This document is part of Appendix A, AFFF NOD (Aqueous Film-Forming Foam): Nature of Discharge for the "Phase I Final Rule and Technical Development Document of Uniform National Discharge Standards (UNDS)," published in April 1999.

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

Appendix A

AFFF NOD
(Aqueous Film-Forming Foam; Nature of discharge)

April 1999

NATURE OF DISCHARGE REPORT

Aqueous Film Forming Foam (AFFF)

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 the AFFF 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

AFFF is the primary firefighting agent used aboard U.S. Coast Guard (USCG) and Navy vessels for flammable liquid fires. A different class of agents, Fluoroprotein foams, are used for the same purpose on vessels in the Military Sealift Command (MSC). Aqueous Film Forming Foam (AFFF) is a particular type of synthetic firefighting foam whose performance is governed by military specification. Fluoroprotein foam is a protein-based material to which fluorinated surfactants have been added to improve fluidity and surface tension properties, while reducing the tendency of the protein base to absorb liquids.

These foams control and extinguish flammable liquid fires and help prevent such fires after spills by spreading a vapor-sealing film over the flammable liquid. The foam layer effectively excludes oxygen from the surface of the fuel, while the high water content cools the surface. The foam layer also provides a reservoir that will reseal a disturbed fuel surface and inhibit reignition. Both foams have excellent “wetting” or penetrating characteristics can be used against fires involving densely packed wood, wood products, cloth, textile and fibrous materials, paper, and paper products. Both types of foam concentrates can be stored for indefinite periods in approved equipment and systems with no degradation in chemical properties or capabilities.

In use, foam concentrate is mixed with seawater to form a dilute seawater foam solution. Seawater foam solution is generated in foam proportioning stations or by portable proportioners.[1] Each type involves metering foam concentrate into pressurized, firefighting seawater. The metering accuracy of the proportioning stations is verified by periodic tests.

Foam is applied both manually, with conventional foam or water/fog equipment such as fire hoses equipped with foam nozzles, and from fixed sprinkler devices. Fixed systems provide seawater foam solution to sprinklers on flight decks, and to overhead sprinklers in hangars, tank decks, well decks, weapon elevator pits, fueled vehicle decks or holds, refueling stations, and fuel pump rooms. If a protected area requires a greater flow rate than can be supplied by a single proportioning station, the area is subdivided into zones or groups, each independently supplied from a single proportioning station. Bilge sprinkler systems are installed in machinery spaces and pump rooms. Firefighting hose reel stations are supplied through a system of proportioners, pumps, and permanently installed piping.

Foam concentrate is stored in tanks, 55-gallon drums, and 5-gallon cans. Aircraft carriers, large amphibious ships, and other large ships can carry more than 20,000 gallons of AFFF or fluoroprotein foam concentrate.

Neither AFFF nor fluoroprotein foam is ever discharged from vessels in concentrated form. Only the dilute seawater foam solution is discharged. Incidental discharge of seawater foam solution occurs during maintenance that is part of the Planned Maintenance System (PMS), Board of Inspection and Survey (INSURV) underway material inspections (UMI), flight deck certifications, or biennial tests on MSC vessels by the USCG Office of Marine Inspection.

Regular preventive maintenance of firefighting systems and equipment requiring the discharge of seawater foam solution aboard ship occurs annually during PMS activities, although some maintenance is performed at 18 month intervals. Table 1 indicates the frequency of foam solution discharges on Navy, MSC, and USCG vessels. For Navy vessels, an INSURV UMI occurs every 3 years and involves the same system checks and resulting seawater foam discharges as the annual PMS activities. An MSC damage control instruction requires that foam solution be present at flight deck nozzles before every flight operation (approximately twice per month per vessel), which is verified by operating the nozzles until foam is sighted.[2] For aircraft carriers, Navy requirements call for a flight deck certification during the first deployment to sea after a shipyard or repair period (approximately every 1.5 years). Other than aircraft carriers, ships with flight decks, whether Navy or MSC, receive flight deck certification inspections every 3 years that test for foam solution at all flight deck nozzles and hoses.

2.2 Releases to the Environment

The seawater foam solutions that are discharged onto flight and weather decks as a result of maintenance, inspection, and certification activities are washed overboard with pressurized seawater from fire hoses, or by activating the seawater washdown system. Foam that is discharged into internal ship compartment bilges during system testing and flushing evolutions is pumped overboard by eductors.

Seawater foam discharge will contain all the constituents from the firemain, in addition to constituents unique to the foam concentrate. As discussed more fully in the Firemain Systems NOD Report, the principal constituent of the firemain discharge that could have an adverse water quality effect is copper, derived from the copper nickel firemain piping. Therefore, copper will be an expected component of the AFFF solution discharge.

2.3 Vessels Producing the Discharge

All Navy surface ships, all classes of USCG cutters, icebreakers and icebreaking tugs, and MSC ship classes with the ability to support helicopter operations produce the discharge. Table 2 shows the vessel classes that produce the discharge.

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

The Navy provides instruction on where seawater AFFF solutions can be discharged during maintenance that tests the proportioning accuracy of AFFF proportioning stations. This test is commonly conducted by discharging an AFFF hose over the side, when beyond the 12 nautical mile (n.m.) limit. The PMS instructions state:

> "Accomplish maintenance requirements only when ship is beyond 12 nautical miles of shore and preferably while underway. When within 3 nautical miles of shore or in port, discharge to a tank, barge or to an authorized truck. In other cases, when between 3 and 12 nautical miles, overboard discharge is permitted with a minimum (ship) speed of 10 knots."[3-9]

Discharges that are part of inspections and certifications are not governed by the maintenance instruction, and can be discharged anywhere, except that seawater foam solution in a machinery space bilge is governed by bilge pumping rules, and cannot be discharged within 12 n.m.[10] In practice, the maintenance policy applies because a single discharge event will be scheduled to satisfy simultaneously the requirements for maintenance, inspection, and certification.

3.2 Rate

When testing the proportioning accuracy of proportioning stations, ships typically test one station at a time by discharging a foam hose over the side. This discharge rate is 125 gallons per minute (gpm) or 250 gpm, depending on the flow rate of the hose selected for the test. When testing or demonstrating flight deck sprinkling, the most common practice is to operate one or two zones at a time, continuing until all the zones have been tested. The nominal flow rate for each zone on Navy ships is 1,000 gpm, so the typical discharge rate is 2,000 gpm.

AFFF concentrate is mixed with seawater from the firemain to form a 6% dilute solution, that is, 100 gallons of solution contains 6 gallons of AFFF concentrate and 94 gallons of seawater.[1] The WTGB 140 Class of icebreaking tugs operated by the USCG use more concentrated base stock which is diluted to a 3% solution. Fluoroprotein foams are mixed on MSC ships in both 3% and 6% solutions, depending on the design of the installed proportioning equipment.[11] These mixing ratios are used in Table 2 to derive discharge quantities of foam concentrate and seawater.

After tests or demonstrations of flight deck sprinkling, the foam blanket is washed off using fire hoses, or by operating the fixed seawater washdown system. Both techniques result in a seawater discharge supplied from the firemain. The flow rate is variable, but a typical range is 250 gpm (two fire hoses on a ship with a helicopter landing platform) to 2,000 gpm (two flight deck zones on an aircraft carrier).

Tests or demonstrations of bilge sprinkling do not result in environmental discharges until bilges are pumped overboard. Bilges can be pumped within 12 n.m. of shore if the discharge is passed through oil water separators. However, the surfactants in AFFF and fluoroprotein foam render the oil water separators ineffective, so crews do not discharge seawater foam solution through their oil water separators. Accordingly, bilges containing seawater foam solution are pumped only beyond 12 n.m. from shore[10]. Therefore, this NOD report does not account for foam discharges attributable to bilge sprinkling, discharge of machinery space bilge hoses, nor the seawater used to wash and pump bilges.

By ship class, Table 2 shows the discharges of seawater foam solution, foam concentrate in the solution, seawater in the solution, and seawater used to wash the solution off the ship. All discharges are assumed to occur within 12 n.m. of shore. The fleetwide estimates are summarized in Table 3.

3.3 Constituents

The ingredients in foam concentrate are listed on material safety data sheets (MSDSs) prepared by the manufacturer. The AFFF concentrate produced by the principal Armed Forces supplier contains water, 2-(2-butoxyethoxy)-ethanol, urea, alkyl sulfate salts (2 in number), amphoteric fluoroalkylamide derivative, perfluoroalkyl sulfonate salts (5), triethanolamine, and methyl-1H-benzotriazole, with fresh water accounting for approximately 80% of the ingredients by weight (see Table 3).[12] Freshwater is the principal ingredient of all the foam concentrates used by the Armed Forces, comprising approximately 80% - 90% of the product by weight.[12-16] The protein base in fluoroprotein foam is nontoxic and biodegradable. The chemical identities and corresponding weight percents of the surfactants in AFFF and fluoroprotein concentrates are proprietary, but are stated by the manufacturers to be nontoxic in the quantities present in the manufactured product, and more benign when diluted with seawater to a 3% or 6% solution. Fluoroprotein foam and 3% AFFF used on MSC and USCG vessels contribute only 4% of the total volume of foam discharged annually from vessels.

No priority pollutants nor bioaccumulators are known to be present in the AFFF product or fluoroprotein foam concentrates used aboard vessels of the Armed Forces.

The firemain provides the seawater in the seawater foam solution. Metals and other materials from the firemain system can be dissolved by the seawater, and particles can be eroded and physically entrained in the seawater flow. Any wetted material in the firemain system can become a constituent of the firemain discharge. None of the potential constituents are known bioaccumulators. The priority pollutants in the discharge are bis(2-ethylhexyl) phthalate, copper, nickel, and iron, which are found in the piping of wet firemain systems.

The piping in Navy AFFF systems is made of copper nickel alloy, the same as used in the firemain system. Total nitrogen, bis(2-ethylhexyl) phthalate, copper, nickel, and iron from this source will be constituents of the discharge.

3.4 Concentrations

Table 3 shows the concentrations of the chemical constituents in AFFF concentrate. The data are based on the type of concentrate that is most widely used. Table 3 also shows the concentrations in the seawater foam solution.

Seawater foam discharges have not been part of the sampling program. The concentrations of total nitrogen, bis(2-ethylhexyl) phthalate, copper, nickel, and iron contributed from the AFFF system are not known. AFFF concentrate includes corrosion inhibitors.

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 constituents in the discharge are estimated and compared with the water quality criteria. In Section 4.3, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Discharge quantities in Table 2 and constituent concentrations in Table 3 are combined to estimate mass loadings.

Based on the approximate mass of 366,000 pounds of AFFF concentrate discharged annually from Navy and USCG vessels, and the weight percentages of AFFF constituents, upper bound estimates of the annual mass loadings for the constituents range from a maximum of approximately 38,500 pounds for 2-(2-butoxyethoxy)-ethanol to a minimum of 370 pounds for methyl-1H-benzotriazole. The mass loadings resulting from 3% AFFF and fluoroprotein foam discharges aboard MSC vessels do not significantly change the calculated loadings because the total volume of these concentrates represents 4.0% of the foam discharged annually.

The annual mass loadings of copper, nickel, and iron from the firemain system are shown in Table 3, based on a total of 4,924,000 gallons of seawater used to produce foam and wash it off the ship after the test.

4.2 Environmental Concentrations

As listed in Table 2, individual constituent concentrations in foam range from 6,400 mg/L for 2-(2-butoxyethoxy)-ethanol down to about 61 mg/L for methyl-1H-benzotriazole. The concentrations presented represent AFFF seawater foam constituent concentrations in the product as discharged from hose nozzles and sprinkler heads aboard ship. These concentrations do not take into account the additional diluting effect of any seawater used to wash the AFFF seawater solution overboard. Thus, the concentration of the constituents in AFFF seawater solutions is reduced when this additional dilution factor is considered. Further, the ship’s motion through the sea causes the discharge to be distributed along the ship’s track, instead of being discharged in a single spot. Upon discharge to the environment, AFFF concentrate has been diluted 94:6 (about

16:1) by the proportioning process, with further dilution during the wash-off procedure, followed by rapid dispersion in the wake of a moving ship.

AFFF could potentially be discharged from vessels in amounts that cause visible foam floating on the water surface. Floating foam detracts from the appearance of surface waters and can violate aesthetic water quality criteria. Several states have standards to prevent "floating

The bis(2-ethylhexyl) phthalate, copper, nickel, and iron constituents are the only priority pollutants sampled which exceed acute water quality criteria. Table 4 shows the concentration of the constituents of firemain water, total nitrogen, bis(2-ethylhexyl) phthalate, copper, nickel, and iron, that exceed acute water quality criteria. The copper concentration exceeds both the Federal and most stringent state criteria while the total nitrogen, bis(2-ethylhexyl) phthalate, nickel, and iron concentrations exceed only the most stringent state criterion.

4.3 Potential for Introducing Non-Indigenous Species

AFFF and fluoroprotein concentrates do not include biota. Seawater foam discharge can include microbial and invertebrate marine organisms, since biofouling accumulates in firemain systems, wet and dry types. See the Firemain Systems NOD Report for a discussion of the potential for introducing non-indigenous species in the firemain discharge.

5.0 CONCLUSION

AFFF discharges from vessels of the Armed Forces have the potential to cause an adverse environmental impact. There is currently an operational policy and procedure that prohibits any overboard discharge of AFFF from Navy vessels within 3 n.m. of shore, and stipulates that discharge could only occur at a minimum speed of 10 knots between 3 and 12 n.m. from shore. If this policy were not in place, the discharge could deposit significant amounts of foam on surface water. This foam would diminish the visual quality of the water.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Process information was used to estimate the volume of discharge. Based on this estimate and on the reported constituent percentages by weight, the concentrations of the AFFF constituents in this discharge were then estimated. Table 5 shows the sources of the data used to develop this NOD report.

<u>Specific References</u>

1. Naval Ships' Technical Manual (NSTM), Chapter 555, Vol. 1, Revision 4, pages 1-23, 2-

6, 2-7, 4-22, and 4-23, Surface Ship Firefighting. 8 December 1997.

2. Military Sealift Command (MSC), Damage Control Manual, COMSCINST 3541.5D, 21 February 1994, page 1-10-2.

3. Naval Sea Systems Command (NAVSEA), Navy PMS Maintenance Index Page (MIP) 5551/026-C5, Fire Extinguishing System, Fog, Foam, and AFFF, December 1995.

4. Naval Sea Systems Command (NAVSEA), Navy PMS Maintenance Index Page (MIP) 5551/027-C6, Fire Extinguishing System, Fog, Foam, and AFFF, December 1996.

5. Naval Sea Systems Command (NAVSEA), Navy PMS Maintenance Index Page (MIP) 5551/029-86, Fire Extinguishing System, Fog, Foam, and AFFF, August 1996.

6. Naval Sea Systems Command (NAVSEA), Navy PMS Maintenance Index Page (MIP) 5551/031-C5, Fire Extinguishing System, Fog, Foam, and AFFF, December 1995.

7. Naval Sea Systems Command (NAVSEA), Navy PMS Maintenance Index Page (MIP) 5551/034-A4, Fire Extinguishing System, Fog, Foam, and AFFF, October 1994.

8. Naval Sea Systems Command (NAVSEA), Navy PMS Maintenance Index Page (MIP) 5551/036-A4, Fire Extinguishing System, Fog, Foam, and AFFF, October 1994.

9. Naval Sea Systems Command (NAVSEA), Navy PMS Maintenance Index Page (MIP) 5551/037-37, Fire Extinguishing System, Fog, Foam, and AFFF, March 1997.

10. Office of Chief of Naval Operations (OPNAV), Environmental and Natural Resource Program Manual, OPNAVINST 5090.1B, 1 November 1994.

11. Weersing, Penny, Military Sealift Command Central Technical Activity. Design of Fire Protection Systems on MSC Ships, 26 March 1997, David Eaton, M. Rosenblatt & Son, Inc.

12. 3M Material Safety Data Sheet, FC-206CF LIGHT WATER™ Brand Aqueous Film Forming Foam, November 13, 1995.

13. Ansul Inc. Material Safety Data Sheet, Ansulite 6% AFFF (AFC-5), May 19, 1995.

14. Chubb National Foam Inc. Material Safety Data Sheet, Aer-0-Water 6EM, March 27, 1991.

15. National Foam Inc. Material Safety Data Sheet, Aer-0-Foam XL-3 3%, October 2, 1996.

16. Ansul Inc. Material Safety Data Sheet, Ansul 3% Fluoroprotein Foam Concentrate, June 2, 1997.

17. Poidinger, Joe, 3-M Corp. MSDS 6% AFFF Concentrate Density, 18 September 1997,

Anil Giri, M. Rosenblatt & Son, Inc.

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).

Coast Guard Uniform Maintenance Card R-A-012, Damage Control, Auxiliary, Fire Extinguishing System, AFFF system.

Darwin, Robert, NAVSEA 03G2. "AFFF Overboard Discharge." M. Rosenblatt & Son, Inc. Crystal City, VA. 17 September 1996.

UNDS Ship Database, August 1, 1997.

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. March 23, 1995.

Table 1. Frequency of AFFF Discharge Events

Months	12	18	24	30	36	42	48	54	60	66	72
USCG Ships											
PMS - annual	X		X		X		X		X		X
FD Cert - triennial					X						X
Hose: 3 times in 3 years											
Flt dk: 1 time in 3 years											
MSC Ships											
PMS - annual	X		X		X		X		X		X
USCG - biennial	X				X				X		
FD Cert - triennial					X						X
INSURV - triennial					X						X
Hose: 9 times in 6 years											
Flt dk: 7 times in 6 years											
T-AKR Class											
Foam maker: 7 times in 6 years											
Hose: 9 times in 6 years											
Flt Dk: 7 times in 6 years											
LPH Class											
PMS - 18 months		X			X			X			X
FD Cert - triennial					X						X
INSURV - triennial					X						X
Hose: 3 times in 3 years											
Flt Dk: 2 times in 3 years											
CV/CVN Classes											
PMS - 18 months		X			X			X			X
FD Cert - 18 months		X			X			X			X
INSURV - triennial					X						X
Hose: 3 times in 3 years											
Flt Dk: 3 times in 3 years											
Other Navy Classes											
PMS - annual	X		X		X		X		X		X
FD Cert - triennial					X						X
INSURV - triennial					X						X
Hose: 4 times in 3 years											
Flt Dk: 2 times in 3 years											

Notes for Table 1:

1. PMS discharges are scheduled by the ship. The ships are assumed to schedule their PMS maintenance tests to coincide with a demonstration required by an off-ship inspection team, when possible. The tests that satisfy off-ship inspection teams are assumed to be separate, not combined.

2. PMS tests are required annually, although, for some ships the periodicity is 18 months. Flight deck certification is required on all air capable ships every 3 years, except for aircraft carriers additional certifications are required after industrial work on the flight deck; the assumed average periodicity for aircraft carriers is every 18 months. INSURV underway material inspections are required every 3 years, only on Navy and MSC ships. For MSC ships, the USCG Office of Marine Inspection requires demonstration of foam making capability every 2 years.

3. Data are derived from references 2, and 3-9.

Table 2. Annual Discharge Due to Tests, Inspections And Certifications

The Ship Class	Number Of Ships Per Class	The Armed Force Owner	Number of Foam Stations	The Foam Dispensing Means	Discharge Events Per Year Per Station (See Table 1)	Solution Disch. Per Station per Event (gal) (See Note 3)	Solution Disch. per Class (gal) (See Note 4)	Foam Con. Disch. Per Class (gal) (See Note 4)	Seawater Disch. Per Class (gal) (See Note 4)	Clean-up Seawater Per Class (gal) (See Note 5)
WAGB	1	USCG	1	Hose	1	125	125	8	118	0
WAGB	2	USCG	1	Hose	1	125	250	15	235	0
WHEC	12	USCG	2	Hose	1	125	3000	180	2820	0
WMEC	31	USCG	1	Hose	1	125	3875	233	3643	0
WTGB	9	USCG	1	Hose	1	125	1125	34	1058	0
T-AE 26	8	MSC	2	Hose	1.5	125	3000	180	2910	0
	8	MSC	2	Fl. Dk	1.167	353	6599	396	6203	54989
T-AFS 1	8	MSC	2	Hose	1.5	311	7459	448	7012	0
	8	MSC	2	Fl. Dk	1.167	350	6529	392	6137	54410
T-AGOS 1	5	MSC	1	Hose	1.5	125	938	56	881	0
19	4	MSC	1	Hose	1.5	125	750	45	705	0
T-AGS 26	2	MSC	1	Hose	1.5	125	375	23	353	0
T-AGS 45	1	MSC	1	Hose	1.5	125	188	11	176	0
T-AGS 51	2	MSC	1	Hose	1.5	125	375	23	353	0
T-AGS 60	4	MSC	1	Hose	1.5	125	750	45	705	0
T-AH 19	2	MSC	1	Hose	1.5	384	1152	69	1083	0
	2	MSC	1	Monitor	1.167	500	1167	70	1097	9725
T-AKR	11	MSC	2	Foam Mkr.	1.167	107	2747	82	2665	22893
	11	MSC	2	Hose	1.5	125	4125	124	4001	0
	11	MSC	2	Fl. Dk.	1.167	1707	43826	1315	42511	365213
T-AO 187	12	MSC	2	Hose	1.5	125	4500	270	4230	0
	12	MSC	2	Fl. Dk.	1.167	360	10083	605	9478	84024
T-ARC 7	1	MSC	1	Hose	1.5	125	188	11	176	0
	1	MSC	1	Fl. Dk.	1.167	360	420	25	395	3501
T-ATF 166	7	MSC	1	Hose	1.5	125	1313	79	1234	0
	7	MSC	1	Fl. Dk.	1.167	125	1021	61	960	8509
AGF 11	2	NAVY	4	Hose	1.33	125	1330	80	1250	0
	2	NAVY	4	Fl. Dk.	0.67	1021	5470	328	5142	45587
AGOR 21	1	NAVY	1	Hose	1.33	125	166	10	156	0
	1	NAVY	1	Fl. Dk.	0.67	0	0	0	0	0

Table 2. Annual Discharge Due to Tests, Inspections And Certifications

The Ship Class	Number Of Ships Per Class	The Armed Force Owner	Number of Foam Stations	The Foam Dispensing Means	Discharge Events Per Year Per Station (See Table 1)	Solution Disch. Per Station per Event (gal) (See Note 3)	Solution Disch. per Class (gal) (See Note 4)	Foam Con. Disch. Per Class (gal) (See Note 4)	Seawater Disch. Per Class (gal) (See Note 4)	Clean-up Seawater Per Class (gal) (See Note 5)
AGOR 23	2	NAVY	1	Hose	1.33	125	333	20	313	0
	2	NAVY	1	Fl. Dk.	0.67	0	0	0	0	0
AO 177	5	NAVY	2	Hose	1.33	125	1663	100	1563	0
	5	NAVY	2	Fl. Dk.	0.67	273	1829	110	1719	15243
AOE 1	4	NAVY	2	Hose	1.33	125	1330	80	1250	0
	4	NAVY	2	Fl. Dk.	0.67	464	2489	149	2339	20738
AOE 6	3	NAVY	3	Hose	1.33	125	1496	90	1406	0
	3	NAVY	3	Fl. Dk.	0.67	374	2258	135	2123	18817
ARS 50	4	NAVY	1	Monitor	1	1000	4000	240	3760	0
	4	NAVY	1	Hose	1	250	1000	108	892	0
AS 33	1	NAVY	2	Hose	1.33	125	333	20	313	0
	1	NAVY	2	Fl. Dk.	0.67	270	362	22	340	3015
AS 39	3	NAVY	2	Hose	1.33	125	998	60	938	0
	3	NAVY	2	Fl. Dk.	0.67	314	1261	76	1185	630
CG 47	27	NAVY	3	Hose	1.33	125	13466	808	12658	0
	27	NAVY	3	Fl. Dk.	0.67	170	9212	553	8659	76765
CGN 36	2	NAVY	2	Hose	1.33	125	665	40	625	0
	2	NAVY	2	Fl. Dk.	0.67	144	386	23	363	3216
CGN 38	1	NAVY	2	Hose	1.33	125	333	20	313	0
59/63/65	4	NAVY	17	Hose	1	250	17000	1836	15164	0
	4	NAVY	17	Fl. Dk.	1	1000	68000	4080	63920	566667
CVN 65/68	8	NAVY	16	Hose	1	250	32000	1920	30080	0
CVN 65/68	8	NAVY	20	Fl. Dk.	1	1000	160000	9600	150400	1333333
DDG 963	31	NAVY	2	Hose	1.33	125	10308	618	9689	0
	31	NAVY	2	Fl. Dk.	0.67	130	5416	325	5091	45133
DDG 51	18	NAVY	2	Hose	1.33	125	5985	359	5626	0
	18	NAVY	2	Fl. Dk.	0.67	210	5065	304	4761	2533
DDG 993	4	NAVY	2	Hose	1.33	125	1330	80	1250	11083
	4	NAVY	2	Fl. Dk.	0.67	130	699	42	657	349

Table 2. Annual Discharge Due to Tests, Inspections And Certifications

The Ship Class	Number Of Ships Per Class	The Armed Force Owner	Number of Foam Stations	The Foam Dispensing Means	Discharge Events Per Year Per Station (See Table 1)	Solution Disch. Per Station per Event (gal) (See Note 3)	Solution Disch. per Class (gal) (See Note 4)	Foam Con. Disch. Per Class (gal) (See Note 4)	Seawater Disch. Per Class (gal) (See Note 4)	Clean-up Seawater Per Class (gal) (See Note 5)
FFG 7	43	NAVY	2	Hose	1.33	125	14298	858	13440	0
	43	NAVY	2	Fl. Dk.	0.67	182	10510	631	9879	87582
IX 308	2	NAVY	1	Hose	1.33	125	333	20	313	0
IX 35	2	NAVY	1	Hose	1.33	125	333	20	313	0
IX 501	1	NAVY	1	Hose	1.33	125	166	10	156	0
LCC 19	2	NAVY	2	Hose	1.33	125	665	40	625	0
	2	NAVY	2	Fl. Dk.	0.67	320	857	51	805	7140
LHA 1	5	NAVY	12	Hose	1.33	250	19950	1197	18753	0
	5	NAVY	12	Fl. Dk.	0.67	1000	40200	2412	37788	335000
LHD 1	4	NAVY	12	Hose	1.33	250	15960	958	15002	0
	4	NAVY	12	Fl. Dk.	0.67	1000	32160	1930	30230	268000
LPD 4	8	NAVY	4	Hose	1.33	125	5320	319	5001	0
	8	NAVY	4	Fl. Dk.	0.67	1021	21882	1313	20569	182347
LPH 2	2	NAVY	10	Hose	1	250	5000	540	4700	0
	2	NAVY	10	Fl. Dk.	0.67	1000	13400	804	12596	111667
LSD 36	5	NAVY	4	Hose	1.33	125	3325	200	3126	0
	5	NAVY	4	Fl. Dk.	0.67	365	4888	293	4595	40736
LSD 41	8	NAVY	4	Hose	1.33	125	5320	319	5001	0
	8	NAVY	4	Fl. Dk.	0.67	936	20068	1204	18864	167232
LSD 49	3	NAVY	4	Hose	1.33	125	1995	120	1875	0
	3	NAVY	4	Fl. Dk.	0.67	936	7525	452	7074	62712
LST 1179	3	NAVY	1	Hose	1.33	125	499	30	469	0
	3	NAVY	1	Fl. Dk.	0.67	216	434	26	408	3618
MCM 1	14	NAVY	1	Hose	1.33	125	2328	140	2188	0
MHC 51	12	NAVY	1	Hose	1.33	125	1995	120	1875	0
PC 1	13	NAVY	1	Hose	1.33	125	2161	130	2032	0
	13	NAVY	1	Fl. Dk.	0.67	162	1408	85	1324	11737
Misc. (See Note 6)	30	MSC	N/A	N/A	N/A	N/A	27500	1650	25850	220000
TOTAL							**722537**	**42902**	**679931**	**4244144**

Table 2. Annual Discharge Due to Tests, Inspections And Certifications

Notes for Table 2:

1. Values in this table are upper bound estimates, because all discharge is assumed to occur within 12 n. m. of shore.

2. Discharges are due to maintenance tests of the proportioning accuracy of the foam proportioners, to demonstrations of foam making capability for flight deck certification teams, and to demonstrations of foam making capability for the Board of Inspection and Survey. Discharges to bilges, by hose nozzles or fixed sprinklers, are not tabulated because the foam solution is not pumped overboard within 12 n.m. of shore.

3. The discharge flow through hoses is 125 gpm or 250 gpm, depending on the ship's installed equipment. The discharge rate through fixed flight deck sprinklers is .06 gpm/ft2 X Flight Deck area. For aircraft carriers, and the big deck amphibious ships, LHD, LHA, and LPH, flight deck discharge is calculated at 1000 gpm per zone.

4. Total hose flow is No. of ships X No. of stations per ship X Hose nozzle flow rate X 1 minute. Foam is 6% of total flow, and seawater is 94% of total flow rate. For ships with fixed speed foam injection pumps, foam flow is 27 gpm and seawater flow = total flow - 27 gpm. Total flight deck flow is No. of ships X flight deck area X .06 gpm/ft2 X 1 minute. For aircraft carriers and the big deck amphibious ships, LHD, LHA, and LPH, the total flow is No. of ships X No. of zones per ship X 1000 gpm per zone X 1 minute. For both cases, foam is 6% of total flow, and seawater is 94% of total flow. For WTGB and T-AKR Class ships foam is 3% of total flow and seawater is 97% of total flow; these ships use a more concentrated foam concentrate than other ships.

5. The flow from demonstrations and tests of flight deck hoses is directed over the side. No seawater is needed for clean up. The flow through fixed flight deck sprinklers is cleaned off the ship by seawater from the firemain, either through hose nozzles or the fixed flight deck sprinklers. As an average figure to account for both options, the cleanup flow is assumed to be .05 gpm/ft2, or 833 gpm per zone, flowing for 10 minutes.

6. Aboard MSC ships with helicopter landing capabilities, the presence of foam must be demonstrated at flight deck nozzles and hoses before each flight operation. Assuming two such operations per month per ship, the total annual discharge of fluoroprotein foam concentrate for the 30 ships involved is 30 ships X 55 gallons foam concentrate per ship per year, which equals 1650 gallons/year. The concentrate is assumed to be 6% of the total flow, so the total flow of solution is 1650/.06 or 27,500 gallons of seawater foam solution per year. The water portion is assumed to be 94% of the total flow. Cleanup seawater flow is assumed to be eight times the total solution flow, or 220,000 gallons.

7. To perform a maintenance test of the proportioning accuracy of a proportioning station, foam solution will be directed over the side via a hose nozzle rated at 125 gpm or 250 gpm, depending on the ship's installed equipment. Test is assumed to require 1 minute of flow.

8. To demonstrate foam-making ability for an off-ship inspection team, foam will be discharged over the side through hose nozzles and onto the flight deck through the fixed sprinklers. Demonstration is assumed to require 1 minute of flow.

9. Data are derived from Table 1 , specific references 1, 2, 11, and general references.

Table 3. Upper Bound Estimates of Annual Mass Loading and Constituent Concentrations Due to AFFF Discharge

Annual discharge of AFFF/seawater solution, gals	722,500	
Annual discharge of AFFF concentrate, gals	42,900	
Annual discharge of AFFF concentrate, lbs	366,366	8.54/lb/gal density
Annual discharge of seawater in the solution, gals	680,000	
Annual discharge of cleanup seawater, gals	4,244,000	
Annual discharge of seawater, including cleanup, gals	4,924,000	

			Mass Loading		Concentration	
Constituent	**Wt % Low**	**Wt % High**	**Low (lb)**	**High (lb)**	**Low mg/L**	**High mg/L**
Fresh water	78.0%	81.0%	286,000	297,000	47,400	49,200
2-(2-butoxyenthoxy)-ethanol	9.5%	10.4%	34,800	38,500	5,800	6,400
urea	3.0%	7.0%	11,000	25,600	1,800	4,300
alkyl sulfate salts (2)	1.0%	5.0%	3,700	18,300	610	3,040
amphoteric fluoroalkylamide derivative	1.0%	2.0%	3,700	7,300	610	1,220
perfluoroalkyl sulfonate salts (5)	0.1%	1.0%	370	3,700	61	610
triethanolamine	0.1%	1.0%	370	3,700	61	610
methyl-1H-benzotriazole	0.0%	0.1%	0	370	0	61
Constituent	**Concentration**		**Mass Loading**			
Total nitrogen	500 µg/L		16.8 lb			
Bis(2-ethylhexyl) phthalate in seawater	22 µg/L		0.74 lb			
Copper in seawater	45.59 µg/L		1.87 lb			
Nickel in seawater	15.24 µg/L		0.62 lb			
Iron in seawater	21.28 µg/L		0.87 lb			

Notes:

1. Conversion: 1 µg/L = 8.345 X 10^{-9} lb/gal
2. Concentrations in mg/L are for the diluted AFFF/seawater solution. The concentrations are accurate for hoses discharged over the side, but overstated by about 30% for flight deck discharges which are washed over the side with additional seawater. Calculation is pounds of constituent, divided by gallons of discharged solution, and converted to mg/L.
3. Data derived from Table 2, and References 12, 17.

Table 4. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituents	Log-normal Mean Effluent	Minimum Concentration Effluent	Maximum Concentration Effluent	Federal Acute WQC	Most Stringent State Acute WQC
Classicals (µg/L)					
Total nitrogen	500			None	200 (HI)[A]
Organics (µg/L)					
Bis(2-ethylhexyl) phthalate	22	BDL	428	None	5.92 (GA)
Metals (µg/L)					
Copper					
Dissolved	24.9	BDL	150	2.4	2.4 (CT, MS)
Total	62.4	34.2	143	2.9	2.5 (WA)
Iron					
Total	370	95.4	911	None	300 (FL)
Nickel					
Total	15.2	BDL	52.1	74.6	8.3 (FL, GA)

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.

CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 5. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation	NSTM Ch 555			X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality	PMS Cards			X
3.2 Rate			X	X
3.3 Constituents	X			
3.4 Concentrations	MSDS Sheets			
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X		X	
4.3 Potential for Introducing Non-Indigenous Species			X	X