

AD A116864

construction
engineering
research
laboratory

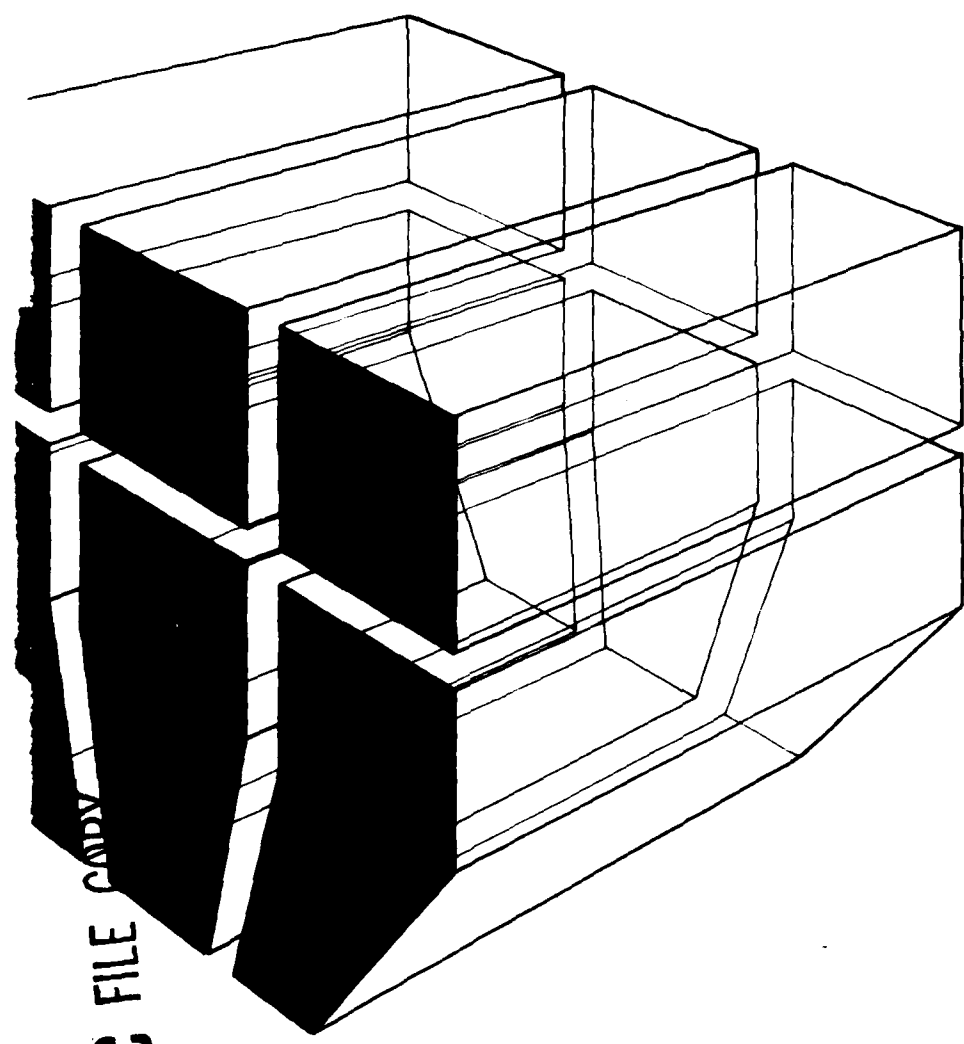


United States Army
Corps of Engineers
... Serving the Army
... Serving the Nation

TECHNICAL REPORT N-128
May 1982
Water Pollution Control
From Troop-Related Maintenance Activities

WATER POLLUTION CONTROL IN ARMY TABLE OF ORGANIZATION
AND EQUIPMENT (TOE) MAINTENANCE OPERATION:
OVERVIEW AND ASSESSMENT

by
R. Fileccia
J. Matherly



DTIC FILE COPY

DTIC
ELECTE
S JUL 1 21982 D

E
W
ERL

Approved for public release; distribution unlimited.

82 07 12 108

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official indorsement or approval of the use of such commercial products. The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

***DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED
DO NOT RETURN IT TO THE ORIGINATOR***

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CERL-TR-N-128	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) WATER POLLUTION CONTROL IN ARMY TABLE OF ORGANIZATION AND EQUIPMENT (TOE) MAINTENANCE OPERATION: OVERVIEW AND ASSESSMENT	5. TYPE OF REPORT & PERIOD COVERED FINAL	
	6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s) R. FILECCIA J. MATHERLY	8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. BOX 4005, CHAMPAIGN, IL 61820	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 4A762720A896-B-044	
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE May 1982	
	13. NUMBER OF PAGES 21	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified	
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Copies are obtainable from the National Technical Information Service Springfield, VA 22151		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Ft. Lewis, WA Water Pollution Military Vehicles Maintenance		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes the principal design features of the Table of Organization and Equipment (TOE) unit maintenance operations concepts developed by the U.S. Army Construction Engineering Research Laboratory (CERL). It also describes the results of a limited survey and evaluation of newly constructed facilities at Fort Lewis and Yakima Firing Center, WA; these facilities were built based on CERL's concepts. Needed design modifications and hardware and concept developments are given.		

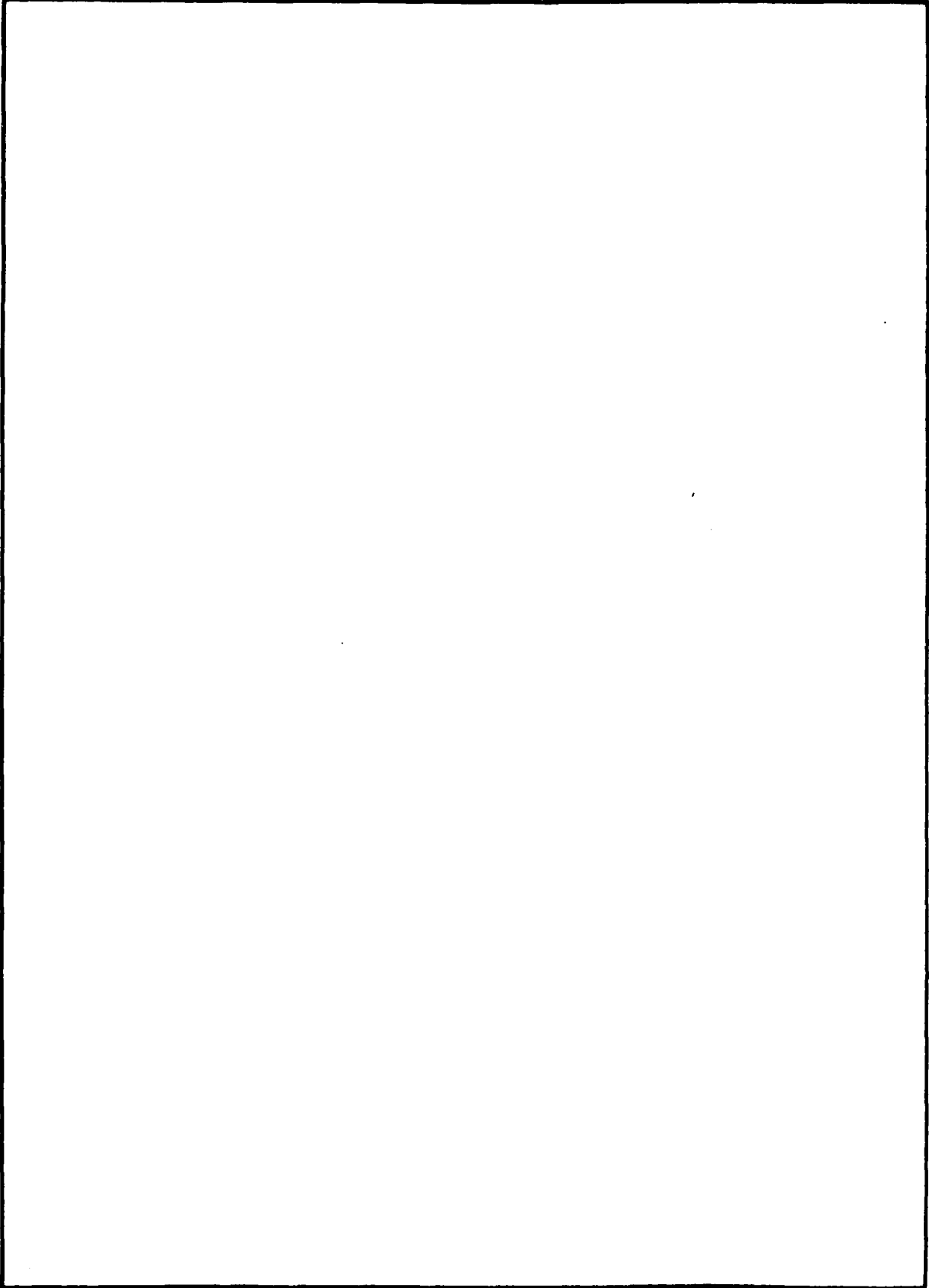
DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

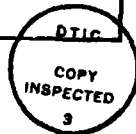
FOREWORD

This report was prepared for the Directorate of Military Programs, Office of the Chief of Engineers (OCE), under Project 4A762720A896, "Environmental Quality for Construction and Operation of Military Facilities"; Technical Area B, "Environmental Design and Construction Strategy"; Work Unit 044, "Water Pollution Control From Troop-Related Maintenance Activities." The applicable QCR is 6.27.20A. The OCE Technical Monitor was Mr. Walt Medding, DAEN-MPE-D.

The report was prepared by the Environmental Division (EN) of the U.S. Army Construction Engineering Research Laboratory (CERL). Dr. R. K. Jain is Chief of CERL-EN.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	



CONTENTS

	Page
DD FORM 1473	1
FOREWORD	3
LIST OF TABLES AND FIGURES	5
1 INTRODUCTION	7
Background	
Purpose	
Approach	
Mode of Technology Transfer	
2 REVIEW OF PRIMARY WATER POLLUTION SOURCES WITHIN TOE MAINTENANCE COMPLEXES	7
General	
Classification of Water Pollution Sources by Operation	
3 NEW FACILITY CONCEPTS FOR ACHIEVING WATER POLLUTION ABATEMENT AT EXISTING TOE MAINTENANCE COMPLEXES	8
Centralized Tactical Vehicle Wash Facilities	
Principal Features of the Fort Lewis Design	
Suggested Concept Modifications and Further Research Requirements	
In-Motor Pool Tactical Vehicle Maintenance Facilities	
Centralized Tracked Vehicle Maintenance Facility Concept –	
Principal Design Features	
Centralized Wheeled Vehicle Maintenance Facility –	
Principal Design Features	
Recommended Design Changes	
Further Research Requirements	
4 NEW TOE MAINTENANCE SHOP DESIGN CONCEPTS	17
Scheduled Maintenance Bay	
Unscheduled Maintenance Bay	
5 CONCLUSIONS	21
DISTRIBUTION	

TABLES

Number		Page
1	<i>Estimated Waste Oil Generated Annually by Various Tactical Units</i>	9
2	<i>Inventory of Vehicle Washracks for Selected Installations</i>	10
3	<i>Effluent Requirements for Pretreated Wastewaters From Vehicle Maintenance Facilities</i>	15

FIGURES

Number		Page
1	<i>Centralized Vehicle Wash Facility at Fort Lewis, WA</i>	12
2	<i>Tracked Vehicle Maintenance Platform</i>	14
3	<i>Wheeled Vehicle Maintenance Facility</i>	16
4	<i>Waste Oil Inlet Details -- Wheeled Vehicle Maintenance Facility</i>	17
5	<i>Waste Oil Collection Funnel -- Tracked Vehicle Maintenance Platform</i>	18
6	<i>Scheduled Maintenance Bay</i>	19
7	<i>Unscheduled Maintenance Bay</i>	20

WATER POLLUTION CONTROL IN ARMY TABLE OF ORGANIZATION AND EQUIPMENT (TOE) MAINTENANCE OPERATION: OVERVIEW AND ASSESSMENT

1 INTRODUCTION

Background

Since 1975, the U.S. Army Construction Engineering Research Laboratory (CERL) has helped develop new facility concepts to improve the performance of troop-related tactical vehicle maintenance operations. Among these new concepts are a centralized tactical vehicle wash facility with an associated, Army-maintainable, wastewater treatment system, and improved in-motor pool maintenance facilities for routine vehicle servicing such as maintenance cleaning, oil changing, and related wet maintenance operations. CERL also has published a compendium of facility information generally applicable to the design of new organization and support maintenance facilities.¹

The primary objective of these concepts is pollution abatement or source control instead of end-of-pipe treatment. Recently, CERL conducted a limited survey of newly constructed maintenance facilities at Fort Lewis and Yakima Firing Center, WA. The facilities at these installations were based on CERL's concept suggestions.

Purpose

The purpose of this study was to (1) evaluate the performance of Table of Organization and Equipment (TOE) maintenance facilities using operation-based water pollution abatement strategies at Fort Lewis and Yakima Firing Center, and (2) identify ways such facilities can be improved.

¹Consolidated Facilities for Washing Tactical Vehicles, Engineer Technical Note (ETN) 77-14 (Office of the Chief of Engineers [OCI], 10 August 1977); R. Fileccia et al., *Pre-treatment of Waste Discharges from Improved Army Tactical Equipment Maintenance Facilities*, Technical Report N-107/ADA105081 (U.S. Army Construction Engineering Research Laboratory [CERL], August 1981); and R. L. Porter et al., *Facility Information for U.W. Army Tactical Vehicle Organization and Support Maintenance*, Technical Report P-108/ADA083683 (CERL, April 1980).

Approach

The information in this report was obtained during site visits and inspections conducted at Fort Lewis and Yakima Firing Center, WA, and from field evaluations of selected hardware and wastewater treatment options.

Mode of Technology Transfer

The information in this report will be incorporated into Army Technical Manual 5-814-7, *Water Pollution Control for Vehicle O & M Activities*.

2 REVIEW OF PRIMARY WATER POLLUTION SOURCES WITHIN TOE MAINTENANCE COMPLEXES

General

Water pollution generated at TOE maintenance complexes can be classified either by (1) the specific operation producing them, or (2) the characteristics of the wastewater discharges appearing at the maintenance complex boundary or sanitary collection system. Before any particular pollution abatement strategy can be selected for first classification, specific operational sequences and the conditions under which a given wastewater is being produced must be examined. If it is found that changes in operational mode, facility design, or equipment would considerably improve the efficiency of the operation and substantially reduce pollution control costs, these changes would be made as part of the overall pollution abatement concept. However, if end-of-pipe treatment methods are used for pollution control, no attempt is made to change existing methods of operation; the character of the wastewater discharges is the sole criterion for wastewater treatment system design.

In virtually all past and contemporary TOE maintenance complex designs, little attempt was made to design operationally efficient facilities that also minimized pollution control requirements. The net effect of this approach was stereotyped designs. More or less standard designs for existing vehicle washracks and grease racks are common; few of these standard designs include new and used oil transfer and storage facilities. Thus, any water pollution control must be provided by the installation Facility Engineer. Such controls usually are simple sand trap/oil separators that service vehicle washrack and maintenance shop drains.

Since the only facilities available in the maintenance complex for handling wet maintenance operations are

the vehicle washrack and the wheeled vehicle grease rack, these operations are invariably conducted on the washrack or on any other part of the vehicle hardstand that is convenient. Under these conditions, the entire hardstand area has to be considered when pollution control requirements are defined. Since this is not practical, various pollution abatement alternatives were selected for concept development.

Classification of Water Pollution Sources by Operation

A brief review of the primary water pollution sources generated by TOE maintenance operations is needed to place in proper perspective the pollution abatement concepts addressed in this report.

Sources of water pollution common to all levels of TOE maintenance (organizational, direct, and general support) include:

1. Vehicle and equipment washing operations.
2. Heavy maintenance cleaning operations (before inspection or repair).
3. Oil changing and various lubrications.
4. New and used oil handling and storage.
5. Small parts cleaning.
6. Radiator flushing of water-cooled equipment.
7. Vehicle and equipment parking (particularly tracked equipment).

Although this list is qualitative and relatively complete for organizational unit maintenance, the amount of pollutants these sources generate varies widely among various units. As would be expected, units having large numbers of tracked vehicles have the greatest potential for creating pollution control problems. (A comparison of the potential waste oil generation rates of several TOE battalions is shown in Table 1.)

For maintenance operations conducted at the direct support level, additional water pollution sources that are encountered include battery shop operations and equipment painting, although this latter source is often present at the organizational level as well. At the general support level the highest ordered maintenance conducted at a Class I installation the list of potential sources increases considerably and can include paint stripping and other metal surface preparations; metal finishing by electroplating, chemical conversion coatings,

etc.; and scrubber wastewaters generated by air pollution control equipment.

Of all these pollution sources, tactical vehicle exterior washing operations are the single most important source of water pollution *by volume* at Class I installations. Maintenance cleaning operations, also generally conducted at the vehicle washrack, account for significant portions of free and emulsified oils, mainly because poor cleaning equipment forces the use of solvents, diesel fuels, or other cleaning aids. Oil changing and various lubrications also produce oily waste, usually during rainfall, because there is no reliable way to store, handle, and dispense new and used oils and lubricants.

3 NEW FACILITY CONCEPTS FOR ACHIEVING WATER POLLUTION ABATEMENT AT EXISTING TOE MAINTENANCE COMPLEXES

Initial efforts to control water pollution at existing TOE maintenance complexes focused on upgrading existing vehicle washracks. This approach was abandoned and a decision made to develop a centralized tactical vehicle wash facility concept because:

1. A large number of individual wastewater treatment units would be required at each installation to meet the pollution control requirements of each washrack. (Table 2 lists vehicle washracks, compiled by installation from an inventory prepared in 1978, and indicates the magnitude of this problem.)

2. Existing vehicle washracks were the focal point for all major exterior washing and maintenance cleaning operations performed within a given motor pool. In some instances, they also were used for waste oil disposal, particularly when large tracked equipment was being serviced. Since most washracks had only low-pressure, high-volume wash equipment, washrack wastewaters contained high concentrations of suspended solids, free and emulsified oils, and biological oxygen demanding materials because of the various cleaning aids that had to be used to supplement the standard equipment. Under these conditions, relatively complex water pollution control equipment would have to be used to clean up wastewater discharges to the storm drainage or sanitary collection system. If this equipment were installed, it was virtually certain it could not be maintained by Facility Engineering personnel at their existing strength levels.

Table 1
Estimated Waste Oil Generated Annually by Various Tactical Units

Unit Designation	Vehicle Track	Counts Wheeled	Estimated Waste Oil Generated Gal (L)*
Cavalry Squadron	36	43	800 (3032)
Artillery Battalion (BN) (inf div)	0-5	91-111	400-900 (1516-3411)
Air Defense Artillery BN	44	115	900 (3411)
Military Policy Group (GP)		54	100 (379)
Ordnance CO	2	46	400 (1516)
Transportation CO		70-73	300-600 (1137-2274)
Adjutant General CO		29	100 (379)
Signal BN		160-222	600 (2274)
Engineer BN	12-18	214	800-1700 (3032-6443)
Military Intelligence GP		21	100 (379)
Armored BN	94	78	3400 (12,886)
Mech Inf BN	88	91	900 (3411)
Medical GP		108	300 (1137)
Infantry BN		116	300 (1137)
Supply & Transport CO		123	600 (2274)
Aviation BN		46	200 (758)

*Rounded to next highest 100 gal (379 L).

Table 2
Inventory of Vehicle Washracks for Selected Installations

<u>Installation</u>	<u>Number of Wash Platforms</u>
*Fort Benning, GA	77
*Fort Sill, OK	72
*Fort Lewis, WA	68
*Fort Riley, KS	65
*Fort Bragg, NC	61
*Fort Stewart, GA	52
Fort Campbell, KY	47
Fort Gordon, GA	45
*Fort Bliss, TX	45
Fort Pickett, VA	41
Fort Ord, CA	41
Schofield Barracks, HI	37
*Fort Carson, CO	34
Fort Huachuca, AZ	24
*Fort Devens, MA	23
*Fort Polk, LA	22
Fort McCoy, WI	20
*Fort Drum, NY	18
*Fort Hood, TX**	6(37)
Fort Knox, KY	5(31)
<hr/>	
Subtotal (above installations)	803
Total (Army in Continental United States)	1548

*Installations visited by CFRL representatives.

**CFRL estimates a minimum of 37 wash platforms.

*CFRL documented 31 wash platforms.

3. Existing vehicle washracks invariably were built without a way to control storm water intrusion from adjacent hardstand areas. Therefore, existing facilities, if they were to be retained, would require considerable structural upgrading before wastewater treatment units could be installed.

Centralized Tactical Vehicle Wash Facilities

Establishing centralized tactical vehicle facilities at a given installation is the first step in achieving pollution abatement in TOE vehicle and equipment maintenance operations. Under this concept, existing vehicle washrack facilities within various motor pool areas are abandoned and replaced with one or two major vehicle exterior wash points. These central wash points are strategically located on the periphery of the cantonment area, where

vehicles returning from training or maneuver areas must pass on their way to their respective motor pools.

The principal design features of these central facilities are:

1. Separate wash facilities for tracked and wheeled equipment. This design recognizes the fundamental differences in required wash capability, as well as the differing wastewater characteristics (mostly sediment quantities) generated by each equipment class.

2. Improved washing equipment for each equipment class. Vehicles can therefore be processed more efficiently using significantly less potable water and troop man-hours.

3. Effective wastewater treatment systems for surface discharge or direct recycle, thus taking advantage of the economics of scale.

A plan for one of two centralized vehicle wash facilities as constructed at Fort Lewis, WA, is shown in Figure 1.

Principal Features of the Fort Lewis Design

Tracked Vehicle Washing Area

Special washrack components are provided in an area reserved for washing tracked vehicles. For exterior washing, a tank bath or spray stand may be provided for prewash and combined with individual wash positions. Prewash provisions were not constructed at Fort Lewis. Within the same area, additional individual wash positions are designated for interior washing only e.g., personnel compartments and truck beds. The exterior and interior wash positions have hand-held hoses equipped with shut-off nozzles. Each exterior wash position has two hoses; each interior wash position has one hose. To prevent equipment damage, all hoses are supported above the washing surface by hose towers mounted on wash equipment islands. A tracked vehicle staging area is located in front of the facility to accommodate parked vehicles during peak-use periods.

Wheeled Vehicle Washing Area

Special washrack components also are provided in the area reserved for wheeled vehicle washing. A wheeled vehicle bath (or an automated track-wash modified for Army use) is combined with exterior and interior wash equipment; the interior equipment for washing personnel areas such as truck beds may be placed ahead of the exterior wash positions. Exterior wheeled vehicle wash points have two hand-held hoses, and each interior wash position has one hose. A vehicle staging area is provided to handle excess vehicle flows during peak-use periods.

Wastewater Treatment

Wastewater collected from tracked or wheeled vehicle wash areas is first treated by passing it through a concrete preliminary sedimentation tank. This tank has an inclined access ramp (3:1 slope) for easy settled sediment removal,* and detains the wastewater long enough for free oil separation (2-hr detention at peak flowrate). The access ramp is designed so accumulated sediment can be removed conveniently by front-end loader. Free oil is removed by skimmers. After the wastewater passes

*CERL recommends a maximum slope of 5:1 to allow convenient access by front-end loaders or other equipment used for sediment removal.

from each area's individual sedimentation tank, the effluents are combined and discharged to a cement, bentonite-lined, or otherwise sealed equalization basin. Ideally, all storm water flows from the curbed paved areas of the facility (exclusive of the active wash areas) are sent to this basin. Equalized wastewaters are then discharged periodically to an intermittent sand filter to remove residual fine sediment and dispersed oil. This filtered effluent then is directed to surface drainage for discharge or to a final detention basin or wet well for direct recycle back to the washing operation. The preliminary sedimentation basin has an overflow rate of about 600 gal/day/sq. ft. (24 444 L/day/m²). Sediment storage of 6 months is provided.

Suggested Concept Modifications and Further Research Requirements

Concept Modifications

CERL conducted a post-construction evaluation of the centralized tactical vehicle wash facilities at Fort Lewis, WA, from 14 to 25 September 1981. It was decided that the only concept modification that should be considered was to drop the distinction between exterior and interior wash positions for both tracked and wheeled vehicle washing. Instead, all wash islands should be designed to perform both exterior and interior washing at one position. The wastewater collection system draining the wash islands then should be designed to hydraulically handle the solids-loading produced under worst-case conditions (i.e., during tracked vehicle exterior washing operations). If interior wash positions are retained, they must not be in a direct line with the exterior wash islands unless a by-pass lane is provided so washed equipment can move out of the vehicle wash area.

Further Research Requirements

Vehicle Baths. Priority should be given to the development of design criteria for the vehicle baths, particularly tank baths, used to preclean tactical equipment. A successful tank bath design would cut vehicle cleaning times significantly, reduce the number of exterior wash stations required, and lower overall water use and wastewater treatment costs. The first step in identifying such a design is to measure the cleaning-time effectiveness, water use profiles, and desludging capabilities of existing bath designs.

Exterior Vehicle Wash Equipment. The hose tower, wash hose, hose nozzle, and shut-off system designed for Fort Lewis must be improved. A top priority is identifying or developing a trigger-operated nozzle and shut-off system that can withstand hard treatment.

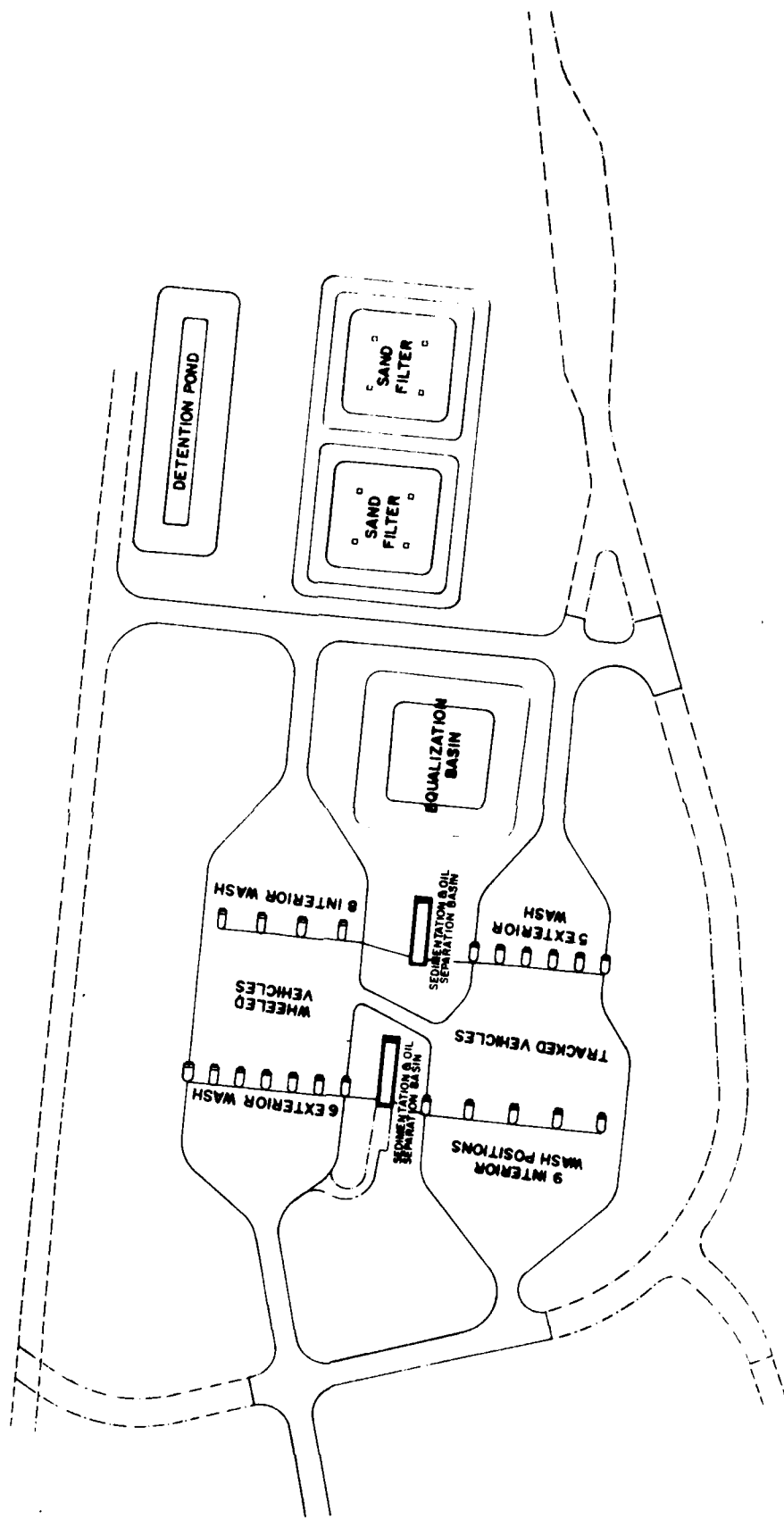


Figure 1. Centralized vehicle wash facility at Fort Lewis, WA.

Wastewater Treatment System. The Fort Lewis wastewater treatment system appears to be functioning properly. But the extent to which it may be over-designed is not known. A thorough study of the treatment system at Fort Lewis and its use as a test bed for alternate treatment system components could resolve many questions and ultimately lead to standard design criteria for various wastewater treatment components. A U.S. Army Environmental Hygiene Agency (AEHA) report has detailed operational results of the treatment system during early operation.²

Recycled Water Quality. The selection of an effective wastewater treatment process is closely tied to the level of acceptable recycled water quality. If treated washrack wastewater is to be directed to surface discharge or to an installation's sanitary collection system, effluent requirements must be fairly well defined. If acceptable recycled water quality could be quantitatively defined, and if it was found to be considerably less stringent than that required for surface discharge, wastewater treatment costs could be reduced significantly.

In-Motor Pool Tactical Vehicle Maintenance Facilities

The results of a survey of oil pollution sources within TOE maintenance complexes conducted during 1977 and 1978 indicated:

1. In general, storage and handling facilities for new oils and lubricants were extremely primitive.
2. Most TOE unit maintenance was conducted on the vehicle parking or hardstand area.
3. Far more maintenance operations were conducted at the vehicle washrack than just exterior vehicle washing.
4. No pollution control was available for any of the maintenance services performed on tracked equipment.

Because existing washracks were based on vague or unspecified design criteria, with little or no consideration for operation-based pollution control, only end-of-pipe treatment was historically attempted. Treatment facilities for exterior washing wastewaters in motor pool areas would be impractical at most installations because of size and operation and maintenance requirements. However, under the CERL concept, centralized

tactical vehicle wash facilities would replace all existing in-motor pool vehicle washracks within the limits of economic acceptability.

CERL's tracked vehicle maintenance facility concept was designed to minimize overall water pollution control requirements, and at the same time effectively meet the wet maintenance requirements of tracked equipment. Primary wet maintenance operations were defined as (1) maintenance cleaning of engines, engine packs (engines plus transmissions), engine compartments and other large vehicle components; (2) fine cleaning of vehicle exteriors before painting; and (3) all oil changing operations associated with tracked equipment. CERL's concept design met the wet maintenance requirements of all wheeled equipment in the Army's current inventory. A plan of the facility as designed for use at Fort Lewis is shown in Figure 2.

Centralized Tracked Vehicle Maintenance Facility Concept — Principal Design Features

The tracked vehicle maintenance facility has a canopied service platform raised above the hardstand area to preclude most storm water intrusion from adjacent hardstand areas. It also protects troops and vehicles from inclement weather.

Service Platforms

The service platform is divided into an oil changing area and a maintenance cleaning area. As designed, all oil changing is done in a lighted service pit equipped with a sliding waste oil collection funnel. The funnel, which is sized to contain a quantity of oil equal to the maximum combined crankcase and transmission capacity of an M-88 tracked vehicle, discharges into a collection trough mounted on the sidewall of the service pit. This trough is connected by rigid piping to a 100-gal (3790-L) underground waste oil storage tank.

The sliding waste oil collection funnel was designed so it has limited movement within the service pit. This lets it act as a vehicle positioner for the M-60 tank. Vehicle position is important when servicing this vehicle type because the engine pack can only be removed after the gun has been rotated. The vehicle must be positioned correctly to protect the canopy columns from being damaged when the gun turret is rotated. A desirable modification would be the elimination of the center columns shown on the Fort Lewis platforms.

Maintenance cleaning can be done either with the vehicle in position over the service pit or in the maintenance cleaning area proper. The service pit area is used mainly to clean engine compartments and wheeled

²Evaluation of Consolidated Washrack and POI Pollution Control Facilities, Ft. Lewis, WA, 14-25 Sep 81, Water Quality Engineering Special Study No. 32-66-8828-82 (AEHA, 26 January 1982).

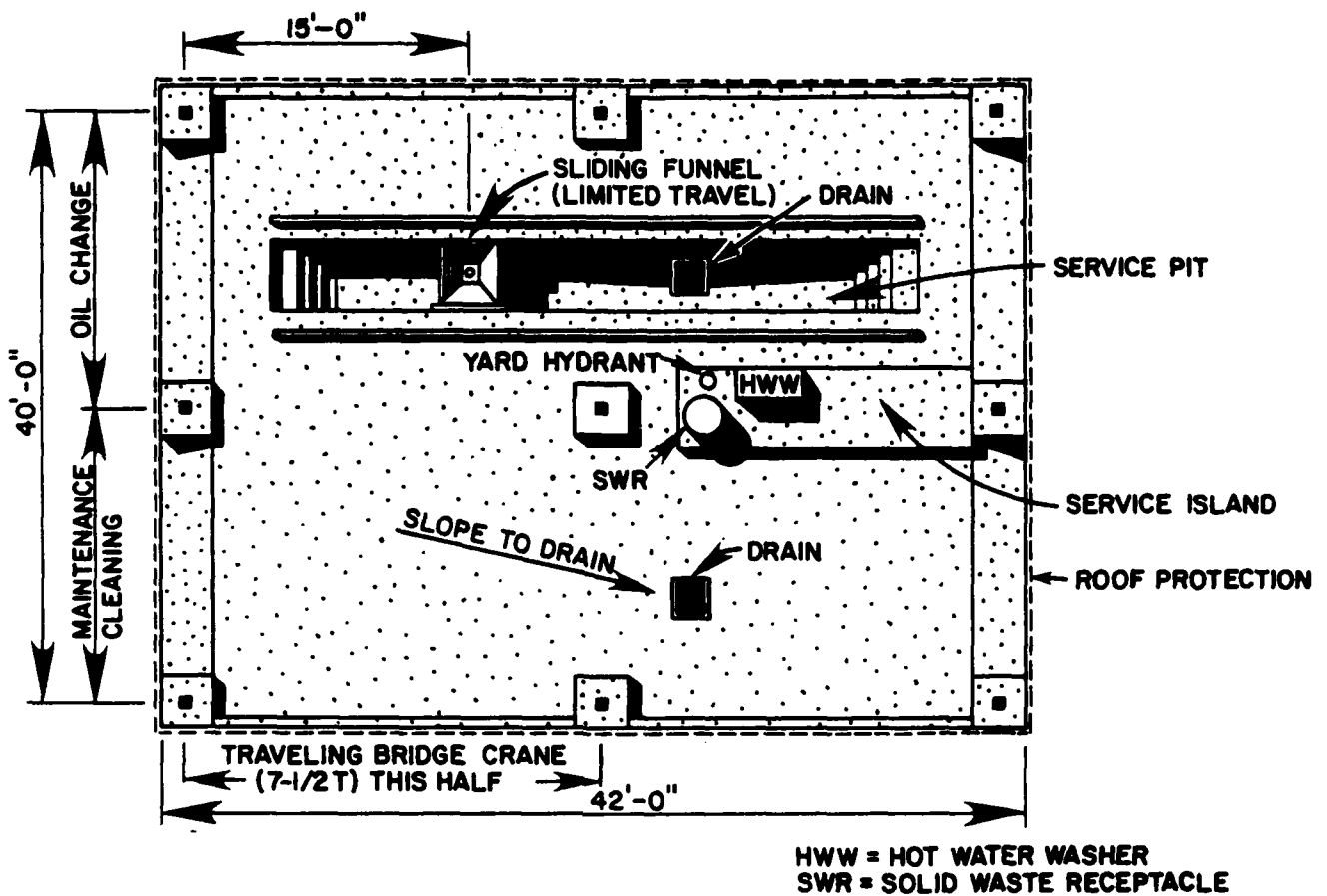


Figure 2. Tracked vehicle maintenance platform. (Source: D. Seman, KPFF Engineers, Inc., Seattle, WA.)

vehicle undercarriages. The main maintenance cleaning area is used for equipment inspection cleaning, and to prepare exterior vehicle surfaces before painting or for cleaning engine packs and other large components. Engine packs are moved from the service pit to the adjacent maintenance cleaning area by a 7-1/2-ton (6795-kg) capacity traveling bridge crane. Cleaning equipment is located on a raised service island which includes a waste receptacle for used filters, worn parts, and other litter generated during vehicle servicing.

Cleaning Equipment

The facility has a commercial hot water washer modified for Army use. This washer, which can be used in a hot or cold water mode of operation, is an electricaly driven, kerosene-fired unit rated at 3.5 gal (13.3 L) per minute at 700 psi (4828 kPa). It was modified by removing the piping and valves associated with its chemical injection system, removing the oil burner

adjustment knob, and adjusting it to deliver wash water at 160°F (71°C). Instead of a potable water feed system that incorporated an air-break for backflow prevention, a reduced-pressure principle backflow preventer was used in conjunction with a cold water pressure regulator system. The entire exposed cold water feed system up to the boiler inlet has a thermostatically controlled heat trace to allow all-weather operation.

Wastewater Treatment

A packed gravity separator wastewater treatment unit was selected for use at Fort Lewis. The unit consists of a rectangular concrete basin separated into two distinct areas: a presettling area for the separation of readily separable solids and free oils, and an area housing a corrugated plate interceptor package* for removal of fine solids and dispersed oils. Separated oils contained

*Manufactured by ERC/Lancy, Inc., St. Paul, MN.

on the surface within the basin to a depth established by the elevation of an adjustable skimmed oil weir are conveyed by pipe to an external skimmed oil holding tank. Effluent from the unit is conveyed by gravity or pumped to the sanitary collection system.

Design standards included (1) a design overflow rate not to exceed 60 gal/day/sq ft (2444 L/day/m²) of effective surface at maximum flow, and (2) a combined sediment storage capacity of not less than 68 cu ft (2 m³). These criteria were necessary to meet the effluent standards listed in Table 3.

Centralized Wheeled Vehicle Maintenance Facility – Principal Design Features

The wheeled vehicle maintenance facility concept provides a weather-protected area where general wheeled vehicle maintenance tasks other than routine exterior vehicle washing can be performed. A plan and section of the facility as designed for use at Fort Lewis is shown in Figure 3.

The facility has an elevated grease rack co-located with a curbed and canopied maintenance cleaning pad. Like the tracked vehicle maintenance facility, it has two primary functional areas: oil changing and maintenance cleaning.

Oil Changing Area

Oil is changed on the elevated grease rack's horizontal section for all wheeled equipment capable of being driven onto it. This section has two fixed waste-oil collection funnels and is lighted overhead and at working level for 24-hour operation. The funnels have hinged, two-section covers and drain into an underground waste-oil storage facility with a minimum capacity of 300 gal (1136 L). (If a unit does not have a tracked vehicle maintenance platform, the waste-oil inlet shown in Figure 4 should be put in the maintenance cleaning slab.)

Maintenance Cleaning Area

For wheeled equipment, maintenance cleaning can be performed either with the vehicle elevated on the horizontal section of the grease rack (for under-carriage cleaning) or with the vehicle parked on the adjacent maintenance cleaning pad. Wastewater is conveyed to the treatment unit in the nearby maintenance facility area.

Cleaning Equipment

The wheeled vehicle maintenance facility uses the same cleaning equipment as the tracked vehicle maintenance facility.

Wastewater Treatment

The wheeled vehicle maintenance facility should have a wastewater treatment arrangement similar to that used for the tracked vehicle maintenance facility. Although no specific design criteria are available, it is likely that the overflow rates and sediment storage allowed for pretreatment of wastewater discharges from tracked vehicle maintenance operations could be reduced to meet established wastewater pretreatment requirements.

Recommended Design Changes

CERL conducted a post-construction evaluation of the new in-motor pool maintenance facilities at Fort Lewis from 14 to 25 September 1981. Based on that evaluation, it is recommended that the following changes be made to the tracked vehicle maintenance facility:

1. A raised and covered waste-oil inlet should be included in all facilities of this type constructed in the future (Figure 5). The inlet should be in the center of the section of the maintenance changing area serviced by the overhead traveling crane. The interior pit dimensions should be about 42 X 42 in. (1070 X 1070 mm) to accommodate oil removed from the M-60 tank when oil is changed with the engine pack in the vehicle.

Table 3
Effluent Requirements for Pretreated Wastewaters From Vehicle Maintenance Facilities

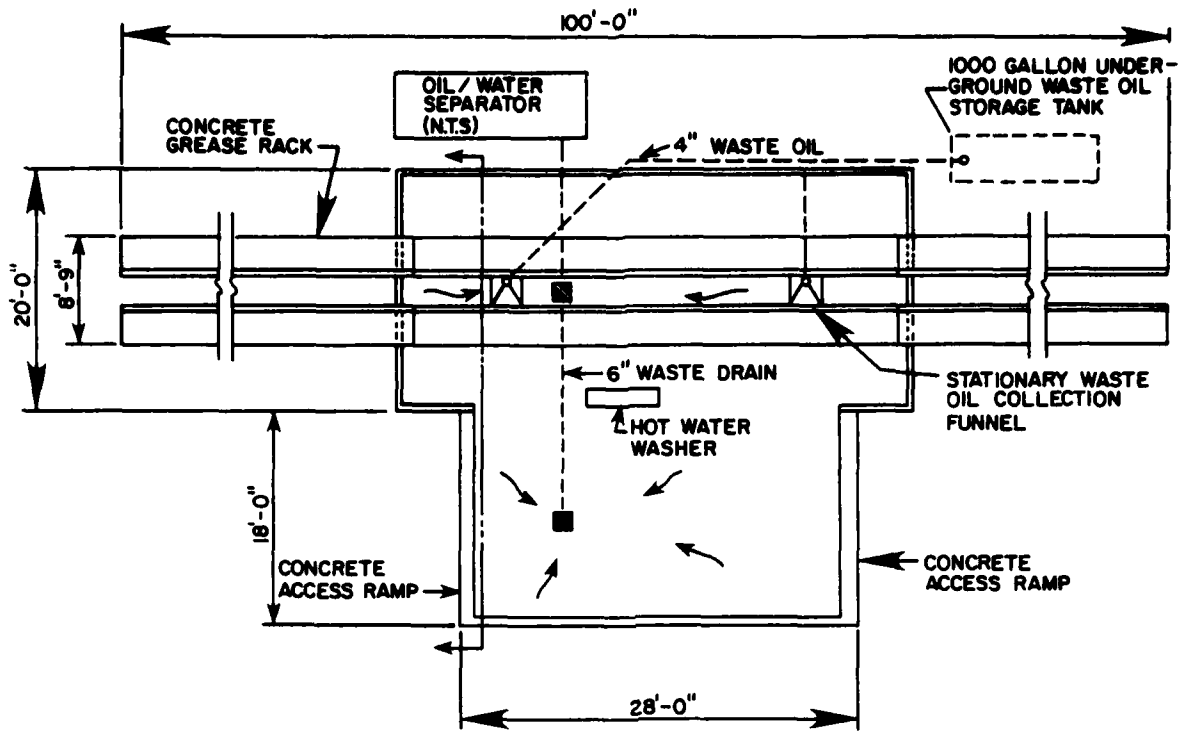
Total Suspended Solids: 30 mg/L (maximum), 200 mg/L (average)

Total Grease and Oil: 100 mg/L (maximum), 50 mg/L (average)

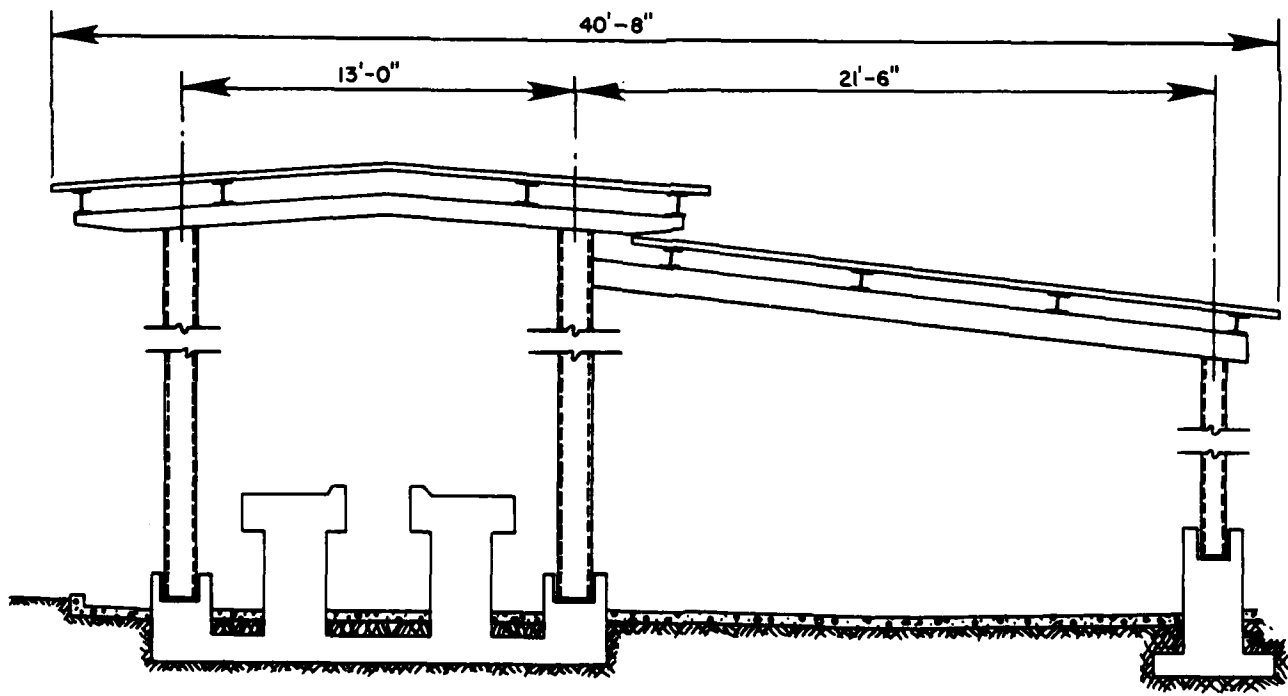
pH: 6.0 to 9.0

BOD₅: 400 mg/L (maximum), 300 mg/L (average)

Other: Effluent shall not contain any visible sheen nor interfere in any respect with an installation's or other domestic wastewater collection and treatment plant processes.



PLAN
SCALE: 1" = 10'



SECTION
SCALE: 1/4" = 1'-0"

Figure 3. Wheeled vehicle maintenance facility. (Source: D. Seman, KPFF Engineers, Inc., Seattle, WA.)

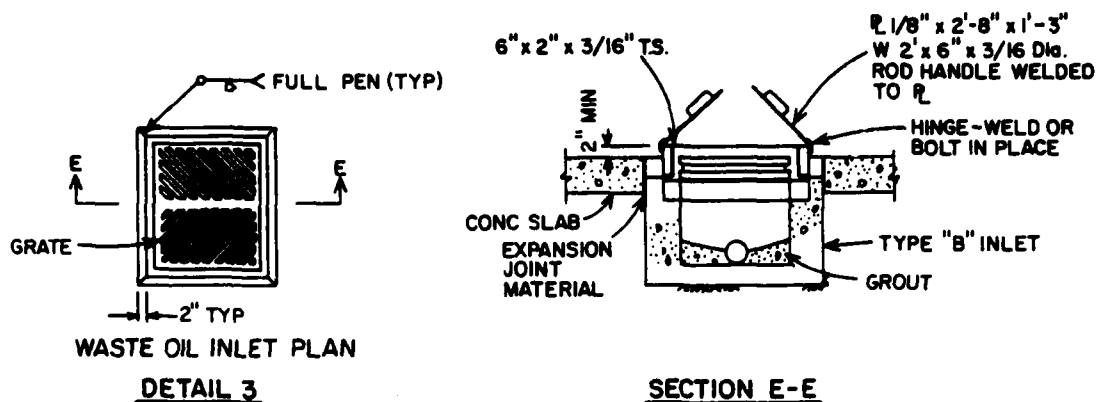


Figure 4. Waste oil inlet details -- wheeled vehicle maintenance facility.
 (Source: D. Seman, KPFF Engineers, Inc., Seattle, WA.)

2. The sliding waste-oil collection funnel in the pit area should be designed to allow 48 in. (1219 mm) of funnel centerline travel rather than the 5 in. (127 mm) allocated in the present design.

3. The service pit depth should be increased to 60 in. (1524 mm). The present pit depth is 46 in. (1168 mm).

4. The present sliding waste-oil collection funnel cover assembly should be redesigned so oil can be caught and transferred for disposal from 21 in. (530 mm) on either side of the funnel centerline. This would accommodate oil removed from the M-60 engine pack inside the vehicle if no raised waste-oil inlet is included in the facility design.

Further Research Requirements

1. A self-propelled, universal engine pack dolly would increase the effectiveness of "Q" servicing of the M-60 tank (and of the M-1 tank when it is deployed). When developed, this dolly would be placed on an installation's Table of Distribution and Allowances (TDA) list; it would not be part of a particular unit's TOE.

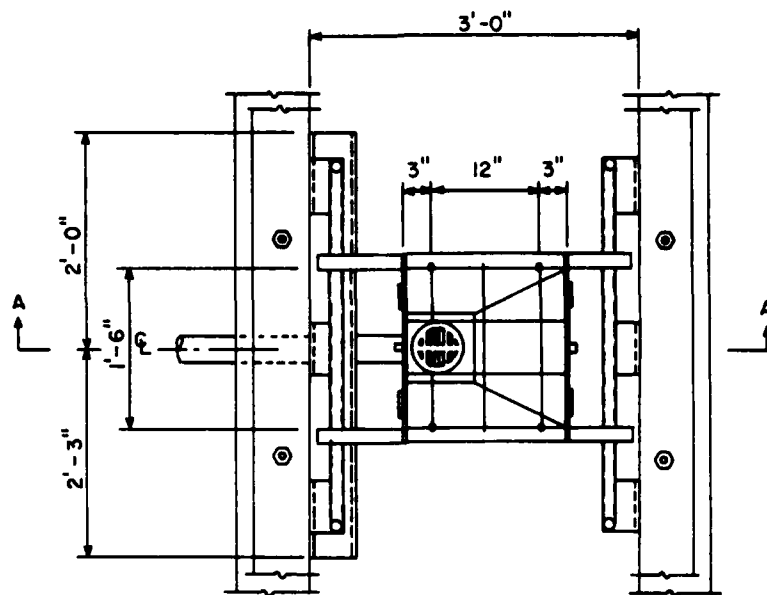
2. Design criteria must be developed for the pre-treatment of wastewaters from wheeled vehicle maintenance facilities.

3. A full evaluation of the "Q" servicing requirements of various organizational units must be made and compared to the capabilities of the tracked vehicle maintenance facility.

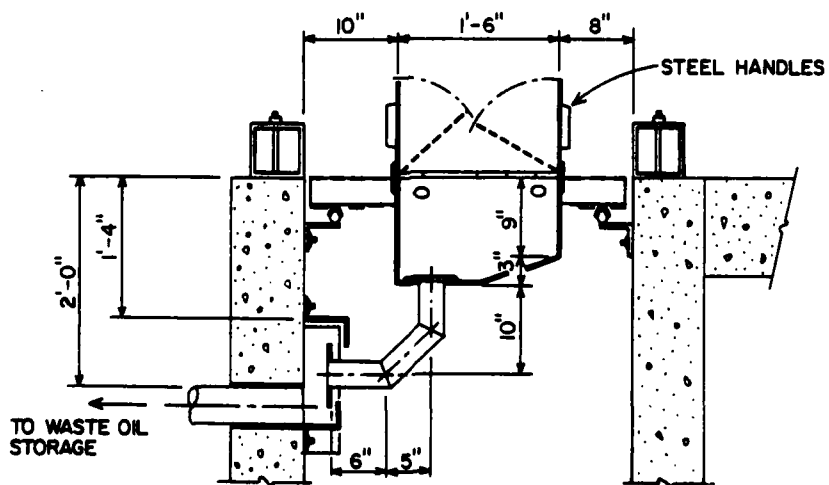
4 NEW TOE MAINTENANCE SHOP DESIGN CONCEPTS

The new in-motor pool maintenance facilities described in Chapter 3 were developed to make up for the lack of functional design considerations within existing TOE maintenance shops. Ideally, if new TOE maintenance shops were designed so all wet maintenance operations could be performed in a covered area under controlled conditions, the concept of centralized vehicle wash facilities would resolve all the major water pollution control problems of TOE unit maintenance.

To guarantee effective pollution abatement, existing standard facilities such as the vehicle washrack and the wheeled vehicle grease rack must be replaced. New shop structures must be developed that incorporate highly efficient maintenance bay areas in their design. This will require detailed research into individual TOE unit operations so the new maintenance areas are as operationally flexible as possible. The scheduled and unscheduled maintenance bay area concept appears to have considerable merit and should be evaluated. Under this concept, one highly developed maintenance bay would handle the scheduled maintenance load of a given organizational unit battalion. This main maintenance area would be supported by two or more unscheduled maintenance bays equipped to perform nonroutine vehicle and equipment maintenance.



PLAN
SLIDING FUNNEL DETAIL I



SECTION A-A

Figure 5. Waste oil collection funnel -- tracked vehicle maintenance platform. (Source: D. Seman, KPFF Engineers, Inc., Seattle, WA.)

Scheduled Maintenance Bay

The scheduled maintenance bay would handle the wet maintenance requirements of four large tactical vehicles (wheeled or tracked) simultaneously (Figure 6). It would have two identical service pits running virtually the full length of the maintenance bay, two central service islands, and two runways for servicing engine packs. Lift capability would be provided by a 7-1/2-ton (6795-kg) traveling bridge crane and fixed or portable floor jacks. Each service island would have a hot water

washer, a large parts washer, and space for tool chests, solid waste receptacles, small parts storage, and other, ancillary equipment. Each service pit would be lighted, and have electrical outlets for trouble lights, etc.; a movable waste-oil collection funnel; and a floor drain to accept wastewaters from the cleaning of engine compartments, heat shields, and wheeled vehicle undercarriages, etc. The two engine pack runways would contain one or more raised used-oil drops and a waste-water inlet. Fluid dispensing equipment and compressed

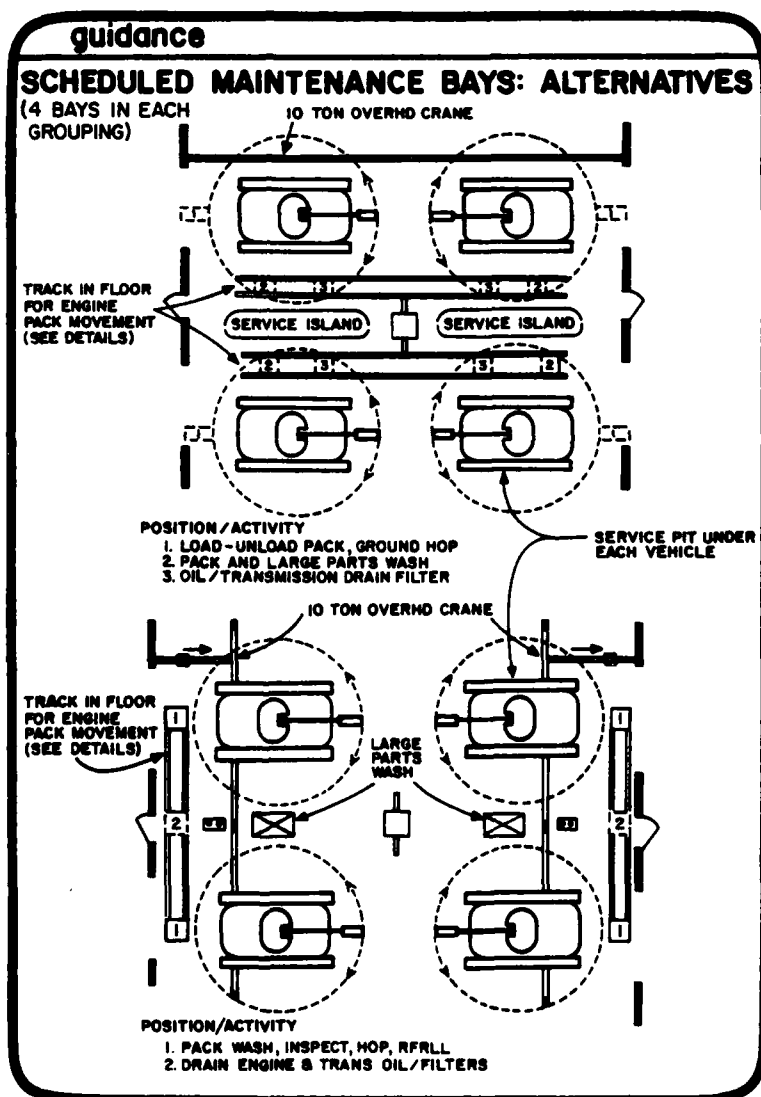


Figure 6. Scheduled maintenance bay.

air would be provided overhead at each service pit. Bulk fluid would be stored outside the maintenance shop in underground containers. Separate drainage systems would collect used oils and spent solvents and discharge them to underground waste holding tanks. Engine packs would be ground-hopped at the four entrance doors.

Unscheduled Maintenance Bay

Each company would have an unscheduled vehicle maintenance bay in which to inspect vehicles, adjust

fluid levels, paint equipment, and make minor repairs (Figure 7). The bay's service pit would occupy about one-half of the length of the bay and a clear forebay area. The service pit would be equipped with a sliding waste-oil collection funnel; it would also have a floor drain so the pit area could be cleaned periodically. No major hot water wash equipment would be provided, but the service pit area would have a small parts washer and an overhead fluid dispenser. Lift capability would consist of floor or portable jacks in the clear bay area and movable, A-frame, manually operated lift stands.

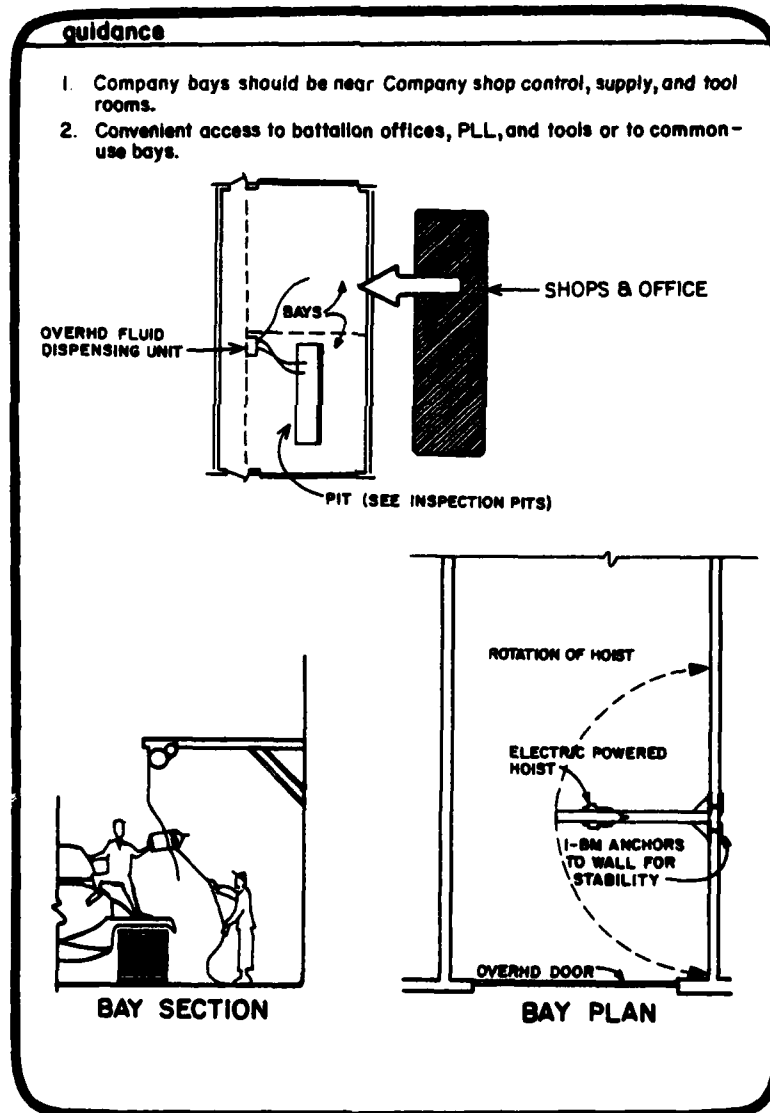


Figure 7. Unscheduled maintenance bay.

5 CONCLUSIONS

This report described the principal design features of CERL's TOE unit maintenance operation water pollution control concepts and described the results of a limited survey and evaluation of newly constructed facilities at Fort Lewis and Yakima Firing Center; these facilities were built based on CERL's concepts.

For the centralized tactical vehicle wash facility concept, it was concluded that the design must be modified to include:

1. A single wash position for exterior and interior washing.
2. Wastewater collection systems hydraulically flushed to handle the solids-loading of exterior tracked vehicle washing.
3. Improved vehicle baths and exterior wash equipment that can optimize water pollution control.
4. A standard wastewater treatment system that can guarantee effluent quality.

For the tracked vehicle maintenance facility concept, it was concluded that the design must be modified to include:

1. A raised and covered waste-oil inlet.
2. Interior pit dimensions of at least 42 X 42 in. (1070 X 1070 mm).
3. A sliding waste-oil collection funnel in the pit area that allows 48 in. (1219 mm) of funnel centerline travel.
4. A service pit at least 60 in. (1524 mm) deep.
5. A sliding waste-oil collection assembly that allows oil to be caught and transferred for disposal from 21 in. (530 mm) on either side of the funnel centerline.

In addition, the following should be developed:

1. A self-propelled, universal engine pack dolly.
2. Design criteria for wastewater pretreatment.
3. Criteria for "Q" servicing.

Chief of Engineers
ATTN: Tech Monitor
ATTN: DAEN-AS1-L (2)
ATTN: DAEN-CCP
ATTN: DAEN-CW
ATTN: DAEN-CWE
ATTN: DAEN-CW-R
ATTN: DAEN-CWO
ATTN: DAEN-CWP
ATTN: DAEN-MP
ATTN: DAEN-MPC
ATTN: DAEN-MPE
ATTN: DAEN-MPD
ATTN: DAEN-MPR-A
ATTN: DAEN-RD
ATTN: DAEN-RDC
ATTN: DAEN-RDM
ATTN: DAEN-RM
ATTN: DAEN-ZC
ATTN: DAEN-ZCE
ATTN: DAEN-ZCI
ATTN: DAEN-ZCM

FESA, ATTN: Library 22060

FESA, ATTN: DET III 79906

US Army Engineer Districts

ATTN: Library
Alaska 98501
Al Betin 09616
Albuquerque 87103
Baltimore 21203
Buffalo 14207
Charleston 29402
Chicago 60604
Detroit 48231
Far East 96301
Fort Worth 76102
Galveston 77550
Huntington 25721
Jacksonville 32232
Japan 96343
Kansas City 64106
Little Rock 72203
Los Angeles 90053
Louisville 40201
Memphis 38103
Mobile 36628
Nashville 37202
New Orleans 70160
New York 10007
Norfolk 23510
Omaha 68102
Philadelphia 19106
Pittsburgh 15222
Portland 97208
Riyadh 09038
Rock Island 61201
Sacramento 95814
San Francisco 94105
Savannah 31402
Seattle 98124
St. Louis 63101
St. Paul 55101
Tulsa 74102
Vicksburg 39180
Walla Walla 99362
Wilmington 28401

US Army Engineer Divisions

ATTN: Library
Europe 09757
Huntsville 35807
Lower Mississippi Valley 39180
Middle East 09038
Middle East (Rear) 22601
Missouri River 68101
New England 02154
North Atlantic 10007
North Central 60605
North Pacific 97208
Ohio River 45201
Pacific Ocean 96858
South Atlantic 30303
South Pacific 94111
Southwestern 75202

US Army Europe

HQ, 7th Army Training Command 08114
ATTN: AETTG-DEH (5)
HQ, 7th Army ODCS/Engr. 09403
ATTN: AEAEH-EH (4)
V. Corps 09079
ATTN: AETVDEH (5)
VII. Corps 09154
ATTN: AETSDEH (5)
21st Support Command 09325
ATTN: AEREH (5)
Berlin 09742
ATTN: AEBA-EH (2)
Southern European Task Force 09188
ATTN: AESE-ENG (3)
Installation Support Activity 09403
ATTN: AEUES-RR

8th USA, Korea
ATTN: EAFE (8) 96301
ATTN: EAFE-Y 96358
ATTN: EAFE-ID 96224
ATTN: EAFE-AM 96208
ATTN: EAFE-H 96271
ATTN: EAFE-P 96259
ATTN: EAFE-T 96212

Rocky Mt. Arsenal, SARRM-IS 80022

Area Engineer, AEDC-Area Office
Arnold Air Force Station, TN 37389

Western Area Office, CE
Vanderberg AFB, CA 93437

418th Engineer Command 60623
ATTN: Facilities Engineer

USA Japan (USARJ)
Ch, FE Div, AJEN-FE 96343
Fac Engr (Honehu) 96343
Fac Engr (Okinawa) 96331

ROK/US Combined Forces Command 96301
ATTN: EUSA-HHC-CFC/Engr

US Military Academy 10896
ATTN: Facilities Engineer
ATTN: Dept of Geography &
Computer Science
ATTN: DSCPER/MAEN-A

Engr. Studies Center 20315
ATTN: Library

AMMRC, ATTN: DRXMR-WE 02172

USA ARRCOM 61299
ATTN: DRCIS-RI-I
ATTN: DR SAR-IS

DARCOM - Dir., Inst., & Svcs.
ATTN: Facilities Engineer
ARRADCOM 07801

Aberdeen Proving Ground 21005
Army Matls. and Mechanics Res. Ctr.
Corpus Christi Army Depot 78419
Harry Diamond Laboratories 20783
Dugway Proving Ground 84022
Jefferson Proving Ground 47250
Fort Monmouth 07703
Letterkenny Army Depot 17201
Natick R&D Ctr. 01780
New Cumberland Army Depot 17070
Pueblo Army Depot 81001
Red River Army Depot 75501
Redstone Arsenal 35809
Rock Island Arsenal 61289
Savanna Army Depot 61074
Sherpe Army Depot 95331
Seneca Army Depot 14541
Tobyhanna Army Depot 18466
Tooele Army Depot 84074
Watervliet Arsenal 12189
Yuma Proving Ground 85364
White Sands Missile Range 88002

OLA ATTN: OLA-WI 22314

FORSCOM

FORSCOM Engineer, ATTN: AFEN-FE
ATTN: Facilities Engineer
Fort Buchanan 00934
Fort Bragg 28307
Fort Campbell 42223
Fort Carson 80913
Fort Devens 01433
Fort Drum 13601

FORSCOM

ATTN: Facilities Engineer
Fort Hood 76544
Fort Indiantown Gap 17003
Fort Irwin 92311
Fort Sam Houston 78234
Fort Lewis 98433
Fort McCoy 54856
Fort McPherson 30330
Fort George G. Meade 20755
Fort Ord 93941
Fort Polk 71459
Fort Richardson 99505
Fort Riley 66442
Presidio of San Francisco 94129
Fort Sheridan 60037
Fort Stewart 31313
Fort Wainwright 98703
Vancouver Bks. 98860

HSC

ATTN: HSLD-F 78234
ATTN: Facilities Engineer
Fitzsimons Army Medical Center 80240
Walter Reed Army Medical Center 20012
National Guard Bureau 20310
Installation Division

INSCOM - Ch, Inatl. Div.
ATTN: Facilities Engineer
Arlington Hall Station (2) 22212
Vint Hill Farms Station 22188

MDW

ATTN: Facilities Engineer
Cameron Station 22314
Fort Lesley J. McNair 20319
Fort Myer 22211

MTMC

ATTN: MTMC-SA 20315
ATTN: Facilities Engineer
Oakland Army Base 94626
Bayonne MDT 07002
Sunny Point MDT 28481

NARADCOM, ATTN: DRDWA-F 071160

TAHCOM, Fac. Div. 48090

TECOM, ATTN: DRSTE-LG-F 21005

TRADOC

HQ, TRADOC, ATTN: ATEN-FE
ATTN: Facilities Engineer
Fort Belvoir 22060
Fort Benning 31905
Fort Bliss 79916
Carlisle Barracks 17013
Fort Chaffee 72902
Fort Dix 08640
Fort Eustis 23604
Fort Gordon 30905
Fort Hamilton 11252
Fort Benjamin Harrison 46216
Fort Jackson 29207
Fort Knox 40121
Fort Leavenworth 66027
Fort Lee 23801
Fort McLean 36205
Fort Monroe 23651
Fort Rucker 36362
Fort Sill 73503
Fort Leonard Wood 65473

TSARCOM, ATTN: STSAS-F 83120

USACC

ATTN: Facilities Engineer
Fort Huachuca 85613
Fort Ritchie 21719

WESTCOM

ATTN: Facilities Engineer
Fort Shefter 96858

SHAPE 09055

ATTN: Survivability Section, CQB-OPS
Infrastructure Branch, LANDA

HQ USEUCOM 09128

ATTN: ECJ 4/7-LOE

Fort Belvoir, VA 22060

ATTN: ATZA-DTE-EH

ATTN: ATZA-DTE-SW

ATTN: ATZA-FE

ATTN: Engr. Library

ATTN: Canadian Liaison Office (2)

ATTN: INR Library

Cold Regions Research Engineering Lab 03755

ATTN: Library

ETL, ATTN: Library 22060

Waterways Experiment Station 39180

ATTN: Library

HQ, XVIII Airborne Corps and 28307

Fl. Bragg

ATTN: AFZA-FE-EE

Chanute AFB, IL 61868

3346 CES/DE, Stop 27

Norton AFB 92409

ATTN: AFRCE-ND/DEE

NCEL 93041

ATTN: Library (Code LD8A)

Tyndall AFB, FL 32403

AFESC/Engineering & Service Lab

Defense Technical Info. Center 22314

ATTN: DDA (12)

Engineering Societies Library 10017

New York, NY

National Guard Bureau 20310

Installation Division

US Government Printing Office 22304
Receiving Section/Depository Copies (2)

ENE team Distribution

Chief of Engineers
 ATTN: DAEN-MPO-B
 ATTN: DAEN-MPO-U
 ATTN: DAEN-MPR
 ATTN: DAEN-MPZ-A

US Army Engineer district
 New York 10007
 ATTN: Chief, NANEN-E
 ATTN: Chief, Design Br.
 Pittsburgh 15222
 ATTN: Chief, Engr Div
 Philadelphia 19106
 ATTN: Chief, NAPEN-E
 Norfolk 23510
 ATTN: Chief, NAOEN-D
 Huntington 25721
 ATTN: Chief, ORHED-H
 Wilmington 28401
 ATTN: Chief, SAWEN-PM
 ATTN: Chief, SAWEN-E
 Charleston 29402
 ATTN: Chief, Engr Div
 Savannah 31402
 ATTN: Chief, SASAS-L
 Jacksonville 32232
 ATTN: Env Res Br
 Mobile 36128
 ATTN: Chief, SAMEN-C
 Vicksburg 39180
 ATTN: Chief, Engr Div
 Louisville 40201
 ATTN: Chief, Engr Div
 St. Paul 55101
 ATTN: Chief, ED-H
 Chicago 60604
 ATTN: Chief, NCCCO-R
 ATTN: Chief, NCCED-H
 ATTN: Chief, NCCPD-ER
 ATTN: Chief, NCCPE-PES
 St. Louis 63101
 ATTN: Chief, ED-B
 ATTN: Chief, ED-D
 Kansas City 64106
 ATTN: Chief, Engr Div
 Omaha 68102
 ATTN: Chief, Engr Div
 Little Rock 72203
 ATTN: Chief, Engr Div
 Tulsa 94102
 ATTN: Chief, Engr Div
 Fort Worth 76102
 ATTN: Chief, SWFED-D
 ATTN: Chief, SWFED-MA/MR
 Galveston 77550
 ATTN: Chief, SWGAS-L
 ATTN: Chief, SWGCO-M
 Los Angeles 90053
 ATTN: Chief, SPLED-E
 San Francisco 94105
 ATTN: Chief, Engr div
 Sacramento 95814
 ATTN: Chief, SPKED-D
 Far East 96301
 ATTN: Chief, Engr Div
 Seattle 98124
 ATTN: Chief, NPSEN-FM
 ATTN: Chief, EN-DB-SE
 ATTN: Chief, NPSEN-PL-WC
 ATTN: Chief, NPSEN-PL-ER
 Walla Walla 99362
 ATTN: Chief, Engr Div
 Alaska 99501
 ATTN: Chief, NPASA-R

US Army Engineer Division
 New England 02154
 ATTN: Chief, NEDED-E
 North Atlantic 10007
 ATTN: Chief, NADEN-T
 Middle East (Rear) 22601
 ATTN: Chief, MEDED-T
 South Atlantic 30303
 ATTN: Chief, SADEN-Te

US Army Engineer Division
 Huntsville 35807
 ATTN: Chief, HNDED-CS
 ATTN: Chief, HNDED-ME
 ATTN: Chief, HNDED-SR
 Lower Mississippi Valley 39180
 ATTN: Chief, PD-R
 Ohio River 45201
 ATTN: Chief, Engr Div
 North Central 60605
 ATTN: Chief, Engr Planning Br
 Missouri River 68101
 ATTN: Chief, MRDED-T
 Southwestern 75202
 ATTN: Chief, SWDED-TH
 South Pacific 94111
 ATTN: Chief, SPDED-TG
 ATTN: Laboratory
 Pacific Ocean 96858
 ATTN: Chief, Engr Div
 ATTN: Chief, PUDED-MP
 ATTN: Chief, PUDED-P

5th US Army 78234
 ATTN: AFKB-LG-E

6th US Army 94129
 ATTN: AFKC-EN

7th US Army 09407
 ATTN: AETM-HRD-LHD

US Army Foreign Science & Tech Center
 ATTN: Charlottesville, VA 22901
 ATTN: Far East Office 96328

USA ARRADCOM
 ATTN: DRDAR-LCA-OK

West Point, NY 10996
 ATTN: Dept of Mechanics
 ATTN: Library

Ft. Belvoir, VA 22060
 ATTN: Learning Resources Center
 ATTN: ATSE-TD-TL (2)
 ATTN: British Liaison Officer (5)

Ft. Clayton Canal Zone 34004
 ATTN: DFAE

Ft. A. P. Hill 24502
 ATTN: FE

Ft. Leavenworth, KS 66027
 ATTN: ATZLCA-SA

Ft. Lee, VA 23801
 ATTN: DRXMC-D (2)

Ft. McPherson, GA 30330
 ATTN: AFEN-CD

Ft. Monroe, VA 23651
 ATTN: ATEN-AD (3)
 ATTN: ATEN-FE-E
 ATTN: ATEN-FE-U

Aberdeen Proving Ground, MD 21005
 ATTN: AMXHE
 ATTN: HSE-EW

Naval Facilities Engr Command 22332
 ATTN: Code 04

US Naval Oceanographic Office 39522
 ATTN: Library

Naval Training Equipment Center 32813
 ATTN: Technical Library

Port Hueneme, CA 93043
 ATTN: Morell Library

Bolling AFB, DC 20332
 AF/LEEEU

WASH DC 20330
 AF/RDXT

Little Rock AFB
 ATTN: 314/DEEE

Patrick AFB, FL 32925
 ATTN: XRQ

Tinker AFB, OK 73145
 2854 ABG/DEEE

Tyndall AFB, FL 32403
 AFESC/PRT

Bldg Research Advisory Board 20418

Dept of Transportation
 Tallahassee, FL 32304

Dept of Transportation Library 20590

Transportation Research Board 20418

Airports and Construction Services Dir
 Ottawa, Ontario, Canada K1A 0N8

Division of Building Research
 Ottawa, Ontario, Canada K1A 0R6

National Defense Headquarters
 Ottawa, Ontario, Canada K1A 0K2

Fileccia, Robert J

Water pollution control in Army Table(s) of Organization and Equipment (TOE) Unit Maintenance Operation: overview and assessment / by R. Fileccia and J. Matherly -- Champaign, IL : Construction Engineering Research Laboratory ; Springfield, VA : available from NTIS, 1982.

21 p. (Technical report ; N-128)

1. Ft Lewis, WA. 2. Vehicles, military - maintenance and repair.
3. Water - pollution. I. Matherly, Joseph E. II. Title. III. Series :
U.S. Army Construction Engineering Research Laboratory. Technical Report ;
N-128.