2013-2017 Valdez Marine Terminal Water Quality Data Review

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Terminal Operations and Environmental Monitoring Committee

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Prince William Sound RCAC Regional Citizens' Advisory Council

Contents

Acronyms

ADEC - Alaska Department of Environmental Conservation
Alyeska - Alyeska Pipeline Service Company
ANS - Alaska North Slope
APDES - Alaska Pollutant Discharge Elimination System
ATC - Alaska Tanker Company (BP)
BOD - Biological Oxygen Demand
BTEX - Benzene, Toluene, Ethylbenzene, Xylene
BTT - Biological Treatment Tank
BWTF - Ballast Water Treatment Facility
CFU - Colony Forming Unit
CWA - Clean Water Act
DAF - Dissolved Air Floatation
DMR - Discharge Monitoring Report
ECHO - Enforcement and Compliance History Online
EPA - United States Environmental Protection Agency
GPD - Gallons per Day
LTEMP - Long Term Environmental Monitoring Program
mg/L - Milligrams per Liter
MGD - Million Gallons Daily
NPDES - National Pollutant Discharge Elimination System
OSG - Overseas Shipholding Group
PAH - Polycyclic Aromatic Hydrocarbon
Polar - ConocoPhillips Polar Tankers
PSD - Passive Sampling Device
PWSRCAC - Prince William Sound Regional Citizens' Advisory Council
SeaRiver - SeaRiver Maritime (ExxonMobile)
STP - Sewage Treatment Plant
TAH - Total Aromatic Hydrocarbons
TAPS - Trans-Alaska Pipeline System
TAqH - Total Aqueous Hydrocarbons
TOEM - Terminal Operations and Environmental Monitoring
TSS - Total Suspended Solids
TU - Toxic Unit
ug/L - Micrograms per Liter
VMT - Valdez Marine Terminal
WET - Whole Effluent Toxicity

Introduction

The purpose of this report is to provide information that will help identify potential or actual problems pertaining to the operation and maintenance of the Valdez Marine Terminal's (VMT) Ballast Water Treatment Facility (BWTF) and Sewage Treatment Plant (STP). This report is intended to help inform the Terminal Operations and Environmental Monitoring (TOEM) Committee's review of the VMT's water quality permit, which is currently in the process of being renewed. The information provided herein focuses on water quality data gathered and reported by Alyeska Pipeline Service Company (Alyeska) to the Alaska Department of Environmental Conservation (ADEC) and the U.S. Environmental Protection Agency (EPA) from 2013-2017. The current water quality permit was originally valid for that period of time, although an extension of that permit has been granted by ADEC while it is being renewed (such permit extensions are common and allowable under ADEC regulations). The VMT's water quality permit was last renewed in 2012, became effective in 2013, and expired on December 31, 2017, but is still in force per the previously mentioned ADEC-granted extension (U.S. EPA, 2012).

At the time of the last permit renewal, the EPA was the regulatory agency in charge of issuing, renewing, reviewing, and enforcing the terms of the VMT's water quality permit, but since then ADEC has taken over those responsibilities. This is not unusual; many states run their own water quality permitting program, and the Clean Water Act (CWA) allows states to do so as long as they adhere to the requirements of the CWA. In environmentally meaningful respects, this change in permitting authority should have no impact on the VMT's water quality permit aside from some minor administrative changes. For example, under the EPA the permit was formally called the National Pollutant Discharge Elimination System (NPDES) Permit, but under ADEC it will be called the Alaska Pollutant Discharge Elimination System (APDES) Permit.

Two sources of effluent are governed by the VMT's water quality permit. One is from the BWTF and the other is the STP. Far more effluent is discharged from the BWTF than from the STP. The actual average and maximum monthly flow from the BWTF is three orders of magnitude larger than the effluent flow from the STP (millions of gallons versus thousands of gallons daily). Flow data and summary statistics for both of those effluent sources is provided later in this report. Historically, the water quality of the BWTF's effluent has been of higher concern to Prince William Sound Regional Citizens' Advisory Council (PWSRCAC). For example, PWSRCAC's comments submitted during the last renewal of the VMT's water quality permit in 2012 focused almost exclusively on the BWTF (Payne, Driskell, & Kalmar, 2012). The quality of the BWTF effluent has been of higher concern to

PWSRCAC because it contains various hydrocarbon compounds including markedly toxic aromatic and polycyclic aromatic hydrocarbons (PAHs). The sources of those hydrocarbons include crude oil from various VMT operational (e.g. draining down loading arms after tanker loading) and maintenance activities (e.g. cleaning PIGs after pipeline runs), and dirty ballast water delivered from tanker ships. Detailed information regarding the two sources of wastewater effluent at the VMT, as well as dirty ballast water deliveries, is provided in subsequent sections of this report.

Methodology

The effluent water quality data analyzed in this report came from Alyeska and the EPA. Alyeska's paper Discharge Monitoring Reports (DMRs), sent monthly to ADEC, provided the data ranging from January 2013 through June 2017. The Council has stored all of those DMRs in their document management system, and DMR data has been extracted and stored in a spreadsheet. Beginning with July 2017, all of the remaining discharge monitoring data was obtained from the EPA's Enforcement and Compliance History Online (ECHO) web portal. Starting in 2017, an EPA regulation required facilities like the VMT to report their effluent water quality data electronically instead of filing paper reports. The purpose of that regulation is to "save time and resources for permittees, states, tribes, territories, and the U.S. Government while increasing data accuracy, improving compliance, and supporting EPA's goal of providing better protection of the nation's waters." [1] VMT water quality data from the ECHO portal will continue to be stored by PWSRCAC in a spreadsheet for easy access and analysis.

The ballast water delivery data was obtained from Alyeska's Vessels Nearby Schedule. This is a report the Council receives at least daily from Alyeska and includes information pertaining to tanker ship arrival and departure from the VMT, as well as crude oil cargo loading and ballast water delivery volumes.

[1] The EPA's final regulation was published on 10/22/2015 in the Federal Register. Document Citation: 80 FR 64063-64158.

Ballast Water Treatment Facility Effluent

This section of the report is focused on the water quality of the treated wastewater discharged from the BWTF from 2013 through 2017. Table 1 lists the water quality constituents that Alyeska is currently required to monitor in the BWTF's effluent. While Alyeska is required to monitor all the chemical, physical, and biological parameters listed in Table 1, permit limitations only apply for the constituents listed in Table 2. Table 3 lists state water quality standards relevant to the BWTF effluent. The standards in Table 3 must be met either at the "end of pipe" or at the edge of a mixing zone granted to a source of wastewater (mixing zones are described in more detail later). The following subsections focus on the water quality constituents listed in Table 2 but also on two other constituents particularly relevant to the potential environmental impacts of the VMT – total aqueous aromatic hydrocarbons (TAqH) and whole effluent toxicity (WET) testing.

Table 1. Ballast Water Treatment Facility water quality monitoring requirements (Source: current VMT Water Quality Permit).

Parameter	Sampling Method	Collection Frequency	Reported Values
Flow	Meter	Continuous	Average monthly and maximum daily; *MGD*
pH	Meter	Continuous	Maximum, Minimum, and all exceedances; *s.u.*
Total Suspended Solids (TSS)	24-hour composite	3 times/week	Average monthly and maximum daily; *mg/L*
Total Aromatic Hydrocarbons (TAH)	Grab	Weekly	Average monthly and maximum daily; *mg/L*
Total Aqueous Hydrocarbons (TAqH)	Grab	Weekly	Concentration; *mg/L*
Total Recoverable Oil and Grease	Grab	Monthly	Concentration; *mg/L*
Density	Meter	Monthly	Average monthly and maximum daily; *sigma t*
Dissolved Inorganic Phosphorus	Grab	Quarterly	Concentration; *mg/L as P*
Ammonia	Grab	Quarterly	Concentration; *mg/L as N*
Total Recoverable Zinc	24-hour composite	Twice annually	Concentration; *mg/L*
Chronic Whole Effluent Toxicity (WET)[2]	Grab	Quarterly	Report; TU_C

[2] TU means toxic unit.

Table 2. BWTF permit limits (Source: current VMT Water Quality Permit).

Parameter	Average Monthly Limit	Maximum Daily Limit	Sampling Method and Frequency
Flow	5.54 MGD	10.1 MGD	Calculation or Meter; Continuous
pH[3]	6.0 s.u. – 8.5 s.u. at all times		Meter; Continuous
Total Suspended Solids (TSS)[4]	25 mg/L	40 mg/L	24-hour composite; 3/week
Total Suspended Solids (TSS)[5]	--	170 mg/L	
Total Aromatic Hydrocarbons (TAH)[6]	0.21 mg/L	0.73 mg/L	Grab; weekly
	9.7 lb./day	61.5 lb./day	

Table 3. Alaska water quality standards applicable to BWTF's effluent. All of the standards in this table must be met at the edge of the BWTF's mixing zone (Source: ADEC. February 5, 2017. Alaska Water Quality Standards. 18 AAC 70).

Parameter	Beneficial Use	Standard
Total Aromatic Hydrocarbons (TAH)	Water supply for aquaculture	10 ug/L
Total Aqueous Hydrocarbons (TAqH)	Water supply for aquaculture	15 ug/L
pH	Water supply for seafood processing and contact water recreation (e.g. swimming)	Range of 6.0 – 8.5
Chronic Whole Effluent Toxicity (WET)	All waters.	1.0 chronic toxic unit (TU_C)

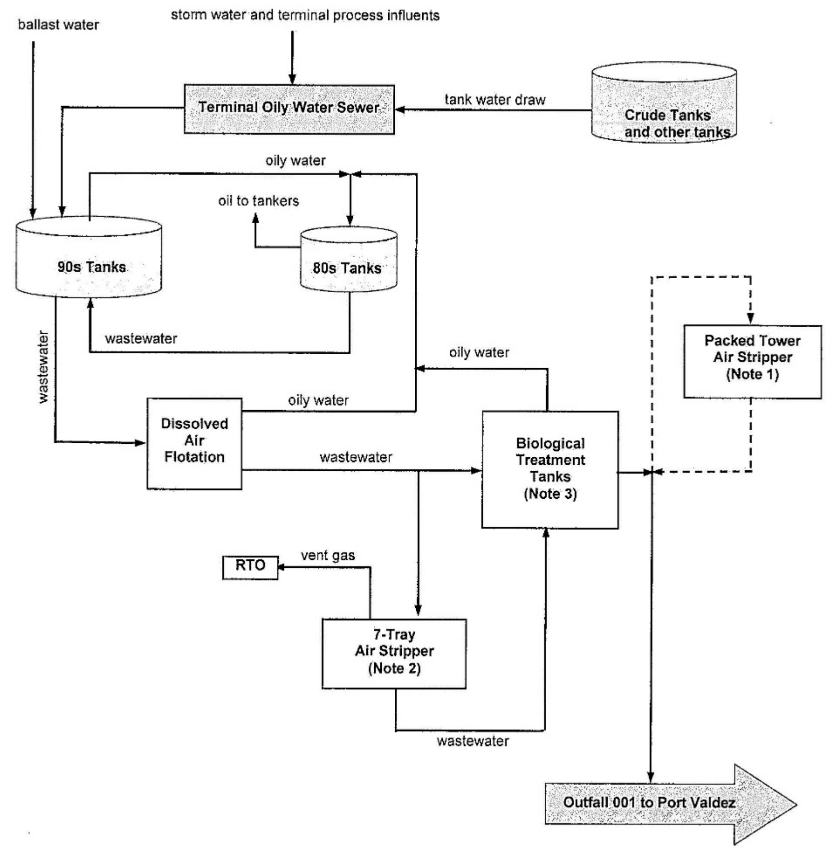
[3] Some excursions from this range are allowed by the permit, "excursions between 5.0 and 6.0, or 8.5 and 9.5 shall not be considered violations provided no single excursion exceeds 60 minutes in length and total excursions do not exceed 7 hours and 26 minutes per month. Any excursions below 5.0 and above 9.5 are violations (U.S. EPA, 2012)."

[4] These are TSS limitations applicable to the normal operation of the BWTF, excluding the use of the Packed Tower Air Strippers.

[5] This is a TSS limitation applicable only on the "day of and day after BTT effluent" Packed Tower Air Stripper operation.

[6] TAH includes the combined concentration of the isomers of benzene, toluene, ethylbenzene, and xylene (BTEX).

Before providing details related to the water quality of the BWTF's effluent, Figure 1 has been included to provide context regarding how the BWTF normally works. Figure 1 highlights the typical four-step process used to treat ballast and other oily wastewater collected at the VMT. The first step involves gravity separation in the 90's Tanks. Oil that rises to the top of the 90's Tanks is skimmed off and piped to Recovered Crude Tank 80. That oil is then pumped up into a storage tank in the East Tank Farm. Water from the bottom of the 90's Tanks is mixed with plastic beads, which enhance oil removal efficiency, and piped into one of the two Dissolved Air Flotation (DAF) Cells. The DAF Cells represent the second step in the normal treatment process, and there wastewater is combined with "micro-bubbles of air to enhance oil separation" and recirculated in those cells as necessary (Alyeska, 2017). The third step involves routing wastewater from the DAF Cells through the 7-Tray Air Strippers located inside the BWTF Building. Waste gas, containing hydrocarbon vapors, collected from those air strippers and the DAF Cells is sent to Regenerative Thermal Oxidizers (RTOs) for incineration. The last step in the normal treatment process involves the usage of one of two Biological Treatment Tanks (BTTs). In the BTTs, microbes degrade any remaining hydrocarbons in the wastewater. After being processed in the BTTs, the BWTF effluent is normally discharged into Port Valdez.



Notes
1. Packed tower air stripper used as needed following biological treatment tanks (BTTs).
2. 7-Tray air strippers used to supplement biological treatment.
3. Two biological treatment tanks (BTTs) with one typically in operation and one in standby.

Figure 1. Simplified diagram of the Ballast Water Treatment Facility process (Alyeska, 2017).

If, after treatment in the BTTs, Alyeska is unable to meet the BWTF effluent water limits listed in Table 2, Alyeska can use additional treatment steps to ensure the discharged effluent will meet permitted water quality requirements. For example, Alyeska can run wastewater from the BTTs to the Packed Tower Air Strippers shown in Figure 1 to further reduce the hydrocarbon content of the wastewater. However, this is rarely, if ever, done; data from 2013-2017 indicates that Alyeska operated the Packed Tower Air Strippers once in that time period, in October 2013, for a total of 44 hours and 26 minutes (Alyeska, 2013).

Figure 2 has been included to provide context regarding where the BWTF effluent is discharged into Port Valdez, as well as the Sewage Treatment Plant (STP). The BWTF's effluent is discharged from a plastic pipe about 1000 ft. offshore from the VMT at a depth of 236 ft. (Alyeska, 2017). The last 200 ft. section of that pipe is called a diffuser. The diffuser is a section of the pipe with a number of engineered holes in it that allow for the BWTF's effluent to be discharged in a spread out manner;

this enables better mixing and dilution. There are 20 holes in the BWTF's diffuser, ranging from about 4-5 inches in diameter. Also depicted or noted in Figure 2 are mixing zones for each outfall. A mixing zone is a permitted area that allows for dilution to occur in order to meet state water quality standards at the edge of the mixing zone. Of note, the current mixing zone applicable to the BWTF's effluent is about 164 ft. (50 meters), in all directions, centered on the diffuser; that is accurately depicted in Figure 2 (see the rectangle drawn around Outfall 001). However, the mixing zone applicable to the other VMT effluent source, the Sewage Treatment Plant (STP) is not accurately described in Figure 2. The STP's mixing zone in the current permit is a radius of approximately one foot (0.32 meters) in all directions from the STP's single-port diffuser, not 33 feet (10 meters) as noted in Figure 2. The STP's effluent is discharged through a pipe with a single, 4-inch (10 cm) diameter hole (aka single-port diffuser), at a depth of about 40 feet.

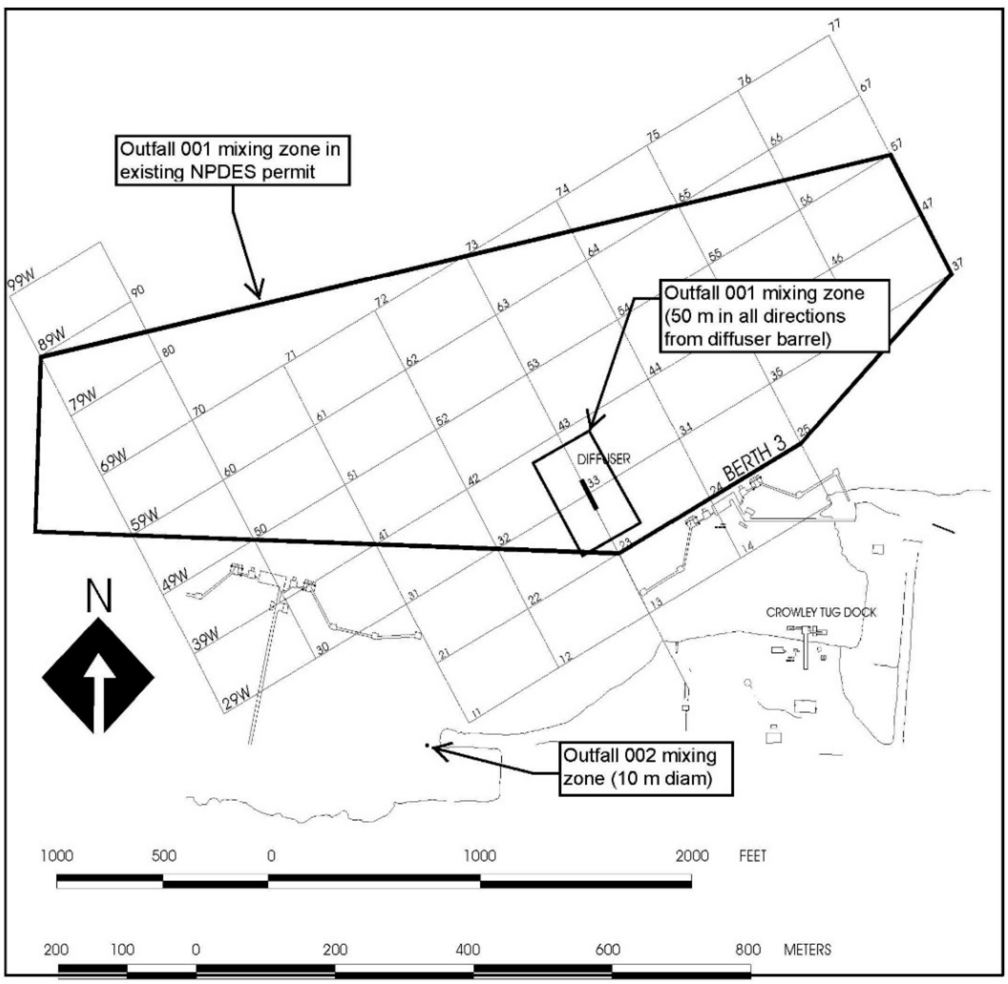


Figure 2. Diagram of mixing zone for Outfall 001 and Outfall 002. Current mixing zone is also shown for comparison (Alyeska, 2017).

In addition to the BWTF's effluent water quality information, this section also includes data related to the volumes of dirty ballast water delivered to the VMT from 2013 through 2017. This data is provided to the reader in order to give a sense of how much dirty ballast has been and is being treated by the BWTF.

Ballast Water Deliveries

Compared to historic averages, very little dirty tanker ship ballast water is currently being treated at the BWTF. For example, during peak pipeline throughput in the late 1980's the average annual effluent flow from the BWTF was more than 15 million gallons daily (MGD), but in 2017 the average annual flow from the BWTF was less than 1 MGD (Bureau of Land Managment, 2002). That large historic decrease in BWTF flow can be attributed to a decrease in the frequency of tanker ship dirty ballast deliveries over time and because the entire TAPS tanker fleet is now double-hulled, meaning they don't normally need to store ballast water in their crude oil storage tanks. At times of particularly heavy weather at sea, tankers will still load additional ballast water into their crude tanks, and this will get deposited at the VMT for processing in the BWTF.

From 2014 through 2017 there has been a downward trend in ballast water delivered to the VMT. Figure 3 depicts the trend in ballast water deliveries from 2014-2017 (2013 data is available but had not been compiled at the time of this writing). A number of factors could be causing the negative trend shown in Figure 3, including a change in the tanker ship fleet, a change in how the fleet manages its ballast water, or a decrease in the frequency of tanker ship arrivals. The frequency of annual tanker ship arrivals, shown in Figure 4, does not correlate with the downward trend in ballast water deliveries shown in Figure 3 – from 2014 through 2017 annual tanker ship arrivals have been relatively equal. Since 2014, there has been a change in the tanker fleet that has decreased the volume of annual ballast water deliveries. Two older SeaRiver (ExxonMobile) tanker ships, the Sierra and Kodiak, were replaced by the newly constructed Liberty Bay and Eagle Bay.[7] The Liberty Bay replaced the Kodiak in the last quarter of 2014 and the Eagle Bay replaced the Sierra in the second quarter of 2015. Due to the older design of the doubled-hulled Sierra and Kodiak, they always carried ballast water in their crude storage tanks, in addition to their segregated ballast, in order to keep their propellers properly submerged (A. Fuschetto, personal communication, May 2018). Therefore, they always had to offload ballast at the VMT upon arrival, and when the Sierra and Kodiak left the tanker fleet the amount of dirty ballast water delivered decreased; that trend is shown

[7] In the past year, the Liberty Bay and Eagle Bay were bought by Crowley Alaska and renamed the California and Washington respectively.

in yellow in Figure 5. The total amount of ballast water delivered by SeaRiver to the VMT, between 2014 and 2015, decreased with the replacement of the Kodiak, and further decreased between 2015 and 2016 with the replacement of the Sierra. The decreased deliveries from the phased out SeaRiver ships at least partially explain the downward trend in annual dirty ballast deliveries shown in Figure 3

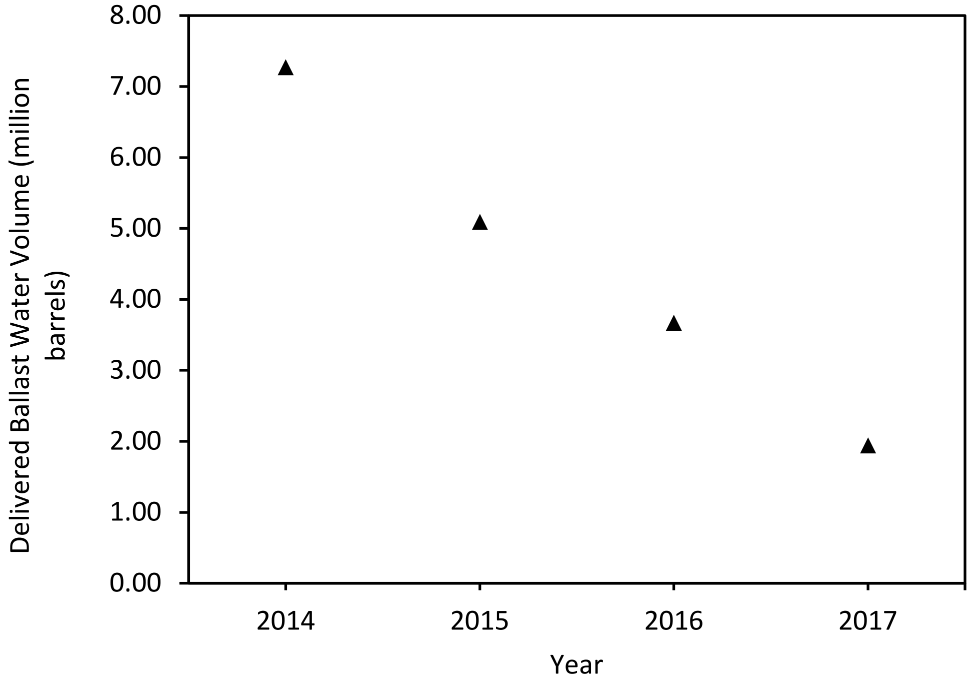


Figure 3. Annual dirty ballast water deliveries to the Valdez Marine Terminal from TAPS tanker ships (Source: Alyeska, Vessels Nearby Schedule).

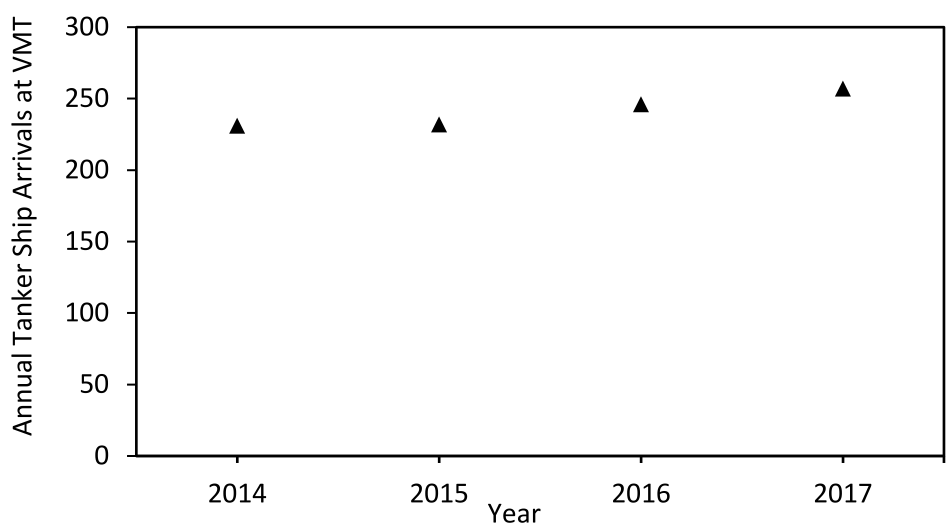


Figure 4. Annual tanker ship arrivals at the Valdez Marine Terminal (Source: Alyeska Vessels Nearby Schedule).

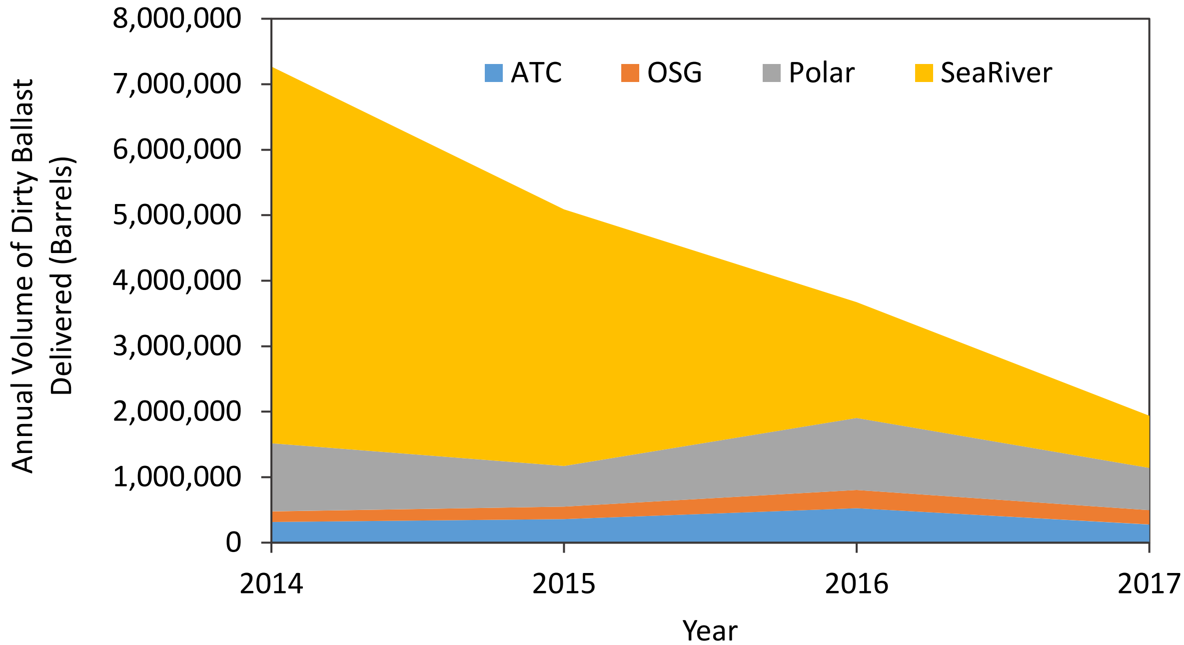


Figure 5. Annual ballast water deliveries by individual tanker ship companies (Source: Alyeska, Vessels Nearby Schedule).

Flow

The flow from the BWTF is limited by the terms of the VMT's water quality permit. The maximum allowable flow rate is 10.1 million gallons daily (MGD) and the average is 5.54 MGD. From 2013 through 2017 no flow permit exceedances occurred. Monthly flow data collected from January 2013 through December 2017 is shown in Figure 6. Today, the single largest input of water to the BWTF is stormwater (e.g. snowmelt and rainwater) collected throughout the VMT. On average, the BWTF treats about 0.500 MGD of stormwater compared to an average of 0.425 MGD of tanker ballast water – in other words 54% of the BWTF's influent is stormwater (Alyeska, 2017). Therefore, on average the BWTF currently treats more stormwater than dirty ballast water.

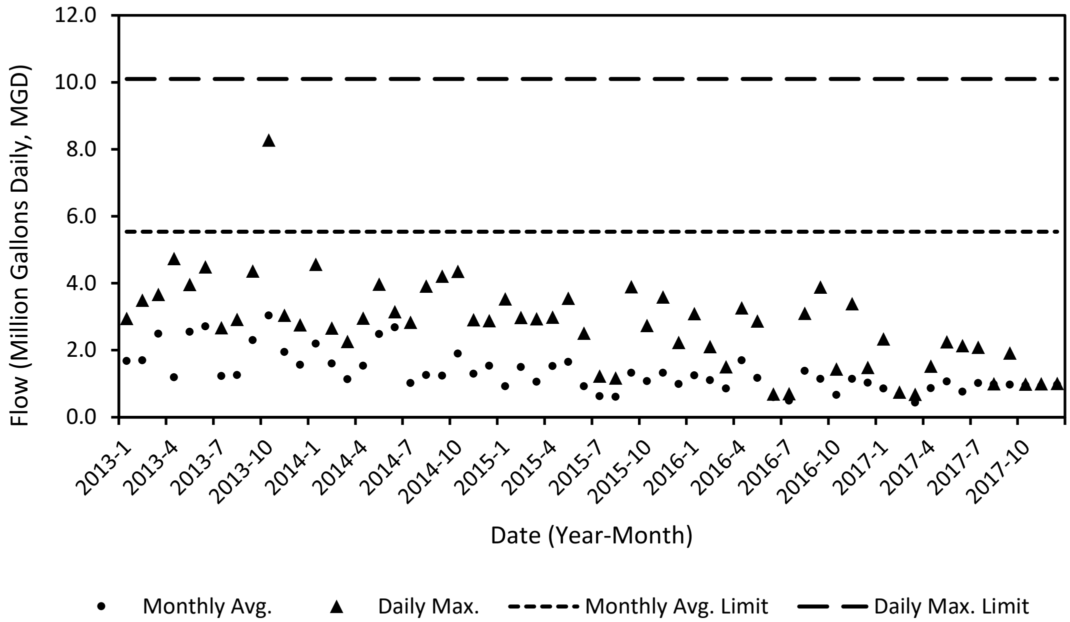


Figure 6. Monthly average and daily maximum flow from the BWTF to Port Valdez.

Summary flow statistics, covering 2013-2017, are included in Table 4 for the monthly average flow data, and Table 5 for the daily maximum flow data.

Table 4. BWTF monthly average flow summary statistics for Jan. 2013 – Dec. 2017, values are in MGD unless not applicable.

Mean	1.34
Standard Error	0.08
Median	1.18
Mode	1.70
Standard Deviation	0.59
Range	2.60
Minimum	0.44
Maximum	3.04
Count	60.00

Table 5. BWTF daily maximum flow summary statistics for Jan. 2013 – Dec. 2017, values are in MGD unless not applicable.

Mean	2.78
Standard Error	0.17
Median	2.90
Mode	1.00
Standard Deviation	1.32
Range	7.59
Minimum	0.69
Maximum	8.28
Count	60.00

pH

The pH of the BWTF effluent is limited by the VMT's water quality permit. The permit stipulates that the pH of the BWTF effluent must be in the range of 6.0-8.5 at all times. From 2013 through 2017, Alyeska did not violate the pH limitations placed on the BWTF's effluent. Monthly minimum and maximum pH data, collected from January 2013 through December 2017, is shown in Figure 7.

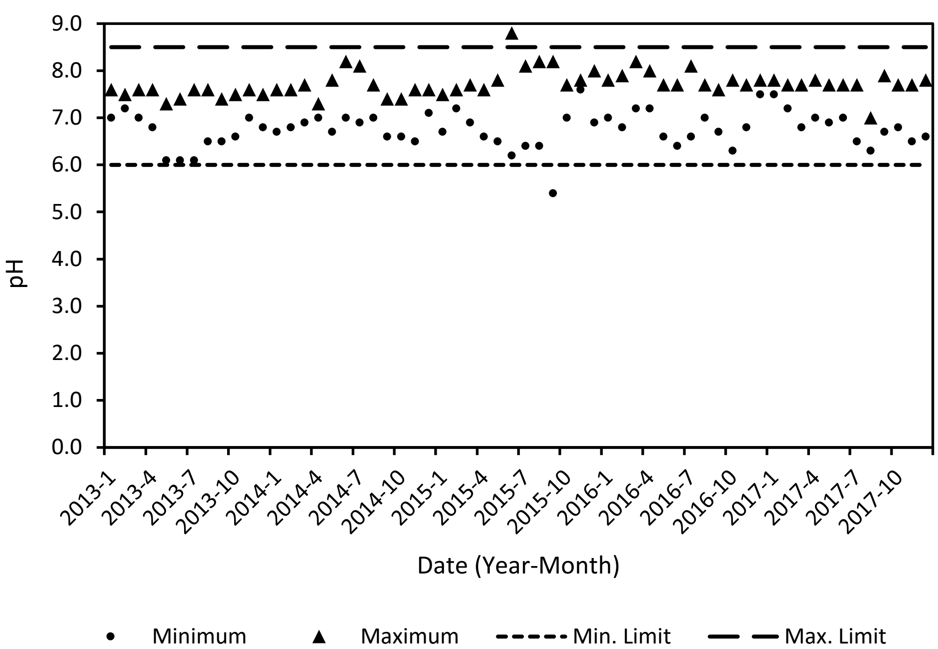


Figure 7. Minimum and Maximum pH of the BWTF's effluent.

In June 2015, Alyeska measured pH of the BWTF effluent to be greater than 8.5, but this was not a permit violation. Under the terms of the permit, pH excursions "shall not be considered violations provided no single excursion exceeds 60 minutes in length and total excursions do not exceed 7 hours and 26 minutes per month," and the June 2015 exceedance only lasted "for a total of 91 minutes, of which no single excursion exceeded 60 minutes in length" (Alyeska, 2015). The reason why the pH was temporally elevated was not discussed in Alyeska's June 2015 DMR nor in the cover letter accompanying it. Such a discussion was likely omitted by Alyeska in those documents because no permit violation had occurred.

In September 2015, Alyeska measured a pH of 5.4 for the BWTF effluent, which is lower than the limit of 6.0, but this was not a permit exceedance because the pH excursion only lasted for a limited amount of time. In their monthly report to ADEC, Alyeska noted, "The excursion lasted for a total of (8) minutes" (Alyeska, 2015).

Total Suspended Solids

The concentration of total suspended solids (TSS) in the BWTF effluent is limited by the VMT's water quality permit. That permit stipulates that the average monthly TSS must be 25 mg/L or less and the maximum daily limit is 40 mg/L. Monthly average and daily maximum TSS data, collected from January 2013 through December 2017, is shown in Figure 8. From 2013 through 2017 there was one exceedance of the daily maximum TSS limit applicable to the BWTF's effluent.

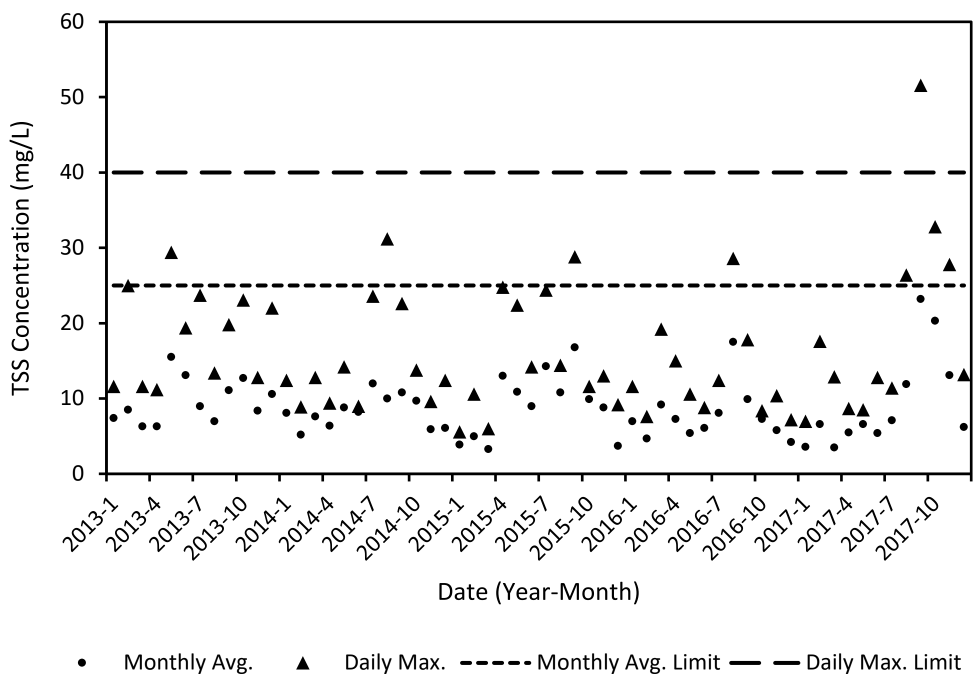


Figure 8. Concentration of total suspended solids in the BWTF's effluent.

The September 2017 exceedance of the BWTF's daily maximum TSS limit was caused by high loads of sediment getting suspended in stormwater due to intense rainfall in Valdez. In Alyeska's noncompliance report to ADEC they explain the exceedance "was caused by the increased sedimentation associated with storm flows into the Industrial Waste Water System (IWWS) which is designed to capture stormwater at the VMT and route it to the BWTF for treatment," and emphasize that Valdez, "experienced heavy and prolonged precipitation for the week prior to the non-compliance which caused the increased TSS" (Alyeska, 2017). The origins of the sediment were the secondary containment areas at the VMT. Also contributing to the exceedance, or non-compliance event, was the fact that the BWTF's settling tank storage capacity was limited at the time due to maintenance work. While Alyeska is usually able to manage TSS concentrations during events like this, similar incidents have motivated Alyeska to ask "that ADEC provide alternative methods for managing stormwater as part of the upcoming permit renewal" (Alyeska, 2017). In their 2017 application Alyeska asks that the renewed permit include "an allowance for discharges of uncontaminated stormwater from secondary containment areas to surface waters when conditions exist that create operational constraints" (Alyeska, 2017). In essence, Alyeska is asking ADEC if they can be allowed to use pumps to route clean stormwater out of the secondary containment areas into surface water drainages that drain into Port Valdez, during periods of high rainfall, in order to avoid exceedances of permitted BWTF TSS limits.

Total Aqueous Hydrocarbons

There is no permit limit applicable to the total aqueous hydrocarbons (TAqH) emitted in the BWTFs effluent, but the VMT's water quality permit does stipulate that they must be monitored. TAqH is the summed concentration of the isomers of benzene, toluene, ethylbenzene and xylene, as well as 16 polycyclic aromatic hydrocarbons (PAHs) listed in EPA's Analytical Chemistry Method 610. Figure 9 includes TAqH monitoring data measured from January 2013 through December 2017. Each data point represents the instantaneous maximum concentration of TAqH in the BWTF effluent measured during the respective month. While no TAqH permit limit is applicable to the BWTF effluent, the state of Alaska does have a water quality standard for this pollutant. In Alaska, in marine waters like Port Valdez that support aquaculture operations, TAqH cannot exceed 15 μg/L (see dashed line in Figure 9). The chart below shows that the highest measured concentration of TAqH in the BWTF effluent was 40 μg/L (0.04 mg/L) in April 2016. That relatively high TAqH concentration would be buffered by the 56:1 dilution factor of the mixing zone granted to the BWTF effluent. Given that dilution factor, at the edge of the BWTF's mixing zone one could expect a TAqH concentration of 40 μg/L in the BWTF effluent to be decreased below the state standard to 0.71 μg/L.

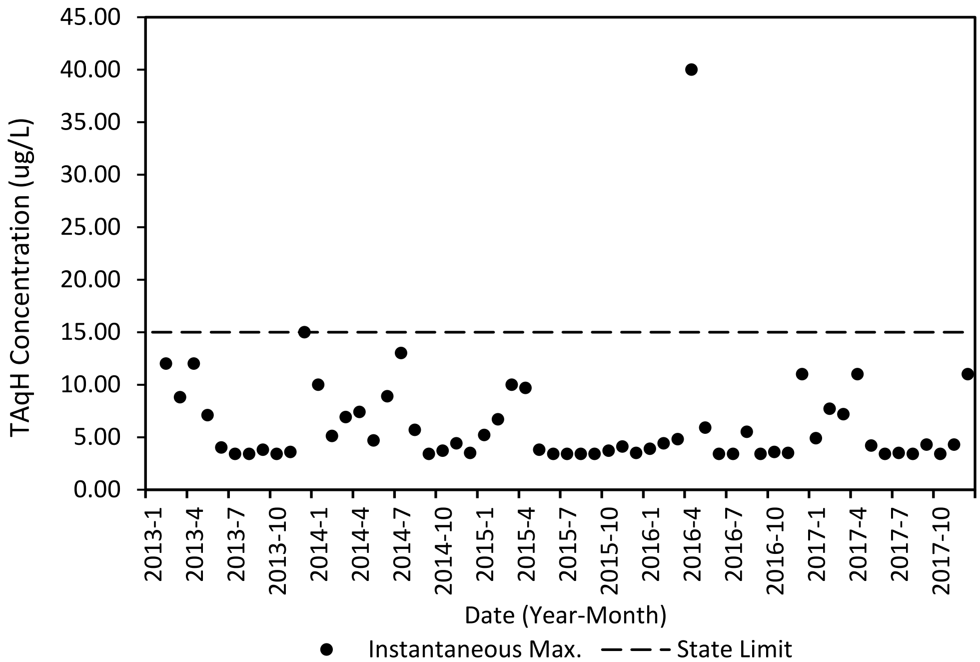


Figure 9. Instantaneous maximum TAqH concentration, in micrograms/L, of the BWTF effluent. Note the dashed line is the Alaska State Water Quality Standard for TAqH, not a permit mandated limit.

No TAqH limits were set in the current permit because the EPA analyzed historic BWTF TAqH data and determined no limits were necessary. In their 2012 Fact Sheet, supporting the reissuance of the VMT's water quality permit, EPA states, "Using reasonable potential analysis and data collected from January, 2004 through August, 2011, EPA determined the effluent TAqH limits were not necessary to meet water quality standards at the edge of the 50-meter chronic mixing zone" (U.S. EPA, 2012). From that 2004-2011 data analysis EPA calculated a maximum daily value of 1.8 ug/L TAqH and a mean value of 0.9 ug/L TAqH. They used that information to support their conclusion that, "there is no reasonable potential for TAqH to exceed the criterion (15 ug/L) at the edge of the mixing zone," and therefore, "effluent limitations are not needed."

Summary statistics calculated from data gathered from January 2013 through December 2017 show elevated mean and maximum TAqH concentrations compared to the EPA's aforementioned analysis back in 2012. Summary statistics have been calculated for the 2013-2017 TAqH data and are included below in Figure 7. The mean TAqH concentration for 2013-2017 was 6.35 ug/L and the maximum was 40.00 ug/L, compared to the 2004-2011 mean of 0.9 ug/L and maximum of 1.8

ug/L. The reason(s) for the differences in these statistical measures are unknown. Perhaps TAqH concentration was measured or chemically analyzed differently from 2004-2011 compared to 2013-2017 or perhaps some operational or maintenance practice is causing elevated TAqH concentrations. Regardless of the explanation, even the maximum measured 2013-2017 TAqH concentration should not lead to an exceedance of Alaska TAqH water quality standard (15 μg/L) at the edge of the BWTF's mixing zone.

Table 6. BWTF instantaneous maximum TAqH summary statistics for Jan. 2013 – Dec. 2017, values are in ug/L unless not applicable.

Mean	6.35
Standard Error	0.70
Median	4.30
Mode	3.40
Standard Deviation	5.38
Range	36.60
Minimum	3.40
Maximum	40.00
Count	59.00

While measured TAqH values indicate that Alaska's water quality standards will be met at the edge of the BWTF's mixing zone, the method used to measure TAqH concentrations in the BWTF effluent may be deficient. The VMT's current permit instructs Alyeska, "to measure polycyclic aromatic hydrocarbons (PAHs) listed in EPA Method 610" using EPA Method 625 (U.S. EPA, 2012). EPA Method 610 lists 16 different PAH compounds, therefore Alyeska is only looking for those PAH compounds in the BWTF effluent. However, many more PAH compounds exist; they exist in Alaska North Slope (ANS) Crude Oil, and they have been measured in the BWTF's effluent. The sixteen PAHs listed in EPA Method 610 "only represent 4 and 10 percent of the <u>true</u> PAH contribution to Total Aqueous Hydrocarbon (TAqH) concentration for summer and winter effluent, respectively" (Payne, Driskell, & Kalmar, Review of EPA Draft Permit, Fact Sheet, and Other Documents for Proposed Reissuance of Valdez Marine Terminal NPDES Wastewater Discharge Permit (AK-002324-8), 2012). A chemical analysis of a 2015 ANS Crude sample found more than 40 different PAHs in the sample (Hollebone, 2016). A PWSRCAC-sponsored study of hydrocarbon biodegradation by the BWTF measured many other PAH compounds in the BWTF's effluent, in addition to the 16 PAHs listed in in EPA Method 610 (Payne, Driskell, Braddock, & Bailey, 2005).

Therefore, by only measuring the concentration of the 16 PAHs listed in EPA Method 610, Alyeska is not actually measuring the total amount of TAqH constituents in the BWTF's effluent.

EPA Method 8270D is a more comprehensive and thoroughly validated analytical method to comprehensively measure TAqH concentrations. This method "has been widely used and universally accepted for major oil spill environmental forensics programs (e.g. EVOS and Deepwater Horizon) for over 20 years" (Payne, Driskell, & Kalmar, Review of EPA Draft Permit, Fact Sheet, and Other Documents for Proposed Reissuance of Valdez Marine Terminal NPDES Wastewater Discharge Permit (AK-002324-8), 2012). EPA Method 8270D can be used to measure the concentrations of the sixteen PAHs listed in EPA Method 610 as well as the multitude (>40) PAHs not listed in that method (Hollebone, 2016). This method is, "published in the Federal Register, and analysis of hundreds of check samples and NIST-certified reference materials over the last 10-15 years have allowed the development of statistically valid precision and accuracy," of data generated using EPA Method 8270D (Payne, Driskell, & Kalmar, Review of EPA Draft Permit, Fact Sheet, and Other Documents for Proposed Reissuance of Valdez Marine Terminal NPDES Wastewater Discharge Permit (AK-002324-8), 2012). The use of EPA Method 8270D does not appear to be excluded by Alaska's Water Quality Standards. The definition of TAqH in Alaska's Water Quality Standards is the, "collective dissolved and water-accommodated monoaromatic and polycyclic aromatic petroleum hydrocarbons that are persistent in the water column" (Alaska Department of Environmental Conservation, 2017). That definition does not restrict how or what method should be used to measure the concentration of TAqH. Although, in the Notes Section of the Alaska Water Quality Standards it does explicitly state to use, "EPA Method 610 or EPA Method 625 to quantify polycyclic aromatic hydrocarbons listed in EPA Method 610." This would seem to exclude the use of EPA Method 8270D to determine concentrations of TAqH in Alaska, but the Notes go on to state that, "use of an alternative method requires department approval" (Alaska Department of Environmental Conservation, 2017). Therefore, it appears that ADEC has the discretion to approve the use of EPA Method 8270D as an alternative to measure the concentration of TAqH in the BWTF's effluent. Therefore, in order to promote the comprehensively, accurate measurement of TAqH in the BWTF effluent, the TOEM Committee should consider recommending that ADEC require Alyeska to use EPA Method 8270D to determine the concentration of TAqH in the BWTF effluent.

Total Aromatic Hydrocarbons

This water quality parameter is "determined by summing the concentrations of the isomers: benzene, toluene, ethylbenzene and xylene." Those four chemicals are commonly referred to as BTEX. Isomers refer to compounds with the same chemical formula (e.g. C_8H_{10} (xylene)) but with their atoms arranged differently in space, differing spatial arrangements of atoms can affect the chemical properties of the compound. A good analogy for a chemical isomer is comparing your left versus right hand; both are made of the same components but are arranged differently in space.

The concentration of total aromatic hydrocarbons (TAH) in the BWTF effluent is limited by the VMT's water quality permit.[8] The permit stipulates the average monthly TAH concentration must be 0.21 mg/L or less and the maximum daily limit is 0.73 mg/L. Alyeska is required to report the average monthly and maximum daily concentration of TAH in the BWTF's effluent. Measured concentrations of the BWTF's TAH are depicted in Figure 10 and shows that for the time period of 2013 through 2017 there were no exceedances of the BWTF's TAH permit limits. In fact, for the most part, the measured TAH concentrations were an order of magnitude lower than permitted concentrations.

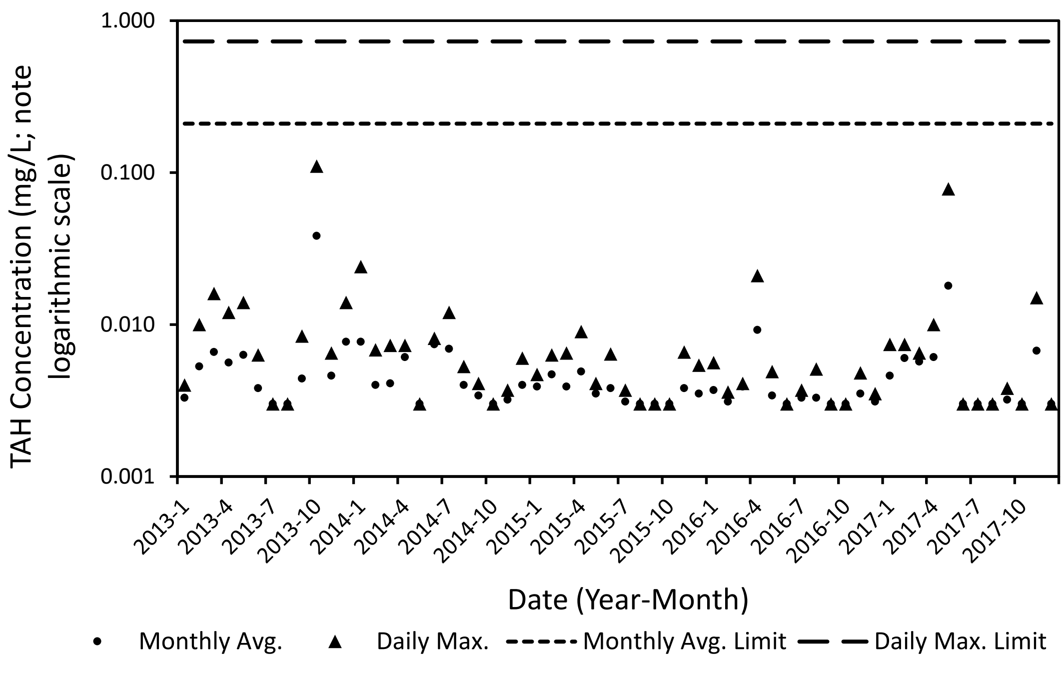


Figure 10. Concentration of total aromatic hydrocarbons discharged from the BWTF into Port Valdez, note the logarithmic scale of the y-axis (vertical axis).

[8] In the VMT's 2012 water quality permit, the concentration of total aromatic hydrocarbons is defined as "summing the concentrations of the isomers: benzene, toluene, ethylbenzene, and xylene."

In 2013-2017, Alyeska's release of TAH into Port Valdez per year did not exceed the permitted limits. In the VMT's water quality permit, Alyeska is allowed to discharge an average monthly mass of 9.7 lb TAH/day and a daily maximum mass of 61.5 lb TAH/day. Using the average value of 9.7 lb TAH/day over an entire year would mean that, on average, Alyeska is permitted to discharge 3,540.5 lb TAH/year into Port Valdez. However, on an annual basis, much less TAH is discharged to Port Valdez as shown in Figure 11. To calculate the mass of TAH discharged from the BWTF annually the EPA used the following data: average monthly concentration of TAH, average monthly flow, and number of days in the reporting month. Figure 11 shows that while Alyeska is permitted to discharge 3,540 lb TAH/year into Port Valdez they discharge less than 60 lbs. annually.

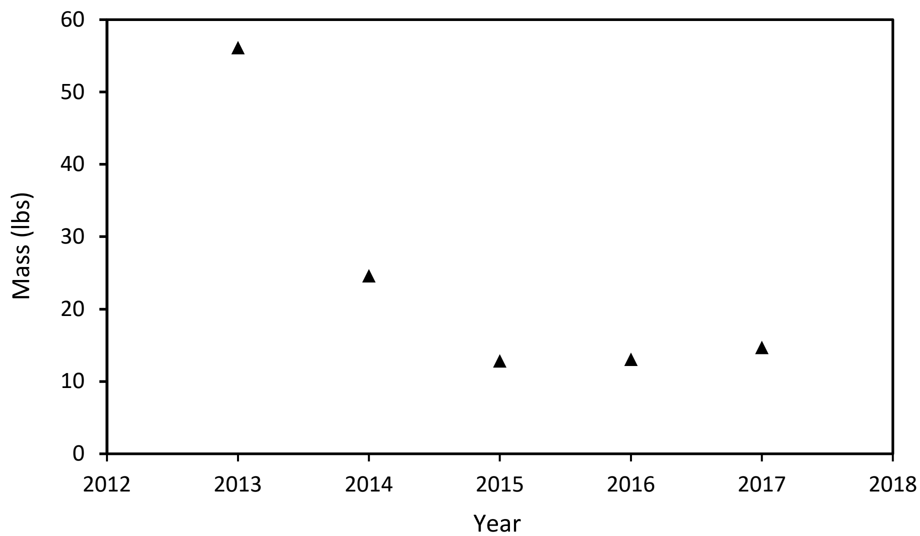


Figure 11. Annual mass of total aromatic hydrocarbons discharged from the Ballast Water Treatment Facility into Port Valdez (Source: U.S. EPA)

Whole Effluent Toxicity

The whole effluent toxicity (WET) of the BWTF effluent is not limited in the VMT's water quality permit, but it must be monitored. The permit requires that the following chronic WET testing be conducted quarterly: echinoderm (non-vertebrate species) gametes of either purple sea urchin or sand dollar, and a topsmelt (vertebrate) larval growth and survival test (U.S. EPA, 2012). While the VMT's water quality permit does not include WET limits, Alaska State Water Quality Standards restrict chronic WET to 1.0 TU at the edge of the mixing zone. Figure 12 includes WET measurements taken from 2013-2017, using the BWTF's effluent. The data in Figure 12 show that given the 56:1 dilution factor of the BWTF's mixing zone, no violations of Alaska's chronic WET standards occurred from 2013 through 2017 due to the operation of the BWTF.

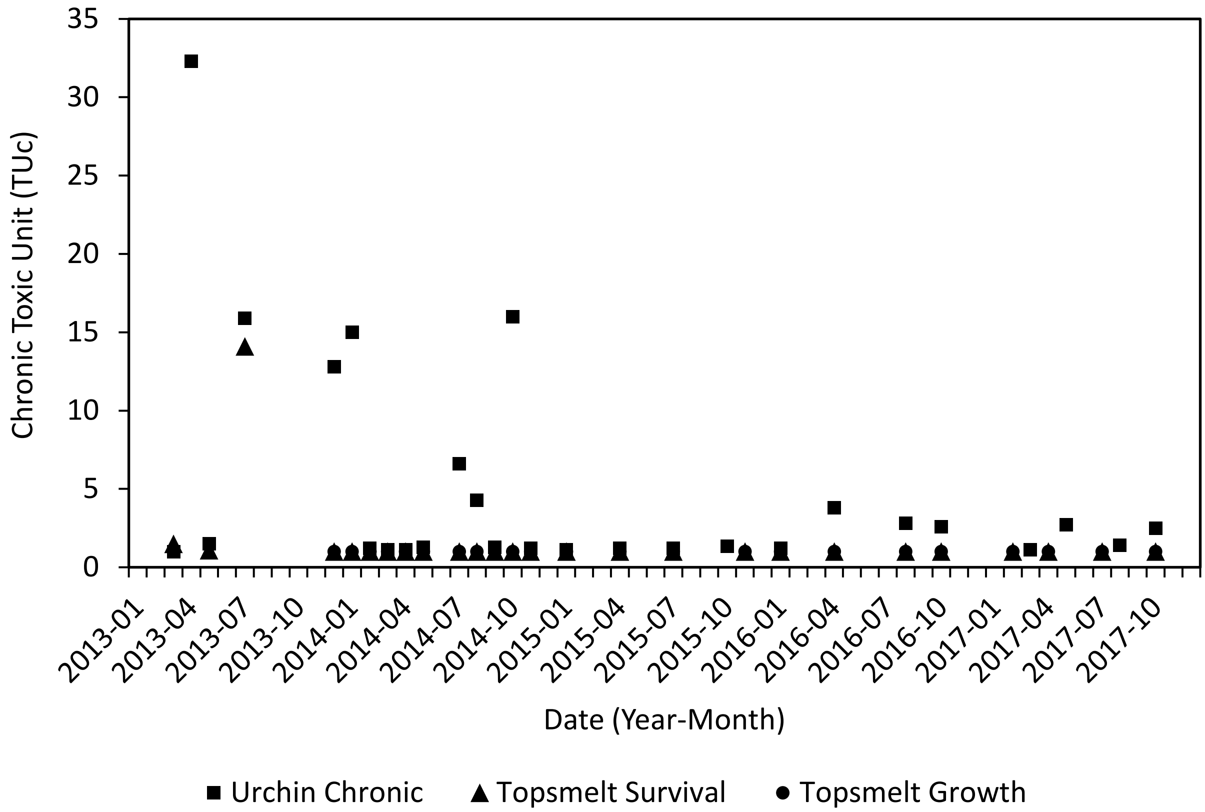


Figure 12. Whole effluent toxicity of the effluent from the BWTF.

Note, many of the data points of 2.0 TU or less, in Figure 12, were actually reported as "less than," not "equal to." But in order to display the data in the chart that nuance has been omitted here.

Total Permit Exceedances

Over the 60 month period between January 2013, when the current VMT Water Quality Permit became effective, and December 2017, when it was due to expire, there was one exceedance of a limitation placed on the BWTF's effluent. Information regarding that singular exceedance is provided in Table 7 and was previously described in more detail in the total suspended solids section.

Table 7. Exceedances of BWTF's permit limits, 2013-2017 (U.S. EPA, 2018).

Date	Parameter	Limit Type	Measured Value	Limit Value	% Exceedance
Sept. 2017	Total Suspended Solids	Daily max.	51.6 mg/L	40 mg/L	29

Sewage Treatment Plant Effluent

This section of the report is focused on the water quality of the treated wastewater discharged from the VMT's Sewage Treatment Plant (STP) into Port Valdez from 2013 through 2017. The STP services the western portion of the VMT, including the Power Vapor Facility, Chemistry Laboratory, Emergency Response Building, and the Marine Contingency Building; the rest of the VMT's sewage is managed by leach fields and septic tanks. Compared to a municipal STP, the VMT's STP is rather small, being designed to treat 10,000 gallons per day (GPD). For contrast, the City of Valdez's sewage treatment plant is designed to treat 1.5 million gallons per day and it only serves about 4,000 people (Alaska Department of Environmental Conservation, 2015). The treatment of the sewage in the STP can be broken down into two essential processes, biological degradation and disinfection. First, the sewage is processed through an activated sludge sequencing batch reactor (SBR). Inside the activated sludge SBR the sewage is aerated and mixed to create an oxygen rich environment, and an assemblage of microorganisms degrades the organic material present in the sewage.[9] At the end of the treatment cycle, when biological reactions have slowed or ceased, the resulting solids are allowed to settle at the bottom of the SBR tank, with the resulting treated sewage liquid ending up on top.[10] Next, the liquid resulting from the activated sludge SBR process is piped out of the tank, disinfected with ultraviolet light, and finally discharged into Port Valdez through an offshore pipe in approximately 40 feet (12 meters) of water, just outside the VMT's Small Boat Harbor (see Figure 2 back on page 8).

A number of discharge limits and state water quality standards are applicable to the STP's effluent. Recall, discharge limits are the permit-stipulated standards Alyeska is required to achieve at the end of the pipe, while state water quality standards must be met at either the end of pipe or edge of mixing zone. The STP's permit limits are listed in Table 8 and the applicable state water quality standards are listed in Table 9. The STP also has a permitted mixing zone surrounding its outfall pipe, and the size of the mixing zone in the current permit is a cylinder with a radius of 1.05 feet (0.32 meters) centered on the end of the pipe, providing a dilution factor of 9.2:1. This means that the STP's effluent does not have to meet the state standards described in Table 9 until it reaches the edge of the mixing zone. The limits in Table 8 were designed in order to ensure state water quality standards are met at the edge of the STP's mixing zone.

[9] Atmospheric air is used for aeration in the VMT's SBR; some SBRs use pure oxygen.

[10] Sludge solids are only removed approximately every 5-10 years via vacuum truck and sent to the City of Valdez's wastewater treatment facility for treatment and disposal. Alyeska manages this bioactive sludge so that it remains "middle aged," not too young or old, in order to maintain optimal sewage treatment efficiency.

Of note, the limits for biological oxygen demand, fecal coliform, and *Enterococci* bacteria in Table 8 were not applicable until three years after the issuance of the VMT's Water Quality Permit; therefore, the limits weren't applicable until January 2016. This postponement was allowed in order to provide Alyeska enough time to design, install, and begin operating sanitation equipment. Alyeska ended up installing an ultraviolet radiation system to meet the permit-stipulated requirement to sanitize the STP's effluent before discharge into Port Valdez. The ultraviolet sanitation system was operational as of December 2015.

Table 8. STP's permit limits (U.S. EPA, 2012).

Parameter (units)	Maximum Daily Limit	Weekly Average Limit	Monthly Average Limit
Flow	10,000 GPD	--	Report
pH	6.0 s.u. – 9.0 s.u at all times		
Total Suspended Solids	60 mg/L	45 mg/L	30 mg/L
	5 lb/day	3.8 lb/day	2.5 lb/day
Biological Oxygen Demand	60 mg/L	45 mg/L	30 mg/L
	5 lb/day	3.8 lb/day	2.5 lb/day
Fecal Coliform Bacteria[11]	396 CFU/100 mL	--	129 CFU/100 mL
Enterococci	2,540 CFU/100 mL	--	322 CFU/100 mL

[11] CFU stands for colony-forming unit

Table 9. Alaska water quality standards applicable to STP's effluent. All of the standards in this table must be met at the edge of the STP's mixing zone (Source: ADEC. February 5, 2017. Alaska Water Quality Standards. 18 AAC 70).

Parameter	Beneficial Use	Standard
Fecal Coliform Bacteria	Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life	Geometric mean may not exceed 14 CFU/100 mL and 43 CFU/100 mL for a five-tube decimal dilution test.
Enterococci Bacteria	Water Recreation, contact recreation	In a 30-day period, the mean of samples cannot exceed 35 CFU/100 mL, and not more than 10% of the samples may exceed 130 CFU/100 mL.

Flow

The flow from the STP is limited by the VMT's water quality permit. The permit requires that the maximum daily flow from the STP is 10,000 gallons per day (GPD) or less. There are no average flow permit stipulations related to the STP's effluent. Alyeska is required to report the maximum daily and average monthly flow of the STP effluent. As shown below in Figure 13, from 2013 through 2017, there were no exceedances of the STP's maximum flow limit. Also, provided in Table 10 are the STP's average monthly flow summary statistics pertaining for the years 2013-2017.

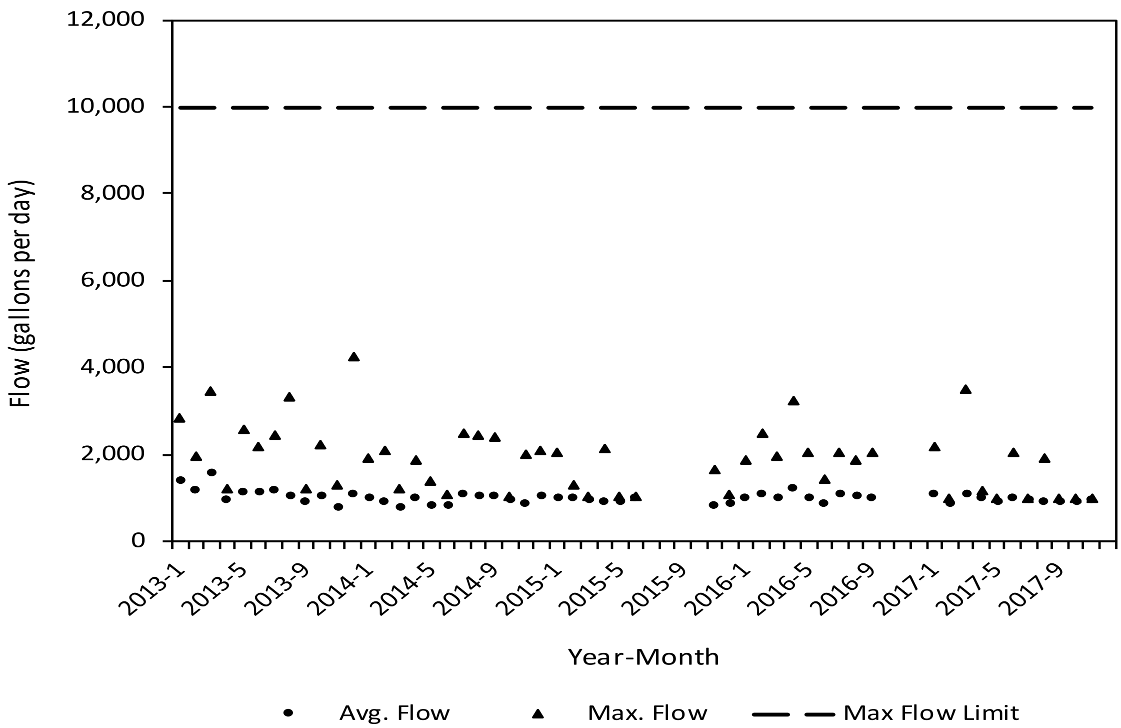


Figure 13. Effluent flow from the STP.

Table 10. Average Monthly Flow Summary Statistics for the STP, Jan. 2013 – Dec. 2017 (gallons per day unless not applicable)

Mean	1,035.47
Median	1,018.00
Mode	967.00
Standard Deviation	140.53
Range	820.00
Minimum	809.00
Maximum	1,629.00
Count	53.00

pH

The pH of the effluent from the STP is limited by the VMT's water quality permit. The permit stipulates that the pH of the STP's effluent must range from 6.0-9.0 at all times. Alyeska is required to report the minimum and maximum monthly pH values of the STP's effluent. For receiving waters that support aquaculture, like Port Valdez, Alaska water quality standards stipulate that the pH "May not be less than 6.5 or greater than 8.5, and may not vary more than 0.2 pH unit outside of the naturally occurring range (Alaska Department of Environmental Conservation, 2017)." As shown in Figure 14, no exceedances of the STP's pH limits occurred from 2013-2017

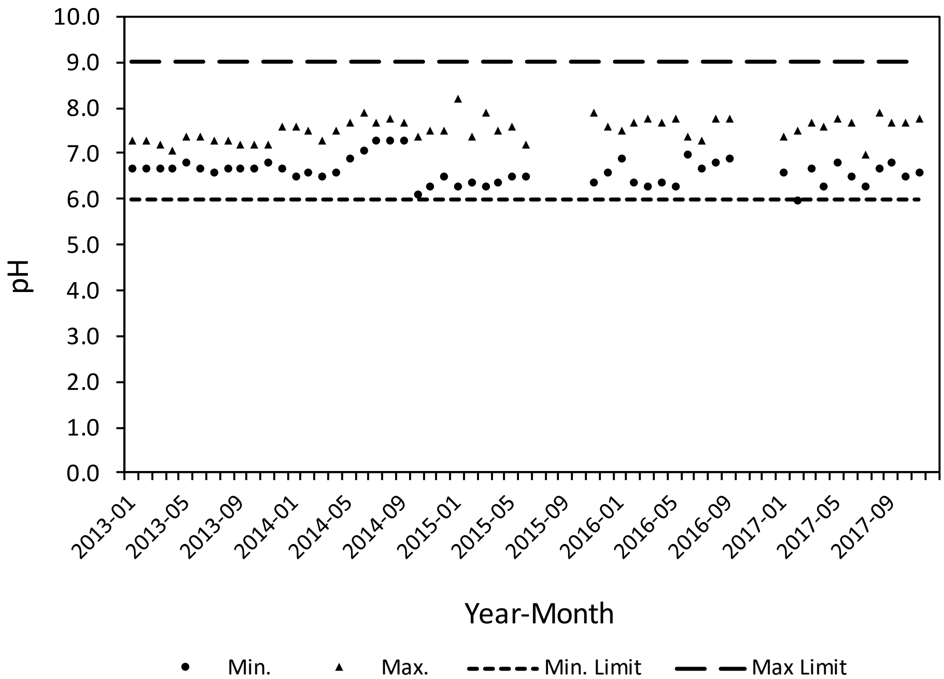


Figure 14. pH of the STP's effluent, 2013-2017.

Total Suspended Solids

The concentration and mass of total suspended solids (TSS) in the effluent from the STP is limited by the VMT's water quality permit; the horizontal lines in Figure 15 depict those limits. From 2013 through 2017, there was one exceedance of the STP's monthly average TSS limitation in August 2017, as shown in Figure 15.

The cause of the August 2017 TSS exceedance was a bloom of *Daphnia*, which are, "a genus of small planktonic crustaceans," ranging from 0.01-0.20 inches in length (Wikipedia, 2018). According to Alyeska, "*Daphnia* is common in [wastewater treatment] lagoons and can be a beneficial organism in the control of algae in that type of treatment system," but is, "very uncommon in sequential batch reactors," like the VMT's STP (J. Fannin, personal communication, May 2018). In fact after consulting with some sewage treatment experts Alyeska learned that the presence of *Daphnia* "is indicative of a system that has a low toxicity" (J. Fannin, personal communication, May 2018). Regardless of their presence indicating low toxicity, *Daphnia* inside the STP system are problematic and can lead to TSS concentration spikes. To stop the *Daphnia* blooms Alyeska ceases discharge from the STP and treats the effluent, "with low doses of hydrogen peroxide to kill off the *Daphnia*.

We monitor to verify the hydrogen peroxide fully reacts and then have to go through the process of restoring the beneficial biology to the STP through normal operations" (J. Fannin, personal communication, May 2018). Until the STP is ready to commence normal operations the sewage is pumped out with a vacuum truck and sent over to the City of Valdez's Waste Water Treatment Facility.

For unknown reasons, the reported maximum daily, weekly, and monthly average concentrations of TSS in the STP effluent are all equal during the years 2013-2017, with the exception of April 2013, when the monthly average concentration differed from the weekly average and daily maximum, but not by much.

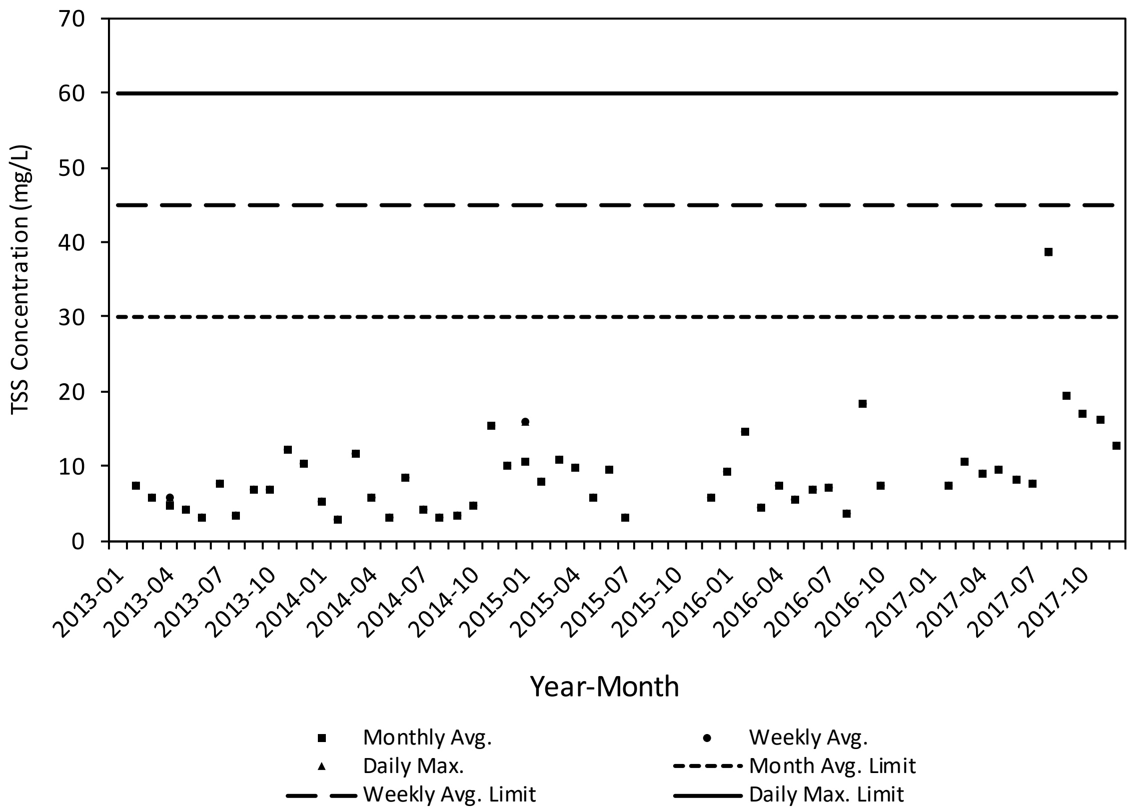


Figure 15. Total suspended solids in STP effluent (mg/L).

Biological Oxygen Demand

The concentration and mass of biological oxygen demand (BOD) from the STP is limited by the VMT's water quality permit.[12] The STP's BOD limits and measurements are depicted in Figure 16.

[12] BOD is the amount of oxygen required by aerobic microorganisms to breakdown organic matter in a given volume of water and is used as an indicator of the effectiveness of sewage treatment plants; higher BOD indicates more organic matter in the water.

From 2013 through 2017 there were four exceedances of the permit's BOD limitations assigned to the STP's effluent. Three of those exceedances occurred in March 2014 and the other exceedance occurred in October 2014. In March 2014 the maximum daily, weekly average, and monthly average BOD limits were all exceeded. According to Alyeska these exceedances were, "caused by filament bacteria infiltration and growth in the sewage treatment process" and they fixed the problem by making some operational adjustments and changing chlorine concentrations to reduce the filament bacteria population (Alyeska, 2014). Excess filamentous bacteria can interfere with the activated sludge sewage treatment process by interfering with how sludge settles or by causing unwanted foam formation (Richards, 2003). In October 2014 only the weekly average BOD concentration was exceeded. According to Alyeska, that exceedance was likely an artifact of how the permit stipulates BOD sampling frequency to once a month; Alyeska did take follow-up samples that indicated the October 2014 exceedance "was an isolated event" (Alyeska, 2014).

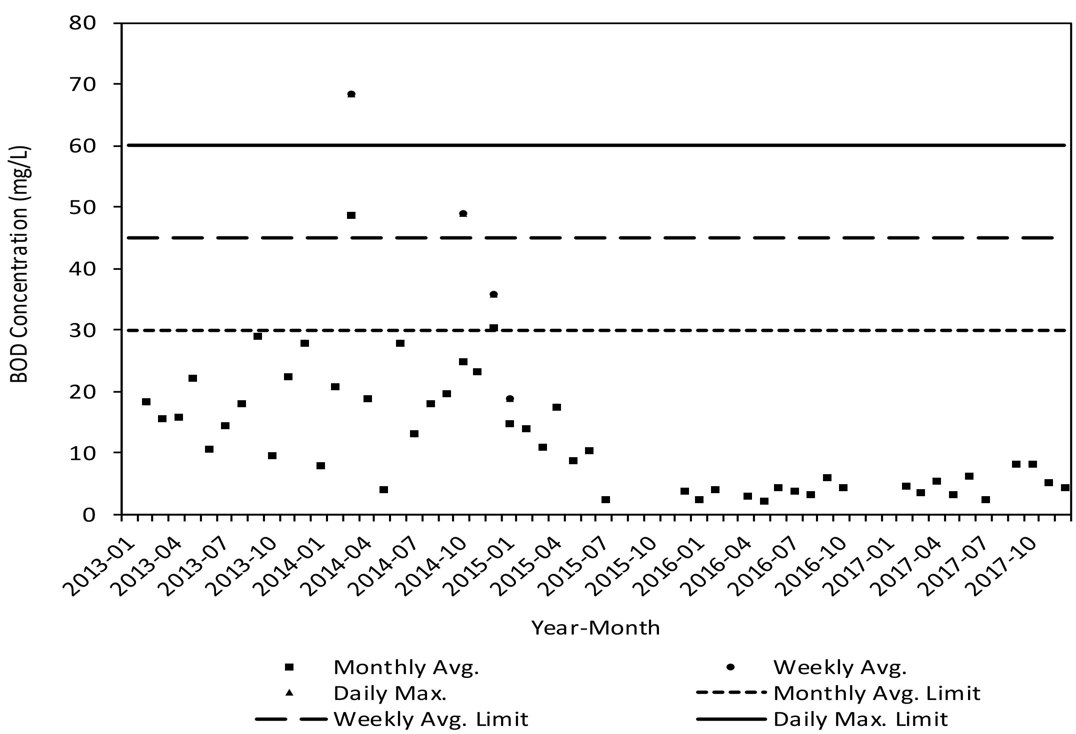


Figure 16. Biological oxygen demand data from the STP.

Fecal Coliform Bacteria

The concentration of fecal coliform in the STP effluent is limited by the VMT's water quality permit. The STP's fecal coliform limits and measurements from 2013-2017 are shown in Figure 17. Recall, the permit stipulated that Alyeska did not have to meet those fecal coliform permit limits for three years, until January 1, 2016, in order to allow Alyeska enough time to study, design, plan, construct, and operate a new disinfection treatment process. Alyeska ended up installing an ultraviolet radiation disinfection system for the STP that began operating in December 2015.

October 2017 data for the monthly average fecal coliform bacteria, 189 CFU/100 mL, shows that there was one exceedance of the applicable monthly average permit limit of 129 CFU/100 mL. Alyeska believes this October 2017 fecal coliform exceedance was caused by bacteria building up in the sampling apparatus used to pull water samples out of the STP's discharge piping because "follow-up sampling and testing results indicated we were below permit limits" (J. Fannin, personal communication, May 2018). The sampling apparatus includes tubing and pump that pulls a sample out of the STP's discharge piping and water sits inside the pump and tubing in between quarterly sampling events. While water remains in the test system, bacteria can grow in the tubing or pump. Since October 2017 Alyeska has shortened the sampling tubing and changed the test procedure to allow flow through the tubing and pump prior to taking a sample, hopefully those changes will eliminate any fecal coliform bacteria growing inside the sampling system.

To further investigate the in-between-sampling bacteria buildup hypothesis, Alyeska is taking and analyzing two separate water samples for bacterial concentration for the next couple years. One sample is taken and analyzed from the sampling system and another straight from the ultraviolet disinfection trough. This will help them understand if their assumed in-between-sampling bacteria buildup is occurring inside the sampling system – even with the changes they made to the testing apparatus and protocol.

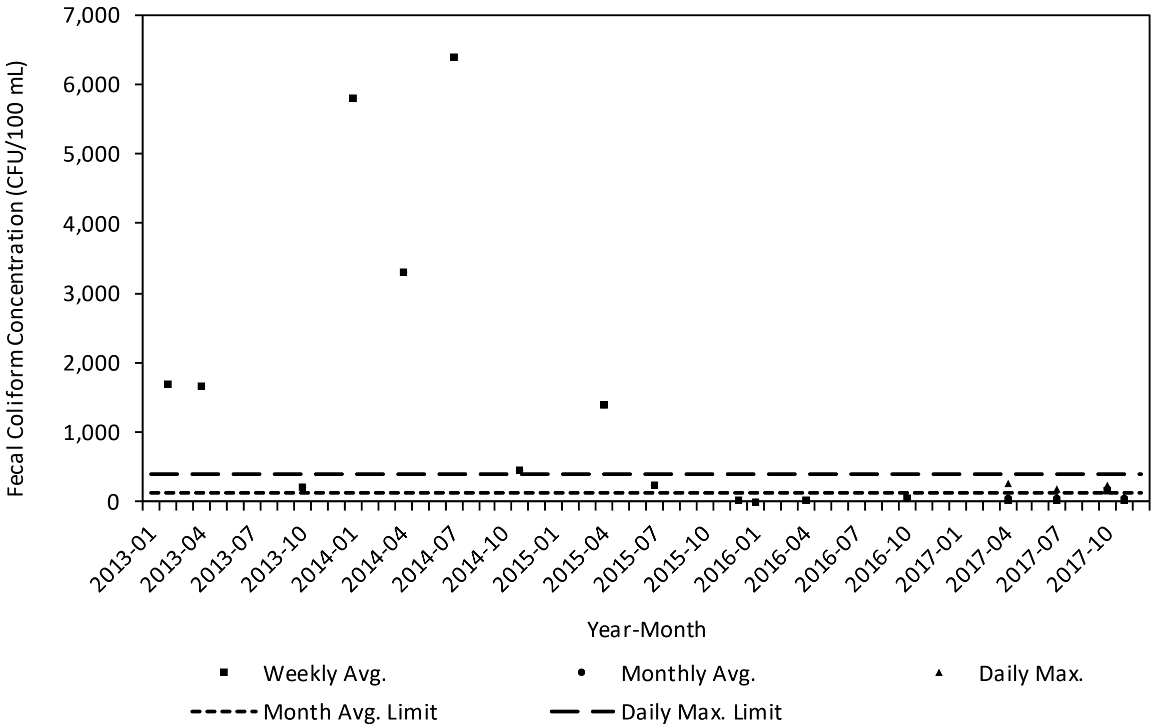


Figure 17. Fecal coliform data for the STP.

A number of potential outliers were removed from the fecal coliform data set. In July 2013 all data points equaled 41,300 colony forming units (CFU)/100 mL and Jan 2015 all equaled 61,000 CFU/100 mL. All of those data were removed from Figure 17.

Table 11. Monthly Average Fecal Coliform Concentration Summary Statistics for the STP. Included data ranged from December 2015 through December 2017 (CFU/100 mL unless not applicable).

Mean	50.38
Standard Error	20.67
Median	39.00
Standard Deviation	58.45
Range	183.00
Minimum	5.00
Maximum	188.00
Count	8.00

The data range was limited for Table 11 in order to align the summary statistics with the period of time in which Alyeska had to meet the permit's fecal coliform concentration limits. Recall, that time period was January 2016 onward. December 2015 was also included because that was the month Alyeska began operating the STP's ultraviolet disinfection system.

Total Residual Chlorine

The concentration of total residual chlorine (TRC) in the STP's effluent is limited by the VMT's water quality permit but Alyeska does not use chlorine for disinfecting the effluent of the STP. Therefore, Alyeska does not monitor its concentration because they installed an ultraviolet radiation disinfection unit to treat the STP's effluent.

Enterococci

The concentration of *Enterococci* bacteria is limited in the STP's effluent by the VMT's water quality permit. The 2013-2017 *Enterococci* limits and data are depicted in Figure 18. After the January 1, 2016 effective limit date, there was one recorded permit exceedance for *Enterococci* bacteria. In October 2017, the average monthly measured concentration of *Enterococci* was 348 CFU/100 mL, while the limit is 322 CFU/100 mL. The cause of this exceedance is the same discussed previously regarding the October 2017 exceedance of fecal coliform bacteria.

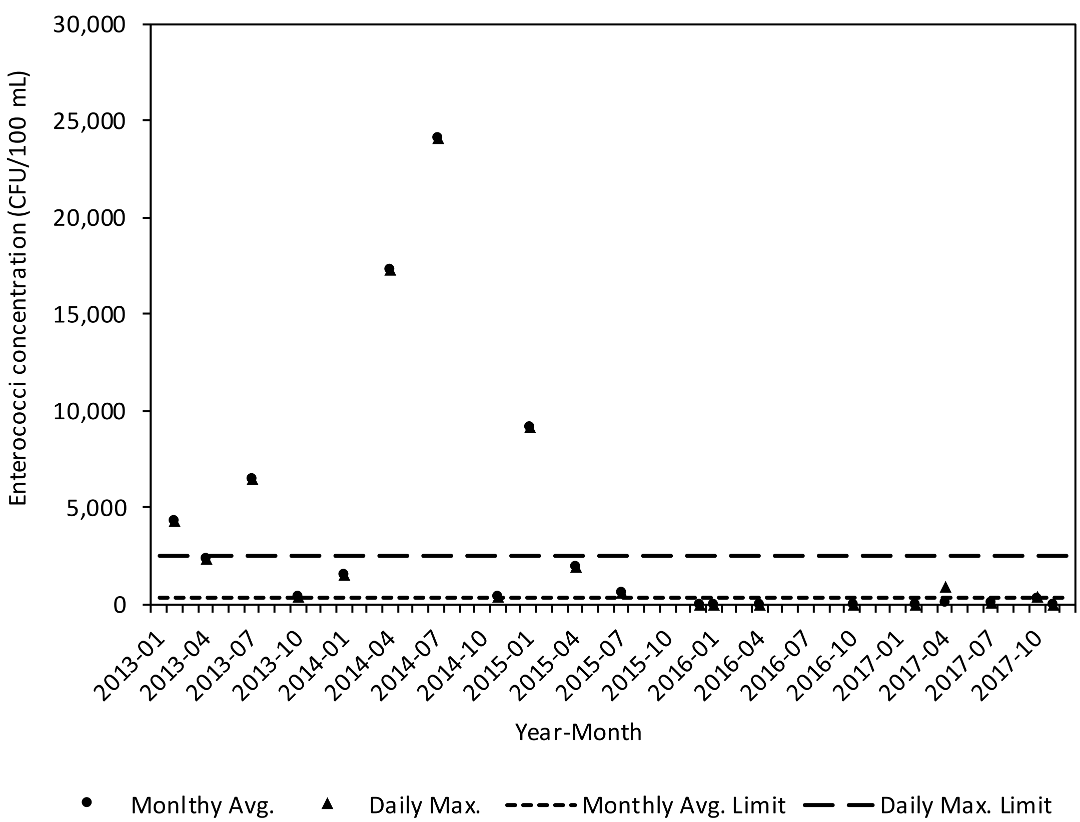


Figure 18. *Enterococci* concentration in STP effluent, 2013-2017.

Note, April 2013 monthly and daily maximum concentration data was recorded as greater than 2,420 CFU/100mL but simply displayed as 2,420 CFU/100mL in Figure 18.

Table 12 provides *Enterococci* concentrations summary statistics pertaining the STP's effluent. As previously applied to the fecal coliform summary statistics, the data range was limited for Table 12 in order to align the summary statistics with the period of time in which Alyeska had to meet the permit's *Enterococci* concentration limits.

Table 12. Monthly average *Enterococci* concentration summary statistics, December 2015-December 2017 (CFU/100 mL unless not applicable).

Mean	194.11
Median	25.00
Standard Deviation	333.60
Range	975.00
Minimum	5.00
Maximum	980.00
Count	9.00

Total Permit Exceedances

Over the 60-month period between January 2013, when the current VMT Water Quality Permit became effective, and December 2017, when it was due to expire, there were seven exceedances of limitations placed on the STP's effluent. Information regarding those exceedances is provided below in Table 13. More detailed information regarding why each exceedance occurred is provided in previous parts (delineated by parameter) of the STP section of this report.

Table 13. Exceedances of STP's permit limits, 2013-2017 (U.S. EPA, 2018).

Monitoring Period Date	Parameter	Limit Type	Measured Value	Limit Value	% Exceedance
March 2014	Biological Oxygen Demand	Daily max.	68.4 mg/L	60 mg/L	14
March 2014	Biological Oxygen Demand	Wkly avg.	68.4 mg/L	45 mg/L	52
March 2014	Biological Oxygen Demand	Month. max.	48.9 mg/L	30 mg/L	63
October 2014	Biological Oxygen Demand	Wkly avg.	49 mg/L	45 mg/L	9
August 2017	Total Suspended Solids	Month. max.	38.7 mg/L	30 mg/L	29
October 2017	Fecal Coliform	Month. Avg.	188 CFU/100 mL	129 CFU/100mL	46
October 2017	*Enterococci*	Month. Avg.	348 CFU/100 mL	322 CFU/100mL	8

Conclusion

Overall, based on the relatively few exceedances of permit-mandated water quality limits, Alyeska has effectively operated and maintained the BWTF and STP at the VMT from 2013 through 2017. There were a total of eight permit limit exceedances, one for the BWTF and seven for the STP, over the 60-month period between January 2013 and December 2017. Moreover, the known causes of the exceedances were isolated and unrepeated, indicating that Alyeska was able to make effective changes to either the STP or BWTF process to prevent similar exceedances in the future. Alyeska's effective operation and maintenance of the VMT's BWTF and STP has helped limit permit excursions, ensuring the environmental impacts of these two effluent sources have been limited over the 2013-2017 time period. Other data gained from the Council's Long Term Environmental Monitoring Program (LTEMP) helps confirm the conclusion that the environmental impacts of the BWTF and STP effluent are very likely negligible.

For more than twenty years PWSRCAC has been collecting sediment and blue mussel samples near the VMT to analyze them for their hydrocarbon content, specifically for polycyclic aromatic hydrocarbons (PAHs), the more toxic components of crude oil. The purpose of collecting and analyzing the samples is to evaluate how the operation and maintenance of the VMT may be impacting the local marine environment. LTEMP results from 2008 through 2016 show that concentrations of potentially toxic hydrocarbons in mussels and sediments near the VMT are very low compared to other places in the United States and Alaska. In their recent report for PWSRCAC Payne and Driskell conclude, "Compared to the recent West Coast Mussel Watch data (2004-05) and the more recent Alaskan Mussel Watch sites, LTEMP results continue to demonstrate that the sampled region is exceptionally clean" (Payne & Driskell, 2017).

In 2016 a newer, different type of hydrocarbon or PAH sampling method was added to the LTEMP: passive sampling devices (PSDs). PSDs were added to the LTEMP in order to augment the information provided by the sediment and blue mussel collection & analysis. In 2016 PSDs were deployed just offshore of the locations used to sample mussels at the VMT. Unlike the mussel and sediment sampling, PSDs allow for the measurement of hydrocarbons in the water column and at much lower concentrations. "While the mussels provide data about trends in waterborne contaminants, the PSDs provide a measurement of chemical concentrations in the water that can be directly compared to toxicity thresholds" (Allan, 2018). Comparing the 2016 PSD sampling results to cardiotoxicity thresholds associated with the embryonic development of salmon and herring shows that concentrations of PAHs in the water column just offshore of the VMT should not adversely affect those species. "The observed concentrations are also below demonstrated embryonic exposure concentration thresholds for cardiotoxicity in herring and salmon for both sum PAHs and sum of 3-ring PAHs" (Allan, 2018). Furthermore, the 2016 PSD results show that, "PAHs at all sites in Port Valdez are low compared to other marine ports in the United States," and were, "at least three orders of magnitude below published water quality standards" (Allan, 2018). For example, in Alaska the water quality standard for total aqueous aromatic hydrocarbons[13] is 15 micrograms per liter but 2016 PSD data from Saw Island (adjacent to Berth 5 at the VMT) showed that measured concentration of dissolved PAHs was $0.024 \pm .003$ micrograms per liter.

[13] Total aqueous hydrocarbons or TAqH is defined as the dissolved concentration of the sum of the isomers of benzene, toluene, ethylbenzene, and xylene, plus all polycyclic aromatic hydrocarbons.

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