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MILITARY HANDBOOK

NONDOMESTIC WASTEWATER CONTROL AND PRETREATMENT DESIGN CRITERIA

AMSC N/A AREA FACR 1180

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ABSTRACT

This handbook provides guidance to environmental, operations, and design personnel for controlling the discharge of nondomestic wastewater to domestic wastewater systems for compliance with municipal and military pretreatment requirements. Key sources of nondomestic discharges at military installations are identified and characterized, and guidelines for selecting and implementing industrial wastewater management strategies are presented. The use of pollution prevention measures is emphasized as a preferred approach to compliance, and pollution prevention guidelines are presented. In addition, the handbook contains guidance for the selection, conceptual design, and procurement of systems for pretreatment or recycling of nondomestic wastewaters.

The guidance presented in this handbook applies to most major military installations, but is not intended for shipyards, depots, or large industrial facilities discharging to industrial wastewater treatment systems. Direct discharge to a receiving water body is also not addressed. Likewise, the handbook is not intended as a detailed design manual but rather as an overview of the important considerations involved in implementing nondomestic wastewater pretreatment and recycling systems.

FOREWORD

This handbook is approved for use by all Departments and Agencies of the Department of Defense. It is intended to guide the reader in controlling nondomestic wastewater according to military and nonmilitary standards. Commercial equipment and materials mentioned in this handbook are included for illustration only and do not constitute an endorsement.

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NONDOMESTIC WASTEWATER CONTROL AND PRETREATMENT DESIGN CRITERIA

CONTENTS

			Page
Section	1	INTRODUCTION	
	1.1	Scope of Handbook	1
	1.2	Organization of Handbook	1
Section	2	APPLICABLE LAWS, REGULATIONS, AND POLICIES	
	2.1	Section Overview	3
	2.2	Clean Water Act	3
	2.3	General Pretreatment Regulations	3
	2.3.1	Overview	3
	2.3.2	Applicability to POTWs	4
	2.3.3	Applicability to Nondomestic Dischargers	4
	2.3.4	Applicability to Military Installation	5
	2.3.5	Requirements of the General Pretreatment Regulations	5
	2.4	Local Limits	6
	2.4.1	Pollutants Included in Local Limits	7
	2.4.2	Point at Which Local Limits Apply	7
	2.4.3	Calculation of Local Limits	7
	2.4.4	Examples of Local Limits	7
	2.5	Categorical Pretreatment Standards	7
	2.5.1	Electroplating	11
	2.5.2	Metal Finishing	11
	2.5.3	Other Categories	12
	2.6	Federal Facilities Compliance Act	12
	2.7	Pollution Prevention Act	12
	2.8	Directives	13
	2.8.1	Executive Order 12088	13
	2.8.2	Department of Defense Directive 5100.50	14
	2.8.3	Department of Defense Directive 4715.5	14
	2.8.4	Air Force Policy Directive 32-70	14
	2.8.5	Navy Policy OPNAVINST 5090.1A	14
	2.8.6	Army Environmental Policy Statements	15
	2.9	Occupational Safety and Health Administration Standards	15

Page

Section 3 DEVELOPMENT OF TECHNICALLY BASED LOCAL LIMITS
3.1 Section Overview 16
3.2 Purpose of Local Limits 16
3.3 General Approaches to Developing Local Limits 16
3.4 The MAHL Approach 17
3.4.1 Regulatory Criteria 17
3.4.1.1 Process Inhibition 19
3.4.1.2 Biosolids Disposal 19
3.4.1.3 Effluent Discharge 19
3.4.1.4 Air Emissions Criteria 26
3.4.2 Pollutants of Concern 27
3.4.3 Treatment Plant Removal Efficiencies ... 28
3.4.4 Calculation of MAHLs 30
3.4.5 Allocation of MAHLs to Nondomestic Sources 30
3.4.5.1 Domestic/Background Pollutant Loadings . 31
3.4.5.2 Safety Factors 32
3.4.6 Calculation of Local Limits 32
3.5 Development of Discharge Limitations Based on Protection of the Collection System and Worker Health and Safety 33
3.5.1 Prohibited Discharge Standards 33
3.5.2 Oil and Grease Limits 34
3.5.3 Protection Against Vapor Toxicity 34
3.5.4 Protection Against Flammability/ Explosivity 35

Section 4 WASTEWATER SOURCES, CHARACTERISTICS, AND POLLUTION PREVENTION
4.1 Section Overview 36
4.2 Wastewater Characterization Data 36
4.3 Pollution Prevention 37

Page

4.3.1 Pollution Prevention Policy 37
4.3.2 Pollution Prevention Opportunity Assessments 37
4.3.3 Pollution Prevention Methods 37
4.3.3.1 Material Substitution 38
4.3.3.2 Process Modifications 39
4.3.3.3 Housekeeping and Operational Improvements 39
4.3.3.4 Material Recycle, Reuse, and Recovery .. 40
4.4 AFFF Fire Suppression 40
4.4.1 Activity Description 40
4.4.2 Wastewater Characteristics 41
4.4.3 Pollution Prevention 42
4.5 Aircraft Corrosion Control 42
4.5.1 Activity Description 42
4.5.2 Wastewater Characteristics 42
4.6 Aircraft Deicing 42
4.6.1 Activity Description 42
4.6.2 Wastewater Characteristics 44
4.6.3 Pollution Prevention 44
4.6.3.1 Glycol Recovery 44
4.6.3.2 Glycol Use Reduction 44
4.7 Aircraft Washing 45
4.7.1 Activity Description 45
4.7.2 Wastewater Characteristics 45
4.7.3 Pollution Prevention 45
4.7.3.1 Water Conservation 47
4.7.3.2 Process Modifications 47
4.7.3.3 Diversion of Stormwater from Washracks . 47
4.8 Battery Maintenance 47
4.8.1 Activity Description 47
4.8.2 Wastewater Characteristics 48
4.9 Dental Clinic Operations 49
4.9.1 Activity Description 49
4.9.2 Wastewater Characteristics 49

Page

4.9.3 Pollution Prevention 50
4.10 Engine Washing 51
4.10.1 Activity Description 51
4.10.2 Wastewater Characteristics 51
4.11 Fire Fighting Training 52
4.11.1 Activity Description 52
4.11.2 Wastewater Characteristics 52
4.12 Fuel Storage 53
4.12.1 Activity Description 53
4.12.2 Wastewater Characteristics 54
4.13 Hospital Operations 55
4.13.1 Activity Description 55
4.13.2 Wastewater Characteristics 55
4.13.3 Pollution Prevention 56
4.14 Maintenance Area Floor Washing 56
4.14.1 Activity Description 56
4.14.2 Wastewater Characteristics 57
4.14.3 Pollution Prevention 59
4.14.3.1 Cleaning Practices 59
4.14.3.2 Spill Control 59
4.14.3.3 Spill Prevention 60
4.15 Non-Destructive Inspection Testing 60
4.15.1 Activity Description 60
4.15.2 Wastewater Characteristics 60
4.16 Parts Washing 61
4.16.1 Activity Description 61
4.16.2 Wastewater Characteristics 61
4.16.3 Pollution Prevention 62
4.16.3.1 Cleaning Process Assessment 63
4.16.3.2 Elimination of Solvents 63
4.16.3.3 Use of Filters 64
4.17 Photo/X-Ray Processing 64
4.17.1 Activity Description 64
4.17.2 Wastewater Characteristics 65

Page

4.17.3	Pollution Prevention	66
4.17.3.1	Metallic Replacement	67
4.17.3.2	Electrolysis	68
4.17.3.3	Other Technologies	68
4.18	Steam Generation	68
4.18.1	Activity Description	68
4.18.2	Wastewater Characteristics	69
4.19	Vehicle Painting	70
4.19.1	Activity Description	70
4.19.2	Wastewater Characteristics	70
4.19.3	Pollution Prevention	71
4.20	Vehicle and Equipment Washing	71
4.20.1	Activity Description	71
4.20.2	Wastewater Characteristics	71
4.21	Other Sources of Nondomestic Wastewater	72
4.21.1	Cafeteria/Restaurant Services	72
4.21.2	Water Treatment	72
4.21.3	Metal Plating	73
4.21.4	Shipboard Wastewater	74
4.21.5	Drydocking Facilities	74
4.22	Summary of Pollutants Contributed	74
Section 5	GUIDELINES FOR SELECTING A WASTEWATER MANAGEMENT SYSTEM	
5.1	Section Overview	76
5.2	Wastewater Inventory	76
5.3	Wastewater Characterization	76
5.3.1	Wastewater Volume	76
5.3.2	Wastewater Composition	77
5.3.3	Sampling	78
5.4	Discharge Limitations	78
5.5	Wastewater Management Alternatives	79
5.5.1	Development of Wastewater Management Alternatives	79

Page

	5.5.2	Evaluation of Wastewater Management Alternative	79
	5.6	Selection of a Treatment System Alternative	80
	5.7	Sources Potentially Subject to Treatment	81
	5.8	Consultants and Vendors	81
Section	6	OIL AND GREASE REMOVAL	
	6.1	Section Overview	84
	6.2	Oily Wastewater Origin and Classification	84
	6.2.1	Free Oil	84
	6.2.2	Emulsified Oil	84
	6.2.3	Dissolved Oil	85
	6.3	Sampling and Measurement	85
	6.4	Regulatory Basis for Considering Oil Removal	85
	6.5	Evaluating the Need for OWSs	86
	6.6	Treatment Technology	89
	6.6.1	Gravity Separation	89
	6.6.1.1	Conventional Gravity Separators	90
	6.6.1.2	Parallel-Plate Separators	92
	6.6.2	Oil Collection	94
	6.6.3	Air-Flotation Separators	94
	6.6.4	Emulsion Breaking Processes	95
	6.6.4.1	Chemical Processes	95
	6.6.4.2	Mechanical Impingement and Filtration Processes	97
	6.6.4.3	Centrifugal Processes	98
	6.6.5	Treatment of Dissolved Oil	98
	6.6.6	Emerging Technologies	98
	6.7	Design of OWS Systems	99
	6.7.1	Wastewater Characterization	99
	6.7.2	Site Considerations	99

Page

	6.7.3	Establishing the Design Flow	100
	6.7.4	Pretreatment for Grit Removal	101
	6.7.5	Design Criteria for Conventional Separators	101
	6.7.6	Design Criteria for Parallel-Plate Separators	102
	6.8	Sludge Removal and Disposal	102
	6.9	Grease Separators	103
	6.10	Guidance Documents	103
Section	7	HEAVY METALS REMOVAL	
	7.1	Section Overview	105
	7.2	Types and Sources of Heavy Metals	105
	7.2.1	Metals of Concern	105
	7.2.2	Sources of Metals	105
	7.2.3	Metals Classification	106
	7.3	Evaluating the Need for Metals Removal	106
	7.4	Treatment Technology	106
	7.5	Chemical Precipitation, Flocculation, and Sedimentation	106
	7.5.1	Process Description	107
	7.5.2	Jar Testing	107
	7.5.3	Precipitation	107
	7.5.4	Sedimentation	108
	7.5.5	Package Systems	108
	7.6	Filtration	110
	7.6.1	Granular Media Filtration	111
	7.6.1.1	Process Description	111
	7.6.1.2	Filter Media	111
	7.6.1.3	Design Criteria	112
	7.6.1.4	Package Systems	112
	7.6.2	Bag Filtration	112
	7.6.2.1	Process Description	112
	7.6.2.2	Design Criteria	115
	7.6.2.3	Package Systems	115

Page

	7.6.3	Cartridge Filtration	115
	7.6.3.1	Process Description	115
	7.6.3.2	Design Criteria	115
	7.6.3.3	Package Units	115
	7.6.4	Membrane Filtration	117
	7.6.4.1	Process Description	117
	7.6.4.2	Design Criteria	120
	7.6.4.3	Package Systems	121
	7.7	Ion Exchange	121
	7.7.1	Process Description	123
	7.7.2	Design Criteria	123
	7.7.3	Package Systems	124
	7.8	Evaporation	126
	7.8.1	Process Description	126
	7.8.2	Design Criteria	126
	7.8.3	Package Units	127
Section	8	TREATMENT FOR WASHWATER RECYCLING	
	8.1	Section Overview	129
	8.2	Washwater Sources	129
	8.3	Assessing the Need for a Washwater Recycling System	129
	8.4	Pollutants to be Removed	130
	8.5	Treatment Technologies	130
	8.6	Prefabricated Package Systems	130
	8.6.1	LANDA Water Cleaning Systems	131
	8.6.2	Pan America Environmental	132
	8.6.3	RGF Environmental	132
	8.6.4	Universal Recycled Water Systems Inc.	132

FIGURES

Page

Figure 1 Schematic for Development of Local Limits 18
2 Decision Tree for Oil/Water Separators .. 87
3 Conventional Gravity Separator 91
4 Downflow Parallel-Plate Separator 93
5 Dissolved Air Flotation 96
6 Chemical Precipitation, Flocculation, and Sedimentation Schematic 109
7 Pressure Granular Media Filtration Schematic 113
8 Gravity Bag Filtration System Schematic 116
9 Cartridge Filter Schematic 118
10 Membrane Filtration Schematic 122
11 Ion Exchange System Schematic 125
12 Evaporator System Schematic 128
13 LANDA’s Delta Washwater Recycling System 133
14 RFG’s VEW-2 Washwater Recycling System . 134
15 Pan American Environmental VEW-2 Washwater Recycling System 135
16 Universal Recycled Water Systems; Deluge Recycled Water Plant 136

Page

TABLES

Table 1 Selected List of Local Limits 8
2 Selected Categorical Pretreatment Standards for Existing Sources 10
3 Processes Covered in Metal Finishing Regulations 11
4 Toxic Pollutant Inhibition Threshold Levels 20
5 U.S. EPA Sludge Pollutant Limitations for Land Application 21
6 Water Quality Criteria for Priority Pollutants 22
7 Literature Values for POTW Pollutant Removal Efficiencies 29
8 Residential/Background Pollutant Concentrations 31
9 Characteristics of AFFF Fire Suppression Wastewater 41
10 Characteristics of Aircraft Corrosion Control Wastewater 43
11 Characteristics of Aircraft Washing Wastewater 46
12 Characteristics of Battery Maintenance Wastewater 48
13 Characteristics of Dental Clinic Wastewater 50
14 Characteristics of Engine Washing Wastewater 51
15 Characteristics of Fire Fighting Training Wastewater 53
16 Characteristics of Fuel Storage Wastewater 54
17 Characteristics of Hospital Wastewater 55

Page

TABLES

18 Characteristics of Maintenance Area Floor Washing Wastewater 58
19 Characteristics of NDI Testing Wastewater 60
20 Characteristics of Parts Washing Wastewater 62
21 Characteristics of Photo/X-Ray Processing Wastewater 65
22 Characteristics of Steam Generation Wastewater 69
23 Characteristics of Vehicle Painting Wastewater 70
24 Characteristics of Vehicle/Equipment Washing Wastewater 73
25 Summary of Wastewater Categories and Pollutants Contributed 74
26 Suppliers of Precipitation/Flocculation/ Clarification Systems 110
27 Suppliers of Pressure Filtration Systems 114
28 Suppliers of Bag Filters 117
29 Suppliers of Cartridge Filters 119
30 Suppliers of Membrane Filtration Systems 121
31 Suppliers of Ion Exchange Systems 124
32 Suppliers of Wastewater Evaporators 127
33 Partial Vendor Listing/Washwater Recycling Systems 131

REFERENCES 137

GLOSSARY 142

Section 1: INTRODUCTION

1.1 Scope of Handbook. This handbook provides integrated guidance for operations, design, and environmental personnel for controlling the discharge of nondomestic wastewater to domestic wastewater systems for compliance with local, state, federal, and military pretreatment requirements. Key sources of nondomestic discharges at military installations are identified and characterized, and guidelines for selecting and implementing industrial wastewater management strategies are presented. The use of pollution prevention measures is emphasized as a preferred approach to achieve compliance, and pollution prevention guidelines are presented. In addition, the handbook contains guidance for the selection, conceptual design, and procurement of systems for pretreatment or recycling of nondomestic wastewaters.

The guidance in this handbook applies to most major military installations, but is not intended for shipyards, depots, or large industrial facilities discharging to industrial wastewater treatment facilities. Direct discharge to a receiving water body is also not addressed. Direct discharge is regulated through a National Pollutant Discharge Elimination System (NPDES) permit, and usually requires an extensive treatment facility. A military treatment facility that discharges directly to a surface water may be designated as a Federally Owned Treatment Works (FOTW).

This handbook is intended to provide an overview of the important considerations involved with implementing nondomestic wastewater pretreatment and recycling systems. For detailed design guidance, the reader is referred to available military handbooks, such as MIL HDBK-1005/9, Industrial and Oil Wastewater Control Handbook and MIL HDBK-1005/16, Wastewater Treatment System Design Augmenting Handbook.

1.2 Organization of Handbook. The handbook is organized as follows:

a) Section 1: Introduction

b) Section 2: Applicable Laws, Regulations, and Policies

c) Section 3: Development of Technically Based Local Limits

d) Section 4: Wastewater Sources, Characteristics, and Pollution Prevention

e) Section 5: Guidelines for Selecting a Wastewater Management System

f) Section 6: Oil and Grease Removal

g) Section 7: Heavy Metals Removal

h) Section 8: Treatment for Washwater Recycling

Section 2: APPLICABLE LAWS, REGULATIONS, AND POLICIES

2.1 Section Overview. This section provides information on the applicable laws, regulations, and guidelines that govern the discharge of nondomestic wastewater to domestic wastewater systems and thereby drive the need for implementation of pollution prevention measures and pretreatment systems. Key among these is the General Pretreatment Regulation, 40 CFR 403, which mandates the development and enforcement of local pretreatment limits, as well as the enforcement of certain uniform national pretreatment standards. All of the laws, regulations, and policies discussed are national in scope and are applicable to all military installations, including overseas installations. For wastewater discharges to waters of an overseas host nation, the standards included in the Overseas Environmental Baseline Guidance Document (OEBGD) and/or country-specific Final Governing Standards (FGS) must be complied with.

2.2 Clean Water Act. The Federal Water Pollution Control Act of 1972, as amended by the Clean Water Act of 1977 and the Water Quality Act of 1987, gives the U.S. Environmental Protection Agency (EPA) the authority to regulate the discharge of pollutants to waters of the United States. The NPDES Permit Program (40 CFR 122) was established under this Act. NPDES permits must be obtained for all direct discharges to surface waters, but are not required for indirect discharges to domestic wastewater systems.

Military installations should review their NPDES permit application to ensure that all operations and processes are clearly identified. An NPDES permit does not authorize pollutant discharges associated with existing waste streams, operations, or processes that the permit holder failed to clearly identify when filing the permit application. Failure to knowingly disclose processes or contaminants may subject the installation and possibly the associated personnel to fines and penalties.

2.3 General Pretreatment Regulations

2.3.1 Overview. The General Pretreatment Regulations, promulgated under 40 CFR 403, have been the basis for the

development and implementation of local and state pretreatment programs throughout the United States since 1978. The regulations set forth general discharge prohibitions that apply to all nondomestic discharges to a Publicly Owned Treatment Works (POTW), and they establish an administrative mechanism to ensure that these general discharge prohibitions, as well as Categorical Pretreatment Standards, are applied and enforced. Through the Federal Facilities Compliance Act (FFCA) (see Section 2.5), portions of the regulations also apply to discharges to FOTWs.

The objectives of the General Pretreatment Regulations are to:

a) Prevent the pass-through of pollutants in violation of the POTW's NPDES permit limitations.

b) Prevent interference with the operation of the POTW, including inhibiting or disrupting the effective treatment or causing a violation of the POTW's NPDES permit.

c) Prevent contamination of the POTW's sludge (i.e., biosolids), causing a violation of applicable standards or preventing the beneficial use or disposal of residual solids.

d) Protect POTW worker health and safety.

e) Improve opportunities to recycle and reclaim municipal and industrial wastewaters and sludges.

2.3.2 Applicability to POTWs. Under the General Pretreatment Regulations, POTWs with a total design flow greater than 5 million gallons per day (mgd) and receiving nondomestic discharges that pass through or interfere with the POTW are required to establish an approved pretreatment program. Smaller POTWs may also be required to develop a pretreatment program if they are experiencing process upsets or permit violations caused by nondomestic wastes.

2.3.3 Applicability to Nondomestic Dischargers. The General Pretreatment Regulations apply to all nondomestic sources of wastewater. However, enforcement of pretreatment standards through POTW pretreatment programs is aimed primarily at

"Significant Industrial Users" (SIUs). SIUs include all industrial users subject to national categorical pretreatment standards, and any other industrial user that: discharges an average of 25,000 gallons per day (gpd) or more of process wastewater to the POTW; contributes a process waste stream that makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment plant; or has a reasonable potential for adversely affecting the POTW's operation. Where POTWs do not have an approved local pretreatment program, the state or EPA has the responsibility of enforcing pretreatment requirements.

2.3.4 Applicability to Military Installations. A military installation discharging to a POTW may be classified in whole or in part as an SIU and thus be subject to the General Pretreatment Regulations, enforceable by the POTW. As noted previously, if the POTW does not have an approved pretreatment program, the state or EPA may enforce the regulations directly.

Military installations discharging to FOTWs have not historically been subject to pretreatment regulations. However, under the FFCA, Section 108, FOTWs are subject to pretreatment requirements similar to POTWs under certain conditions (See par. 2.6 for the requirements).

2.3.5 Requirements of the General Pretreatment Regulations. The General Pretreatment Regulations require compliance with the following discharge standards:

a) Prohibited Discharge Standards (40 CFR 403.5(b)). These standards restrict discharge of the following pollutants to a POTW:

1) Pollutants that could create a fire or explosion hazard (e.g., fuels)

2) Corrosives that could cause structural damage, and in no case discharges with pH lower than 5.0

3) Solid or viscous pollutants that could obstruct flow

4) Heat in amounts that could inhibit biological activity, and in no case cause the treatment plant influent temperature to exceed 40 degrees Celsius (°C) (104 degrees Fahrenheit [°F])

5) Pollutants at a flow rate and/or concentration that could cause interference with treatment processes

6) Pollutants that could produce toxic gases, vapors, or fumes within the sewer system in quantities endangering workers

7) Trucked or hauled industrial wastewater pollutants, except at approved discharge points

b) Local Limits (40 CFR 403.5(c)and(d)). These are specific concentration limits for pollutants of concern that may be discharged to a domestic wastewater system. They are to be derived by the local POTW on a technical basis, considering protection of plant processes, effluent and biosolids quality, and worker health and safety (29 CFR 1910). FOTWs are encouraged, and may be required, to develop such limits, which would be applicable to nondomestic discharges at military installations.

c) National Categorical Pretreatment Standards (40 CFR 403.6). These are concentration and/or mass limits developed by the EPA for selected industrial categories; some military installations have the type of industrial processes that are subject to these limits. Installations should review the Categorical Standards discussed in par. 2.5 to determine their applicability.

2.4 Local Limits. As noted above, POTWs subject to the General Pretreatment Regulations are required to develop and enforce technically based local limits for all pollutants of concern. FOTWs have not been required to develop or enforce local limits, but may be required to do so under the Federal Facilities Compliance Act, or may elect to do so if they

experience difficulties in complying with NPDES or biosolids disposal permits. Thus, nondomestic discharges at military installations are subject to either the local limits of the POTW to which the installation wastewater discharges, or to the FOTW local limits developed for the installation.

2.4.1 Pollutants Included in Local Limits. Most POTW local limits include heavy metals, cyanide, and oil and grease. In some cases, local limits have also been established for toxic organic compounds, such as benzene, toluene, ethylbenzene, and xylene (BTEX compounds).

2.4.2 Point at Which Local Limits Apply. For military installations, many POTWs have elected to enforce local limits only at the final point(s) connecting the military installation with the POTW pipeline system. However, some POTWs enforce local limits within the military installation either at specific nondomestic discharge points or at a location that combines several nondomestic sources.

2.4.3 Calculation of Local Limits. Local limits are site specific for each treatment system. Variations are caused by differences in treatment processes, pollutant removal efficiencies, receiving water discharge standards, biosolids disposal standards, domestic wastewater pollutant background concentrations, and the type and magnitude of industrial wastewater contributions. The calculation of local limits is described in Section 3.

2.4.4 Examples of Local Limits. Table 1 presents a summary of selected local limits. These examples are presented to illustrate a range of discharge standards that military installations may be required to meet. Each military installation should check with its local regulatory authority to determine the applicable local limits.

2.5 Categorical Pretreatment Standards. EPA has established specific “categorical pretreatment standards” for indirect dischargers in 33 industrial categories. These are national standards enforceable in addition to any local limits. Both the local limits and categorical standards are required to be met.

Table 1
Examples of Local Limits(1)

Location	As	Cd	Cr	Cu	Pb	Hg	Mo	Ni	Ag	Zn	O&G	BTEX	CN
Military Installations Discharging to POTWs													
Dover AFB, DE(2)	--	0.12	--	0.14	0.22	.0015	--	.055	--	0.47	360		--
Fairchild AFB, WA(2)	0.94	0.11	5.0	1.4	0.32	0.2	--	3.95	0.40	7.47	100	--	0.49
Keesler AFB, MS(2)	0.05	0.02	0.05	0.02	0.10	0.002	--	0.08	0.01	0.05	--	--	0.05
Langley AFB, VA(2)	0.026	0.026	0.62	0.64	0.25	0.003	--	0.25	0.08	0.68	50	--	0.12
Malmstrom AFB, MT(2)	0.461	3.551	5.67	4.98	0.94	0.028	--	4.78	0.53	1.02	100	--	0.51
McChord AFB, WA(2)	1.0	0.5	2.75	3.0	2.0	0.1	--	2.5	1.0	5.0	100	--	2.0
Norfolk Naval Sta., VA(3)	0.5	0.5	25	25	10	0.1	--	10	2.5	25	500	--	5.0
Onizuka AFB, CA(2)	0.3	0.1	1.7	0.5	0.5	0.01	--	0.25	0.2	1.48	100	--	0.5
Patrick AFB, FL(2)	0.05	0.1	1.0	0.5	0.05	0.05	--	0.5	0.05	1.0	50	--	0.01
Sheppard AFB, TX(2)	0.29	0.14	5.25	5.49	1.01	.0033	0.06	1.93	0.08	10.6	--	--	0.84
Travis AFB, CA(2)	0.1	0.05	0.15	1.3	0.05	0.01	--	0.9	0.2	2.3	100	25	0.7
Tyndall AFB, FL(2)	--	0.028	0.15	.094	.017	.00008	--	.025	0.01	0.55	--	10	--
Wright/Patt AFB, OH(2)	--	0.3	4.0	2.0	1.0	.0025	0.30	.067	--	5.0	--	--	--
Bolling AFB, DC(2)	--	1.2	7.0	4.5	0.6	0	--	4.1	1.0	4.2	100	--	--
Vance AFB, OK(2)	--	0.26	1.77	2.07	0.43	--	--	2.38	0.24	1.48	--	--	0.65
Lackland AFB, TX(2)	0.70	8.0	10	7.0	0.70	0.05	--	5.5	0.50	4.0	200	--	2.5
Griffiss AFB, NY(2)	0.5	0.1	2.0	1.5	0.7	0.2	--	0.5	0.5	2.6	100	--	2.0
Vandenberg AFB, CA(2)	--	0.2	1.71	1.0	0.43	--	--	2.38	0.24	1.0	--	--	0.65
Barksdale AFB, LA(4)	--	0.4	--	6.5	1.1	--	--	--	1.7	--	100	1.5	--
Other POTWs													
Chattanooga, TN(5)	--	1.0	5.0	5.0	1.5	0.1	--	5.0	1.0	5.0	--	--	2.0
Anchorage, AK(6)	1.7	1.0	5.0	5.8	5.0	0.085	--	12	5.0	--	--	31.7	2.6
El Paso, TX(7)	0.17	0.11	1.22	2.39	0.66	0	0.15	1.71	0.98	5.37	--	70	1.31
Santa Rosa, CA(8)	--	0.26	1.71	2.07	3.9	--	--	3.6	0.24	1.48	--	--	0.4

Table 1 (Continued)

Location	As	Cd	Cr	Cu	Pb	Hg	Mo	Ni	Ag	Zn	O&G	BETX	CN
Newark, NJ(9)	0.15	0.09	2.64	1.74	0.33	0.08	0.23	2.69	--	1.67	--	--	--
Cincinnati, OH(10)	--	6.0	10	10	6.0	0.02	--	10	--	10	50	--	15
San Jose, CA(11)	1.0	0.7	1.0	2.7	0.4	0.01	--	2.6	0.7	2.6	150	10	1.0
Lakeland, FL(12)	0.12	0.04	4.6	1.3	0.30	0.004	0.22	0.56	0.64	3.0	450	--	0.22
Fort Pierce, FL(13)	0.90	0.62	--	5.0	4.2	0.30	0.42	11.0	7.8	6.4	--	--	9.8
Orange County, CA(14)	2.0	1.0	2.0	3.0	2.0	0.03	--	10	5.0	10	100	--	5.0
Median	0.38	0.23	2.0	2.07	0.63	0.015	0.23	2.38	0.50	2.6	100	17.5	0.77
Maximum	2.0	8.0	25	25	10	5	0.42	11	7.8	25	500	70	9.8
Minimum	0.026	0.02	0.05	0.02	.017	0	0.06	.025	0.01	0.05	50	1.5	0.01

(1) All units in milligrams per liter (mg/L). Limits are generally applicable at the point of discharge to the sewer system and expressed as daily maximums.

(2) Department of the Air Force, February 1997.

(3) Effluent Discharge Limitations, Hampton Roads Sanitation District, Virginia, August 8, 1996 Addendum. Limitations vary by flow category; limitations shown are for flow category of 0 – 9,999 gpd.

(4) Sanitary Sewer Pretreatment Study, Phase II, Barksdale AFB, Louisiana, Sverdrup Environmental, Inc., August 1995.

(5) Sewer Use and Industrial Wastewater Discharge Regulations, City of Chattanooga, TN Code, June 5, 1990.

(6) Development of Technically Based Local Limits, Anchorage AK Water and Wastewater Utility, CH2M HILL, February 1997.

(7) Revision and Development of Technically Based Local Limits for the Industrial Waste Pretreatment Program, El Paso Water Utilities Public Service Board, TX, CH2M HILL, September, 1996.

(8) Pretreatment Program: Technically Based Local Limits, Santa Rosa, CA, CH2M HILL, April 1989.

(9) Technically Based Local Pretreatment Limits, Passaic Valley Sewerage Comm., Newark, N.J., CH2M HILL, October 1993.

(10) Rules and Regulations, Metropolitan Sewer District (MSD) of Greater Cincinnati Hamilton County, OH, April 1, 1991.

(11) Industrial Waste Discharge Regulations, San Jose-Santa Clara Water Poll. Control Plant, San Jose, CA Ord. No. 20710.

(12) Industrial Pretreatment Program Update, City of Lakeland, FL, CH2M HILL, August 1995.

(13) Development of Revised Technically Based Local Limits, Fort Pierce Utilities Authority, FL, CH2M HILL, August 15, 1996.

(14) Wastewater Discharge Regulations, County Sanitation Districts of Orange County, CA, Feb. 7, 1992.

Table 2 summarizes existing categorical pretreatment standards for the Electroplating (40 CFR 413) and Metal Finishing (40 CFR 433) categories, which are the two categories most likely to apply at military installations. Other categories, such as the Steam Electric Power Generating category (40 CFR 423), could also apply at some military installations, depending on the activities conducted. In addition, new categories with potential applicability to military installations, including Metal Products and Machinery and Industrial Laundries, are under consideration. EPA maintains a listing and schedule of proposed and promulgated categorical standards.

Table 2
Selected Categorical Pretreatment Standards for Existing Sources(1)

	Electroplating(2)		Metal Finishing(3)	
Pollutant	Max. Day	4-Day Avg.	Max. Day	Mo. Avg.
Aluminum	--	--	--	--
Cadmium	1.2	0.7	0.69	0.26
Chromium	--	--	2.77	1.71
Copper	--	--	3.38	2.07
Cyanide	5.0	2.7	1.2	0.65
Iron	--	--	--	--
Lead	0.6	0.4	0.69	0.43
Nickel	--	--	3.98	2.38
Silver	--	--	0.43	0.24
Zinc	--	--	2.61	1.48
TTO	--	--	2.13	--
Oil & Grease	--	--	--	--

(1)All limits are in mg/L.
(2)Source: 40 CFR 413. Limits shown are for facilities discharging less than 10,000 gallons/day; facilities discharging more than 10,000 gallons/day are subject to additional limits.
(3)Source: 40 CFR 433.15, Pretreatment Standards for Existing Sources. Pretreatment Standards for New Sources (PSNS) are given in 40 CFR 433.17.

2.5.1 Electroplating. Electroplating categorical standards apply to common metals electroplating, precious metals electroplating, anodizing, coating, chemical etching and milling, electroless plating, and printed circuit board facilities. Further, the regulations contain only pretreatment standards for existing sources (PSES), which are sources that were in existence on September 7, 1979, when the regulations were promulgated. New sources performing electroplating operations after that date are subject to the Metal Finishing regulations. Military installations performing any of the operations noted above should refer to 40 CFR 413 for additional information.

2.5.2 Metal Finishing. Metal Finishing Regulations (40 CFR 433) apply to all facilities that perform electroplating, electroless plating, anodizing, coating (chromating, phosphating, and/or coloring), chemical etching and milling, and printed circuit board manufacturing but are not subject to the Electroplating Regulations. Some military installations perform these processes. If a facility performs one or more of these six processes, some 40 additional processes are also subject to the Metal Finishing Regulations. A list of the 46 processes covered in the regulations is shown in Table 3.

Table 3
Processes Covered in Metal Finishing Regulations (40 CFR 433)

Electroplating	Electric Discharge Machining
Electroless Plating	Electrochemical Machining
Anodizing	Electron Beam Machining
Coating	Laser Beam Machining
Chemical Etching and Milling	Plasma Arc Machining
Printed Circuit Board Manufacturing	Ultrasonic Machining
Cleaning	Sintering
Machining	Laminating
Grinding	Hot Dip Coating
Polishing	Sputtering
Tumbling	Vapor Plating
Burnishing	Thermal Infusion
Impact Deformation	Salt Bath Descaling
Pressure Deformation	Solvent Degreasing
Shearing	Paint Stripping
Heat Treating	Painting
Thermal Cutting	Electrostatic Painting

Table 3 (Continued)

Welding	Electropainting
Brazing	Vacuum Metalizing
Soldering	Assembly
Flame Spraying	Calibration
Sand Blasting	Testing
Other Abrasive Jet Machining	Mechanical Plating

2.5.3 Other Categories. It should be noted that effluent limitations for direct discharges have also been promulgated for other categories present at military installations, such as hospitals (40 CFR 460) and photographic processing (40 CFR 459). However, these standards apply only to direct discharges to surface waters and not to indirect discharges to FOTWs or POTWs.

2.6 Federal Facilities Compliance Act. Military installations discharging to their own wastewater treatment plants have not historically been subject to pretreatment regulations. However, under the FFCA, Section 108, treatment plants designated as FOTWs are subject to hazardous waste disposal and pretreatment requirements similar to POTWs.

Under draft guidance implementing the FFCA, to qualify for FOTW status, the treatment plant must be owned and operated by the federal government; on an annual basis more than 50 percent of the plant influent must be domestic sewage, and the plant effluent must be subject to a Section 402 (NPDES) permit. If FOTW status is attained, then waste introduced to the FOTW is not subject to hazardous waste regulations under RCRA, provided that no individual activity at the military installation generates more than 220 lbs(100 kg) of hazardous waste per month or acutely hazardous waste of any quantity. If these requirements are not met, then the FOTW must implement a pretreatment program. Pretreatment requirements would be administered by the FOTW’s host installation and, at a minimum, would require the host installation to:

a) Identify the FOTW funding needs for the pretreatment program, prioritize them, and request such funding.

b) Identify industrial activities that might be subject to the FOTW pretreatment program.

c) Identify the character and volume of pollutants contributed to the FOTW by the industrial activities identified under paragraph (b).

d) Conduct surveillance activities and investigate instances of noncompliance with general and categorical pretreatment standards.

e) Incorporate pollution prevention activities to reduce the volume or toxicity of wastes received by the FOTW.

For FOTWs with a design flow greater than 5 mgd, and for certain FOTWs with a design flow of less than 5 mgd where circumstances warrant, additional requirements would apply. These include sampling and analysis of wastewater discharges from industrial activities; evaluation of the need for a slug-control plan for sources discharging more than 25,000 gpd, and requiring the development of such a plan when needed; and developing and implementing an enforcement action plan.

2.7 Pollution Prevention Act. The Pollution Prevention Act of 1990 (PPA) (Public Law 101-508) makes pollution prevention the national policy of the United States. The goals of the PPA are that “pollution should be prevented or reduced whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner, whenever feasible; pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and disposal or release into the environment should be employed only as a last resort.” In other words, source reduction is the preferred choice, where source reduction is defined as reducing the amount of a pollutant that enters a waste stream or that is otherwise released into the environment prior to out-of-process recycling, treatment, or disposal.

2.8 Directives

2.8.1 Executive Order 12088. Executive Order 12088, Federal Compliance with Pollution Control Standards, requires military

installations to take all necessary actions to prevent, control, and abate environmental pollution at all military installations; to comply with applicable federal environmental regulations; and to correct noncompliance. This order further requires that the head of each Executive agency responsible for the construction or operation of federal facilities outside the United States ensure that such construction or operation complies with the environmental pollution control standards of general applicability in the host country or jurisdiction.

2.8.2 Department of Defense Directive 5100.50. Department of Defense Directive 5100.50, Protection and Enhancement of Environmental Quality, directs the military to comply with the spirit and letter of federal environmental laws, executive orders, and regulations, and to demonstrate leadership in environmental pollution abatement and environmental enhancement.

2.8.3 Department of Defense Directive 4715.5. Defense Directive 4715.5, Management of Environmental Compliance at Overseas Installations, directs the military to establish minimum environmental protection standards applicable to all Department of Defense (DoD) installations and facilities overseas. Similarly, the North Atlantic Treaty Organization (NATO) Status of Forces Agreement (SOFA) obligates U.S. Forces to “respect the law of the receiving State.”

2.8.4 Air Force Policy Directive 32-70. Air Force Policy Directive 32-70, Environmental Quality, is implemented through Air Force Instruction 32-7041 and in general requires that a water quality compliance program be established at all Air Force installations to assess, attain, and sustain compliance with the federal Clean Water Act and other applicable federal, state, and local environmental regulations and related DOD and Air Force directives.

2.8.5 Navy Policy OPNAVINST 5090.1A. The basic policy of the Navy regarding pollution control is that the Navy will cooperate with all other concerned agencies at the local, state, and federal level. This policy is detailed in the Office of the Chief of Naval Operations Instruction (OPNAVINST) 5090.1A, Environmental and Natural Resources Program Manual. Additional

guidance is given in MIL-HDBK-1190, Facility Planning and Design Guide.

2.8.6 Army Environmental Policy Statements. The Army Environmental Management Policy Memorandum, 17 July 1990 (reiterated 5 December 1995), endorsed by the Army Chief of Staff and the Secretary of the Army, states that “All of us, Total Army members and leaders, military and civilian, must ensure that we are well aware of our responsibilities as we set the standard for the Department of Defense and the Nation in meeting the environmental challenges of the 1990s and beyond.” Additional Army policy statements are included in AR 200-1, Environmental Protection and Enhancement, 21 February 1997, and AR 420-49, Utility Systems, April, 1997.

2.9 Occupational Safety and Health Administration (OHSA) Standards. OSHA Standards for Process Safety Management of Highly Hazardous Chemicals, 29 CFR 1910.119, implements requirements for preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals. The standard provides guidance on implementation of required programs in the event of accidental release, and requires that adequate information be gathered for highly hazardous chemicals and that appropriate process safety management programs are in place.

Section 3: DEVELOPMENT OF TECHNICALLY BASED LOCAL LIMITS

3.1 Section Overview. The purpose of this section is to provide guidance for the development of technically-based local limits to control the discharge of pollutants of concern from nondomestic military sources to FOTWs and POTWs. For military installations that discharge to a POTW, the guidance could be useful in assessing whether local limits developed by the POTW are reasonable and defensible.

3.2 Purpose of Local Limits. Development of local sewer discharge standards and limits for both POTWs and FOTWs is driven by the following goals:

a) Protect the treatment system's biological processes (activated sludge, anaerobic digestion, etc.) from toxic inhibition.

b) Ensure that the quality of the treatment system effluent complies with its NPDES permit limitations or applicable water quality standards.

c) Ensure that the quality of biosolids (sludge) produced by the treatment system complies with applicable regulations.

d) Protect the sewer system from damage and obstruction and workers from excessive toxic or explosive fumes.

3.3 General Approaches to Developing Local Limits. General approaches and methodologies for developing local limits are described in the EPA document EPA 833/B-87-202 entitled Guidance Manual for the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program. Four technical approaches are outlined in this manual, as follows:

a) Maximum allowable headworks loading (MAHL) approach - Recommended for developing local limits for pollutants that affect treatment system performance and regulatory compliance, such as heavy metals and cyanide.

b) Collection system protection approach - Recommended as the basis for establishing prohibited discharge standards, either numeric or general in nature, to protect against fire/explosion, corrosion, flow obstruction, heat effects, and fume toxicity.

c) Pollution prevention approach - Recommended to minimize the discharge of toxic or hazardous pollutants to the sewer, or to minimize their impacts.

d) Best professional judgment approach - Recommended to establish limits on a case-by-case basis where a rational methodology and technical basis for a limit may not exist.

This section addresses the first two approaches: the development of local limits and prohibited discharge standards. Pollution prevention is addressed in Section 4.

3.4 The MAHL Approach. In this approach, the maximum allowable loads (lbs/day) that can be accepted into the treatment plant (i.e., the MAHLs) are calculated for each pollutant of concern. A knowledge of the applicable standards and criteria to be met by the plant, and its pollutant removal efficiencies, are needed to make these calculations. Residential/background contributions of pollutants and an appropriate safety factor are then subtracted from the MAHLs to determine the maximum allowable industrial loading (MAIL) for each pollutant of concern. Local limits (mg/L) are then calculated by one of three methods, but typically by dividing the MAIL by the total industrial flow.

A schematic diagram of the development process for local limits based on the maximum allowable headworks loading approach is given in Figure 1. The process is further described in the following subsections.

3.4.1 Regulatory Criteria. The regulatory guidelines and criteria that serve as the technical basis for developing local limits encompass process inhibition, biosolids disposal, and effluent discharge. Applicable standards and criteria in each of these three areas are used to calculate MAHLs. The lowest computed MAHL for each pollutant is then used in the determination of local limits.

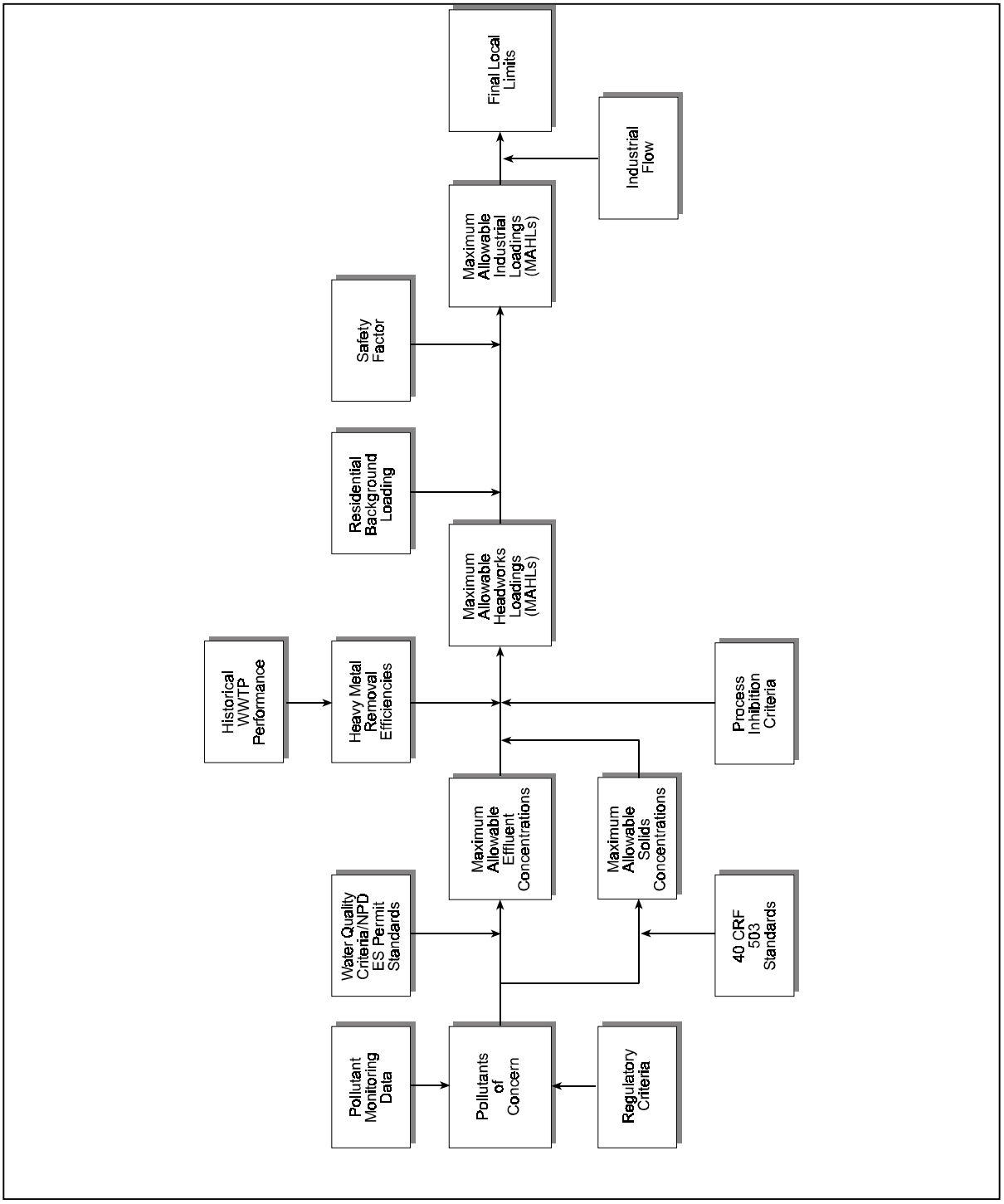


Figure 1
Schematic for Development of Local Limits

3.4.1.1 Process Inhibition. Any biological treatment process is potentially subject to toxic inhibition, including the activated sludge process, the trickling filter process, and the anaerobic digestion process. Threshold inhibition levels for these processes are given in EPA 833/B-87-202 and are summarized in Table 4. These inhibition concentrations are not well established and may vary widely from plant to plant.

3.4.1.2 Biosolids Disposal. Allowable pollutant concentrations in biosolids disposed by a treatment plant depend on the final use or disposal destination of the solids. Table 5 presents the allowable pollutant concentrations for land application and surface disposal of biosolids, based on federal regulations (40 CFR 503). State requirements generally follow the federal regulations but may be more stringent. For lagoon treatment systems, biosolids regulations apply when sludge is removed from the lagoons for disposal.

3.4.1.3 Effluent Discharge. Allowable pollutant concentrations in treatment system effluent are normally specified in the system’s NPDES permit. If not, they may be derived from applicable receiving water quality criteria. Table 6 presents EPA’s water quality criteria under Section 304(a) of the Clean Water Act for the priority toxic pollutants. These criteria are applicable in states that have not developed their own water quality criteria and are the basis for the criteria developed and enforced individually by other states. Differences in the values of individual parameters may exist from state to state.

The approach used to derive allowable treatment system effluent concentrations from water quality criteria also varies from state to state. The basic approach is to assume that the effluent must comply with the Criterion Maximum Concentrations (CMCs) at or near the point of discharge and comply with the Criterion Continuous Concentrations (CCCs) and Human Health Concentrations (HHCs) after dilution in a mixing zone. However, a number of different factors should be discussed with regulatory authorities in implementing this approach, including the following:

Table 4
Toxic Pollutant Inhibition Threshold Levels

Pollutant	Activated Sludge	Nitrification	Trickling Filters	Anaerobic Digestion
Arsenic	0.1	1.5	--	1.6
Cadmium	1-10	5.2	--	20
Chromium (total)	1-100	0.25-1.9	1-100	--
Chromium (III)	10-50	--	3.5-67.6	130
Chromium (VI)	1	1-10	--	110
Copper	1	0.05-0.48	--	40
Lead	1	0.5	--	340
Nickel	1	0.25-5	--	10-36
Zinc	0.3-10	0.08-0.5	--	400
Mercury	0.1	--	--	--
Silver	0.25-5	--	--	13-65
Cyanide	0.1-5	0.34-0.5	30	1-100
Acrylonitrile	--	--	--	5
Anthracene	500	--	--	--
Benzene	100	--	--	
Carbon Tetrachloride	--	--	--	2-159.4
Chlorobenzene	--	--	--	0.96-3
Chloroform	--	10	--	1-16
2-Chlorophenol	5-200	--	--	--
1,2-Dichlorobenzene	5	--	--	0.23-3.8
1,3-Dichlorobenzene	5	--	--	--
1,4-Dichlorobenzene	5	--	--	1.4-5.3
2,4-Dichlorophenol	64	64	--	--
2,4-Dinitrophenol	--	150	--	--
2,4-Dimethylphenol	40-200	--	--	--
2,4-Dinitrotoluene	5	--	--	--
1,2-Diphenylhydrazine	5	--	--	--
Ethylbenzene	200	--	--	--
Hexachlorobenzene	5	--	--	--
Pentachlorophenol	0.95-150	--	--	0.2-1.8
Phenanthrene	500	--	--	--
Phenol	50-200	4-10	--	--
Tetrachloroethylene	--	--	--	20
Trichloroethylene	--	--	--	1-20
Toluene	200	--	--	--
2,4,6-Trichlorophenol	50-100	--	--	--
Surfactants	100-500	--	--	--

Source: EPA 833/B-87-202, Tables 3-2 through 3-5, EPA Office of Water, December 1987.
Note: All units are in mg/L.

Table 5
U.S. EPA Sludge Pollutant Limitations for Land Application

Pollutant	Condition 1(a)	Condition 2(b)		Condition 3(c)	Condition 4(d)		Condition 5(e)
		Alternate 1	Alternate 2		Alternate 1	Alternate 2	
	Ceiling Concentration (mg/kg)	Maximum Cumulative Loads (kg/ha)	Maximum Concentrations (mg/kg)	Maximum Concentrations (mg/kg)	Maximum Concentrations (mg/kg)	Maximum Annual Pollutant Loading Rates (kg/ha/yr)	Maximum Concentrations (mg/kg)
Arsenic	75	41	41	41	41	2.0	73
Cadmium	85	39	39	39	39	1.9	--
Chromium	00	00	00	00	00	00	600
Copper	4,300	1,500	1,500	1,500	1,500	75	--
Lead	840	300	300	300	300	15	--
Mercury	57	17	17	17	17	0.85	--
Molybdenum	75	--	--	--	--	--	--
Nickel	420	420	420	420	420	21	420
Selenium	100	100	36	100	36	5.0	--
Zinc	7,500	2,800	2,800	2,800	2,800	140	--

(a)Condition 1: Bulk sewage sludge or sewage sludge sold or given away in a bag or container [40 CFR 503.13(a)(1) – Table 1].
(b)Condition 2: Bulk sewage sludge applied to agricultural land, forest, a public contact site, or a reclamation site [40 CFR 503.13(a)(2) – Tables 2 and 3].
(c)Condition 3: Bulk sewage sludge applied to a lawn or home garden [40 CFR 503.13(a)(3) - Table 3].
(d)Condition 4: Sewage sludge sold or given away in a bag or other container [40 CFR 503.13(a)(4) - Tables 3 and 4].
(e)Condition 5: Sewage sludge placed in a surface disposal site (sludge-only landfill) [40 CFR 503.13(a)(1) - Table 6].

Note: Maximum concentrations are less than those shown if distance from sludge unit to property line is less than 150 meters.

mg/kg milligram per kilogram
kg/ha kilogram per hectare

Table 6
Water Quality Criteria for Priority Pollutants

Pollutant	Freshwater		Saltwater		Human Health	
	Criterion Maximum Concentration (µg/L)	Criterion Continuous Concentration (µg/L)	Criterion Maximum Concentration (µg/L)	Criterion Continuous Concentration (µg/L)	Consumption of Water & Organisms (µg/L)	Consumption of Organisms Only (µg/L)
Antimony					14	4,300
Arsenic	360	190	69	36	0.018	0.14
Cadmium	3.9(a)	1.1(a)	43	9.3	16	170
Chromium (III)	1,700(a)	210(a)			33,000	670,000
Chromium (VI)	16	11	1,100	50	170	3,400
Copper	18(a)	12(a)	2.9	2.9		
Lead	82(a)	3.2(a)	220	8.5		
Mercury	2.4	0.012	2.1	0.025	0.14	0.15
Nickel	1,400 [a]	160 [a]	75	8.3	610	4,600
Selenium	20	5	300	71		
Silver	4.1 [a]		2.3			
Thallium					1.7	6.3
Zinc	120 [a]	110 [a]	95	86		
Cyanide	22	5.2	1	1	700	220,000
Acrolein					320	780
Acrylonitrile					0.059	0.66
Benzene					1.2	71
Bromoform					4.3	360
Carbon Tetrachloride					0.25	4.4
Chlorobenzene					680	21,000
Chlorodibromomethane					0.41	34
Chloroform					5.7	470
Dichlorobromomethane					0.27	22
1,2-Dichloroethane					0.38	99
1,1-Dichloroethylene					0.057	3.2
1,3-Dichloropropylene					10	1,700

Table 6 (Continued)

Pollutant	Freshwater		Saltwater		Human Health	
	Criterion Maximum Concentration (µg/L)	Criterion Continuous Concentration (µg/L)	Criterion Maximum Concentration (µg/L)	Criterion Continuous Concentration (µg/L)	Consumption of Water & Organisms (µg/L)	Consumption of Organisms Only (µg/L)
Dioxin					0.000000013	0.000000014
Ethylbenzene					3,100	29,000
Methyl Bromide					48	4,000
Methylene Chloride					4.7	1,600
1,1,2,2-Tetrachloroethane					0.17	11
Tetrachloroethylene					0.8	8.85
Toluene					6,800	200,000
1,1,2-Trichloroethane					0.60	42
Trichloroethylene					2.7	81
Vinyl Chloride					2	525
2,4-Dichlorophenol					93	790
2-Methyl-4,6-Dinitrophenol					13.4	765
2,4-Dinitrophenol					70	14,000
Pentachlorophenol	20(b)	13(b)	13	7.9	0.28	8.2
Phenol					21,000	4,600,000
2,4,6-Trichlorophenol					2.1	6.5
Anthracene					9,600	110,000
Benzidine					0.00012	0.00054
Benzo(a)Anthracene					0.0028	0.031
Benzo(a)Pyrene					0.0028	0.031
Benzo(b)Fluoranthene					0.0028	0.031
Benzo(k)Fluoranthene					0.0028	0.031
Bis(2 Chloroethyl)Ether					0.031	1.4
Bis(2 Chloroisopropyl)Ether					1,400	170,000
Bis(2 Ethylhexyl)Phthalate					1.8	5.9
Chrysene					0.0028	0.31
Dibenzo(a,h)Anthracene					0.0028	0.31

Table 6 (Continued)

Pollutant	Freshwater		Saltwater		Human Health	
	Criterion Maximum Concentration (µg/L)	Criterion Continuous Concentration (µg/L)	Criterion Maximum Concentration (µg/L)	Criterion Continuous Concentration (µg/L)	Consumption of Water & Organisms (µg/L)	Consumption of Organisms Only (µg/L)
1,2-Dichlorobenzene					2,700	17,000
1,3-Dichlorobenzene					400	2,600
1,4-Dichlorobenzene					400	2,600
3,3-Dichlorobenzidine					0.04	0.077
Diethyl Phthalate					23,000	120,000
Dimethyl Phthalate					313,000	2,900,000
Di-n-Butyl Phthalate					2,700	12,000
2,4-Dinitrotoluene					0.11	9.1
1,2-Diphenylhydrazine					0.040	0.54
Fluoranthene					300	370
Fluorene					1,300	14,000
Hexachlorobenzene					0.00075	0.00077
Hexachlorocyclopentadiene					0.44	50
Hexachlorocyclopentadiene					240	17,000
Hexachloroethane					1.9	8.9
Indeno(1,2,3-cd)Pyrene					0.0028	0.031
Isophorone					8.4	600
Nitrobenzene					17	1,900
N-Nitrosodimethylamine					0.00069	8.1
N-Nitrosodiphenylamine					5.0	16
Pyrene					960	11,000
Aldrin	3	1.3			0.00013	0.00014
Alpha-BHC					0.0039	0.013
Beta-BHC					0.014	0.046
Gamma-BHC	2	0.16			0.019	0.063
Chlordane	2.4	0.09			0.00057	0.00059
4,4-DDT	1.1	0.13			0.00059	0.00059

Table 6 (Continued)

Pollutant	Freshwater		Saltwater		Human Health	
	Criterion Maximum Concentration (µg/L)	Criterion Continuous Concentration (µg/L)	Criterion Maximum Concentration (µg/L)	Criterion Continuous Concentration (µg/L)	Consumption of Water & Organisms (µg/L)	Consumption of Organisms Only (µg/L)
4,4-DDE					0.00059	0.00059
4,4-DDD					0.00083	0.00084
Dieldrin	2.5	0.71			0.00014	0.00014
Alpha-Endosulfan	0.22	0.034			0.93	2.0
Beta-Endosulfan	0.22	0.034			0.03	2.0
Endosulfan Sulfate					0.93	2.0
Endrin	0.18	0.0023	0.037	0.0023	0.76	0.81
Endrin Aldehyde					0.76	0.81
Heptachlor	0.52	0.0038	0.053	0.0036	0.00021	0.00021
Heptachlor Epoxide	0.52	0.0038	0.053	0.0036	0.00010	0.00011
PCB-1242		0.014		0.03	0.000044	0.000045
PCB-1254		0.014		0.03	0.000044	
PCB-1221		0.014		0.03	0.000044	
PCB-1232		0.014		0.03	0.000044	
PCB-1248		0.014		0.03	0.000044	
PCB-1260		0.014		0.03	0.000044	
PCB-1016		0.014		0.03	0.000044	
Toxaphene	0.73	0.0002	0.21	0.0002	0.00073	0.00075

Source: National Toxics Rule, Federal Register, December 22, 1992.

(a)Freshwater criteria are a function of total hardness; values shown correspond to a total hardness of 100 mg/L.
(b)Freshwater criteria are a function of pH; values shown correspond to a pH of 7.8.

µg/L micrograms per liter

a) Establishment of the dimensions of the mixing zone to which the CCCs and HHCs apply, or the dimensions of the zone of initial dilution (ZID), the smaller area within the mixing zone, to which the CMCs apply.

b) If the discharge is to a flowing stream, determination of the low stream flow available for dilution.

c) Determination of the bioavailability of the pollutants of concern, recognizing that some processes discharge heavy metals that are organically bound or otherwise not bioavailable. The EPA and some states recognize and accept various approaches to account for metals bioavailability, including chemical translator ratios, bioassay water effects ratios, and significant indigenous species evaluations.

d) Establishment of the hardness, pH, and chloride content of the receiving water, which impact the toxicity of some metals and hence the magnitude of some water quality criteria.

e) Establishment of the background concentrations of pollutants in the receiving water; the lower the background concentration, the greater the allowable effluent discharge concentration.

f) Consideration of the practical quantitative level of a pollutant in cases where the water quality criterion may actually be lower than EPA’s approved method detection limit for the pollutant.

3.4.1.4 Air Emissions Criteria. Hazardous air pollutants (HAPs) at wastewater treatment plants (WWTPs) are regulated under the Federal Clean Air Act Amendments (CAAA) of 1990. Four titles under the CAAA of 1990 may apply to WWTPs, but only one of these, Title III, has potential ramifications on the development and setting of local limits. Title III requires implementation of maximum achievable control technology (MACT) for major sources of HAPs at WWTPs. Major sources are defined as those that have the potential to emit at least 10 tons/year of any individual HAP, or 25 tons/year total HAPs. EPA has designated 189 compounds and elements as federal HAPs, but only about 26 of these have been

detected at WWTPs. For practical purposes, the conventional priority pollutant scans address the HAPs of concern at WWTPs.

EPA has issued guidance to assist in determining whether a WWTP is a major source of HAPs and therefore subject to implementation of MACT. Under this guidance, a WWTP would be subject to installing MACT if it met two of the following three criteria:

a) Has a capacity greater than 50 mgd

b) Accepts more than 30 percent industrial waste contribution

c) Has influent priority pollutant volatile organic chemical (VOC) concentrations greater than 5 mg/L

Few FOTWs and POTWs are expected to exceed these criteria and thus be subject to implementation of MACT. However, under Section 112(r) of Title III, even non-major sources of HAPs must prepare a Risk Management Plan if they use or store acutely hazardous material in quantities above specified threshold limits. The threshold limits are 2,500 lbs for chlorine, 5,000 lbs for sulfur dioxide, and 10,000 lbs for ammonia and methane.

3.4.2 Pollutants of Concern. “Pollutants of concern” are those having the potential to cause process inhibition, interference, permit violations, or endangerment of worker health and safety. Local limits must be developed for all pollutants of concern.

EPA has provided guidance for identifying pollutants of concern, which is described in EPA 833/B-87-202. Pollutants of concern generally include cadmium, chromium, copper, lead, nickel, zinc, silver, arsenic, mercury, and cyanide. In addition, EPA guidance directs that a toxic pollutant may be classified as a pollutant of concern if it meets any one of the following screening criteria:

a) The maximum concentration of the pollutant in the WWTP influent is more than 1/500th of the allowable biosolids

concentration, or more than one-fourth of the inhibition threshold for the biological process.

b) The maximum concentration of the pollutant in the WWTP biosolids is more than half of the allowable biosolids concentration. The allowable biosolids concentration will depend on the method of disposal (see Table 5 and 40 CFR 503 for further details).

c) The maximum concentration of the pollutant in the diluted mixture of WWTP effluent and receiving water is more than half of the allowable water quality standard or criteria.

3.4.3 Treatment Plant Removal Efficiencies. Treatment plant removal efficiencies are needed to compute MAHLs from effluent and biosolids criteria. Site-specific data collected over a period of at least a year are preferred for this purpose. The removal efficiency, R, for any given conservative or non-degradable pollutant may be computed as follows:

$$R = \frac{\text{(Influent Concentration - Effluent Concentration)}}{\text{Influent Concentration}}$$

Frequently, the measured influent and effluent concentrations are near, or even less than, the method detection limit. Consequently, computed removal efficiencies can be erratic.

Where adequate data is lacking to establish reliable percentage removals, regulatory agencies may allow EPA national survey values to be used. These are summarized in Table 7.

Table 7
Literature Values for POTW Pollutant Removal Efficiencies

Pollutant	Median Removal Percentage Through Primary Treatment	Median Removal Percentage Through Activated Sludge Treatment	Median Removal Percentage Through Trickling Filter Treatment
Arsenic	--	45	--
Cadmium	15	67	68
Chromium	27	82	55
Copper	22	86	61
Cyanide	27	69	--
Lead	57	61	55
Mercury	10	60	50
Nickel	14	42	29
Selenium	--	50	--
Silver	20	75	66
Zinc	27	79	67
Benzene	25	80	75
Chloroform	14	67	73
1,2 trans-Dichloroethylene	36	67	50
Ethylbenzene	13	86	80
Methylene chloride	--	62	70
Tetrachloroethylene	4	80	80
Toluene	--	93	93
1,1,1-Trichloroethane	40	85	89
Trichloroethylene	20	89	94
Anthracene	--	67	--
Bis (2-ethylhexyl)phthalate	--	72	58
Butyl benzyl phthalate	62	67	60
Di-n-butyl phthalate	36	64	60
Diethyl phthalate	56	62	57
Naphthalene	44	78	71
Phenanthrene	--	68	--
Phenol	8	90	84
Pyrene	--	86	--

Source: EPA 833/B-87-202, Tables 3-9 and 3-10, EPA Office of Water, December 1987.

3.4.4 Calculation of MAHLs. The MAHL of a treatment plant is the maximum pollutant load in pounds per day that the plant can receive without exceeding effluent, biosolids, or process inhibition criteria. The MAHL for any given pollutant of concern is the smallest value computed from the following equations.

MAHL based on effluent discharge criteria:

$$\text{MAHL} = \frac{\text{Allowable effluent concentration (mg/L)} \times \text{Flow} \times 8.34}{1-R_T}$$

MAHL based on biosolids criteria:

$$\text{MAHL} = \frac{\text{Allowable biosolids concentration (mg/kg)} \times P_T \times 10^{-6}}{R_T}$$

MAHL based on activated sludge or trickling filter inhibition criteria:

$$\text{MAHL} = \frac{\text{Inhibition level (mg/L)} \times \text{Flow} \times 8.34}{1-R_P}$$

MAHL based on anaerobic digestion inhibition criteria:

$$\text{MAHL} = \frac{\text{Inhibition level (mg/kg)} \times P_D \times 10^{-6}}{R_T}$$

where,

MAHL = Maximum Allowable Headworks Loading, lbs/day

Flow = Average daily treatment plant flow (mgd)

R_T = Total plant pollutant removal rate

R_P = Primary treatment removal rate

P_T = Plant average daily biosolids disposal rate (lbs/day)

P_D = Average daily sludge feed to digester (lbs/day)

3.4.5 Allocation of MAHLs to Nondomestic Sources. The portion of each pollutant MAHL allocable to nondomestic users,

termed the or MAIL, is equal to the total MAHL, less the loading contributed by domestic/background sources ($L_{D/B}$), less an amount held in reserve as a safety factor (L_{SF}):

$$MAIL = MAHL - L_{D/B} - L_{SF} \text{ (all units in lbs/day)}$$

3.4.5.1 Domestic/Background Pollutant Loadings. EPA recommends that domestic/background pollutant concentrations be obtained through site-specific monitoring conducted at locations that receive wastewater solely from domestic sources. However, alternative approaches may be accepted. One conservative approach, which takes advantage of data that may already exist, is to assume that domestic/background concentrations are equal to plant influent concentrations. A second approach is to utilize EPA's national survey results for domestic/background pollutant concentrations, which are summarized in Table 8.

Table 8
Residential/Background Pollutant Concentrations

Pollutant	Average Concentration (mg/L)
Arsenic	0.007
Cadmium	0.008
Chromium	0.034
Copper	0.109
Cyanide	0.082
Lead	0.116
Mercury	0.002
Nickel	0.047
Silver	0.019
Zinc	0.212
Methylene Chloride	0.027
Tetrochloroethene	0.014
1,2-Dichloroethene	0.013
Chloroform	0.009
1,1-Dichloroethene	0.007
1,1-Dichloroethane	0.007

Source: Supplemental Manual On the Development And Implementation of Local Discharge Limitations Under the Pretreatment Program, EPA 21W-4002, Office of Water.

3.4.5.2 Safety Factors. EPA recommends allocating only a portion of the MAHL for each pollutant to the treatment plant's current users. The remaining portion is recommended to be held in reserve as a safety factor to account for future industrial growth, potential slug loadings, and other uncertainties. A safety factor of 10 to 25 percent should be adequate in most cases (i.e., L_{SF}=(0.1 to 0.2) MAHL).

3.4.6 Calculation of Local Limits. Local limits are calculated by allocating MAHL values to domestic and nondomestic users. Three basic alternative allocation methods are accepted:

a) Uniform concentration method

$$\text{Local Limit} = \text{MAIL}/Q_{NDU}(8.34)$$

Here, Q_{NDU} represents the total flow from all nondomestic users not included as part of the domestic/background class. This method results in the same local limits for all such nondomestic users, regardless of whether they discharge the pollutant in question. This is a conservative method and is the one most commonly used.

b) Contributory flow method

$$\text{Local Limit} = \text{MAIL}/Q_{NDUCONTRIB}(8.34)$$

Here, $Q_{NDUCONTRIB}$ represents the total flow from only those nondomestic users who actually discharge the pollutant in question in concentrations above the background. All such users would have the same local limits, while other nondomestic users would be allowed to discharge up to the background concentration of the particular pollutant. This method is sometimes used when the uniform concentration method yields exceptionally stringent local limits.

c) Wasteload allocation method

$$\text{Local Limit}_x = L_x / Q_x(8.34)$$

Here, L_x and Q_x represent the allocated pollutant load, and corresponding flow of nondomestic user "X", respectively.

In this method, all significant nondomestic users have their own individual limits.

3.5 Development of Discharge Limitations Based on Protection of the Collection System and Worker Health and Safety

3.5.1 Prohibited Discharge Standards. These standards, applicable to all users, prohibit the discharge of any nondomestic wastes containing certain types or amounts of pollutants which would interfere with the operation of collection and treatment systems. Nationally prohibited discharges under 40 CFR 403.5 include the following:

a) Pollutants that create a fire or explosion hazard, including but not limited to waste streams with a closed cup flash-point of less than 140°F or 60°C

b) Pollutants that will cause corrosive structural damage, and in no case discharges with a pH lower than 5.0 unless the treatment works is designed to accommodate such discharges

c) Solid or viscous pollutants in amounts which will cause obstruction to the flow resulting in interference

d) Any pollutant, including oxygen demanding pollutants released in a discharge at a flow rate and/or pollutant concentration which will cause interference

e) Heat in amounts that will inhibit biological activity in the treatment plant resulting in interference, but in no case heat in such quantities that the temperature at the treatment plant exceeds 40°C unless alternate temperature limits are approved

f) Petroleum oil, nonbiodegradable cutting oil, or products of mineral oil origin in amounts that will cause interference or pass through

g) Pollutants that result in the presence of toxic gases, vapors, or fumes within the collection or treatment system in a quantity that may cause acute worker health and safety problems

h) Any trucked or hauled pollutants, except at approved discharge points

3.5.2 Oil and Grease Limits. Although many municipal sewer use ordinances contain a numeric oil and grease limitation, these limits vary greatly because no technical basis presently exists for establishing such a limit (see Table 1). As preliminary guidance, EPA has suggested that a limit of 100 mg/L may be used for “petroleum oils, nonbiodegradable cutting oils, or products of mineral oil origin.” Likewise, a limit of 100 to 200 mg/L may be appropriate for polar oils and greases derived from animal and vegetable materials, which is approximately their background concentration in raw domestic wastewater.

3.5.3 Protection Against Vapor Toxicity. Discharges to sewers of volatile pollutants whose vapors are toxic can create conditions hazardous to workers who must enter the wastewater collection system. The national prohibited discharge standard given previously (par. 3.5.1g) is the minimum standard of protection for discharges of volatile pollutants. Where high concentrations of volatile organic concentrations are detected through wastewater monitoring, additional protection standards based on worker health and safety criteria may be warranted.

A simplified approach for calculating the aqueous concentration of a given VOC that results in an equilibrium atmospheric concentration harmful to workers is given in the EPA guidance manual Guidance to Protect POTW Workers from Toxic and Reactive Gases and Vapors EPA 812/B-92-001. The approach is based on Henry's Law and maximum atmospheric concentrations established by the American Conference of Governmental Industrial Hygienists (ACGIH), which are based on continuous worker exposure during a 40-hour work week. These limiting concentrations are termed threshold limit values--time-weighted averages (TLV-TWA). These limits are conservative because equilibrium concentrations are not attained in a sewer system and because workers would likely not be exposed to fumes 40 hours/week. As a result, EPA recommends this approach for establishing screening levels (trigger for further action) and not enforceable limits.

The screening levels for the four BTEX compounds based on the EPA vapor toxicity approach are as follows:

Compound	Vapor Toxicity Screening Level (mg/L)
Benzene	0.13
Ethylbenzene	1.59
Toluene	1.35
Total Xylenes	2.02

3.5.4 Protection Against Flammability/Explosivity. U.S. EPA amendments to the General Pretreatment Regulations require municipalities to implement local limits that prevent flammable/ explosive conditions from occurring in the sewer atmosphere (Federal Register, 55, 142, 1990). As noted previously, the specific requirement prohibits pollutants with a closed cup flashpoint of less than 140°F (60°C). While the flashpoint limitation is not in itself a sufficient local limit for all industrial users, it does provide a good supplement to other limitations by effectively prohibiting the discharge of undiluted volatiles such as gasoline, diesel, jet fuel, BTEX compounds, methyl ethyl ketone (MEK), and ethyl alcohol.

As an adjunct to the flashpoint limitation, EPA has also provided screening levels of the aqueous concentration of selected volatile chemicals that can be used to identify explosion hazards. Screening levels for the four BTEX compounds, which are based on 10 percent of their lower explosive limit (LEL), are given below:

Compound	Explosivity Screening Level (mg/L)
Benzene	20
Ethylbenzene	16
Toluene	17
Total Xylenes	17

These screening levels are higher than the screening levels computed based on vapor toxicity. Therefore, they should be used as a screening tool where explosivity is the only consideration.

Section 4: WASTEWATER SOURCES, CHARACTERISTICS, AND POLLUTION PREVENTION

4.1 Section Overview. Included in this section are descriptions of typical sources of nondomestic wastewater at military installations and a summary of the key wastewater characteristics for each source, as compiled from a number of studies. Pollution prevention guidelines are also presented for several of the sources. The wastewater categories included are listed below in alphabetical order. Other sources may also be present (see par. 4.21), but adequate data were not available for sources beyond the following:

AFFF Fire Suppression	Fuel Storage
Aircraft Corrosion Control	Hospital Operations
Aircraft Washing	Maintenance Area Floor Washing
Battery Maintenance	Parts Washing
Dental Clinic Operations	Photo/X-ray Processing
Engine Washing	Steam Generation
Fire Fighting Training	Vehicle Painting
	Vehicle/Equipment Washing

4.2 Wastewater Characterization Data. Wastewater characterization data presented in this section were derived from sampling at 33 military installations. The data were compiled into a single database according to the sources listed above. For each source, the median and range of measured parameters are presented. Also included are the number of samples analyzed and the number of detected values. Non-detect values were excluded in calculating median values and in the listing of minimum values. The flow values presented are daily volumes; actual discharge rates would be higher, depending on the duration of the wastewater generating activity.

The purpose of the characterization data presented in this section is to assist military installations in determining the types of pollutants that may be present in various sources of nondomestic wastewater and their approximate concentrations when present. Contaminants other than those shown may also be present, and concentrations will be dependent on site-specific activities. Therefore, actual wastewater characteristics should

be verified through sampling and analysis prior to designing any treatment facility.

4.3 Pollution Prevention. Pollution prevention methods may be used to reduce or eliminate the volume and/or concentration of a waste stream. By its nature, pollution prevention usually has greater potential than wastewater treatment (or pretreatment) to achieve discharge reduction of toxic pollutants, and it is often less costly. For this reason, pollution prevention should be the first choice for waste reduction. The following paragraphs provide some general ideas for pollution prevention opportunities and techniques that are generally applicable. Specific pollution prevention guidelines are included under the subsequent discussion of individual sources.

4.3.1 Pollution Prevention Policy. As indicated in Section 2, pollution prevention is a policy specifically mandated by the U.S. Congress in the 1984 Hazardous and Solid Waste Amendments to the RCRA, and the Pollution Prevention Act of 1990. All branches of the military have adopted this policy as indicated by Department of Defense Instruction 4715.4. For example, the Air Force has issued Air Force Policy Directive 32-70 and Air Force Instruction 32-7080 to implement the requirements of Federal pollution prevention legislation and to establish specific pollution prevention goals for Air Force installations. The Army and Navy have established similar policies. All pollution prevention processes must conform with applicable military technical orders, and any variances must be approved.

4.3.2 Pollution Prevention Opportunity Assessments. Pollution prevention opportunity assessments have been conducted at some military installations. These studies focus on identifying and evaluating pollution prevention opportunities based on technical and economic feasibility and waste reduction potential. A complete opportunity assessment focuses on all waste streams from all identified processes within the installation. Guidelines for conducting a pollution prevention opportunity assessment are given in the Federal Facility Pollution Prevention Planning Guide (EPA, December 1994).

4.3.3 Pollution Prevention Methods. The Pollution Prevention Act of 1990 and Executive Order 12856 define pollution prevention

as “any practice which reduces the amount of a hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and any practice which reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants.”

Pollution prevention refers to the use of materials, processes, or practices that eliminate or reduce the quantity and toxicity of wastes at the source of generation. It represents the first step in a hierarchy of options for managing waste. This environmental protection hierarchy lists, in descending order of preference, source reduction, recycling, treatment, and disposal as the recommended options for waste management. Source reduction is assigned the highest priority because it eliminates or reduces wastes at the source of generation. Source reduction activities include:

a) Substitution of process materials with materials that reduce waste, are less toxic, or can be recycled more easily

b) Modification of processes to reduce or eliminate water consumption or the use of toxic chemicals

c) Improvements in operating practices and housekeeping so smaller amounts of pollutants are produced or discharged

These methods are further described in the following paragraphs. Implementation of these methods reduces wastewater pollution, as well as air emissions and solid waste generation.

4.3.3.1 Material Substitution. Frequently, less toxic or non-toxic water-based solvents or cleaning agents may be substituted for toxic products. Likewise, cleaners may sometimes be completely eliminated if hot water is used. Hot water alone is preferable because the cleaners commonly used at military installations impart a high BOD to the wastewater, and they emulsify oils, rendering OWSs ineffective. Before any material substitution is made it must be approved by environmental and equipment managers.

Care should be taken that material substitution does not simply introduce a different environmental issue or health and safety risk. For example, switching from solvents to water-soluble cleaners usually results in new or increased discharges to the sewer and associated discharge requirements because solvent cleaners are not discharged to the sewer. Similarly, the use of high pressure hot water sprays to eliminate the use of detergents can pose safety concerns.

4.3.3.2 Process Modifications. Process modifications include operational or equipment modifications to reduce waste, including any of the following:

a) Changes in the waste-generating process, including those suggested by employees

b) Equipment, layout, calibration, or piping changes

c) Use of automation

d) Changes in process operating conditions, such as flow rates, temperatures, pressures, or residence times

For example, plastic media blasting for paint stripping as a replacement for solvent-based paint stripping eliminates a hazardous waste stream containing phenol and/or methylene chloride that can require expensive treatment. Before any process changes are made, they must be approved by environmental and equipment managers.

4.3.3.3 Housekeeping and Operational Improvements. Good operating procedures, sometimes referred to as Best Management Practices (BMPs), are procedural and administrative measures that military installations can use to minimize waste. BMPs include:

a) Good housekeeping practices

b) Personnel awareness training and incentives to reduce waste

c) Materials purchasing and inventory control methods to reduce the need to dispose of unused materials because of expired shelf life or product substitutions

d) Loss prevention to avoid leaks from equipment and spills

4.3.3.4 Material Recycle, Reuse, and Recovery. After source reduction, recycling is the next preferable approach because it involves the reuse or regeneration of materials and wastes into usable products. Material recycle, reuse, and recovery includes:

a) Return of a waste material either to the originating process as a substitute for an input material, or to another process as an input material

b) Recovery of a valuable material for sale to an outside vendor, such as silver recovered from photoprocessing wastewater via a silver recovery unit

c) Reuse of wastewater multiple times with little or no associated treatment, such as in recycling parts washers where the addition of a filter can greatly extend the useful life of the washwater

The installation of a separate treatment system for recycling and reuse, such as for vehicle and aircraft washwater, is discussed separately in Section 9. Similarly, installations of oil/water separators and treatment systems for metals are discussed separately in Sections 6 and 7, respectively.

4.4 AFFF Fire Suppression

4.4.1 Activity Description. Aqueous film-forming foam (AFFF) is a water miscible, clear, amber-colored liquid used at military installations nationwide to combat aircraft fuel-related fires. AFFF is used by crash rescue vehicles in responding to runway and terminal accidents and in foam-water sprinkler systems in fuel storage areas and in buildings such as aircraft hangars. The material may be discharged during actual firefighting, training, or testing of AFFF systems. Discharge of wastewater containing AFFF to surface waters is not permitted except in emergency conditions, when spill prevention, control, and counter measures (SPCC) must be implemented.

4.4.2 Wastewater Characteristics. AFFF wastewater characteristics are summarized in Table 9. The principal wastewater contaminant is AFFF, which is a water-based solution containing 15 percent by weight of 2-(2-butoxyethoxy)-ethanol and smaller amounts of urea, fluoroalkyl surfactants, synthetic detergent, and methyl-lH-benzotriazole. The product is typically diluted and used as a 3 percent solution for fire-fighting, which has chemical oxygen demand (COD)and biochemical oxygen demand (BOD) values of 12,000 mg/L and 1,400 mg/L, respectively. In addition to the high organic loading, AFFF causes foaming at wastewater treatment facilities.

Table 9
Characteristics of AFFF Fire Suppression Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number of Detects
BOD	mg/L	1900	15	11000	3	3
COD	mg/L	3800	76	860000	3	3
Cyanide, Total	mg/L	0.005	0.005	0.005	2	1
Oil & Grease	mg/L	55.2	55.2	55.2	1	1
TPH	mg/L	0.031	0.01	0.0512	2	2
TSS	mg/L	49	6.5	92	2	2
Cadmium	mg/L	0.0091	0.0091	0.0091	2	1
Chromium	mg/L	0.011	0.011	0.011	2	1
Copper	mg/L	0.031	0.031	0.031	2	1
Lead	mg/L	0.0094	0.0094	0.0094	2	1
Zinc	mg/L	0.098	0.098	0.098	2	1
Bis(2-ethylhexyl) phthalate	µg/L	465	10	920	3	2
Phenols	µg/L	99	18	180	2	2
Benzene	µg/L	42.5	42.5	42.5	3	1
Toluene	µg/L	28.7	28.7	28.7	3	1

4.4.3 Pollution Prevention. Limited pollution prevention options exist for fire suppression systems using AFFF. AFFF wastewater generated during training operations, system testing, or false alarms should be contained for disposal or reuse rather than released to the wastewater system. Also, detergent or dyes (colored water) have been substituted for AFFF in training operations; however, the fire chief must approve such substitutions.

4.5 Aircraft Corrosion Control

4.5.1 Activity Description. Aircraft corrosion control encompasses all surface preparation and coating application processes. These processes may include paint removal, sanding, hydroblasting, plastic media blasting, chromate conversion coating, priming, solvent cleaning, painting, and washing of various aircraft parts. Wastewater is generated from surface washing and preparation, blowdown of paint booth air scrubbing water, and cleaning of floors and painting equipment.

The chromate conversion process is employed at some military installations to pretreat metal before painting. The metal object is dipped into alkaline, acid, and rinse tanks in a six-step process. At some installations, the entire aircraft fuselage may be treated. Cleaning the dip tanks and disposing of the rinse tank liquids results in wastewater contaminated with chromium.

4.5.2 Wastewater Characteristics. Aircraft Corrosion Control wastewater characteristics are summarized in Table 10. Contaminants may include paint residue, paint overspray, sanding residue, solvents, MEK, heavy metals, chromates, aircraft cleaning compounds, fuel, hydraulic fluids, oils, antifreeze, and detergents.

4.6 Aircraft Deicing

4.6.1 Activity Description. Deicing fluids are sprayed on aircraft at many military installations during icing conditions. The concentrated deicing fluid mixes with melted snow and ice on the aircraft wings and on the ground. The resultant runoff is subject to stormwater regulations and NPDES permitting requirements. Prior approval should be obtained before discharging deicing runoff to a POTW or FOTW. Further information on deicing policies and procedures may be found in Air Force TO 42C-1-2, 1997.

Table 10
Characteristics of Aircraft Corrosion Control Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	125	0	10929	10	8
BOD	mg/L	140	15	520	7	6
COD	mg/L	420	62	35000	12	11
Cyanide, Total	mg/L	0.0095	0.007	0.012	7	2
Oil & Grease	mg/L	39	2.1	1500	15	10
pH	SU	7.5	7.0	13.0	8	7
TPH	mg/L	6.4	0.6	288	12	9
TSS	mg/L	92	8	270	9	9
Arsenic	mg/L	0.021	0.01	0.1	14	4
Cadmium	mg/L	0.114	0.005	1.1	16	7
Chromium	mg/L	0.185	0.025	2.92	17	12
Copper	mg/L	0.106	0.033	5.7	16	8
Lead	mg/L	0.046	0.021	2.7	14	8
Mercury	mg/L	0.0027	0.0004	0.005	15	2
Molybdenum	mg/L	0.02	0.009	0.15	10	3
Nickel	mg/L	0.041	0.027	0.078	16	5
Silver	mg/L	-	-	-	-	-
Zinc	mg/L	0.189	0.025	8.9	16	12
Bis(2-ethylhexyl) phthalate	µg/L	46	46	46	3	1
Phenols	µg/L	100	100	100	1	1
Acetone	µg/L	-	-	-	-	-
Benzene	µg/L	-	-	-	-	-
Ethylbenzene	µg/L	0.7	0.7	0.7	12	1
Methylene Chloride	µg/L	523	2.4	1044	12	2
Toluene	µg/L	6.5	1.2	130	13	4

4.6.2 Wastewater Characteristics. Representative data on deicing wastewater were not available. Deicing fluids for aircraft are comprised of propylene glycol or ethylene glycol. For runway deicing, sodium acetate, potassium acetate, and sodium formate are replacing urea. The resultant runoff may be high in organic strength and, in the case of runway deicing with urea, ammonia. The BOD_5 of ethylene glycol and propylene glycol is approximately 450,000 mg/L and 700,000 mg/L, respectively. The quantity of glycol used varies from about 50 to 500 gallons, depending on the size of the aircraft and weather conditions.

4.6.3 Pollution Prevention. As indicated above, glycol-contaminated aircraft deicing wastewater contains high concentrations of BOD, and discharge of this wastewater to surface waters is not allowed without an NPDES permit. Likewise, discharge of deicing runoff to WWTPs may not be permissible or, if allowed, the costs of treatment may be prohibitive. Military installations should first evaluate pollution prevention options, such as recovery of spent glycol and/or reduction or elimination of the use of glycol-based chemicals.

4.6.3.1 Glycol Recovery. Glycol recovery through distillation has been cost-effectively implemented at some large commercial airports, but has not yet seen widespread use. In the United States, the recovered glycol is generally sold rather than reused for deicing because of certification requirements. The economics of glycol recovery depend on such factors as weather conditions, aircraft activity during storm periods, capture rate of contaminated runoff, and concentration of the captured wastewater. Existing areas can be retrofitted with a drainage system to limit the amount of storm runoff that can mix with the deicing fluid, with vacuum trucks used to collect the spent deicing fluid.

4.6.3.2 Glycol Use Reduction. High-velocity, forced air sprays may be used to reduce the volume of glycol needed for deicing. The forced hot air is applied first to remove loose ice and snow, prior to application of a mixture of glycol and heated water to reduce the volume of glycol used for deicing. Computer-controlled gantry systems with high-efficiency nozzles are also available, which spray a combination of hot air, hot water, and deicing fluid at precisely controlled application rates to

minimize glycol use. It should be noted that Technical Order 42C-1-2 prohibits the use of hot water alone for deicing.

4.7 Aircraft Washing

4.7.1 Activity Description. This source includes washing of all types of aircraft, including helicopters. Washing of support equipment is included under vehicle/equipment washing, although in some cases large ground support equipment may be washed using aircraft washing facilities. Washing encompasses the entire exterior of the aircraft, exterior surfaces of the engine and turbine blades, and the landing gear wheel well. It may also include floor areas inside the aircraft.

4.7.2 Wastewater Characteristics. Aircraft washing wastewater characteristics are summarized in Table 11. Contaminants in the waste stream may include cleaning agents, oils and grease, gasoline, jet fuel, hydraulic fluid, paint flakes, and metals. Cleaning agents should only be used when required and approved. Such agents may have a very high BOD content (see par. 4.10) and may cause pH and corrosion problems. Because the database covered predominately fixed-wing aircraft, the characteristics shown in Table 11 may not be representative of rotary-wing aircraft, which typically contain more solids and oil and grease.

Flow volumes for aircraft washing depend on the number and size of pressure washers used, the size of the aircraft, and the washing procedures. Volumes are estimated to range from approximately 7,500 gallons for a single large aircraft such as a C-5 or C-141, to less than 500 gallons for a small aircraft. The complete washing cycle for a single medium to large aircraft takes from 6 to 10 hours.

4.7.3 Pollution Prevention. Aircraft washing represents the largest volumetric source of nondomestic wastewater generation at military installations. Pollution prevention methods are primarily aimed at reducing the amount of water used and the volume of wastewater generated. Methods should also be applied to reduce the extent of oil emulsification so that downstream oil/water separation, if applied, is more effective. Treatment and reuse of wastewater is also an option and is discussed separately in Section 8.

Table 11
Characteristics of Aircraft Washing Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	286	0.2	7500	34	26
BOD	mg/L	156	12	2200	40	38
COD	mg/L	560	32	20700	45	45
Cyanide, Total	mg/L	0.02	0.007	2	26	10
Oil & Grease	mg/L	32	0.1	76800	61	55
pH	SU	7.5	5.3	8.2	33	26
TPH	mg/L	16.1	0.003	548000	37	33
TSS	mg/L	47	0.3	1150	52	47
Arsenic	mg/L	0.006	0.004	1.8	45	9
Cadmium	mg/L	0.086	0.005	5.4	75	54
Chromium	mg/L	0.04	0.007	4.6	75	40
Copper	mg/L	0.15	0.008	11	51	39
Lead	mg/L	0.040	0.005	3.5	76	54
Mercury	mg/L	0.0006	0.0001	0.017	50	9
Molybdenum	mg/L	0.027	0.008	0.119	21	4
Nickel	mg/L	0.038	0.005	1.5	50	22
Silver	mg/L	0.04	0.002	0.109	45	11
Zinc	mg/L	0.39	0.04	7.5	69	65
Bis(2-ethylhexyl) phthalate	µg/L	92	6	350	7	6
Phenols	µg/L	62	10	230	16	8
Acetone	µg/L	440	440	440	6	1
Benzene	µg/L	500	500	500	25	1
Ethylbenzene	µg/L	251	1.9	500	26	2
Toluene	µg/L	7.8	2.6	3600	26	4

4.7.3.1 Water Conservation. Both aircraft and vehicle washing are primarily accomplished with pressure washers. Units are available with various combinations of discharge pressure and flow rate. A combination of pressure and discharge rate should be selected to accomplish the necessary cleaning with minimum water consumption.

4.7.3.2 Process Modifications. When pressure washers are used in conjunction with cleaning agents, emulsification of oil will occur, rendering downstream oil/water separation ineffective. Where high oil concentrations are encountered in washwater and the washwater is to be discharged to an oil/water separator (OWS), the preferred process modification is the use of hot-water pressure washers without cleaning agents to minimize oil emulsification. Appropriate safety precautions must be used when employing hot-water pressure washers. When permissible, so-called “short-lived” detergents (erroneously referred to as non-emulsifying detergents) should also be used when oil removal is required because they produce an unstable emulsion that dissipates and allows gravity oil separation.

4.7.3.3 Diversion of Stormwater from Washracks. If a washrack is located outdoors and discharges to a wastewater system, facilities should be in place to restrict stormwater from entering the wastewater system. Facilities should include curbing around the periphery of the washrack area to prevent the entry of extraneous storm runoff.

Some facilities have a valve, slide gate, or other control device located upstream of the wastewater system connection that can be opened before washing operations and closed afterward. Where flow diversion control devices are used, a standard operating procedure must be in place to ensure that the devices are properly operated. In wetter climates, providing a cover over washracks may be preferred over installation of diverter valves to limit entry of stormwater to the wastewater system.

4.8 Battery Maintenance

4.8.1 Activity Description. This source covers maintenance conducted on lead/acid batteries in vehicle maintenance facilities or separate battery shops. Wastewater is generated from cleaning battery cells. Activities generating wastewater

include neutralizing waste acid and then discharging the neutralized solution to a sink or floor drain.

4.8.2 Wastewater Characteristics. Battery maintenance wastewater characteristics are summarized in Table 12. Typical contaminants include heavy metals, sulfuric acid, sodium bicarbonate, and detergents. Floor washing in battery maintenance areas is also included in this category because of its unique characteristics.

Table 12
Characteristics of Battery Maintenance Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	Gpd	11	0.5	186	5	5
BOD	mg/L	190	190	190	1	1
COD	mg/L	600	600	600	1	1
Oil & Grease	mg/L	11	11	11	1	1
pH	SU	8.6	7.7	9.6	2	2
TSS	mg/L	140	140	140	1	1
Arsenic	mg/L	0.002	0.002	0.002	5	1
Cadmium	mg/L	0.043	0.01	0.12	5	5
Chromium	mg/L	0.028	0.01	0.06	5	4
Copper	mg/L	0.16	0.032	0.9	5	5
Lead	mg/L	0.12	0.008	16.6	5	4
Mercury	mg/L	0.00024	0.00022	0.0005	5	3
Molybdenum	mg/L	0.01	0.01	0.01	2	1
Nickel	mg/L	0.048	0.048	0.23	5	3
Zinc	mg/L	0.39	0.15	2.17	5	5
Acetone	µg/L	36	36	36	1	1
Toluene	µg/L	5	5	5	1	1

Some battery shops and electronics repair areas also have a separate area for lithium and nickel/cadmium batteries, but the wastewater characteristics provided in Table 12 may not

have included these areas. Battery maintenance wastewater is low in flow but may be highly concentrated.

4.9 Dental Clinic Operations

4.9.1 Activity Description. Wastewater discharged from dental clinics results from water spray and rinsing of patients' mouths. Sanitary wastewater may also be included. Likewise, discharges from X-ray processing within the clinic may be included in some cases; however, samples specifically identified as dental clinic X-ray processing in the database were excluded from this category and placed in the photo/X-ray processing category.

4.9.2 Wastewater Characteristics. Wastewater characteristics from dental clinic operations are summarized in Table 13. The types of contaminants that could be discharged from dental clinics, other than from X-ray processing, include the following:

a) Chlorine solution from denture disinfection

b) Amalgam/water mixture (amalgam is a tooth filler alloy material of about 50 percent mercury and some portion of silver, tin, copper, and, in some cases, other metals, such as zinc, palladium, or indium)

c) Neutralized acid

d) Powdered stone and residue from wet sanding dentures

e) Sodium citrate used to dissolve plaster

Although mercury and silver were not detected in the database samples, these metals are typically present. Studies have shown an average discharge rate of 35-40 mg of mercury per dentist per day, based on 14 amalgam procedures per day and 23 mg of mercury generated per amalgam (Kunkel et al., "The Fate of Mercury in Dental Amalgam", Water Environment & Technology, December 1996).

Table 13
Characteristics of Dental Clinic Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	48	48	48	5	1
BOD	mg/L	71	55	86	2	2
COD	mg/L	215	140	290	2	2
Oil & Grease	mg/L	12	12	12	2	1
pH	SU	6.8	6.8	6.8	1	1
TSS	mg/L	72	43	100	2	2
Copper	mg/L	0.03	0.03	0.03	4	1
Zinc	mg/L	0.07	0.04	0.08	4	4
Bis(2-ethylhexyl) phthalate	µg/L	22	12	31	2	2
Phenols	µg/L	29	29	29	1	1
Acetone	µg/L	79	79	79	1	1
Methylene Chloride	µg/L	7.7	0.4	15	5	2
Toluene	µg/L	17.5	8	27	5	2

TSS total suspended solids

4.9.3 Pollution Prevention. Amalgam and X-ray fixer solution are the waste products of most concern from dental clinics. Pollution prevention methods associated with amalgam are discussed below, while those associated with X-ray processing are discussed separately in par. 4.17.3.

Amalgam may be classified as hazardous because of its mercury and silver content. Spent amalgam, including that from traps or filters, should be stored in a closed container to minimize the release of mercury vapor, and disposed of via a recycling company. Many such companies also sell, lease, install, and maintain equipment for efficient amalgam capture, including the fine particles that may pass through amalgam traps and filters and get discharged to the sewer. Precapsulated amalgam should be used to eliminate the possibility of a bulk mercury spill. Otherwise, bulk mercury should be stored in unbreakable containers on stable surfaces.

Kits should be available to clean up a mercury spill. Elemental mercury should not be poured down a drain or discarded but rather should be recycled.

4.10 Engine Washing

4.10.1 Activity Description. This category includes washing jet, turboprop, or helicopter engines, internal combustion engines, and engine components on a washrack. Generally, engine washing takes place in an engine maintenance facility where engines may be removed, disassembled, and reinstalled; however, washracks may also be located outdoors. A carbon-removing compound is sometimes used in the washing process.

4.10.2 Wastewater Characteristics. Wastewater characteristics are summarized in Table 14. Typical wastewater contaminants include fuel, oils, lubricants, detergents, and heavy metals. For example, nickel and cadmium are prevalent in the washing of C-130 aircraft engines because the compressor vanes/blades assembly is electroplated with nickel/cadmium for corrosion control. Alcohol and high concentrations of oil and grease may also be present where helicopter engines are washed. The database shown did not include washing of helicopter or internal combustion engines.

Typically, steam cleaners discharge approximately 2 gpm over a washing period of 10 minutes, for a total washwater of 20 gallons per engine. A report describing the washing of Allison T56 turboprop engines estimated an average of 40 gallons of washwater per engine.

Table 14
Characteristics of Engine Washing Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
COD	mg/L	82	1	33600	19	11
Oil & Grease	mg/L	195	0.2	14600	20	12
TPH	mg/L	1.46	0.002	3.1	19	4
TSS	mg/L	454	10	2910	20	13

Table 14 (Continued)

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Arsenic	mg/L	0.16	0.12	0.2	7	2
Cadmium	mg/L	0.03	0.003	2.8	26	26
Chromium	mg/L	0.6	0.4	1.23	7	7
Lead	mg/L	0.3	0.06	1.8	7	4
Mercury	mg/L	0.001	0.001	0.01	4	4
Nickel	mg/L	1.71	0.006	14.8	19	16
Silver	mg/L	0.06	0.01	0.6	7	7

TPH total petroleum hydrocarbons

4.11 Fire Fighting Training

4.11.1 Activity Description. Fire fighting training involves extinguishing fires set using fuels under controlled conditions. The volume of wastewater generated and the contaminants present vary depending on the exercise being conducted. Fire fighting training is performed at an outside pit by igniting a fuel supply at various points on a mock aircraft or other structure and then extinguishing the fire. Another facility used a lined pit filled with water and jet fuel. The fuel was ignited on the water and extinguished with AFFF solution. Drainage from the training areas is often recycled but may be discharged to a properly designed OWS and then to the sewer system.

New Air Force fire-fighting training facilities use liquid propane fuel with water as the extinguishing agent, resulting in a process that is less polluting. These new facilities discharge to a retention pond.

4.11.2 Wastewater Characteristics. Wastewater characteristics for fire fighting training are summarized in Table 15. Typical contaminants discharged in fire fighting training wastewater include fuel by-products, oils, and AFFF. Products of fuel combustion are also present, including aldehydes, light aromatic hydrocarbons (benzene, toluene, and xylene), polynuclear aromatic hydrocarbons, and carbon.

An in-depth characterization study performed at Charleston AFB found that the concentrations of nonmetallic contaminants decreased significantly within 1 day following the conclusion of burning as a result of volatilization and biochemical degradation.

Table 15
Characteristics of Fire Fighting Training Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	Gpd	114	114	114	1	1
BOD	mg/L	9.5	9.5	9.5	1	1
COD	mg/L	49	36	1800	3	3
Oil & Grease	mg/L	890	890	890	1	1
pH	SU	7	6.5	7.5	2	2
TPH	mg/L	1.7	1.4	2	2	2
TSS	mg/L	24	22	35	3	3
Cadmium	mg/L	0.060	0.008	0.12	2	2
Chromium	mg/L	0.04	0.04	0.04	2	1
Copper	mg/L	0.04	0.04	0.04	2	1
Lead	mg/L	0.02	0.01	0.02	2	2
Molybdenum	mg/L	0.03	0.03	0.03	2	1
Nickel	mg/L	0.05	0.05	0.05	2	1
Silver	mg/L	0.005	0.005	0.005	2	1
Zinc	mg/L	0.08	0.08	0.08	2	1
Benzene	µg/L	28.5	22	35	3	2
Toluene	µg/L	4.2	3.1	5.2	3	2

4.12 Fuel Storage

4.12.1 Activity Description. Wastewater included in this category is generated at fueling areas and fuel storage tank containment areas. Wastewater is generated when large fuel storage tanks collect condensate or water from other sources that must be separated from the fuel. Water is decanted from the tanks, often on a daily basis, and separated from the fuel. The

fuel is returned to the tank, and the water is typically discharged to an OWS prior to discharge to the sewer system.

Wastewater may also be generated from the containment structures surrounding fuel transfer and aboveground storage tanks (ASTs). Stormwater and fuel spilled in the containment area are typically discharged through an OWS to the sewer system. Similarly, when fuel tankers are purged, tanks are flushed with water, which is then discharged, creating fuel-contaminated wastewater.

4.12.2 Wastewater Characteristics. Fuel storage wastewater characteristics are summarized in Table 16. Contaminants present in the wastewater typically include oil, fuel, and fuel icing-prevention compounds.

Table 16
Characteristics of Fuel Storage Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	40	0.7	100	8	5
BOD	mg/L	540	200	630	9	3
COD	mg/L	457	31	5100	11	7
Oil & Grease	mg/L	22.8	1.3	336	13	12
pH	SU	6.4	6.0	8.0	6	5
TPH	mg/L	8	2	160	12	10
TSS	mg/L	29	3	1500	7	7
Cadmium	mg/L	0.006	0.001	0.535	12	7
Chromium	mg/L	0.18	0.02	0.34	12	2
Copper	mg/L	0.11	0.02	0.55	12	4
Lead	mg/L	0.039	0.007	1.41	11	4
Mercury	mg/L	0.0006	0.0002	0.001	12	2
Nickel	mg/L	0.060	0.060	0.060	12	1
Zinc	mg/L	0.17	0.05	6.09	12	11
Ethylbenzene	µg/L	7	7	7	14	1
Toluene	µg/L	2	2	2	14	1

4.13 Hospital Operations

4.13.1 Activity Description. This source includes the total wastewater discharge from hospitals, which may include water from laboratories, X-ray processing, laundries, bathrooms, and other miscellaneous sources.

4.13.2 Wastewater Characteristics. Hospital wastewater characteristics are summarized in Table 17. Hospital wastewater is expected to contain normal sanitary wastewater contaminants plus cleaning agents, germicides, acids, and chemicals associated with laboratory and health care services. Silver may be present in the combined hospital wastewater as a result of X-ray processing, but this wastewater is characterized separately (see par. 4.17).

Table 17
Characteristics of Hospital Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	7500	5	217641	41	7
BOD	mg/L	153	16	1400	31	31
COD	mg/L	290	44	7500	45	45
Cyanide, Total	mg/L	0.013	0.007	0.21	34	7
Oil & Grease	mg/L	14	0.17	2000	31	30
PH	SU	7.5	5.9	8.5	20	20
TPH	mg/L	4	0.004	688	30	20
TSS	mg/L	52	7	1600	32	32
Arsenic	mg/L	0.0065	0.006	0.007	40	2
Cadmium	mg/L	0.002	0.002	0.002	41	1
Chromium	mg/L	0.032	0.012	8	41	3
Copper	mg/L	0.052	0.022	0.38	41	36
Lead	mg/L	0.0048	0.002	0.03	38	8
Mercury	mg/L	0.0014	0.0003	0.019	41	20
Molybdenum	mg/L	0.33	0.05	30.8	20	7
Nickel	mg/L	0.072	0.05	9	41	6
Silver	mg/L	0.039	0.01	7	40	22

Table 17 (Continued)

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Zinc	mg/L	0.11	0.03	0.56	41	36
Bis(2-ethylhexyl) phthalate	µg/L	53	2.1	1100	17	8
Phenols	µg/L	54	10	920	31	30
Methylene Chloride	µg/L	1.6	1.1	2.0	36	2
Toluene	µg/L	2.3	1.0	490	36	8

4.13.3 Pollution Prevention. Hospitals may discharge low levels of heavy metals and toxic organics, primarily through the use of laboratory reagents, disinfectants, and preservatives. Generally, the quantities discharged are small and can be minimized with BMP, including spill prevention and inventory control. The principal waste product of concern at military hospitals is likely to be spent fixer solution from X-ray processing, which is discussed separately in par. 4.17.

4.14 Maintenance Area Floor Washing

4.14.1 Activity Description. In general, floor washing in maintenance areas is accomplished using a mop and 5-gallon bucket containing water and cleaning agent or a floor-cleaning machine (such as the Zamboni or Tennant machines). The floor-washing machines have a reservoir to contain the water/cleaning agent solution, which typically ranges from 10 to 150 gallons. The machines also vacuum excess wash water, which is then discharged via sinks or floor drains. Where floor drains are present, a hose may be used to wash the floor and then followed by using a squeegee to push excess water into the drains. Floor washing frequency may vary from daily to monthly, depending on activities in the building.

Floor washing is conducted at a variety of military maintenance facilities, including the following:

a) Aircraft Maintenance Facilities—routine maintenance, repair, inspections, and modifications of aircraft and aircraft engines.

b) Engine Testing Facilities—testing and tuning of jet engines in test cells, located indoors or outdoors.

c) Fuel System Maintenance Facilities—draining and repair of aircraft fuel systems and maintenance of fuel trucks, performed separately from other aircraft and vehicle maintenance facilities because of the fire potential.

d) Power Production Shops—maintenance on electrical equipment, including portable emergency generators and transformers.

e) Vehicle Maintenance Facilities—maintenance on motor pool and private vehicles, ground support equipment, tractors, and special purpose vehicles, including engine work, transmission work, brake work, body work, oil changes, antifreeze changes, and air conditioning servicing.

f) Weapons Maintenance Facilities—maintenance and cleaning of guns, bomb release devices, and other weapons systems; in some cases, these activities may generate wastewater other than floor washwater that may contain lead and other metals.

4.14.2 Wastewater Characteristics. Biodegradable detergent cleaners are generally used in floor-washing operations. Solvents should not be used for floor washing. Contaminants in vehicle maintenance floor washing wastewaters typically include residual oil, fuel, hydraulic fluid, antifreeze, lubricants, degreasers, cleaning agent, and other maintenance-related fluids. These liquid cleaners are known to have high BOD and COD values. Measurements of BOD on liquid cleaners in one study at Dover AFB found the following:

Liquid	BOD_5 (mg/L)
Alkaline Cleaner	42,000
Antifreeze	29,000
Automatic Transmission Fluid	30,000

Wastewater characteristics for floor washing wastewater are summarized in Table 18. The character and volume would be expected to depend on the method of floor washing, the floor area, and the type of activities being conducted in the building. However, data indicate that floor washwater sample results are quite similar for each of the types of facilities mentioned previously. Wastewater volumes are a function of the floor area and method of floor washing. Volumes are greatest where hoses are used for washing and rinsing. Garden hoses typically discharge approximately 5 to 8 gpm.

Table 18
Characteristics of Maintenance Area Floor Washing Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	14	0.5	3870	180	126
BOD	mg/L	181	4	5300	100	74
COD	mg/L	330	12	29300	132	124
Cyanide, Total	mg/L	0.012	0.005	0.14	56	13
Oil & Grease	mg/L	50	0.07	640000	214	199
pH	SU	7.1	5	10.6	74	73
TPH	mg/L	30	0.002	446000	187	159
TSS	mg/L	74	1	22670	164	159
Arsenic	mg/L	0.007	0.002	0.109	186	53
Cadmium	mg/L	0.039	0.001	21.2	204	140
Chromium	mg/L	0.048	0.004	29.4	205	110
Copper	mg/L	0.17	0.01	51	204	148
Lead	mg/L	0.12	0.003	35.3	187	143
Mercury	mg/L	0.0007	0.0001	0.039	201	59
Molybdenum	mg/L	0.07	0.01	8.2	125	45
Nickel	mg/L	0.076	0.004	16	202	100
Silver	mg/L	0.017	0.001	0.252	178	22
Zinc	mg/L	0.67	0.02	34.2	202	173
Bis(2-ethylhexyl) phthalate	µg/L	19	2.4	170	26	17
Phenols	µg/L	35	0.09	600	53	27

Table 18 (Continued)

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Acetone	µg/L	48	24	72	6	2
Benzene	µg/L	4	0.5	1000	163	12
Ethylbenzene	µg/L	31	0.5	13000	164	25
Methylene Chloride	µg/L	2	0.6	133	164	11
Toluene	µg/L	15	0.9	4680	164	46

4.14.3 Pollution Prevention. Floor washing in maintenance facilities lends itself to the application of pollution prevention techniques, as opposed to pretreatment, because of the relatively small volume of wastewater generated. Various pollution prevention techniques are applicable, as described below.

4.14.3.1 Cleaning Practices. Water consumption and wastewater generation will be minimized with the use of mechanical floor washers. Facilities that use mechanical floor washers generate only 10 to 15 percent as much wastewater as those employing fire or garden hoses.

Dry cleanup practices should be used prior to washing to minimize pollutant concentrations in the washwater discharge. These practices include the use of rags or absorbent materials, vacuum cleaning, and sweeping. A wet/dry type vacuum cleaner may be useful to collect and salvage spilled material, but only an explosion-proof vacuum should be used for gasoline, solvents, or other volatile fluids. Alternatively, special hydrophobic mops or squeegees may be used. Concrete floors should be sealed or coated with an oil-resistant coating to facilitate cleaning.

4.14.3.2 Spill Control. Floor drains in maintenance areas should be sealed to prevent spills or contaminated wastewater from directly entering the wastewater system, except where needed for health and safety requirements. Spills to the floor should be minimized with the use of drip pans. These should be placed under vehicles when detaching hoses, unscrewing filters, or

removing parts that may cause a leak. Used fluids should be kept separate and promptly transferred to storage for recycling. Drip pans and other open containers should be properly used and maintained.

4.14.3.3 Spill Prevention. A written spill prevention and response procedure should be posted in areas where spills may occur. Staff should be trained on how to respond to a spill.

4.15 Non-Destructive Inspection Testing

4.15.1 Activity Description. Operations performed at Non-Destructive Inspection (NDI) facilities include those associated with the use of dye penetrants and other solutions to view stress fractures in ultraviolet light. The penetrant is typically a green liquid dye into which the parts are dipped. The parts are subsequently immersed in remover and developer solutions, with water rinsing taking place after each immersion. Typically, the rinsate from this process is discharged to the sewer system.

4.15.2 Wastewater Characteristics. NDI wastewater characteristics are summarized in Table 19. The wastewater contains organics that impart a high COD. Heavy metals are also likely to be present.

Table 19
Characteristics of NDI Testing Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	43	0.1	200	9	5
BOD	mg/L	234	143	1900	4	3
COD	mg/L	465	50	2870	7	6
Cyanide, Total	mg/L	0.007	0.007	0.007	7	2
Oil & Grease	mg/L	14	3.8	886	7	5
pH	SU	6.3	6.2	7	4	3
TPH	mg/L	15.2	3.2	27.2	4	2
TSS	mg/L	29.5	21	720	5	4
Arsenic	mg/L	0.086	0.086	0.086	9	1

Table 19 (Continued)

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Cadmium	mg/L	0.049	0.006	0.11	10	4
Chromium	mg/L	0.18	0.11	0.25	10	2
Copper	mg/L	0.12	0.02	1.68	10	6
Lead	mg/L	0.04	0.01	0.36	5	4
Mercury	mg/L	0.00053	0.00053	0.00053	10	1
Molybdenum	mg/L	0.042	0.042	0.042	7	1
Nickel	mg/L	0.13	0.13	0.13	9	1
Silver	mg/L	0.035	0.01	9.69	6	4
Zinc	mg/L	0.16	0.07	4.54	10	7
Phenols	µg/L	20	20	20	1	1
Methylene Chloride	µg/L	1.4	1.4	1.4	5	1
Toluene	µg/L	35	25	45	5	2

4.16 Parts Washing

4.16.1 Activity Description. This category includes cleaning and degreasing metal parts from weapons, vehicles, aircraft, heavy equipment, and ground-support equipment. Parts may be washed in vats containing mineral spirits or some other type of cleaner or solvent, followed by rinsing in a parts washer. Hot-water washers are also increasingly used, with a detergent as the cleaning agent. Some locations use a plastic media blaster that generates cadmium and chromium dust, which can enter the waste stream through cleanup operations.

4.16.2 Wastewater Characteristics. Parts washing wastewater characteristics are summarized in Table 20. Parts washers are located in virtually all maintenance facilities, but data from various locations indicate that the wastewater characteristics are similar. Contaminants that may be encountered in parts washing wastewater include fuel, oil, hydraulic fluids, petroleum distillates, heavy metals, organic solvents, and detergent cleaning agents.

Table 20
Characteristics of Parts Washing Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	50	2	1957	21	15
BOD	mg/L	290	21	1300	11	10
COD	mg/L	560	70	2700	13	12
Cyanide, Total	mg/L	0.1	0.03	0.17	4	2
Oil & Grease	mg/L	47	4.5	2030	23	23
pH	SU	7.8	7	9.0	4	4
TPH	mg/L	17	0.008	496	22	21
TSS	mg/L	55	0.04	850	19	18
Arsenic	mg/L	0.0085	0.007	0.01	16	2
Cadmium	mg/L	0.15	0.001	227	18	15
Chromium	mg/L	0.098	0.01	29.4	18	11
Copper	mg/L	0.18	0.03	6.27	18	15
Lead	mg/L	0.028	0.003	4.96	18	16
Mercury	mg/L	0.0019	0.0002	0.0037	18	4
Molybdenum	mg/L	0.10	0.03	1.57	11	6
Nickel	mg/L	0.38	0.14	1	18	5
Silver	mg/L	0.23	0.07	0.5	17	2
Zinc	mg/L	0.30	0.042	13.7	18	17
Bis(2-ethylhexyl) phthalate	µg/L	33	33	33	2	1
Phenols	µg/L	308	35	580	3	2
Benzene	µg/L	12.1	8.2	16	19	2
Ethylbenzene	µg/L	3.3	3.3	3.3	19	1
Methylene Chloride	µg/L	130	10	1422	20	3
Toluene	µg/L	7.6	2.7	500	19	4

4.16.3 Pollution Prevention. EPA's recommended strategy for pollution prevention from parts washing is set forth in EPA 625/7-91-016 Guides to Pollution Prevention, the Automotive Repair Industry. The strategy is based on systematic implementation of the following sequential steps:

a) Avoid the need to clean.

b) Select the least hazardous cleaner.

c) Maximize cleaning efficiency.

d) Segregate cleaning wastes.

e) Maximize recycling and reuse.

The extent, type, and method of parts washing should be determined from technical orders or guidance documents.

4.16.3.1 Cleaning Process Assessment. Before using a solvent or aqueous cleaner, a determination should be made about whether cleaning is necessary and how clean a part needs to be. Rigorous chemical cleaning should only be performed when guidance documents require it. Pre-cleaning before solvent use is recommended to reduce solvent use or prolong the life of solvent cleaning solutions.

4.16.3.2 Elimination of Solvents. Many of the solvents in use for parts washing consist of or contain priority pollutant organics, such as trichloroethane, dichlorobenzene, methylene chloride, and the BTEX compounds. Because of problems associated with the use and disposal of organic solvents, these solvents should only be used when no other substitute is suitable. When used, solvent sinks should be operated properly to reduce solvent losses and waste generation. Proper operating procedures include removing parts slowly after immersion to reduce drippage, installing drip trays or racks to drain cleaned parts, allowing sufficient drainage time over the sink after withdrawal, and monitoring the solvent composition to avoid premature replacement. Contracting with a solvent service company has generally proven less costly than managing solvent purchase, tank maintenance, and solvent recovery or waste disposal.

Aqueous cleaning using water and one of a variety of detergents or alkaline compounds is a suitable alternative to solvent cleaning for many parts washing operations. The type of cleaner should be carefully selected because cleaners vary in their effectiveness, their compatibility with the materials being

cleaned, and the degree of oil emulsification they produce. Stable oil emulsions limit reuse of the cleaning solution and restrict its disposal options. In some cases, the spent washwater may be suitable for discharge to the wastewater system after emulsion breakdown and oil removal. In this case, an analysis of the wastewater may be necessary to assure compliance with local limits.

In evaluating alternative solvents or solvent elimination, the impacts on the parts being cleaned should be considered. Factors to consider include the effectiveness of the cleaner, the degree of emulsion produced, and the compatibility of the cleaner with the part’s materials of construction. Before any production substitutions or process changes are made, they must be approved by environmental and equipment managers.

4.16.3.3 Use of Filters. Some parts washers are equipped with oil skimmers and filters to remove contaminants. These washers allow almost indefinite use of the washing fluid, but require periodic removal and proper disposal of oily residue and sludge and filter replacement.

4.17 Photo/X-Ray Processing

4.17.1 Activity Description. Photograph and X-ray processing is carried out at military installations in dental clinics, hospitals, NDI facilities, and photo-processing laboratories. At NDI facilities, X-ray photography is used to view stress fractures in equipment and aircraft frames. Silver-based photographic materials consist of solid crystals of silver chloride or silver bromide suspended in gelatin and coated on a film or paper support. The processing of photographic films and papers may vary somewhat, but generally consists of the following three steps:

a) Development of the image, in which metallic silver is formed in the image areas

b) Removal of some or all of the silver, in which silver is converted to crystals of silver bromide or silver chloride and then removed as a soluble silver-thiosulfate complex in a fix solution

c) Stabilizing the image by rinsing residual thiosulfate and silver-thiosulfate complexes out of the emulsion layers with water, or, in the case of washless processing, with a stabilizer solution instead of water

4.17.2 Wastewater Characteristics. Photo/X-ray processing wastewater characteristics, prior to discharge through a silver recovery unit (SRU), are summarized in Table 21. Silver is the primary contaminant of concern in photo processing wastewater. Discharges may also contain elevated concentrations of ammonia, bromide, chromium, cyanide, iron, selenium, and zinc. The SRUs that are often used at photo/X-ray processing facilities are effective for silver removal if properly maintained, but do not have a significant impact on other pollutants.

Table 21
Characteristics of Photo/X-ray Processing Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	Gpd	22	0.1	2057	123	86
BOD	mg/L	113	44	38000	15	14
COD	mg/L	720	10	1530000	51	50
Cyanide, Total	mg/L	0.056	0.005	47500	73	16
Oil & Grease	mg/L	14.8	1.1	368	22	18
pH	SU	6.6	4.0	7.9	14	14
TPH	mg/L	4.8	0.001	240	17	11
TSS	mg/L	57	10	1840	20	19
Arsenic	mg/L	0.020	0.003	0.12	66	34
Cadmium	mg/L	0.051	0.001	1.5	73	27
Chromium	mg/L	0.077	0.01	0.54	79	30
Copper	mg/L	0.097	0.02	48	78	54
Lead	mg/L	0.10	0.007	1.67	68	20
Mercury	mg/L	0.0012	0.0002	3.7	72	49
Molybdenum	mg/L	0.005	0.005	0.005	63	1
Nickel	mg/L	0.38	0.02	8.43	78	30

Table 21 (Continued)

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Silver	mg/L	0.50	0.005	740	114	87
Zinc	mg/L	0.23	0.04	6.89	78	64
Bis(2-ethylhexyl) phthalate	µg/L	24.5	5.9	44	9	6
Phenols	µg/L	63.5	11	1620	32	24
Methylene Chloride	µg/L	11.5	7.9	15.1	29	2
Toluene	µg/L	2	1.3	31	31	3

Silver-rich solutions include spent-fix, bleach-fix, and washless stabilizer; low-silver solutions include used developers, bleaches, stop baths, stabilizers following washes, and washwaters. According to The Code of Management Practice for Silver Dischargers, published by the Silver Coalition and the Association of Metropolitan Sewer Agencies (September 1995), silver-rich solutions will contain between 2,000 and 8,000 mg/L of silver. Low-silver process solutions are likely to average less than 1 mg/L.

In the code referenced above, photoprocessing facilities are classified as small, medium, or large, depending on the quantity of silver-rich and low-silver solutions generated. Most military photo-processing facilities fall within the small facility category, which is characterized by discharges of less than 2 gpd of silver-rich solution and less than 1,000 gpd of low-silver solution.

4.17.3 Pollution Prevention. Silver recovery represents the chief method of pollution prevention for photoprocessing. Silver recovery methods are most effective on concentrated wastewater, so, if used, they should be applied to the silver-rich solutions prior to any mixing or dilution with low-silver solutions. The decision to employ silver recovery and the selection of a method of silver recovery should be determined based on economics,

environmental protection, or compliance with local silver limits. If less than 20 gallons per month of waste fix is generated, contracting with an outside recovery company is likely to be the most cost-effective and environmentally sound solution. For larger discharges, utilization of one of the silver recovery methods described below may be warranted. When appropriate, use of the Defense Logistics Agency Precious Metals Recovery Program is warranted.

Fixer can be recovered and recycled using a dedicated electrolytic unit so as to de-silver the spent fixer to a silver concentration of approximately 500 mg/L. However, the process must be done on a continuous basis rather than as a batch operation to maintain consistent composition of the fixer. Electrolysis also produces changes in the chemical composition of the fixer that may affect fixer quality. Therefore, fixer recovery is normally only applied at large photoprocessing facilities and will not generally be applicable at military installations. However, spent fixer may be hauled offsite by a private company for recovery at a centralized facility.

Bleach fix can be regenerated through a three-step de-silvering process using metal replacement cartridges and chemical treatment to restore bleaching ability. Likewise, ion exchange can be used to recover developer. However, both of these methods are cost-effective only for large volume photolabs. Methods that can be used by military installations to reduce the amount of chemicals used include proper storage, inventory management, stock rotation, and use of containers and lids that allow exclusion of air.

4.17.3.1 Metallic Replacement. In the metallic replacement method of silver recovery, elemental iron undergoes an oxidation-reduction reaction with silver thiosulfate to produce ferrous ions and metallic silver. In practice, the process takes place by metering the silver-rich solution through a container of steel wool, iron particles, or an iron-impregnated resin. These containers are variously referred to as metallic replacement cartridges (MRCs), chemical recovery cartridges (CRCs), or silver recovery cartridges (SRCs). These cartridges are the most economical form of silver recovery and are usually considered cost effective for spent-fix volumes greater than 20 gallons/month.

A properly designed, operated, and maintained MRC is capable of recovering more than 95 percent of the silver from silver-rich solutions. With two MRCs connected in series, a removal efficiency of 99 percent is possible. However, as the recovery cartridge is used, the active surface area is reduced and channels develop in the iron substrate. As a result, the recovery efficiency gradually diminishes, and significant breakthrough of silver may occur. Therefore, proper maintenance and timely cartridge replacement is essential. The use of two-cartridge systems also provides more effective and consistent recovery.

4.17.3.2 Electrolysis. In electrolysis, or electrolytic silver recovery, electric current reduces the silver-thiosulfate complex in the spent-fix solution resulting in almost pure silver metal plating onto the negatively charged electrode (cathode). In one type of equipment, the solution flows around a stationary cathode, while in another the cathode rotates in the solution. Either type is capable of recovering more than 90 percent of the silver from silver-rich solutions of black and white photographic processes. Bleach-fix and fix solutions from color processes that contain iron-complex oxidizing agents are more difficult to de-silver electrically and may require pH control to achieve silver-recovery efficiencies approaching 90 percent. Electrolytic units are typically only cost effective for installations where spent fixer volumes are greater than 40 gallons/month.

4.17.3.3 Other Technologies. Other technologies for silver removal include precipitation, ion exchange, and reverse osmosis. These technologies are not cost effective for silver recovery and would normally only be applied to meet stringent silver discharge limitations for large facilities treating both silver-rich and low-silver solutions.

4.18 Steam Generation

4.18.1 Activity Description. Boilers are commonly used for steam generation at military installations and, in some cases, may be used for power generation. The wastewater generated from power/steam generation facilities could include boiler blowdown and a variety of other types of wastewater, such as demineralizer

regenerant wastewater, boiler cleaning wastewaters, ash/handling wastewater (where coal is fired), and fireside washwater. Wastewater from these sources should be discharged to a wastewater system and not to a storm sewer.

If boiler blowdown results from steam electric power generation, it is subject to national categorical pretreatment standards. No such blowdown was identified in the database.

4.18.2 Wastewater Characterization. Steam generation process wastewater characteristics are summarized in Table 22. Typical contaminants include water treatment chemicals such as de-scaler, caustic soda, oxygen scavenger, corrosion inhibitor, and phosphate used to prevent scaling and corrosion. The wastewater may be characterized by high pH values and elevated temperatures.

Table 22
Characteristics of Steam Generation Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	43	2	357	8	7
COD	mg/L	99	10	360	6	5
Oil & Grease	mg/L	6.7	0.8	15.0	7	6
pH	SU	9.3	6.5	12.0	5	4
TPH	mg/L	1.64	0.7	1.8	7	5
TSS	mg/L	16	4	4100	5	5
Arsenic	mg/L	0.02	0.02	0.02	7	1
Cadmium	mg/L	0.001	0.001	0.001	8	2
Chromium	mg/L	0.079	0.014	0.14	8	2
Copper	mg/L	0.25	0.13	1.7	8	8
Lead	mg/L	0.11	0.03	0.24	8	6
Molybdenum	mg/L	0.05	0.05	0.05	7	1
Nickel	mg/L	0.038	0.031	0.21	8	3
Silver	mg/L	0.01	0.01	0.01	8	1
Zinc	mg/L	0.35	0.12	0.61	8	7
Phenols	µg/L	48.5	38	59	3	2

4.19 Vehicle Painting

4.19.1 Activity Description. Vehicle painting is typically conducted in a paint booth that contains some type of scrubber to reduce particulate and paint overspray air emissions. If waterfall-type scrubbers are used, the scrubber water is normally recycled and paint solids are concentrated in the scrubber sump. The resulting water may be hazardous and should be analyzed to determine the proper disposal method. Other sources of wastewater include paint stripping (to remove hardened paint from surfaces), floor washdown, and paint spray-gun cleaning.

4.19.2 Wastewater Characteristics. Vehicle painting wastewater characteristics are summarized in Table 23. Typical contaminants include paint solids and solvents. Paint solids may contain metals, particularly cadmium, chromium (hexavalent), lead, and zinc. The more common paint solvents are MEK, xylene, 1,1,1-trichloroethane, toluene, butyl acetate, ethylene glycol, monoethyl acetate, and alcohol. In addition, paint-stripping solvents contain phenols and methylene chloride and may have a low pH.

Table 23
Characteristics of Vehicle Painting Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	30	2	50	4	4
BOD	mg/L	92.5	42	120	4	4
COD	mg/L	275	81	360	4	4
Oil & Grease	mg/L	3.5	1.8	20	5	4
TPH	mg/L	14	14	14	4	1
TSS	mg/L	250	9	2700	5	5
Cadmium	mg/L	0.0044	0.002	0.0068	8	2
Chromium	mg/L	0.5	0.4	1.22	8	5
Copper	mg/L	0.035	0.02	0.050	6	3
Lead	mg/L	0.16	0.005	2.9	8	3
Nickel	mg/L	0.03	0.03	0.03	6	1

Table 23 (Continued)

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Silver	mg/L	0.018	0.018	0.018	6	1
Zinc	mg/L	0.39	0.053	12.9	6	5
Bis(2-ethylhexyl) phthalate	µg/L	21.5	21	22	2	2
Ethylbenzene	µg/L	16	16	16	5	2
Toluene	µg/L	96	95	97	5	2

4.19.3 Pollution Prevention. Painting operations typically produce only a small amount of wastewater. Pollution prevention usually focuses on improving painting techniques to reduce overspray, and minimizing the use of solvent paint thinners and cleanup solvents. The use of plastic media blasting (PMB) paint stripping as an alternative to conventional solvent stripping has also been successfully implemented at many military installations.

4.20 Vehicle and Equipment Washing

4.20.1 Activity Description. This category includes the washing of a variety of vehicles and equipment such as automobiles, tactical vehicles, ground support equipment, and trucks. At some installations, engines are also steam-cleaned. Washing systems for vehicles and equipment range from automatic car washes with recycled washwater and rinsewater to handwashing using a pressure wand or hose and bucket. High-pressure systems using hot water or steam without detergent are preferred. Detergent may be used when necessary and approved.

4.20.2 Wastewater Characteristics. Vehicle and equipment washing wastewater characteristics are summarized in Table 24. Typical contaminants include solids, metals, detergents, oil and grease, fuel, and other lubricants.

The quantity of water used in vehicle/equipment washing varies with the method of washing. Garden hoses normally

discharge 5 to 8 gpm, and automobiles hand washed with garden hoses are estimated to require about 15 to 20 minutes of water flow per automobile. Pressure wand systems discharge only 2 to 4 gpm, and automobile washed with these systems take an average of only 5 to 10 minutes. Thus, wastewater flow may vary from 10 to 200 gallons per automobile. For tactical vehicles, the washing process may take 1 to 2 hours, consuming up to 500 gallons with a pressure system.

The data included in Table 24 and described above may not be applicable to Army and Marine installations, where greater quantities of water are employed in the washing process, and grit loads are significantly higher than at other military installations. Washing facilities at Army installations range from manual or automatic spray booths to “bird baths” (large vehicle-sized bath tubs). Tracked vehicles can accumulate up to 1 ton of soil during field activities, and wash hoses may deliver water at 30 gpm or more.

4.21 Other Sources of Nondomestic Wastewater. The wastewater sources discussed previously in this section are not all-inclusive. Some additional sources are briefly described in the following paragraphs.

4.21.1 Cafeteria/Restaurant Services. Cafeterias, dining halls, and restaurants generate wastewaters at most military installations. The primary concern with this type of wastewater is grease, which may cause blockages in collection systems and interference with treatment plant operations. Grease traps are typically provided to reduce grease discharges to the wastewater system, but they must be serviced regularly to maintain their effectiveness.

4.21.2 Water Treatment. Water treatment operations may include water softening, demineralization, and filtration. High-quality water is often required for boilers, aircraft engine testing, or other specialty uses. The waste streams generated from these sources include reverse osmosis reject water, ion exchange regenerant, and filter backwash. Contaminants include dissolved minerals and treatment chemicals.

Table 24
Characteristics of Vehicle/Equipment Washing Wastewater

Parameter	Units	Median	Min	Max	Number Analyzed	Number Of Detects
Flow	gpd	80	0.6	3500	85	73
BOD	mg/L	57	5	14000	35	32
COD	mg/L	249	25	130000	49	46
Cyanide, Total	mg/L	0.023	0.016	0.04	19	4
Oil & Grease	mg/L	23.5	0.009	136000	96	88
pH	SU	7.67	3.5	9.2	25	23
TPH	mg/L	19	0.003	290000	86	72
TSS	mg/L	56	0.5	1630	82	81
Arsenic	mg/L	0.0078	0.005	0.03	70	19
Cadmium	mg/L	0.015	0.002	5.6	82	57
Chromium	mg/L	0.02	0.01	5	82	39
Copper	mg/L	0.074	0.007	3	84	59
Lead	mg/L	0.053	0.004	4.7	83	68
Mercury	mg/L	0.0005	0.0002	0.12	82	11
Molybdenum	mg/L	0.02	0.007	0.19	49	9
Nickel	mg/L	0.045	0.021	10	84	25
Silver	mg/L	0.059	0.021	0.096	76	2
Zinc	mg/L	0.37	0.023	10.1	84	80
Bis(2-ethylhexyl) phthalate	µg/L	4	1	9	5	5
Phenols	µg/L	39.5	12	260	10	8
Benzene	µg/L	7.3	1.0	27	72	6
Ethylbenzene	µg/L	8.1	1.0	42	72	12
Methylene Chloride	µg/L	515	6.3	1024	72	2
Toluene	µg/L	26.5	1.0	3600	72	24

4.21.3 Metal Plating. Metal plating operations generate wastewater that may contain relatively high concentrations of nickel, chromium, copper, cadmium, zinc, lead, cyanide, oil and grease, solvents, acids, and alkalies. Cyanide-bearing wastes

should be kept separate from acid wastes to avoid cyanide conversion to toxic hydrogen cyanide gas. Chrome-bearing wastes should be kept separate from cyanide-containing wastes so that hexavalent chrome can be acid-reduced prior to alkaline precipitation with other metal-bearing wastes.

4.21.4 Shipboard Wastewater. Oily waste originates in numerous locations on ships, including bilges, oily waste holding tanks, condensate lines, and ballast tanks. Oil and grease concentrations typically range from 200 to 2,000 mg/L, with peak concentrations as high as 100,000 mg/L. Copper and zinc may be present in concentrations up to 1 to 2 mg/L. Average oily waste volumes range from 50 gpd to 50,000 gpd, depending on the ship class. Additional information on characterization and handling of shipboard wastewater can be found in MIL-HDBK-1005/9.

4.21.5 Drydocking Facilities. Ship maintenance activities at drydocks/generate wastewater containing grit, other suspended matter, and heavy metals. Heavy metal concentrations vary widely and must be monitored on a case-by-case basis to determine the need for removal prior to discharge to a domestic wastewater system.

4.22 Summary of Pollutants Contributed. Table 25 summarizes the primary wastewater sources and the pollutants expected to be contributed by each source in elevated concentrations. The contributed pollutants shown are those whose median concentrations from Tables 9 through 24 exceeded the average residential/background concentrations in Table 8. In the case of oil and grease and TPH, sources with median concentrations greater than 30 mg/L and 5 mg/L, respectively, are indicated.

The purpose of this table is to assist military installations in identifying key sources of pollutants that may be contributing to a discharge violation. Once the sources have been identified, pollution prevention or pretreatment can be evaluated and implemented as required. As indicated in par. 4.2, contaminants other than those shown may also be present, so actual wastewater characteristics should be verified through sampling and analysis.

Table 25
Summary of Wastewater Categories and Pollutants Contributed

Wastewater Category	As	Cd	Cr	Cu	CN	Pb	Hg	Ni	Ag	Zn	O&G	TPH	Toxic Organics
Fire Suppression											X		X
Aircraft Corrosion Control	X	X	X			X(1)	X	X		X(1)	X	X	X
Aircraft Washing		X	X	X	X	X(1)	X	X	X	X	X	X	X
Battery Maintenance		X		X		X		X		X			
Dental Clinic Operations							X(1)						X
Engine Washing	X	X	X			X		X	X		X		
Fire Fighting Training		X	X	X				X			X		
Floor Washing	X	X	X	X		X		X		X	X	X	X
Fuel Storage			X	X				X				X	X
Hospital Operations								X	X				X
NDI Testing	X	X	X					X	X			X	X
Parts Washing	X	X	X	X			X	X	X	X	X	X	X
Photo/X-ray Processing	X	X	X		X			X	X				X
Steam Generation	X		X	X									X
Vehicle Painting			X			X						X	X
Vehicle/ Equipment Washing	X	X				X(1)			X			X	X

(1) Pollutant was not measured but is expected to be present in elevated concentrations.

Section 5: GUIDELINES FOR SELECTING A WASTEWATER MANAGEMENT SYSTEM

5.1 Section Overview. Several alternative strategies exist for managing wastewater from out-of-compliance sources, including implementing pollution prevention actions, treating the wastewater, hauling the wastewater offsite, and seeking regulatory relief. This section presents guidelines for evaluating these alternative strategies and selecting the most favorable strategy to meet the desired objectives.

5.2 Wastewater Inventory. Initially, an inventory should be made of the processes performed within the facility of interest. Preparing a facility layout and a flow chart of the processes performed is usually helpful. Each process should be evaluated regarding its potential to produce wastewater. In addition, a list should be made of all process chemicals, such as solvents and cleaners, found in the facility. Where aqueous processes are employed, rinsewater is generally the largest source of wastewater and may be contaminated by process chemicals whether or not the chemicals are directly associated with a rinsing step.

5.3 Wastewater Characterization. Wastewater must be characterized to determine if it is meeting regulatory requirements (e.g., local pretreatment limits or categorical pretreatment standards). If the wastewater discharge is out of compliance, wastewater characterization data are needed to identify appropriate pollution-prevention opportunities, or to design a process capable of effectively treating the wastewater if pollution prevention actions are inadequate. The important characteristics include the volume of wastewater generated, the time pattern of generation, and the chemical composition of the wastewater for pollutants of concern.

5.3.1 Wastewater Volume. Wastewater flow rate is a primary determinant of disposal costs, whether the wastewater is hauled offsite or discharged to the collection system. The size of a wastewater treatment system, including tanks, pipes, pumps, and valves, also depends on the volume or flow of wastewater treated during any given period of time. For batch treatment systems, the volume of the batch and the time to collect the batch are important, whereas flow variations while collecting the batch are

not of concern. For continuous-flow treatment systems without flow equalization, flow variations must be established so that the system can handle peak, as well as minimum, flow rates.

Preliminary guidance on wastewater volumes and flow rates can be found in Section 4. However, design of a treatment system requires site-specific information. Wastewater volumes from existing sources can usually be satisfactorily measured by one of the following methods:

a) Measurement of time to fill a known volume (bucket, tank, or sump)

b) Installation of a weir, flume, or other flow metering device in a sewer or open channel and measurement of the associated water depth

c) Installation of a Venturi, electromagnetic, or sonic flow meter on pipes flowing full

d) Measurement of process water consumption with a conventional water meter

Measured volumes will be a function of the activity or production level and process procedures existing at the time of measurement. If the design must accommodate future increases in activity level or implementation of water conservation measures, these factors should be accounted for in establishing design flows and volumes.

5.3.2 Wastewater Composition. Wastewater composition determines the pollution-prevention method or type of treatment process that should be used. If treatment is necessary, a knowledge of wastewater composition also is used to design the process and determine the type and amount of waste by-product (sludge) produced. As with flow, preliminary guidance on wastewater composition for military nondomestic wastewater sources can be found in Section 4, but site-specific information should also be obtained through sampling and analysis.

Pollutants of concern typically include some of the heavy metals, cyanide, oil and grease, and the BTEX compounds (see Section 3). Additional parameters that generally warrant

measurement for design purposes include pH, BOD, TSS, and surfactants. Depending on concerns, other parameters of interest may include total dissolved solids and toxic organic compounds.

5.3.3 Sampling. A sufficient number of samples should be obtained and analyzed to establish the wastewater composition with reasonable certainty. The number will depend on the process variability, but should usually be no less than three samples. Prior to sampling, a sampling strategy should be prepared that addresses the following topics:

a) Sampling locations

b) Sampling personnel

c) Safety precautions

d) Number and type of samples

e) Sample dates

f) Sampling procedures

g) Sample transport procedures

h) Methods of analysis and detection limits

i) Quality assurance/quality control

j) Laboratory to perform the analyses

For additional background and details concerning sampling, analysis, and flow measurement, see the following references:

a) EPA 831/B-94-001, Industrial User Inspection and Sampling Manual for POTWs.

b) Pretreatment Facility Inspection. Kenneth D. Kerry, 1991.

5.4 Discharge Limitations. Wastewater discharges must meet all applicable discharge limitations. The characteristics of the wastewater must be compared to the applicable limitations to determine compliance. Various applicable limitations are discussed in Section 2.

5.5 Wastewater Management Alternatives. A number of alternative strategies exist for managing wastewater. When a wastewater discharge is out of compliance, the potentially feasible management alternatives should be identified and evaluated, and the most favorable alternative selected for implementation.

5.5.1 Development of Wastewater Management Alternatives. In broad terms, the wastewater management alternatives for a given out-of-compliance discharge include the following:

a) Implement additional pollution prevention techniques to eliminate the discharge or render it acceptable for continuing discharge.

b) Negotiate more favorable compliance terms with the regulatory authority.

c) Install a treatment system and continue discharging.

d) Install a treatment system and recycle the treated effluent.

e) Contain the wastewater and have it hauled offsite for treatment and disposal. While the most appropriate alternative is sometimes obvious, a careful evaluation of each strategy is warranted. In some cases, more than one alternative may be acceptable. Professional engineering services may be warranted to determine the most cost-effective and appropriate action.

5.5.2 Evaluation of Wastewater Management Alternatives. Within each of the broad wastewater management alternatives identified in par. 5.5.1, various sub-alternatives may be available. For example, different options may exist for pollution prevention or treatment. These sub-alternatives should be identified and evaluated. More than one alternative may work, but each will have its own particular advantages and disadvantages. Even some pollution prevention alternatives may have unacceptable side effects. The evaluation should be based on selected key criteria, such as the following:

a) Effectiveness in consistently meeting discharge limitations

b) Flexibility in adapting to changing personnel and wastewater characteristics

c) Cost of installation, operation, and maintenance

d) Space requirements

e) Impacts on personnel

f) Disposal of new residues resulting from process changes or treatment

Where treatment processes are being seriously considered, sufficient information should be obtained about the treatment process to complete the evaluation. In some cases, bench tests should be conducted and possibly pilot-scale units should even be brought onsite for demonstration purposes.

In selecting the optimal alternative(s), costs should normally be weighted most heavily. In addition to capital (design, purchase, and installation) cost, annual operation and maintenance costs should be determined. These should include labor, power, chemical, training, monitoring, permitting, and offsite sludge disposal costs. Offsite disposal costs can be significant, especially if the sludge is classified as a hazardous waste. In considering costs, it should be recognized that cost estimates at the planning stage have inherent uncertainty such that alternatives having a cost differential within 10 percent of one another may generally be considered equal.

5.6 Selection of a Treatment System Alternative. For most military installation wastewater sources, the application of additional pollution prevention techniques will be the most favorable wastewater management strategy for discharges that are out of compliance. Treatment of a nondomestic wastewater at the source will seldom be cost effective or advantageous, but may be appropriate when pollution prevention techniques are unavailable or have been applied and are still insufficient to provide the

requisite degree of pollutant reduction. In addition, treatment may be appropriate under the following conditions:

a) Treatment and continued discharge is less expensive than containment and truck-hauling for offsite disposal.

b) Treatment and wastewater recycle is mandated by a local water shortage or is less expensive than either sewer discharge or offsite disposal.

5.7 Sources Potentially Subject to Treatment. In general, wastewater sources potentially subject to treatment include those having pollutant concentrations exceeding local POTW or FOTW pretreatment requirements, and those having high volumes which may be treated and recycled for economic or water conservation purposes.

Based on sample characterization data presented in Section 4, many activities at military installations will not require pretreatment. Each military installation should evaluate its individual waste streams to determine if pretreatment is needed.

Most nondomestic wastewater sources at military installations have insufficient flow to warrant treatment/recycle systems. Recycling of wastewater generally requires a higher degree of treatment and higher associated costs and maintenance requirements than does discharge to a wastewater system, so it will rarely be warranted unless water conservation is a major issue. Aircraft and central vehicle washing wastewaters are potential exceptions (see TM 5-814-9, Central Vehicle Wash Facilities).

5.8 Consultants and Vendors. Consulting engineers should be retained on larger projects where an independent evaluation of alternative processes or equipment is needed or where a customized design is required. Consulting services may include wastewater characterization, evaluations, design, permitting, surveying, and services during bidding and construction. Consulting engineers may be an architect/engineering firm (A/E) or a service agency engineering division.

Vendors are primarily equipment and chemical suppliers. Some supply individual products, such as pumps or valves, while others provide complete treatment systems through so-called prefabricated “package plants.” Additionally, some can provide complete services for design, installation, equipment startup, operator training, and even contract operations for their own systems. Purchased agreements with vendors should clearly specify the equipment and services to be provided. Services should include provisions for startup assistance, operator training, and provision of an operation and maintenance (O&M) manual. The vendor should also be required to provide a performance bond and a warranty (to begin at startup, not at the time of equipment purchase). Additional provisions may include service and maintenance agreements.

Equipment may be purchased through vendors listed with the U.S. Government Services Agency (GSA). While procurement through GSA may be less expensive, the process does not provide flexibility for modifying the equipment or services to be provided, and it excludes non-GSA vendors who could provide quality equipment and services at competitive prices. In addition, the installation of major pieces of equipment usually requires a general contractor; providing government-furnished equipment to a general contractor for installation results in more complex contract management issues than having the general contractor furnish and install the equipment under a single contract. The following is a general approach to working with vendors:

a) Before contacting a vendor, define the local wastewater problem, including wastewater flow rates and characteristics, pollutants of concern, and performance standards. In addition, define the scope of work, budget, and schedule.

b) Establish what the vendor will be expected to provide.

c) Identify more than one vendor who can provide the needed equipment and services.

d) Solicit written proposals from competing vendors for equipment and services to be provided and capital and O&M cost estimates.

e) If performance uncertainty exists, request that the vendor provide a reference list and contact the references for additional information. If uncertainty still exists, request that vendors test their equipment at the local site, or visit other similar sites where the vendor’s equipment is installed.

f) In development of the procurement package, specify that the vendors provide qualifications. When procurement methods allow, consider experience, qualifications, and reputation, as well as cost, in the selection of vendors.

Section 6: OIL AND GREASE REMOVAL

6.1 Section Overview. This section addresses military applications of OWSs. It provides general information on OWSs, as well as specific information on determining the need for an OWS, principles of oil/water separation, OWS design criteria, and selection of OWS technology. Emphasis is given to conventional and parallel-plate gravity OWSs, which are the prevailing types installed at military installations. Other technologies, such as flotation, filtration, and adsorption are also briefly discussed.

6.2 Oily Wastewater Origin and Classification. Oily wastewaters are generated in the industrial and maintenance areas of military installations from such activities as aircraft and vehicle maintenance and washing and other activities involving petroleum, oil and lubricants (POL). The oils present in wastewaters may be of several types, including gasoline, jet fuel, diesel fuel, and lubricants (e.g., grease). Regardless of type, they are typically classified into three major categories: free, emulsified, and dissolved. Oily wastes discharged at military installations may include any or all of these classifications.

6.2.1 Free Oil. Free oil consists of globules large enough to rise as a result of buoyant forces and form an oil layer on top of the water. Theoretically, oil globules as small as about 20 microns can be classified as free oil. However, research indicates that the size of oil globules must be approximately 150 microns or greater to be effectively removed in a conventional gravity-separation chamber.

6.2.2 Emulsified Oil. Emulsified oil exists as smaller droplets, approximately 1-20 microns, which form a stable dispersion in the water and are incapable of rising to form a separate oil layer without additional treatment. Emulsification of free oil may be chemically caused by the cleaning agents designed to increase solvency of oil in water, and commonly used in the washing of floors, vehicles, aircraft, and other equipment at military installations. Additionally, free oil can be mechanically emulsified through excessive agitation and turbulence, such as that caused by high velocities or pumping. Centrifugal pumps are especially prone to emulsify oil so, where

pumping to an OWS is required, a positive displacement pump (such as a diaphragm pump) is preferable.

6.2.3 Dissolved Oil. Dissolved oil is oil that is soluble in water. It is also incapable of removal by gravity separation. The solubility of oily substances in water increases with a decrease in molecular weight and with the presence of dispersants, such as synthetic detergents. Lubricants are highly insoluble, but certain fuel components, such as benzene and toluene, are soluble to the extent of several hundred milligrams per liter. Treatment of dissolved oil is generally not required and is rarely practiced at military installations.

6.3 Sampling and Measurement. The total oil and grease content of a wastewater may be determined by EPA Method 413.1 or 413.2. The former method measures only nonvolatile hydrocarbons, while the latter method measures most volatile hydrocarbons in addition to heavier compounds. These methods of measuring oil and grease do not differentiate free, emulsified, and dissolved oil. A method to provide this differentiation is described in American Petroleum Institute (API) Publication 421, Design and Operation of Oil and Water Separators. Also, the TPH content may be determined by EPA Method 418.

6.4 Regulatory Basis for Considering Oil Removal. Regulations that may require the use of OWSs are primarily associated with Public Law 100-4, Water Quality Act of 1987. Direct discharges of wastewater to surface waters of the United States must be permitted under the NPDES program. Applicable regulations are found in 40 CFR Section 402, NPDES Permit Regulations, and 40 CFR Section 122.26, Stormwater Permit Requirements. Discharge to wastewater collection systems is regulated under 40 CFR Section 403, General Pretreatment Regulations. Emergency spill control is regulated under 40 CFR 112.7, Spill Prevention Containment and Control Requirements. Further discussion of applicable regulations is covered in Section 2.

Specific provisions of the General Pretreatment Regulations applicable to oily waste discharges to wastewater collection systems are found in Section 403.5(b). These provisions prohibit discharge of the following:

a) Any pollutants which cause interference or pass through treatment works

b) Pollutants which create a fire or explosive hazard in the sewer system

c) Petroleum oil, nonbiodegradable cutting oil, or products of mineral oil origin, in amounts that will cause interference, pass through, or exceed effluent discharge limits (some sewer-use ordinances also contain specific numerical limits)

d) Pollutants that result in the presence of toxic gases, vapors, or fumes within the sewer system that may cause acute worker health and safety problems

In addition to these provisions, many POTW sewer-use ordinances prohibit oil and grease discharges that could accumulate in collection system piping and obstruct flow, or that could accumulate in the sludge of treatment works, resulting in hazardous substance disposal requirements. Local sewer use ordinances and discharge requirements should be obtained from the treatment facility serving the project prior to design.

6.5 Evaluating the Need for OWSs. Numerous OWSs exist at military installations, some of which are not needed or are not accomplishing their intended purpose. Misapplications and inadequate performance have resulted from poor design, improper selection of pre-manufactured units, failure to adequately understand the character of wastewaters being treated or pretreated, inadequate personnel training, and lack of proper maintenance. Consequently, the need for an OWS should be carefully evaluated before undertaking its design.

Figure 2 presents a decision diagram for determining whether an OWS is needed at a particular location. In using the decision diagram, the following source control issues should be considered:

a) Using detergents to clean up work areas increases emulsification and inhibits gravity oil/water separation. Use of high-pressure water also causes emulsification but is generally less detrimental to oil/water separation than the use of detergents (see par. 4.7.3.2).

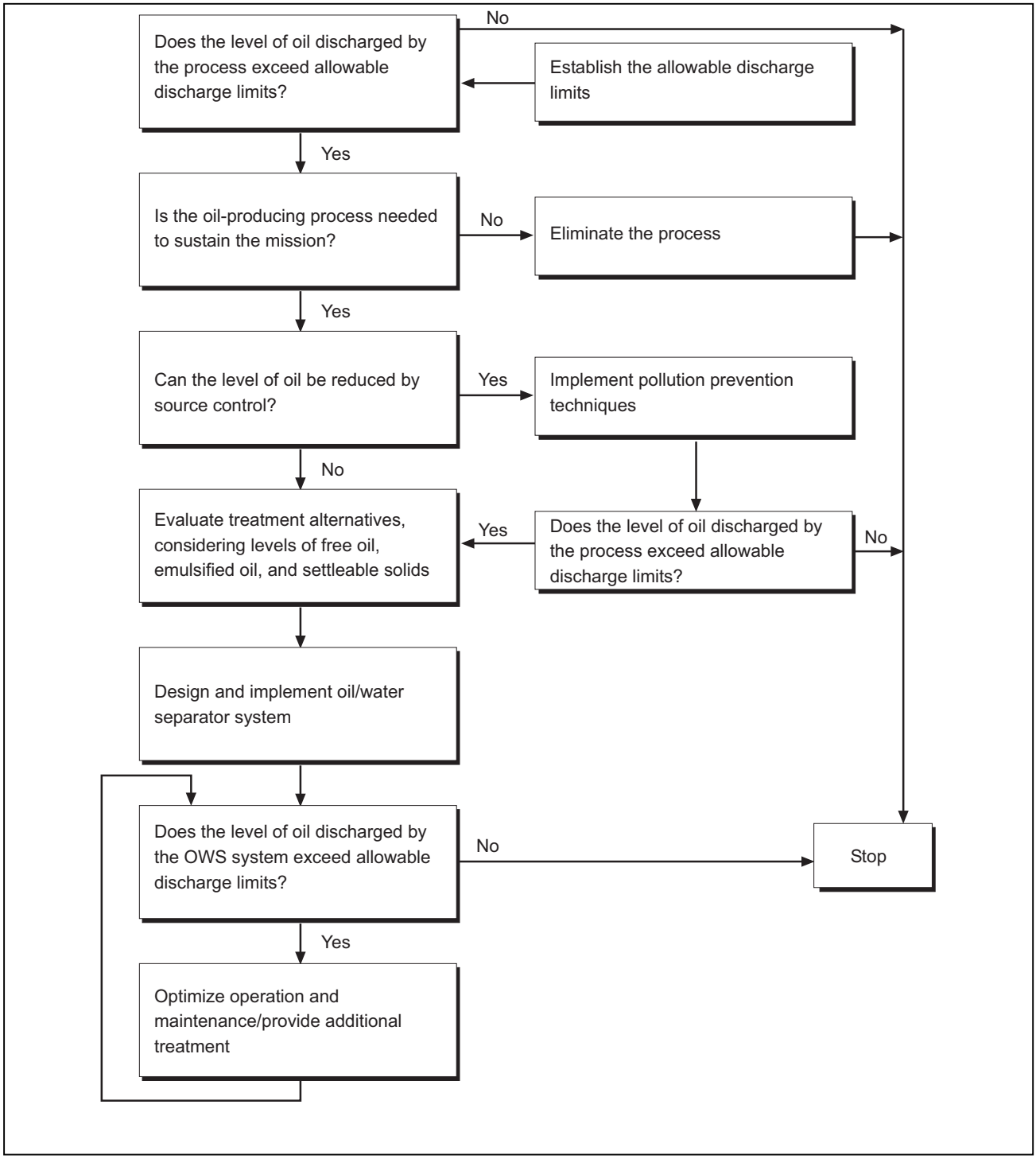


Figure 2
Decision Tree for Oil/Water Separators

b) Use of dry absorbents should be considered to minimize the amount of oils reaching sewers. Dry absorbents may be collected and disposed of with solid waste materials. If possible, wet processes should be replaced with dry processes, and floor drains should be plugged and hose bibs removed. Floor drains and interior hose bibs (used for floor washing) should not be used in new buildings whenever possible.

c) Implementation of point source controls may eliminate or reduce the wastewater volume and contaminant concentrations. For example, used oils may be segregated for disposal or reuse rather than allowing them to enter the wastewater stream. Implementing point source controls may also be more economical than providing a wastewater treatment system. Point source control techniques include process change or modification, material recovery, material substitution, wastewater segregation, and water reuse/recycling (see par. 4.3.3 for additional details).

d) Changing the point of discharge to negotiate less stringent requirements and to protect sensitive environmental areas should be considered. For example, it may be practical to reroute a stormwater-permitted outfall to a wastewater collection system when the stormwater flows are low and the permitted stormwater discharge limits are overly restrictive. However, extraneous stormwater should be excluded from wastewater collection systems.

e) The stormwater pollution prevention plan should implement best management practices, which may minimize or eliminate the need for OWSs in some instances. Stormwater should be eliminated from process water whenever possible.

f) The formation of oil emulsions should be minimized and emulsions should be segregated for special treatment whenever possible. Emulsions are usually complex, and bench or pilot plant testing is generally necessary to determine an effective method for emulsion breaking (see par. 6.6.4).

g) Current process operating practices should be investigated to determine if good housekeeping practices are employed and if changes can be made to reduce waste materials or use of excess water. In many cases, proper attention to operations control can greatly reduce the amount of soluble oil requiring treatment. Minimizing leaks, avoiding spills, using drip trays and pans, employing spill containment techniques, and

discarding oil only when it is no longer serviceable should be a part of any oily waste control program.

h) OWSs are intended for removal of a small volume of oil from an aqueous waste stream, and should not be designed or used for spill containment.

6.6 Treatment Technology. Selection of the appropriate treatment process for oily waste is dependent on the required level of treatment, flow volume, and oil classification. Under proper quiescent conditions, free oil can be removed by gravity separation. Emulsified oil cannot be removed by gravity separation unless it can first be converted to free oil by breaking the emulsion. Emulsified oil may be removed by air flotation, although the emulsion may also have to first be broken for this process to be effective. Removal of soluble (dissolved) oil generally requires biological treatment or adsorption onto a solid-phase sorbent such as activated carbon. All oil separation technologies may require flow equalization and grit removal pretreatment to maximize their effectiveness (see par. 6.7.3 and 6.7.4).

It should be noted that some pollutants, such as solvents, phenols, dissolved metals, and other toxic and hazardous pollutants, are not effectively removed by oil/water separation technology and may require additional source control or pretreatment. Nevertheless, some of these toxic materials may be removed and render the OWS sludge hazardous.

Principal removal technologies are discussed in the following paragraphs. Additional information may be found in New Technology for Oil/Water Emulsion Treatment: Phases I and II (Air Force Research Laboratory, AFRL/MLQE, April 1998).

6.6.1 Gravity Separation. Two basic types of gravity OWSs are in common use: conventional, rectangular-channel units, commonly called API separators because they are usually based upon design standards developed by the API; and parallel-plate separators. In either case, removal is a function of residence time, specific gravity of the oil, oil droplet size, fluid salinity, and fluid temperature.

Well designed and operated API gravity separators are capable of removing free oil and achieving effluent levels of free oil of 100 mg/L or less. Parallel plate separators are more efficient and capable of somewhat better removal of free oil. In

some cases, retrofitting an existing API gravity separator with parallel plates to enhance removal may be feasible. Manufacturer claims of removals below 15 mg/L should not be accepted without onsite demonstration.

While gravity separators are designed to remove oil, they also function as a sedimentation unit. As a result, solid particles will have a tendency to settle out and provisions must be included to remove accumulated solids. Knowledge of the solids content of the influent wastewater stream is particularly important in the selection of parallel-plate separators because they are prone to increased maintenance and clogging problems. A separate grit-removal chamber should be provided for wastewaters with a known or suspected high suspended solids content.

6.6.1.1 Conventional Gravity Separators. A typical conventional separator system is shown in Figure 3. The separator itself has three chambers separated by baffles: an influent chamber, the main separator chamber, and an effluent chamber. The operation of these chambers is described below:

a) Influent Chamber. The influent chamber removes free oil that has already separated from the oil/water mixture during conveyance to the unit. Two baffles separate the influent chamber from the larger, main settling chamber. The upper baffle is placed at the top of the water level and extends three quarters of the way to the bottom. It prevents the floating oil and scum from entering the main chamber, and allows it to be skimmed off through an overflow pipe. The lower baffle extends from the bottom and directs the wastewater to the top of the main chamber and to prevent short-circuiting.

b) Main Separator Chamber. In the main separator chamber, the oily wastewater flows from one end to the other under quiescent conditions. The wastewater velocity is kept very low, typically less than 3 feet per minute (0.9 m/min) to prevent turbulent mixing. For flat-bottom chambers, removal of settled solids is typically accomplished by taking the chamber out of service; the chamber is drained and accumulated solids are removed either manually or by a vacuum truck. If the floor is sloped, the solids can be removed from the hopper or V-bottom trough by pumping or gravity discharge while the unit is still in service.

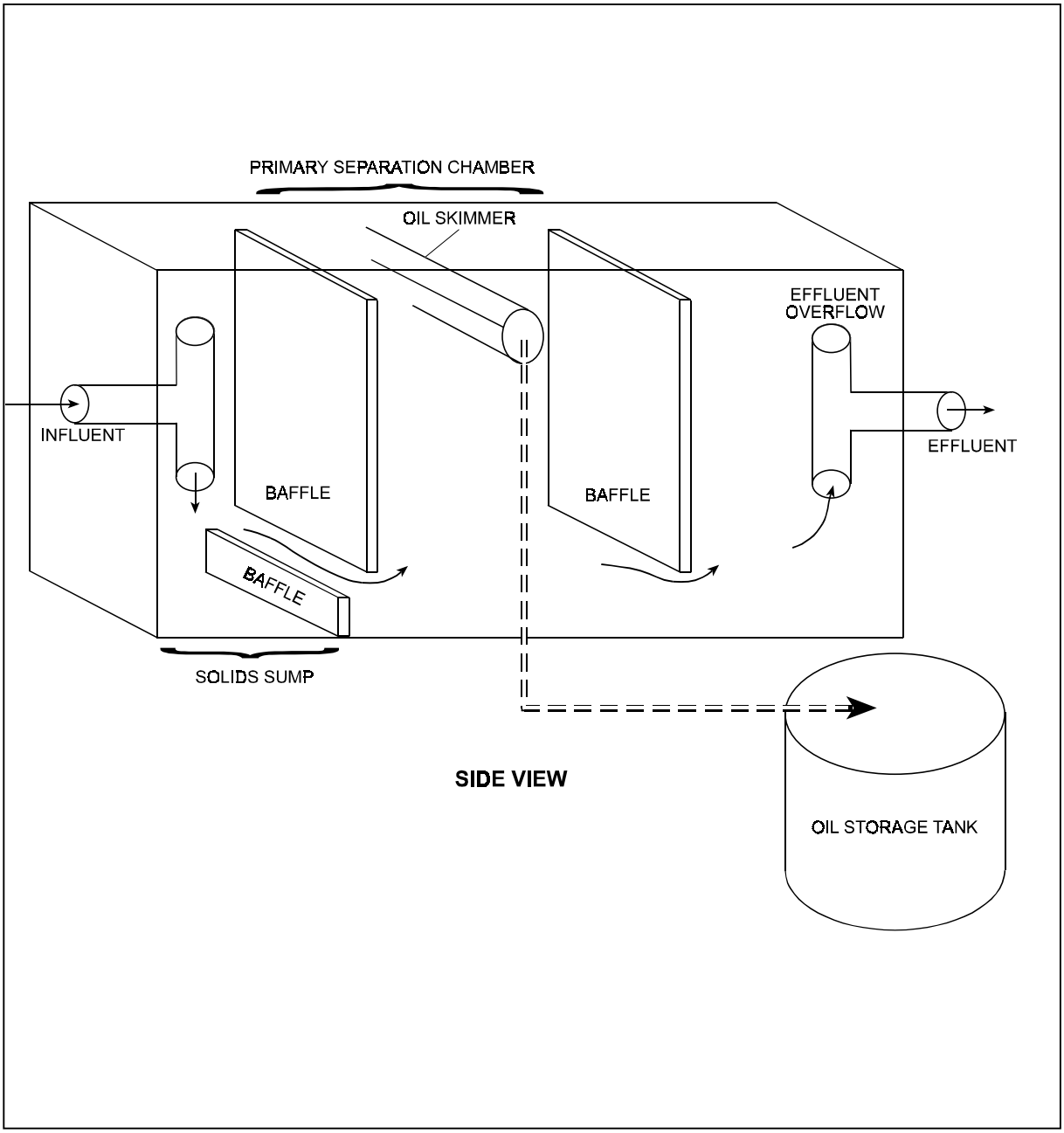


Figure 3
Conventional Gravity Separator

Conventional gravity separators can also be equipped with a chain-drive mechanism to move settled solids to a collection hopper. Attached between a pair of chains are crosspieces, or “flights," extending the full width of the tank or bay and spaced at specific intervals. The use of these chain and flight mechanisms is discouraged because of maintenance considerations. If used, flights should be of fiberglass construction with polyurethane wear shoes to protect edges from abrasion damage. The drag chain should be specified as a high strength nylon resin.

An oil-skimming device should be provided at the end of the separation chamber. The rotatable, slotted-pipe skimmer is the most common type. Other oil-skimming devices include belt skimmers and floating skimmers. The oil collected by the skimmer is discharged to a used oil holding tank (see Section 6.6.4).

c) Effluent Chamber. The effluent chamber is also separated from the main chamber by upper and lower baffles. Wastewater flows under and over the baffles into the effluent chamber. From the effluent chamber, the treated water can be discharged to the sewer system or to additional treatment if necessary.

6.6.1.2 Parallel-Plate Separators. A typical parallel-plate separator system is shown in Figure 4. Parallel-plate separators function on the same principles as conventional gravity separators, but they require less space. Incorporating an array of closely spaced parallel plates within the separator chamber increases the surface settling area, allowing the overall size of the unit to be reduced. Flow through a parallel-plate unit can be two to three times that of an equivalently sized conventional separator. The oil is removed by passing the wastewater at laminar velocity through the pack of closely spaced plates, which are constructed at various inclines ranging from 45 to 60 degrees. The oil droplets rise vertically until they contact the underside of the plates, where the oil coalesces and continues to gradually move upward along the underside of the inclined plates. Eventually, the floating oil is collected at the surface of the tank. The plates aid in separation in the following ways:

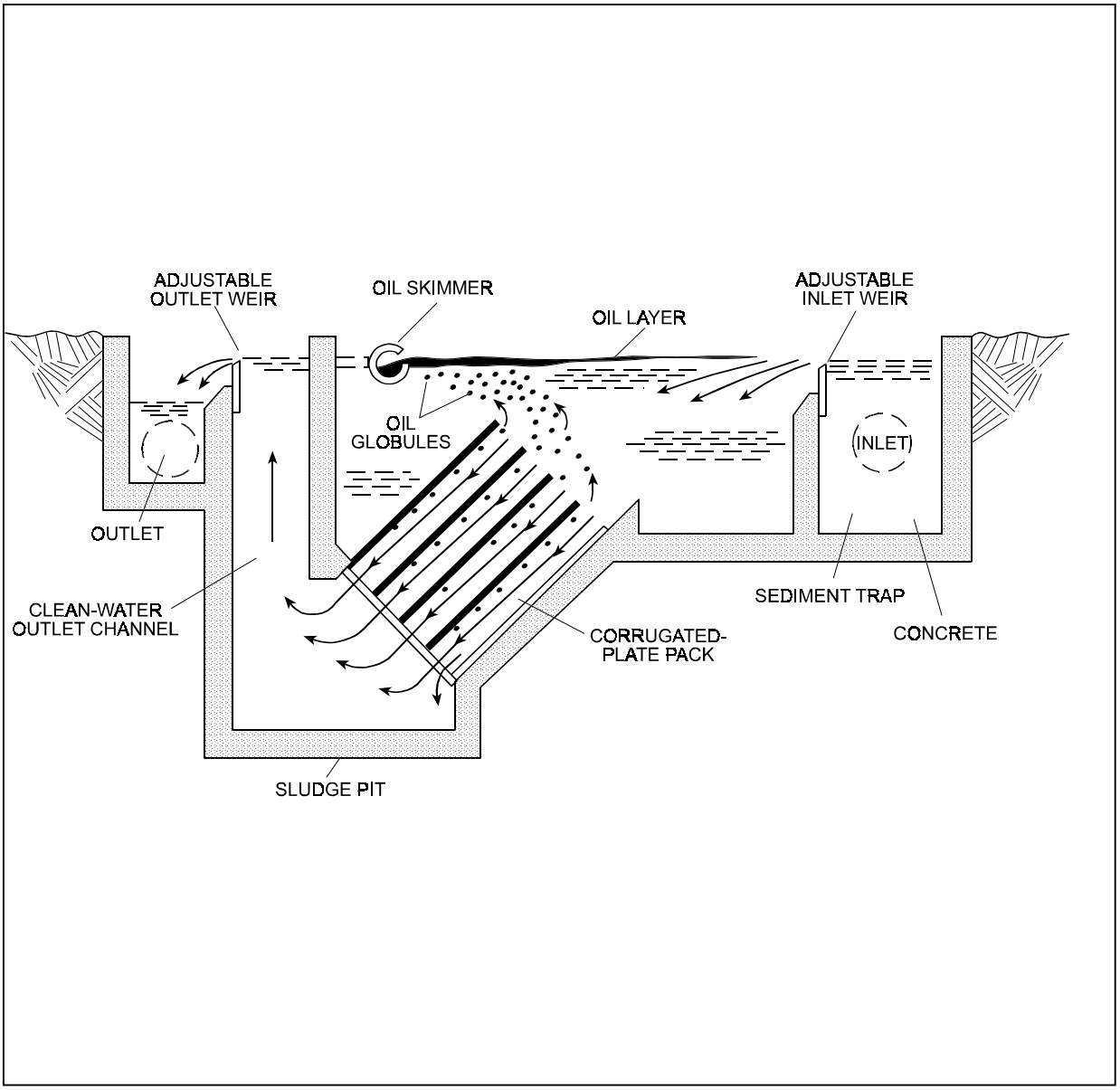


Figure 4
Downflow Parallel-Plate Separator

a) Preventing short-circuiting of the oily waste

b) Increasing the effective settling area

c) Enhancing contact/agglomeration of oil particles

The plates may be made of an oleophilic (oil-attracting) material, such as polyethylene, fiberglass, or nylon to promote coalescence of oil droplets. For this reason, the units are sometimes referred to as coalescing plate separators. Parallel or coalescing plate separators are usually recommended only for light oil loadings when a higher level of oil removal is required, when the wastewater stream contains minimal solids concentrations, and when the facility is committed to the additional maintenance procedures required to keep the coalescing pack free of debris. The plates may also be constructed in a corrugated configuration with alternate troughs and ridges, such as in the Corrugated Plate Interceptor (CPI). It should be noted that polypropylene is not recommended for use in coalescing plates because it has been found to have excessively strong oleophilic properties that prevent oil droplets from detaching and floating to the surface.

In parallel-plate separators, solids settle to the bottom and are collected in a sludge well. From the well, sludge is pumped or withdrawn by gravity. If sludge transfer is by gravity displacement, an automatic valve is usually provided.

6.6.2 Oil Collection. A tank should be provided for collection of used oil collected by the skimmer. The tank should be designed as an integral part of the OWS system or it could be subject to storage tank regulations under RCRA. The tank should also be designed so that confined space entry is not required for O&M.

6.6.3 Air-Flotation Separators. In the air flotation process, separation of both oil and solid particles is brought about by introducing fine air bubbles into the liquid waste stream. The bubbles attach to the particulate matter and oil droplets, and the buoyant force of the air bubbles causes both particles and small oil droplets to rise to the surface. The oil/solids/air bubble mixture forms a froth layer at the surface, which is skimmed away.

A typical air-flotation system is shown in Figure 5. The removal efficiency of air flotation separators for free oil is similar to that of gravity separators. However, air flotation units can also remove dispersed oil droplets in the 40 to 150 micron size range. The addition of coagulants, such as salts of iron and aluminum with or without organic polyelectrolytes, may further enhance the effectiveness of the air flotation process in removing emulsified oil.

Despite their greater effectiveness in removing emulsified oil, the use of air flotation systems at military installations is discouraged because of high maintenance requirements. If emulsified oil is a problem, alternative means of reducing emulsified oil, such as reducing or eliminating detergent use, should first be explored. Air flotation units should never be used to treat AFFF wastewater because they will produce adverse foaming conditions. If the use of an air flotation system is considered necessary, design criteria may be found in EPA 625/1-79-001, Process Design Manual for Sludge Treatment and Disposal.

6.6.4 Emulsion Breaking Processes. Emulsion-breaking processes should only be employed when necessary to meet local discharge limits and when methods to reduce the formation of emulsified oil cannot be employed or are inadequate (see par. 4.7.3.2 and 6.2.2). Methods of breaking emulsions are described in the following sections.

6.6.4.1 Chemical Processes. Treatment of oil emulsions is usually directed toward destabilizing the dispersed oil droplets, causing them to coalesce and form free oil. The process typically consists of rapidly mixing coagulant chemicals with the wastewater, followed by gentle mixing (flocculation). The agglomerated oil droplets may then be removed by gravity or flotation.

Alternative chemical emulsion breaking processes include the addition of acid (acid cracking), iron or aluminum salts (coagulation), or chemical emulsion breakers. In acid cracking, the pH is reduced to approximately 3 to 4, so the wastewater must be neutralized after oil/water separation. The use of iron or aluminum salts with or without polyelectrolytes may be less costly, but produces additional solids from the chemical precipitates. Proprietary chemical emulsion breakers

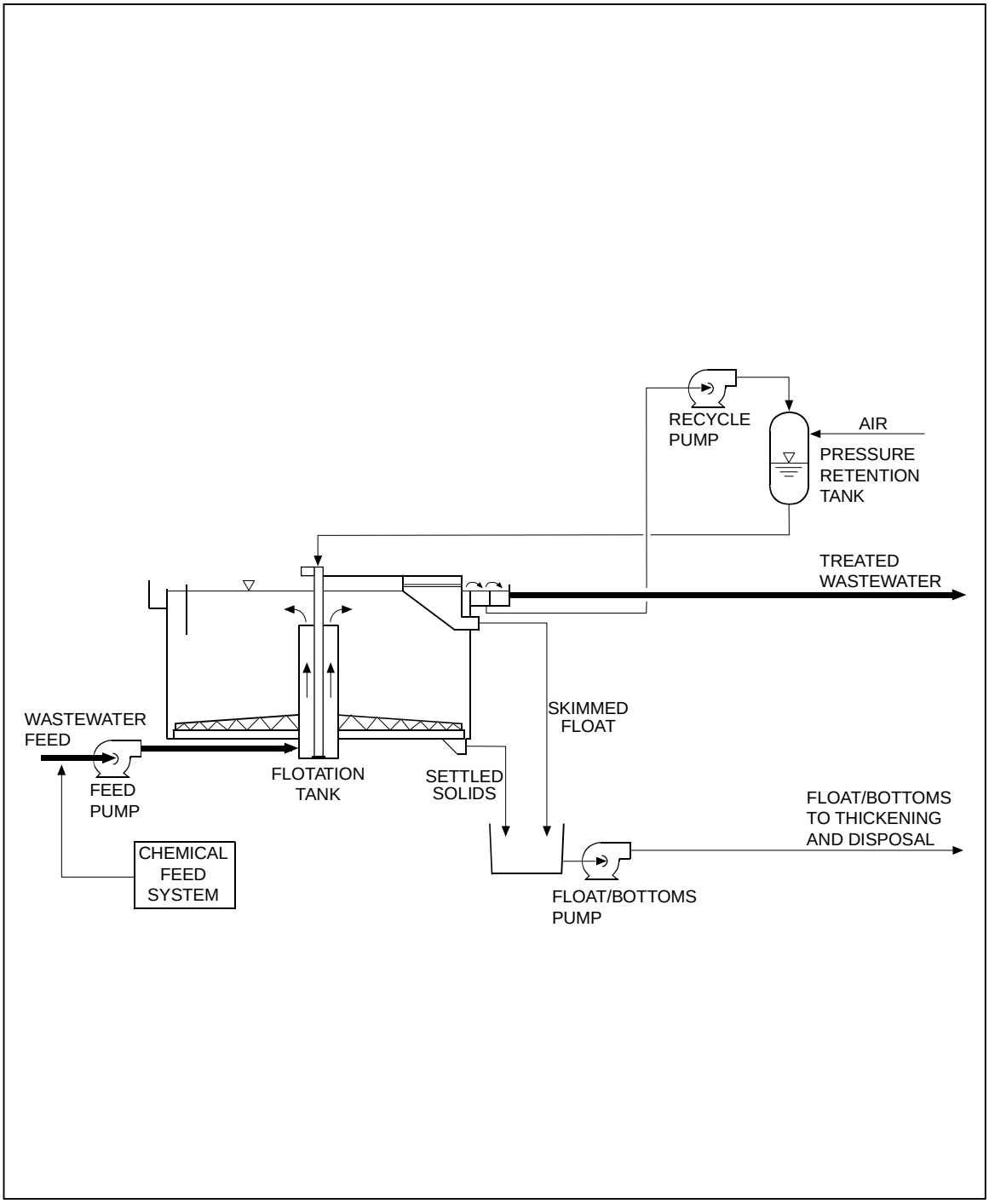


Figure 5
Dissolved Air Flotation

are very effective, but they are more costly than iron or aluminum salts. A number of proprietary emulsion breakers are available through specialty chemical suppliers. Different products should be evaluated through bench-scale tests to determine which are most effective for a particular application. Some factory-manufactured OWSs are designed with emulsion breaking chambers where chemicals are added and mixed. Otherwise, emulsion breakers should generally be added to the wastewater as far upstream of the OWS as practical. Chemical emulsion treatment generally is most effective when the waste stream is fairly consistent. Waste streams that have inconsistent or intermittent flow rates and varying contaminant levels may present operational challenges for chemical treatment. Further guidance in the treatment of emulsions is given in API Publication 421.

6.6.4.2 Mechanical Impingement and Filtration Processes. Other methods for removing emulsified oil include mechanical impingement devices and filtration, both of which induce coalescence of dispersed oil droplets. Representative of mechanical impingement devices are the coalescing filters and the cartridge-type emulsion breakers that are used as the final step in oily water separation systems (following solids filtration or sedimentation and free oil removal). Cartridge units typically contain a medium having numerous small (25 microns), irregular, continuous passages through which the wastewater flows. The emulsion is broken by impingement of the oil droplets on the surface of the medium. The cartridge can be backwashed and/or replaced. Mechanical impingement separators have generally been unsatisfactory in the military environment and are recommended only in special circumstances. Such circumstances may include light oil loadings when a higher level of oil removal is required, when the wastewater stream contains minimal solids concentrations, and when the facility is committed to the additional maintenance procedures required to keep the unit free of debris.

Pressure filters may also be used to remove dilute concentrations of mechanically emulsified oil, usually as a polishing step downstream of gravity or flotation units. Activated carbon, other proprietary solid phase sorbents, or bentonite clay/anthracite are typically used as the media. Application of filters at military installations strictly for oil

removal is expected to be extremely rare, so the design of these units is not covered herein. Design of filters for suspended solids removal is covered in Section 8.

6.6.4.3 Centrifugal Processes. Centrifugal removal of emulsified oil using a hydrocyclone or air-sparged hydrocyclone (ASH) is relatively new and unproven at military installations but has shown promise. Hydrocyclones are simple conical-shaped devices with no moving parts. Wastewater is pumped and introduced tangentially at the top of the cone, inducing fluid rotation and associated centrifugal force within the unit. Water and solids are driven to the hydrocyclone wall and discharged at the bottom, while oil migrates to the center of the hydrocyclone, spirals upward, and exits through an overflow pipe at the top. ASH units operate in a similar manner, but air bubbles are forced into the water stream, which promote collisions of dispersed oil droplets and enhanced oil removal. Hydrocyclones systems potentially offer cost and performance advantages over other separation systems, but should be carefully evaluated because of the lack of documented experience at military installations. Additional information may be found in the technical report "Removal of Oil and AFFF from Wastewater by Air-Sparged Hydrocyclone Technology" (Yi, Y., 1996).

6.6.5 Treatment of Dissolved Oil. Treatment of dissolved oil is also not normally practiced at military installations. Dissolved oil that might be present would be expected to be removed by the biological treatment processes employed by the FOTW or POTW to which the wastewater is discharged. Where pretreatment of dissolved oil at an upstream location is required, adsorption would be the probable method of choice.

6.6.6 Emerging Technologies. Several newer technologies for enhanced oil/water separation are commercially available but as yet are unproven in military applications. Examples include membrane separation, organoclay filtration, and various proprietary biological treatment systems. Use of these technologies should rarely be necessary and should only be considered on a case-by-case basis when specific local circumstances warrant a higher degree of oil removal. Additional information on several of these emerging technologies may be found in the report the AFRL/MLQE April 1998 publication.

6.7 Design of OWS Systems. Design of conventional and parallel-plate OWS systems requires proper characterization of the wastewater, establishment of the design flow and required effluent quality, sizing of the separator, and proper flow attenuation/flow equalization of the influent. Sludge disposal and used oil disposal also needs to be properly considered. The designer should work to identify the user's needs and the capability of any vendor-supplied equipment. These aspects of system design are discussed generally in Section 5 and more specifically in the following paragraphs.

6.7.1 Wastewater Characterization. If possible, the wastewater to be treated should be analyzed for total oil and grease, including determination of the free, emulsified, and dissolved oil fractions as described in par. 6.2. As indicated previously, although OWSs are designed to remove free oil, they also remove solids. Therefore, the solids content of the wastewater is important in overall system design. Analyses should include TSS, volatile suspended solids (VSS), and settleable solids. These analyses will help determine the amount and frequency of settled materials that will need to be removed from the bottom of the OWS and the advisability of providing grit removal upstream of the OWS.

Other wastewater characteristics important in the design of OWSs are the specific gravities of the oil and water phases and the absolute viscosity of the wastewater, both at the minimum design temperature. Wastewater temperature and pH have a major impact on the efficiency of the separator, with poorer separation occurring at lower temperatures and high pH values. Separators are not designed to remove pollutants such as phenols, solvents, and heavy metals. These pollutants should be addressed by the use of pollution-prevention techniques.

If the wastewater characteristics cannot be determined through testing, the facility should refer to the general wastewater characteristics for similar facilities as provided in Section 4.

6.7.2 Site Considerations. The OWS should be designed to be readily accessible for maintenance and inspection, including access for a vacuum truck or other oil- and grit-removal equipment. Visual inspection and the ability to probe for solids

levels are critical to good operation. Aboveground units are the easiest to access for maintenance and inspection; however, they may require pumping of the wastewater, which may cause emulsification of oils.

Belowgrade systems have the advantage of providing greater temperature consistency, especially in cold temperature climates. However, belowgrade separators with only manhole access are difficult to maintain and should be avoided. When belowgrade installations are necessary, they should preferably be located within an accessible vault for ease of operation and maintenance. If buried, units should have ample access points or open tops for inspection and cleaning, and should be installed with a double liner and leak-detection system. OWSs are generally exempt wastewater treatment units under 40 CFR 260.10; however, no hazardous waste should be processed through an OWS.

6.7.3 Establishing the Design Flow. The efficiency of separation also decreases when flow exceeds the design capacity of the separator. Therefore, the design flow should be based on the maximum flow rate to be treated, including the addition of any future oily wastewaters and stormwater runoff. In determining peak flow rates, variations between shifts and daily and seasonal variations should be considered. Flow rates should be measured where the wastewater generating process already exists, or accurately estimated where it does not.

In some cases, establishing production-based wastewater generation rates may be useful for projecting future flows. For example, the maximum flow expected from an aircraft washing facility may be estimated from the expected washwater per aircraft multiplied by the maximum number of aircraft to be washed in a given period. If unit wastewater generation rates from another facility are used, differing conditions should be accounted for, such as differences in the type and size of aircraft and washing procedures.

Where high flows of short duration are to be handled, alternatives to constructing a larger separator include: a) providing flow equalization at an upstream grit basin; b) providing flow equalization within the OWS itself by operating the unit in batch treatment mode (emptying after each batch); and c) providing curbing and covering of outdoor washracks to exclude

stormwater. Some installations have installed a manually controlled valve on washrack drains to allow stormwater to be diverted to a storm drain during rainfall periods, but such valves are discouraged because they are prone to be left open and allow washwater to be discharged.

6.7.4 Pretreatment for Grit Removal. A separate basin to remove grit should be provided upstream of the OWS for wastewaters with a high suspended solids concentration. The design should be based on gravity separation of grit with a minimum detention time of 5 minutes at the maximum rate of flow. Larger basins may be used if the grit removal basin is also designed as a flow equalization basin. In either case, access should be provided for a truck with suction equipment to periodically remove grit. In large systems, the use of a ramp at one end of the basin may be considered if the material to be removed is primarily sand and readily dewaterable. Mechanical grit removal equipment should not be provided because it requires extensive maintenance.

6.7.5 Design Criteria for Conventional Separators. Key parameters that should be considered in the design of conventional OWSs include flow rate, minimum wastewater temperature, oil-fraction specific gravity, oil concentration, relative fractions of free and emulsified oils, quantity of solids to be removed, and effluent oil concentration limits to be met. Design criteria should conform to the following:

a) Separator water depth should not be less than 3 feet.

b) Maximum Horizontal Velocity: 3 feet per minute or 15 times the rise rate of soil droplets, whichever is less.

c) Width of Separator: 6 to 20 feet.

d) Length-to-width Ratio: 3:1 to 5:1.

e) Depth-to-width Ratio: 0.3:1 to 0.5:1.

f) Where continuous service is required, a backup channel or unit should be provided.

For a step-by-step design procedure, refer to API Publication 421. Design criteria may also be found in ETL 1110-3-466, Selection and Design of Oil/Water Separators at Army facilities, and MIL-HDBK-1005/9.

6.7.6 Design Criteria for Parallel-Plate Separators. Parallel-plate OWSs are furnished as pre-engineered, factory-assembled units. As such, designs vary by manufacturer, and vendor experience must be used in unit sizing and selection. In general, however, the parameters and procedures used for the design of parallel-plate separators are the same as for conventional separators (see API Publication 421).

The perpendicular distance between plates should range from 0.75 to 1.5 inches (2 to 4 cm), and the angle of plate inclination from the horizontal should typically range between 45 and 60 degrees. Wider plate spacing and steeper plate inclination generally reduces maintenance and improves performance but adds to cost. Manufacturers’ claims of settling area should be checked because some manufacturers incorrectly count both sides of the plates when calculating the effective surface area for their products. Settling area and detention time are key variables that may be used to compare competing equipment.

Accessible placement of the OWS is particularly important for parallel-plate separators, which may require frequent cleaning. Removal for cleaning with high-pressure cleaning equipment is the procedure of choice. If cleaning in place is used, a hose connection and proper provisions to minimize worker health and safety risks should be provided. If high solids concentrations are present, installation of a grit-removal basin upstream of the OWS is highly recommended.

6.8 Sludge Removal and Disposal. Reliable sludge removal from the separation chamber is a frequent problem with both commercially available units and custom-designed separators. Currently, the most satisfactory method involves suction removal by installation personnel using equipment normally used for cleaning catch basins. This equipment is commonly referred to as a “vacuum" or "vac-all” truck.

Oily sludges removed from the OWS system may be disposed of by incineration, sale by the Defense Reutilization and Marketing Office (DRMO), waste hauler, landfill, and land disposal. Final disposal options should be evaluated concurrently with oil/water separation methods and environmental requirements to establish the most cost-effective total system. The material must be characterized prior to reuse or disposal. The sludge may require regulation as a hazardous waste if levels of pollutants exceed RCRA or state hazardous waste standards. Further, a leaking OWS containing a hazardous waste can result in designation as a solid waste management unit (SWMU) and be subject to corrective actions under RCRA regulations (40 CFR Subpart F).

6.9 Grease Separators. Grease separators, also called grease interceptors or grease traps, are a special class of OWS used where grease waste is produced in quantities that could otherwise cause line stoppage or hinder wastewater transmission, such as restaurants (see par. 4.21.1). The design of grease interceptors is generally specified in state or local regulations, plumbing codes, or sewer-use ordinances. Typically, they are rectangular basins of precast concrete construction with baffled inlet and outlet pipes, similar to a septic tank. Sizes normally range from 750 to 2,000 gallons, with multiple units used in a series when additional volume is required.

Grease separators must be maintained by regular removal of accumulated waste or they will either plug or allow pass-through of grease to the wastewater system. Solvents are not to be used as a method of grease control. Consequently, grease separators must be installed to provide ready accessibility to the cover and ease of maintenance. A maintenance schedule should be established and enforced for all grease traps located within military installations.

6.10 Guidance Documents. The following documents provide additional guidance in designing or selecting OWSs. Also refer to the References Section in this handbook.

a) ETL 1110-3-466. Selection and Design of OWS at Army Facilities. This ETL is a comprehensive design guidance document for OWS.

b) API Publication 421, February 1990.

c) HQ USAF/CE Memorandum. Oil/Water Separators: Operation, Maintenance and Construction. This memo includes the Environmental Compliance Policy for OWS O&M and Construction.

d) HQ AFCEE Pro-Act Fact Sheet. Oil/Water Separators. (Web Address: http//www.afcee.brooks.af.mil/pro_act//pro_actform.htm).

e) AFRL/MLQE, April 1998.

f) MIL-HDBK-1005/9.

g) MIL-HDBK-1005/16.

h) MIL-HDBK-1138. Wastewater Treatment System Operations and Maintenance Augmenting Handbook.

Section 7: HEAVY METALS REMOVAL

7.1 Section Overview. Metals are added to water through many of the activities carried out at military installations. The resultant aqueous concentrations are relatively dilute and will usually comply with POTW local limits. However, in some cases, a pretreatment system for metals removal may be required. Photo/X-ray processing wastewater, which contains high concentrations of silver and frequently warrants silver recovery for pretreatment or economic purposes, is a special case that was addressed in Section 4. This section presents information on the proper application and design of removal technologies for relatively dilute concentrations of heavy metals.

7.2 Types and Sources of Heavy Metals

7.2.1 Metals of Concern. Guidance for determining pollutants of concern was presented previously in par. 3.3.2, which indicated that EPA's primary metals of concern are arsenic, cadmium, chromium, copper, lead, nickel, mercury, silver, and zinc. These and any other metals which are present in elevated concentrations and which have a local discharge standard may be considered a metal of concern.

7.2.2 Sources of Metals. Based on the wastewater characteristics presented in Section 4, wastewater sources that may contain metals of concern in elevated concentrations include:

a) Aircraft Corrosion Control
b) Aircraft Washing
c) Battery Maintenance
d) Dental Clinic Operations
e) Engine Washing
f) Floor Washing
g) Fuel Storage
h) Fuel Storage Facilities
i) Hospital Operations
j) NDI Testing
k) Parts Washing
l) Photo/X-ray processing
m) Vehicle Painting (includes paint stripping)
n) Vehicle and Equipment Washing

If metals removal is required, these are the principal sources to be evaluated. In any decision to implement a metals-removal process, the total quantity of metal discharged, as well as the concentration discharged, should be considered. Metals-removal technologies may be applied to combined waste streams when necessary or convenient.

7.2.3 Metals Classification. Metals are present in wastewater in both particulate and dissolved forms. The metals concentrations given in Section 4 are total metals concentrations, which include both forms. To determine the concentration of a dissolved metal, it is necessary to filter the sample through a 0.45-micron filter prior to analysis. Analysis of dissolved metals is useful in the selection and design of metals-removal processes. For example, particulate metals may be removed by direct sedimentation and/or filtration, whereas dissolved metals require precipitation or ion exchange.

7.3 Evaluating the Need for Metals Removal. Metals removal treatment processes typically require a high level of maintenance and generate a metals-laden sludge that may require disposal as a hazardous waste. Therefore, metals removal processes should be considered only when a discharge is out of compliance or when it is necessary to implement wastewater recycling. Even then, alternative wastewater management systems should be evaluated, as discussed in Section 5.

7.4 Treatment Technology. Particulate metals can be removed from wastewater by conventional physical processes, such as sedimentation and filtration. Dissolved metals are most commonly removed by chemical precipitation followed by flocculation, sedimentation, and filtration. Dissolved metals may also be removed by ion exchange. Proper selection and design of these processes is discussed in the following paragraphs.

7.5 Chemical Precipitation, Flocculation, and Sedimentation. Chemical precipitation, flocculation, and sedimentation are three processes commonly linked together in wastewater treatment to effect removal of dissolved and particulate metals. These processes also remove nonmetallic suspended solids.

7.5.1 Process Description. The precipitation process most frequently employed involves adjustment of pH with either lime or caustic to achieve alkaline conditions and precipitation of the metals as an hydroxide or carbonate. Sulfide precipitation through the addition of sodium or hydrogen sulfide at pH 6 or higher is also employed. In either case, flocculation is carried out to promote agglomeration of colloidal precipitates through stirring or mixing and the use of coagulant aids such as polymers. Finally, sedimentation in a quiescent basin allows removal of the flocculated particles.

It should be noted that, for hexavalent chromium, the metal must be reduced to the trivalent form before hydroxide precipitation. The standard reduction treatment technique is to lower the waste stream pH to 2-3 with sulfuric acid, and then add a chemical reducing agent such as sulfur dioxide, sodium bisulfite, hydrosulfite, or ferrous sulfate.

While chemical precipitation followed by flocculation and sedimentation is a proven technology for metals removal, the process scheme requires a fairly high level of operator attention for chemical addition and sludge handling and disposal. Sludge generated must often be classified as a hazardous waste because of its metals concentration. Hazardous sludge would be included under RCRA regulations.

7.5.2 Jar Testing. Prior to design, jar tests are recommended to evaluate various chemical precipitants, polymers, pH values, chemical doses and settling rates, and solids production. The jar test is a small-scale batch precipitation procedure conducted in the field or in a laboratory. Details of the equipment and procedures for the test are readily available. In brief, the test consists of adding varying dosages of coagulant to a series of wastewater samples undergoing rapid agitation. Sequential periods of slow stirring and settling follow, after which residual turbidity or metals concentrations in the supernatant of each sample is measured and compared. The quantity of precipitate formed may also be measured. Jar tests may be conducted by an engineering consulting company or a chemical supplier.

7.5.3 Precipitation. A mixed precipitation tank should be provided to disperse the coagulant and promote the contact and

agglomeration of small colloidal precipitates into larger particles. This single tank replaces the separate rapid mix and flocculation tanks that are typically provided in a conventional water treatment system. The detention time in this tank should normally be about 15 minutes to allow for proper pH control. A turbine mixer should be used to provide the necessary mixing intensity, which should be between that provided in conventional rapid mix and flocculation basins. The addition of recirculated sludge from the sedimentation tank at a rate of 5 to 10 percent of the influent flow has been found helpful in promoting particle growth and good settleability.

7.5.4 Sedimentation. Sedimentation basins have two principal functions: the production of a clarified overflow, and the production of a concentrated underflow. Because of emphasis on the former function, sedimentation basins are commonly called clarifiers. Sedimentation is often carried out as a batch process in low-flow systems. For continuous flow systems, sedimentation tanks should be sized to provide a minimum two-hour detention time and should have sufficient surface area to yield an overflow rate of less than 1/3 gpm/sq ft or about 500 gpd/sq ft at the maximum flow rate. If the sedimentation basin is equipped with inclined plates, the maximum overflow rate should be limited to 1/3 gpm/sq ft of effective plate area. Because localized velocities at the outlet can diminish removal efficiency, the effluent should be discharged over a weir having sufficient length to limit the weir loading rate to less than 15,000 gpd/ft.

7.5.5 Package Systems. Several package systems designed for metals removal are available which provide chemical addition, flocculation, and sedimentation within a prefabricated skid-mounted package system. These systems are available for flow rates as low as 3 to 5 gpm. A schematic diagram of a typical system is provided in Figure 6. Vendors supplying flocculation/ clarification systems and the system descriptions are listed in Table 26. This listing does not constitute an endorsement of listed vendors; many other vendors supply the same type of equipment.

So-called “electrocoagulation” systems are also furnished as package units. In these systems, wastewater is passed between surfaces charged with a direct current. The

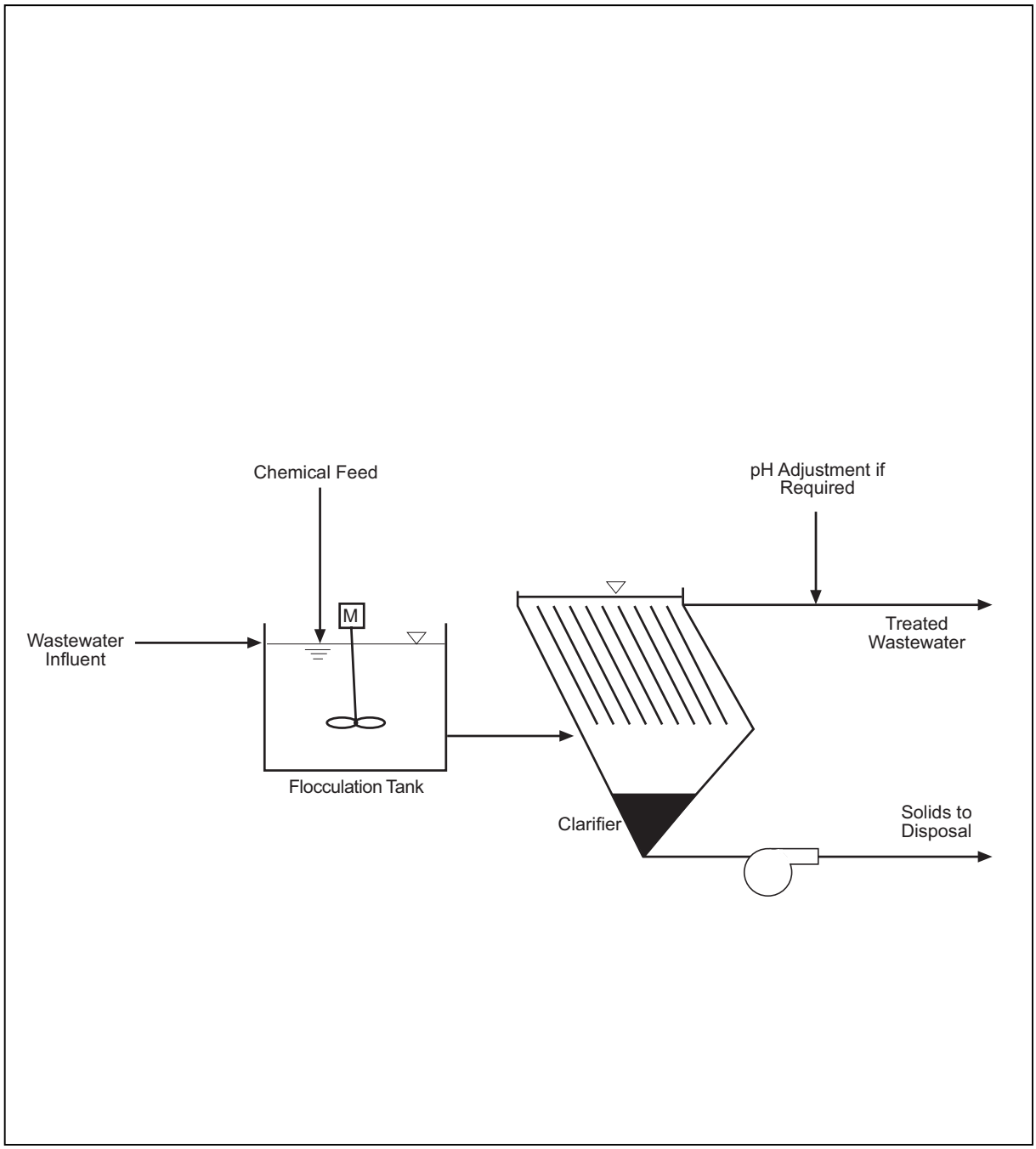


Figure 6
Chemical Precipitation, Flocculation, and Sedimentation Schematic

Table 26
Suppliers of Precipitation/Flocculation/Clarification Systems

Manufacturer	System Description
ETUS, Inc. 1511 Kastner Place Sanford, FL 32771 407-321-7910	CPU-MOD/T System: pH Adjustment, Precipitation/ Flocculation, Separation
Hydro-Flo Technologies, Inc. 205 E. Kehoe Blvd. Carol Stream, IL 630-462-7550	Inclined plate clarifier with integral chemical feed and flocculation system
Kaselco P.O. Box 667 Shiner, TX 77984 888-527-3526	Electrocoagulation package systems
Great Lakes Environmental, Inc. 315 S. Stewart Addison, IL 60101 630-543-9444	Inclined plate clarifier system
Unipure Environmental 1440 N. Harbor Blvd. Suite 125 Fullerton, CA 92635 800-323-8647	Reactor consists of a mix tank and floc tank followed by a Lamella clarifier.

Note: This vendor listing is not inclusive, and does not imply endorsement of these vendors.

electrochemical reactions release ions and result in the formation of metal precipitates. The wastewater then typically flows through a gently agitated tank to promote flocculation and release entrained gas bubbles formed by the electrochemical reactions. Standard sedimentation basins are used to remove the precipitates. The advantage of such systems is that they eliminate the need for chemical handling and feeding.

7.6 Filtration. In metals removal applications, filtration is generally employed downstream of the flocculation/ sedimentation system as a polishing step to remove residual suspended solids and thereby achieve a lower metals content in

the wastewater (less than 0.1 mg/L). Care should be exercised that the appropriate level of pre-application treatment is satisfactory to avoid plugging problems with suspended solids or oil and grease.

The need for filtration to meet metals pretreatment standards prior to discharge to a wastewater collection system should be rare. Normally, filtration would only be required for recycling applications where a high degree of wastewater clarity is required and metals removal may actually be a secondary consideration. In that situation, coagulants such as alum or ferric chloride may be used instead of lime or caustic, but the general processes would be the same.

7.6.1 Granular Media Filtration

7.6.1.1 Process Description. Granular media filters are comprised of a bed of porous material. Wastewater flows through the filter medium at a controlled rate either by gravity or under pressure. Solids accumulate on the surface of the medium or are retained within the bed. The filtration cycle is terminated when a pre-determined head loss is reached or the acceptable concentration of solids in the effluent is exceeded. The filter is then cleaned or backwashed to remove the accumulated solids by reversing the flow through the filter until the granular filter medium is fluidized. Disposal of the suspended solids laden backwash is a significant issue in selection and design of the filtration system. A disposal method needs to be selected prior to selection and installation of the filtration system.

7.6.1.2 Filter Media. The most widely used granular filter media is silica sand. Other media include crushed anthracite coal, diatomaceous earth, perlite, and granular-activated carbon. A dual media consisting of anthracite over sand is also common.

Granular filter media can be defined by effective size and uniformity coefficient. Effective size is the 10-percentile size by weight (i.e., 10-percent by weight of the filter material is finer by sieve analysis). Uniformity coefficient is the ratio of the 60-percentile size to the 10-percentile size. Common ranges in effective size and uniformity coefficient for sand are 0.016 to 0.022 inches (0.40 to 0.55 mm) and 1.3 to 1.7, respectively. The appropriate media size and depth should be

selected through the use of pilot plant studies or use of data from filtration facilities treating similar wastewaters.

7.6.1.3 Design Criteria. Granular media filters should normally be sized based on a filtration rate of 3 gpm/sq. ft. at the average flow rate. Brief excursions up to a loading of 6 gpm/sq. ft. are acceptable. Facilities for backwashing of the filter at a rate of 15 gpm/sq. ft. should be provided for sand media.

The minimum size of granular filters on the market have a surface area of approximately 7.5 sq. ft., which corresponds to a capacity of approximately 25 gpm. Therefore, granular media filters are generally not applicable below this flow rate. Rather, bag or cartridge filters may be considered for low-flow systems (see par. 7.6.2 and 7.6.3).

Filters may be of the gravity or pressure type. Pumping to a pressure filter may cause the floc to fracture and diminish performance. If pressure filters are used, they should be provided with ready and convenient access to the media for inspection or cleaning.

7.6.1.4 Package Systems. Small pressure filtration systems are provided as prefabricated skid-mounted package units. A schematic of a typical system is provided in Figure 7. Vendors supplying pressure filtration systems are listed in Table 27.

7.6.2 Bag Filtration

7.6.2.1 Process Description. Bag filtration involves gravity or pressure filtration through a cloth or fabric bag. Wastewater flows into the bag, filters through the bag media, and is collected in a reservoir surrounding the bag. The bags are removed and cleaned or replaced when they become plugged with solids. Solids buildup is monitored by pressure increase in the case of pressure filters, or flow rate decrease in the case of gravity filters.

The pore sizes of the bag fabric control the size of particles removed during filtration. Bag filters are available in various fabrics for removal of particles down to 5 microns. Gravity systems are supplied with a series of 4 to 8 bags within a reservoir. Pressure systems usually involve one bag within a pressure vessel.

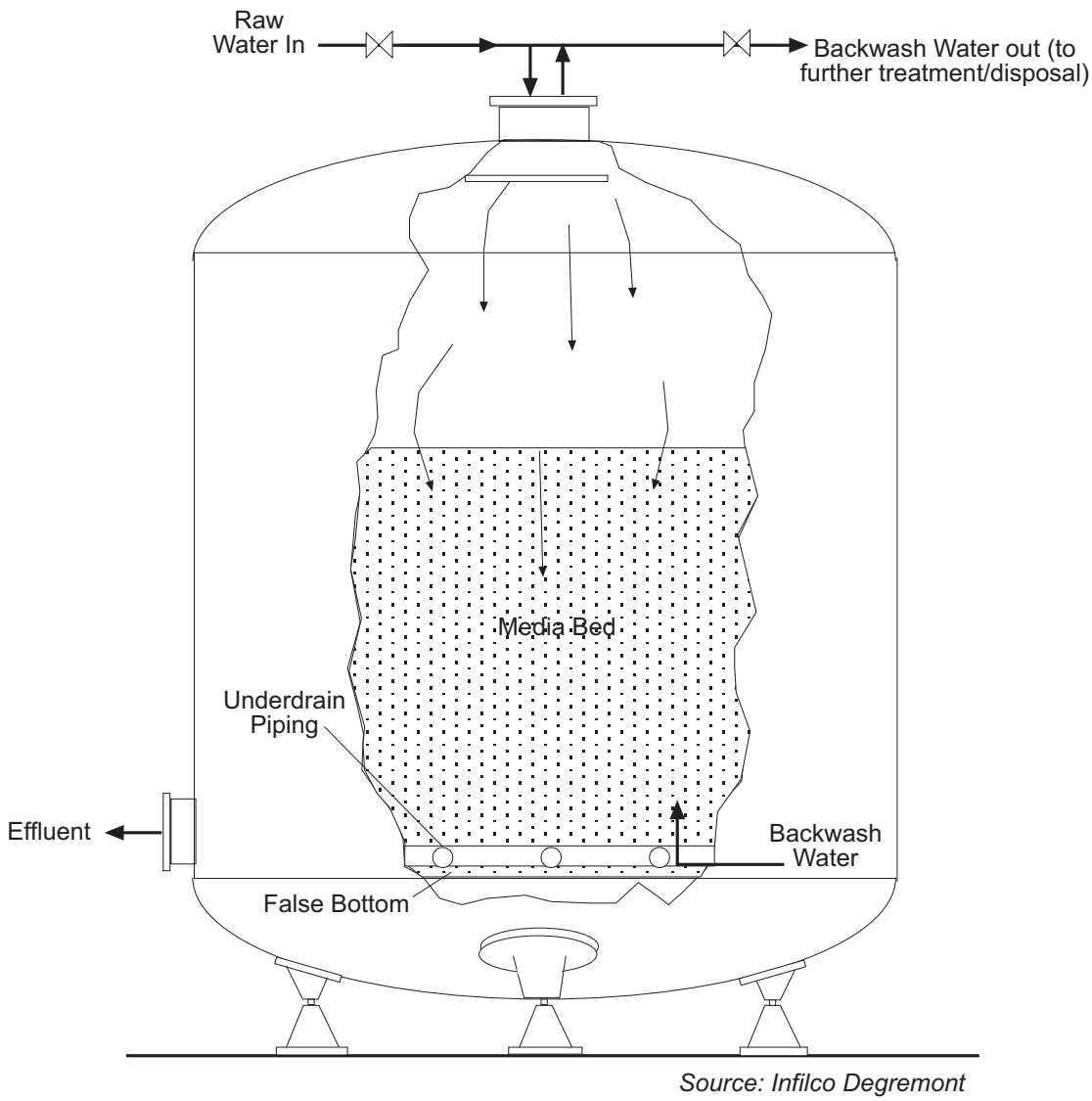


Figure 7
Pressure Granular Media Filtration Schematic

Table 27
Suppliers of Pressure Filtration Systems

Manufacturer	System Description
Aqua-Aerobic Systems, Inc. 6306 N. Alpine Road P.O. Box 2026 Rockford, IL 61130 815-654-2501	Aqua ABF Automatic backwash package filter
EIMCO Process Equipment Company P.O. Box 300 Salt Lake City, UT 84110 801-526-2000	EIMCO Rotoco - upflow continuous cleaning filter
Infilco Degremont Inc. P.O. Box 29599 Richmond, VA 23229 804-756-7600	Pressure Filtration ABW (R) Pressure Filter, downflow, continuous - cleaning multiple downflow, continuous cleaning units
Ingersoll-Rand Industrial Process Machinery 150 Burke Street Nashua, NH 03061 603-882-2711	Continuous pressure filter (CPS)
Pan America Environmental 2385 Hammond Drive, Suite 5 Schaumburg, IL 60173 847-882-5855	Multi-Media Filters
Serfilco, Ltd. 1777 Shermer Road Northbrook, IL 60062-5360 847-559-1777	Sentinel Filtration System, System, Titan-90 Automatic Filtration Systems - automatic backwash filters

Note: This vendor listing is not inclusive, and does not imply endorsement of these vendors.

Bag filtration systems are relatively easy to operate but require visual inspection and periodic bag replacement. Bags must be tested for metals content prior to disposal to determine if they contain hazardous concentrations of metals.

7.6.2.2 Design Criteria. In designing a bag-filtration system, determination of the particle size distribution and TSS concentration of the wastewater is helpful. Bag filter suppliers can then provide assistance in selecting the bag pore size and determining the bag volume and number of bags required for design flow rate.

7.6.2.3 Package Systems. A schematic of a typical gravity bag filtration system employing several bags is provided in Figure 8. A listing of bag filter vendors is provided in Table 28.

7.6.3 Cartridge Filtration

7.6.3.1 Process Description. Cartridge filters operate in essentially the same manner as bag filters. The chief difference is that a rigid filter cartridge is used rather than a flexible filter bag. The cartridge media can be constructed with pleats to increase filter surface area and solids holding capacity. In addition, cartridges are available to remove particles down to 1 micron or less. As a result of these differences, cartridge filters are only provided in pressure systems. Cartridge filters are monitored for pressure build-up, and when the pressure reaches a predetermined level, the cartridge must be removed and cleaned.

As with bag systems, cartridge filter systems are relatively easy to operate but require visual inspection and periodic cartridge replacement. The cartridges also need to be tested for metals content to determine the appropriate disposal method.

7.6.3.2 Design Criteria. As with bag filtration, determination of the particle size distribution and TSS concentration of the wastewater is helpful. Filter suppliers can then provide assistance in selecting the cartridge pore size and determining the number of cartridges required for design flow rate.

7.6.3.3 Package Units. Typical units include a pump and filtration cartridge vessel; more complex systems may include a pump with several cartridge vessels in series. The systems should have pressure gauges on the inlet and outlet of each vessel to monitor for plugging of each cartridge unit. A schematic of a typical cartridge filtration system is provided in Figure 9, and a list of vendors is provided in Table 29.

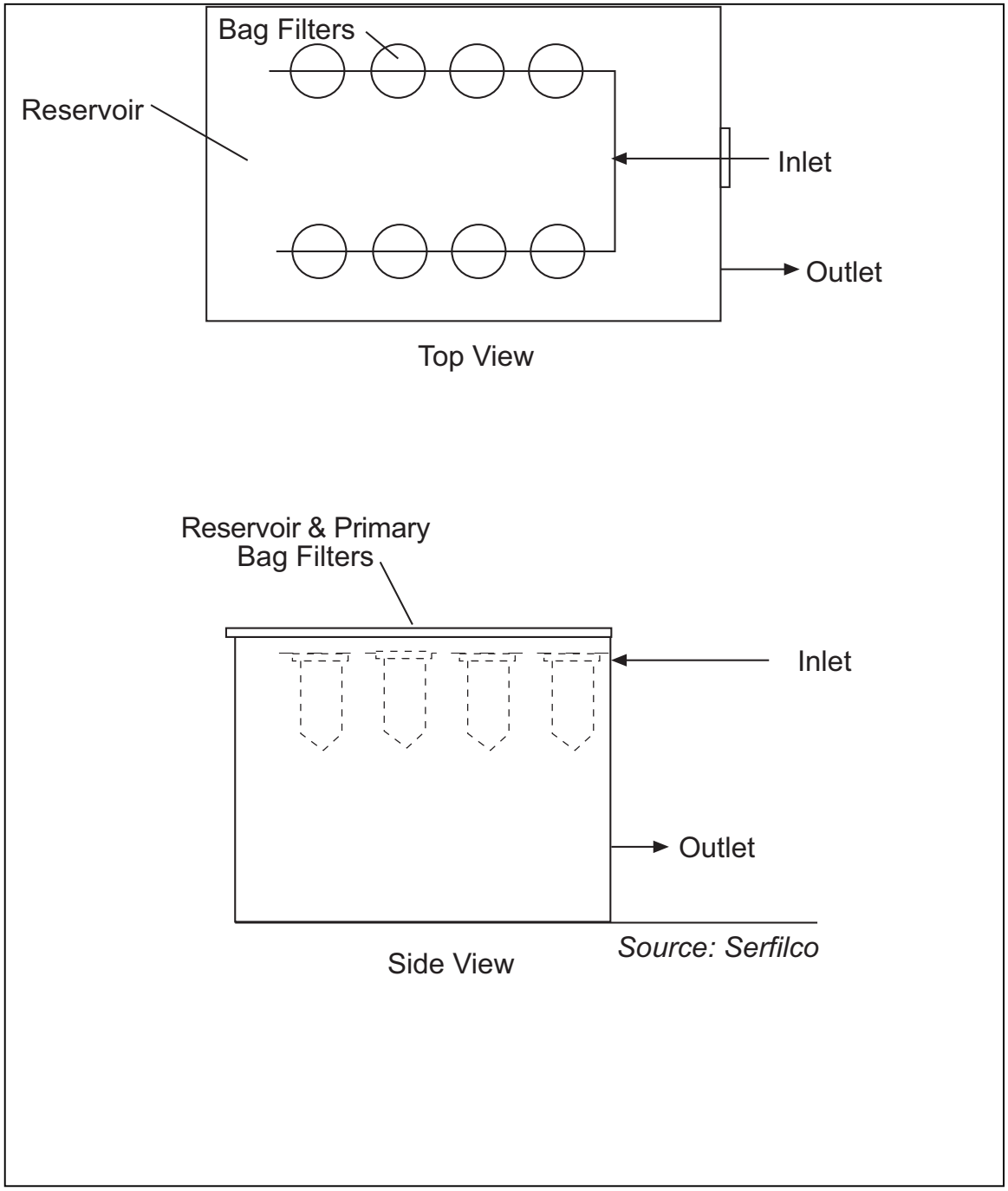


Figure 8
Gravity Bag Filtration System Schematic

Table 28
Suppliers of Bag Filters

Manufacturer
Eden Equipment Co., Inc. 17522 Griffin Street Huntington Beach, CA 92648 714-842-8181
Met-Pro Corp. Sethco 70 Arkay Drive, Box 121128 Hauppauge, NY 11788 516-435-0530
RGF 3875 Fiscal Court West Palm Beach, FL 33404 800-842-7771
Rosedale Products, Inc. P.O. Box 1085 Ann Arbor, MI 48106 800-821-5373
Serfilco, Ltd. 1777 Shermer Road Northbrook, IL 60062-5360 847-559-1777

Note: This vendor listing is not inclusive, and does not imply endorsement of these vendors.

7.6.4 Membrane Filtration

7.6.4.1 Process Description. Membrane filtration involves pressure filtration through a membrane. Membranes can be selected with the appropriate pore diameter to achieve the desired particle removal. Filtration through membranes with pore diameters in the 0.1 to 1-micron range is termed microfiltration. Subsequent membrane filter gradations are referred to as ultrafiltration (0.005 to 0.1 micron), nanofiltration (0.001 to 0.01 micron), and reverse osmosis (0.0001 to 0.01-micron).

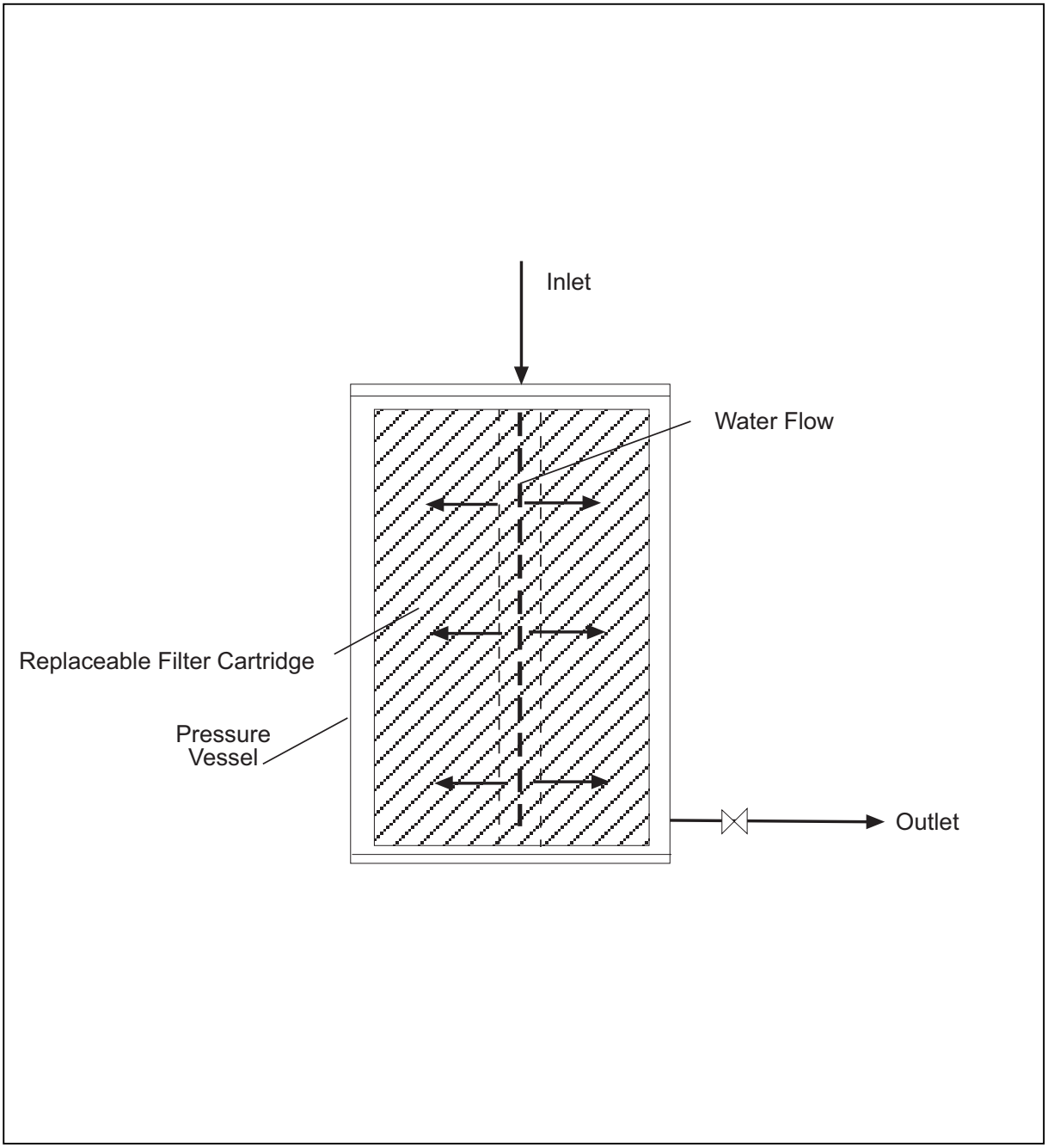


Figure 9
Cartridge Filter Schematic

Table 29
Suppliers of Cartridge Filters

Manufacturer
Eden Equipment Co., Inc. 17522 Griffin Street Huntington Beach, CA 92648 714-842-8181
Met-Pro Corp. Sethco 70 Arkay Drive, Box 121128 Hauppauge, NY 11788 516-435-0530
RGF 3875 Fiscal Court West Palm Beach, FL 33404 800-842-7771
Rosedale Products, Inc. P.O. Box 1085 Ann Arbor, MI 48106 800-821-5373
Serfilco, Ltd. 1777 Shermer Road Northbrook, IL 60062-5360 847-559-1777

Note: This vendor listing is not inclusive and does not imply endorsement of these vendors.

Microfiltration is considered the only membrane process potentially applicable for metals removal at military installations and would be used as an alternative to the other filtration systems described previously. In general, the higher capital and operating costs of these units will not warrant their selection.

In a microfiltration system, wastewater is forced through the membrane under pressure (30 pounds per square inch [psi] or less). The reject water, which is a concentrated stream of suspended solids, is discharged and requires disposal. As with other filter systems, the feed wastewater must be pretreated to ensure that dissolved metals are in a filterable, insoluble form. In addition, pretreatment may be required to avoid

fouling, plugging, or scaling of the membrane filter. Pretreatment measures may include the use of oil/water separation, sedimentation, filtration (bag or cartridge filters), and chlorination. Even with pretreatment, the membranes will eventually become fouled and will require cleaning. The most common cleaning method is back-flushing.

A high degree of operator training and attention is required for these systems because of the pretreatment requirements, reject water disposal, and potential for membrane fouling. Because of these issues, this type of system should be used only when necessary to achieve very high quality water.

7.6.4.2 Design Criteria. The following wastewater parameters should be quantified prior to selecting the membrane system:

a) Suspended solids concentration and/or turbidity

b) Particle size distribution (should be provided onsite to avoid particle size changes that could occur in transit)

c) Total and dissolved pollutants of concern (oil and grease, metals)

d) constituents which can damage or foul the membrane (silica, ferrous iron, organic materials, microorganisms, and solvents)

e) Flow rate

f) pH

g) Pressure

h) Temperature

This information can be used by a membrane system supplier to assist with the selection of a package system with appropriate membranes. Laboratory or pilot testing of membrane filters is recommended prior to implementing this technology to evaluate the treatment efficiency, volume of reject water generated, filtration rates and the potential for membrane fouling. Disposal of the reject water, or concentrate, is a

significant issue to be considered in the design and selection of a membrane system. In many cases, the concentrate will not comply with sewer discharge standards and will have to be hauled offsite for disposal.

7.6.4.3 Package Systems. A schematic of a typical membrane filtration system is provided in Figure 10 and a list of vendors is provided in Table 30.

Table 30
Suppliers of Membrane Filtration Systems

Manufacturer	System Description
Medro Systems Inc. 416 E. Industrial Blvd. McKinney, TX 75069 972-542-8200	Reverse Osmosis and Ultrafiltration Systems; Skid-mounted package systems
Zenon Environmental, Inc. 845 Harrington Court Burlington, Ontario L7N 3P3 905-639-6320	Microfiltration, nanofiltration, and reverse osmosis package treatment systems
FilmTec Corporation Dow North America P.O. Box 1206 Midland, MI 48641 800-447-4369	Membrane elements and pressure vessels
Memtec America Corporation Memcor Division 5 West Aylesbury Road Timonium, MD 21093 410-252-0800	Continuous Microfiltration System; Skid-mounted package plants

Note: This vendor listing is not inclusive and does not imply endorsement of these vendors.

7.7 Ion Exchange. This technology involves passing the water through a column of ion exchange resin, wherein ions in the wastewater with a greater affinity for the resin are exchanged for similarly charged ions attached to the resin. Ion exchange effectively removes most metals, although resins may be selected that have greater specificity for a given metal.

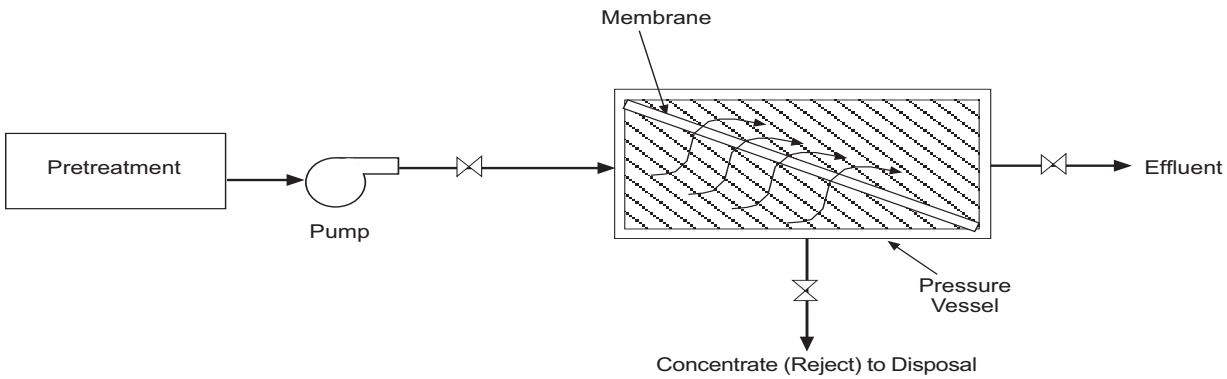


Figure 10
Membrane Filtration Schematic

Ion exchange is typically used as the first step in metals recovery to concentrate heavy metals from a dilute rinsewater. However, it may also be used as a pretreatment method for relatively low concentration waste streams to allow discharge of the treated water to the wastewater system.

7.7.1 Process Description. The ion exchange treatment process involves service (treatment of the water), backwash, regeneration, and rinsing. During service, the wastewater passes through the ion exchange resin bed, and targeted ions in the wastewater (heavy metals) are exchanged with ions on the resin media. When the resin capacity is exhausted, the resin is either discarded and replaced or, more commonly, regenerated and reused. Prior to regeneration, the column is backwashed to remove trapped solids. A regenerate solution, such as an acid or base, is then passed through the resin bed to remove the attached metal ions and replace them with the original ionic species. In the rinse cycle, water is used to remove the residual regenerant from the resin bed and then disposed of with the spent regenerant.

Typical ion exchange systems involve downflow, packed-bed columns. Selection of an appropriate ion exchange media is the key for removing the metal(s) of concern. Pretreatment for suspended solids removal is recommended to reduce plugging of the ion exchange column. Ion exchange resins are also susceptible to fouling by organic constituents, such as oil or detergents, and inorganics, such as iron. The presence of these contaminants may shorten the resin life. Systems must also include provisions for treatment or disposal of the spent regenerant solutions.

7.7.2 Design Criteria. The volumetric flow rate through the unit, which is a measure of the contact time between the solution and the resin, should be in the range of 1 to 10 gpm/cubic feet. The surface loading rate, which is a measure of the linear flow rate or velocity through the resin, should be in the range of 6 to 8 gpm/square feet of surface filter area.

Ion exchange suppliers should be consulted to recommend an ion exchange resin for the specific application and to run bench scale tests to determine the removal efficiency associated with a given exchange resin and wastewater, and the capacity of the resin. As noted above, different resins have a greater affinity for some cations over others. Thus, a significant

drawback of selecting the wrong resin is that its capacity will be prematurely exhausted as a result of removing non-targeted cations in the wastewater as well as the targeted metal ions.

Handling and disposal of the regenerant solution must be considered in the system design. The regenerant solutions are typically corrosive and require special construction materials and precautions in handling and may require disposal as a hazardous waste.

7.7.3 Package Systems. Typical ion exchange systems include a pump, ion exchange columns, and regeneration system. A schematic of a typical ion exchange system is provided in Figure 11 and a list of vendors is provided in Table 31.

Table 31
Suppliers of Ion Exchange Systems

Manufacturer
Cameron Environmental Inc. 527 Van Ness Ave. Torrance, CA 90501 310-212-0610
Medro Systems Inc. 416 E. Industrial Blvd. McKinney, TX 75069 972-542-8200
Kinetico Engineered Systems 10845 Kinsman Road Newbury, OH 44065 216-564-5397
Serfilco, Ltd. 1777 Shermer Road Northbrook, IL 60062-5360 847-559-1777

Note: This vendor listing is not inclusive and does not imply endorsement of these vendors.

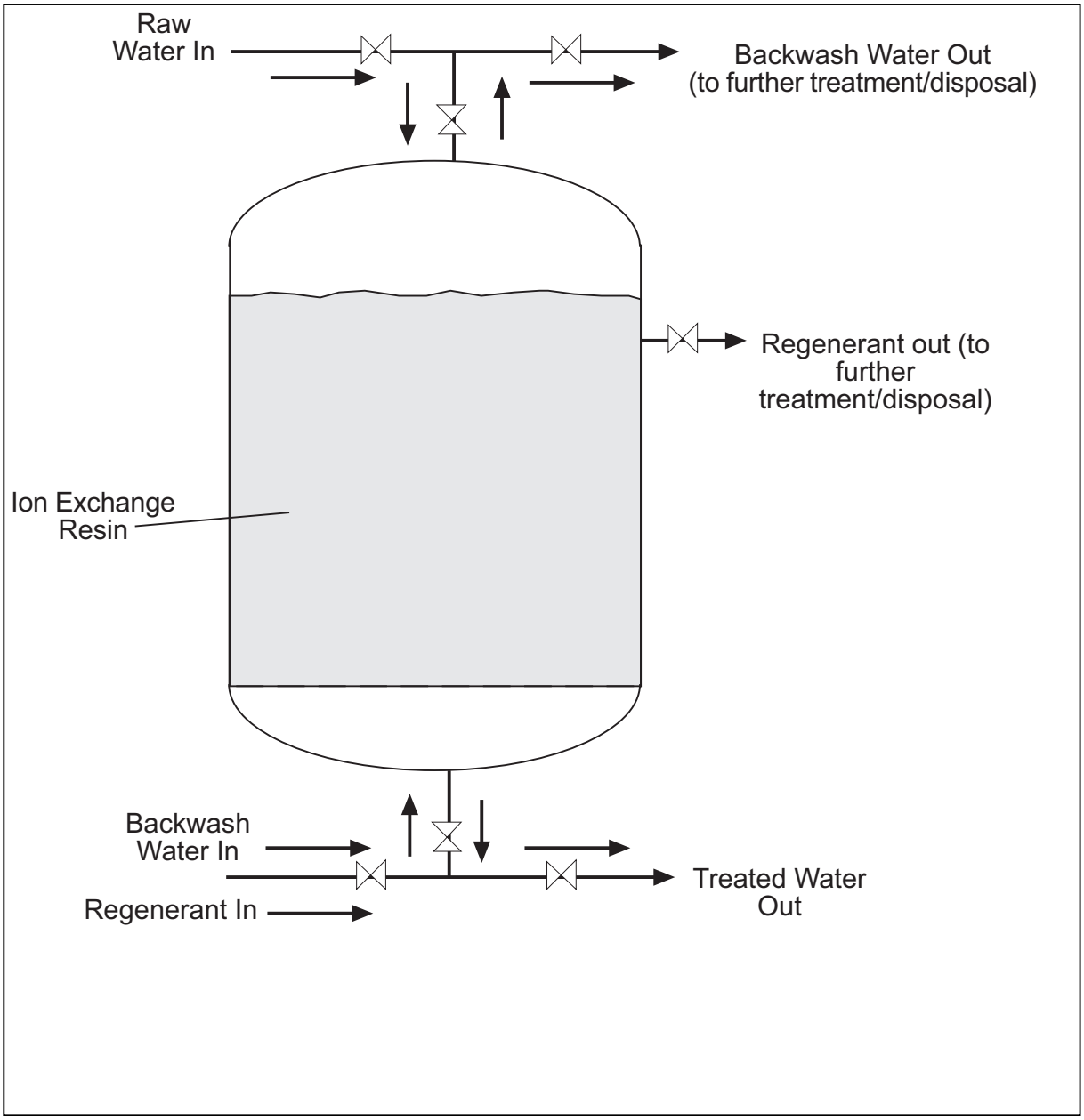


Figure 11
Ion Exchange System Schematic

7.8 Evaporation. Evaporation of wastewater may be considered where wastewater must be hauled away for disposal because a wastewater system is unavailable or because the wastewater cannot be cost effectively pretreated for discharge to a wastewater system. Evaporation systems can reduce wastewater volume by up to 80 percent or more, with a corresponding savings in hauling costs. However, they should only be employed if they are cost effective, considering all capital and operating costs. The evaporator itself will have high operating costs from the electricity or fuel required to operate the unit. In addition, the concentrated residue may qualify as a hazardous waste even if the original wastewater did not. Where evaporation is used, the facility must comply with any state air regulations that apply to the treatment process.

7.8.1 Process Description. Most evaporators in common use function essentially by applying heat to the wastewater and boiling off water. Water enters the tank in either a batch or continuous mode and is heated by a gas-fired heat exchanger. A blower draws in ambient air through the burner and a tank opening. Air is drawn across the surface of the heated liquid and sweeps away water vapor as it breaks the surface. The moisture-saturated air and flue gasses leave the tank via separate passageways, are combined at the blower entrance, and exit the system via a flue gas stack. Free oils and emulsions that float to the water surface in the tank are skimmed off to an external receptacle, and precipitated solids settle to a trough and are removed via a clean-out port at the bottom of the unit. Because volatile organic chemicals may be vaporized in the process, the equipment can be supplied with an activated carbon adsorber for off-gas treatment if necessary.

Other types of evaporators are also marketed. These include units in which heated wastewater is passed over a packing material similar to an air stripper. Another type is a single-stage vacuum evaporator, which uses a heat pump as both a source of heat and a means of cooling the condenser coils. This type of evaporator works with high energy efficiency, but has relatively high capital costs.

7.8.2 Design Criteria. Evaporation systems should be sized based on wastewater volume or flow rate and the desired level of volume reduction. Equipment suppliers should perform a

laboratory test to evaluate the wastewater and determine the maximum volume reduction that is feasible prior to selecting a unit. Materials of construction should be closely evaluated since the concentrated slurry may contain corrosive constituents such as chlorides. Odor emissions from the units are also a concern.

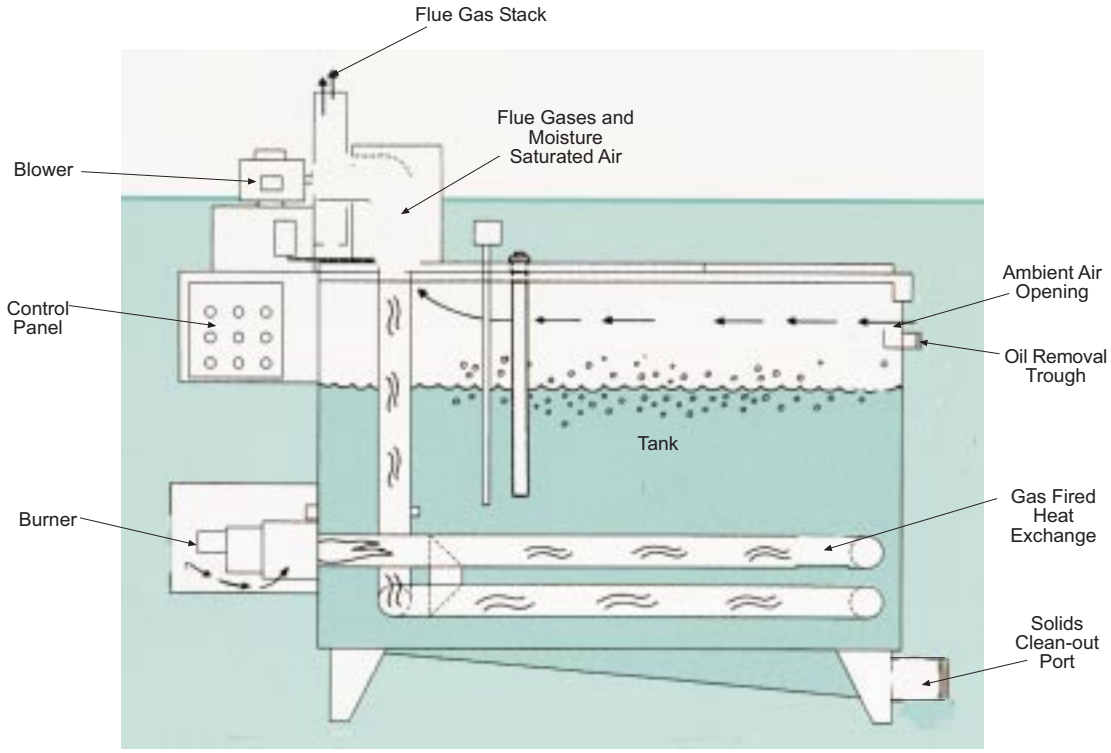
State regulations vary with respect to the use of evaporators. An air emissions permit or a special hazardous waste treatment permit may be required in some cases, so state regulators should be consulted.

7.8.3 Package Units. Evaporator package units are provided as skid-mounted stand-alone systems. Systems as small as 3 to 4 gal/hr and as large as 300 gal/hr are available. A schematic of an evaporation unit is provided in Figure 12. Evaporator manufacturers are listed in Table 32.

Table 32
Suppliers of Wastewater Evaporators

Manufacturer	System Description
Lakeview Engineered Products Div. of Power Plant Service 2500 W. Jefferson Blvd. Fort Wayne, IN 46802 212-432-6716	Wastewater Evaporators 10 to 300 gph
LANDA 13705 NE Airport Way Portland, OR 97230 800-547-8672	Water Blaze and Hot Box Wastewater Evaporators Flows from 3 to 60 gph
RGF 3875 Fiscal Court West Palm Beach, FL 33404 900-842-7771	Wastewater Evaporators Flows up to 15 gph
SAMSCO, Inc. 18 Cote Avenue Goffstown, NH 03045 603-668-7111	Wastewater Evaporators Flows from 8 to 125 gph

Note: This vendor listing is not inclusive and does not imply endorsement of these vendors.



Source: SAMSCO, Inc.

Figure 12
Evaporator System Schematic

Section 8: TREATMENT FOR WASHWATER RECYCLING

8.1 Section Overview. This section provides information on package systems for the treatment of washwater to render it suitable for recycling or discharge under exceptionally stringent limitations. Guidance on the selection of such systems is presented, as well as process and equipment information.

The use of recycle systems at military installations is discouraged except in those rare circumstances where they may be necessary or cost effective. While recycle systems can result in a reduction in water use and wastewater discharged, they are costly to install and require skilled O&M personnel. In addition, these systems are costly to operate and maintain, and they generate a concentrated waste stream that may require disposal as a hazardous waste.

8.2 Washwater Sources. The major washwater sources at military installations are aircraft, vehicle, and equipment washracks. Parts washing is another source, but the volume of washwater generated is generally too small to warrant a recycling treatment system.

8.3 Assessing the Need for a Washwater Recycling System. In general, a treatment system for washwater recycling will not be warranted. However, a system may be considered where:

a) The economics are favorable, i.e., savings in potable water and wastewater disposal costs exceed treatment and recycle costs.

b) A shortage of potable water exists.

c) A wastewater system is not available for discharge.

d) Discharge requirements to the wastewater system are extremely stringent.

e) Wastewater reuse is mandated to meet facility goals for waste reduction.

In deciding whether to implement a recycling system, it should be recognized that these systems generate waste

sidestreams requiring disposal. For example, closed-loop systems incur a buildup of dissolved contaminants until some equilibrium concentration is reached. If the equilibrium concentration of a particular contaminant (e.g., chlorides) is too high to be tolerated, then the system must be designed to remove that contaminant or have the ability to discharge some percentage of blowdown and add an equal amount of fresh makeup water. Likewise, removed solids or other concentrated waste streams will require separate disposal.

Costs to be considered in evaluating a recycle system include the capital cost of the equipment and installation, O&M costs, and waste by-product disposal costs. Capital costs should include all appurtenant components for a complete facility, including buildings or enclosures, slabs, upstream grit removal, yard piping, pumps, electrical hookups, curbing, and fencing. The ongoing need for trained operators and maintenance personnel should also be carefully considered. In addition, special O&M requirements related to corrosion and scaling and intermittent operation need to be addressed. Contact with other military users of recycle systems is encouraged to obtain information on these factors.

8.4 Pollutants to be Removed. In recycle applications, treatment is needed primarily for oil, suspended solids, and dissolved organics. Occasionally other constituents, such as metals or chlorides, may require removal and will result in significantly higher costs.

8.5 Treatment Technologies. Several different pre-engineered, factory-fabricated package treatment systems for washwater are marketed. Virtually all incorporate oil removal and filtration. Some incorporate activated carbon treatment for soluble organics removal, membrane treatment for removal of soluble organics and inorganics, and ozonation for control of microorganisms. In evaluating systems, one should be selected that provides an appropriate level of treatment. Systems that provide unnecessary treatment processes increase costs and O&M requirements.

8.6 Prefabricated Package Systems. Package systems incorporate various treatment components into a skid mounted or package unit. Many vendors provide standard systems with the

combinations of unit processes most frequently needed. These types of systems are most typically used for washwater recycling, but with the various combinations of unit processes available, the systems can be adapted to other applications as well.

A partial listing of equipment suppliers and the recycle systems they offer is provided in Table 33. Four representative systems are described below. These are provided for informational purposes and are not intended to be an endorsement of the suppliers.

Table 33
Partial Vendor Listing
Washwater Recycling Systems

Manufacturer	System Description
LANDA 13705 NE Airport Way Portland, OR 97230 800-547-8672	Clarifier Low Profile Wash Water Recycling System Delta Closed-Loop Wash Water Recycling System 1 to 30 gpm
Pan America Environmental 2385 Hammond Drive, Suite 5 Schaumburg, IL 60173 847-882-5855	Vehicle and Equipment Washwater Treatment/Recycle Systems 1 to 40 gpm
RGF 3875 Fiscal Court West Palm Beach, FL 33404 900-842-7771	Ultrasorb Systems for Washwater Recycle 1 to 30 gpm
Universal Recycled Water Systems, Inc. 4407 Vineland Road, Suite D-16 Orlando, FL 32811 407-245-7877	Deluge Recycled Wash Water Plants 25 to 100 gpm

Note: This vendor listing is not inclusive and does not imply endorsement of these vendors.

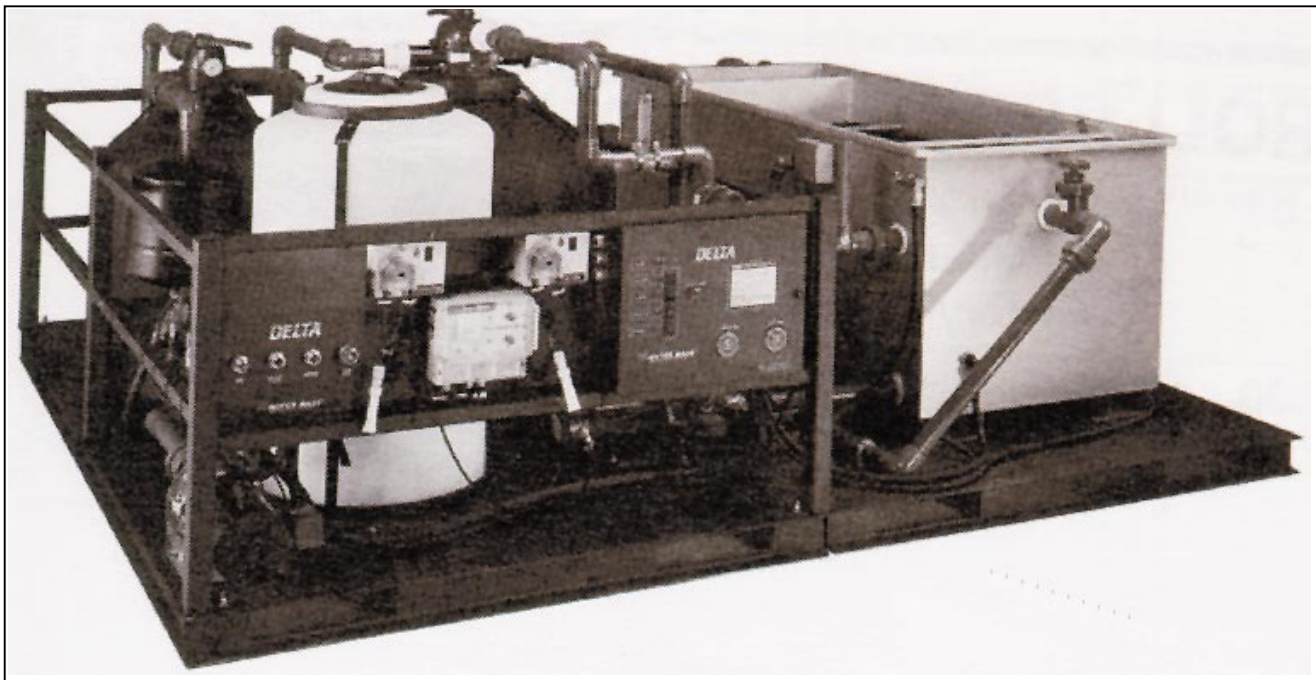
8.6.1 LANDA Water Cleaning Systems. LANDA provides two types of wash water recycling systems: the Clarifier Low Profile (CLP) and the DELTA system. Each unit is available for wastewater flow rates from 1 to 30 gpm. The CLP system includes a cone-shaped

OWS with coalescing plates, ozone addition, cartridge filters, and carbon filters. The Delta includes a standard OWS, cartridge filter, carbon filter, multi-media filter and ozone. An example Delta system is shown in Figure 13.

8.6.2 Pan America Environmental. Pan America provides two systems; the VEW-1 is typically used for single pass treatment and discharge, while the VEW-2 is used for treatment and reuse of washwater. These units are available at flow rates up to 40 gpm. The VEW-1 system includes an OWS and filtration. The VEW-2 systems can include any of the following components: oil/water separation, filtration, carbon filtration, ozone treatment, chlorination, air stripping, chemical precipitation, softening, pH adjustment, sludge dewatering, and membrane treatment. Components are selected as needed for each individual application and are assembled into a package unit. The VEW-2 unit is shown in Figure 14.

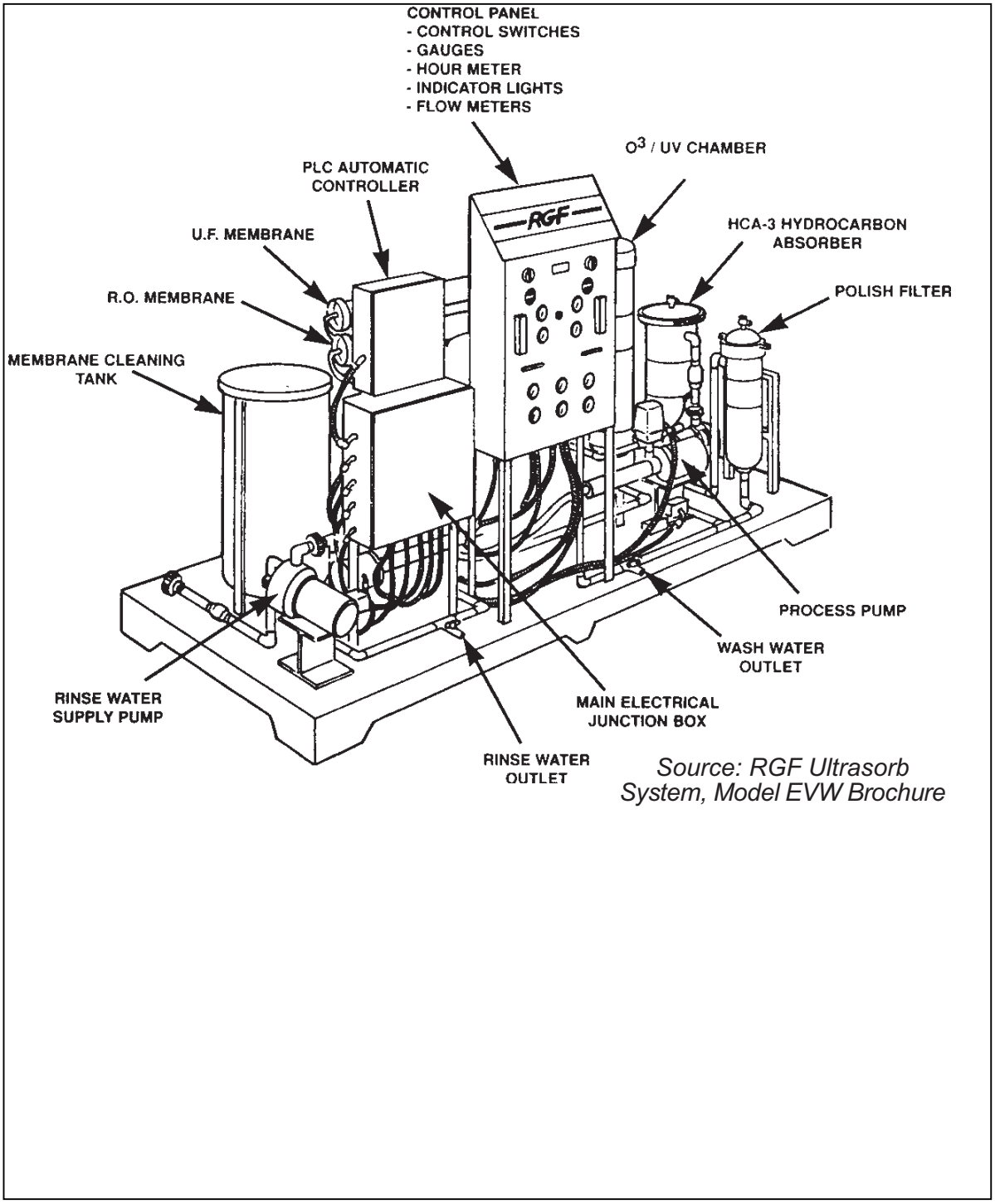
8.6.3 RGF Environmental. RGF offers two types of wastewater recycling systems: the CL2 for automatic car washes and the EVW for cosmetic cleaning applications. The CL2 system includes aeration, gravity oil/water separation, diffused air flotation, centrifugal separation, multi-media filtration, UV/hydrogen peroxide/ozone treatment to control bacteria, a catalytic oxidation process, and an ultrafiltration membrane. The EVW system includes aeration, gravity oil/water separation, oil skimmer, hydrocarbon absorption, filtration, UV/hydrogen peroxide/ozone treatment, catalytic oxidation, ultrafiltration membrane and reverse osmosis membrane treatment. These systems are available at flow rates up to 30 gpm. The VEW-2 system is shown in Figure 15.

8.6.4 Universal Recycled Water Systems Inc. Universal provides units called Deluge Recycled Wash Water Plants, which are designed to recycle washwater for small fleet wash operation, and golf course equipment. A typical system consists of a collection tank, which provides settling of large particles, a cyclone separator, OWS, and sand filtration. For wash water recycling, an activated carbon filter is provided to remove soap, trace oils and other contaminants. Ozone is also provided for reducing odors and bacterial growth. The systems range in size from 25 to 100+ gpm. A schematic of the system is provided in Figure 16.



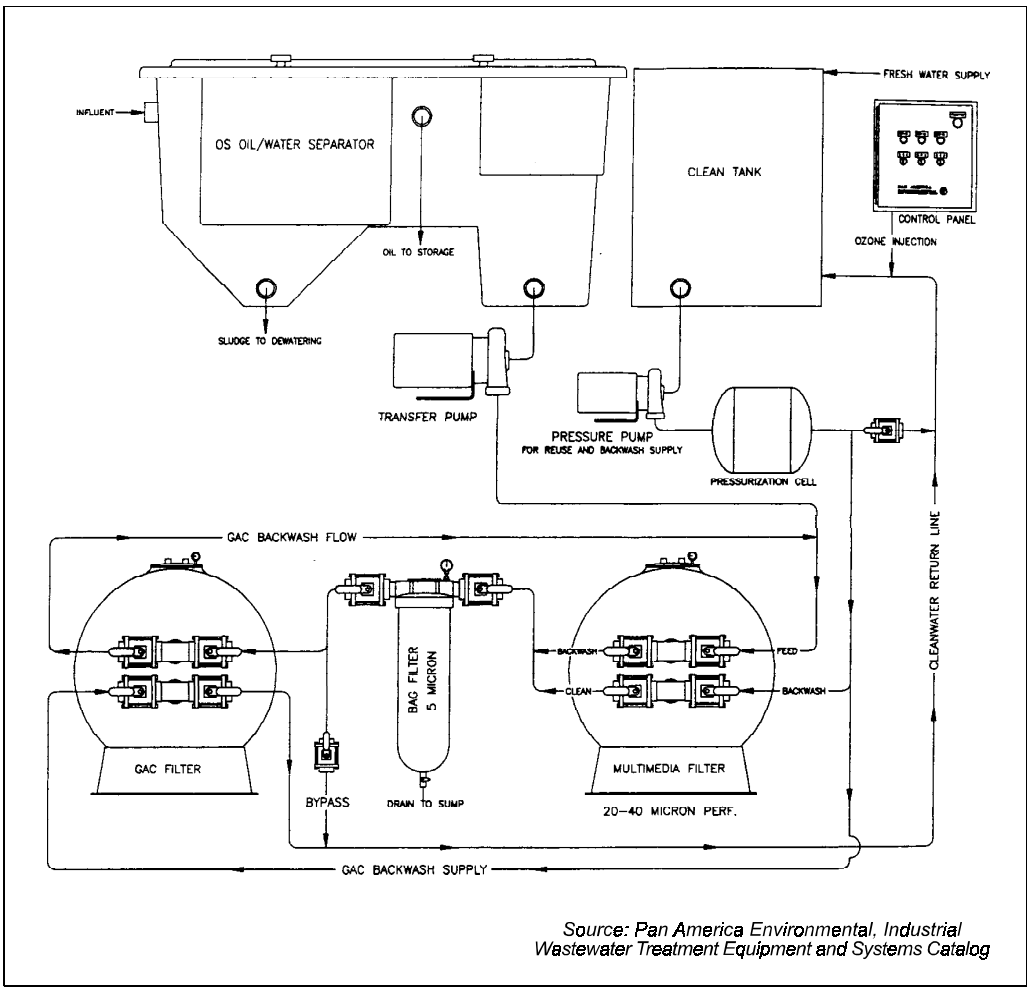
Source: LANDA Wastewater Cleaning System, GSA Brochure, Effective June 1, 1997

Figure 13
LANDA'S Delta Washwater Recycling System



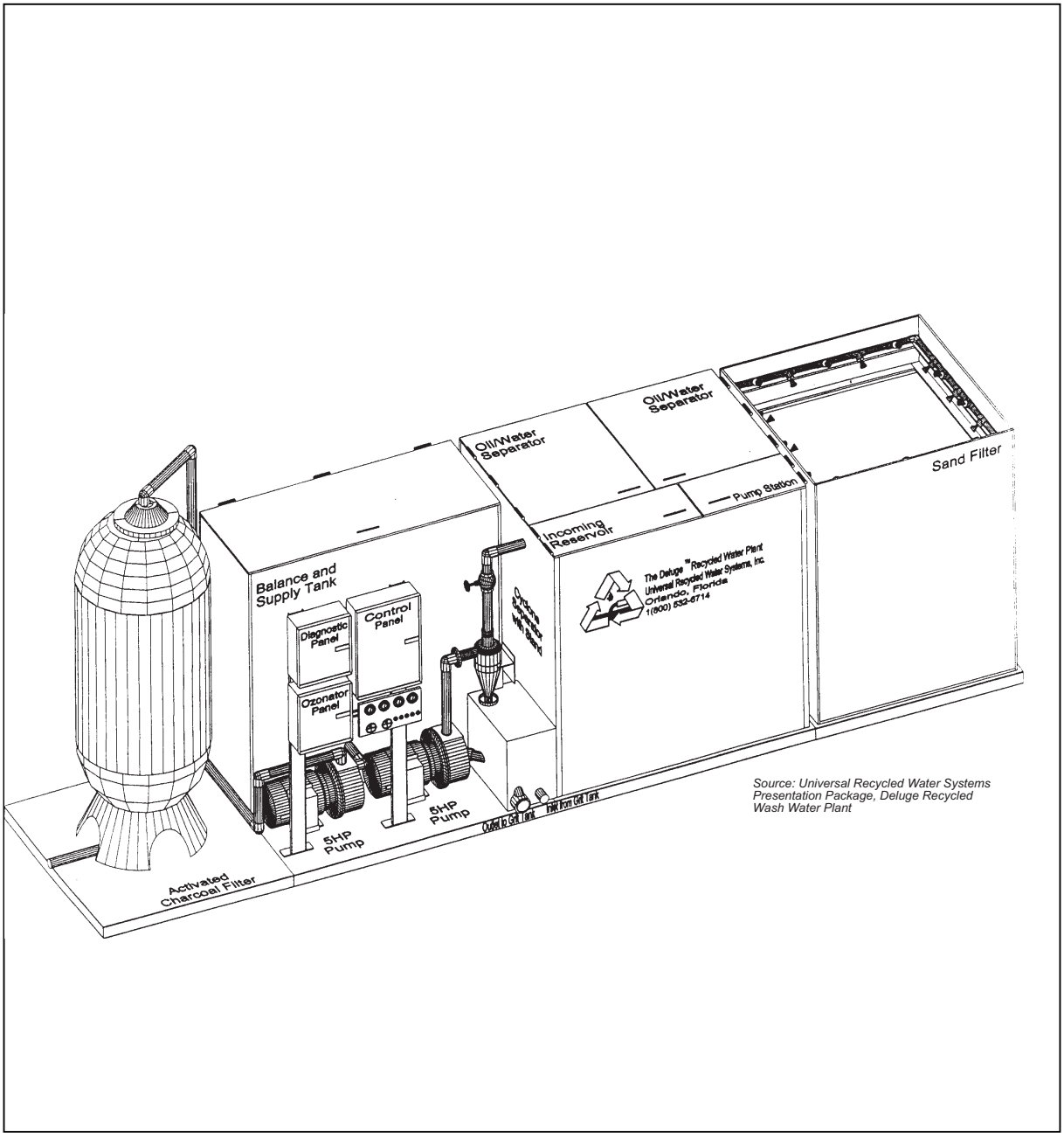
Source: RGF Ultrasorb System, Model EVW Brochure

Figure 14
RGF's VEW-2 Washwater Recycling System



Source: Pan America Environmental, Industrial Wastewater Treatment Equipment and Systems Catalog

Figure 15
Pan America Environmental VEW-2 Washwater Recycling System



Source: Universal Recycled Water Systems Presentation Package, Deluge Recycled Wash Water Plant

Figure 16
Universal Recycled Water Systems
Deluge Recycled Water Plant

REFERENCES

Note: The following referenced documents form a part of this handbook to the extent specified herein. Users of this handbook should refer to the latest revisions of cited documents unless otherwise notified.

Federal/Military Specifications, Standards, Bulletins, Handbooks, and NAVFAC Guide Specifications:

Unless otherwise indicated, copies are available from the Naval Publishing and Printing Service Office (NPPSO), Standardization Document Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

Handbooks

MIL-HDBK-1005/16	Wastewater Treatment System Design Augmenting Handbook
MIL-HDBK-1005/9	Industrial and Oil Wastewater Control
MIL-HDBK-1190	Facility Planning and Design Guide
MIL-HDBK-1138	Wastewater Treatment System Operations and Maintenance Augmenting Handbook

Navy Manuals, P-Publications, and Maintenance Operating Manuals:

A Joint P2-Library is available at http://enviro.nfesc.navy.mil/p2library/. The site contains information and publications on equipment, technologies, and management practices that reduce or eliminate the generation, treatment, and disposal of pollutants at service installations. The site is maintained by Naval Facilities Engineering Service Center.

Industrial Wastewater Management Program Development and Implementation Guidance (Draft).

NAVSEA T0300-AZ-PRO-010, Navy Environmental Compliance Sampling and Field Testing Procedures Manual, January 16, 1997.

5090.1A, Environmental and Natural Resources Program Manual, November 1, 1994.

Air Force Regulations, Manuals, Instructions, and Guides:

Unless otherwise indicated, copies are available from the Air Force Publications Distribution Center, 2800 Eastern Boulevard, Baltimore, MD 21220-2896.

HQ USAF/CE Memorandum	Oil/Water Separators: Operation, Maintenance and Construction, October 21, 1994
HQ AFCEE	Pro-Act Fact Sheet. Oil/Water Separators
Air Force Research Laboratory: AFRL/MLQE	Technology for Oil/Water Emulsion Treatment: Phases I and II, April 1998

Army Regulations, Manuals, Instructions, and Guides:

ETL 1110-3-466	Selection and Design of Oil/Water Separators at Army Facilities
AFRL/MLQE	New Technology for Oil/Water Emulsion Treatment: Phases I and II, April, 1998
AR 200-1	Environmental Protection and Enhancement, April 1990
AR 420-4	Utility Systems, April 1997
TM 5-814-9	Central Vehicle Wash Facilities

Other Government Documents and Publications

EPA 625/7-88-003	Waste Minimization Opportunity Assessment Manual
EPA Office of Water (21W-4002)	Supplemental Manual on Development Implementation of Local Discharge Limitations under Pretreatment Program, May 1991
EPA 831/B-94-001	Industrial User Inspection and Sampling Manual for POTWs, April 1994
EPA 625/7-91-016	Guides to Pollution Prevention, the Automotive Repair Industry, October 1991
EPA 625/1-79-001	Process Design Manual for Sludge Treatment and Disposal
EPA 833/B-87-202	Guidance Manual for the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program, December 1987
EPA 812/B-92-001	Guidance to Protect POTW Workers from Toxic and Reactive Gases and Vapors, June 1992
EPA	Federal Facility Pollution Prevention Planning Guide, December 1994.

AMERICAN PETROLEUM INSTITUTE

API Publication 421 Design and Operation of Oil and Water Separators

(Unless otherwise indicated, copies are available from API, 1220 L Street, Northwest, Washington D.C. 22005)

WATER ENVIRONMENT FEDERATION (WEF)

WEF FD-3 Pretreatment of Industrial Wastes, Manual of Practice

(Available from WEF, 601 Wythe Street, Alexandria, VA 22314-1994)

Authored Publications

CH2M HILL. Pretreatment Program: Technically Based Local Limits. Santa Rosa, CA. April 1989.

CH2M HILL. Technically Based Local Pretreatment Limits. Newark, N.J. October 1993.

CH2M HILL. Development of Technically Based Local Limits, Anchorage AK Water and Wastewater Utility. February 1997.

CH2M HILL. Revision and Development of Technically ased Local Limits for the Industrial Waste Pretreatment Program. El Paso Water Utilities Public Service Board, TX. September 1996.

CH2M HILL. Industrial Pretreatment Program Update. City of Lakeland, FL. Fort Pierce, FL. August 15, 1995.

CH2M HILL. Development of Revised Technically Based Local Limits. Fort Pierce Utilities Authority. August 15, 1996.

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County Sanitation Districts of Orange County. Wastewater Discharge Regulations. CA. February 7, 1992.

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Kunkel, et al. "The Fate of Mercury in Dental Amalgam." Water Environment and Technology. December 1996.

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Yi, Y. "Removal of Oil and AFFF from Wastewater by Air-Sparged Hydrocyclone Technology." Phase I Program Final Report. 1996.

GLOSSARY

Abbreviation or Acronym	Definition
ACGIH	American Conference of Governmental Industrial Hygienists
A/E	architect/engineering
AFFF	aqueous film-forming foam
AFRL	Air Force Research Laboratory
AGE	aerospace ground equipment
API	America Petroleum Institute
ASH	air-sparged hydrocarbons
AST	aboveground storage tank
BMP	best management plan
BTEX	benzene, toluene, ethylbenzene, and xylene
BOD	biochemical oxygen demand
°C	Degrees Celcius
CAAA	Clean Air Act Amendments
CCC	criterion continuous concentrations
CLP	Clarifier Low Profile
CMC	criterion maximum concentrations
CPI	corrugated plate interceptor
CPS	continuous pressure filter
COD	chemical oxygen demand
CRC	chemical recovery cartridge
DRMO	Defense Reutilization and Marketing Office
EPA	Environmental Protection Agency
°F	Degrees Fahrenheit
FFCA	Federal Facilities Compliance Act
FGS	Final Governing Standards
FOTW	Federally Owned Treatment Works
gpd	gallons per day
GSA	Government Service Agency
HAP	hazardous air pollutants
HHC	human health concentrations
Kg/ha	kilogram per hectare
Lbs/day	pounds per day
LEL	lower explosive limit
MACT	maximum achievable control technology
MAIL	maximum allowable industrial loading
MAHL	maximum allowable headwork loading

MEK	methyl ethyl ketone
µg/L	micrograms per liter
mgd	million gallons per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MRC	metallic replacement cartridge
NATO	North Atlantic Treaty Organization
NDI	non-destructive inspection
NPDES	National Pollutant Discharge Elimination System
NPPSO	Naval Publishing and Printing Service Office
OEBGD	Overseas Environmental Baseline Guidance
OHSA	Occupational Safety and Health Administration
O&M	operation and maintenance
OPNAVINST	Office of the Chief of Naval Operations Instruction
OWS	oil/water separator
PMB	plastic media blasting
PPA	Pollution Prevention Act
POL	petroleum, oil and lubricants
POTW	publicly owned treatment works
PSES	pretreatment standards for existing sources
psi	pounds per square inch
PSNS	Pretreatment standards for New Sources
SIU	significant industrial user
SOFA	Status of Forces Agreement
SPCC	spill prevention, control, and countermeasures
SRC	silver recovery cartridge
SRU	silver recovery unit
SWMU	solid waste management unit
TLV-TWA	threshold limit values-time-weighted averages
TPH	total petroleum hydrocarbons
TSS	total suspended solids
VOC	volatile organic compounds
VSS	volatile suspended solids
WEF	Water Environment Federation
WWTP	wastewater treatment plant
ZID	zone of initial dilution

CONCLUDING MATERIAL

Custodians	Preparing Activity
AF-50	AF-50
Army - AEC	AF-50