Department of Environmental Conservation Preliminary Report on Cruise Ship Wastewater

Submitted In Accordance with AS 46.03.464

January 1, 2013

1 INTRODUCTION

During the 2009 legislative session the legislature passed House Bill (HB) 134, requiring the Department of Environmental Conservation (DEC or the Department) to establish a Cruise Ship Science Advisory Panel (SAP or panel), and in consultation with that panel, submit preliminary and final reports to the legislature (Alaska Statute (AS) 46.03.464)[1]. Other requirements of the Department related to the Cruise Ship industry were also contained in HB 134; this document focuses solely on the reporting requirement of AS 46.03.464.

As required by AS 46.03.464(c), this preliminary report, due on or before January 1, 2013, summarizes the Department's progress in evaluating the methods of pollution prevention, control, and treatment in use and the level of effluent quality achieved by commercial passenger vessels; additional economically feasible methods of pollution, prevention, control, and treatment that could be employed to provide the most technologically effective measures to control all wastes and other substances in the discharge; and the environmental benefit and cost of implementing these additional methods of pollution prevention, control, and treatment. The final report is due to the legislature on or before January 1, 2015. This "Preliminary Report on Cruise Ship Wastewater" is submitted by the Department and is accompanied by the report produced by the SAP, "Cruise Ship Wastewater 2009-2012 Science Advisory Panel Preliminary Report to the Alaska Department of Environmental Conservation Commissioner" (SAP Preliminary Report). The SAP Preliminary Report documents the panel's findings.

1.1 Background

Since the 1990's, there has been increasing international, national, and state environmental scrutiny of the operations of large commercial passenger vessels. In 2006, Alaskan voters approved Ballot Measure 2 requiring cruise ships to obtain a wastewater discharge permit from the Department before they could discharge in Alaskan waters. The ballot measure also requires cruise ship wastewater effluent to meet water quality standards at the point of discharge.

The water quality standards are DEC regulations that describe how much of each type of pollutant can be present in a water body (such as marine waters) and still protect all of the designated uses for a water body. Marine waters are protected for many uses including recreation (swimming/wading); growth and propagation of fish, shellfish, and other aquatic life; and harvesting for consumption of raw mollusks or other raw aquatic life. Water quality criteria (levels) are one component of water quality standards and are set for each pollutant to protect each use.

Treating wastewater prior to discharge to meet water quality criteria is a goal for all industrial and municipal discharges, but that is rarely possible. Very few wastewater discharges in Alaska and elsewhere meet water quality criteria for all pollutants prior to discharge. These discharges have a small, permitted mixing zone that provides for rapid dilution of the wastewater in the receiving water (lake, river, or ocean). Mixing zones are only permitted when the water body as a whole will continue to meet water quality criteria. Water quality standards include mixing zone and other policies; however, the Department has interpreted the intent of Ballot Measure 2 to require cruise ships to produce effluent that meets water quality criteria (WQC), with no consideration for wastewater dilution in the ocean and thus no mixing zones. The effluent, not just the receiving water, must meet the water quality criteria.

[1] HB 134 includes other changes to statute in 46.46.03, Article 7 (Commercial Passenger Vessel Environmental Compliance Program) such as the additions of AS 46.03.462(e) through (h) and AS 46.03.465(g) and (h).

By 2008, cruise ships with properly operating Advanced Wastewater Treatment Systems (AWTS) were meeting water quality criteria in their effluents for all parameters except four -- ammonia; and dissolved copper, nickel and zinc. The Department issued the 2008 Large Commercial Passenger Vessel (Cruise Ship) Wastewater Discharge General Permit with effluent limits set at the water quality criteria. However, during the 2008 and 2009 cruise seasons the General Permit included compliance schedules allowing permittees to use interim limits that were less stringent than the water quality criteria for ammonia, copper, nickel and zinc. This was done in order to give companies time to research and implement additional prevention, control and treatment methods. In 2010, after the compliance schedule authorizing less stringent limits expired, cruise ships were still unable to meet water quality criteria in their effluent. This prompted the passage of HB 134.

HB 134 affirmed legislative intent to continue to require cruise ships to meet the water quality standards at the point of discharge, but allowed the Department to issue permits with less stringent effluent limits for a limited time and under certain conditions -- the Department must find that a permittee is "using economically feasible methods of pollution prevention, control, and treatment the Department considers to be the most technologically effective in controlling all wastes and other substances in the discharge but is unable to achieve compliance with Alaska Water Quality Standards at the point of discharge." Per HB 134, however, this allowance for less stringent limits will sunset. Beginning with the 2016 cruise ship season, all cruise ships planning to discharge wastewater in Alaska will be required to meet all water quality criteria at the point of discharge.

1.2 Science Advisory Panel

In 2009, the Department established a diverse eleven-member science panel under AS 46.03.464(a). The panel included representatives from multiple countries and with expertise in wastewater plant design and operation; wastewater engineering and science; ship engineering, design and construction; environmental science; shipping economy; fisheries; and environmental policy.

The panel has met fourteen times, beginning in February of 2010. All meetings have been public noticed and open to the public, and have included time for public comment. As required by AS 46.03.464(b)(2), the panel also hosted a public technical workshop on September 20, 2012. The panel meetings have served as a focus for the work that the Department staff and panel members performed individually or in small self-directed groups. A contractor has facilitated the meetings and the panel work. In its support of panel deliberations, the Department has provided reports and data from the Department's historical information; summarized large amounts of effluent and water quality data; and discussed the relationship and context of the connections between the data, State law, and the mission of the panel.

No deliverables from the panel are required by statute other than assistance and advice to the Department. The panel selected their preliminary report (copy attached) and final report as the mode they would use to assist and advise the Department.

1.3 How to Read This Report

This report is organized into three sections that align with requirements of AS 46.03.464(c)(1)-(3). The sections cover (1) the current methods of pollution prevention, control, and treatment in use and the level of effluent quality; (2) additional economically feasible methods of pollution prevention, control, and treatment that could be employed to provide the most technologically effective measures to

control all wastes and other substances in the discharge; and (3) the environmental benefit and cost of implementing additional methods of pollution prevention, control, and treatment identified in (2).

The Department and the panel have followed the model described in this report both cooperatively and independently at times throughout the analysis that ultimately led to this and the panel's report. Each of the three sections below describes:

- The statutory mandate (the "question" being answered by the panel and/or the Department),
- Background and contextual information to frame the question,
- The approach used for the analysis (how the panel and/or the Department went about answering the question),
- The results of the analysis (the "answer"), and
- A discussion of the important issues related to the section. This section may contain additional information from the Department that was not considered by the panel.

This report is provided to the legislature by the Department and represents the Department's preliminary findings. These findings have been informed by the work and report of the panel. While the panel's report is a standalone, independent product, the work contained therein has significantly contributed to the Department's conclusions. Therefore, both this Department report and the panel's report are complementary.

2 ANALYSIS OF METHODS IN USE AND EFFLUENT QUALITY ACHIEVED

2.1 Mandate

Per AS 46.03.464(c)(1), this section provides a preliminary summary of the "methods of pollution prevention, control, and treatment in use and the level of effluent quality achieved by commercial passenger vessels."

2.2 Background and Contextual Information

Cruise ships have been operating in Alaskan waters since the late 1800's. From 1976 to 2001, the cruise ships treated wastewater using marine sanitation devices (MSD) to treat sewage prior to discharge to Alaskan waters. Since 2000 cruise ships have used more advanced and evolving MSDs, ultimately known as AWTS to treat sewage and graywater prior to discharge. Since 2001 cruise ships have been required by either federal or State law to use AWTS as a condition to discharge in Alaskan waters. Therefore, this analysis of treatment systems in use includes only AWTS.

2.3 Approach for Evaluating Methods of Pollution Prevention, Control, and Treatment in Use

The methods of pollution prevention, control, and treatment include all activities a vessel uses to improve the effluent quality. Equipment used to treat wastewater is only one of several methods used. Below is a description of the methods that the Department and the panel analyzed.

2.3.1 Prevention

The analysis of prevention methods centered upon the 2008 source reduction evaluations (SRE) and annual reports submitted by vessels to the Department. In the 2008 General Permit[2], the Department required permittees who requested interim effluent limits to submit SREs. The Department provided detailed instructions for completing the SREs.

The SREs received by the Department indicated that a significant portion of the dissolved metals originated in the potable water process including onboard production and bunkered, or stored, water. The panel later determined that the amount of dissolved metals in bunker water was insignificant compared to the amount that was likely to be produced by onboard processes, finding, for example, that onboard processes to make potable water from sea water were likely a major contributor to dissolved metals in the effluent. Process components include evaporators, piping material, and collection locations; with corrosion of piping another possible contributor. Ammonia sources were predictably found to originate from sewage generated by passengers and crew, with contributions from chemical products used onboard estimated as being minimal, to none.

2.3.2 Control

There are few control options that do not fall under the prevention or treatment categories. The two options that the Department and the panel evaluated in most detail were discharge outside of Alaskan waters and discharge to shore-based domestic wastewater treatment facilities. This analysis of control methods in use was based on information from vessel specific sampling plans (VSSP) and onsite inspections of vessels conducted by Department staff and Department-managed, on board Ocean Rangers; and the Department's extensive knowledge of shore-based facilities.

Commercial passenger vessels including permitted vessels always have the option of not discharging to State waters. They may decide to hold their wastewater in tanks on board the ships. In order for ships to hold their wastewater for discharges outside of the marine waters of the State (generally beyond 3 miles from shore), they must have suitable tank capacity for storing wastewater produced by passengers and crew while operating in State waters. In the Department-required VSSP for each vessel,[3] the Department requires information about a discharging vessel's tank capacity, sampling port locations, potable water consumption, and wastewater flow rates. Through comparison to the vessel's Alaska transit schedule and daily average and maximum wastewater production, potable water consumption, and a vessel's

[2] State of Alaska Department of Environmental Conservation Large Commercial Passenger Vessel Wastewater Discharge General Permit No. 2007DB0002

[3] Alaska Regulation 18 AAC 69.030, Vessel Specific Sampling Plan

wastewater discharge log, the Department can estimate if a vessel has the tank capacity to hold its wastewater until it departs Alaskan waters; in other words, if the vessel can use the control mechanism of discharging outside of state waters.

Both Department staff and Department-contracted Ocean Rangers perform onsite inspections that verify the VSSP information by comparing the onboard VSSP to the Department approved VSSP; and by verifying the accuracy of the information contained in the VSSP including tank volumes, and assisting vessels in correcting any discrepancies found.

The control mechanism of discharging to shore-based facilities (i.e., municipal wastewater treatment plants) was analyzed by the Department and is discussed in Section 3.4.2.2 of this report.

2.3.3 Treatment

This analysis of treatment methods centered upon the evaluation of individual AWTS information received from vendors and vessels[4], vessel specific sampling plans, and on site visits conducted by panel members and Department staff. Note that most panel members had been onboard and had observed wastewater processes on cruise ships prior to their appointment to the panel.

AWTS were designed to meet required criteria for conventional pollutants and are the most advanced, effective, and proven treatment systems available. When compared with municipal treatment plants discharging to marine waters in Alaska, the AWTSs in operation on discharging cruise ships are significantly more effective than municipal systems. Department staff and panel members evaluated all manufacturers' AWTS currently installed on cruise ships operating in Alaskan waters.

There are a variety of advanced wastewater treatment systems (manufactured by Hamworthy, Scanship, Ovivo, Zenon, Hydroxyl, Hamman, Hamman/Lazarus, ROCHEM, Marisan, and Triton) that are in use on board now, or that have been used since 2001. These systems provide a higher degree of treatment than Alaskan shore-based wastewater treatment facilities and typically produce higher quality effluent.

2.3.4 Effluent Quality Achieved

The Department has been collecting effluent data for discharges from the AWTS since 2001.The Department and panel used effluent data collected since 2001, when cruise ships generally began using AWTS, to evaluate the level of wastewater quality currently achieved using existing pollution prevention, control, and treatment methods.

2.3.5 Review of Historical Reports

The Department and the panel conducted a review of existing reports to frame the history of the issues, the problems encountered by previous researchers, and the history and recommendations of those researchers. The summaries below describe the use of these reviews by the panel and the Department in preparation of this section of the preliminary report.

[4] Feasibility Study: Reducing Concentrations of Dissolved Metals and Ammonia in Large Commercial Passenger Vessel Wastewater Discharge, DEC, June 1, 2010

- *Alaska Cruise Ship Initiative (ACSI) Final Part 1 Final Report (Activities and Work Products up to June 1, 2000.)* This report provided an overall summary of the environmental challenges facing the cruise industry in Alaska, and established a multi-organizational steering committee to undertake fact finding on air emissions, wastewater discharge, waste disposal practices, oil spill prevention and response, and environmental leadership. This report describes plans to implement random unannounced sampling, report the results, and describes plans to develop a list of sensitive areas.
- *Alaska Cruise Ship Initiative (ACSI) Part 2 Report (June 1, 2000 to July 1, 2001).* This report discussed the results of the sampling that vessels conducted in accordance with the sampling methods created in the Part 1 Report.
- *The Impact of Cruise Ship Wastewater Discharge on Alaska Waters, November 2002.* The first, 2001 panel published this report. Using an assessment framework, the panel started with effluent characterization. The panel then determined the available dilution through dispersion modeling and concluded with exposure assessment and recommendations for risk management and additional research. This report was the result of nearly 20 months of research, field work and discussion.
- *Cruise Ship Discharge Assessment Report, December 29, 2008.* This report was published by the U. S. Environmental Protection Agency (EPA). The Assessment Report analyzed several waste streams including sewage and graywater. The report includes a discussion of the nature and volume of waste streams, applicable federal regulations, environmental management and treatment, and potential adverse environmental impacts of the waste stream.
- *Source Reduction Evaluations.* In the 2008 General Permit, the Department required permittees who requested interim effluent limits to submit a source reduction evaluation and annual reports. The Department sent a letter to the Alaska Cruise Association (ACA) and the Northwest Cruise Ship Association (NWCA) that contained detailed instructions for completing the SREs. Carnival Cruise Lines, Holland America Lines, Norwegian Cruise Lines, Princes Cruise Lines, Royal Caribbean Line, Regent Seven Seas Cruises, and Silversea Cruises submitted vessel-specific SREs. The panel reviewed the SREs and the annual reports.
- *Sampling Episode Report, Cruise Ship Plume Dilution Study, Skagway, Alaska, May 2009.* This EPA report describes a plume dilution study conducted under the direction of EPA in collaboration with the Department. Dye studies were used to characterize near-field cruise ship discharge plumes from six cruise vessels while docked.
- *Assessment of the Stationary Cruise Ship Plume Dilution Study, Skagway, Alaska, May 2009.* This companion report by the Department used the results of the dye studies to test and validate the wastewater dilution calculations described in the previous ACSI and panel reports.
- *Feasibility Study: Reducing the Concentrations of Dissolved Metals and Ammonia in Large Passenger Vessel Wastewater Discharges, June 1, 2010.* The Department published this report using information from the 2009 Technology Conference. In addition to new technologies, the report discusses the nine technologies that were in use at that time. The information used in the study was solicited via broad industry-wide requests.

2.3.6 Analysis of Existing Data and Data Reports

The Department compiled all wastewater effluent monitoring data, reviewed it, and presented it to the panel. The list of data and data reports includes:

- *DEC effluent sampling and testing data from 2000 through 2012.* This data provided the Department and the panel information on the historical performance of each permitted vessel for the years each vessel operated and discharged in State waters. The Department developed summaries of effluent produced by individual systems and system categories as requested by the panel.
- *DEC Large Ship Wastewater Sample Result reports from 2008 through 2012.* These reports provided comparisons of the effluent sampling results between vessels, treatment systems, and cruise lines; and provided a format for comparing those results between successive years of operations.
- *DEC sampling exceedance reports from 2008 through 2012.* These reports demonstrated a snapshot of only the sample results that exceeded water quality criteria from vessels permitted to discharge, separate from the effluent results that were in compliance.
- *DEC Large Ship Wastewater Treatment and Discharge Status tables from 2003 through 2010.* These reports provided compiled information on the total number of vessels operating in State waters for each year; which vessels were permitted to discharge and which were not; the types of AWTS installed on each vessel whether the AWTS were permitted to discharge or not; whether a permitted vessel was discharging sewage, graywater, or mixed sewage and graywater, and; whether a vessel was permitted to discharge underway only, or continuously (both underway and stationary).

2.3.7 Science Advisory Panel Presentations from Guest Speakers

During the panel meetings presentations were delivered by State and federal government officials, ship builders, academic scientists, economists, and wastewater engineers. Department staff and panel members learned about the challenges of installing AWTS onboard vessels during construction and when retrofitting existing vessels with new or add-on systems. Presentations discussed the complexity of managing onboard wastewater treatment methods, State water quality criteria and their application to the cruise industry, detailed explanations about wastewater dilution studies, and sources of pollutants that could become a part of a vessel's waste stream. During the statutorily required public technical workshop, Department staff, panel members, and the public had the opportunity for one-on-one interaction with visiting vendors and manufacturers of AWTS.

2.3.8 2012 Data Collection Survey for Vessels Permitted to Discharge

The Department worked with the panel to issue a data questionnaire to operators of cruise ships permitted to discharge in 2011 covering technological and economic questions about existing systems, new technologies, and cost of installation and operation of existing systems. Cruise operators responded to these questionnaires, providing valuable data that allowed the panel to evaluate the cost of implementing currently used systems. The survey also requested technical and cost information for

additional methods capable of meeting water quality criteria at the point of discharge. As discussed in the next section, Analysis of Additional Methods, the survey provided limited technical and cost information on additional methods.

2.4 Results and Discussion of Analysis of Methods in Use and on Effluent Quality Achieved

Both the Department and the panel concluded that existing methods of pollution prevention, control, and treatment produce effluent that can consistently meet the water quality criteria at the point of discharge for all parameters except ammonia, copper, nickel and zinc[5]. Existing systems treat these parameters to varying degrees and in some cases AWTS produced by the same manufacturer and installed on different vessels have varying degrees of success in treating these four parameters. This review of existing systems and effluent levels was conducted jointly between the Department and the SAP, and the Department concurs with the analysis in the SAP's preliminary report.

3 ANALYSIS OF ADDITIONAL METHODS OF POLLUTION PREVENTION, CONTROL, AND TREATMENT THAT COULD BE USED

3.1 Mandate

Per AS 46.03.464(c)(2) this section provides a preliminary summary of "additional economically feasible methods of pollution prevention, control, and treatment that could be employed to provide the most technologically effective measures to control all wastes and other substances in the discharge."

3.2 Background and Contextual Information

Because the ultimate effluent limits will be WQC at the point of discharge, and cruise ships are currently unable to meet these limits for four parameters with existing methods, the Department and the panel sought information on methods used today in other applications and industries and methods that, while not currently available, may become available. These additional methods might have the potential to be installed onboard cruise ships in order to improve effluent quality.

While considerable time has been spent evaluating potential new methods, the Department does not directly regulate the methods or types of wastewater treatment systems. Regulatory authority is limited to the quality of effluent discharged to Alaskan waters.

The Department and panel explored two general areas for additional methods. First, an additional method should be able to improve effluent quality to a level that meets WQC at the point of discharge.

[5] Cruise Ship Wastewater 2009-2012 Science Advisory Panel Preliminary Report to the Alaska Department of Environmental Conservation Commissioner (SAP Report), Section 4.1 Effluent Quality Currently Achieved by Commercial Passenger Vessels.

Second, if an additional method cannot result in meeting WQC at the point of discharge, it should consistently improve a vessel's effluent quality over the methods that the vessel currently employs.

The Department's conclusions in this study are time sensitive. The Department must determine the practical potential of additional methods to meet statutory deadlines. The panel's role in the search for additional methods is broad based. The panel searched for additional methods that may be of practical use at an undetermined future time.

Currently, the Department must meet two milestones; (1) develop and issue a new General Permit for the upcoming 2013 cruise ship season, and (2) prepare for the 2015 expiration of the statutory provision allowing effluent limits less stringent than WQC at the point of discharge. Any changes to effluent limits that the Department would consider rely upon additional methods capable of consistently producing the desired effluent results and available for installation onboard vessels in time to meet those deadlines.

For example, a vessel installed an ion exchange treatment system that discharged wastewater and conducted effluent sampling in State waters in 2011. While the effluent results from that system did not yield results that were significantly or consistently superior to effluent sample results from current systems, the panel considered this a promising system. While the Department concurs that the system is promising from an engineering perspective and it may be a practical alternative in the future, the data received is not sufficient for the Department to adjust permit effluent limits based on the results.

Implementation of new or significantly modified AWTS consists of design, research and development performed by the cruise ship owner or operator, followed by a design review by the classification society[6]. The classification process time is 8-12 weeks if there are no complications. Classification costs can be as low as a few thousand dollars, which can equal about 1-2% of the operational cost. Because the large cruise ships that operate in Alaska are foreign owned, owners and operators would be required to obtain approval of their home countries for their new or significantly modified AWTS.

3.3 Approach for Seeking Additional Methods

The Department and the panel used multiple methods of researching additional methods of pollution prevention, control, and treatment. The research included direct contact with AWTS manufactures and vendors, literature searches, data collection surveys, and the professional experience of Department staff and panel members.

The reports and information listed below served as starting points for analysis. Using these documents and the experience gained over their careers, panel members conducted individual, group, and panel-wide analysis and discussions on additional methods. These starting points allowed panel members to compare the analysis in these reports to the actual and potential capabilities of additional methods.

[6] Science Advisory Panel meeting summary, 10/21-22, 2010; pg. 7-8. Tio Devaney, Lloyds of London Classification society.

3.3.1 Public Comments

Public comments[7] served a valuable function in the panel work. Comments about the possibility of increasing vessel discharges to shore facilities and the possible improvements of existing systems led to panel discussion and additional Department research. In addition to formal public comments, the public was welcomed to interact with panel members during meeting breaks and with the Department staff at any time. Moreover, panel members were free to discuss panel work with their personal networks and constituencies. The ultimate results of the panel and Department work performed based on public comment and interactions is reflected in the conclusions of the panel's preliminary report, and in this report.

3.3.2 2009 Technology Conference

The Department held a cruise ship wastewater treatment technology conference in February of 2009, before the approval of HB 134, the implementation of the current panel, and the requirements for the preliminary and final reports to the legislature. The culmination of information gained from the conference was recorded in the report, *Feasibility Study: Reducing the Concentrations of Dissolved Metals and Ammonia in Large Passenger Vessel Wastewater Discharges, June 1, 2010.*

3.3.3 Review of Historical Reports

The Department and the Panel used the following documents in its analysis of additional methods. Sections in several of these reports proved useful in separate sections of the Preliminary Report. The summaries below describe the use of these documents by the panel and the Department in preparation of this section of the preliminary report.

- *Alaska Cruise Ship Initiative (ACSI) Part 2 Report (June 1, 2000 to July 1, 2001).* Discussed in this report were "New Technologies;" many of which would become the AWTS that were later, and in some cases are still used on vessels operating in Alaska.
- *Cruise Ship Discharge Assessment Report, December 29, 2008.* This report was published by the U. S. Environmental Protection Agency. In addition to the topics previously summarized, this study discussed possible options and alternatives to address sewage and graywater effluent improvement. Alternatives discussed included potential prevention, control, and treatment options.
- *Feasibility Study: Reducing the Concentrations of Dissolved Metals and Ammonia in Large Passenger Vessel Wastewater Discharges, June 1, 2010.* The Department published this report using information for the 2009 Technology Conference. The report discusses five additional technologies. The information used in the study was solicited via broad industry-wide requests, and 60 direct requests to manufacturers, vendors, and researchers. Of those contacted, eleven responded and submitted white papers describing potential solutions for meeting the effluent limits of WQC at the point of discharge.

[7] Public comments are recorded in each Panel meeting summary at http://www.dec.alaska.gov/water/cruise_ships/SciencePanel/index.htm

3.3.4 2011 Department Survey to AWTS Manufactures and Vendors

In 2011, the Department sent voluntary surveys to eight AWTS manufacturers and vendors selected by the panel. The panel selected these eight as the most likely to be actively seeking improvements to current methods of ammonia and dissolved metal (copper, nickel, and zinc) removal. The surveys were sufficiently detailed to indicate if there were prospects for new treatment systems, improvements to existing systems, or development of additional treatment technologies that could be added on to existing systems. The results were mixed.

Of the eight surveys sent, the Department received four responses. One vendor provided information on an ion exchange metal removal system that is discussed in the section titled Ion Exchange. However, no responses were returned fully completed. There are various reasons that surveys were returned incomplete, or not returned. Manufacturers and vendors are not required by State law to provide information, and any information submitted would become a public record under State law. Methods under development by one manufacturer, if revealed publicly, could provide an advantage to a competing manufacturer. Finally, caution about promising the success of a system not yet ready for distribution could impact business.

3.3.5 2012 Data Collection Survey for Vessels Permitted to Discharge

The Department worked with the panel to issue a data questionnaire to operators of cruise ships permitted to discharge during the 2011 cruise ship season about existing systems, new technologies, and cost of installation and operations of current systems or additional methods. Cruise operators responded to these questionnaires, providing valuable data that allowed the panel to evaluate the cost of implementing currently used systems. However, no technical or cost information was obtained on additional methods.

3.3.6 September 2012 Technology Workshop

Because the panel was unable to find additional methods that could consistently produce effluent meeting WQC, the format selected for the legislatively required public workshop was a detailed demonstration to the public of the work that the panel and the Department had undertaken thus far. In addition the workshop provided ample opportunity for members of the public to interact with panel members, Department staff, and visiting vendors.

3.4 Additional Methods Analyzed

3.4.1 Prevention

Neither the Department nor the panel identified additional prevention methods above those identified in the SREs, though both bodies are confident that that vessel dedication to source reduction can reduce pollutants that enter the water.

Vessel source reduction efforts varied in the level of implementation between vessels. Results of source reduction efforts were not clearly identifiable since the efforts were implemented in conjunction with

other methods, resulting in an inability to attribute effluent improvement or degradation to source reduction efforts. In those cases where source reduction was undertaken, then later abandoned, there was no identifiable improvement or degradation in effluent results.

3.4.2 Control

Pollution control includes all actions taken or avoided in order to reduce pollution released into the environment. In a strict sense, pollution control includes prevention and treatment. However, AS 46.03.464 calls-out prevention and treatment separately; therefore, the preliminary reports submitted by the panel and the Department follow this approach. In the context of this report, pollution control will include all other aspects of control not included in the prevention and treatment sections. These methods broadly include vessels discharging outside of state waters, discharge to shore-based facilities, and actions vessels' crews and passengers could take or avoid to prevent the release of pollutants into the water.

In the pollution control category, none of the methods discussed are actually "new." Certain vessels hold wastewater in onboard tanks for discharge outside of State waters; certain vessels discharge to shore-based facilities to a limited extent; and all vessels currently train crews, maintain equipment, and operate the equipment in accordance with manufacturer expectations. The discussions below are in the context of refining methods, or introducing the methods for more widespread use.

3.4.2.1 Holding in tanks

Several permitted and non permitted vessels currently hold wastewater in tanks for discharge outside of State waters. The VSSP information provided by permitted vessels also indicates that most if not all vessels have the capacity to hold their wastewater until leaving State waters, though this would leave little margin for schedule delays or unanticipated increases in wastewater production. If cruise line companies want their vessels to hold more wastewater than they currently do, they will have to add or modify tanks and address vessel stability. Vessel stability is a function of the total weight of stored liquid as well as the distribution of that weight. The challenge with holding additional wastewater is that it increases weight, which makes distribution of that weight more critical, while at the same time reducing the ability to distribute that weight since there is less unutilized space on the ship. This is further complicated by concurrent weight changes such as ballast water redistribution and fuel usage.

Because of the more stringent ballast water requirements proposed in the Draft 2013 EPA Vessel General Permit (VGP) wastewater storage may compete with ballast water storage in the near future, affecting some vessels' ability to store wastewater.

Holding wastewater for discharge offshore may also compel vessels to alter their routes, adding time and distance to their current routes. Additional transit time, travel distance, and displacement from increased weight causes increased fuel handling and consumption and air emissions, the extent of which is unknown. These altered travel routes may also result in vessels visiting fewer ports while in Alaska.

3.4.2.2 Discharge to shore.

The Department does not believe that discharge to a shore-based domestic wastewater treatment facility is a promising alternative. The premise of this method appears to rest on the assumptions that treatment at shore facilities is better (produces higher quality effluent) and that dilution of wastewater discharged to the marine environment from shore facilities is in some way superior to dilution from cruise ship discharges. If the cruise ships discharge into publicly owned water treatment plants, theoretically they would not be discharging into the waters of the State. There are, however a number of considerations that must be addressed before this could be a viable, widely used alternative.

- The discharged wastewater would eventually enter the marine waters of the State.
- The effluent limits for shore facilities are significantly higher (less stringent) than those for cruise ships, so there is the potential for more pollutants reaching the marine environment than if the cruise ships treated their wastewater onboard ship.
- The cruise ship discharges would likely be classified by the Department as wastewater from "significant industrial users" since it is not exclusively sanitary waste and potentially includes waste from galleys, pools, engine room shop sinks/drains, other shop sinks/drains, desalination brine, laundries and medical facilities. This would require the shore facility to address pretreatment:
    - Publicly owned treatment works on shore would be required to design and implement pretreatment standards prior to accepting cruise ship discharges that exceed 25,000 gallons per day.
    - Pretreatment standards are needed to control pollutants from industrial users since they are generally designed to treat domestic sewage only and the industrial pollutants may otherwise pass through or interfere with publicly owned treatment work treatment processes or may contaminate sewage sludge.
    - Accepting industrial waste would change the permitting and monitoring requirements of the shore facility.
    - Accepting industrial waste as well as the increased volume of waste might require modification to the shore facility.
- Shore facilities are designed to accept a specified range of conventional parameters (for example, total suspended solids and biological oxygen demand). They have a legal obligation to monitor the concentrations in the influent and remove a specified percentage of these parameters prior to discharge. If cruise ships "pretreated' using AWTS, the treated cruise ship discharges would be adding very clean water that would dilute the influent with low concentrations of conventional parameters. This creates a problem since those facilities are regulated based on their efficiency in removing conventional parameters. With dilute influent, biological treatment processes are less efficient, and shore facilities would likely have problems with percent-removal requirements.
- If cruise ships were required to pre-treat wastewater, they would likely use AWTS since they are already onboard and are required for other markets. Cruise ships would bear costs that they currently pay for AWTS treatment and then have the additional cost of discharge ashore.

- The seasonal nature of the cruise industry and its discharges will likely cause problems for the on shore treatment plant at least twice per year; at the start and at the end of cruise season. Sewage treatment plants can be very sensitive to the quality of the waste treated. The balance of treatment (bacteria that degrade wastes versus waste) would require adjustments at least twice, and maybe more often during the cruise season and after. The Department already sees these challenges on the North Slope where seasonal populations fluctuate greatly.
- Untreated wastewater from cruise ships is very concentrated. When mixed with municipal wastewater, it will affect the treatment system significantly.
- The only current community that may be able to handle this is the Juneau-Douglas wastewater treatment plant.
- Discharges from shore facilities are regulated and monitored under the Alaska Pollution Discharge Elimination System (APDES), a system governed by different regulations and with different requirements than the cruise ship discharges.

3.4.2.3 Good Operational Practices, Train, Maintain and Operate

While vessel owners currently have relatively good operational practices, train the crewmembers, conduct scheduled and unscheduled maintenance, and maintain and operate AWTS, the Department and the panel intend to explore the effectiveness of those processes to determine if there are any improvements that can be made. The Department will also explore the extent to which vessel owners train other non-AWTS operating crewmembers in how they could contribute to a cleaner influent that is treated onboard.

3.4.3 Treatment

Adaptation of emerging technologies from other industries to cruise ships presents significant feasibility challenges, and will not be readily available to consistently use on cruise ships in the near future.

3.4.3.1 Reverse Osmosis

The Department concurs with the panel that reverse osmosis (RO) is a promising technology for treating effluent to a higher quality than that achieved now[8]. The Department and the panel reviewed historical reports[4] and the results of the installation of RO onboard one vessel that discharged into State waters. RO is used worldwide to desalinate seawater into drinking water for vessel and shore-based applications. RO is also currently used to treat sewage and graywater onboard maritime platforms including vessels and oil drilling platforms, though the Department has no effluent data to compare with the results of these uses to WQC.

Although RO has been used to treat sewage and graywater on vessels discharging in State waters, data made available to the Department and the panel was predominantly from one vessel. The Department has determined that the limited data set was not sufficiently representative of the capabilities of the

[8] SAP Report, Section 6.3 Treatment.

method to extrapolate the results and then project those results on other vessels that may have significantly different waste stream characteristics.

RO was used to treat mixed waste streams on one vessel that discharged from 2001 to 2006. Since that time vessels have stopped discharging, or only treat limited graywater and no sewage by RO. Because of this, there is no data for RO-treated mixed waste streams for the last six years. No ships discharged RO-treated wastewater under the 2008 or 2010 permit.

3.4.3.2 Ion Exchange

The professional judgment of the panel and the Department staff aligns in the opinion that ion exchange (IX) is a promising additional future method[9]. The Department and panel reviewed previous reports[10], one vendor survey response, and the results of the installation and use of an ion exchange system onboard one ship that discharged into the waters of the State for one year.

The vendor response provided a technical and cost estimate for an IX metal removal system. This proposal was based on laboratory removal of metals and not from an operational system that functioned as or was installed as an add-on to an AWTS. The results from the single IX installation did not provide a sufficient foundation for the Department to include that system in the consideration of future effluent limits at this time. The installation indicated that, in some circumstances, entire systems could be replaced while a vessel was operating, and that the installation of the entire system could deliver effluent results on par with the results from current systems. However, effluent results were not consistently or significantly better than effluent from existing systems. Regardless of the result, more sampling is required to establish a rigorous statistical trend.

3.5 Economic Feasibility of Additional Methods

The panel heard a presentation from Northern Economics Inc. (NEI) on an approach to determine capital and operating costs for prevention, control, and treatment options that would meet WQC at the point of discharge. In addition, NEI sought to determine the fiscal impacts of those costs to cruise line operators and to the Alaskan cruise ship market. Though the panel chose a different direction, the presentation promoted good discussion at panel meetings.

The panel identified life cycle costs – direct and indirect capital costs; annual operations and maintenance; and net present value of these costs – as the preferred method to evaluate the economic feasibility of installing and implementing additional treatment methods that could meet WQC at the point of discharge. However, the panel was unable to perform a life cycle analysis since no commercially available additional treatment methods were identified, and therefore there were no detailed cost estimates provided in responses to the 2011 vendor and manufacturer information request and 2012 survey of cruise line operators conducted by the panel.

[9] SAP Report, Section 6.3 Treatment.

[10] Cruise Ship Discharge Assessment Report, EPA (Dec 2008). Section 2.4.4 Potential Treatment Technologies in Addition to AWTS; Feasibility Study: Reducing Concentrations of Dissolved Metals and Ammonia in Large Passenger Vessel Wastewater Discharges, DEC (June 2010). Section 4.2 Wastewater Treatment Alternatives, Ion Exchange,

The panel also evaluated the economic characteristics of the cruise ship industry in order to gain an understanding of how costs could influence where in the world cruise ship operators deploy their ships, passenger traffic, and passenger purchases on board or in Alaskan communities.

3.6 Results of Analysis on Additional Methods

Although methods such as reverse osmosis and ion exchange appear to be promising for future development, they are not yet ready for implementation onboard cruise ships as a reliable method of meeting water quality standards, or significantly improving effluent quality, at the point of discharge.

Other methods, such as discharge to shore facilities and holding wastewater in onboard tanks for later discharge outside of State waters do not meet the intent of having cruise ships discharge effluent that meets WQC at the point of discharge in State waters. In addition, discharging to shore facilities would result in wastewater discharged from cruise ships not being required meet the cruise ship effluent limits.

The panel was unable to identify technologically effective and economically feasible treatment methods capable of consistently meeting the numeric WQC at the point of discharge that have been proven effective on ships[11]. Application of existing technologies in addition to AWTS, such as IX, and RO are expected to further reduce ammonia and dissolved metal concentrations. However, there is no evidence to prove that adding additional technology will be technologically effective at meeting water quality criteria, be economically feasible, or provide significant environmental benefit. Modifying operational procedures and additional staff training may help improve treatment performance. The panel recommends continued sampling and monitoring of cruise ship effluent[12].

3.7 Discussion on Additional Methods

The Department believes that a thorough search for additional methods to improve wastewater quality has been conducted and concurs with the panel's opinion that there are no existing, new, or emerging prevention, control, or treatment methods that could consistently meet WQC at the point of discharge.

4 ANALYSIS OF ENVIRONMENTAL BENEFIT AND COST OF IMPLEMENTING ADDITIONAL METHODS

4.1 Mandate

Per AS 46.03.464(c)(3) this section provides a preliminary summary of "the environmental benefit and cost of implementing additional methods of pollution prevention, control, and treatment."

[11] SAP Report, Section 6.3 Treatment.
[12] SAP Report, Section 9 Findings.

4.2 Background and Contextual Information

For the Department and the panel to have analyzed the environmental benefit and cost of implementing additional methods to improve effluent quality, it would have been necessary that they had found that a practical additional method is, or will soon be, available. As discussed in the previous section of this preliminary report, practical additional methods were not found to be available at this time.

This section discusses the environmental benefits and costs of implementing methods that the Department and the science panel explored and discussed in the previous section of this report. It also contains a discussion of starting points for methods of analysis for environmental benefit and cost that could be used if methods become available that can meet the water quality criteria at the point of discharge.

4.3 Approach for Determining Environmental Benefit and Cost of Additional Methods

Since the science panel did not identify additional methods for improving effluent quality that could reliably meet WQC at the point of discharge, the panel's approach was to compare the environmental benefit and cost of current methods to a hypothetical method that could meet WQC at the point of discharge. To determine environmental benefit, the science panel considered the incremental water quality impacts of different wastewater discharge scenarios as well as non-water quality impacts that would occur if WQC could be met at the point of discharge.

First, the panel considered three wastewater discharge scenarios for the four parameters of concern: 1) direct undiluted cruise ship effluent concentrations; 2) the mix of effluent and receiving water resulting from stationary, in-port cruise ship discharge; and 3) the mix of effluent and receiving water resulting from underway cruise ship discharge and its turbulent wake. Water quality impacts were determined by comparing incremental concentration changes in the receiving water to those that would result if the wastewater effluent met WQC at the point of discharge. To evaluate the environmental benefit and cost, the science panel compared the resulting concentrations to numeric water quality criteria. Second, for perspective only, the panel compared effluent mass loading to the receiving water from one natural source near Juneau, the Mendenhall River.

4.3.1 Study of Additional Methods

4.3.1.1 Water Quality Considerations

The three wastewater discharge scenarios were considered a "worst case" evaluation of current and additional methods since they used the maximum observed effluent concentrations from current methods during the 2008-2009 season for the four parameters of concern – ammonia, dissolved copper, dissolved nickel, and dissolved zinc. Using the maximum effluent values from current treatment methods provides the largest measure of potential environmental benefit when compared with a hypothetical, additional method that could meet WQC at the point of discharge. Such an approach also provides a worst case look at the environmental cost of current methods.

To evaluate the mix of effluent and receiving water, the science panel worked with the Department to identify background concentrations for each parameter of concern in the receiving water. For all four parameters of concern, the background levels in Alaskan marine waters were low compared with water quality criteria. To evaluate mixing, the panel relied upon the Department's findings documented in the Information Sheet for the 2010 Large Commercial Passenger Vessel General Permit, the work of the first Alaska Cruise Ship Wastewater Science Advisory Panel, and EPA effluent dilution studies using dye. For stationary cruise ships or those moving at less than 6 knots, the minimum available dilution factor of 28:1 is achieved in a matter of minutes at 15 meters from the discharge port. Effluent limits are set to ensure that all water quality criteria are met at and beyond 15 meters from the vessel. For cruise ships moving at 6 knots or greater with a high wastewater discharge rate of 200 cubic meters per hour (a conservative estimate), the minimum available dilution factor is 50,000:1 measured in the wake after turbulent mixing. The panel's preliminary report also evaluated an earlier study that determined a minimum dilution factor at the stern, 300 meters from the discharge port and before turbulent mixing in the wake, of 600:1 for cruise ships moving at 6 knots or greater with a high wastewater discharge rate of 200 cubic meters per hour. This means that all water quality criteria are met in the ocean within seconds after discharge from an underway vessel.

The panel discussed concerns raised by one panel member about the total amount of metals being released by cruise ships into the Alaskan marine environment, or the "mass loading" (i.e., how many ounces or pounds of a given metal are introduced into the environment via the wastewater discharge). The panel had concerns about evaluating mass loading, since loadings need proper context for the value to provide meaning. Concentrations in the receiving water, by contrast, can be compared with numeric water quality criteria to determine exceedances. Nonetheless, the science panel used the average effluent copper concentration and an estimate for total annual cruise ship discharge volumes to estimate a total annual copper mass loading (88 pounds) from all discharging cruise ships compared with the loading from a single river in Southeast Alaska, the Mendenhall River (over 2,000 pounds).

4.3.1.2 Non-water Quality Considerations

The panel highlighted several non-water quality issues that need to be considered when evaluating the net environmental benefit of additional methods to meet WQC at the point of discharge. These issues include the potential for additional on board space and staff requirements that result in greater energy use, and an increase in waste production and the potential for disposal challenges with more highly concentrated wastes given greater removal efficiencies. The panel's preliminary report provides specific examples of additional waste disposal challenges such as ion exchange resin regeneration waste and reverse osmosis reject water. In addition, the panel provided an estimation of fuel consumption, fuel costs, and carbon dioxide emissions to the air if it were necessary to travel outside state waters to discharge in federal waters as a control method.

4.4 Environmental Benefit and Cost of Additional Methods

4.4.1 Environmental Benefit

As stated earlier, the panel did not identify additional methods of pollution prevention, control, or treatment that could be used to achieve WQC at the point of discharge. The science panel found that 1) all four parameters of concern in cruise ship effluent currently exceed WQC at the point of discharge; 2) the maximum, historical effluent concentrations for ammonia, copper, and nickel would exceed water quality criteria at 15 meters from the discharge port when the cruise ships was stationary or moving at less than 6 knots if it were not for permit limits; and 3) no water quality criteria are exceeded at the stern of cruise ships moving at 6 knots or greater.

In summary, the panel found that "[a] dilution model developed by the first Alaska Cruise Ship Wastewater Science Advisory Panel and dye studies conducted by EPA demonstrate that concentrations lower than WQC are attained rapidly following AWTS discharge from a moving vessel and acute and chronic exposures would not occur. Similarly, [such] dilution modeling is used for permitting other wastewater discharges. The panel identified little additional environmental benefit to be gained by lowering the current permitted effluent limits to WQC at the point of discharge[13]."

4.4.2 Environmental Cost

Given the small incremental change in concentrations in Alaska marine waters and little additional environmental benefit to be gained if cruise ships were to meet WQC at the point of discharge for the four parameters of concern, the science advisory panel's evaluation identifies that current methods do not have adverse environmental costs[14].

Through a comparison between estimated annual cruise ship copper loading from all vessels and loading from one river, the Mendenhall River, the panel found that natural sources of copper are a minimum of 23 times larger than the copper loading from all cruise ships, and cruise ship copper loading does not represent an environmental cost. The science panel did identify concerns about unintended water quality and non-water quality impacts associated with some of the additional methods considered[15].

Since the state only regulates discharges to Alaskan marine waters, the panel did not consider whether there are environmental costs to discharging minimally treated wastewater outside of state waters.

4.5 Results and Discussion on Environmental Benefit and Cost

The Department concurs with the analyses, findings and conclusions set out in sections 7.5 (pgs. 83 – 84) and 9 (pg. 95) of the SAP's report. The statements contained in those sections are consistent with previous analyses by others examining potential treatment methods and potential environmental impacts of treated wastewater effluent from cruise ships. More specifically, DEC concurs with the

[13] SAP Report, Section 9 Findings.
[14] SAP Report, Section 7.5 Conclusions.
[15] SAP Report, Section 7.5 Conclusions.

panel's statement regarding the lack of evidence that "commercial passenger vessels operating in Alaska waters with AWTS cause acute or chronic toxic exposure to marine organisms," and the panel's conclusion that "[T]here appears to be little environmental benefit of treatment above and beyond that which current advanced wastewater treatment plants provide." Based on DEC's review of the panel's report and the reports and material cited therein, DEC concurs with the panel's conclusion that "costs expended to implement further treatment will not produce substantial additional environmental benefit."

The panel also considered the utility of implementing additional pollution prevention, control, and treatment methods that could incrementally improve existing effluent quality for some vessels, even if such methods would not achieve WQC at the point of discharge. Since the panel did not find an environmental benefit in additional methods that could *meet* WQC at the point of discharge, the panel also did not find an environmental benefit to additional methods that could improve effluent quality but not meet WQC at the point of discharge. The Department concurs with these findings.

As discussed by the panel and EPA[16], the large and rapid dilution of wastewater discharges when a cruise ship is underway results in concentrations of pollutants that are well below Alaska water quality criteria. The Department does not believe that regional studies on long term impacts from cruise ship wastewater discharges are needed or achievable given the low concentrations that would need to be tracked. If the number of vessels discharging simultaneously in port increases significantly in the future in-port discharges would potentially be of more concern since there is less dilution with vessels in port.

DEC's permitting authorities and other regulatory powers can be used to assure good operation of the AWTS already on large cruise ships in Alaska. DEC may include requirements in vessel permits that they only discharge in certain locations or when vessels are underway. DEC can also require the monitoring and reporting of the performance of AWTS, effluent quality, and the location and amounts of any discharge to Alaska waters. Thus, the assumptions the panel made regarding the quality of effluent actually produced on vessels in Alaska and the benefits from rapid mixing from dilution can be assured through permit requirements and monitoring.

At some point, some of the emerging treatment technologies, including reverse osmosis and ion exchange, could become technically and economically feasible for use on large cruise ships. If the cost of installing these systems on new vessels or retrofitting existing vessels with them does become feasible, and there are no other environmental issues with other waste streams generated from these systems, then DEC could adopt technology-based effluent standards that would mandate treatment to the level of better systems. In the interim, it appears the effluent quality produced by the different types of AWTS should set the technology-based standards for wastewater treatment from large cruise ships.

[16] Cruise Ship Discharge Assessment Report, EPA (December 2008). Section 2.4.4 Potential Treatment Technologies in Addition to AWTS