TECHNICAL MANUAL

CENTRAL VEHICLE WASH FACILITIES

HEADQUARTERS, DEPARTMENT OF THE ARMY

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CENTRAL VEHICLE WASH FACILITIES

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

1-1. Purpose

This manual provides a comprehensive reference source for planning, and designing a central vehicle wash facility (CVWF) at U. S. Army installations. The CVWF provides a rapid, economical method for washing tracked and wheeled tactical vehicles. The design elements provide for water pollution control, solid waste disposal, and conservation of manpower and water.

1-2. Scope

This manual is limited to wash facilities and wastewater treatment for cleaning vehicle exteriors only; this design information does not pertain to facilities for treating wastewater from maintenance cleaning activities.

1-3. References

The following documents form a part of this manual to the extent referenced:

> TM 5-820-1   Surface Drainage Facilities for Airfields and Heliports
>
> *Standard Methods for Examination of Water and Wastewater* (1987), American Public Health Association, 1015 15th Street N.W., Washington. D.C. 20005; American Water Works Association, 6666 S. Quincy Avenue, Denver, CO 80235; and Water Pollution Control Federation, 2626 Pennsylvania Avenue, Washington, D.C. 20037
>
> *Elements of Water Supply and Wastewater Disposal,* edited by G.M. Fair, J.C.D. Geyer, and D.A. Okun, Second Edition (1971), John Wiley and Sons, Inc., 605 Third Avenue, New York, NY 10158

1-4. Applicability

Information in this manual applies to all CONUS Army installations that maintain a fleet of vehicles for which there is a consistent washing requirement demanding cost-effective, on-post facilities.

1-5. Explanation of terms and abbreviations

Terms and abbreviations used in the manual are explained in the glossary.

1-6. Background

The Army has unique vehicle cleaning requirements in terms of numbers, types of vehicles, washing time, and degree to which washing is critical. Civilian technologies for cleaning Army off-road tactical vehicles and treating the wastewater created by this washing are not recommended. However, civilian technology may apply to facilities for washing vehicles in a transportation motor pool (TMP), most of which are the wheeled, on-road type such as sedans and buses. Figure 1-1 shows the recommended washing sequence for tactical vehicles. For installations where specific conditions require that a prewash be constructed, the washing procedure is shown in figure 1-2. The central vehicle wash facility is designed to provide expedient, cost-effective vehicle cleaning for tactical vehicles. The concept incorporates water conservation including recycle techniques and pollution control.
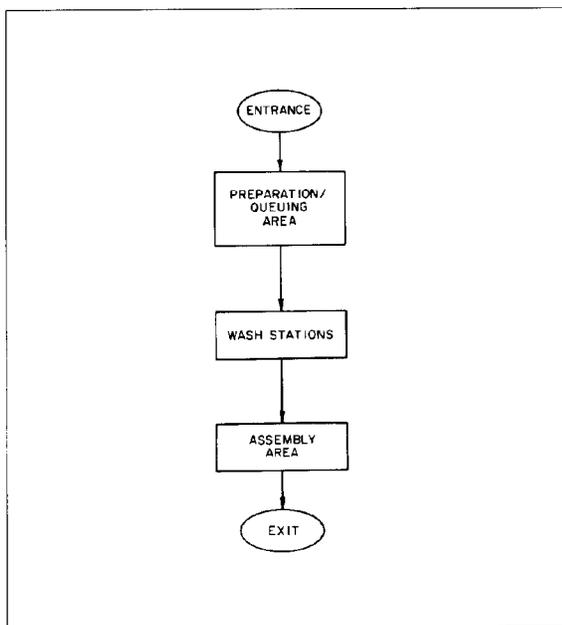
Figure 1-1. Standard washing sequence for tactical vehicles.
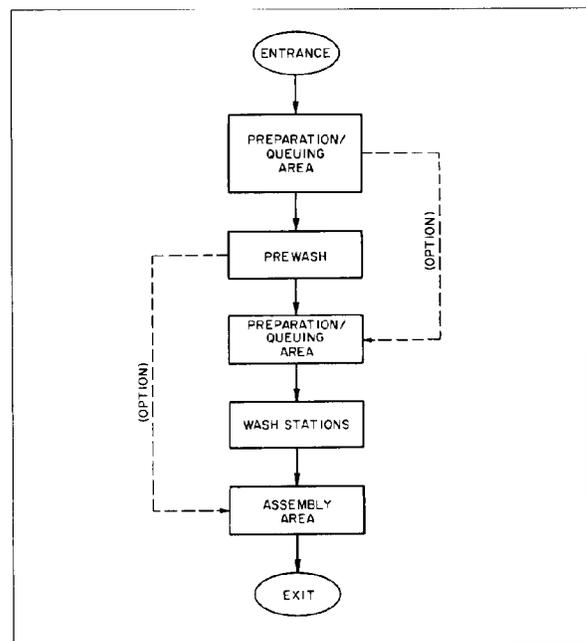
Figure 1-2. Washing procedure with optional prewash.

CHAPTER 2
CVWF DESIGN CONCEPT

2-1. Overview

The standard CVWF consists of a vehicle preparation area, wash stations, and vehicle assembly area (fig 24). However, the layout of a facility will be site-specific, based on the installation's mission and needs. Information on siting and master planning is found in chapter 3. A design example is provided in appendix A.

2-2. Prewash (optional)

At installations with heavy soiling conditions, high demands for washing, and/or limited washing times, a prewash system is recommended. Three types of prewash systems have been constructed for use in tactical vehicle washing: bath, spray stand, and automatic washer. The vehicle bath is the most effective prewash system for Army tactical vehicles. Figure 2-2 shows a typical CVWF plan with the CONUS approved bath prewash system for tactical vehicles. Commercial type, such as those in a Transportation Motor Pool (TMP), would utilize commercial automatic washers and not facilities described for the CVWF.

2-3. Wastewater treatment

A system for conveying and treating wastewater is included in the CVWF design, since water used to wash the vehicles will become contaminated with dirt, debris, and products related to vehicle operation such as oil and grease. All wastewater must receive primary treatment to remove settleable and floating materials. Following primary treatment, the wastewater is either released to a collection system or further treated onsite and stored for reuse during future washing operations. The water used to wash vehicles should be recycled whenever possible and feasible. However, even in a total recycle system, some of the wastewater may need to be released to a discharge system before or after receiving secondary treatment. This discharge is done to ensure that water quality and water balance are maintained. Measured makeup water is added to the recycle system to compensate for the volume of water carried off on the wet vehicles, released, and lost to evaporation.

a. Primary treatment. All wastewater must receive primary treatment. A sediment basin that provides primary treatment is required to allow most of the suspended solids to settle and to allow the free grease and oils to separate from the wastewater.

b. Secondary treatment. For the purposes of this manual, secondary treatment refers to intermittent sand filters, lagoons, or discharges to sanitary sewage systems. Two systems of onsite secondary treatment are used following primary treatment if the water is to be recycled. These methods include intermittent sand filters and lagoons. Lagoons are not the standard system but are included because they have been used as a wastewater treatment method for CVWFs. The third system of handling wastewater, discharge to sanitary sewer, may be available at an installation, but this method is not used in conjunction with a recycle system.

In a discharge system, secondary treatment is done at the installation, local municipal, or regional sanitary wastewater treatment facility. Essentially, all recycle systems are partial treatment systems, as release of some wastewater may become necessary to maintain water quality and to allow discharge of excess storm water collected at the facility.

(1) *Intermittent sand filter system.* This secondary treatment system is comprised of an equalization basin and an intermittent sand filter. The equalization basin holds the wastewater after primary treatment and before it is applied to the filters to equalize flow rates by dampening the high and low-flow variations.

  (a) A dosing tank may be provided after the flow equalization basin to provide a water volume of one charge or dose to a portion of the sand filter. The dosing tank is a designer's option which allows for flexibility in sizing the pumping facilities.

  (b) Water quality testing and metering capabilities are recommended to be provided at a point following the intermittent sand filters to measure the quality and amount of the treated wastewater to be recycled. At this point, facilities should be provided which allow recirculating all or a portion of the filtered water back though filters via the equalization basin. The remaining filtered water flows into the water supply basin and is stored for reuse.

  (c) Water overflow facilities to provide hydraulic protection for the secondary treatment process should be located at the water supply basin for emergency storm release. This overflow system should also be able to make controlled partial wastewater releases to further assist in maintaining the quality and quantity of the recycled water. Hydraulic protection should also be provided at the equalization basin as a backup. Chapter 6 presents details of the sand filter treatment system.

(2) *Lagoon system.* This secondary treatment system consists of a basin or a series of basins where the wastewater is held for an extended period of time to achieve the desired water quality. The treated water is allowed to flow to the water supply basin for reuse. Water quality testing and metering capabilities are recommended to be provided, as well as overflow protection. Chapter 6 explains the lagoon treatment system in greater detail.
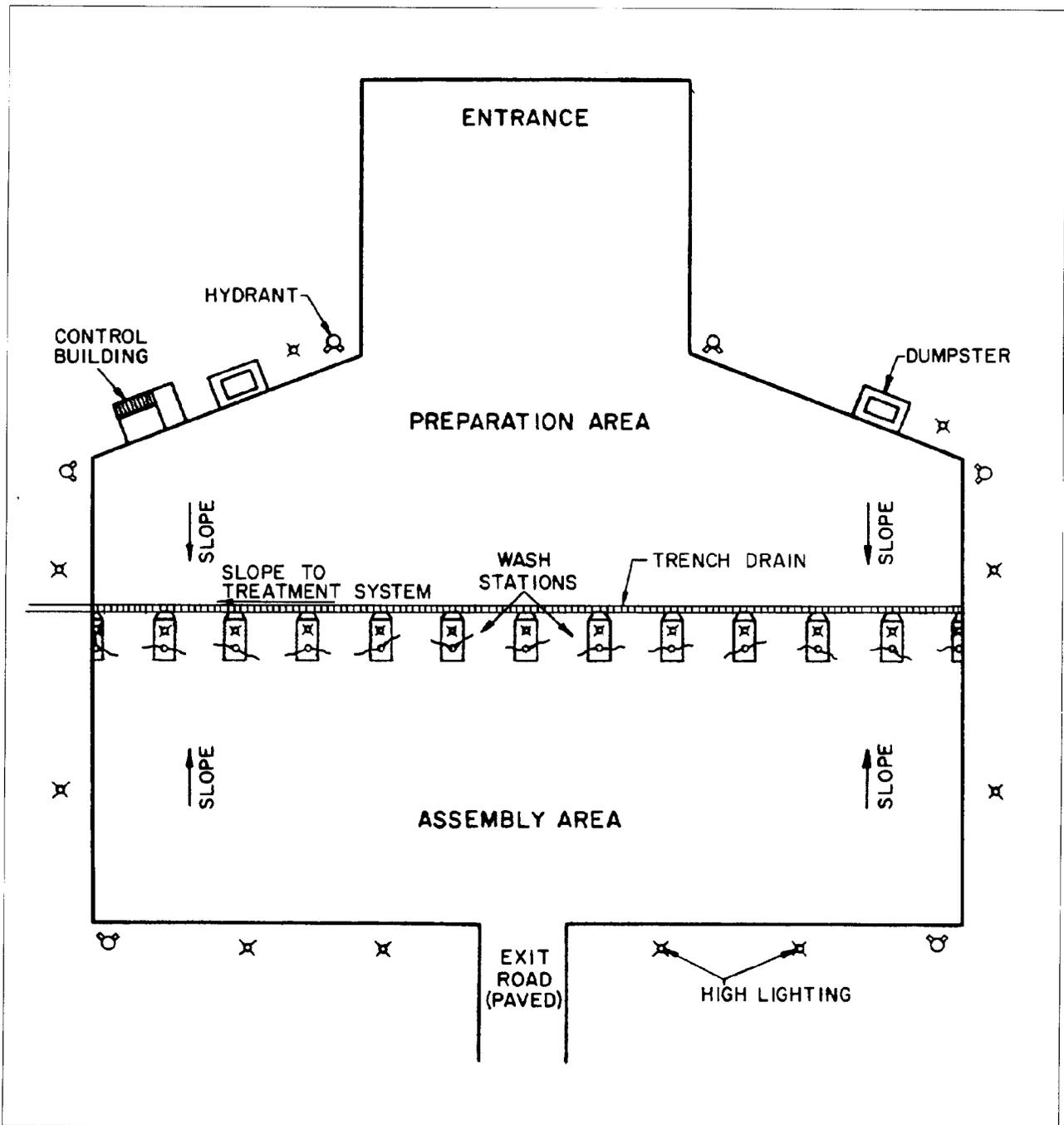
Figure 2-1. Standard central vehicle wash facility plan.
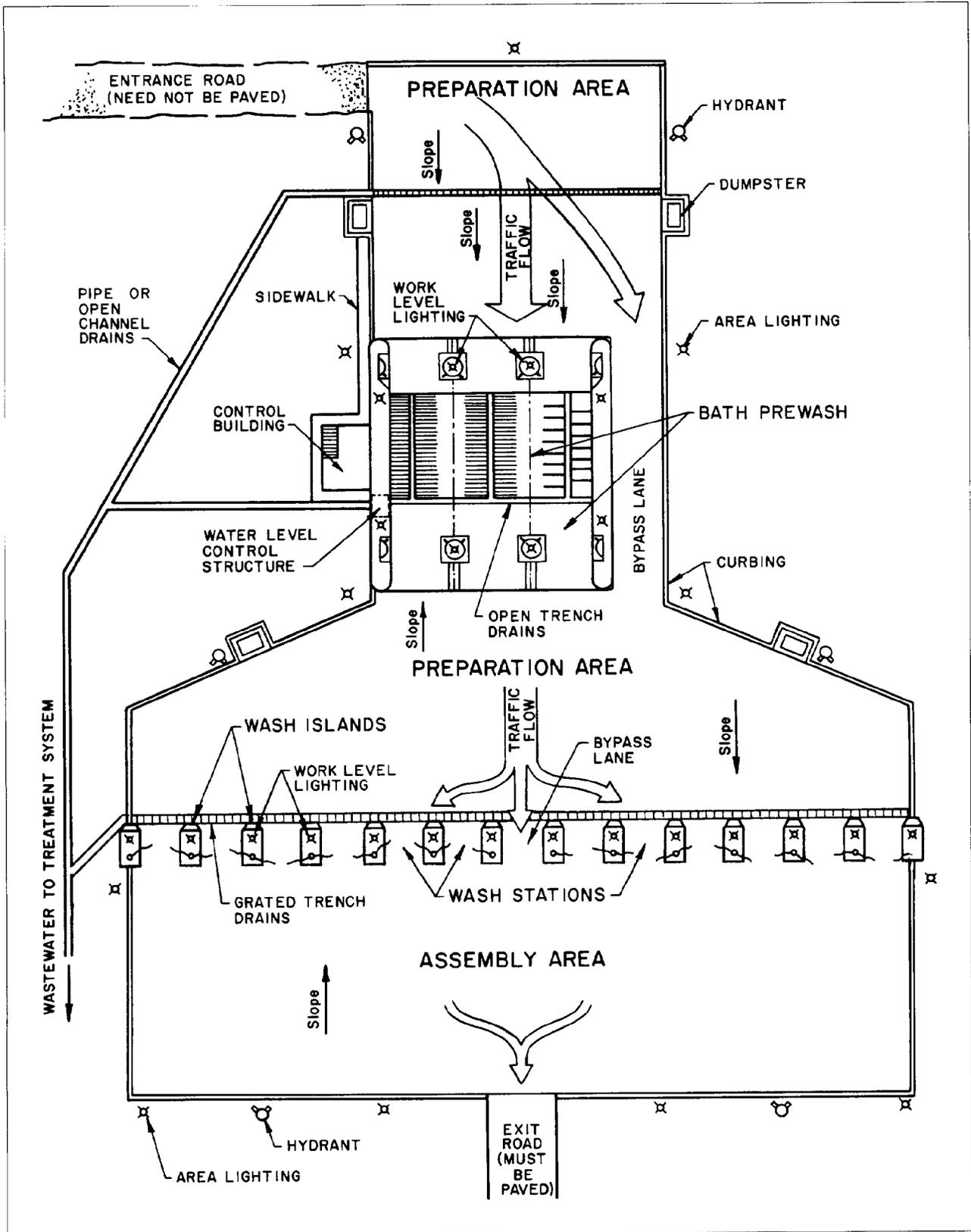
Figure 2–2. Central vehicle wash facility plan with bath prewash.

(3) *Discharge system.* If a recycle treatment system is not economically or technically feasible and/or operationally practical, and if wash water supply is available, wastewater from the CVWF may be discharged to a sanitary sewer system or some other conveyance for further treatment elsewhere. Primary treatment is the minimum level of treatment required to ensure that the wastewater discharged into a system is of a quality acceptable to the receiving authority. Quality, however, may not be the only criterion. The rate of discharge may also be a limiting factor, thus requiring an equalization basin prior to the point of release to the discharge system. The discharge-type treatment system is discussed in detail in chapter 6.

c. Water supply basin. After secondary treatment in a recycle system, the water is discharged to a water supply basin for reuse in the CVWF. In a system without recycling, the water supply basin is optional. If a reliable, consistent source of water is not available, a water supply basin may have to be constructed in a size large enough to hold the wash water volume required. This basin can be filled from the water source at a slower rate during nonpeak hours for the high demand required during the washing operations. The design must protect the water source through the use of air breaks or equipment to prevent backflow and back siphonage. In addition, makeup water that enters the water supply should be metered.

CHAPTER 3
MASTER PLANNING

3-1. Sizing

a. User input. The wash facility must be designed to meet the user's needs. The design will determine the type, size, and configuration of the wash facility and treatment system based on information supplied by the installation. Proper initial planning will result in the best final design. The planner will have to assemble data from many sources and use judgment in applying this data to the guidelines provided for sizing the facility components. Where data is not available, estimates must be made.

(1) *Military mission data.* The wash facility must sup-- port the particular needs of the installation. Troop types, their vehicle types, and their training program, both current and future, must be considered. This includes resident troops as well as transient troops. The combination of numbers of vehicles, types of vehicles, and frequency of washing will determine the type and size wash facility required. A complete list of each military unit which will use the facility is required, along with its vehicular complement and the expected frequency each vehicle would be washed.

(2) *Wash frequency data.* Certain components of the wash facility will be sized based on long term or average numbers of vehicles washed. Other components are sized on short term or peak use numbers. In both cases, the mix of vehicle types is an important consideration.

 (a) The average use of the facility should be provided by the user broken down as weekly or biweekly, monthly, and annually. Seasonal variations must also be a consideration. Where training programs are impacted by seasonal weather or where large numbers of transient units in a particular part of the year impact expected use, the average weekly or monthly numbers would not be a fixed ratio of the average annual numbers. Monthly average should be the average of the six highest use months; weekly should be the average of the ten highest use weeks.

 (b) The peak use of the facility should be provided by the user as the largest number of vehicles to be washed in a continuous short term period. If night washing is to be designed for, the peak use may, for example, be a continuous three day (72 hour) period. The peak use will represent full utilization of the wash facility components for the chosen time period. The planner must consider the

length of time it will take for all the vehicles scheduled to wash in this peak exercise to return to the cantonment area after training. The rate of movement of these vehicles will help determine the time period to allow for in the peak use operation. Ideally the CVWF would accommodate all units as they arrived, without excessive backup, and at a continuous full utilization of the washing components. It is important that the planner consider the frequency of the defined peak use; in some cases, a large-scale facility may not be justified based on the low frequency of this peak activity. The peak use should be a condition expected to occur at least three times per year.

(3) *Vehicle soiling data.* The types of soil found in the training ranges along with weather conditions are predictors for the amount of dirt which will have be to washed off of the vehicles. This will affect the type of washing components, the time required for washing, the amount of water used and the waste-water treatment components.

 (a) A characterization of the soils is needed. A study of the installation maps showing soil types throughout the total training areas should be made to determine if sands, clays, or combinations of soils occur. Samples of Soils should be taken from the range areas, as well as samples taken directly from dirty vehicles returning to the cantonment area after a heavy rain. Separate samples should be collected for each identifiable soil type (3 to 5 gallons each) and analyzed in a soils laboratory. The laboratory should prepare a standard gradation curve of grain size distribution showing gravel, sand, silt, and clay utilizing both a mechanical analysis and a hydrometer analysis down to 0.001 mm diameter. Both a dispersed and a non-dispersed hydrometer analysis need to be performed. The dispersed, which breaks the particles into individual grains, is used for standard classification. This will be used to categorize the soiling expected on the vehicles. The dispersed, which assesses the agglomerated particles, is used in the treatment analysis (chap 6), since the washing operation does not totally disperse the soil. Figure 3-1 shows an example of a cohesive (silty clay) soil gradation curve both dispersed and dispersed. Figure 3-2 shows an example of a noncohesive (sandy) soil.
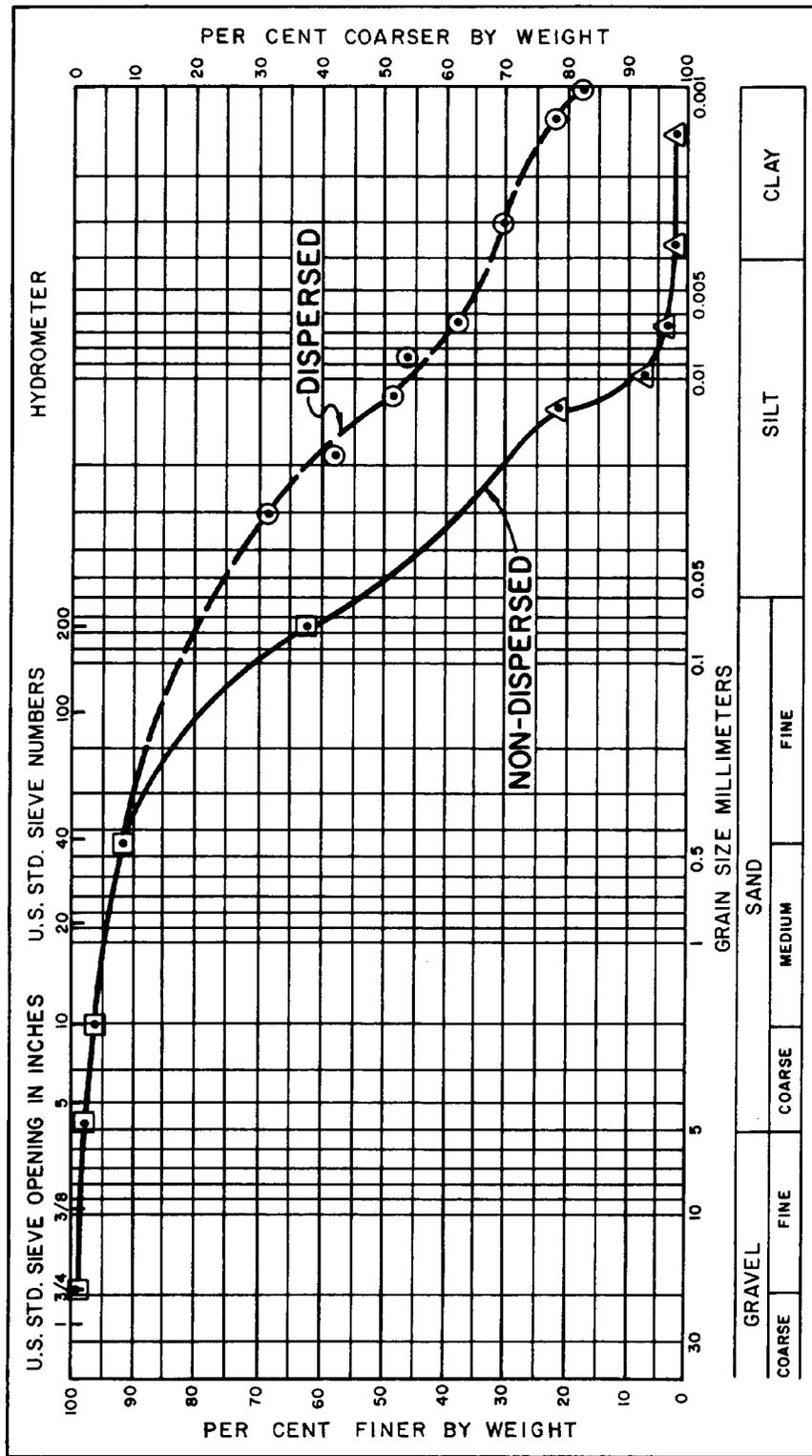
Figure 3-1. Cohesive soil gradation curve.
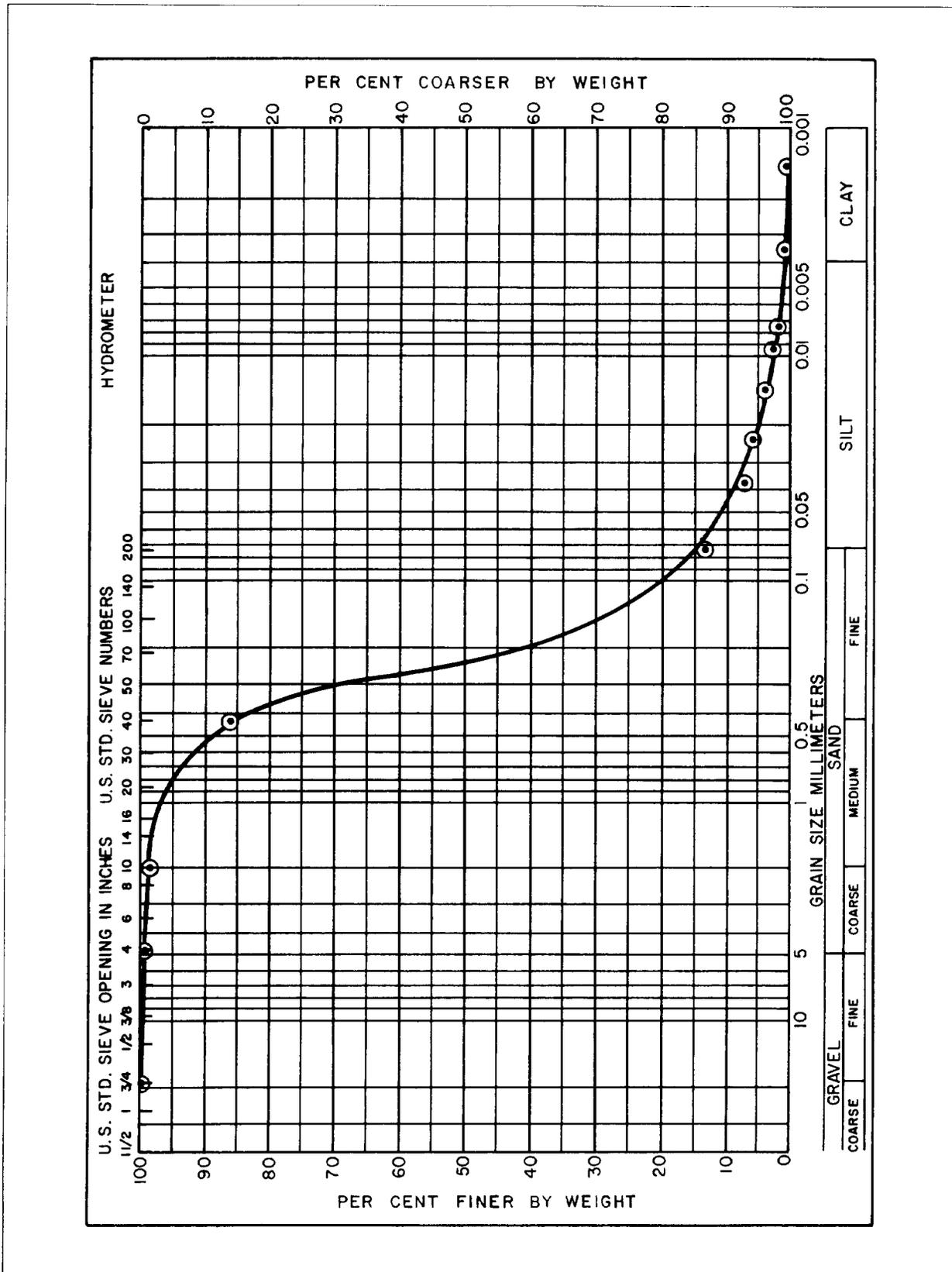
Figure 3-2. Noncohesive soil gradation curve.

(b) A classification of the soils expected to be on the vehicles is needed. By taking the particle size curve previously discussed and plotting the percentage of sand, silt, and clay (dispersed) on a triangular classification chart as shown on figure 3-3, a combined classification can be made. As an indicator of soiling potential expected on the vehicles, the chart is divided into 5 categories or soil type numbers (S_t) The sands and silty sands are given a type number of 1, being the least likely to soil a vehicle and being the easiest to clean. The clays are given a type number of 5, being the most likely to soil a vehicle and being the hardest to clean. Where a particular analysis may plot on the chart close to the line between two types, interpolation should be applied (i.e. a soil could be given a type number of 2.5). Where different soils occur in the training ranges, an average of those found may be used. The designer should use judgment when making this determination and give due consideration to the extreme adverse affects caused by high clay content soils.
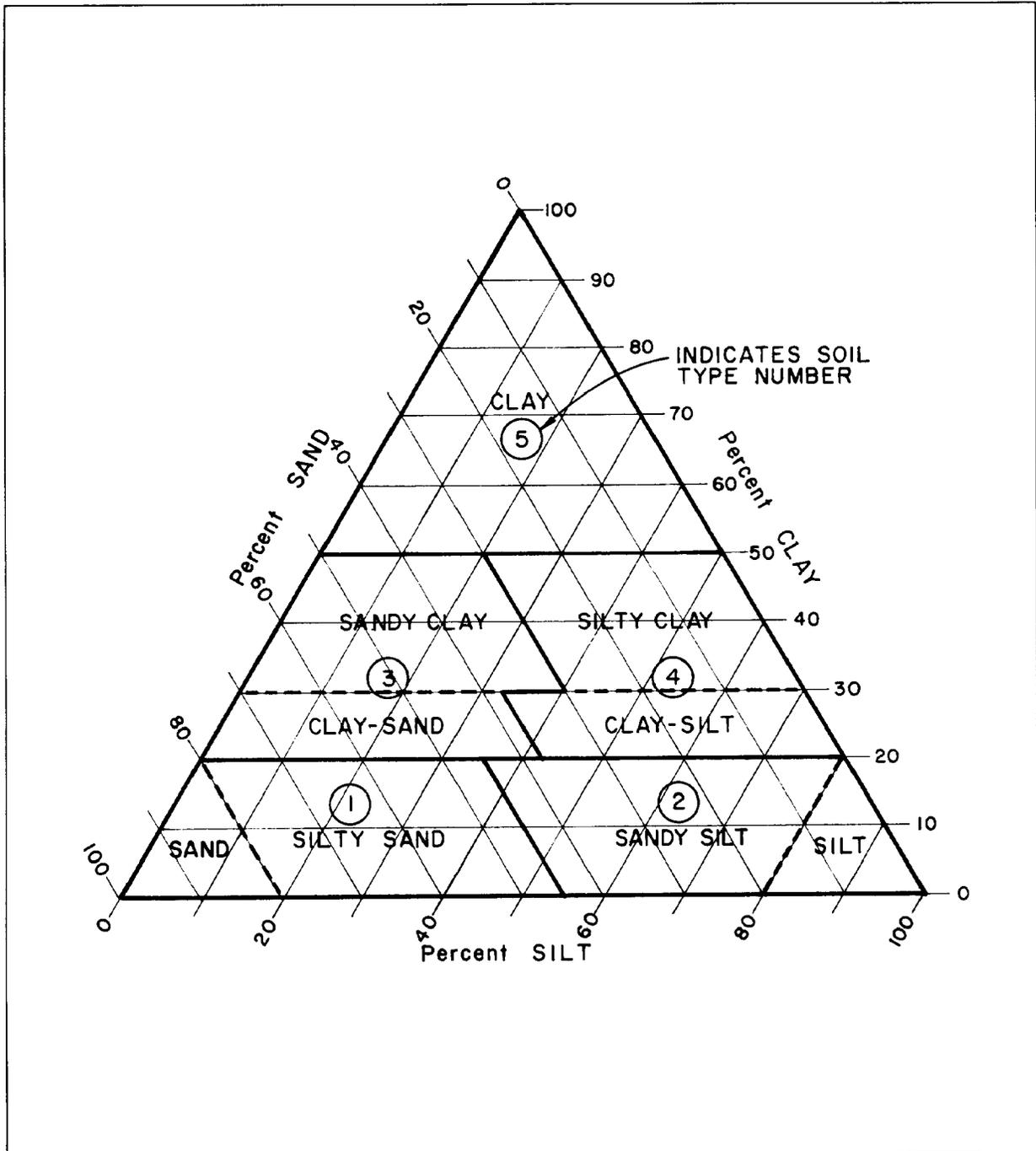
Figure 3-3. Soil classification and soil type number diagram.

(c) Actual soiling of vehicles is a function of both soil type and the amount of rain or wet conditions expected in the training areas. Therefore, climatic data must be provided in order to fully assess the potential for vehicle soiling. Arid regions would have minimum soiling potential where rainy regions would have maximum soiling potential. By assigning a climatic factor (Fc) to the area, ranging from 1 being arid to 2 being very rainy or wet, and multiplying this by the soil type number, a soiling index can be obtained for the installation. This is given by equation 3-1.

$$S_i = S_t x F_c \qquad \text{(eq 3-1)}$$

The soiling index will be used to predict times and determine the need for a prewash.

(4) *Climatic data.* As previously stated, climatic data at the installation is necessary. In addition to amount of rain, seasonal variations in moisture and temperature are needed. Areas with long periods of

COMPONENT – TYPE VEHICLE

SOILING INDEX (Si)

	1	2	3	4	5	6	7	8	9	10

PREWASH – HEAVY TRACKED — 8, 7, 6, 5, 4

PREWASH – LIGHT TRACKED — 10, 9, 8, 7, 6

PREWASH – WHEELED — 15, 14, 13, 12, 11, 10

WASH – TRACKED (AFTER PREWASH) — 6, 5, 4, 3

WASH – LARGE WHEELED (AFTER PREWASH) — 6, 5, 4, 3

WASH – TRACKED (W/O PREWASH) — 4, 3, 2, 1

WASH – LARGE WHEELED (W/O PREWASH) — 4, 3, 2

WASH – SMALL WHEELED (W/O PREWASH) — 10, 9, 8, 7, 6, 5, 4
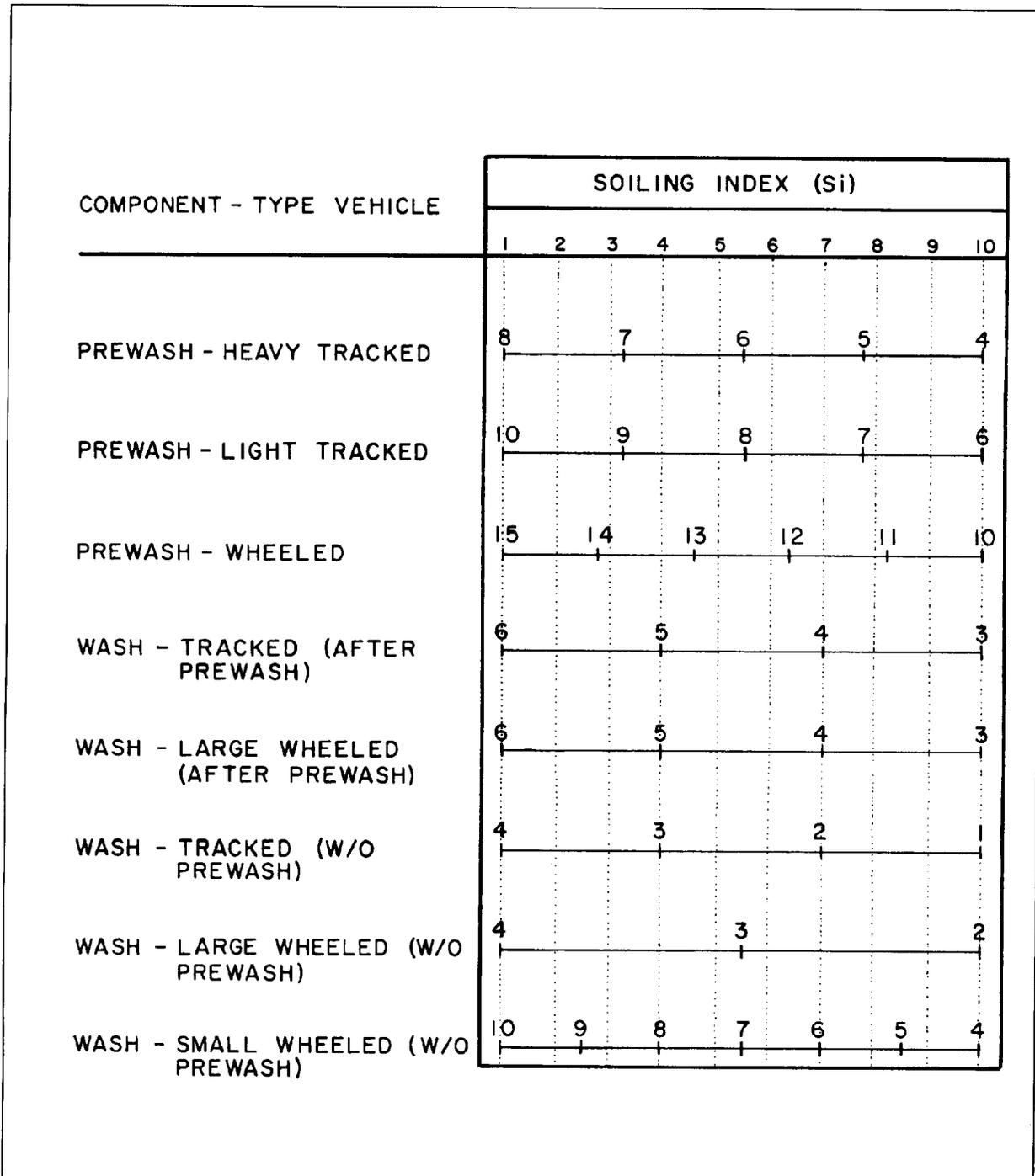
Figure 3–4. Vehicle processing rates.

freezing weather will require special design considerations to protect wash components, pumps and piping. Most of the wash components, particularly the prewash, may not be feasible to operate near freezing conditions because of the safety hazard caused by overspray freezing on the pavement. Enclosed facilities may be warranted, however, they are very expensive from both a capital and operations standpoint. Another climatic consideration in the design is the evaporation rate in the region. In an area with high evaporative losses and low rainfall, certain features of the CVWF may not be practical. For example, a spray stand creates large water losses due to overspray. Use of any prewash system increases the volume required in the treatment system; with the higher water volume, the surface area of the basins must be increased (particularly a lagoon treatment), which promotes evaporative losses even more. The designer must evaluate the potential evaporative loss as it affects the need for make-up water and weigh this against the benefits of either a recycle system or a discharge system.

b. Prewash. A prewash is used to reduce the time needed to wash vehicles, since it removes the bulk of the dirt in a timely, efficient way. Its function is to reduce the amount of time each vehicle must spend at the wash stations.

    (1) *Bath prewash.* A bath prewash is currently the most efficient and effective method to remove dirt from the exteriors of tactical vehicles. A large volume of water is required to fill the bath, but because of the reduced wash time required, the overall water volume required for cleaning a large number of vehicles may be reduced. Lanes specifically designed for washing tracked vehicles can be provided; lanes which can accommodate both tracked and wheeled vehicles (referred to as dual purpose lanes) can also be provided. These are described further in chapter 5. Wheeled vehicles under 2.5 tons would not normally use the prewash bath.

        (a) *Process Rate.* In a tracked bath lane, six to ten tracked vehicles per hour can be washed. In a dual-purpose lane, ten to fifteen wheeled vehicles per hour can be washed. The amount of soiling will determine the actual number of vehicles that can be processed through the facility; the heavier the soiling, the slower the vehicles can be processed. By using the Soiling Index (S_i) in conjunction with the processing rate chart shown on figure 3-4, the throughput rate can be determined for a particular design.

        (b) *Number of lanes.* The number of lanes for the prewash will depend on two factors:

The maximum number of vehicles that must be washed at the facility in a time specified by the installation (peak wash period) and the expected process rate through the facility. Equations 3-2 and 3-3 will help the designer determine the number of each type of lane needed for the prewash system. The installation's requirements will dictate how the result should be treated. If the maximum washing time is critical, the number should be rounded up; otherwise, the number of lanes should be rounded to the nearest whole number.

$$\frac{\text{No. tracked}}{\text{lanes}} = \frac{\text{Max. no. tracked vehicles to be washed}}{(\text{Process rate x peak washing period})}$$

$$(\text{eq 3-2})$$

In equation 3-3, only the tracked and wheeled vehicles expected to use the dual-purpose lane should be considered in the equation. The number of tracked vehicles using the tracked vehicle lane should not be included, since they will not be washed twice in the prewash.

$$\frac{\text{No. dual-purpose lanes}}{} = \frac{1}{\text{Peak wash period}} \text{ x } \frac{\text{No. tracked}}{\text{Process rate}} \text{ x } \frac{\text{No. wheeled}}{\text{Process rate}}$$

$$(\text{eq 3-3})$$

        (c) An example will better explain how to use the equations. Consider an installation that needs to wash 42 heavy tracked vehicles, 88 light tracked vehicles, and 125 wheeled vehicles in the prewash during peak use. The installation requires that all of the vehicles be washed in 9 hours. Soils at the installation are extremely cohesive clays, so the process rates through the prewash are expected to be slow. The designer had determined that the soiling index (S_i) is 8 and from the chart (fig 3-4 estimates that five heavy tracked vehicles per hour can be washed in each lane; seven light tracked vehicles per hour per lane can be washed; and eleven wheeled vehicles per hour per lane can be washed in a dual-purpose lane. For initial calculations the following will be used.

$$\frac{42 \text{ heavy tracked}}{5 \text{ veh/hr/lane x 9 hr}} + \frac{88 \text{ light tracked}}{7 \text{ veh/hr/lane x 9 hr}} = 0.93 + 1.40$$

$$= 2.33 \text{ tracked lanes}$$

$$\frac{125 \text{ wheeled vehicles}}{11 \text{ veh/hr/lane x 9 hr}} = 1.26 \text{ dual-purpose}$$

The designer realizes that, with three tracked vehicle lanes and one dual-purpose lane, the tracked vehicles will be washed in less than 9 hours, but the wheeled vehicles will require more than 9 hours. To achieve a more even distribution of vehicle washing, the designer recalculates the number of lanes needed by assuming that some of the light tracked vehicles will use the dual-purpose lanes. The designer adjusts the process rate for the

light tracked vehicles in a dual-purpose lane. It Will take longer to process a tracked vehicle in dual-purpose lane than in a tracked lane, since the flexors in a dual-purpose lane are not as effective as those in a tracked lane at removing the embedded soil from the tracks.

$$\frac{42 \text{ heavy tracked}}{5 \text{ veh/hr/lane x 9 hr}} + \frac{65 \text{ light tracked}}{7 \text{ veh/hr/lane x 9 hr}} = 0.93 + 1.03$$

$$= 1.96 \text{ tracked lanes}$$

$$\frac{125 \text{ heavy tracked}}{11 \text{ veh/hr/lane x 9 hr}} + \frac{23 \text{ light tracked}}{5 \text{ veh/hr/lane x 9 hr}} = 1.26 + 0.5$$

Two tracked vehicle lanes and two dual-purpose lanes would offer a more efficient use of the bath than would the results given by the first calculations.

    (2) *Automatic washers.* The types and number of vehicles in the motor pool must be considered in sizing the automatic wash area. Administrative-type vehicles in a TMP usually return one at a time and are washed as they return. Thus, large numbers of units will not be waiting to be washed in a limited amount of time as is the case with tactical vehicles at CVWFs. Civilians usually are employed to do the washing at TMP wash facilities; therefore, all of the daily washing normally will occur during an 8-hour period during daylight. A one-or-two position automatic prewash unit may be all that is required. Again, number of vehicles per cycle and average time of washing are used to determine the size of the prewash unit.

    c. Wash stations. Before sizing the facility, with or without a prewash, the designer must have a clear understanding of the installation's washing requirements. The number of stations needed at the wash facility will depend on whether a prewash system is provided. A prewash will lessen the time that these vehicles must spend at the wash stations, thus reducing the number of stations needed.

    (1) *Sizing with a prewash.* When a bath prewash is provided, the number of wash stations should be between two and five per tracked vehicle bath lane. A process rate of 3 to 6 vehicles per hour at each wash station can be expected after the vehicles have been washed in the bath. Since all vehicles will not go through the prewash bath, calculations of lanes must account for longer wash times for these vehicles. A process rate of 2 to 4 vehicles per hour for large, odd shaped, or tandem units can be expected. A process rate of 4 to 10 vehicles per hour for small wheeled vehicles such as jeeps or ½ tons can be expected. Installations with a limited washing time or a large percentage of wheeled vehicles to wash will require more wash stations. In any case, the number of stations can be calculated using the processing rates for each type vehicle and its type

wash, as shown on figure 3-4, and following the same logical steps used to size the prewash.

    (2) *Sizing without a prewash.* If no prewash is provided, the planner predicts the number of wash stations needed based on, soiling conditions and process rates.

      (a) The process rate for vehicles at the wash stations will depend on several factors, but usually will be between 1 and 10 vehicles per hour. This range is given to allow an adjustment for the vehicle types and soiling index at the site. Installations that have vehicles soiled with large amounts of cohesive soils (clays) will have slower processing rates than those with only noncohesive soils (sand) or dust on the vehicles. By using the Soiling Index (S_i) in conjunction with the processing rate chart shown on figure 3-4, the throughput can be determined for each vehicle type. The mission of the installation also will affect the process rate. At some installations, vehicles may return to the motor pool immediately for inspection. In this case, the processing rate will be slower than if the vehicle were not being inspected, since the troops will most likely perform a detailed washing. Less time will be taken to clean the vehicles if they will be returned directly to the field for further training.

      (b) *Number of wash stations.* The number of tracked and wheeled vehicles to be washed is used in equation 34 to estimate the number of wash stations needed at a facility:

(eq 3-4)

$$\text{No. stations} = \frac{1}{\text{Max. wash period}} \times \frac{\text{No. tracked}}{\text{Tracked process rate}} +$$

$$\frac{\text{No. wheeled (Lg.)}}{\text{Lg. Wheeled process rate}} + \frac{\text{No. wheeled (Sm.)}}{\text{Sm. Wheeled process rate}}$$

The user's requirements will determine how this number should be rounded. If the maximum washing time is critical, the number should be rounded up; otherwise, it should be rounded to the nearest whole number.

3-2. Siting

    a. Geography. All future development and land uses at the installation must be considered when siting a CVWF. These future plans must not adversely affect the vehicle and equipment movement inside and outside the facility. At the same time, the facility must not interfere with activities in the cantonment and training areas and vice-versa; the land uses should be compatible. Vehicle noise and movement must not interfere with family housing, hospitals, and other installation activities. If night washing is planned, it must not disrupt local activities; for example, the high mast lighting at the facility must not disturb the surrounding area.

(1) *Space requirements.* Planners and designers must consider overall space requirements for the facility. Large, open areas will be needed if a total recycle treatment system is to be installed. Lagoon treatment systems require even larger areas than intermittent sand filter systems. Smaller areas will suffice for partial or total discharge systems. A CVWF with eight wash stations, no prewash, and no recycle system can require 2 to 4 acres; one with 20 wash stations, 4 lane prewash, and a complete recycle treatment system can require as much as 50 acres.

(2) *Cantonment boundary.* The wash facility should be located near the permanent cantonment boundary and between the training areas and maintenance shops/motor pools. The vehicles must be cleaned before they enter the cantonment area; otherwise, the dirt will fall onto the roads and trails within this area. Future changes in the cantonment boundary must also be considered when siting the CVWF.

(3) *Training area.* The facility should be located as close as possible to the main tank trails, access roads from the training areas, or similar sites. The vehicles are washed as they return from the training field areas prior to entry onto cantonment roads. Future locations for training areas also must be considered with respect to the CVWF site.

(4) *Transportation arteries.* Several routes usually enter the cantonment area from many different training areas. A CVWF usually cannot be constructed at each entry point, so new roads or tank trails may have to be built to link the primary routes from the training areas with the wash facility. To prevent the vehicles from becoming soiled immediately after washing, they must return from the wash facility to the maintenance shops/motor pools on paved roads or tank trails. If the exit from the facility is placed close to existing roads or tank trails that are paved, new construction will be kept to a minimum. The facility must also be located to minimize the distance that dirty vehicles must travel on major transportation arteries. Otherwise, the dirty vehicles will drop soil on roads over which other vehicles travel. The number of tank-trail crossings over major roads, both to and from the wash facility, must also be minimized. The entrance and exit of the wash facility should be sited to avoid adverse effects on traffic both there and in the cantonment area. The facility should not be located in congested areas such as near the main gates, major intersections, hospitals, administration offices, and other high traffic areas.

(5) *Maintenance shops/motor pools.* Present and future locations for tactical maintenance shops and motor pools must be considered in siting the CVWF. The facility should be located between the training areas and the maintenance shops/motor pools. The vehicles should return from the training areas and, after washing, return to the maintenance shops/motor pools with minimal travel on cantonmen roads.

b. Weather. The wash facility must be designed with due consideration to all local and regional weather conditions.

(1) *Temperature.* If the installation is in a region with long periods of freezing temperatures, some standard CVWF components, such as the prewash bath may not be useable since the CVWF is not intended to be operated continuously at temperatures below 40°F. In areas with seasonal or occasional freezing temperatures, special piping and plumbing fixtures must be installed at the outdoor facilities to drain the exposed pipes and keep them from freezing. South-facing slopes should be considered for construction sites to take the greatest advantage of the sun for heating during the winter months. The washing structures and treatment system still must be protected from freezing temperatures to prevent pipes and other vulnerable components from freezing and rupturing.

(2) *Winds.* The designer should consider locating the wash facility and treatment system to minimize adverse effects from wind. Wind blowing over basins increases the rate of evaporation. In addition, winds that blow over the long axis of an elongated basin can create waves that will erode the banks. Wind can be used to move surface oil toward the oil skimmer in sediment basins provided the oil skimmer is located properly. Strategically placed vegetation, structures, and fences can reduce the adverse effects of wind. However, vegetation must not interfere with pipes, trenches, pavement, liners, or other functional parts of the facility.

(3) *Precipitation.* Gently sloping ground which is elevated slightly with respect to the surrounding grounds should be chosen to ensure that stormwater can be controlled. Stormwater collected on the pavement during washing operations should be directed toward the treatment system since this water may require treatment; in addition, it can be used as makeup water for a recycle system. Curbing should be installed where the soil and pavement interface, and where it is needed to control the drainage flow and to prevent erosion. Rainwater falling on the surrounding area should be directed away from the facility unless it is to be used as a source of makeup water.

(4) *Vegetation.* The site layout should make effective use of existing vegetation to protect the buildings, personnel, and basins against wind and sunlight.

Trees, shrubs, and grass should not be removed except as necessary for construction or operation. The roots hold soil in place, thus preventing sheet wash and soil deposition onto the paved surfaces and into the stormwater collection system. Moisture in the treatment basins will promote growth of vegetation such as trees and shrubs on the surfaces and along the edges of the basins. Trees and shrubs that grow very close to the filters and the basins must be cleared because their root systems may penetrate the liners and cause leaks. Slopes for berms should be designed to allow convenient maintenance.

(5) *Fauna.* The abundance of water will promote insect and animal life in the area around the basins. Fences may have to be constructed around the basins, especially in arid regions, to prevent wildlife from entering the area to drink or bathe since their activities could damage the slopes and liners. The water also may attract burrowing animals that can damage liners and berms; their presence may, in time, increase maintenance needs.

(6) *Evaporation rates.* The region's evaporation rate must be considered when siting and designing the facility.

(a) *Arid regions.* Wash facilities in arid regions must have the wash structures and treatment system designed to minimize the effects of evaporation. Water from the pavement should be directed toward the treatment system; in this way, stormwater can be collected and used as an additional source of makeup water. In hot, arid regions, the pavement should be light-colored to reflect heat; the evaporation rate will be less when the wash water hits a cooler, lighter surface than when it hits a hotter, darker one. Another major point of evaporation is from the basins in the treatment system. A high rate of evaporation from the basins can increase the concentration of dissolved solids in the water. This higher dissolved solids content can result in spotting on vehicles after washing and increased corrosion. The exposed surface area of the basins should be minimized. The basins' depth can be increased to the upper limits to allow them to hold the required volume while reducing the exposed surface area. Wind blowing over the basins also can raise the evaporation rate. Fences and shrubs can be placed around the basins to help block winds. Vented covers also can be placed over the basins to reduce evaporation. Basin liners and the materials used for filters should be light-colored.

(b) *Water-rich regions.* In water-rich areas, provisions must be made to handle a heavy water volume. Onsite control to prevent stormwater damage to the treatment system becomes critical when heavy rainfalls are expected.

c. *Geology.*

(1) *Topography.* The site should have some fall if the designer is to consider using a gravity-controlled recycle wastewater treatment system. A 2 to 3 percent slope across the site is desirable, with the high side being adjacent to access roads or tank trails. If the terrain is too flat, the treatment system would require extra pumping in order to recycle the water. This requirement would increase costs for initial construction and for operation. It is essential that the wastewater flow by gravity from the wash structures to the sediment basins. Should the wastewater be pumped before primary treatment, any oils in the water would become emulsified and thus more difficult to remove. Low-lift pumps can be used elsewhere in the facility if necessary. The entire site should be elevated with respect to the surrounding area. Slopes in the immediate area should fall away from the site to help move stormwater and cold air away from the site. It is desirable that the local topography not funnel water or strong winds toward the site.

(2) *Soils.* Soil borings must be taken at the proposed site to determine the soil types, the depth of the bedrock, and the depth of the water table. The soil should be able to support concrete, bentonite, and similar sealers that will be applied to the bottoms of basins, sand filters, and facilities such as pumphouses and control buildings. Large soil particles tend to slide and shift more than small ones; therefore, in sandy areas, the walls of excavated basins will have to be built with a low-sloped angle to prevent this problem. Excavation of a basin at a site with cohesive soils may be more expensive than a site with noncohesive soils. However, it may be more expensive to stabilize the slopes at the site with noncohesive soils. It may also be more cost-effective to use native, cohesive soils for basin construction than other types of liners or imported soil. Bentonite liners may be difficult to seal on noncohesive soils; later, settling and shifting of the soils may create leaks in the liner. Bentonite liners can also be damaged by hydraulic pressure from groundwater, especially when noncohesive soils are present.

(3) *Bedrock.* The site should have deep bedrock since shallow bedrock hinders excavation. An excavation into bedrock may penetrate into fissures that are part of a subsurface water recharge network for a public water supply; this supply could become

contaminated by wastewater from the facility. Excavation into bedrock also increases construction costs. If no other site is available, fill material may be used to increase the soil depth at the site. Another alternative would be to excavate material that is easy to remove down to the bedrock, then use the excavated material to build a berm around the basins. The gradient of the berm slopes must be low enough to avoid interfering with operations and maintenance (O&M) and to prevent sheet erosion of the slope.

(4) *Water table.* The planner must know the depth of the water table at the proposed construction site. Sites near marshes, swamps, or low areas should be studied to determine if the water table will have an adverse effect on construction or O&M of the facility. The facility must be placed above the maximum height of the seasonal and permanent water tables. Areas with high water tables may require complex drainage systems, usually with high construction costs. Should the basins and filters be constructed when the water level is low and then water rises and surrounds the structures, the hydraulic pressure can damage the liners and cause leaks. Clay lenses or other impervious sub-surface features can create a high, perched water table. Excavation to repair the subsurface structures would be hindered by the high water table; it would also be expensive because the groundwater would have to be removed from the site to allow personnel to work.

(5) *Drainage.* It is important that wastewater generated by the facility not contaminate drinking water supplies. Therefore, wastewater from the washing structures must not drain into a surface or subsurface water recharge area for a public drinking supply. Surface and shallow subsurface water should be directed away from the site unless it will be used as a source of makeup water. The area will be wet due to washing, storage, and treatment; in certain climates, ponding and uncontrolled collection of stormwater can cause discomfort to the workers (i.e., from being cold and wet) and speed the rate at which equipment wears. Sites with permeable soils allow surface waters to percolate, which prevents ponding and sheet erosion.

(6) *History.* It is important to have historical knowledge of the site. Past uses of the site may make it unsuitable; this could be from an archaeological standpoint such as old burial grounds, or from a hazardous standpoint such as old landfills or old firing ranges and impact areas.

d. Utilities. The planner must consider all utilities required at the facility with respect to those available at the site. If some of the utilities are not available, the best alternative must be found.

(1) *Water.* The wash facility should be sited near existing water or supply lines if possible. Water meters should be installed so that the potable and recycled water can be metered.

(a) *Potable water.* A potable supply must be provided as drinking water for personnel. If it is not feasible to tie the facility into the potable water system, portable equipment can be used to supply drinking water. Signs must be posted informing personnel not to drink the wash water and telling them where drinking water is available.

(b) *Makeup water.* Potable water is not required for washing the vehicles; however, the water must be free of particulate matter that would interfere with pump operation and cause premature wear of the wash equipment. The water source must charge and maintain a working water level in the treatment system. A dedicated well may be used if that proves more economical than tying into the existing water lines. If the planner considers using an untreated well, the groundwater must be of an acceptable quality and must provide a consistent supply. If the area is water-rich, rain can be used as a source of makeup water. Ponds, lakes, and streams are other potential raw water supply sources for the facility. The amount of water needed at the facility will depend on several factors: frequency of washing, number of vehicles, types of vehicles, and type and size of treatment system provided. The planner must also consider the best source and method of charging a recycle treatment system initially. Once a recycle treatment facility is charged, the only demand for water will be to makeup that lost to vehicle carry-off, evaporation, and leakage.

(2) *Electricity.* The wash facility should be located near existing power lines. If electrical power is not available at the site, new lines must be run. Electricity will be required to run the pumps that circulate water throughout the facility and to provide power for security and night lighting. The amount of power that the planner should expect the facility to use will depend on the volume of water treated, recycled, and discharged; the type of washing operations; the frequency and duration of washing at night; and the number of washing operations performed each year. It is important that electrical lines not span areas of vehicle movement. Vehicle antennas, especially on wet vehicles, must not come

into contact with electrical lines as this occurrence would pose a safety hazard to the area. At remote locations, it may be necessary to have the electrical power generated onsite.

(3) *Sanitary.* The facility should be located near the sanitary sewer lines if possible. This arrangement allows the designer to tie latrines at the wash facility into the sanitary lines. Other options such as pit latrines, composting chemical toilets, or septic tanks with field lines are possible; selection will depend on local practices and preference. A location near sewer lines also allows the designer to divert all or part of the wastewater to the installation's sewer

plant. If this type of discharge system is used, the planner must determine if the sewage treatment facility can handle the discharged wastewater, including the hydraulic and solids loadings created. The cost of connecting with and maintaining the sewer lines must also be considered when deciding whether to tie the facility into the sewage treatment system.

(4) *Communication.* Communication lines should be provided at the site. These lines must not span areas of vehicle movement. As with electrical lines, wet vehicles with free antennas would create a safety hazard should the antennas contact these lines.

CHAPTER 4
STANDARD WASH FACILITY

Section I. VEHICLE PREPARATION AREA

4-1. General

CVWFs have two types of paved staging areas, each with different functions. These are designated as the preparation and vehicle assembly areas. Staging involves alignment of vehicles for orderly movement through the CVWF; in addition, vehicles are sorted according to type and washing requirements. Vehicles waiting and being prepared for washing are aligned for direct entry into the designated wash stations. The preparation area provides troops with a location to remove trash from vehicle interiors, plug drain holes, open bilge pump discharge lines, remove camouflage, check tiedowns, and use restroom facilities (when provided) prior to washing the vehicles.

4-2. Sizing

The area and configuration requirements of the staging areas at CVWFs depend on the queuing arrangement, amount of assembly needed, and the number and types of vehicles washed.

    a. *Preparation area.* The preparation area should allow at least one vehicle to *be* staged behind each wash station. Additional vehicles using the CVWF during a major washing effort are queued in a linear fashion along the CVWF entrance road and/or trails leading to the facility. The paved preparation area should be sized to accommodate a minimum of 1000 square feet (92.9 square meters) of paved area per lane. This figure includes the vehicle area and a minimum of 10 feet (3.0 meters) of pedestrian clearance in all directions between vehicles. Since vehicles are aligned in rows according to wash station lanes, the layout of the preparation area can be established based on the gross width of the facility, including vehicle wash lanes, sidewalks, and bypass lanes. The staging area configuration

will vary, depending on whether the wash station is linear, skewed, or parallel.

    b. *Vehicle assembly area.* This area can be sized to accommodate a company of vehicles which is assembled as a group prior to exiting the CVWF for the cantonment area. If vehicles are allowed to proceed to the cantonment area individually, the vehicle assembly area requirements can be reduced or eliminated. The layout of this area is based on the gross width dimension of the wash station divided into the required area; however, the area should be designed such that no vehicles in the wash stations are slowed because of a backup of units in the assembly area.

4-3. Staging area cleanup

Hydrants should be provided adjacent to the vehicle preparation areas to aid in cleanup of the pavement after a washing effort. Design flow rate for these hydrants should be 25 gallons per minute (gpm) (95 liters per minute). The location of hydrants must be such as to allow hose streams to move soil from all portions of the paved area toward trench drains.

4-4. Drainage

The vehicle preparation areas are sloped to drain from the edge of the pavement toward the trench drains. Trench drains may be required in the assembly areas to facilitate drainage and cleanup. Flushers are included in the trench drains to move the dirt and debris to the collection system. Vehicle preparation areas are generally not curbed; however, curbs may be used at the entrance for traffic control, at locations where vehicles might back off the pavement, or where water would otherwise run off the pavement edge and cause undermining of slab. Curbs used at tracked facilities should be designed to resist damage from tracked vehicles.

Section II. WASH STATION

4-5. Function

The wash station is the central feature of the CVWF which permits manual washing of both tracked and wheeled vehicles. The stations consist of concrete islands with towers placed on either side of the lanes. The vehicles enter the lane and stop for washing. Water hoses are hung from towers so that they do not clutter the area of vehicle movement. The stations should be designed such that two persons can use the hoses from two adjacent towers to wash a single vehicle. This design saves time by allowing both sides of a vehicle or piece of equipment to be washed at once. No solvents or detergents are used to wash vehicles at the facility.

4-6. Configuration

The islands should be spaced in a single, straight line (as in fig 2-1) or skewed (fig 4-1) so that traffic lanes are parallel. This design will ensure smooth traffic flow with a minimum of turning, because vehicles move in only one direction. Vehicles waiting to be washed can queue behind those being washed. Since the vehicles always move forward, there is no hazard due to reverse travel. The islands should have a center-to-center spacing of approximately 25 feet (7.6 meters) (fig 4-2) to allow the widest vehicle to pass easily between the islands. However, the lane width should allow only one vehicle at a time to pass through the station. If the installation will wash very long

vehicles, semitrailers, or units in tow which could not be cleaned easily at a standard island, double-tower stations may be desirable. At a double-tower station, a tower is placed at each end of the island. A longer island may have to be constructed to accommodate the arms of the two towers. The

hose located on each arm is intended to service one-quarter of the oversized vehicle, unlike the hoses on a single-tower island which are designed to service one-half of the vehicle. Figure 4-3 shows the layout of a double-tower station.
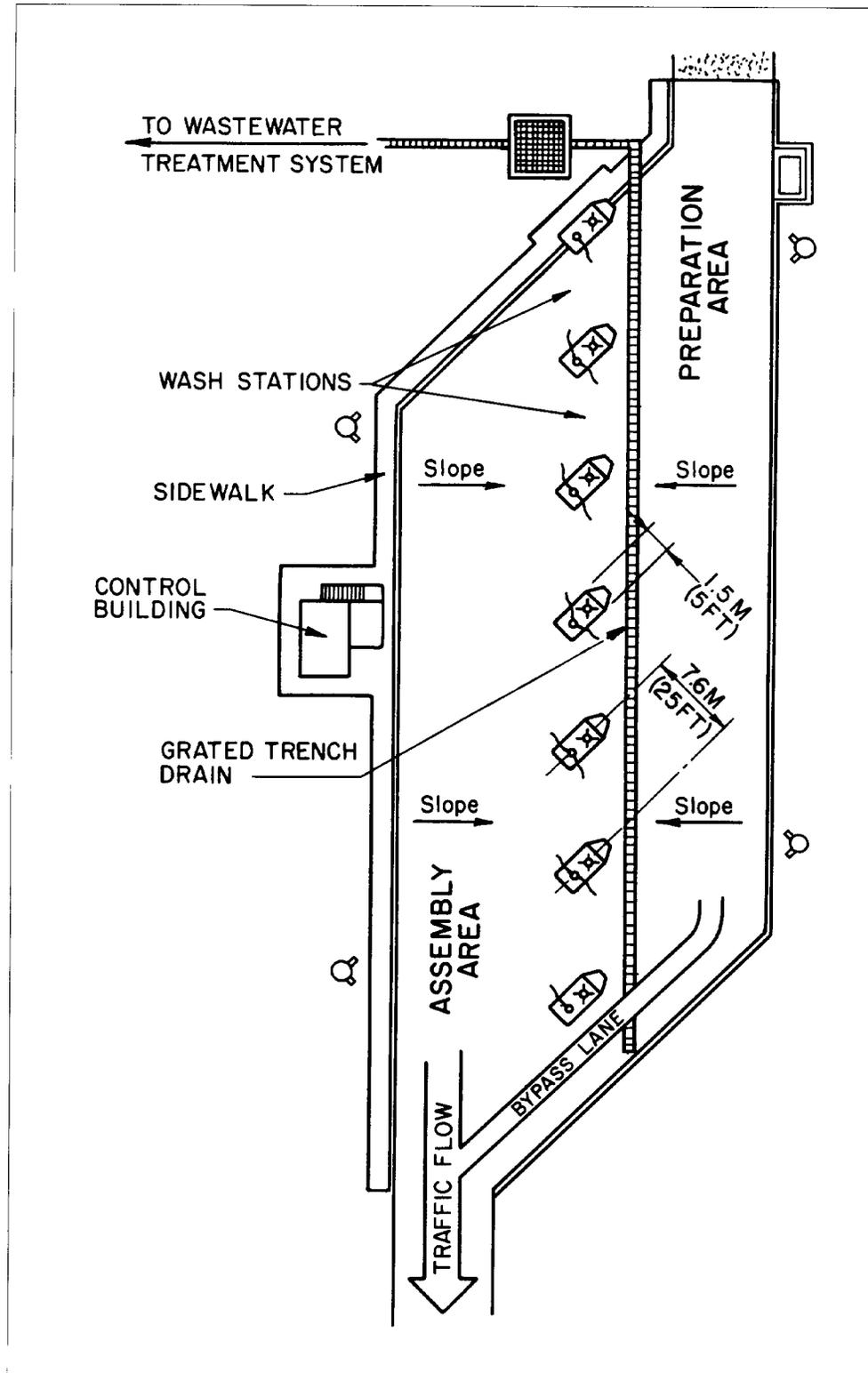
Figure 4-1. Skewed wash station arrangement.

4-7. Island design

Each island should be approximately 5 feet wide (1.5 meters). Figure 4-4 shows the island in cross section. The top of the island should have a crest to prevent water from pending on the island. The surface of the island should have a broom finish to help provide traction to troops when the area becomes wet. At all wash facilities, concrete barriers should be placed on the entrance ends of each island as shown on (fig 4-5). These barriers will protect the tower and the person working at that station against damage or injury by the vehicles.

4-8. Tower design

The tower should be constructed of standard pipe, tapered-metal signal pole or its equal. The tower supports the flexible wash hose and lighting (if needed). Towers installed on interior wash lanes can support two wash hoses fastened horizontally above the island with swivel-type joints. The exact height of pole and length of the hoses will be site-specific, depending on the orientation of the island and the size of the vehicles to be serviced. Towers installed on outer wash islands only need one
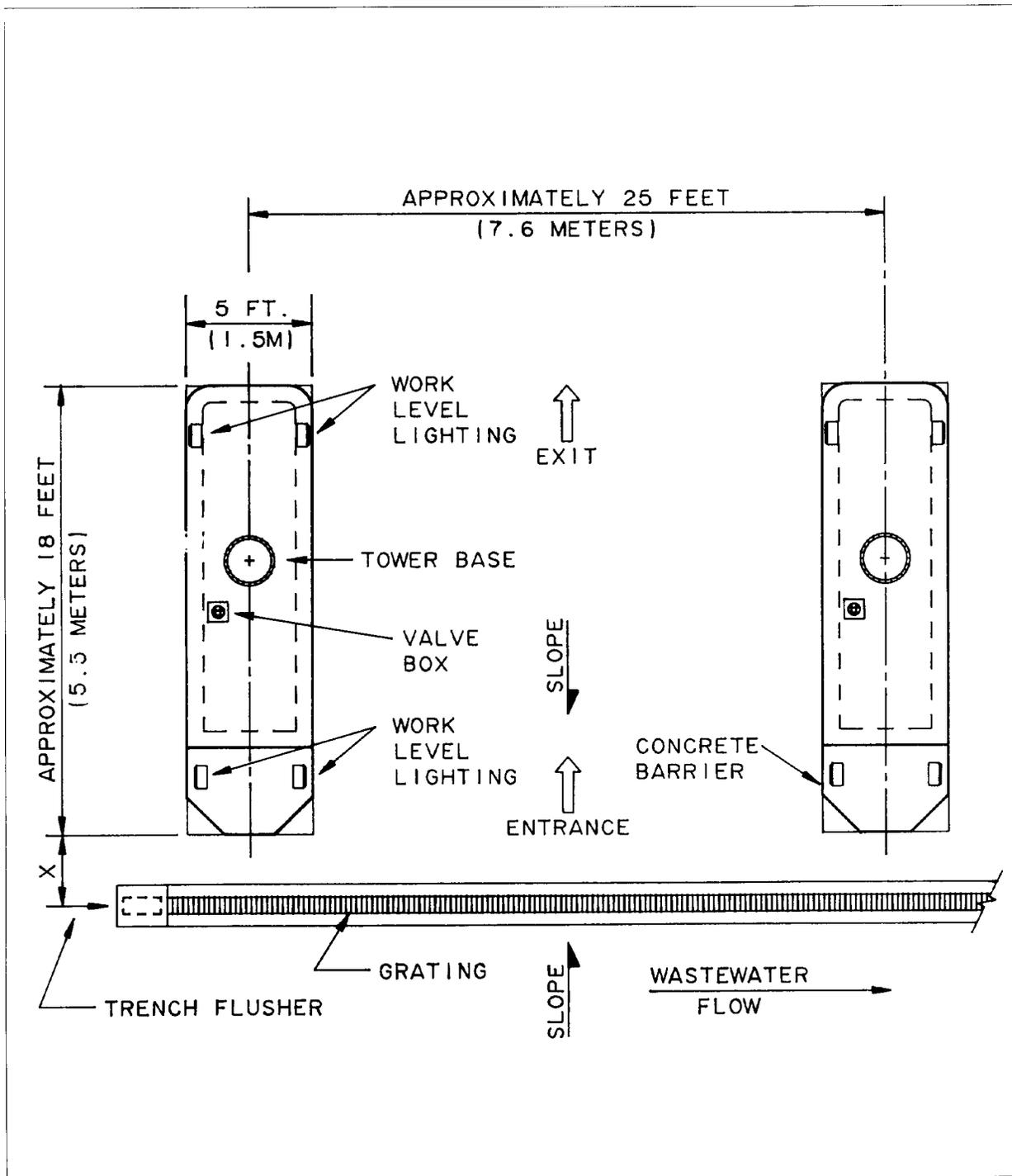
Figure 4-2. Wash island plan showing spacing.

4-3

hose, since only one vehicle will be served by the island. Figure 4-6 shows the tower in cross section.

a. Height. At least 15 feet (4.6 meters) clearance is needed between the pavement and the hose pivot point. If a vehicle taller than this height will be washed at the facility, a higher clearance can be used at one or more wash stations, as required.

b. Hose pivots. The hose pivots support the hose and should be properly sized steel beams which support the hose and allow horizontal rotation of the hose. Cushioned stops should be installed on the towers to limit the movement of the pivot to 180 degrees in the horizontal plane. A tie rod or other form of brace should be used to stabilize the pivot in the vertical direction. A system should be included to secure the hose after use. This system shall allow for draining of all water out of the hose and keep it from being run over by the vehicles.
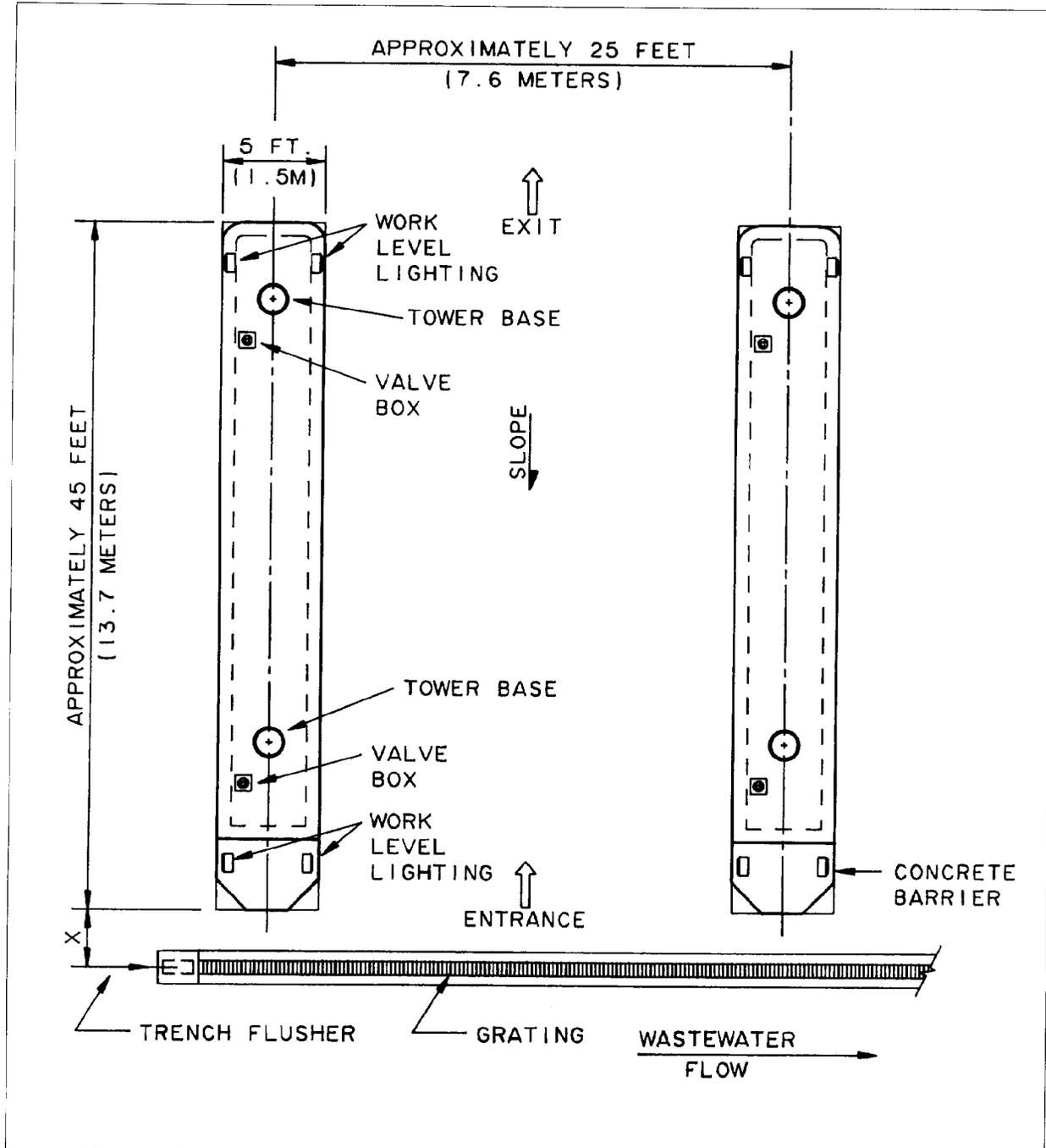
Figure 4–3. Double-tower island.

c. Water pressure and flow rates. The recommended de--sign pressure is 75 pounds per square inch (psi) (5.2 atmospheres). The water pressure is measured at the nozzle. The recommended design flow rate is 25 gallons per minute (95 liters per minute). Pressures and flow rates are given here to facilitate pump selection. Control should be provided to limit maximum pressures at the nozzle to 90 psi. Valving must be installed to allow each island to be isolated from the water supply. Manually operated valves are required to allow troops to control flow from each hose on the island.

d. Hoses. The hoses to be specified at the vehicle wash stations are made of reinforced rubber. The reinforcement should be an all-textile braid made of resilient synthetic yams; this material is covered with thick rubber. The hoses must be flexible for ease of handling and rated for a minimum working pressure of 300 psi (20.4 atmospheres). Hoses must be durable, suitable for use in water, and resistant to abrasion, oil, and sunlight. Orifice diameter of the nozzle should be 5/16 inch in order to provide chosen flow at 75 psi (5.2 atmospheres) pressure at the nozzle inlet. Each hose must be long enough at each location to reach the side, front, and back sections of the vehicles being washed.

e. Nozzles. The nozzles must be durable to withstand frequent punishment and heavy use. The inner diameter of the hose connection at the tower will be determined by the required pressure and flow rate. The hoses should be designed with rubber nozzles built in by the manufacturer.

4-9. Protection against freezing

In regions where freezing conditions may occur, the water supply piping, valves and fittings at the wash stations must be self-draining and designed for protection from damage due to freezing.

4-10. Water supply piping

Valves which will be frequently operated on the supply piping to the wash stations must be accessible through valve pits, valve boxes, or manholes. Isolation valves within the system can be directly buried.

4-11. Paved area drainage

a. Surface drainage. All water used for washing vehicles and cleaning the CVWF as well as all precipitation falling on or flowing through the paved area shall be collected through a drainage system that flows to the primary treatment basin. This volume may be captured as makeup water if necessary. The assembly area located after the wash area and the preparation area shall be paved and sloped toward a grated trench drain. Concrete curbing should be installed at all pavement/ soil interfaces when the designer deems necessary to contain and direct the runoff to the treatment system. In areas where water is not expected to occur and vehicular control is not required, such as the preparation area, the designer may choose to limit or not use curbing. Other surface water shall be drained away from the facility unless it is to be captured for use as makeup water.
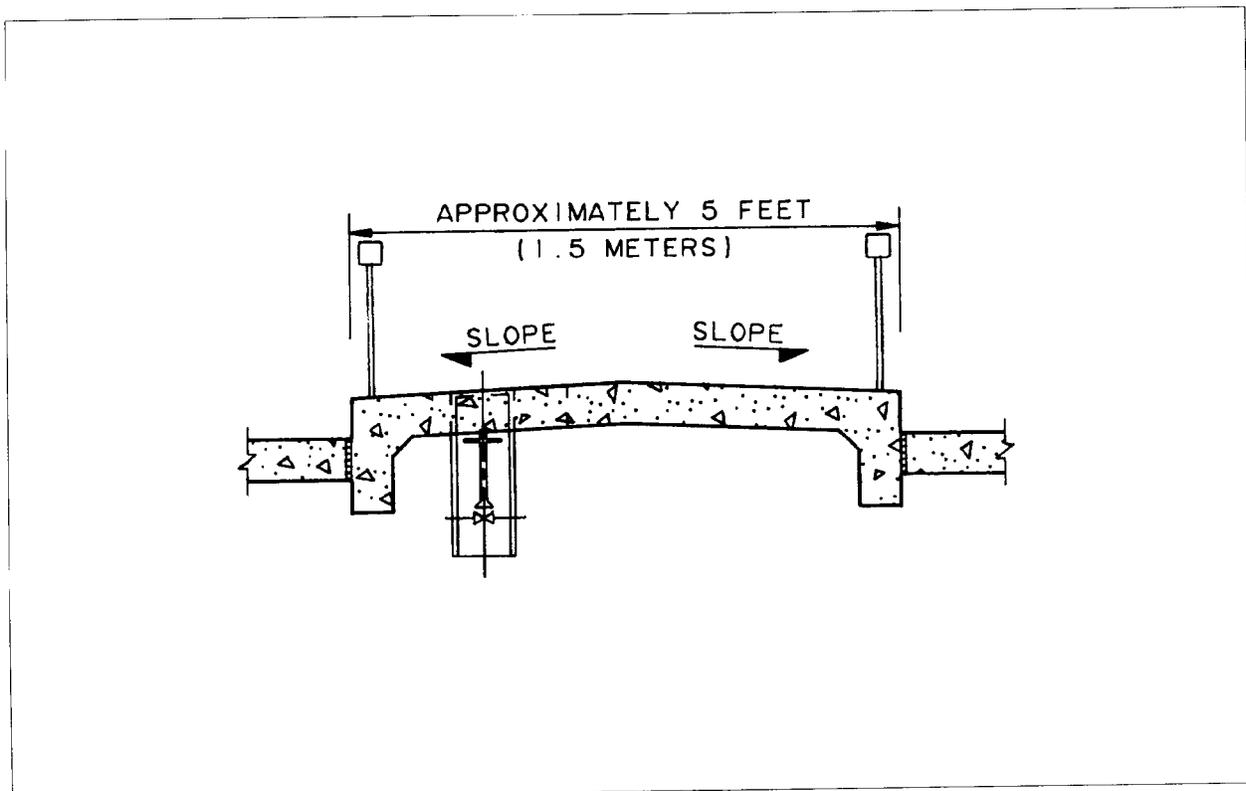
Figure 4–4. Cross section of an island.

b. Trench drains. Open-grated trench drains are provided to move soil-laden wastewater from the paved staging and wash station areas to the wastewater collection system. Figure 4-7 shows a typical trench drain in cross section. The trench should have a circular (U-shaped) bottom with a smooth surface for good open channel hydraulics and abrasion resistance. Grating should be galvanized steel or cast iron and able to support the vehicle loads to be imposed. Grate openings should be at least 1 inch (2.54 centimeters) wide to allow gravel to pass through. Grating sections should be of a weight and attachment design that allow easy removal for maintenance of flow in the trench drain system.

(1) *Trench drain layout.* Trench drains are usually oriented transverse or diagonally across the direction of vehicular traffic. A trench drain system is required the length of each row of wash stations at the entrance end (see figs 2-1, 4-1, 4-2 and 4-3). The location of additional trench drains in the staging areas will depend on the following:

(a) The amount and distance that soil-laden material must be moved during wash area cleanup operations.

(b) The location of staging area hose hydrants and their effective area of coverage.

(2) *Trench drain flushing system.* The trench flushing system consists of a supply line with motor-operated valve and nozzle injection points along the trench drain. An adequate slope must be maintained in the trench which will move the dirt and debris to the collection system. Flow velocities of at least S fps (1.5 meters per second) are required. Trench slopes shall be at least 2 percent. Bottom grades at bends, junctions, slope changes, and section changes in the trench drains should be designed for energy losses. The flushing nozzles are located in the trench just above the normal flow surface and point downward and downstream. Flushing is accomplished intermittently during vehicle washing periods and during cleanup operations at the wash station trenches, and only during cleanup in other staging area trenches. Flush system control by the facility operator is critical and is independent of other pumping supply systems. Flushers are operated only when necessary in order to conserve water and power. A well designed flushing system utilizes water drawn from the equalization basin as discussed in chapter 6.

c. Wastewater collection system.

(1) *General.* Wastewater and stormwater collected on the paved areas and moved to the trench drains are
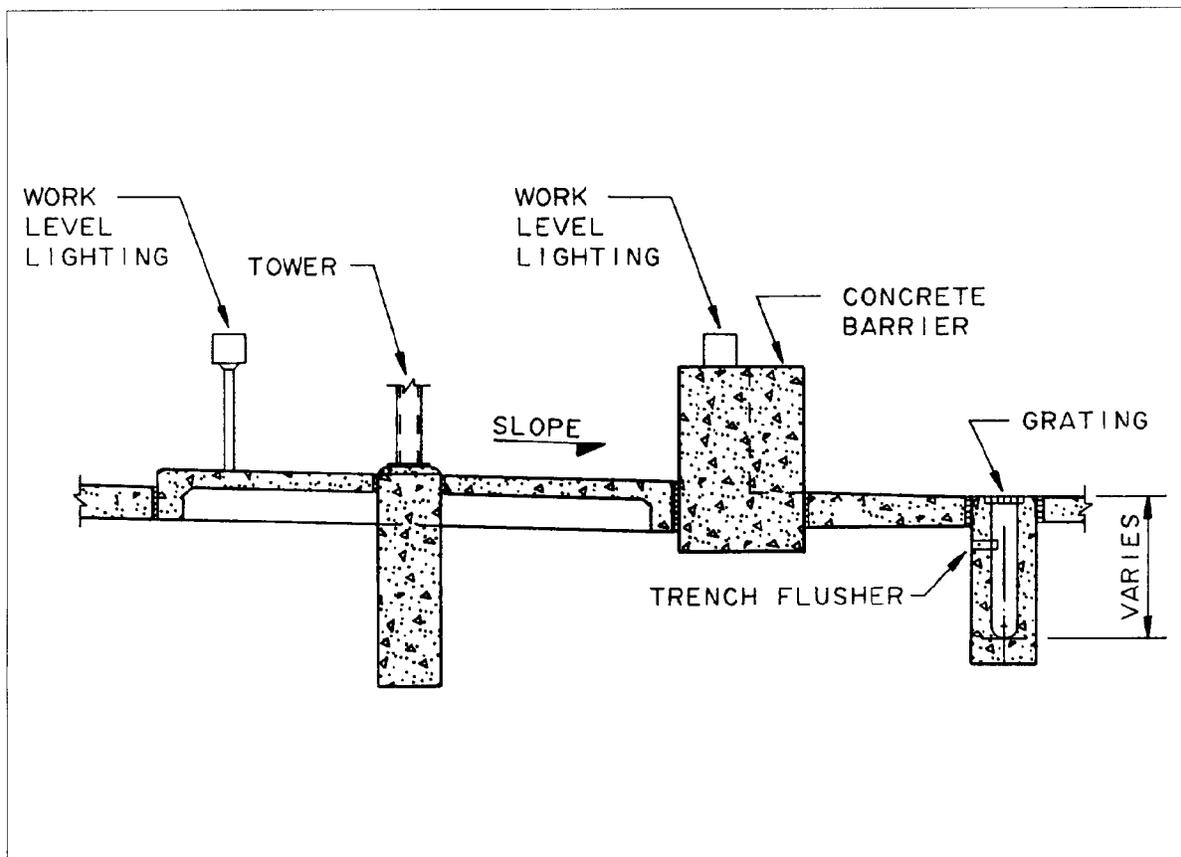
Figure 4-5. Longitudinal section of an island.

tied to an open trench or underground piping network, or combination thereof, and conveyed by gravity to the sediment basin for primary treatment. If site conditions and grades permit, the collection system for stormwater to the sediment basin should be an open channel for easy cleaning of the open trench. Lines and channels should be as straight as possible. Minimizing the number of changes in direction will avoid mud and debris accumulation. Manholes should be provided for pipe systems at pipe intersections, changes in direction, and

changes in slope, and at no greater than 400-foot (121.9-meter) intervals on straight runs. Gravity collection systems without flushers that empty into the sediment basin are designed to maintain a minimum velocity of 5 fps (1.5 meters per second). A minimum of 2 percent slope shall be required on all gravity wastewater lines.

(2) *Materials.* Open channels are cast concrete rectangular, trapezoidal, or semicircular cross sections. Semicircular channels limit areas where dirt and
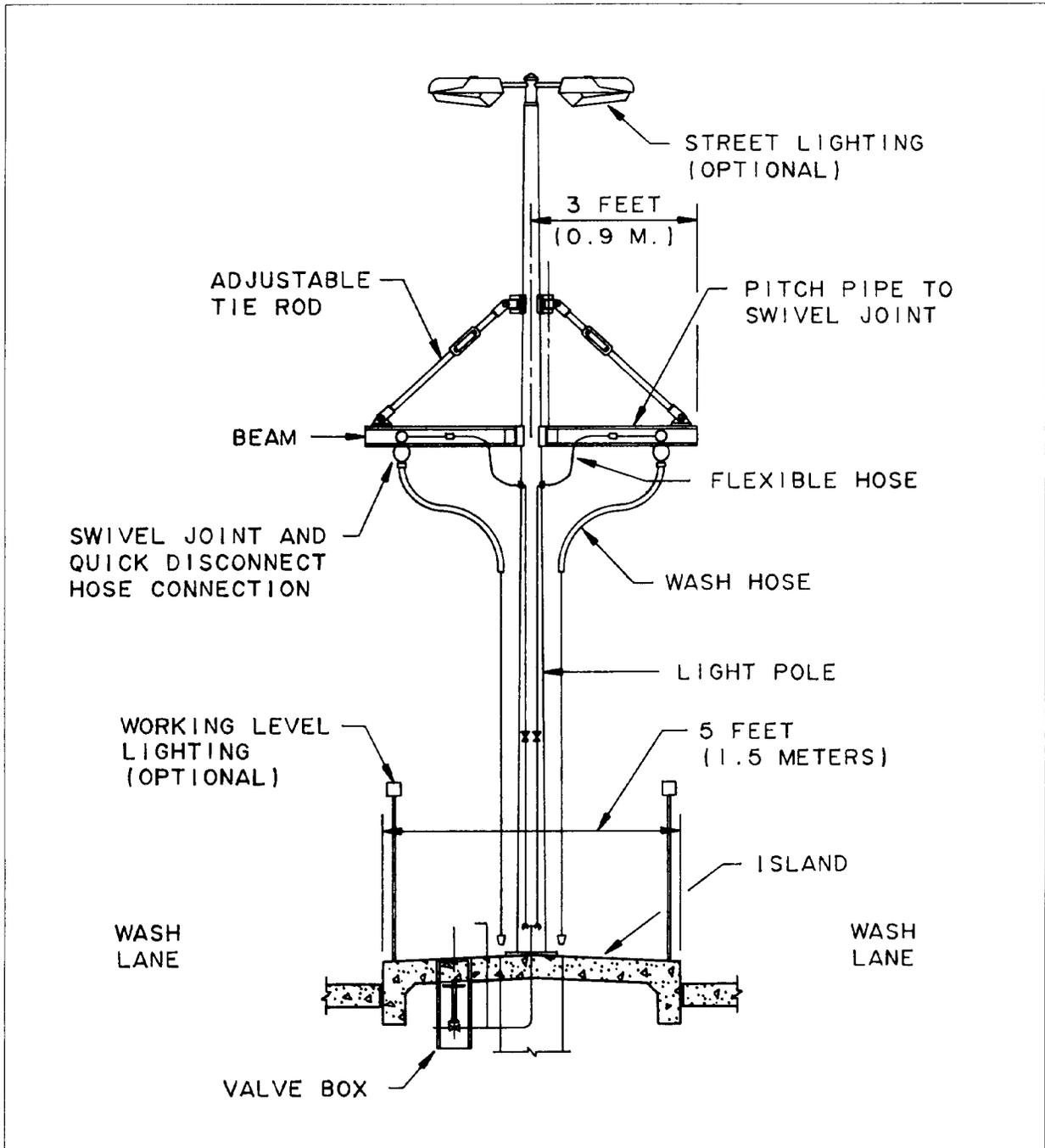
Figure 4-6. Tower detail in cross section.

debris can accumulate. Gravity pipe systems usually are reinforced concrete, steel, or ductile iron pressure piping. Plastic pipe may be used, as local practices and experience permit, except under pavements.

4-12. Pavement

All ground surfaces within the CVWF that will support vehicle movement must be covered with a hard surface and curbing for water and vehicle control. Pavement is required to keep the clean vehicles from driving and parking on surfaces where they would become soiled. It also ensures that vehicles do not track dirt from unpaved areas into places reserved for clean vehicles. Concrete is recommended in areas of tracked vehicle movement, including pavements over which both tracked and wheeled vehicles will maneuver. Asphalt paving will suffice in most areas where only wheeled vehicles will operate or in areas of straight tracked vehicle movement. The paving and base should be designed to meet the needs of the vehicles that will

use the facility. Concrete should be used around critical drainage structures, such as at wash stations. Roads and trails leading to motor pool areas from the wash facility shall be paved to prevent clean vehicles from be-coming soiled again. Roller-compacted concrete should be considered for all paving areas except at critical drainage structures, where form-worked concrete should be used.

4-13. Interior wash equipment (optional)

Low-flow, interior wash equipment should be provided at the islands, at user request, for washing truck beds, cab floors, jeep interiors, and other such areas. This equipment is used for washing personnel compartments only and is not intended for cleaning engines. Engine cleaning is prohibited at these locations. The outlet should provide a water pressure of 40 psi (2.8 atmospheres) and a flow rate of 5 (19 liters per minute). A 3/4 inch heavy duty utility hose is attached to the outlet. A sign shall be posted warning personnel not to wash engine compartments.
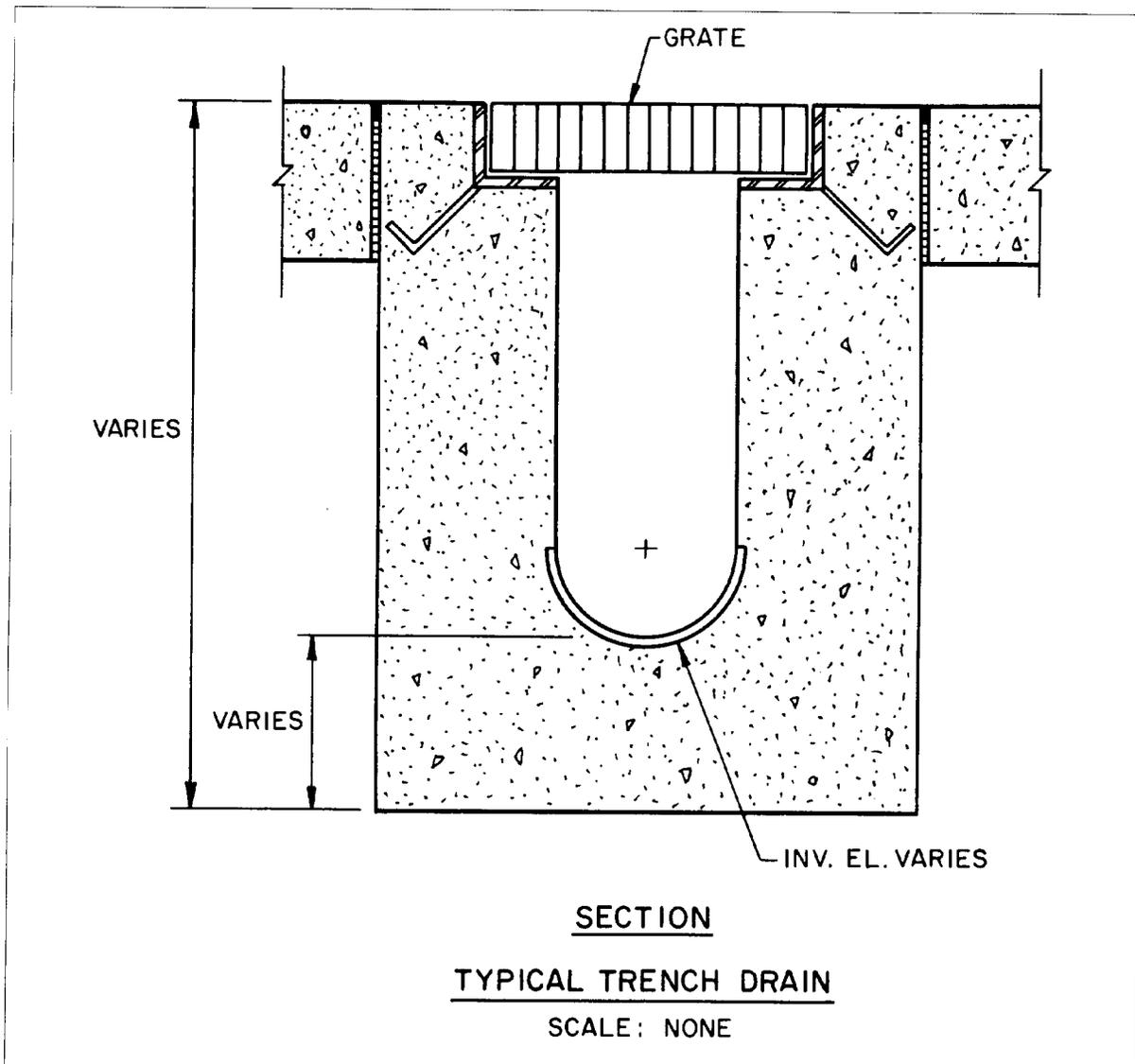
Figure 4–7. Cross section of a trench drain.

Section III. SUPPORT FACILITIES

4-14. Lighting

Adequate overhead and working-level lighting must be provided at CVWFs where users will be washing vehicles at night. Overhead tower structures provide lighting for the staging areas. Towers may be high- or low-mast, but must be located so as to provide total wash area coverage without interfering with traffic. Wash station towers may have lighting fixtures for this area as shown on figure 44. Lighting levels of at least 3 foot-candles measured at ground level should be provided in the wash areas and at least one foot-candle at all points on the CVWF hardstand. Working-level, high-intensity, horizontal mounted flood lighting is provided at each wash station to reduce shadows on vehicle sides and to aid in inspection of vehicles after washing. At least 5 foot-candles should be provided in the wash area, measured at the extreme end of a vehicle. The two types of lighting should not be additive in computing lighting intensity levels since one is a vertical projection and the other is a horizontal projection. No lighting is provided at CVWFs where only daytime use is planned. However, security lighting is always provided at entrance/exit doors of each building and other locations as required. A selected portion of the tower fixtures may be used as security lighting.

4-15. Physical security

Physical security consists of locks on building doors. The CVWF usually is not fenced unless the user requests it for safety and protection against vandalism. Fencing of the basin areas is recommended.

4-16. Signage

Signs must be posted warning personnel not to drink the wash water and directing them where potable water is available. Traffic flow signs as well as pavement markings should be provided to ensure safe, effective use of the facility.

4-17. Solid waste collection

Commercial dumpsters should be located strategic points along the edge of the preparation area for disposal of solid waste. Dedicated concrete pads adjacent to the pavement are preferred to avoid damage to dumpsters and moving vehicles. Extra dumpsters may be required at the wash stations.

4-18. Operation and controls

Equipment operating, maintenance, and repair manuals should be specified to be provided by the contractor at completion of the construction contract.

a. Operator. The requirement for an operator will depend on the size and complexity of the CVWF. The operator is responsible for shutting off the equipment in times of emergency and at the end of the washing operation. This person controls the pumps and valves, oversees cleanup, reports any maintenance problems, and assures safe operations. At facilities which have recycled water systems, the operator will also be responsible for monitoring the treatment process.

b. Control building. A building shall be provided to house controls for the wash facility in one central location. A master control panel shall be installed to permit the operator to shut off all washing operations at one point. This design allows the operator to shut down the facility quickly and efficiently if required. The building shall provide protection for the operator during inclement weather. Insulation, heating, ventilation, and air-conditioning may have to be provided for the control building at some installations. Latrines and potable water for the troops can also be included in the control building. A telephone should be installed in this building to allow the operator to report O&M problems and emergencies. Figure 4-8 shows a recommended layout, for the control building.

(1) *Location and design.* The control building must be located such that the operator can easily see washing operations at all wash stations. The entire treatment system also should be visible from the control building. Latrines for troops and operators and a lockable storage space can be included in the building as required. An efficient design places the control panel in a second-story room above the latrine and/or storage rooms (fig–9). This allows the operator to have a good view of all washing and treatment operations. The operator should be able to operate the control panel and still have a clear view of the operations. Depending on the orientation of the facility and the control building, tinted glass or sunscreens may have to be installed to reduce glare which may inhibit the operator's view of the wash facility or control panel. Area and control-room lighting must not interfere with the operator's visibility during nighttime operations.

(2) *Size.* The control building must be sized to house wash facility controls, building electrical and mechanical equipment, storage, and latrines for the wash facility in one location.

(3) *Protection.* If the control building is to be located adjacent to vehicle movement, protective barriers must be installed at its comers. Other protective barriers such as guard rails may also be required.
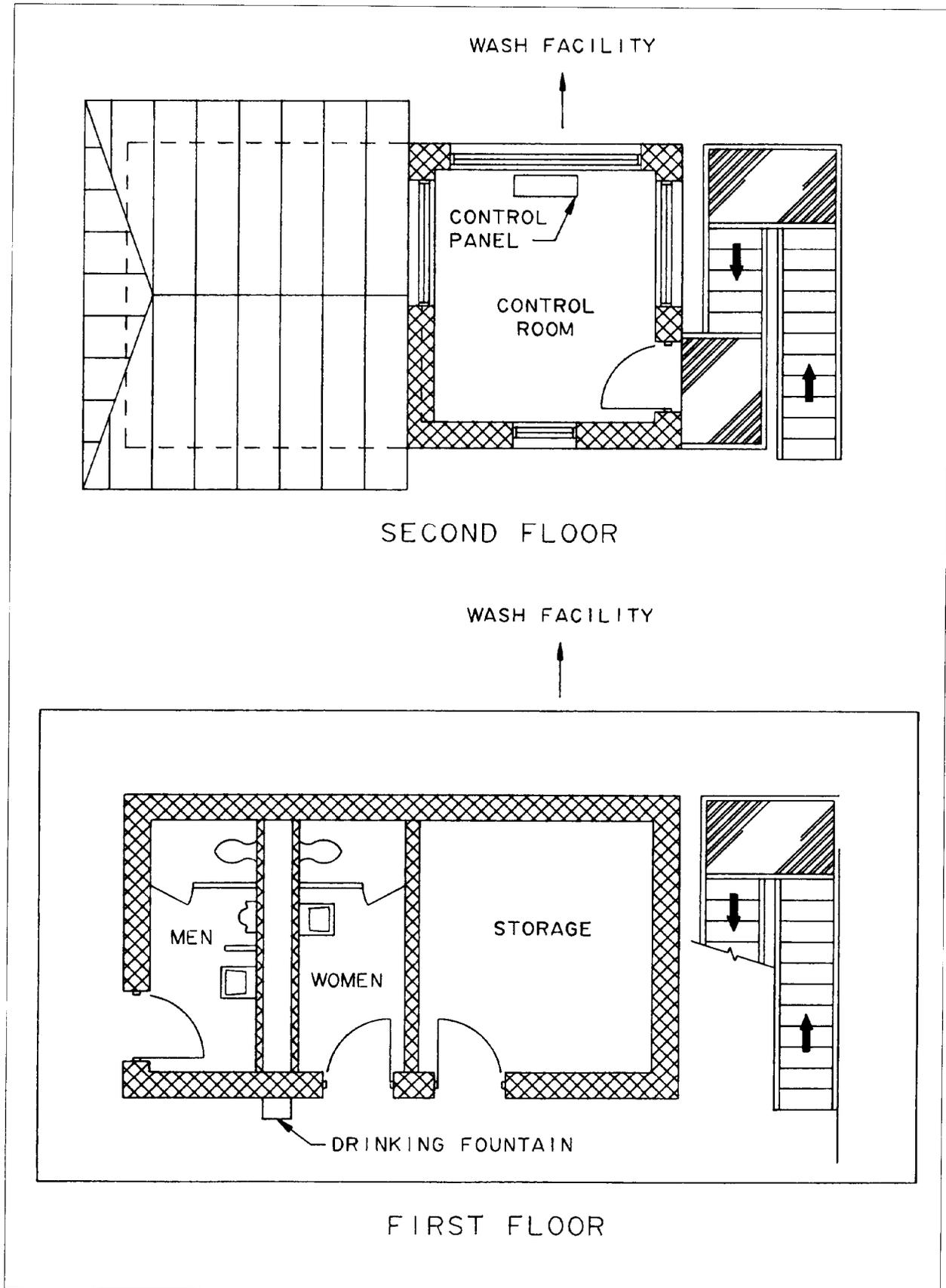
WASH FACILITY

CONTROL
PANEL

CONTROL
ROOM

SECOND FLOOR

WASH FACILITY

MEN

WOMEN

STORAGE

DRINKING FOUNTAIN

FIRST FLOOR

Figure 4–8. Example floor plan for the control building.
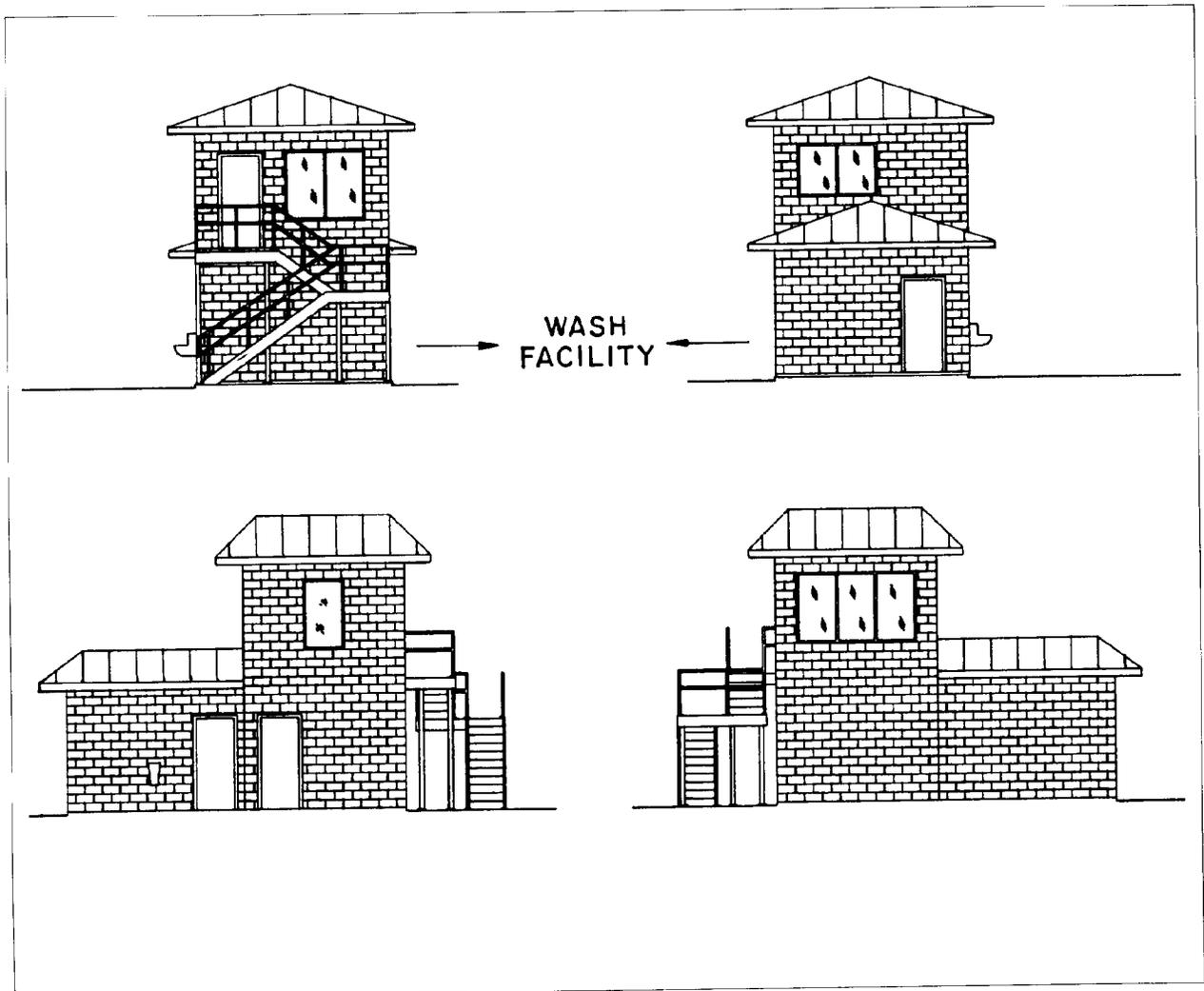
WASH FACILITY

Figure 4-9. Control building exterior.

CHAPTER 5
OPTIONAL PREWASH

Section I. TYPES OF PREWASHES

5-1. Introduction

a. The prewash is designed to remove a large amount of dirt from vehicle exteriors in the most efficient way. The prewash should be flexible enough to handle the number and types of vehicles expected to use the facility. After the prewash, most vehicles will require additional washing at the wash stations so that troops can do a more detailed cleaning, reaching into crevices where a prewash might not clean. Not all vehicles will require cleaning at a prewash. Lightly soiled and smaller vehicles, such as jeeps, may proceed directly to the final wash stations.

b. Two types of prewash facilities have been constructed for washing tactical vehicles: baths and spray stands. The bath is a water-filled basin with water cannons mounted at each of the four corners of each lane. As vehicles are driven through the bath, persons stationed at the water cannons spray them with high -pressure water to remove the dirt. Spray stands emit high-pressure streams of water from many small nozzles directed toward vehicles driving through the facility. The bath is the recommended prewash, since it removes the bulk of the dirt, including that under the vehicle, and is the most efficient water conservative method. The spray stand is neither as efficient nor as effective as the bath for gross removal of soil from tactical vehicles.

5-2. Bath prewash

The bath is a water-filled basin through which vehicles drive. Three actions in the bath operate at the same time to remove dirt from tracks, from wheel wells, and tank side skirts. First, the water in the bath provides a soaking action that allows the dirt to be more easily removed. Second, troop operated water cannons placed at each corner of the bath lane spray high-pressure streams of water at the vehicles. Third, raised pipe flexors built into the bottom of the bath flex the tracks and wheels of the vehicles to aide in loosening embedded dirt. This, flexing motion is accomplished by driving the vehicle back and forth through the bath. The combination of wave action and turbulence helps remove dirt from under skirts and wheel wells. Under light to average soiling conditions, one pass through the bath may be sufficient to remove the dirt. However, for heavier soiling, vehicles may require two or more forward and reverse passes over the flexors. An additional advantage of a bath prewash over the spray stand system is that various types and shapes of tactical vehicles can be cleaned without modifying the equipment. Also, the bath is more efficient at water usage than is the spray stand, so treatment systems can be smaller. Finally, the bath can more efficiently clean "skirted" vehicle types such as the M-1 battle tank.

a. Types of bath lanes. Two types of lanes have been designed and developed to accommodate all type tactical vehicles. Tracked vehicle lanes are designed for use by tracked vehicles only. Large, offset flexors on the bottom of the tracked vehicle lane allow maximum flexing of tracks but make it difficult for wheeled vehicles to traverse and maneuver. Dual-purpose lanes can be used by both tracked and wheeled vehicles. In the dual-purpose lanes, the smaller pipe flexors, which are not offset, are easily traversed by wheeled vehicles. However, the smaller flexors are not as effective as the. track lane flexors for cleaning tracked vehicles.

b. Configuration. Dual-purpose lanes can be used in conjunction with tracked lanes at the same facility. Figure 5-1 shows a prewash design that uses both types of lanes. It is recommended that no more than three lanes be combined to form one bath. Multiple baths can be linked with walls between them. This configuration will provide maximum flexibility for the installation, since not all bath facilities will need to be filled to wash vehicles if a small group arrives. If tracked and dual-purpose lanes are combined to form one facility, the tracked lanes should be located as close as possible to the sediment basin. Most of the sediment leaving the bath will be removed from the vehicles in the tracked lanes. This layout will reduce the distance that wastewater with high suspended solids content must travel prior to primary treatment. Figure 5-2 presents a tracked lane in cross section. Signs may be required to direct users to the proper type of bath lane.

c. Lane width. The recommended effective width of a lane is 22 feet (6.7 meters).

d. Bath bottom length. The length of the bath bottom is based on the track perimeter of the largest tracked vehicle expected to use the bath. A typical lane is 50 feet (15.2 meters) long from the bottom of the entrance ramp to the bottom of the exit ramp, including the width of the trench drain opening.

e. Water level. The water level in the bath should be adjustable. A range of 0 to 3.5 feet (0 to 1.10 meters) is recommended for maximum flexibility. Depth of water is measured at the deepest point in the bath (fig 5-2), excluding the depth of the trench drain. Not all vehicles can operate in a 3.5-foot (1. 10-meter) water level; in these cases, it must be possible to lower the water level. Depending on the types of vehicles using the bath and the different units' requirements, an operator can regulate the level within the recommended range. An extra 1.0 foot (30.5 centimeters) of freeboard should be added to the walls of the bath. A staff gauge or other water level indicator should be placed in the bath or painted on the side wall to guide the operator when adjusting the bath depth.

f. Water cannons. The bath prewash is equipped with two stages of stand-mounted fire-fighting-type hardware with nozzles, each of which can deliver the required design wash water pressure and flow to the exterior tracks or wheels of the

vehicle being washed. Each bath lane is provided with a total of two primary (entrance) cannons and two secondary (exit) cannons, one at each corner of the lane. Each lever-directed cannon system consists of water supply riser, manually operated flow control valve, play pipe, and nozzle. During the first stage, a vehicle enters the bath slowly from the entrance staging area

and troops aim the primary cannon water stream at it for gross removal of solids from wheels, tracks, idlers, and behind skirts and fenders. During the second stage, parts of the vehicle with soil not dislodged at the primary cannons or by submergence and flexing in the bath are exposed to the high-pressure, high-volume water stream from the secondary cannons prior to
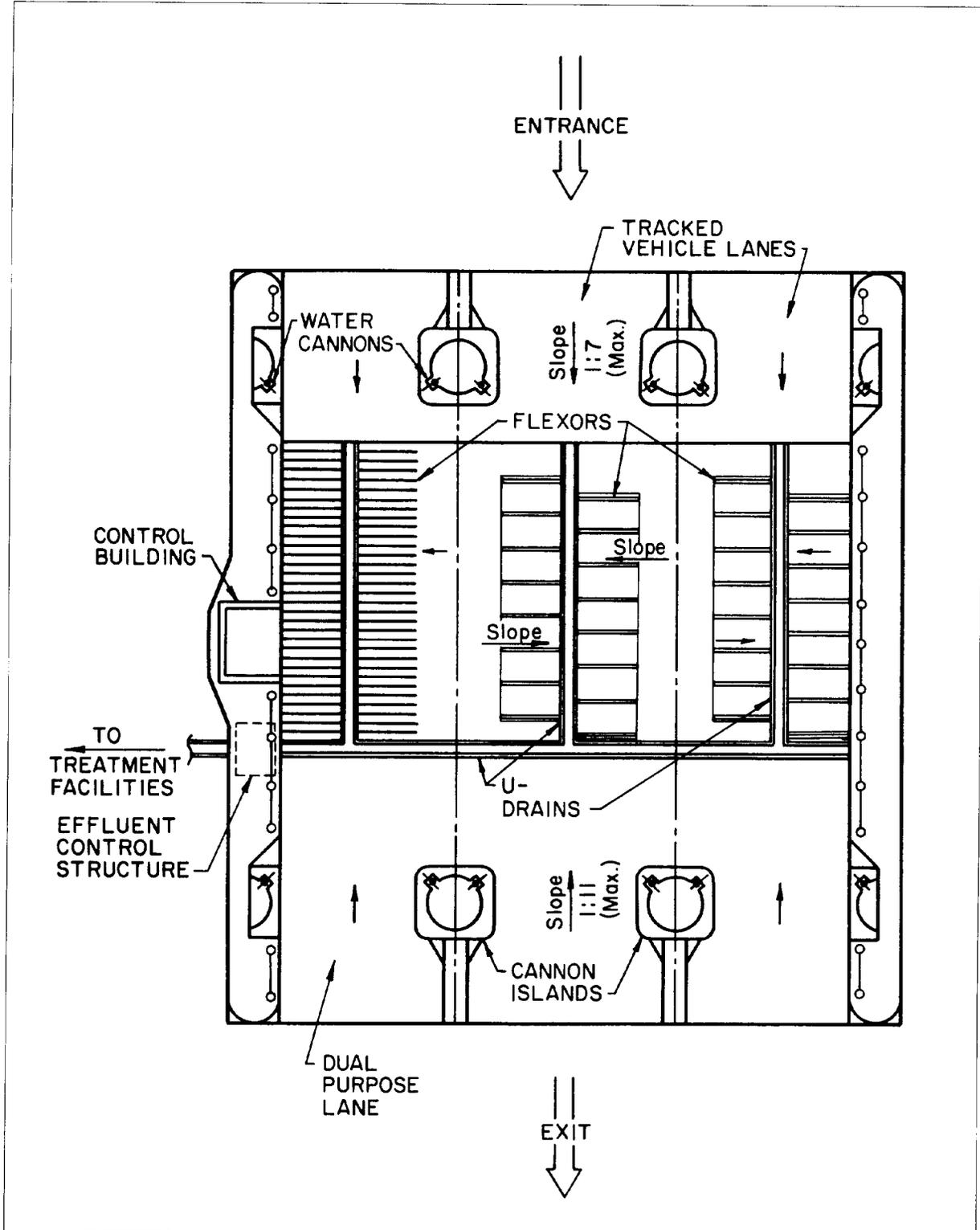
Figure 5–1. Example combined bath lane facility—plan view.

exiting the bath. To allow flexibility of lane usage, each water cannon system is designed to deliver and operate in the required flow and pressure ranges, regardless of whether a lane is dual-purpose or tracked.

(1) *Water pressure and flow rates.* The recommended water pressure is 100 psi (6.8 atmospheres) at the nozzles. The recommended nozzle flow rate is 80 gpm (300 liters per minute). A flow control valve shall be installed on each cannon to allow troops to stop and start the water flow. As discussed in

chapter 4, pressure and flow rates are provided to facilitate pump selection and control, and to handle different soiling conditions.

(2) *Height.* The center line of the nozzle on the cannon should be 50 inches (127 centimeters) above the can pavement adjacent to the island as shown on figure 5-5.

(3) *Nozzles.* The nozzle tip shall provide a stream of water with a zero-degree spray-angle nozzle. The
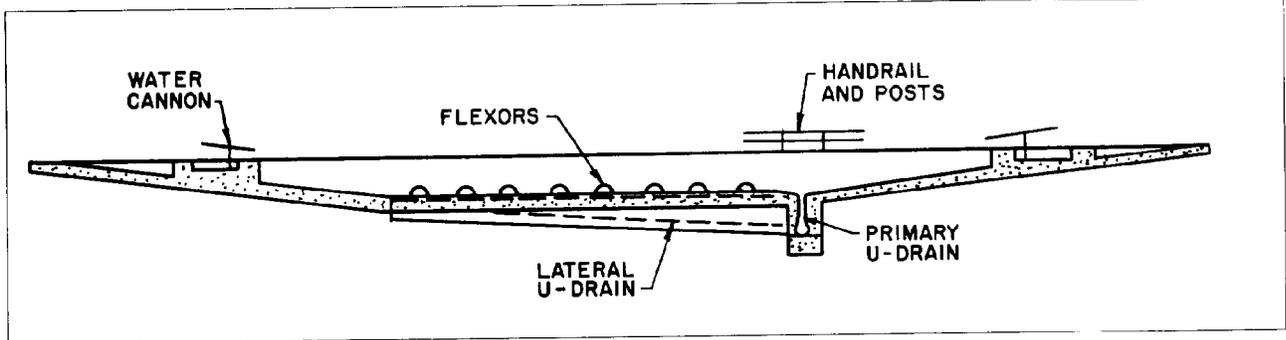
Figure 5-2. Tracked bath lane—cross section.
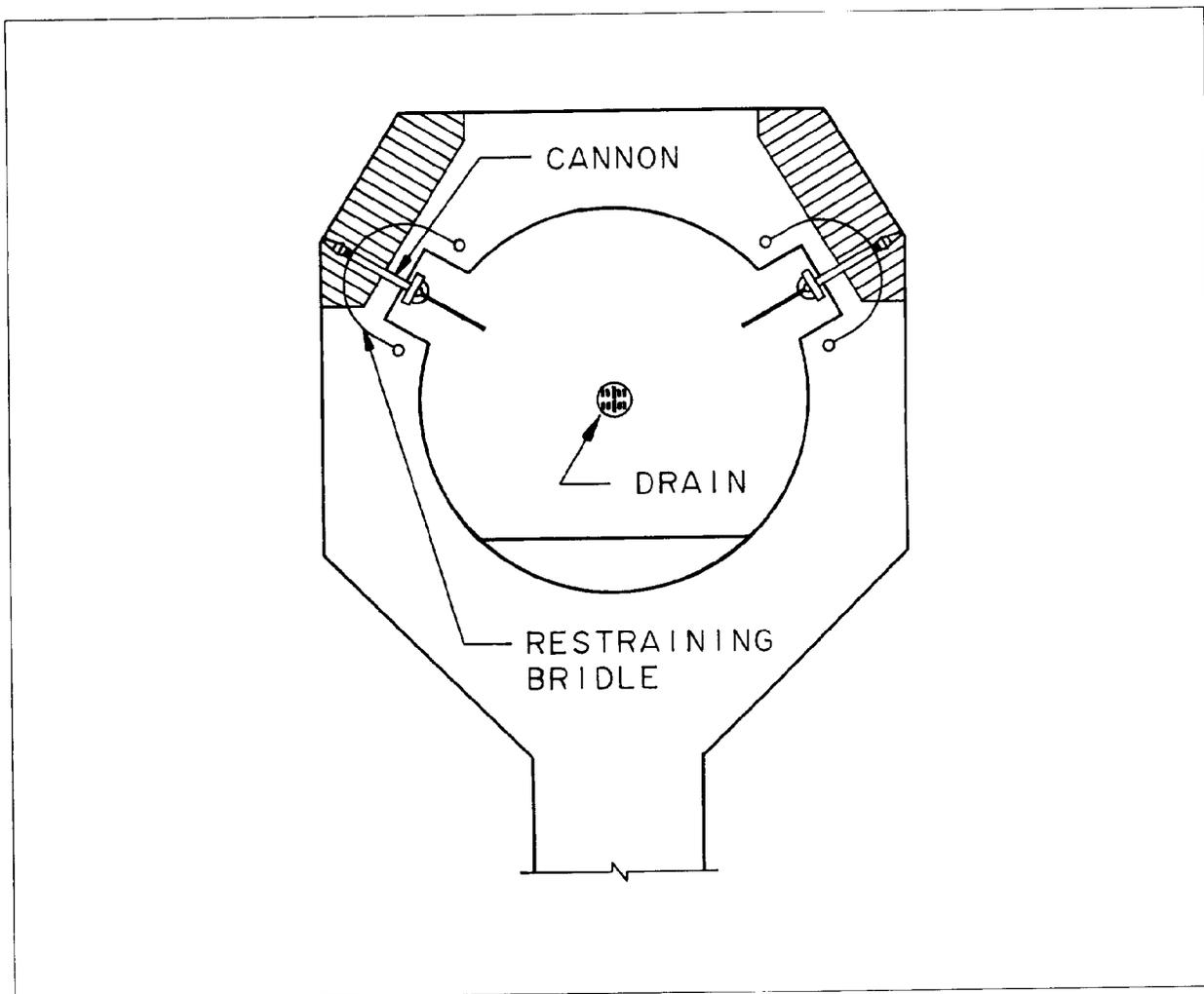
Figure 5-3. Example inner wash islands.

RESTRAINING
BRIDLE

DRAIN

CANNON
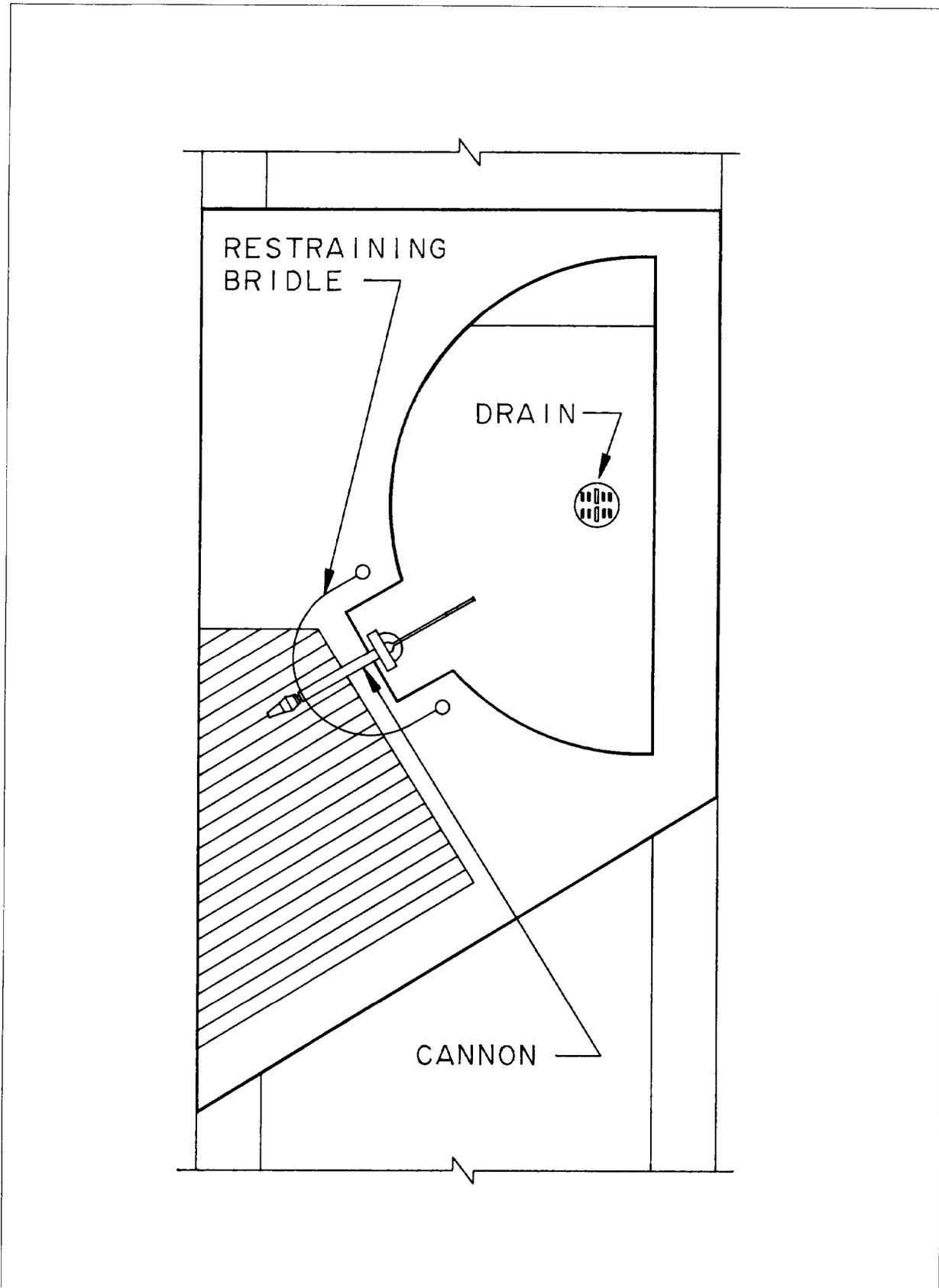
Figure 5–4. Example outer wash islands.

inner diameter of the nozzle orifice should be ½ inch (12.7 millimeters). The nozzle must be able to deliver pressures and flow rates within the recommended ranges with minimum losses.

(4) *Motion restriction.* Adjustable restraining bridles (fig 5-3) should be placed at each water cannon position to limit both horizontal and vertical movement. Without the restraints, personnel could accidentally spray each other during cleaning operations which could result in injury.

g. Cannon islands. Water cannons are mounted in concrete islands constructed at each corner of the bath lane. Figure 5-3 shows two example configurations. The concrete islands should be located on the entrance and exit ramps of the bath. Two cannons should be placed in each inner cannon island (fig 5-3). The outer islands should have one cannon per island (fig 5-4). The islands must have drainage so that troops will not be standing in water. All corner sections within the bath should be filleted to avoid the buildup of debris. Cannon island shall be designed such that they do not impede the movement of the cannons or the wash water flow stream. If the user requires, hose connections may be included in the island design for clean up purposes. Figures-S shows a cross section of the wash island.

h. Flexors. Flexors are grout or concrete filled, steel piping installed on the bottom of the bath lane to improve removal of encrusted dirt from under the skirts, around drive wheels, and other areas of the vehicles that cannot be cleaned by the water cannon flowstream. By driving the vehicles back and forth over the flexors, much of the dirt can be loosened and removed. The turbulence created from this action also removes dirt from hard-to-reach areas in the undercarriage, and behind side skirts. The spacing and height of the flexors cause the tracks and wheels to move in an up-and-down motion. This movement loosens dirt from the tracks and from under wheel wells and skirts. The space between the flexors also serves as a collection channel sloped toward bath lateral trench drain.
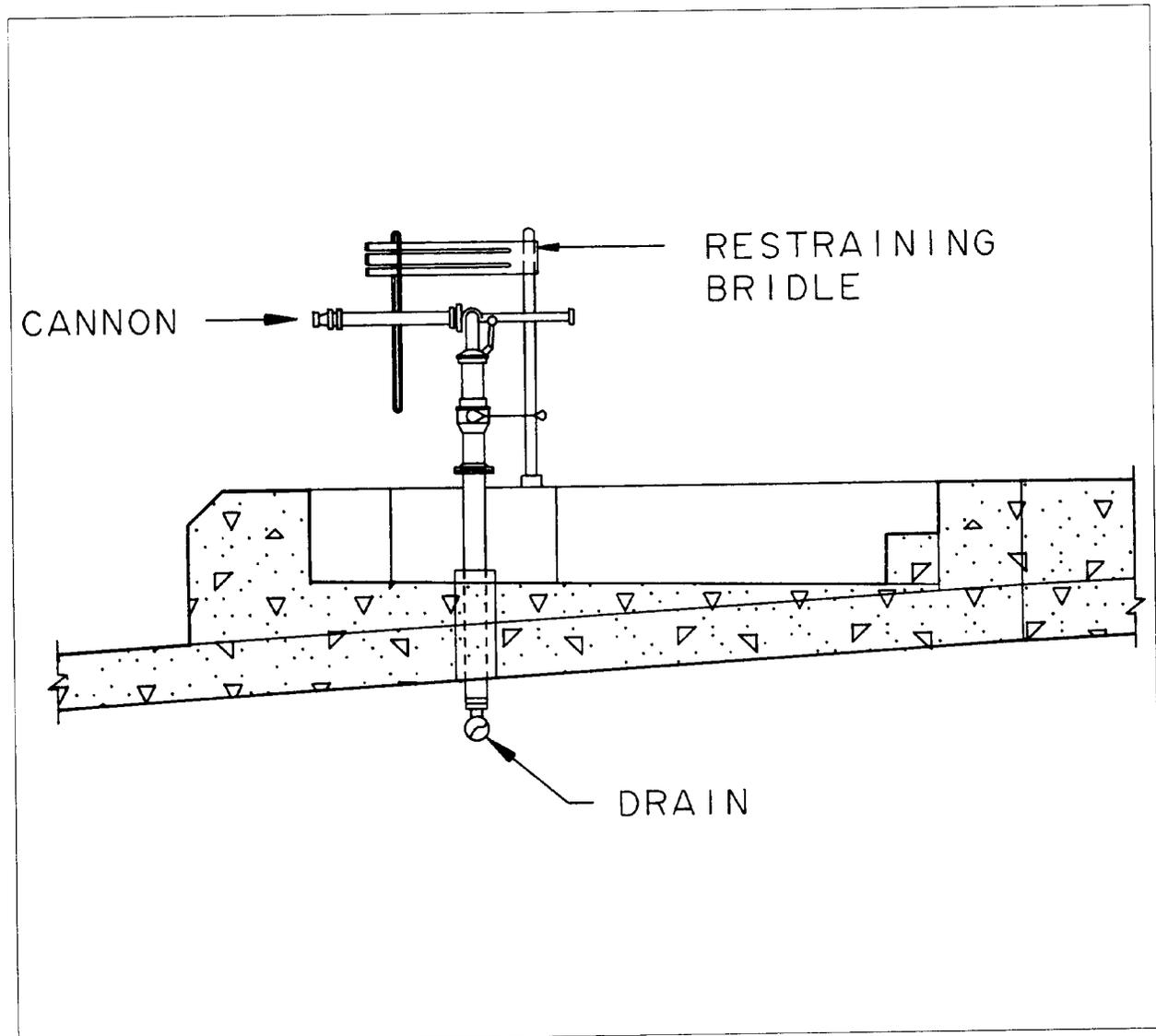
Figure 5-5. Example cross section of a cannon island.

ENTRANCE

CANNON ISLANDS

Slope 1:7 (Max.)

LONGITUDINAL U-DRAIN

5.5 FEET (1.7 METERS)

Slope

Slope

50 FEET (15.2 METERS)

FLEXORS

TO EFFLUENT CONTROL STRUCTURE

TRANSVERSE U-DRAIN

Slope 1:11 (Max.)

WATER CANNONS

TRACKED VEHICLE LANE

EXIT

Figure 5–6. Tracked bath lane.

(1) *Tracked vehicle lanes.* The recommended center-to-center flexor spacing is 5.5 feet (1.7 meters). The flexors are offset (fig 5-6) to allow the vehicle's running gear to achieve the maximum flexing motion possible. Outer lanes of the bath should have the flexors extended to the side walls to prevent dirt from building up between the ends of the flexors and the walls. Each flexor in a tracked vehicle lane should be 9 inches (22.8 centimeters) high. The method of connecting or imbedding the flexors to the bottom of the bath must be able to withstand the impact of all types of vehicles using the bath.

(2) *Dual-purpose lanes.* The design of flexors in dual-purpose lanes will be similar to those in the tracked lanes. The flexors should be spaced 18 inches (45.7 centimeters) apart. The flexors shall be installed at right angles to the lane and extend from the edge of lateral trench drain in the lane to the side walls of the bath. This design prevents dirt from collecting between the wall and the flexor. The flexors are not offset (fig 5-7) in order to allow better vehicle control. Each flexor shall be 3 inches (7.6 centimeters) above the floor level and constructed in such a way to withstand the impact of both tracked and wheeled vehicles.

i. Entrance ramp. The slope of the entrance ramp is measured from the top of the first flexor in the bath lane. The maximum allowable slope into the bath is 1:7 (14 percent).

j. Exit ramp. The maximum allowable slope for the bath exit ramp is 1:11(9 percent).
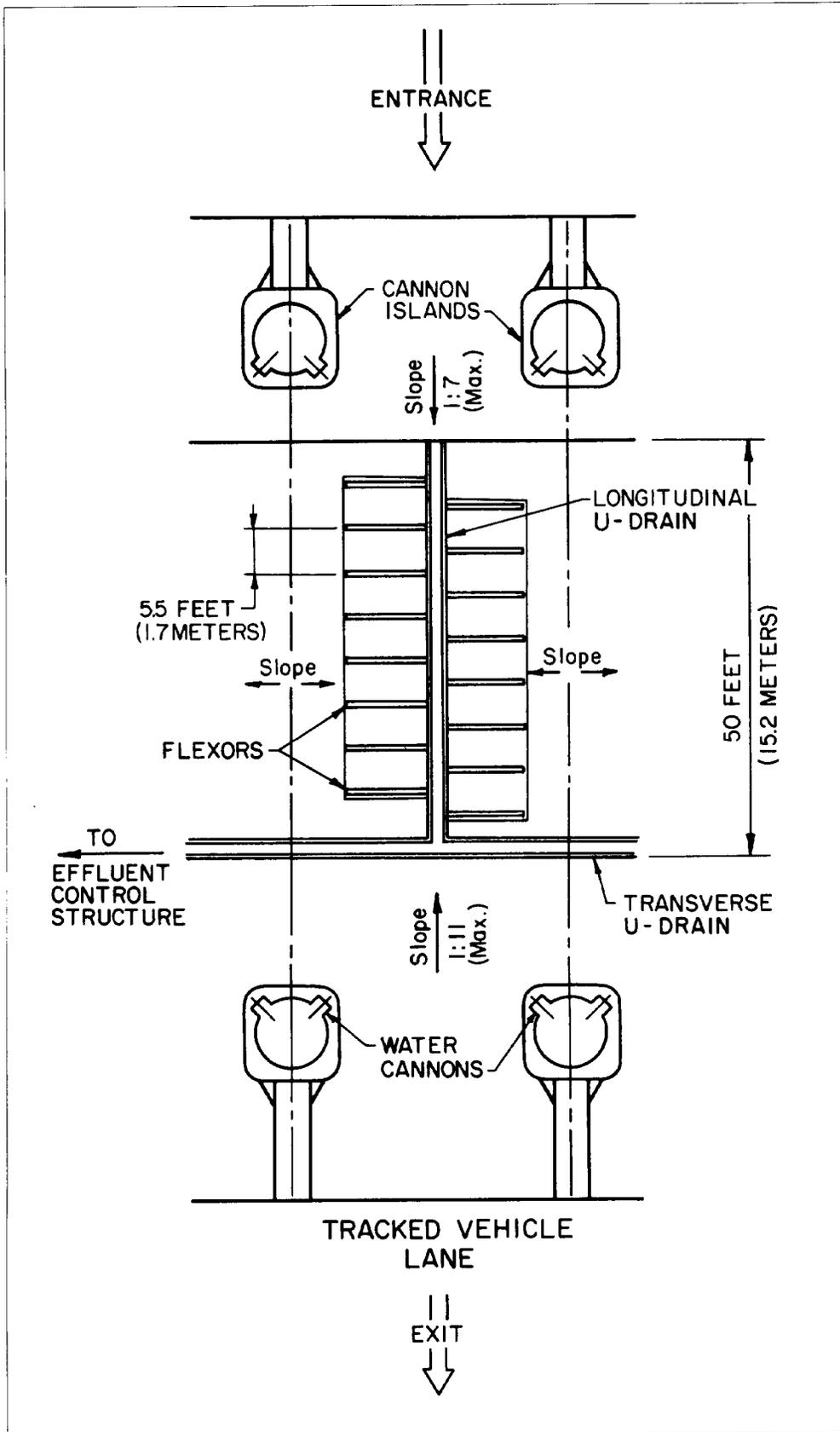
k. Ramp Slope. Slopes selected will affect the volume of water required to fill the bath and the resulting amount of wastewater to be treated. Therefore, the maximum slopes allowable should be selected except where local conditions require flatter slopes.

1. U-Drains. Open u-drains shall be used to move soil-laden wastewater from the bath area to the collection system (fig 5-8). The bottom of the bath should slope toward these drains at a minimum of 2 percent to help move mud and debris into the collection system (fig 5-9).

(1) *Configuration.* A lateral u-drain is installed along the centerline of each bath lane. Each lateral drain is connected to the transverse u-drain that runs perpendicular to the lanes. This transverse drain discharges directly into the bath outlet control structure. Figure 5-10 shows how these drains are arranged.

(2) *Fill/flush system.* A fill/flush system with motorized valves is provided in the bath to allow for timed filling of the bath and movement of dirt and debris to the outlet structure when the bath is drained, flushed and cleaned. A flusher supply discharge should be placed into the uppermost end of each u-drain. The flushers will provide increased flow in the u-drains to prevent sediment deposition. The recommended flushing rate is 600 gpm (2280 liters per second) for the lateral u-drains and 900 gpm (3420 liters per second) for the primary u-drains and should be set to provide 5 fps (2.4 meters per second) velocity in the u-drain. Flushing time is arbitrarily set at 15 to 25 minutes, depending on soiling conditions. The flow rate for filling may be increased in order to fill the bath in a reasonable amount of time; a fill time of 30 minutes or less is recommended. The fill/flush procedures are controlled by the wash facility operator (see chap 4.) The system of pumps and supply piping is designed to be independent of other systems. The source of fill/flush water is the equalization basin.

(3) *Design.* U-drains are to be designed to handle the peak solids and hydraulic loadings that occur in moving wastewater to the effluent structure. A minimum grade of 2 percent is required in the drains along with 5 fps velocity to prevent settling.

(4) *Materials.* U-drains should be lined with concrete or other impervious material such as plastic, metal, or vitrified clay. The liner should have a smooth, circular finish to reduce roughness in the trench.

m. Outlet control structure. A moveable weir on the outlet structure is used to regulate the depth of water in the bath (fig 5-11). This weir is located at the interface of the structure and the bottom of the bath and is designed to be raised or lowered to vary the water depth. A valve or gate is located in the structure at the intersection with the transverse u-drain to allow wastewater to discharge into the structure. Weirs, valves and gates may be motorized or manually operated. The structure should be designed to minimize solids deposition.

5-3. Vehicle spray stands

A spray stand operates much as a commercial car wash in that the vehicle is driven into the facility and sprayed by high-pressure water from many small nozzles. This method is not suited, nor recommended, for the irregular-shaped tactical vehicles, because M-1 tanks and other vehicles with heavy side skirts cannot be cleaned effectively. The spray does not effectively remove dirt from the treads, under the skirts, and other places that are difficult to reach. Spray stands also require larger amounts of water than comparably sized bath prewash facilities. Therefore they are not recommended for use at CONUS installations.

ENTRANCE

CANNON
ISLANDS

Slope 1:7 (Max.)

LONGITUDINAL
U-DRAIN

15-18 INCHES
(38.1 TO 45.7
CENTIMETERS)

Slope   Slope

50 FEET
(15.2 METERS)

FLEXORS

TO
EFFLUENT
CONTROL
STRUCTURE

TRANSVERSE
U-DRAIN

Slope 1:11 (Max.)

WATER
CANNONS

DUAL PURPOSE
LANE

EXIT
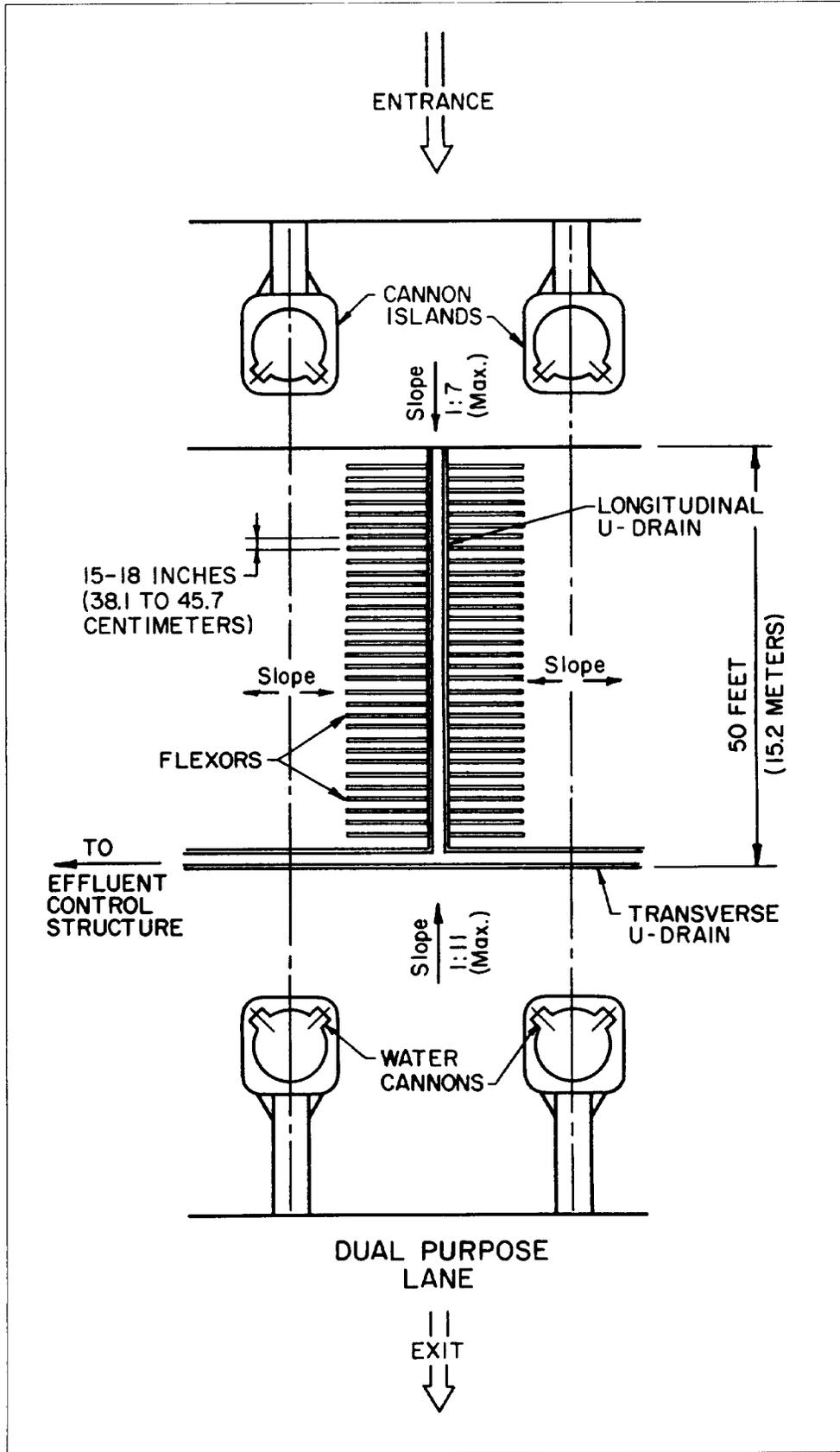
Figure 5–7. Dual-purpose lane.

VARIES

VARIES

9" MAX
6" MIN

VARIES

VARIES

INV. EL. VARIES

Figure 5–8. U-Drain.

CENTERLINE
OF
LANE

Slope 2%(Min.)

Slope
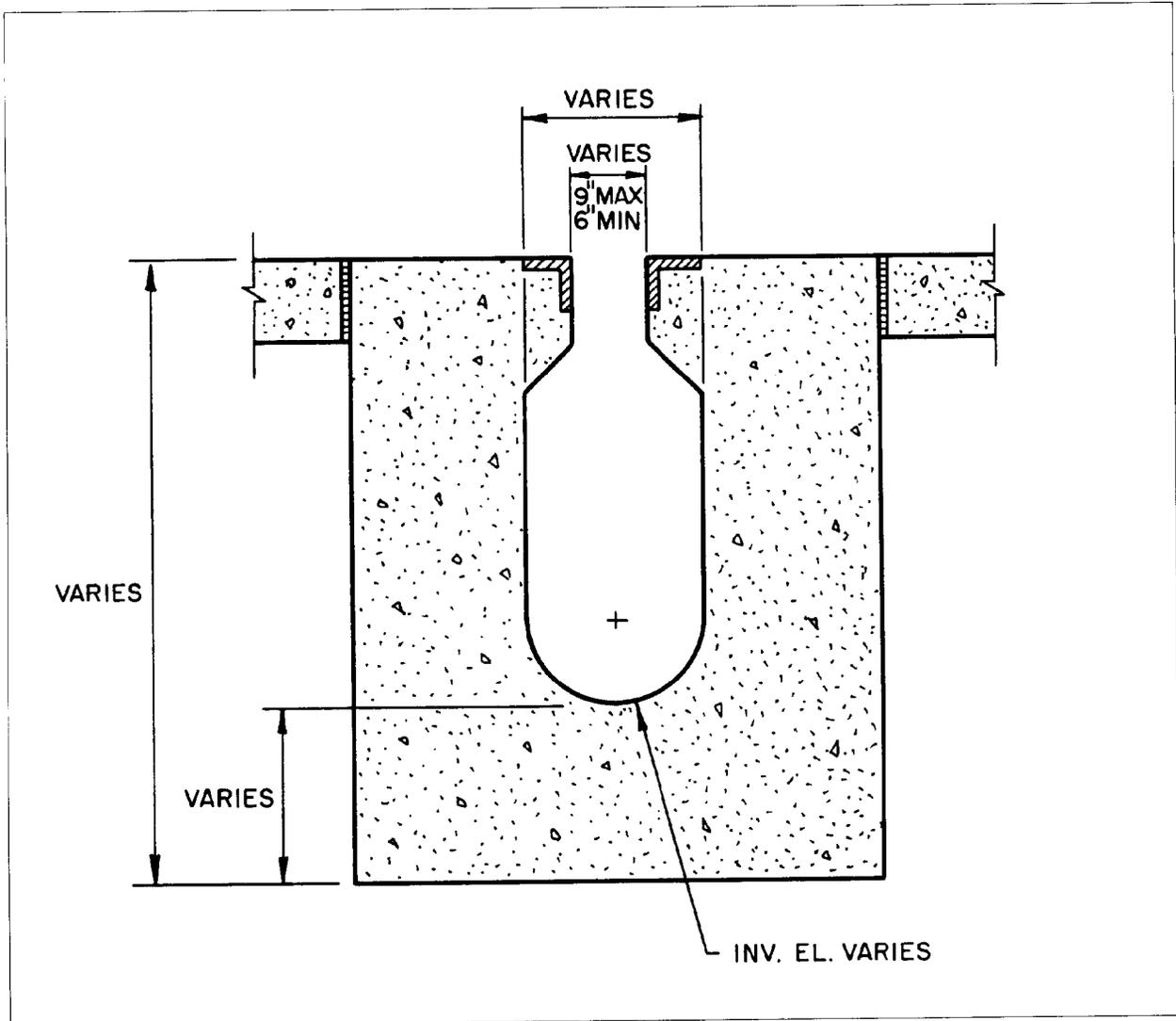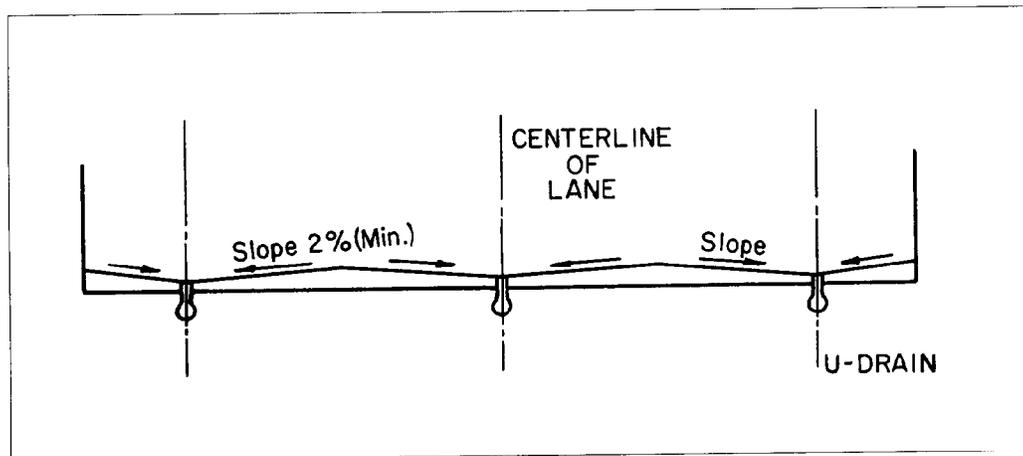
U-DRAIN

Figure 5–9. Bath cross section.
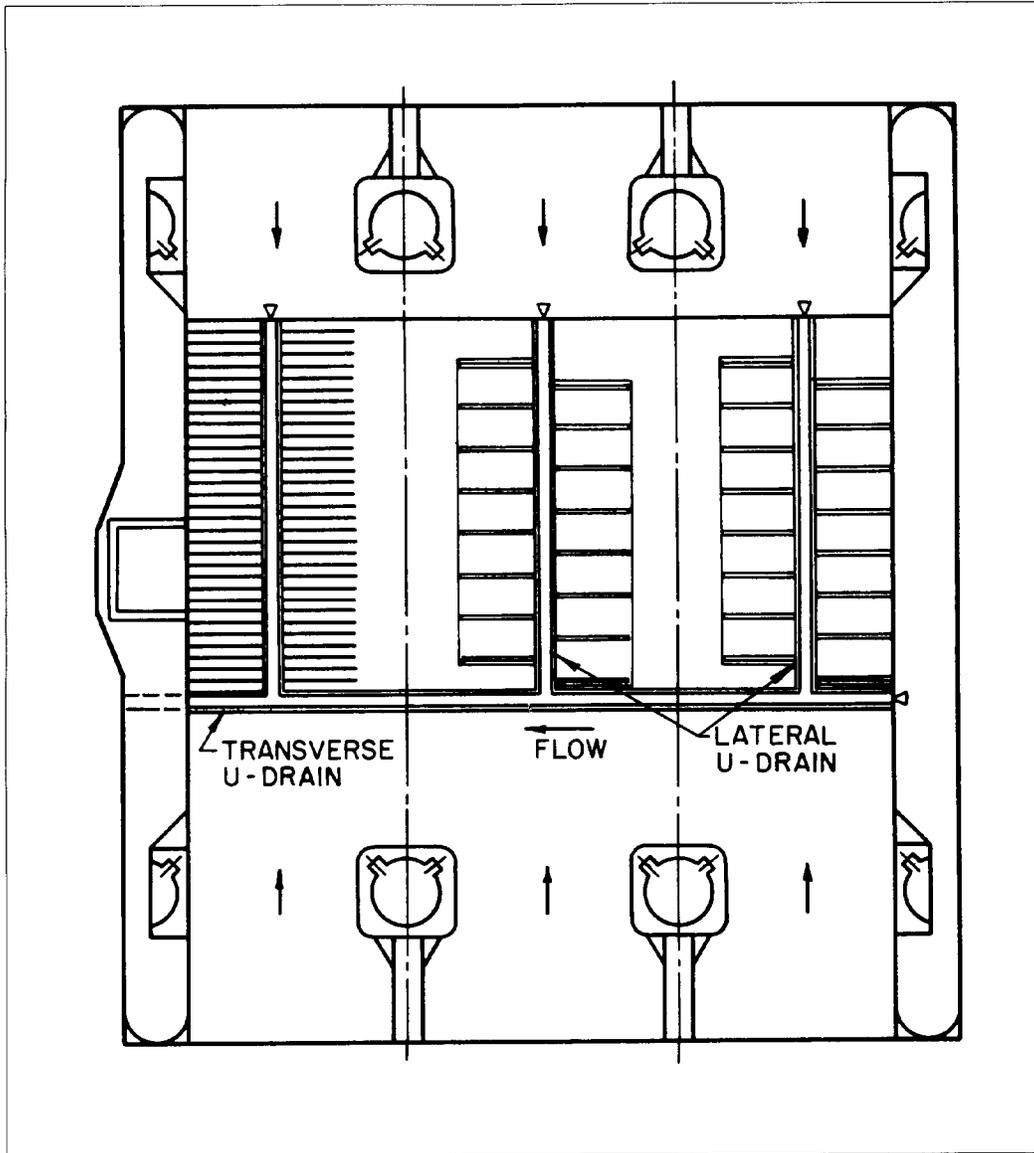
Figure 5–10. Configuration of u-drains in the bath.

WEIR OPENING

A

TRANSVERSE
U-DRAIN FROM BATH

GRATING

PIPE OR TRENCH
TO TREATMENT
SYSTEM

A

SECTION A-A

MOVEABLE WEIR

CONTROL GATE
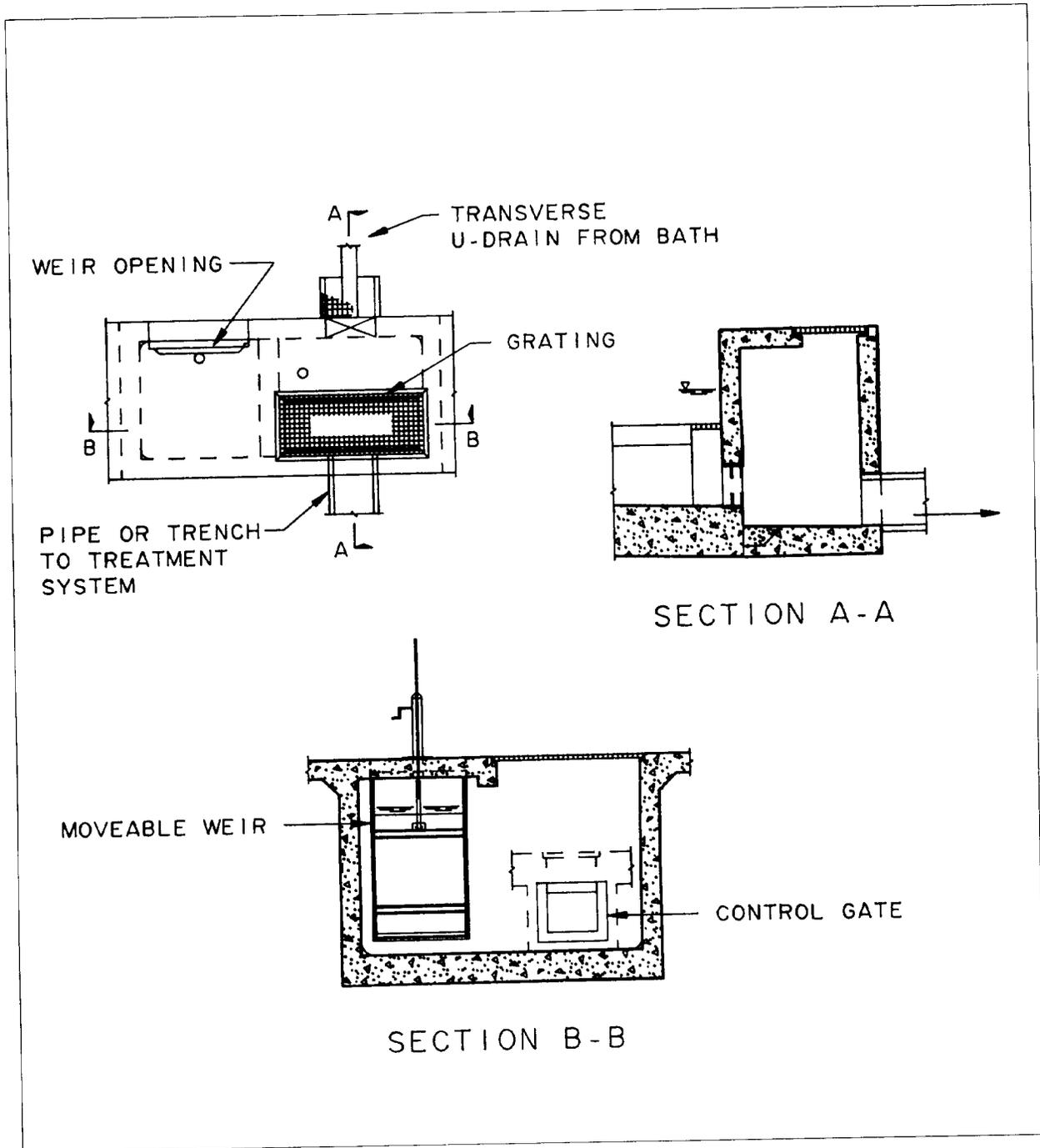
SECTION B-B

Figure 5–11. Water level control structure.

Section II. BATH PREWASH SUPPORT FACILITIES

5-4. Wash water supply lines

Wash water supply lines transport water under pressure, from the source to the washing structures. Supply piping shall be ductile iron, steel or other material resistant to damage from water hammer. Plastic pipe is not acceptable for use in the supply piping. Frequently operated underground valves shall be accessible via manholes or valve boxes. In regions that have freezing temperatures, the system must be self-draining to prevent freezing. Adequate valving should be incorporated to allow for isolation of individual wash stations or wash positions.

5-5. Wastewater conveyances

The wastewater conveyances from the washing structure to the treatment system should be open trenches with a slope sufficient to produce 5 fps (1.8 meters per second) velocity. The conveyances to the treatment system shall be as straight as possible; limiting the number of turns will minimize solids deposition which can build up and block the pipes and trench drains. If closed conduit is used due to site constraints, such as the need to pass under a road, manholes must be provided at each change in pipe direction and slope and at each pipe intersection (see chap 6).

5-6. Bypass lane

A bypass lane is provided to allow lightly soiled vehicles to bypass the prewash and advance to the wash stations. Experience has shown that wheeled vehicles bypass the prewash most often. The recommended lane width is 22 feet (6.7 meters). The bypass lane must have positive drainage to prevent the buildup of water and sediment. When a prewash is provided, a bypass lane around the wash stations must also be provided. This enables the vehicles leaving the prewash which do not require additional washing to bypass the wash stations and advance to the final assembly area.

5-7. Lighting

Adequate lighting should be provided if nighttime washing operations are required by the installation. For worker safety, overhead lighting must also be installed in the areas of vehicle movement. Work-level lighting must be provided at the bath prewash so that users can see the vehicle areas to be cleaned. Lighting intensities of 3 foot-candles from most lights measured at ground level and 5 foot-candles from horizontal projecting work-level lights measured at the vehicle sides should be maintained in the washing area. All areas of adjacent hardstand such as assembly/staging and travel lanes should have a minimum lighting intensity of one foot-candle.

CHAPTER 6
WASTEWATER TREATMENT

Section I. GENERAL CONCEPTS

6-1. Overview

The wastewater generated at a CVWF is widely variable in quantity and quality. The frequency and duration on the system will be site-specific. In addition, CVWF wastewater properties differ greatly from those of a typical sewage waste-water. The suspended solids concentration in a sewage wastewater usually is 200 to 400 milligrams per liter. In contrast, suspended solids in CVWF wastewater will range from 100 to more than 20,000 milligrams per liter.

    a. Typical sewage treatment collection systems and plants are not equipped to handle the high sus-pended solids loading generated at a CVWF. A typical sewage treatment wastewater will flow through the collection system without depositing in the sewers because of the low solids content. However, the solids in a CVWF wastewater will deposit readily in the collection system if proper precautions are not taken. This buildup occurs primarily because of the large amount of solids and the fact that they are generally heavy compared with those in a sewage wastewater. These precautions include steeper slopes, higher velocities and a flusher system in the collection system. The wash facility will discharge a large volume of silt, clay, sand, and gravel, and an array of solid debris, such as ordnance, rags, rocks, and ration cans. This type of material does not normally occur in such large volumes in a sewage treatment wastewater.

    b. The wastewater from a CVWF also will contain higher levels of grease and oils than a typical sewage treatment wastewater. Therefore, oil re-moval equipment must be installed at a CVWF waste treatment facility. The biological oxygen demand (BOD) and chemical oxygen demand (COD) are usually in the 200 to 400-milligram per liter range in a sewage treatment waste stream compared with 20 to 100 milligrams per liter in CVWF wastewater.

6-2. Treatment system

The water used to wash vehicles at CVWFs must be reason--ably clean but is not required to be drinking water quality. All wastewater to be recycled or discharged to an offsite treatment system must first undergo primary treatment in a sediment basin to remove gross sediment, free oils and grease.

    a. A recycle system is a closed-loop system in which wastewater is treated, circulated, and reused. Sec-ondary treatment of this wastewater is considered essential to minimize pump O&M, meet all regula-tions, and protect the environment and health of the users. The waste water overflows from the sediment basin to a secondary treatment system consisting of either an equalization basin, followed by intermit-tent sand filters or a lagoon system, and wash water supply basin.

    b. In a nonrecycle (or discharge) system, the sediment basin is followed only by an equalization basin, if required, to bring the discharge to a quality and quantity that complies with requirements of the off-site treatment plant.

    c. A water supply basin may also be required in a discharge system if the water source cannot meet the immediate demands of the wash facility. If water is not recycled, a good quality, reliable watersource must be used. If a discharge system Is being considered, the designer should consider the flow and quality requirements of the installation's sewage treatment plant authority and design the onsite treatment system and conveyance accord-ingly.

Section II. DESIGN PARAMETERS

6-3. Criteria

In designing the wastewater treatment system for the CVWF, the hydraulic floor will dictate the size of the collection and treatment system needed. Local water supply and weather conditions also affect the choice of treatment systems. In regions with a limited water supply, strict water conservation and reuse techniques need to be reviewed before deciding to recycle the water. Factors to consider in designing the treatment system are the wash period, cleanup time, water usage factor, wash, stormwater, water flow demand, and wastewater volume.

6-4. Wash period (Tw)

The wash period is the continuous time, in hours, that the CVWF is expected to operate each time the facility is used. This time is not the minimum or maximum time that individual vehicles spend at the facility; it is the time during which the facility is expected to be operated (see chap. 3). The wash period does not include the time required to fill and drain the prewash bath (when included) or to clean the facility. The installation must establish an operating schedule of the CVWF based on projected facility demand.

6-5. Cleanup time (K)

The recommended design time to drain the prewash bath and clean up the facility is one (1) hour.

6-6. Water usage factor (U$_f$)

The usage factor is the estimated percentage of time that water will be flowing at maximum capacity for any component at the facility. This factor is used in determining the overflow rate into the sediment basin. The range is between 20 and 90 percent. Usage factors vary between component parts of a CVWF; a prewash bath will normally require the use of a different usage factor than a wash station.

6-7. Storm water

Rain that falls onto the pavement should be directed toward the treatment system since this stormwater may contain residual contaminants from the handstands. Stormwater runoff from adjacent unpaved areas should be directed away from the wash facility. The treatment system should be large enough to treat stormwater collected on the paved areas of the wash facility or captured on the basins; but not necessarily concurrently with water generated during a peak use period. Excess water generated from a storm event can be treated during low use periods. Stormwater flow is estimated by the Rational Method as discussed in TM 5-820-1. The area of each surface type must be estimated first. After the treatment system is sized, the computations used for each surface type should be compared with those used for the estimate and appropriate adjustments made to sizing the basin.

6-8. Stormwater bypass

A stormwater bypass should be provided at the head end of the treatment system just before the sediment basin. Stormwater diversion prior to treatment should be considered standard practice only if the CVWF is in a shutdown mode and the wash facility has been cleaned up. This diversion should be operated after each day's shutdown and when it is expected that the facility will not be in use for long periods of time, such as over a winter season.

6-9. Washwater demand

The following section defines the washwater demand parameters and computations for use in sizing the various conveyances, wash facilities and treatment facilities in a CVWF.

    a.   *Parameters.*

        (1)   *Terminology*

V_B	=	volume of tracked bath(s)plus volume of dual-purpose bath(s), filled to maximum operating depth, in gallons.
N_{wc}	=	total number of water cannon nozzles at the bath
$F_{(i)}$	=	design flow rate per demand location, in gpm (1pm)
i	=	demand location

$N_{(st)}$	=	total number of wash hoses at the wash stations
N_{t1}	=	total number of flusher points in additional trench drains at preparation areas
N_{ud}	=	total number of flusher points in u-drains at the bath(s)
C	=	coefficient of runoff
I	=	rainfall intensity for region
A	=	area of rainfall for surface type
N_{t2}	=	total number of flusher points in trench drains at the wash station area
N_{int}	=	number of vehicle interior wash points at the wash stations
N_y	=	number of yard hydrants in wash area

        (2)   *Water demand calculations.* Water demands in gpm (1pm) are calculated using the following formulations.

Demand	Formulation
1. Bath flush, each occurrence	$Q_1 = V_B/D$
2. Bath water cannons, vehicle washing	$Q_2 = N_{wc}F_{wc}$
3. Wash stations, vehicle washing	$Q_3 = N_{st}F_{st}$
4. Flushing, additional trench drains	$Q_4 = N_{t1}F_{t1}$
5. Flushing, bath u-drains	$Q_5 = N_{ud}F_{ud}$
6. Flushing, wash station trench drains	$Q_6 = N_{t2}F_{t2}$
7. Wash stations, interior washing	$Q_7 = N_{int}F_{int}$
8. Yard hydrants, clean-up	$Q_8 = N_yF_y$
9. Stormwater runoff, paved areas	$Q_9 = C_pIA_p$
10. Stormwater, on basins	$Q_{10} = C_bIA_b$

    b.   *Maximum Flow.* The pipes, trench drains, and weirs at the facility must be designed to handle the maximum (Q_{max}) flow rate expected at any given instant. The designer must consider all of the water and solids from each source expected at any instant. The maximum flow is usually expected to occur during cleaning operations when the bath is flushed, the trench flushers are on, and the wash station hoses and water cannons are in full use. The usage factor adjustment is not applied, since this is the peak situation and all systems are operating. The maximum flow rate is the greater of either the sum of Q_1 thru Q_8, contributions or the sum of Q_9 and Q_{10} stormwater.

$$Q_{max} = Q_1 + Q_2 + Q_3 + Q_4 + Q_5 + Q_6 + Q_7 + Q_8 \qquad \text{(eq 6-1)}$$

or

$$Q_{max} = Q_9 + Q_{10}$$

Note: The designer must determine which combination of flows are applicable to any particular conveyance feature; not all flows will be present in all conveyances, trench drains, or overflows.

6-10. Water volume

a. *Parameters.* Water volume computations are based on the following parameters:

(1) *Terminology.*

K = cleanup time (generally 1 hour)

T_w = wash period

T_t = wash period + cleanup

T_s = storm duration (generally l hour)

B = number of times the bath is filled from the water supply basin per wash period. (Bath volumes taken from the equalization basin are not counted since these volumes do not receive complete treatment through the secondary treatment system. The number of times that the bath is drained and filled will depend on the length of the wash period and the visual quality of bath water.)

U_i = usage factor (from 20 to 90 per cent) at source

(2) *Volume calculations*

<u>Formulation</u>

Volume from bath flush $\qquad V_1 = V_B B$

Volume from bath water cannons $\qquad V_2 = Q_2 T_t$

Volume treated at wash station hoses $\qquad V_3 = Q_3 T_t$

Volume from additional preparation area flushers $\qquad V_4 = Q_4 K$

Volume from bath U-drain flushers $\qquad V_5 = Q_5 K$

Volume from wash station trench flushers $\qquad V_6 = Q_6 T_t$

Volume from interior wash points $\qquad V_7 = Q_7 T_w$

Volume from yard hydrant $\qquad V_8 = Q_8 K$

Volume of stormwater runoff-pavements $\qquad V_9 = Q_9 T_s$

Volume of stormwater falling on basin surface $\qquad V_{10} = Q_{10} T_s$

b. *Average volume.* V_{ave} is an estimate of the total volume of water used during an average wash period. The average wash period is the period of time during which the vehicles are being washed in typical washing operation. Usage factors are applied to each source of water, since not all water cannons, hoses, and trench flushers will be operating at all times. V_{ave} (eq 6-2) is used to estimate the size of the water supply basin and the equalization basin or polishing lagoon:

$$\begin{aligned} V_{ave} &= U_1 V_1 + U_2 V_2 + U_3 V_3 + U_4 V_4 + U_5 V_5 + U_6 V_6 \\ &\quad + U_7 V_7 + U_8 V_8 + V_9 + V_{10} \end{aligned}$$
$$\text{(eq 6-2)}$$

Note 1: V_1, V_5 and V_6 are included in the equation only if these volumes are withdrawn from the water supply basin. Volumes withdrawn from the equalization basin are not included in the formulation.

Note 2: V_9 and V_{10} are not apart of V_{ave} in a standard design. Including V_9 and V_{10} as a part of V_{ave} is the designer's option.

c. *Maximum volume.* V_{max} is an estimate of the total volume of water used during the peak use period of the facility. The same equation (6-2) used to calculate V_{ave} is also used to calculate V_{max}; the difference is that the wash period used to calculate the individual volumes, V_2 through V_8, is the length of the peak washing operations, not the length of the average washing conditions. Usage factors are still applied in the equation to compensate for the time during which the nozzles are not operating. The V_{max} value is the primary volume used in sizing the water supply basin and the equalization basin or settling lagoon. V_{max} is also used in the sizing of the intermittent sand filters.

d. *Water balance.* The designer must perform a water balance during the preliminary design phase. The purpose of the water balance is to ensure that basins such as the equalization basin do not overflow and that the water supply is not totally drained. Thus, the designer must make provisions to handle the peak use water volume in each basin during the washing operations. Based on the results of the water balance, the designer may be required to increase, or may be able to decrease the size of the basins.

Section III. PRIMARY TREATMENT

6-11. Function

All wastewater from the CVWF must undergo primary treatment. A concrete sediment basin with a oil skimmer device is provided to separate and remove contaminants such as grease, oil, and sediment by gravity. Free oil shall be removed in this basin prior to pumping which could cause oils to emulsify. Wheeled vehicle access shall be provided to this basin for removing the large volumes of sediment that accumulate in this basin. The bottom of the basin should be sloped approximately one percent away from the entrance ramp to assist in dewatering when the basin is emptied. Sediment basins are designed with oil recovery, inlet and outlet control structures, and drains.

6-12. Number of basins

In a wash facility, with or without bath, a sediment basin with only one cell may be provided, however, it must be designed to treat the entire volume of water and sediment expected. Maintenance procedures must insure minimizing down time when the single basin is cleaned. A sediment basin with two cells should be provided if the wash facility cannot be shut down for scheduled cleaning and repairs. Providing a two-celled sediment basin allows one cell to be isolated for cleaning and repairs while the other one remains in service for primary treatment. The detention time of the waste water may be reduced in the basin if only one cell is operable due to closure of the other, but the wash facility may still be utilized. During normal operations of a facility with a bath, one cell is used to treat the volume of waste wash generated from vehicle washing water from the wash, while the adjacent cell is used to treat the volume of water from the bath flush and clean-up activities. The functions of the two cells should be alternated frequently, to distribute the sediment loads evenly between basins.

    a. *Single-cell configuration without bath.* At small facilities without bath, a single-basin system as depicted in figures 6-l and 6-2 should be provided. A single sediment basin system should function hydraulically, such that the inflow volume is equivalent to the overflow volume. If a large surge of water is expected, then sufficient storage volume must be allowed in the basin to ensure that a minimum detention time of 2 hours is maintained. The basin volume must account for the accumulated sediment storage volume between cleanouts. The outlet structure is a weir constructed across the width of the access ramp. The location of overflow weir ensures a constant water level in the basin.

    b. *Dual-cell configuration without bath.* At larger facilities, without bath, where washing down time during basin cleaning may not be desired or practical, dual cells similar to figures 6-1 and 6-2 should be provided. Cells would have a common wall and be provided with common inflow and outflow control structures.

    c. *Dual-cell configuration with bath.* A dual-cell system for use with baths in large facilities is shown in figures 6-3 and 6-4. Before bath(s) are to be emptied into the sediment basin, the operator should assure that the water level in one of the basin cells in the sediment basin is at low level. The volume of bath water will be stored in this cell. The adjacent cell continues to provide primary treatment for wastewater from the washing facilities. This configuration allows the entire surge volume of wastewater from the bath to be held for the proper detention time and not become short circuited in the sediment basin. The volume of each cell is designed to hold the storage of sediment between scheduled cleanouts plus the entire volume of a bath release and clean-up water.

    d. *Single-cell configuration with bath.* For small facilities with bath, a single-cell configured similar to that depicted in figure 6-3 may be provided if the wash facility can be taken out of service during the cumulative period of time to drain the bath(s) and draw down the sediment basin.

6-13. Siting

Sediment basins are sited to receive gravity flow of wastewater from the wash facility. The basin should be close to the washing operations to avoid long conveyance distances and severe depths of conveyances being placed at the required grades. Basins should be oriented along the axis of prevailing winds with the outlet end and oil skimmers located downwind so that surface currents will carry free oils toward the removal equipment. The basins must not be readily accessible to troops but should be visible from the control building and easily accessed by the CVWF operators.

6-14. Sizing

The size of each cell in the sediment basin will be based on the volume of water to be treated and the volume of sediment to be stored in the basin between cleanings. The user must determine how often the sediment will be removed from the basin. It is recommended that each cell of the basin be cleaned at least once per year; however, the exact number of basin cleanings will depend on variations of soiling, user requirements, and other considerations unique to the installation. In addition to the water and sediment depths, from 1 to 2 feet (0.3 to 0.6 meter) of freeboard must be provided. Figure 6-4 shows typical water and sediment depths. Each cell should have a minimum length-to-width ratio of 3 to 1 to allow for the proper settling time. The turning radius of cleaning equipment, such as a front-end loader, should be considered in determining the width of the cells.

    a. *Velocity.* A uniform horizontal flow-through velocity of from 0.5 to 2 feet per minute during washing operations is desirable. The lower range is preferred for predominantly silt and for clay-type
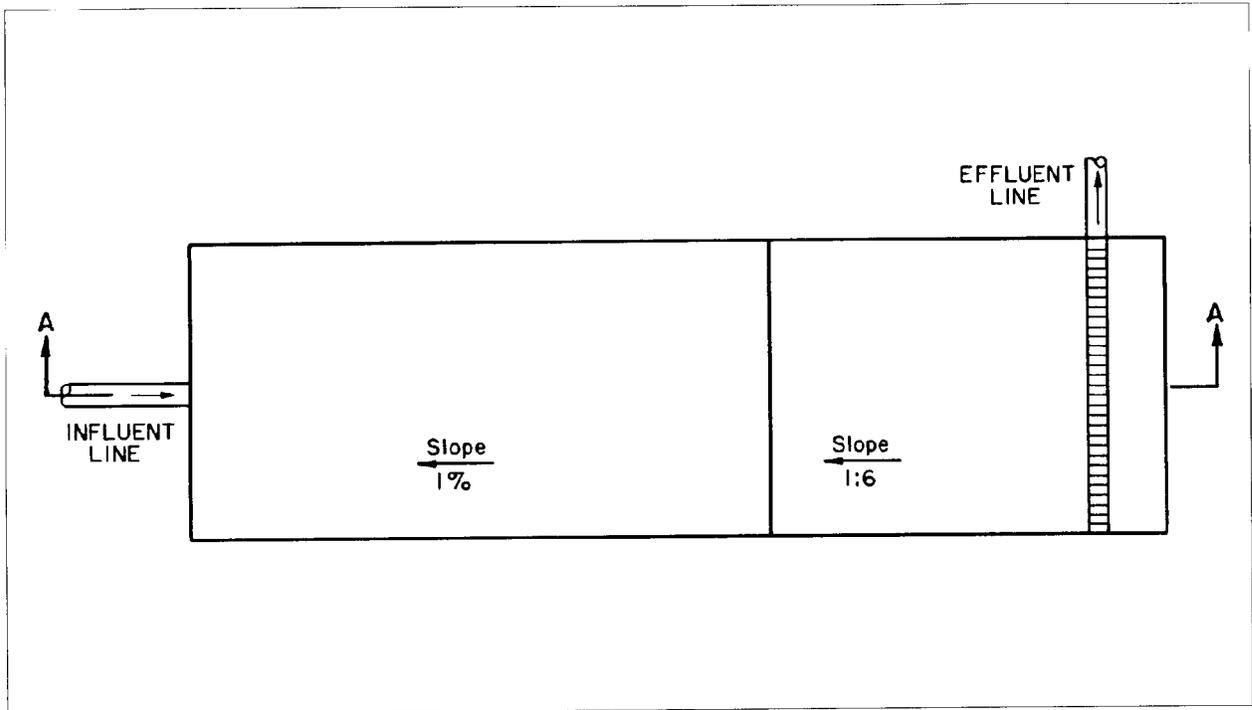
Figure 6-1. Single-cell sediment basin—plan view.
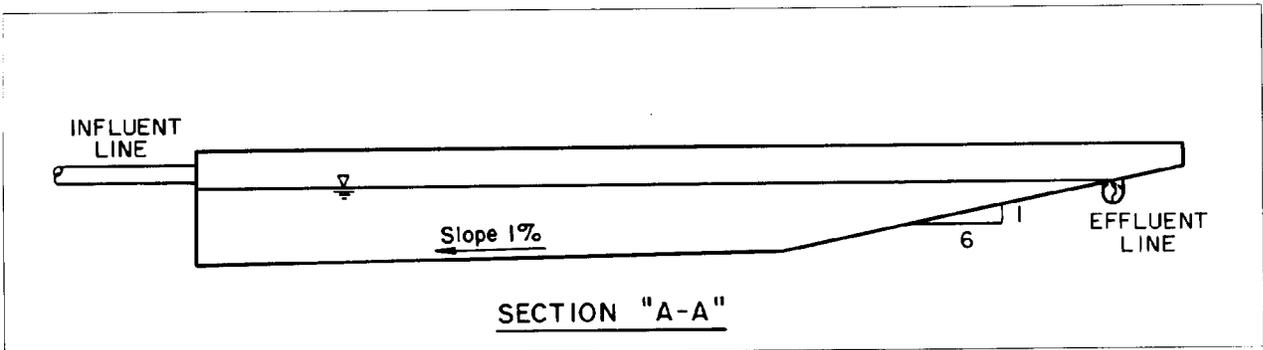
SECTION "A-A"

Figure 6-2. Single-cell sediment basin—cross section.
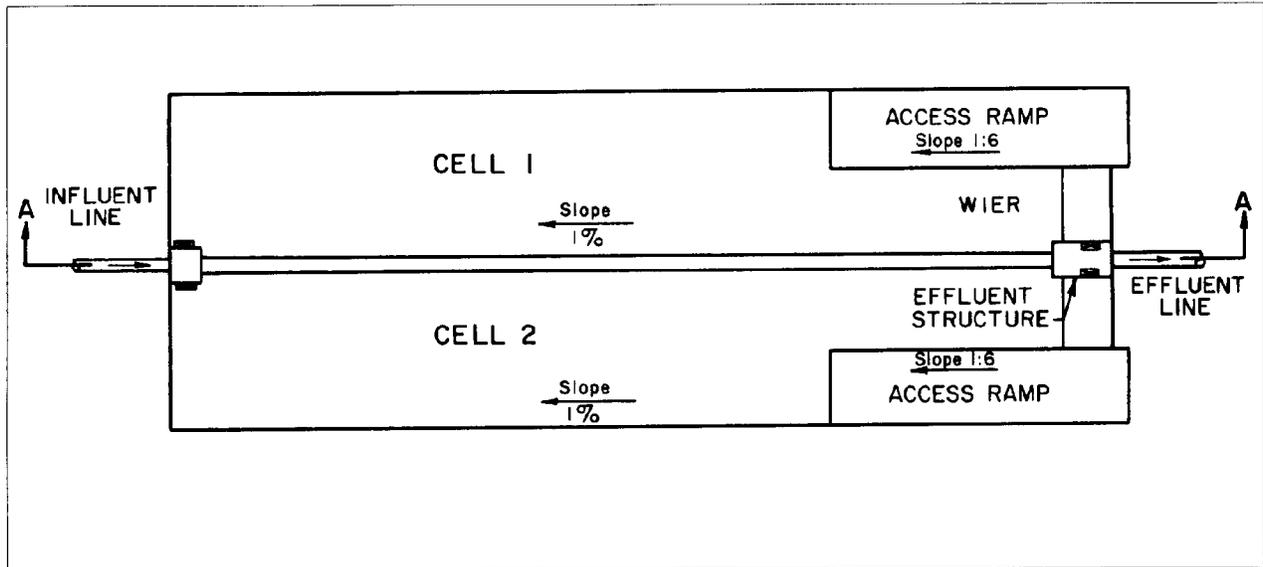
Figure 6–3. Dual-cell sediment basin—plan view.
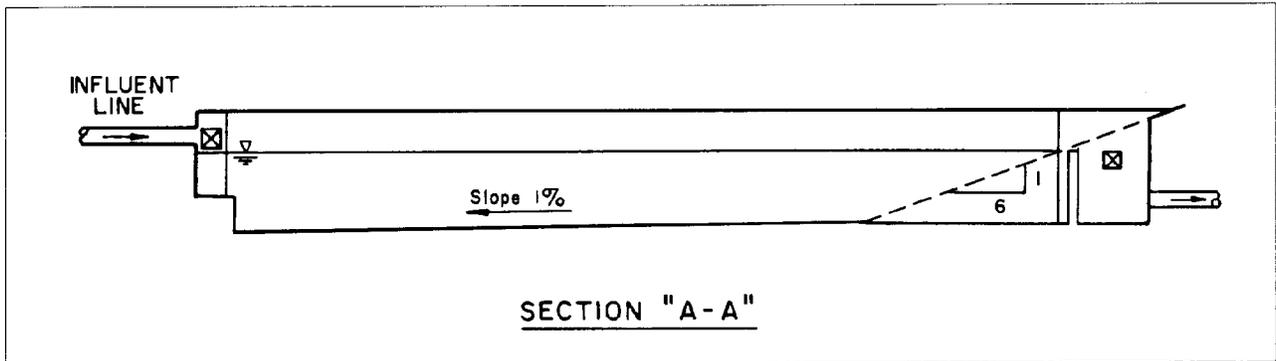
Figure 6–4. Dual-cell sediment basin—cross section.
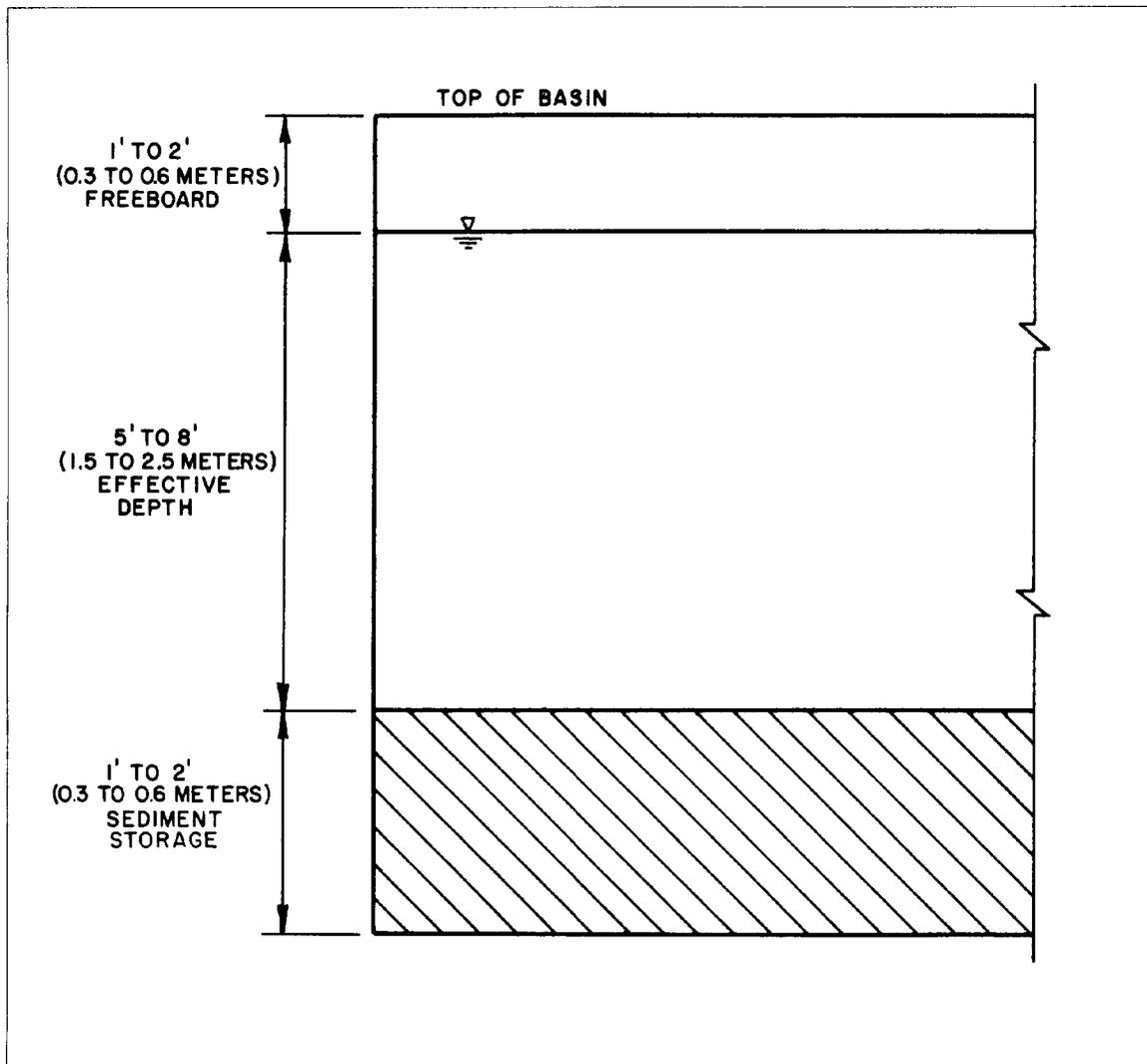
Figure 6–5. Typical design water and sediment depths.

soils; the higher rate applies predominantly to sandy soils.

b.   Sediment volume (V$_{sed}$).

(1)   Each basin must store the volume of sediment expected to accumulate between basin cleanouts. The value used to predict sediment volume (V$_{sed}$) must be based on the expected vehicle soiling and number of basin cleanings per year. Heavy soiling can be expected on vehicles returning from training exercises in off-road areas that have wet field conditions and cohesive soils. The sediment volume will vary between installations and even within the installation due to different soil types in the training areas, training schedules, climate and weather conditions. Table 6-1 lists estimates of the amount of dirt removed from different tactical vehicles each time it is washed. Experience may indicate that a value outside of this

recommended range be used to estimate the sediment volume.

Table 6–1.   Estimated volume of material per vehicle

Vehicle type	Average heavy soiling, cu ft/vehicle (m^3/vehicle)	Average light soiling, cu ft/vehicle (m^3/vehicle)
Tracked	2.0 (0.06)	1.5 (0.04)
Wheeled	0.6 (0.02)	0.5 (0.01)

(2)   Equation 6-3 can be used to determine to predict the total annual sediment volume. If dual-cells are provided, each basin will store half of the total sediment volume expected over the time period between cleanouts, assuming cells have been evenly alternated. Equation 6-4 is used to calculate the required basin volume.

$$\frac{\text{Sediment Volume}}{\text{Year}} = \frac{\text{Sediment Vol}}{\text{per Tracked Vehicle}} \times \frac{\text{No. tracked washed}}{\text{Year}} + \quad \text{(eq 6-3)}$$

$$\frac{\text{Sediment Vol}}{\text{per Wheeled Vehicle}} \times \frac{\text{No. wheeled washed}}{\text{Year}} \quad \text{(eq 6-4)}$$

V_{sed} = sediment volume per year/number of cleanout per year

c. *Water volume.* For a single-cell sediment basin, the cell should be sized for a detention time of from 2 to 4 hours. For a dual-cell basin, each cell should be sized to detain the wastewater for 2 to 4 hours with cells operating in parallel; or from 1 to 2 hours with one cell in operation. Wastewater having a high cohesive soil content will require settling times at the upper limit of the range; settling times for noncohesive soils should be at the lower end of the range. One method of determining optimal detention time (T_D) and settling velocity is to perform bench-scale settling tests for the soil conditions at each training site. Another method is to use Stoke's Law in computing trap efficiency. The basin should have a total effective water depth of 5 to 8 feet (1.5 to 2.5 meters).

(1) *Sediment basin overflow rate.* The basin overflow rate is an estimate of the flow rate of wash water used during a wash period (T_w (eq 6-5). It is determined by reducing the maximum flow rate by usage factors. This flow rate is used when determining the detention time and sizing the cells for the sediment basin. The designer must use discretion as to whether the trench flushers in the wash area will be operable while the vehicles are being washed. The trench flushers in a bath will not operate during washing. The designer also must use engineering judgment as to what percentage of time the trench flushers (if any) in the vehicle preparation area will be operable while the vehicles are being washed.

$$Q_{over} = U_2 Q_2 + U_3 Q_3 + U_4 Q_4 + U_5 Q_5 + U_6 Q_6 + U_7 Q_7 \quad \text{(eq 6-5)}$$

(2) *Single-cell system.* In a single-cell system, the cell should be designed to store the water for the designed detention time and should also hold the sediment volume collected between cleanouts. Equation 66 gives the water and sediment volumes needed for sizing a single cell at a facility without a bath. If a bath is provided, the bath volume, V_1, must be added to the equation. This equation calculates only water and sediment volumes; it does not include the freeboard which must also be added. Also Q_9, stormwater flow, would not be normally considered an additive flow. The basin should be sized to handle the greater of two

volumes, maximum wash water volume or stormwater volume.

$$\text{Volume} = (Q_{over} + U^8 \times Q_8) \times T_D + V_{sed} \quad \text{(eq 6-6)}$$

(3) *Dual-cell system.* In a dual-cell system, each cell must be sized to store the maximum volume expected at any given time. The volume of each cell will depend on the larger of:

Case 1: Volume = $0.5 \times V_{sed} + Q_{over} \times T_D + V_1$

Case 2: Volume = $0.5 \times V_{sed} + 0.5 \, Q_9 T_s$

6-15. Sediment basin influent structure

The influent line should empty into the deep end of each cell of the basin, opposite a ramped entrance that provides access for the cleaning equipment. A structural baffle or energy dissipator may need to be installed at the influent end to disperse the wastewater and solids across the width and to help prevent water and solids from short-circuiting to the effluent structure. The inlet invert must be placed higher than the maximum water level in the basin to prevent deposition of solids in the influent line or inlet structure. Motorized gates may be used in a two cell basin to make it convenient for the operator to switch the influent flow from one cell to the other or to use both.

6-16. Sediment basin effluent structure

The effluent structure must be located opposite the influent end in order to maximize the detention time in the basin. Protective baffles, fixed or removable, may be installed in front of the effluent opening to prevent discharge of floating debris and oil. A section through the overflow trench for a basin without bath is shown in figure 66. The effluent structure for a basin with bath consists of adjustable, motorized gates used to regulate the height of the water in the basin (fig 6-7). This arrangement allows the operator to alternate treatment from one cell to the other or use both cells in parallel.

6-17. Sediment basin construction

Sediment basins are constructed of concrete in order that a front-end loader can enter the basin at the ramp and remove the sediment without damaging the liner. In addition, a concrete basin prevents oil and other wastes from seeping out of the basin into the surrounding soils.

6-18. Sediment basin drainage

a. The sediment basin must be provided with a drainage system which (1) allows the captured sediment to dewater for easier removal from the basin; (2) controls the discharge of large volumes after draining the prewash bath facilities; (3) permits other routine maintenance to the structure and/or equipment; and (4) permits preparation for winter shutdown.

b. Drain down of the basins for cleaning is accomplished through a drain line with a manually operated valve as depicted in fig 6-8. Drain down of

water trapped in the sediment is aided by gravel packed drains placed along the center wall or in the bottom of each cell. The pumping system shown in the figure is an alternate since, at this point in the treatment system, the main stream flow is by gravity and drainage may occur below the hydraulic grade line. The immediate return of the water drained from the sediment basin to the treatment process is desirable in order to facilitate the removal of any disturbed sediment and oil.

c. The valving depicted in figure 6-8 allows lowering the water level in the sediment basin to the expected maximum sediment level and dewater the captured sediment. Gravel packed drains or trenches are located around the inside perimeter of the basin or in the floor and consist of a perforated pipe encased in filter fabric and gravel. Valving and pumping facilities may be placed at either end of the sediment basin. Drains shall be located below the bottom of the basin or otherwise protected so that, during removal of sediment, they will not be disturbed or damaged. The trench method can be used at either the influent or effluent end of the sediment basin.

6-19. Sediment removal

Sediment basins are not equipped for continuous removal of solids and therefore, the basin should be sized to allow solids accumulation over at least one year based on the estimated solids removed from the vehicles. To remove the accumulated solids, the basins are first drained of water to the maximum extent possible with slow drains, sediment dewatering drains, and/or pumps as described in the previous section. The solids are then removed using front-end loaders and dump trucks that access the solids zone via the concrete ramp. The material is hauled away for proper disposal in accordance with local, State, and Federal regulations.

6-20. Oil removal

Free floating oils and greases carried into the sediment basin as a product of vehicle washing are lighter than water and therefore rise to the surface. The oils and greases are removed using motorized surface tube-type oil skimmers in each basin. The skimmings are stored in an above-ground or underground waste oil storage tank located near the sediment basins. Skimmers are usually located at the downwind end of the basins. Floating or fixed baffles which extend below the effluent weir elevation may be provided to direct oils toward the skimmer and to prevent the carryover of oils past the effluent weir.
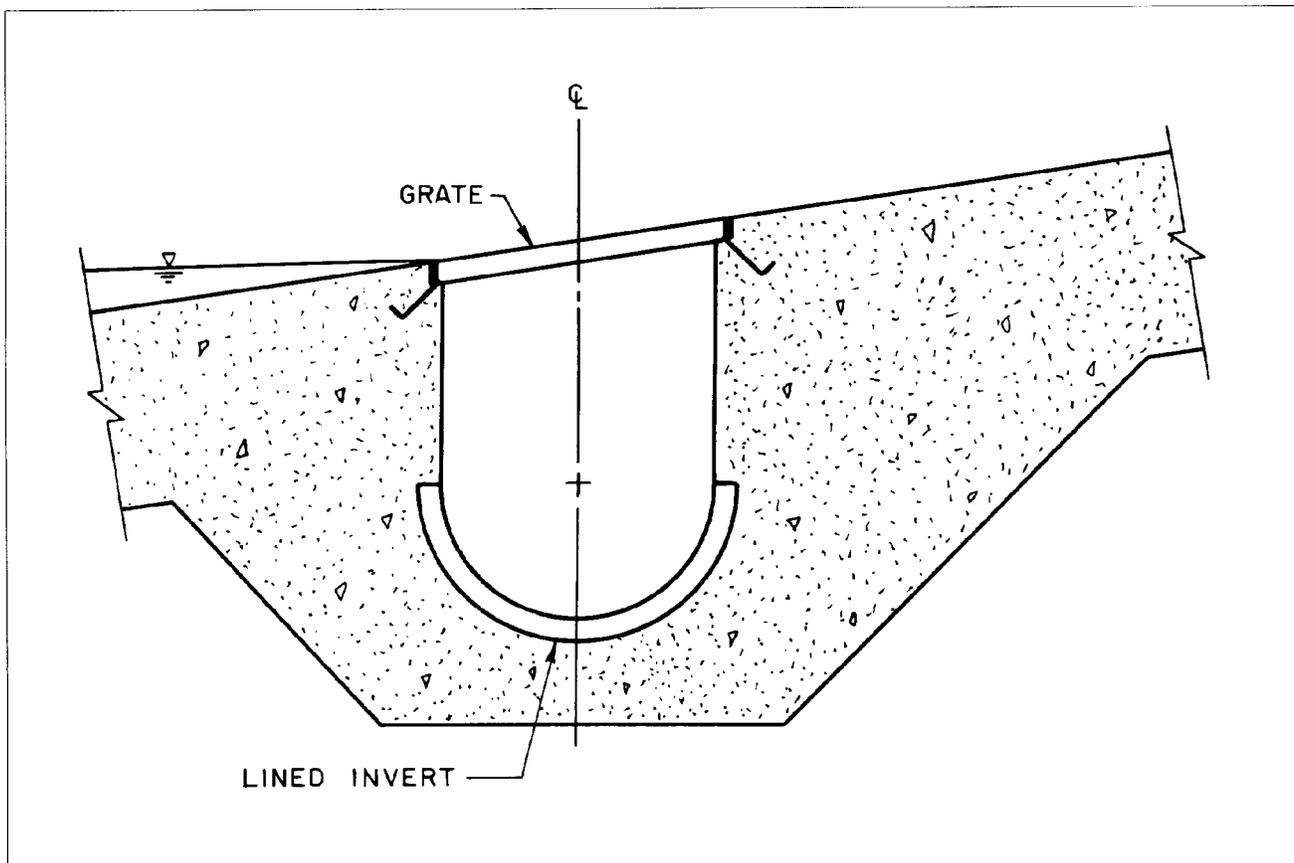
Figure 6-6. Typical effluent structure with an overflow trench. Sediment basins, without bath.

FLUSH WATER LEVEL

BAFFLE WALL

WASH WATER LEVEL

WASTE OIL STORAGE
AND OIL SKIMMER

FLUSH WATER
SLOW DRAIN

WEIR

EFFLUENT DRAIN

1'-O"
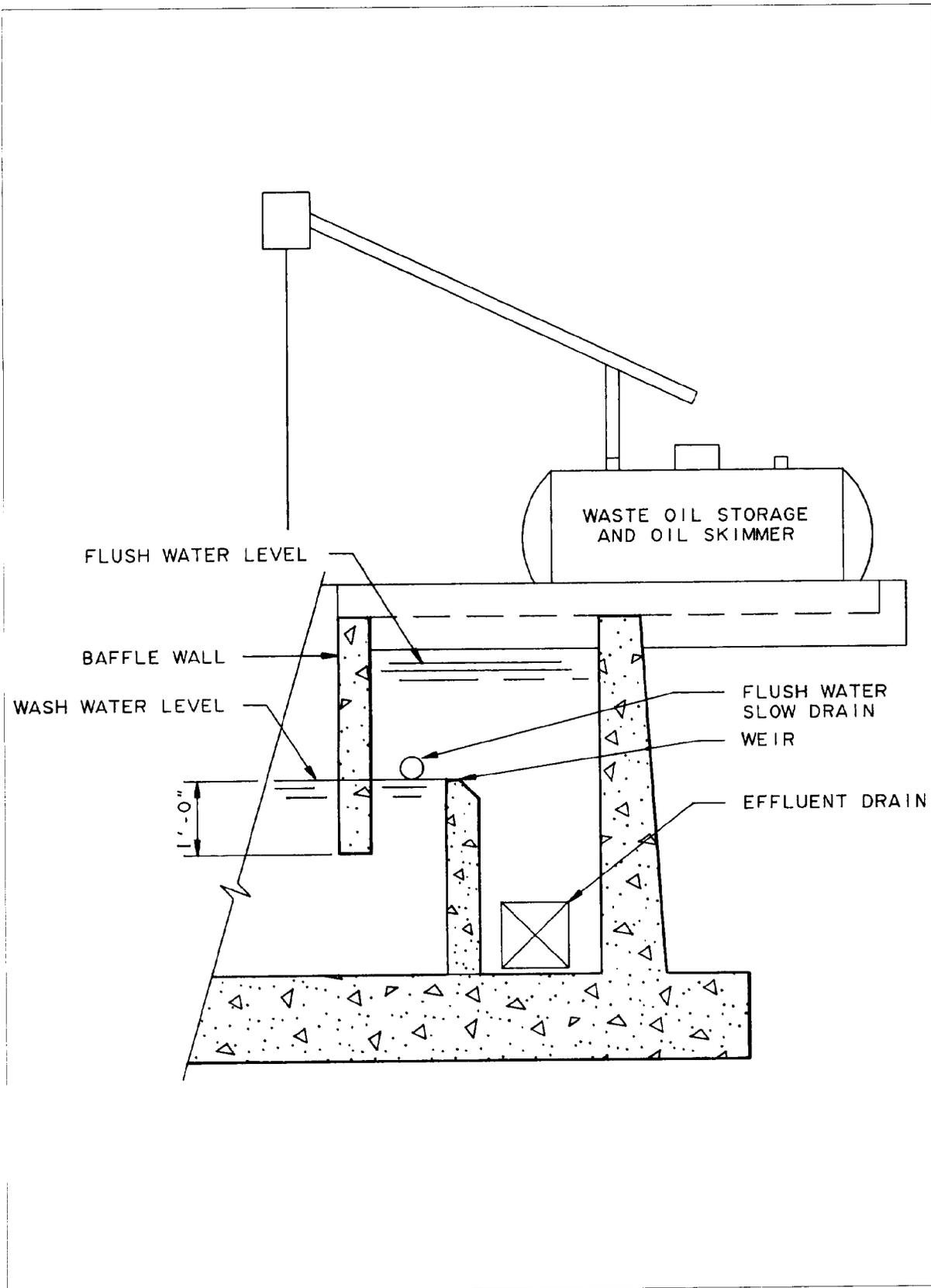
Figure 6-7. Typical effluent structure with motorized gates. Sediment basins, with bath.

EFFLUENT

PUMP (OPTIONAL)

MOTORIZED GATE

WASTE OIL STORAGE

ACCESS RAMP

ACCESS RAMP

DEWATER VALVES

SLOPE

SLOPE

BAFFLE

OIL SKIMMER

GRAVEL DRAIN

CELL NO. 2

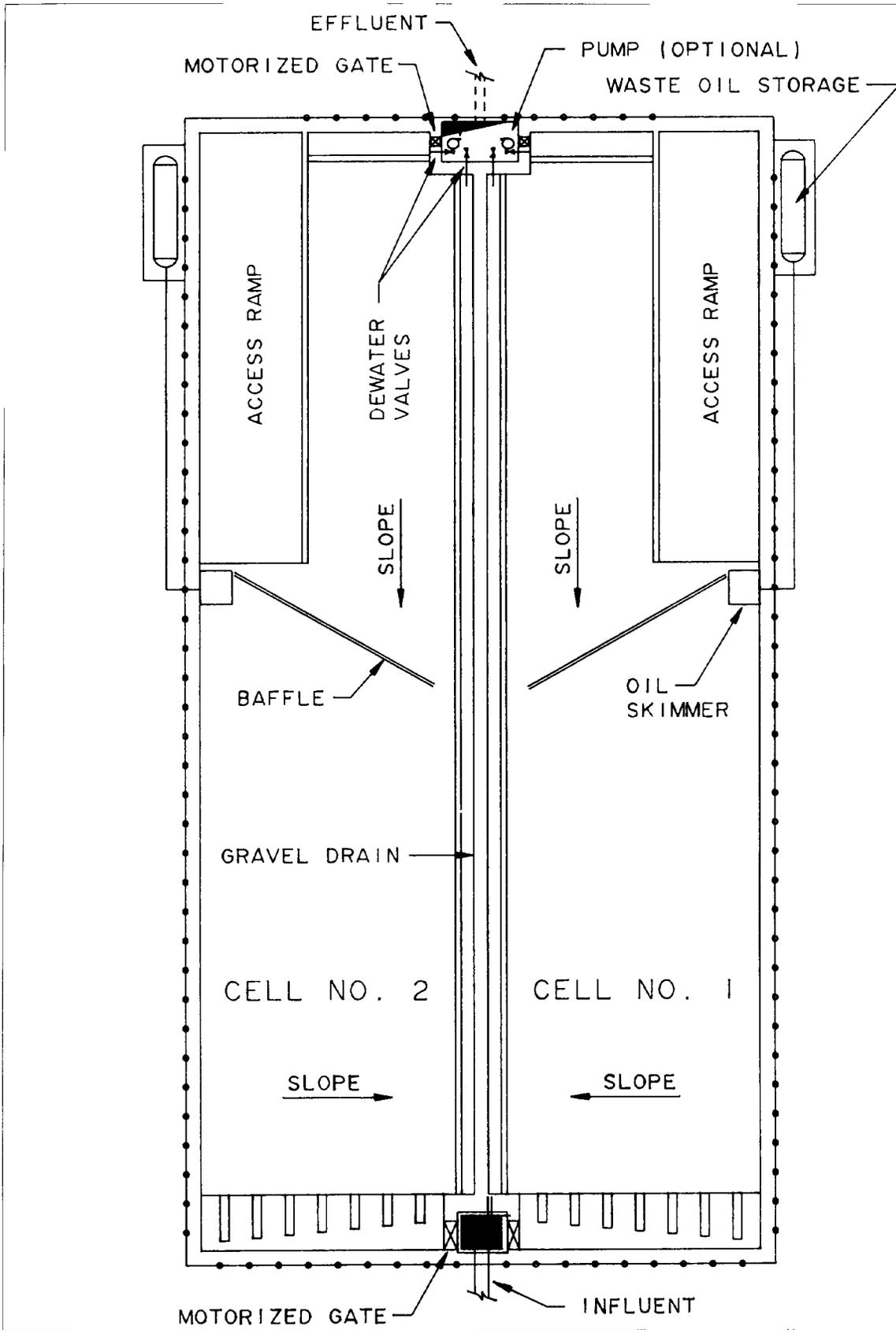CELL NO. 1

SLOPE

SLOPE

MOTORIZED GATE

INFLUENT

Figure 6–8. Sedimentation basin drain system.

6.21 Waste oil storage

Waste oil storage tanks are designed, constructed and installed in accordance with current U.S. Environmental Protection Agency, State, or Local regulations for above ground or underground storage tanks. Storage tanks should be 500- to 2000-gallon (1893- to 7570-liter) capacity, depending on the estimated amount of oil recovery and frequency of cleanout. Positive spill containment should be provided at the cleanout port and directed back to the sediment basin.

6-22. Maintenance

Routine maintenance of the sediment basin and appurtenances will be minimal. Sediment should be removed from each cell at least once per year. The waste oil storage tank should be emptied before its capacity has been reached. Provide appropriate site gauges and/or high level alarms. Oil skimmer devices must be strategically located, easily accessible for servicing and durable. Daily inspection of the oil skimmer unit is required to insure continuous, trouble-free operation.

6-23. Other considerations

Sediment basins should have pipe rail or fencing mounted on the wall in accordance with OSHA requirements for safety considerations; or the grade surrounding basins located lower than top of wall to provide a safety barrier. Hydrostatic pressure relief should be provided where generally high water tables exist and basins should be designed to prevent flotation when empty. Access ramps should be serrated for vehicle traction. Inlet and outlet ends should be readily accessible to operators, through an access road around the basins. Lighting should be provided at the inlet structure and at the outlet structure.

Section IV. SECONDARY TREATMENT

6-24. Onsite secondary treatment

At installations where an adequate, dependable, low-cost wash water source cannot be found, and favorable site and weather conditions exist, a recycle water system should be used. The water source must adequately supply clean water on demand during the peak wash periods. The quality of effluent from a sediment basin usually is not adequate for discharge to a sewage treatment plant, even if treating non-cohesive soils and therefore, cannot be used as recycled water. For recycling, secondary treatment is required. If an adequate water supply source is available and recycling would not be economical, the wastewater may be discharged to an existing sewage treatment plant for further treatment. In this case, onsite sediment basins followed by an equalization basin would still need to be provided. Two alternative onsite secondary treatment systems are available for treating waste washwater to a quality suitable for reuse in vehicle washing, namely, intermittent sand filtration and series lagoons. Intermittent sand filter systems are the preferred secondary treatment method for CVWFs. Where existing ponds, lagoons, or basins are available and environmentally suitable for use, a lagoon system should be considered. The most environmentally acceptable, cost-effective system should be used.

6-25. Objective

Secondary treatment removes suspended matter, microorganisms, impurities, and minor residual oils from the product water. These materials are carryovers from the primary treatment process and consist mostly of colloidal materials such as clays and fines that have not been removed during sedimentation. The removal of these suspended solids is essential to produce a relatively clean, clear, acceptable product for recycling as wash water.
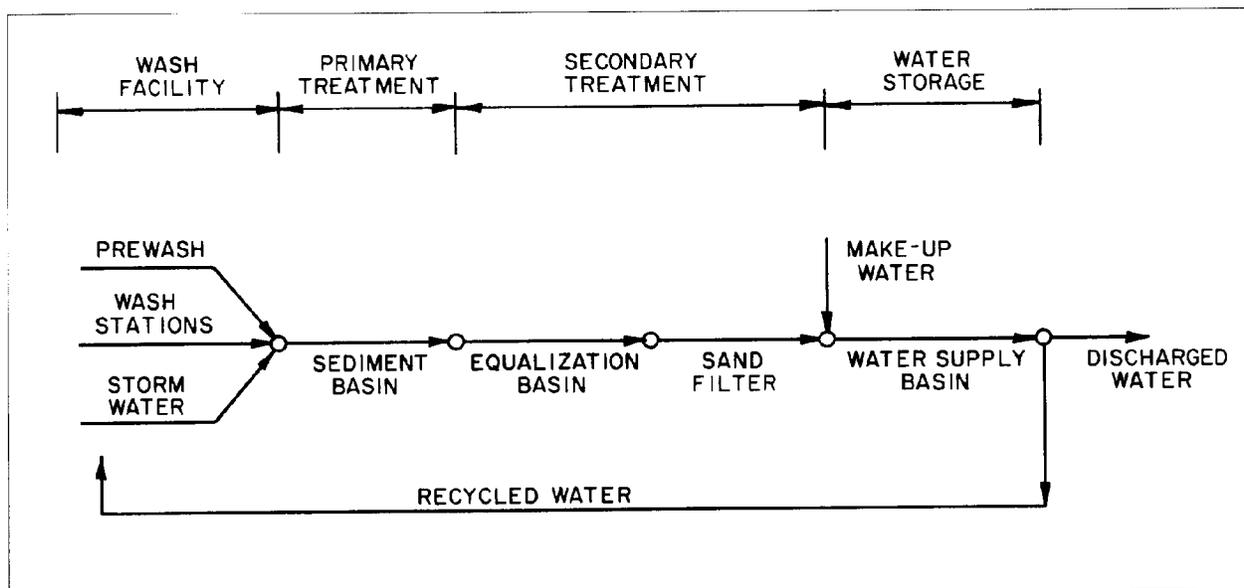
Figure 6-9. Components of an intermittent sand filter system.
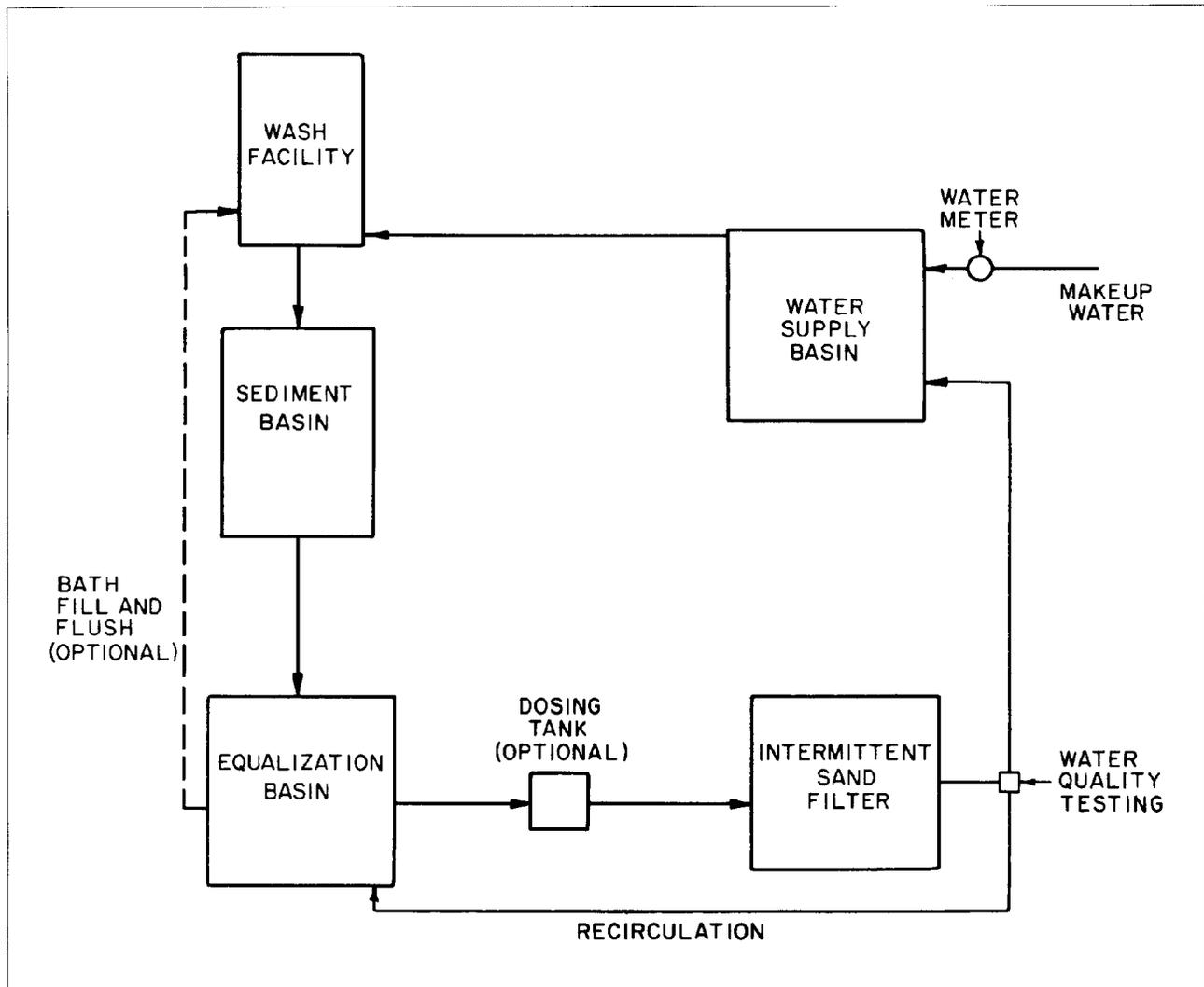
Figure 6–10. General schematic of an intermittent sand filter recycle system.

6-26. Intermittent sand filter system

This system, depicted in figures 6-9 and 6-10, consists of three components: equalization basin, optional dosing tank, and intermittent sand filter. All three units are located downstream of the sediment basin in the order listed.

 a. *Equalization basin.* The equalization basin (figs 6-11 and 6-12) serves two main functions. First, it is considered a part of secondary treatment because it provides storage and flow dampening of the sediment basin effluent so that this water can be delivered at a controlled rate to the intermittent sand filters for final treatment. The basin buffers the fluctuations in wastewater flow and quality caused by variable use of the wash facilities. It also compensates for the difference between basin inflow and intermittent sand filter application rates. By regulating the dose of water to the intermittent sand filter at designated intervals and rates, the filter size can be minimized. Second, the equalization basin is considered part of primary treatment because it provides a quiescent zone for settling of fine, suspended solids that have been carried over from the sediment basin. This function improves the overall suspended solids removal efficiency of the treatment process. Unfiltered water from the equalization basin should be used as a source of water for filling the bath prewash and for trench drain flushing, thereby conserving the water supply. When equalization basin water is used in this way, separate delivery pumps and piping are required, but the size of intermittent sand filters and water supply basins are usually reduced.

 (I) *Siting.* The equalization basin is located at a lower elevation than the sediment basin and the wastewater should flow by gravity from the sediment basin to the equalization basin.

 (2) *Sizing.* The size of the equalization basin will be based on several factors, including the

6-13
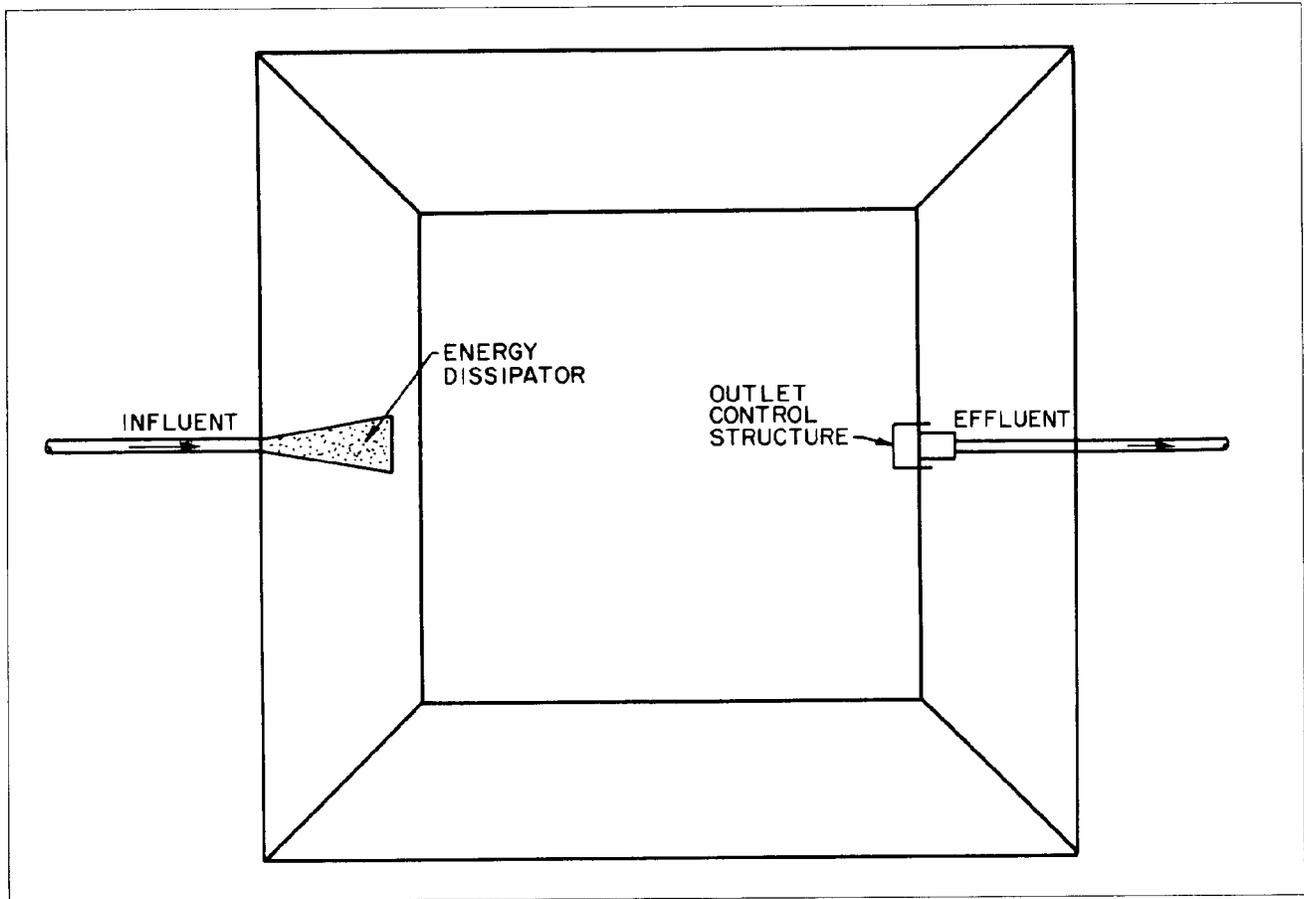
Figure 6–11. Example equalization basin—plan view.
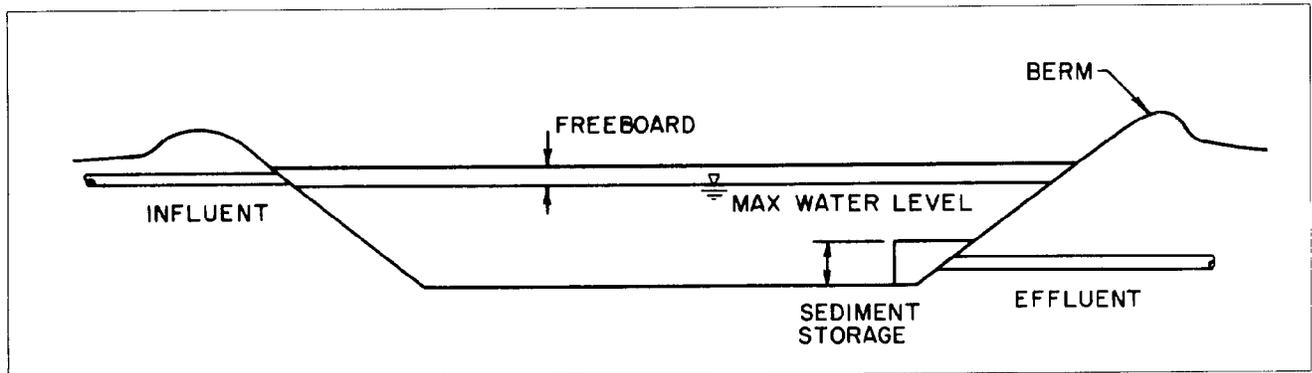
Figure 6–12. Equalization basin—cross section.

volume of water from the sediment basin, the number and capacity of intermittent sand filters, the frequency of dosing the filters, and the volume of sediment expected to collect between cleanouts. The designer must ensure that the size of the equalization basin is compatible with the influent volume from the sediment basin and the effluent to the dosing tank or intermittent sand filters. If it is too large, it will not be cost-effective. If the basin is too small, it will ovefflow. An extra 2 to 3

feet (0.6 to 0.9 meter) of freeboard should be included above the maximum loading volume.

(a) *Water volume.* The basin's size should be based on V_{ave}, for a one week wash period or V_{max} for a peak use period, whichever is greater. A safety factor ranging from 1.25 to 2.0 times V_{ave} or V_{max} should be incorporated to help insure adequate water volume at all times. The effective depth of the basin should be 5 to 8 feet (1.5 to 2.4

meters). Deeper basins should be considered in arid regions to reduce water surface areas, thereby minimizing evaporation.

(b) Sediment volume. A depth of from 1 to 2 feet (0.3 to 0.6 meter) should *be* allowed for sediment storage at the bottom of the basin and this volume added to the water storage requirements.

(c) Dead storage volume. A depth of 2 to 4 feet (0.6 to 1.2 meter) should be allowed directly above the sediment volume for dead storage. This additional volume allows for submergence of the basin effluent control structure and provides a minimum water volume to optimize settling.

(3) *Influent structure.* A concrete trough should be installed at the inlet to prevent liner erosion. The inlet pipe should he higher than the maximum water elevation in the basin to allow free discharge of wastewater. If the wastewater Influent line were submerged, sediment could collect and eventually clog the line.

(4) *Effluent control structure.* The effluent structure should be located opposite the Influent structure thereby maximizing the water detention time in the basin. If cohesive soils are present, float supported baffles may be required to increase the detention time and minimize short circuiting of wastewater in the basin. Stormwater diversion prior to treatment should be considered as standard procedure only if the CVWFis in a shutdown mode. This diversion should be in operation after each day's shutdown and when it is expected that the facility will not be in use for long periods of time, such as during winter.

(5) *Construction.* In-ground equalization basins are designed and constructed with water-tight walls and bottom. Several liner materials, or combinations, can be considered for water-tight construction. However, local experience with earthen basins may suggest that no lining is needed. In-ground basins should be designed and constructed in accordance with and with approval by the state regulatory authority in which the facility is located. The most cost effective, environmentally acceptable basin construction should be provided.

(a) Concrete. A concrete liner is permanent and can resist freeze/thaw cycles. If a concrete lined basin is used, the foundation must support the weight of the structure, concrete, sediment, and water at maximum depth. Concrete can crack and deteriorate and can be relatively expensive to install and repair compared with other types of liners. The slope of the walls will depend on the method of construction. Expansion/contraction joints are required and may be difficult to seal tightly.

(b) Bentonite and natural clay. A bentonite or natural clay liner can be installed only over certain soils. Noncohesive soils that contain large amounts of fines without coarse lenses (sands and gravels) are susceptible to movement which can cause leakage in bentonite and clay liners. A site without shallow bedrock and without a perched water table is desirable for installing these types of liners. When these materials are used, the slope of the walls will vary, depending on local conditions such as the soil's angle of repose. Sediment removal equipment could damage a bentonite liner, since movement of the bentonite can cause leakage. Therefore, a concrete ramp and floor must be installed to provide access for removing the sediment. Leaks may occur at each point where the bentonite and concrete interface. The inlet must have an energy dissipator such as a concrete trough with rocks to prevent erosion of the bentonite walls. Bentonite-treated basins must be protected from stormwater erosion to maintain their integrity.

(c) Synthetic materials. Various types of synthetic rolled material can be used to line the equalization basin. A synthetic liner is installed in the same way that a landfill is lined. A proper base is prepared and the liner is positioned, then covered with soil. Equipment can move over the bottom of the basin if the soil covering the liner is thick enough to protect it, a proper base is under the liner, and the walls are not sloped too steeply. A concrete ramp and floor can be installed in the basin before the rolled material is placed. A concrete trough must be used to channel the Influent over rocks and other obstacles to dissipate the energy of the falling water. If a synthetic liner material is selected, it should be resistant to petroleum products and sunlight such as high density polyethylene (HDPE).

(d) Asphalt. Asphalt also can be used as a basin liner. However, it should he noted that petroleum-based products, solvents, lubricants, and other fluids used in vehicle operations and cleaning can degrade an asphalt liner. These products destroy the binder material in the asphalt and cause the liner to fail. The designer should he aware of this potential problem before using asphalt as a liner.

(6) *Sediment removal.* The equalization basin design should include means for dewatering and gaining access to the basin. Basins should be designed for infrequent sediment removal in the range of from 10 to 20 years based on estimated solids carryover from the sediment basin. Sediment storage should he from 1 to 2 feet (0.3 to 0.6 meters). In selecting the liner, designers should consider the method and equipment the facility will use to remove sediment. The liner used should sustain the least damage to its bottom and side walls during cleanout. A ramp with a slope of 1 to 6 (17 percent) may have to be constructed to allow cleaning equipment access to the basin.

b. Dosing tank (optional). A dosing tank or device is a storage structure or component located after the equalization basin and before the filters. The purpose of the dosing tank is to discharge settled water to the intermittent sand filters at the desired dosing rate and frequency. The first choice for delivering Influent to the filter surface is by gravity flow; however, if this design is not possible, automatic operation is an important alternative. Automated delivery is done using flow-activated valves, dosing siphons, timer-controlled valves, or pumps. It is suggested that a dosing siphon or electronically triggered valve he provided in the dosing basin in conjunction with the distribution piping. The most economical dosing siphon in sewage systems is the type with proper bypass pipes and valves; however, electronic float-actuated valves with manual override mechanisms are also effective. Both approaches require a minimum elevation differential between equalization basin water level and filter surface. Water flows by gravity from the equalization basin to the filter pump wet well and then is pumped to the filters via a filter valve control box or valve house.

c. Intermittent sand filters. Intermittent sand filters provide an economical, effective method of treating water prior to reuse at the wash facility. Filters provide a final polishing step by further reducing residual BOD_5 and suspended solids that maybe in the water. This step renders the water suitable to be pumped and reused for washing. The mechanisms involved in removing suspended solids by filtration are complex. Some straining occurs at the filter surface; however, most solids removal in granular filters of the type used at CVWFs occurs within the pore space of the filter media particles and by absorption of impurities onto the filter media surfaces. Additional straining between media particles in the filter also contributes to overall solids removal. Although the primary purpose of the filters is to remove suspended solids and provide a polishing step prior to recycling, they also are effective in reducing BOD_5, nitrogen compounds, and algal populations through a combination of physical and biological processes without the addition of chemicals. The effluent quality from filtration is such that any discharge or reuse is environmentally safe and will cause no increased pump wear. Adequate product water is achieved with minimal O&M costs and personnel. This type sand filter does not require backwashing.

(1) *Configuration* The surface of an intermittent sand filter may he divided into two, three, or four cells. The cells may share a common underdrain collection system, but will have separate distribution systems. Each cell should be physically separated by surface partitions to prevent wastewater from spilling over from one cell to another. At the designers option, the partitions may also completely separate the 36-inch (0.9 meter) sand layer between cells; a minimum of 12-inch (0.3 meter) penetration is recommended.

(2) *Siting.* Intermittent sand filters can require large areas. Therefore, the most desirable topographic and location criteria would include a level site that is free of trees, woody vegetation, and rock; a deep groundwater table; good natural drainage away from the filters; and proximity to the main pump station and water supply basin. Open filters should he located away from or protected against windblown dust from unpaved tank trails. Site conditions may require windbreaks such as fences, trees, or shrubs to prevent wind erosion of the filter media and/or prevent dust from settling on the filter surface. It is desirable that the site be high enough above the maximum water elevation in the water supply basin to allow for gravity flow into the water supply basin.

(3) *Sizing.* The size of these filters and their pumping system is determined by three factors: daily dosing rate, dosing frequency, and dosing rate.

(a) Daily dosing rate. This rate is the maximum wastewater volume per day

per unit area (in acres) which is applied to the surface of the filter. The application rate shall be from 490,000 and 980,000 gallons per acre per day (524 and 1048 liters per square meter per day), which is the equivalent to flooding the filter to a depth from 6 to 12 inches (15.2 to 30.4 centimeters) every 8 hours. The daily dosing rate of the filter currently is chosen according to soil conditions. Soil type (S_t) for the installation (chap 3) should he used in evaluating the design loading rate. CVWFs serving installations with mainly sandy soil $(S_t=1)$ and little or no suspended clay in the training areas may be designed at higher loading rates. However, since some clay-type soils $(S_t=5)$ occur at most installations, design should he adjusted toward the lower end of the recommended loading rate.

(b) *Dosing frequency.* The daily dosing volume is applied to the filters in three intervals to maintain wetness of the filter and also allow the filter to "breathe" between doses, thus maintaining the aerobic biological treatment which results from intermittent dosing. Normally, a filter will have more than one cell and each cell must be dosed every 8 hours, but the actual dosing interval may he alternated from cell to cell. A dosing sequence using equal dosing per day per filter to he delivered by an automatic dosing device or pumps is recommended. Using the available filters on an alternating basis, with rest periods between doses, effectively reduces the hydraulic dosing rate. This procedure is achieved by using electronic timers to control the application of wastewater to the filters.

(c) *Dosing rate.* This value is the flow rate to the filter during each of the three dosing intervals. Dosing flow to the filter should be 95 to 190 gpm per 1000 square feet of filter surface area (6 to 8 inches [15.2 to 20.3 centimeters]) applied for 20 to 40 minutes to give the desired daily loading rate.

(d) *Filter surface area.* The total filter surface area is calculated by dividing the average weekly flow by the daily loading rate x 7 as the filter can be designed to operate 7 days per week unattended. The total filter surface area is then divided into two or more filter cells. This design minimizes the size of the wastewater distribution network on the filter surface and lowers the effect of taking one filter cell off-line for servicing. Because the distribution lines must be easily removable for servicing the filter surface, it is useful to limit their length and size. Small filters also minimize pump capacity and velocity of flow through the distribution systems. Cell sizes of approximately 1/4 acre (1012 m^2) are desirable; however, they may be larger.

(e) *Example Sizing.* Assume that a CVWF requires an average weekly wash water flow of 1.6 million gallons per day for 5 days/week; soiling conditions indicates a loading rate of 650,000 gallons/acre/ day.

Then, total filter surface area = 1,600,000 gpd x 5 days/ 650,000 gal/day/acre x 7 days = 1.76 acres

Further assume that two filters will be used, each divided into four cells:

Cell size = 1.76 acres/2 filters x 4 cells/filter
            = 0.22 acres/cell

Dosing frequency: one of the eight cells is dosed every hour.

Volume per filter dose=8,000,000gal/21 doses= 380,950-gal dose.

Volume of dose per filter cell = 380,950 gal/8cells = 47,620gal.

Dosing rate = 150 gpm/1000 square feet x 0.22 acre (9,583 square feet) = 1438 gpm.

Pumping time to dose each cell = 47,620 gal/I 438 gpm = 33 min.

(4) *Distribution system.* The designer may choose one of several distribution systems to apply waste water evenly over the surface of the sand. Whichever system is chosen, the designer must ensure that it will be easy to remove and replace for cleaning. One design uses perforated plastic pipes placed on the surface of the sand in a grid pattern (fig 6-l3). The drilled orifices in the pipes should be at least 0.16 inch (4 millimeters) in diameter or larger to prevent the openings from clogging. The pipes must be sized to distribute the water as evenly as possible. Another distribution system uses wooden troughs placed on the surface of the filter (fig 6-14) and positioned so as to apply water to the
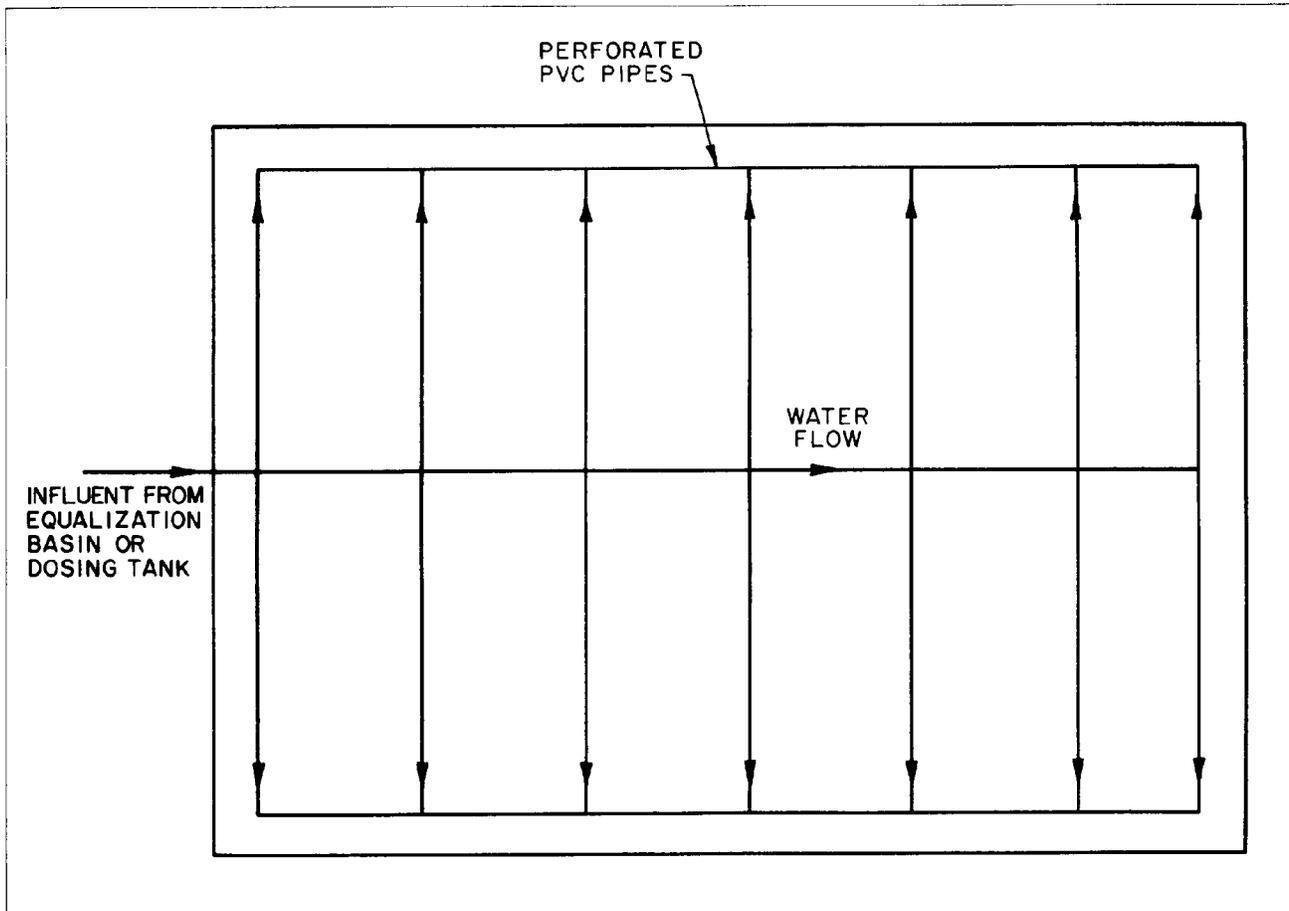
Figure 6-13. Distribution system using grid arrangement.

surface of the filters as evenly as possible (fig 6-15). The number of distribution troughs needed will depend on the area of the filters and the volume of water to be filtered. Plastic pipes with drainage holes may have to he installed in the troughs to extend the distribution system and apply the water uniformly over the surface. The holes in the pipes should be the same size as those in the grid system. The filter distribution system used should he capable of being disassembled when maintenance of the filters is required and the supply pipe to the distributors should he buried.

(5) *Underdrain system.* Perforated collection pipes for the filters are installed near the bottom of the filter embedded in gravel just above an impervious layer. Water will percolate downward through the sand and collect in the pipes (fig 6-16). These underdrains should be placed on a minimal grade (less than 0.25 percent) to provide gravity flow. The designer must consider the surface area of the filters and design the collection system to also handle stormwater falling on the filter

(6) *Materials.* Local sands and gravels should he used whenever possible. The material may have to be washed and screened to obtain clean and properly sized aggregate. The top 36 inches (0.9 meter) of the filter should contain sand with less than 1 percent of the fines passing the number 200 sieve. The D_{10} should be between 0.2 and 0.4 millimeters with a uniformity coefficient (D_{60}/D_{10})[1] of less than 3.5. The next layer contains 4 inches (10.2 centimeters) of 0.5-inch (1.3-centimeter) aggregate. The next layer is 3-inches (7.6- centimeter) of 1-inch (2.5-centimeter) aggregate. The bottom layer consists of 11 inches (27.9 centimeters) of aggregate ranging in size from 1.5- to 2.0-inch (3.8-to 5.1-centimeter). The depth of the bottom layer should be measured from the bottom of the lowest collection pipe. The bottom and walls of the filter must be relatively impervious. Liners of clay soil or geotextile membranes should be provided similar to those described for the earthen basins (para 6-26). Figure 6-17 shows an intermittent sand filter in cross section.

DISTRIBUTION
BOX

DISTRIBUTION
PIPE

WATER INLET
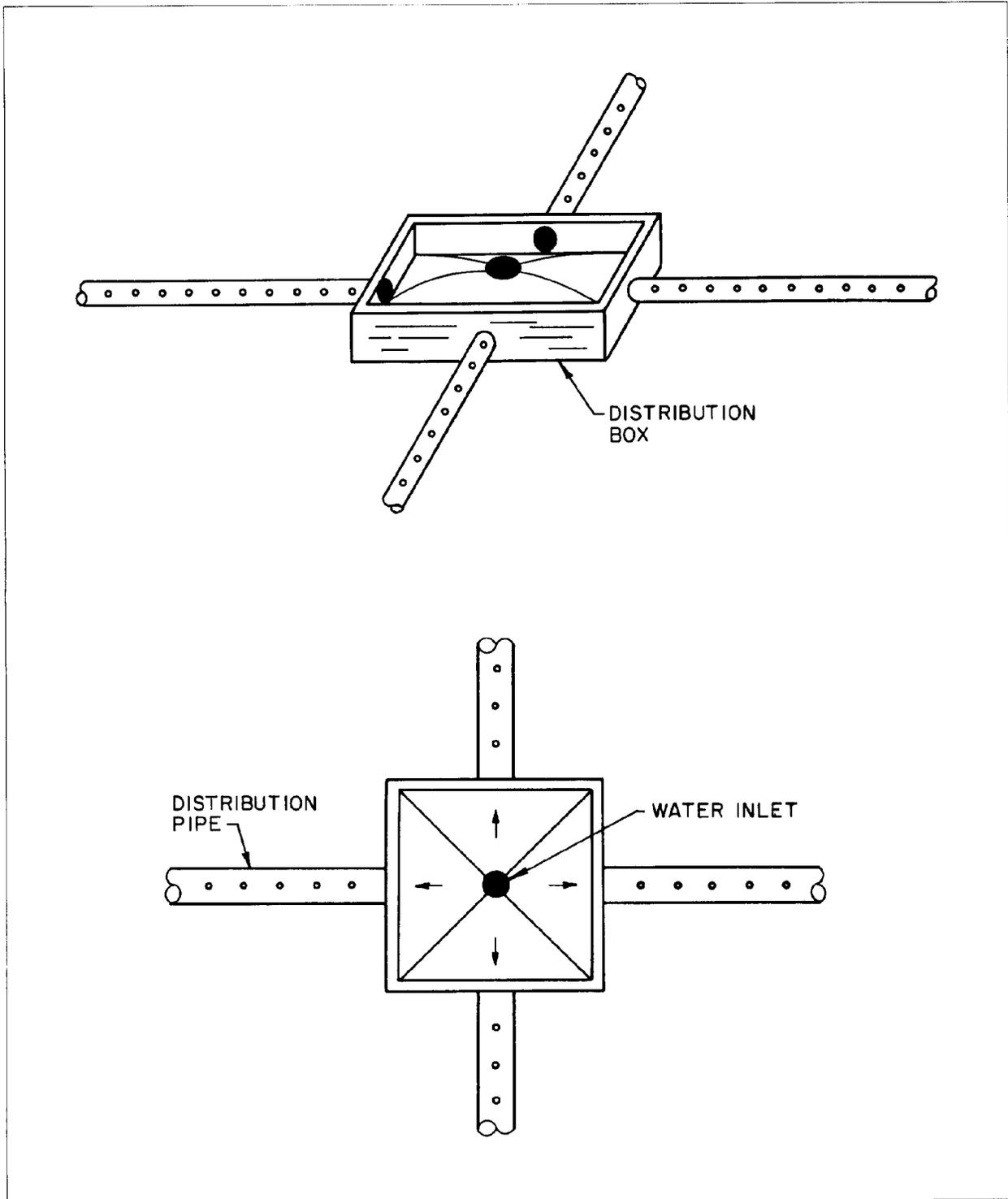
Figure 6–14. Distribution box.
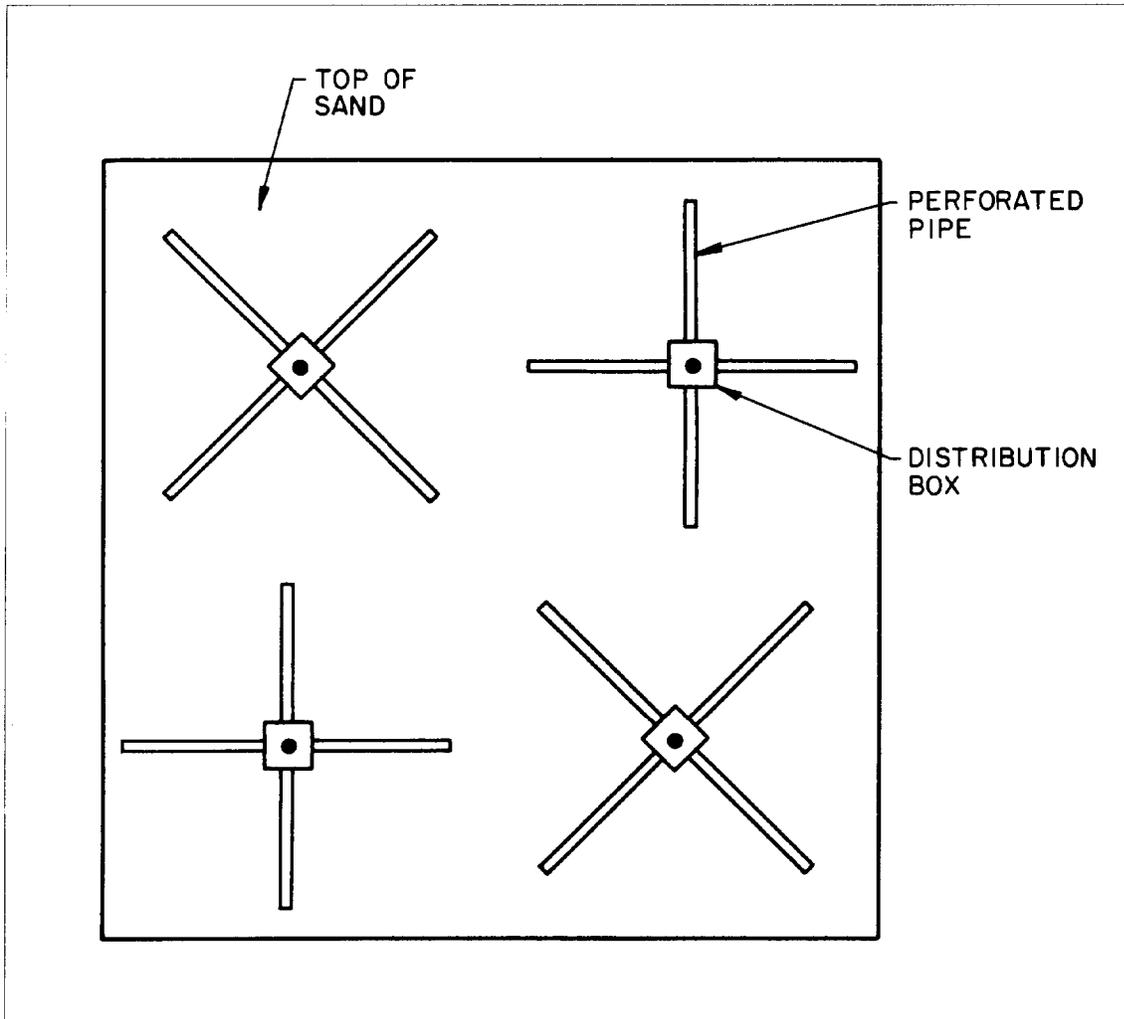
Figure 6–15. Distribution system using distribution boxes.

(7) *Filter maintenance considerations.* The filter sand and the filtered matter support the growth of weeds and grass. Weed control is not required since low grasses and weeds can protect the surface sand from direct sun rays. This shades the sand and reduces evaporation. However, trees and other plants with root systems that could clog or otherwise interfere with the filtering process should be removed.

(a) Winter operations are mostly similar to those during warm weather except that cleaning the filters during cold weather is more difficult. Cold season filtering should be started with a clean, raked filter surface. If the CVWF (and therefore the filters) will not be used during freezing months, the distribution piping including header, distribution main, and laterals must be designed to be fully drained to prevent damage due to freezing. The underdrain network must also be designed to be fully drained or to

prevent water from collecting in the filter and underdrain to a depth at which freezing damage can occur.

(b) Where wind-blown dust and dirt could be transported to the filters from unpaved tank trails or erosion-prone areas, natural or artificial screens may be considered.

(c) When a filter is observed to be plugged or approaching a plugged condition, it will be necessary to rejuvenate the filter surface. Two approaches are recommended. The first consists of raking the media surface to remove debris and breaking the surface incrustation that results from the drying of fines and debris. The filter is raked manually with a garden rake or a small tractor rake or disk attachment. When raking no longer appears to rejuvenate the filter surface due to the buildup of filtered

EFFLUENT PIPE

PERFORATED
COLLECTION
PIPES

CLEANOUT
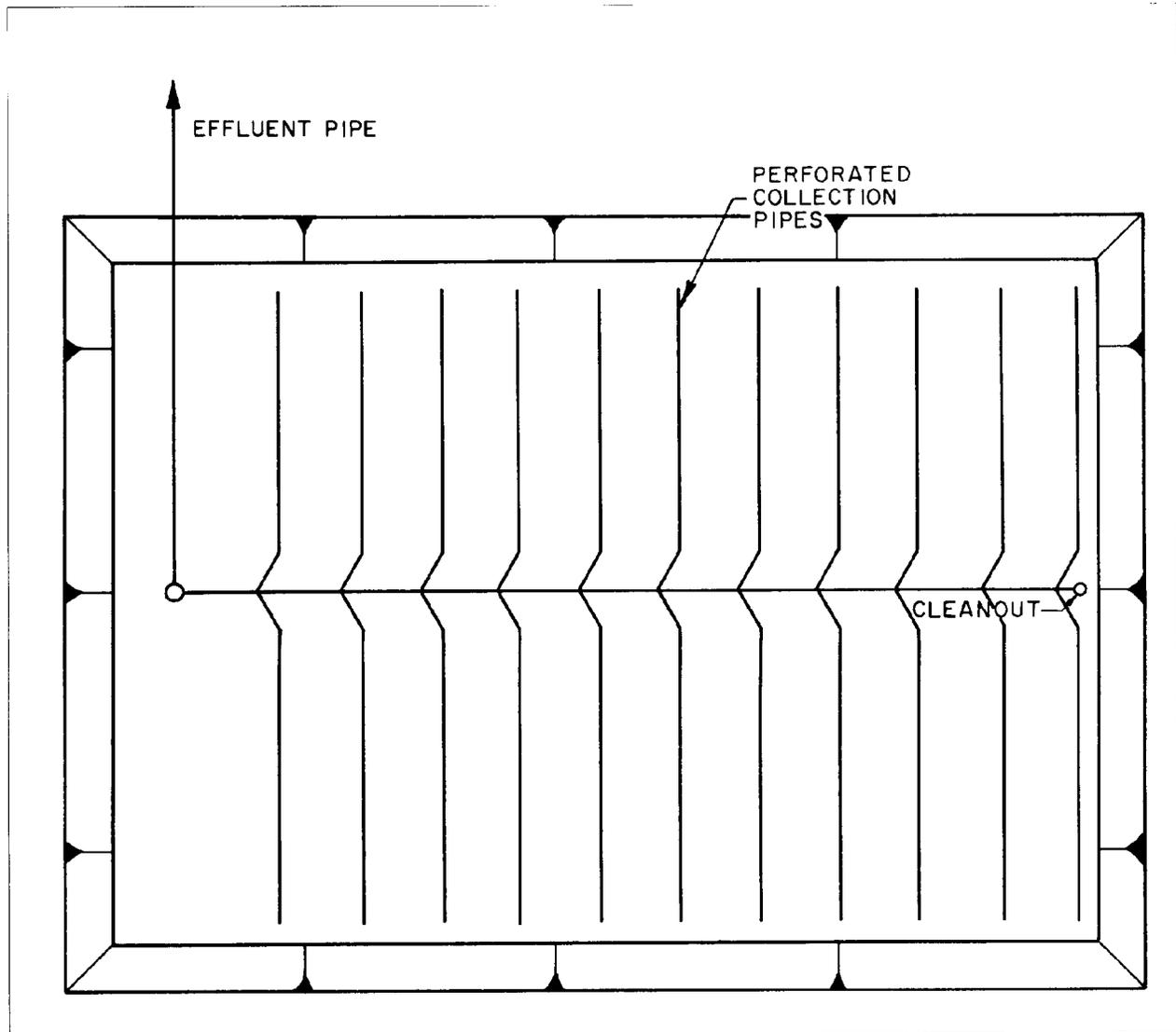
Figure 6–16. Collection system.

matter in the top layer of the sand media, then it is necessary to remove and replace the solids-laden layer. The sand is removed manually or with mechanical devices. A four-wheel-drive garden tractor equipped with a hydraulically operated scraper, bucket loading device, and either flotation-type or dual rear tires works well. The decision to discard or reuse the spent filter sand will largely depend on local availability of this material. When sand costs are high, the removed sand should be stockpiled, washed, and recycled. This approach is especially attractive in wet climates. It is also possible that filter effluent could be used to clean the sand.

(d) The designer must consider the above maintenance aspects of intermittent sand filters and include in the design measures for access, cleaning equipment, intermittent sand filter layers, distribution piping design and ease of removal, and freeze protection.

(8) *Monitoring.* The effluent stream should be monitored for quantity and quality at a point between the intermittent sand filters and the water supply basin. If the water quality meets the standards of the regulatory agency, it is allowed to flow into the wash water supply basin. Otherwise, it is rerouted to the equalization basin for further treatment. The effluent also should be tested periodically for grease, oil, BOD_5, COD, hydrogen-ion
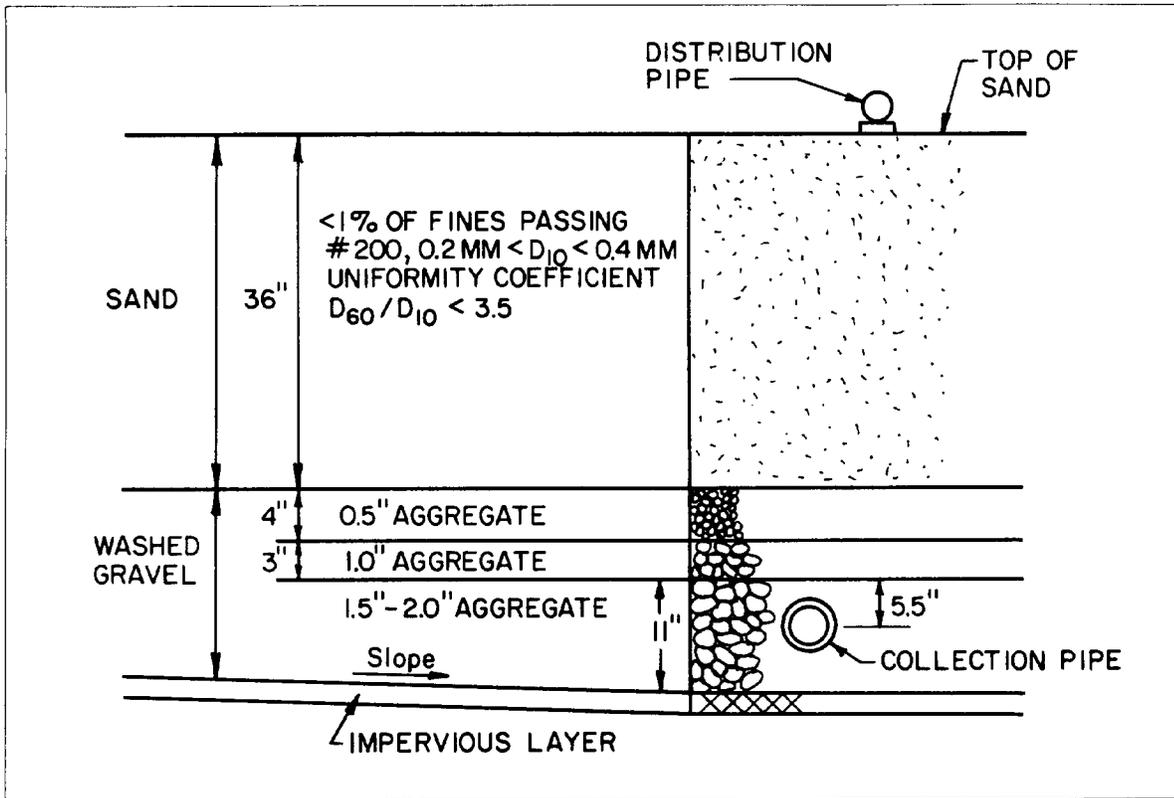
Figure 6-17. Intermittent sand filter cross section.

concentration (pH), total dissolved solids (TDS), and suspended solids (SS) levels.

(a) A recycle system should be monitored at least weekly for the first year of operation. This time span will give the installation a good profile of the treatment system's operation. After the first year, the system may need to be monitored once per month or every other month. These data should be compared with the initial profile data to confirm that the system is working properly.

(b) If primary treated and equalized water is discharged to a sewage treatment plant, the system should be monitored weekly for the first 3 to 4 months to assure the plant operator that the biological, solids, oils, or hydraulic load being discharged from the wash facility are in compliance.

(c) A system that discharges to the environment will require permitting in accordance with the state regulatory agency. The agency must be consulted to determine the monitoring frequency required. Measurements and laboratory tests should he performed in accordance with the instructions in Standard Methods for the Examination of Water and Wastewater.

6-27. Lagoon system

Using lagoons as a secondary treatment system for wastewaters from a CVWF is not the recommended standard. The use of lagoons instead of intermittent sand filters requires Office of the Chief of Engineers (OCE) approval prior to programming and design. Lagoons can be used for secondary treatment only if ponds exist in the vicinity of the CVWF and they are environmentally, hydraulically and structurally acceptable; and if they are more cost effective than sand filters; and long term settling test confirm the ability of lagoons to produce acceptable water quality. However, past designs have used the lagoon treatment system for secondary treatment at CVWFs as described below.

a. *Description.* A lagoon system, like an intermittent sand filter system, includes a sediment basin for sediment and free oil removal (fig 6-18). If the wastewater is to be recycled, an equalization basin and wash water supply basin are also required. The polishing lagoon is sized to give a minimum of 14 days detention time for the wastewaters after pretreatment. This minimum detention time is calculated at peak hydraulic flow conditions into the lagoon. Sediment storage within the lagoon must be provided for the design life of the lagoon. This storage volume is calculated by multiplying the
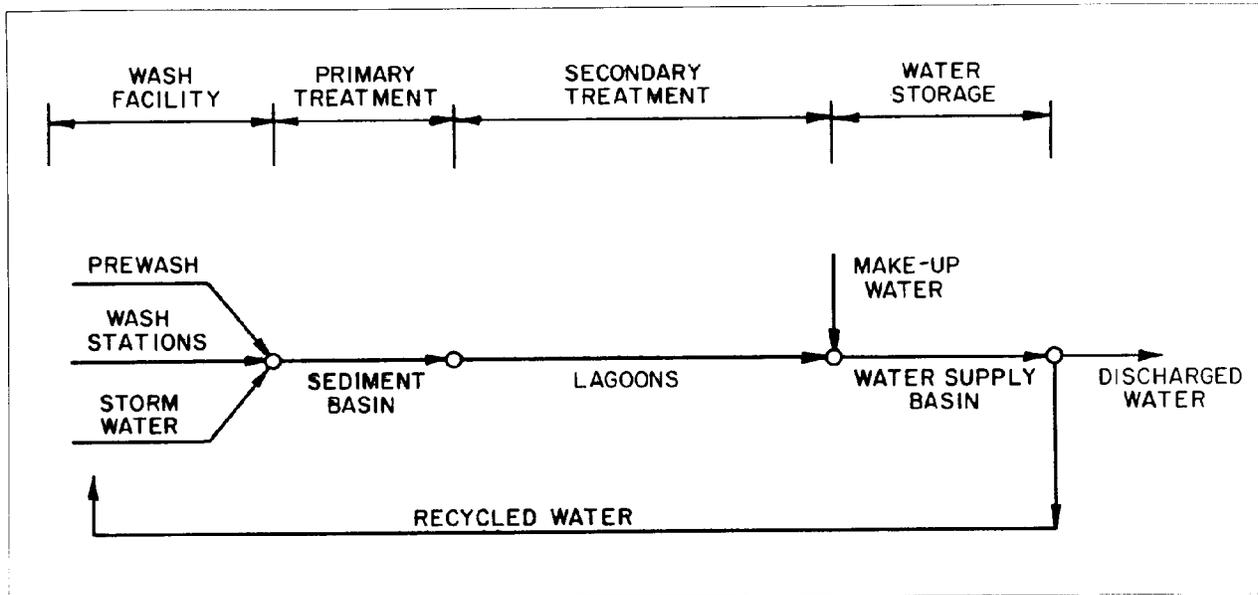
Figure 6-18. Components of a lagoon system.

anticipated flow by the sediment load in the flow by the design life. Figure 6-19 shows the basic lagoon arrangement.

b. *Components.*

    (1) *Influent structure.* The influent structure is located and designed so that it is not submerged.

    (2) *Effluent structure.* The effluent structure is designed to prevent the overflow residual floating oils and solids.

    (3) *Liner.* Liner performance should be resistant to the action of petroleum products.

    (4) *Oil removal.* Continuous oil removal in the lagoon is not required.

    (5) *Stormwater.* Stormwater capacity is designed into the lagoon based on rainfall for the site. It should be assumed that washing operations at the CVWF can occur during a design storm event.

    (6) *Waste discharge (recycle only).* The lagoon should have the capability of discharging *50* percent of its capacity to control dissolved solids that will have accumulated in the wash water. This amount can be reduced to 30 percent in areas where the rainfall meets or exceeds the evaporation rate. The lagoon should be monitored for dissolved solids each month of operation.

    (7) *Maintenance.* The lagoon should be monitored for deterioration of water quality and for leakage.

6-28. Discharge system

A total discharge treatment system removes dirt and debris from the wastewater before discharging the entire volume to a secondary treatment system, usually a sewage treatment plant. Figure 6-20 shows the unit process in a discharge system, and figure 6-21 is a schematic depicting the treatment sequence. Primary treatment is required to remove free oils and prevent sediment deposition in the conveyances and causing a blockage. This treatment also prevents large volumes of sediment and oil slugs from entering a sewage treatment plant which is usually not designed to handle this type of waste. If it is not feasible or practical to discharge the wastewater to a sanitary sewer system, the water may have to be discharged to stormwater surface drainage channels or storm sewers. If one of these methods is used, the water must be treated to produce an effluent quality complying with the installation's National Pollutant Discharge Elimination System (NPDES) permit since this type of discharge is classed as a point source. The discharges must be regularly monitored and reported.

    a. *Equalization basin.* An equalization basin may be required if the sewer lines or plant cannot accept the total instantaneous volume of pretreated wastewater. If the water volume is to be introduced slowly to the discharge location, an equalization basin should be constructed to hold wastewater until it is discharged. The basin should be designed as previously described.

    b. *Water supply basin.* A water supply basin may be required in a non-recycle system if the wash demand exceeds the available source of supply. This should be planned, designed and constructed as previously described.
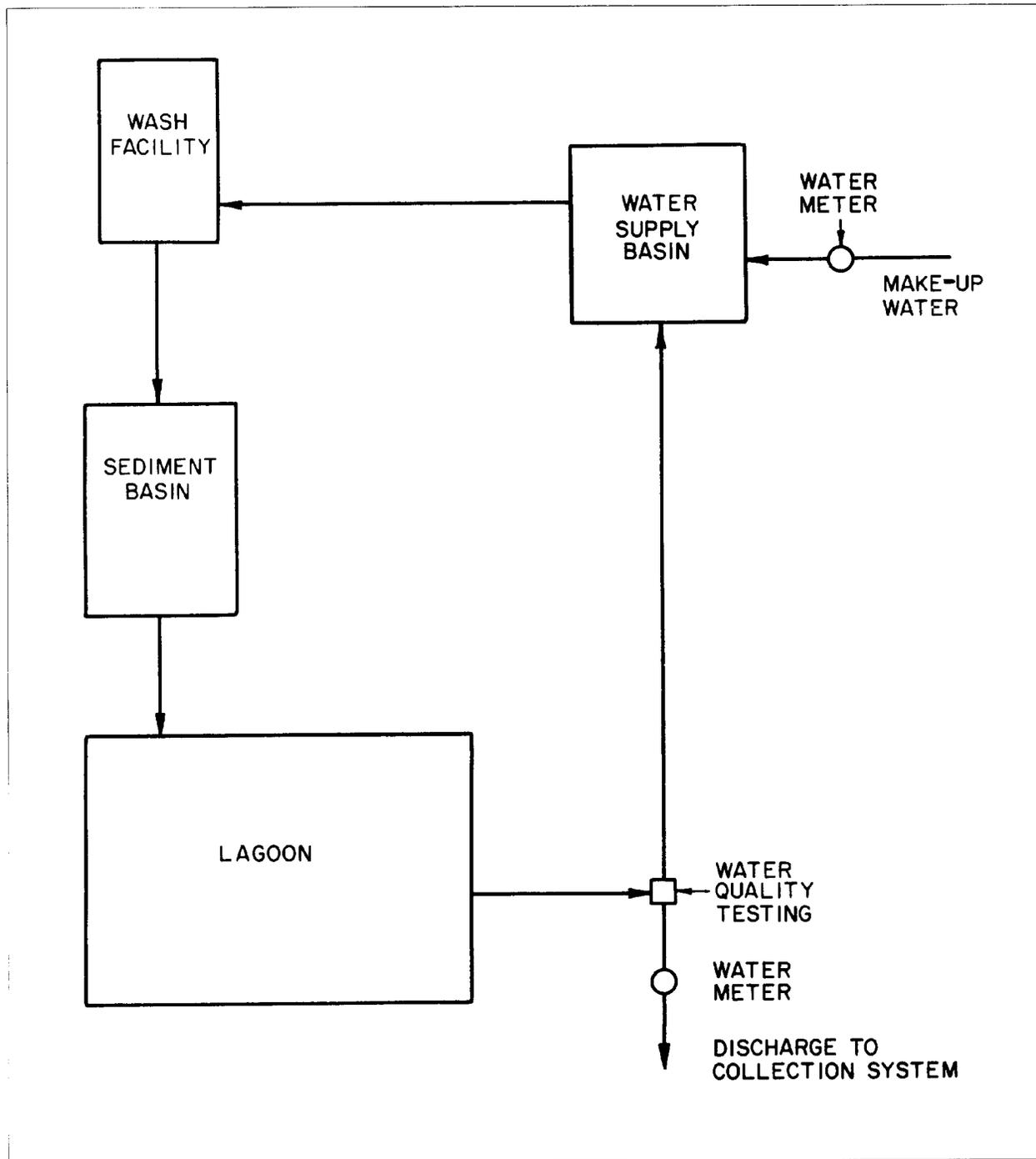
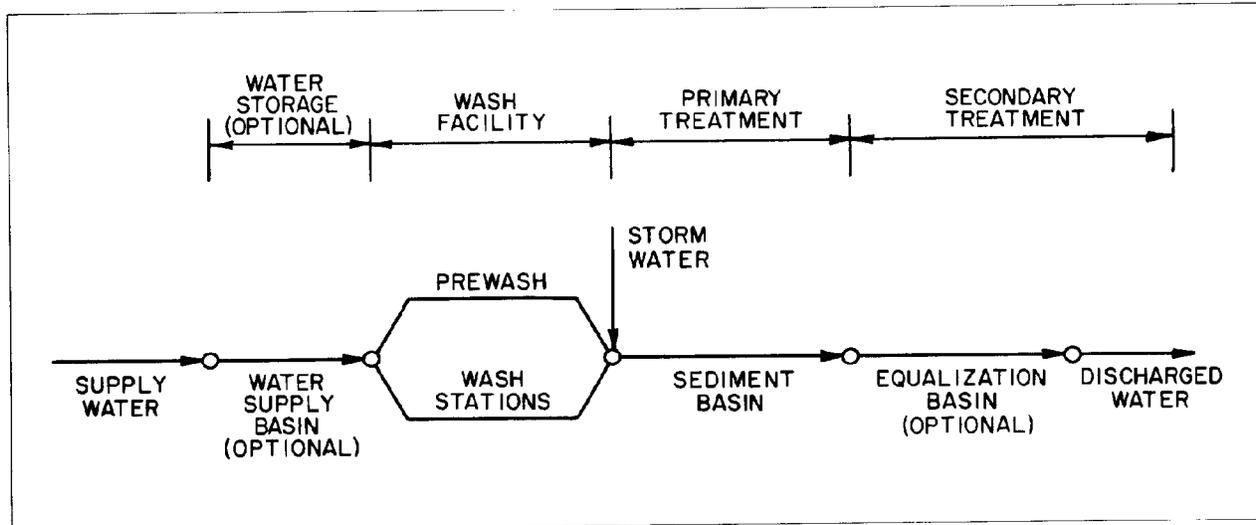*Figure 6–19. General flow schematic of a lagoon system.*

Figure 6-20. Components of a total discharge system.

Section V. WATER SUPPLY BASIN

6-29. Introduction

Filtered water from the secondary treatment facility (sand filter or lagoon) flows by gravity into the wash water supply basin. This is a lined basin which stores the filtered wash water supply for the vehicle wash area. Maximum and minimum operating levels are monitored by level sensors in the wash water pumping station. The basin is sized to store, at a minimum, the quantity of water required to wash the maximum number of vehicles for which the facility is designed during the design wash period. Makeup water for the CVWF is added into the water supply basin. If necessary, excess water can be discharged from this basin; however, the basin should be sized to hold the water demand volume plus storm water from a one-hour duration 10-year storm event.

6-30. Capacity

The effective water volume of the basin should be based on V_{ave} for a one week wash period or V_{max} for a peak use period, whichever is greater. A safety factor ranging from 1.25 to 2.0 times V_{ave} or V_{max}, should be incorporated to help insure adequate water volume at all times. The basin should include 3 feet (1.0 meter) of freeboard above the highest water level, including an allowance for stormwater. There is no need to provide for sediment storage in this basin since the water in the basin should not contain sediment. A depth of 2 to 4 feet should be allowed for dead storage at the bottom of the basin. This additional volume allows for submergence of the effluent control structure. Figures 6-22 and 6-23 show different views of a water supply basin. The designer must ensure that the size of the water supply basin is compatible with the influent volume from the secondary treatment or water source and with the

effluent volume to the wash facility. If the basin is too small, there will not be enough wash water, but if it is too large, it will not be cost-effective. The effective depth of the water supply basin should be 5 to 8 feet (1.5 to 2.5 meters). Deeper basins should be considered in arid regions to reduce water surface areas, thereby minimizing evaporation.

6-31. Liner

The water supply basin may be lined with concrete, clay, or a synthetic material, if required, such as those described for the equalization basin (para 6-26 above). In areas with high evaporation rates, light-colored basin liners might be considered to lower solar heat gain and decrease the evaporation rate.

6-32. Influent structure

An energy dissipation device or treatment should be installed at the inlet to dissipate the energy of the influent water and prevent liner erosion. The inlet should be close to the maximum water elevation in the basin to prevent water from backing up into the pipe and surcharging the sand filter drain system.

6-33. Service

There should be little, if any, solids deposition in this basin, so there is no need for a ramped service entrance into it. There should also be no oil in this basin, so no oil removal equipment is needed.

6-34. Security

Fences may have to installed around the basin to prevent animals from entering the area to drink or bathe.
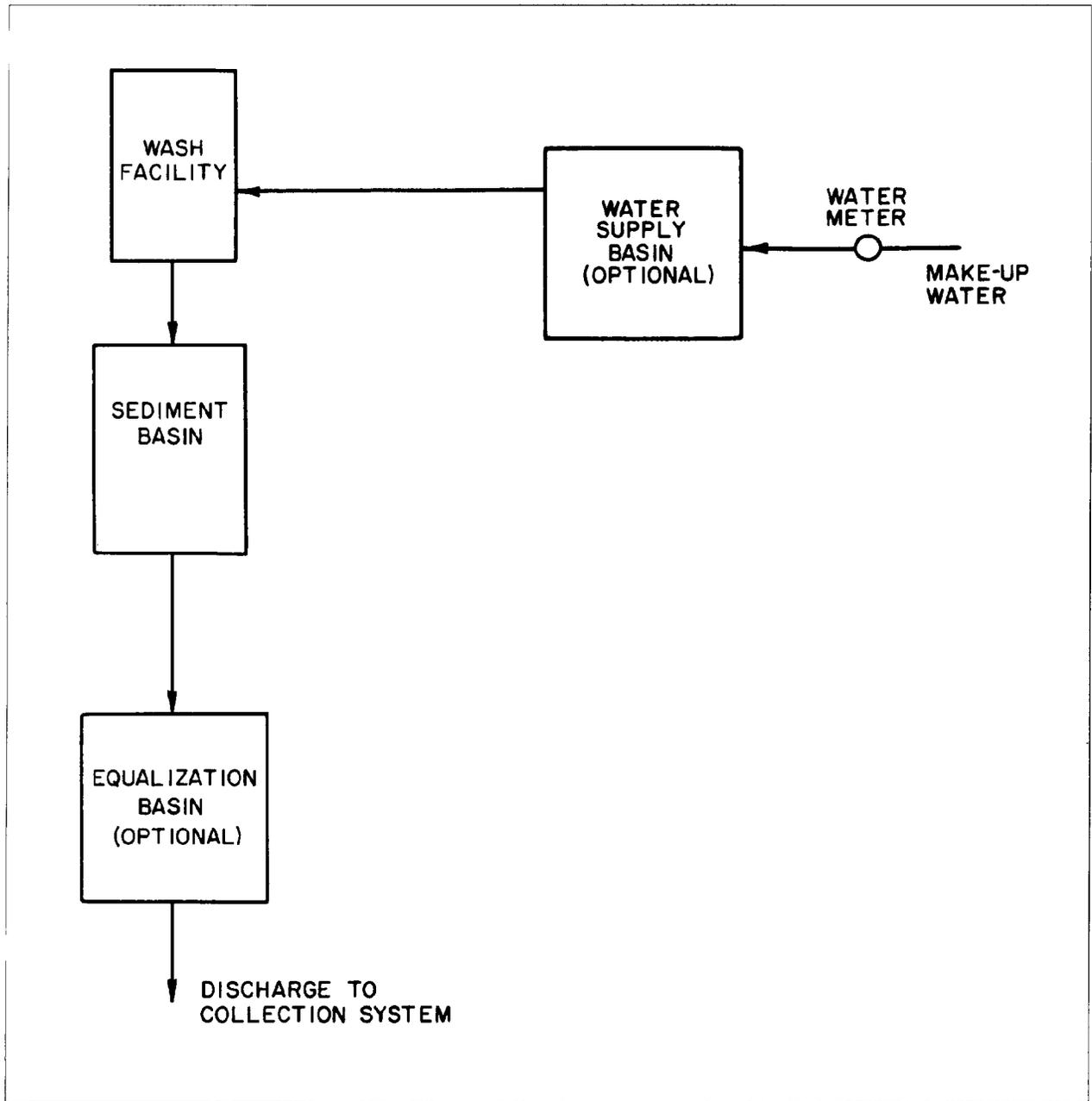
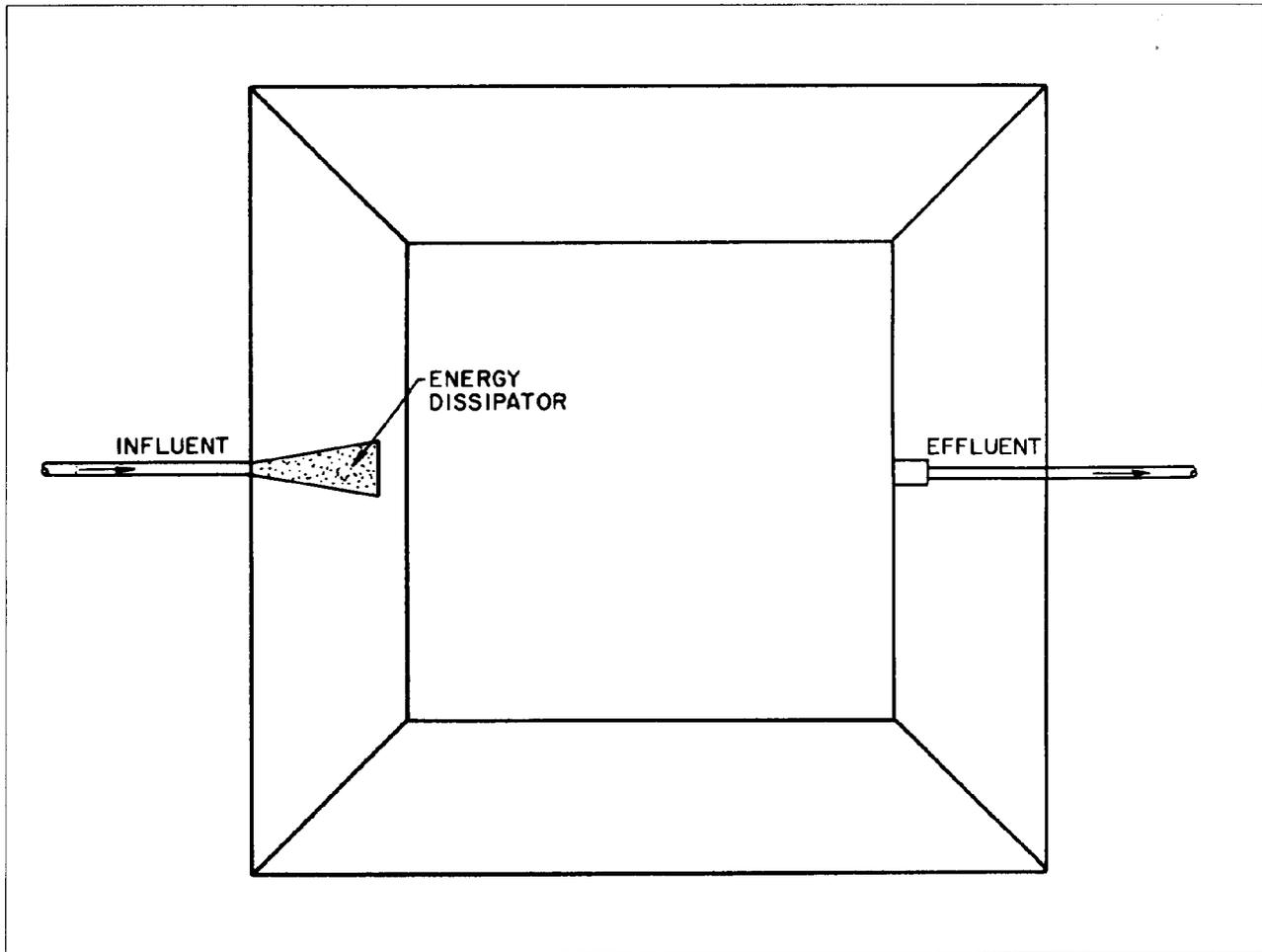*Figure 6–21. General flow schematic of a total discharge system.*
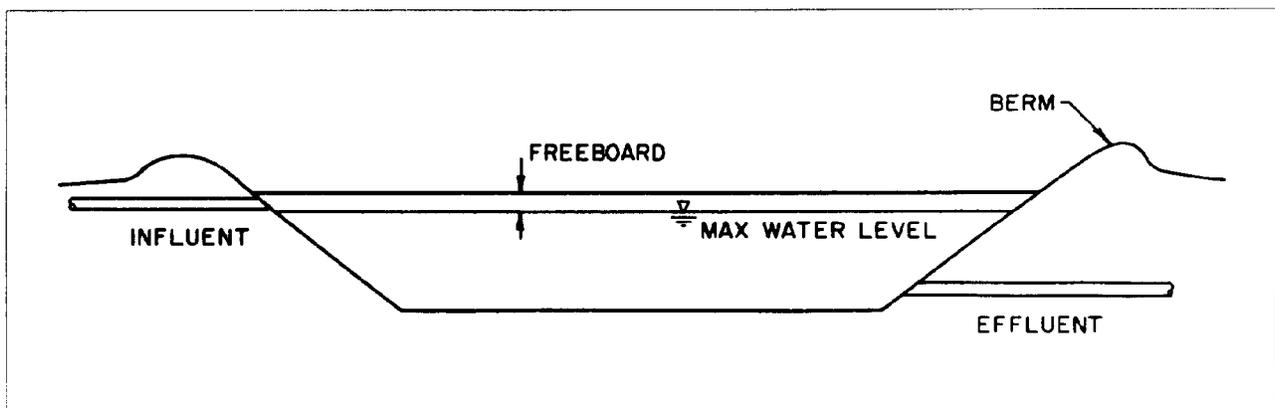
Figure 6–22. Water supply basin—plan view.

Figure 6–23. Water supply basin—cross section.

Section VI. OTHER TREATMENT SYSTEM COMPONENTS

6-35. Water source

All treatment Systems will require a reliable water source for charging the CVWF initially for make-up, regardless of the form of secondary treatment. The volume of water required will depend on the type of wash facility constructed, type and configuration of the treatment system, frequency of use, losses, and the local climate. If a recycle system is provided, the designer must determine the most feasible and economical method of filling the system initially and then maintaining the water level in the system by adding makeup water from the water source. Makeup water will be required to restore the system to a working level as water to carried off by the vehicles or lost to evaporation and overspray. All original source and makeup water should be added at the water supply basin, if provided. This water should be uncontaminated, reasonably clean, and should not require treatment before being introduced into the system. All sources of water available at the installation should be considered for use, singly or in combination, as sources of water at a CVWF including dedicated wells, surface water, tapping into the existing potable water supply or captured rainwater.

a. Type of facility. A wash facility that has a prewash will require more makeup water than a facility with only wash stations because of increased water lost by vehicle carry-off, overspray, and evaporation. Water losses from carry-off can be as high as 160 gallons per vehicle. Losses due to overspray and evaporation can be as high as 10% from water cannons and 5% from hoses at wash stations.

b. Type and configuration of treatment system. The type and configuration of the treatment system is another factor to consider when estimating the volume of makeup water required. A discharge system will require that the total water demand including makeup be taken from the developed water source. In a recycle system, only the water lost to overspray,

evaporation and vehicle carry-off will need to be replaced from the water source. Treatment systems with basins that have large surface areas may have greater water losses due to evaporation than basins with smaller surface areas. This loss will increase the volume of makeup water required, as discussed below.

c. Climate. The evaporation rate at the installation must be considered when calculating the volume of make-up water needed to maintain the total demand. The volume of rainfall at the installation as well as the amount lost to evaporation should be calculated to determine the volume of water needed from the water source. Water balance computations should be performed by the designer to assure adequate supplies of water throughout the entire washing season.

6-36. Piping

Wastewater should be conveyed by gravity whenever possible for economy. Pumping should be avoided because residual oils may become emulsified and difficult to remove, solids cause wear on pumps and pumps add significant capital and operating cost to the facility. Conveyances, whether gravity sewers or open channel, must be constructed to grades which will provide adequate scouring velocity to prevent solids deposition. All pipes must be designed for peak hydraulic and solids loadings, including that contribution from storm water runoff from hardstands. Open-channel flow should be used whenever possible for ease of maintenance. If siting problems or severe slopes make open-channel flow impractical, the designer should use large-diameter pipes. Locate manholes at each change in slope or direction and at each pipe intersection. Design long, straight sections of conduit to minimize the number of manholes required. All frequently operated, buried valves should be accessible through pits or manholes.

CHAPTER 7
OTHER DESIGN CONSIDERATIONS

7-1. Water source

All treatment systems will require a reliable source for charging the CVWF initially and for make-up, regardless of the form of secondary treatment. The volume of water required will depend on the type of wash facility constructed, type and configuration of the treatment system, frequency of use, losses, and the local climate. If a recycle system is provided, the designer must determine the most feasible and economical method of filling the system initially, and then maintaining the water level in the system by adding makeup water from the water source. Makeup water will be required to restore the system to a working level as water is carried off by the vehicles or lost to evaporation and overspray. All original source and makeup water should be added at the water supply basin, if provided. This water should be uncontaminated, reasonably clean, and should not require treatment before being introduced into the system. All sources of water available at the installation should be considered for use, singly or in combination, as sources of water at a CVWF including dedicated wells, surface water, tapping into the existing potable water supply or captured rainwater.

    a. *Type of facility.* A wash facility that has a prewash will require more makeup water than a facility with only wash stations because of increased water lost by vehicle carry-off, overspray and evaporation. Water losses from carry-off can be as high as 160 gallons per vehicle. Losses due to overspray and evaporation can be as high as 10 percent from water cannons and 5 percent from hoses at wash stations.

    b. *Type and configuration of treatment system.* The type and configuration of the treatment system is another factor to consider when estimating the volume of makeup water required. A discharge system will require that the total water demand including makeup be taken from the developed water source. In a recycle system, only the water lost to overspray, evaporation and vehicle carry-off will need to be replaced from the water source. Treatment systems with basins that have large surface areas may have greater water losses due to evaporation than basins with smaller surface areas. This loss will increase the volume of makeup water required, as discussed below.

    c. *Climate.* The evaporation rate at the installation must be considered when calculating the volume of make-up water needed to maintain the total demand. The volume of rainfall at the installation as well as the amount lost to evaporation should be calculated to determine the volume of water needed from the water source. Water balance computations should be performed by the designer to assure adequate supplies of water throughout the entire washing season.

7-2. Piping

Wastewater should be conveyed by gravity whenever possible for economy. Pumping should be avoided because residual oils may become emulsified and difficult to remove, solids cause wear on pumps and pumps add significant capital and operating costs to the facility. Conveyances, whether gravity sewers or open channels, must be constructed to grades which will provide adequate scouring velocity to prevent solids deposition. All pipes must be designed for peak hydraulic and solids loadings, including that contribution from stormwater runoff from hardstands. Because of the external and internal abuse and because of inaccessibility, piping systems must be durable. Leakage or infiltration allowances normally associated with gravity piping should not be used; gravity lines should be water tight. Other factors such as soil corrosion and freeze protection need to be addressed also. Open-channel flow should be used whenever possible for ease of maintenance. If siting problems or severe slopes make open-channel flow impractical, the designer should use large-diameter pipes. Locate manholes at each change in slope or direction and at each pipe intersection. Design long, straight sections of conduit to minimize the number of manholes required. All frequently operated, buried valves should be accessible through pits or manholes.

7-3. Hoses, water cannons, and nozzles

Hoses must be of a size and weight which a person can handle, but yet be durable enough to withstand the abuse of repetitive use, vehicular traffic, and internal abrasion from fines in the water. Nozzles and water cannons undergo similar treatment. The industry is lacking for equipment that can stand up under the continuous use given at a CVWF; therefore the designer must be very selective when selecting hoses, water cannons and nozzles.

7-4. Control systems

The process controls for a CVWF can be very complex to a Contractor who has never seen a wash facility. Material specifications for controls are standard. The logic of the control system is special to the design. It is very important that the designer clearly describe within the plans and specifications how the components are to function.

7-5. Systems operating manual

Complete manuals should be prepared by the designer describing the various components of the CWF and how they were designed to be used. The manual should establish standard operating procedures including staffing, scheduling, safety, records keeping, and other operational responsibilities. All the control systems should be illustrated and step-by-step

instructions provided for not only standard procedures, but also special procedures. The manual should also establish maintenance responsibilities for all the elements in the CVWF. Preventive maintenance will be performed by the operators. Tools for their use must be made available along with spare parts for critical items. Training of operators is very important. Providing them with the written documents previously de-scribed is a start, but the best training can be done through hands-on operation under the instruction of the designer. The amount of training time will depend on the size and complexity of the CVWF, whether it has a prewash and whether it has a recycle water system. For the simplest CVWF, training could be accomplished in a day; for the most complex, the training period could be up to a week.

APPENDIX A
DESIGN EXAMPLE

A-1. Introduction

The following fictional case study example illustrates the planning and design procedures presented in this manual. This example involves Fort Swampy, a U.S. Army Forces Command (FORSCOM) installation which also trains National Guard units. The installation is located in a region with annual precipitation level of 63 inches (1.6 meters), and a 1-hr., 10-yr design storm of 2 inches (5.1 centimeters) intensity. The evaporation rate at the installation is 68 inches (1.7 meters) per year. The soil in the training areas contains some expansive, cohesive clays that will be a problem to remove from vehicles during the rainy periods throughout the year. Freezing temperatures are not expected at the installation. The prevailing winds are from the west-northwest.

A-2. Master planning considerations

a. Training schedule. Two major training activities were scheduled at Fort Swampy last year, with the same number of major exercises expected to continue in the future. The installation requires vehicle washing all year. Table A-I lists all of the troop units on-post by motor pool assignment. During a major exercise, the installation sends all working vehicles to the field. Range Control reports that it takes from 2 to 4 days to recall all of the vehicles from the field. Daily training activities consist of three or four company teams going to and returning from the field. Each company team consists of approximately 8 tracked vehicles and 30 wheeled vehicles. The National Guard units perform both monthly and annual training activities at the installation. The installation has provided the planner with a summary of the estimated number and types of N. 0. vehicles returning from the training field on a monthly basis. This information is listed in table A-2 and graphically in figure A-l to show the distribution of vehicles used throughout the training year.

b. Number and types of vehicles.

(1) *Regular Army.* Table A-1 shows the vehicle types by motor pool. Several units are in each motor pool. A major training exercise assumes that every unit in every motor pool goes out to the field. Skirted vehicles, such as the M-l tank, are more difficult to clean since dirt can collect under the skirt. Fort Swampy currently has 85 M-l tanks, and more are expected to be acquired in the future. Seventy-nine percent of the vehicles are wheeled.

(2) *National Guard units.*

(a) The following vehicles will return after the monthly National Guard training events:

31 light track	146 light wheel
26 heavy track (no M-ls)	58 heavy wheel
57 total tracked vehicles	204 total wheeled vehicles

(b) Seventy-eight percent of the total number of vehicles to be washed at the CVWF are wheeled.

(c) Washing requirements. The Regular Army at Fort Swampy requires that all vehicles be washed as they return from field exercises. The installation requires that vehicles returning from major field exercises be washed within a period of 54 hours. Vehicles returning from routine, daily training activities must be washed within a period of 3 hours. The National Guard requires its vehicles to be washed within 8 hours of completing field exercises. Both the installation and the National Guard have indicated some flexibility with these washing times. Night time washing operations must be provided to meet the installation's requirements; therefore, lighting will be provided in the preparation, bath, wash station, and vehicle assembly areas. Vehicle interior washing capabilities are also required by the installation. Since the vehicles are returned to the motor pools for maintenance inspections, they must receive a detailed washing.

d. Vehicle soiling. Soil samples taken from the training areas, as well as off dirty vehicles, have been tested in a soils laboratory. A grain size analysis (dispersed) was made as described in chapter 3. Results indicated a composition of 14 percent sand, 54 percent silt, and 32 percent clay. From the soil classification diagram (fig 3-3), the soil is a silty clay with a soil type number (S_i) of 4. Based on the amount of rain received annually at the installation and the fact that the rainy season is also a training season, the climatic factor was chosen as 2.0. From equation 3-1, the soiling index (S_i) is calculated to be 8, which indicates heavy soiling conditions and thus potentially longer washing times using standard means. A nondispersed particle size analysis was also made by the laboratory which indicated that 50 percent of the

Table A—1. Number of vehicle types by motor pool assignment

Unit names by motorpool	Heavy track	Light track	Heavy wheel	Light wheel	Nonstandard and trailers
HHC Infantry	2	6	5	11	4
Infantry	85	11	49	18	2
Armor	74	7	53	12	7
HHB Divarty		1	11	17	
Field Artillery	14	26	41	27	2
Field Artillery, FC	16	19	57	31	2
Field Artillery	10	24	41	29	2
HHC Division Support Cmd		7	11	5	
Maintenance BN			118	50	9
Supply and Transport EN			101	25	17
NBC BN (Provisional)			27	39	1
Infantry	3	1	5	24	2
Medical BN			62	47	1
Engineer BN	6		39	36	5
Engineer BN	10		42	11	20
Maintenance Company	1		29	2	5
Maintenance Company	1		37	9	5
Ordnance Company			25	6	4
supply & Support Co			25	7	6
Supply Company			21	6	6
HHD, TVans BN			1	6	3
Military Police EN			5	72	2
Air Defense Artillery	18	2	39	101	3
Cavalry	94	5	32	25	2

Table A-1. Number of vehicle types, by motor pool assignment—continued

Engineer BK	82	5	53	64	9
Engineer BK			49	2	8
Signal BK			38	131	
MIEN	14	1	25	47	4
Air BK			42	28	
TOTAL					
Total Tracked	538				
Total Wheeled	1973				

Table A-2. Number of vehicles returning from the field each month.

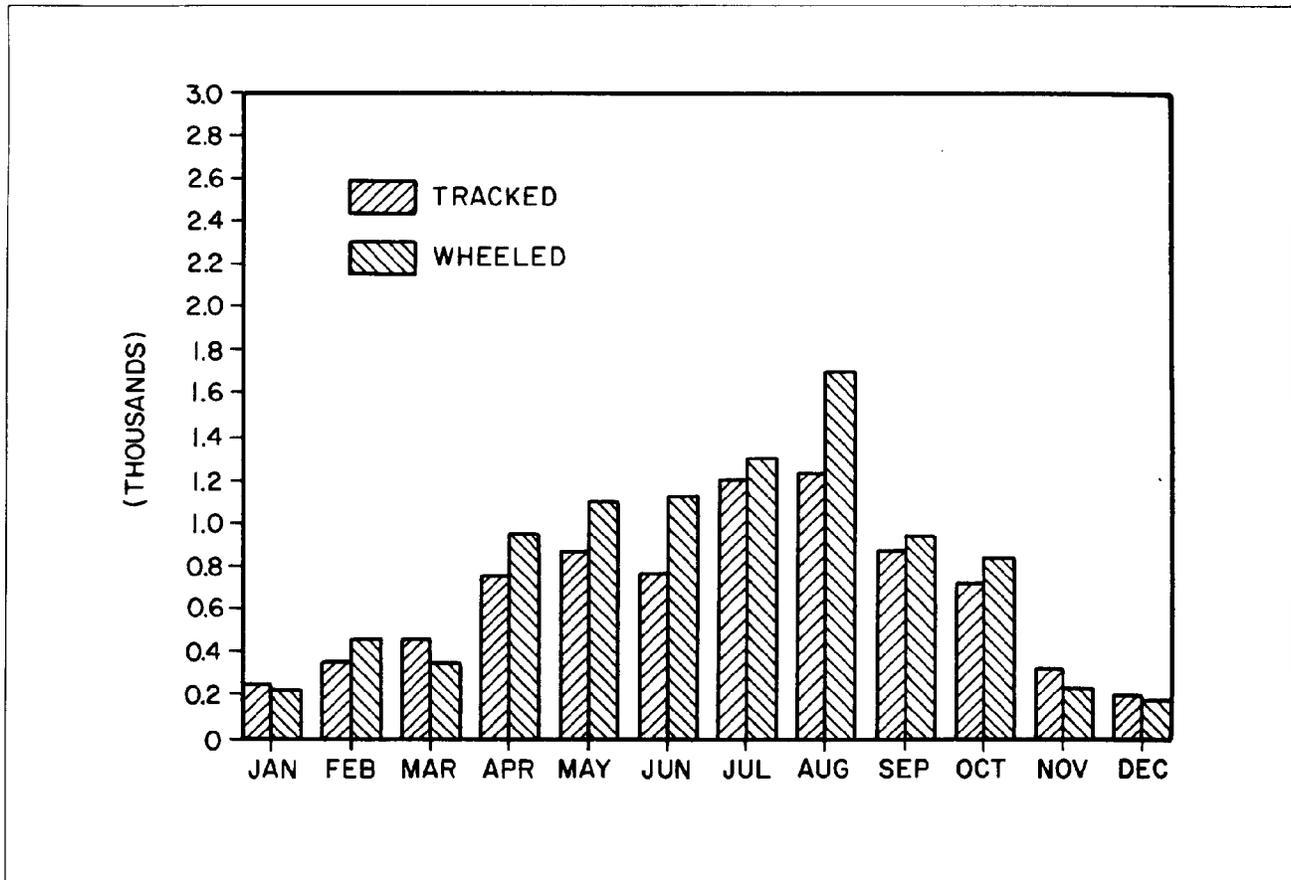| Month	Total tracked	Total wheeled
Jan	253	233
Feb	354	467
Mar	456	343
Apr	753	958
May	872	1089
Jun	768	1125
Jul	1198	1299
Aug	1227	1698
Sep	865	944
Oct	723	834
Nov	321	232
Dec	194	176
Avg per month	665	783

Figure A-1 Vehicles returning from the training areas each month.

particles were larger than 0.05 mm, 80 percent of the particles were larger than 0.02 mm, 90 percent of the particles were larger than 0.01 mm, and 97 percent of the particles were larger than 0.005 mm.

e. Installation requirements.

(1) *Prewash.* A bath prewash is indicated at Fort Swampy because cohesive soil found in the training areas, combined with the limited washing period, require the type of prewashing best served by a bath facility. To achieve the desired soaking action on the skirted M-1 tanks for gross soil removal, the depth of water in the bath should be adjustable up to 3.5 feet (1.1 meters).

(2) *Wash stations.* The wash stations will be the standard design described in chapter 4. Interior wash equipment will be included. Since tracked vehicles will also be using the wash stations, each island must be protected by concrete barriers and all pavement in the CVWF must be constructed of concrete.

(3) *Preparation area.* Since the CVWF will have a bath, two preparation areas are required. The

first area will be located before the bath to allow troops to prepare the vehicles for washing and to queue-up behind the bath lane. The second preparation area will be between the bath exit and the entrance to the wash stations, this is a queuing area for vehicles that have left the bath or have bypassed the bath.

(4) *Waste washwater treatment.* Fort Swampy purchases potable water from a local water district at a current price of $ 1 per 1000 gallons (3785 liters). The existing wastewater treatment system at the installation does not have the capacity to treat the large hydraulic and solids loadings expected from the CVWF. In addition, the State will not allow discharge to the environment. Therefore, a total recycle system is required. Due to the high clay content of soils in the training area, laboratory settling tests have indicated extremely long detention times should be required for a lagoon treatment, therefore a sand filter system was chosen as the form of secondary treatment

(5) *Makeup water.* Sources have been investigated and the only reliable, environmentally acceptable source of makeup water is the po-table water system. The potable water supply

is limited to 3 million gallons (11.36 million liters) per day. Daily water usage at the installation is 2 million gallons (7.57 million liters) per day, with 1 million gallons (3.79 million liters) reserved for firefighting. No water is available for expansion of facilities. However, it is estimated that the motor pools now use 0.13 to 0.20 million gallons (0.49 to 0.76 million liters) of water per day to wash vehicles. Part of this volume of conserved water can be used as makeup water for the new CVWF.

f. Sizing.

(1) *Bathprewash.* The designer estimates that the processing rate through the bath will be 6 vehicles per hour per tracked vehicle lane and 11 vehicles per hour per dual-purpose lane. This decision was based on the soiling index computed for the site and the processing rates given in chapter 3 and illustrated on figure 3-4.

(a) *Regular Army.* The designer uses equations 3-2 and 3-3 from chapter 3 to determine how many tracked and dual-purpose lanes are needed for prewashing Regular Army vehicles. The tracked lanes will be used for most of the large tactical vehicles; therefore, dual-purpose lanes are estimated without including the tracked vehicles, as discussed in chapter 3. The installation has estimated that 80 percent of the tracked vehicles and 65 percent of the wheeled vehicles returning from the field will require immediate washing in the bath with the rest bypassing to the wash stations. It has been assumed that trailers and nonstandard vehicles, such as bulldozers and goers, will proceed directly to the wash stations. Other vehicles, such as ambulances and support vehicles, may not require immediate washing and will use the facility at a later time. Malfunctioning vehicles may be returned to the motor pool directly or may be left in the field until all other vehicles return. The designer has also considered vehicles in-tow such as tanks and trailers. Using the vehicle counts from table A-2, the number of tracked and dual-purpose lanes required for washing after a major training exercise are computed:

A. Number of tracked lanes: $\dfrac{0.80 \times (538 \text{ veh})}{6 \text{ veh/hr/lane} \times (54 \text{ hr})} = = 1.33$ lanes

B. Number of dual-purpose lanes: $\dfrac{0.65 \times (1973 \text{ veh})}{11 \text{ veh/hr/lane} \times (54 \text{ hr})} = 2.16$ lanes

Since the installation is flexible with respect to washing times, the designer rounds the number of lanes as described in chapter 3. One tracked lane and two dual-purpose lanes were recommended to accommodate the Regular Army's needs. Using the above information, the numbers of tracked and dual-purpose lanes required for washing after routine daily training exercises are computed:

C. Number of tracked lanes $\dfrac{0.80 \times 8 \text{ veh/team} \times 4 \text{ teams}}{6 \text{ veh/hr/lane} \times 3 \text{ hr}} = 1.42$ lanes

D. No. dual-purpose lanes $\dfrac{0.65 \times 30 \text{ veh/team} \times 4 \text{ teams}}{11 \text{ veh/hr/lane} \times 3 \text{ hr}} = 2.36$ lanes

It is apparent that the one tracked vehicle lane and the two dual-purpose lanes estimated above will meet the requirements for both major training exercises and routine daily training activities.

(b) *National Guard.* The same computation is used to compare the bath requirements for the National Guard units except that a high percentage of vehicles will use the bath because there are few support vehicles and all units are to be returned to the motor pool extremely clean. It is estimated that 90 percent of tracked vehicles and 75 percent of wheeled vehicles will use the bath prewash. Using information from above, the number of bath lanes required is computed:

E. No. tracked lanes $\dfrac{0.90 \times 57 \text{ veh}}{6 \text{ veh/hr/lane} \times 83 \text{ hr}} = 1.07$ lanes
F. F.

F. No. dual-purpose lanes $\dfrac{0.75 \times 204 \text{ veh}}{11 \text{ veh/hr/lane} \times 8 \text{ hr}} = 1.74$ lanes

A comparison of the results shows that the one tracked lane and two dual-purpose lanes will satisfy both Regular Army and National Guard needs at the prewash facility. Designer realizes that light-tracked vehicles may be washed in the dual-purpose lanes.

(2) *Wash stations.* The clay content in the soils at the installation and the requirement that vehicles return to the motor pools well cleaned for inspection and maintenance after washing suggest that the processing time required for troops to do a detailed washing at the wash stations will be at the high end of the range. From the processing rates given in chapter 3 (fig 3-4) and the soiling index (S_i) previously computed, the designer has determined that 3.75 vehicles can be processed per hour in each wash station following the prewash. For the tracked vehicles not using the prewash, a processing rate of 1.75 vehicles per hour is selected; and for wheeled vehicles not using the prewash, a processing rate of 5 vehicles per hour is selected. Compute the number of wash

lanes required after a major training exercise:

G. Tracks from bath:
$$\frac{0.80 \times 538 \text{ veh}}{3.75 \text{ veh/hr/lane} \times 54 \text{ hr}} = 2.12$$

Tracks bypassing bath:
$$\frac{0.20 \times 538 \text{ veh}}{1.75 \text{ veh/hr/lane} \times 54 \text{ hr}} = 1.14$$

Wheeled from bath:
$$\frac{0.65 \times 1973 \text{ veh}}{3.75 \text{ veh/hr/lane} \times 54 \text{ hr}} = 6.33$$

Wheeled bypassing bath:
$$\frac{0.35 \times 1973 \text{ veh}}{5 \text{ veh/hr/lane} \times 54 \text{ hr}} = 2.56$$

Total Wash Lanes = 12.15 lanes

The number of lanes required to meet the daily training exercise is computed:

H. Tracks from bath:
$$\frac{0.80 \times 32 \text{ veh}}{3.75 \text{ veh/hr/lane} \times 3 \text{ hr}} = 2.28$$

Tracks bypassing bath:
$$\frac{0.20 \times 32 \text{ veh}}{1.75 \text{ veh/hr/lane} \times 3 \text{ hr}} = 1.22$$

Wheeled from bath:
$$\frac{0.65 \times 120 \text{ veh}}{3.75 \text{ veh/hr/lane} \times 3 \text{ hr}} = 6.93$$

Wheeled bypassing bath:
$$\frac{0.35 \times 120 \text{ veh}}{5 \text{ veh/hr/lane} \times 3 \text{ hr}} = 2.80$$

Total Wash Lanes = 13.23 lanes

Requirements for the Regular Army exceed those for the National Guard and because the installation is flexible in regard to wash times, the designer selects 12 wash stations.

g. *Site selection.*

(1) *Geography.* The site selected over several possibilities is adjacent to the only main route, Range Road, that the vehicles will travel as they return to the cantonment area from the training fields.

(2) *Geology.* The site has 45 feet (13.7 meters) of relief over a 25-acre (0.10-square kilometer) area. The site is on the top of a ridge that is approximately 200 feet (61 .0 meters) wide and 700 feet (213.4 meters) long. Site borings have shown that the water table will not interfere with construction or operation of the CVWF. The site has never been used for any purpose. Engineers have determined that if work to lengthen or widen the ridge is to be done at the site, it will raise construction costs considerably due to the location of the bedrock. Figure A-2 shows a topographic map of the site.

(3) *Utilities.* All required utilities are within a reasonable distance to the proposed site. A 10 inch (25.4-centimeter) potable water line runs

parallel to Range Road. Electrical and telephone lines also run parallel to this road. The latrines can be tied into the sanitary sewer lines which are within 0.75 miles (1.2 kilometers) of the site. As long as wastewater from the facility is recycled, the added load from the CVWF is not expected to burden any of the existing sewer lines.

A-3. Engineering and design

a. *Bath design.* Figure A-3 shows the bath arrangement for the new Fort Swampy CVWF consisting of one tracked lane and two dual purpose lanes. Dimensions are taken from the definitive drawings and entrance and exit slopes are selected as shown. Overall length is computed using these slopes.

(1) *Water cannons.* The flow rate from the water cannons in all lanes is selected as 80 gallons per minute (gpm) (303 liters per minute). The delivered pressure selected is 100 pounds per square inch (psi) (6.8 atmospheres). These are the maximum flow rate and pressure values recommended and are chosen because the soil consists of clays which are not easily removed.

(2) *Flexors.* Flexors in the dual-purpose lane should be exposed 4 inches (10.1 centimeters) with a center-to-center spacing of 17 inches (43.2 centimeters), since about the same number of light- and heavy-wheeled vehicles are expected to use the bath. The tracked lane should have flexors exposed 10 inches (25.4 centimeters) and spaced 5.5 feet (1.7 meters) o.c. because the primary user will be heavy tracked vehicles.

(3) *Entrance ramp.* Because Fort Swampy does not have freezing weather, the maximum slope on the entrance ramp, 1 in 7, can be used. This design will give a projected ramp length of 24.5 feet (7.5 meters).

(4) *Exit ramp.* The maximum slope of 1 in 11 can be used for the exit ramp. With this slope, the projected ramp length is 38.5 feet (11.7 meters).

b. *Wash station design.* The flow rate selected per hose is 30 gpm (114 liters per minute) at 90 psi (6.1 atmospheres) pressure. These are the maximum flow rate and pressure values recommended and were chosen because the soil consists of clays which are not easily removed. Interior washing points, which are low-pressure, low-flow outlets consisting of yard hydrant and utility hose will be placed at each island. The limited area for construction on the natural ridge will dictate the configuration of the wash station area. Two configurations, A and B, are evaluated.

Figure A–2. Site map with a proposed layout—Fort Swampy.

(1) *Configuration A.* With the 12 stations placed in a linear fashion perpendicular to traffic flow and a standard center-to-center spacing of 25 feet (7.6 meters), the total width of the wash station would be 300 feet (91.2 meters) (fig A-4). Adding the width of the bypass lane, 22 feet (6.7 meters), yields a facility width of 322 feet (97.9 meters), which is too wide to be constructed on this narrow ridge.

(2) *Configuration B.* This configuration would place the islands in two parallel rows, with a queuing area down the center of the rows and two bypass lanes on the outside of the stations (fig A-5). Half-islands are placed at the ends of each row. The islands would be placed at a 60 degree skew to the normal flow of traffic. This layout would require more area to be cleared and paved, but the facility width would be no more than 180 feet (54.9 meters), which is less than the constraint imposed by the ridge. The designer chooses configuration B as the best alternative after performing a cost comparison.

c. Vehicle preparation areas. The installation has stated that three vehicles queuing to enter each bath lane should be sufficient. Other vehicles waiting to use the facility can queu-up along Range Road adjacent to the wash facility. If traffic problems occur, Range Control will coordinate the number of vehicles leaving the training areas with the wash facility activities.

(1) The entrance vehicle preparation area should provide enough room for three vehicles per lane to wait to be washed in the bath. The longest tracked vehicle to use the facility is the M-1 tank, which is some 32 feet (9.8 meters) long. The longest wheeled vehicle is the M-978 Tanker Truck at 33 feet (10 meters). At least 52 feet (12.8 meters) per vehicle should be allowed (10 feet (3.lm) clear on each end). Therefore, the preparation area should be at least 156 feet (47.5 meters) long. An additional 20 percent or 30 feet (9.0 meters) of entrance staging is added yielding a total length of 165 feet (50.3 meters).

(2) The preparation area between the bath and the wash stations should be at least two vehicle lengths, rounded to 60 feet (18.2 meters) with all other factors considered. The assembly area after the wash stations should also allow for two vehicles, again rounded to 60 feet (18.2 meters).

(3) The aisle space between the two rows of islands should be at least 75 feet (22.9 meters)

wide to allow the vehicles to maneuver and queue and the Exit lanes should be a minimum of 22 feet (6. 7m) wide. The exit vehicle assembly area will be the full width of the facility, 159 feet (48.5 meters). Figure A-S shows these dimensions.

d. Sizing the treatment system.

(1) *Water usage factor.* A bath system is to be installed. The soils on the vehicles will be partially cohesive, and not easily removed; therefore, a reasonably steady rate of vehicles is expected through the bath and the wash stations. The designer selects the following estimates for the various water usage factors, based on experience: $U_1 = 1.0$; $U_2 = $ (bath full)

$U_2 = 0.90$; $U_3 = 0.80$; $U_4 = 0.20$; $U_5 = 0.20$; $U_6 = 0.20$; $U_7 = 0.80$; $U_8 = 0.20$

(2) *Cleanup time.* The cleanup time (K) is estimated to be 1 hour based on the 30 minutes it will take the operator to drain the bath (T_D) and an additional 30 minutes for troops to hose down the bath and staging areas. It is assumed that bath flushing and area clean-up will occur once per wash period.

(3) *Flow rate.* Using the parameters defined in chapter 6, the designer computes the various flow conditions.

(a) *Bath drain flow rate, Q_1:*

Refer to figure A–6.

Q_1 = (width x cross section) x 7.48 gpcf/drain time

Q_1 = (90 ft x 285sf) x 7.48/30 min

Q_1 = 6395 gpm (24207 Lpm)

(b) *Bath overflow, Q_2:*

Q_2 = Number of cannons x cannon discharge

Q_2 = N_{wc} x F_{wc}

Q_2 = 12 x 80 gpm

Q_2 = 960 gpm (3634 Lpm)

(c) *Wash station flow, Q_3:*

Q_3 = Number of wash station hoses x hose discharge

Q_3 = N_{st} x F_{st}

Q_3 = 24 x 30 gpm

Q_3 = 720 gpm (2725 Lpm)

ENTRANCE

22 FT
(6.7M)

22 FT
(6.7M)

Slope
1:7

28 FT
(8.4 M)

28 FT
(8.6M)

34 FT
(10.4 M)

CONTROL
BUILDING

50 FT
(15.2 M)

122 FT
(36.8 M)

Slope
1:11

44 FT
(13.2 M)

EXIT

12 FT
(3.6 M)

7 FT
(2.1M)

90 FT
(27.6M)

104 FT
(31.8 M)

Figure A–3. Bath design.

TRAFFIC FLOW

BYPASS
LANE

PREWASH
BATH

22 FT
(6.9 M)

126 FT
(38.5M)

BYPASS
LANE

WASH ISLANDS

25 FT (7.6M)
TYPICAL

22 FT
(6.7 M)

WASH STATIONS

HALF ISLAND

322 FT
(97.9 M)

TRAFFIC FLOW

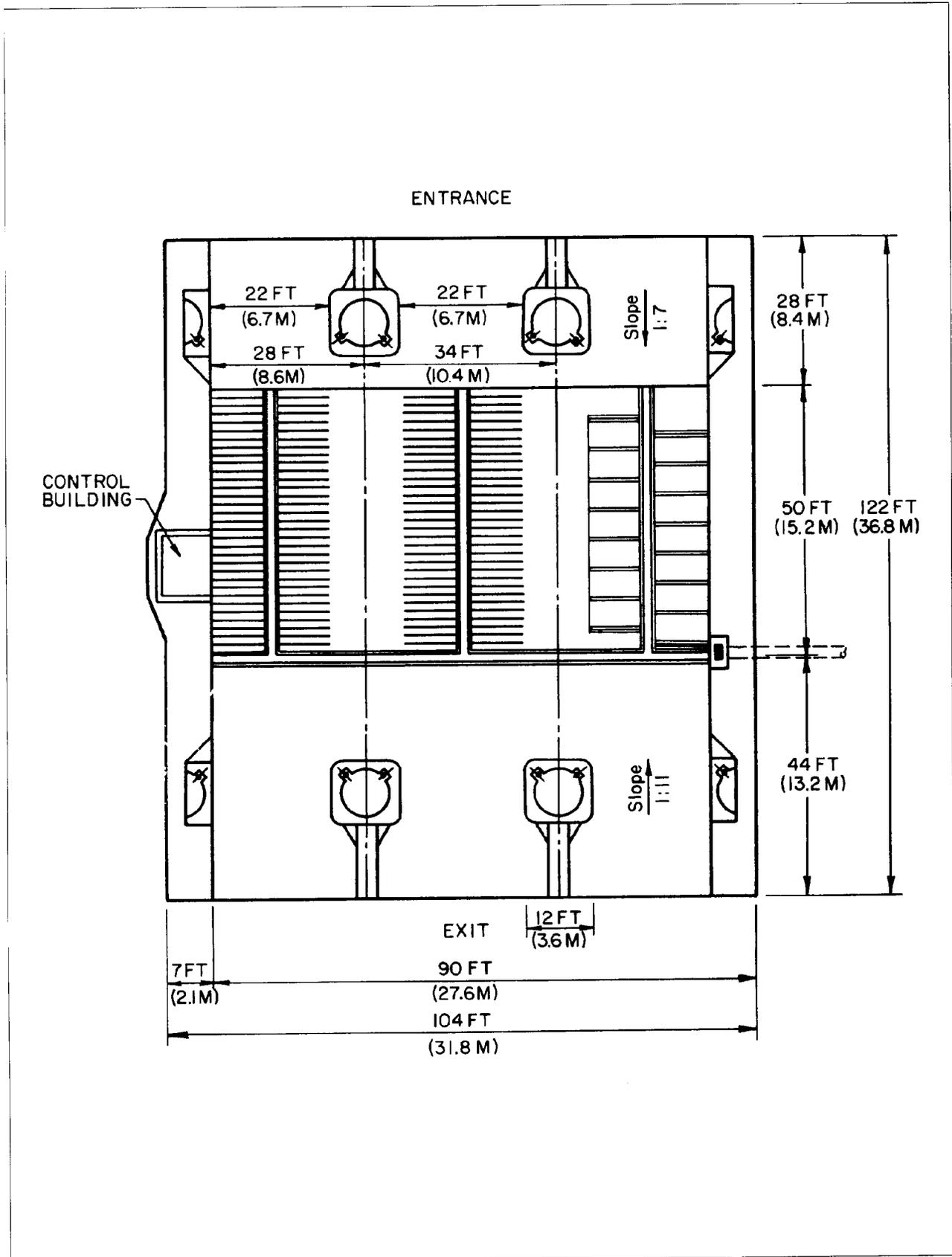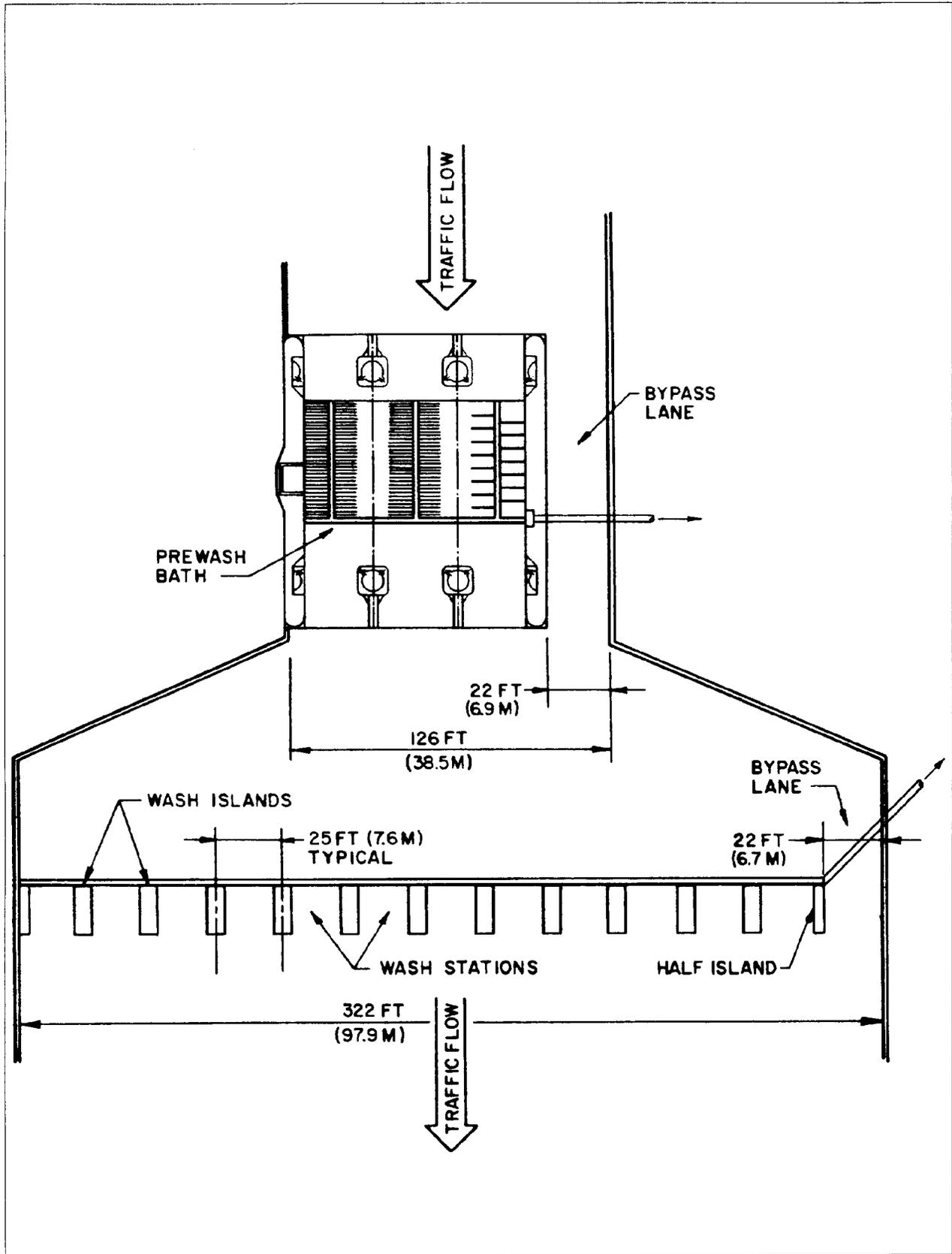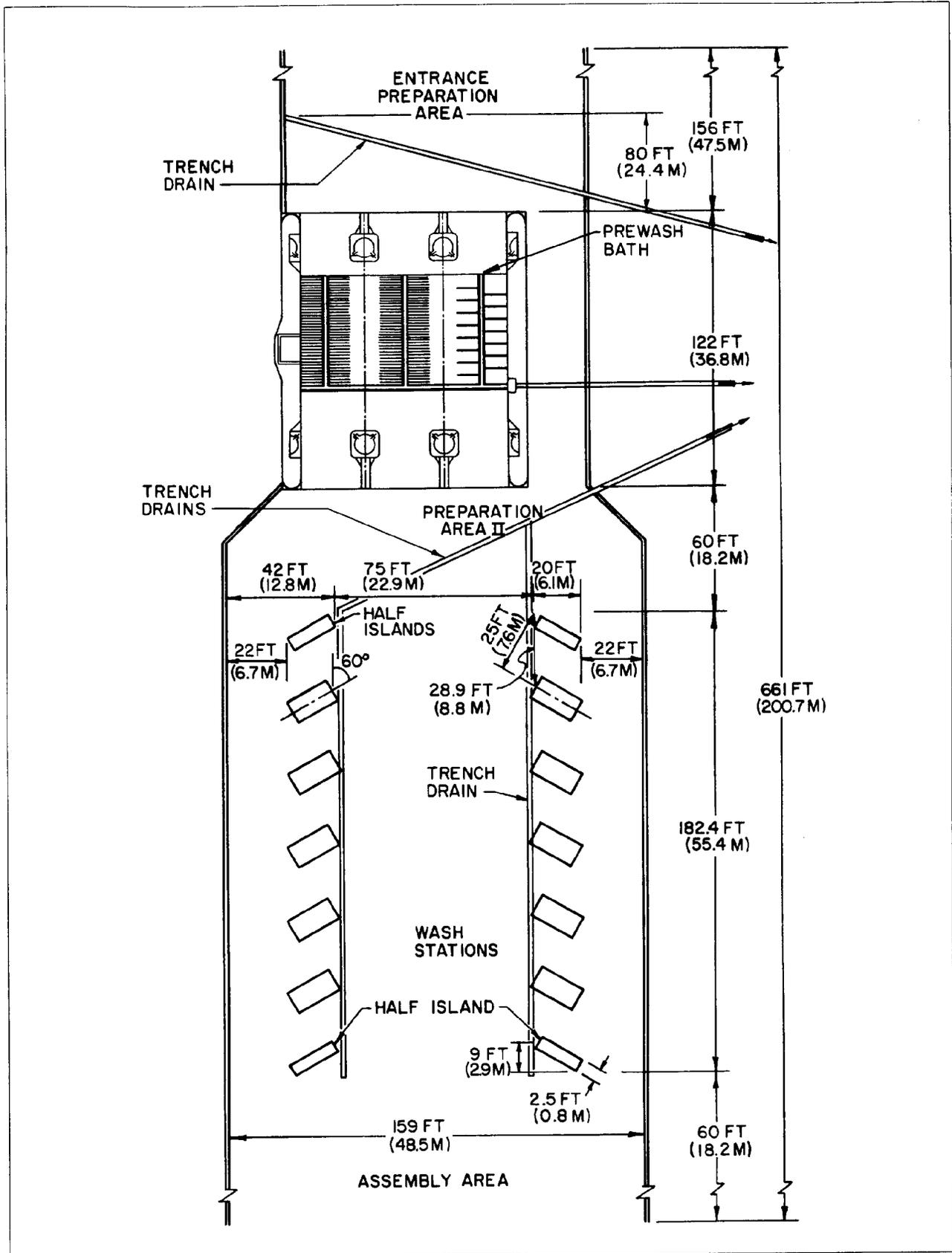*Figure A–4. Configuration A.*

Figure A–5. Configuration B.

(d) *Entrance area trench flush flow, Q_4*

Q_4 = Number of flusher points x flusher discharge

Q_4 = N_{tl} x F_{tl}

Q_4 = 1 x 75 gpm

Q_4 = 75 gpm (284 Lpm)

(e) *Bath flush flow, Q_5:*

Q_5 = Number of flush points x flusher discharge

Q_5 = N_{ud} x F_{ud}

Q_5 = 4 x 750 gpm

Q_5 = 3000 gpm (11355 Lpm)

(f) *Wash station trench flushes flow, Q_6*

Q_6 = Number of flush points x flusher discharge

Q_6 = N_{tz} x F_{tz}

Q_6 = 3 x 75 gpm

Q_6 = 225 gpm (852 Lpm)

(g) *Interior hydrant flow at wash stations, Q_7*

A total of six duplex hose bibs are placed on alternating full islands to serve the 12 wash stations.

Q_7 = Number of interior washpoints x hose discharge

Q_7 = N_{int} x F_{int}

Q_7 = 12 x 10 gpm

Q_7 = 120 gpm (454 Lpm)

(h) *Clean-up yard hydrant flow, Q_8:*

A total of six hydrants, strategically placed, are required to hose down the paved areas.

Q_8 = Number of hydrant hose connections x hydrant discharge

Q_8 = N_y x F_y

Q_8 = 6 x 30 gpm

Q_8 = 180 gpm (681 Lpm)

(i) *Storm runoff from paved wash facility, Q_9:*

Use Rational Formula with runoff coefficient, C, of *0.95* and a rainfall intensity for a 1-hr., 1.-yr storm of 2.0 inches. Then,

Q_9 = C x I x Length x width / 43560 gfpa

Q_9 = 0.95 x 2.0 x 580 ft. x 160 ft. 43560 gfpa

Q_9 = 4.05 cfs or 1818 gpm (6881 Lpm)

CROSS SECTION AREA: $\frac{1}{2}$(24.5 FT + 38.5 FT)(3.5 FT) + 3.5 FT x 50 FT = 285 FT^2 (27.1 M^2)

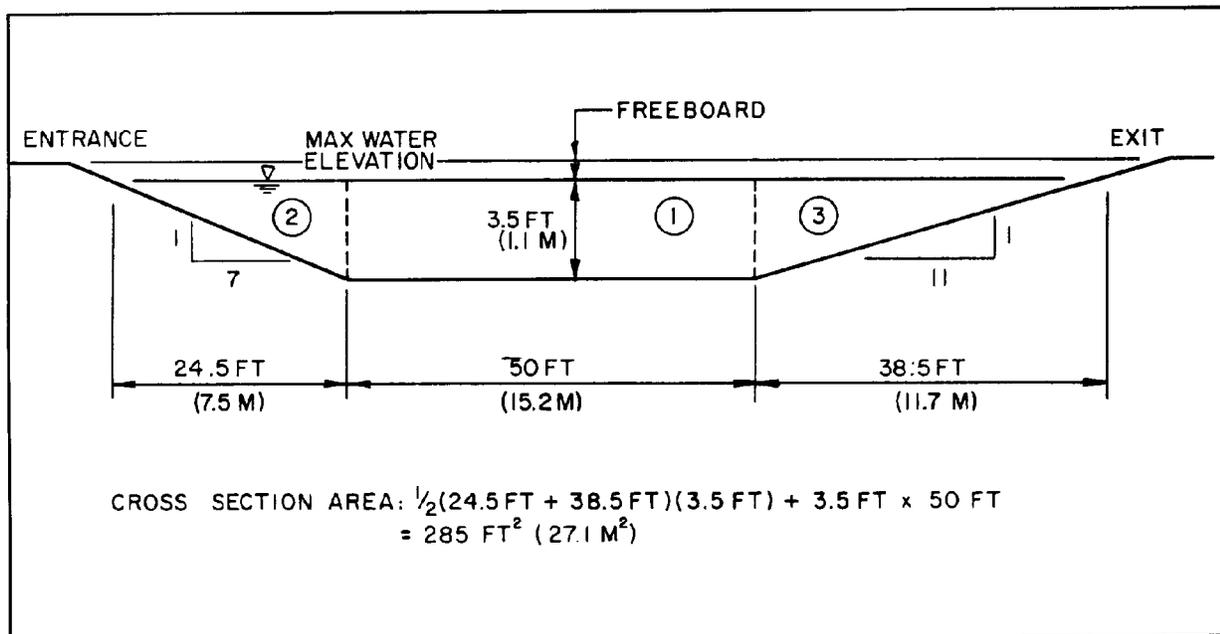*Figure A–6 Cross section of the bath.*

(j) Rainfall falling on open basins, Q_{10}

    1) Estimate surface area of dual-cell sediment basin

    L x W x 2 = 150 ft x 50 ft x 2 = 15,000 sf

    2) Estimate surface area of equalization basin

    L x W = 300 ft x 300 ft - 90,000 sf

    3) Estimate surface area of sand filters

    L x W=300 ft x 150 ft = 45,000 sf

    4) Estimate surface area of washwater supply basin

    L x W = 300 ft x 300 ft = 90,000 sf

    Then: $Q_{10} = C \times I \times A_B/143560$ sfpA

    $Q_{10} = 1.0 \times 2.0 \times 240,000$ sf/ 43560 sfpA

    $Q^{10} = 11$ cfs or 4937 gpm (18686 Lpm)

(k) A summary of computed flows is presented in Table A-3.

Overflow rate, Q_{over}:

    Using equation 6-5, calculate the sediment basin overflow rate during the washing period. The designer assumes that the entrance preparation area trench flusher, represented by Q_4, and the bath flushers, represented by Q_5, are not in operation after the bath is filled and, therefore these values are not used in the calculation. Apply the appropriate usage factor at each flow source. Then,

    $Q_{over} = U_2Q_2 + U_3Q_3 + U_6Q_6 + U_7Q_7$

    $Q_{over} = 0.90$ (960 gpm) + 0.80 (720 gpm) + 0.20 (225 gpm) + 0.30)(120 gpm)

    $Q_{over} = 1581$ gpm (5984 Lpm)

(4) *Volumes.* Using equations defined in chapter 6, the designer computes the various component volumes for the following selected average daily conditions:

Clean-up period, K   60 min

Daily wash period, T_w 180 min

Total Wash and clean -up T^2 240 min

Storm Duration, T_s 60 min

(a) Earth volume drained, V_1. Assume only one bath fill/flush per wash period.

Then, V_1 = Bath volume x Number of fills

V_1 = 90 ft x 285 sf x 7.48 gpcf x l fill

V_1 = 191862 gal (726198L)

(b) Bath overflow volume, V_2:

    V_2 = Bath weir overflow rate x (wash period + clean up)

    $V_2 = Q_2 \times T_w = 960$ gpm x 240 min

    $V_2 = 230400$ gal (872064L)

(c) Wash station volume, V_3:

    V_3 = Wash station flow rate x wash period

    $V_3 = Q_3 \times T_w = 720$ gpm x 180 min

    $V_3 = 129600$ gal (490536L)

(d) Entrance trench flusher volume, V_4:

    V_4 = trench flush flow rate x cleanup period

    $V_4 = Q_4 \times K = 75$ gpm x 60 min

    $V_4 = 4500$ gal (17032L)

(e) Bath flusher volume,

    V_5 = bath flusher flow rate x cleanup period

    V_5 $Q_5 \times k = 3000$ gpm x 60 min

    $V_5 = 180000$ gal (681300L)

(f) Wash station trench flusher volume, V_6:

    V_6 = trench flusher flow rate x (wash period + clean-up)

    $V_6 = Q_6 \times T_t = 225$ gpm x 240 min

    $V_6 = 54000$ gal (204390 L)

(g) Interior wash water volume, V_7:

    V_7 = Interior wash flow rate x wash period

    $V_7 = Q_7 \times T = 12$ gpm x 180 min

    $V_7 = 21600$ gal (81756L)

(h) Clean-up yard hydrant volume, V_8:

    V_8 = yard hydrant flow rate x cleanup period

$V_8 = Q_8$ x K = l80 gpm x 60 min

V_8 = 10800 gal (40878L)

(i) *Pavement runoff volume, V_9:*

V_9 = pavement runoff rate x storm duration

$V_9 = Q_9$ x T^5 = 1818 gpm x 60 min

V_9 = 109080 gal (412868 L)

(J) *Rainfall volume added to basins, V_{10}:*

V_{10}= Rainfall rate x storm duration

$V_{10} = Q_{10}$ x T_S = 4937 gpm x 60 min

V_{10}= 296220 gal (1121193 L)

(k) *Summary of average daily volume.* Table A-4 summarizes the computed average daily volumes for the stated design conditions at Fort Swampy.

Total average daily volume for facility V_{avg}: The designer uses equation 6-2, however, designer chooses not to include pavement runoff volume, V_9 or rainfall volume on basins, V_{10} Designer also assumes that flush water will be withdrawn from the washwater supply basin and therefore, V_1, V_5, and V_6 are included in the computation. Then,

$$V_{avg} = U_1V_1+U_2V_2+U_3V_3+U_4V_4+U_5V_5+U_6V_6+U_7V_7+U_8V_8$$

$$V_{avg} = 1.0(191862) + 0.9 (230400) + 0.8(129600) + 0.2(4500) + 0.2(180000) + 0.2(54000) + 0.8(21600) + 0.2(10800)$$

$$V_{avg} = 570042 \text{ gal } (2157609 \text{ L})$$

(5) *Calculate maximum volume for the peak use period, V_{max}:* The designer computes the various component maximum volumes for the following selected peak use conditions:

Clean-up period, K   60 min (1 hr)
Peak use period. T_w 3240 min (55 hr)
Total wash and clean-up, T_t 3300 min (56 hr)
Storm duration, T_s 60 min (1 hr)

The designer assumes that one bath fill, B, will be withdrawn from the equalization basin.

(a) *Maximum bath volume drained, V_1:*

V_1 = V_B x Number of fills

V^1 =   191862 gal x 1

V_1 =   191862 gal (726198 L)

(b) *Maximum bath overflow volume, V_2:*

V_2 =   bath overflow rate x (total wash period plus clean-up)

V_2 = Q_2 x T_2 = 960 gpm x 3300 min

V_2 =   3168000 gal (11990880 L)

(c) *Maximum volume from washstations, V_3:*

V_3 =   washstation flow rate x peak wash period

V_3 = Q_3 x T_w = 720 gpm x 3240 min

V_3 =   2332800 gal (8829648 L)

(d) *Maximum volume from entrance trench flusher, V_4:*

V_4 =   entrance trench flusher flow rate x clean-up period

V_4 = Q_4 x K = 75 gpm x 60 min x 3 cleanups

V_4 =   13500 gal (51,098 L)

(e) *Maximum volume from bath flushing, V_5:*

V_3 =   bath flusher flow rate x cleanup period

V_5 = Q_5 x K = 3000 gpm x 60 min

V_5 =   l80000 gal (681300 L)

(f) *Maximum volume from wash station flushing. V6:*

V_6 =   flusher flow rate x (wash plus cleanup + two additional clean-up periods)

V_6 = Q_6 x (T_1 + 2K)

V_6 =   225 gpm (3300 min + 2 x 60 min)

V_6 =   769500 gal (2912558 L)

(g) *Maximum interior wash water volume, V_7:*

V_7 =   Interior wash flow rate x wash period

V_7 = Q_7 x T w = 120 gpm x 3240 min

V_7 =   388880 gal (1471608 L)

(h) *Maximum volume from yard hydrants, V_8:*

Table A—3. Summary of CVWF flow rates.

Parameter	Discharge Points		Unit Flow Rate		Total Flow (Q)	
			gpm	Lpm	gpm	Lpm
Q_1 Bath		outflow	6395	24207	6395	24207
Q_2 Water cannons	12	cannons	80	303	960	3634
Q_3 Wash stations	24	home.	30	114	720	2725
Q_4 Prep flushers	1	flusher	75	284	75	284
Q_5 Bath flushers	4	flushers	75	2840	3000	11355
Q_6 Trench flushers	3	flushers	75	284	225	852
Q_7 Interior wash	12	hoses	10	38	120	454
Q_8 Yard hydrants	6	nozzle.	30	114	180	681
Q_9 Rainfall pavement	2.13	acres	1818	6881	1818	6881
Q_{10} Rainfall basins	5.51	acres	4937	18686	4937	18686

Table A—4. Summary of average daily volume.

Parameter	Discharge Points	Total Flow Rate		Operating time, min	Volume (V)	
		gpm	1pm		gal	L
V_1 Bath	outflow	6395	24207	30	191862	726198
V_2 Water cannons	12 cannons	960	3634	240	230400	872064
V_3 Wash stations	24 hoses	30	2725	180	129600	490536
V_4 Prep flushers	1 flusher	75	284	60	4500	17032
V_5 Bath flushers	4 flushers	3000	11355	60	180000	681300
V_6 Trench flushers	3 flushers	225	852	240	54000	204390
V_7 Interior wash	12 hoses	120	454	180	21600	81756
V_8 Yard hydrants	6 nozzles	180	681	60	10800	40878
V_9 Rainfall pavement	2.13 acres	1818	6881	60	109080	412868
V_{10} Rainfall basins	5.51 acres	4937	18686	60	296220	1121193

V_8 = yard hydrant flow rate x clean-up period x number clean-ups

V^8 = Q_6 x K x 3=10800 gal x 60 min x 3

V_8 = 32400 gal (122634 L)

(i) Maximum pavement runoff volume, V_9:

V_9 = pavement runoff rate x storm duration

V_9 = Q_9 x T_S = 1818 gpm x 60 min

V_9 = 109080 gal (412868 L)

(j) Maximum rainfall volume on basins, V_{10}:

V_{10} = rainfall rate x storm duration

V_{10} = Q_{10} x T_S = 4937 gpm x 60 min

V_{10} = 296220 gal (1121193 L)

(k) Summary of maximum volumes. Table A-5 summarizes the computed maximum volumes for the stated conditions at Fort Swampy.

Calculate maximum wash volume for facility, V:

V_{max} = $U_1V_1+U_2V_2+U_3V_3+U_4V_4+$ $U_5V_5+U_6V_6+U_7V_7+U_8V_8$

V_{max} = $1.0(19186^2$ gal$) + 0.9$ $(3168000$gal$) + 0.8(2332800$ gal$) + 0.2(13500$ gal$) +$ $0.2(180000$ gal$) +0.2(769500$ gal$) +0.8(388800$ gal$) +$ $0.2(32400$ gal$)$

V_{max} = 54319422 gal (20512512L) or

V_{max} = 724,522 cf (20287 CM)

(6) *Sediment basin design.* The effective water depth of the basin will be 8 feet (2.4 meters) and free board is 2 feet (0.6 meters). The sediment depth will be determined by calculations. Settling tests performed on soils found in the training areas showed that 82 percent of the suspended solids will settle in less than 2 hours (120 minutes). This can be checked theoretically by using Stoke's Law and the nondispersed soil particle gradation test results, after the basin size has been determined.

(a) *Operation.* A dual-celled sediment basin is required. One cell will be used to settle solids during continuous washing and the adjacent basin will detain the surge volume created when the bath is flushed. A dual-cell arrangement will also allow one cell to be closed for cleaning while the other is treating wastewater; the wastewater will not have the designed detention time, but the wash facility will be operable. The installation has indicated that the basins will be cleaned every 6 months and it will take approximately 5 days to drain and clean each cell.

(b) *Water volume.* In addition to a sediment volume, each cell in the basin must be able to hold the greater of the overflow and bath volume or the stormwater volume; therefore, the bath and the overflow volumes are compared with the stormwater volume to determine which value will control the basin site. The total volume of water required in each cell is computed:

V_w = Bath overflow volume + bath volume = Q_{over} detention time + V_B

V_w = 1581 gpmx 120 min + 202633 gal

V_w = 392353 gallons (1485056 L)

V_w = 52453 cf (1469 CM)

Calculate storm water volume:

V_{st} = paved area storm runoff

V_{st} = V_o/7.48 gpcf

V_{st} = 109080/7.48 = 14582 cf (408 CM)

Since the overflow plus the bath volume is larger than the stormwater runoff volume, the ovefflow plus bath volume is the controlling factor and each cell is sized to detain at least 52453 cf (1504 CM) of water. The designer chooses an effective water depth of 8 ft. (2.4 M), an access ramp slope of 1 on 6, a ramp width of 18 ft. and a basin length-to-width ratio of 3 to 1. Figure A-7 shows the general geometry of each cell. The dimensions of the basin are then calculated using the information given and noting that the volume occupied by the ramp must be considered:

V_{sw}= L_S x W_S x D_w - 1/2 x L_r x D_w x W_r = 52453

$3W_S$ x W_S x 8 - 1/2 x 48 x 8 x 18 = 52453

W_S = 2^{042}

W_S = 45 ft. (13. 7M)

and L_S = 135 ft (41.2M)

(c) Sediment volume. The designer estimates that the installation has average-to-heavy soiling conditions. By applying Stoke's Law, using Q_{over} with the basin size previously calculated, and checking the soil particle size information, removal of 82 percent of the soil, as determined by settling tests, is verified. Using equa-

Table A—5 Summary of Maximum Volumes

Parameter	Discharge Points	Flow Rate		Operating time, min	Volume (V)	
		gpm	1pm		gal	L
V_1 Bath	outflow	6395	24207	30	191862	726198
V_2 Water cannons	12 cannons	80	303	3300	3168000	11990880
V_3 Wash stations	24 hoses	30	114	3240	2332800	8829648
V_4 Prep flushers	1 flusher	75	284	180	13500	51098
V_5 Bath flushers	4 flushers	750	2840	60	180000	681300
V_6 Trench flushers	3 flushers	75	284	3420	769500	2912558
V_7 Interior wash	12 hoses	10	38	3240	388000	1471608
V_8 Yard hydrants	6 nozzles	30	114	180	32400	122634
V_9 Rainfall pavement	2.15 acres	1818	6881	60	109080	412868
V_{10} Rainfall basins	5.51 acres	4937	18686	60	296220	1121193

tions 6-3 and 6-4 with data from table A-2:
Sediment Volume = (Tracked vol. + Wheeled
vol.) x duration of wash season x sediment
basin trap efficiency.

Sediment volume = (2.0 cu ft x 665 washed + 0.6 cu ft x 783 washes)
          wash   month   wash   month

          x 6 months x 0.82 percent
            cleaning
          =8855 cf (248 CM)

The same equations that were used to size the cell based on
water volume are used to size the cell for the sediment volume,
except that the volume of the ramp is assumed negligible. The
width and length of the cell are known, and the depth is
calculated. Thus—

$(L_s - L_r)$ x W_x x D_s = Sediment volume
(145 ft - 48 ft) x 48 ft x D_s = 8855 cf
D_s = 1.9 ft. (0.58M)
say D_s = 2.0 ft. (0. 61M)

  (d) Total cell size. The calculated sediment
  basin dimensions are summarized in fig-
  ure A-8.

(7) Equalization basin. The volume of water in the
equalization basins is based on the greater of
V_{avg} for any assumed *5* day wash period or
V_{max}:

V_{EB} = 5xV_{avg}=5x570042 gal= 2850210 gal

(10788045 L)
V_{EB} =381044 cf (10699 CM) or;
V_{EB} =V_{max} = 724522 cf (20287 CM)

The designer uses a safety factor of 1.25 times the value of
Vmax or 905653 cf (25358CM to size the basin. The designer
selects an effective water depth of 8 ft (2.4 M), 2.0 ft (0.6 M) of
sediment storage, 2.0 ft (0.6 M) of dead storage or a total depth
of 15 ft (3.7 M). The average area at the mid point of the
equalization basin water zone is:

905653 cf/8 ft = 113207 sf (10528 SM)

The designer selects to use a square basin (fig A-9) with side
slopes of 1 to 3.5. The basin is sized by taking the square root
of the average area required to determine the average length and
width of the basin. This method gives the average basin size—
336 feet by 336 feet (102 meters by 102 meters). With the slope
of the walls at 1 to 3.5,7.0 ft (2.2 M) are added to the average
side for each foot (meter) of depth above or subtracted below
the average depth. The length of the basin at the water surface
would be 364 feet by 364 feet (110 meters by 110 meters).
With 3 feet (0.9 meters) of freeboard added, the overall top
dimension of the basin will be 385 feet by 385 feet (117 meters
by 117 meters). Subtracting 3.5 feet (1.1 meters) off of each
side for each foot (meter) below the average depth, the
dimensions of the bottom of the basin, with 2 feet (0.6 meters)
allowed for sediment storage and 2 feet (0.6 meters) allowed for
dead storage, would be 280 feet by 280 feet (86 meters by 86
meters).

(8) *Intermittent sand filters*. The installation has indicated that the facility need not be fully operational for 7 days after a major washing operation that takes about 2 days (54 hours). The designer chooses two filters, which will allow one filter to operate while the other one is allowed to rest. A loading rate of 8 inches (20.3 centimeters) per filter dose will be used. The filter dose frequency is every 8 hours. The designer calculates the area required for the sand filters:

$$\text{Filter Area} = A_F = V_{max}/\text{Dosing Rate}$$

$$A_F = \frac{724522 \text{ cf}}{(2 \text{ days} + 7 \text{ days}) \, 650000 \text{ gal}} \times \frac{\text{acre/day}}{} \times \frac{7.48 \text{ gpcf}}{\text{cu ft}}$$

$$A_F = 0.93 \text{ acres or } 19040 \text{ sf } (1770 \text{ SM})$$

Thus, each filter should be 0.47 acres or 20473 sf(1904 SM).

(9) *Dosing base*. The designer has performed an economic study which showed that a dosing basin would be cost-effective when compared with installing larger pumps. Water can flow by gravity to the sand filter. Small pumps can take water from the equalization basin to the dosing basin. With a dosing basin, the de-- signer is able to use smaller pumps for charging the dosing basin over a long period of time. The basin is sized to hold the volume of water to charge one filter. The volume is calculated as follows:

$$\text{Volume} = 20473 \text{ sf} \times \frac{8 \text{ inches}}{12 \text{ inches}} \times \frac{\text{foot}}{\text{charge}} \times \frac{7.48 \text{ gal}}{\text{cu ft}} \text{ gpcf}$$

$$= 102093 \text{ gal } (386422 \text{ L})$$

(10) *Water supply basin*. Design criteria call for the size of the water supply basin to be the larger of V_{max} (724522 cf or 20287 CM); or V_{ave} for a S day wash period.

$$V_{ws} = 5 \times V_{ave} = 5 \times 570042 \text{ gal} = 2850210 \text{ gal } (10788045 \text{L}) \text{ or}$$
$$381044 \text{ cf } (10669 \text{M})$$

Since V_{max} is larger than five times V_{ave}, the designer uses a safety factor of 1.25 times V_{max} to size the water supply basin or 905653 cf (25358 CM). Because of the large water volume required, the designer chooses an effective depth of 10 feet (3.0 meters) with 2.0 feet (0.6 meters) of dead storage for a total

depth of 12 feet (3.7 meters). The water surface area can then be calculated as follows:

$$A_{ws} = 905653 \text{ cf}/10 \text{ ft} = 90565 \text{ sf}$$

Using the method described for sizing the equalization basin and assuming a square basin gives the average basin size at the midpoint of water depth is 301 feet by 301 feet (92 meters by 92 meters). With the side slopes of I to 3.5, the dimensions of the basin at the top of the water level would be 336 feet by 336 feet (102.4 meters by 102.4 meters). With the 3 feet (0.9 meters) of freeboard added, the overall top dimension of the basin will be 357 feet by 357 feet (109 meters by 109 meters). The bottom of the basin would be 252 feet by 252 feet (77 meters by 77 meters).

(11) *Makeup water*. An economic analysis has revealed that, if wells are drilled as the primary source of makeup water for the CVWF, the return on investment will be 37 years. Since the design life of the facility is only 20 to 25 years; the installation chooses to use the existing potable water supply as a source of makeup water since the supply is dependable. The existing 10-in (25.4-cm) water line running adjacent to Range Road can be tapped. Makeup water will be added to the water supply basin at night when demand on the potable water supply is lowest.

(12) *Emergency discharge*. The closest sanitary sewer connection is approximately 0.75 mi (1.2 km). The designer decides to provide a sewer from the water supply basin to the existing sanitary sewer line to handle emergency overflows. This will prevent overflows from otherwise being discharged to the environment.

(13) *Checking calculations*. Figure A-l 1 shows the expected water volume in the equalization basin at any given time during the washing activities. This graph confirms that at no time during a major wash will the equalization basin volume of 5.5 mg be exceeded during the peak water usage period. The projected volume for the water supply basin is also plotted (fig A-12). This graph shows that 5.5 Mg is sufficient to ensure that an adequate supply of wash water is available at all times.

(a)

(b)
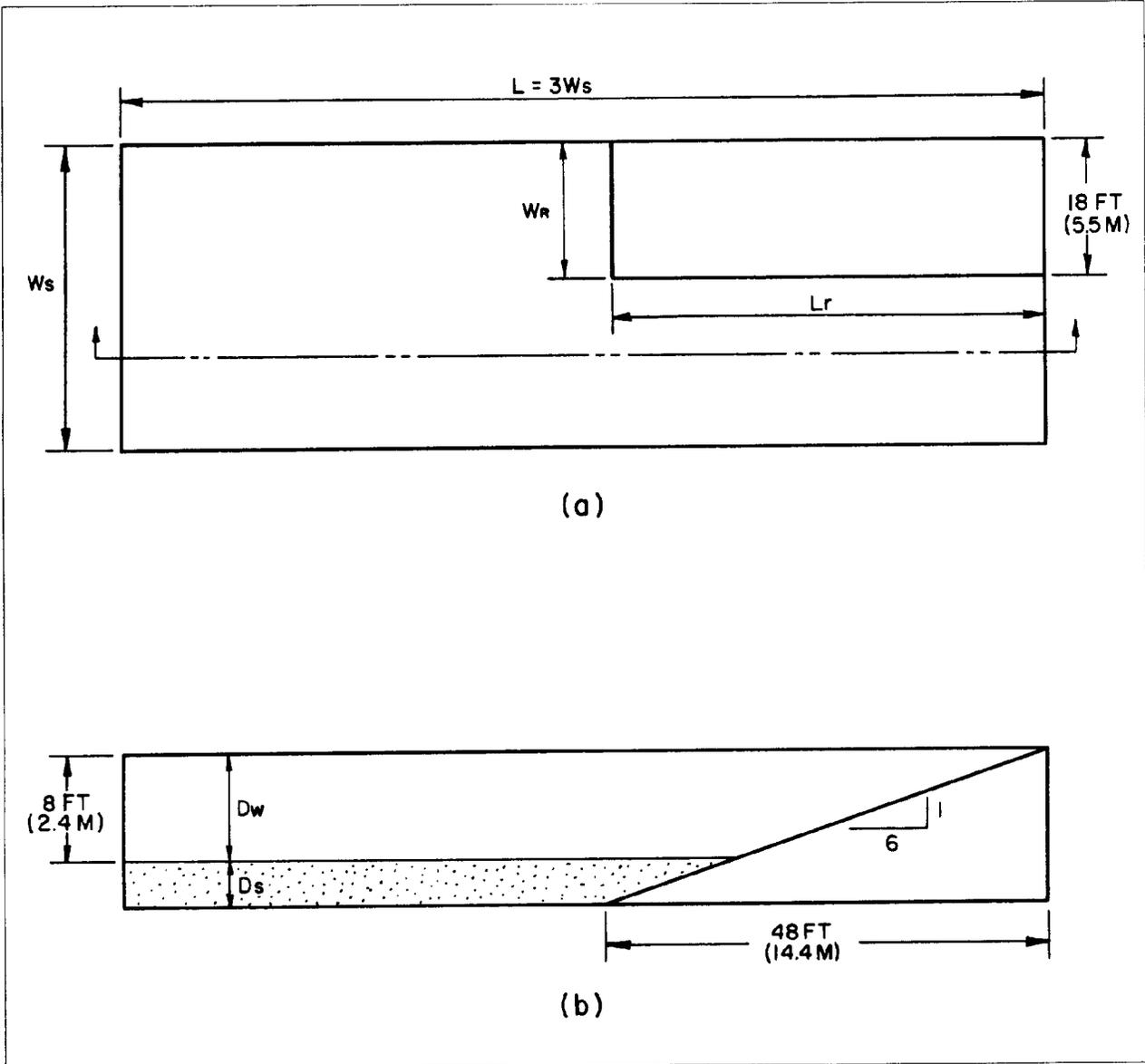
Figure A–7. Water volume configuration: (a) plan view and (b) cross section.
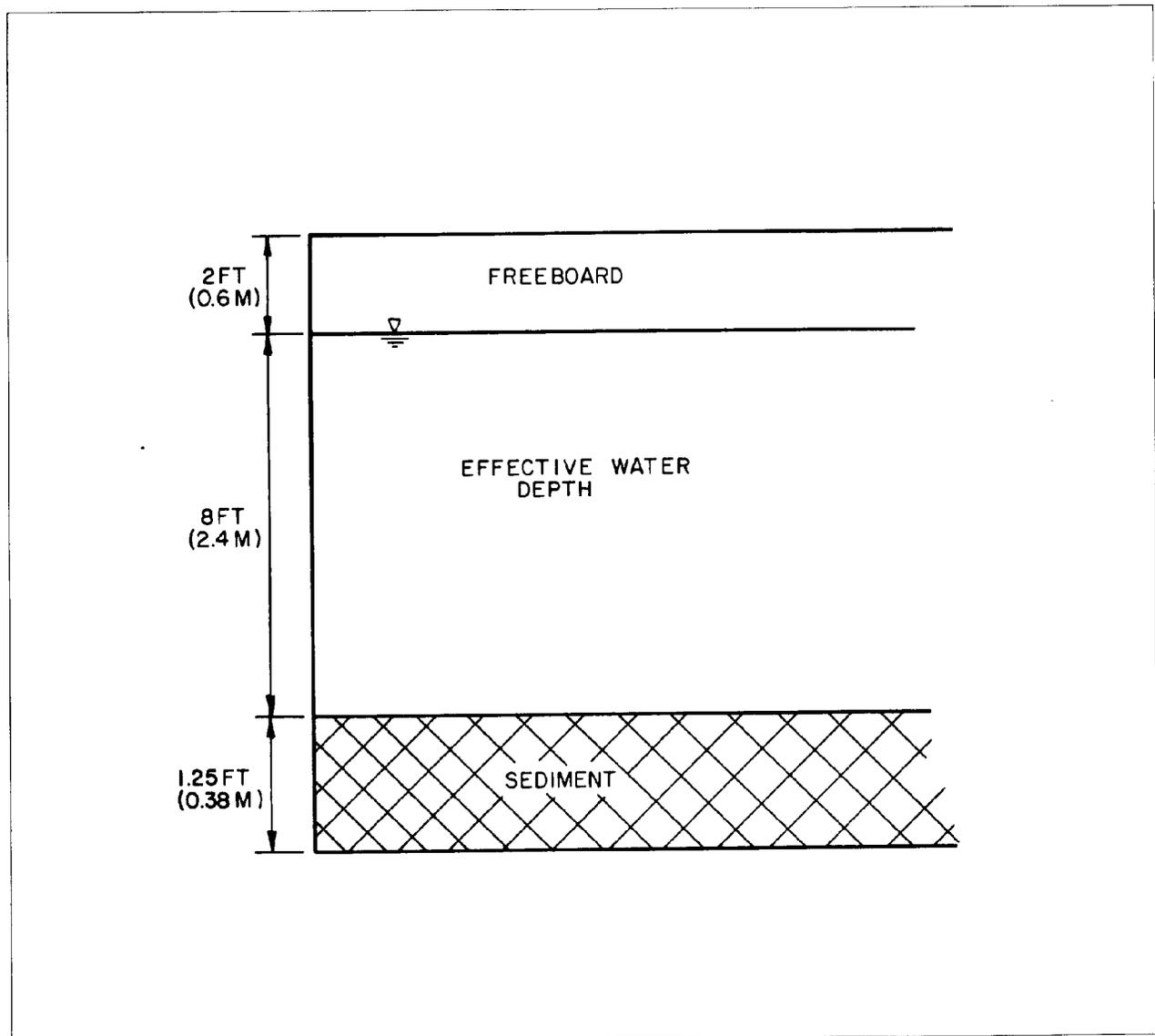
Figure A–8. Overall cell configuration.

(a)

FREEBOARD

TOP OF BASIN

3FT
(0.9M)

MAXIMUM
WATER LEVEL

8FT
(2.4M)

AVERAGE
WATER LEVEL

DEAD
STORAGE

TOP OF
D. STORAGE

2FT
(0.6M)

TOP OF SEDIMENT

2FT
(0.6M)

BOTTOM OF
BASIN

280FT
(85.3M)

10.5FT
(3.2M)

14FT
(4.3M)

7FT
(2.1M)

SEDIMENT
STORAGE

7FT
(2.1M)

14FT
(4.3M)

10.5FT
(3.2M)

(b)

Figure A–9. Equalization basin: (a) plan view and (b) cross section.

(a)

FREEBOARD

3 FT (0.9 M)

10 FT (3.0 M)

2 FT (0.6 M)

DEAD STORAGE

252 FT (76.8 M)

TOP OF BASIN

MAXIMUM WATER LEVEL

AVERAGE WATER LEVEL

TOP OF DEAD STORAGE

BOTTOM OF BASIN

7 FT

(b)

7 FT (2.1 M)

10.5 FT (3.2 M)

17.5 FT (2.1 M) (5.3 M)

17.5 FT (5.3 M)

10.5 FT (3.2 M)

Figure A–10. Water supply basin: (a) plan view and (b) cross section.

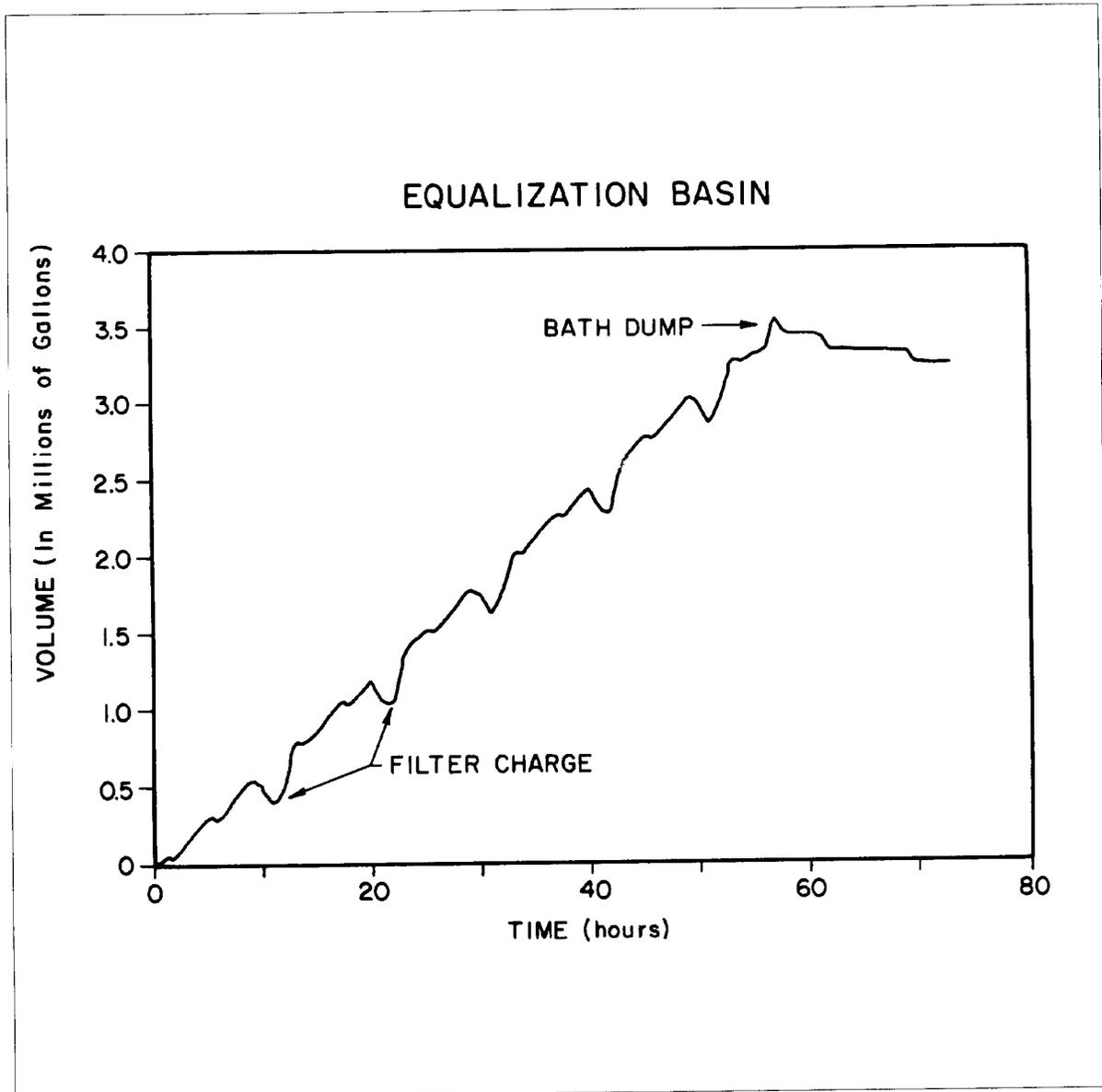## EQUALIZATION BASIN

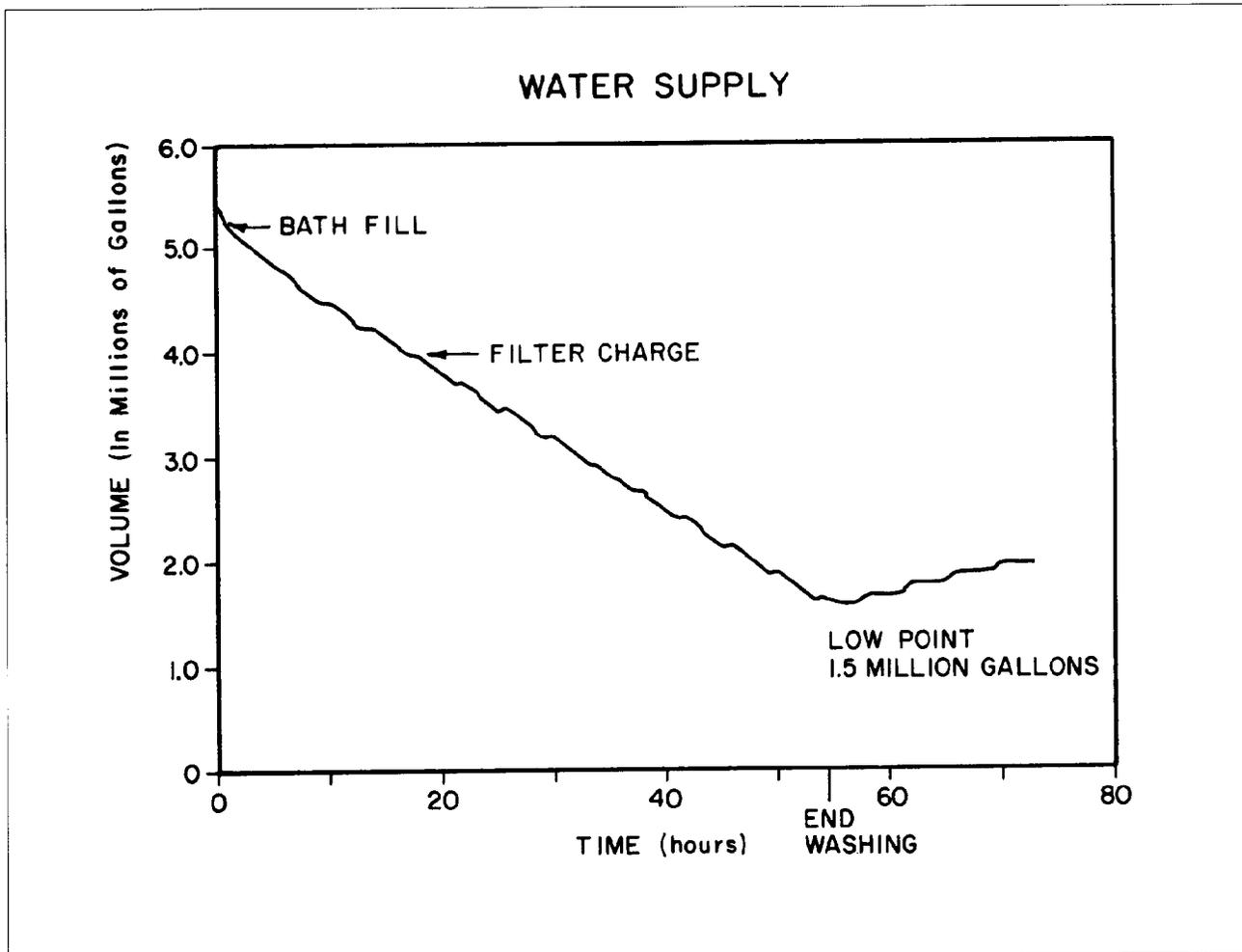*Figure A–11. Equalization basin water balance—water volume versus time.*

WATER SUPPLY

Figure A-12. Water supply basin capacity.

GLOSSARY

SECTION I. ABBREVIATIONS

A — surface area as used to determine storm drainage flow.

B — number of times a bath is filled from the water supply basin per wash period.

BOD — biochemical oxygen demand.

C — runoff coefficient used in determining storm drainage flow.

CVWF — Central vehicle wash facility.

D — drain time for the bath(s) at a CVWF.

EPA — Environmental Protection Agency.

F_c — climatic factor.

$F_{(i)}$ — flow rate location.

gpm — gallons per minute.

i — demand location.

I — rainfall intensity of design storm (10-year, 1-hour storm).

K — cleanup time.

Lpm — liters per minute.

mgL — milligrams per liter.

mgd — million gallons per day.

Nint — number of interior wash nozzles.

NPDES — National Pollutant Discharge Elimination System.

N_{wc} — number of nozzles used in a prewash.

N_{st} — number of nozzles in a wash station.

N_{t1} — number of flusher nozzles used in trenches in the vehicle preparation area.

N_{t2} — number of flusher nozzles in trenches in the wash stations.

N_{ud} — number of flusher nozzles in u-drains in the prewash.

N_y — number of yard hydrants.

pH — hydrogen ion concentration.

Q — volume per unit time of flow.

Q_1 — V_B/D (flow rate from bath drainage).

Q_2 — $N_{wc}F_{wc}$ (flow rate from nozzles in prewash).

Q_3 — $N_{st}F_{st}$ (flow rate from nozzles at wash stations).

Q_4 — $N_{t1}F_{t1}$ (flow rate from flusher nozzles in preparation area).

Q_5 — $N_{ud}F_5$ rate from flusher nozzles in prewash).

Q_6 — $N_{t2}F_{t2}$ (flow rate from flusher nozzles in wash stations).

Q_7 — $N_{int}F_{int}$ (flow rate from nozzles at interior wash stations).

Q_8 — N_yF_y (flow rate from nozzles at yard hydrants).

Q_9 — $C_pI\ A_p$ (stormwater flow rate from the Rational Method on paved area).

Q_{10} — $C_bI\ A_b$ (stormwater flow rate from Rational Method on basins).

Q_{over} — overflow rate; average rate of wash water flow into a sediment basin.

S_i — soiling index.

S_t — soil type number.

SS — suspended solids.

TDS — total dissolved solids.

TMP — transportation motor pool.

Ts — length of design storm.

T_t — wash period + cleanup (T_w + K).

T_w — wash period.

U_f — usage factor.

V_1 — V_B (volume treated from bath prewash).

V_2 — Q_2T_t (volume treated from nozzles in prewash).

V_3 — Q_3T_t (volume treated from nozzles at wash stations).

V_4 — Q_4K (volume treated from preparation area trench flushers).

V_5 — Q_5K (volume treated from bath prewash trench flushers).

V_6 — Q_7T_w (volume treated from washstation area trench flushers).

V_7 — Q_7T_w (volume treated from interior wash stations).

V_8 — Q_8K (volume treated from yard hydrants).

V_9 — Q_9T_8 (volume treated from stormwater).

V_{avg} — average volume.

V_B — volume of tracked bath, plus the volume of dual-purpose bath.

V_{max} — maximum volume.

V_{sed} — sediment volume per year divided by number of cleanings per year.

SECTION II. TERMS

Assembly area
Paved space located after the wash stations to allow replacement of interior items, drying, assembly of vehicles into units, and final inspection prior to exiting the CVWF.

Bentonite
Clay with a high content of the mineral montmorillonite group. Characterized by high adsorption and very high volume changes with wetting and drying.

Biological treatment
Process in which bacteria and other microrganisms use waste constituents as a food source; results in the breakdown of complex organic materials into simple, more stable sub-stances.

Bypass lane
Driving lane reserved for vehicles in the CVWF to go past the prewash basin and/or the wash stations to expedite forward movement.

Cantonment
Developed portion (city-like area) of a permanent military installation.

Central vehicle wash facility
Structure designed specifically to clean large numbers of tactical or transportation motor pool vehicles.

Chemical oxygen demand
Standard laboratory procedure for measuring the oxygen required for oxidation of carbonaceous (organic) material in wastewater.

Cleanup time
Period required to clean a CVWF, including drainage and cleaning of the prewash bath.

Cohesive soil
Fine-grained soil that sticks together, such as a clay or silt.

Collection system
Network of underground conduits and appurtenances that receives and conveys wastewater.

Colloids
Microscopic suspended particles that do not settle in a standing liquid and can be removed only by coagulation or biological action.

Control building
Structure at a CVWF that provides the operator a central location to observe the washing operations and regulate pumps, valves, and other equipment.

Detention time
Theoretical period that it takes a particle of matter to flow through a tank or basin.

Dissolved solid
Solid material remaining in a wastewater after filtering; determined by specific tests.

Dosing tank
Receptacle that automatically and hydraulically empties itself each time it is filled to capacity.

Drainage area
Rainfall catchment area common to a single runoff point.

Drainage structure
Construction used to collect and/or divert surface waters to a collection system; includes inlets, trench drains, catch basins, and manholes.

Dual-purpose lab
Area of a prewash facility that serves both wheeled and tracked vehicles.

Effective depth
Usable depth of sediment basin and/or lagoon for treatment or settling purposes, after deducting the depth reserved for storage of solids and freeboard allowance.

Effluent
Liquid flowing out of a reservoir, basin, tank, or other container.

Energy dissipator
Structure used to dampen erosion potential of a flowing body of water by reducing its forward velocity.

Equalization basin
Receptacle used to dampen variations in the flow of water.

Evaporation rate
Rate at which water becomes a vapor and is lost from a body of water.

Filter charge
Total volume of water necessary to flood the surface of a filter to a specific depth.

Filter medium
Granular material (sand and/or gravel) in a filter through which water passes.

Filtration
Unit operation in which solid or colloidal material is separated from a liquid by movement through a granular or porous material such as sand.

Flexor
Device installed in the bottom of a water bath at a prewash facility for causing the wheels or tracks of a vehicle to move up and down (flex) to assist in removing dirt from the vehicle.

Flushers
Devices such as water sprays that increase water flow and velocity to prevent solids deposition or to remove deposited solids in a pipe, channel, or other conduit.

Freeboard
Distance in elevation from the maximum water surface of a tank or basin to the top of its walls or overflow.

Grade
Inclination or slope of a surface in terms of a ratio or percentage of vertical rise to horizontal distance.

Grease
General term used to describe the lubricants applied to tactical and TMP vehicles.

Hardstand
Impervious surface, either bituminous or concrete, used as a pavement for pedestrian and/or vehicular traffic.

Hydraulic loading
Volume of a liquid per unit time applied to a given system or treatment process.

Hydrogen ion concentration (ph)
Measure of the number of hydrogen ions in a solution indicting acidity/alkalinity.

Impervious
Term used to describe the condition in which water or some other fluid cannot easily pass through a material such as soil.

Inflow
Water or wastewater entering a basin, pond, channel, or other storage or collection facility.

Influent
Liquid flowing into a container, basin, or tank.

Interior wash
Low-pressure, low-flow volume of water used to clean the interior of tactical vehicles, such as truck beds and cab areas.

Intermittent sand filter
Filter system with a granular medium (sand and/or gravel) which is flooded at given time intervals with a water or wastewater for treatment.

Lagoon
Pond-like body of water used to treat industrial, commercial, and sanitary wastewaters.

Loading
Rate at which a filter charge is applied to a filter.

Makeup water
Water added to a system or process to compensate for the amound of water lost due to leakage, percolation, evaporation, release, overflows, usage, or similar action.

Manhole
Structure, usually located at the junction of two or more underground pipes, that-allows access to pipes for inspection and maintenance.

Oil skimmer
Device used for removing oil and grease from a water surface.

Percolation
Downward movement of a liquid through a soil.

Permeability
Term describing the ability of water to move through a soil when the soil is saturated.

Pond
Engineered impoundment containing raw or partially treated wastewater in which aerobic and/or anaerovic stabilization occurs (also see lagoon).

Porosity
Ratio, usually expressed as a percentage, or the volume of voids in a given soil mass to the total volume of the soil mass.

Potable water
Water supply that is safe for human consumption.

Preparation area
Paved area for troops to remove trash from vehicle interiors, plug drain holes, open bilge pump discharge lines, and other tasks prior to the prewash or wash facilities.

Primary treatment
The first phase in treating wastewater in which all debris and settleable solids, along with floating materials (e.g., oil and grease) are removed.

Roller-compacted concrete
A stiff concrete, low in water content which is placed with a paver-compactor and then rolled.

Sanitary plant
Wastewater treatment plant designed to process a municipal waste (sanitary, commercial, or industrial).

Secondary treatment
Second phase in wastewater treatment in which the major portion of the suspended solids and a portion of dissolved solids are removed by physical and/or biological means.

Sediment basin
Receptacle immediately downstream of the wash stations and prewash, if provided, designed to settle and contain solids from a CVWFs wastewater.

Settling test
Assay to determine the rate at which a particular material settles from a quiescent water.

Staff gauge
Device for measuring water depth in a basin, pond, or lagoon.

Stop
Device used to limit the movement of a piece of equipment.

Surface water
Water found on the surface of the ground due to rainfall or snow melt; includes incidental water (e.g., that dripping from vehicles).

Suspended solids
Weight unit of measurement of the nonsettling particles or solids in a dispersed state in the wastewater.

Total dissolved solids
Weight unit of measurement indicating the sum of all dissolved solids (volatile and nonvolatile) in a water or wastewater.

Transportation motor pool
Facility that provides and maintains commercial vehicles for daily use at an installation (cars, buses, trucks, etc.).

Turbidity
Measure of water clarity.

Usage factor
Estimated percentage of time that the maximum water usuage condition will exist at a CVWF.

Valve box
A premanufactured structure made of concrete, steel, plastic, or fiberglass, which is placed around an underground valve.

Wash period
Time during which vehicles are washing at a CVWF.

Wash station
Area of a CVWF where high-pressure, high-flow volumes of water are supplied to hoses for cleaning vehicles.

Wastewater treatment plant
Facility designed to process sanitary, commercial, and/or industrial wastewater.

Water cannon
Device used to direct a large volume of water, at high pressure, toward an object.

Water supply basin
Receptacle at a CVWF that holds treated water for reuse at prewash and wash stations.

Weir
Usally a flat piece of metal with a characteristic shape (rectangular, V-notched, etc.) which is inserted into flowing Water for determining the flow rate.

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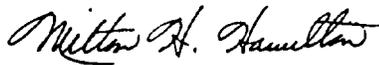
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