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Sampling Episode Report
Holland America Oosterdam
Sampling Episode 6506

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EXECUTIVE SUMMARY

Sampling Episode Report for Holland America Oosterdam

This Sampling Episode Report describes the sampling and analysis activities to characterize wastewater (graywater and sewage) generated and discharged by the cruise vessel Holland America Oosterdam while in Alaska waters. This sampling took place from September 18 through September 23, 2004, under the direction of the U.S. Environmental Protection Agency (EPA). The sampling program is part of EPA's data collection effort to evaluate whether to develop wastewater discharge standards for cruise vessels, under 33 USC 1901 Note, for cruise vessels authorized to carry 500 or more passengers for hire when operating in the waters of the Alexander Archipelago or the navigable waters of the United States within the State of Alaska or within the Kachemak Bay National Estuarine Research Reserve. EPA will use information from the sampling of this vessel and three other cruise ships in Alaska to characterize wastewater generated and discharged by large cruise vessels with advanced wastewater treatment systems.

EPA selected the Holland America Oosterdam to characterize the performance of two ROCHEM UF Systeme GmbH wastewater treatment systems. The ROCHEM LPRO treatment system, which is used to treat accommodations and laundry wastewater onboard the Oosterdam, is an advanced wastewater treatment system that uses low pressure reverse osmosis followed by ultraviolet (UV) disinfection. The ROCHEM Bio-Filt® treatment system, which is used to treat sewage, galley wastewater, and membrane concentrate generated by the ROCHEM graywater treatment system onboard the Oosterdam, is an advanced wastewater treatment system that uses aerobic biological oxidation followed by ultrafiltration and UV disinfection. Samples were collected of various wastewater sources (accommodations, laundry, galley, and food pulper wastewater), influents to the treatment systems, influents to the UV disinfection components of the treatment systems, effluents from the treatment systems, source water, wastewater treatment residuals (screening solids and wastewater biosludge), and incinerator ash. Wastewater source samples were collected for a single 24-hour sampling period, while samples of the influents to and effluents from the treatment systems were collected for five consecutive 24-hour sampling periods.

Strap-on ultrasonic flow meters were installed near the sampling locations for accommodations wastewater, influents to treatment, effluents from treatment, and combined effluent discharge to collect flow data and, in some cases, to trigger automatic sampling machines.

Various sample collection methods (composite by flow, composite by time, grab, and grab composite) were used depending on the sampling point and the analyte. Tested analytes include pathogen indicators (fecal coliform, *E. coli*, enterococci), classical pollutants, total and dissolved metals, volatile and semivolatile organics, pesticides, polychlorinated biphenyls, and dioxins and furans. Not all samples were analyzed for all target analytes.

Accommodations wastewater contained the greatest number of analytes detected at the highest concentrations among graywater sources, most notably *E. coli*, enterococci, and most metals. Food pulper wastewater contained relatively few analytes detected at the highest concentrations among graywater sources; however, it showed the highest concentrations for several analytes commonly used to measure wastewater strength: biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and total organic carbon (TOC). Galley and laundry wastewater samples showed the highest concentrations for only 15 and 7 analytes, respectively.

The influent to the ROCHEM graywater treatment system contained key analytes, such as pathogen indicators, BOD_5, COD, and total suspended solids (TSS), at concentrations similar to those in typical domestic wastewater, even though this system does not treat any sewage. Of the 54 metal analytes tested for, 26 were detected in every influent to graywater treatment system sample. Among the 201 target analytes for volatile and semivolatile organics and pesticides, only 4 were detected in any influent to graywater treatment samples, most at concentrations close to their detection limits.

Because of water conservation measures onboard cruise ships (such as vacuum toilets), the influent to the ROCHEM sewage/graywater treatment system contained key analytes such as pathogen indicators, BOD_5, COD, and TSS at concentrations much higher than those in typical domestic wastewater. Of the 54 metals analytes tested for, 32 were detected in every

influent to sewage/graywater sample. Among the 360 target analytes for volatile and semivolatile organics, pesticides, and polychlorinated biphenyls, 20 were detected in Oosterdam influent to sewage/graywater treatment samples, most at concentrations close to their detection limits.

The ROCHEM graywater treatment system successfully removed almost all pathogen indicators (>99%) and most classical pollutants, metals, and organics. Fecal coliform was detected in 2 of the 15 effluent graywater treatment samples, enterococci was not detected in any effluent samples, and *E. coli* was detected in 1 of 15 effluent samples. The graywater treatment system removed most BOD_5 (80%), COD (85%), and TOC (70%), and removed settleable residue and TSS to below detectable levels. The graywater system reduced total Kjeldahl nitrogen (TKN), which measures both ammonia and organic forms of nitrogen by 76%, and total phosphorus by 90%, while nitrate/nitrite levels remained relatively unchanged. The graywater treatment system was highly efficient at removing particulate metals, and removed dissolved metals at an average of 52%. The graywater treatment system did not significantly reduce volatile and semivolatile organics.

The ROCHEM sewage/graywater treatment system successfully removed almost all pathogen indicators (>99%) and most classical pollutants, metals, and organics. Fecal coliform was not detected in any of the 15 effluent sewage/graywater treatment samples, enterococci was detected in 4 of 15 effluent samples, and *E. coli* was detected in 1 of 15 effluent samples. The sewage/graywater treatment systems removed almost all BOD_5 (>99%), COD (95%), and TOC (86%), and removed settleable residue and TSS to below detectable levels. The sewage/graywater treatment systems reduced total Kjeldahl nitrogen (TKN), which measures both ammonia and organic forms of nitrogen by 70%, and total phosphorus by 41%, while nitrate/nitrite levels remained relatively unchanged. The sewage/graywater system was highly efficient at removing particulate metals, and removed dissolved metals at an average of 40%. The sewage/graywater treatment system removed most of the volatile and semivolatile organics to concentrations below detection levels.

The ROCHEM graywater treatment system generates two types of residuals: screening solids (from a vibratory screen filter at the beginning of the treatment system) and spent bag filters (used for pretreatment prior to reverse osmosis). Screening solids are collected manually and disposed of in the incinerator system for discharge outside of 12 nm from shore. Spent bag filters are shredded and incinerated onboard. The ROCHEM sewage/graywater treatment system also generates two types of residuals: screening solids (from a vibratory screen filter at the beginning of the treatment system) and waste biosludge (excess biological mass from the treatment system's bioreactors). The screening solids and biosludge are pumped to a double-bottom holding tank for overboard discharge outside of 12 nm from shore. Most of the analytes detected in these residual wastes were also detected in the influent to the treatment system. For many analytes, concentrations in the screening solids and waste biosludge exceeded those in the influent to treatment, suggesting that these analytes are removed from the system in these waste streams.

On average, each person generated 31 gallons of untreated accommodations and laundry wastewater and 23 gallons of untreated sewage, galley wastewater, and membrane concentrate per day. Average combined discharge from the graywater and sewage/graywater treatment systems was 45 gallons per person per day.

1.0 INTRODUCTION

This Sampling Episode Report (SER) describes the Environmental Protection Agency's sampling and analysis activities to characterize graywater and sewage generation and treatment by Holland America Cruise Line's cruise ship ms Oosterdam (Oosterdam) while in Alaska waters. This sampling episode took place from September 18 through September 23, 2004, under the direction of the Engineering and Analysis Division of the Office of Science and Technology, and the Oceans and Coastal Protection Division of the Office of Wetlands, Oceans, and Watersheds of the U.S. Environmental Protection Agency (EPA).

The Oosterdam is an 85,000 gross-ton cruise vessel launched in 2003. The vessel has 11 decks, a length of 951 feet, and a beam of 105.8 feet. The Oosterdam's maximum cruising speed is 24 knots. Its port of registry is Rotterdam, Netherlands. During the sampling episode, the Oosterdam carried 1,857 passengers and 768 crew. The ship's itinerary was as follows:

Date	Port
September 18, 2004	Seattle, WA
September 19, 2004	Cruising Inside Passage
September 20, 2004	Juneau, AK
September 21, 2004	Cruising Hubbard Glacier
September 22, 2004	Sitka, AK
September 23, 2004	Ketchikan, AK
September 24, 2004	Victoria, BC

This sampling program is part of EPA's data collection efforts to evaluate whether to develop wastewater discharge standards for cruise vessels authorized to carry 500 or more passengers for hire when operating in the waters of the Alexander Archipelago or the navigable waters of the United States within the State of Alaska or within the Kachemak Bay National Estuarine Research Reserve (hereafter referred to as Alaska waters). Such regulations are authorized by "Title XIV - Certain Alaskan Cruise Ship Operations" of the Miscellaneous Appropriations Bill (H.R. 5666) passed by Congress on December 21,2000 in the Consolidated

Appropriations Act of 2001 (Pub L. 106-554, Sections 1401-1414, 33 USC 1901 Note). The data and information gathered through this sampling episode were collected using EPA's authority under section 308 of the Clean Water Act, as also provided by Title XIV. Holland America Line voluntarily provided information and data gathered for and represented in this report, notwithstanding the above cited authority, in the interest of research for the improvement of wastewater treatment standards.

EPA selected the Holland America Oosterdam to characterize the performance of two ROCHEM UF Systeme GmbH (Hamburg, Germany) wastewater treatment systems. The ROCHEM LPRO treatment system, which is used to treat accommodations and laundry wastewater onboard the Oosterdam, is an advanced wastewater treatment system that uses low pressure osmosis followed by ultraviolet (UV) disinfection. The ROCHEM Bio-Filt® treatment system, which is used to treat sewage, galley wastewater, and membrane concentrate generated by the ROCHEM graywater treatment system onboard the Oosterdam, is an advanced wastewater treatment system that uses aerobic biological oxidation followed by ultrafiltration and UV disinfection. EPA will use the analytical and flow data included in this sampling episode report to evaluate the performance of the ROCHEM graywater and sewage/graywater treatment systems, and to analyze patterns and variability in wastewater sources.

Samples were collected in accordance with procedures specified in the to *Generic Sampling and Analysis Plan for Large Cruise Ships in Alaska Waters* (Generic SAP) and the ship-specific *Sampling and Analysis Plan for Holland America Oosterdam* (Oosterdam SAP). The Oosterdam SAP is presented in Appendix E and the Generic SAP is available on EPA's website at http://www.epa.gov/owow/oceans/cruise_ships/GenericSAP040602.pdf. Pathogen indicator analyses were performed onboards and samples for all other analyses were shipped to shoreside EPA-contract laboratories for analysis. Appendix D identifies all EPA-contract laboratories used in this sampling episode.

Section 2.0 of this SER describes the generation, collection, and treatment of graywater and sewage on the Oosterdam, as well as the sampling point and flow meter locations

used in this sampling episode. Section 3.0 describes the sample collection methods and deviations from the Oosterdam SAP. Section 4.0 presents and analyzes the analytical, flow, and shipboard data collected during the sampling episode. Section 5.0 describes the quality assurance and quality control (QA/QC) procedures and results. Section 6.0 presents references used in this document. Tables and figures referred to in the text are located at the end of each section.

2.0 WASTEWATER SYSTEM AND SAMPLING POINTS

This section describes graywater and sewage generation, collection, and treatment on the Oosterdam, as well as the sample collection points and flow meter locations and installation points used in this sampling episode.

2.1 Wastewater Generation and Collection

The ship's collection, holding, and transfer system (CHT) collects and transfers graywater and sewage generated onboard to the ship's ROCHEM graywater and sewage/graywater treatment systems or to overboard discharge. For the purpose of this report, graywater refers to non-sewage wastewaters that are collected by the CHT system. The CHT system is composed of five subsystems, referred to by the ship's crew as the galley, food pulper, accommodations, laundry, and sewage systems. Figure 2-1 is a simplified diagram of the Oosterdam's graywater and sewage CHT system. Wastewater sources collected by each of the five subsystems are described in Table 2-1. Potable water is used as source water for all ship operations that generate graywater and sewage (e.g., laundry, galley, food pulper, sinks, showers, and toilets). Potable water is produced onboard and seldom bunkered while in port.

2.2 Wastewater Treatment

Wastewater treatment onboard the Oosterdam is composed of two different types of ROCHEM systems designed to treat low concentration wastewater and high concentration wastewater separately. Low concentration wastewater (laundry and accommodations wastewater) are routed to the ROCHEM graywater treatment system (see Section 2.2.1 below), and high concentration wastewater (passenger and crew galley wastewater, sewage, and membrane concentrate from the ROCHEM graywater treatment system) are routed to the ROCHEM sewage/graywater treatment system (see Section 2.2.2 below). Effluent from the two treatment systems are combined for discharge overboard through a single port. Figure 2-2 is a simplified diagram of the ROCHEM graywater treatment system and Figure 2-3 is a simplified diagram of the ROCHEM sewage/graywater treatment system.

2.2.1 ROCHEM Graywater Treatment System

The Oosterdam is outfitted with a ROCHEM LPRO treatment system (referred to in this report as the ROCHEM graywater treatment system), an advanced wastewater treatment system that uses low pressure reverse osmosis followed by ultraviolet (UV) disinfection to treat low concentration wastewater (i.e., accommodations and laundry wastewater). Figure 2-2 is a simplified diagram of the ROCHEM graywater treatment system.

Wastewater from the accommodations and laundry CHT subsystems culminates in three graywater holding tanks. From the graywater holding tanks, the wastewater is pumped through a vibratory screen filter (mesh size 104 µm) to remove coarse solids such as fibers, hair, and large sediment (the system has two filters, which alternate operation each month). After the vibratory screen filter, antiscale chemicals are added and the wastewater is filtered using a bag filter to prevent fouling or blockage of the subsequent reverse osmosis membranes. Next, the wastewater passes through two trains of reverse osmosis membrane units operated in parallel. Together, the two trains contain a total of 80 individual reverse osmosis modules organized in multiple sets or blocks of 8. The reverse osmosis modules use cross flow design (wastewater flows parallel to membrane surface) to minimize fouling. Membrane permeate (85% of treatment system influent by volume) collects in small permeate tanks (one tank for each train), while membrane concentrate (15% of treatment system influent by volume) is routed to the ROCHEM sewage/graywater treatment system for further treatment (see below). Sodium hydroxide is added to the permeate for pH control as it is pumped from the permeate tanks to the final stage of treatment, UV disinfection. The hydraulic residence time of the treatment system (i.e., the amount of time the wastewater stays in the treatment system) is approximately 12 hours.

The ROCHEM graywater treatment system is also equipped with a second stage of reverse osmosis membranes and permeate tanks designed to operate in series with the first stage described above. However, treated wastewater from the first stage bypasses these components of the system as they are not needed to achieve Holland America's effluent quality requirements. The second stage membranes are arranged in two parallel trains with a combined

total of 40 reverse osmosis modules. The second stage can be used in emergency situations, such as during upset or maintenance of the first stage.

According to the ship's crew, the ROCHEM graywater treatment system can treat approximately 650 m^3 (172,000 gallons) per day of low concentration wastewater. During the sampling episode, the average daily load to the system was 307 m^3 (81,000 gallons), as determined by measured flows collected by the sampling crew.

The ROCHEM graywater treatment system operates continuously, regardless of the ship's location (e.g., in port, at sea within Alaska waters, at sea outside Alaska waters). The vessel typically continuously discharges treated wastewater from this system overboard. When overboard discharge is suspended, such as when the ship cruised Hubbard Glacier, the treated effluent is diverted to double-bottom holding tanks, where it is held for eventual discharge outside of 12 nautical miles (nm) from shore.

The ROCHEM graywater treatment system generates two types of residuals: screening solids (from the vibratory screen filter) and spent bag filters. Screening solids (approximately 20 gallons per day) are collected manually and disposed of in the incinerator system. Four spent filter bags are generated each day and are shredded and incinerated onboard.

The graywater system is cleaned when transmembrane pressure exceeds 5 bars (approximately every 600 hours). The membranes soak in caustic and then acid cleaning solutions for 45 minutes and are then rinsed. Spent cleaning solutions and rinse water are routed to the ROCHEM sewage/graywater treatment system for treatment. The individual reverse osmosis modules in the treatment system are placed in standby mode while in the cleaning sequence. Occasionally, the membrane modules undergo a more aggressive chemical soak similar to that described in Section 2.2.2 for the ROCHEM sewage/graywater treatment system.

2.2.2 ROCHEM Sewage/Graywater Treatment System

The Oosterdam is outfitted with a ROCHEM Bio-Filt® treatment system (referred to in this report as the ROCHEM sewage/graywater treatment system), an advanced wastewater treatment system that uses aerobic biological oxidation followed by ultrafiltration and UV disinfection to treat high concentration wastewater (sewage, galley wastewater, and membrane concentrate generated by the ROCHEM graywater treatment system). Figure 2-3 is a simplified diagram of the ROCHEM sewage/graywater treatment system.

Wastewater from the galley and sewage CHT subsystems culminates in two buffer tanks, the first component of the ROCHEM sewage/graywater treatment system. Membrane concentrate from the ROCHEM graywater treatment system is also routed to the buffer tanks. Wastewater is pumped between the two buffer tanks to produce a homogeneous influent to the treatment system. An antifoam chemical is added to the recirculation loop. From the buffer tanks, the wastewater is pumped through a vibratory screen filter (mesh size 104 μm) to remove coarse solids (the system has two filters, which alternate operation each month). Filtered wastewater collects in a filtrate tank, where sodium hydroxide is added to control pH.

From the filtrate tank, the wastewater is pumped to eight aerated bioreactor/ ultrafiltration membrane treatment trains operated in parallel. Each bioreactor/ultrafiltration train consists of eight segments of bioreactors and nine membrane modules. The bioreactor segments operate in parallel while the ultrafiltration modules are arranged in both parallel and serial formation (three sets of modules operate in series with each set consisting of three modules operated in parallel). (Note that ROCHEM personnel and the ship's crew refer to the treatment trains as "blocks," with two blocks in a "stage" and two stages in a "line," for a total of two lines.)

The ultrafiltration modules use cross flow design (wastewater flows parallel to membrane surface) to minimize fouling. Membrane permeate (10 to 15 % of treatment system influent) collects in small permeate tanks (one tank for each train). Membrane concentrate (85 to 90% of treatment system influent), consisting of particulate matter and mixed liquor (wastewater

containing organic matter and biological floc), is returned to the bioreactors. This pressurized return stream also serves as the mechanism for bioreactor aeration and mixing by driving eductor pumps that take in air which is then released as fine bubbles in the bioreactors. A transmembrane pressure of 4 bars is required for proper operation.

Combined wastewater from the permeate tanks undergoes UV disinfection as the final stage of treatment. The hydraulic residence time of the treatment system is less than one day.

According to the ship's crew, the ROCHEM sewage/graywater treatment system can treat approximately 330 m^3 (87,200 gallons) per day of high concentration wastewater. During the sampling episode, the average daily load to the system was 227 m^3 (59,900 gallons), as determined by measured flows collected by the sampling crew.

The ROCHEM sewage/graywater treatment system operates continuously, regardless of the ship's location (e.g., in port, at sea within Alaska waters, at sea outside Alaska waters). The vessel typically continuously discharges treated wastewater from this system overboard. When overboard discharge is suspended, such as when the ship cruised Hubbard Glacier, the treated effluent is diverted to double-bottom holding tanks, where it is held for discharge outside of 12 nautical miles (nm) from shore.

The ROCHEM sewage/graywater treatment system generates two types of residuals: screening solids (from the vibratory screen filter) and waste biosludge (excess biological mass from the bioreactors). Screening solids (approximately 50 gallons per day) are pumped from the filter's solids collection tank to a double-bottom holding tank for discharge outside of 12 nm from shore. Waste biosludge is removed (or "wasted") from the bioreactors to maintain a constant biomass concentration in the bioreactors. The typical wasted biosludge volume is approximately 25 m^3 per day and is determined by measuring the bioreactor total suspended solids (mixed-liquor suspended solids (MLSS) concentration. The target MLSS

concentration is 15,000 mg/L. Waste biosludge is held in a double-bottom holding tank for discharge outside of 12 nm from shore.

While the cross-flow design minimizes membrane fouling, solids accumulate on the membrane surface, which increases transmembrane pressure and reduces permeate production. The system backwashes the membranes every 40 minutes to keep the membranes clean; this backwash remains in the system. In addition, air is periodically introduced from the permeate side to physically remove solids from the membrane surface. The ultrafiltration membranes are also chemically cleaned when transmembrane pressure reaches 5 bars (approximately every 600 hours). The cleaning cycle takes a full day. During the cleaning process, two different chemicals are cycled through the modules in both forward and reverse directions: caustic for five hours and then acid for four to five hours. Finally, the modules are rinsed with fresh water to avoid any contamination of the bioreactors with cleaning agents. Spent cleaning solutions and rinse water are routed to a double-bottom holding tank (the same tank as for waste biosludge) for discharge outside of 12 nm from shore. During the cleaning cycle, the bioreactor/ultrafiltration stage is in stand-by mode, and all wastewater is diverted to other bioreactor/ultrafiltration stages. While in stand-by mode, the eductor system on that stage does not operate; air spargers located at the bottom of the bioreactors provide sufficient air supply and mixing to maintain the microorganisms.

2.3 Graywater, Sewage, and Residual Sample Collection Points

Samples were collected from the graywater source (accommodations, laundry, galley, food pulper), influents to the treatment systems, influents to the UV disinfection portion of the treatment systems, effluents from the treatment systems, source water (water from the ship's potable water system), wastewater treatment residuals, and incinerator ash. Table 2-1 describes the wastewaters sampled, their sampling point locations, their flow measurement locations (if applicable), and the number of days they were sampled. Table 2-2 provides the same information for the treatment residuals and incinerator ash sampled. In general, graywater and wastewater treatment residual samples were taken for one 24-hour period, while samples of

the influents to and effluents from the treatment systems were taken for five 24-hour periods. See Section 3.2 and Table 3-2 for information on the analytes tested.

Samples were collected from the ship's potable water system (source water) to determine if any of the target analytes were present as background contamination. One trip blank was prepared and analyzed for volatile organics to evaluate possible contamination during shipment and handling of samples. Finally, an equipment blank was prepared and analyzed to evaluate possible contamination by the sampling equipment.

Samples were not taken directly from the sewage CHT system. In addition, samples could not be collected of wastewater held in double-bottom holding tanks for discharge outside 12 nm from shore (i.e., treated effluent diverted to storage while the ship cruised Hubbard Glacier) because (1) double-bottom holding tanks cannot be accessed directly due to safety consideration, and (2) sampling from the holding tank discharge manifold would characterize combined holding tank discharges and not discharges specific to the holding tanks of interest.

2.4 Flow Meter Locations

Strap-on ultrasonic flow meters (Controlotron Model 1010) were installed at six sampling locations to collect flow data and, in some cases, to control an automatic composite sample machines (by triggering sample collection after a defined amount of flow passed through the pipe). The first location was on the outlet pipe from one of the accommodations holding tanks (accommodations wastewater, SP-1; see Table 2-1 for a description of wastewaters and Figure 2-1 for a simplified graywater and sewage CHT system diagram showing sampling points and flow meter locations). The second location was the at the influent to the graywater treatment system on the combined graywater inlet pipe to the vibratory screen filter (SP-6; see Table 2-1 and Figure 2-2). The flow meter at SP-6 could not be used to trigger collection of flow-weighted composite samples because high wastewater pressure caused continuous collection of sample when the sample tap was left open. Instead, influent to graywater treatment system samples were collected as grab composite samples (see Table 3-1 for a description of sample collection

methods). The third location was at the effluent from the graywater treatment system on the outlet pipe from the UV disinfection unit (SP-8/9; see Table 2-1 and Figure 2-2). This flow meter collected flow data and triggered collection of flow-weighted composite samples through the end of Day 3 of sampling. At this time, high wastewater pressure caused the flow meter to lose signal strength. Repeated attempts to run the flow meter set-up and calibration procedures were unsuccessful. Flow data for sampling Days 4 and 5 were not collected and the corresponding samples were collected as grab composite samples.

The fourth location was at the influent to the sewage/graywater treatment system on the inlet pipe to the vibratory screen filter (SP-11; see Table 2-1 and Figure 2-3). The fifth location was the effluent from the sewage/graywater treatment system on the outlet pipe from the UV disinfection unit (SP-13/14; see Figure 2-3). The final location was the final combined effluent from the graywater and sewage/graywater treatment systems on the overboard discharge line (SP-16; see Table 2-1 and Figures 2-2 and 2-3).

Sampling points for galley and laundry wastewaters were located on piping that would not support the installation of strap-on ultrasonic flow meters (see Table 2-1), precluding collection of flow data and flow-weighted composite samples at these sampling points. Time-weighted composite samples were collected at the galley and laundry wastewater sampling points (see Table 3-1 for a description of the sample collection methods). Flow estimates for the food pulper wastewater were provided by the ship's crew.

Table 2-1

Wastewater, Sampling Point, and Flow Meter Descriptions, Holland America Oosterdam

Descriptions of wastewaters sampled, sampling point locations, flow meter locations, and number of days sampled for the Oosterdam sampling episode (September 18 through September 23, 2004).

Wastewater Name	Wastewater Description (a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Accommodations	Wastewater from sinks, tubs, and showers in guest and crew rooms, bar sinks, salon sinks and floor drains, medical sinks and floor drains, most interior deck drains, and non-engine room shop sinks. Accommodations wastewater drains to five accommodations wastewater holding tanks approximately equal in size.	SP-1	Sample tap was installed on the outlet pipe from one of the holding tanks. According to the ship's crew, all six holding tanks receive similar wastewater; therefore, the specific holding tank sampled was selected based on accessibility.	Strap-on flow meter was installed on the outlet pipe from one of the accommodations wastewater holding tanks (the same discharge line as the installed sample tap).	1 (Day 3)
Laundry	Wastewater from laundry equipment and laundry floor drains. All laundry wastewater drains to a single laundry holding tank. Discharge pumps for the laundry holding tank activate by both a liquid level indicator and a timer to provide relatively constant flow to the ROCHEM graywater treatment system.	SP-2	Sample tap was installed on the outlet pipe from the laundry wastewater holding tank.	Flow data for laundry wastewater were not obtained. Strap-on flow meter set-up and calibration procedure was unsuccessful on the outlet pipe from the laundry wastewater holding tank, most likely due to close proximity to pumps and other sources of turbulence. Pipe configurations precluded all other locations.	1 (Day 1)
Galley	Wastewater from dishwashers, food preparation, galley sinks, galley deck drains, and galley floor washing (typically hand mops). Galley wastewater drains through grease traps into two galley holding tanks (one for the crew galley and one for the two passenger galleys).	SP-3	Sample tap was installed on the inlet pipe to the crew galley grease tap. According to the ship's crew, both grease traps receive similar wastewater; therefore, the specific grease trap sampled was selected based on accessibility.	Flow data for galley wastewater were not obtained. Strap-on flow meter was not suitable for gravity flow piping (i.e., piping that is not full) at the inlet to the grease trap. Pipe configurations precluded all other locations.	1 (Day 2)

(a) List of wastewater sources may not be comprehensive.
(b) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations. Food Pulper Wastewater, Vacuum System (SP-4) is not listed in this table as samples could not be collected from this sampling location (see Table 3-5).
(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

Table 2-1 (Continued)

Wastewater Name	Wastewater Description (a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Food Pulper, Centrifuge System	Wastewater from the centrifuge food pulper system (one of two food pulper systems on the Oosterdam). Food waste is mixed with water and processed into a slurry. The food slurry is then separated into semi-dry food solids and wastewater (food pulper wastewater) using a centrifuge. Food solids are incinerated onboard, while food pulper wastewater is recirculated within the food pulper system. Once per day the food pulper wastewater is drained from the centrifuge to a drain tank and replaced with fresh water. The drain tank has additional inlet pipes to receive wastewater from a second food pulper system (not operated during the sampling episode), as well as waste from galley grease traps.	SP-5	Sample tap was installed on the food pulper centrifuge system outlet pipe (i.e., the inlet pipe to the drain tank).	Flow measurements not required. Approximately 8 to 10 m^3 of food pulper wastewater is generated per day from the two food pulper systems, according to the ship's crew.	1 (Day 5)
Influent to ROCHEM Graywater Treatment System	Combined wastewaters from the accommodations and laundry collection, holding, and transfer (CHT) subsystems. Wastewater from the accommodations and laundry CHT subsystems culminates in three graywater holding tanks.	SP-6	Sample tap was installed on the combined graywater inlet pipe to the treatment system (before the vibratory screen filter).	Strap-on flow meter was installed on the combined graywater inlet pipe to vibratory screen filter (the same inlet/pipe as the installed sample tap). Flow meter could not be used to trigger collection of flow-weighted composite samples because of high wastewater pressure.	5
Influent to UV Disinfection part of the ROCHEM Graywater Treatment System	Graywater following treatment by reverse osmosis but prior to ultraviolet (UV) disinfection.	SP-7	Sample tap was installed on the inlet pipe to the UV disinfection unit.	Flow measurements not required.	5

(a) List of wastewater sources may not be comprehensive.
(b) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations. Food Pulper Wastewater, Vacuum System (SP-4) is not listed in this table as samples could not be collected from this sampling location (see Table 3-5).
(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

Table 2-1 (Continued)

Wastewater Name	Wastewater Description (a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Effluent from ROCHEM Graywater Treatment System	Final treated graywater effluent from the ROCHEM graywater treatment system. Effluent from the ROCHEM graywater treatment system is combined with effluent from the ROCHEM sewage/graywater treatment system and is typically continuously discharged overboard. Where discharge is prohibited, the combined effluent is diverted to storage tanks for overboard discharge outside 12 nm from shore.	SP-8/9	Sample tap was installed on the outlet pipe from UV disinfection unit, close to the unit and upstream of where the graywater effluent is combined with sewage/graywater effluent for overboard discharge. Piping distance from the graywater effluent sample tap to the overboard discharge port is 30 m.	Strap-on flow meter was installed on the outlet pipe from UV disinfection, close to the unit and upstream of where the graywater effluent is combined with sewage/graywater effluent for overboard discharge (the same outlet pipe as the installed sample tap). Flow data for the effluent from the ROCHEM graywater treatment system were collected through Day 3 of the sampling episode, but were not obtained on Days 4 and 5. At the end of Day 3, high wastewater pressure caused the flow meter to lose signal strength. Repeated attempts to run the flow meter set-up and calibration procedures were unsuccessful.	5
Influent to ROCHEM Sewage/Graywater Treatment System	Combined wastewaters from the galley and sewage CHT systems. Also includes reverse osmosis concentrate from the ROCHEM graywater treatment system. Wastewater from the galley and sewage CHT subsystems culminates in two buffer tanks, the first component of the ROCHEM sewage/graywater treatment system. Reverse osmosis concentrate from the ROCHEM graywater treatment system is also routed to the buffer tanks. Wastewater is pumped between the two buffer tanks to produce a homogeneous influent to the treatment system.	SP-11	Sample tap was an existing sample tap installed on the recirculation loop that mixes wastewater from the two buffer tanks.	Strap-on flow meter was installed on the inlet pipe to the vibratory screen filter.	5
Influent to UV Disinfection part of ROCHEM Sewage/Graywater Treatment System	Wastewater following treatment by biological oxidation and ultrafiltration but prior to UV disinfection.	SP-12	Sample tap was installed on the inlet pipe to the UV disinfection unit.	Flow measurements not required.	5

(a) List of wastewater sources may not be comprehensive.
(b) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations. Food Pulper Wastewater, Vacuum System (SP-4) is not listed in this table as samples could not be collected from this sampling location (see Table 3-5).
(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

Table 2-1 (Continued)

Wastewater Name	Wastewater Description (a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Effluent from ROCHEM Sewage/Graywater Treatment System	Final treated sewage/graywater effluent from the ROCHEM sewage/graywater treatment system. Effluent from the ROCHEM graywater treatment system is combined with effluent from the ROCHEM sewage/graywater treatment system and is typically continuously discharged overboard. Where discharge is prohibited, the combined wastewater is diverted to storage tanks for overboard discharge outside 12 nm from shore.	SP-13/14	Sample tap was installed on the outlet pipe from the UV disinfection unit, close to the unit and upstream of where the sewage/graywater effluent is combined with graywater effluent for overboard discharge. Piping distance from the sewage/graywater effluent sample tap to the overboard discharge port is 45 to 50 m.	Strap-on flow meter was installed on the outlet pipe from the UV disinfection unit, close to the unit and upstream of where the sewage/graywater effluent is combined with graywater effluent for overboard discharge (the same outlet pipe as the installed sample tap).	5
Final Combined Treated Effluent	Combined treated effluent from the graywater and the sewage/graywater treatment systems. Combined effluent is typically continuously discharged overboard. Where discharge is prohibited, the combined wastewater is diverted to storage tanks for overboard discharge outside 12 nm from shore.	SP-16	Sample tap was installed on the overboard discharge line, downstream of where graywater and sewage/graywater effluents are combined and downstream of the diversion valve that directs wastewater to either overboard discharge or storage in double-bottom holding tanks. Piping distance from the combined effluent sample tap to the overboard discharge port is <1 m.	Strap-on flow meter was installed on the overboard discharge line, downstream of where graywater and sewage/graywater effluent and combined and downstream of the diversion valve that directs wastewater to either overboard discharge or storage in double-bottom holding tanks (the sample discharge line as the installed sample tap).	5
Source Water	Potable water used as source water for all systems that generate wastewater that is treated by the ROCHEM graywater and sewage/graywater treatment systems.	SP-17	Samples collected from a bathroom sink in a sampling team member's cabin.	Flow measurements not required.	1 (Day 2)

(a) List of wastewater sources may not be comprehensive.
(b) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations. Food Pulper Wastewater, Vacuum System (SP-4) is not listed in this table as samples could not be collected from this sampling location (see Table 3-5).
(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

Table 2-2

Treatment Residual and Incinerator Ash Descriptions, Holland America Oosterdam

Treatment Residual Name	Treatment Residual Description	Sampling Point # (a)	Sampling Point Description (a)	Flow Meter Description (a)	# Days Sampled
Incinerator Ash	Ash generated from the incineration of trash (e.g., cardboard, paper, plastic), food solids from the food pulper systems, ROCHEM sewage/graywater screening solids, and spent bag filters. Incinerator ash is collected in incinerator ash storage hoppers for disposal onshore.	SP-10	Samples were collected directly from an incinerator ash storage hopper.	Flow measurements not required.	1 (Day 5)
Graywater Screening Solids	Solids generated by the vibratory screen of the ROCHEM graywater treatment. Screening solids are collected manually and disposed of in the incinerator system for discharge outside of 12 nm from shore.	SP-15	Samples were collected directly from a plastic screening solids storage container.	Flow measurements not required. Approximately 20 gallons of graywater screening solids are generated per day, according to the ship's crew.	1 (Day 3)
Sewage/Graywater Screening Solids	Solids generated by the vibratory screen of the ROCHEM sewage/graywater treatment system. Screening solids are pumped from the filter's solids collection tank to a double-bottom holding tank for discharge outside of 12 nm from shore.	SP-20	Sample tap was installed on the pipe that transfers screening solids from the filter's solids collection tank to the double-bottom holding tank.	Flow measurements not required. Approximately 50 gallons of sewage/graywater screening solids are generated per day, according to the ship's crew.	1 (Day 3)
Sewage/Graywater Waste Biosludge	Waste biosludge removed daily from the bioreactors of the ROCHEM sewage/graywater treatment system. Waste biosludge is pumped to a double-bottom holding tanks for overboard discharge outside 12 nm from shore.	SP-21	Sample tap was installed on the pipe that transfers waste biosludge from the bioreactors to the double-bottom holding tank.	Flow measurements not required. Approximately 25 m^3 of waste biosludge is generated per day, according to the ships crew.	1 (Day 3)

(a) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.

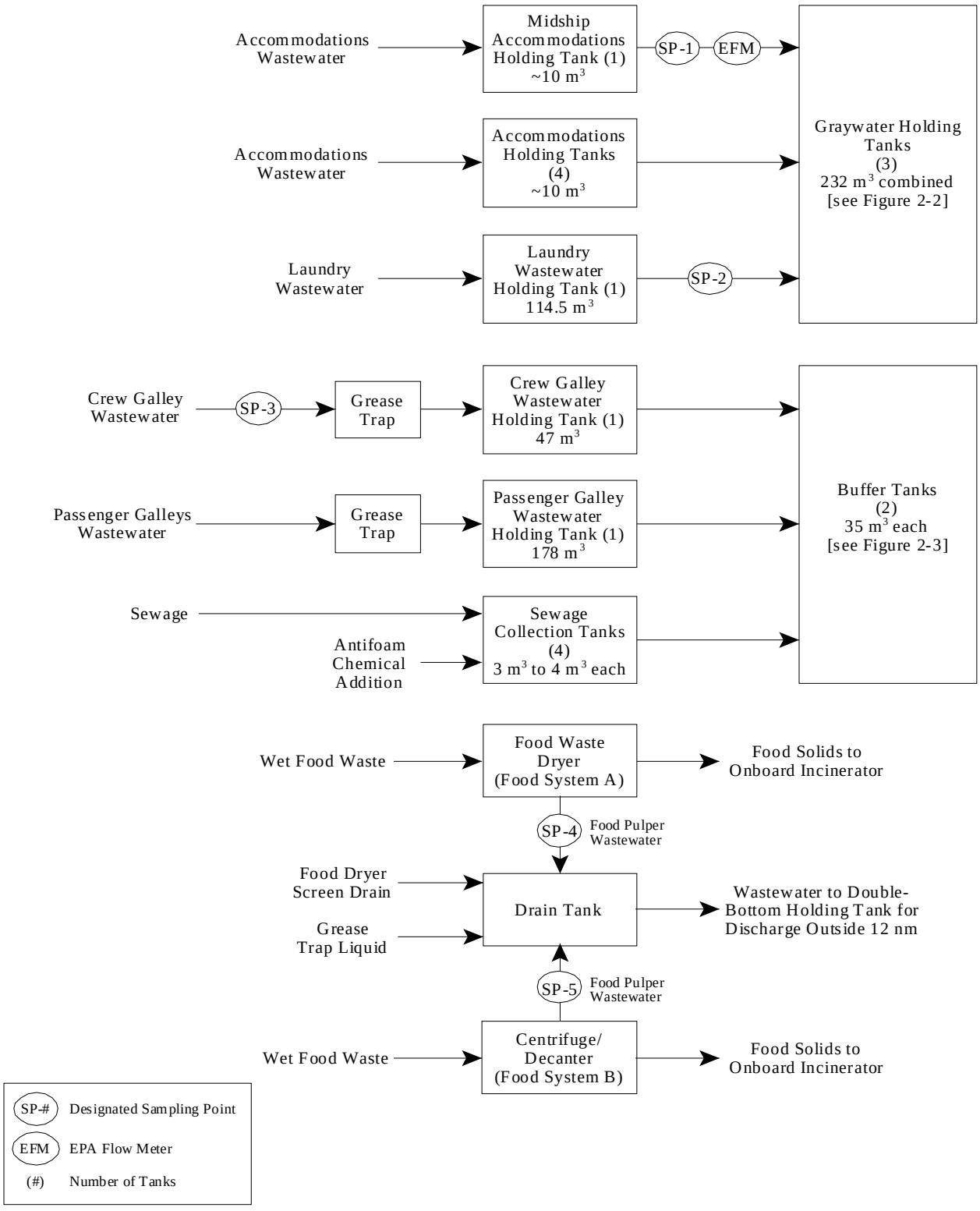

Figure 2-1. Graywater and Sewage Collection, Holding, and Transfer System - Holland America Oosterdam

Simplified diagram of the Holland America Oosterdam graywater and sewage CHT system. See Table 2-1 for a list of wastewater streams in each wastewater source.

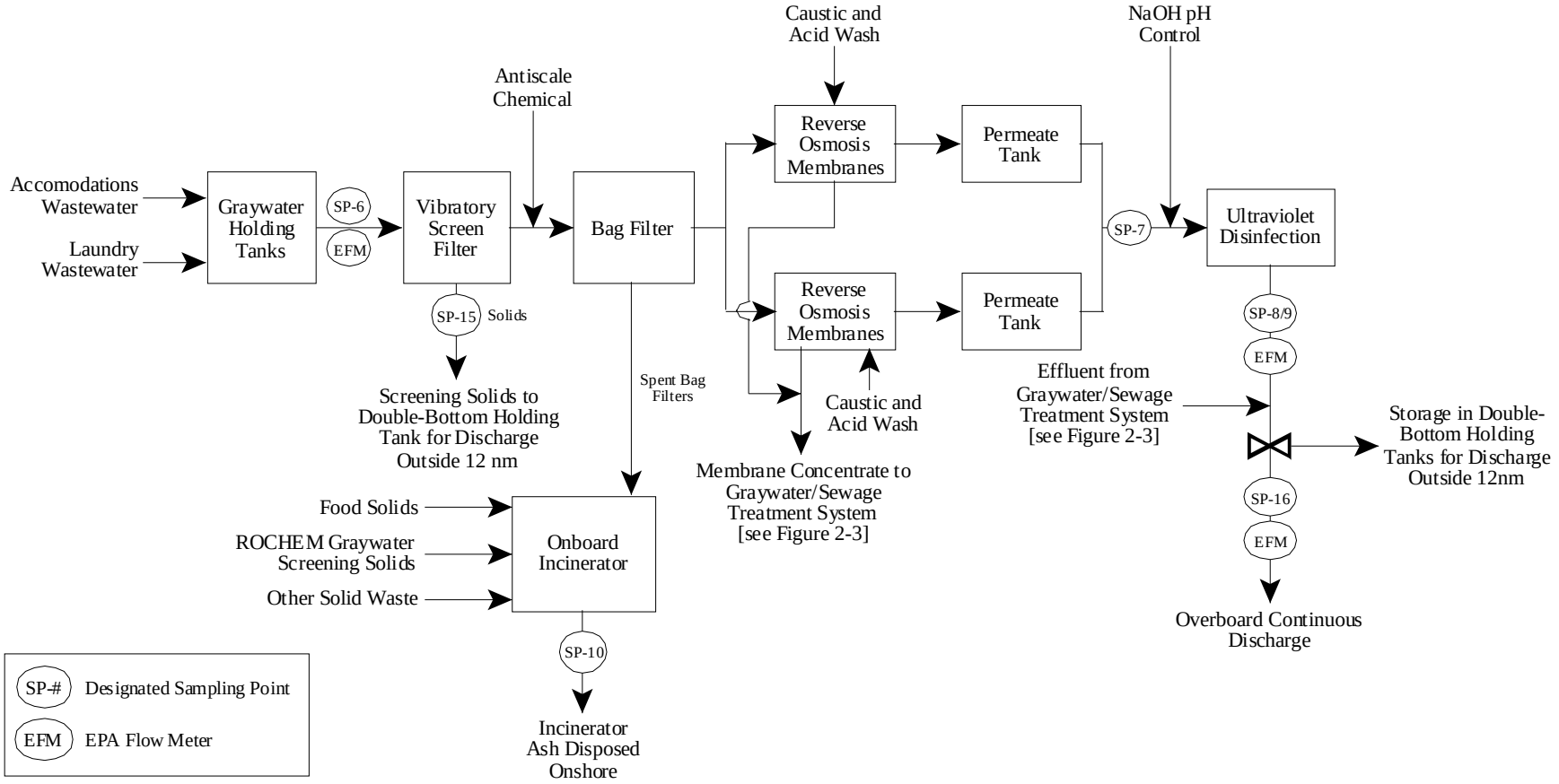

Figure 2-2. ROCHEM Graywater Treatment System - Holland America Oosterdam

Simplified diagram of the Holland America Oosterdam ROCHEM graywater treatment system. See Table 2-1 for a list of wastewater streams in each wastewater source, and Figure 2-1 for their collection and conveyance to the treatment system.

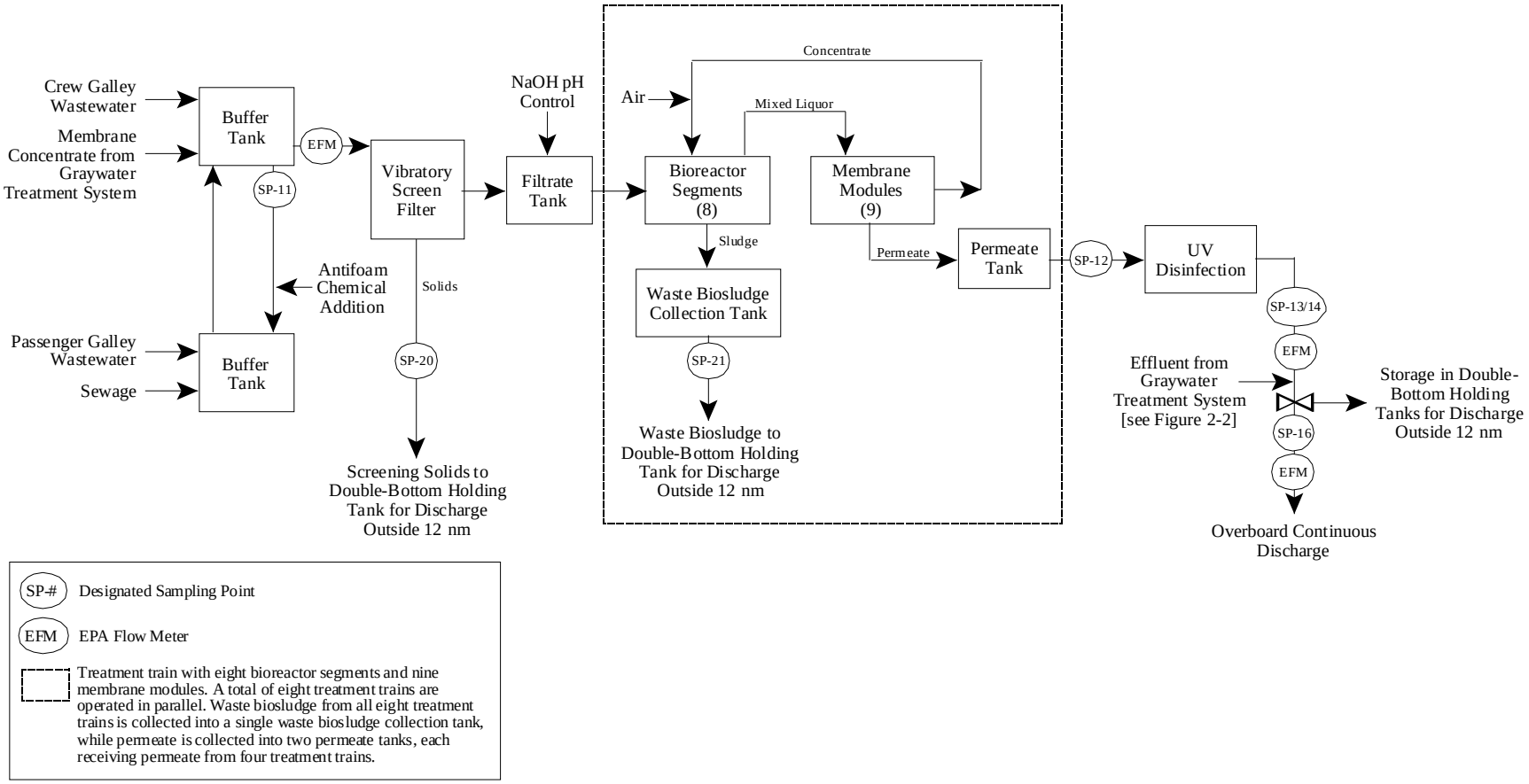

Figure 2-3. ROCHEM Sewage/Graywater Treatment System - Holland America Oosterdam

Simplified diagram of the Holland America Oosterdam ROCHEM sewage/graywater treatment system. See Table 2-1 for a list of wastewater streams in each wastewater source, and Figure 2-1 for their collection and conveyance to the treatment system

3.0 SAMPLE COLLECTION

This section describes the sample collection and analysis methods and deviations from the ship-specific Sampling and Analysis Plan for Holland America Oosterdam (Oosterdam SAP; Appendix E). A more detailed explanation of the sampling methodologies, analytes and analytical methods, sampling frequency and duration, schedule, and logistics that were followed during sampling onboard the Oosterdam can be found in Section 3.0 of the Oosterdam SAP.

3.1 Pre-Sampling Activities

EPA performed an engineering ship visit to the Oosterdam on March 28, 2004. The Oosterdam SAP was prepared based on information collected during that ship visit and from subsequent follow-up communication with Holland America personnel. One week prior to the sampling episode, personnel conducted sampling setup activities onboard the Oosterdam, including loading sampling equipment and the onboard laboratory, inspecting the installed sampling ports, installing the strap-on ultrasonic flow meters, and installing and programming the automatic sampling machines.

3.2 Sample Collection and Analysis Methodology

In general, graywater and wastewater treatment residual samples were taken for one 24-hour period, while samples of the influents to and effluents from the treatment systems were taken for five consecutive 24-hour periods (see Tables 2-1 and 2-2). Various sample collection methods (described in Table 3-1) were used depending on the waste stream and analyte (see Table 3-2). Most samples were composited over each 24-hour sampling period or were single grab samples in a 24-hour period. However, multiple (1 to 3) grab samples per 24-hour period were collected for pathogen indicator analyses because these samples must be analyzed within 6 hours of collection (see Table 3-2). Table 3-3 describes the analyte groups and lists the analytical methods used.

Each time a grab or grab composite sample was taken, another separate sample was placed in a separate container to perform field measurements of pH, temperature, conductivity, salinity, turbidity, sulfide, and free and total chlorine. Temperature and pH were measured immediately at the sampling point, and the remaining parameters were measured at the sample staging area onboard. See Table 3-4 for equipment used for these measurements. Field measurements were used primarily to determine sample preservation requirements. Samples (other than those for field measurements) were preserved in accordance with procedures described in the Oosterdam SAP (Appendix E), with exceptions as noted in Section 3.6 and Table 3-5. Note that while Alaska and Federal regulations for cruise ship discharges include standards for total residual chlorine, the equipment used to measure residual chlorine onboard was not suitable for measuring low levels of chlorine (detection limit of 20 µg/L compared to a standard of 10 µg/L) and was subject to various interferences, such as from oxidized forms of manganese. Accordingly, the field measurements collected during this sampling episode should not be used to assess compliance with cruise ship discharge standards.

Flow data were collected from the strap-on flow meters installed by the sampling team. See Section 2.4 for descriptions of the flow meter locations and Figures 2-1 through 2-3 for their locations. The flow meters were programmed to record the instantaneous flow rate (m^3/min) and total flow (m^3) every five minutes.

3.3 Converting Solids Mass Units to Volume Units

The food pulper, screening solids (from both treatment systems), and waste biosludge samples had high solids contents; therefore, the results listed below were reported by the laboratories in mass units.

- Food pulper: classical pollutants (except settleable residue and BOD_5), metals, and volatile and semivolatile organics;
- Screening solids: classical pollutants, metals, and volatile and semivolatile organics; and
- Waste biosludge: classical pollutants (except available cyanide), metals, and volatile organics.

Solids contents for these samples ranged from 1.4% to 26%. To allow for direct comparison of these results to those of other wastewater samples, mass units for these samples were converted to volume units using the following equation and assuming a sample density of 1:

Amount (mass units) * (% solids/100) = Amount (volume units)

All data in this report pertaining to food pulper, screening solids, and waste biosludge samples are reported in volume units. The laboratory data packages, which are included in the Cruise Ship Rulemaking Record and available upon request, contain the original mass units results reported by the laboratories. Note that the analytical results for the incinerator ash sample were also reported in mass units. However, the incinerator ash results were not converted because the sample was 100% solids.

3.4 Quality Assurance/Quality Control

Duplicate samples were collected for quality assurance and quality control. Results for duplicate samples were averaged. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling. Other field quality control samples prepared for this sampling episode include a trip blank and an equipment blank, which are discussed in Sections 5.2.1 and 5.2.2, respectively.

3.5 Interview with the Ship's Crew

The ship's crew was interviewed to obtain information regarding activities that impact wastewater generation. See Appendix C for details on these interviews and Section 4.2 for a summary.

3.6 Deviations from the Sampling and Analysis Plan

The sampling episode proceeded as specified in the Oosterdam SAP with the deviations described in Table 3-5.

Table 3-1

Sample Collection Method Descriptions, Holland America Oosterdam

Sample Collection Method	Description
Composite by Flow	Flow-weighted composite samples were collected using an automatic sampling machine interfaced with an installed strap-on ultrasonic flow meter (see Section 2.4). The flow meter signaled the automatic sampling machine to collect a 250-mL sample aliquot each time a fixed quantity of wastewater passed through the wastewater pipe. The number of composite sample aliquots collected per 24-hour sampling period ranged from approximately 30 to 70, depending on the total volume of sample required for planned analyses each sampling day. Sample aliquots were collected into a 10-L sample composite jar stored within the sampling machine. At the end of each 24-hour sampling period, the sample composite jar(s) were mixed and poured into individual sample bottles for analysis. Samples collected using the composite-by-flow method best represent a waste stream flowing through a pipe.
Composite by Time	Time-weighted composite samples were collected using an automatic sampling machine programmed to collect 250-mL sample aliquots at fixed time intervals. The programmed time interval differed by sampling point (see Table 3-2). The number of composite sample aliquots collected per 24-hour sampling period ranged from approximately 40 to 50, depending on the total volume of sample required for planned analyses. Sample aliquots are collected into a 10-L sample composite jar stored within the sampling machine. At the end of the 24-hour sampling period, the sample composite jar(s) were mixed and poured into individual sample bottles for analysis. The composite-by-time method was used when the composite-by-flow method was not feasible (see Table 3-2).
Grab	Grab samples were discrete samples collected directly into the sample bottles from the sample tap or through Teflon® tubing connected to the sample tap. Note that samples for pathogen indicator analyses were collected as grab samples (as opposed to composite samples) because they must be analyzed within a 6-hour holding time.
Grab Composite	Samples (1 to 4 per 24-hour sampling period) were manually collected as grab samples but composited either in the field or at the laboratory for a single analysis. The grab composite method was used when the composite-by flow or composite-by-time methods were not appropriate. **Volatile organics** - grab samples were collected directly into sample vials, which were filled completely to avoid loss of target analytes by volatilization. Grab samples for each 24-hour period for analysis of volatile organics were composited by the laboratory for a single analysis. **Total and available cyanide** - grab samples were chemically preserved as soon as possible to minimize interferences. The preserved total and available cyanide grab samples for each 24-hour period were composited onboard by the sampling team for a single analysis. **Hexane extractable material/silica-gel treated hexane extractable material (HEM/SGT-HEM)** - grab samples were collected directly into sample containers to avoid loss of HEM/SGT-HEM that might adhere to the interior of any interim sampling container (e.g., sample composite jar). The sampling team prepared composite HEM/SGT-HEM samples onboard for a single analysis per sampling period per day by filling approximately one-fourth (250-mL) of the sample containers when they collected each grab sample, resulting in 1-liter of sample in each container at the end of each sampling period.

Table 3-2

Sample Collection Methods and Analyte Groups Tested by Sampling Point, Holland America Oosterdam

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Accommodations	SP-1	**Composite by flow** Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD_5 - Settleable Residue - Group I - Group II Total and dissolved metals Semivolatile organics	1 (Day 3)
		Grab composite Collection times of the four subsamples in the composite can be found in Appendix A-3..	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab One grab sample was taken. Appendix A-1 shows the collection time.	Pathogen Indicators	
Laundry	SP-2	**Composite by time** Automatic sampling machine was programmed to collect sample aliquots at 10-minute time intervals during the 24-hour sampling period. The sampling machine successfully collected sample aliquots only during the relatively few intervals during the 24-hour sampling period (0600 on 9/18/04 to 0600 on 9/19/04) when the laundry wastewater holding tank discharge pump turned on, thereby closely approximating a flow-weighted composite sample.	Classical pollutants: - BOD_5 - Settleable Residue - Group I - Group II Total and dissolved metals Semivolatile organics Dioxins and furans	1 (Day 1)
		Grab composite Collection times of the four subsamples in the composite can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab One grab sample was taken. Appendix A-1 shows the collection time.	Pathogen indicators	

(a) See Figures 2-1 through 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Galley	SP-3	**Composite by time** Automatic sampling machine was programmed to collect 250-mL sample aliquots at 20-minute time intervals. The sampling machine successfully collected sample aliquots only during the relatively few intervals during the 24-hour sampling period (0600 on 9/19/04 to 0600 on 9/20/04) when crew galley wastewater flowed through the inlet pipe to the grease trap, thereby closely approximating a flow-weighted composite sample.	Classical pollutants: - BOD_5 - Settleable Residue - Group I - Group II Total and dissolved metals Semivolatile organics Pesticides	1 (Day 2)
		Grab composite Collection times of the four subsamples in the composite can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab One grab sample was taken. Appendix A-1 shows the collection time.	Pathogen indicators	
Food Pulper, Centrifuge System	SP-5	**Grab** One grab sample was collected when the food pulper wastewater was drained from the centrifuge to the drain tank. See Appendix A-3 for the collection time.	Pathogen indicators Classical pollutants: - BOD_5 - Settleable Residue - Group I (except TDS and TSS) - Group II - Total and available cyanide Total and dissolved metals Volatile and semivolatile organics	1 (Day 5)

(a) See Figures 2-1 through 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Influent to ROCHEM Graywater Treatment System	SP-6	**Grab composite** Collection times for the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - BOD_5 - Settleable Residue - Group I - Group II - HEM/SGT-HEM - Total and available cyanide Total and dissolved metals Volatile and semivolatile organics	5
		Grab Two grab samples were taken per sampling day. Results presented in Table 4-2 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Influent to UV Disinfection part of ROCHEM Graywater Treatment System	SP-7	**Grab** Three grab samples were taken per sampling day. Results presented in Table 4-3 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	5
Effluent from ROCHEM Graywater Treatment System	SP-8/9	**Composite by flow (Days 1 through 3)** Twenty-four-hour sampling periods began at 0600 each day. **Grab composite (Days 4 and 5)** Collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - BOD_5 - Settleable Residue - Group I - Group II Total and dissolved metals Semivolatile organics	5
		Grab composite Collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab Three grab samples were taken per sampling day. Results presented in Table 4-4 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Incinerator Ash	SP-10	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Total metals Semivolatile organics Dioxins and furans	1 (Day 5)

(a) See Figures 2-1 through 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Influent to ROCHEM Sewage/Graywater Treatment System	SP-11	**Composite by flow** Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD_5 - Settleable Residue - Group I - Group II Total and dissolved metals Semivolatile organics Pesticides Polychlorinated biphenyls	5
		Grab composite Collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab Two grab samples were taken per sampling day. Results presented in Table 4-7 are an average for each sampling day. Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Influent to UV Disinfection part of ROCHEM Sewage/Graywater Treatment System	SP-12	**Grab** Three grab samples were taken per sampling day. Results presented in Table 4-8 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	5

(a) See Figures 2-1 through 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Effluent from ROCHEM Sewage/Graywater Treatment System	SP-13/14	**Composite by flow** Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD_5 - Settleable Residue - Group I - Group II Total and dissolved metals Semivolatile organics	5
		Grab composite Collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab Three grab samples were taken per sampling day. Results presented in Table 4-9 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Graywater Screening Solids	SP-15	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Classical pollutants: - Group I - Group II - Total and available cyanide Total metals Volatile and semivolatile organics	1 (Day 5)

(a) See Figures 2-1 through 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Final Combined Treated Effluent	SP-16	**Composite by flow** Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD_5 - Settleable Residue - Group I - Group II Total and dissolved metals Semivolatile organics	5
		Grab composite Collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab The number of grab samples taken per sampling day were as follows: 2, 3, 3, 3, 3. Results presented in Table 4-12 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Source Water	SP-17	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Pathogen indicators Classical pollutants: - BOD_5 - Settleable Residue - Group I - Group II - Total and available cyanide Total and dissolve metals Volatile and semivolatile organics	1 (Day 2)
Trip Blank	SP-18	**Grab sample** One grab sample was taken. High performance liquid chromatography (HPLC) water was poured directly into sample vials in the contractor's Chantilly, VA sampling room and shipped to the Oosterdam. The trip blank was shipped back (unopened) to the laboratory along with the collected samples.	Volatile organics	1 (Day 4)
Equipment Blank	SP-19	**Grab sample** One grab sample was taken. The equipment blank consisted of HPLC water pumped through the automatic sampling machine and tubing and directly into the sample bottles.	Total and dissolved metals Semivolatile organics	1 (Day 2)

(a) See Figures 2-1 through 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Sewage/Graywater Screening Solids	SP-20	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Classical pollutants: - Group I - Group II - Total and available cyanide Total metals Volatile and semivolatile organics	1 (Day 3)
Sewage/Graywater Waste Biosludge	SP-21	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Classical pollutants: - Group I - Group II - Total and available cyanide Total metals Volatile and semivolatile organics	1 (Day 3)

(a) See Figures 2-1 through 2-3 for simplified diagrams of the Oosterdam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

Table 3-3

Analytes and Analytical Methods, Holland America Oosterdam

Analyte Group	Analytes	Analytical Method Number
Pathogen Indicators	*E. coli*	EPA 9223B
	Enterococci	ASTM D6503-99
	Fecal coliform	EPA 9222D
Classical Pollutants	Biochemical oxygen demand (BOD_5)	EPA 405.1
	Settleable Residue (SS)	EPA 160.5
	Group I: - Total suspended solids (TSS) - Total dissolved solids (TDS) - Sulfate - Chloride - Alkalinity	 EPA 160.2 EPA 160.1 EPA 375.4 EPA 325.3 EPA 310.1
	Group II: - Total organic carbon (TOC) - Chemical oxygen demand (COD) - Ammonia as nitrogen - Nitrate/nitrite as nitrogen - Total Kjeldahl nitrogen - Total phosphorus	 EPA 415.1, Lloyd Kahn (“solids” samples) EPA 410.4 EPA 350.3 EPA 353.1 EPA 351.3 EPA 365.2
	Oil and grease measured as hexane extractable material and petroleum hydrocarbons measured as silica-gel treated hexane extractable material (HEM/SGT-HEM)	EPA 1664A
	Cyanide: - Total cyanide - Available cyanide	 EPA 335.2 EPA 1677
	Hardness	EPA 2340B
Total and Dissolved Metals	See Appendix A-2 for a complete list of total and dissolved metals analyzed.	EPA 200.7, EPA 200.9 (thallium), EPA 245.1(mercury “liquid” samples), 245.5 (mercury “solids” samples)
Volatile and Semivolatile Organics	See Appendix A-2 for a complete list of volatile and semivolatile organics analyzed.	EPA 624 EPA 625
Pesticides	See Appendix A-2 for a complete list of organohalide and organophosphorus pesticides.	EPA 1656A EPA 1657A
Polychlorinated Biphenyls (PCBs)	See Appendix A-2 for a complete list of PCBs analyzed.	EPA 1668A
Dioxins and Furans	See Appendix A-2 for a complete list of dioxins and furans analyzed.	EPA 1613B

Table 3-4

Field Measurement Equipment, Holland America Oosterdam

Parameter	Measured by:
pH	Four-color pH paper
Temperature	Alcohol thermometer
Conductivity and Salinity	Portable conductivity/salinity meter (YSI Model 30)
Turbidity	Pocket turbidimeter (Hach Cat. No. 52600-00)
Sulfide	Colorimeter (Hach DR 890)
Free and Total Chlorine	Pocket colorimeter (Hach Cat. No. 46700-00)

Table 3-5

Deviations from the Sampling and Analysis Plan, Holland America Oosterdam

Deviation	Description
Pathogen Indicators Laboratory Duplicates	For 5% of the pathogen indicators samples, duplicate 100-mL sample volumes were taken with the intention that the laboratory would composite the 100-mL sample volumes and then analyze duplicate samples from each composite sample to evaluate laboratory precision (i.e., laboratory duplicates). However, the laboratory did not prepare composites, but instead analyzed each of the 100-mL sample volumes individually. Accordingly, the results obtained from these analyses are field duplicate samples, not laboratory duplicates, and are presented and handled as such in this report. See Section 5.2.3 and Table 5-5 for details on duplicate sampling for pathogen indicators.
Laundry Wastewater (SP-2), Composite Samples	The strap-on flow meter set-up and calibration procedure was unsuccessful at the laundry wastewater sampling point (on the outlet pipe from the laundry wastewater holding tank), most likely due to close proximity to pumps and other sources of turbulence such as nearby machinery. As a result, flow data could not be collected at this sampling point. In addition, the flow meter could not be used to initiate collection of flow-weighted composite samples at SP-2 as described in the Oosterdam SAP. As an alternative sampling methodology, the automatic sampling machine was programmed to collect a time-weighted composite sample as described in Table 3-2. EPA concluded that the collected samples were representative of laundry wastewater as generated onboard the Oosterdam.
Food Pulper Wastewater, Vacuum System (SP-4)	Samples of food pulper wastewater generated by the vacuum food pulper system could not be collected because this food pulping system was not operating during the sampling episode.
Influent to ROCHEM Graywater Treatment System (SP-6), Composite Samples	The installed strap-on flow meter could not be used to trigger collection of flow-weighted composite samples at this sampling point because high wastewater pressure caused continuous collection of sample when the sample tap was left open. As an alternative sampling methodology, the sampling team collected manual grab composite samples as described in Table 3-2. EPA concluded that the collected samples were representative of the influent to the graywater treatment system onboard the Oosterdam.
Effluent from ROCHEM Graywater Treatment System (SP-8/9), Composite Samples	At the end of Day 3, high wastewater pressure caused the installed strap-on flow meter to lose signal strength. Repeated attempts to run the flow meter set-up and calibration procedures were unsuccessful. As a result, flow data could not be collected at this sampling point for Days 4 and 5. In addition, the flow meter could not be used to initiate collection of flow-weighted composite samples at SP-8/9 on Days 4 and 5. As an alternative sampling methodology, the sampling team collected manual grab composite samples on these days as described in Table 3-2. EPA concluded that the collected samples were representative of the effluent from the graywater treatment system onboard the Oosterdam.
Final Combined Treated Effluent (SP16), Composite and Grab Samples	Composite by flow sampling at SP-16 was suspended on Day 1 from 0600 to 1800 because overboard discharge was suspended while the ship was in Washington waters, and on Day 4 from 1000 to 1430 because overboard discharge was suspended while the ship cruised Hubbard Glacier. (The flow meter that controlled composite by flow sample collection was located on the overboard discharge pipe, but during this time the effluent was diverted to double-bottom holding tanks.) On Day 1, only two of the planned grab and grab composite samples were collected as the sample tap was also located downstream of the valve that diverts the combined treated effluent to the double-bottom holding tanks. See Appendix A-1 for the sample collection times. Grab and grab composite sample collection times on Day 4 were not impacted by the suspended discharge.

Table 3-5 (Continued)

Deviation	Description
Combined Graywater and Sewage/Graywater Treatment System Waste Sludge (planned SP-15)	The Oosterdam SAP inaccurately described wastewater treatment residuals from the graywater and sewage/graywater treatment systems as being commingled inline as they are pumped to storage in the double-bottom holding tank. Instead, the graywater screening solids are collected manually and incinerated onboard while the sewage/graywater screening solids and waste biosludge are pumped to storage at different times and are generally not commingled until combined in the double-bottom holding tank.. Accordingly, there was no means of collecting a single sample of combined wastewater treatment residuals (planned SP-15) as described in the Oosterdam SAP. As a result, samples of each of the three treatment residuals (graywater screening solids (SP-15), sewage/graywater screening solids (SP-20), and waste biosludge (SP-21) were collected separately. See Table 2-2 for descriptions of the treatment residuals and their sampling point locations, and Table 3-2 for their sampling methodologies.
Volatile Organics Preservation	Free chlorine was detected in the pre-sampling field tests at all sampling points. Based on these results, the sampling team prepreserved all volatile organics sample vials with sodium thiosulfate rather than waiting to determine preservation requirements based on the free chlorine field test results. Free chlorine was generally detected in grab samples collected throughout the sampling episode. (Sample vials were also prepreserved with hydrochloric acid to control biological activity as discussed in the Oosterdam SAP.)
Analytical Methods	EPA-contracted laboratories substituted comparable EPA analytical methods for certain analytes. Table 3-3 lists the actual analytical methods used by the laboratories. Note that while the Oosterdam SAP correctly listed EPA Methods 624 and 625 as the planned methods for analyzing volatile and semivolatile organics, respectively, Appendix E of the Oosterdam SAP mistakenly listed the target analytes for EPA Methods 1624 and 1625. Appendix A-2 of this report presents the actual list of target volatile and semivolatile organics.
Sampling Schedule	The sampling team adjusted the sampling schedule in Appendix C of the Oosterdam SAP to accommodate sampling logistics and ship operations. Refer to Appendix A-3 of this report for actual samples collected and sample collection dates/times.
Food Pulper Wastewater, Centrifuge System (SP-5), Analyte Groups Tested	Analyses for hardness, hexane extractable material (HEM), silica-gel treated hexane extractable material (SGT-HEM), total dissolved solids (TDS), total suspended solids, and dissolved metals were not performed due to the high solids content in the sample.

4.0 RESULTS AND DISCUSSION

This section presents the data collected during this sampling episode. Section 4.1 presents the analytical results and discussion; Section 4.2 presents interview results for activities that impact wastewater generation; and Section 4.3 presents flow data and analysis. Analytical results for field measurements performed onboard are presented in Appendix A-3. Note that anomalous analytical results were obtained for ammonia and total and available cyanide; these data have not been excluded from the data set, but the results are presented and discussed in Sections 5.1.1 and 5.1.2 (in the data quality section of this report) and not in the current section. During the 2005 cruise season, EPA conducted a supplementary sampling program to collect additional ammonia data to better assess this analyte in cruise ship wastewater (See Section 5.1.2).

4.1 Laboratory Analytical Results and Discussion

4.1.1 Graywater

Table 4-1 presents analytical results for laundry, accommodations, food pulper, and galley wastewaters, which were sampled for one 24-hour period. Only those analytes detected at least once in any wastewater samples (i.e., graywater sources, influents to treatment systems, or effluents from treatment systems) are included in this table. Appendices A-1 and A-2 present results for both detected and nondetected analytes.

Of the 290 analytes tested for in the graywater sources, 65 were detected in these waste streams. Fifteen of these 65 analytes were also detected at some level in the equipment blank (flagged by an "e" in Table 4-1; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of these analytes to the samples. EPA will consider the impact of possible contamination from sampling equipment in a future analysis. Twenty-nine of these 65 detected analytes were also detected at some level in the potable water used as source water for all graywater systems (flagged by an "s" in Table 4-1; see Table 4-14

for source water results), meaning that the source water may have contributed some or all of these analytes to the samples.

Chart 1 presents the number of analytes detected in each graywater source.

Chart 1. Number of Analytes Detected in Graywater Sources

Analyte Group (a)	Number of Analytes Detected			
	Laundry	**Accommodations**	**Food Pulper (b)**	**Galley**
Pathogen Indicators	3	3	3	3
Classical Pollutants	13	13	9 (b)	14
Total and Dissolved Metals	30	34	16 (b)	33
Volatile and Semivolatile Organics	3	3	0	3
Total	**49**	**53**	**28**	**53**

(a) See Table 3-3 for information on analyte groups.
(b)Food pulper wastewater was not analyzed for hardness, HEM/SGT-HEM, TDS, TSS, and dissolved metals due to the high solids content of the sample (see Table 3-5).

Chart 2 presents the number of analytes that were detected in each graywater source at the highest concentration. For example, the highest detected concentrations for two of the pathogen indicators were found in the food pulper wastewater, while the highest detected concentration for the third indicator was found in the accommodations wastewater. Note that a graywater source that has the highest concentration of an analyte will not necessarily contribute the greatest amount of that analyte to the wastewater treatment system. The total amount of an analyte contributed by a particular graywater source also will depend on that source's volume compared to the volumes of the other sources. Flow (and thus volume) information was not able to be collected for all graywater sources (see Table 2-1).

Chart 2. Number of Analytes Detected at Highest Concentration in Graywater

Analyte Group(a)	Number of Analytes Detected in Graywater	Number of Analytes Detected at the Highest Concentration			
		Laundry	Accommodations	Food Pulper (b)	Galley
Pathogen Indicators	3	0	1	2	0
Classical Pollutants	14	0	1	9 (b)	4
Total and Dissolved Metals	43	5	28	1 (b)	9
Volatile and Semivolatile Organics	5	2	1	0	2
Total	**65**	**7**	**31**	**12**	**15**

(a) See Table 3-3 for information on analyte groups.
(b)Food pulper wastewater was not analyzed for hardness, HEM/SGT-HEM, TDS, TSS, and dissolved metals due to the high solids content of the sample (see Table 3-5).

Food pulper wastewater contained a total of 28 analytes and showed the highest concentration for 12 analytes. Most notably, food pulper wastewater showed the highest concentrations for several analytes commonly used to measure wastewater strength: biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and total organic carbon (TOC).

Accommodations wastewater contained the greatest number of analytes detected at the highest concentration (31 out of 65 detected analytes). Accommodations wastewater had the highest concentrations of *E. coli* and enterococci, and most metals. Fifty-three of the 65 analytes detected in graywater sources were detected in accommodations wastewater.

Galley wastewater contained 53 of the 65 analytes detected in graywater sources and showed the highest concentration among the graywater sources for 15 of the analytes, including 4 classical pollutants, several metals (most notably total and dissolved lead, and dissolved copper), 4-chloro-3-methylphenol, and phenol. Galley wastewater was the only graywater source that was analyzed for pesticides because this was the most likely possible source; none were detected.

Laundry wastewater contained a total of 49 analytes and showed the highest concentration for 7 analytes (the least among the graywater sources). Most notably, the laundry contributed the highest concentrations of bis(2-ethylhexyl)phthalate and chloroform. Laundry

wastewater was the only graywater source that was analyzed for dioxins and furans because this was the most likely possible source of these analytes; none were detected.

4.1.2 Influent to Graywater Treatment System

Table 4-2 presents analytical results for the influent to the ROCHEM graywater treatment system, which was sampled for five consecutive 24-hour sampling periods. Only those analytes detected at least once in any of the wastewater samples (i.e., graywater sources, influents to treatment systems, or effluents from treatment systems) are included in this table. Appendices A-1 and A-2 present results for both detected and nondetected analytes.

Pathogen Indicators and Classical Pollutants

All 3 pathogen indicators and all 15 classical pollutants were detected in the influent to the graywater treatment system samples. One of these 18 analytes (hardness) was also detected at some level in the equipment blank (flagged by an "e" in Table 4-2; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of this analyte to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Seven of these detected analytes were also detected at some level in the potable water used as source water for all graywater and sewage systems (flagged by an "s" in Table 4-2; see Table 4-14 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples. Note that anomalous analytical results were obtained for ammonia; these results are presented and discussed in Section 5.1.2.

Chart 3 compares the influent to the Oosterdam graywater treatment system to typical domestic wastewater for selected pathogen indicators and classical pollutants. Key analytes commonly used to assess wastewater strength, such as BOD_5, TSS, and COD, were detected in the Oosterdam influent to graywater treatment at concentrations similar to those in typical domestic wastewater, even though this treatment system does not treat any sewage.

Chart 3. Comparison of Influent to Oosterdam Graywater Treatment System to Untreated Domestic Wastewater

Analyte	Influent to Oosterdam Graywater Treatment System	Untreated Domestic Wastewater (a)
Enterococci	10^2 to 10^3 MPN/100 mL	10^2 to 10^3 number/100 mL
Fecal Coliform	10^6 to 10^7 CFU/100 mL	10^4 to 10^5 number/100 mL
Biochemical Oxygen Demand (BOD_5)	132 to 149 mg/L	110 to 400 mg/L
Chemical Oxygen Demand (COD)	335 to 538 mg/L	250 to 1,000 mg/L
Nitrate/Nitrite	0.0110 to 0.120 mg/L	0 mg/L
Oil and Grease	37.0 to 143 mg/L	50 to 150 mg/L
Total Phosphorus	0.850 to 3.94 mg/L	4 to 15 mg/L
Total Suspended Solids (TSS)	73.0 to 99.0 mg/L	100 to 350 mg/L

(a) Source: Metcalf & Eddy, *Wastewater Engineering*, Third Edition, 1991.

Total and Dissolved Metals

Of the 34 metal analytes detected in the influent to graywater treatment samples, 26 were detected in every influent to treatment sample (Table 4-2). Twelve of these 34 analytes were detected at some level in the equipment blank (flagged by an "e" in Table 4-2; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of these analytes to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Twenty of these detected analytes were also detected at some level in the potable water used as source water for all graywater systems (flagged by an "s" in Table 4-2; see Table 4-14 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples.

The 10 metal analytes detected at the highest concentrations were: total and dissolved sodium, total and dissolved calcium, total zinc, total and dissolved aluminum, total and dissolved magnesium, and total iron. Total and dissolved chromium, total and dissolved copper, total and dissolved lead, total and dissolved nickel, and total and dissolved zinc are priority pollutant metals (designated by EPA in 40 CFR Part 423, Appendix A) that were detected in every influent to graywater treatment sample. Some metals may result from carbon steel and stainless steel pipe and tanks in the ship.

Semivolatile and Volatile Organics, Pesticides, PCBs, and Dioxin and Furans

Among the 80 target analytes for volatile and semivolatile organics, only 4 were detected in any Oosterdam influent to graywater treatment samples: 1 volatile organic, and 3 semivolatile organics (Table 4-2). Many of these analytes were detected at concentrations close to their detection limits. Phenol was detected in the equipment blank (see Table 5-3 for equipment blank results) (volatile organics were not analyzed for in the equipment blank). EPA will consider the impact of possible contamination from sampling equipment in a future analysis.

The three semivolatile organics detected in the influent to graywater treatment were: bis(2-ethylhexyl)phthalate, diethyl phthalate, and phenol. Bis(2-ethylhexyl)phthalate and diethyl phthalate are plasticizers (chemicals added to plastics to make them flexible) and are commonly detected in environmental samples (ATSDR, 2002 and ATSDR, 1996). Cruise ships use a wide variety of plastic products (e.g., floor tiles, shower curtains, hoses, packaging materials and containers, PVC piping) that may result in the presence of these plasticisers in the influent to graywater treatment.

Phenol is both man-made and produced naturally. It is found in human wastes (urine). It is also found in some foods (smoked summer sausage, fried chicken, mountain cheese, some species of fish). Man-made sources include the use of phenol as a slimicide, as a disinfectant, and in medicinal preparations such as ointments, ear and nose drops, and antiseptic wipes (ATSDR, 1998). All of these are possible sources for the presence of phenol in cruise ship wastewater. Phenol was also detected in the source water (see Table 4-14 for source water results), meaning that the source water may have contributed some or all of this analyte to the samples.

The one volatile organic detected in the influent to treatment was toluene. Toluene occurs naturally in crude oil and is used to produce gasoline, other fuels, and coal. It is also used to make paints, paint thinners, fingernail polish, adhesives, and rubber (ATSDR, 2001).

Pesticides, PCBs, and dioxins and furans were not analyzed for in the influent to the Oosterdam wastewater treatment system.

4.1.3 Influent to the Ultraviolet (UV) Disinfection Part of the Graywater Treatment System

Table 4-3 presents pathogen indicator results for the influent to UV disinfection part of the Oosterdam graywater treatment system. Grab samples for pathogen indicator analyses were collected at this sampling point for five consecutive 24-hour sampling periods. Pathogen indicators, which were generally in the thousands to millions at the influent to the treatment system (see Table 4-2), were reduced by three orders of magnitude after reverse osmosis (i.e., before the UV disinfection step). Data for pathogen indicators in the final effluent (i.e., after the UV disinfection step) are presented in the next section.

4.1.4 Effluent from Graywater Treatment System

Table 4-4 presents analytical results for the effluent from the graywater treatment system, which was sampled for five consecutive 24-hour sampling periods. Only those analytes detected at least once in any of the wastewater samples (i.e., graywater sources, influents to treatment systems, or effluents from treatment systems) are included in this table. Appendices A-1 and A-2 present results for both detected and nondetected analytes.

Pathogen Indicators and Classical Pollutants

A total of 15 grab samples were collected for analysis of the three pathogen indicators over the five 24-hour sampling periods (results and collection times for each grab sample are presented in Appendix A-1). Pathogen indicators generally were not detected in the effluent from the treatment system; the exceptions to this were 3 grab samples, with fecal coliform detected at concentrations close to the detection limit on Days 1 and 2, and *E. coli* detected at 6.30 MPN/100 mL on Day 5 (detection limit is 1 MPN/100 mL).

Eleven of the 15 classical pollutants were detected in effluent from graywater treatment system; 4 classical pollutants (HEM, settleable residue, SGT-HEM, and TSS) were not detected in any effluent samples. Only one of the 11 detected classical analytes–hardness–was detected at some level in the equipment blank (flagged by an "e" in Table 4-4; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of this analyte to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Seven of the detected analytes were also detected at some level in the potable water used as source water for all graywater and sewage systems (flagged by an "s" in Table 4-4; see Table 4-14 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples. Note that anomalous analytical results were obtained for ammonia; these results are presented and discussed in Section 5.1.2.

Chart 4 shows that classical pollutant concentrations in the graywater effluent from the Oosterdam graywater treatment system are lower than EPA's standards for secondary treatment.

Chart 4. Classical Pollutant Comparison of Effluent from Oosterdam Graywater Treatment System to Secondary Treatment Standards

Classical Pollutant	Average Effluent from Oosterdam Graywater Treatment System	Secondary Treatment Standards (a)
Biochemical Oxygen Demand (BOD_5)	28.1 mg/L	45 mg/L
Total Suspended Solids (TSS)	ND(5.00) mg/L	45 mg/L

(a) 40 CFR 133.102 Secondary Treatment Regulations, 7-day average.
ND - Not detected (number in parentheses is detection limit).

Total and Dissolved Metals

Among the 54 total and dissolved metal analytes, 27 were detected in one or more effluent from treatment samples (Table 4-4). Of these 27 detected metals analytes, 15 were detected in every effluent from treatment sample. Twelve of the 27 detected analytes were also detected at some level in the equipment blank (flagged by an "e" in Table 4-4; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of these analytes to the samples. EPA will consider the impact of contamination from

equipment in a future analysis. Twenty of these detected analytes were also detected at some level in the potable water used as source water for all graywater systems (flagged by an "s" in Table 4-4; see Table 4-14 for source water results), meaning that the source water may have contributed some or all these analytes to the samples.

The ten metal analytes detected at the highest concentrations were total and dissolved calcium, magnesium, iron, sodium, and zinc. Total and dissolved zinc and copper, and total nickel are priority pollutant metals (designated by EPA in 40 CFR Part 423, Appendix A) that were detected in every effluent from treatment sample. Some metals may result from contact with carbon steel and stainless steel pipes and tanks in the ship. There are no EPA secondary treatment standards for metals.

Semivolatile and Volatile Organics, Pesticides, PCBs, and Dioxin and Furans

Among the 80 target analytes for volatile and semivolatile organics analyzed, only one–phenol– was detected in any Oosterdam graywater effluent samples (Table 4-4). Phenol was detected in the Oosterdam graywater effluent at an average concentration of 67.0 µg/L. Phenol was detected in the source water (flagged by an "s" in Table 4-4; see Table 4-14 for source water results) at a concentration of 58.0 µg/L, meaning that the source water may have contributed some or all of the detected phenol to the effluent samples.

Pesticides, PCBs, and dioxins and furans were not analyzed for in the effluent from the graywater treatment system.

4.1.5 Wastewater Treatment System Performance: Comparison of Influent to Graywater Treatment System and Effluent from Graywater Treatment System

The ROCHEM graywater treatment system successfully removed almost all pathogen indicators (>99%; Table 4-5), and most classical pollutants and metals (Table 4-6).

Pathogen Indicators and Classical Pollutants

Pathogen indicators were substantially removed by reverse osmosis (>99%); any remaining pathogen indicators were generally removed by UV disinfection to levels below detection (overall system efficiency >99%, see Table 4-5). Enterococci was not detected in any of the 15 effluent from treatment samples. Fecal coliform was detected in 2 of the 15 samples at levels close to the detection limit, and *E. coli* was detected 1 of the 15 samples at a level of 6.30 MPN/100mL.

The graywater treatment system removed most biochemical oxygen demand (BOD_5) (80%), chemical oxygen demand (COD) (85%), and total organic carbon (TOC) (70%) (Table 4-6). The system also removed all settleable residue, HEM/SGT-HEM, and total suspended solids (TSS) to levels below detection.

The treatment system reduced total Kjeldahl nitrogen (TKN, which measures both ammonia and organic forms of nitrogen) by 76%, while the removal of nitrate/nitrite was 44%. Total phosphorus was removed by 90%. TKN, nitrate/nitrite, and total phosphorus were likely removed from the graywater treatment system via the reverse osmosis concentrate as the graywater treatment system has no mechanism for biodegradation. Ammonia results for this sampling episode were anomalous; therefore, EPA is unable to assess the performance of the graywater treatment system for this analyte at this time. During the 2005 cruise season, EPA conducted a supplementary sampling program to collect treatment performance data for ammonia (see Section 5.1.2).

Total and Dissolved Metals

The total metals analysis measures both the particulate and dissolved forms of metals, while the dissolved metals analysis measures only the dissolved form. The difference between the total and dissolved metals measurements is the particulate metals concentration. Metals were present in both particulate and dissolved forms in the influent to the graywater treatment system (i.e., the total metals concentrations exceeded the dissolved metals

concentrations for most metals analytes) (Table 4-2). In comparison, metals were predominantly present in the dissolved form in the effluent from the graywater treatment system (i.e., the total and dissolved metals concentrations were similar in these samples for most metal analytes (Table 4-4). This means that the graywater treatment system is highly efficient in removing particulate metals, as would be expected for reverse osmosis (and as supported by removal of settleable residue and TSS to levels below detection). The treatment system removed dissolved metals with an average efficiency of 52% (Table 4-11).

Semivolatile and Volatile Organics, Pesticides, PCBs, Dioxin and Furans

Among the four volatile and semivolatile analytes detected in the influent to the graywater treatment system, none showed significant removals. For bis-(2-ethylhexyl) phthalate and diethyl phthalate, the detection limits in the effluent from graywater treatment samples exceed the average detected concentrations in the influent samples. Toluene was reduced from levels close to the detection limit to less than the detection limit. Phenol concentrations were not reduced by the graywater treatment system.

Pesticides, PCBs, and dioxins and furans were not analyzed for in either the influent to or effluent from the graywater treatment system; EPA has no data regarding the performance of the ROCHEM graywater treatment system for removing these analytes.

4.1.6 Influent to Sewage/Graywater Treatment System

Table 4-7 presents analytical results for the influent to the sewage/graywater treatment system, which was sampled for five consecutive 24-hour sampling periods. Only those analytes detected at least once in any of the wastewater samples (i.e., graywater sources, influents to treatment systems, or effluents from treatment systems) are included in this table. Appendices A-1 and A-2 present results for both detected and nondetected analytes.

Pathogen Indicators and Classical Pollutants

All 3 pathogen indicators and all 15 classical pollutants were detected in the influent to treatment samples. One of these 18 analytes (hardness) was also detected at some level in the equipment blank (flagged by an "e" in Table 4-7; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of this analyte to the samples. EPA will consider the impact of contamination from equipment in a future analysis. Seven of these detected analytes were also detected at some level in the potable water used as source water for all graywater and sewage systems (flagged by an "s" in Table 4-7; see Table 4-14 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples. Note that anomalous analytical results were obtained for ammonia; these results are presented and discussed in Section 5.1.2.

Wastewater conservation practices used onboard, such as use of vacuum toilets, results in highly concentrated wastewater. In addition, sources that would serve to dilute the influent to treatment, such as accommodations wastewater, are not routed to the sewage/ graywater treatment system. Chart 5 compares the influent to the Oosterdam sewage/graywater treatment system to typical domestic wastewater for selected pathogen indicators and classical pollutants. Fecal coliform and enterococci concentrations in the influent to the Oosterdam sewage/graywater treatment system were two or more orders of magnitude greater than in typical untreated domestic wastewater. Key analytes commonly used to assess wastewater strength, such as BOD_5, TSS, and COD, were detected at concentrations two or more times greater than typical domestic wastewater.

Chart 5. Comparison of Influent to Oosterdam Sewage/Graywater Treatment System to Untreated Domestic Wastewater

Analyte	Influent to Oosterdam Sewage/Graywater Treatment System	Untreated Domestic Wastewater (a)
Enterococci	10^5 to 10^6 MPN/100 mL	10^2 to 10^3 number/100 mL
Fecal Coliform	10^6 to 10^7 CFU/100mL	10^4 to 10^5 number/100 mL
Biochemical Oxygen Demand (BOD_5)	690 to 1,380 mg/L	110 to 400 mg/L
Chemical Oxygen Demand (COD)	1,800 to 2,830 mg/L	250 to 1,000 mg/L
Nitrate/Nitrite	0.0160 to 0.0370 mg/L	0 mg/L
Oil and Grease	48.0 to 85.0 mg/L	50 to 150 mg/L
Total Phosphorus	20.9 to 31.8 mg/L	4 to 15 mg/L
Total Suspended Solids (TSS)	560 to 1,110 mg/L	100 to 350 mg/L

(a) Source: Metcalf & Eddy, *Wastewater Engineering*, Third Edition, 1991.

Total and Dissolved Metals

Of the 40 metal analytes detected in the influent to treatment samples, 32 were detected in every influent to sewage/graywater treatment sample (see Table 4-7 for the metals analytical results). Twelve of these 40 analytes were detected at some level in the equipment blank (flagged by an "e" in Table 4-7; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of these analytes to the samples. EPA will consider the impact of contamination from equipment in a future analysis. Twenty of these detected analytes were also detected at some level in the potable water used as source water for all graywater and sewage systems (flagged by an "s" in Table 4-7; see Table 4-14 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples.

The 10 metals detected at the highest concentrations were: total and dissolved sodium, calcium, magnesium, and iron, and total zinc and aluminum. Total and dissolved chromium, copper, lead, nickel, and zinc, and total mercury and silver are priority pollutant metals (designated by EPA in CFR Part 423, Appendix A) that were detected in every influent to treatment sample. Some metals may result from contact with carbon steel and stainless steel pipe and tanks in the ship.

Semivolatile and Volatile Organics, Pesticides, PCBs

Among the 360 target analytes for volatile and semivolatile organics, pesticides, and polychlorinated biphenyls (PCBs), 20 were detected in Oosterdam influent to sewage/graywater treatment samples: 17 PCBs and three semivolatile and volatile organics. Many of these analytes were detected at concentrations close to their detection limits. Phenol was detected in the equipment blank (see Table 5-3 for equipment blank results) (volatile organics were not analyzed for in the equipment blank). EPA will consider the impact of possible contamination from sampling equipment in a future analysis.

The two semivolatile organics detected in the influent to sewage/graywater treatment: bis(2-ethylhexyl) phthalate and phenol. Bis(2-ethylhexyl)phthalate is a plasticizer (a chemical added to plastics to make them flexible) and is commonly detected in environmental samples (ATSDR, 2002). Cruise ships use a wide variety of plastic products (e.g., floor tiles, shower curtains, hoses, packaging materials and containers, PVC piping) that may result in the presence of bis(2-ethylhexyl)phthalate in the influent to treatment.

Phenol is both man-made chemical and produced naturally. It is found in human wastes (urine). It is also found in some foods (smoked summer sausage, fried chicken, mountain cheese, some species of fish). Man-made sources include the use of phenol as a slimicide, as a disinfectant, and in medicinal preparations such as ointments, ear and nose drops, and antiseptic wipes (ATSDR, 1998). All of these are possible sources for the presence of phenol in cruise ship wastewater. Phenol was also detected in the source water (see Table 4-14 for source water results), meaning that the source water may have contributed some or all of this analyte to the samples.

The one volatile organic detected in the influent to treatment was toluene. Toluene occurs naturally in crude oil and is used to produce gasoline, other fuels, and coal. It is also used to make paints, paint thinners, fingernail polish, adhesives, and rubber (ATSDR 2001).

No pesticides were detected in the influent to the Oosterdam sewage/graywater treatment system.

Seventeen PCB congeners and co-eluting congener groups were detected in the influent to the sewage/graywater wastewater treatment system. Total PCBs in the influent were measured at a concentration of 11,400 pg/L. One of the detected PCBs was identified as "toxic" by the World Health Organization: PCB 180 (PCB-180+PCB-193, 620 pg/L). PCBs have traditionally been associated with electrical equipment, such as transformers; however, they have also been used in paint formulations, carbonless copy paper and plastics (EPA, 2005). None of the detected PCBs have any known manufacturers. (Note that PCBs were not analyzed for in the source water.)

4.1.7 Influent to the Ultraviolet (UV) Disinfection Part of the Sewage/Graywater Treatment System

Table 4-8 presents pathogen indicator results for the influent to UV disinfection part of the Oosterdam sewage/graywater treatment system. Grab samples for pathogen indicator analyses were collected at this sampling point for five consecutive 24-hour sampling periods. Pathogen indicators, which were generally in the millions at the influent to the treatment system (see Table 4-7), were reduced to the hundreds after the bioreactor and membrane filter (i.e., before the UV disinfection step). Data for pathogen indicators in the final effluent (i.e., after the UV disinfection step) are presented in the next section.

4.1.8 Effluent from the Sewage/Graywater Treatment System

Table 4-9 presents analytical results for the effluent from the sewage/graywater treatment system, which was sampled for five consecutive 24-hour sampling periods. Only those analytes detected at least once in any of the wastewater samples (i.e., graywater sources, influents to treatment systems, or effluents from treatment systems) are included in this table. Appendices A-1 and A-2 present results for both detected and nondetected analytes.

Pathogen Indicators and Classical Pollutants

A total of 15 grab samples were collected for analysis of the three pathogen indicators over the five 24-hour sampling periods (results and collection times for each grab sample are presented in Appendix A-1). Pathogen indicators generally were not detected in the effluent from the treatment system. Exceptions are enterococci detected in 4 of the 15 samples and *E. coli* detected in 1 of the 15 samples. Most detections were close to the detection limit; however, the second grab sample collected on Day 5 contained enterococci and *E. coli* at 184 and 13.2 MPN/100mL, respectively (detection limit is 1 MPN/100 mL).

Eleven of the 15 classical pollutants were detected in effluent from treatment system; 4 classical pollutants (HEM, settleable residue, SGT-HEM, and TSS) were not detected in any effluent samples. Only one of the 11 detected classical analytes–hardness–was detected at some level in the equipment blank (flagged by an "e" in Table 4-9; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of this analyte to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Seven of the 11 detected classical analytes were also detected at some level in the potable water used as source water for all graywater and sewage systems (flagged by an "s" in Table 4-9; see Table 4-14 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples. Note that anomalous analytical results were obtained for ammonia; these results are presented and discussed in Section 5.1.2.

Chart 6 shows that classical pollutant concentrations in the sewage/graywater effluent from the Oosterdam sewage/graywater treatment system are lower than EPA's standards for secondary treatment.

Chart 6. Classical Pollutant Comparison of Effluent from Oosterdam Sewage/Graywater Treatment System to Secondary Treatment Standards

Classical Pollutant	Average Effluent from Oosterdam Sewage/Graywater Treatment System	Secondary Treatment Standards(a)
Biochemical Oxygen Demand (BOD_5)	4.22 mg/L	45 mg/L
Total Suspended Solids (TSS)	ND(5.00) mg/L	45 mg/L

(a) 40 CFR 133.102 Secondary Treatment Regulations, 7-day average.
(b) ND - Not detected (number in parentheses is detection limit).

Total and Dissolved Metals

Among the 54 total and dissolved metals analytes tested for, 32 were detected in one or more effluent from treatment samples (Table 4-9). Of these 32 detected metals analytes, 24 were detected in every effluent from treatment sample. Thirteen of the 32 detected metal analytes were also detected at some level in the equipment blank (flagged by an "e" in Table 4-9; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of these analytes to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Twenty of these detected metal analytes were also detected at some level in the potable water used as source water for all graywater systems (flagged by an "s" in Table 4-9; see Table 4-14 for source water results), meaning that the source water may have contributed some or all these analytes to the samples.

The ten metal analytes detected at the highest concentrations were total dissolved calcium, magnesium, iron, sodium, and zinc. Total and dissolved zinc, nickel, lead, chromium, and copper are priority pollutant metals (designated by EPA in 40 CFR Part 423, Appendix A) that were detected in every effluent from treatment sample. Some metals may result from contact with carbon steel and stainless steel pipes and tanks in the ship. There are no EPA secondary treatment standards for metals.

Semivolatile and Volatile Organics, Pesticides, PCBs, Dioxins and Furans

Among the 80 target analytes for volatile and semivolatile organics analyzed, only one–phenol– was detected in any Oosterdam sewage/graywater effluent samples (Table 4-9). Phenol was detected in the Oosterdam sewage/graywater effluent at an average concentration of 63.4 μg/L. Phenol was detected in the source water (flagged by an "s" in Table 4-9; see Table 4-14 for source water results) at a concentration of 58.0 μg/L, meaning that the source water may have contributed some or all of the detected phenol to the effluent samples.

Pesticides, PCBs, and dioxins and furans were not analyzed for in the effluent from the sewage/graywater treatment system.

4.1.9 Wastewater Treatment System Performance: Comparison of Influent to Sewage/Graywater Treatment System and Effluent from Sewage/Graywater Treatment System

The ROCHEM sewage/graywater treatment system successfully removed most pathogen indicators (>99%; Table 4-10), and most classical pollutants, metals, and organics (Table 4-11).

Pathogen Indicators and Classical Pollutants

Pathogen indicators were substantially removed by the bioreactor and membrane filter (>99%); any remaining pathogen indicators were generally removed by UV disinfection to levels below detection (overall system efficiency >99%, see Table 4-10). Fecal coliform was not detected in any of the 15 effluent from treatment samples. Enterococci was detected in 4 of the 15 samples, and *E. coli* was detected in 1 of the 15 samples. Most detections were close to the detection limit; however, the second grab sample on Day 5 contained enterococci and *E. coli* at 184 and 13.2 MPN/100mL, respectively (the detection limit 1 MPN/100 mL).

The sewage/graywater treatment system removed most biochemical oxygen demand ($BOD_{5)}$ (>99 %), chemical oxygen demand (COD) (95 %) and total organic carbon

(TOC) (86 %) (Table 4-11). The system also removed settleable residue, HEM/SGT-HEM, and total suspended solids (TSS) to levels below detection.

The treatment system reduced total Kjeldahl nitrogen (TKN, which measures both ammonia and organic forms of nitrogen) by 70%, while nitrate/nitrite levels remained relatively unchanged (Table 4-11). Total phosphorus was removed by 41%. Nitrogen and phosphorus are likely taken up by the microorganisms in the bioreactor and removed from the system in the waste biosludge, as evidenced by elevated TKN and total phosphorus concentrations in the waste biosludge (see Section 4.1.11 and Table 4-13). It is unlikely that nitrogen is removed by nitrification (the mechanism of ammonia biodegradation) as nitrification would have resulted in significant increases in nitrate/nitrite concentrations, but these levels remained relatively unchanged. Ammonia results for this sampling episode were anomalous; therefore, EPA is unable to assess the performance of the sewage/graywater treatment system for this analyte at this time. During the 2005 cruise season, EPA conducted a supplementary sampling program to collect additional performance data for ammonia (see Section 5.1.2).

Total and Dissolved Metals

The total metals analysis measures both the particulate and dissolved forms of metals, while the dissolved metals analysis measures only the dissolved form. The difference between the total and dissolved metals measurements is the particulate metals concentration. Metals were present in both particulate and dissolved forms in the influent to the sewage/ graywater treatment system (i.e., the total metals concentrations exceeded the dissolved metals concentrations for most metals analytes) (Table 4-7). In comparison, metals were predominantly present in the dissolved form in the effluent from the sewage/graywater treatment system (i.e., the total and dissolved metals concentrations were similar in these samples for most metals analytes) (Table 4-9). Furthermore, there were elevated metals concentrations in the screening solids and waste biosludge (see Table 4-13). This means that the treatment system is highly efficient in removing particulate metals, as would be expected for membrane filtration (and as supported by >99% removal of settleable residue and TSS, see Table 4-11). The treatment system removed dissolved metals with an average efficiency of 40% (Table 4-11).

Semivolatile and Volatile Organics, Pesticides, PCBs, Dioxins and Furans

The sewage/graywater treatment system removed bis(2-ethylhexyl)phthalate and toluene to levels below detection, and removed phenol by 33%. Possible removal mechanisms include biological degradation, adsorption onto screening solids and waste biosludge (Table 4-13), and/or volatilization.

Pesticides were not detected in the influent to sewage/graywater treatment and were not analyzed for in the effluent from sewage/graywater treatment. While PCBs were detected in the influent to treatment at low levels, they were not analyzed for in the effluent from sewage/graywater treatment; EPA has no data regarding the performance of the ROCHEM sewage/graywater treatment system for removing PCBs. Dioxin and furans were not analyzed for in either the influent to or effluent from the sewage/graywater treatment system. Dioxins and furans were analyzed for in laundry wastewater, and none were detected.

4.1.10 Final Combined Treated Effluent from Graywater and Sewage/Graywater Treatment Systems

Table 4-12 presents analytical results for the final combined discharge from the graywater and sewage/graywater treatment systems (final combined treated effluent), which was sampled for five consecutive 24-hour sampling periods. Only those analytes detected at least once in any of the wastewater samples (i.e., graywater sources, influents to treatment systems, or effluents from treatment systems) are included in this table. Appendices A-1 and A-2 present results for both detected and nondetected analytes.

Pathogen Indicators and Classical Pollutants

A total of 14 grab samples were collected for analyses of the three pathogen indicators over the five 24-hour sampling periods (results and collection times for each grab sample are presented in Appendix A-1). Pathogen indicators generally were not detected in the final combined treated effluent. Exceptions are *E. coli* detected in 2 of 14 samples, enterococci detected in 3 of 14 samples, and fecal coliform detected in 2 of 14 samples. Most detections were close to the detection limit; however, the second grab sample collected on Day 1 contained *E. coli* at 49.6 MPN/100mL (detection limit is 1 MPN/100mL).

Eleven of the 15 classical pollutants were detected in the final combined effluent; four classical pollutants (HEM, settleable residue, SGT-HEM, and TSS) were not detected in any effluent samples. Only one of the 11 detected analytes–hardness–was detected at some level in the equipment blank (flagged by an "e" in Table 4-12; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of this analyte to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Seven of these detected analytes were also detected at some level in the potable water used as source water for all graywater and sewage systems (flagged by an "s" in Table 4-12; see Table 4-14 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples.

Chart 7 shows that classical pollutant concentrations in the final combined effluent from the Oosterdam graywater and sewage/graywater treatment systems are lower than EPA's standards for secondary treatment.

Chart 7. Classical Pollutant Comparison of Final Combined Effluent from the Oosterdam Graywater and Sewage/Graywater Treatment Systems to Secondary Treatment Standards

Classical Pollutant	Average Final Combined Treated Effluent	Secondary Treatment Standards(a)
Biochemical Oxygen Demand (BOD_5)	17.6 mg/L	45 mg/L
Total Suspended Solids (TSS)	ND(5.00) mg/L	45 mg/L

(a) 40 CFR 133.102 Secondary Treatment Regulations, 7-day average.
(b) ND - Not detected (number in parentheses is detection limit).

Total and Dissolved Metals

Among the 54 total and dissolved metals analytes, 29 were detected in one or more Final Combined Discharge from treatment samples (Table 4-12). Of these 29 detected metals analytes, 19 were detected in every effluent from treatment sample. Twelve of the 29 detected analytes were also detected at some level in the equipment blank (flagged by an "e" in Table 4-12; see Table 5-3 for equipment blank results), meaning that the sampling equipment may have contributed some or all of these analytes to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Twenty of these detected analytes were also detected at some level in the potable water used as source water for all graywater systems (flagged by an "s" in Table 4-12; see Table 4-14 for source water results), meaning that the source water may have contributed some or all these analytes to the samples.

The 10 metal analytes detected at the highest concentrations were total and dissolved calcium, magnesium, iron, sodium, and zinc. Total and dissolved zinc, nickel, and copper, and dissolved chromium are priority pollutant metals (designated by EPA in 40 CFR Part 423, Appendix A) that were detected in every effluent from treatment sample. Some metals may result from contact with carbon steel and stainless steel pipes and tanks in the ship. There are no EPA secondary treatment standards for metals.

Semivolatile and Volatile Organics, Pesticides, PCBs, Dioxins and Furans

Among the 80 target analytes for volatile and semivolatile organics analyzed, only one-phenol- was detected in any Oosterdam final combined treated effluent samples (Table 4-12). Phenol was detected in the combined Oosterdam effluent at an average concentration of 53 μg/L. Phenol was detected in the source water (flagged by an "s" in Table 4-12; see Table 4-14 for source water results) at a concentration of 58.0 μg/L, meaning that the source water may have contributed some or all of the detected phenol to the effluent samples.

Pesticides, PCBs, and dioxins and furans were not analyzed for in the final combined effluent from the treatment systems.

4.1.11 Screening Solids, Waste Biosludge, and Incinerator Ash

Table 4-13 presents the results for analytes detected in one-time grab samples of graywater screening solids, sewage/graywater screening solids, sewage/graywater waste biosludge (extra biological mass from the treatment system's bioreactor), and incinerator ash (from incineration of trash, including food solids from the food pulper, ROCHEM sewage/graywater treatment system screening solids, and spent bag filters) collected during the sampling episode. Table 4-13 also shows the average influents to the graywater and sewage/ graywater treatment systems analyte concentrations from Tables 4-2 and 4-7 for comparison.

Most of the analytes detected in the screening solids and waste biosludge were also detected in the influents to the treatment systems. For many analytes, concentrations in the screening solids and waste biosludge exceeded those in the influents to the treatment systems, suggesting that these analytes are removed from the systems in these waste streams. See Sections 4.1.5 and 4.1.9 for a detailed discussions of wastewater treatment system performance.

4.1.12 Source Water

Potable water is used as source water for all ship operations that generate graywater and sewage (e.g., laundry, galley, food pulper, sinks, showers, and toilets). Potable water is produced onboard and seldom bunkered while in port. Ten total metals, 10 dissolved metals, 7 classical pollutants, and 2 volatile and semivolatile organics were detected in the one-time grab sample of potable water collected during this sampling episode (Table 4-14). None of the analytes detected in the source water exceeded Federal drinking water standards (Table 4-14). Pathogen indicators were not detected in the source water sample.

4.2 Summary of Interviews Regarding Activities that Impact Wastewater Generation

The ship's crew was interviewed to obtain information regarding activities that impact wastewater generation (see Appendix C for detailed reports). The ship's crew provided operational, discharge, and wastewater treatment operating logs corresponding to the period of the sampling episode. These documents are included in the Cruise Ship Rulemaking Record and are available upon request.

4.2.1 Wastewater Generation

Galley

The Oosterdam has three dining rooms and 24-hour room service. Approximately 9,000 total meals (breakfast, lunch, dinner, snacks) are served daily. Initial preparation of fish, pork, and beef are performed on Deck A, while cooking occurs in the galleys (two passenger galleys and one crew galley). The ship galleys are equipped with twelve dishwashers in total, including six large and six smaller machines. Dishwashers operate each day from the start of meal sittings until 3 ½ - 4 hours after each meal sitting (breakfast, lunch, and dinner). Dishes are washed using Solid Power and Rinse Dry, which are dispensed automatically to each machine. The Oosterdam also uses Solitaire and Solid Metal Pro, for washing hands, pots, and pans; Bioclean for cleaning hoods and sinks; Absorbit for cleaning floors; Grill Shine (a lemon juice extract) for cleaning galley grills; and Hepburn Bio WC Clean for cleaning floor drains. All cleaning agents are listed on Holland American Cruise Line's approved chemicals list (ACL). Material Safety Data Sheets (MSDS) for these products are included in the Cruise Ship Rulemaking Record and are available upon request.

Laundry

The main Oosterdam laundry operates 15 hours per day between the hours of 0900 and 2400. It has a total of seven washers and six driers. Three large washers process approximately eight loads of towels (400 lb per load) per day, and two medium washers process

one or more loads of passenger clothing (125 lb per load) per day. Two small washers process 20 loads (15 lb per load) per day. The crew laundry contains 15 launderette machines. All laundry and laundrette machines include auto-dispense of cleaning agents listed on the ACL. Laundry cleaning agents include: Diverdet 2A, Emphasize, Launch, Liquid Diveralk 1C, Renew Extra, Super Impede, and Valid II. MSDS for these products are included in the Cruise Ship Rulemaking Record and are available upon request.

Photo Processing

The Oosterdam has a photo processing lab. All waste photographic chemicals are collected into drums for disposal onshore. Silver-containing wastes are pretreated by a silver recovery cartridge, which retains the silver within the filter for recovery. There is one primary cartridge and one backup; each provides approximately 600 hours of operation. Use of two digital machines has significantly reduced the volume of chemicals used as compared to analog film machines; however, the chemicals used in digital photo processing machines are more concentrated. A laboratory sink is used to rinse equipment such as chemical trays. The sink is physically blocked to prohibit discharges to the graywater CHT system, and collected rinse waters are pumped to the silver recovery cartridges. Two floor drains in the photo lab are blocked to ensure spilled chemicals do not enter the drain system.

Print Shop

The Oosterdam houses an onboard print shop, with one offset printer, three copiers, and one laser printer. Wastes, such as rags and residual chemicals, are disposed of onshore as hazardous waste. Spent toner cartridges are recycled through onshore vendors. Two print shop sinks are used for hand washing only and are plumbed to the accommodations CHT system. The shop has an open floor drain; the ship's crew indicated no chemical spills to date. Cleaning solvents and offset printing chemicals (alcohol, deglazer, plate etch) are stored in a locked cabinet.

Dry Cleaning

The Oosterdam has a dry cleaning facility with one dry cleaning machine and one small spot-cleaning machine. The dry cleaning machine is self-contained, with perchloroethylene distilled and recycled. Dry cleaning condensate and other solvent wastes and sludge (approximately 20L per month) are disposed of onshore as hazardous waste; no solvent wastes or wastewaters enter the graywater CHT system.

Chemical Storage

Any spills from the engine room storage areas are captured in the bilge and do not enter the graywater or sewage systems. See Appendix C for more information on chemicals stored in each engine room. Chemicals are also stored in other rooms of the ship as listed in Appendix C; these storage rooms have no floor drains to ensure that spilled chemicals do not enter the graywater and sewage systems.

Medical Infirmary/Dental Care

The Oosterdam provides onboard medical and dental care. Wastes such as machine cleaning chemical residuals, rags, outdated medications, and screened residual amalgam are disposed of onshore. Sinks and floor drains in the pantry and sinks in the examining rooms drain to the graywater CHT system. In addition, general cleaning wastewater and wastewater from the autoclave/sanitizing machine and from digital imaging are routed to the graywater CHT system. Sewage from toilets is collected by the sewage CHT systems. Floor drains in the garbage room drain to the bilge for treatment by oil/water separation prior to discharge.

Garbage Room

The Oosterdam has a garbage room onboard. The room is refrigerated, with solid/wet separation and crushing equipment. There is extensive recycling with hand separation of all garbage (e.g., glass, aluminum, tin cans, box board, wet garbage, flourescent tubes, and

batteries). The sink located in the garbage room is for hand washing only. Chemical storage is kept in a hazardous chemical locker with no drains.

4.2.2 Pesticide, Fungicide, and Rodenticide Use

No pesticides, fungicides, or rodenticides are used on the Oosterdam.

4.3 Flow Data

Strap-on ultrasonic flow meters were used to collect flow measurements and, in some cases, to control automatic composite sample machines on: (1) the outlet pipe from one of the accommodations holding tanks, (2) the influent to the graywater treatment system, (3) the effluent from the graywater treatment system, (4) the influent to the sewage/graywater treatment system, (5) the effluent from the sewage/graywater treatment system, and (6) the final combined effluent from the graywater and sewage/graywater treatment systems (see Section 2.4 and Figures 2-1 through 2-3). The flow meters were programmed to record instantaneous flow rate (m^3/min) at total flow (m^3) every five minutes. Flow data analyses presented in this section are based on only those flow data collected during the sampling episode of September 18 through September 23. Appendix B presents all flow data collected while onboard the Oosterdam from September 18 through September 23, 2005.

The total daily volume of wastewater from each of the six flow meter locations for each 24-hour sampling period are presented in Figure 4-1. The Oosterdam suspended overboard discharge (final combined treated effluent) for part of Day 1 while in State of Washington waters and for part of Day 4 while the ship cruised Hubbard Glacier. In addition, at the end of Day 3, high pressure caused the installed flow meter on the effluent to the graywater treatment system to lose signal strength; no flow measurements were collected at this location on Days 4 and 5. With the exception of the final overboard discharge (which was suspended for parts of Day 1 and Day 4), total daily flow at all locations remained relatively constant over the five-day sampling episode, regardless of whether the ship was in port (Day 1, 3, and 5) or at sea (Day 2 and 4).

Daily flow rates and flow per capita are presented in Table 4-15. Per capita flow rates were calculated based on 2,625 people (1,857 passengers and 768 crew) onboard during the sampling episode, as reported by the ship's crew. (Per capita volumes of accommodations wastewater generated were not calculated because the flow for only one collection tank was monitored.) On average, each person generated 31 gallons of untreated accommodations and laundry wastewater and 23 gallons of untreated sewage, galley wastewater, and membrane concentrate generated by the ROCHEM graywater treatment system. Average combined discharge from the graywater and sewage/graywater treatment systems was 45 gallons per person per day.

Figures 4-2 and 4-3 present the average flows for effluent from graywater treatment and effluent from sewage/graywater treatment for each hour interval over the five consecutive 24-hour sampling periods. The effluent flow from the graywater treatment system fluctuates substantially throughout the day. Flow rates were higher during the day and lower at night, as expected because accommodations wastewater composes the majority of influent flow to the treatment system. Laundry wastewater composes the remainder of the influent to the treatment system; the laundry operates from 0900 to 2400. The effluent flow from the sewage/graywater treatment system remains relatively constant throughout the day.

Table 4-1

Graywater Analytical Results, Holland America Oosterdam

Analytical results for each graywater source for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1 and A-2 for all analytical results (detected and nondetected). Graywater samples were collected for one 24-hour period; see Section 3.2 for the sample collection methodology. Table 2-1 lists the specific wastewater streams in each graywater source, and Figure 2-1 identifies sampling point locations. Certain food pulper wastewater results were converted from mass to volume units; see Section 3.3. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Laundry (SP-1) (a)	Accommodations (SP-3) (a)	Food Pulper (SP-4) (a)	Galley (SP-5) (a)
Pathogen Indicators						
E. coli	MPN/100 mL		7,700	10,700	100,000	3,880
Enterococci	MPN/100 mL		272	450	1,600,000	2,690
Fecal Coliform	CFU/100 mL		17,000	120,000,000	100,000	1,900
Classical Pollutants						
Alkalinity	mg/L		35.9	ND(20.0)	ND(200)	75.9
Biochemical Oxygen Demand (BOD_5)	mg/L		106	376	50,200	801
Chemical Oxygen Demand (COD) (s)	mg/L		323	1,730	25,300	1,740
Chloride (s)	mg/L		13.0	175	2,250	45.0
Hardness (e) (s)	mg/L		2.00	43.3	NC	12.2
Hexane Extractable Material (HEM)	mg/L		9.00	47.0	NC	51.0
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0580	0.100	0.951	0.0270
Settleable Residue	mL/L		ND(0.120)	15.0	1,000	3.40
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(6.00)	ND(6.00)	NC	ND(6.00)
Sulfate (s)	mg/L		3.22	103	612	108
Total Dissolved Solids (TDS)	mg/L		93.0	379	NC	631
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		3.27	34.1	362	40.6
Total Organic Carbon (TOC) (s)	mg/L		69.1	79.7	77,500	298
Total Phosphorus	mg/L		0.380	2.31	371	10.6

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).

Table 4-1 (Continued)

Analyte	Unit	Priority Pollutant Code	Laundry (SP-1) (a)	Accommodations (SP-3) (a)	Food Pulper (SP-4) (a)	Galley (SP-5) (a)
Total Suspended Solids (TSS)	mg/L		24.0	430	NC	564
Total and Dissolved Metals						
Aluminum, Total	ug/L		1,270	1,400	3.92	178
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(0.0411)	2.89
Barium, Total (e) (s)	ug/L		12.7	292	1.14	222
Boron, Total	ug/L		148	232	ND(0.0630)	180
Cadmium, Total	ug/L	P118	ND(0.0800)	0.880	0.0151	ND(0.0800)
Calcium, Total (e) (s)	ug/L		457	4,800	630	2,580
Chromium, Total	ug/L	P119	ND(0.270)	77.1	0.532	3.53
Cobalt, Total	ug/L		ND(0.660)	0.880	ND(0.00548)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	35.3	988	2.32	417
Iron, Total (e) (s)	ug/L		117	2,570	112	579
Lead, Total (e) (s)	ug/L	P122	ND(0.620)	ND(0.620)	0.103	63.8
Magnesium, Total (s)	ug/L		209	7,610	105	1,400
Manganese, Total (e) (s)	ug/L		3.34	33.8	5.22	22.3
Mercury, Total	ug/L	P123	ND(0.0500)	0.130	ND(0.00274)	ND(0.0500)
Molybdenum, Total	ug/L		ND(1.60)	4.04	0.0562	ND(1.60)
Nickel, Total (s)	ug/L	P124	3.09	85.8	0.285	47.2
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	0.110	ND(1.40)
Silver, Total	ug/L	P126	ND(0.770)	4.96	ND(0.0151)	ND(0.770)
Sodium, Total (s)	ug/L		19,400	153,000	1,050	58,800
Tin, Total	ug/L		ND(0.940)	14.3	ND(0.0493)	2.10
Titanium, Total	ug/L		1.59	14.9	0.210	2.17
Vanadium, Total	ug/L		ND(0.470)	4.19	ND(0.0137)	ND(0.470)
Zinc, Total (e) (s)	ug/L	P128	151	10,100	3.22	3,260

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).

Table 4-1 (Continued)

Analyte	Unit	Priority Pollutant Code	Laundry (SP-1) (a)	Accommodations (SP-3) (a)	Food Pulper (SP-4) (a)	Galley (SP-5) (a)
Aluminum, Dissolved	ug/L		317	202	NC	108
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	NC	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	NC	3.37
Barium, Dissolved (e) (s)	ug/L		0.990	191	NC	127
Beryllium, Dissolved	ug/L	P117	0.0800	ND(0.0700)	NC	ND(0.0700)
Boron, Dissolved (e)	ug/L		108	258	NC	244
Cadmium, Dissolved (e)	ug/L	P118	0.240	ND(0.0800)	NC	0.0850
Calcium, Dissolved (s)	ug/L		318	4,020	NC	2,190
Chromium, Dissolved	ug/L	P119	0.980	0.890	NC	1.43
Cobalt, Dissolved (s)	ug/L		1.90	2.37	NC	1.96
Copper, Dissolved (s)	ug/L	P120	35.6	26.3	NC	335
Iron, Dissolved (e)	ug/L		94.8	1,120	NC	332
Lead, Dissolved (e) (s)	ug/L	P122	2.36	2.04	NC	30.7
Magnesium, Dissolved (s)	ug/L		230	7,050	NC	1,350
Manganese, Dissolved (s)	ug/L		5.29	23.4	NC	21.3
Mercury, Dissolved	ug/L	P123	ND(0.0500)	ND(0.0500)	NC	ND(0.0500)
Nickel, Dissolved (s)	ug/L	P124	4.46	28.2	NC	49.1
Silver, Dissolved	ug/L	P126	0.960	ND(0.770)	NC	ND(0.770)
Sodium, Dissolved (e) (s)	ug/L		21,800	79,500	NC	66,800
Tin, Dissolved	ug/L		ND(0.940)	ND(0.940)	NC	1.38
Titanium, Dissolved	ug/L		0.720	ND(0.620)	NC	ND(0.620)
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	NC	ND(0.470)
Zinc, Dissolved (s)	ug/L	P128	82.4	1,910	NC	2,390

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).

Table 4-1 (Continued)

Analyte	Unit	Priority Pollutant Code	Laundry (SP-1) (a)	Accommodations (SP-3) (a)	Food Pulper (SP-4) (a)	Galley (SP-5) (a)
Volatile and Semivolatile Organics						
4-Chloro-3-methylphenol	ug/L	P022	ND(10.0)	ND(11.0)	ND(233)	33.0
Bis(2-ethylhexyl) phthalate	ug/L	P066	42.0	ND(11.0)	ND(233)	22.0
Chloroform (s)	ug/L	P023	6.00	5.12	ND(0.685)	ND(5.00)
Diethyl phthalate	ug/L	P070	ND(10.0)	ND(11.0)	ND(233)	ND(10.0)
Phenol (e) (s)	ug/L	P065	52.0	62.0	ND(233)	64.0
Toluene	ug/L	P086	ND(5.00)	87.0	ND(0.685)	ND(5.00)

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).

Table 4-2

Influent to Graywater Treatment System Analytical Results, Holland America Oosterdam

Analytical results for the influent to the graywater treatment system for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1 and A-2 for all analytical results (detected and nondetected). Influent to graywater treatment system samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for the sample collection methodology. Figure 2-2 identifies sampling point location. Average influent to treatment concentrations determined from the daily results. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Influent to GW Treatment (SP-6) (a) Day 1	Influent to GW Treatment (SP-6) (a) Day 2	Influent to GW Treatment (SP-6) (a) Day 3	Influent to GW Treatment (SP-6) (a) Day 4	Influent to GW Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		37,600 [N=2]	59,400 [N=2]	36,500 [N=2]	55,200 [N=2]	79,400 [N=2]	53,600
Enterococci (b)	MPN/100 mL		> 1,260 [N=2]	201 [N=2]	674 [N=2]	1,420 [N=2]	< 1,800 [N=2]	#1,070
Fecal Coliform (b)	CFU/100 mL		14,200,000 [N=2]	6,450,000 [N=2]	6,550,000 [N=2]	17,000,000 [N=2]	< 65,000,000 [N=2]	<21,800,000
Classical Pollutants								
Alkalinity	mg/L		31.8	43.1	56.4	50.2	35.9	43.5
Biochemical Oxygen Demand (BOD_5)	mg/L		149	132	146	143	145	143
Chemical Oxygen Demand (COD) (s)	mg/L		538	335	403	359	392	405
Chloride (s)	mg/L		13.0	13.0	25.0	25.0	17.0	18.6
Hardness (e) (s)	mg/L		5.39	5.18	5.42	8.88	5.82	6.14
Hexane Extractable Material (HEM)	mg/L		143	37.0	51.0	47.0	43.0	64.2
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0110	0.0160	0.0160	0.120	0.0170	0.0360
Settleable Residue	mL/L		0.530	1.10	0.590	3.00	0.500	1.14

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-2 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to GW Treatment (SP-6) (a) Day 1	Influent to GW Treatment (SP-6) (a) Day 2	Influent to GW Treatment (SP-6) (a) Day 3	Influent to GW Treatment (SP-6) (a) Day 4	Influent to GW Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Silica Gel Treated HEM (SGT-HEM)	mg/L		7.00	ND(6.00)	ND(6.00)	ND(6.00)	ND(6.00)	<6.20
Sulfate (s)	mg/L		11.9	12.0	12.2	10.8	6.91	10.8
Total Dissolved Solids (TDS)	mg/L		86.0	95.0	132	160	64.0	107
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		9.87	0.380	10.2	15.5	9.44	9.08
Total Organic Carbon (TOC) (s)	mg/L		54.7	44.5	60.4	56.3	51.3	53.4
Total Phosphorus	mg/L		1.47	3.94	1.13	1.13	0.850	1.70
Total Suspended Solids (TSS)	mg/L		95.0	73.0	86.0	99.0	93.0	89.2
Total and Dissolved Metals								
Aluminum, Total	ug/L		653	672	702	1,020	673	744
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Total (e) (s)	ug/L		134	134	137	137	135	135
Boron, Total	ug/L		ND(18.0)	ND(18.0)	ND(18.0)	ND(18.0)	74.3	<29.3
Cadmium, Total	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Total (e) (s)	ug/L		1,640	1,570	1,600	1,960	1,640	1,680
Chromium, Total	ug/L	P119	2.76	3.50	3.80	9.52	6.67	5.25
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	156	289	219	197	204	213
Iron, Total (e) (s)	ug/L		366	339	334	423	406	374
Lead, Total (e) (s)	ug/L	P122	5.41	9.34	7.36	6.91	7.88	7.38

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-2 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to GW Treatment (SP-6) (a) Day 1	Influent to GW Treatment (SP-6) (a) Day 2	Influent to GW Treatment (SP-6) (a) Day 3	Influent to GW Treatment (SP-6) (a) Day 4	Influent to GW Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Magnesium, Total (s)	ug/L		317	305	346	968	417	471
Manganese, Total (e) (s)	ug/L		7.65	6.95	7.61	8.87	8.19	7.85
Mercury, Total	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	0.0550	0.0850	<0.0580
Molybdenum, Total	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Total (s)	ug/L	P124	14.5	17.7	16.6	18.5	18.3	17.1
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)
Silver, Total	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	2.27	2.27	<1.37
Sodium, Total (s)	ug/L		16,000	20,300	24,800	26,400	18,800	21,300
Tin, Total	ug/L		ND(0.940)	1.03	ND(0.940)	6.92	2.45	<2.46
Titanium, Total	ug/L		1.47	1.69	1.76	3.51	1.79	2.04
Vanadium, Total	ug/L		0.810	ND(0.470)	0.840	0.890	ND(0.470)	<0.696
Zinc, Total (e) (s)	ug/L	P128	667	598	924	870	895	791
Aluminum, Dissolved	ug/L		279	223	183	209	271	233
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		73.5	40.1	25.9	25.3	78.4	48.6
Beryllium, Dissolved	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Dissolved (e)	ug/L		114	95.0	59.0	69.6	ND(18.0)	<71.1
Cadmium, Dissolved (e)	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-2 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to GW Treatment (SP-6) (a) Day 1	Influent to GW Treatment (SP-6) (a) Day 2	Influent to GW Treatment (SP-6) (a) Day 3	Influent to GW Treatment (SP-6) (a) Day 4	Influent to GW Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Calcium, Dissolved (s)	ug/L		1,450	1,130	761	1,200	1,630	1,230
Chromium, Dissolved	ug/L	P119	0.390	0.760	0.660	0.640	0.370	0.564
Cobalt, Dissolved (s)	ug/L		2.14	1.72	3.16	3.85	5.11	3.20
Copper, Dissolved (s)	ug/L	P120	70.6	205	100	77.1	92.0	109
Iron, Dissolved (e)	ug/L		199	192	165	179	212	189
Lead, Dissolved (e) (s)	ug/L	P122	1.01	4.47	1.84	1.58	2.20	2.22
Magnesium, Dissolved (s)	ug/L		268	239	234	929	464	427
Manganese, Dissolved (s)	ug/L		9.00	7.30	9.43	11.0	14.9	10.3
Mercury, Dissolved	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)
Nickel, Dissolved (s)	ug/L	P124	13.7	15.5	12.7	12.6	14.6	13.8
Silver, Dissolved	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium, Dissolved (e) (s)	ug/L		19,100	23,900	23,800	30,700	23,200	24,100
Tin, Dissolved	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	1.04	ND(0.940)	<0.960
Titanium, Dissolved	ug/L		0.920	ND(0.620)	ND(0.620)	ND(0.620)	0.630	<0.682
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Dissolved (s)	ug/L	P128	130	134	252	160	172	170

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-2 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to GW Treatment (SP-6) (a) Day 1	Influent to GW Treatment (SP-6) (a) Day 2	Influent to GW Treatment (SP-6) (a) Day 3	Influent to GW Treatment (SP-6) (a) Day 4	Influent to GW Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Volatile and Semivolatile Organics								
4-Chloro-3-methylphenol	ug/L	P022	ND(10.0)	ND(10.0)	ND(11.0)	ND(10.0)	ND(12.0)	ND(10.6)
Bis(2-ethylhexyl) phthalate	ug/L	P066	19.0	23.0	ND(11.0)	ND(10.0)	ND(12.0)	<15.0
Chloroform (s)	ug/L	P023	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Diethyl phthalate	ug/L	P070	ND(10.0)	14.0	14.0	12.0	12.2	<12.4
Phenol (e) (s)	ug/L	P065	47.0	55.0	62.0	51.0	32.0	49.4
Toluene	ug/L	P086	ND(5.00)	ND(5.00)	ND(5.00)	6.00	ND(5.00)	<5.20

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-3

Influent to Graywater UV Disinfection Analytical Results, Holland America Oosterdam

Analytical results for the influent to UV disinfection part of the graywater treatment system. Influent to UV disinfection samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for the sample collection methodology. Figure 2-2 identifies sampling point location. Average influent to UV concentrations determined from the daily result.

Analyte	Unit	Influent to GW UV (SP-7) (a) Day 1	Influent to GW UV (SP-7) (a) Day 2	Influent to GW UV (SP-7) (a) Day 3	Influent to GW UV (SP-7) (a) Day 4	Influent to GW UV (SP-7) (a) Day 5	Average Influent to GW UV (SP-7) (a)
Pathogen Indicators							
E. coli (b)	MPN/100 mL	< 15.2 [N=3]	72.2 [N=3]	12.2 [N=3]	16.1 [N=3]	< 3.17 [N=3]	<23.8
Enterococci (b)	MPN/100 mL	ND(1.00) [N=3]	< 1.00 [N=3]	ND(1.00) [N=3]	ND(1.00) [N=3]	ND(1.00) [N=3]	<1.00
Fecal Coliform (b)	CFU/100 mL	30,400 [N=3]	2,330 [N=3]	883 [N=3]	1,510 [N=3]	80.3 [N=3]	7,030

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-4

Effluent from Graywater Treatment System Analytical Results, Holland America Oosterdam

Analytical results for the effluent from the graywater treatment system for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1 and A-2 for all analytical results (detected and nondetected). Effluent from treatment system samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for the sample collection methodology. Figure 2-2 identifies sampling point location. Average effluent from treatment concentrations determined from the daily results. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Effluent from GW Treatment (SP-8) (a) Day 1	Effluent from GW Treatment (SP-8) (a) Day 2	Effluent from GW Treatment (SP-8) (a) Day 3	Effluent from GW Treatment (SP-8) (a) Day 4	Effluent from GW Treatment (SP-8) (a) Day 5	Average Effluent from GW Treatment (SP-8) (a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		ND(1.00) [N=3]	ND(1.00) [N=3]	ND(1.00) [N=2]	ND(1.00) [N=3]	< 2.77 [N=3]	<1.35
Enterococci (b)	MPN/100 mL		ND(1.00) [N=3]	ND(1.00) [N=3]	ND(1.00) [N=2]	ND(1.00) [N=3]	ND(1.00) [N=3]	ND(1.00)
Fecal Coliform (b)	CFU/100 mL		< 1.67 [N=3]	< 1.42 [N=3]	ND(2.00) [N=2]	ND(2.00) [N=3]	ND(2.00) [N=3]	<1.82
Classical Pollutants								
Alkalinity	mg/L		23.6	23.6	ND(10.0)	34.9	19.5	<22.3
Biochemical Oxygen Demand (BOD_5)	mg/L		27.9	27.1	24.8	23.2	37.3	28.1
Chemical Oxygen Demand (COD) (s)	mg/L		68.0	56.0	58.0	50.5	79.0	62.3
Chloride (s)	mg/L		8.00	12.0	17.0	17.0	13.0	13.4
Hardness (e) (s)	mg/L		1.17	0.750	0.390	1.30	1.90	1.10
Hexane Extractable Material (HEM)	mg/L		ND(6.00)	ND(6.00)	ND(6.00)	ND(6.00)	ND(6.00)	ND(6.00)
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		ND(0.0100)	ND(0.0100)	0.0270	0.0270	0.0270	<0.0202
Settleable Residue	mL/L		ND(0.110)	ND(0.110)	ND(0.110)	ND(0.110)	ND(0.105)	ND(0.109)
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(6.00)	ND(6.00)	ND(6.00)	ND(6.00)	ND(6.00)	ND(6.00)
Sulfate (s)	mg/L		2.17	2.70	4.17	2.80	3.43	3.05
Total Dissolved Solids (TDS)	mL/L		ND(10.0)	35.0	53.3	67.0	ND(10.0)	<35.1

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from GW Treatment (SP-8) (a) Day 1	Effluent from GW Treatment (SP-8) (a) Day 2	Effluent from GW Treatment (SP-8) (a) Day 3	Effluent from GW Treatment (SP-8) (a) Day 4	Effluent from GW Treatment (SP-8) (a) Day 5	Average Effluent from GW Treatment (SP-8) (a)
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		0.120	0.0800	0.470	6.74	3.36	2.15
Total Organic Carbon (TOC) (s)	mg/L		16.5	16.0	12.9	13.4	21.0	15.9
Total Phosphorus	mg/L		0.150	0.120	0.220	0.170	0.220	0.176
Total Suspended Solids (TSS)	mg/L		ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Total and Dissolved Metals								
Aluminum, Total	ug/L		ND(8.80)	ND(8.80)	ND(8.80)	28.0	21.8	<15.2
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Total (e) (s)	ug/L		26.8	14.6	11.2	8.60	31.9	18.6
Boron, Total	ug/L		ND(18.0)	ND(18.0)	ND(18.0)	83.0	57.5	<38.9
Cadmium, Total	ug/L	P118	ND(0.0800)	ND(0.0800)	< 0.0867	ND(0.0800)	ND(0.0800)	<0.0813
Calcium, Total (e) (s)	ug/L		352	213	112	164	502	269
Chromium, Total	ug/L	P119	ND(0.270)	ND(0.270)	ND(0.270)	ND(0.270)	ND(0.270)	ND(0.270)
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	26.8	22.5	167	35.6	97.7	69.9
Iron, Total (e) (s)	ug/L		419	222	469	193	720	405
Lead, Total (e) (s)	ug/L	P122	3.74	ND(0.620)	28.5	2.42	7.21	<8.50
Magnesium, Total (s)	ug/L		70.2	53.3	34.4	216	156	106
Manganese, Total (e) (s)	ug/L		8.18	5.27	81.1	3.77	14.0	22.5
Mercury, Total	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)
Molybdenum, Total	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Total (s)	ug/L	P124	2.64	2.23	2.99	2.81	5.22	3.18

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from GW Treatment (SP-8) (a) Day 1	Effluent from GW Treatment (SP-8) (a) Day 2	Effluent from GW Treatment (SP-8) (a) Day 3	Effluent from GW Treatment (SP-8) (a) Day 4	Effluent from GW Treatment (SP-8) (a) Day 5	Average Effluent from GW Treatment (SP-8) (a)
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)
Silver, Total	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium, Total (s)	ug/L		12,500	11,900	11,300	20,000	14,200	14,000
Tin, Total	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)
Titanium, Total	ug/L		ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)
Vanadium, Total	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Total (e) (s)	ug/L	P128	236	237	675	196	572	383
Aluminum, Dissolved	ug/L		ND(8.80)	ND(8.80)	< 16.9	ND(8.80)	ND(8.80)	<10.4
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		11.3	5.37	8.06	2.58	21.7	9.80
Beryllium, Dissolved	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Dissolved (e)	ug/L		58.4	83.7	73.6	ND(18.0)	ND(18.0)	<50.3
Cadmium, Dissolved (e)	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Dissolved (s)	ug/L		290	256	ND(7.00)	ND(7.00)	478	<208
Chromium, Dissolved	ug/L	P119	ND(0.270)	ND(0.270)	0.440	ND(0.270)	ND(0.270)	<0.304
Cobalt, Dissolved (s)	ug/L		1.26	1.32	ND(0.660)	2.14	3.61	<1.80
Copper, Dissolved (s)	ug/L	P120	4.74	11.7	47.0	2.96	24.9	18.3
Iron, Dissolved (e)	ug/L		190	197	445	103	343	256
Lead, Dissolved (e) (s)	ug/L	P122	2.05	1.89	14.8	ND(0.620)	2.50	<4.37
Magnesium, Dissolved (s)	ug/L		61.6	61.7	ND(6.30)	196	170	<99.1

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from GW Treatment (SP-8) (a) Day 1	Effluent from GW Treatment (SP-8) (a) Day 2	Effluent from GW Treatment (SP-8) (a) Day 3	Effluent from GW Treatment (SP-8) (a) Day 4	Effluent from GW Treatment (SP-8) (a) Day 5	Average Effluent from GW Treatment (SP-8) (a)
Manganese, Dissolved (s)	ug/L		8.35	7.27	8.15	6.21	14.1	8.82
Mercury, Dissolved	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)
Nickel, Dissolved (s)	ug/L	P124	3.10	3.69	4.15	ND(0.310)	5.24	<3.30
Silver, Dissolved	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium, Dissolved (e) (s)	ug/L		11,500	14,000	12,100	18,600	14,000	14,000
Tin, Dissolved	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)
Titanium, Dissolved	ug/L		ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Dissolved (s)	ug/L	P128	147	228	605	147	268	279
Volatile and Semivolatile Organics								
4-Chloro-3-methylphenol	ug/L	P022	ND(20.0)	ND(20.0)	ND(22.0)	ND(20.0)	ND(22.0)	ND(20.8)
Bis(2-ethylhexyl) phthalate	ug/L	P066	ND(20.0)	ND(20.0)	ND(22.0)	ND(20.0)	ND(22.0)	ND(20.8)
Chloroform (s)	ug/L	P023	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Diethyl phthalate	ug/L	P070	ND(20.0)	ND(20.0)	ND(22.0)	ND(20.0)	ND(22.0)	ND(20.8)
Phenol (e) (s)	ug/L	P065	61.7	64.3	67.0	71.0	71.0	67.0
Toluene	ug/L	P086	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-5

Graywater Treatment System: Performance Data for Pathogen Indicators, Holland America Oosterdam

Pathogen indicators performance data for the Oosterdam's ROCHEM graywater treatment system. Average analyte concentrations were determined from the daily results presented in Tables 4-2 through 4-4. Percent removals were calculated using the average influent to and effluent from treatment analyte concentrations.

Analyte	Unit	Average Influent to Graywater Treatment Concentration (SP-6) (a)	Average Influent to Graywater UV Disinfection Concentration (SP-7) (a)	Average Effluent from Graywater Treatment Concentration (SP-8) (a)	Percent Removal
Pathogen Indicators					
E. coli	MPN/100 mL	53,600	<23.8	<1.35	>99
Enterococci	MPN/100 mL	#1,070	<1.00	ND(1.00)	>99
Fecal Coliform	CFU/100 mL	<21,800,000	7,030	<1.82	>99

(a) Sampling point location; see Figure 2-2.
ND - Not detected (number in parentheses is detection limit).
< - Average result reported includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-6

Graywater Treatment System: Performance Data for Analytes Other Than Pathogen Indicators, Holland America Oosterdam

Performance data for the Oosterdam's ROCHEM graywater treatment system for analytes other than pathogen indicators detected in either the influent to or effluent from graywater treatment. Range and average analyte concentrations were determined from the daily results presented in Tables 4-2 and 4-4. Percent removals were calculated using the average graywater influent and effluent analyte concentrations. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Average Influent to GW Treatment Concentration (SP-6) (a)	Influent to GW Treatment Concentration Range (SP-6) (a)	Average Effluent from GW Treatment Concentration (SP-8) (a)	Effluent from GW Treatment Concentration Range (SP-8) (a)	Percent Removal
Classical Pollutants							
Alkalinity	mg/L		43.5	31.8 - 56.4	<22.3	ND(10.0) - 34.9	49
Biochemical Oxygen Demand (BOD_5)	mg/L		143	132 - 149	28.1	23.2 - 37.3	80
Chemical Oxygen Demand (COD) (s)	mg/L		405	335 - 538	62.3	50.5 - 79.0	85
Chloride (s)	mg/L		18.6	13.0 - 25.0	13.4	8.00 - 17.0	28
Hardness (e) (s)	mg/L		6.14	5.18 - 8.88	1.10	0.390 - 1.90	82
Hexane Extractable Material (HEM)	mg/L		64.2	37.0 - 143	ND(6.00)	ND(6.00)	> 91
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0360	0.0110 - 0.120	<0.0202	ND(0.0100) - 0.0270	44
Settleable Residue	mL/L		1.14	0.500 - 3.00	ND(0.109)	ND(0.105) - ND(0.110)	> 90
Silica Gel Treated HEM (SGT-HEM)	mg/L		<6.20	ND(6.00) - 7.00	ND(6.00)	ND(6.00)	> 3.2
Sulfate (s)	mg/L		10.8	6.91 - 12.2	3.05	2.17 - 4.17	72
Total Dissolved Solids (TDS)	mg/L		107	64.0 - 160	<35.1	ND(10.0) - 67.0	67
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		9.08	0.380 - 15.5	2.15	0.0800 - 6.74	76
Total Organic Carbon (TOC) (s)	mg/L		53.4	44.5 - 60.4	15.9	12.9 - 21.0	70
Total Phosphorus	mg/L		1.70	0.850 - 3.94	0.176	0.120 - 0.220	90
Total Suspended Solids (TSS)	mg/L		89.2	73.0 - 99.0	ND(5.00)	ND(5.00)	> 94

(a) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to GW Treatment Concentration (SP-6) (a)	Influent to GW Treatment Concentration Range (SP-6) (a)	Average Effluent from GW Treatment Concentration (SP-8) (a)	Effluent from GW Treatment Concentration Range (SP-8) (a)	Percent Removal
Total and Dissolved Metals							
Aluminum, Total	ug/L		744	653 - 1,020	<15.2	ND(8.80) - 28.0	98
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	NC
Barium, Total (e) (s)	ug/L		135	134 - 137	18.6	8.60 - 31.9	86
Boron, Total	ug/L		<29.3	ND(18.0) - 74.3	<38.9	ND(18.0) - 83.0	NC
Cadmium, Total	ug/L	P118	ND(0.0800)	ND(0.0800)	<0.0813	ND(0.0800) - <0.0867	NC
Calcium, Total (e) (s)	ug/L		1,680	1,570 - 1,960	269	112 - 502	84
Chromium, Total	ug/L	P119	5.25	2.76 - 9.52	ND(0.270)	ND(0.270)	> 95
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	NC
Copper, Total (e) (s)	ug/L	P120	213	156 - 289	69.9	22.5 - 167	67
Iron, Total (e) (s)	ug/L		374	334 - 423	405	193 - 720	NC
Lead, Total (e) (s)	ug/L	P122	7.38	5.41 - 9.34	<8.50	ND(0.620) - 28.5	NC
Magnesium, Total (s)	ug/L		471	305 - 968	106	34.4 - 216	77
Manganese, Total (e) (s)	ug/L		7.85	6.95 - 8.87	22.5	3.77 - 81.1	NC
Mercury, Total	ug/L	P123	<0.0580	ND(0.0500) - 0.0850	ND(0.0500)	ND(0.0500)	> 14
Molybdenum, Total	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	NC
Nickel, Total (s)	ug/L	P124	17.1	14.5 - 18.5	3.18	2.23 - 5.22	81
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	NC
Silver, Total	ug/L	P126	<1.37	ND(0.770) - 2.27	ND(0.770)	ND(0.770)	> 44
Sodium, Total (s)	ug/L		21,300	16,000 - 26,400	14,000	11,300 - 20,000	34
Tin, Total	ug/L		<2.46	ND(0.940) - 6.92	ND(0.940)	ND(0.940)	> 62

(a) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to GW Treatment Concentration (SP-6) (a)	Influent to GW Treatment Concentration Range (SP-6) (a)	Average Effluent from GW Treatment Concentration (SP-8) (a)	Effluent from GW Treatment Concentration Range (SP-8) (a)	Percent Removal
Titanium, Total	ug/L		2.04	1.47 - 3.51	ND(0.620)	ND(0.620)	> 70
Vanadium, Total	ug/L		<0.696	ND(0.470) - 0.890	ND(0.470)	ND(0.470)	> 32
Zinc, Total (e) (s)	ug/L	P128	791	598 - 924	383	196 - 675	52
Aluminum, Dissolved	ug/L		233	183 - 279	<10.4	ND(8.80) - <16.9	96
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	NC
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	NC
Barium, Dissolved (e) (s)	ug/L		48.6	25.3 - 78.4	9.80	2.58 - 21.7	80
Beryllium, Dissolved	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	NC
Boron, Dissolved (e)	ug/L		<71.1	ND(18.0) - 114	<50.3	ND(18.0) - 83.7	29
Cadmium, Dissolved (e)	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	NC
Calcium, Dissolved (s)	ug/L		1,230	761 - 1,630	<208	ND(7.00) - 478	83
Chromium, Dissolved	ug/L	P119	0.564	0.370 - 0.760	<0.304	ND(0.270) - 0.440	46
Cobalt, Dissolved (s)	ug/L		3.20	1.72 - 5.11	<1.80	ND(0.660) - 3.61	44
Copper, Dissolved (s)	ug/L	P120	109	70.6 - 205	18.3	2.96 - 47.0	83
Iron, Dissolved (e)	ug/L		189	165 - 212	256	103 - 445	NC
Lead, Dissolved (e) (s)	ug/L	P122	2.22	1.01 - 4.47	<4.37	ND(0.620) - 14.8	NC
Magnesium, Dissolved (s)	ug/L		427	234 - 929	<99.1	ND(6.30) - 196	77
Manganese, Dissolved (s)	ug/L		10.3	7.30 - 14.9	8.82	6.21 - 14.1	15
Mercury, Dissolved	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	NC
Nickel, Dissolved (s)	ug/L	P124	13.8	12.6 - 15.5	<3.30	ND(0.310) - 5.24	76
Silver, Dissolved	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	NC

(a) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to GW Treatment Concentration (SP-6) (a)	Influent to GW Treatment Concentration Range (SP-6) (a)	Average Effluent from GW Treatment Concentration (SP-8) (a)	Effluent from GW Treatment Concentration Range (SP-8) (a)	Percent Removal
Sodium, Dissolved (e) (s)	ug/L		24,100	19,100 - 30,700	14,000	11,500 - 18,600	42
Tin, Dissolved	ug/L		<0.960	ND(0.940) - 1.04	ND(0.940)	ND(0.940)	> 2.1
Titanium, Dissolved	ug/L		<0.682	ND(0.620) - 0.920	ND(0.620)	ND(0.620)	> 9.1
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	NC
Zinc, Dissolved (s)	ug/L	P128	170	130 - 252	279	147 - 605	NC
Volatile and Semivolatile Organics							
4-Chloro-3-methylphenol	ug/L	P022	ND(10.6)	ND(10.0) - ND(12.0)	ND(20.8)	ND(20.0) - ND(22.0)	NC
Bis(2-ethylhexyl) phthalate	ug/L	P066	<15.0	ND(10.0) - 23.0	ND(20.8)	ND(20.0) - ND(22.0)	NC
Chloroform (s)	ug/L	P023	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	NC
Diethyl phthalate	ug/L	P070	<12.4	ND(10.0) - 14.0	ND(20.8)	ND(20.0) - ND(22.0)	NC
Phenol (e) (s)	ug/L	P065	49.4	32.0 - 62.0	67.0	61.7 - 71.0	NC
Toluene	ug/L	P086	<5.20	ND(5.00) - 6.00	ND(5.00)	ND(5.00)	> 3.8

(a) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-7

Influent to Sewage/Graywater Treatment System Analytical Results, Holland America Oosterdam

Analytical results for the influent to the sewage/graywater (Sewage/GW) treatment system for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1 and A-2 for all analytical results (detected and nondetected). Influent to sewage/graywater treatment system samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for the sample collection methodology. Figure 2-3 identifies sampling point location. Average influent to treatment concentrations determined from the daily results. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Influent to Sewage/GW Treatment (SP-11) (a) Day 1	Influent to Sewage/GW Treatment (SP-11) (a) Day 2	Influent to Sewage/GW Treatment (SP-11) (a) Day 3	Influent to Sewage/GW Treatment (SP-11) (a) Day 4	Influent to Sewage/GW Treatment (SP-11) (a) Day 5	Average Influent to Sewage/GW Treatment (SP-12) (a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		10,400,000 [N=2]	10,100,000 [N=2]	8,940,000 [N=2]	7,050,000 [N=2]	5,940,000 [N=2]	8,480,000
Enterococci (b)	MPN/100 mL		1,400,000 [N=2]	1,970,000 [N=2]	949,000 [N=2]	819,000 [N=2]	602,000 [N=2]	1,150,000
Fecal Coliform (b)	CFU/100 mL		52,000,000 [N=2]	15,000,000 [N=2]	8,950,000 [N=2]	28,000,000 [N=2]	30,800,000 [N=2]	26,900,000
Classical Pollutants								
Alkalinity	mg/L		529	537	508	650	564	558
Biochemical Oxygen Demand (BOD_5)	mg/L		919	1,380	690	736	717	888
Chemical Oxygen Demand (COD) (s)	mg/L		2,490	2,830	1,800	1,960	2,040	2,220
Chloride (s)	mL/L		125	95.0	125	145	145	127
Hardness (e) (s)	mg/L		51.8	28.5	51.3	40.7	44.4	43.3
Hexane Extractable Material (HEM)	mg/L		52.0	85.0	62.0	50.0	48.0	59.4
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0170	0.0160	0.0290	0.0370	0.0350	0.0268
Settleable Residue	mL/L		20.0	51.0	39.0	ND(0.130)	0.660	<22.2
Silica Gel Treated HEM (SGT-HEM)	mg/L		7.00	8.00	8.00	6.00	6.00	7.00
Sulfate (s)	mg/L		113	121	131	153	96.5	123

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-7 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Sewage/GW Treatment (SP-11) (a) Day 1	Influent to Sewage/GW Treatment (SP-11) (a) Day 2	Influent to Sewage/GW Treatment (SP-11) (a) Day 3	Influent to Sewage/GW Treatment (SP-11) (a) Day 4	Influent to Sewage/GW Treatment (SP-11) (a) Day 5	Average Influent to Sewage/GW Treatment (SP-12) (a)
Total Dissolved Solids (TDS)	mg/L		756	608	596	842	788	718
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		192	197	192	200	182	193
Total Organic Carbon (TOC) (s)	mg/L		262	225	271	302	267	265
Total Phosphorus	mg/L		23.1	24.2	20.9	23.3	31.8	24.7
Total Suspended Solids (TSS)	mg/L		650	1,110	635	560	680	727
Total and Dissolved Metals								
Aluminum, Total	ug/L		1,360	847	1,460	1,330	1,630	1,330
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Total (e) (s)	ug/L		318	185	309	234	273	264
Boron, Total	ug/L		ND(18.0)	ND(18.0)	ND(18.0)	98.5	121	<54.7
Cadmium, Total	ug/L	P118	0.380	0.220	0.520	0.380	0.470	0.394
Calcium, Total (e) (s)	ug/L		13,900	6,870	13,700	9,550	11,200	11,000
Chromium, Total	ug/L	P119	8.63	4.52	12.6	7.66	8.78	8.44
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	384	372	542	468	490	451
Iron, Total (e) (s)	ug/L		1,190	820	1,560	1,220	1,460	1,250
Lead, Total (e) (s)	ug/L	P122	7.85	7.94	10.7	10.1	13.4	10.0
Magnesium, Total (s)	ug/L		4,130	2,760	4,150	4,100	3,980	3,820
Manganese, Total (e) (s)	ug/L		68.8	44.1	58.7	65.7	62.6	60.0
Mercury, Total	ug/L	P123	0.240	0.190	0.220	0.190	0.260	0.220
Molybdenum, Total	ug/L		2.43	ND(1.60)	2.08	1.82	ND(1.60)	<1.91

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-7 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Sewage/GW Treatment (SP-11) (a) Day 1	Influent to Sewage/GW Treatment (SP-11) (a) Day 2	Influent to Sewage/GW Treatment (SP-11) (a) Day 3	Influent to Sewage/GW Treatment (SP-11) (a) Day 4	Influent to Sewage/GW Treatment (SP-11) (a) Day 5	Average Influent to Sewage/GW Treatment (SP-12) (a)
Nickel, Total (s)	ug/L	P124	22.8	20.9	35.5	28.1	32.1	27.9
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	2.85	2.70	2.99	<2.27
Silver, Total	ug/L	P126	3.11	1.24	5.28	2.40	2.52	2.91
Sodium, Total (s)	ug/L		81,500	61,900	88,100	103,000	90,800	85,100
Tin, Total	ug/L		6.52	5.20	8.83	8.79	8.47	7.56
Titanium, Total	ug/L		2.79	2.38	3.29	3.01	3.63	3.02
Vanadium, Total	ug/L		1.50	0.540	1.64	1.63	ND(0.470)	<1.16
Zinc, Total (e) (s)	ug/L	P128	1,440	1,000	3,190	1,580	1,730	1,790
Aluminum, Dissolved	ug/L		235	310	244	408	464	332
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	2.78	ND(2.00)	<2.16
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		84.7	59.4	88.7	73.9	100	81.3
Beryllium, Dissolved	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Dissolved (e)	ug/L		109	129	ND(18.0)	ND(18.0)	ND(18.0)	<58.4
Cadmium, Dissolved (e)	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Dissolved (s)	ug/L		5,770	3,080	5,170	4,480	6,360	4,970
Chromium, Dissolved	ug/L	P119	2.06	1.83	4.11	2.91	3.51	2.88
Cobalt, Dissolved (s)	ug/L		5.78	9.36	5.46	13.7	23.3	11.5
Copper, Dissolved (s)	ug/L	P120	56.6	153	86.6	130	125	110
Iron, Dissolved (e)	ug/L		903	882	550	938	1,230	901
Lead, Dissolved (e) (s)	ug/L	P122	1.41	3.22	2.50	3.12	2.57	2.56

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-7 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Sewage/GW Treatment (SP-11) (a) Day 1	Influent to Sewage/GW Treatment (SP-11) (a) Day 2	Influent to Sewage/GW Treatment (SP-11) (a) Day 3	Influent to Sewage/GW Treatment (SP-11) (a) Day 4	Influent to Sewage/GW Treatment (SP-11) (a) Day 5	Average Influent to Sewage/GW Treatment (SP-12) (a)
Magnesium, Dissolved (s)	ug/L		3,110	2,800	3,350	3,740	3,930	3,390
Manganese, Dissolved (s)	ug/L		64.7	62.5	33.0	86.4	96.3	68.6
Mercury, Dissolved	ug/L	P123	ND(0.0500)	ND(0.0500)	0.0570	0.0550	ND(0.0500)	<0.0524
Nickel, Dissolved (s)	ug/L	P124	21.1	29.1	27.3	28.1	33.3	27.8
Silver, Dissolved	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium, Dissolved (e) (s)	ug/L		92,900	94,100	84,100	107,000	106,000	96,800
Tin, Dissolved	ug/L		2.19	2.58	2.49	2.94	2.49	2.54
Titanium, Dissolved	ug/L		0.840	0.960	ND(0.620)	0.670	0.840	<0.786
Vanadium, Dissolved	ug/L		0.560	0.560	0.490	0.760	0.730	0.620
Zinc, Dissolved (s)	ug/L	P128	409	524	644	569	459	521
Volatile and Semivolatile Organics								
4-Chloro-3-methylphenol	ug/L	P022	ND(10.0)	ND(10.0)	ND(11.0)	ND(13.0)	ND(12.0)	ND(11.2)
Bis(2-ethylhexyl) phthalate	ug/L	P066	49.0	94.0	45.0	47.0	47.0	56.4
Chloroform (s)	ug/L	P023	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Diethyl phthalate	ug/L	P070	ND(10.0)	ND(10.0)	ND(11.0)	ND(13.0)	ND(12.0)	ND(11.2)
Phenol (e) (s)	ug/L	P065	95.0	67.0	60.0	100	150	94.4
Toluene	ug/L	P086	ND(5.00)	ND(5.00)	6.00	7.00	7.00	<6.00
Polychlorinated Biphenyls								
PCB-2	pg/L		17.5	NC	NC	NC	NC	
PCB-6	pg/L		121	NC	NC	NC	NC	
PCB-11	pg/L		1,900	NC	NC	NC	NC	

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-7 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Sewage/GW Treatment (SP-11) (a) Day 1	Influent to Sewage/GW Treatment (SP-11) (a) Day 2	Influent to Sewage/GW Treatment (SP-11) (a) Day 3	Influent to Sewage/GW Treatment (SP-11) (a) Day 4	Influent to Sewage/GW Treatment (SP-11) (a) Day 5	Average Influent to Sewage/GW Treatment (SP-12) (a)
PCB-16	pg/L		367	NC	NC	NC	NC	
PCB-17	pg/L		360	NC	NC	NC	NC	
PCB-18+PCB-30	pg/L		704	NC	NC	NC	NC	
PCB-20+PCB-28	pg/L		1,080	NC	NC	NC	NC	
PCB-21+PCB-33	pg/L		603	NC	NC	NC	NC	
PCB-22	pg/L		399	NC	NC	NC	NC	
PCB-31	pg/L		891	NC	NC	NC	NC	
PCB-44+PCB-47+PCB-65	pg/L		849	NC	NC	NC	NC	
PCB-52	pg/L		654	NC	NC	NC	NC	
PCB-61+PCB-70+PCB-74+PCB-76	pg/L		1,190	NC	NC	NC	NC	
PCB-64	pg/L		279	NC	NC	NC	NC	
PCB-129+PCB-138+PCB-160+PCB-163	pg/L		958	NC	NC	NC	NC	
PCB-153+PCB-168	pg/L		1,070	NC	NC	NC	NC	
PCB-180+PCB-193	pg/L		620	NC	NC	NC	NC	
Total Dichloro Biphenyls	pg/L		2,020	NC	NC	NC	NC	
Total Hexachloro Biphenyls	pg/L		2,030	NC	NC	NC	NC	
Total PCBs	pg/L		11,400	NC	NC	NC	NC	
Total Tetrachloro Biphenyls	pg/L		2,970	NC	NC	NC	NC	
Total Trichloro Biphenyls	pg/L		4,400	NC	NC	NC	NC	

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-8

Influent to Sewage/Graywater UV Disinfection Analytical Results, Holland America Oosterdam

Analytical results for the influent to UV disinfection part of the sewage/graywater wastewater treatment system. Influent to UV disinfection samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for the sample collection methodology. Figure 2-3 identifies sampling point location. Average influent to UV concentrations determined from the daily results.

Analyte	Unit	Influent to Sewage/GW UV (SP-12) (a) Day 1	Influent to Sewage/GW UV (SP-12) (a) Day 2	Influent to Sewage/GW UV (SP-12) (a) Day 3	Influent to Sewage/GW UV (SP-12) (a) Day 4	Influent to Sewage/GW UV (SP-12) (a) Day 5	Average Influent to Sewage/GW UV
Pathogen Indicators							
E. coli (b)	MPN/100 mL	13.9 [N=3]	22.2 [N=3]	141 [N=3]	192 [N=3]	< 22.4 [N=3]	<78.3
Enterococci (b)	MPN/100 mL	24.8 [N=3]	128 [N=3]	> 1,120 [N=3]	408 [N=3]	< 12.1 [N=3]	#338
Fecal Coliform (b)	CFU/100 mL	33.0 [N=3]	30.3 [N=3]	113 [N=3]	294 [N=3]	30.0 [N=3]	100

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-9

Effluent from Sewage/Graywater Treatment System Analytical Results, Holland America Oosterdam

Analytical results for the effluent from sewage/graywater treatment system for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1and A-2 for all analytical results (detected and nondetected). Effluent from treatment system samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for sample collection methodology. Figure 2-3 identifies sampling point location. Average effluent from treatment concentrations determined from the daily results. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Effluent from Sewage/GW Treatment (SP-13) (a) Day 1	Effluent from Sewage/GW Treatment (SP-13) (a) Day 2	Effluent from Sewage/GW Treatment (SP-13) (a) Day 3	Effluent from Sewage/GW Treatment (SP-13) (a) Day 4	Effluent from Sewage/GW Treatment (SP-13) (a) Day 5	Average Effluent from Sewage/GW Treatment (SP-13) (a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		ND(1.00) [N=3]	ND(1.00) [N=3]	ND(1.00) [N=3]	ND(1.00) [N=3]	< 5.07 [N=3]	<1.81
Enterococci (b)	MPN/100 mL		< 1.00 [N=3]	< 1.00 [N=3]	ND(1.00) [N=3]	ND(1.00) [N=3]	< 62.0 [N=3]	<13.2
Fecal Coliform (b)	CFU/100 mL		ND(1.00) [N=3]	ND(1.33) [N=3]	ND(2.00) [N=3]	ND(2.00) [N=3]	ND(2.00) [N=3]	ND(1.67)
Classical Pollutants								
Alkalinity	mg/L		321	436	319	362	338	355
Biochemical Oxygen Demand (BOD_5)	mg/L		3.87	5.89	3.93	4.25	3.18	4.22
Chemical Oxygen Demand (COD) (s)	mg/L		148	112	102	109	123	119
Chloride (s)	mg/L		125	85.0	125	145	142	124
Hardness (e) (s)	mg/L		37.7	34.4	33.0	34.1	32.3	34.3
Hexane Extractable Material (HEM)	mg/L		ND(6.00)	ND(5.00)	ND(5.00)	ND(6.00)	ND(6.00)	ND(5.60)
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0950	0.0160	0.0770	0.0323	0.0590	0.0559
Settleable Residue	mL/L		ND(0.115)	ND(0.120)	ND(0.130)	ND(0.110)	ND(0.103)	ND(0.116)
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(6.00)	ND(5.00)	ND(5.00)	ND(6.00)	ND(6.00)	ND(5.60)
Sulfate (s)	mg/L		43.5	34.9	46.5	53.2	24.9	40.6
Total Dissolved Solids (TDS)	mL/L		470	434	442	493	513	470

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-9 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Sewage/GW Treatment (SP-13) (a) Day 1	Effluent from Sewage/GW Treatment (SP-13) (a) Day 2	Effluent from Sewage/GW Treatment (SP-13) (a) Day 3	Effluent from Sewage/GW Treatment (SP-13) (a) Day 4	Effluent from Sewage/GW Treatment (SP-13) (a) Day 5	Average Effluent from Sewage/GW Treatment (SP-13) (a)
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		4.13	83.2	68.6	72.4	64.0	58.5
Total Organic Carbon (TOC) (s)	mg/L		45.4	36.0	42.2	30.2	33.9	37.5
Total Phosphorus	mg/L		23.7	14.4	11.1	10.7	13.1	14.6
Total Suspended Solids (TSS)	mg/L		ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Total and Dissolved Metals								
Aluminum, Total	ug/L		125	138	76.9	108	111	112
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Total (e) (s)	ug/L		77.2	73.8	76.8	75.9	69.3	74.6
Boron, Total	ug/L		ND(18.0)	ND(18.0)	158	116	132	<88.3
Cadmium, Total	ug/L	P118	0.105	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	<0.0850
Calcium, Total (e) (s)	ug/L		9,580	8,790	8,800	8,960	8,500	8,920
Chromium, Total	ug/L	P119	0.750	0.530	1.92	1.75	1.63	1.32
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	58.7	6.51	5.81	3.49	7.80	16.5
Iron, Total (e) (s)	ug/L		758	749	270	541	901	644
Lead, Total (e) (s)	ug/L	P122	7.56	3.74	2.10	2.10	7.07	4.51
Magnesium, Total (s)	ug/L		3,350	3,020	2,690	2,850	2,690	2,920
Manganese, Total (e) (s)	ug/L		52.7	55.6	14.8	45.1	41.3	41.9
Mercury, Total	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)
Molybdenum, Total	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Total (s)	ug/L	P124	24.7	28.6	25.2	30.1	33.2	28.3

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-9 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Sewage/GW Treatment (SP-13) (a) Day 1	Effluent from Sewage/GW Treatment (SP-13) (a) Day 2	Effluent from Sewage/GW Treatment (SP-13) (a) Day 3	Effluent from Sewage/GW Treatment (SP-13) (a) Day 4	Effluent from Sewage/GW Treatment (SP-13) (a) Day 5	Average Effluent from Sewage/GW Treatment (SP-13) (a)
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	< 2.18	ND(1.40)	ND(1.40)	<1.56
Silver, Total	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium, Total (s)	ug/L		103,000	101,000	106,000	120,000	114,000	109,000
Tin, Total	ug/L		ND(0.940)	ND(0.940)	< 0.993	ND(0.940)	ND(0.940)	<0.951
Titanium, Total	ug/L		ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)
Vanadium, Total	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Total (e) (s)	ug/L	P128	905	568	363	720	1,050	721
Aluminum, Dissolved	ug/L		113	116	78.4	116	161	117
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		70.1	64.7	74.2	80.1	88.6	75.5
Beryllium, Dissolved	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Dissolved (e)	ug/L		137	114	ND(18.0)	ND(18.0)	ND(18.0)	<61.0
Cadmium, Dissolved (e)	ug/L	P118	< 0.105	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	<0.0850
Calcium, Dissolved (s)	ug/L		8,690	7,920	8,170	9,330	10,900	9,000
Chromium, Dissolved	ug/L	P119	1.32	1.24	1.35	1.43	2.02	1.47
Cobalt, Dissolved (s)	ug/L		ND(0.660)	1.60	< 1.46	1.93	3.76	<1.88
Copper, Dissolved (s)	ug/L	P120	53.9	6.33	4.67	3.60	10.5	15.8
Iron, Dissolved (e)	ug/L		781	736	274	507	1,130	685
Lead, Dissolved (e) (s)	ug/L	P122	6.92	5.08	1.71	2.03	7.98	4.74
Magnesium, Dissolved (s)	ug/L		3,050	2,710	2,580	3,000	3,460	2,960

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-9 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Sewage/GW Treatment (SP-13) (a) Day 1	Effluent from Sewage/GW Treatment (SP-13) (a) Day 2	Effluent from Sewage/GW Treatment (SP-13) (a) Day 3	Effluent from Sewage/GW Treatment (SP-13) (a) Day 4	Effluent from Sewage/GW Treatment (SP-13) (a) Day 5	Average Effluent from Sewage/GW Treatment (SP-13) (a)
Manganese, Dissolved (s)	ug/L		49.6	53.2	17.3	50.4	64.7	47.0
Mercury, Dissolved	ug/L	P123	< 0.0555	ND(0.0500)	< 0.0680	ND(0.0500)	0.0950	<0.0637
Nickel, Dissolved (s)	ug/L	P124	24.6	28.7	22.8	29.6	41.2	29.4
Silver, Dissolved	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium, Dissolved (e) (s)	ug/L		103,000	102,000	94,000	117,000	134,000	110,000
Tin, Dissolved	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)
Titanium, Dissolved	ug/L		ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Dissolved (s)	ug/L	P128	849	528	354	687	1,360	755
Volatile and Semivolatile Organics								
4-Chloro-3-methylphenol	ug/L	P022	ND(10.0)	ND(10.0)	ND(24.0)	ND(22.0)	ND(21.0)	ND(17.4)
Bis(2-ethylhexyl) phthalate	ug/L	P066	ND(10.0)	ND(10.0)	ND(24.0)	ND(22.0)	ND(21.0)	ND(17.4)
Chloroform (s)	ug/L	P023	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Diethyl phthalate	ug/L	P070	ND(10.0)	ND(10.0)	ND(24.0)	ND(22.0)	ND(21.0)	ND(17.4)
Phenol (e) (s)	ug/L	P065	48.0	60.0	71.0	69.0	69.0	63.4
Toluene	ug/L	P086	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)

(a) Sampling point location; see Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-10

Sewage/Graywater Treatment System: Performance Data for Pathogen Indicators, Holland America Oosterdam

Pathogen indicators performance data for the Oosterdam's ROCHEM sewage/graywater treatment system. Average analyte concentrations were determined from the daily results presented in Tables 4-7 through 4-9. Percent removals were calculated using the average influent to and effluent from treatment analyte concentrations.

Analyte	Unit	Average Influent to Sewage/GW Treatment Concentration (SP-11) (a)	Average Influent to Sewage/GW UV Disinfection Concentration (SP-12) (a)	Average Effluent from Sewage/GW Treatment Concentration (SP-13) (a)	Percent Removal
Pathogen Indicators					
E. coli	MPN/100 mL	8,480,000	<78.3	<1.81	>99
Enterococci	MPN/100 mL	1,150,000	#338	<13.2	>99
Fecal Coliform	CFU/100 mL	26,900,000	100	ND(1.67)	>99

(a) Sampling point location; see Figure 2-3.
ND - Not detected (number in parentheses is detection limit).
< - Average result reported includes at least one nondetect value (calculation uses detection limit for nondetected results.).
> - Indicates a minimum level of removal.
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-11

Sewage/Graywater Treatment System: Performance Data for Analytes Other than Pathogen Indicators, Holland America Oosterdam

Performance data for the Oosterdam's ROCHEM sewage/graywater Reverse Osmosis treatment system for analytes other than pathogen indicators detected in either the influent to or effluent from sewage/graywater treatment. Range and average analyte concentrations were determined from the daily results presented in Tables 4-7 and 4-9. Percent removals were calculated using the average sewage/graywater influent and effluent analyte concentrations. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Average Influent to Sewage/GW Treatment Concentration (SP-11) (a)	Influent to Sewage/GW Treatment Concentration Range (SP-11) (a)	Average Effluent from Sewage/GW Treatment Concentration (SP-13) (a)	Effluent from Sewage/GW Treatment Concentration Range (SP-13) (a)	Percent Removal
Classical Pollutants							
Alkalinity	mg/L		558	508 - 650	355	319 - 436	36
Biochemical Oxygen Demand (BOD_5)	mg/L		888	690 - 1,380	4.22	3.18 - 5.89	> 99
Chemical Oxygen Demand (COD) (s)	mg/L		2,220	1,800 - 2,830	119	102 - 148	95
Chloride (s)	mg/L		127	95.0 - 145	124	85.0 - 145	2.1
Hardness (e) (s)	mg/L		43.3	28.5 - 51.8	34.3	32.3 - 37.7	21
Hexane Extractable Material (HEM)	mg/L		59.4	48.0 - 85.0	ND(5.60)	ND(5.00) - ND(6.00)	> 91
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0268	0.0160 - 0.0370	0.0559	0.0160 - 0.0950	NC
Settleable Residue	mL/L		<22.2	ND(0.130) - 51.0	ND(0.116)	ND(0.103) - ND(0.130)	> 99
Silica Gel Treated HEM (SGT-HEM)	mg/L		7.00	6.00 - 8.00	ND(5.60)	ND(5.00) - ND(6.00)	> 20
Sulfate (s)	mg/L		123	96.5 - 153	40.6	24.9 - 53.2	67
Total Dissolved Solids (TDS)	mg/L		718	596 - 842	470	434 - 513	34
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		193	182 - 200	58.5	4.13 - 83.2	70
Total Organic Carbon (TOC) (s)	mg/L		265	225 - 302	37.5	30.2 - 45.4	86
Total Phosphorus	mg/L		24.7	20.9 - 31.8	14.6	10.7 - 23.7	41
Total Suspended Solids (TSS)	mg/L		727	560 - 1,110	ND(5.00)	ND(5.00)	> 99

(a) Sampling point location; see Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-11 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to Sewage/GW Treatment Concentration (SP-11) (a)	Influent to Sewage/GW Treatment Concentration Range (SP-11) (a)	Average Effluent from Sewage/GW Treatment Concentration (SP-13) (a)	Effluent from Sewage/GW Treatment Concentration Range (SP-13) (a)	Percent Removal
Total and Dissolved Metals							
Aluminum, Total	ug/L		1,330	847 - 1,630	112	76.9 - 138	92
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	NC
Barium, Total (e) (s)	ug/L		264	185 - 318	74.6	69.3 - 77.2	72
Boron, Total	ug/L		<54.7	ND(18.0) - 121	<88.3	ND(18.0) - 158	NC
Cadmium, Total	ug/L	P118	0.394	0.220 - 0.520	<0.0850	ND(0.0800) - 0.105	78
Calcium, Total (e) (s)	ug/L		11,000	6,870 - 13,900	8,920	8,500 - 9,580	19
Chromium, Total	ug/L	P119	8.44	4.52 - 12.6	1.32	0.530 - 1.92	84
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	NC
Copper, Total (e) (s)	ug/L	P120	451	372 - 542	16.5	3.49 - 58.7	96
Iron, Total (e) (s)	ug/L		1,250	820 - 1,560	644	270 - 901	48
Lead, Total (e) (s)	ug/L	P122	10.0	7.85 - 13.4	4.51	2.10 - 7.56	55
Magnesium, Total (s)	ug/L		3,820	2,760 - 4,150	2,920	2,690 - 3,350	24
Manganese, Total (e) (s)	ug/L		60.0	44.1 - 68.8	41.9	14.8 - 55.6	30
Mercury, Total	ug/L	P123	0.220	0.190 - 0.260	ND(0.0500)	ND(0.0500)	> 77
Molybdenum, Total	ug/L		<1.91	ND(1.60) - 2.43	ND(1.60)	ND(1.60)	> 16
Nickel, Total (s)	ug/L	P124	27.9	20.9 - 35.5	28.3	24.7 - 33.2	NC
Selenium, Total	ug/L	P125	<2.27	ND(1.40) - 2.99	<1.56	ND(1.40) - <2.18	31
Silver, Total	ug/L	P126	2.91	1.24 - 5.28	ND(0.770)	ND(0.770)	> 74
Sodium, Total (s)	ug/L		85,100	61,900 - 103,000	109,000	101,000 - 120,000	NC
Tin, Total	ug/L		7.56	5.20 - 8.83	<0.951	ND(0.940) - <0.993	87

(a) Sampling point location; see Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-11 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to Sewage/GW Treatment Concentration (SP-11) (a)	Influent to Sewage/GW Treatment Concentration Range (SP-11) (a)	Average Effluent from Sewage/GW Treatment Concentration (SP-13) (a)	Effluent from Sewage/GW Treatment Concentration Range (SP-13) (a)	Percent Removal
Titanium, Total	ug/L		3.02	2.38 - 3.63	ND(0.620)	ND(0.620)	> 79
Vanadium, Total	ug/L		<1.16	ND(0.470) - 1.64	ND(0.470)	ND(0.470)	> 59
Zinc, Total (e) (s)	ug/L	P128	1,790	1,000 - 3,190	721	363 - 1,050	60
Aluminum, Dissolved	ug/L		332	235 - 464	117	78.4 - 161	65
Antimony, Dissolved	ug/L	P114	<2.16	ND(2.00) - 2.78	ND(2.00)	ND(2.00)	> 7.2
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	NC
Barium, Dissolved (e) (s)	ug/L		81.3	59.4 - 100	75.5	64.7 - 88.6	7.1
Beryllium, Dissolved	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	NC
Boron, Dissolved (e)	ug/L		<58.4	ND(18.0) - 129	<61.0	ND(18.0) - 137	NC
Cadmium, Dissolved (e)	ug/L	P118	ND(0.0800)	ND(0.0800)	<0.0850	ND(0.0800) - <0.105	NC
Calcium, Dissolved (s)	ug/L		4,970	3,080 - 6,360	9,000	7,920 - 10,900	NC
Chromium, Dissolved	ug/L	P119	2.88	1.83 - 4.11	1.47	1.24 - 2.02	49
Cobalt, Dissolved (s)	ug/L		11.5	5.46 - 23.3	<1.88	ND(0.660) - 3.76	84
Copper, Dissolved (s)	ug/L	P120	110	56.6 - 153	15.8	3.60 - 53.9	86
Iron, Dissolved (e)	ug/L		901	550 - 1,230	685	274 - 1,130	24
Lead, Dissolved (e) (s)	ug/L	P122	2.56	1.41 - 3.22	4.74	1.71 - 7.98	NC
Magnesium, Dissolved (s)	ug/L		3,390	2,800 - 3,930	2,960	2,580 - 3,460	13
Manganese, Dissolved (s)	ug/L		68.6	33.0 - 96.3	47.0	17.3 - 64.7	31
Mercury, Dissolved	ug/L	P123	<0.0524	ND(0.0500) - 0.0570	<0.0637	ND(0.0500) - 0.0950	NC
Nickel, Dissolved (s)	ug/L	P124	27.8	21.1 - 33.3	29.4	22.8 - 41.2	NC
Silver, Dissolved	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	NC

(a) Sampling point location; see Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-11 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to Sewage/GW Treatment Concentration (SP-11) (a)	Influent to Sewage/GW Treatment Concentration Range (SP-11) (a)	Average Effluent from Sewage/GW Treatment Concentration (SP-13) (a)	Effluent from Sewage/GW Treatment Concentration Range (SP-13) (a)	Percent Removal
Sodium, Dissolved (e) (s)	ug/L		96,800	84,100 - 107,000	110,000	94,000 - 134,000	NC
Tin, Dissolved	ug/L		2.54	2.19 - 2.94	ND(0.940)	ND(0.940)	> 63
Titanium, Dissolved	ug/L		<0.786	ND(0.620) - 0.960	ND(0.620)	ND(0.620)	> 21
Vanadium, Dissolved	ug/L		0.620	0.490 - 0.760	ND(0.470)	ND(0.470)	> 24
Zinc, Dissolved (s)	ug/L	P128	521	409 - 644	755	354 - 1,360	NC
Volatile and Semivolatile Organics							
4-Chloro-3-methylphenol	ug/L	P022	ND(11.2)	ND(10.0) - ND(13.0)	ND(17.4)	ND(10.0) - ND(24.0)	NC
Bis(2-ethylhexyl) phthalate	ug/L	P066	56.4	45.0 - 94.0	ND(17.4)	ND(10.0) - ND(24.0)	> 69
Chloroform (s)	ug/L	P023	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	NC
Diethyl phthalate	ug/L	P070	ND(11.2)	ND(10.0) - ND(13.0)	ND(17.4)	ND(10.0) - ND(24.0)	NC
Phenol (e) (s)	ug/L	P065	94.4	60.0 - 150	63.4	48.0 - 71.0	33
Toluene	ug/L	P086	<6.00	ND(5.00) - 7.00	ND(5.00)	ND(5.00)	> 17

(a) Sampling point location; see Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-12

Final Combined Treated Effluent, Holland America Oosterdam

Analytical results for the final combined treated effluent (graywater and sewage/graywater treatment effluents combined for overboard discharge) for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1 and A-2 for all analytical results (detected and nondetected). Final combined treated effluent samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for the sample collection methodology. Average final combined effluent concentrations determined from the daily results. Priority pollutants (designated by EPA in CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Final Combined Discharge (SP-16) (a) Day 1	Final Combined Discharge (SP-16) (a) Day 2	Final Combined Discharge (SP-16) (a) Day 3	Final Combined Discharge (SP-16) (a) Day 4	Final Combined Discharge (SP-16) (a) Day 5	Average Final Combined Discharge (SP-16) (a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		< 25.3 [N=2]	< 3.43 [N=3]	ND(1.00) [N=3]	ND(1.00) [N=3]	ND(1.00) [N=3]	<6.35
Enterococci (b)	MPN/100 mL		6.45 [N=2]	< 1.00 [N=3]	ND(1.00) [N=3]	ND(1.00) [N=3]	< 1.00 [N=3]	<2.09
Fecal Coliform (b)	CFU/100 mL		ND(1.00) [N=2]	< 1.67 [N=3]	ND(2.00) [N=3]	< 2.00 [N=3]	ND(2.00) [N=3]	<1.73
Classical Pollutants								
Alkalinity	mg/L		161	146	138	98.4	155	140
Biochemical Oxygen Demand (BOD_5)	mg/L		17.5	19.8	17.0	18.9	15.0	17.6
Chemical Oxygen Demand (COD) (s)	mg/L		129	74.0	80.0	75.0	86.0	88.8
Chloride (s)	mg/L		595	75.0	75.0	475	45.0	253
Hardness (e) (s)	mg/L		114	24.3	20.1	113	18.8	58.0
Hexane Extractable Material (HEM)	mg/L		ND(6.00)	ND(5.00)	ND(6.00)	ND(6.00)	ND(6.00)	ND(5.80)
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0630	0.0790	0.0690	0.0170	0.0560	0.0568
Settleable Residue	mL/L		ND(0.110)	ND(0.100)	ND(0.110)	ND(0.110)	ND(0.110)	ND(0.108)
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(6.00)	ND(5.00)	ND(6.00)	ND(6.00)	ND(6.00)	ND(5.80)

(a) Sampling point location; see Figure 2-2 and Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-12 (Continued)

Analyte	Unit	Priority Pollutant Code	Final Combined Discharge (SP-16) (a) Day 1	Final Combined Discharge (SP-16) (a) Day 2	Final Combined Discharge (SP-16) (a) Day 3	Final Combined Discharge (SP-16) (a) Day 4	Final Combined Discharge (SP-16) (a) Day 5	Average Final Combined Discharge (SP-16) (a)
Sulfate (s)	mg/L		89.2	16.6	20.0	68.4	23.2	43.5
Total Dissolved Solids (TDS)	mg/L		1,190	256	259	998	257	592
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		2.94	22.0	0.840	0.460	31.4	11.5
Total Organic Carbon (TOC) (s)	mg/L		21.7	20.7	19.5	12.6	21.9	19.3
Total Phosphorus	mg/L		3.61	4.06	31.6	2.82	6.31	9.68
Total Suspended Solids (TSS)	mg/L		ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Total and Dissolved Metals								
Aluminum, Total	ug/L		ND(8.80)	ND(8.80)	27.6	30.5	66.0	<28.3
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Total (e) (s)	ug/L		48.7	30.1	29.9	18.8	42.4	34.0
Boron, Total	ug/L		159	ND(18.0)	88.8	146	101	<103
Cadmium, Total	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Total (e) (s)	ug/L		10,400	3,770	3,580	8,470	4,180	6,080
Chromium, Total	ug/L	P119	ND(0.270)	ND(0.270)	0.810	0.340	0.900	<0.518
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	8.59	6.14	6.62	4.33	15.5	8.24
Iron, Total (e) (s)	ug/L		332	284	194	114	525	290
Lead, Total (e) (s)	ug/L	P122	ND(0.620)	ND(0.620)	1.30	ND(0.620)	3.95	<1.42
Magnesium, Total (s)	ug/L		21,300	3,620	2,710	22,400	2,020	10,400
Manganese, Total (e) (s)	ug/L		22.4	19.8	8.22	7.32	21.9	15.9

(a) Sampling point location; see Figure 2-2 and Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-12 (Continued)

Analyte	Unit	Priority Pollutant Code	Final Combined Discharge (SP-16) (a) Day 1	Final Combined Discharge (SP-16) (a) Day 2	Final Combined Discharge (SP-16) (a) Day 3	Final Combined Discharge (SP-16) (a) Day 4	Final Combined Discharge (SP-16) (a) Day 5	Average Final Combined Discharge (SP-16) (a)
Mercury, Total	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	0.0510	0.0510	<0.0504
Molybdenum, Total	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Total (s)	ug/L	P124	10.4	9.88	12.3	6.76	17.6	11.4
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)
Silver, Total	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium, Total (s)	ug/L		196,000	61,800	61,100	219,000	64,900	121,000
Tin, Total	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)
Titanium, Total	ug/L		ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)
Vanadium, Total	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Total (e) (s)	ug/L	P128	454	335	295	326	662	414
Aluminum, Dissolved	ug/L		ND(8.80)	ND(8.80)	ND(8.80)	ND(8.80)	73.8	<21.8
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		44.9	28.3	30.3	22.7	41.9	33.6
Beryllium, Dissolved	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Dissolved (e)	ug/L		204	93.6	135	181	ND(18.0)	<126
Cadmium, Dissolved (e)	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Dissolved (s)	ug/L		12,700	3,760	3,830	9,910	4,210	6,880
Chromium, Dissolved	ug/L	P119	0.360	0.390	0.440	0.280	0.290	0.352
Cobalt, Dissolved (s)	ug/L		ND(0.660)	1.13	1.67	2.47	1.85	<1.56
Copper, Dissolved (s)	ug/L	P120	4.90	5.77	6.17	2.03	10.2	5.81
Iron, Dissolved (e)	ug/L		292	296	167	82.9	412	250

(a) Sampling point location; see Figure 2-2 and Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-12 (Continued)

Analyte	Unit	Priority Pollutant Code	Final Combined Discharge (SP-16) (a) Day 1	Final Combined Discharge (SP-16) (a) Day 2	Final Combined Discharge (SP-16) (a) Day 3	Final Combined Discharge (SP-16) (a) Day 4	Final Combined Discharge (SP-16) (a) Day 5	Average Final Combined Discharge (SP-16) (a)
Lead, Dissolved (e) (s)	ug/L	P122	1.72	1.05	0.770	ND(0.620)	2.43	<1.32
Magnesium, Dissolved (s)	ug/L		30,500	3,650	2,940	26,900	2,020	13,200
Manganese, Dissolved (s)	ug/L		21.4	22.2	11.3	12.3	24.2	18.3
Mercury, Dissolved	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	0.0720	0.120	<0.0684
Nickel, Dissolved (s)	ug/L	P124	10.8	11.8	12.0	7.72	16.1	11.7
Silver, Dissolved	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium, Dissolved (e) (s)	ug/L		283,000	68,700	62,000	246,000	61,200	144,000
Tin, Dissolved	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)
Titanium, Dissolved	ug/L		ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Dissolved (s)	ug/L	P128	322	299	284	222	573	340
Volatile and Semivolatile Organics								
4-Chloro-3-methylphenol	ug/L	P022	ND(10.0)	ND(20.0)	ND(22.0)	ND(22.0)	ND(22.0)	ND(19.2)
Bis(2-ethylhexyl) phthalate	ug/L	P066	ND(10.0)	ND(20.0)	ND(22.0)	ND(22.0)	ND(22.0)	ND(19.2)
Chloroform (s)	ug/L	P023	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Diethyl phthalate	ug/L	P070	ND(10.0)	ND(20.0)	ND(22.0)	ND(22.0)	ND(22.0)	ND(19.2)
Phenol (e) (s)	ug/L	P065	66.0	40.0	72.0	49.0	38.0	53.0
Toluene	ug/L	P086	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)

(a) Sampling point location; see Figure 2-2 and Figure 2-3.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2. and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-13

Treatment System Residuals and Incinerator Ash Analytical Results, Holland America Oosterdam

Analytical results for one-time grab samples of treatment system residuals (i.e., graywater screening solids, sewage/graywater screening solids, and sewage/graywater waste biosludge) and incinerator ash for analytes detected at least once in these samples. See Appendix A-2 for all analytical results (detected and nondetected). Figures 2-2 and 2-3 identify sampling point locations. See Table 3-2 for sample collection methodology. Also shown are average concentrations for the influents to the graywater and sewage/graywater treatment concentrations from Tables 4-2 and 4-7 for comparison. Certain treatment system residual results were converted from mass to volume units; see Section 3.3. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Priority Pollutant Code	Incinerator Ash (SP-10) (a)	Graywater Screening Solids (SP-15) (a)	Average Influent to GW Treatment (SP-6) (a)	Sewage/GW Screening Solids (SP-16) (a)	Sewage/GW Biosludge (SP-21) (a)	Average Influent to Sewage/GW Treatment (SP-11) (a)
Classical Pollutants							
Alkalinity		NC	1,130 mg/L	43.5 mg/L	ND(1,000) mg/L	ND(1,000) mg/L	558 mg/L
Chemical Oxygen Demand (COD) (s)		NC	15,200 mg/L	405 mg/L	2,390 mg/L	332 mg/L	2,220 mg/L
Chloride (s)		NC	79.8 mg/L	18.6 mg/L	97.4 mg/L	251 mg/L	127 mg/L
Nitrate/Nitrite (NO2-N + NO3-N) (s)		NC	2.20 mg/L	0.0360 mg/L	1.41 mg/L	8.33 mg/L	0.0268 mg/L
Sulfate (s)		NC	486 mg/L	10.8 mg/L	498 mg/L	1,600 mg/L	123 mg/L
Total Kjeldahl Nitrogen (TKN) (s)		NC	733 mg/L	9.08 mg/L	9.87 mg/L	1,260 mg/L	193 mg/L
Total Organic Carbon (TOC) (s)		NC	9,960 mg/L	53.4 mg/L	756 mg/L	4,060 mg/L	265 mg/L
Total Phosphorus		NC	53.0 mg/L	1.70 mg/L	15.8 mg/L	192 mg/L	24.7 mg/L
Total and Dissolved Metals							
Aluminum, Total		43,500 mg/kg	131,000 ug/L	744 ug/L	3,590 ug/L	22,400 ug/L	1,330 ug/L
Antimony, Total	P114	6.92 mg/kg	260 ug/L	ND(2.00) ug/L	ND(0.00630) ug/L	ND(0.00420) ug/L	ND(2.00) ug/L
Arsenic, Total	P115	4.37 mg/kg	ND(0.0771) ug/L	ND(2.00) ug/L	9.87 ug/L	5.60 ug/L	ND(2.00) ug/L
Barium, Total (s)		427 mg/kg	49,600 ug/L	135 ug/L	1,010 ug/L	3,790 ug/L	264 ug/L
Beryllium, Total	P117	0.350 mg/kg	ND(0.00257) ug/L	ND(0.0700) ug/L	ND(0.000210) ug/L	ND(0.000140) ug/L	ND(0.0700) ug/L

(a) Sampling point location; see Figure 2-2 and Figure 2-3.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-13 (Continued)

Analyte	Priority Pollutant Code	Incinerator Ash (SP-10) (a)	Graywater Screening Solids (SP-15) (a)	Average Influent to GW Treatment (SP-6) (a)	Sewage/GW Screening Solids (SP-16) (a)	Sewage/GW Biosludge (SP-21) (a)	Average Influent to Sewage/GW Treatment (SP-11) (a)
Boron, Total		324 mg/kg	ND(0.118) ug/L	<29.3 ug/L	676 ug/L	626 ug/L	<54.7 ug/L
Cadmium, Total	P118	0.330 mg/kg	23.9 ug/L	ND(0.0800) ug/L	2.52 ug/L	7.00 ug/L	0.394 ug/L
Calcium, Total (s)		179,000 mg/kg	568,000 ug/L	1,680 ug/L	44,300 ug/L	103,000 ug/L	11,000 ug/L
Chromium, Total	P119	71.7 mg/kg	3,060 ug/L	5.25 ug/L	134 ug/L	253 ug/L	8.44 ug/L
Cobalt, Total		18.2 mg/kg	ND(0.0103) ug/L	ND(0.660) ug/L	ND(0.000840) ug/L	ND(0.000560) ug/L	ND(0.660) ug/L
Copper, Total (s)	P120	920 mg/kg	33,200 ug/L	213 ug/L	1,090 ug/L	6,900 ug/L	451 ug/L
Iron, Total (s)		8,530 mg/kg	272,000 ug/L	374 ug/L	4,310 ug/L	13,800 ug/L	1,250 ug/L
Lead, Total (s)	P122	14.2 mg/kg	1,600 ug/L	7.38 ug/L	3.19 ug/L	153 ug/L	10.0 ug/L
Magnesium, Total (s)		8,900 mg/kg	37,500 ug/L	471 ug/L	6,740 ug/L	32,800 ug/L	3,820 ug/L
Manganese, Total (s)		450 mg/kg	1,720 ug/L	7.85 ug/L	170 ug/L	554 ug/L	60.0 ug/L
Mercury, Total	P123	ND(0.0200) mg/kg	8,740 ug/L	<0.0580 ug/L	ND(0.000420) ug/L	3.50 ug/L	0.220 ug/L
Molybdenum, Total		15.5 mg/kg	414 ug/L	ND(1.60) ug/L	20.6 ug/L	55.9 ug/L	<1.91 ug/L
Nickel, Total (s)	P124	97.4 mg/kg	3,340 ug/L	17.1 ug/L	101 ug/L	192 ug/L	27.9 ug/L
Selenium, Total	P125	ND(0.230) mg/kg	170 ug/L	ND(1.40) ug/L	7.35 ug/L	37.5 ug/L	<2.27 ug/L
Silver, Total	P126	18.0 mg/kg	1,430 ug/L	<1.37 ug/L	12.4 ug/L	55.4 ug/L	2.91 ug/L
Sodium, Total (s)		30,800 mg/kg	504,000 ug/L	21,300 ug/L	125,000 ug/L	137,000 ug/L	85,100 ug/L
Tin, Total		29.3 mg/kg	ND(0.0925) ug/L	<2.46 ug/L	288 ug/L	339 ug/L	7.56 ug/L
Titanium, Total		2,660 mg/kg	1,370 ug/L	2.04 ug/L	ND(0.0298) ug/L	153 ug/L	3.02 ug/L
Vanadium, Total		96.6 mg/kg	910 ug/L	<0.696 ug/L	8.40 ug/L	32.8 ug/L	<1.16 ug/L
Yttrium, Total		2.73 mg/kg	ND(0.0154) ug/L	ND(0.310) ug/L	ND(0.00126) ug/L	1.11 ug/L	ND(0.310) ug/L
Zinc, Total (e) (s)	P128	572 mg/kg	177,000 ug/L	791 ug/L	4,050 ug/L	21,400 ug/L	1,790 ug/L

(a) Sampling point location; see Figure 2-2 and Figure 2-3.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-13 (Continued)

Analyte	Priority Pollutant Code	Incinerator Ash (SP-10) (a)	Graywater Screening Solids (SP-15) (a)	Average Influent to GW Treatment (SP-6) (a)	Sewage/GW Screening Solids (SP-16) (a)	Sewage/GW Biosludge (SP-21) (a)	Average Influent to Sewage/GW Treatment (SP-11) (a)
Volatile and Semivolatile Organics							
Bis(2-ethylhexyl) phthalate	P066	ND(170) ug/kg	20,100 ug/L	<15.0 ug/L	ND(168) ug/L	59.0 ug/L	56.4 ug/L
Chloroform (s)	P023	NC	5.74 ug/L	ND(5.00) ug/L	ND(4.92) ug/L	ND(0.0700) ug/L	ND(5.00) ug/L
Ethylbenzene	P038	NC	13.1 ug/L	ND(5.00) ug/L	ND(4.92) ug/L	ND(0.0700) ug/L	ND(5.00) ug/L
Phenol (e) (s)	P065	250 ug/kg	ND(8,370) ug/L	49.4 ug/L	ND(168) ug/L	380 ug/L	94.4 ug/L
Toluene	P086	NC	19.1 ug/L	<5.20 ug/L	21.7 ug/L	ND(0.0700) ug/L	<6.00 ug/L
Dioxins and Furans							
1,2,3,4,6,7,8-HpCDF		6.00 pg/g	NC	NC	NC	NC	NC
1,2,3,4,7,8-HxCDF		5.20 pg/g	NC	NC	NC	NC	NC
2,3,7,8-TCDF		5.70 pg/g	NC	NC	NC	NC	NC
Octachlorodibenzo-p-dioxin		12.5 pg/g	NC	NC	NC	NC	NC

(a) Sampling point location; see Figure 2-2 and Figure 2-3.
(s) Analyte detected at some level in the source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-14

Source Water Analytical Results, Holland America Oosterdam

Analytical results for one-time grab sample of source water for detected analytes. See Appendix A-2 for all analytical results (detected and nondetected). Also shown are Federal drinking water standards for comparison. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Source Water (SP-17) (a) Day 2	Federal Drinking Water Standards (b)
Classical Pollutants				
Chemical Oxygen Demand (COD)	mg/L		28.0	
Chloride	mg/L		4.40	250
Hardness	mg/L		2.91	
Nitrate/Nitrite (NO2-N + NO3-N)	mg/L		0.0160	10 (Nitrate) 1 (Nitrite)
Sulfate	mg/L		13.9	250
Total Kjeldahl Nitrogen (TKN)	mg/L		0.320	
Total Organic Carbon (TOC)	mg/L		1.05	
Total and Dissolved Metals				
Barium, Total	ug/L		185	2,000
Calcium, Total	ug/L		1,000	
Copper, Total	ug/L	P120	193	1,300
Iron, Total	ug/L		118	300
Lead, Total	ug/L	P122	42.8	0
Magnesium, Total	ug/L		96.8	
Manganese, Total	ug/L		2.67	50
Nickel, Total	ug/L	P124	66.0	
Sodium, Total	ug/L		6,640	
Zinc, Total	ug/L	P128	1,140	5,000
Barium, Dissolved	ug/L		181	
Calcium, Dissolved	ug/L		912	
Cobalt, Dissolved	ug/L		2.30	
Copper, Dissolved	ug/L	P120	14.0	
Lead, Dissolved	ug/L	P122	0.790	

(a) Sampling point number; see Table 2-1.
(b) 40 CFR 141.62 National Primary Maximum Contaminant Levels for Inorganic Contaminants (nitrate/nitrite, barium); 40 CFR 141.51 National Primary Maximum Contaminant Level Goals for Inorganic Contaminants (copper, lead); and 40 CFR 143.3 Secondary Maximum Contaminant Levels (chloride, sulfate, iron, manganese, zinc).

Table 4-14 (Continued)

Analyte	Unit	Priority Pollutant Code	Source Water (SP-17) (a) Day 2	Federal Drinking Water Standards (b)
Magnesium, Dissolved	ug/L		92.9	
Manganese, Dissolved	ug/L		4.09	
Nickel, Dissolved	ug/L	P124	3.62	
Sodium, Dissolved	ug/L		3,880	
Zinc, Dissolved	ug/L	P128	24.9	
Volatile and Semivolatile Organics				
Chloroform	ug/L	P023	24.0	
Phenol	ug/L	P065	58.0	

(a) Sampling point number; see Table 2-1.
(b) 40 CFR 141.62 National Primary Maximum Contaminant Levels for Inorganic Contaminants (nitrate/nitrite, barium); 40 CFR 141.51 National Primary Maximum Contaminant Level Goals for Inorganic Contaminants (copper, lead); and 40 CFR 143.3 Secondary Maximum Contaminant Levels (chloride, sulfate, iron, manganese, zinc).

Table 4-15

Flow Data by Sampling Period, Holland America Oosterdam

Flow data collected via strap-on ultrasonic flow meters installed by the sampling team. Figures 2-1 through 2-3 show the flow meter locations. Flow per capita was calculated by dividing the daily flow totals by the number of passengers and crew (2,625 people) onboard the Oosterdam during the sampling episode. Daily flow per capita was not calculated for accommodations because accommodations wastewater flows were measured for only one of six accommodations wastewater holding tanks.

Sampling Period	Total Daily Flow (m^3)										
	Accommodations (SP-1)(a)	Influent to Graywater Treatment System (SP-6)(a)		Effluent from Graywater Treatment System (SP-8)(a)		Influent to Sewage/Graywater Treatment System (SP-11)(a)		Effluent from Sewage/Graywater Treatment (SP-13)(a)		Final Combined Treated Effluent (SP-16)(a)	
	Daily Total Flow, gallons/day (m^3/day)	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita gallons/ day/person (m^3/day/ person)	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita gallons/ day/person (m^3/day/person)	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita gallons/ day/person (m^3/day/person)	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita gallons/ day/person (m^3/day/person)	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita gallons/ day/person (m^3/day/ person)
Day 1	4,040 (15.3)	75,700 (287)	28.8 (0.109)	43,600 (165)	16.6 (0.0629)	65,700 (249)	25.0 (0.0947)	43,900 (166)	16.7 (0.0633)	35,500 (134) (b)	13.5 (0.0512) (b)
Day 2	5,190 (19.7)	84,300 (319)	32.1 (0.122)	61,000 (231)	23.2 (0.0880)	66,400 (251)	25.3 (0.0957)	44,200 (167)	16.9 (0.0638)	106,000 (400)	40.3 (0.152)
Day 3	1,830 (6.92)	78,500 (297)	29.9 (0.113)	56,000 (212)	21.3 (0.0808)	62,500 (237)	23.8 (0.0902)	41,600 (158)	15.9 (0.0600)	114,000 (430)	43.3 (0.164)
Day 4	2,600 (9.84)	78,100 (296)	29.8 (0.113)	NR	NC	53,100 (201)	20.2 (0.0766)	36,500 (138)	13.9 (0.0526)	89,600 (339) (b)	34.1 (0.129) (b)
Day 5	4,230 (16.0)	88,900 (337)	33.9 (0.128)	NR	NC	52,700 (200)	20.1 (0.0760)	40,600 (154)	15.5 (0.0585)	137,000 (519)	52.3 (0.198)
Average	3,580 (13.5)	81,000 (307)	30.9 (0.117)	53,600 (203)	20.4 (0.0774)	60,100 (227)	22.9 (0.0867)	41,400 (157)	15.8 (0.0597)	119,000 (450) (b)	45.3 (0.171) (b)

(a) Sampling point number; see Figures 2-1 through 2-3.
(b) Average daily discharge flow rate for final combined treated effluent excludes data from Day 1 and 4 when the Oosterdam suspended discharge while in Washington waters and while cruising Hubbard Glacier.
NC - Not calculated.
NR - Not recorded, see Section 4.3.

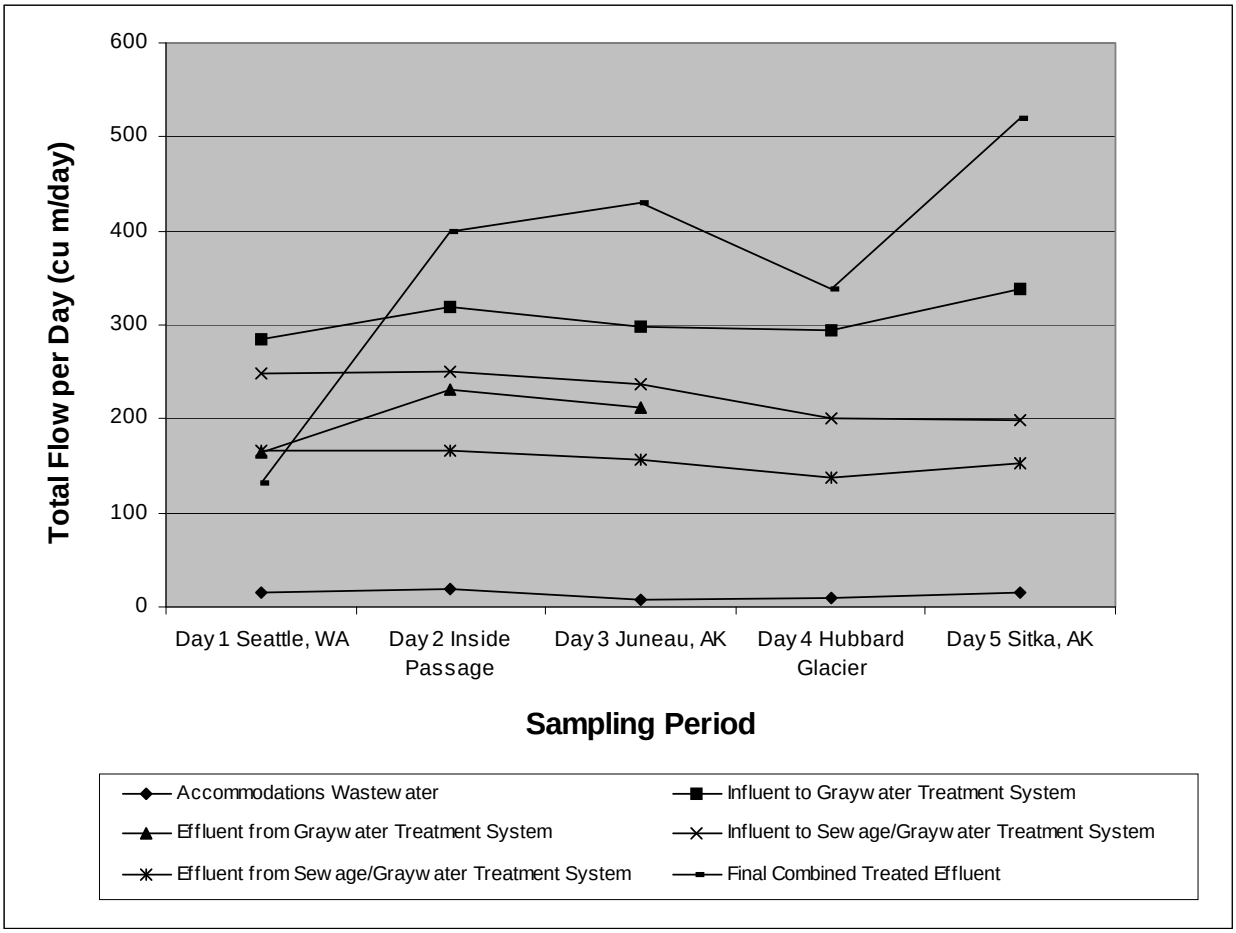

Figure 4-1. Total Daily Flow, Holland America Oosterdam

Flow data collected via strap-on ultrasonic flow meters installed by the sampling team. Flow data are presented as daily totals for each location. Figures 2-1 through 2-3 show the flow meter locations.

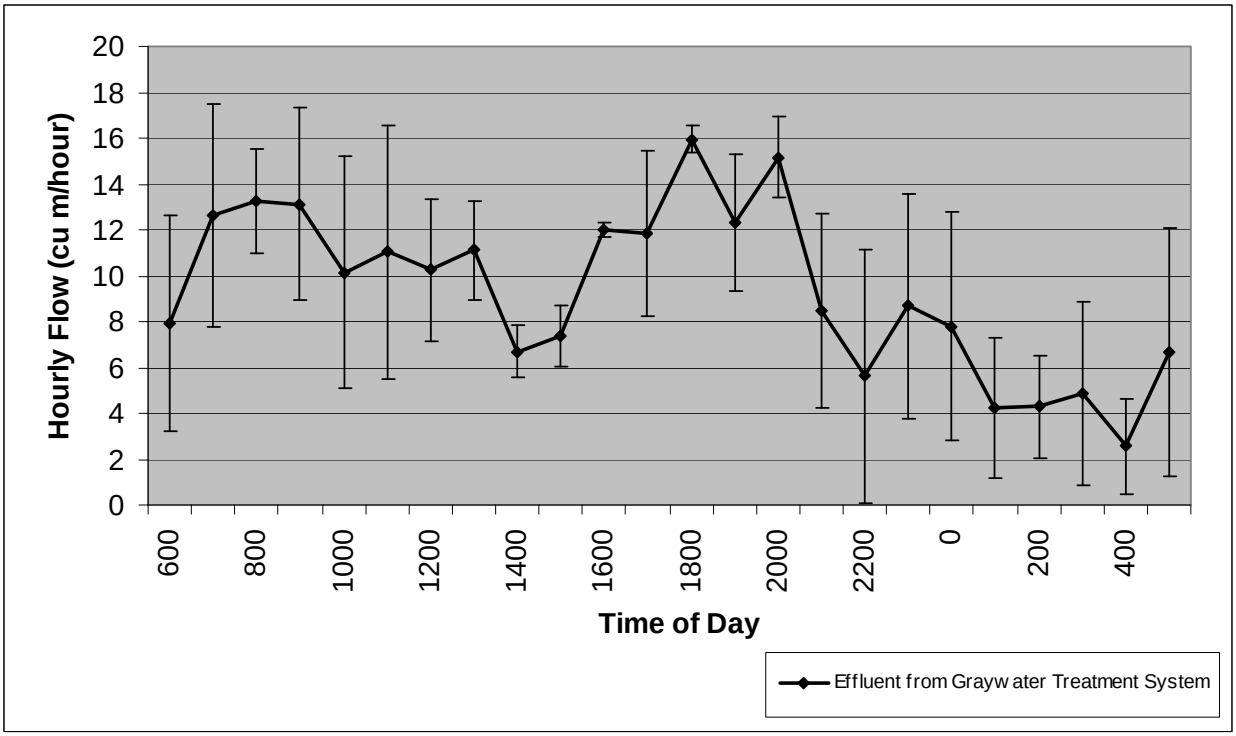

Figure 4-2. Average Hourly Graywater Treatment System Flow, Holland America Oosterdam

Average effluent flow for each hour interval over the three consecutive 24-hour sampling periods, calculated and plotted from the strap-on flow meter installed by the sampling team. Figure 2-2 shows the flow meter location. Bars represent the standard error of the hourly flow calculated for the three consecutive sampling days. Standard error is calculated as the standard deviation divided by the square root of the number of hourly flow measurements (three).

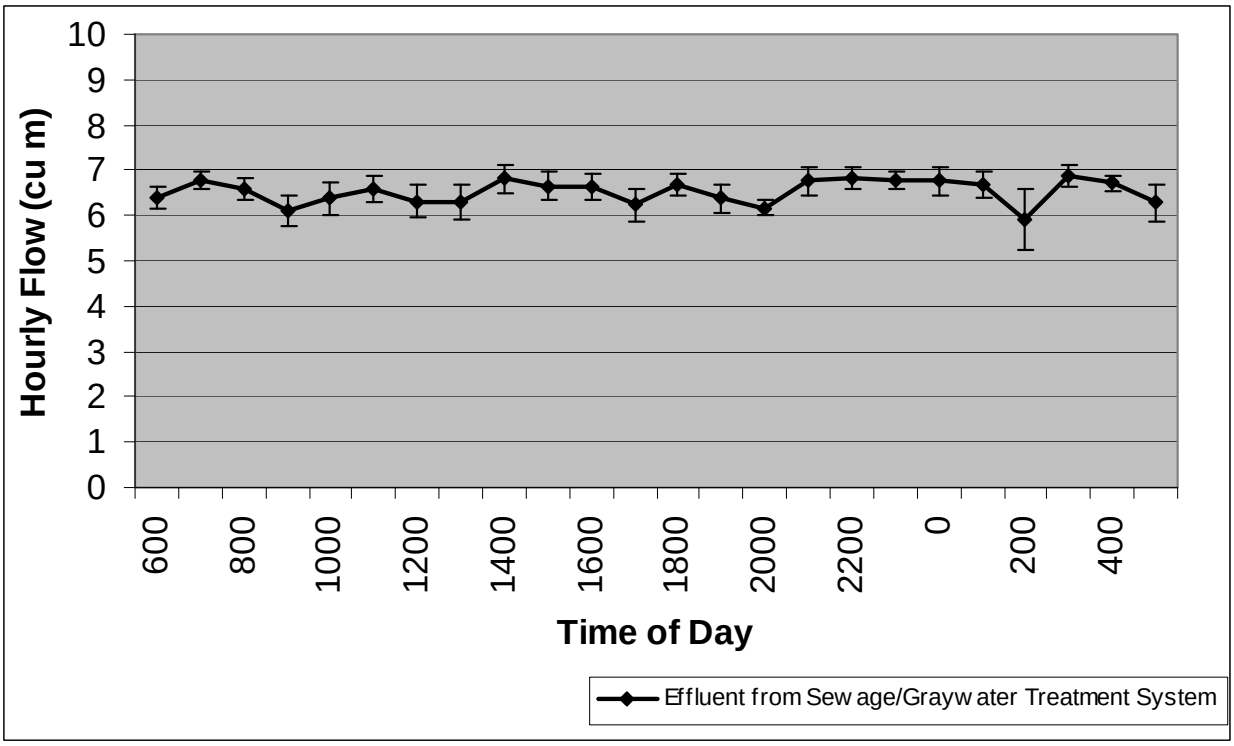

Figure 4-3. Average Hourly Sewage/Graywater Treatment System Flow, Holland America Oosterdam

Average effluent flow for each hour interval over the five consecutive 24-hour sampling periods, calculated and plotted from the strap-on flow meter installed by the sampling team. Figure 2-1 shows the flow meter location. Bars represent the standard error of the hourly flow calculated for the five consecutive sampling days. Standard error is calculated as the standard deviation divided by the square root of the number of hourly flow measurements (five).

5.0 DATA QUALITY

Quality assurance/quality control (QA/QC) procedures applicable to the Oosterdam sampling episode are outlined in the *Quality Assurance Project Plan for Rulemaking Support for Large Cruise Ships in Alaska Waters (QAPP)*, which is included in the Cruise Ship Rulemaking Record and is available upon request. This section describes the quality control practices used to assess the precision and accuracy of the analytical data presented in Section 4.0. Quality control (QC) practices used for this sampling episode include the analysis of matrix spikes, duplicate samples, and quality control standard checks.

5.1 Analytical Quality Control

EPA verified that laboratory performance was acceptable by conducting quality checks of the analytical data as specified by the QAPP. Data review chemists prepared written data review narratives (Appendix D) describing any qualifications of the analytical data. The following data were not considered to be of acceptable quality for the reasons discussed in Appendix D and were excluded from the data set:

- Three pathogen indicators:
  - *E. coli,* enterococci, and fecal coliform in sample 65861.
- Three volatile and semivolatile organics:
  - 2-chloroethylvinyl ether in samples 65876 and 65960; and
  - 3,3'-dichlorobenzidine and 4-nitrophenol in sample 65960.

5.1.1 Cyanide Results

There was uncertainty regarding the analytical results for available and total cyanide. Although the data have not been excluded from the database, the results are presented in Table 5-1 and not in the analytical results summary tables in Section 4.1. Available cyanide was detected in many samples, while total cyanide was not detected in these samples. In theory, the total cyanide results for any given sample will be greater than the available cyanide results in the same sample. Because it was not possible to determine which analysis was correct, EPA flagged the irreconcilable results in the database to alert users of the presence of such problems (see memoranda *Data Review Narrative for Classical Analyses for the Alaska Cruise Ship Industry Episode 6053* and *Issues Associated with Results for Total Cyanide Versus Available Cyanide* in Appendix D for a complete discussion).

EPA did not identify any known source of cyanide onboard the Oosterdam during its onboard interviews regarding activities that impact wastewater generation.

5.1.2 Ammonia Results

EPA considers the Oosterdam ammonia data to be anomalous because ammonia was either not detected or detected at very low concentrations in all samples of the influent to and effluent from treatment system. Although these data have not been excluded from the database, the results are presented in Table 5-2 and not in the analytical results summary tables in Section 4.1. Ammonia is produced within humans when proteins are digested and used by the body, and excess ammonia is excreted in urine. Therefore, ammonia is expected to be present in combined cruise vessel graywater and sewage. In general, 2004 compliance testing data provided by the U.S. Coast Guard (a total of 25 data points) for treated cruise ship wastewater showed ammonia concentrations generally ranging from 4 mg/L to 110 mg/L, with an average concentration of 31 mg/L; none of the ammonia concentrations were reported as nondetect.

It is important to note that EPA's review of the ammonia data for all four sampling episodes did not reveal any obvious errors. The quality control results from each

laboratory support the results provided and do not suggest any pervasive problems with the analyses (i.e., matrix spike recoveries and ongoing precision and recovery results were well within the acceptance limits, blanks were free of ammonia at the levels of interest). The Veendam and the Island ammonia were analyzed by a different laboratory than the Star and the Oosterdam ammonia samples.

EPA considers ammonia to be a critical analyte in characterizing graywater and sewage generation and treatment onboard cruise vessels. Accordingly, EPA believed it was necessary to collect additional ammonia data to better assess this analyte in cruise ship wastewater. During the 2005 cruise season, EPA conducted a supplementary sampling program to collect samples of the influents to and effluents from the treatment systems onboard the same four ships that were sampled in 2004. Five sets of samples were collected from each ship and analyzed for nitrogen compounds (ammonia, TKN, and nitrate/nitrite). Samples were also analyzed for chemical oxygen demand and total suspended solids to benchmark these classical pollutant concentrations to those measured during the 2004 cruise season. The 2005 sampling activities, including the analytical results, will be described in a separate sampling episode report.

5.2 Field Quality Control

The trip blank, equipment blank, and field duplicate sample results are the field QA/QC measures discussed in this subsection. Section 3.8 of the Oosterdam SAP discusses field QC specifications. Tables presented in this section include results for only those analytes detected in the field QC samples during the sampling episode. Appendix A-1 and A-2 contain the results for all analytes, both detected and nondetected.

5.2.1 Trip Blank

A trip blank was collected and analyzed for volatile organics to evaluate possible contamination during shipment and handling of samples. This sample consisted of high performance liquid chromatography (HPLC) water. The trip blank was prepared prior to the

start of the sampling episode, and accompanied samples shipped to the laboratory on September 22, 2004.

No volatile organics were detected in the trip blank, indicating that there was no contamination of samples during transport, field handling, storage, or shipping. A table with the results of the analyses in this section of the report was not included, because all results are nondetects.

5.2.2 Equipment Blank

The sampling team collected an equipment blank to assess the potential introduction of contaminants by sample collection equipment. The sample collection equipment used to collect the equipment blank was the same as that used at the sampling points: approximately 4 feet of Teflon® tubing connected on one end to a series of metal plumbing fixtures installed on each sample port, and the other end to a small segment of silicone tubing used in the peristaltic pump mechanism of the automatic sampler. The equipment blank was collected by pumping HPLC water through this equipment directly into sample bottles.

Table 5-3 presents the detected results for the equipment blank. Seven total metals, 6 dissolved metals, and one organic were detected in the equipment blank. Table 5-3 also includes a value for hardness (a classical analyte), which is calculated based on the total magnesium and calcium concentrations detected in the sample using Standard Method 2340B. In tables presenting the analytical results in Section 4.1, all 15 of these analytes are flagged with an "(e)" to indicate they were detected in the equipment blank. EPA will consider the impact of possible contamination from sampling equipment in a future analysis.

5.2.3 Field Duplicates

Field duplicate samples were collected to assess the precision of the entire sample collection, handling, preparation, and analysis process. The relative percent difference (RPD) between the two duplicate sample results is calculated and compared to the data quality

objective. For this program, the QAPP provides an RPD target for field duplicate samples as less than 30% for all analytes of a specific analytical method.

Classical Pollutants, Total and Dissolved Metals, and Semivolatile Organics

For classical pollutants, total and dissolved metals, and semivolatile organics, field duplicate samples were samples collected from the same source, at the same time, then stored and analyzed independently. The duplicate samples were collected as split samples poured from the same mixed sample composite jars to minimize sample wastestream variability. Duplicate samples for these analytes were collected from the effluents from the graywater treatment system (SP-8/9) and sewage/graywater treatment (SP-13/14). Note that duplicate samples for dioxins and furans, and pesticide analytes were collected during a previous sampling episode, and duplicate samples for HEM and SGT-HEM were not planned for this sampling program.

Table 5-4 presents analytical results and the RPDs for these duplicate samples and includes analytical results for only those analytes that were detected at least once in wastewater samples during the sampling episode.

There was excellent precision in sampling and analysis for this sampling episode. Of the 207 duplicate pairs listed in Table 5-4, 188 either achieved the RPD target, or the RPD could not be calculated because both of the duplicate samples were less than the reporting limit. The RPD could not be calculated for 12 of the duplicate pairs because the analyte was detected in one sample but not the other. Analytical variability increases as analyte concentrations approach their detection limits. The seven duplicate pairs with an RPD outside of the target (i.e., $\geq$30% difference) include hardness, nitrate/nitrite (2 pairs), total manganese, phenol, and sulfate (2 pairs). These results are not uncommon in complex wastewater samples.

In tables presenting the analytical results in Section 4.1, duplicate sample results are presented as averages (calculation uses detection limits for nondetected results).

Pathogen Indicators and Volatile Organics

For pathogen indicators and volatile organics, field duplicate samples were collected sequentially and not as split samples as was done for the other analytes. For these samples, this methodology introduced sample wastestream variability into the assessment of the precision of sample collection and analysis. Duplicate samples for these analytes were collected from the effluent from the two treatment systems (SP-8/9 and SP-13/14). Table 5-5 presents analytical results and the RPDs for these duplicate samples. RPDs could not be calculated for 34 of the 36 duplicate pairs listed in Table 5-5 because both of the duplicate samples were less than the reporting limit. For the remaining two duplicate pairs (both fecal coliform in the effluent from the graywater treatment system), one achieved the QAPP-specified target (i.e., <30% difference) and one did not. Analytical variability increases as analyte concentrations approach their detection limits.

In tables presenting the analytical results in Section 4.1, duplicate sample results are presented as averages (calculation uses detection limits for nondetected results). In the case of pathogen indicators, average daily results presented incorporate both duplicate grab samples and multiple grab samples collected for individual analysis during each 24-hour sampling period. First, duplicate results, where applicable, were averaged to determine the average individual grab sample results for each day (e.g., grab 1 duplicate sample results for Day 3 were averaged together to represent the average grab 1 sample result for Day 3). Next, the individual grab sample results for each day were averaged to calculate the average daily pathogen indicators results presented in the tables (e.g., grab sample results 1 through 3 for Day 3 were averaged together to calculate the average Day 3 pathogen indicators sample results). In this way, the average daily pathogen indicators results presented in the tables are weighted equally by time of day, rather than weighted more heavily by the particular time of day when duplicate grab samples were collected.

Table 5-1

Available and Total Cyanide Analytical Results, Holland America Oosterdam

Available and total cyanide analytical results are irreconcilable; see Section 5.1.1.

Waste Stream	Available Cyanide (ug/L)	Total Cyanide (mg/L)
Accommodations (SP-1)	4.20	ND(0.00500)
Laundry (SP-2)	11.6	0.00700
Galley (SP-3)	ND(2.00)	ND(0.00500)
Food Pulper, Centrifuge System (SP-5)	0.0534	ND(0.249)
Influent to GW Treatment (SP-6), Day 1	3.91	ND(0.00500)
Influent to GW Treatment (SP-6), Day 2	2.84	ND(0.00500)
Influent to GW Treatment (SP-6), Day 3	3.18	ND(0.00500)
Influent to GW Treatment (SP-6), Day 4	3.35	ND(0.00500)
Influent to GW Treatment (SP-6), Day 5	2.21	ND(0.00500)
Effluent from GW Treatment (SP-8), Day 1	3.49	ND(0.00500)
Effluent from GW Treatment (SP-8), Day 2	2.31	ND(0.00500)
Effluent from GW Treatment (SP-8), Day 3	7.55	ND(0.00500)
Effluent from GW Treatment (SP-8), Day 4	ND(2.00)	ND(0.00500)
Effluent from GW Treatment (SP-8), Day 5	ND(2.00)	ND(0.00500)
Influent to Sewage/GW Treatment (SP-11), Day 1	45.5	ND(0.00500)
Influent to Sewage/GW Treatment (SP-11), Day 2	36.2	ND(0.00500)
Influent to Sewage/GW Treatment (SP-11), Day 3	75.6	ND(0.00500)
Influent to Sewage/GW Treatment (SP-11), Day 4	72.2	ND(0.00500)
Influent to Sewage/GW Treatment (SP-11), Day 5	76.5	ND(0.00500)
Effluent from Sewage/GW Treatment (SP-13), Day 1	< 3.04	< 0.00550
Effluent from Sewage/GW Treatment (SP-13), Day 2	4.41	ND(0.00500)
Effluent from Sewage/GW Treatment (SP-13), Day 3	3.49	ND(0.00500)
Effluent from Sewage/GW Treatment (SP-13), Day 4	3.22	ND(0.00500)
Effluent from Sewage/GW Treatment (SP-13), Day 5	3.34	ND(0.00500)
Graywater Screening Solids (SP-15)	0.474	ND(0.250)
Final Combined Discharge (SP-16), Day 1	ND(2.00)	ND(0.00500)
Final Combined Discharge (SP-16), Day 2	ND(2.00)	ND(0.00500)
Final Combined Discharge (SP-16), Day 3	7.60	ND(0.00500)
Final Combined Discharge (SP-16), Day 4	ND(2.00)	ND(0.00500)
Final Combined Discharge (SP-16), Day 5	9.00	ND(0.00500)

ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-1 (Continued)

Waste Stream	Available Cyanide (ug/L)	Total Cyanide (mg/L)
Sewage/GW Screening Solids (SP-20)	9.20	ND(0.250)
Sewage/GW Waste Biosludge (SP-21)	493	ND(0.251)
Source Water (SP-17)	ND(2.00)	ND(0.00500)

ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-2

Ammonia Analytical Results, Holland America Oosterdam

Ammonia analytical results are anomalous; see Section 5.1.2

Waste Stream	Ammonia as Nitrogen (mg/L)
Accommodations (SP-1)	ND(0.0500)
Laundry (SP-2)	ND(0.0500)
Galley (SP-3)	ND(0.0500)
Food Pulper, Centrifuge System (SP-5)	5.96
Influent to GW Treatment (SP-6), Day 1	ND(0.0500)
Influent to GW Treatment (SP-6), Day 2	ND(0.0500)
Influent to GW Treatment (SP-6), Day 3	ND(0.0500)
Influent to GW Treatment (SP-6), Day 4	ND(0.0500)
Influent to GW Treatment (SP-6), Day 5	ND(0.0500)
Effluent from GW Treatment (SP-8), Day 1	ND(0.0500)
Effluent from GW Treatment (SP-8), Day 2	ND(0.0500)
Effluent from GW Treatment (SP-8), Day 3	ND(0.0500)
Effluent from GW Treatment (SP-8), Day 4	< 0.0900
Effluent from GW Treatment (SP-8), Day 5	ND(0.0500)
Influent to Sewage/GW Treatment (SP-11), Day 1	ND(0.0500)
Influent to Sewage/GW Treatment (SP-11), Day 2	ND(0.0500)
Influent to Sewage/GW Treatment (SP-11), Day 3	ND(0.0500)
Influent to Sewage/GW Treatment (SP-11), Day 4	ND(0.0500)
Influent to Sewage/GW Treatment (SP-11), Day 5	ND(0.0500)
Effluent from Sewage/GW Treatment (SP-13), Day 1	2.49
Effluent from Sewage/GW Treatment (SP-13), Day 2	0.160
Effluent from Sewage/GW Treatment (SP-13), Day 3	0.0800
Effluent from Sewage/GW Treatment (SP-13), Day 4	< 0.0700
Effluent from Sewage/GW Treatment (SP-13), Day 5	ND(0.0500)
Graywater Screening Solids (SP-15)	148
Final Combined Discharge (SP-16), Day 1	ND(0.0500)
Final Combined Discharge (SP-16), Day 2	ND(0.0500)
Final Combined Discharge (SP-16), Day 3	ND(0.0500)
Final Combined Discharge (SP-16), Day 4	ND(0.0500)
Final Combined Discharge (SP-16), Day 5	ND(0.0500)

ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-2 (Continued)

Waste Stream	Ammonia as Nitrogen (mg/L)
Sewage/GW Screening Solids (SP-20)	7.33
Sewage/GW Waste Biosludge (SP-21)	136
Source Water (SP-17)	ND(0.0500)

ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-3

Equipment Blank Analytical Results, Holland America Oosterdam

Analytical results for analytes detected in the equipment blank. See Appendix A-2 for all analytical results (detected and nondetected). The equipment blank was collected as a one-time grab sample. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Equipment Blank (SP-19)
Classical Pollutants			
Hardness	mg/L		0.300
Total and Dissolved Metals			
Barium, Total	ug/L		18.9
Calcium, Total	ug/L		119
Copper, Total	ug/L	P120	3.41
Iron, Total	ug/L		30.2
Lead, Total	ug/L	P122	12.6
Manganese, Total	ug/L		0.720
Zinc, Total	ug/L	P128	13.3
Barium, Dissolved	ug/L		0.390
Boron, Dissolved	ug/L		24.3
Cadmium, Dissolved	ug/L	P118	0.210
Iron, Dissolved	ug/L		15.2
Lead, Dissolved	ug/L	P122	16.6
Sodium, Dissolved	ug/L		83.9
Volatile and Semivolatile Organics			
Phenol	ug/L	P065	48.0

Table 5-4

Field Duplicate Analytical Results for Classical Pollutants, Total and Dissolved Metals, and Semivolatile Organics, Holland America Oosterdam

Field duplicate analytical results for classical pollutants, total and dissolved metals, and semivolatile organics, detected at least once in wastewater samples during the sampling episode. See Appendix A-2 for all field duplicate analytical results (detected and nondetected). Field duplicate samples for these analytes are split samples collected from the same source, at the same time, stored and analyzed independently. See Figures 2-2 and 2-3 for sampling point locations. Also listed are the average result and relative percent difference calculated for each duplicate pair. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Graywater Treatment (SP-8/9) (b)	**Classical Pollutants**								
	Alkalinity	mg/L		65860	65880	ND (10.0)	ND (10.0)	ND (10.0)	NC
	Ammonia As Nitrogen (NH3-N)	mg/L		65864	65884	ND (0.0500)	0.130	< 0.0900	NC
	Ammonia As Nitrogen (NH3-N)	mg/L		65868	65888	ND (0.0500)	ND (0.0500)	ND (0.0500)	NC
	Available Cyanide	ug/L		65852	65872	3.57	3.33	3.49	7.0
	Available Cyanide	ug/L		65860	65880	7.48	7.68	7.55	2.6
	Biochemical Oxygen Demand (BOD_5)	mg/L		65856	65876	25.9	29.4	27.1	13
	Biochemical Oxygen Demand (BOD_5)	mg/L		65864	65884	23.9	22.5	23.2	6.0
	Chemical Oxygen Demand (COD) (s)	mg/L		65864	65884	48.0	53.0	50.5	9.9
	Chemical Oxygen Demand (COD) (s)	mg/L		65868	65888	77.0	81.0	79.0	5.1
	Chloride (s)	mg/L		65860	65880	17.0	17.0	17.0	0.0
	Hardness (e) (s)	mg/L		65860	65880	0.440	0.290	0.390	41

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Graywater Treatment (SP-8/9) (cont.) (b)	Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		65864	65884	0.0380	0.0160	0.0270	81
	Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		65868	65888	0.0160	0.0380	0.0270	81
	Settleable Residue	mL/L		65868	65888	ND (0.110)	ND (0.100)	ND (0.105)	NC
	Sulfate (s)	mg/L		65860	65880	4.17	4.17	4.17	0.0
	Total Cyanide	mg/L	P121	65852	65872	ND (0.00500)	ND (0.00500)	ND (0.00500)	NC
	Total Cyanide	mg/L	P121	65860	65880	ND (0.00500)	ND (0.00500)	ND (0.00500)	NC
	Total Dissolved Solids (TDS)	mg/L		65860	65880	52.0	56.0	53.3	7.4
	Total Kjeldahl Nitrogen (TKN) (s)	mg/L		65864	65884	6.49	6.99	6.74	7.4
	Total Kjeldahl Nitrogen (TKN) (s)	mg/L		65868	65888	3.38	3.33	3.36	1.5
	Total Organic Carbon (TOC) (s)	mg/L		65864	65884	13.3	13.4	13.4	0.75
	Total Organic Carbon (TOC) (s)	mg/L		65868	65888	20.4	21.5	21.0	5.3
	Total Phosphorus	mg/L		65864	65884	0.170	0.170	0.170	0.0
	Total Phosphorus	mg/L		65868	65888	0.210	0.230	0.220	9.1
	Total Suspended Solids (TSS)	mg/L		65860	65880	ND (5.00)	ND (5.00)	ND (5.00)	NC
	Total and Dissolved Metals								
	Aluminum, Total	ug/L		65860	65880	ND (8.80)	ND (8.80)	ND (8.80)	NC
	Aluminum, Dissolved	ug/L		65860	65880	ND (8.80)	33.1	< 16.9	NC
	Antimony, Dissolved	ug/L	P114	65860	65880	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Arsenic, Total	ug/L	P115	65860	65880	ND (2.00)	ND (2.00)	ND (2.00)	NC

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Graywater Treatment (SP-8/9) (cont.) (b)	Arsenic, Dissolved	ug/L	P115	65860	65880	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Barium, Total (e) (s)	ug/L		65860	65880	11.9	9.66	11.2	21
	Barium, Dissolved (e) (s)	ug/L		65860	65880	7.34	9.51	8.06	26
	Beryllium, Dissolved	ug/L	P117	65860	65880	ND (0.0700)	ND (0.0700)	ND (0.0700)	NC
	Boron, Total	ug/L		65860	65880	ND (18.0)	ND (18.0)	ND (18.0)	NC
	Boron, Dissolved (e)	ug/L		65860	65880	74.3	72.1	73.6	3.0
	Cadmium, Total	ug/L	P118	65860	65880	0.0900	ND (0.0800)	< 0.0867	NC
	Cadmium, Dissolved (e)	ug/L	P118	65860	65880	ND (0.0800)	ND (0.0800)	ND (0.0800)	NC
	Calcium, Total (e) (s)	ug/L		65860	65880	117	103	112	13
	Calcium, Dissolved (s)	ug/L		65860	65880	ND (7.00)	ND (7.00)	ND (7.00)	NC
	Chromium, Total	ug/L	P119	65860	65880	ND (0.270)	ND (0.270)	ND (0.270)	NC
	Chromium, Dissolved	ug/L	P119	65860	65880	0.410	0.500	0.440	20
	Cobalt, Total	ug/L		65860	65880	ND (0.660)	ND (0.660)	ND (0.660)	NC
	Cobalt, Dissolved (s)	ug/L		65860	65880	ND (0.660)	ND (0.660)	ND (0.660)	NC
	Copper, Total (e) (s)	ug/L	P120	65860	65880	172	157	167	9.1
	Copper, Dissolved (s)	ug/L	P120	65860	65880	46.9	47.2	47.0	0.64
	Iron, Total (e) (s)	ug/L		65860	65880	490	427	469	14
	Iron, Dissolved (e)	ug/L		65860	65880	436	463	445	6.0
	Lead, Total (e) (s)	ug/L	P122	65860	65880	30.3	25.0	28.5	19

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Graywater Treatment (SP-8/9) (cont.) (b)	Lead, Dissolved (e) (s)	ug/L	P122	65860	65880	14.7	14.9	14.8	1.4
	Magnesium, Total (s)	ug/L		65860	65880	34.9	33.4	34.4	4.4
	Magnesium, Dissolved (s)	ug/L		65860	65880	ND (6.30)	ND (6.30)	ND (6.30)	NC
	Manganese, Total (e) (s)	ug/L		65860	65880	8.16	227	81.1	190
	Manganese, Dissolved (s)	ug/L		65860	65880	8.13	8.20	8.15	0.86
	Mercury, Total	ug/L	P123	65860	65880	ND (0.0500)	ND (0.0500)	ND (0.0500)	NC
	Mercury, Dissolved	ug/L	P123	65860	65880	ND (0.0500)	ND (0.0500)	ND (0.0500)	NC
	Molybdenum, Total	ug/L		65860	65880	ND (1.60)	ND (1.60)	ND (1.60)	NC
	Nickel, Total (s)	ug/L	P124	65860	65880	3.09	2.80	2.99	9.8
	Nickel, Dissolved (s)	ug/L	P124	65860	65880	3.90	4.65	4.15	18
	Selenium, Total	ug/L	P125	65860	65880	ND (1.40)	ND (1.40)	ND (1.40)	NC
	Silver, Total	ug/L	P126	65860	65880	ND (0.770)	ND (0.770)	ND (0.770)	NC
	Silver, Dissolved	ug/L	P126	65860	65880	ND (0.770)	ND (0.770)	ND (0.770)	NC
	Sodium, Total (s)	ug/L		65860	65880	11,600	10,600	11,300	9.0
	Sodium, Dissolved (e) (s)	ug/L		65860	65880	12,000	12,400	12,100	3.3
	Tin, Total	ug/L		65860	65880	ND (0.940)	ND (0.940)	ND (0.940)	NC
	Tin, Dissolved	ug/L		65860	65880	ND (0.940)	ND (0.940)	ND (0.940)	NC
	Titanium, Total	ug/L		65860	65880	ND (0.620)	ND (0.620)	ND (0.620)	NC
	Titanium, Dissolved	ug/L		65860	65880	ND (0.620)	ND (0.620)	ND (0.620)	NC

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Graywater Treatment (SP-8/9) (cont.) (b)	Vanadium, Total	ug/L		65860	65880	ND (0.470)	ND (0.470)	ND (0.470)	NC
	Vanadium, Dissolved	ug/L		65860	65880	ND (0.470)	ND (0.470)	ND (0.470)	NC
	Zinc, Total (e) (s)	ug/L	P128	65860	65880	702	621	675	12
	Zinc, Dissolved (s)	ug/L	P128	65860	65880	594	626	605	5.2
	Semivolatile Organics								
	4-Chloro-3-methylphenol	ug/L	P022	65852	65872	ND (20.0)	ND (20.0)	ND (20.0)	NC
	4-Chloro-3-methylphenol	ug/L	P022	65856	65876	ND (20.0)	ND (20.0)	ND (20.0)	NC
	Bis(2-ethylhexyl) phthalate	ug/L	P066	65852	65872	ND (20.0)	ND (20.0)	ND (20.0)	NC
	Bis(2-ethylhexyl) phthalate	ug/L	P066	65856	65876	ND (20.0)	ND (20.0)	ND (20.0)	NC
	Diethyl phthalate	ug/L	P070	65852	65872	ND (20.0)	ND (20.0)	ND (20.0)	NC
	Diethyl phthalate	ug/L	P070	65856	65876	ND (20.0)	ND (20.0)	ND (20.0)	NC
	Phenol (e) (s)	ug/L	P065	65852	65872	60.0	65.0	61.7	8.0
	Phenol (e) (s)	ug/L	P065	65856	65876	71.0	51.0	64.3	33

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Sewage/Graywater Treatment (SP-13/14) (b)	**Classical Pollutants**								
	Alkalinity	mg/L		65944	65964	321	315	319	1.9
	Alkalinity	mg/L		65952	65972	332	349	338	5.0
	Ammonia As Nitrogen (NH3-N)	mg/L		65948	65968	0.0800	ND (0.0500)	< 0.0700	NC
	Available Cyanide	ug/L		65936	65956	4.08	ND (2.00)	< 3.04	NC
	Biochemical Oxygen Demand (BOD_5)	mg/L		65948	65968	4.42	3.90	4.25	13
	Chemical Oxygen Demand (COD) (s)	mg/L		65948	65968	111	104	109	6.5
	Chloride (s)	mg/L		65944	65964	125	125	125	0.0
	Chloride (s)	mg/L		65952	65972	145	135	142	7.1
	Hardness (e) (s)	mg/L		65936	65956	37.6	37.8	37.7	0.53
	Hardness (e) (s)	mg/L		65944	65964	32.2	34.6	33.0	7.2
	Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		65948	65968	0.0310	0.0350	0.0323	12
	Settleable Residue	mL/L		65936	65956	ND (0.100)	ND (0.130)	ND (0.115)	NC
	Settleable Residue	mL/L		65952	65972	ND (0.100)	ND (0.110)	ND (0.103)	NC

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Sewage/Graywater Treatment (SP-13/14) (cont.) (b)	Sulfate (s)	mg/L		65944	65964	52.4	34.7	46.5	41
	Sulfate (s)	mg/L		65952	65972	14.6	45.4	24.9	100
	Total Cyanide	mg/L	P121	65936	65956	ND (0.00500)	0.00600	< 0.00550	NC
	Total Dissolved Solids (TDS)	mg/L		65944	65964	444	439	442	1.1
	Total Dissolved Solids (TDS)	mg/L		65952	65972	511	517	513	1.2
	Total Kjeldahl Nitrogen (TKN) (s)	mg/L		65948	65968	73.3	70.6	72.4	3.8
	Total Organic Carbon (TOC) (s)	mg/L		65948	65968	30.5	29.6	30.2	3.0
	Total Phosphorus	mg/L		65948	65968	10.4	11.3	10.7	8.3
	Total Suspended Solids (TSS)	mg/L		65944	65964	ND (5.00)	ND (5.00)	ND (5.00)	NC
	Total Suspended Solids (TSS)	mg/L		65952	65972	ND (5.00)	ND (5.00)	ND (5.00)	NC
	Total and Dissolved Metals								
	Aluminum, Total	ug/L		65936	65956	126	123	125	2.4
	Aluminum, Total	ug/L		65944	65964	75.3	80.2	76.9	6.3
	Aluminum, Dissolved	ug/L		65936	65956	114	111	113	2.7
	Aluminum, Dissolved	ug/L		65944	65964	77.5	80.1	78.4	3.3
	Antimony, Dissolved	ug/L	P114	65936	65956	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Antimony, Dissolved	ug/L	P114	65944	65964	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Arsenic, Total	ug/L	P115	65936	65956	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Arsenic, Total	ug/L	P115	65944	65964	ND (2.00)	ND (2.00)	ND (2.00)	NC

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Sewage/Graywater Treatment (SP-13/14) (cont.) (b)	Arsenic, Dissolved	ug/L	P115	65936	65956	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Arsenic, Dissolved	ug/L	P115	65944	65964	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Barium, Total (e) (s)	ug/L		65936	65956	76.0	78.3	77.2	3.0
	Barium, Total (e) (s)	ug/L		65944	65964	75.2	79.9	76.8	6.1
	Barium, Dissolved (e) (s)	ug/L		65936	65956	69.7	70.4	70.1	1.0
	Barium, Dissolved (e) (s)	ug/L		65944	65964	73.6	75.4	74.2	2.4
	Beryllium, Dissolved	ug/L	P117	65936	65956	ND (0.0700)	ND (0.0700)	ND (0.0700)	NC
	Beryllium, Dissolved	ug/L	P117	65944	65964	ND (0.0700)	ND (0.0700)	ND (0.0700)	NC
	Boron, Total	ug/L		65936	65956	ND (18.0)	ND (18.0)	ND (18.0)	NC
	Boron, Total	ug/L		65944	65964	158	157	158	0.63
	Boron, Dissolved (e)	ug/L		65936	65956	118	156	137	28
	Boron, Dissolved (e)	ug/L		65944	65964	ND (18.0)	ND (18.0)	ND (18.0)	NC
	Cadmium, Total	ug/L	P118	65936	65956	0.110	0.100	0.105	9.5
	Cadmium, Total	ug/L	P118	65944	65964	ND (0.0800)	ND (0.0800)	ND (0.0800)	NC
	Cadmium, Dissolved (e)	ug/L	P118	65936	65956	0.130	ND (0.0800)	< 0.105	NC
	Cadmium, Dissolved (e)	ug/L	P118	65944	65964	ND (0.0800)	ND (0.0800)	ND (0.0800)	NC
	Calcium, Total (e) (s)	ug/L		65936	65956	9,560	9,590	9,580	0.31
	Calcium, Total (e) (s)	ug/L		65944	65964	8,600	9,190	8,800	6.6

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Sewage/Graywater Treatment (SP-13/14) (cont.) (b)	Calcium, Dissolved (s)	ug/L		65936	65956	8,630	8,740	8,690	1.3
	Calcium, Dissolved (s)	ug/L		65944	65964	8,090	8,340	8,170	3.0
	Chromium, Total	ug/L	P119	65936	65956	0.800	0.700	0.750	13
	Chromium, Total	ug/L	P119	65944	65964	1.81	2.15	1.92	17
	Chromium, Dissolved	ug/L	P119	65936	65956	1.44	1.20	1.32	18
	Chromium, Dissolved	ug/L	P119	65944	65964	1.32	1.40	1.35	5.9
	Cobalt, Total	ug/L		65936	65956	ND (0.660)	ND (0.660)	ND (0.660)	NC
	Cobalt, Total	ug/L		65944	65964	ND (0.660)	ND (0.660)	ND (0.660)	NC
	Cobalt, Dissolved (s)	ug/L		65936	65956	ND (0.660)	ND (0.660)	ND (0.660)	NC
	Cobalt, Dissolved (s)	ug/L		65944	65964	ND (0.660)	3.07	< 1.46	NC
	Copper, Total (e) (s)	ug/L	P120	65936	65956	65.7	51.7	58.7	24
	Copper, Total (e) (s)	ug/L	P120	65944	65964	5.92	5.60	5.81	5.6
	Copper, Dissolved (s)	ug/L	P120	65936	65956	58.6	49.1	53.9	18
	Copper, Dissolved (s)	ug/L	P120	65944	65964	4.65	4.70	4.67	1.1
	Iron, Total (e) (s)	ug/L		65936	65956	773	742	758	4.1
	Iron, Total (e) (s)	ug/L		65944	65964	266	279	270	4.8
	Iron, Dissolved (e)	ug/L		65936	65956	801	760	781	5.3
	Iron, Dissolved (e)	ug/L		65944	65964	293	235	274	22
	Lead, Total (e) (s)	ug/L	P122	65936	65956	8.43	6.68	7.56	23
	Lead, Total (e) (s)	ug/L	P122	65944	65964	2.05	2.20	2.10	7.1

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Sewage/Graywater Treatment (SP-13/14) (cont.) (b)	Lead, Dissolved (e) (s)	ug/L	P122	65936	65956	7.43	6.41	6.92	15
	Lead, Dissolved (e) (s)	ug/L	P122	65944	65964	1.76	1.60	1.71	9.5
	Magnesium, Total (s)	ug/L		65936	65956	3,340	3,360	3,350	0.60
	Magnesium, Total (s)	ug/L		65944	65964	2,620	2,830	2,690	7.7
	Magnesium, Dissolved (s)	ug/L		65936	65956	3,020	3,080	3,050	2.0
	Magnesium, Dissolved (s)	ug/L		65944	65964	2,530	2,690	2,580	6.1
	Manganese, Total (e) (s)	ug/L		65936	65956	54.6	50.8	52.7	7.2
	Manganese, Total (e) (s)	ug/L		65944	65964	14.4	15.5	14.8	7.4
	Manganese, Dissolved (s)	ug/L		65936	65956	51.1	48.1	49.6	6.0
	Manganese, Dissolved (s)	ug/L		65944	65964	16.4	19.0	17.3	15
	Mercury, Total	ug/L	P123	65936	65956	ND (0.0500)	ND (0.0500)	ND (0.0500)	NC
	Mercury, Total	ug/L	P123	65944	65964	ND (0.0500)	ND (0.0500)	ND (0.0500)	NC
	Mercury, Dissolved	ug/L	P123	65936	65956	0.0610	ND (0.0500)	< 0.0555	NC
	Mercury, Dissolved	ug/L	P123	65944	65964	0.0770	ND (0.0500)	< 0.0680	NC
	Molybdenum, Total	ug/L		65936	65956	ND (1.60)	ND (1.60)	ND (1.60)	NC
	Molybdenum, Total	ug/L		65944	65964	ND (1.60)	ND (1.60)	ND (1.60)	NC
	Nickel, Total (s)	ug/L	P124	65936	65956	25.4	23.9	24.7	6.1
	Nickel, Total (s)	ug/L	P124	65944	65964	24.3	26.9	25.2	10
	Nickel, Dissolved (s)	ug/L	P124	65936	65956	25.0	24.2	24.6	3.3
	Nickel, Dissolved (s)	ug/L	P124	65944	65964	22.9	22.7	22.8	0.88

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Sewage/Graywater Treatment (SP-13/14) (cont.) (b)	Selenium, Total	ug/L	P125	65936	65956	ND (1.40)	ND (1.40)	ND (1.40)	NC
	Selenium, Total	ug/L	P125	65944	65964	ND (1.40)	3.73	< 2.18	NC
	Silver, Total	ug/L	P126	65936	65956	ND (0.770)	ND (0.770)	ND (0.770)	NC
	Silver, Total	ug/L	P126	65944	65964	ND (0.770)	ND (0.770)	ND (0.770)	NC
	Silver, Dissolved	ug/L	P126	65936	65956	ND (0.770)	ND (0.770)	ND (0.770)	NC
	Silver, Dissolved	ug/L	P126	65944	65964	ND (0.770)	ND (0.770)	ND (0.770)	NC
	Sodium, Total (s)	ug/L		65936	65956	103,000	103,000	103,000	0.0
	Sodium, Total (s)	ug/L		65944	65964	104,000	110,000	106,000	5.6
	Sodium, Dissolved (e) (s)	ug/L		65936	65956	104,000	101,000	103,000	2.9
	Sodium, Dissolved (e) (s)	ug/L		65944	65964	93,900	94,300	94,000	0.43
	Tin, Total	ug/L		65936	65956	ND (0.940)	ND (0.940)	ND (0.940)	NC
	Tin, Total	ug/L		65944	65964	ND (0.940)	1.10	< 0.993	NC
	Tin, Dissolved	ug/L		65936	65956	ND (0.940)	ND (0.940)	ND (0.940)	NC
	Tin, Dissolved	ug/L		65944	65964	ND (0.940)	ND (0.940)	ND (0.940)	NC
	Titanium, Total	ug/L		65936	65956	ND (0.620)	ND (0.620)	ND (0.620)	NC
	Titanium, Total	ug/L		65944	65964	ND (0.620)	ND (0.620)	ND (0.620)	NC
	Titanium, Dissolved	ug/L		65936	65956	ND (0.620)	ND (0.620)	ND (0.620)	NC
	Titanium, Dissolved	ug/L		65944	65964	ND (0.620)	ND (0.620)	ND (0.620)	NC
	Vanadium, Total	ug/L		65936	65956	ND (0.470)	ND (0.470)	ND (0.470)	NC
	Vanadium, Total	ug/L		65944	65964	ND (0.470)	ND (0.470)	ND (0.470)	NC

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	SCC Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Sewage/Graywater Treatment (SP-13/14) (cont.) (b)	Vanadium, Dissolved	ug/L		65936	65956	ND (0.470)	ND (0.470)	ND (0.470)	NC
	Vanadium, Dissolved	ug/L		65944	65964	ND (0.470)	ND (0.470)	ND (0.470)	NC
	Zinc, Total (e) (s)	ug/L	P128	65936	65956	955	854	905	11
	Zinc, Total (e) (s)	ug/L	P128	65944	65964	354	380	363	7.1
	Zinc, Dissolved (s)	ug/L	P128	65936	65956	884	813	849	8.4
	Zinc, Dissolved (s)	ug/L	P128	65944	65964	358	345	354	3.7
	Semivolatile Organics								
	4-Chloro-3-methylphenol	ug/L	P022	65940	65960	ND (10.0)	ND (10.0)	ND (10.0)	NC
	Bis(2-ethylhexyl) phthalate	ug/L	P066	65940	65960	ND (10.0)	ND (10.0)	ND (10.0)	NC
	Diethyl phthalate	ug/L	P070	65940	65960	ND (10.0)	ND (10.0)	ND (10.0)	NC
	Phenol (e) (s)	ug/L	P065	65940	65960	60.0	60.0	60.0	0.0

(a) Sample numbers identify corresponding analytical results in Appendix A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-5

Field Duplicate Analytical Results for Pathogen Indicators and Volatile Organics, Holland America Oosterdam

Field duplicate analytical results for pathogen indicators and volatile organics detected at least once in wastewater samples during the sampling episode. Field duplicate samples were collected from the same source, stored, and analyzed independently. See Figures 2-2 and 2-3 for sampling point locations. Also listed are the average result and relative percent difference calculated for each duplicate pair. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Waste Stream	Analyte	Unit	Sample Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Graywater Treatment (SP-8/9) (b)	**Pathogen Indicators**							
	E. coli	MPN/100 mL	65852	65872	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65856	65876	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65860	65880	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65852	66014	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65856	66015	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65860	66016	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65852	65872	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65856	65876	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65860	65880	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65852	66014	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65856	66015	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65860	66016	ND (1.00)	ND (1.00)	ND (1.00)	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory reporting limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-5 (Continued)

Waste Stream	Analyte	Unit	Sample Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Graywater Treatment (SP-8/9) (b) (cont.)	Fecal Coliform	CFU/100 mL	65852	65872	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Fecal Coliform	CFU/100 mL	65856	65876	1.00	1.00	1.00	0.0
	Fecal Coliform	CFU/100 mL	65860	65880	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Fecal Coliform	CFU/100 mL	65852	66014	ND (1.00)	1.00	< 1.00	NC
	Fecal Coliform	CFU/100 mL	65856	66015	1.00	2.00	1.50	67
	Fecal Coliform	CFU/100 mL	65860	66016	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Volatile Organics							
	Chloroform (s)	ug/L	65856	65876	ND(5.00)	ND(5.00)	ND(5.00)	NC
	Ethylbenzene	ug/L	65856	65876	ND(5.00)	ND(5.00)	ND(5.00)	NC
	Toluene	ug/L	65856	65876	ND(5.00)	ND(5.00)	ND(5.00)	NC
Effluent from Sewage/Graywater Treatment (SP-13/14) (b)	**Pathogen Indicators**							
	E. coli	MPN/100 mL	65944	65964	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65948	65968	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65952	65972	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65944	66011	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65948	66012	ND (1.00)	ND (1.00)	ND (1.00)	NC
	E. coli	MPN/100 mL	65952	66013	ND (1.00)	ND (1.00)	ND (1.00)	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory reporting limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-5 (Continued)

Waste Stream	Analyte	Unit	Sample Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Sewage/Graywater Treatment (SP-13/14) (b) (cont.)	Enterococci	MPN/100 mL	65944	65964	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65948	65968	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65952	65972	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65944	66011	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65948	66012	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Enterococci	MPN/100 mL	65952	66013	ND (1.00)	ND (1.00)	ND (1.00)	NC
	Fecal Coliform	CFU/100 mL	65944	65964	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Fecal Coliform	CFU/100 mL	65948	65968	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Fecal Coliform	CFU/100 mL	65952	65972	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Fecal Coliform	CFU/100 mL	65944	66011	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Fecal Coliform	CFU/100 mL	65948	66012	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Fecal Coliform	CFU/100 mL	65952	66013	ND (2.00)	ND (2.00)	ND (2.00)	NC
	Volatile Organics							
	Chloroform (s)	ug/L	65940	65960	ND(5.00)	ND(5.00)	ND(5.00)	NC
	Chloroform (s)	ug/L	65948	65968	ND(5.00)	ND(5.00)	ND(5.00)	NC
	Ethylbenzene	ug/L	65940	65960	ND(5.00)	ND(5.00)	ND(5.00)	NC
	Ethylbenzene	ug/L	65948	65968	ND(5.00)	ND(5.00)	ND(5.00)	NC
	Toluene	ug/L	65940	65960	ND(5.00)	ND(5.00)	ND(5.00)	NC
	Toluene	ug/L	65948	65968	ND(5.00)	ND(5.00)	ND(5.00)	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; See Figure 2-2 and Figure 2-3.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.12 and Table 4-14 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory reporting limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

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