Air Monitoring Options for Measuring Benzene Concentrations in Valdez

Contract 557.03.1 – Valdez Air Quality
Recommendations Regarding Valdez Air Monitoring Options for Benzene

Executive Summary:

PWSRCAC has expressed an interest in collecting ambient air samples in Valdez and at the Valdez Marine Terminal ("terminal") to quantitatively evaluate the current air quality data for comparison with previous (1990-1991) sampling data. PWSRCAC is specifically interested in monitoring the level of benzene in air, since benzene is a known human carcinogen.[1]

There are five remaining sources of benzene emissions at the terminal: (1) Ballast Water Treatment Facility (BWTF) emissions; (2) uncontrolled loading at Berth 3[2]; (3) oil storage tank vents and other associated fugitive emissions; (4) combustions sources; and (5) other minor miscellaneous sources. PWSRCAC currently estimates that the BWTF is the largest remaining source of benzene.

It is recommended that PWSRCAC use a phased approach to air emission testing. The initial testing would include source specific sampling at the terminal and air sampling in the City of Valdez. The priority for source specific sampling at the terminal would be to quantify the emissions from the BWTF using the Flux Chamber Test Method. BWTF total hazardous air pollutant emissions are estimated at 128-342 tons per year. Actual air emission testing would confirm these estimates.

Air sampling in the City of Valdez could be conducted concurrently with, or subsequently to, BWTF testing. This initial phase of testing would include ambient benzene testing in the City of Valdez at the three previous monitoring locations (Valdez High School, Old Valdez, and Valdez Spit) and ambient benzene testing at various locations at the terminal (including the previous East Gate location) using EPA Method TO-14a (Summa® canisters). Summa® canisters testing will provide a benzene concentration in parts per billion (ppb). A mass emission rate in tons per year (tpy) cannot be easily or reliably obtained from this method; however, for purposes of a screening level test, a concentration is sufficient. Updated benzene concentrations would be compared to the benzene data collected in 1990-1991, which showed that outdoor benzene concentrations averaged 1-8 parts per billion (ppb) in Valdez, and 8 ppb at East Gate.

Initial testing would include simpler, more cost-effective, intermittent air sampling to obtain a set of screening samples in the highest priority areas. Based on the initial testing results, more complex, higher cost continuous air sampling could be implemented if warranted. This approach is aligned with PWSRCAC's limited air quality source testing budget.

[1] Typically air samples are taken and tested for total volatile organic compounds and then speciated for particular hazardous air pollutants such as benzene.
[2] Berths 1 and 3 do not have a vapor recovery system; vapors generated by uncontrolled loading are vented directly to the atmosphere. Alyeska is preparing to permanently decommission Berth 1.

Data obtained from the initial testing phase would provide:

- Data for comparison with published health standards, state and national air quality data and historic air quality data collected in Valdez;
- Data to quantify the cancer risk reduction since the installation of the Tanker Vapor Recovery Project at the terminal;
- Quantitative estimates of the current level of benzene emissions from specific VMT sources, to end the technical debate over the theoretically derived emission estimates;
- Benzene emission estimates to support PWSRCAC's comments to EPA on the proposed Organic Liquid Distribution (OLD) National Emissions Standards for Hazardous Air Pollutants (NESHAP), which proposed further benzene emission control at the BWTF; and
- Sufficient data to determine if additional testing is warranted to justify additional emission reduction strategies at the terminal.

Emission testing of the oil storage tanks vents, other fugitive emissions at the terminal, combustion sources and uncontrolled loading is not recommended in the initial testing phase. Alternatively, it is recommended that PWSRCAC review Alyeska oil storage tank and fugitive emission test data, prior to funding additional data collection. No additional testing is recommended for combustion sources or other minor miscellaneous sources, due to their small benzene emission contribution. It is recommended that PWSRCAC track Alyeska's uncontrolled loading usage in 2003. Provided that the uncontrolled loading at Berth 3 remains small, additional testing may not be necessary. However, continued uncontrolled loading may warrant additional testing. Summa® canisters can be used to collect ambient air samples on the days that uncontrolled loading occurs to test the benzene contribution from uncontrolled loading at Berth 3.

Source-specific testing to determine the concentration (ppb) and mass emission rate (tpy) of benzene from sources such as the Dissolved Air Filtrations (DAF) cells and the Biological Treatment Tanks (BTT's) will require specialized emissions testing such as the Isolation Flux Chamber Test Method which was specifically developed to test air toxic emissions from waste water treatment facilities. Isolation Flux Chamber testing is an EPA recognized test method. The test is complex, requires specialized equipment, and should be conducted by a highly qualified team with specific experience using this method. A rough cost estimate of $40k was obtained from a team of scientists that developed the Isolation Flux Chamber Test Method and has previous experience with VMT air emissions as part of the PWSRCAC Valdez Air Health Study Review Committee.

A review of various ambient benzene monitoring options has revealed that an initial, cost-effective screening level testing program could be conducted using EPA Method TO-14a. This method requires collection of air samples in evacuated Summa® canisters; the collected gases are then analyzed in a laboratory using EPA analytical Method T0-14a using gas chromatography to quantify the amount of benzene. This method is inexpensive. The cost of canister rental and laboratory analysis is approximately $225-$275 per canister. To keep the sample collection cost low, PWSRCAC staff can be trained to collect samples. A rough total project cost of $16K was estimated, which includes a sampling plan, staff training, equipment and lab analysis for 30 samples. It is recommended that Summa® canisters samples be collected over a period of time, and at various meteorological conditions, duplicating the four 1990-1991 Valdez Air Health Study benzene monitoring sites (Valdez High School, Old Valdez, Valdez Spit, East Gate of VMT). Other sites could be added if desired. No additional meteorology data costs would be required since the National Oceanic Atmospheric Administration (NOAA) has meteorological data collection stations at both the Valdez Airport and in the downtown area of Valdez.

If PWSRCAC is interested in evaluating benzene emissions from the oil storage tanks, the first step would be to obtain Alyeska's recent leak detection and repair program emissions testing records for review and to determine if additional testing is necessary to verify Alyeska's claim that storage tank emissions are no longer an issue. Additional source-specific testing of the oil storage tank vents can be achieved using the Tedlar® bag method (EPA Method 18). Method 18 testing will require both expertise and equipment and is roughly estimated to cost $15-20K,[3] depending on the number of vents tested.

Upon completion of the initial testing phase, additional phases of testing may be warranted to further investigate continued high levels of benzene in Valdez. It is recommended that the EPA estimate of 0.4 ppb benzene (equivalent to a 1 in 100,000 cancer risk) be used as a trigger point for further testing and analysis in the City of Valdez. It is also recommended that concentrations of benzene that equal or exceed current benzene estimates from sources at the facility be used as a trigger point for further testing and analysis. Additional testing phases will require careful consideration and planning, and will be costly. Further testing options may include Continuous Emission Monitoring Systems (CEMS), tracer studies, and/or Personal Benzene Monitoring.

This report examines four specific questions, provides technical information on various testing options, and provides a listing of potential test vendors. The four questions examined include:

Question 1: ***What were the benzene concentrations in ambient air prior to the Tanker Vapor Recovery Project? What are they now?***

- Benzene concentrations ranged 1-8 ppb in outdoor Valdez air prior to vapor recovery, which is equivalent benzene levels measured in major cities such as Los Angeles, Boston and Houston.
- 2003 testing is expected to yield lower benzene levels in the City of Valdez
- Benzene levels can be measured using Summa® canisters, or CEMS.
- Benzene levels above 0.4ppb would warrant further attention

Question 2: ***What was the cancer risk prior to the Tanker Vapor Recovery Project? Is the cancer risk acceptable for the citizens of Valdez now that the VMT tanker vapor recovery system is in place, or is additional emission control necessary?***

- Cancer risk ranged from 50-180 times the Clean Air Act health goal in the City of Valdez prior to vapor recovery.
- Cancer risk was over 400 times higher than the Clean Air Act health goal at the East Gate monitoring site at the terminal prior to vapor recovery.
- Additional testing at the terminal and in the town of Valdez is required to determine the current cancer risk.
- A combination of Isolation Flux Chamber Testing and Summa® canisters sampling is recommended.

[3] This estimate is based on a local Alaskan source testing company providing testing equipment and personnel for a one-week period of time.

Question 3: ***How can an accurate total benzene emission estimate be obtained for the BWTF?***

- ❖ BWTF hazardous air emissions are estimated to range from 128-342 tons per year.
- ❖ BWTF is one of the largest remaining sources of benzene emissions at the terminal.
- ❖ The Isolation Flux Chamber Testing is recommended to quantify the BWTF emissions.

Question 4: ***Are VMT employees at risk from benzene exposure?***

- ❖ Cancer risk was over 400 times higher than the Clean Air Act health goal at the East Gate monitoring site at the terminal prior to vapor recovery.
- ❖ On-site monitoring is conducted by Alyeska to comply with benzene exposure monitoring standards; however, PWSRCAC has not reviewed this data.
- ❖ Additional testing at the terminal may be required to determine the current cancer risk for employees.
- ❖ PWSRCAC will need to review any limitations imposed by their contract with Alyeska prior to conducting further work on this matter.

Draft **Way Forward**

Listed below is a *draft* potential plan of action for a way forward. This recommendation is a rough draft, and will certainly be enhanced by TOEM Committee contributions and recommendations; however, it will serves as a "straw-man" from which we can build a more formal course of action.

1. **Confirm Goals and Objectives for Emissions Testing**
   Meet and review this draft recommendation with the TOEM Committee and solicit input and expertise from the Scientific Advisory Committee. Discuss expected outcomes, cost, goals and objectives for testing, and the long-term plan for use of the data collected.

2. **Review all available emission data collected by Alyeska since 1992.**
   TOEM Committee should consider approving a formal RCAC request to Alyeska for a copy of all air emission testing that has been completed at the VMT since the 1992 Valdez Air Health Study. Specifically request any testing data that has been obtained at the BWTF, the oil storage tank vents, and at berths still loading in an uncontrolled fashion (e.g. Berth 3). Alyeska management has indicated that no data has been collected; however, it would useful to document this in the record, and/or obtain any data that has been collected.

3. **Meet with Alyeska**
   TOEM Committee should consider meeting with Alyeska staff and/or with Alyeska management to review Valdez air health history, communicate PWSRCAC remaining concerns, and brainstorm on potential benzene testing options. Alyeska approval will be required for access to the VMT, use of VMT equipment, and collection of process monitoring data (e.g. flow rates, temperature data, etc.) during the testing. TOEM Committee may want to discuss the potential for joint funding of this project with Alyeska.

4. **Meet with EPA and ADEC staff**
   Meet with EPA and ADEC staff to review Valdez air health history, communicate PWSRCAC remaining concerns, and brainstorm potential monitoring and regulatory options

for the future. Timing of this meeting is key. It is recommended that a meeting be held in the Spring of 2003, such that RCAC concerns can be addressed as part of the VMT Title V permitting action and as part of the final decision on air toxic rules for Organic Liquid Distribution facilities (OLD NESHAP). This meeting would investigate the type and level of "compelling" data that would trigger additional air toxic emission controls at the terminal. It is recommended that Alyeska be invited to attend this meeting. TOEM committee may want to discus the potential for joint funding of this project with ADEC and/or EPA, as federal funds are available for communities to examine air toxins.

5. **Meet with NOAA**
   Meet with NOAA to discuss the need for access to meteorological data during the test. Seek cooperation and assistance in obtaining quality data at both the downtown and airport meteorology data stations.

6. **Hire Air Emissions Testing Team**
   Based on the type of testing selected, an air emissions testing team should be assembled to develop the final written plan, locate the equipment and laboratory services necessary to execute the plan.

7. **Develop Benzene Testing Plan**
   Develop a Phase I benzene testing plan and quality assurance plan. Set specific goals and objectives for the testing and establish benzene monitoring thresholds at which additional Phase II testing will be warranted.

8. **Review Final Phase I Benzene Testing Plan with Alyeska & Regulators**
   Review Phase I: 2003 benzene testing plan with Alyeska, ADEC, EPA and NOAA, to ensure that all agree on test methods, plans, procedures and quality assurance plans.

9. **Obtain PWSRCAC Board Approval**
   Obtain approval for Phase I: 2003 benzene testing plan from PWSRCAC Board.

10. **Present Plan to Valdez City Council**
    Present plan to Valdez City Council to keep them apprised of PWSRCAC's scope of work, goals and objectives, as follow-up to the Tom Kuckertz's January 21, 2003 VMT Air Quality Presentation.

11. **Conduct Testing**
    Conduct Phase I: 2003 benzene testing and develop a written assessment.

12. **Review Findings and Decision Way Forward**
    Review testing program findings and recommended way forward with PWSRCAC Board, Alyeska Management, ADEC, EPA and the Valdez City Council.

Background

Primary Goal: Quantify Actual Hazardous Air Emissions from VMT

PWSRCAC's primary concern is the health hazard associated with the release of Hazardous Air Pollutants (HAP's) from the Valdez Marine Terminal (VMT) and the corresponding health risks to the Alyeska employees and citizens of Valdez. Benzene emissions are a primary concern, since

benzene is listed as a Group A known human carcinogen. Toluene, Ethylbenzene, and Xylene emissions are also of concern since they are EPA listed hazardous air pollutants.

PWSRCAC's consultants currently estimate that the total Benzene, Toluene, Ethylbenzene, and Xylene (BETX) emissions from the VMT are in the range of 143-524 tons of hazardous air pollution per year. This paper provides an initial recommendation for the PWSRCAC TOEM Committee's consideration to further validate these emission estimates through actual quantitative air emission source testing.

Why is benzene of concern?

Benzene is a known human carcinogen[4] and has been shown to cause rare forms of leukemia including acute myelogenous leukemia, acute lymphocytic leukemia, and chronic myelogenous leukemia. Breathing very high levels of benzene can result in death, while high levels can cause drowsiness, dizziness, rapid heart rate, headaches, tremor, confusion, and unconsciousness.

The major concern for long-term exposure to benzene is the effect on the blood. When a person breathes high levels of benzene, about half of it leaves the body through exhalation. The other half passes through the lining of the lungs and into the blood stream. Once in the blood stream, benzene can be stored in bone marrow and fat. In the bone marrow and liver, benzene is converted to products called metabolites, which are linked to the cause of leukemia. Chronic, or long-term exposure to benzene is linked to leukemia (cancer of the bone marrow needed to produced blood cells).[5]

Industrial emissions can be a source of benzene. Other known sources of benzene include tobacco smoke, automobile service stations, motor vehicle exhaust, glues, paints, and industrial emissions. EPA estimates that roughly 50% of the nation's exposure to benzene is from tobacco smoke; motor vehicles and industrial emissions follow at roughly 20% each, depending on the area of the country.

Why source test?

Air emission tests (source tests) are conducted to quantify the specific amount and type of pollutants emitted from a specific source or to determine the pollutant concentration levels in an area (area tests), such as in a city or a neighborhood. Emission data is used to identify human health or environmental concerns by comparing the collected data against published health standards, state and national air quality data, and historic air quality in the area. Emission control options are then evaluated to control elevated levels of pollutants that pose a risk to human health or the environment.

From August 1990- September 1991, Alyeska conducted a number of air emission tests in the Port of Valdez to monitor for VOCs, and more specifically for benzene. Continuous Emission Monitoring Stations (CEMS) were installed at four different locations in the Valdez area to collect data for a one year period (August 1990- September 1991), personal benzene monitoring was conducted, and tracer studies were completed. Alyeska summarized the results of this air monitoring in a 1992 report entitled "Valdez Air Health Study." In 1992, PWSRCAC hired Dr. Cohen to prepare a report entitled "Multimedia Fate and Effects of Airborne Petroleum Hydrocarbons in the Port Valdez Region" and subsequently hired a team of experts to review

[4] Department of Health and Human Services (DHHS), International Agency for Cancer Research (IARC), and the Environmental Protection Agency (EPA).
[5] Comprehensive Health and Environmental Monograph on Benzene, Health & Environment International, Ltd. Wilmington, DE, 1990.

Alyeska's Valdez Air Health Study. The team was called the Valdez Air Study Review (VASR) Committee.[6]

In 1996, Alyeska installed the Valdez Marine Terminal Tanker Vapor Recovery Project. Alyeska estimates that the vapor recovery project reduced VOC emissions by approximately 32,000 tons per year (tpy), to a current estimate of approximately 5,200 tpy.

Since 1992, most of the hazardous air emission data for the VMT has been based on the data collected in 1990 and 1991, combined with emission estimates developed by PWSRCAC consultants, Alyeska, and the regulators. Estimates are based on the system design, system throughput, compositional data, and EPA standard emission factors. No ambient air quality monitoring was conducted after the installation of the vapor recovery project to quantify the air quality improvements made as a result of the project.

Additional source testing will provide a more accurate, quantitative assessment of the amount and type of pollutants emitted from each specific source tested at the VMT, and will provide an updated assessment of the benzene health risk to Valdez residents. Source testing will provide the quantitative data needed to move forward with recommendations for enhanced emissions control or confirm that the cancer risk has been reduced to an acceptable level.

Why develop and implement a joint testing program with Alyeska?

It is recommended that the PWSRCAC meet with Alyeska management and propose a joint source testing program for further quantification of the hazardous air emissions at the VMT. A joint testing program will provide a number of benefits:

- ***Facility access***: Alyeska must approve any testing that is to be conducted within the fence line of the VMT facility. Air emission testing teams will require access to operational data (e.g. flow rates, temperature) to ensure that representative samples are obtained.
- ***Access to VMT equipment***: Tests such as the Isolation Flux Chamber Test will require Alyeska staff and equipment (e.g. use of boom to lower the flux chamber over BTT's).
- ***Safety***: Conducting benzene tests in the BWTF area will require strict adherence to Alyeska, OSHA and NIOSH procedures and requirements to ensure the safety of all personnel. Respirator fit testing and certification may be required, in addition to VMT work permit approval.
- ***Cost-effective***: It is economically more efficient to jointly share the testing program costs.
- ***Acceptance of results***: Joint development of a sampling, laboratory and quality control program will contribute to general acceptance of the final results

Why develop a phased source testing plan?

It is logical to start with simpler, more cost-effective, intermittent air sampling for the initial testing, to obtain a set of screening samples to see if further, more complex, higher cost, continuous air sampling if warranted. This approach is aligned with PWSRCAC's limited air quality source testing budget. Thus, it is recommended that the PWSRCAC implement a phased source testing program to obtain an initial screening assessment to obtain updated benzene concentration levels in City of Valdez and source-specific testing at the BWTF, and potentially at uncontrolled loading at Berth 3. This approach will provide an updated assessment of the benzene level in the Valdez City ambient air, and will provide more accurate emissions data on the level

[6] Preliminary Review of the Valdez Air Health Study, Report Prepared for the Prince William Sound Regional Citizens Advisory Council, by Yoram Cohen, G.E. Chinkin, G. Pascoe, C.E. Schmidt, and A Winer, March 1992.

of benzene emitted from the BWTF and potentially uncontrolled loading. Based on this data a determination would be made as to whether or not more complete, higher cost sampling is warranted.

What are the sources of BETX at the VMT?

The major remaining sources of hazardous air emissions include uncontrolled loading, the Ballast Water Treatment Facility (BWTF), fugitive emissions, and combustion sources. Hazardous Air Pollutants (HAP'S) are contained within the general category of Volatile Organic Compound (VOC) emissions. Specific VOCs of concern include Benzene, Toluene, Ethylbenzene, and Xylene (BETX); however, the primary human health hazard is benzene. HAP's emission estimates have been developed by PWSRCAC contractors and are summarized in the Tables 1 and 2.

Table 1: Total VMT HAP's Emissions Estimate

Emission Source	Total VOC's	Total BETX Low Estimate	Total BETX Upper Estimate
BWTF Total	842	128[7]	342[8]
Fugitive Emissions	5,600[9]	1[10]	168[11]
Combustion Sources	2600	13[12]	13[13]
Miscellaneous Sources	24	1[14]	1[15]
Total	**9066**	**143**	**524**

Uncontrolled Loading

The Marine Vessel Loading Rule (40CFR, Part 63, Subpart Y) regulates uncontrolled loading at the VMT. Currently, the total number of barrels of crude oil that can be loaded uncontrolled is limited to approximately 4% of the previous year's throughput via an algorithm codified in the rule . Uncontrolled loading is further limited to those periods of time wherein either Berth 4 or Berth 5 or both are out of service for maintenance. Because Berth 1 has been cannibalized to provide parts for the controlled berths, all uncontrolled loading occurs at Berth 3[16]. Several tanker companies and owner companies have policies prohibiting uncontrolled loading (e.g. Alaska Tanker Company, British Petroleum, Sea River). In this last year, only Polar Tankers and Sea Bulk participated in the 3 uncontrolled loadings that took place at Berth 3.

The 2002 allowance for uncontrolled loading was approximately 1,400 tons of VOC's per year. As long as this allowance is not being fully utilized, additional air emission testing may not be necessary. However, if some shipping companies continue to load uncontrolled, further source specific testing at Berth 3 may be required to determine the concentrations of benzene at the terminal during active uncontrolled loading. PWSRCAC has repeatedly requested that Alyeska either install vapor controls on Berth 3 or shut it down permanently. Additional testing would support PWSRCAC's position.

[7] Assumes efficient biodegradation in the Biological Treatment Tanks.
[8] Assumes no biodegradation in the Biological Treatment Tanks.
[9] Used conservative 5,600 tons per year, settlement estimate between APSC and ADEC. Although ADEC did estimate that the fugitive VOC emissions could be as high as 26,000 tons per year.
[10] Based on Alyeska's estimate of less than 1% provided in the 1998 EPA ICR Survey response.
[11] Based on 3% HAPs in 5,600 tons of fugitive VOC emissions.
[12] Based on Alyeska's estimate of 13 tpy provided in the 1998 EPA ICR Survey response.
[13] Based on Alyeska's estimate of 13 tpy provided in the 1998 EPA ICR Survey response.
[14] Based on 5% HAPs in 24 tons of Miscellaneous VOC source emissions.
[15] Based on 5% HAPs in 24 tons of Miscellaneous VOC source emissions.
[16] Aleyska is in the process of decommissioning Berth 1. Berths 1 and 3 do not have vapor recovery.

Ballast Water Treatment Facility

There are five specific components of the BWTF that have a potential to emit BETX (BWTF 90's Tanks, BWTF 80's tanks, DAF units, Weir and the Biological Treatment Tanks).

Table 2: BWTF Emissions Estimate (Updated DAF Cell Emissions)

Emission Source	Total BETX Assuming Biodegradation	Total BETX Assuming NO Biodegradation
BWT Tanks (90's tanks)	5.75	5.75
BWT Tanks (80's tanks)	0.03	0.03
DAF Units	105	105
Weir	10.94	10.94
Biological Treatment Tanks (BTT)	5.9	220
Total	**128**	**342**

The lower end of the range is consistent with Alyeska and BLM's estimates. The upper end of the range assumes no biodegredation is occurring in the Biological Treatment Tanks, due to cold water temperatures and short retention times in the tanks.

The total amount of HAP's emitted from the BWTF is largely a function of the efficiency of the Biological Treatment Tanks (BTT's). If the biological efficiency is high, there is less BETX emitted directly to the atmosphere. Conversely, there is concern that in cold climates, it is difficult to maintain warm enough temperatures in the BTT's to achieve optimal biological treatment efficiency. At colder temperatures, there is less consumption of BETX by oil-eating microbes resulting in higher levels of HAP's emissions to the atmosphere. In a separate 1992 report, Dr. Cohen studied the likelihood of biodegradation in the BTT's.[17] Dr. Cohen concluded that while there is sufficient evidence that biodegradation is possible, there was no compelling evidence quantifying the amount of biodegradation that was actually taking place. Of concern was the short retention time (less than one day) in the BTT's. In lab studies and natural water bodies, the biodegradation rate constant for benzene is on the order of 2 to 16 days. With the very short retention period in the BTT's, Dr. Cohen concluded that volatilization to the atmosphere may be a major pathway of loss for these compounds from the BTT's.

In April 2002 a more recent study was completed for the RCAC on BWTF pollution by Dr. Payne et.al. al.[18] Dr. Payne's report estimates that at the current BWTF flow rate[19] the total annual BETX emissions are approximately 105 tons. Dr. Payne notes that the DAF cells are specially designed to remove BETX compounds through volatilization to the atmosphere. There is no system in place to capture and destroy the volatilized HAPs. Dr. Payne's report also notes that the temperature drop in the colder months is significant enough to drop the treatment efficiency of the biological treatment and that historical data shows that the highest effluent BETX is seen in the winter and early spring months when biological efficiency is at it's lowest. Table 2 updates Dr. Cohen's 1992 emission estimates with Dr. Payne' updated DAF cell emission estimates.

[17] Biodegradation in the Biological Treatment Units in the Alyeska Marine Terminal, Dr. Cohen report to the Prince William Sound Regional Citizen's Advisory Committee, June 3, 1992.

[18] Evaluation of Mixing Zone and NPDES Permit Renewal Applications for BWTF at Alyeska Marine Terminal, Dr. Payne et.al., Report for the Prince William Sound Regional Citizen's Advisory Committee, April 24, 2002.

[19] 12,000,000 gallons per day

The BWTF has been tested for the amount of BETX in the water phase; however, to PWSRCAC's knowledge Alyeska has not conducted specific source tests at the BWTF to quantify the amount of BETX in the air phase. Source-specific testing of the BWTF is necessary to quantify the amount of BETX emitted from this facility.

Fugitive Emissions

Fugitive emissions at the VMT facility include vapors released to atmosphere from tank vents, crude oil piping, vapor recovery system piping, and miscellaneous vents and leaks. In year 2000, ADEC completed an independent assessment of the VOC emissions from leaks from the vacuum/vent valves on the crude oil storage tanks (assumed to be one of the largest sources of fugitive emissions at the facility). ADEC estimated that the VOC emissions could range from 5,600 to 26,000 tons per year. Alyeska disputed this estimate, but agreed via settlement to pay FY01 emission fees on a total of 5,600 tons per year.[20] APSC and ADEC continue to dispute the estimated fugitive emission total even as recently as March 2002.[21]

Using a vent gas sample provided by APSC, the HAP's content in the gas was estimated at approximately 3% by weight of the total organic crude VOC vapor.[22] The 3% HAP's was used to estimate the amount of HAP's in the 5,600-26,000 tons of VOC fugitive emissions per year which were estimated by ADEC. A 3% HAP estimate resulted in an estimated 168-780 tons of HAP's per year. PWSRCAC consultants used the lower end of the range, agreed to by Alyeska, of 5600 tons per year of total VOC's to estimate the amount of fugitive BETX emissions (168 tons per year).

Alyeska's more recent correspondence to ADEC states that an intensive leak detection and repair program has significantly reduced the amount of fugitive emissions at the VMT. Alyeska has indicated to EPA that this leak detection and repair program has reduced fugitive emissions to less than 1 ton of BETX per year.

Alyeska indicates that they have extensive records, including source testing, on the leak detection and repair program. It is recommended that PWSRCAC request those records and review the revised program to evaluate the program's actual effectiveness, prior to launching a separate fugitive emission testing program.

Combustion Sources

Combustion Equipment at the VMT is estimated to contribute over 2,600 tons of VOC's per year. Alyeska has indicated to EPA that the estimated the amount of HAP's contained as a percentage of VOC's is 13 tons per year. However, Alyeska provided no supporting data in their response the 1998 EPA request for HAP data at the terminal, to validate this estimate.

Due to the low level of VOC's from these sources it is recommended that no further emission testing be conducted. However, if PWSRCAC would like to pursue validation of Alyeska's benzene emission estimates for combustion sources it is recommended that PWSRCAC first evaluate the tests that Alyeska has already obtained on these sources.

[20] Valdez Marine Terminal Assessable Emission Estimates for Fiscal Year 2002, APSC letter to the Alaska Department of Environmental Conservation, April 30, 2001.
[21] Valdez Marine Terminal Assessable Emission Estimates for Fiscal Year 2002, APSC letter to the Alaska Department of Environmental Conservation, March 13, 2002.
[22] June 14, 1999 VMT Vent Gas Sample, Core Lab Analysis.

Miscellaneous Sources

In year 2000 Alyeska added two emission sources that contributed to the total VOC emissions at the VMT: a new tank bottom processing system and a soil vapor extraction system. Alyeska voluntarily agreed to control the level of VOC's emitted from these new sources to avoid the complexity of a major permit review. The maximum permitted VOC emissions from these new sources adds a total of 23.5 tons per year[23]. A very conservative estimate of 5% HAP's of the total VOC's would add an additional 1 ton of HAP's to the VMT emissions estimate per year.

Due to the low level of VOC's from these sources and the extensive VOC control requirements of these permitted sources, it is recommended that no further emission testing be conducted.

Setting Goals and Objectives for the Air Emissions Testing Program

Prior to conducting additional source tests, goals and objectives must be established along with a long term plan for use of the collected data. Key questions need to be addressed, such as:

- What data has already been collected?
- What has that data told us?
- What deficiencies are there in the data collected to date?
- What are the benefits of collecting additional data?
- What additional data needs to be collected?
- What do we expect the new monitoring data to show?
- What is the best method for data collection?
- What can be done with the monitoring data?

Question #1

What were the benzene concentrations in ambient air prior to the Tanker Vapor Recovery Project? What are they now?

What data has already been collected?

Continuous Emission Monitoring Stations (CEMS) were installed at four different locations in the Valdez area to collect VOC emission data for a one-year period (August 1990- September 1991). CEMS were located at the Valdez High School, on the Valdez Spit, in Old Valdez, and at the East Gate of the VMT facility to monitor ambient benzene concentrations, among other VOCs. A personal benzene monitoring study was conducted in residential areas of Valdez. Benzene was specifically targeted, since it is a known human carcinogen and a known constituent of VMT emissions.

What has the data told us?

Ambient benzene monitoring during August 1990 through September 1991 quantitatively determined that benzene levels monitored at the High School, Old Valdez and the Valdez Spit were in the range of 1-2 ppb, consistent with the low to mid-range benzene levels monitored in major urban centers such as Houston, Los Angeles, and Boston (1-6 ppb range). Benzene levels obtained from the personal monitoring study averaged 7.7 ppb in outdoor residential air and 20.2 ppb in indoor residential air. Benzene levels averaged 8 ppb at the East Gate monitoring site.

[23] PSD Avoidance, Permit No. 0071-AC005, Condition 22.

What deficiencies are there in the data collected to date?

PWSRCAC's expert, Dr. Cohen, was concerned with the very high percentage of missing data for the one-year monitoring period. He noted that EPA typically requires high quality CEMS monitoring data to yield data for at least 75% of the operating time period. Alyeska's CEMS data was missing for an average of 40-49% of the data. The significance of the "missing" data is not known, since it was not clear whether the missing data would have represented periods of high or low emissions that would have changed the final average benzene estimate for each monitoring site.

Benzene levels obtained from the personal monitoring study averaged 7.7 ppb in outdoor residential air, yet there is no logical explanation as to why the residential benzene concentrations are 4-7 times larger than the CEMS monitoring data, which only showed 1-2 ppb in the City of Valdez. Although Alyeska attributed the higher residential benzene levels to other non-terminal sources of data, that explanation doesn't add up. Benzene associated with vehicle emissions would have yielded correspondingly elevated levels of carbon monoxide. If benzene associated with other industrial emissions, such as the Petrostar Refinery, was the source it should have resulted in elevated levels of benzene at the Valdez High School and Valdez Spit CEMS, rather than the measured high levels of benzene at neighborhoods such as the Robe River Subdivision, Mineral Creek Loop Road or Alpine Woods Estates.

Indoor residential levels of benzene of 20.2 ppb seem questionable. A recent study in Anchorage investigated indoor benzene levels at approximately 3ppb (which is about double what they measured outdoors.)[24] Using that as a benchmark, the 20 ppb number looks very high.

PWSRCAC's review of the personal monitoring study concluded Alyeska's study was flawed, and that their analysis showed that the terminal contributed to about 30-90% of the indoor exposures and 30-60% of the personal exposure to benzene.

What are the benefits of collecting additional data?

RCAC has expressed an interest in collecting ambient air samples in Valdez to quantitatively evaluate improvement to the air quality since the 1990-1991 sampling data was obtained. Valdez ambient benzene monitoring data is over ten years old. Ambient, "urban" concentrations of benzene were collected in 1990 and 1991 prior to the installation of the Valdez Marine Terminal Tanker Vapor Recovery Project. Alyeska estimates that the vapor recovery project reduced VOC emissions by approximately 32,000 tons per year (tpy), to a current estimate of approximately 5,200 tpy. Post tanker vapor recovery project emission estimates have not been obtained. It would be beneficial to obtain benzene emission data to determine the current exposure levels for Valdez residents and terminal employees and to assist in quantifying reductions in benzene exposure due to the vapor recovery project. Collecting data at the previous sites is logical since it will provide for direct comparison to the 1990 and 1991 data.

What additional data needs to be collected?

The PWSRCAC TOEM committee has expressed an interest in collecting air samples at the same sites tested in 1990 and 1991 (Valdez High School, Valdez Spit, Old Valdez, and at East Gate). In addition, TOEM has recommended adding additional sites inside the "fenceline" of the terminal to evaluate the exposure risk to the terminal employees.

[24] Air Quality in Anchorage, A summary of Air Monitoring Data and Trends (1980-1998), Air Quality Program, Environmental Services Division, Department of Health and Human Services, Municipality of Anchorage, May 1999.

What do we expect the new monitoring data to show?

It is expected that benzene levels would be lower than the 1-2 ppb range previously monitored in the City of Valdez, the 7.7 ppb average monitored in outdoor residential air, and the 8 ppb average benzene concentration measured at the VMT East Gate, prior to vapor control.

What is the best method for data collection?

If RCAC desires to obtain updated ambient benzene emission data in Valdez, that data can be collected in one of two ways: (1) by collecting several 8-hour samples in various locations in the Port of Valdez using evacuated Summa® canisters and analyzing the gases collected in a laboratory using EPA Method T0-14a; or (2) by installing Continuous Emission Monitors (CEMS) to measure benzene on a continuous basis.

It is recommended that initial updated ambient benzene concentration data be obtain by using a simple, and cost-effective method of collecting several 8-hour samples in various locations in the Port of Valdez using evacuated Summa® canisters, then sending the canisters to a lab to be analyzed for benzene.[25] Use of Summa® canisters is much more cost-effective than installation of a CEM, and this approach has been used successfully by regulatory agencies to obtain meaningful, technically valid data. For example, EPA used this approach in the "Toxic Air Monitoring System (TAMS) Study" to measure the levels of VOC's in Boston, Chicago, Houston and Seattle during 1987-1988.[26] More recently, the Municipality of Anchorage used the TAMS study approach to measure the level of benzene in the Anchorage area, particularly in response to concerns about benzene exposure to citizens living in the community of Government Hill, above the Port of Anchorage tank farm area.[27]

Based on a cost-effective initial screening assessment, using Summa® canisters testing, PWSRCAC would have sufficient information to determine whether additional testing is warranted. A sufficient number of samples should be obtained to ensure that samples are collected at various times of the year, and under various wind and weather patterns, to ensure statistical validity. The sample collection program should be correlated with meteorological data in the area.[28] RCAC staff could be trained to collect these samples and ship them to a qualified laboratory for analysis. The cost of canister rental and laboratory analysis is approximately $225-$275 per canister, and PWSRCAC staff can be trained to collect the samples to keep the sample collection cost low. At a rough estimated cost of $16K, a sampling plan, staff training, equipment and lab analysis can be completed for 30 samples.

What can be done with the monitoring data?

Ambient benzene concentration data collected in the City of Valdez can be compared to published health standards, state and national air quality data and historic air quality data collected in Valdez, such as the data listed in Table 3. Due to the large decrease in benzene emissions from the vapor control project in 1996, and the fact that there has been no significant increase in other industrial emission sources in Valdez, or significant increase in populations since 1996, it is estimated that the benzene levels monitored in the City of Valdez in 2003 should be less than the benzene levels detected in 1990 and 1991.

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[25] Samples would be tested for toluene, ethylbenzene, and xylene, however benzene would be the primary pollutant of concern.

[26] Final Report on the Operations and Findings of the Toxic Air Monitoring System (TAMS), G. Evans, Atmospheric Research and Exposure Assessment Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, N.C., 1990.

[27] Air Quality in Anchorage, A summary of Air Monitoring Data and Trends (1980-1998), Air Quality Program, Environmental Services Division, Department of Health and Human Services, Municipality of Anchorage, May 1999.

[28] NOAA has a meteorology station in downtown Valdez and at the airport.

Table 3: Benzene Exposure Limits and Monitoring Data		
Benzene (ppb)	**Human Health Impact and Action Levels**	**Organization or Government Agency**
10,000,000 to 20,000,000	5-10 minute fatal exposure level	National Institute for Occupational Safety and Health (NIOSH)
700,000 to 3,000,000	Short-term exposure level (unconsciousness, tremor, headaches drowsiness, dizziness,)	Comprehensive Health and Environmental Monograph on Benzene[29]
1,000,000	OSHA requires employees to wear the "most protective" class of respirators	Occupational Safety and Health Administration (OSHA)[30]
50,000	one hour emergency exposure guidance level	National Research Council
5,000	Emergency Exposure Guidance Levels (EEGLs), 24 hour limit not to be exceeded during any 15 minute work period	National Research Council[31] Occupational Safety and Health Administration (OSHA)
4,500-1,500	Can smell benzene in the air	Agency for Toxic Substance and Disease Registry (ATSDR)[32]
2,500	Short-term exposure limit	American Conference of Governmental Industrial Hygienists (ACGIH)
2,000	Emergency Exposure Guidance Levels (EEGLs), 24 hour limit	National Research Council[33]
1,000	OSHA 8 hour Permissible Exposure Level (PEL) over a 40 hour work week[34] NIOSH 15 minute exposure limit.	Occupational Safety and Health Administration (OSHA)[35] National Institute for Occupational Safety and Health (NIOSH)
500	Recommended airborne exposure limit not be exceed over an 8 hour work shift.	American Conference of Governmental Industrial Hygienists (ACGIH)
100	School Evacuation Requires "most protective" respirators above this level[36]. Limit is set at 0.1 ppm averaged over a 10 hour work shift.	Pennsylvania Department of Health[37] National Institute for Occupational Safety and Health (NIOSH)

[29] Comprehensive Health and Environmental Monograph on Benzene, Health & Environment International, Ltd. Wilmington, DE., 1990.
[30] [29 CFR 1910.1028]
[31] Emergency and Continuous Exposure Guidance Levels for Selected Airborne Contaminants. Vol. 6, Benzene and Ethylene Oxide. Washington, DC. National Academy Press, Committee on Toxicology, Board on toxicology and Environmental Health Hazards, Commission on Life Sciences, National Research Council (NRC), 1986.
[32] Toxicological Profile for Benzene, Agency for Toxic Substances and Disease Registry, Atlanta, Ga., U.S. Department of Commerce Nations Technical Information Service (NTIS), 1997.
[33] National Research Council (NRC), 1986.
[34] Occupational Safety and Health Administration (OSHA) currently requires employees to wear respirators when benzene exceeds 1ppm, the 8 hour Permissible Exposure Level (PEL) over a 40 hour work week.
[35] OSHA Carcinogen Policy [29 CFR 1990]
[36] National Institute for Occupational Safety and Health (NIOSH) recommends that all employees likely to be exposed to benzene wear special breathing equipment and that "most protective" class of respirators be worn for benzene at concentrations above 0.1 ppm.

Table 3: Benzene Exposure Limits and Monitoring Data		
Benzene (ppb)	**Human Health Impact and Action Levels**	**Organization or Government Agency**
8.2	Benzene level measured at VMT East Gate in 1992	PWSRCAC report, by Dr. Cohen, 1992
7.7	Benzene level measured in outdoor residential air in Valdez	Aleyska Valdez Air Health Study, 1992.
6-1	Benzene level measured in LA	California Air Research Board (CARB)
5.4	Benzene level measured in Anchorage at Spenard and Benson[38]	Municipality of Anchorage, Department of Health and Human Services, Air Pollution Agency[39]
4-1	Benzene level measured in Houston	EPA AIRS[40] Database
3-1	Benzene level measured in Boston	EPA AIRS Database
1.8	Benzene level measured at Valdez High School in 1992	PWSRCAC report, by Dr. Cohen, 1992
1.4	Benzene level measured in Old Valdez in 1992	PWSRCAC report, by Dr. Cohen, 1992
1.2	Benzene level measured in Anchorage at Raspberry Road[41]	Municipality of Anchorage, Department of Health and Human Services, Air Pollution Agency[42]
0.4	One additional cancer for every 100,000 exposed persons	EPA's life time exposure risk for cancer
0.1	70 year residential criteria One in a 1,000,000 cancer risk screening level.	EPA, Supplemental Guidance for Evaluating Indoor Air Pollution EPA Cancer Risk Threshold for HAP'S[43]

Question #2

What was the cancer risk prior to the Tanker Vapor Recovery Project? Is the cancer risk acceptable for the citizens of Valdez now that the VMT tanker vapor recovery system is in place, or is additional emission control necessary?

What data has already been collected?

Two studies were prepared in 1992: one by PWSRCAC (Multimedia Fate and Effects of Airborne Petroleum Hydrocarbons in the Port Valdez Region, by Dr. Cohen) and one by Alyeska (Valdez Air Health Study). The PWSRCAC study estimated the cancer risk to the Valdez residents using a multimedia modeling approach, based on CEMS data collected by Alyeska in 1990 and 1991 and meteorological monitoring data. The Alyeska study estimated the cancer risk to the Valdez residents using a combination of CEMS data, meteorological monitoring, tracer gases, indoor and

[37] "Is this Building Safe to Occupy: Hazmat Response to Schools and Public Occupancies", Dr. Cocciardi, May 2002 and www.state.pa.health/site.
[38] Data collected in 1993-1994
[39] Final Report on the Operations and Findings of the Anchorage Volatile Organic Compounds (VOC) Monitoring Project, Municipality of Anchorage, Air Pollution Control Agency, February 29, 1996
[40] Environmental Protection Agency's Aerometric Information Retrieval System (AIRS) database.
[41] Data collected in 1993-1994
[42] Final Report on the Operations and Findings of the Anchorage Volatile Organic Compounds (VOC) Monitoring Project, Municipality of Anchorage, Air Pollution Control Agency, February 29, 1996
[43] Clean Air Act Hazardous Air Pollution "Health Goal" of one additional cancer case per million exposed individuals.

outdoor air quality monitoring, and personal air quality monitoring data collected in 1990 and 1991.

What has the data told us?

Based on the basin-wide average concentration of benzene in 1992, prior to the installation of the tanker vapor recovery system, Dr. Cohen estimated that the expected incremental lifetime cancer health risk via the inhalation pathway is about 1 in 20,000 in Valdez, as compared EPA's "acceptable risk level" of 1 in 1,000,000. Los Angeles' incremental lifetime cancer health risk is estimated at 1 in 10,000. EPA's cancer risk estimate was even more conservative than PWSRCAC's, at 1 in 10,000 for Valdez.[44]

Alyeska's Valdez Air Health Study (Dr. Goldstein, et.al.) concluded that incremental lifetime cancer health risk was no greater than 1.7 in 1,000,000 for Valdez residents for risks associated purely with terminal emissions, and 180 in 1,000,000 for the risks associated with personal exposure to all sources of benzene in Valdez. Alyeska concluded, based on their calculations, that the VMT contributed less than 1% of the total lifetime benzene cancer risk in Valdez. Alyeska attributed most of the benzene exposure (89%) to personal exposure to non-terminal sources of benzene (e.g. cigarette smoke, vehicle emissions, other industrial sources, wood stoves, solvents, etc.). Alyeska estimated that the installation of vapor control would reduce the lifetime cancer risk from 1.7 to 0.87 in 1,000,000.

Table 3 lists each of the cancer risk estimates in consistent exponential terms. Table 4 compares them to the nationwide health goal for the Clean Air Act (EPA) which is to reduce cancer risks to below 1 in 1,000,000 (0.01×10^{-4}).

- Alyeska's risk estimate was nearly double the nationwide health goal, based on the risk from the VMT alone.
- PWSRCAC risk estimate was approximately 50 times the national health goal prior to vapor recovery, attributed mostly to VMT sources of benzene.
- Alyeska risk estimate for all sources of benzene in Valdez was approximately 180 times the national health goal, but attributed most of the impact to other non-VMT sources of benzene emissions in Valdez.
- Alyeska estimated that the installation of vapor recovery would reduce the risk associated with VMT sources of benzene to below the national health goal.
- Neither Aleyska nor PWSRCAC estimated the cancer risk for VMT employees. However, based on monitoring data collected during 1990 and 1991 at the VMT facility East Gate, the benzene levels were observed at an average of 8 ppb, with a range of 2-32 ppb depending on wind, weather and source conditions. Thus, in 1990 and 1991, the air quality at the terminal gate yielded a cancer risk that was 400 times higher at this location than the national health goal.

[44] Screening Risk Assessment for Exposure Resulting from Tanker Loading at the Valdez Marine Terminal, Letter from Ann Pontius USEPA, Region 10 to Leonard Verrelli, ADEC, Juneau), May 21, 1990

Table 4: Benzene Cancer Risk Estimates			
Source of Estimate	**Affected Population**	**Lifetime Benzene Cancer Risk (# cancers per population)**	**Lifetime Benzene Cancer Risk (exponential terms)**
EPA Clean Air Act	Nationwide	1 in 1,000,000	0.01×10^{-4}
Alyeska 1992 (Goldstein, et.al.)	Valdez Due to VMT only **post** vapor recovery	0.87 in 1,000,000	0.0087×10^{-4}
Alyeska 1992 (Goldstein, et.al.)	Valdez Due to VMT only **prior** to vapor recovery	1.7 in 1,000,000	0.017×10^{-4}
PWSRCAC 1992 (Cohen)	Valdez	1 in 20,000	0.5×10^{-4}
EPA, 1990	Valdez	1 in 10,000	1.0×10^{-4}
California EPA 1992	Los Angles	1 in 10,000	1.0×10^{-4}
Alyeska 1992 (Goldstein, et.al.)	Valdez Due to all Valdez Sources prior to vapor recovery	180 in 1,000,000	1.8×10^{-4}
CA EPA 1999	Los Angles with ambient benzene levels at 6ppb	426 in 1,000,000	4.3×10^{-4}

Table 5: Benzene Cancer Risk Relative to National Health Goal			
Benzene Emissions Ambient Air (ppb)	**Cancer Risk Over EPA Health Goal (1 in 1,000,000)**	**Estimate Source**	**Lifetime Benzene Cancer Risk (exponential terms)**
1-2	1.7	Alyeska, 1992 VMT only	0.017×10^{-4}
1-2	100	EPA, 1990[45]	1.0×10^{-4}
1-2	50	PWSRCAC, 1992	0.5×10^{-4}
1-2	180	Alyeska, 1992 All Valdez Sources	1.8×10^{-4}
6	426	CA EPA, 1999	4.3×10^{-4}
8 [Range 2-32]	(not quantified but >426)	Alyeska, 1990 to 1991 CEMS data at VMT East Gate	(not quantified but $>4.3 \times 10^{-4}$)

Overall, the main difference in the risk estimates was whether the increased cancer risk was attributed to VMT benzene emissions or other non-VMT sources of benzene emissions in Valdez. Alyeska concluded that only a small portion of the increased cancer risk was attributable to the VMT (about 1%). Alyeska used a combination of CEMS data, meteorological monitoring, tracer gases, indoor and outdoor air quality monitoring and personal air quality monitoring data collected in 1990 and 1991 to show that other sources of benzene in the Valdez air shed were much more significant contributors to the cancer risk. In 1990 and 1991, Alyeska released an inert tracer gas, sulfur hexafloride, from the terminal and measured the amounts of tracer gas that

[45] [45] Screening Risk Assessment for Exposure Resulting from Tanker Loading at the Valdez Marine Terminal, Letter from Ann Pontius USEPA, Region 10 to Leonard Verrelli, ADEC, Juneau), May 21, 1990

traveled to selected monitoring locations in the City of Valdez. Alyeska's tracer studies concluded that very little emissions from the terminal actually reached the City of Valdez due to winds in the Valdez basin that carry the benzene emitted from the terminal away from populated areas about 50-60% of the time. Alyeska also concluded than any terminal emissions that did reach the city were significantly diluted.

Alyeska selected 58 people to participate in a personal monitoring study to examine personal exposure to benzene in both the winter and summer months. Alyeska's personal monitoring study concluded that most of the benzene risk was attributed to indoor residential sources or non-terminal related sources of benzene. They provided personal monitoring data that showed the indoor benzene levels were approximately three times the outdoor concentrations, stating that this was significant since most Valdez residents are indoors over 90% of the time. Alyeska's personal monitoring data showed that outdoor residential air averaged 7.7 ppb, but there was not adequate explanation as to why the CEMS data in the city of Valdez was so much lower (1-2 ppb).

EPA concluded that the benzene emissions from the VMT posed an unacceptable health risk to the community of Valdez at 1 in 10,000 vs. the Clean Air Act health goal of 1 in 1,000,000 and required installation of a tanker vapor recovery system at the VMT in 1996 to reduce total VOC's from the VMT by over 32,000 tons per year. Although Alyeska's experts estimated that installation of the vapor recovery system would reduce the cancer risk to below the EPA national heath goal of 1 cancer in 1,000,000 people, there has been no post-project benzene monitoring conducted to determine whether this is in fact the case.

As for other air toxics emitted from the terminal, Dr. Cohen's 1992 study also found that the human health hazard indices for ethylbenzene, toluene, and xylenes were within acceptable levels. Alyeska also found that ethylbenzene, toluene, and xylenes were found in breathing zone air in concentrations far below the lowest concentrations know to adversely affect human health.

What deficiencies are there in the data collected to date?

PWSRCAC argued that Alyeska's study came to an illogical conclusion since the VMT was one of the largest emitters of benzene in the nation, contributing over a million pounds of benzene to the Valdez air shed on an annual basis prior to 1996. PWSRCAC hired a team of experts to review Alyeska's Valdez Air Health Study. The team attributed over 90% of the Valdez benzene emission to the terminal.

The Valdez Air Study Review (VASR) Committee[46] identified several flaws in Alyeska's study, strongly criticizing the fact that the tracers were not co-mingled with the terminal sources of emissions under study, were not released from the same location at the terminal, and were not released while collecting meteorological data which would demonstrate that the tracer releases were conducted on days representative of Valdez basin conditions. VASR criticized Alyeska's use of future oil throughput estimates that were below the state oil forecasts. VASR disagreed with Alyeska's approach to limiting the exposure estimate to a period of 23 years (assuming the terminal would shut down in 2015), rather than the traditional 70-year lifetime exposure risk used by EPA and other scientists. VASR also criticized Alyeska's study for not examining the cancer risk for those Valdez residents working at the terminal. VASR argued that since Alyeska employees and contract employees make up a large percentage of the Valdez population, control of benzene at the terminal would significantly improve reduce the cancer risk for many of the Valdez citizens. PWSRCAC's summary reports also reflect that EPA concurred with many of

[46] Preliminary Review of the Valdez Air Health Study, Report Prepared for the Prince William Sound Regional Citizens Advisory Council, by Yoram Cohen, G.E. Chinkin, G. Pascoe, C.E. Schmidt, and A Winer, March 1992.

VASR's concerns; however, a report documenting EPA's findings has not been located at this time.
VASR also issued a report which refuting the indoor benzene monitoring data reported by Alyeska. VASR was critical of the personal monitoring population (less than 1.5% of the Valdez population) and make-up (e.g. 67% females in study vs. 45% females in Valdez population). The high indoor benzene levels were questioned.

It is interesting to note the very high level of benzene reported by Alyeska on indoor residential air, at 20ppb. From that data, Alyeska concluded that the terminal contributed only 1% of benzene and that the remaining 99% came from non-terminal sources (especially indoor sources of benzene such as smoking). By comparison, a recent study in Anchorage investigated indoor benzene levels at approximately 3ppb (which is about double what they measured outdoors.)[47] Using that as a benchmark, the 20 ppb number looks very high. It is also noteworthy that the CEMS in Valdez yielded 1-2ppb benzene, but the outdoor residential personal monitoring data yielded around 8 ppb. Once again, Alyeska attributes the high residential benzene to vehicle emissions and smoking in residential areas.

What are the benefits of collecting additional data?

PWSRCAC has expressed an interest in collecting ambient air samples in Valdez to quantitatively evaluate the current cancer risk remaining for both Valdez residents and VMT employees, due to remaining sources of benzene emissions from the VMT. In particular, PWSRCAC is concerned that the benzene emissions were never properly quantified from the BWTF, and may have been severely under estimated. Although PWSRCAC acknowledges that the tanker vapor recovery project resulted in a significant reduction in cancer risk, they would like to quantify the remaining cancer risk and jointly evaluate options for further cancer risk reduction with Alyeska and with state and federal regulators.

What additional data needs to be collected?

Collection of updated ambient benzene monitoring data in 2003 would aide in quantifying the cancer risk reduction attributed to the installation of the vapor recovery system. However, to assess the remaining cancer risk directly attributed to sources of benzene emissions from the terminal, additional air quality monitoring studies would need to be completed (e.g. tracer tests, personal monitoring and CEMS), taking into account the previous Valdez Air Health Study pitfalls, to ensure that the results can accurately estimate the terminal's contribution to the cancer risk.

What do we expect the new monitoring data to show?

It is expected that any new data collected would show that the benzene level would be lower than the 1-2 ppb range previously monitored in the City of Valdez, and lower than the 8 ppb average benzene concentration measured at the VMT East Gate, prior to vapor control. Lower benzene emission estimates will aide in quantifying reductions in Valdez benzene exposure due to the vapor recovery project. Previous 1992 cancer risk estimates, based on 1990-1991 benzene monitoring data, yielded cancer risks that ranged from 50-180 times the national health goal in the City of Valdez.

Collecting only concentration data will be a starting point, but will not establish the scientific link between benzene emission sources and increased cancer risk, nor will it provide the data necessary to compute the annual emission rate in tons per year (tpy). However, in developing a

[47] Air Quality in Anchorage, A summary of Air Monitoring Data and Trends (1980-1998), Air Quality Program, Environmental Services Division, Department of Health and Human Services, Municipality of Anchorage, May 1999.

cost-effective approach, collection of concentration data could be the initial step in the 2003 investigation. An initial step of collecting near-field (samples at the VMT) and far-field (samples in various locations throughout the Port of Valdez), using the inexpensive collection and analysis technique of evacuated Summa® canisters, and analyzing the gases collected in a laboratory using EPA Method T0-14, coupled with meteorological data available from NOAA, would provide an initial assessment of the current level of benzene emissions in the Valdez air shed. The PWSRCAC TOEM committee has expressed an interest in collecting air samples at the same sites tested in 1990 and 1991 (high school, Valdez Spit, Old Valdez, and at East Gate). In addition, TOEM has recommended adding additional sites inside the "fence line" of the terminal to evaluate the exposure risk to the terminal employees. Based on a cost-effective initial screening assessment, using Summa® canisters testing, PWSRCAC would have sufficient information to determine whether additional testing is warranted.

What is the best method for data collection?

As outlined above, in the *Data Collection Section* of Question #1, benzene concentrations can be determined in one of two ways: (1) by collecting several 8-hour samples in various locations using evacuated Summa® canisters and analyzing the gases collected in a laboratory using EPA Method T0-14, or (2) by installing Continuous Emission Monitors (CEMS) to measure benzene on a continuous basis. A third monitoring option is available at the terminal, called Fourier Transform Infrared Spectroscopy (FTIR). FTIR is a proven new technology for monitoring air toxics, such as benzene. Results are immediately displayed in the field, but this technology requires higher concentrations of benzene in the part per million range, more likely to only be observed at the terminal location.

Continued high levels of benzene in the Valdez city area may warrant additional CEMS data collection, tracer studies, and/or personal benzene monitoring combined with meteorological data to appropriately allocate terminal and non-terminal sources of air pollution. Pitfalls from previous studies would need to be addressed when developing the monitoring program. Additional modeling work is not recommended at this time, due to the complexity of the modeling the Valdez air shed and the time and money required to develop an appropriate model and the appropriate input parameters. Any updated 2003 air quality modeling would need updated emission concentration at a minimum, due to the large change in VOC emissions since the last monitoring data was collected in 1990 and 1991; thus, obtaining monitoring data is the first step. Modeling may be used to assist in the ultimate data refinement and analysis, but certainly not as a first step.

Additional source-specific testing at the terminal to determine benzene concentrations in terms of parts per million could include:

- Collection of Summa® canisters samples during ballast water unloading at the BWTF.[48]
- Collection of Summa® canisters samples during uncontrolled loading events at Berth 3.
- Collection of VOC samples for benzene analysis at the oil storage tank vents, using Tedlar® bag sampling.

Additional source-specific testing options at the terminal to determine benzene concentrations in terms of tons per year would include:

- Flux Chamber Testing at all the BWTF open tanks during ballast water unloading at the BWTF.[49]
- FTIR data monitoring at BWTF over a specific period of time.

[48] Careful test planning would be necessary to ensure that testing is conduced with representative flow rates and oil concentrations in the ballast water from typical sized unsegregated tankers.

- ❖ CEMS data monitoring at the uncontrolled loading berths over a specific period of time.
- ❖ CEMS data monitoring at BWTF over a specific period of time.

What can be done with the monitoring data?

If it can be established that terminal benzene emission rates have been reduced, this information will be useful in estimating any residual human health risks. Previous 1992 cancer risk estimates, based on 1990-1991 benzene monitoring data, yielded cancer risks ranging from 50-180 times the national health goal in the City of Valdez. Lower benzene emission estimates will also be useful in determining the current level of benzene exposure for the residents of Valdez. This data will assist PWSRCAC in determining if the ambient benzene concentrations are low enough to protect the citizens of Valdez, or if there is a continued unacceptable level of benzene that warrants further attention. As a benchmark, the benzene data can be compared to national EPA data and the Clean Air Act health goals.

EPA has set a 0.4 ppb threshold for ambient concentrations of benzene, which they have equated to a 1 in 100,000 cancer risk. Although the Clean Air Act has set a health goal of less than 1 in 1,000,000 cancer risk, that goal has not been met in most urban areas of the nation. Previous 1992 cancer risk estimates, based on 1990-1991 benzene monitoring data yielded cancer risks, which ranged from 50-180 times the national health goal in the City of Valdez to well over 400 times the national health goal at the terminal. Recognizing that the national air toxic problem can not be addressed simultaneously, in 1997 a Presidential and Congressional Commission on Risk Assessment and Risk Management recommended that EPA establish a tiered approach for addressing environmental cancer risks. They recommended that areas with 0.4 ppb benzene levels and higher, be prioritized for further emission control and EPA attention. Thus, initial testing which yields 0.4 ppb benzene or greater could be used as a trigger point for further testing and analysis in the Valdez area.

Additional testing phases will require careful consideration and planning, and will be costly, as Alyeska's previous 1992 Valdez Air Health Study attributed 99% of the benzene level in the City of Valdez to non-terminal sources of benzene. Further testing options such as Continuous Emission Monitoring Systems (CEMS), Tracer Studies, and/or Personal Benzene Monitoring may be required to correctly allocate the non-terminal and the terminal sources of benzene.

Question #3

How can an accurate total benzene emission estimate be obtained for the BWTF?

What data has already been collected?

PWSRCAC is not aware of any source-specific air emission data that has been collected from the BWTF.

What has the data told us?

To date, only theoretical emission estimates have been developed by Alyeska, PWSRCAC and the BLM. BWTF hazardous air emissions are estimated to range from 128-342 tons per year, which is one of the largest remaining sources of benzene emissions at the terminal. Total terminal hazardous air emissions are estimated at 143-524 tons per year.

What deficiencies are there in the data collected to date?

This question is not applicable, since data has not been collected.

What are the benefits of collecting additional data?

Source-specific air emission testing of the BWTF will provide quantitative emission data to replace theoretical emission estimates, which have been heavily debated by Alyeska, PWSRCAC and the regulators. Data collected will help answer questions such as:

- What is the actual amount of Benzene, Toluene, Ethylbenzene, and Xylene (BETX) currently emitted from the VMT?
- How efficient are the Biological Treatment Tanks (BTT) at the BWTF?
- Is there sufficient retention time in the BTT's to allow for consumption of BETX by organisms capable of biodegrading BETX?
- How much volatilization is occurring at the Dissolved Air Floatation (DAF) cells?

PWSRCAC, in their recent comments to EPA on the Organic Liquid Distribution (OLD) National Emission Standard for Hazardous Air Pollutants (NESHAP), recommended further emission controls to be imposed at the BWTF to reduce the high level of hazardous air emissions emitted from this portion of the facility. Alyeska's comments to EPA contested PWSRCAC assertion that the BWTF needed further control, and criticized PWSRCAC's emission estimates, but provided no quantitative data to support their lower estimate. OLD NESHAP is expected to be finalized in the summer of 2003; additional data collected in the spring of 2003 would be helpful to support PWSRCAC's comments to EPA on this rule.

What additional data needs to be collected?

Source specific surface air emission data at the BTTs and the DAF cells at the BWTF.

What do we expect the new monitoring data to show?

It is expected that the BWTF testing data will confirm PWSRCAC's hazardous air emissions estimates with quantitative data. It is expected that emission data will indicate emissions are at the higher end of the estimated range, due to low biological efficiency in the BTT's and increased volatilization in both the BTT's and DAF cells, over what has been previously predicted.

What is the best method for data collection?

It is recommended that the BWTF testing be conducted using a combination of the Summa® canister testing to monitor ambient benzene concentrations and the surface emissions isolation flux chamber testing technique to collect mass emission rates (tons per year) at the BTT's and the DAF cells. The surface emissions isolation flux chamber testing technique is an approved EPA test method[50] that is typically used to obtain a mass emissions rate from wastewater treatment facilities. A rough cost estimate of $40K has been obtained for this type of testing and is provided in Attachment #1.

What can be done with the monitoring data?

Data collected from BWTF air emission testing can be used to support PWSRCAC's comment on the OLD NESHAP final rule.

[50] Measurement of Gaseous Emission Rates form Land Surfaces Using an Emission Isolation Flux Chamber – User's Guide, EPA 600/8-86-008 (NTIS PB86-223161)

Question #4

Are VMT employees at risk from benzene exposure?

What data has already been collected?

The 1992 Valdez Air Heath Study did not examine the benzene exposure or risk for the VMT employees. Alyeska follows OSHA requirements, which require benzene monitoring at the terminal, and use of respirators above 1 ppm benzene. Alyeska may have conducted additional employee testing, but that data has not been requested by PWSRCAC, or provided to PWSRCAC to date.

What has the data told us?

Benzene monitoring equipment at the facility has detected benzene concentrations above 1 ppm, which has on occasion required use of respirators in certain areas of the terminal.

What deficiencies are there in the data collected to date?

Further discussions with Alyeska would be required to examine the extent of the benzene monitoring program in place for worker protection. After a review of this program, any deficiencies could then be identified.

What are the benefits of collecting additional data?

PWSRCAC has expressed an interest in collecting data to determine the current exposure levels for terminal employees; however, PWSRCAC will need to review any limitations imposed by their contract with Alyeska prior to conducting further work on this matter.

What additional data needs to be collected?

This is difficult to predict until Alyeska's data is reviewed. On-site benzene monitoring has been collected to comply with OSHA standards; however, the details of the program will require further review to determine the locations, type and frequency of sampling.

What do we expect the new monitoring data to show?

This is difficult to predict until Alyeska's data is reviewed. Assuming that on-site benzene monitoring has been collected to comply with OSHA standards, that data could be compared to new data collected. Reduction in benzene emissions, due to the installation of tanker vapor recovery in 1996, should result in lower benzene concentrations at the terminal. However, ambient benzene concentrations may still be well above the Clean Air Act's health goal of 1 in 1,000,000 cancers, and employees may be exposed to non-acute lower levels of benzene that may result in a higher risk of cancer. That risk could be determined from additional testing.

What is the best method for data collection?

Air emission testing at the terminal, recommended in response to Questions 2-3 above, would be appropriate as an initial screening level test program. Additional studies may include an employee monitoring program, which would entail the use of personal benzene monitoring and, potentially, breath and blood sampling programs.

What can be done with the monitoring data?

The EPA only regulates the public's exposure to hazardous air pollutants such as benzene whereas; organizations such as OSHA regulate employee's exposure. OSHA does not limit the maximum concentration of benzene that can be emitted from the facility; rather they only impose protective equipment use requirements in the presence of elevated benzene levels. Additional

monitoring and review could be performed to determine if Alyeska is complying with OSHA standards; however, this analysis is unlikely to result in any additional emission control technology imposed by the regulators.

Benzene Measurement Technique Options

Summa® canisters

Benzene has been successfully measured in ambient air to the parts per billion level using EPA Method TO-14a. EPA's Technical document "Locating and Estimating Air Emissions from Sources of Benzene" lists EPA Method TO-14a[51] as a reliable technique for measuring benzene.

Air samples are collected in pre-cleaned and evacuated Summa® canisters. Collection is simple and requires little expertise or training, essentially the canister valve is opened for a pre-determined period of time and then closed. Collected gases are analyzed in a laboratory using EPA analytical Method T0-14a. Method T0-14a essentially uses a gas chromatography and mass spectrometer to speciate pollutants of interest. This method will only yield a benzene concentration (ppb), unless it is coupled with EPA Methods 1-4 to simultaneously collect a volumetric flow rate, such that a mass emission rate can then be calculated for the sample period. Samples collected in Summa® canisters can be stored for up to 28 days before analysis. Detection to 0.1 ppb is achievable.

Tedlar® bag method (EPA Method 18)

Benzene has been successfully measured in ambient air or at source-specific locations to the parts per billion level using EPA Method TO-18 ("Measurement of Gaseous Organic Compound Emissions by Gas Chromatography'). EPA's Technical document "Locating and Estimating Air Emissions from Sources of Benzene" lists EPA Method TO-18[52] as a reliable technique for measuring benzene.

Air samples are collected in an evacuated Tedlar® bag using a pump. Collected gases are analyzed in a laboratory by gas chromatography to speciate pollutants of interest. This method will only yield a benzene concentration (ppm), unless it is coupled with EPA Methods 1-4 to simultaneously collect a volumetric flow rate, such that a mass emission rate can then be calculated for the sample period.

The Tedlar® bag sampling technique could be used to capture emissions from VMT facility vents, or alternatively EPA Method 21 ("Determination of Volatile Organic Compound Leaks") could be used. Tedlar® bag sampling should be consider as an alternative to Summa® canister sampling, when the use of canisters is not practical. Samples collected in Tedlar® bags can only be stored for up to 3 days before analysis. Special care would be necessary to ensure that samples are transported from Valdez to the laboratory on time for analysis. The cost of obtaining Tedlar® bag samples will be higher than the Summa® canister sampling, since some specialized equipment and training is required to collect the samples. The laboratory analysis cost would be similar.

Continuous Emission Monitoring

Continuous Emission Monitoring Systems (CEMS) are used to determine pollutant concentrations over a period of time. This method will yield both a concentration (ppm) and a mass emission rate (tpy). CEMS can either be installed on an exhaust stack of a specific piece of

[51] http://www.epa.gov/ttn/chief/le/benzene/
[52] http://www.epa.gov/ttn/chief/le/benzene/

equipment to measure the pollutants emitted from that unit on a continuous basis, or a CEMS can be installed in various locations at a facility or within a community to measure pollutants on a continuous basis. CEMS are used to demonstrate continuous compliance with, applicable emission limitations or standards, or to determine exceedance of the standards.

The term CEMS refers to the total equipment necessary to determine the concentration or emission rate using pollutant analyzer measurements and a conversion equation, graph, or computer program to produce results in units of the applicable emission limitation or standard. The individual subparts of the EPA rules specify the reference methods that are used to substantiate the accuracy and precision of the CEMS. Performance specifications are used for evaluating the acceptability of the CEMS at the time of or soon after installation and whenever specified in the regulations. Quality assurance procedures in Appendix F to 40 CFR 60 are used to evaluate the effectiveness of quality control (QC) and quality assurance (QA) procedures and the quality of data produced by any CEMS that is used to determine compliance with the emission standards on a continuous basis as specified in the applicable regulation. Further information on CEMS requirements and procedures can be found on EPA's website at http://www.epa.gov/ttn/emc/cem.html.

Fourier Transform Infrared (FTIR) Spectrometry

EPA Method 320[53] is an approved test method for the measurement of hazardous air pollutants, by extractive Fourier Transform Infrared (FTIR) Spectrometry. Benzene concentrations can be successfully measured with this technique at higher concentrations (ppm).

FTIR directs an infrared beam through a sample to a detector. Some of the infrared radiation is absorbed by the sample and some of it passes through the sample. For most molecules, the absorbance occurs in a characteristic and reproducible pattern. A compound can be uniquely identified from this pattern or "spectrum," much like a molecular fingerprint. Like a fingerprint, no two unique molecular structures produce the same infrared spectrum. Compounds are identified by comparing the measured spectra to "reference spectra," which are developed in a laboratory using standard samples at known concentrations. (Reference spectra of over 100 Hazardous Air Pollutants (HAP) is available from the EPA). Similarly, concentrations of the compounds are measured by comparing sample band intensities with reference band intensities. Thus, with a PC and modern software algorithms, the FTIR can provide accurate, quantitative benzene concentration data in real time at the measurement site.

Proponents of FTIR claim several advantages of these techniques. These include real time analysis, reduced field measurement costs, improved data quality, and practical measurements of previously impractical-to-measure emissions. Also, since the measured spectra are stored in the memory of the computer, unknown compounds can be identified at a later date by comparing measured spectra to reference spectra that become available later.

FTIR measurement can only be used in higher benzene concentrations (ppm), due to the equipment's detection limit; thus, this method would be limited to use at the VMT. Water vapor and carbon dioxide can interfere with FTIR analysis, and both are commonly present in BWTF emissions sources. This limitation should be carefully considered before using FTIR.

[53] EPA Method 320, Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy.

Surface Emission Isolation Flux Chamber Testing

Surface emissions isolation flux chamber testing is an approved EPA test method for the measurement of hazardous air pollutants. Although EPA has not formally assigned this test method with an EPA number, EPA hired Radian Corporation to develop a guidance document for testing companies to properly implement this standardized technique.[54] Benzene concentrations can be successfully measured with this technique, and a guidance document is available from EPA.[55]

Surface emissions isolation flux chamber testing is typically used to obtain a mass emissions rate (tons per year) from wastewater treatment facilities. Direct emission measurement technologies, such as the emission isolation flux chamber, are used to measure emission rates from water bodies because they offer greater sensitivity and lower variability. The isolation chamber is suspended on/over the liquid surface isolating a known surface area for emissions measurement. Clean, dry sweep air is added to the chamber at a metered rate. Within the chamber, the sweep air is mixed with emitted vapors and gases by the physical design of the sweep air inlet and/or an impeller. Exhaust gas concentration is measured at the chamber outlet for specific VOCs by real-time instruments and/or is usually collected as a sample for laboratory analysis.

Statistical methods are used to determine the number of measurements required to characterize the emissions from an area source. These methods are based on the source surface area and the variability of the measured emission rate at randomly selected locations across the site. Principal advantages of this technology are that an emission rate can be measured in the field without modeling, and the field personnel can control the testing conditions. This technique can be successfully used to measure benzene emissions from the surface of the DAF cells and the BTT's. A boom crane would be required to lower this equipment over various areas of the tanks.
A cost estimate for conducting surface emissions isolation flux chamber testing at the VMT was obtained from the person that developed this method for EPA (Dr. Schmidt), and is provided in Attachment #2. Dr. Schmidt was part PWSRCAC's previous Valdez Air Health Study Review Team.

Air Emission Testing Companies and Labs

A list of companies that have the specific testing capability recommended for the initial Valdez testing program has been provided below. I have also attached an excel spreadsheet which is maintained by EPA, listing other potential companies for consideration (Attachment #2)

VOC/Benzene Testing Companies

- Air Kinetics, Tony Wong 1-800-899-3687
- Air Pollution Testing, Inc., 1-800-268-6213
- Air Toxics Ltd., 1-800-985-5955 (lab recommended by Taylor MOA, for Summa analysis)
- Alaska Source Testing, Bill Hudson, 1-907-562-2880
- AmTest, James Guenthoer, 1-425-222-7746
- CH2M Hill. Kurt Stopenhaggen, 1-425-453-5000
- Clean Air Engineering, John Chapman 1-800-627-0033
- Entropy Inc., Tony Wong 1-919-781-3550

[54] Measurement of Gaseous Emission Rates From Land Surfaces Using an Emission Isolation Flux Chamber User's Guide, EPA Contract No. 68-02-3889, Radian Corporation, 1986.
[55] Measurement of Gaseous Emission Rates form Land Surfaces Using an Emission Isolation Flux Chamber – User's Guide, EPA 600/8-86-008 (NTIS PB86-223161)

- Enthalpy, Toni Mastrioni 1-919-850-4392
- EnviroAnalysis, Carl Blume, 1-206-329-4634
- Severn Trent Laboratories (STL), Paul Christy, 1-714-258-8610 (recommended by Bill Hudson, Alaska Source Testing)

FTIR Testing Companies
- Air Kinetics, Tony Wong 1-800-899-3687
- Enthalpy, Toni Mastrioni 1-919-850-4392

Flux Chamber Testing Companies
- Dr. Chuck Schmidt, 1-530-529-4256 (developed Method 320 for EPA)
- Tom Card, 1-360-802-5540
- CH2M Hill, Kurt Stopenhaggen, 1-425-453-5000

List of Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
ADEC	Alaska Department of Environmental Conservation
AIRS	Aerometric Information Retrieval System – (EPA's Database)
AQ	Air Quality
ATSDR	Agency for Toxic Substance and Disease Registry
BETX	Benzene, Ethylbenzene, Tolulene, Xylene
BTT	Biological Treatment Tanks
BWTF	Ballast Water Treatment Facility
CAA	Clean Air Act
CEMS	Continuous Emission Monitoring Systems
DAF	Dissolved Air Floatation
EPA	Environmental Protection Agency
FTIR	Fourier Transform Infrared Spectroscopy
HAP's	Hazardous Air Pollutants
ICR	Information Collection Request
NAAQS	National Air Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health (NIOSH)
NOAA	National Oceanic and Atmospheric Administration
OLD	Organic Liquid Distribution
OSHA	Occupational Safety and Health Administration
PM_{10}	Particulate Matter
ppb	parts per billion
ppm	parts per million
PWS RCAC	Prince William Sound Regional Citizens Advisory Council
SAC	Scientific Advisory Committee
TAPS	Trans Alaska Pipeline System
TOEM	Terminal Operations & Environmental Monitoring Committee
tpy	Tons per year
VASR	Valdez Air Study Review committee
VMT	Valdez Marine Terminal
VOC's	Volatile Organic Compounds