UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

This document is part of Appendix A, and includes the Steam Condensate: Nature of Discharge for the "Phase I Final Rule and Technical Development Document of Uniform National Discharge Standards (UNDS)," published in April 1999. The reference number is EPA-842-R-99-001.

Phase I Final Rule and Technical Development Document of Uniform National Discharge Standards (UNDS)

Steam Condensate:
Nature of Discharge

April 1999

NATURE OF DISCHARGE REPORT

Steam Condensate

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes steam condensate discharge and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Many surface ships in the Navy and Military Sealift Command (MSC) use steam from shore facilities when in port to operate auxiliary systems, such as laundry facilities, heating systems, and other hotel services.[1] Shore steam is piped above ground from land based boiler plants at pressures between 100 and 150 pounds per square inch (psi) to connections on the pier. The steam is routed via hoses from pier connections to topside connections on the ships.[1] Within the ship, the steam is routed through the ship's auxiliary steam lines to the equipment. The heat exchangers and shipboard piping are usually fabricated of copper/nickel alloy and carbon steel, but can also contain titanium, copper, or nickel. Steam distribution systems on all naval ships use comparable designs and consistent standards for system materials; therefore, there is little variation in steam distribution and condensate collection system design between ships. In the process of supplying heat to the ship systems, the steam cools and most condenses into water. This condensed water is referred to as condensate.

The condensate passes through a series of traps and orifices and collects in insulated drain collection tanks in the lowest points of the machinery spaces. The tanks are usually made of carbon steel or galvanized carbon steel. When a ship is making its own steam, the condensate in these drains is recycled as boiler feedwater. When taking on shore steam, this condensate is discharged overboard because shore facilities do not have infrastructure to receive returned condensate from ships. The condensate normally is pumped to a topside riser connection for discharge overboard. The overboard discharge pump is controlled automatically, by means of a float switch or similar device in the collection tank. In limited cases, the condensate is combined with non-oily machinery wastewater in the non-oily machinery wastewater drain tank for discharge overboard below the waterline. Discharge of steam condensate as a component of non-oily machinery wastewater is discussed in the non-oily machinery wastewater NOD report.

The naval facilities that provide shore steam to ships are designed and operated in accordance with Navy standards.[2] These facilities are required to sample and test shore steam and provide certification to ships that the steam meets the following requirements:[3]

• pH	8.0 to 9.5
• conductivity	25 μmho/cm^2 max. (micromhos per square centimeter)
• dissolved silica	0.2 ppm max. (parts per million)
• hardness	0.10 epm max. (equivalents per million)
• total suspended solids	0.10 ppm max.

2.2 Releases to the Environment

Steam condensate discharge can contain metals or treatment chemicals entrained in or eroded from the shore facilities and ships' steam systems. Steam condensate is discharged at elevated temperatures relative to the receiving waters. The discharge can be periodic or continuous based on the condensate flow rate, size of the condensate collection tank, and design of the collection tank's pumping control system. The discharge occurs 5 to 10 feet above the waterline. A portion of the condensate flashes into steam when discharged at ambient air pressure.

2.3 Vessels Producing the Discharge

Currently 179 Armed Forces surface ships discharge steam condensate. The classes and numbers of Navy and MSC ships that discharge shore-supplied steam condensate overboard are listed in Table 1. Submarines do not take on shore steam and do not discharge steam condensate because the design of their steam systems do not provide shore steam connections. The U.S. Coast Guard (USCG) does not discharge steam condensate because USCG vessels run their auxiliary boilers on a continuous basis. Also, most USCG homeports do not have readily available shore steam.[1] Army, Air Force, and Marine Corps vessels do not discharge steam condensate in port.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

Steam condensate is discharged only in port when shore steam is supplied to ships. There are 179 ships that produce steam condensate discharge located in 10 ports along the coastal U.S. The larger ships producing this discharge are located in the ports of Norfolk, VA, Mayport, FL, San Diego, CA, Pearl Harbor, HI, and Everett and Bremerton, WA. In some ports, the ships are at several locations within the port instead of being centered at one set of piers.

3.2 Rate

The discharge rate of steam condensate is directly related to the amount of shore steam provided per hour to a ship. Table 2 provides the total estimated heating load for each ship class. These loads were obtained from a handbook on dockside utilities and reflect the sum of the constant (year round, such as, galley, laundry, hot water) and intermittent (seasonal) heating loads for the ship.[2] This handbook contains estimated steam load requirements for various ship classes at 10, 30, 50 and 70 degrees Fahrenheit (°F). For estimating purposes, the condensate discharge volumes were based on an average outside air temperature of 50 °F (Table 2). A survey of meteorological data indicates that the 50 °F data is estimated to represent the average outside air temperature of most naval ports. Column (b) in Table 2 shows the equivalent number of gallons per year of condensate discharged at 180 °F that was obtained by applying the appropriate conversion factors to the figures in Column (a) and multiplying it by the number of days in port as listed in Table 1 (taken from the Ship Movement Data[4]) as shown below.

Condensate Drain, gal/yr = (Loads, lbs/hr)(0.12 gal/lb)(24 hr/day)(No. of days in port per year)

Column (c) is obtained by multiplying the figures in Column (b) by the number of ships in the class. Condensate flow rates for ships where steam requirement data was unavailable were interpolated based on the ship's size and similarities to other ship classes. Based upon the calculations presented in Table 2 for an average air temperature of 50 °F, the average steam condensate flow rate for all ship classes is 4,500 gallons per day per ship. As mentioned in Section 2.2, a small portion of the condensate will flash to steam as it is discharged; however, no data are available to determine the exact amount of the discharge that is steam. Therefore, to provide an upper bound on the flow that will enter the water, it is assumed that all of the discharge will be water.

3.3 Constituents

Steam condensate is primarily water that contains materials from the shore steam piping, ship piping, and heat exchangers and boiler water chemicals. This discharge was sampled for constituents that had a potential for being in the discharge. Based on the steam condensate process, system designs, and analytical data available, analytes in the metals, organics, and classicals classes were tested.[1,5] Sampling was conducted on the LHD 1, CG 68, LSD 51, and T-AO 198 in accordance with the Rationale for Discharge Sampling Report.[5] The results of the sampling are provided in reference 6. Table 3 provides a list of all constituents and their concentrations that were detected in the discharge. Discharges of steam condensate are expected to be warmer than ambient water temperatures with a maximum overboard discharge temperature of 180 °F because this is the maximum operational temperature that condensate discharge pumps can withstand.

Antimony, arsenic, cadmium, copper, lead, nickel, selenium, thallium, zinc, benzidine and bis(2-ethylexyl) phthalate are priority pollutants that were detected in this discharge. There were no bioaccumulators detected in this discharge.

3.4 Concentrations

The concentrations of detected constituents are presented in Table 3. This table shows the constituents, the log-normal mean, the frequency of detection for each constituent, the maximum and minimum concentrations, and the mass loadings for each constituent. For the purposes of calculating the log-normal mean, a value of one-half the detection limit was used for nondetected results.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. Section 4.3 discusses thermal effects. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Based on the discharge volume estimates developed in Table 2, mass loadings are presented in Table 3. Table 4 is present in order to highlight constituents with log-normal mean concentrations that exceed water quality criteria. A sample calculation of the estimated annual mass loading for copper is shown here:

Mass Loading for Copper (Dissolved)
Mass Loading = (Net Positive Log-normal Mean Concentration)(Flow Rate)
(13.44 µg/L)(3.785 L/gal)(296,000,000 gal/yr)(g/1,000,000 µg)(lb/453.593 g) ≅ 33 lbs/yr

4.2 Environmental Concentrations

The constituent concentrations in the steam condensate discharge and their corresponding Federal and the most stringent state water quality criteria (WQC) are listed in Table 5. The copper and nickel concentrations exceed the Federal and the most stringent state WQC. Ammonia, nitrogen (as nitrate/nitrite and total kjeldahl nitrogen), and phosphorous exceeds the Hawaii WQC. Benzidine and bis(2-ethylhexyl) phthalate exceed the Georgia WQC.

4.3 Thermal Effects

The potential for steam condensate to cause thermal environmental effects was evaluated by modeling the thermal plume generated by the discharge and then comparing the model results to state thermal discharge water quality criteria. Thermal plumes from steam condensate discharge were modeled primarily using the Cornell Mixing Zone Expert System (CORMIX) model. Additional modeling of discharge plume characteristics was conducted using CH3D, a three-dimensional hydrodynamic and transport model. The models were used to estimate the plume size and temperature gradients in receiving water bodies.[7, 8] Modeling was performed for discharges from an aircraft carrier (CVN – 68 Class) and an underway replenishment vessel (AOE-1 Class).

The discharge plumes were modeled for the Navy ports in Norfolk, VA and Bremerton, WA. Virginia and Washington State are the only states that have established thermal mixing zone criteria in the form of allowable plume dimensions and ambient temperature increases in the receiving water body. Other coastal states require thermal mixing zones be established on a case-by-case basis during the discharge permitting process, taking into account site- and discharge-specific information. Typically, criteria are developed to restrict the increase in the ambient water temperature and the extent of the plume in the water body to limit the duration of exposure for organisms passing through the plume, to prevent mortalities of bottom-dwelling organisms, and to prevent long-term effects such as migratory or community changes. State criteria for Virginia and Washington are summarized in Table 6.

The Virginia thermal regulations state that the discharge shall not cause the receiving ambient water temperature to increase by more than 3 °C at the edge of an allowable mixing zone. Virginia's allowable mixing zone for a thermal plume permits the plume to extend over no more than one-half the width of the receiving watercourse. In addition, the plume shall not extend downstream a distance greater than five times the width of the receiving watercourse at the point of discharge.[7]

The Washington thermal criteria vary depending upon the waterbody classification established by the State. The water in the vicinity of the Navy port at Bremerton has been classified by Washington as a Class A waterbody. The State thermal criteria for a Class A waterbody requires that discharges shall not result in the receiving water temperature exceeding 16 °C at the edge of an allowable mixing zone. If the water temperature exceeds 16 °C due to natural conditions, no discharge shall raise the receiving water temperature by greater than 0.3 °C at the edge of an allowable mixing zone. If the water temperature does not exceed 16 °C due to natural conditions, the Washington criteria provide a formula to determine the allowable incremental temperature increase at the mixing zone boundary. Washington has established the mixing zone to permit the plume to extend over a horizontal distance no greater than 200 feet plus the depth of the water over the discharge point, and no greater than 25% of the width of the water body.[7]

The aircraft carrier and amphibious vessel were modeled for Norfolk in winter conditions because these situations result in the greatest steam condensate discharge. Modeling for Bremerton was performed for all months of the year because, while cold (i.e., winter) conditions result in the greatest flow rate, the warm (i.e., summer) conditions result in the lowest allowable temperature increase.

Based on the CORMIX modeling, steam condensate discharges do not exceed Virginia thermal mixing zone criteria. CORMIX model predictions do indicate that steam condensate discharge from an aircraft carrier into the inlet in Bremerton can exceed Washington's thermal mixing zone criteria. The model predictions indicate that the discharge from AOE-1 Class vessels are not expected to exceed criteria. The AOE-1 Class is the next largest generator of steam condensate typically found in Bremerton.

There are several real-world considerations applicable to this discharge that CORMIX is not designed to simulate. These limitations result in over-conservative predictions. Such considerations include the effect of tidal action and turbulent mixing beyond the plunge zone (i.e. area of initial mixing from a discharge above the waterline) on the discharge plume. The additional mixing from tidal action and turbulence would be expected to reduce plume size. In addition, when applied to steam condensate discharge, CORMIX underestimates the initial mixing that occurs when the discharge enters the water. Since the version of CORMIX used for this exercise is designed for submerged release, the modeling effort was performed assuming the discharge hose touches the water surface. The fact that the discharge is known to occur 5-10 feet above the surface could not be simulated. The result is that the entry velocity assigned by CORMIX, based on flow rate and discharge pipe diameter, does not reflect accurately the true entry velocity, which is expected to be greater due to the acceleration from gravity. With higher entry velocities, the initial mixing would be greater and the plume size would be smaller. To illustrate, the CORMIX prediction for Bremerton Harbor estimates a plume depth of only 4 cm based on an initial discharge velocity of 1.67 meters per second (m/s). If the acceleration due to gravity from a 5-10 foot drop were considered, the entry velocity would increase significantly, to 5.7 m/s. The resulting plume depth would be considerably deeper and would result is more mixing with receiving water. Another occurrence that the CORMIX model can not simulate is the loss of heat to the atmosphere, especially during free-fall.

Because of the CORMIX model limitations for this discharge, the Navy and EPA modeled the steam condensate thermal plume from an aircraft carrier in Bremerton Harbor using the hydrodynamic and transport model CH3D. CH3D is expected to predict more accurately the plume dimensions than CORMIX because CH3D simulates the mixing of the buoyant plume with ambient flows by ways of advection and turbulent mixing both horizontally and vertically in the water column. CH3D is still expected to provide an overestimate of the plume size because this model does not account for the full extent of initial mixing in the plunge zone. CH3D estimates that the thermal plume for an aircraft carrier moored at the pier at Bremerton would extend a distance of 80 m from the discharge port along the vessel hull, not extending past the end of the hull. The plume would also extend outward no more than a distance of 30 m from the vessel hull at any point along the hull. CH3D predicts that, during the first 24 hours after discharge, the plume would cover only 5% of the width, 2% of the length, and 0.07% of the total surface of Sinclair Inlet.

Although the modeling described above indicates that the thermal plume from steam condensate released from an aircraft carrier may exceed Washington criteria in a small, localized area, the EPA and Navy do not consider that the plume results in a significant environmental impact. Such a localized plume would have a low potential for interfering with the passage of aquatic organisms in the water body and would have a limited impact on the organisms that reside in the upper water layer (sea surface boundary layer). In addition, because the discharge is freshwater (no salinity) and warmer than the receiving water, the plume floats in the surficial layer of the water body and has no impact on bottom-dwelling organisms. Therefore, EPA and DOD do not consider that the thermal loads from steam condensate discharge have the potential to cause an adverse environmental impact.

4.4 Potential for Introducing Non-Indigenous Species

This discharge does not present the potential for the transport of non-indigenous species because: the source of the steam is potable water from the same geographic area; it is discharged in the same vicinity; and it enters the ship as steam above 212 °F.

5.0 CONCLUSIONS

Steam condensate discharge has a low potential to cause an adverse environmental impact. This conclusion is based on the following two findings:

1) Although concentrations of copper, nickel, benzidine, bis(2-ethylhexyl) phthalate, phosphorous, and nitrogen exceed the most stringent water quality criteria, the mass loadings for these constituents are small. The distribution of the ships among several ports and within the ports themselves disperses the discharge (multiple discharge points) into a variety of receiving waters.
2) There are only two states that have established thermal mixing zone criteria in the form of codified plume dimensions (Washington and Virginia). The thermal criteria of other coastal states require thermal mixing zones be established on a case-by-case basis during the permitting process. The discharge is predicted to meet Virginia and Washington State thermal criteria with the exception of an aircraft carrier in the port at Bremerton, Washington.. However, conservative modeling of discharge from an aircraft carrier at Bremerton predicts thermal plumes that would cover only 5% of the width, 2% of the length, and 0.07% of the total surface of Sinclair Inlet. Since the plume is restricted to such a localized area, the EPA and DoD do not consider that the plume results in an adverse environmental impact and no further analyses are required.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Information from a military handbook on dockside services was used to calculate the rate of discharge. Sampling data from four surface ships provided concentrations, and mass loadings were calculated from the rate and the concentrations. Table 7 shows the sources of data used to develop this NOD report.

Specific References

1. UNDS Equipment Expert Meeting Minutes - Steam Condensate Drain, September 12, 1996.

2. Military Handbook - 1025/2, Dockside Utilities for Ship Service, 1 May 1988.

3. Naval Ship's Technical Manual (NSTM), Chapter 220, Vol. 2, Revision 7, Boiler Water/Feed Water Test & Treatment. pp 22-6, 22-7, and 22-50. December 1995.

4. Pentagon Ship Movement Data for Years 1991-1995, March 4, 1997.

5. UNDS Rationale for Discharge Sampling, Undated.

6. UNDS Phase I Sampling Data Report, Volumes 1-13, October 1997.

7. NAVSEA. Thermal Effects Screening of Discharges from Vessels of the Armed Services. Versar, Inc. July 3, 1997.
8. NAVSEA. Supplemental Thermal Effects Analysis. March 1999.

General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.

USEPA. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants. 57 FR 60848. December 22, 1992.

USEPA. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California, Proposed Rule under 40 CFR Part 131, Federal Register, Vol. 62, Number 150. August 5, 1997.

Connecticut. Department of Environmental Protection. Water Quality Standards. Surface Water Quality Standards Effective April 8, 1997.

Florida. Department of Environmental Protection. Surface Water Quality Standards, Chapter 62-302. Effective December 26, 1996.

Georgia Final Regulations. Chapter 391-3-6, Water Quality Control, as provided by The Bureau of National Affairs, Inc., 1996.

Hawaii. Hawaiian Water Quality Standards. Section 11, Chapter 54 of the State Code.

Mississippi. Water Quality Criteria for Intrastate, Interstate and Coastal Waters. Mississippi Department of Environmental Quality, Office of Pollution Control. Adopted November 16, 1995.

New Jersey Final Regulations. Surface Water Quality Standards, Section 7:9B-1, as provided by The Bureau of National Affairs, Inc., 1996.

Texas. Texas Surface Water Quality Standards, Sections 307.2 - 307.10. Texas Natural Resource Conservation Commission. Effective July 13, 1995.

Virginia. Water Quality Standards. Chapter 260, Virginia Administrative Code (VAC) , 9 VAC 25-260.

Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

Baumeister, Theodore; Avallone, Eugene; Baumeister III, Theodore; Marks' Standard Handbook for Mechanical Engineers, Eighth Edition. McGraw-Hill Book Company, 1978. .

Rawson, K.J.; and E.C. Tupper. Basic Ship Theory 2, Second Edition, Longman Group London and New York. 1978.

Jane's Information Group, Jane's Fighting Ships. Capt. Richard Sharpe, Ed. Sentinel House: Surrey, United Kingdom, 1996.

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. 23 March 1995.

Summary of Meteorological Data to Determine Air and Water Temperatures, October 1997.

UNDS Ship Database, August 1, 1997.

Table 1. Vessel Classes Generating Steam Condensate Discharge

VESSEL CLASS	VESSEL DESCRIPTION	QUANTITY OF VESSELS PER CLASS	NUMBER OF DAYS IN PORT PER YEAR
CVN 68	Nimitz Class Aircraft Carriers	7	147
CV 63	Kitty Hawk Class Aircraft Carriers	3	137
CVN 65	Enterprise Class Aircraft Carriers	1	76
CV 59	Forrestal Class Aircraft Carriers	1	143
CG 47	Ticonderoga Class Guided Missile Cruisers	27	166
CGN 38	Virginia Class Guided Missile Cruiser	1	161
CGN 36	California Class Guided Missile Cruisers	2	143
DDG 993	Kidd Class Guided Missile Destroyers	4	175
DD 963	Spruance Class Destroyers	31	178
AGF 11	Austin Class Miscellaneous Command Ship	1	183
AGF 3	Raleigh Class Miscellaneous Command Ship	1	183
LCC 19	Blue Ridge Class Amphibious Command Ship	2	179
LHD 1	Wasp Class Amphibious Assault Ship	4	185
LHA 1	Tarawa Class Amphibious Assault Ship	5	173
LPH 2	Iwo Jima Class Amphibious Assault Ship	2	186
LPD 4	Austin Class Amphibious Transport Docks	3	178
LSD 49	Harpers Ferry Class Dock Landing Ships	3	170
LSD 41	Whidbey Island Class Dock Landing Ships	8	170
LSD 36	Anchorage Class Dock Landing Ships	5	215
MCM 1	Avenger Class Mine Countermeasures Vessels	14	232
T-AE 26	Kilauea Class Ammunition Ships	8	26
T-AFS 1	Mars Class Combat Stores Ships	8	148
AO 177	Jumboised Cimarron Class Oilers	5	188
T-AO 187	Henry J. Kaiser Class Oilers	12	78
AOE 1	Sacramento Class Fast Combat Support Ships	4	183
AOE 6	Supply Class Fast Combat Support Ships	3	114
T-AG 194	Mission Class Navigation Research Ships	2	151
T-AGM 22	Compass Island Class Missile Range Instrumentation Ships	1	133
T-ARC 7	Zeus Class Cable Repairing Ships	1	8
ARS 50	Safeguard Class Salvage Ships	4	208
T-AH 19	Mercy Class Hospital Ships	2	184
AS 33	Simon Lake Class Submarine Tenders	1	229
AS 39	Emory S Land Class Submarine Tenders	3	293

Notes:

Number of days inport per year for each ship class taken from the Ship Movement Database.

Vessel classes receiving shore steam are identified in Military Handbook 1025/2, Dockside Utilities for Ship Service.

Table 2. Steam Condensate Discharge By Vessel Class At Outdoor Temperatures of 50 Degrees F

VESSEL CLASS	**ACTIVE**	**(a) Total Heating Load in lbs/hr per vessel**	**(b) Condensate Drain in gallons/yr per vessel**	**(c) Condensate Drain in gallons/yr per vessel class**
CVN 68	7	15,000	6,582,090	46,074,627
CV 63	3	13,000	5,316,418	15,949,254
CVN 65	1	15,000	3,402,985	3,402,985
CV 59	1	13,000	5,549,254	5,549,254
CG 47	27	1,100	545,075	14,717,015
CGN 38	1	3,400	1,634,030	1,634,030
CGN 36	2	3,400	1,451,343	2,902,687
DDG 993	4	1,800	940,299	3,761,194
DD 963	31	1,800	956,418	29,648,955
AGF 11	1	2,650	1,447,612	1,447,612
AGF 3	1	2,650	1,447,612	1,447,612
LCC 19	2	7,700	4,114,328	8,228,657
LHD 1	4	6,300	3,479,104	13,916,418
LHA 1	5	6,300	3,253,433	16,267,164
LPH 2	2	5,800	3,220,299	6,440,597
LPD 4	3	4,400	2,337,910	7,013,731
LSD 49	3	3,600	1,826,866	5,480,597
LSD 41	8	3,600	1,826,866	14,614,925
LSD 36	5	3,600	2,310,448	11,552,239
MCM 1	14	1,000	692,537	9,695,522
T-AE 26	8	2,300	178,507	1,428,060
T-AFS 1	8	3,350	1,480,000	11,840,000
AO 177	5	3,350	1,880,000	9,400,000
T-AO 187	12	3,350	780,000	9,360,000
AOE 1	4	5,600	3,059,104	12,236,418
AOE 6	3	5,600	1,905,672	5,717,015
T-AG 194	2	1,500	676,119	1,352,239
T-AGM 22	1	2,700	1,071,940	1,071,940
T-ARC 7	1	2,700	64,478	64,478
ARS 50	4	500	310,448	1,241,791
T-AH 19	2	500	274,627	549,254
AS 33	1	6,500	4,443,284	4,443,284
AS 39	3	6,500	5,685,075	17,055,224
			Total =	**295,504,776**

Notes:

Source: Military Handbook 1025/2, Dockside Utilities for Ship Service.

Total heating load values include constant loads and intermittent loads.

Intermittent loads were taken at 50 °F outside air temperature.

Calculations based on water at 212 °F.

Table 3. Summary of Detected Analytes

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Alkalinity	2.78	4 of 4	1	15	6,852
Ammonia as Nitrogen	0.18	4 of 4	0.12	0.37	444
Biochemical Oxygen Demand	6.56	3 of 4	BDL	21	16,169
Chemical Oxygen Demand (COD)	16.87	2 of 4	BDL	54	41,581
Chloride	3.60	3 of 4	BDL	14	8,873
Nitrate/Nitrite	0.44	4 of 4	0.3	0.81	1,085
Sulfate	1.98	3 of 4	BDL	3.6	4,880
Total Dissolved Solids	18.9	2 of 4	BDL	102	46,585
Total Kjeldahl Nitrogen	0.80	4 of 4	0.24	2	1,972
Total Organic Carbon (TOC)	4.07	3 of 4	BDL	12	10,032
Total Phosphorous	0.09	3 of 4	BDL	0.27	222
Total Recoverable Oil and Grease	1.15	4 of 4	0.6	2.3	2,835
Total Sulfide (Iodometric)	13.3	4 of 4	4	40	32,880
Volatile Residue	18.9	2 of 4	BDL	102	46,585
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Antimony					
Total	7.13	1 of 4	BDL	26.8	18
Arsenic					
Total	0.74	2 of 4	BDL	2.3	2
Barium					
Dissolved	1.02	1 of 4	BDL	4.4	3
Total	0.8	1 of 4	BDL	1.65	2
Cadmium					
Total	2.86	1 of 4	BDL	6.1	7
Calcium					
Dissolved	98.6	3 of 4	BDL	336	243
Total	146	4 of 4	61.6	334	359
Copper					
Dissolved	13.4	2 of 4	BDL	49.0	33
Total	20.1	3 of 4	BDL	91.0	49
Iron					
Dissolved	20.0	2 of 4	BDL	262	49
Total	22.6	2 of 4	BDL	527	56
Lead					
Dissolved	3.58	3 of 4	BDL	12.7	9
Total	4.38	3 of 4	BDL	18.9	11
Magnesium					
Dissolved	77.8	1 of 4	BDL	982	192
Total	77.2	1 of 4	BDL	949	190

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Manganese					
Dissolved	1.17	2 of 4	BDL	6	3
Total	2.57	4 of 4	1.85	5.1	6
Molybenum					
Dissolved	1.72	1 of 4	BDL	3.7	4
Nickel					
Dissolved	10.3	1 of 4	BDL	22	25
Total	11.6	1 of 4	BDL	34.7	28
Selenium					
Total	2.87	1 of 4	BDL	3.5	7
Sodium					
Dissolved	482	3 of 4	BDL	8220	1,188
Total	432	2 of 4	BDL	8280	1,065
Thallium					
Dissolved	1.18	2 of 4	BDL	13.3	3
Titanium					
Total	2.73	1 of 4	BDL	6.4	7
Vanadium					
Dissolved	5.25	1 of 4	BDL	10.5	13
Zinc					
Dissolved	13.94	4 of 4	7.15	21.9	34
Total	11.35	3 of 4	BDL	23.0	28
ORGANICS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
4-Chloro-3-Methylphenol	6.84	1 of 4	BDL	30	17
Benzidine	32.8	1 of 4	BDL	73.5	81
Bis(2-Ethylhexyl) Phthalate	19.4	2 of 4	BDL	112	48

BDL = Below Detection Limit
Log-normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., “non-detect” samples), estimated analyte concentrations equivalent to one-half of the detection levels were also used to calculate the log-normal mean. For example, if a “non-detect” sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log-normal mean calculation.

Table 4. Estimated Annual Mass Loadings of Constituents

Constituent*	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.18	4 of 4	0.12	0.37	444
Nitrate/Nitrite	0.44	4 of 4	0.3	0.81	1085
Total Kjeldahl Nitrogen	0.80	4 of 4	0.24	2	1972
Total Nitrogen[A]	1.24				3057
Total Phosphorous	0.09	3 of 4	BDL	0.27	222
ORGANICS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Benzidine	32.8	1 of 4	BDL	73.5	81
Bis(2-Ethylhexyl) Phthalate	19.4	2 of 4	BDL	112	48
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Copper					
Dissolved	13.4	2 of 4	BDL	49.0	33
Total	20.1	3 of 4	BDL	91.0	49
Nickel					
Dissolved	10.3	1 of 4	BDL	22	25
Total	11.6	1 of 4	BDL	34.7	28

* Mass loadings are presented for constituents that exceed WQC. See Table 3 for a complete listing of mass loadings.

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 5. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituent	**Log-normal Mean** (µg/L)	**Minimum Concentration** (µg/L)	**Maximum Concentration** (µg/L)	**Federal Chronic WQC** (µg/L)	**Most Stringent State Chronic WQC** (µg/L)
Ammonia as Nitrogen	180	120	370	None	6 (HI)[A]
Nitrate/Nitrite	440	300	810	None	8 (HI)[A]
Total Kjeldahl Nitrogen	800	24	2000	None	-
Total Nitrogen[B]	1240			None	200 (HI)[A]
Total Phosphorous	90	BDL	270	None	25 (HI)[A]
Benzidine	32.8	BDL	73.5	None	0.000535 (GA)
Bis(2-Ethylhexyl) Phthalate	19.4	BDL	112	None	5.92 (GA)
Copper					
Dissolved	13.4	BDL	49.0	2.4	2.4 (CT, MS)
Total	20.1	BDL	91.0	2.9	2.9 (GA, FL)
Nickel					
Dissolved	10.3	BDL	22	8.2	8.2 (CA, CT)
Total	11.6	BDL	34.7	8.3	7.9 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA = California
CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington
BDL = Below Detection Limit

Table 6. Summary of Thermal Effects of Steam Condensate Discharge

Ship Modeled	Discharge Temp (°F)	Average Air Temp (°F)	Discharge Flow (gallons per hour)	Ambient Winter Water Temp (°F)	Predicted Plume Length (m)	Allowable Plume Length (m)	Predicted Plume Width (m)	Allowable Plume Width (m)
Washington State (1.5°C ΔT)								
CVN*	180	50	1,866	50	80	73	30	400
AOE	180	50	672	50	2.3	73	10**	400
Virginia (3.0°C ΔT)								
CVN	212	40	2,207	40	689	32,000	203	3,200
LCC	212	40	1,007	40	180	32,000	70.1	3,200

Note: Flow rates for Virginia were calculated based on a linear interpolation of the data available in reference 2 for 30°F and 50°F air temperature.

*Indicates CH3D model predictions after the first 24 hours after discharge. All other predictions are based on CORMIX model results.

**CORMIX output displays the plume width to the point where ΔT ≅ 0°C.

Table 7. Data Sources

	Data Sources			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment		X		X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents		X		
3.4 Concentrations		X		
4.1 Mass Loadings			X	
4.2 Environmental Concentrations		X		
4.3 Thermal Effects			X	X
4.4 Potential for Introducing Non-Indigenous Species				X