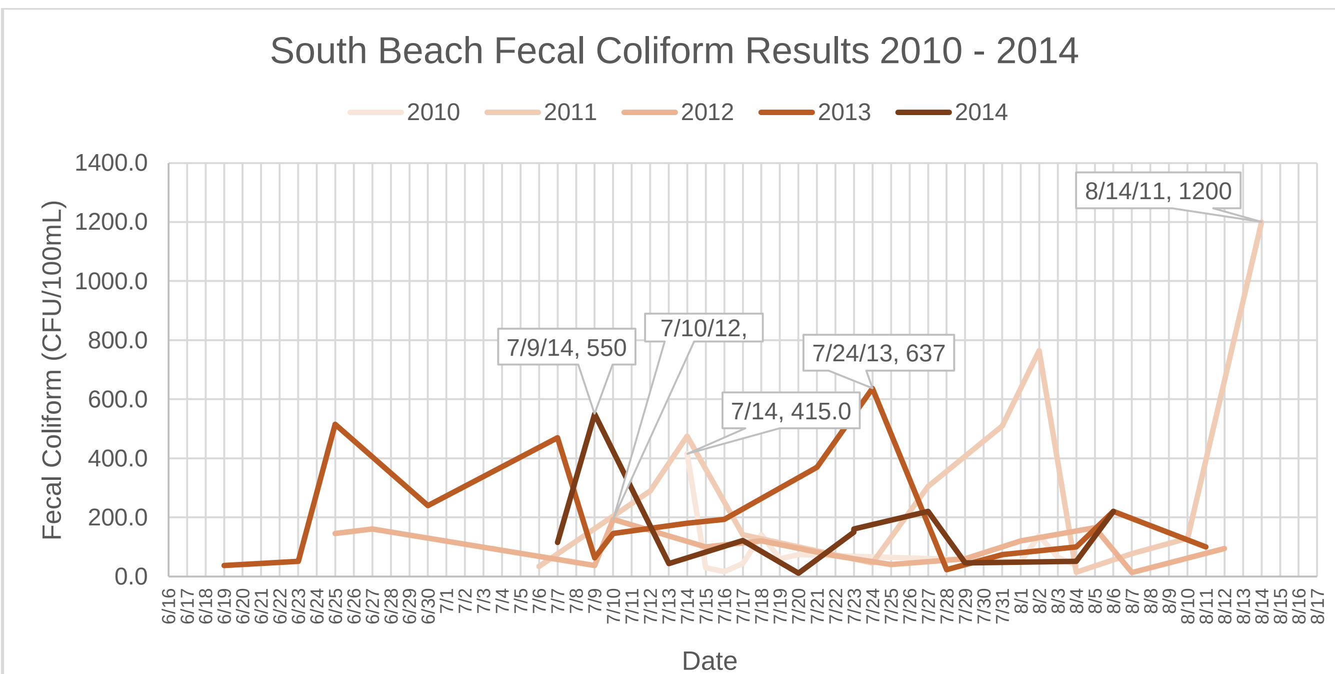

FIGURE 5: SOUTH KENAI BEACH FECAL COLIFORM RESULTS 2010 – 2014

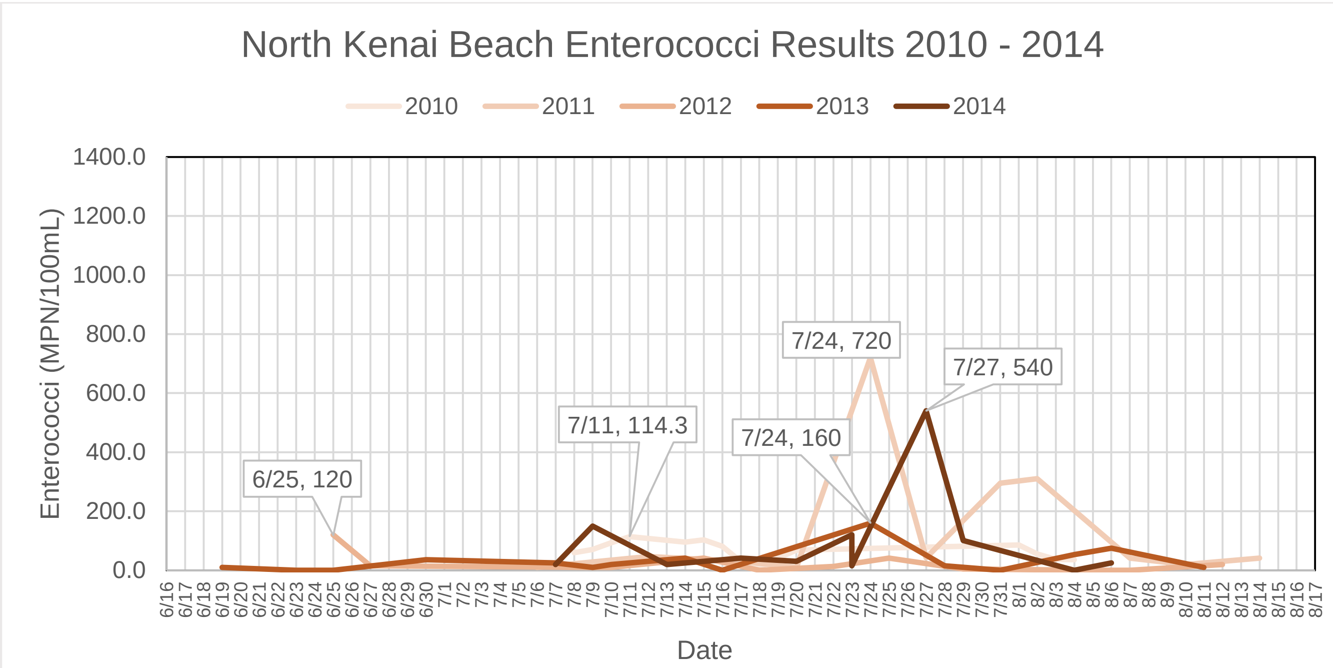

FIGURE 6: NORTH KENAI BEACH FECAL COLIFORM RESULTS 2010 – 2014

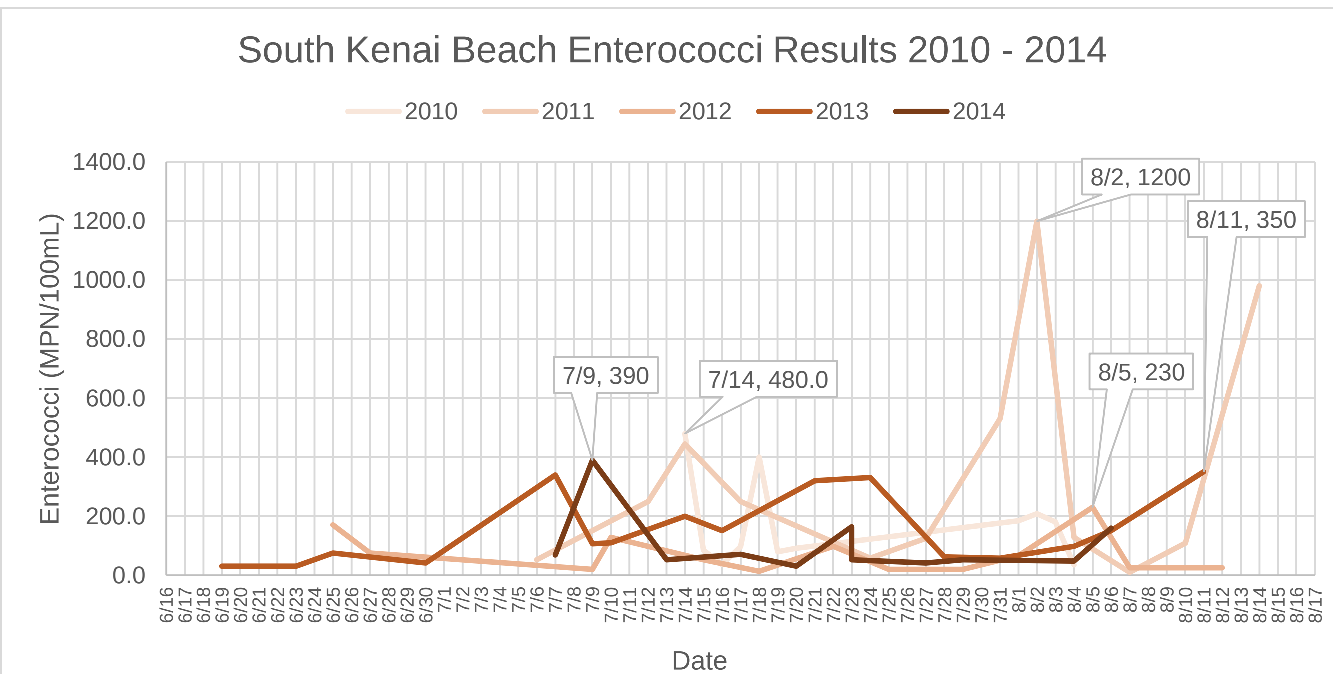

FIGURE 7: SOUTH KENAI BEACH ENTEROCOCCI RESULTS 2010 – 2014

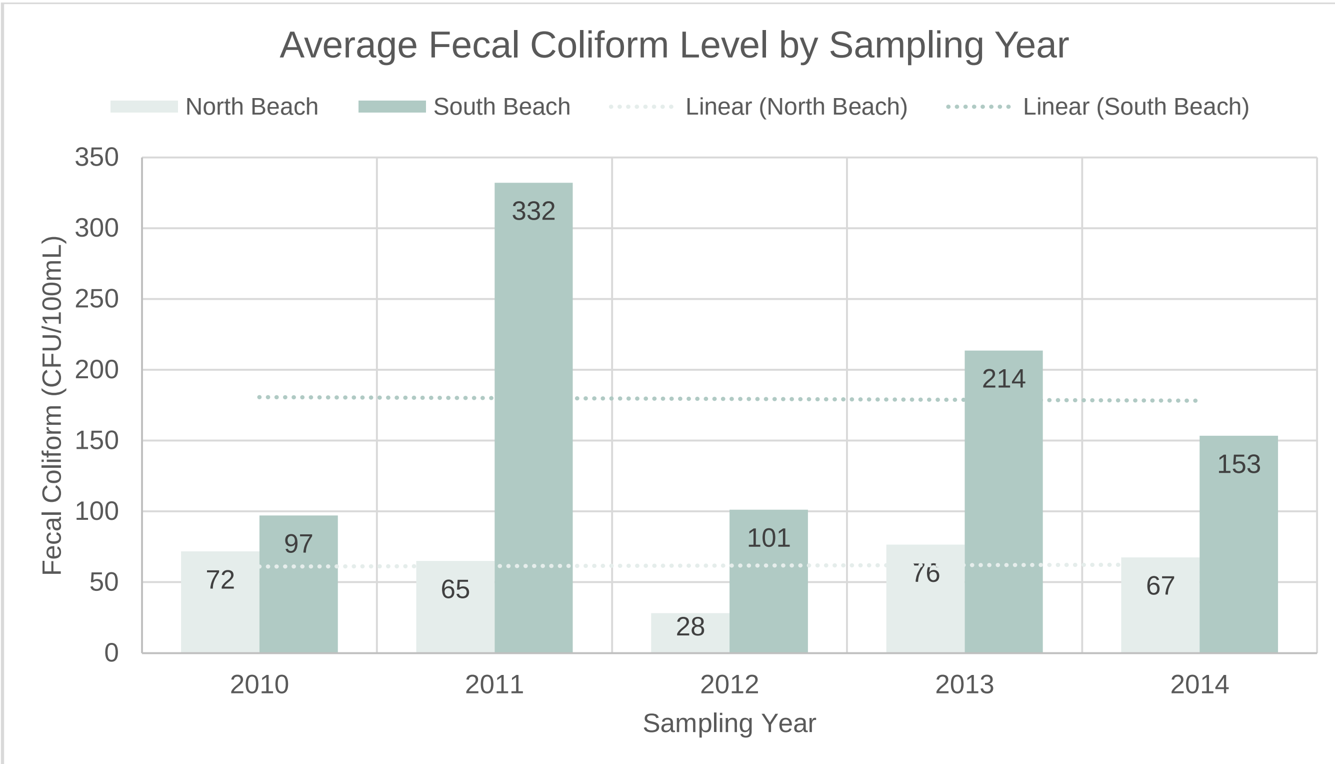

FIGURE 8: AVERAGE FECAL COLIFORM LEVEL BY SAMPLING YEAR

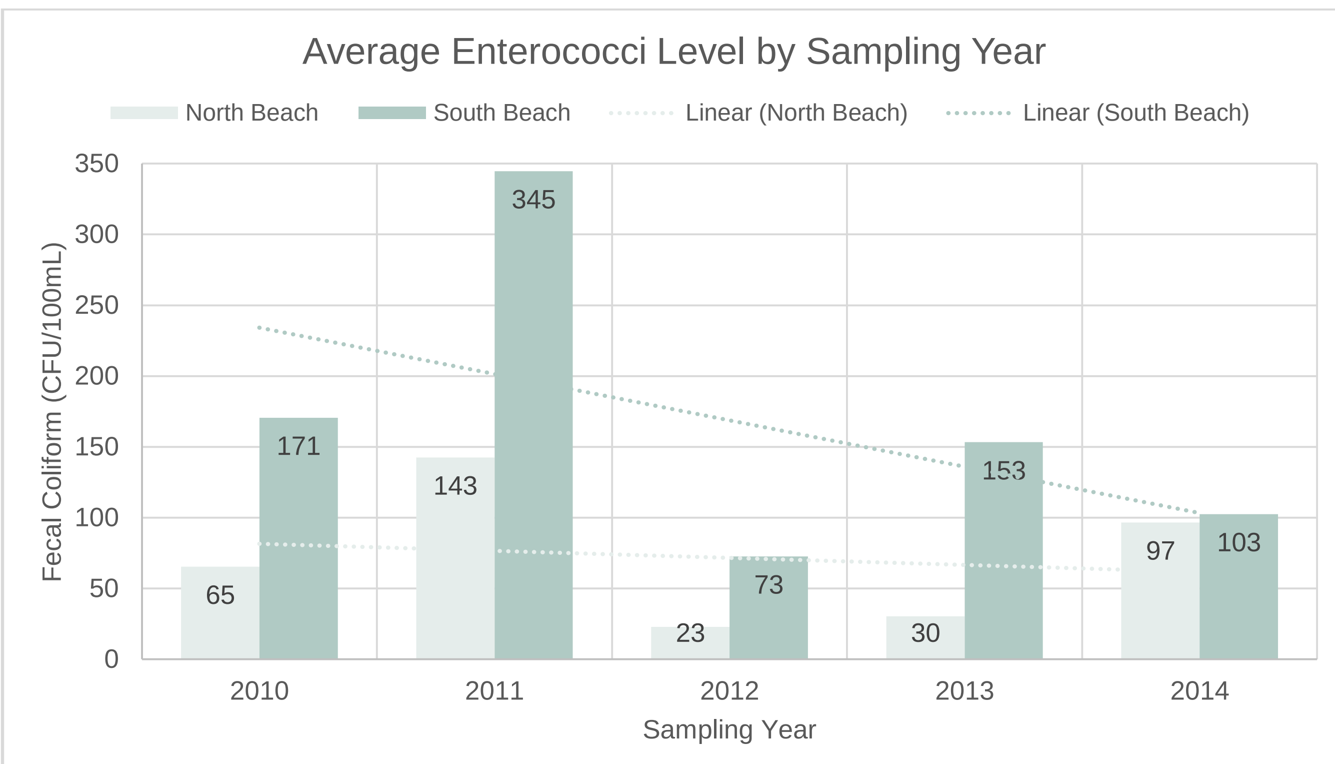

FIGURE 9: AVERAGE ENEROCOCCI LEVEL BY SAMPLING YEAR

Analysis of Potential Factors in Bacteria Fluctuation

Potential factors in day-to-day and year-to-year bacteria level fluctuation during the annual sampling period have been identified as follows:

- The Kenai River Personal Use Fishery and the users of Kenai public use beaches during the fishery's open season
- Tidal activity
- The annual late-run of sockeye salmon
- Gull presence on the beaches and in the surrounding area

While these factors may have some independent influence on bacteria levels, it is more likely that all of these factors (among others that are yet to be identified) interact and depend on each other, thereby having a combined impact on water-borne bacteria levels at the mouth of the Kenai River.

The Kenai River Personal Use Fishery and Human Activity

As previously stated, the Kenai River Personal Use Fishery season runs from July 10th through July 31st each year. It attracts families from around the state of Alaska to North and South Kenai Beach. Many of these families camp for several days at a time while harvesting fish from the Kenai River. The subsistence fishery results in large crowds of people and the establishment of temporary encampments (Figure 10) that present potential human waste and fish waste management issues.

Although the City of Kenai regularly provides adequate sanitary facilities for fishery users, there have been numerous anecdotal reports of improper human waste disposal over the years. In addition, Microbial Source Tracking (MST) resulted in positive hits for fecal bacteria of human origin in 2011 and 2014. While being more hazardous for humans than bacteria of other origins, human sourced fecal bacteria has not been found to be a consistent contributor to overall fecal bacteria presence in Kenai beach water. It's more probable that human activity has an indirect effect on bacteria levels on North and South Kenai Beach waters.

FIGURE 10: CAMPING FISHERY USERS, 2011

In recent years, the COK has made a concerted effort to manage fish waste on Kenai public use beaches during the annual fishery. Per the 2013 COK fishery report:

> *The City undertook a new policy towards management of fish waste during the 2013 season, requiring that fishery participants either remove all fish waste from the beach or…dispose of fish waste into the waters of the Kenai River or Cook Inlet. A small number of fishery participants removed their fish whole from the mouth of the Kenai, but the majority adhered to the City's requirement that fish waste be directly deposited into the water. (City of Kenai, 2013 Dipnet Report)*

In addition to this requirement, city employees have consistently used large machinery to rake fish carcasses off the beach for the past few years. COK reports suggest that amount of fish waste left on the beach by fishery users has decreased since sampling commenced in 2010. However, there are periods of time when city employees are unable to keep up with fish waste generation rates.

> *The beach areas remained mostly void from fish waste throughout the fishery with the exception of July 17th – 20th when catch rates appeared to be much higher. (City of Kenai, 2014 Dipnet Report)*

Therefore, carcasses in the water and on the beach remain a major attractant for large bird flocks, primarily gulls. As will be discussed later, there is a relationship between KWF bird counts and high bacteria levels. MST analysis in 2011 and 2014 also proved gulls to be a major contributor in almost every fecal bacteria sample tested.

KWF was provided with COK records for number of transactions carried out with fishery users on a yearly basis for 2013 through 2015. This number grew significantly in that time period, with the majority of users paying fees at North Kenai Beach (City of Kenai, 2015 Dipnet Report). Daily user data from 2010 through 2014 is not available. As a result, current data is not sufficient for establishing a direct relationship between an escalation in human activity and a rise or fall in bacteria levels.

It is worth noting that nearly all of the highest yearly values labeled in Figure 4 through Figure 7 do occur during or shortly after the fishery. While this may be an indirect result of increased human activity during the fishery, other potential factors are examined in the following sections.

Tide Activity

The lower Kenai River, especially the area within Kenai River Personal Use Fishery boundaries (Figure 11) is heavily affected by ocean tides. Tide swings occur up to four times a day and can be larger than 25 feet in amplitude. Large tides can result in slack water in lower sections of the river. Perhaps most relevant to this assessment, tidal activity has the ability to sweep debris off the Kenai public use beaches and into the Cook Inlet. While ebbing can reduce and ultimately dispose of fish waste, a major gull attractant, it can also carry any fecal matter deposited on the beach into the water.

At low tide, expansive mud flats are exposed on both North and South Kenai Beach. While exposed, the flats become a gathering point for gulls from the nearby rookery. Naturally, large groups of gulls and other birds will deposit fecal matter on the flats and other sections of the beach. It's possible that incoming tides suspend this fecal matter in beach water, thereby increasing the overall level of fecal pollution.

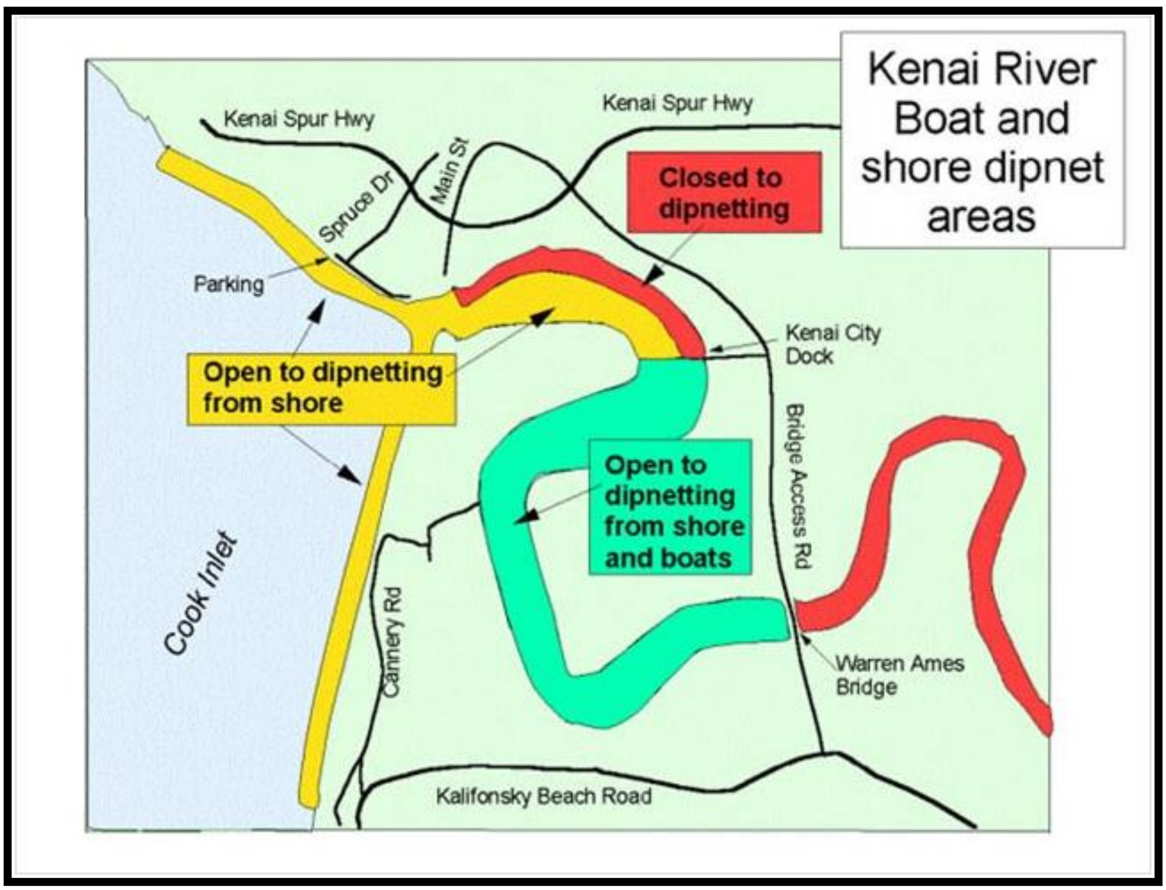

FIGURE 11: KENAI DIPNET FISHERY BOUNDARIES

In order to evaluate these ideas, representative sample results from 2010 through 2014 were compared with their respective tide levels at the time of the sampling event. Samples were categorized as having been taken at High Tide (within one hour of NOAA predicted high tide), Low Tide (within one hour of NOAA predicted low tide), or during a flooding (moving from low to high) tide or ebbing (moving from high to low) tide. Data organized by tide status can be seen in Appendix C.

Using the organization discussed above, Figure 12 and were created to compare the distribution of bacteria levels for varying tides. As shown, ebbing tides resulted in many of the highest bacteria levels found from 2010 through 2014. Bacteria levels at or near low tide and high tide were comparably low. Finally, flooding tides produced some high bacteria results, and some low bacteria results. In Figure 14, results for each tide status were averaged to simplify the data and to show that ebbing tide bacteria levels are much higher on average than those found at any other tide. There are several possible explanations for these findings.

Low bacteria levels at high tide may be the result of a larger volume of water at the mouth of the Kenai River, leading to a dilution of fecal bacteria. While that would lead one to believe bacteria levels would be relatively high at low tide, it could be that a higher ratio of river water to marine water also dilutes fecal bacteria. As shown earlier in this report, there has never been an exceedance of AWQS or EPA standards at the Warren Ames Bridge sampling location, where one can assume samples contain much more river water than those taken at the Kenai River mouth. This claim is substantiated by in-situ conductivity measurements taken at each sampling location. Further, as high tides create slack water in lower sections of the river, low tides allow for a much stronger river current in these sections and at the mouth. Stronger river currents may provide more efficient removal of fish waste disposed in the water, and therefore reduce gull attractants. In the same way, stronger river currents may reduce fecal pollution by sweeping contaminated water into the Cook Inlet.

Explaining bacteria levels during ebbing and flooding tides is slightly more complex. As discussed previously, it’s likely that flooding and ebbing tides both have the ability to pick up debris and fecal matter deposited on the sand and mud flats. However, ebbing tides produced significantly higher bacteria levels on average. One explanation for this could be the fact that a large number of the samples taken during ebbing tides were taken in 2011, when bacteria levels were high in general. Further, no samples were taken during ebbing tides in 2012, the year which produced the lowest bacteria levels on average. Therefore, it is difficult to confirm that ebbing tides consistently result in elevated bacteria levels. It could be that bacteria levels were low in 2012 because no samples were taken during ebbing tides. Conversely, it could be that the averages for ebbing tides are not representative of the data as a whole.

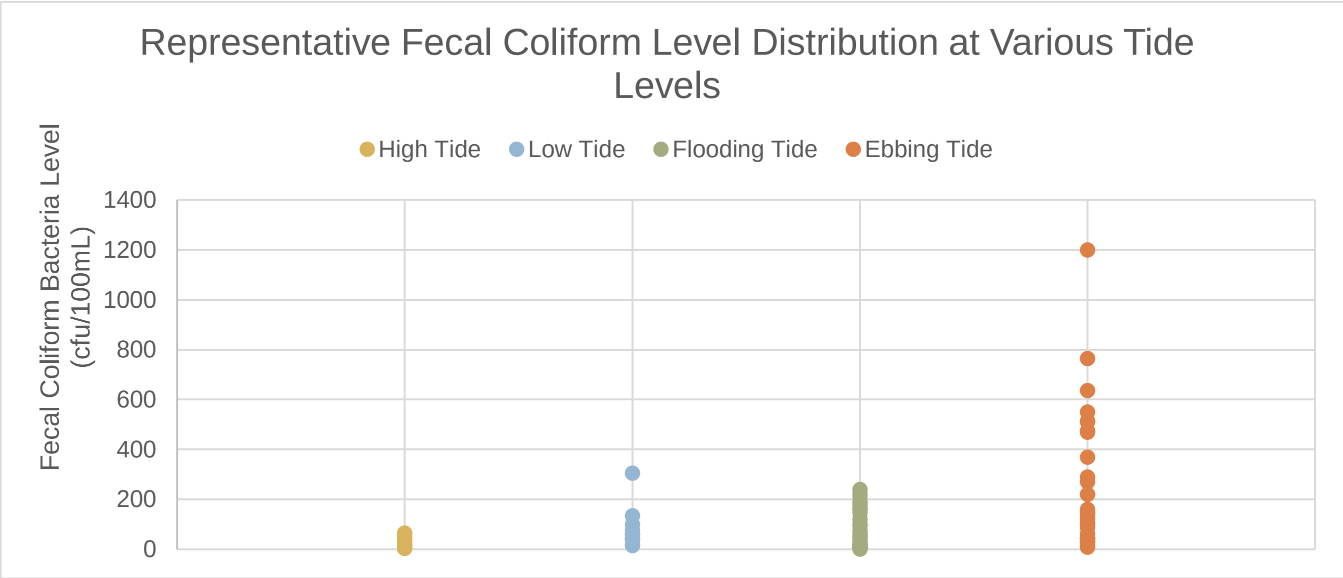

FIGURE 12: FECAL COLIFORM LEVEL DISTRIBUTION AT VARIOUS TIDE LEVELS

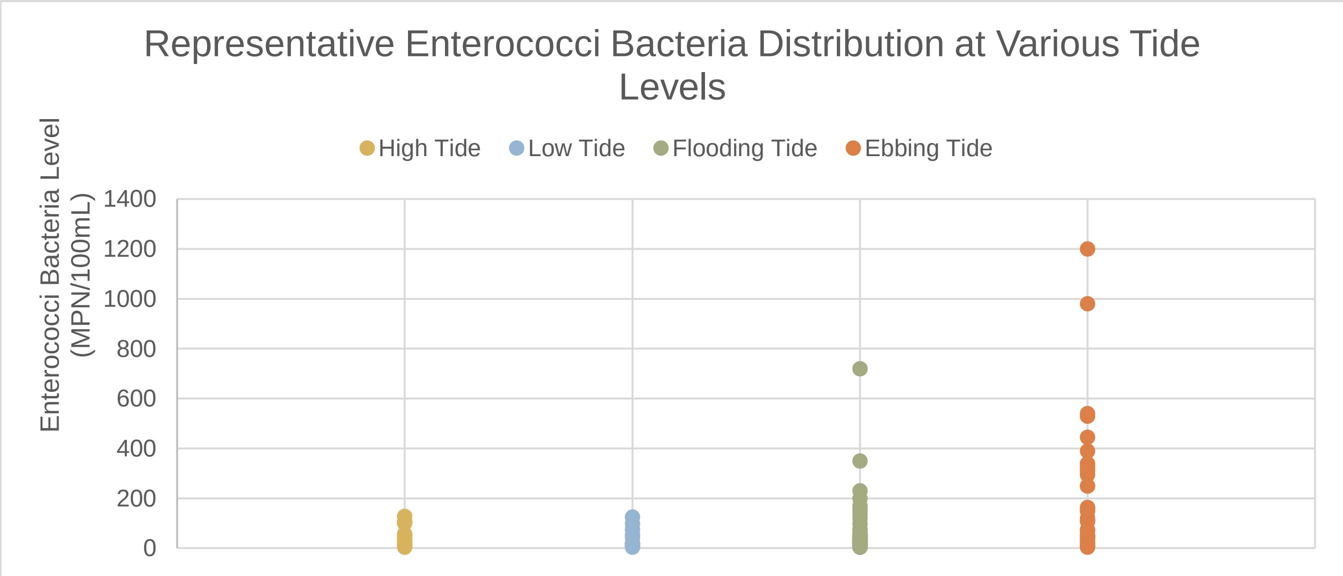

FIGURE 13: ENTEROCOCCI LEVEL DISTRIBUTION AT VARIOUS TIDE LEVELS

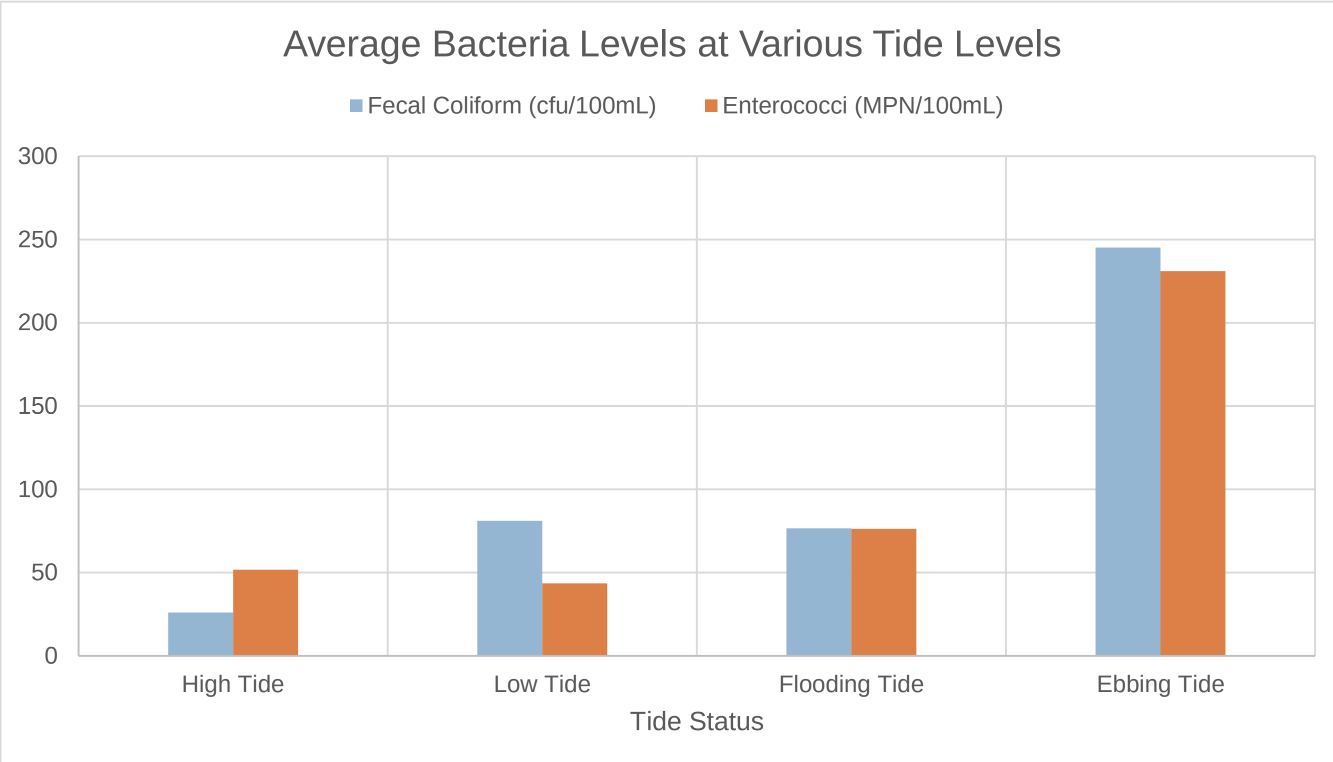

FIGURE 14: AVERAGE BACTERIA LEVELS AT VARIOUS TIDE LEVELS

The Sockeye Salmon Run

The Kenai River Personal Use Fishery is scheduled around the Kenai River's annual run of sockeye salmon. As shown in Figure 15, peak daily sockeye salmon counts (labeled), as recorded by the Alaska Department of Fish and Game (ADF&G), typically occur in the third week of July each year. In 2014, the highest daily sockeye salmon count did not occur until after the fishery season. Again, while it is unlikely that salmon make a significant, direct contribution to fecal pollution, it is quite possible that their elevated presence during this time period affects other variables that may lead to increased bacteria levels.

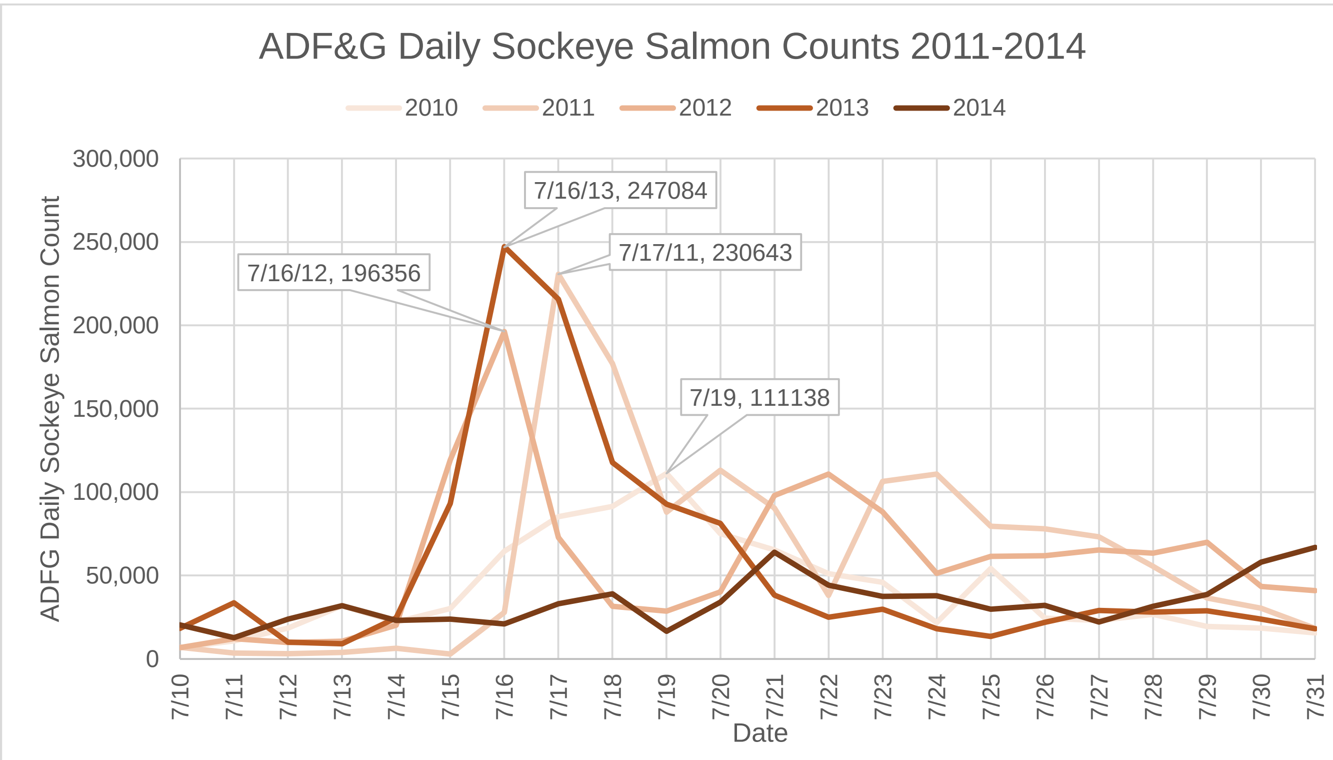

FIGURE 15: ADF&G SOCKEYE SALMON COUNTS 2010 – 2014

Figure 16 and Figure 17 demonstrate that there is no meaningful relationship between cumulative sockeye count during the fishery, and bacteria levels at Kenai public use beaches. This indicates that bacteria levels do not fluctuate based on higher cumulative salmon passage during the fishery's open season. Thus, based on this data, it can be stated that salmon do not directly contribute to bacteria levels.

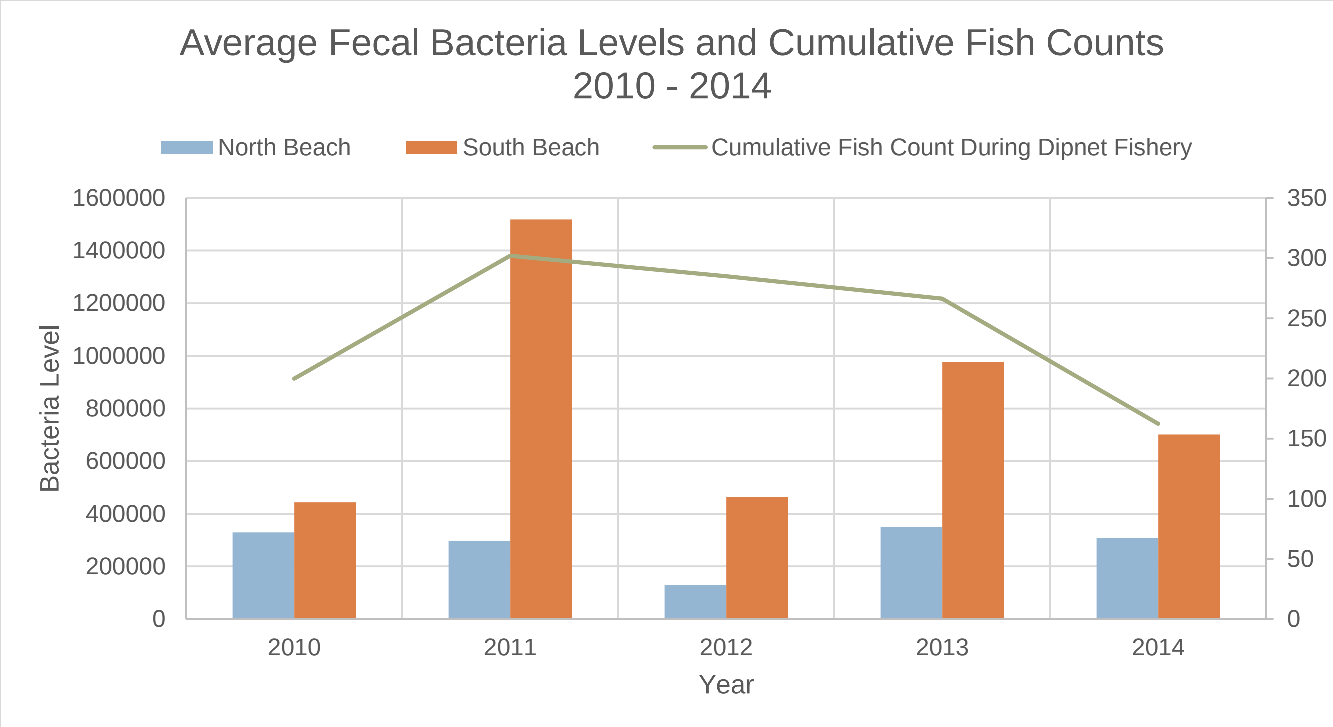

FIGURE 16: AVERAGE FECAL BACTERIA LEVELS VS. FISH COUNT 2010 – 2014

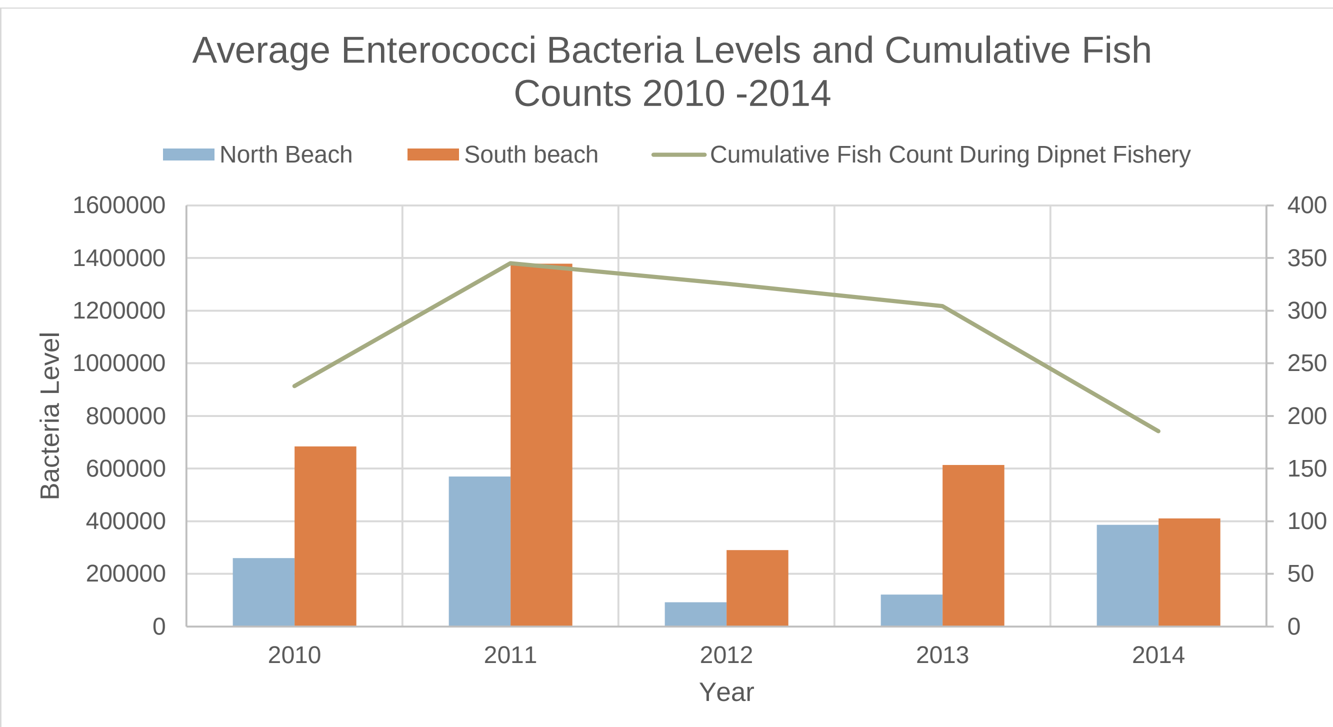

FIGURE 17: AVERAGE ENTEROCOCCI BACTERIA LEVELS AND FISH COUNTS 2010 – 2014

Further examination of sockeye counts as they relate to bacteria levels at North and South Kenai Beach led to the development of Table 12, which lists the dates of fish count spikes, dates of corresponding bacteria spikes, and the number of days between respective spikes. These results demonstrate how spikes in daily fish count may be related to spikes in bacteria levels. Often, an elevated bacteria result followed high daily fish counts by a period of 7-10 days. In order to confirm this relationship, additional data collection is necessary.

TABLE 12: AVERAGE DELAY BETWEEN FISH SPIKES AND BACTERIA SPIKES

Date of Fish Count Spike	Date of Corresponding Bacteria Spike	Days Between Fish Count and Bacteria Spikes
7/17/2011	7/24/2011	7
7/24/2011	8/2/2011	9
7/22/2012	8/1/2012	10
7/16/2013	7/24/2013	8
7/21/2014	7/27/2014	6
	Average =	**8**

Gull Activity

Based on MST analysis results from 2011 and 2014 (Table 13, 2014; Appendix D, 2011), it is evident that gulls are the most consistent major contributor to fecal bacteria at Kenai public use beaches. While the beaches are a common gathering point for birds throughout the year, it's probable that an unnatural increase in the availability of fish scraps leads to unusually large flocks during summer months. In addition, a large rookery is located just upstream of the Kenai River mouth, making the beaches extremely accessible to thousands of gulls.

TABLE 13: 2014 MST RESULTS

SM #	Client #	Approximate Contribution of Gull Fecal Pollution in Water Sample	Comment
SM-4I18015	SKB2-1	Major Contributor	High levels of Gull fecal biomarker
SM-4I18016	SKB2-2	Major Contributor	High levels of Gull fecal biomarker
SM-4I18017	SKB2-3	Major Contributor	High levels of Gull fecal biomarker
SM-4I18018	SKB2-4	Major Contributor	High levels of Gull fecal biomarker
SM-4I18019	SKB2-5	Major Contributor	High levels of Gull fecal biomarker
SM-4I18020	SKB3-1	Major Contributor	High levels of Gull fecal biomarker
SM-4I18021	NKB4-1	Major Contributor	High levels of Gull fecal biomarker

SM #	Client #	Approximate Contribution of Human Fecal Pollution in Water Sample	Comment
SM-4I18001	SKB2-1	**Potential Contributor**	Presence of human fecal biomarker
SM-4I18002	SKB2-2	Negative	Negative for human fecal biomarker
SM-4I18003	SKB2-3	Negative	Negative for human fecal biomarker
SM-4I18004	SKB2-4	Negative	Negative for human fecal biomarker
SM-4I18005	SKB2-5	Negative	Negative for human fecal biomarker
SM-4I18006	SKB3-1	Negative	Negative for human fecal biomarker
SM-4I18007	NKB4-1	Negative	Negative for human fecal biomarker

SM #	Client #	Approximate Contribution of Dog Fecal Pollution in Water Sample	Comment
SM-4I18029	SKB2-1	**Potential Contributor**	Presence of dog fecal biomarker
SM-4I18030	SKB2-2	**Potential Contributor**	Presence of dog fecal biomarker
SM-4I18031	SKB2-3	Negative	Negative for dog fecal biomarker
SM-4I18032	SKB2-4	Negative	Negative for dog fecal biomarker
SM-4I18033	SKB2-5	Negative	Negative for dog fecal biomarker
SM-4I18034	SKB3-1	**Potential Contributor**	Presence of dog fecal biomarker
SM-4I18035	NKB4-1	Major Contributor	Presence of dog fecal biomarker

SM #	Client #	Approximate Contribution of Ruminant Fecal Pollution in Water Sample	Comment
SM-4I18022	SKB2-1	Negative	Negative for ruminant fecal biomarker
SM-4I18023	SKB2-2	Negative	Negative for ruminant fecal biomarker
SM-4I18024	SKB2-3	**Potential Contributor**	Presence of ruminant fecal biomarker
SM-4I18025	SKB2-4	Negative	Negative for ruminant fecal biomarker
SM-4I18026	SKB2-5	Negative	Negative for ruminant fecal biomarker
SM-4I18027	SKB3-1	Negative	Negative for ruminant fecal biomarker
SM-4I18028	NKB4-1	Negative	Negative for ruminant fecal biomarker

In 2014, an attempt was made to assess the impact of the nearby gull-rookery on overall bacteria levels in waters within the Kenai River Personal Use Fishery. During four sampling events, samples were taken from locations upstream and downstream of the rookery. No samples taken from these locations resulted in exceedances of AWQS or EPA standards. Further, the resulting data (Figure 18) did not indicate that the gull rookery made significant contributions to downstream fecal pollution. This finding may indicate that fecal bacteria at the mouth of the Kenai River is largely the result of activity on the beaches, and not a result of upstream factors.

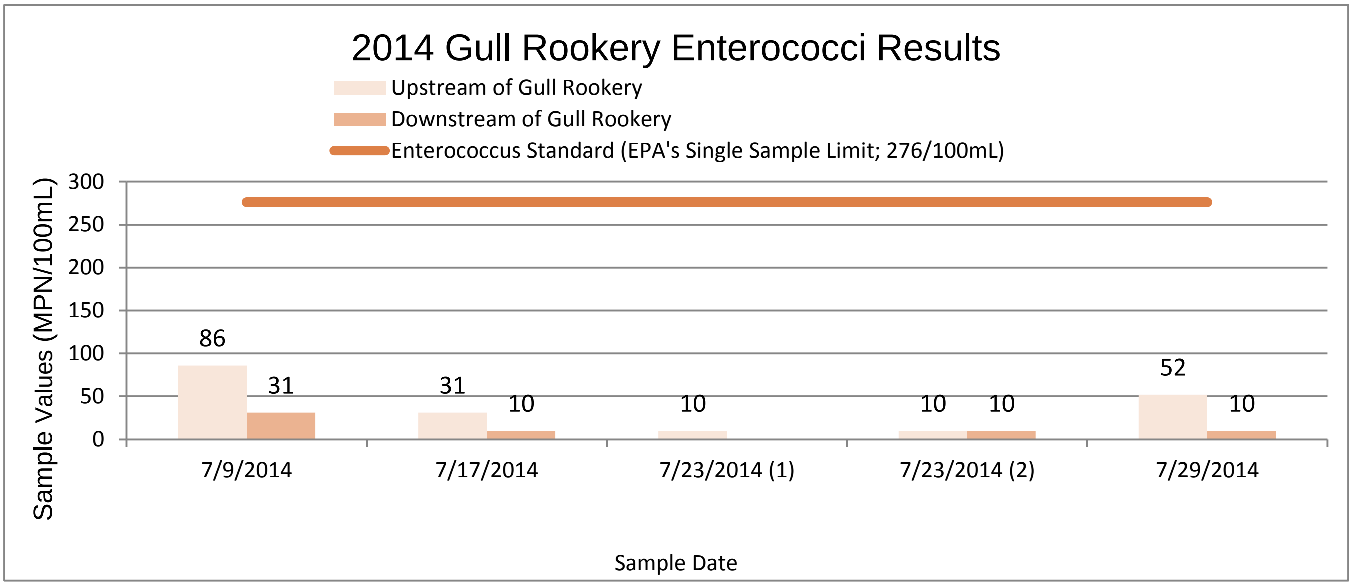

FIGURE 18: 2014 GULL ROOKERY ENTEROCOCCI RESULTS

Analysis of year-to-year bacteria levels and KWF observed gull presence during sampling events further substantiated the idea that gulls play a direct role in bacteria level fluctuation. During each sampling event from 2011 through 2014 (not in 2010), KWF scientists estimated the number of gulls present on each beach before sample collection. In order to use gull count estimates for this analysis, a rating system was developed as follows (Table 14).

TABLE 14: GULL COUNT RATING SYSTEM

Estimated Gull Count	Descriptive Classification	Rating Number
0 – 250	Low	1
250 – 500	Low – Medium	2
500 – 1000	Medium	3
1000 – 5000	High	4
5000+	Very High	5

This rating system allowed for the creation of Figure 19 which plots each yearly average gull count rating numbers against their respective average fecal coliform and enterococcus bacteria levels. This graph shows a clear relationship between high gull counts and elevated bacteria levels. Further, Figure 20 and Figure 21 display this information on a year-by-year basis, demonstrating bacteria levels typically rise and fall with bird presence. This is true for both indicator bacteria in every year except for enterococcus in 2014.

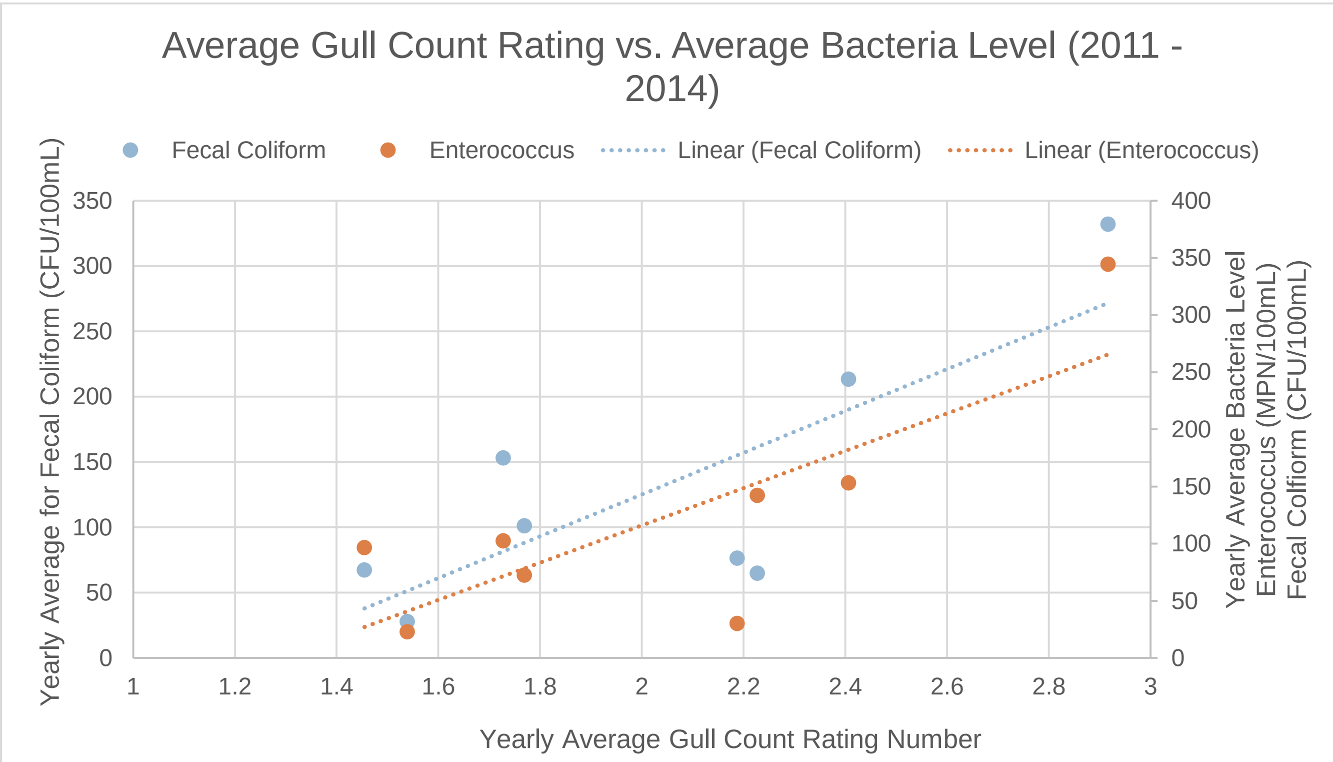

FIGURE 19: AVERAGE GULL COUNT VS. AVERAGE BACTERIA LEVEL (2011 – 2014)

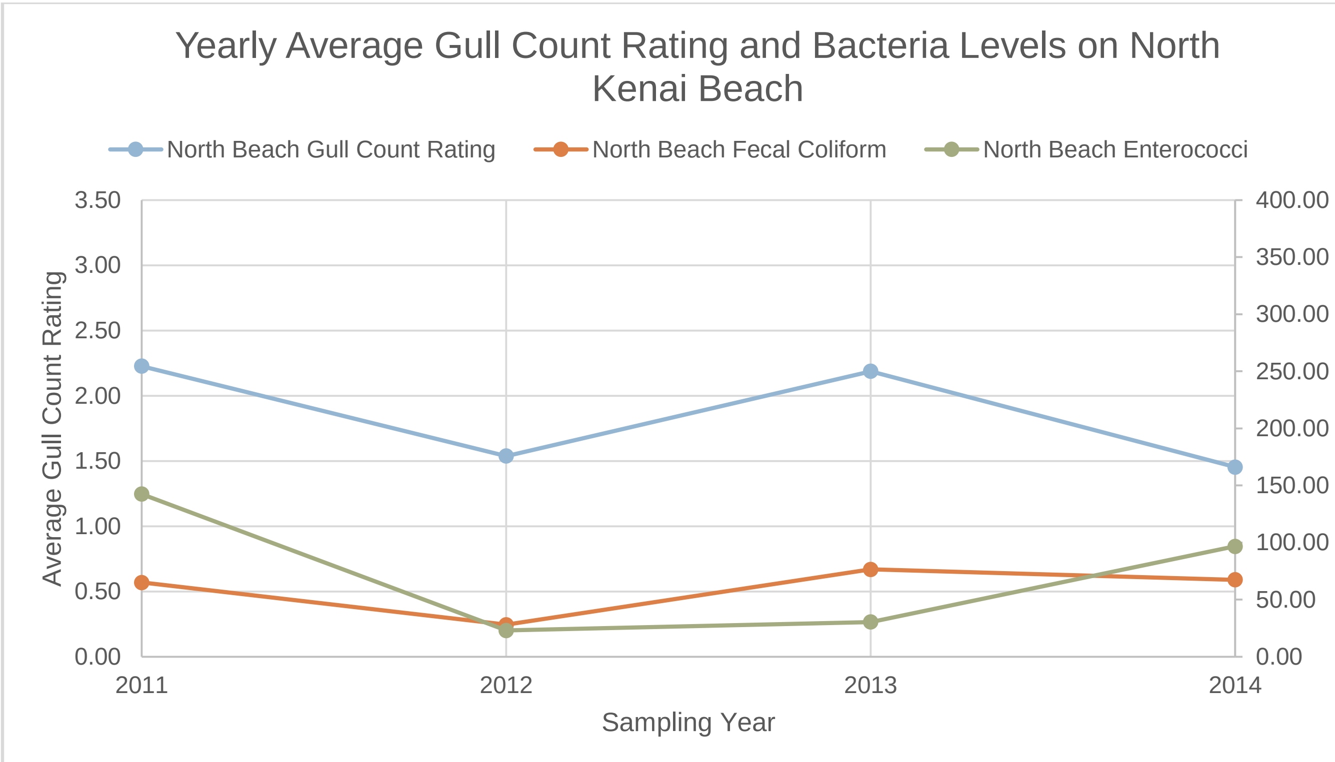

FIGURE 20: GULL COUNT RATING AND BACTERIA LEVELS ON NORTH KENAI BEACH

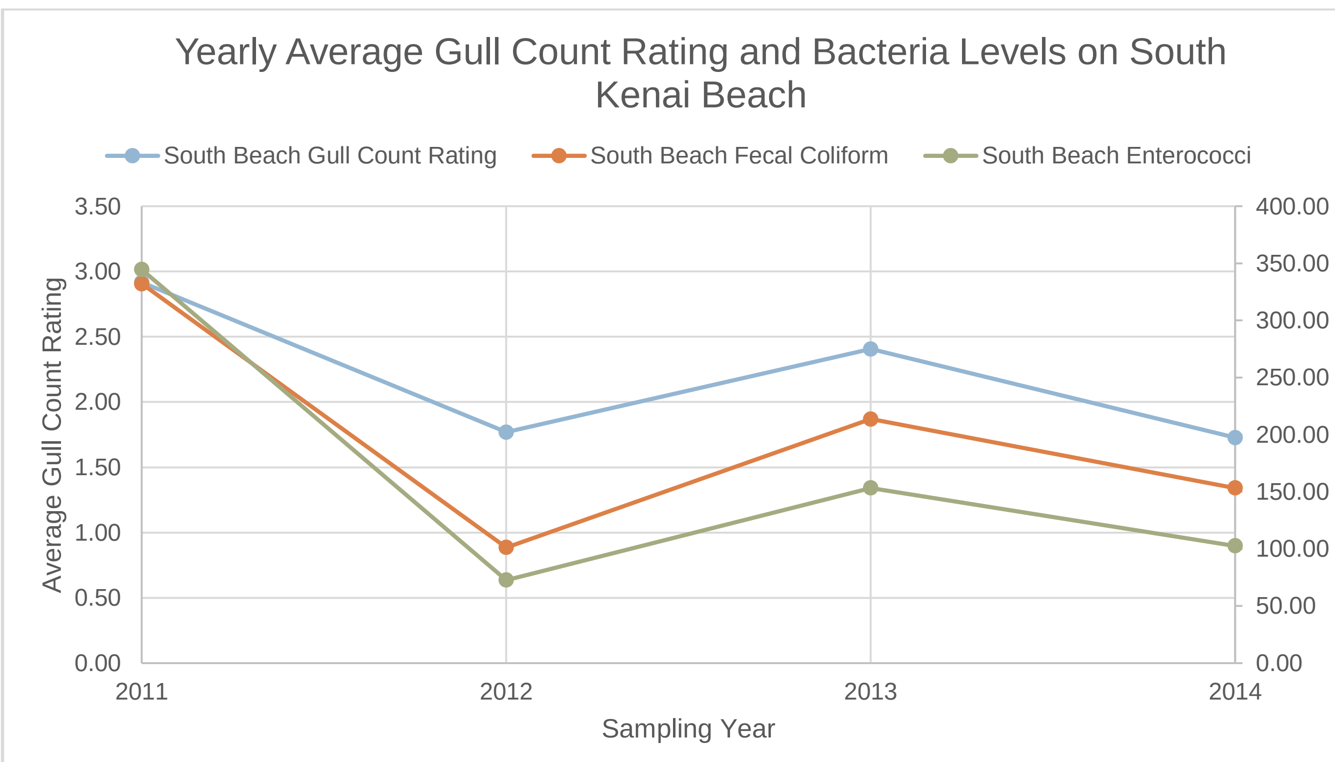

FIGURE 21: GULL COUNT RATING AND BACTERIA LEVELS ON SOUTH KENAI BEACH

DISCUSSION

The analyses performed and results displayed in this report allow for further discussion of major questions as previously listed:

- What are the factors that influence bacteria levels at the Kenai River entrance during the Kenai River Personal Use Fishery, and are these factors dependent on one another?
- What caused relatively high bacteria levels in 2011?
- Why were bacteria levels relatively low in 2012?
- What causes bacteria levels at South Kenai Beach to be consistently higher than those at North Kenai Beach?

What are the factors that influence bacteria levels at the Kenai River mouth during the Kenai River Personal Use Fishery, and are these factors dependent on one another?

While there are likely a multitude of factors involved in bacteria fluctuation at Kenai public use beaches during the fishery, data was collected and analyzed for those that were most logical, apparent, and measureable. Based on the data available at this time, as well as figures and tables displayed in the previous section, the only factor that can be said to have a clear and direct relationship with bacteria levels is gull presence. However, it is probable that each of the other factors discussed has some level of influence on gull activity and, therefore, an indirect impact on bacteria levels.

It can be suggested, based solely on the existence of the fishery, that the annual run of sockeye salmon has a large impact on human activity levels at North and South Kenai Beach. Eventually, fish cleaning and improper disposal of carcasses result in a compounding fish waste issue.

While tidal and river currents have the ability to sweep fish waste away from the beaches, gulls have been reported to congregate in large numbers on the mudflats exposed during low tide. Fish waste has been known to collect on these flats and other beach areas. In addition, with the majority of human fishery users located on the firmer, sandy sections of the beaches, the flats provide convenient feeding grounds for gulls. Wherever there is a large group of gulls, fecal matter will be produced in a similarly large quantity. Naturally, this fecal matter will be suspended and transported by tidal activity.

Although further data would be necessary to truly confirm these suggestions and theories, it can be said that relationships do exist between the annual sockeye salmon run, human activity, tides, gull presence, and bacteria levels. The question remains to what extent and with what significance in regards to fishery and beach management policies.

What caused relatively high bacteria levels in 2011?

Analyzing the data from a broader perspective revealed relatively high bacteria levels in 2011. It is possible that high bacteria levels in 2011 were the direct result of the highest average bird count for any year. With more birds and consequently more fecal matter on the beaches, the probability that any given water sample will contain high levels of fecal bacteria is increased.

Another possible explanation for this result is the fact that many of the samples taken in 2011 were taken during ebbing tides. Ebbing tides were shown to produce higher bacteria levels on average. However, it is unclear whether bacteria and tide relationships are representative of the entire dataset.

Why were bacteria levels relatively low in 2012?

2012 resulted in the lowest average bacteria levels, and ranked just above 2014 for lowest average bird count. With some amount of error involved in bird count estimates (e.g. large flocks arriving/leaving before sample collection, small number of observations etc.), and with the relatively small difference between each year's respective average value, it is certainly possible that overall gull activity was actually lower in 2012 than in 2014. However, it's also possible that one of the previously discussed factors, such as the fact that no 2012 samples were taken during ebbing tides, had a more significant influence on bacteria levels in 2012. Further study would be necessary to establish different elements involved in year-to-year fluctuation of bacteria levels.

What causes bacteria levels at South Kenai Beach to be consistently higher than those at North Kenai Beach?

As displayed in Figure 22, bird counts were consistently higher on South Kenai Beach than on North Kenai Beach. Based on the data available at this time, higher average bird count is the most probable explanation for the greater bacteria levels documented at South Kenai Beach.

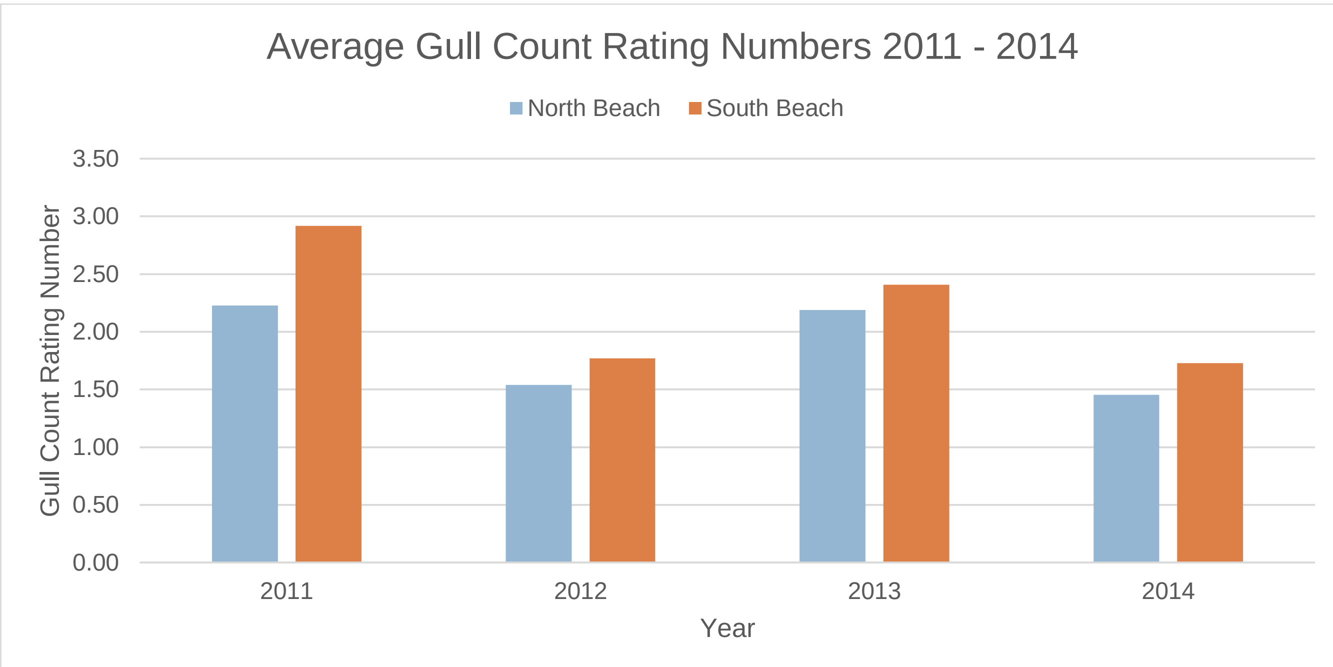

FIGURE 22: AVERAGE GULL COUNT RATING NUMBERS FOR NORTH AND SOUTH KENAI BEACH

CONCLUSION

Data collected to this point has provided important insight into some of the factors involved in fluctuation of bacteria levels at Kenai beaches during the annual fishery. While the relatively small number of samples taken each year do not provide the volume of data necessary to establish concrete trends and relationships, the most important results indicate a strong correlation between bird presence and fecal pollution. From this correlation, a number of conclusions can be drawn about the other factors involved in bacteria level fluctuation and how it can be managed.

The most significant finding that can be extracted from this data is the direct dependence of bacteria levels on fecal matter produced by gulls. Gulls were found to be the major contributor to fecal bacteria in nearly all samples analyzed with MST. In addition, KWF field notes have indicated a strong relationship between bird presence and average bacteria levels. While the initial response to this finding may be that there is a “bird problem” at Kenai beaches, the appropriate response would be that there are several issues which are, to some extent, related to an elevated bird presence during the fishery. In order to address fecal pollution caused by birds, the reasons for their elevated presence must be addressed first.

It is apparent that gulls are attracted in large numbers to North and South Kenai Beach by large quantities of fish waste, which is produced by fishery users capitalizing on the large sockeye salmon run that takes place during the fishery’s open season. As gulls feed on this fish waste, they deposit fecal matter on the beach and in the water. As the tides come in and go out, fecal matter on the beach and on the mud flats is suspended and transported by the river, tidal currents, and waves moving towards shore. All of these factors likely play a role in the regular exceedances of AWQS and EPA standards at Kenai public use beaches documented from 2010 through 2014.

Water samples taken from Kenai public use beaches often exceeded single-sample and 30-day geometric mean standards for both indicator bacteria utilized in this study. In order to mitigate potential public health issues and environmental degradation, fishery management personnel, environmental regulators, and all relevant agencies should collaborate to:

1. **Revise fish waste management policies during the Kenai River Personal Use Fishery**

   It appears the most important factor in elevated bacteria levels is the presence of gulls on Kenai public use beaches. While gulls are active in the area throughout the year, they are likely attracted in large numbers by fish scraps on the beach and in the water. Although the COK enforces appropriate fish waste management practices and regularly cleans both beaches, current protocols and resources may not be sufficient for controlling gull-sourced fecal pollution.

Ideally, large quantities of fish waste should be deposited off-site. This would significantly reduce the concentration of gull attractants during the fishery. Fishermen should be encouraged to use the dumpsters provided by the COK as the primary means of on-site fish waste disposal. However, the ultimate disposal of this fish waste may present additional challenges for the COK. For that reason, sustainable solutions must be generated through stakeholder input.

Support should also be given to specific management measures already proposed by the COK, such as the elimination of emergency orders which open the fishery for 24 hours. The normal hours (12am – 6am) during which the fishery is closed provide a valuable opportunity for the COK to clean beaches and perform necessary facility maintenance.

Relevant authorities should further promote and distribute educational material regarding fish waste management and proper fish cleaning procedures. This information could be attached to each permit, posted at various locations in the community and on the beach, and related to the public by stewardship programs such as Stream Watch. In addition, the COK and other relevant officials should continue to advertise and enforce current fish waste disposal regulations.

2. **Continue to monitor bacteria levels at Kenai public use beaches and consider further examination of specific factors in bacteria fluctuation**

While the major source of fecal bacteria in Kenai beach waters appears to be gulls, it remains unclear to what extent this issue can be influenced or controlled by other fishery variables. Fishery management personnel, environmental regulators, the environment itself, and the general public all stand to benefit from continued monitoring of fecal bacteria at the Kenai River mouth. In particular, quality fishery user data would be extremely helpful in assessing the impact of human activity on gull presence and bacteria levels. In order to isolate cause and effect relationships between previously discussed factors in bacteria fluctuation, sampling plans could be revised and/or expanded. Data collected long before and after the fishery would provide further insight into the direct effect of the fishery on gull presence and bacteria levels. Several samples taken throughout the course of one day might establish relationships between tidal activity and bacteria levels. Finally, it would be valuable to examine the effect of upstream fish processing plants which, by anecdotal reports, can contribute to fish waste found on Kenai beaches.

Further study would provide officials with the ability to make decisions regarding the general safety of public use beaches in Kenai, and to ensure the long-term sustainability of the Kenai River Personal Use Fishery.

3. **Ensure the fishery does not grow to a point which prevents appropriate fish waste management, and consider forming an inter-agency council to assist the COK and to provide comprehensive fishery management**

Based on COK transaction data from the past three fishery seasons, the number of fishery users continues to grow substantially each year (Figure 23). It can be suggested that additional fishermen will lead to more fish waste and, therefore, more gulls and a greater potential for fecal pollution. Without additional resources being devoted to all aspects of fishery management, more beach users may be exposed to harmful levels of fecal bacteria.

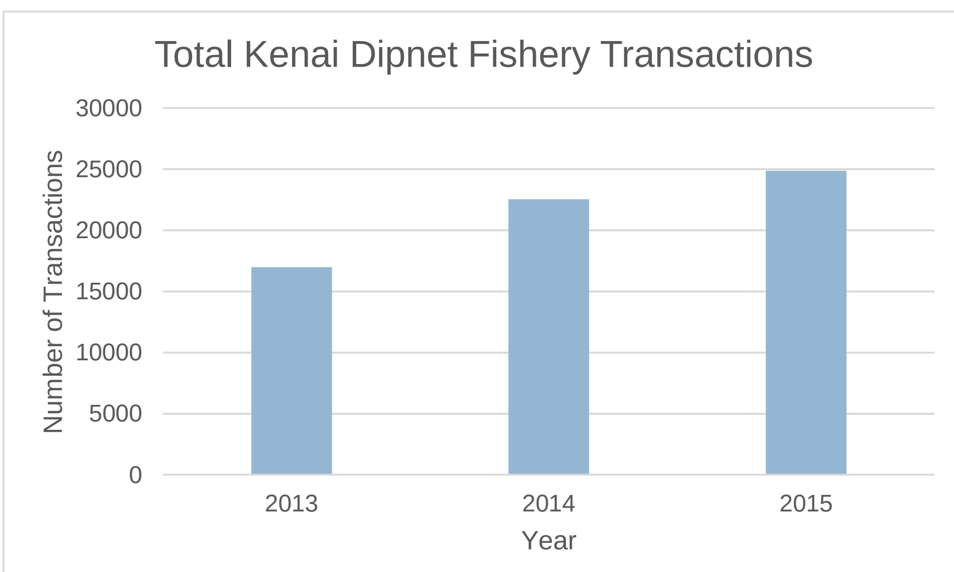

FIGURE 23: TOTAL KENAI DIPNET FISHERY TRANSACTIONS, 2013 – 2015

Strong consideration should be given to the establishment of an inter-agency council to manage the Kenai River Personal Use Fishery and other fisheries with similar issues. With representation from various stakeholders, such as the COK, Alaska Department of Fish & Game, US EPA, ADEC, Alaska State Parks, and the public, strategies can be developed to address a wide range of fishery matters for years into the future. This council should provide support to the City of Kenai, especially as the fishery continues to expand. In addition, management policies enacted at the Kenai River Personal Use Fishery can be applied to other fisheries with similar concerns, such as the Kasilof River Personal Use Salmon Fishery.

These three actions would support educated management decisions, encourage preservation of environmental habitat, mitigate potential public health issues, and ensure the continued success of the Kenai River Personal Use Fishery.

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Rebecca Zulueta
David Stahl
Joe Charbonnet
Elizabeth Charbonnet (Jones)
Olivia Pfeifer
Grant Humphreys

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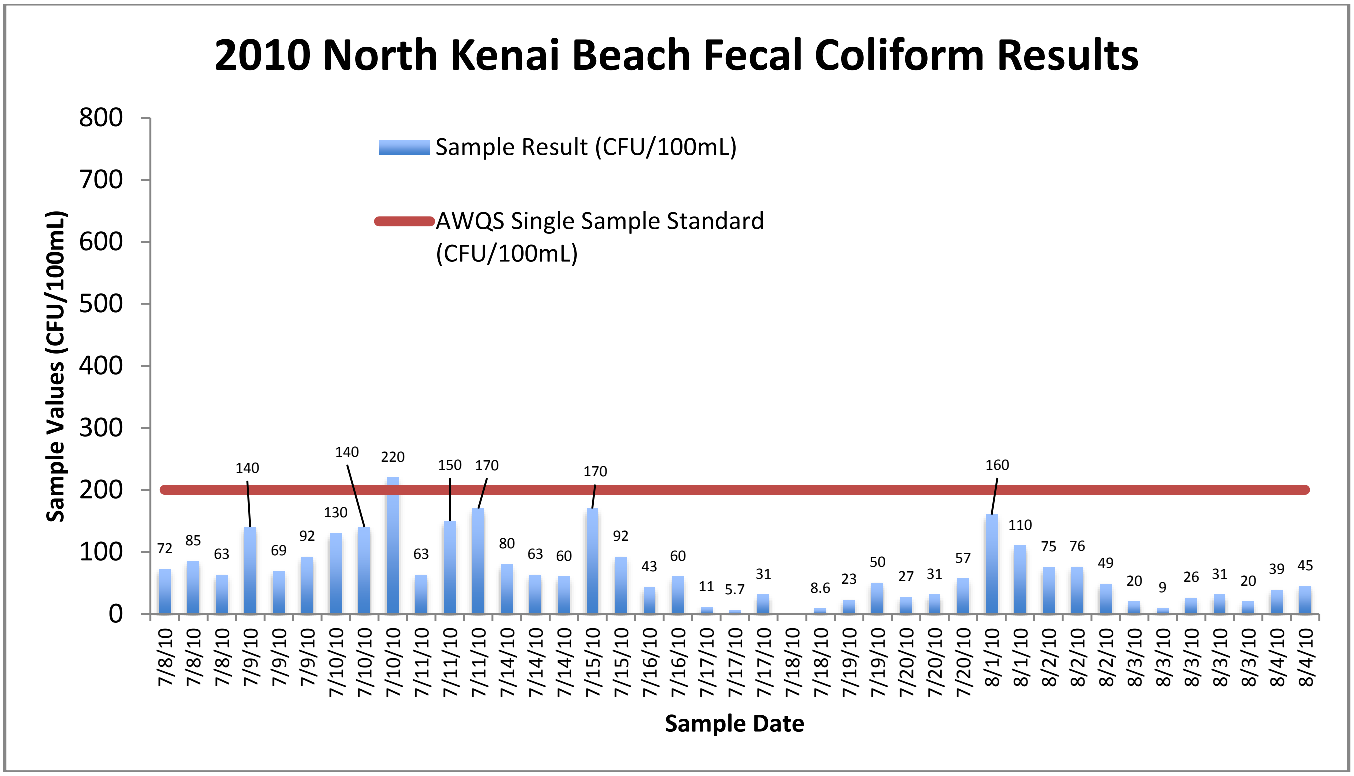
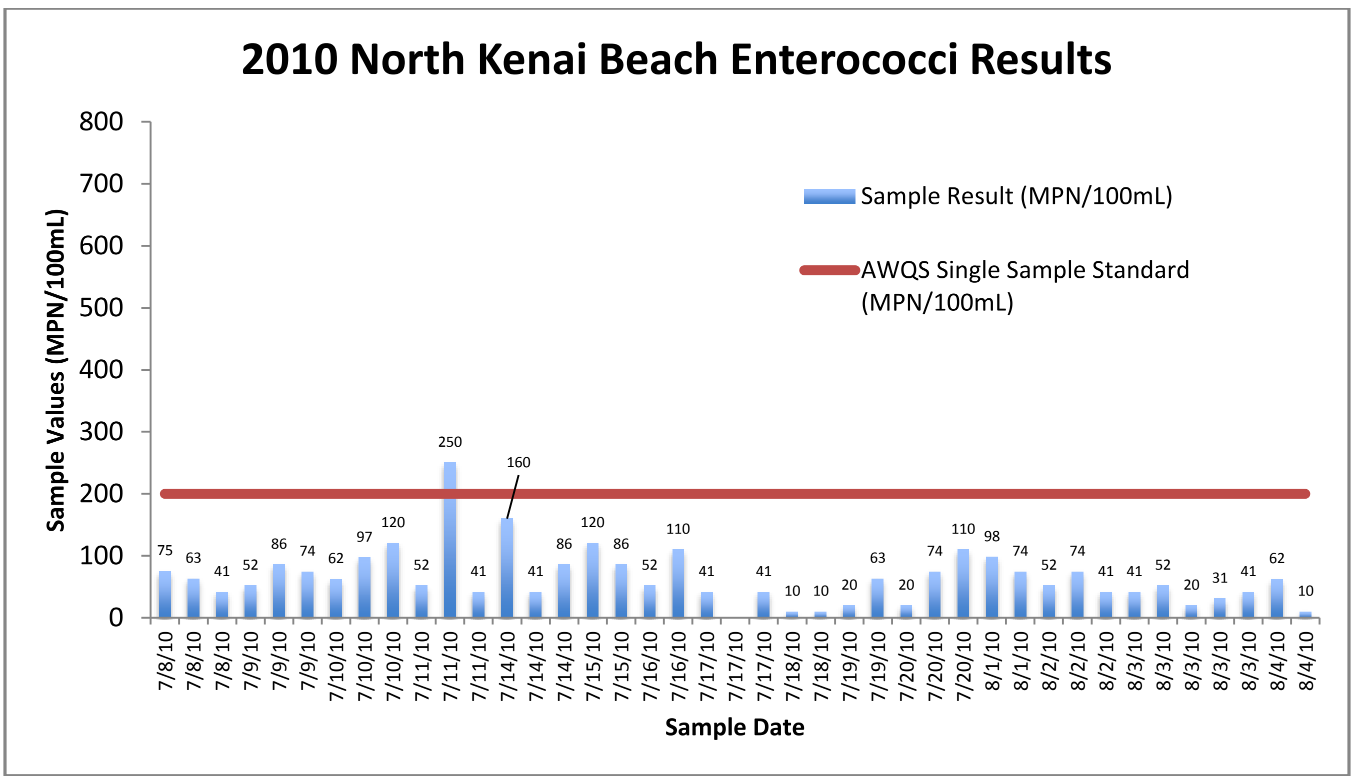
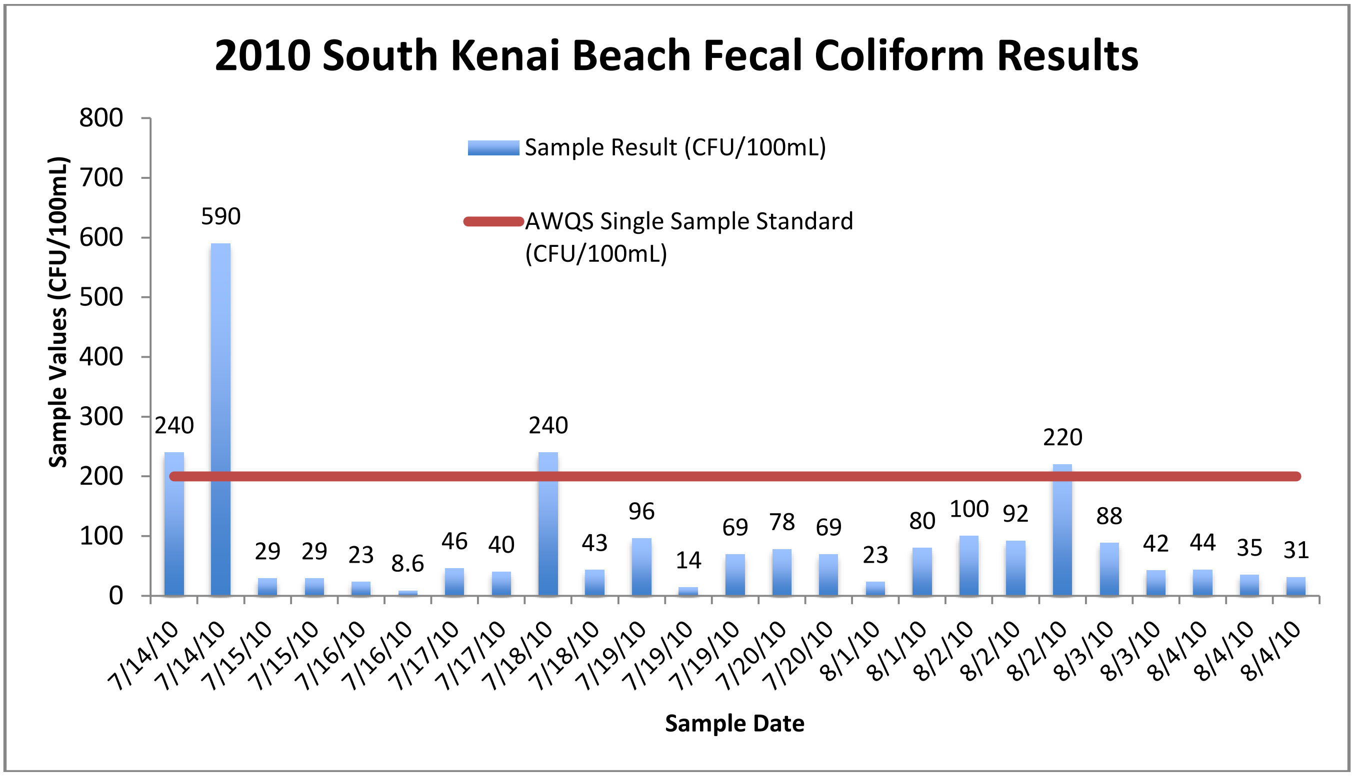
APPENDIX A - RAW DATA (2010-2014)






2010 South Kenai Beach Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
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700
600
500
400
300
200
100
0
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590
29
29
23
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46
40
240
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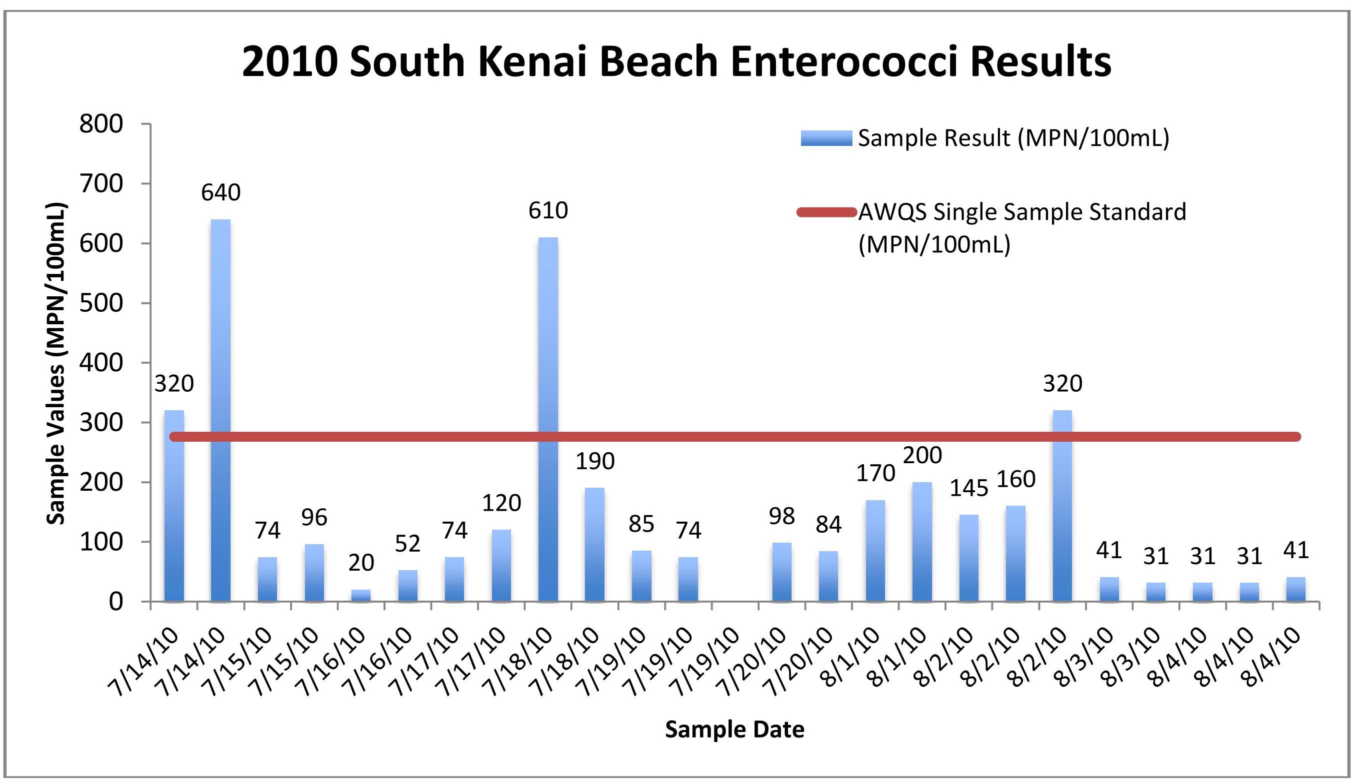
Sample Date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Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
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400
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200
100
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640
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96
20
52
74
120
610
190
85
74
98
84
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200
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160
320
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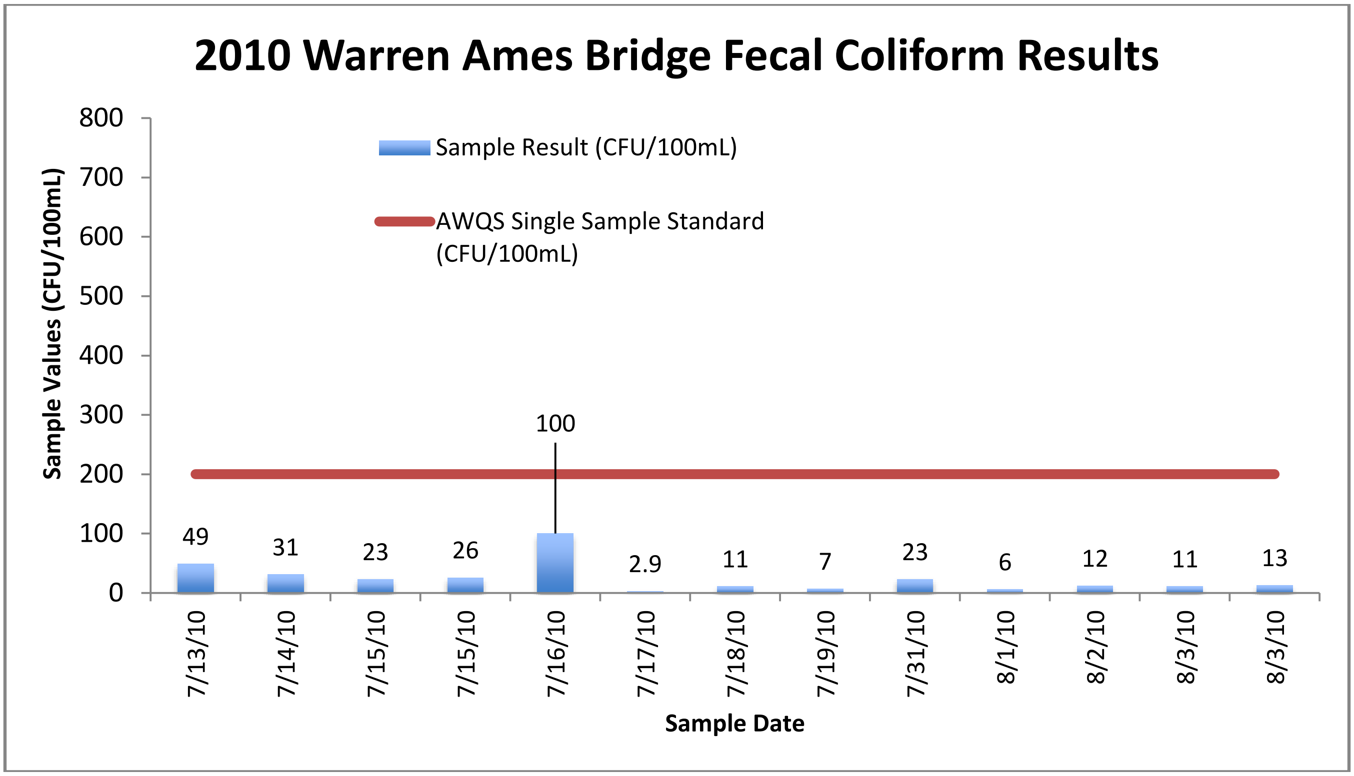
Sample Date


2010 Warren Ames Bridge Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
800
700
600
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400
300
200
100
0
49
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100
2.9
11
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23
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12
11
13
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7/19/10
7/31/10
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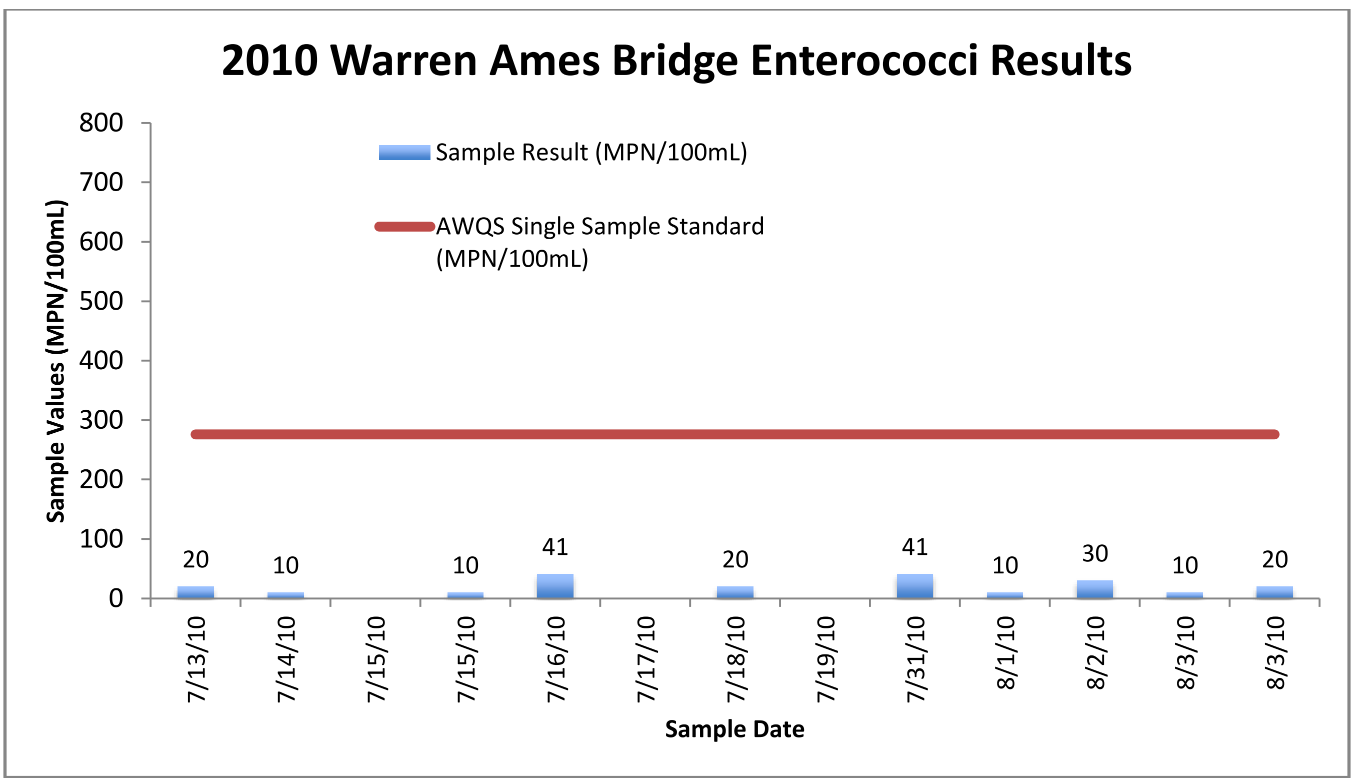
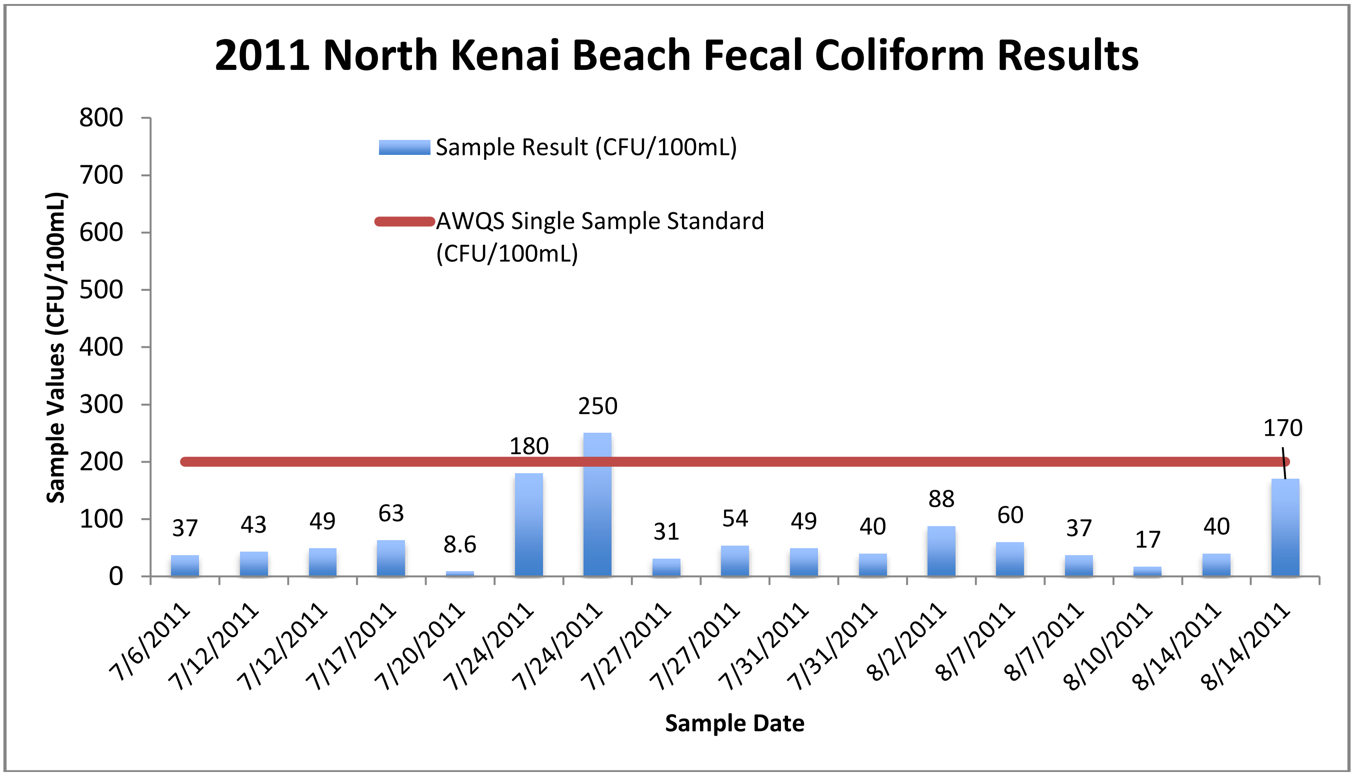
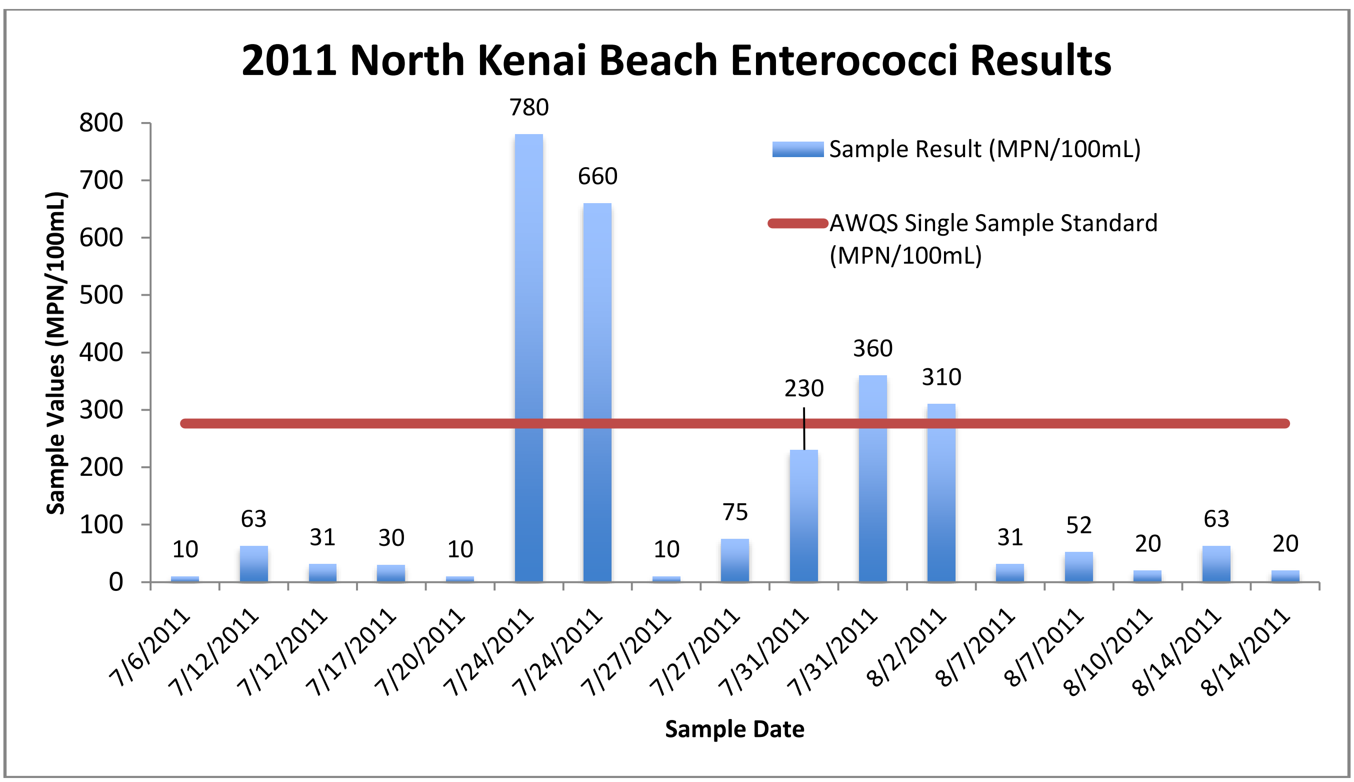
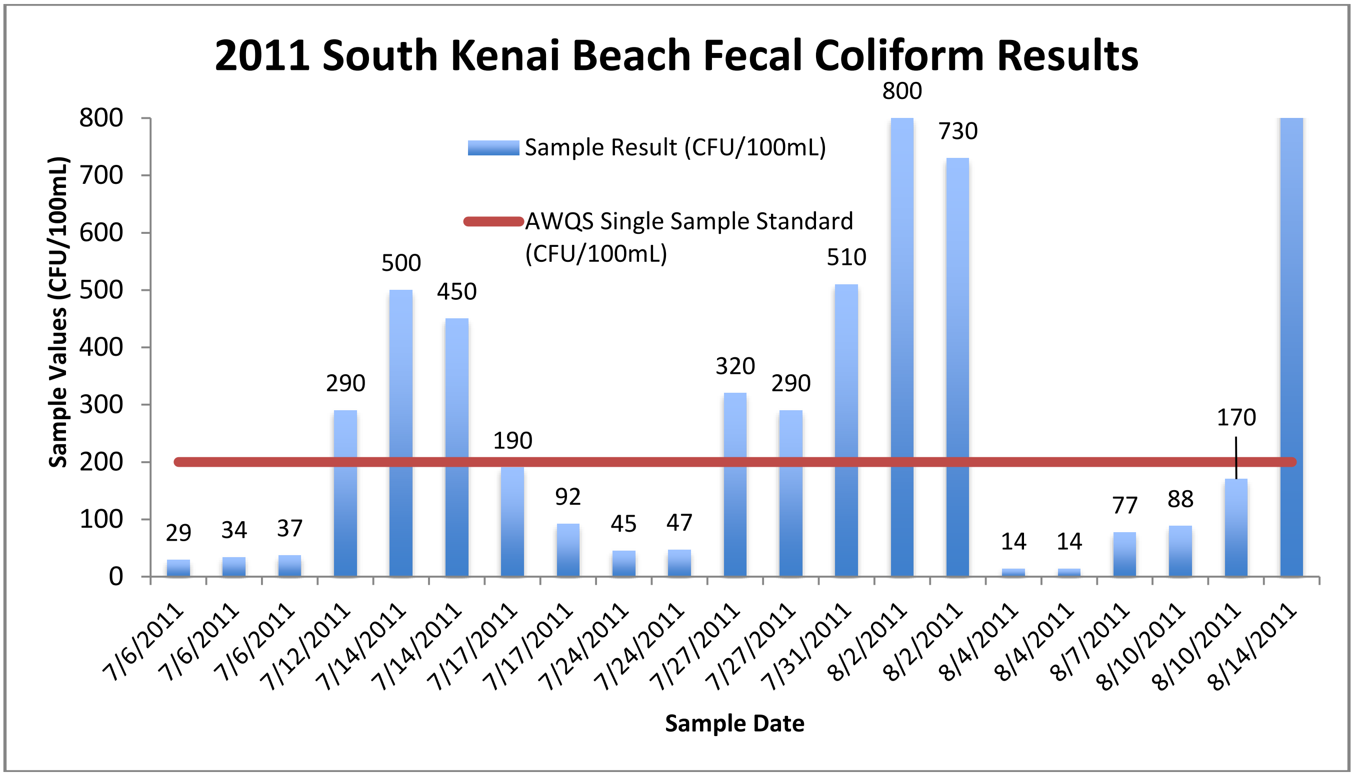
8/3/10
8/3/10
Sample Date


2010 Warren Ames Bridge Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
800
700
600
500
400
300
200
100
0
20
10
10
41
20
41
10
30
10
20
7/13/10
7/14/10
7/15/10
7/15/10
7/16/10
7/17/10
7/18/10
7/19/10
7/31/10
8/1/10
8/2/10
8/3/10
8/3/10
Sample Date


2011 North Kenai Beach Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
0
100
200
300
400
500
600
700
800
37
43
49
63
8.6
180
250
31
54
49
40
88
60
37
17
40
170
7/6/2011
7/12/2011
7/12/2011
7/17/2011
7/20/2011
7/24/2011
7/24/2011
7/27/2011
7/27/2011
7/31/2011
7/31/2011
8/2/2011
8/7/2011
8/7/2011
8/10/2011
8/14/2011
8/14/2011
Sample Date


2011 North Kenai Beach Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
0
100
200
300
400
500
600
700
800
10
63
31
30
10
780
660
10
75
230
360
310
31
52
20
63
20
7/6/2011
7/12/2011
7/12/2011
7/17/2011
7/20/2011
7/24/2011
7/24/2011
7/27/2011
7/27/2011
7/31/2011
7/31/2011
8/2/2011
8/7/2011
8/7/2011
8/10/2011
8/14/2011
8/14/2011
Sample Date


2011 South Kenai Beach Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
0
100
200
300
400
500
600
700
800
29
34
37
290
500
450
190
92
45
47
320
290
510
800
730
14
14
77
88
170
7/6/2011
7/6/2011
7/6/2011
7/12/2011
7/14/2011
7/14/2011
7/17/2011
7/17/2011
7/24/2011
7/24/2011
7/27/2011
7/27/2011
7/31/2011
8/2/2011
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8/10/2011
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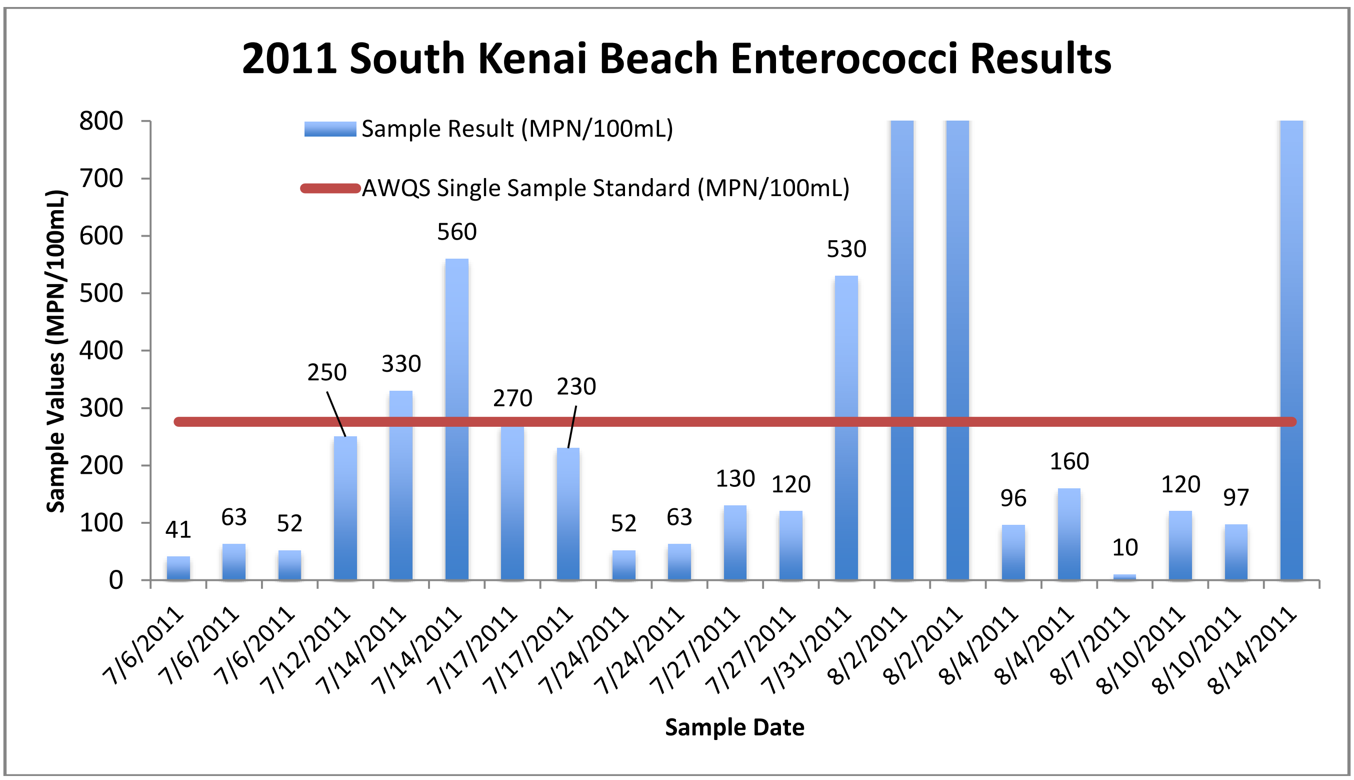
8/14/2011
Sample Date


2011 South Kenai Beach Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
0
100
200
300
400
500
600
700
800
41
63
52
250
330
560
270
230
52
63
130
120
530
96
160
10
120
97
7/6/2011
7/6/2011
7/6/2011
7/12/2011
7/14/2011
7/14/2011
7/17/2011
7/17/2011
7/24/2011
7/24/2011
7/27/2011
7/27/2011
7/31/2011
8/2/2011
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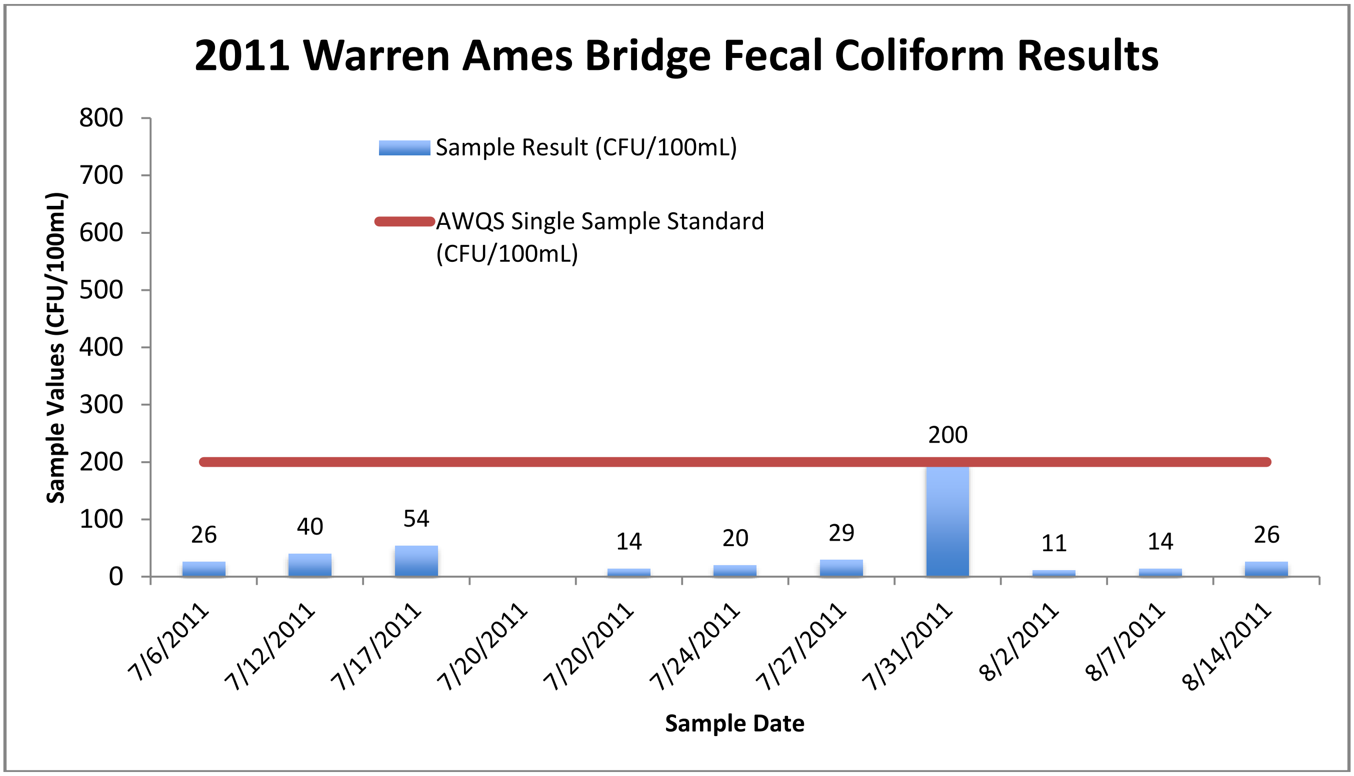
8/4/2011
8/4/2011
8/7/2011
8/10/2011
8/10/2011
8/14/2011
Sample Date


2011 Warren Ames Bridge Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
800
700
600
500
400
300
200
100
0
26
40
54
14
20
29
200
11
14
26
7/6/2011
7/12/2011
7/17/2011
7/20/2011
7/20/2011
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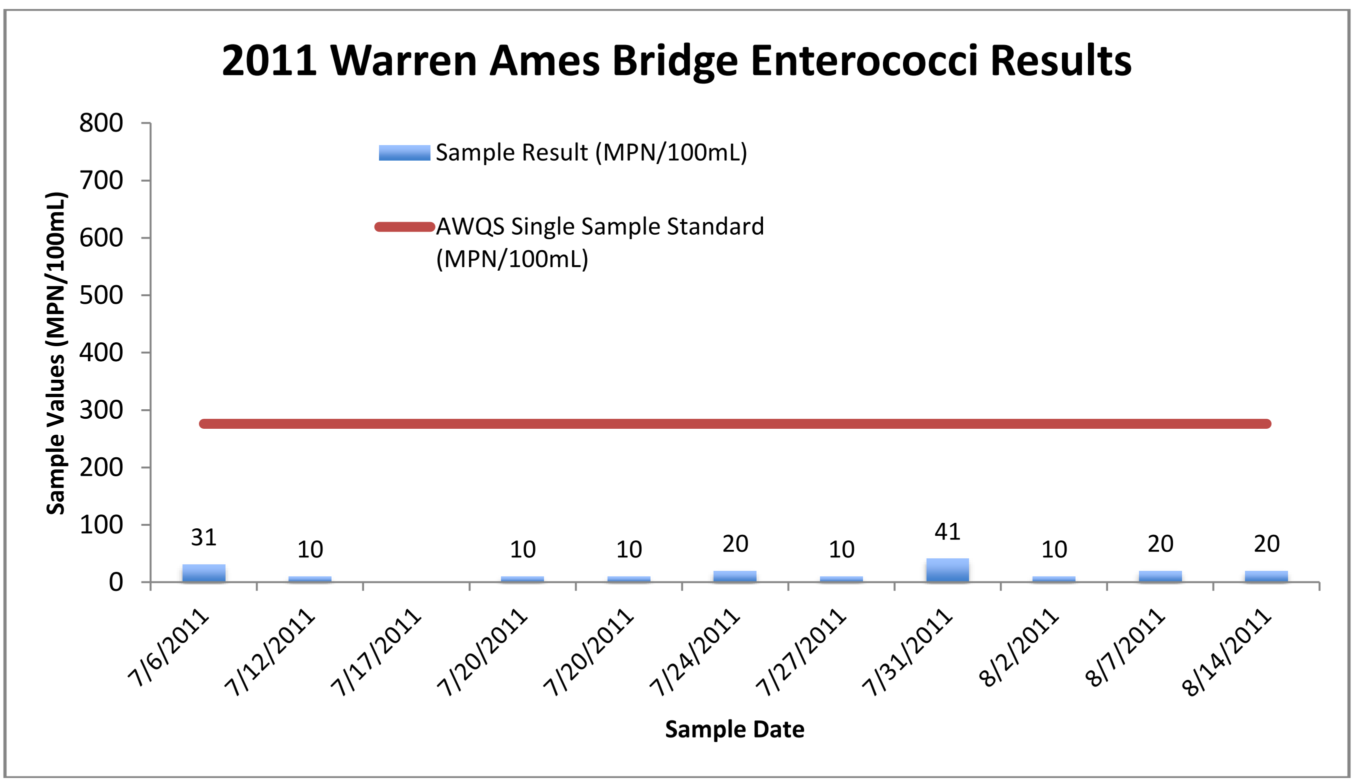
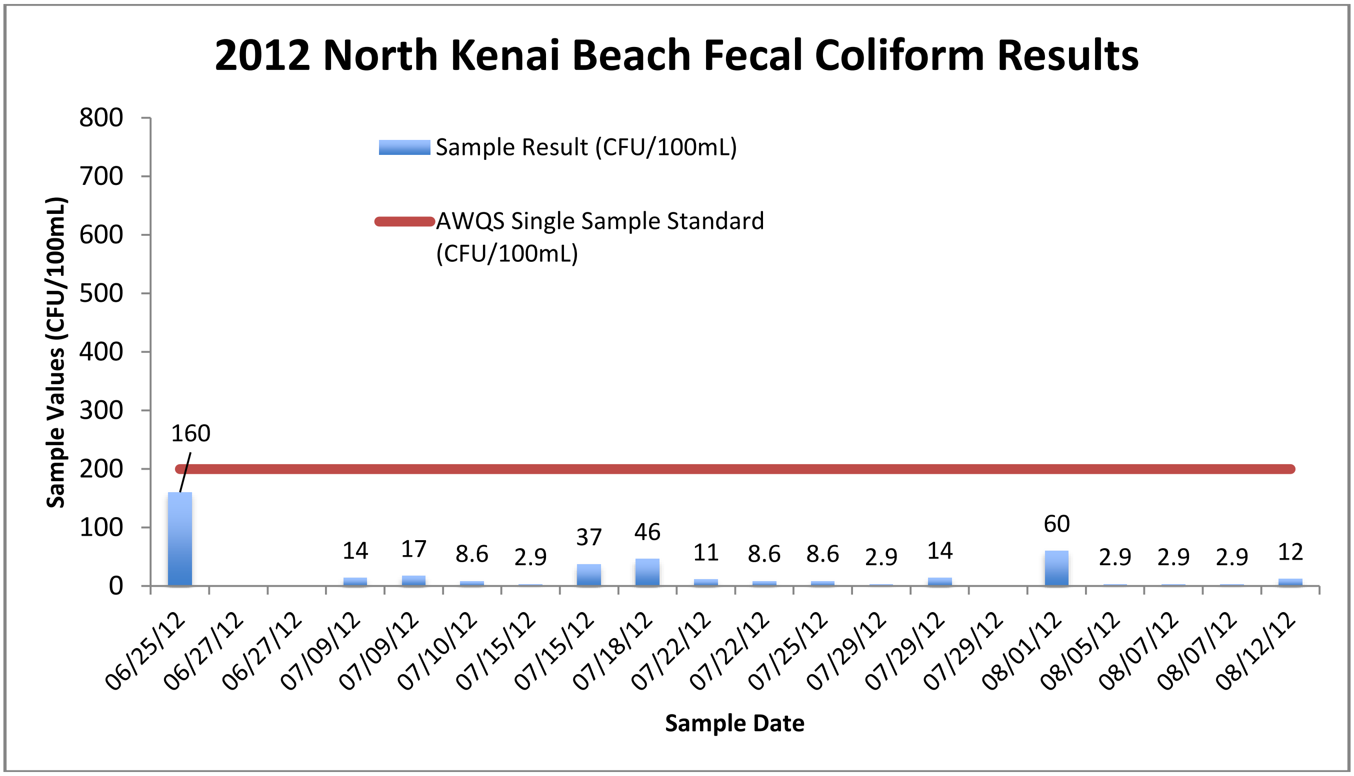
7/27/2011
7/31/2011
8/2/2011
8/7/2011
8/14/2011
Sample Date


2011 Warren Ames Bridge Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
800
700
600
500
400
300
200
100
0
31
10
10
10
20
10
41
10
20
20
7/6/2011
7/12/2011
7/17/2011
7/20/2011
7/20/2011
7/24/2011
7/27/2011
7/31/2011
8/2/2011
8/7/2011
8/14/2011
Sample Date


2012 North Kenai Beach Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
0
100
200
300
400
500
600
700
800
160
14
17
8.6
2.9
37
46
11
8.6
8.6
2.9
14
60
2.9
2.9
2.9
12
06/25/12
06/27/12
06/27/12
07/09/12
07/09/12
07/10/12
07/15/12
07/15/12
07/18/12
07/22/12
07/22/12
07/25/12
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07/29/12
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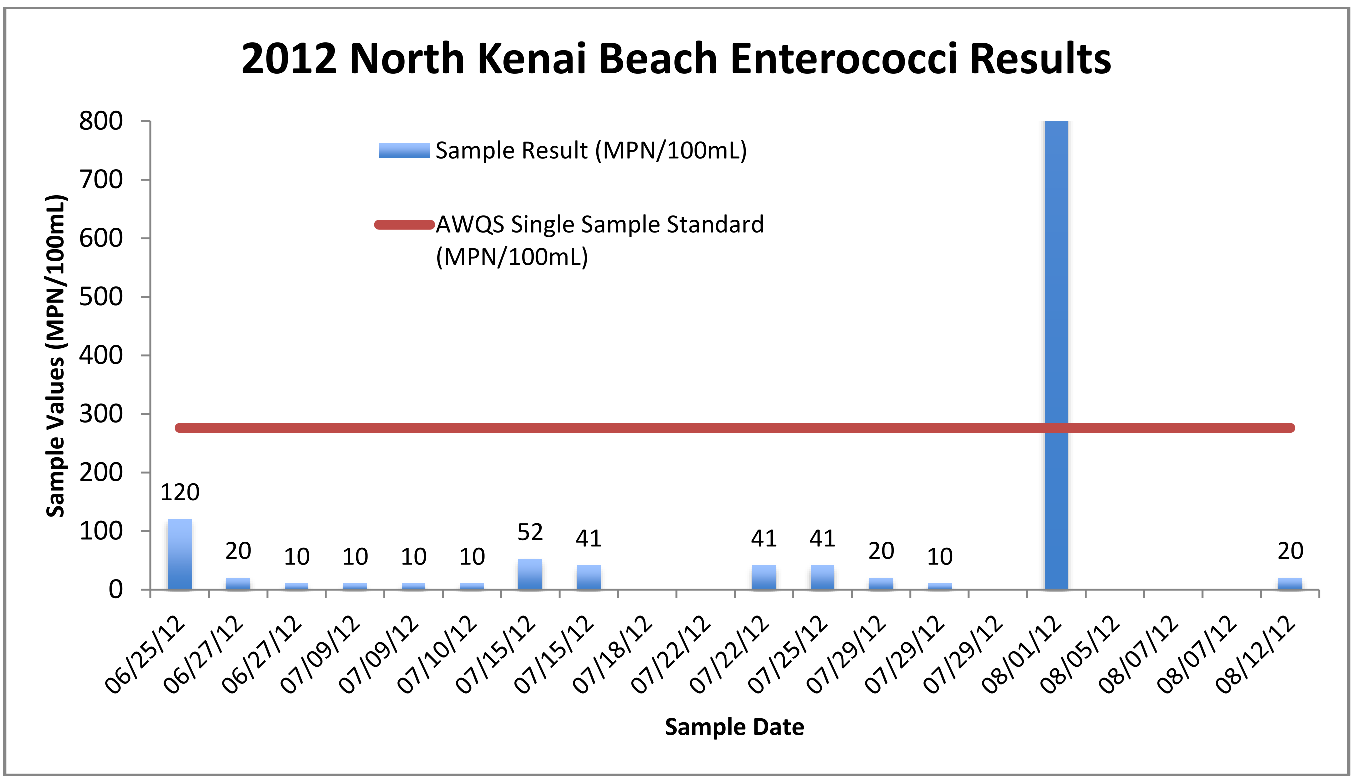
08/05/12
08/07/12
08/07/12
08/12/12
Sample Date


2012 North Kenai Beach Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
0
100
200
300
400
500
600
700
800
120
20
10
10
10
10
52
41
41
41
20
10
20
06/25/12
06/27/12
06/27/12
07/09/12
07/09/12
07/10/12
07/15/12
07/15/12
07/18/12
07/22/12
07/22/12
07/25/12
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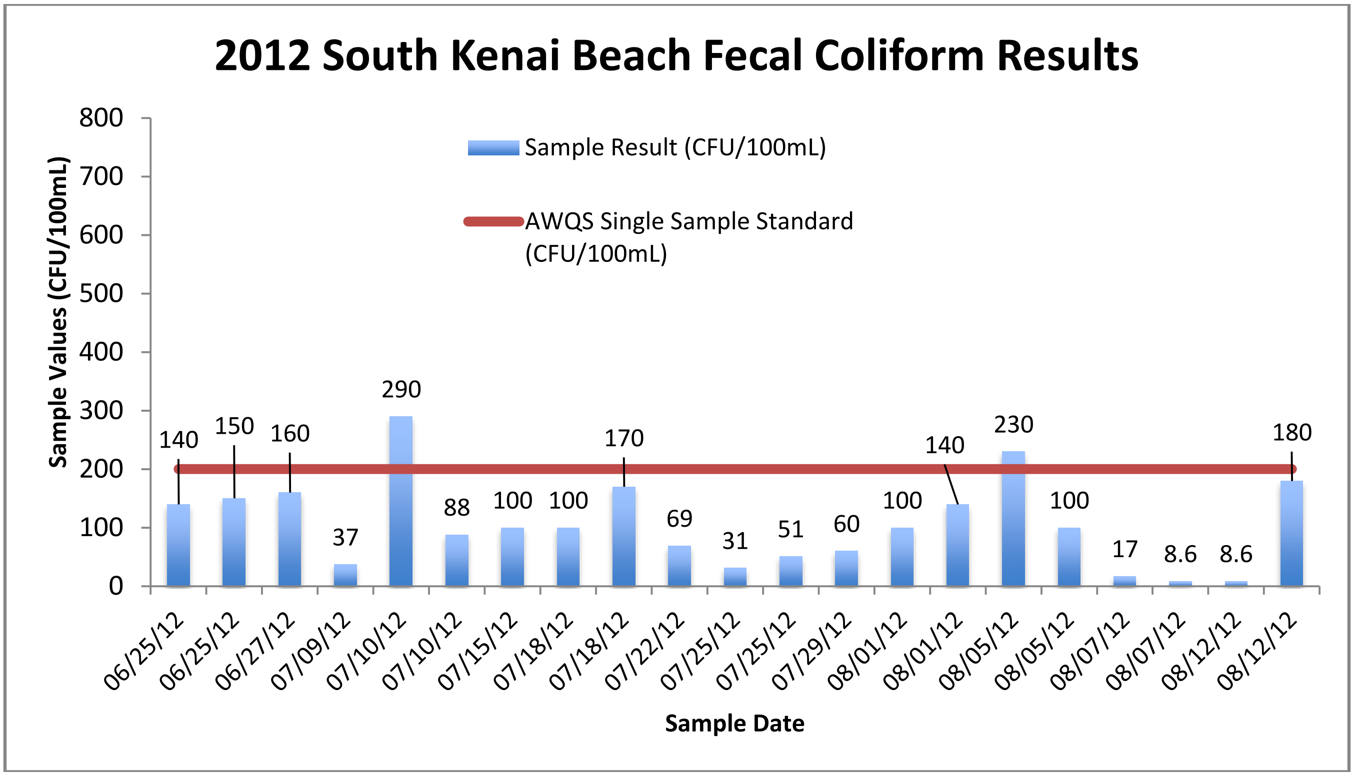
07/29/12
08/01/12
08/05/12
08/07/12
08/07/12
08/12/12
Sample Date


2012 South Kenai Beach Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
800
700
600
500
400
300
200
100
0
140
150
160
37
290
88
100
100
170
69
31
51
60
100
140
230
100
17
8.6
8.6
180
06/25/12
06/25/12
06/27/12
07/09/12
07/10/12
07/10/12
07/15/12
07/18/12
07/18/12
07/22/12
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07/29/12
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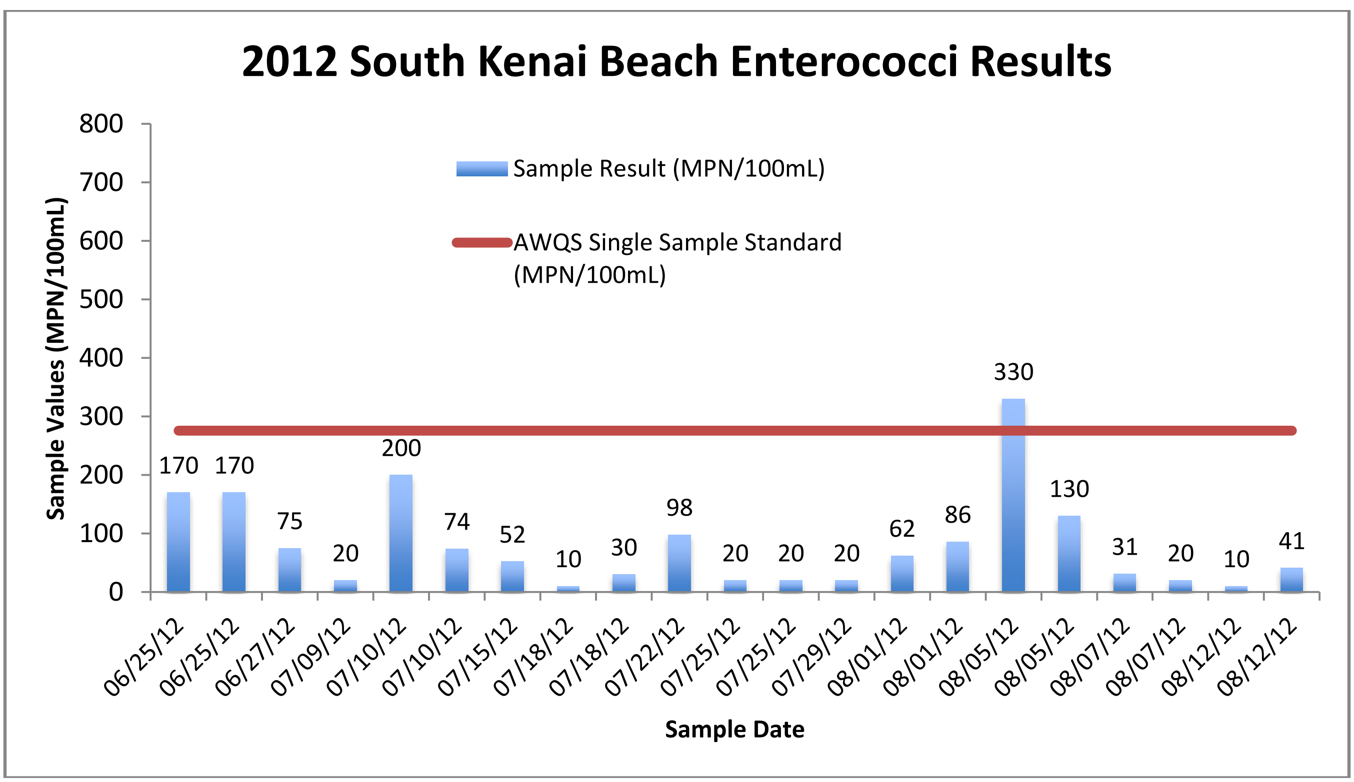
08/12/12
Sample Date


2012 South Kenai Beach Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
800
700
600
500
400
300
200
100
0
170
170
75
20
200
74
52
10
30
98
20
20
20
62
86
330
130
31
20
10
41
06/25/12
06/25/12
06/27/12
07/09/12
07/10/12
07/10/12
07/15/12
07/18/12
07/18/12
07/22/12
07/25/12
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07/29/12
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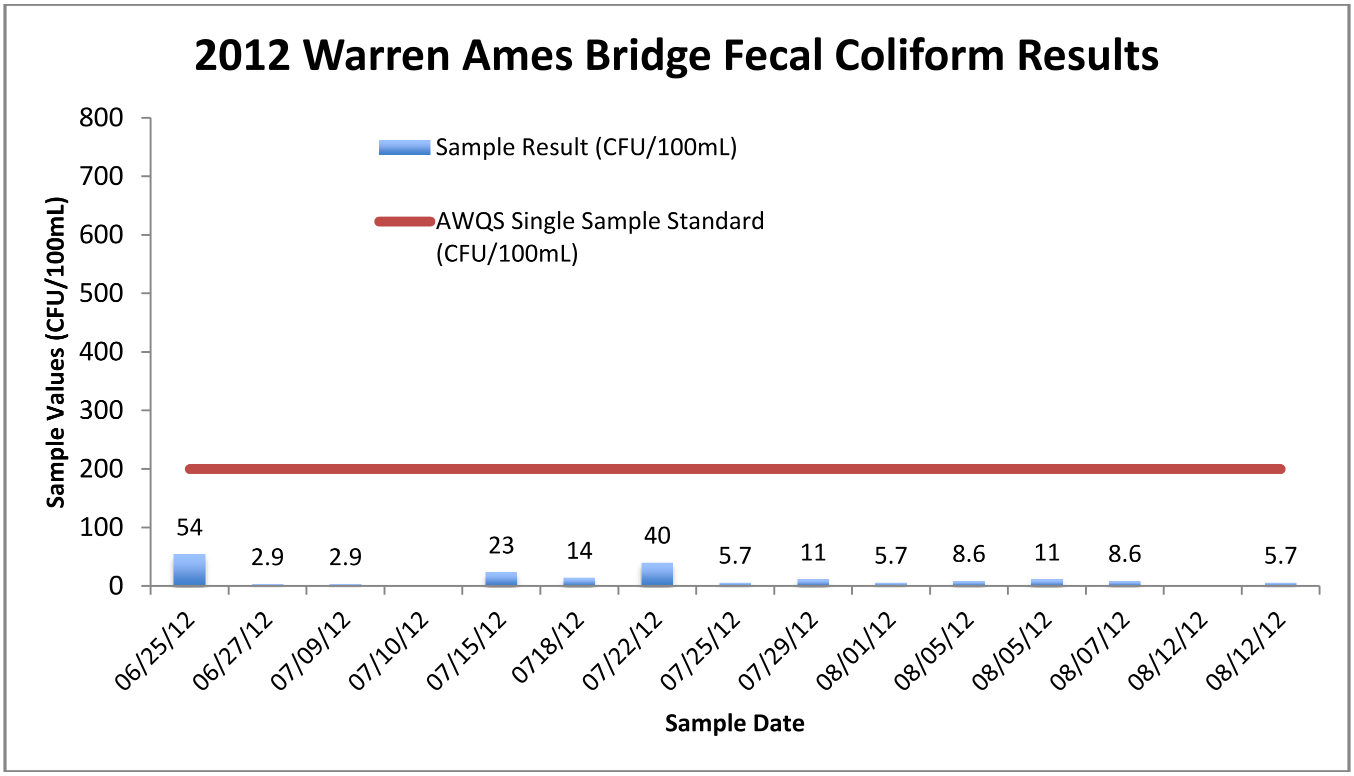
08/07/12
08/12/12
08/12/12
Sample Date


2012 Warren Ames Bridge Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
800
700
600
500
400
300
200
100
0
54
2.9
2.9
23
14
40
5.7
11
5.7
8.6
11
8.6
5.7
06/25/12
06/27/12
07/09/12
07/10/12
07/15/12
0718/12
07/22/12
07/25/12
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08/05/12
08/07/12
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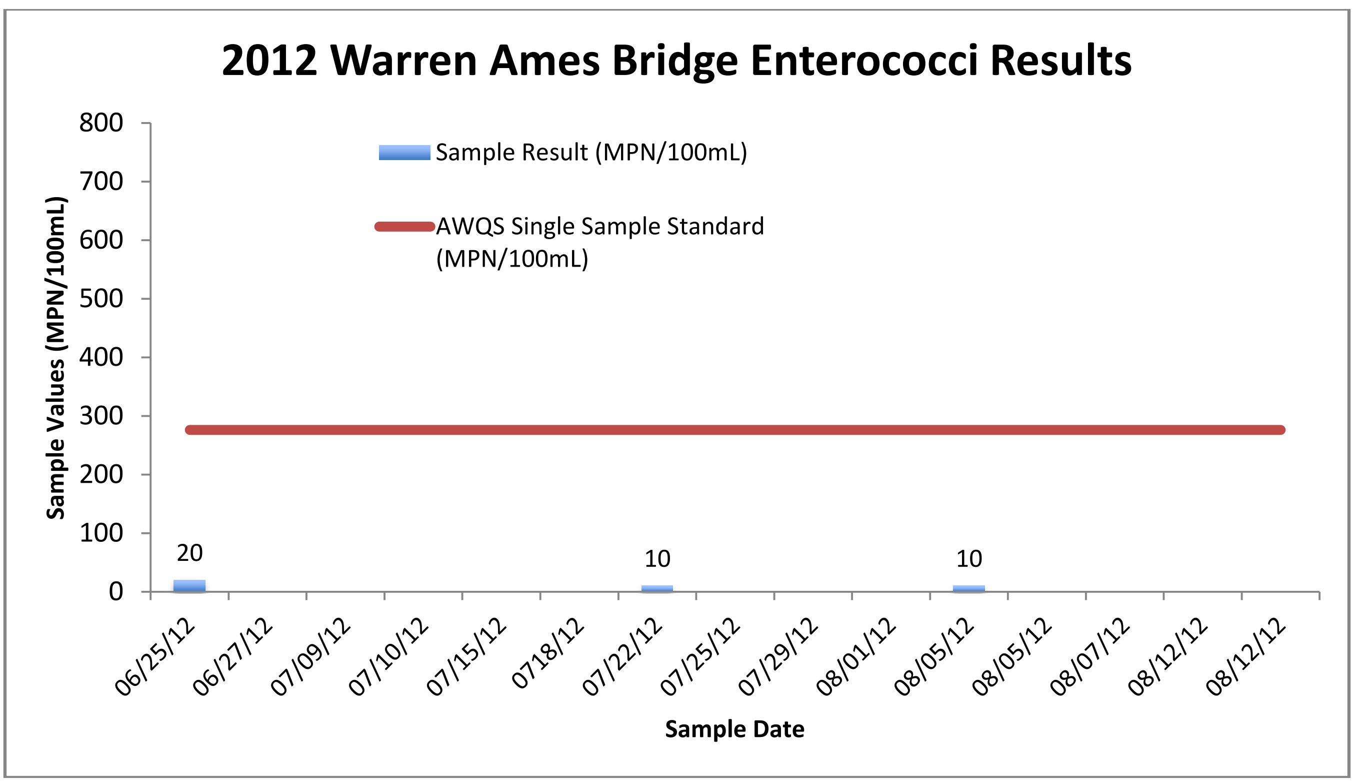
08/12/12
Sample Date


2012 Warren Ames Bridge Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
800
700
600
500
400
300
200
100
0
20
10
10
06/25/12
06/27/12
07/09/12
07/10/12
07/15/12
0718/12
07/22/12
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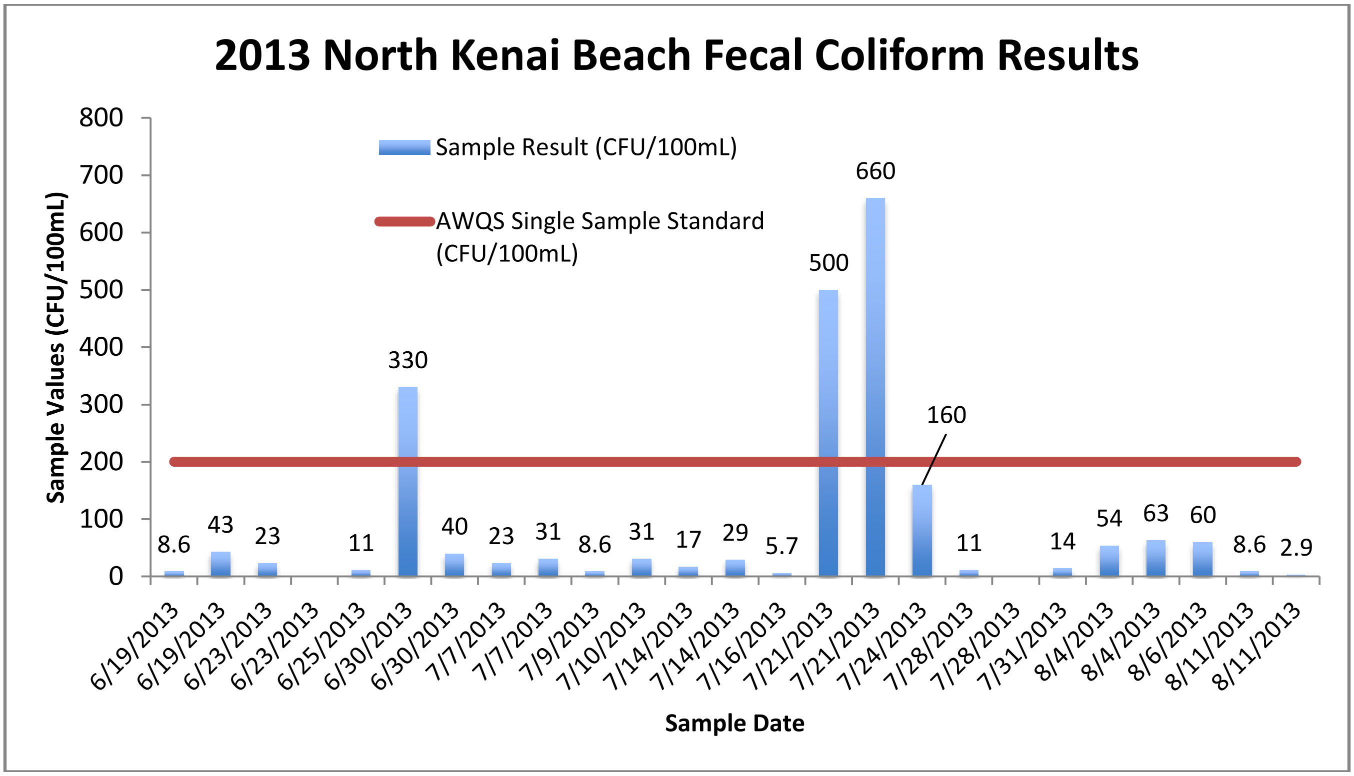
08/12/12
Sample Date


2013 North Kenai Beach Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
Sample Date
0
100
200
300
400
500
600
700
800
8.6
43
23
11
330
40
23
31
8.6
31
17
29
5.7
500
660
160
11
14
54
63
60
8.6
2.9
6/19/2013
6/19/2013
6/23/2013
6/23/2013
6/25/2013
6/30/2013
6/30/2013
7/7/2013
7/7/2013
7/9/2013
7/10/2013
7/14/2013
7/14/2013
7/16/2013
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7/21/2013
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8/6/2013
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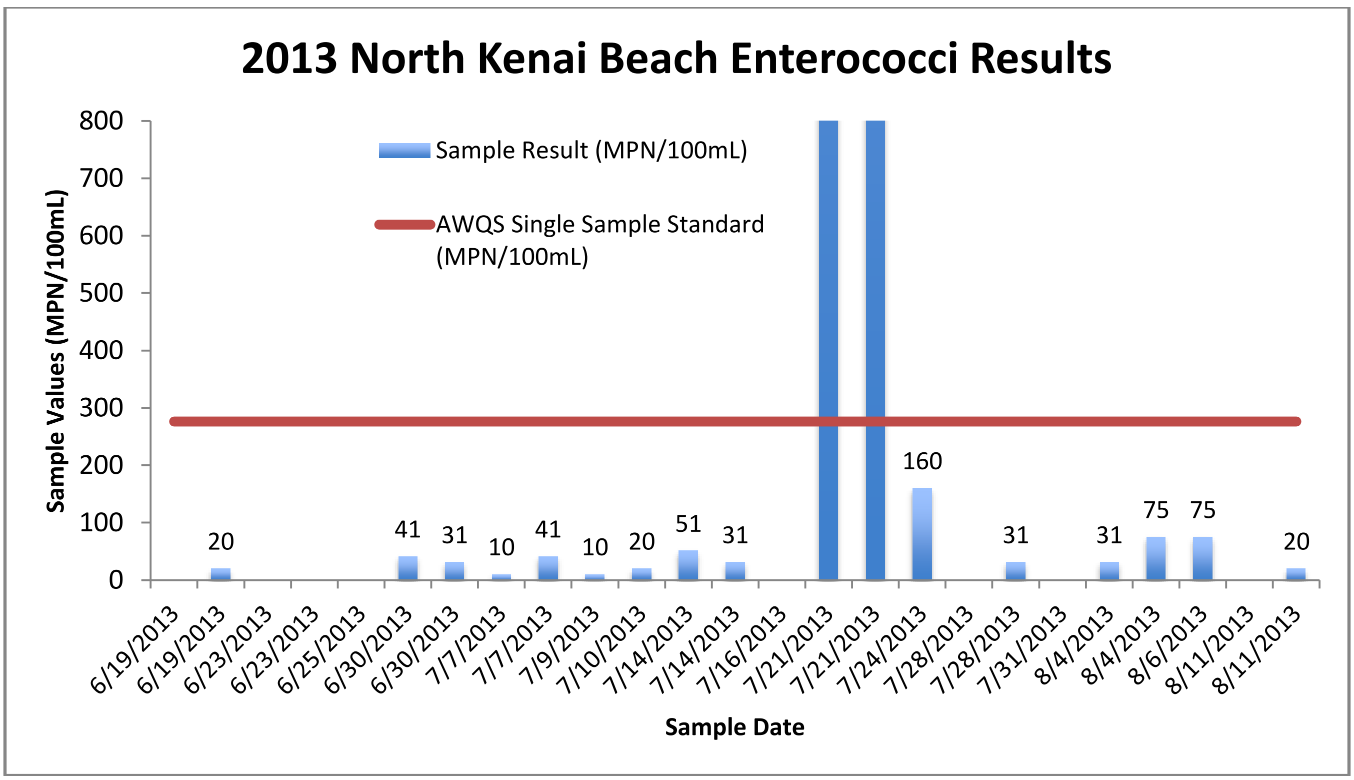
8/11/2013


2013 North Kenai Beach Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
Sample Date
0
100
200
300
400
500
600
700
800
20
41
31
10
41
10
20
51
31
160
31
31
75
75
20
6/19/2013
6/19/2013
6/23/2013
6/23/2013
6/25/2013
6/30/2013
6/30/2013
7/7/2013
7/7/2013
7/9/2013
7/10/2013
7/14/2013
7/14/2013
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7/21/2013
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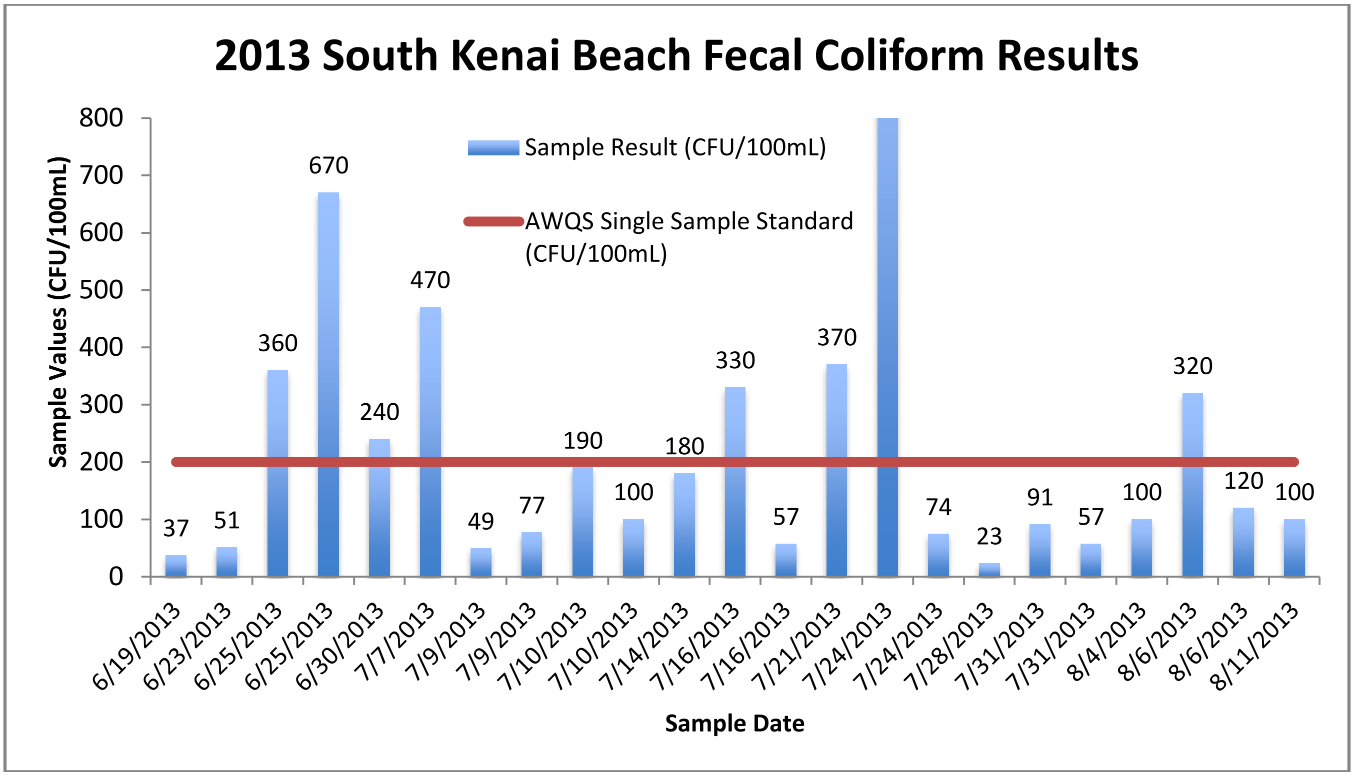
8/6/2013
8/11/2013
8/11/2013


2013 South Kenai Beach Fecal Coliform Results
Sample Values (CFU/100mL)
800
700
600
500
400
300
200
100
0
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
37
51
360
670
240
470
49
77
190
100
180
330
57
370
74
23
91
57
100
320
120
100
6/19/2013
6/23/2013
6/25/2013
6/25/2013
6/30/2013
7/7/2013
7/9/2013
7/9/2013
7/10/2013
7/10/2013
7/14/2013
7/16/2013
7/16/2013
7/21/2013
7/24/2013
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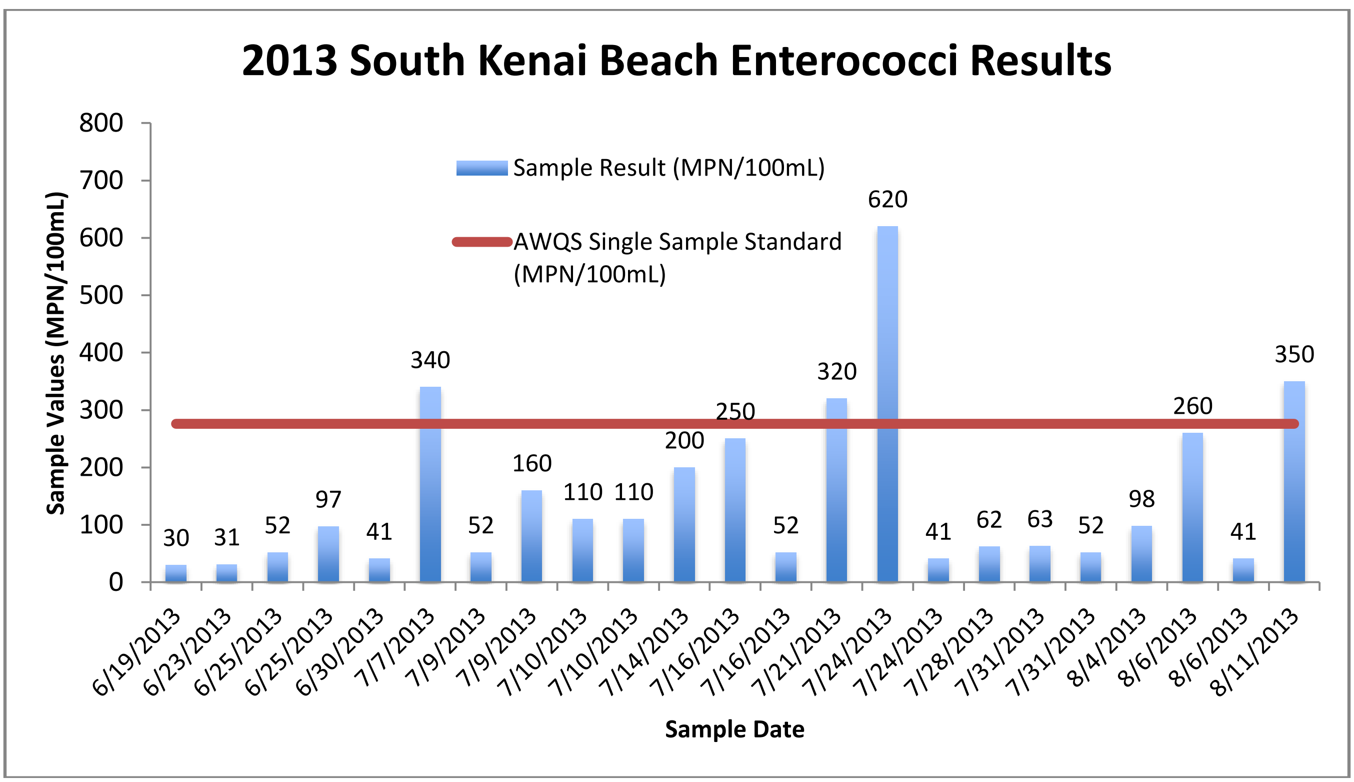
8/11/2013
Sample Date


2013 South Kenai Beach Enterococci Results
Sample Values (MPN/100mL)
800
700
600
500
400
300
200
100
0
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
30
31
52
97
41
340
52
160
110
110
200
250
52
320
620
41
62
63
52
98
260
41
350
6/19/2013
6/23/2013
6/25/2013
6/25/2013
6/30/2013
7/7/2013
7/9/2013
7/9/2013
7/10/2013
7/10/2013
7/14/2013
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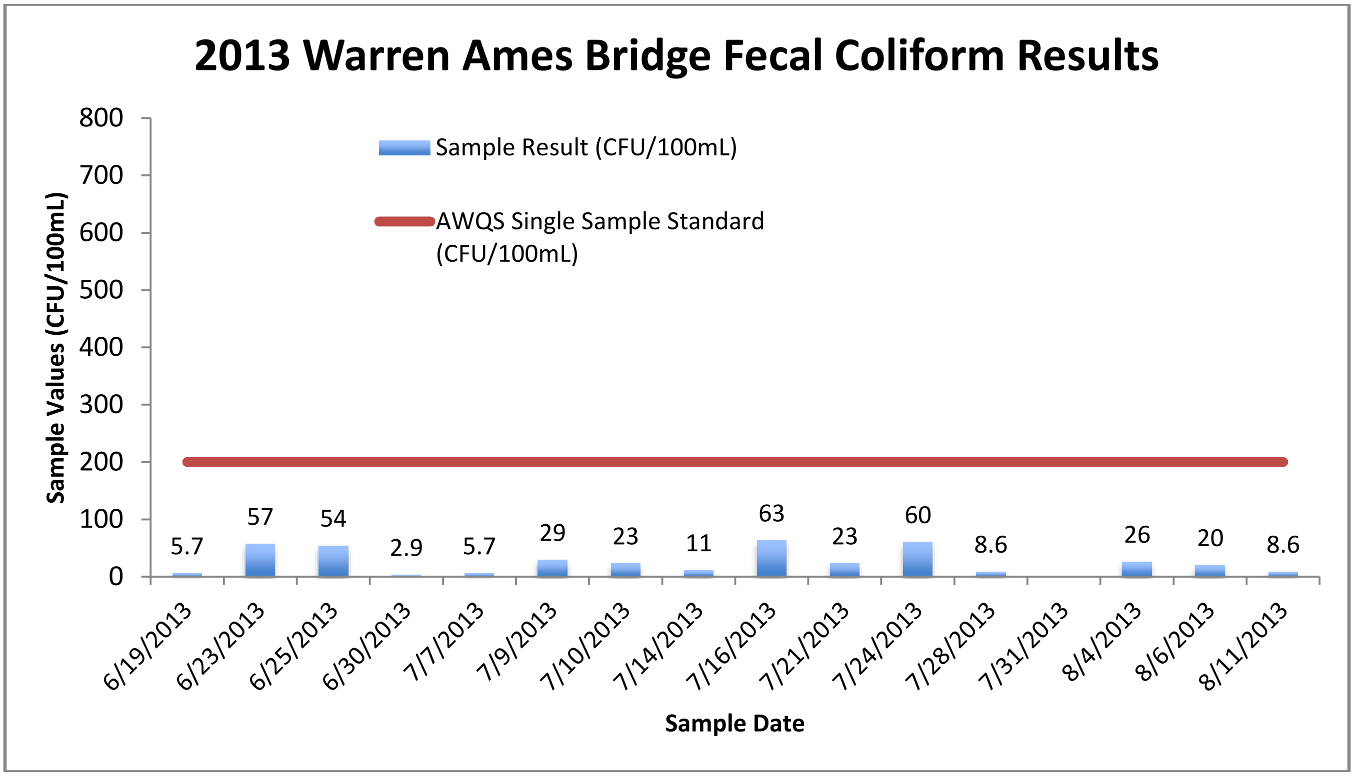
Sample Date


2013 Warren Ames Bridge Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
800
700
600
500
400
300
200
100
0
5.7
57
54
2.9
5.7
29
23
11
63
23
60
8.6
26
20
8.6
6/19/2013
6/23/2013
6/25/2013
6/30/2013
7/7/2013
7/9/2013
7/10/2013
7/14/2013
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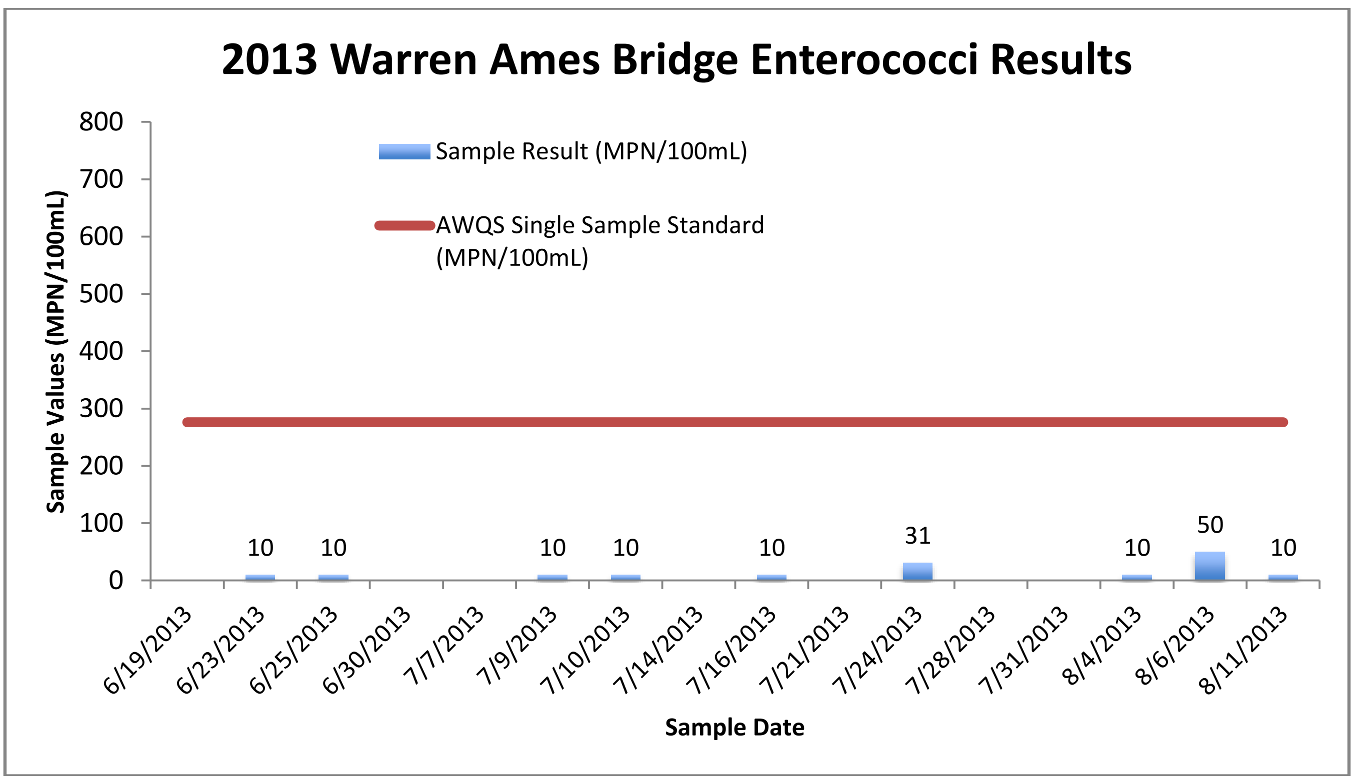
8/11/2013
Sample Date


2013 Warren Ames Bridge Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
800
700
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500
400
300
200
100
0
10
10
10
10
10
31
10
50
10
6/19/2013
6/23/2013
6/25/2013
6/30/2013
7/7/2013
7/9/2013
7/10/2013
7/14/2013
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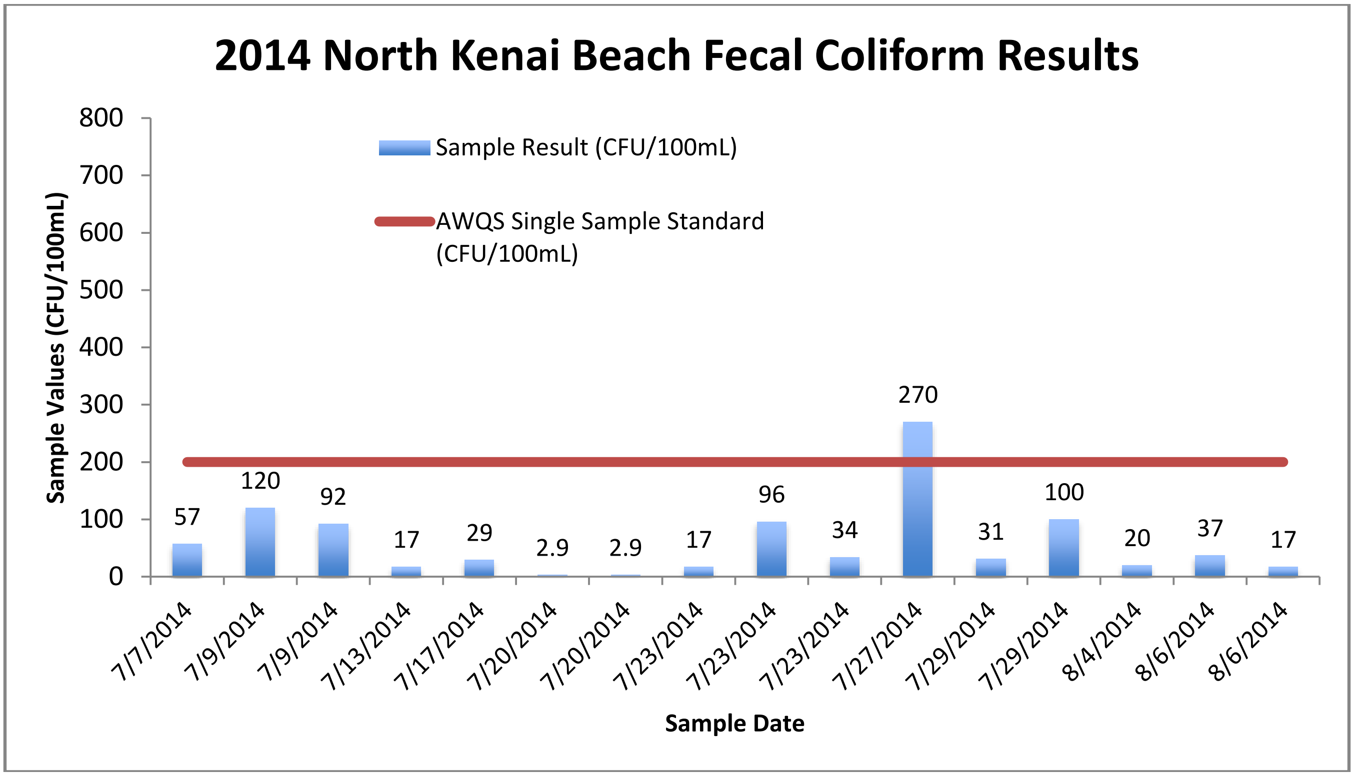
8/11/2013
Sample Date


2014 North Kenai Beach Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
800
700
600
500
400
300
200
100
0
57
120
92
17
29
2.9
2.9
17
96
34
270
31
100
20
37
17
7/7/2014
7/9/2014
7/9/2014
7/13/2014
7/17/2014
7/20/2014
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7/23/2014
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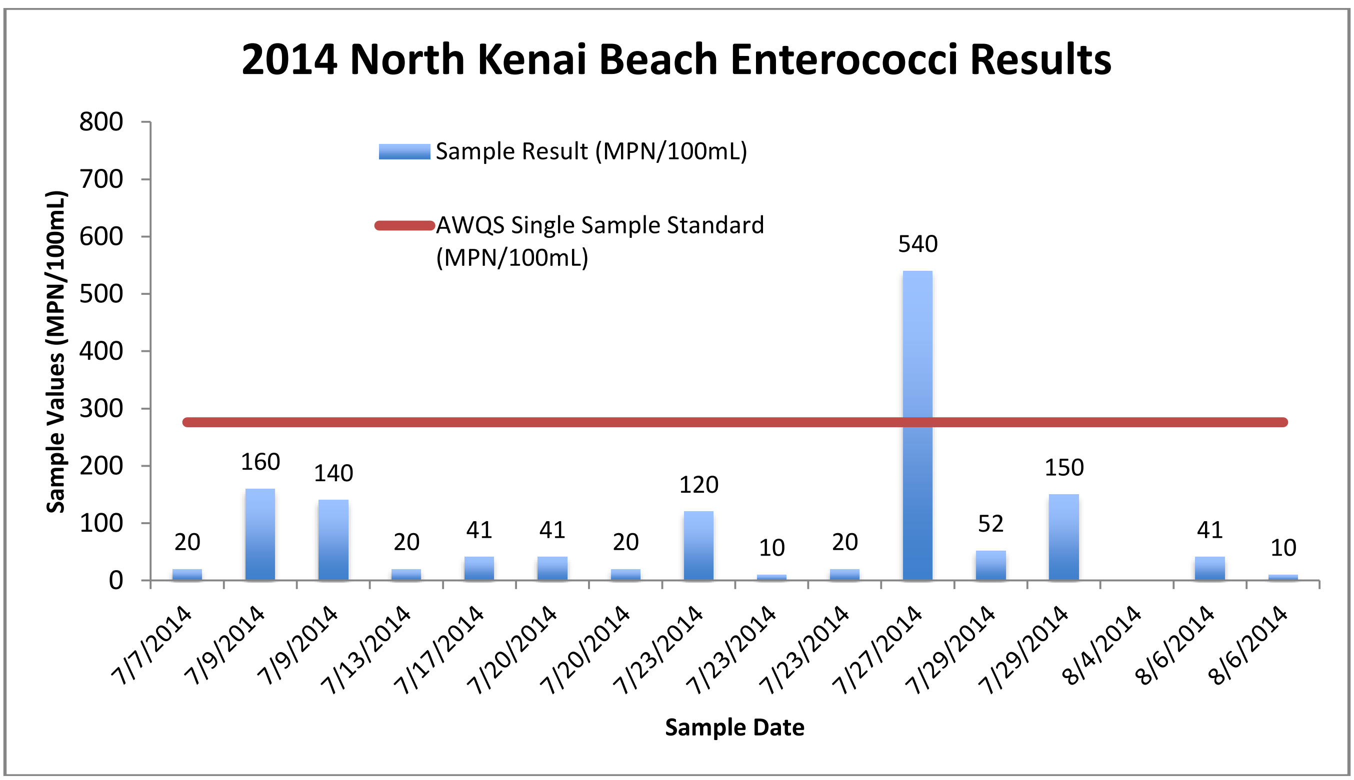
8/6/2014
8/6/2014
Sample Date


2014 North Kenai Beach Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
800
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500
400
300
200
100
0
20
160
140
20
41
41
20
120
10
20
540
52
150
41
10
7/7/2014
7/9/2014
7/9/2014
7/13/2014
7/17/2014
7/20/2014
7/20/2014
7/23/2014
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8/4/2014
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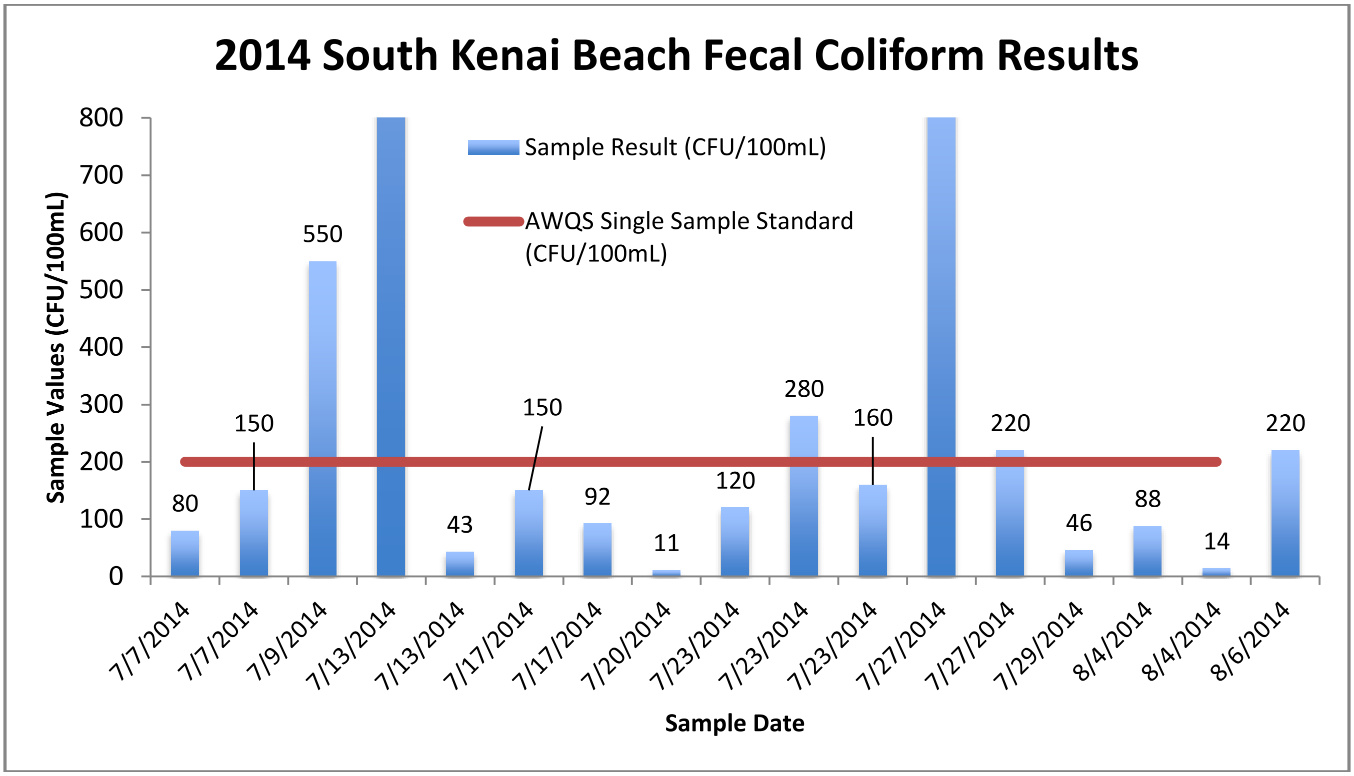
8/6/2014
Sample Date


2014 South Kenai Beach Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
0
100
200
300
400
500
600
700
800
80
150
550
43
150
92
11
120
280
160
220
46
88
14
220
7/7/2014
7/7/2014
7/9/2014
7/13/2014
7/13/2014
7/17/2014
7/17/2014
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7/23/2014
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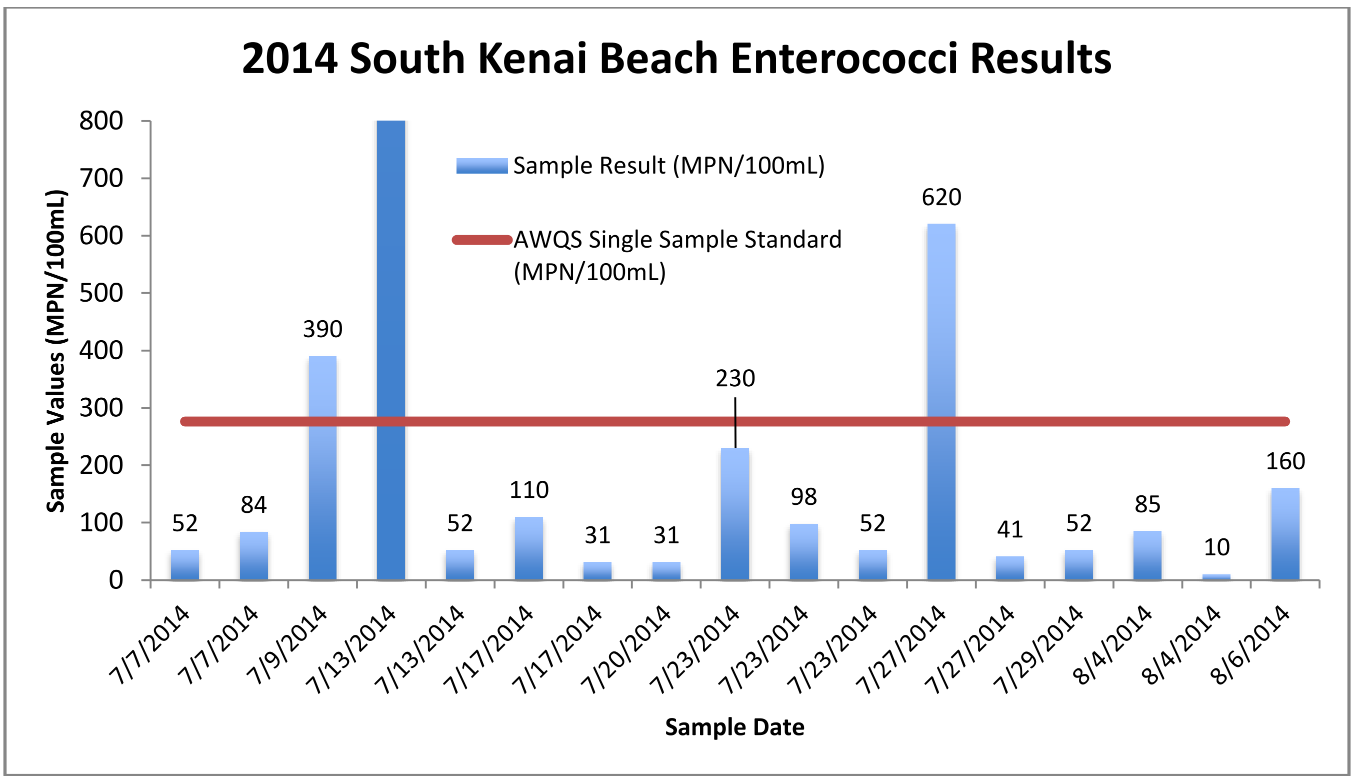
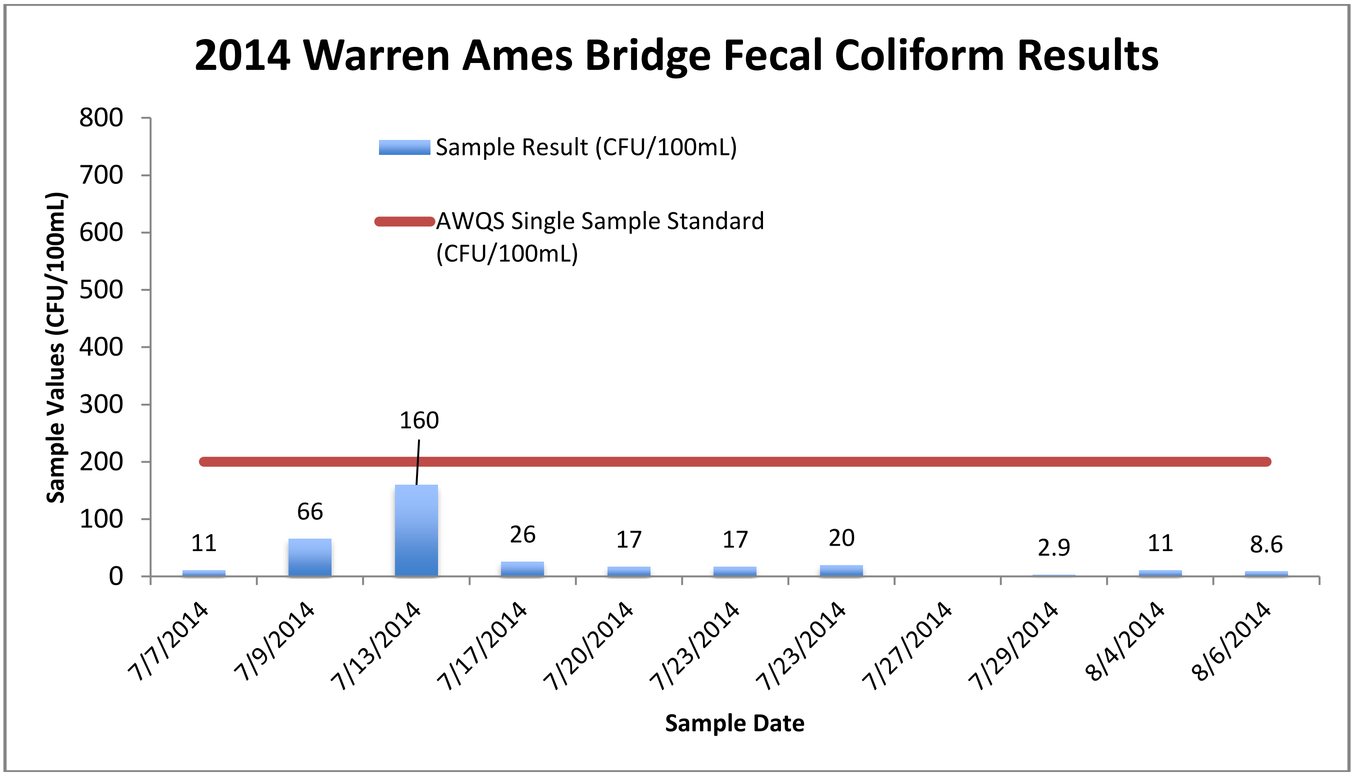
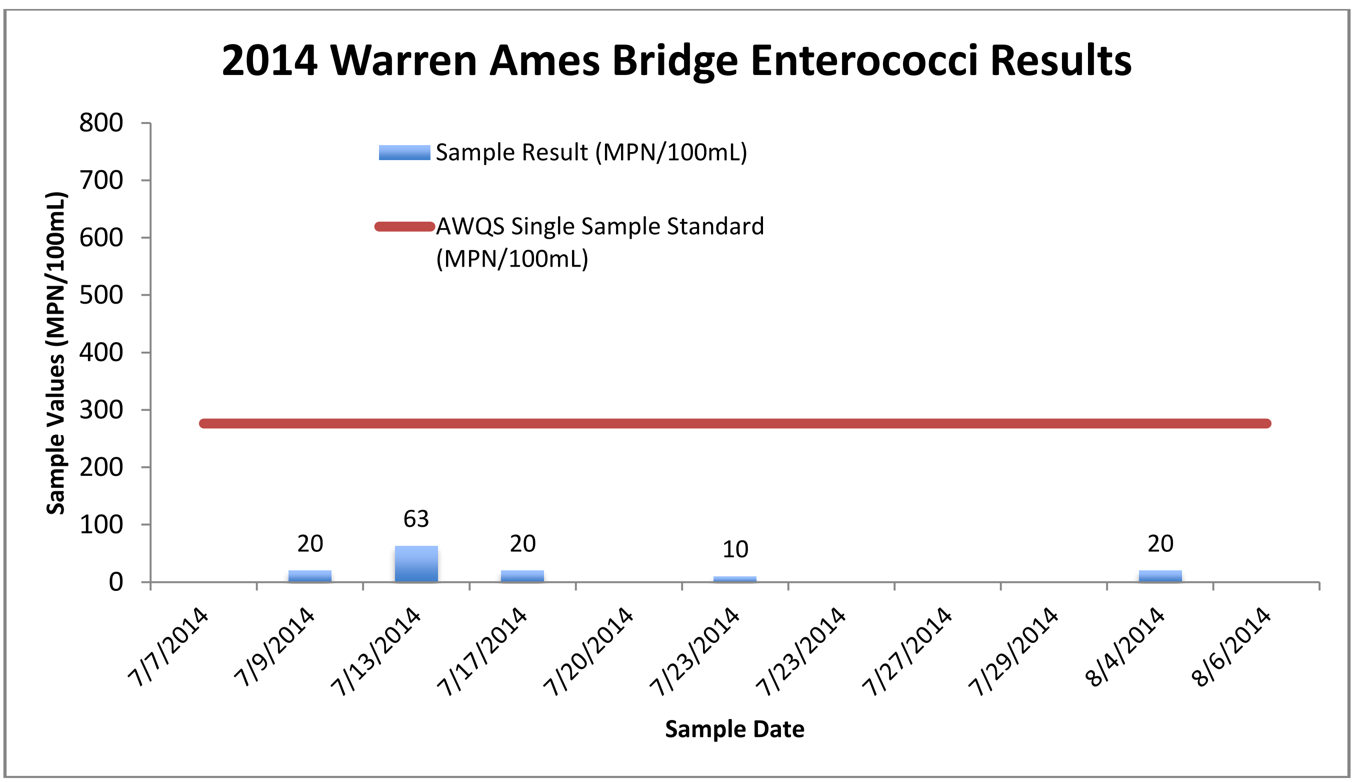
8/6/2014
Sample Date


2014 South Kenai Beach Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
0
100
200
300
400
500
600
700
800
52
84
390
52
110
31
31
230
98
52
620
41
52
85
10
160
7/7/2014
7/7/2014
7/9/2014
7/13/2014
7/13/2014
7/17/2014
7/17/2014
7/20/2014
7/23/2014
7/23/2014
7/23/2014
7/27/2014
7/27/2014
7/29/2014
8/4/2014
8/4/2014
8/6/2014
Sample Date


2014 Warren Ames Bridge Fecal Coliform Results
Sample Result (CFU/100mL)
AWQS Single Sample Standard (CFU/100mL)
Sample Values (CFU/100mL)
800
700
600
500
400
300
200
100
0
11
66
160
26
17
17
20
2.9
11
8.6
7/7/2014
7/9/2014
7/13/2014
7/17/2014
7/20/2014
7/23/2014
7/23/2014
7/27/2014
7/29/2014
8/4/2014
8/6/2014
Sample Date


2014 Warren Ames Bridge Enterococci Results
Sample Result (MPN/100mL)
AWQS Single Sample Standard (MPN/100mL)
Sample Values (MPN/100mL)
800
700
600
500
400
300
200
100
0
20
63
20
10
20
7/7/2014
7/9/2014
7/13/2014
7/17/2014
7/20/2014
7/23/2014
7/23/2014
7/27/2014
7/29/2014
8/4/2014
8/6/2014
Sample Date

APPENDIX B – OUTLIER CALCULATIONS

Date	Location	Fecal Coliform (cfu/100mL)
7/8	North Beach	73.3
7/9	North Beach	100.3
7/10	North Beach	163.3
7/11	North Beach	127.7
7/14	North Beach	67.7
7/15	North Beach	131.0
7/16	North Beach	51.5
7/17	North Beach	15.9
7/18	North Beach	5.0
7/19	North Beach	36.5
7/20	North Beach	38.3
8/1	North Beach	135.0
8/2	North Beach	66.7
8/3	North Beach	21.2
8/4	North Beach	42.0

Calculation for Determination of Outliers

1. *Find median of given dataset. In this case the median is* $66.7\,\frac{cfu}{100mL}$

2. *Calculate the first quartile (Q1) and the third quartile (Q3):*

$$Q1 = \frac{n+1}{4},\ Q3 = \frac{3(n+1)}{4},\ where\ n = the\ number\ of\ samples$$

$$Q1 = \frac{15+1}{4} = 4,\ therefore\ the\ 4th\ observation\ represents\ Q1 = 36.5\,\frac{cfu}{100mL}$$

$$Q3 = \frac{3(15+1)}{4} = 12,\ therefore\ the\ 12th\ observation\ represents\ Q1 = 127.7\,\frac{cfu}{100mL}$$

3. *Calculate the interquartile range (IQR):*

$$IQR = Q3 - Q1 = 127.7 - 36.5 = 91.7$$

4. *Determine the inner and outer fence values, which isolate minor and major outliers, respectively:*

$$Inner\ Fence = Q3 + 1.5(IQR) = 127.7 + 136.8 = 264.5\,\frac{cfu}{100mL}$$

$$Outer\ Fence = Q3 + 3(IQR) = 127.7 + 273.5 = 401.2\,\frac{cfu}{100mL}$$

There are no values greater than 264.5 in this dataset. Therefore, there are no minor or major outliers.

APPENDIX C – RESULTS BY TIDE STATUS

Date	Location	Fecal Coliform (cfu/100mL)	Enterococcus (MPN/100mL)	Tide Status
7/9/2012	North Beach	15.5	10	Low Tide
7/18/2012	North Beach	46	5	Low Tide
7/9/2012	South Beach	37	20	Low Tide
7/18/2012	South Beach	135	20	Low Tide
7/27/2011	North Beach	42.5	42.5	Low Tide
8/10/2011	North Beach	17	20	Low Tide
7/27/2011	South Beach	305	125	Low Tide
8/7/2011	South Beach	77	10	Low Tide
8/4/2013	North Beach	58.5	53	Low Tide
8/6/2013	North Beach	60	75	Low Tide
8/4/2013	South Beach	100	98	Low Tide
7/9/2014	North Beach	106	150	Ebbing Tide
7/23/2014	North Beach	96	120	Ebbing Tide
7/27/2014	North Beach	270	540	Ebbing Tide
7/9/2014	South Beach	550	390	Ebbing Tide
7/13/2014	South Beach	43	52	Ebbing Tide
7/17/2014	South Beach	121	70.5	Ebbing Tide
7/23/2014	South Beach	150	164	Ebbing Tide
7/27/2014	South Beach	220	41	Ebbing Tide
7/29/2014	South Beach	46	52	Ebbing Tide
7/6/2011	North Beach	37	10	Ebbing Tide
7/12/2011	North Beach	46	47	Ebbing Tide
7/17/2011	North Beach	63	30	Ebbing Tide
7/20/2011	North Beach	8.6	10	Ebbing Tide
7/31/2011	North Beach	44.5	295	Ebbing Tide
8/2/2011	North Beach	88	310	Ebbing Tide
8/14/2011	North Beach	105	41.5	Ebbing Tide
7/12/2011	South Beach	290	250	Ebbing Tide
7/14/2011	South Beach	475	445	Ebbing Tide
7/17/2011	South Beach	141	250	Ebbing Tide
7/31/2011	South Beach	510	530	Ebbing Tide
8/2/2011	South Beach	765	1200	Ebbing Tide
8/10/2011	South Beach	129	108.5	Ebbing Tide
8/14/2011	South Beach	1200	980	Ebbing Tide
6/25/2013	North Beach	11	5	Ebbing Tide
7/7/2013	North Beach	27	25.5	Ebbing Tide
7/10/2013	North Beach	31	20	Ebbing Tide

Date	Location	Fecal Coliform (cfu/100mL)	Enterococcus (MPN/100mL)	Tide Status
7/24/2013	North Beach	160	160	Ebbing Tide
6/25/2013	South Beach	515	74.5	Ebbing Tide
7/7/2013	South Beach	470	340	Ebbing Tide
7/10/2013	South Beach	145	110	Ebbing Tide
7/21/2013	South Beach	370	320	Ebbing Tide
7/24/2013	South Beach	637	330.5	Ebbing Tide
8/6/2013	South Beach	220	150.5	Ebbing Tide
7/20/2014	North Beach	9.95	30.5	Flooding Tide
7/23/2014	North Beach	59	15	Flooding Tide
8/4/2014	North Beach	20	5	Flooding Tide
8/6/2014	North Beach	27	25.5	Flooding Tide
7/23/2014	South Beach	160	52	Flooding Tide
8/4/2014	South Beach	51	47.5	Flooding Tide
8/6/2014	South Beach	220	160	Flooding Tide
6/25/2012	North Beach	160	120	Flooding Tide
6/27/2012	North Beach	1.45	15	Flooding Tide
7/10/2012	North Beach	8.6	10	Flooding Tide
7/15/2012	North Beach	19.95	47	Flooding Tide
7/22/2012	North Beach	9.8	23	Flooding Tide
7/25/2012	North Beach	8.6	41	Flooding Tide
7/29/2012	North Beach	8.45	15	Flooding Tide
8/5/2012	North Beach	2.9	5	Flooding Tide
8/7/2012	North Beach	2.9	5	Flooding Tide
8/12/2012	North Beach	12	20	Flooding Tide
6/25/2012	South Beach	145	170	Flooding Tide
6/27/2012	South Beach	160	75	Flooding Tide
7/10/2012	South Beach	189	137	Flooding Tide
7/15/2012	South Beach	100	52	Flooding Tide
7/22/2012	South Beach	69	98	Flooding Tide
7/25/2012	South Beach	41	20	Flooding Tide
7/29/2012	South Beach	60	20	Flooding Tide
8/1/2012	South Beach	120	74	Flooding Tide
8/5/2012	South Beach	165	230	Flooding Tide
8/7/2012	South Beach	12.8	25.5	Flooding Tide
8/12/2012	South Beach	94.3	25.5	Flooding Tide
7/24/2011	North Beach	215	720	Flooding Tide
8/7/2011	North Beach	48.5	41.5	Flooding Tide
6/19/2013	North Beach	25.8	12.5	Flooding Tide

Date	Location	Fecal Coliform (cfu/100mL)	Enterococcus (MPN/100mL)	Tide Status
6/23/2013	North Beach	12.225	5	Flooding Tide
6/30/2013	North Beach	185	36	Flooding Tide
7/14/2013	North Beach	23	41	Flooding Tide
7/31/2013	North Beach	14	5	Flooding Tide
8/11/2013	North Beach	5.75	10	Flooding Tide
6/19/2013	South Beach	37	30	Flooding Tide
6/23/2013	South Beach	51	31	Flooding Tide
6/30/2013	South Beach	240	41	Flooding Tide
7/14/2013	South Beach	180	200	Flooding Tide
7/16/2013	South Beach	193.5	151	Flooding Tide
7/28/2013	South Beach	23	62	Flooding Tide
7/31/2013	South Beach	74	57.5	Flooding Tide
8/11/2013	South Beach	100	350	Flooding Tide
7/13/2014	North Beach	29	20	High Tide
7/17/2014	North Beach	2.9	41	High Tide
7/29/2014	North Beach	65.5	101	High Tide
7/20/2014	South Beach	11	31	High Tide
7/6/2011	South Beach	33.33	52	High Tide
7/24/2011	South Beach	46	57.5	High Tide
8/4/2011	South Beach	14	128	High Tide
7/9/2013	North Beach	8.6	10	High Tide
7/16/2013	North Beach	5.7	5	High Tide
7/28/2013	North Beach	6.225	18	High Tide
7/9/2013	South Beach	63	106	High Tide

APPENDIX D – 2011 MST RESULTS

CERTIFICATE OF ANALYSIS

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WO: 84854 Samples Received: 11/15/2011 Report Date: 4/20/2012 Report No: L2.1-11R030006240

LabSample No	CustomerSampleNo	SampleDesc	CustomerComments	SampleAmount	Bacteroides MST Avian	Bacteroides MST Dog	Bacteroides MST General	Bacteroides MST Horse	Bacteroides MST Human
84854_01	SKB2-07/06/11-(1)	Filtered Water	Filter Time: 14:30	100ml	Positive	Negative	Positive	Negative	Negative
84854_02	SKB2-07/06/11-(2)	Filtered Water	Filter Time: 14:47	100ml	Positive	Negative	Positive	Negative	Negative
84854_03	SKB2-07/06/11-(3)	Filtered Water	Filter Time: 14:55	100ml	Positive	Negative	Positive	Negative	Negative
84854_04	SKB2-07/06/11-(4)	Filtered Water	Filter Time: 15:00	100ml	Positive	Negative	Negative	Negative	Negative
84854_05	SKB2-07/06/11-(5)	Filtered Water	Filter Time: 15:05	100ml	Positive	Negative	Negative	Negative	Negative
84854_06	NKB4-07/12/11-(1)-08:55	Filtered Water	Filter Time: 11:06	100ml	Positive	Negative	Positive	Negative	Negative
84854_07	NKB4-07/12/11-(2)-08:55	Filtered Water	Filter Time: 11:18	100ml	Positive	Negative	Negative	Negative	Negative
84854_08	NKB4-07/12/11-(3)-08:55	Filtered Water	Filter Time: 11:23	100ml	Positive	Negative	Positive	Negative	Negative
84854_09	NKB4-07/12/11-(4)-08:55	Filtered Water	Filter Time: 11:29	100ml	Positive	Negative	Positive	Negative	Negative
84854_10	NKB4-07/12/11-(5)-08:55	Filtered Water	Filter Time: 11:35	100ml	Positive	Negative	Positive	Negative	Negative
84854_11	NKB4-07/12/11-(c)	Filtered Water	Filter Time: 10:58	100ml	Negative	Negative	Negative	Negative	Negative
84854_12	SKB2-07/17/11-(1)-08:05	Filtered Water	Filter Time: 11:03	100ml	Positive	Negative	Positive	Negative	Negative
84854_13	SKB2-07/17/11-(2)-08:05	Filtered Water	Filter Time: 11:08	100ml	Positive	Negative	Positive	Negative	Negative
84854_14	SKB2-07/17/11-(3)-08:05	Filtered Water	Filter Time: 11:12	100ml	Positive	Negative	Positive	Negative	Negative
84854_15	SKB2-07/17/11-(4)-08:05	Filtered Water	Filter Time: 11:17	100ml	Positive	Negative	Positive	Negative	Negative
84854_16	SKB2-07/17/11-(5)-08:05	Filtered Water	Filter Time: 11:21	100ml	Positive	Negative	Positive	Negative	Negative

Friday, Apr 20 2012 16:40:53 Page 1 Of 5

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LabSample No	CustomerSampleNo	SampleDesc	CustomerComments	SampleAmount	Bacteroides MST Avian	Bacteroides MST Dog	Bacteroides MST General	Bacteroides MST Horse	Bacteroides MST Human
84854_17	SKB2-07/17/11-(c)	Filtered Water	Filter Time: 10:58	100ml	Negative	Negative	Positive	Negative	Positive
84854_18	NKB4-07/20/11-(1)-09:10	Filtered Water	Filter Time: 10:32	100ml	Negative	Positive	Positive	Negative	Negative
84854_19	NKB4-07/20/11-(2)-09:10	Filtered Water	Filter Time: 10:41	100ml	Negative	Negative	Positive	Negative	Negative
84854_20	NKB4-07/20/11-(3)-09:10	Filtered Water	Filter Time: 10:47	100ml	Negative	Negative	Positive	Negative	Negative
84854_21	NKB4-07/20/11-(4)-09:10	Filtered Water	Filter Time: 10:54	100ml	Positive	Negative	Positive	Negative	Negative
84854_22	NKB4-07/20/11-(5)-09:10	Filtered Water	Filter Time: 11:01	100ml	Positive	Negative	Positive	Negative	Negative
84854_23	NKB4-07/20/11-(c)	Filtered Water	Filter Time: 10:28	100ml	Positive	Negative	Positive	Negative	Negative
84854_24	SKB2-07/24/11-(1)-07:20	Filtered Water	Filter Time: 09:52	100ml	Positive	Negative	Positive	Negative	Positive
84854_25	SKB2-07/24/11-(2)-07:20	Filtered Water	Filter Time: 09:59	100ml	Negative	Negative	Positive	Negative	Negative
84854_26	SKB2-07/24/11-(3)-07:20	Filtered Water	Filter Time: 10:04	100ml	Positive	Negative	Positive	Negative	Negative
84854_27	SKB2-07/24/11-(4)-07:20	Filtered Water	Filter Time: 10:11	100ml	Positive	Negative	Positive	Negative	Positive
84854_28	SKB2-07/24/11-(5)-07:20	Filtered Water	Filter Time: 10:20	100ml	Positive	Negative	Positive	Negative	Negative
84854_29	SKB2-07/24/11-(c)	Filtered Water	Filter Time: 09:45	100ml	Negative	Negative	Negative	Negative	Negative
84854_30	NKB4-07/27/11-(1)-09:30	Filtered Water	Filter Time: 11:01	100ml	Positive	Negative	Positive	Negative	Negative
84854_31	NKB4-07/27/11-(2)-09:30	Filtered Water	Filter Time: 11:06	100ml	Positive	Negative	Positive	Negative	Positive
84854_32	NKB4-07/27/11-(3)-09:30	Filtered Water	Filter Time: 11:21	100ml	Positive	Negative	Positive	Negative	Negative
84854_33	NKB4-07/27/11-(4)-09:30	Filtered Water	Filter Time: 11:27	100ml	Positive	Negative	Positive	Negative	Positive

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Friday, Apr 20 2012 16:40:53 Page 2 Of 5

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LabSample No	CustomerSampleNo	SampleDesc	CustomerComments	SampleAmount	Bacteroides MST Avian	Bacteroides MST Dog	Bacteroides MST General	Bacteroides MST Horse	Bacteroides MST Human
84854_34	NKB4-07/27/11-(5)-09:30	Filtered Water	Filter Time: 11:34	100ml	Positive	Negative	Positive	Negative	Negative
84854_35	NKB4-07/27/11-(c)	Filtered Water	Filter Time: 10:54	100ml	Negative	Negative	Negative	Negative	Negative
84854_36	SKB2-07/31/11-(1)-08:55	Filtered Water	Filter Time: 10:57	100ml	Positive	Negative	Positive	Negative	Negative
84854_37	SKB2-07/31/11-(2)-08:55	Filtered Water	Filter Time: 11:06	100ml	Negative	Negative	Positive	Negative	Negative
84854_38	SKB2-07/31/11-(3)-08:55	Filtered Water	Filter Time: 11:14	100ml	Positive	Negative	Positive	Negative	Negative
84854_39	SKB2-07/31/11-(4)-08:55	Filtered Water	Filter Time: 11:21	100ml	Positive	Negative	Positive	Negative	Negative
84854_40	SKB2-07/31/11-(5)-08:55	Filtered Water	Filter Time: 11:32	100ml	Positive	Negative	Positive	Negative	Negative
84854_41	SKB2-07/31/11-(c)	Filtered Water	Filter Time: 10:52	100ml	Negative	Negative	Negative	Negative	Negative
84854_42	NKB4-08/02/11-(1)-09:40	Filtered Water	Filter Time: 11:36	100ml	Positive	Positive	Positive	Negative	Negative
84854_43	NKB4-08/02/11-(2)-09:40	Filtered Water	Filter Time: 11:42	100ml	Positive	Negative	Positive	Negative	Negative
84854_44	NKB4-08/02/11-(3)-09:40	Filtered Water	Filter Time: 11:47	100ml	Positive	Negative	Positive	Negative	Negative
84854_45	NKB4-08/02/11-(4)-09:40	Filtered Water	Filter Time: 11:54	100ml	Positive	Negative	Positive	Negative	Negative
84854_46	NKB4-08/02/11-(5)-09:40	Filtered Water	Filter Time: 12:00	100ml	Positive	Negative	Positive	Negative	Negative
84854_47	NKB4-08/02/11-(c)	Filtered Water	Filter Time: 11:29	100ml	Negative	Negative	Negative	Negative	Negative
84854_48	SKB2-08/07/11-(1)-06:55	Filtered Water	Filter Time: 09:29	100ml	Positive	Negative	Positive	Negative	Negative
84854_49	SKB2-08/07/11-(2)-06:55	Filtered Water	Filter Time: 09:32	100ml	Negative	Negative	Positive	Negative	Negative
84854_50	SKB2-08/07/11-(3)-06:55	Filtered Water	Filter Time: 09:37	100ml	Positive	Negative	Positive	Negative	Negative

Friday, Apr 20 2012 16:40:53

Page 3 Of 5

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LabSample No	CustomerSampleNo	SampleDesc	CustomerComments	SampleAmount	Bacteroides MST Avian	Bacteroides MST Dog	Bacteroides MST General	Bacteroides MST Horse	Bacteroides MST Human
84854_51	SKB2-08/07/11-(4)-06:55	Filtered Water	Filter Time: 09:41	100ml	Positive	Negative	Positive	Negative	Negative
84854_52	SKB2-08/07/11-(5)-06:55	Filtered Water	Filter Time: 09:44	100ml	Positive	Negative	Positive	Negative	Negative
84854_53	SKB2-08/07/11-(c)	Filtered Water	Filter Time: 09:26	100ml	Negative	Negative	Negative	Negative	Negative
84854_54	NKB4-08/10/11-(1)-09:15	Filtered Water	Filter Time: 10:38	100ml	Positive	Negative	Positive	Negative	Negative
84854_55	NKB4-08/10/11-(2)-09:15	Filtered Water	Filter Time: 10:41	100ml	Negative	Negative	Positive	Negative	Negative
84854_56	NKB4-08/10/11-(3)-09:15	Filtered Water	Filter Time: 10:45	100ml	Negative	Negative	Positive	Negative	Negative
84854_57	NKB4-08/10/11-(4)-09:15	Filtered Water	Filter Time: 10:51	100ml	Negative	Negative	Positive	Negative	Negative
84854_58	NKB4-08/10/11-(5)-09:15	Filtered Water	Filter Time: 10:54	100ml	Positive	Negative	Positive	Negative	Negative
84854_59	NKB4-08/10/11-(c)	Filtered Water	Filter Time: 10:34	100ml	Negative	Negative	Negative	Negative	Negative
84854_60	SKB2-08/14/11-(1)-07:15	Filtered Water	Filter Time: 10:11	100ml	Positive	Negative	Positive	Negative	Negative
84854_61	SKB2-08/14/11-(2)-07:15	Filtered Water	Filter Time: 10:15	100ml	Positive	Negative	Positive	Negative	Negative
84854_62	SKB2-08/14/11-(3)-07:15	Filtered Water	Filter Time: 10:20	100ml	Positive	Negative	Positive	Negative	Negative
84854_63	SKB2-08/14/11-(4)-07:15	Filtered Water	Filter Time: 10:24	100ml	Positive	Negative	Positive	Negative	Negative
84854_64	SKB2-08/14/11-(5)-07:15	Filtered Water	Filter Time: 10:28	100ml	Positive	Negative	Positive	Negative	Negative
84854_65	SKB2-08/14/11-(c)	Filtered Water	Filter Time: 10:07	100ml	Negative	Negative	Negative	Negative	Negative
84854_66	NKB4-10/03/11-(1)-08:45	Filtered Water	Filter Time: 11:41	100ml	Positive	Negative	Positive	Negative	Negative
84854_67	NKB4-10/03/11-(2)-08:45	Filtered Water	Filter Time: 11:48	100ml	Negative	Negative	Positive	Negative	Negative

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Page 4 Of 5

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LabSample No	CustomerSampleNo	SampleDesc	CustomerComments	SampleAmount	Bacteroides MST Avian	Bacteroides MST Dog	Bacteroides MST General	Bacteroides MST Horse	Bacteroides MST Human
84854_68	NKB4-10/03/11-(3)-08:45	Filtered Water	Filter Time: 11:55	100ml	Negative	Negative	Positive	Negative	Negative
84854_69	NKB4-10/03/11-(4)-08:45	Filtered Water	Filter Time: 11:57	100ml	Negative	Negative	Positive	Negative	Negative
84854_70	NKB4-10/03/11-(5)-08:45	Filtered Water	Filter Time: 12:01	100ml	Negative	Negative	Positive	Negative	Negative
84854_71	NKB4-10/03/11-(c)	Filtered Water	Filter Time: 11:35	100ml	Negative	Negative	Negative	Negative	Negative

Test Method: <*> Bacteroides MST Avian = Bacteroides MST Avian Applied and Enviromental Microbiology Oct. 2000 p.4571-4574 Vol 66 No.10 <*> Bacteroides MST Dog = Bacteroides MST Dog Applied and Enviromental Microbiology Oct. 2000 p.4571-4574 Vol 66 No.10 <*> Bacteroides MST General = Bacteroides MST General Applied and Enviromental Microbiology Oct. 2000 p.4571-4574 Vol 66 No.10 <*> Bacteroides MST Horse = Bacteroides MST Horse Applied and Enviromental Microbiology Oct. 2000 p.4571-4574 Vol 66 No.10 <*> Bacteroides MST Human = Bacteroides MST Human Applied and Enviromental Microbiology Oct. 2000 p.4571-4574 Vol 66 No.10

Authorized Analyst Kristina Tenney

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Friday, Apr 20 2012 16:40:53

Page 5 Of 5