DRAINAGE HANDBOOK

for surface mining

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF RECLAMATION

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For

SURFACE MINING

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Prepared by: DIVISION OF PLANNING AND DEVELOPMENT
DEPARTMENT OF NATURAL RESOURCES
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INDEX

PRE–PLANNING

Extensive pre-planning is necessary if the conservation of soil and water resources in surface mined areas is to be effectively undertaken. Pre-planning must be done prior to the beginning of surface mining operations with the aim to eliminate or reduce some of the foreseeable problems associated with the specific area to be mined. The problems associated with surface mining are many and varied; however, the primary aim of pre-planning should be to arrive at a satisfactory method of site drainage. Reducing sedimentation loads and preventing acid water discharge are two very important items to consider when working on a comprehensive drainage plan.

Other problems inherent in surface mining that must be considered during the planning stage are land stabilization, geology, and water disposal. Consideration should be given to total environmental effects on air, wildlife, fish, plants, and esthetics with a desire for improved land use upon completion of mining. Possible detrimental effects of surface mining can be controlled within reasonable time limits if careful pre-planning coupled with good mining practices and effective reclamation work is carried out.

In the following articles some of the major problems and their possible solutions are discussed. Each should be considered during the pre-planning phase.

Sediment Control

Sediment is one of the greatest polluters of water and causes more off-site damages and problems than any other aspect of surface mining.

A number of factors influence erosion and sedimentation rates, among these are (1) type of soil and cover, (2) erodibility of the soil, (3) degree of slope, (4) length of slope, (5) amount and rate of rainfall, (6) climate, (7) distance from source, and (8) degree of filtering between source and sampling point.

Short duration high intensity rains are responsible for much of the erosion. Cover is a very important factor. Well vegetated areas are seldom serious sediment producing sources. Cover is effective in absorbing the energy of rainfall and holding it long enough to infiltrate.

Steepness affects the potential that runoff has to transport sediment and the stability of the particles subject to erosion. The longer the slope, the more likely that runoff will develop rills and gullies thereby greatly increasing the erosion potential.

The physical properties of soil influence erodibility. Some of these properties are: texture, percentage of coarse fragments, - especially on the surface-soil structure, mineralogy, amount and type of clay, organic content, and depth of soil. Coarse sands and stoney soils are generally least erosive and shallow fine grained cohesionless soils over impermeable bedrock are most erosive.

The sediment storage value of 0.125 acre-feet per acre of disturbed area is based on studies by the U. S. Forest Service and the Soil Conservation Service. As sediment ponds are installed and monitored, more knowledge will be gained to provide a better basis for storage values. It is imperative that provisions for cleanout and maintenance of all sediment ponds be provided.

There are various methods that may be used to eliminate sediment problems provided they are skillfully planned and applied:

1. Sediment dams or excavated sediment ponds shall be installed and maintained to remove sediment from streams and drainageways leaving the disturbed area.
2. The smallest practical area of land should be exposed at any one time during the mining phase. This means progressive backfilling and reclamation. Exposure should be kept to the shortest practical period of time.
3. Final dressing and grading shall be done pregressively and temporary vegetation and/or mulching shall be done where permanent vegetation is delayed.
4. Spoil material shall in all cases be kept out of the stream channel. Stream relocation should be avoided if at all possible.
5. Adequate water-tight conduits or bridges shall be used where haulage roads must cross natural drainways. Again, care shall be taken to insure that spoil does not get into the stream where such structures are built. Road banks shall be mulched or seeded as soon as final grading is complete.
6. Diversions may be installed above the highwall to divert upland runoff around the disturbed area to a suitable crossing of the disturbed areas.
7. Rock lined flumes or other suitable structures shall be provided where necessary to convey concentrated flows down steep slopes.
8. Toe berms or other acceptable filter devices shall be constructed near the toe of spoil banks to slow down sheet flow and trap sediment before leaving the site. Vigorous vegetation shall be maintained on the berm.
9. Stone check dams and/or log and pole structures may be used to assist in sediment control. However, they will not be considered as substitutes for sediment dams and excavated sediment ponds.

The attached standard for sediment dams shall be used only for dams with drainage areas of 200 acres or less. Design assistance is available from the U. S. Department of Agriculture, Soil Conservation Service for dams exceeding this limitation.

After construction, each sediment dam must be certified as conforming to the design and construction drawings prior to the disturbance of any land located within the drainage area of subject structure. U. S. Department of Agriculture, Soil Conservation Service Technicans, working through the Soil Conservation Districts, will assist the Department of Natural Resources personnel in certification of sediment dams.

Acid Water

The formation of acid water accompanys practically every surface mining operation to some extent due mainly to the stratas of pyrite that are frequently encountered overlying the coal seam. The keys to acid formation are: pyrite or other acid-forming compounds, a continuous supply of oxygen, and flowing water to pick up and carry out the acid. Remove one of the keys, oxygen for example, and acid generation normally is halted.

Control methods for the abatement of acid water shall be as follows:

1. Intercept ground water that may flow into the pit by constructing diversion ditches above the highwall.
2. When acid producing materials are encountered in overburden, these materials should be handled so as to prevent or minimize the production of acid mine drainage.
3. Water treatment impoundments can be constructed to trap acid water. Treatment may include chemical processes for the nuetralization of the acid such as limestone spreaders, limestone drums, et cetera.

Land Stabilization

Land stabilization as used here means long term stability of soil and rock masses against slides, slips, and mud flows. It is only through a long period of time, including a full cycle of wet and dry periods, that true stability can realistically be judged. Unless good stability is established at the start, a poor environment will result for the establishment of grasses and plants and high erosion rates will continue resulting in sustained off-site damages. Stability is controlled by (1) bench width, (2) outer slope of spoil, (3) bench surface drainage, (4) bedrock lithology and stratigraphy, and (5) soil and rock content of the spoil.

Slips and landslides are caused by the top heavy nature of a soil mass and usually occur when the soil becomes saturated. Uncontrolled spoil placement results in the most unstable situation possible.

The outer slope of spoil has a direct affect on stability. Uncontrolled placement has resulted in slopes varying from about 65% to 100% depending upon the amount and kind of rock and moisture content of the intermixed soil. Based on a study in the Coal River Watershed, the maximum stable slope was found to be about 66%. However, this is in an area with predominantly sandstone bedrock. Areas with predominantly shale will require a flatter slope (50%) to insure stability.

Surface drainage of the bench and spoil by prompt removal of rainfall and runoff will aid in land stabilization. Minimizing the infiltration of rainfall will reduce the tendency of any spoil on a slope to slide. After water has entered the spoil remedial measures for drainage and stability are considerably more expensive. Water trapped on the bench will aggravate slides when the bench is a sandstone or limestone underlain by a shale layer or strata which forces the water to seep out under the cast over spoil.

Geology

The geology of the area must be known if a satisfactory plan is to be developed for water control and disposal, sediment pollution control, acid drainage control, and successful establishment of a productive vegetative cover. Geologic factors indicate (1) potential acidity, (2) potential slope stability, (3) potential stoniness of spoil, and (4) dip of coal strata. The strike and dip of the coal strata must be known in order to plan an effective drainage plan.

Drainage plans can be enhanced by taking advantage of the dip (or slope) of coal seams in determining which way to drain the benches. This also permits determining which natural waterways to use.

Water Disposal

Collection and delivery of water to a safe and stable outlet is an important aspect in developing a drainage plan. Water will always occur and provisions must be made to handle it at all times. Inadequate methods of water disposal result in washed out culverts, flooded houses, and impassable roads due to high water. Water disposal usually will be concerned with bench and diversion drainage and the methods of getting this water to a natural drainway.

Water in diversions shall be directed to an adequate outlet. The outlet may be a natural drainway, a vegetated area or some other stable watercourse. In all cases, the outlet must convey runoff to a point where outflow will not cause damage.

Bench drainage is usually done by waterways draining to an outlet in the direction of bench slope. In no case will the water be discharged over the bench crest unless protected against concentration by use of structural means (pipes, riprap, concrete, et cetera). Such waterways shall be located away from the highwall sufficient to prevent future filling by plugging or wall sloughing. The gradients must be flat enough to prevent gullying when located on erodible soil. Shallow ponds or swales on the solid bench can be used to settle out sediment before the water is outletted over the bench only if acid producing materials are not present. The ponds should be constructed to be dry between runoff periods.

Lowering of water from the bench to the valley stream should be done by using the natural drainways available. Since surface mining activities will be suspended 50' on either side of a natural drainway, sediment problems should be minimized if haul roads are properly constructed along and across natural drainways. When a natural drainway is not available, structural means will be used. These are by use of pipe, a rock riprap flume, or by grading a channel to underlying rock that is non-erosive.

It must be recognized that all control measures are not equally effective at all sites. Diversions may work well at some locations but may be ineffective at others. Rock lined chutes, ditches or pipe drop spillways will be required at many places in lieu of natural or grassed waterways. The methods of controlling erosion and sediment from the outer slopes will vary.

Sediment ponds must be installed on all drainage ways carrying concentrated flows from the disturbed areas. Dry ponds are safer in that the fill and foundation are not subject to constant saturation, they provide for easier cleanout, and do not require a drain. However, they are not as effective as a wet pond in settling out silt size particles during low flow periods. It must be recognized that ponds of the size which will normally be constructed will not retain the runoff long enough to settle out clay particles and colloidal material.

Where possible sediment ponds should be located before drainageways reach the main stream. A good rule to remember is to locate them as close to the source as possible. Where feasible, they should be of the diversion type. This will keep sediment storage accumulations out of the main water courses. After reclamation is complete the diversions can be closed and sediment deposits isolated from further flows. Land disturbed by previous operations that is not stabilized must be included when determining the disturbed area above sediment ponds.

All overburden materials subject to disturbance should be classified for potential acidity and a plan developed for handling and placing of materials which will result in enough suitable material at the finished surface to support the planned crop or vegetation. Massive rocks and acid-producing strata shall be placed where it is not a part of the finished surface.

The after-mining use possibilities of the area affected should be based upon capabilities of the disturbed area, compatibility with adjacent land uses, and the needs and desires of the landowner.

Water capable of supporting fish and other desirable aquatic life shall be the goal where impoundments occur or are made.

Good planning, design, installation, and maintenance of erosion and sediment control measures will provide for effective control at many sites. However, it must be recognized that there are locations where the physical characteristics of the land are such that effective erosion and sediment control cannot be provided for. This may be for either of the following reasons: (1) control measures are too expensive resulting in an uneconomical operation or (2) it is physically impossible to install the needed measures. Where these conditions exist, consideration for surface mining may be denied.

SEDIMENT DAMS

EMBANKMENT TYPE

DEFINITION

A barrier or dam constructed across a waterway or other suitable locations to form a silt or sediment basin.

PURPOSE

To preserve the capacity of reservoirs, ditches, canals, diversions, waterways and streams and to prevent undesirable deposition on bottom lands, in channels or waterways, and other areas by providing basins for the deposition and storage of silt, sand, gravel, stone and other detritus.

SCOPE

This standard establishes the minimum acceptable quality for the design and construction of sediment dams located in predominantly rural or agricultural areas in West Virginia when:

1. Failure of the structure would not result in loss of life; in damages to homes, commercial or industrial buildings, main highways, or railroads; in interruption of the use of service of public utilities; or damage existing water impoundments; or
2. The contributing drainage area does not exceed 200 acres; or
3. The vertical distance between the lowest point along the ℄ of the dam and the crest of the emergency spillway does not exceed 15 feet.
4. The sediment dam conforms to all state and local laws and/or regulations pertaining to the storage of water.

Structures which exceed 15 feet vertical distance between the lowest point along the ℄ of the dam and the crest of the emergency spillway and those which exceed 10 feet vertical distance and have a surface area at the emergency spillway crest greater than 10 acres must be approved by the Public Service Commission.

The contributing watershed above the site shall have an adequate plan for providing protection against erosion of disturbed areas. This plan shall provide for rapid revegetation of the disturbed areas in order to stabilize the area as quickly as possible after it has been disturbed. It is required to prevent excessive sedimentation from exceeding the design capacity of the sediment dam. All disturbed areas (old and new) in the watershed shall be revegetated according tp West Virginia Division of Reclamation regulations.

Site condition shall be such that the following capacity requirements can be met.

I. SEDIMENT

The sediment pool shall have a minimum capacity (from the lowest elevation in the reservoir to the crest of the principal spillway) to store 0.125 acre-feet per acre of disturbed area in the watershed. The disturbed area includes all land affected by previous operations that is not presently stabilized and all land that will be affected during the surface mining and reclamation work. The basin shall be cleaned out when the sediment accumulation approaches 60% of the design capacity. The design and construction drawings shall indicate the corresponding elevation.

II. STRUCTURES IN SERIES

When structures are built in series, the principal spillway and emergency spillway sizes for the lower structure shall be based on the total drainage area above the lower structure. The required storage for sediment for any structure shall be based on the disturbed area in the uncontrolled drainage area above that structure.

When an existing upstream structure is not considered adequate or safe according to the specification herein, a lower structure in series must be designed considering failure of the upstream structure. This means that the sediment, principal spillway and emergency spillway shall be based on the total drainage area above the lower structure.

Construction must be completed on all upstream structures prior to construction of a lower structure **in a series.**

PRINCIPAL SPILLWAYS

I. CAPACITY

A drop inlet principal spillway will be required on all structures. This requirement will be waived when the drainage area is less than 4 acres and no spring flow enters the reservoir at any time during the year. The crest of the principal spillway shall be located at the maximum elevation of the sediment pool.

The minimum size of the principal spillway and drop inlet shall be obtained from Table 1, Minimum Required Principal Spillway Size, and shall be based on the total drainage area above the structure.

TABLE I

MINIMUM REQUIRED PRINCIPAL SPILLWAY SIZE

Drainage Area (Ac)	Pipe Conduit Diameter (In)	Drop Inlet Diameter (In)	Square Drop Inlet Dimensions (Ft)	Minimum Drop Inlet Height (Ft)
0-100	18	30	2 x 2	3.0
100-150	24	36	2.5 x 2.5	4.0
150-200	30	42	3 x 3	5.0

II. LAYOUT

The principal spillway shall be straight in alignment when viewed in plan. The outlet end must extend to an elevation approximately 6 inches above the stable channel bottom and a minimum of 6 feet beyond the toe of the embankment. An adequate outlet structure shall be provided when needed to prevent damage to the toe of the embankment. The minimum slope of the pipe conduit shall be 1 percent in order to insure free drainage.

III. PIPE CONDUITS

All conduits under embankments must support the external loads with an adequate factor of safety. They must withstand the internal hydrostatic pressures without leakage under full external load and settlement.

Suitable types of conduits include steel, wrought-iron, cast iron, corrugated metal, asbestos cement, concrete and rubber-gasket vitrified clay.

1. Asbestos Cement, Concrete and Vitrified Clay

These rigid conduits must be laid in a concrete bedding. The maximum fill height over vitrified clay pipe cannot be more than 20 feet and it shall not be placed over more than 10 feet of compacted earth fill.

a. Bedding:

Concrete bedding shall be placed beneath the pipe at a minimum thickness of 4 inches and extend up on the sides of the pipe for at least 10 percent of the overall height of the conduit. The bedding shall have a base width equal to the outside diameter of the pipe.

b. Joints:

Conduit joints are to be designed and constructed to remain watertight. A rubber gasket set in a positive seat which will prevent displacement is to be provided.

2. Corrugated Metal Pipe

a. Iron or Steel (Zinc-Coated):

Corrugated metal pipe (iron or steel) shall conform to Federal Specification WW–P–405. It shall be close-riveted and asphalt-coated or helical corrugated with welded seam and can be used only where the pH of the normal stream flow is expected to be greater than 5.0 during the life of the structure. Where the pH of the normal stream flow is expected to be between 4.0 and 5.0 the pipe shall be close riveted abestos-bonded, bituminous-coated, and have a paved invert. Corrugated metal pipe will not be used where the pH is expected to be less than 4. The minimum thickness of the pipe shall be 16 gage for conduits 18 inches and less in diameter. For larger sizes, the minimum thickness shall be 14 gage.

Bituminous coating damaged by breaks, scuffs or welding shall be repaired by the application of two coats of hot asphaltic paint or a coating of cold-applied bituminous mastic.

b. Aluminum:

Corrugated aluminum shall conform to Federal Specification WW–P–402. It can be used only in soils having a pH greater than 5 and less than 9. The minimum thickness of the pipe shall be 14 gage.

c. Joints:

All corrugated metal pipe shall be connected by a watertight flange-type connection or by a watertight connecting band specifically manufactured for a connecting band (band with rods and lugs). The area between the pipe and connecting bands shall be treated with an asphalt cement during installation to assure a watertight joint.

3. Steel (Smooth)

   Steel pipe may be used where the pH of the normal stream flow during the life of the structure is expected to be 5.0 or greater. It shall be of standard strength and be connected by a watertight mechanical or welded joint.

4. Wrought-Iron or Cast Iron

   Iron pipe may be used under all soil and water conditions. It must be of standard thickness or greater and be connected by a watertight mechanical joint.

IV. DROP INLET

The minimum size and height is given in Table 1. The drop inlet may be perforated to provide a gradual drawdown after each storm event.

1. Perforations:

   Metal drop inlets when perforated shall be done so throughout the top 2/3 of their length with ¾ inch diameter holes spaced 8 inches vertically and 12 inches horizontally center to center. Nonmetal drop inlets shall be ported to permit draining the pond in approximately 5 days (such ports shall be similar to those described for the metal drop inlets).

2. Base:

   The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent flotation of the riser. Two approved bases are: (1) A concrete base 18" thick with the riser imbedded 6" in the base. The base should be square with each dimension 1 ft. greater than the riser diameter. (2) a ¼" minimum thickness steel plate welded all around the base of the riser to form a watertight connection. The plate shall be square with each side equal to 2 times the riser diameter. The plate shall have two feet of stone, gravel or tamped earth placed on it to prevent flotation.

V. DRAIN PIPE

A drain pipe with a suitable valve or cap shall be provided when the drop inlet is not perforated. The drain size shall be sufficient to drain the pond in 5 days and shall have a perforated vertical riser.

VI. ANTI–SEEP COLLARS

All conduits through the embankment are to be provided with a minimum of three anti-seep collars, except when the embankment is 5 feet or less. When the embankment if 5' or less, 2 collars will be required. The collars will be at 15' intervals with the middle collar at the centerline of the dam. The anti-seep collars shall extend a minimum of 2' from the conduit in all directions. The collars and their connections to the pipe shall be watertight.

VII. ANTI–VORTEX DEVICE

An anti-vortex device shall be installed on the principal spillway inlet.

1. It shall consist of a thin, vertical plate normal to the centerline of the dam and firmly attached to the top of the riser. The plate dimensions shall be: length = diameter of the riser plus 12 inches; height = diameter of the horizontal conduit; or
2. It shall consist of a horizontal circular plate having a diameter 2 feet greater than the drop inlet and firmly mounted 1.5 feet above the crest of the inlet.

VIII. TRASH RACKS

A suitable trash rack will be provided where the drainage area will contribute trash to the reservoir.

EMERGENCY SPILLWAYS

Emergency spillways are provided to convey large flows safely past an earth embankment. They are usually open channels excavated in earth or rock or constructed of compacted embankment or reinforced concrete.

1. CAPACITY

The crest elevation of the emergency spillway will be located at a minimum distance of 1.5 feet above the crest elevation of the principal spillway. The emergency spillway shall be designed to safely carry the expected peak rate of discharge from a 10 year frequency storm. There shall be one foot of freeboard between the maximum design flow elevation in the emergency spillway and the top of the dam. The 10-year frequency peak discharge shall be obtained from Figure 1, Emergency Spillway Design Peak Discharge. The spillway shall be proportioned to pass the peak discharge from Figure 1 at the safe velocity determined for the site. Table 2, Emergency Spillway hydraulics, shall be used to proportion emergency spillways. Chart No. 1, Emergency Spillway Velocity Chart, shall be used in conjunction with these tables to proportion the emergency spillway.

The emergency spillway may be waived when the height of embankment is less than 5 feet and when the drainage area is 20 acres or less. When the emergency spillway is not required, the crest elevation of the riser shall be at least 2' below the crest elevation of the embankment.

II. LAYOUT

The emergency spillway shall be excavated in rock or in earth. It shall consist of an inlet channel, a control section, and an exit channel. The capacity and size of the emergency spillway shall be as outlined under CAPACITY. Minimum bottom width shall be **10 feet.**

The inlet channel shall be level for a minimum distance of 20 feet upstream from the control section if the Hp in the emergency spillway is equal to or less than 2.5 feet. The level section shall be 30 feet upstream from the control section if the Hp exceeds 2.5 feet.

The level part of the inlet channel shall be the same width as the exit channel and its centerline shall be straight and coincident with the centerline of the exit channel. A curved centerline is permissible in the inlet channel upstream from the level section, but it must be tangent to the centerline of the level section. The level section of the inlet channel shall be located so that the projected centerline of the dam will pass through it.

The centerline of the exit channel shall be straight and perpendicular to the control section extending downstream to a point opposite the downstream toe of the dam. Curvature may be introduced below this point if it is certain that the flowing water will not impinge on the embankment should the channel fail at the curve. The slope of the exit channel shall be determined from Chart No. 1.

The layout will provide that the spillway when cut around the end of the dam in the abutment be in natural ground (cut) to a depth equal to the maximum design flow for at least the level section and the exit channel to a point opposite the downstream toe of the dam. It is preferable that the flow be confined without the use of levees, but where site conditions are such that the exit channel will not contain the design flow, a levee or dike shall be constructed along the exit channel to a height above the exit channel equal to the depth of flow through the spillway at the control section. The levee shall have a minimum top width of 4 feet and side slopes not steeper than 2 horizontal to 1 vertical. The levee shall be constructed in accordance with the requirements for embankment.

The spillway shall be trapezoidal in shape and the side slopes shall not be steeper than ¼ horizontal to 1 vertical in rock or 2 horizontal to 1 vertical in earth.

III. PERMISSIBLE VELOCITIES

A. Earth Emergency Spillways

The maximum allowable velocity in the exit channel shall be 5 feet per second for earth emergency spillways. This velocity must not be exceeded in the exit channel of the spillway from the control section to a point in the exit channel opposite the downstream toe of the dam or to a point downstream where a channel failure would not cause the flow to impinge on the toe of the dam. All earth spillways shall be vegetated with the most suitable permanent grass vegetation for the site.

Spillways excavated in earth shall be protected throughout the level section and the exit channel with durable rock riprap when the exit channel velocity falls between 5 feet per second and 12 feet per second. The rock riprap will be placed in a 1.5 feet thick blanket through the bottom and sides of the level section and exit channel. Twenty five percent of the rock will be 18 inches or sligntly larger. The remaining 75% shall be well graded material consisting of sufficient rock small enough to fill the voids between the larger rocks. Shale shall not be used for riprap.

B. Rock Emergency Spillways

The maximum allowable velocity shall be 14 feet per second for rock emergency spillways. A spillway shall be classed as a rock emergency spillway when durable bedrock occurs throughout the level section and in the exit channel to a point opposite the downstream toe of the dam. Durable bedrock is defined as a layer of continuous bedrock equal or greater in thickness than the depth of flow through the spillway at the control section.

EARTH EMBANKMENT

I. HEIGHT

The earth embankment shall be high enough to have one foot of freeboard between the maximum design flow elevation in the emergency spillway and the top of the dam.

II. TOP WIDTH

The minimum top width of earth embankments shall be 14 feet.

III. SIDE SLOPES

The side slopes of the settled embankment shall be no steeper than 3 horizontal to 1 vertical on the upstream side and 2 horizontal to 1 vertical on the downstream side.

Embankments constructed without emergency spillways shall have an upstream slope of 3 horizontal to 1 vertical and a downstream slope of 5 horizontal to 1 vertical. The entire downstream slope shall be protected with a 1.5 foot layer of rock riprap which shall have 25% of the material 18 inches in diameter or slightly larger and the remaining 75% well graded with sizes to fill the voids between the larger rocks.

IV. CUTOFF TRENCH

The elevation of the top of a compacted cutoff will not be lower than the crest of the principal spillway. The cutoff trench should have a bottom width adequate to accommodate the construction equipment but shall not be less than 8 feet. The trench shall have minimum side slopes of 1 to 1. The cutoff trench shall be located on the embankment centerline and be of sufficient depth to extend into a relatively impervious layer of soil or to bedrock.

V. SETTLEMENT ALLOWANCE

The design height of the embankment shall be increased by 5 percent to allow for settlement.

VI. UTILITIES UNDER EMBANKMENTS

Utilities encountered at dam sites must be relocated away from the site according to the standard criteria and procedure of the utility company involved.

VII. VEGETATIVE PROTECTION AGAINST EROSION

The embankment, spillways, borrow areas and other disturbed areas shall be mulched and vegetated in accordance with Reclamation Rules and Regulations for revegetation.

VIII. SAFETY

The embankment, pool area and vegetated spillway shall be fenced as needed to restrict accessibility for reasons of safety. All fences shall be constructed in accordance with good fencing practices. Warning signs of danger shall be installed where deemed necessary.

IX. PLANS, DESIGN DATA AND SPECIFICATIONS

In addition to the "Proposed Drainage Map", there shall also be submitted the following items concerning sediment dams of the embankment type:

1. A "Structure Proportioning Computations Sheet" to be completed for each proposed dam.
2. Construction Plans showing:
   a. A topographic map on a 1" = 50' scale and 4 feet contour intervals showing the reservoir area, embankment and the emergency spillway. Topographic map is to be made using transit-stadia survey method.
   b. A profile view of the embankment along the ℄ of the principal spillway showing all pertinent dimensions, elevations, and principal spillway design.
   c. A profile view of the emergency spillway showing the entrance slope, level section and **exit channel** slope.

d. A cross–section view of the emergency spillway showing the bottom width, side slopes, and the type of material used.

e. A cross-section view taken along the centerline of the dam showing cutoff trench depth, original ground line, unsettled and settled dam heights, length of dam and other pertinent dimensions and elevations.

3. A "Stage-Area-Storage" computations sheet and Stage-Area-Storage curves.

4. Construction Specifications

CONSTRUCTION SPECIFICATIONS

SEDIMENT DAMS
EMBANKMENT TYPE

I. SITE PREPARATION

The embankment site shall be cleared of all brush, trees, stumps, roots and other undesirable material. Sod and topsoil shall be stripped from the embankment site and borrow area and stockpiled for use on the emergency spillway and embankment. Brush, trees and other undesirable material shall be cleared from the sediment pool area.

II. CUTOFF TRENCH

A cutoff trench shall be excavated along the centerline of the embankment. The cutoff trench shall extend into both abutments to an elevation no lower than the crest of the principal spillway. It shall be of sufficient depth to extend into a relatively impervious layer of soil or to bedrock and shall be backfilled with the most impervious material available at the site. The trench shall be kept free of standing water during the backfilling operations. The cutoff trench should have a bottom width adequate to accommodate the construction equipment but shall not be less than 8 feet. The trench shall have minimum side slopes of 1 to 1. Compaction requirements shall be the same as those for the embankment.

III. EXCAVATION AND BACKFILL OF STREAM CHANNEL

Existing stream channels crossing the foundation area shall be deepened and widened as necessary to remove all stones, gravel, sand, stumps, roots and other objectionable material, and to accommodate compaction equipment. Such channels shall then be backfilled with suitable material as specified for earth embankment. The excavated channels shall be kept free of standing water during backfill operations.

IV. PIPE CONDUIT

The pipe conduit shall be placed in a trench excavated in solid undisturbed ground or formed by compacted earth. The conduit shall be imbedded in a formed trench to a depth no less than 1/10 times the outside diameter of the pipe. Trench sides shall be sloped back no steeper than 1 to 1. Selected impervious backfill material shall be placed around the conduit in 4 inch layers and thoroughly compacted to at least the same density as the adjacent embankment.

Bedding for asbestos cement, concrete or vitrified clay pipe shall be concrete and will be placed beneath the pipe at a minimum thickness of 4 inches and extend up on the sides of the pipe for at least 10 percent of the overall height of the conduit. The bedding should have a base width equal to the outside diameter of the pipe.

All pipe joints and anti-seep collar connections to the conduit shall be watertight.

V. EMERGENCY SPILLWAY

The emergency spillway shall conform to the lines, grades, bottom width and side slopes as shown on the plans.

VI. BORROW AREAS

All borrow excavation will have side slopes no steeper than 2 horizontal to 1 vertical and shall be graded and left in such a manner as to provide suitable drainage.

VII. SELECTION AND PLACEMENT OF EMBANKMENT MATERIALS

The most impervious material shall be used in the cutoff trench and center portion of the dam. When sandy gravelly material is encountered, it should be placed in the outer shell preferably in the downstream portion of the dam. The distribution and gradation of materials throughout the fill shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. Where it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the dam. Very dry or wet material shall not be used. The fill material shall be free of all sod, roots, stones over 6 inches in diameter and other objectionable material. The moisture content of the material should be such that when kneaded in the hand, it will just form a ball that will not readily separate.

The embankment shall be brought up on uniform 6-8 inch layers of approximate uniform elevation over its entire area. Each layer shall be thoroughly compacted by making at least 4 complete passes with a sheepsfoot roller or by applying equal compactive effort with rubber tired equipment.

VIII. PROTECTION AGAINST EROSION

The earth embankment, spillways, and borrow areas above the sediment pool shall be mulched and vegetated in accordance with Reclamation Rules and Regulations for revegetation.

FIGURE 1

EMERGENCY SPILLWAY DESIGN PEAK DISCHARGE

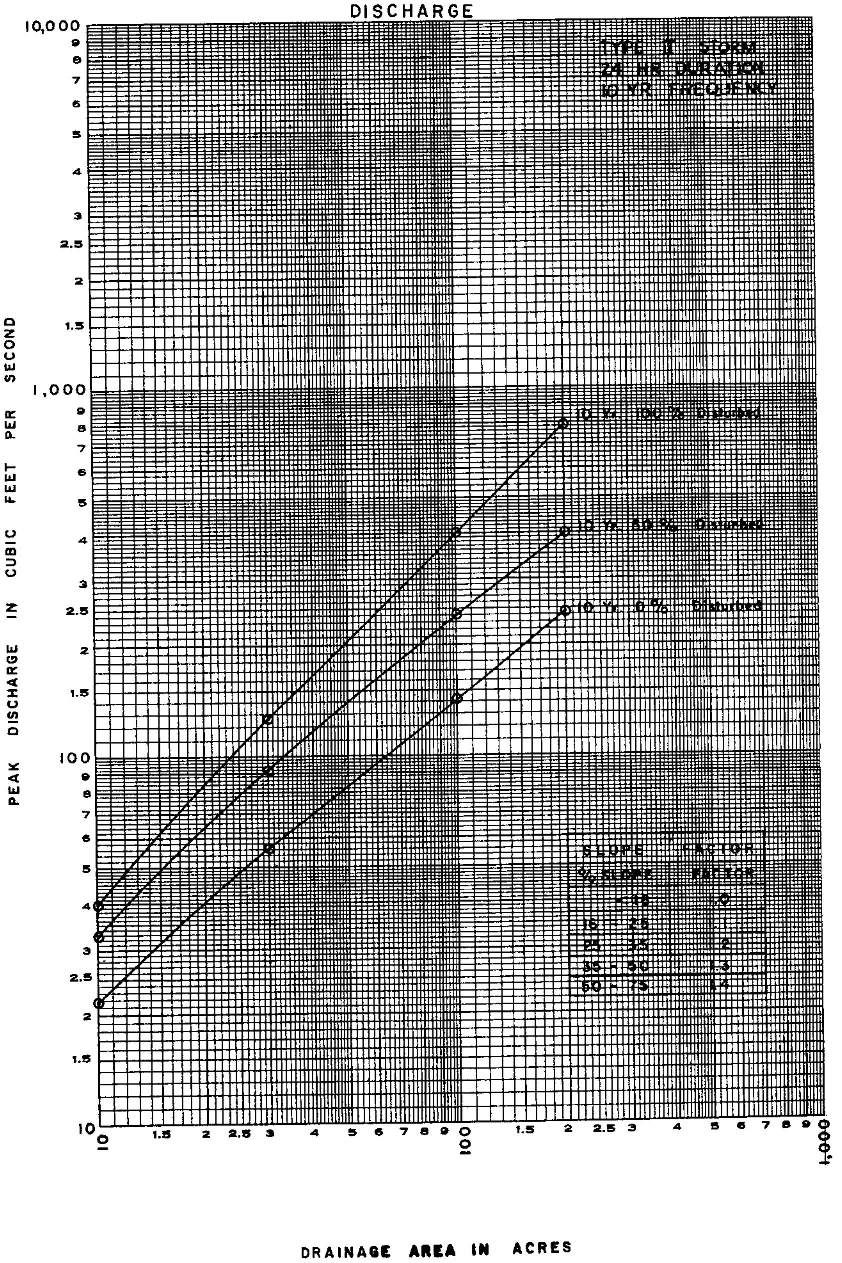


TABLE 2

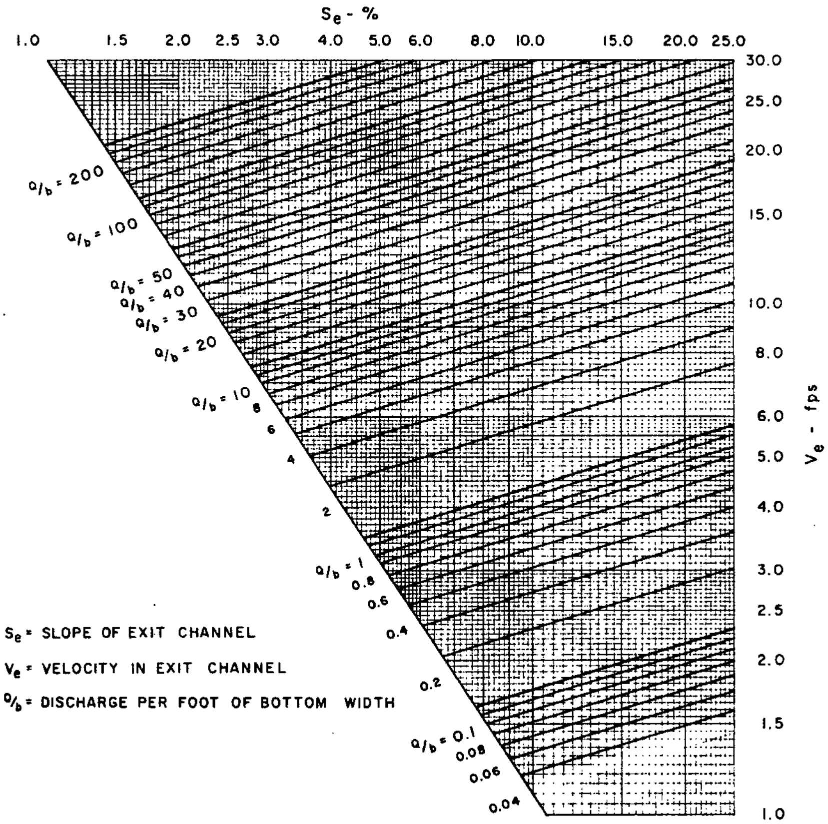
EMERGENCY SPILLWAY HYDRAULICS

Hp-Ft \ b-Ft	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	DISCHARGE CFS													
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	6	9	12	15	18	21	24	27	30	33	36	39	42	45
1.0	20	30	40	50	60	70	80	90	100	110	120	130	140	150
1.5	39	59	78	98	118	137	157	176	196	216	235	255	274	294
2.0	64	96	128	160	192	224	256	288	320	352	384	416	448	480
2.5	94	141	188	235	282	329	376	423	470	517	564	611	658	705
3.0	129	194	258	323	387	452	516	581	645	710	774	839	903	968
3.5	169	254	338	423	507	592	676	761	845	930	1014	1099	1183	1268
4.0	212	318	424	530	636	742	848	954	1060	1166	1272	1378	1484	1590
4.5	258	367	516	645	774	903	1032	1161	1290	1419	1548	1677	1806	1935
5.0	305	458	610	763	915	1068	1220	1373	1525	1678	1830			
5.5	364	546	728	910	1092	1274	1456	1638	1820					
6.0	422	633	844	1055	1266	1477	1688	1899						
6.5	482	723	964	1205	1446	1687	1928							
7.0	550	825	1100	1375	1650	1925								
7.5	618	927	1236	1545	1854									
8.0	690	1035	1380	1735										
8.5	764	1146	1528	1910										
9.0	845	1268	1690											
9.5	924	1386	1848											
10.0	1010	1515												

Reference - SCS Technical Release No. 35 (Z=?, n=0.040, L=100 Ft.)

CHART NO. 1

EMERGENCY SPILLWAY VELOCITY CHART



S_e = SLOPE OF EXIT CHANNEL

V_e = VELOCITY IN EXIT CHANNEL

Q/b = DISCHARGE PER FOOT OF BOTTOM WIDTH

STAGE-AREA-STORAGE COMPUTATIONS

Dam No. ________

Elev. (ft.)	Area ($in.^2$)	Area (Ac.)	Area (Ac.)	Average Area (Ac.)	Diff. in Elev. (ft.)	Storage (Ac. ft.)	Storage (Ac. ft.)

NOTE: 1 $in.^2$ = .0573 Ac. for scale of 1" = 50'

STRUCTURE PROPORTIONING COMPUTATIONS SHEET

Dam Number ________

SEDIMENT STORAGE REQUIREMENTS

Drainage Area = ________ Acres Average Land Slope = __________%
Area Disturbed = ________ Acres = ________ % of Drainage Area
Sediment Volume = .125 Ac. Ft./Ac. x Area Disturbed = _____ Ac. Ft.
Sediment Pool Elevation = ______ Ft. = Principal Spillway Crest

PRINCIPAL SPILLWAY DESIGN

Principal Spillway Diameter = ________ inches
Type ______________________________________
Principal Spillway Length ________________ Ft.
Principal Spillway Slope ____________ Percent

DROP INLET

Type Base ________________ Type Riser ________________
Dimensions = ________ inches diameter or ________ $Ft.^2$
Height of Riser (base to crest) = ________________ Ft.
Perforated ______ Yes ________ No

DRAIN PIPE

Diameter = ________ inches Type ________________
Length = __________ Ft. Height of Riser ________________ Ft.

EMERGENCY SPILLWAY DESIGN

Emer. Spillway Elev. = Prin. Spillway Elev. + 1.0 Ft.(min.) =

________ + ________ = ________.

Peak Discharge (Figure 1) = ______ c.f.s. x _____ (slope factor) = _____ c.f.s.

Emergency Spillway Proportions (Table 2)

Bottom Width, b = _______ Ft.
Emergency Spillway Stage, Hp = ______ Ft.
$\frac{\text{Peak Discharge}}{\text{Bottom Width}} = \frac{Q}{b} =$ ______________
Slope of Exit Channel, S_e = ________% (Chart 1)
Velocity in Exit Channel, V_e = ______ f.p.s. (Chart 1)
Spillway Material __________ Allowable V_e = ______ f.p.s.
Top of Dam Elevation = Emer. Spillway Elev. + Hp + 1.0 ft. =

________ + ________ + ________ = ________.

Sample

STRUCTURE PROPORTIONING COMPUTATIONS SHEET

Dam Number 3

SEDIMENT STORAGE REQUIREMENTS

Drainage Area = 51.4 Acres Average Land Slope = 45 %
Area Disturbed = 26.6 Acres = 52 % of Drainage Area
Sediment Volume = .125 Ac. Ft./Ac. x Area Disturbed = 3.33 Ac. Ft.
* Sediment Pool Elevation = 97.1 Ft. = Principal Spillway Crest

PRINCIPAL SPILLWAY DESIGN

Principal Spillway Diameter = 18" inches
Type Corrugated Metal Pipe
Principal Spillway Length 132 Ft.
Principal Spillway Slope 3.0 Percent

DROP INLET

Type Base Concrete Type Riser C.M.P.
Dimensions = 30 inches diameter or ____ $Ft.^2$
Height of Riser (base to crest) = 12.5 Ft.
Perforated ✓ Yes ____ No

DRAIN PIPE Not Needed

Diameter = ____ inches Type ____
Length = ____ Ft. Height of Riser ____ Ft.

EMERGENCY SPILLWAY DESIGN

Emer. Spillway Elev. = Prin. Spillway Elev. + 1.5 Ft.(min.) =

97.1 + 1.5 = 98.6.

Peak Discharge (Figure 1) = 148 c.f.s. x 1.3 (slope factor) = 192.4 c.f.s

** Emergency Spillway Proportions (Table 2)

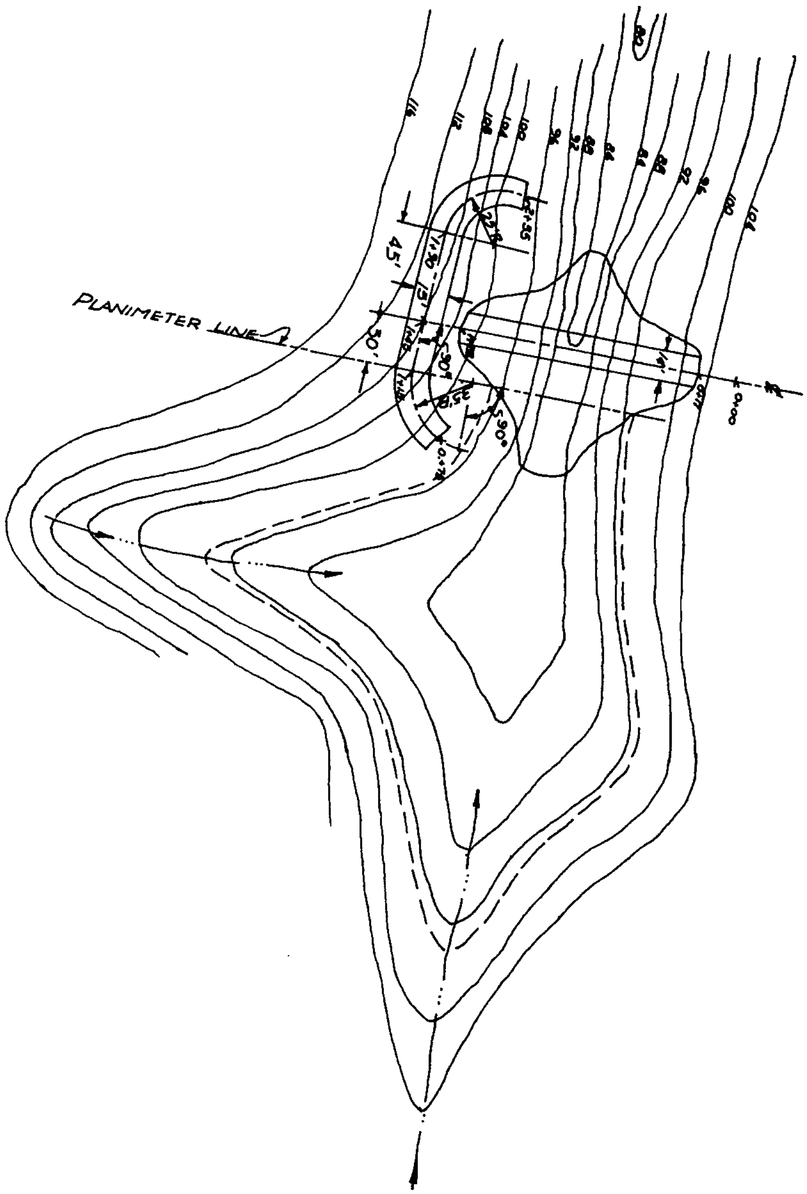
Bottom Width, b = 15 Ft.
Emergency Spillway Stage, Hp = 3.0 Ft.
$\frac{\text{Peak Discharge}}{\text{Bottom Width}} = \frac{Q}{b} =$ 192.4/15 = 12.8
Slope of Exit Channel, S_e = 2.85 % (Chart 1)
Velocity in Exit Channel, V_e = 7.3 f.p.s. (Chart 1)
Spillway Material Rock Riprap Allowable V_e = 12 f.p.s.
Top of Dam Elevation = Emer. Spillway Elev. + Hp + 1.0 ft. =

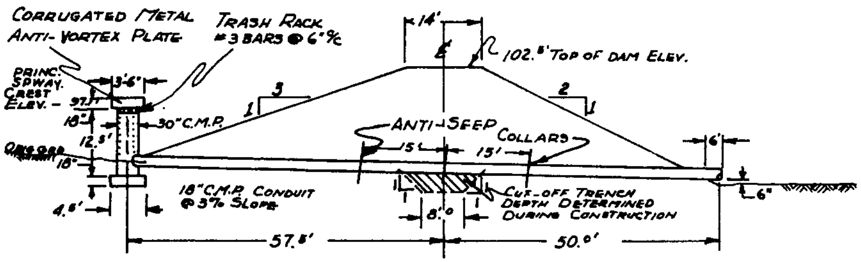
98.6 + 3.0 + 1.0 = 102.6.

* See following page.
**

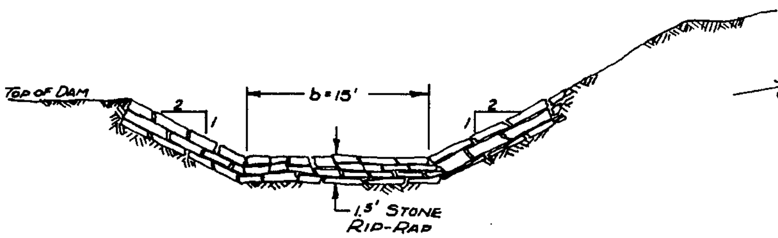
* From field survey, draw topographic map and complete Stage-Area-Storage computations and curves. Determine sediment pool elevation from Stage-Storage-Curve. When using a planimeter to determine areas on topographic map, it is permissable to use a "planimeter line" located approximately ½ the distance from the anticipated upstream toe and the centerline of embankment. This line may be used for all contour line planimetering.

** Obtain bottom width and stage for emergency spillway using peak discharge as shown on sample. Although it was not done in the sample, interpolation may be necessary to correctly determine Hp for any given bottom width. Q/b is then located on the slanted line on Chart No. 1. Slope and velocity are then read as shown and spillway material determined.

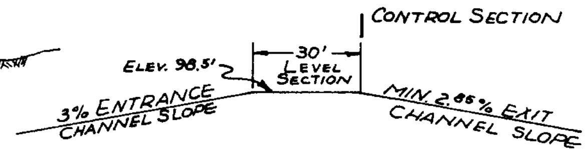

PLANIMETER LINE
45'
30'



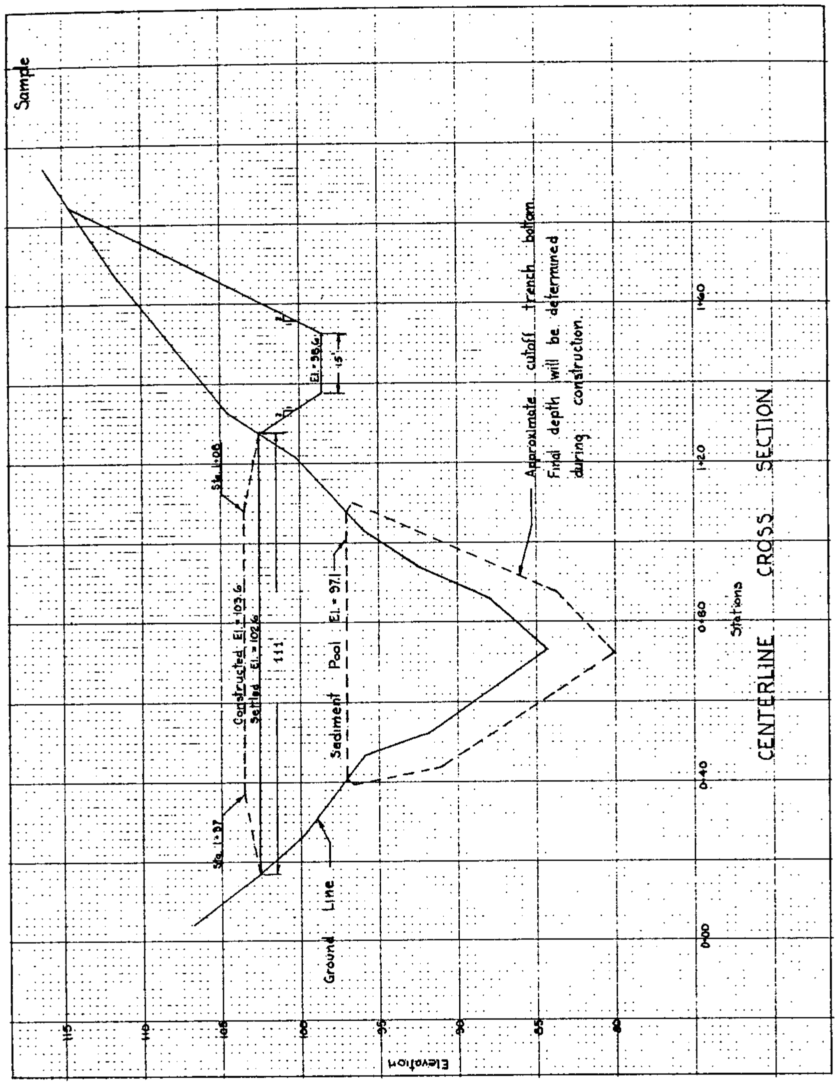
EMBANKMENT PROFILE ALONG PRINCIPAL SPILLWAY ℄



EMERGENCY SPILLWAY SECTION



EMERGENCY SPILLWAY PROFILE


Sample
CENTERLINE CROSS SECTION
Stations
Elevation
Ground Line
Sediment Pool El. = 97.1
Constructed El. = 103.6
Settled El. = 102.6
Sta. 1+08
111'
El. = 98.6
15'
Approximate cutoff trench bottom. Final depth will be determined during construction.
0+00
0+40
0+80
1+20
1+60
115
110
105
100
95
90
85
80

Sample

STAGE-AREA-STORAGE COMPUTATIONS

Dam No. 3

Elev. (ft.)	Area (in.^{2})	Area (Ac.)	Area (Ac.)	Average Area (Ac.)	Diff. in Elev. (ft.)	Storage (Ac. ft.)	Storage (Ac. ft.)
84	0	0					0
			.112	.056	4	.224	
88	1.96	.112					.224
			.410	.205	4	.820	
92	5.20	.298					1.044
			.820	.410	4	1.640	
96	9.10	.522					2.684
			1.355	.678	4	2.712	
100	14.52	.833					5.396

NOTE: 1 in.^{2} = .0573 Ac. for scale of 1" = 50'

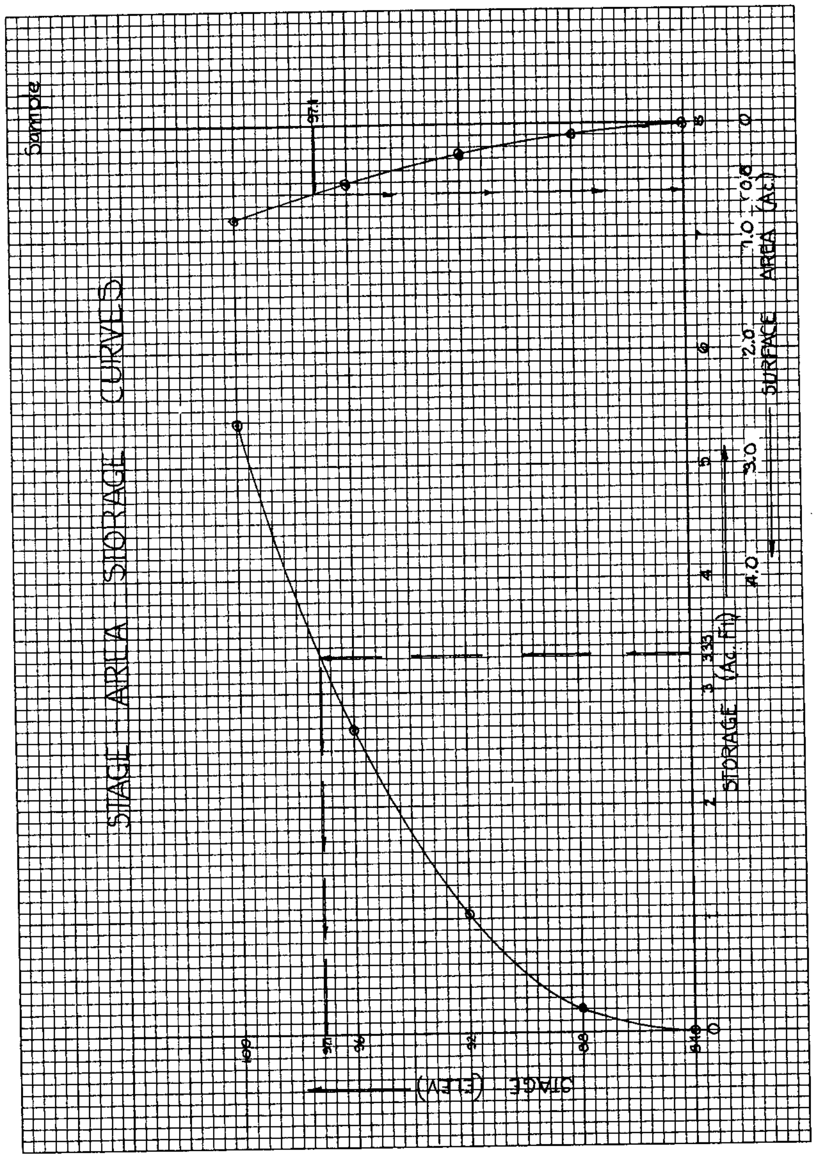
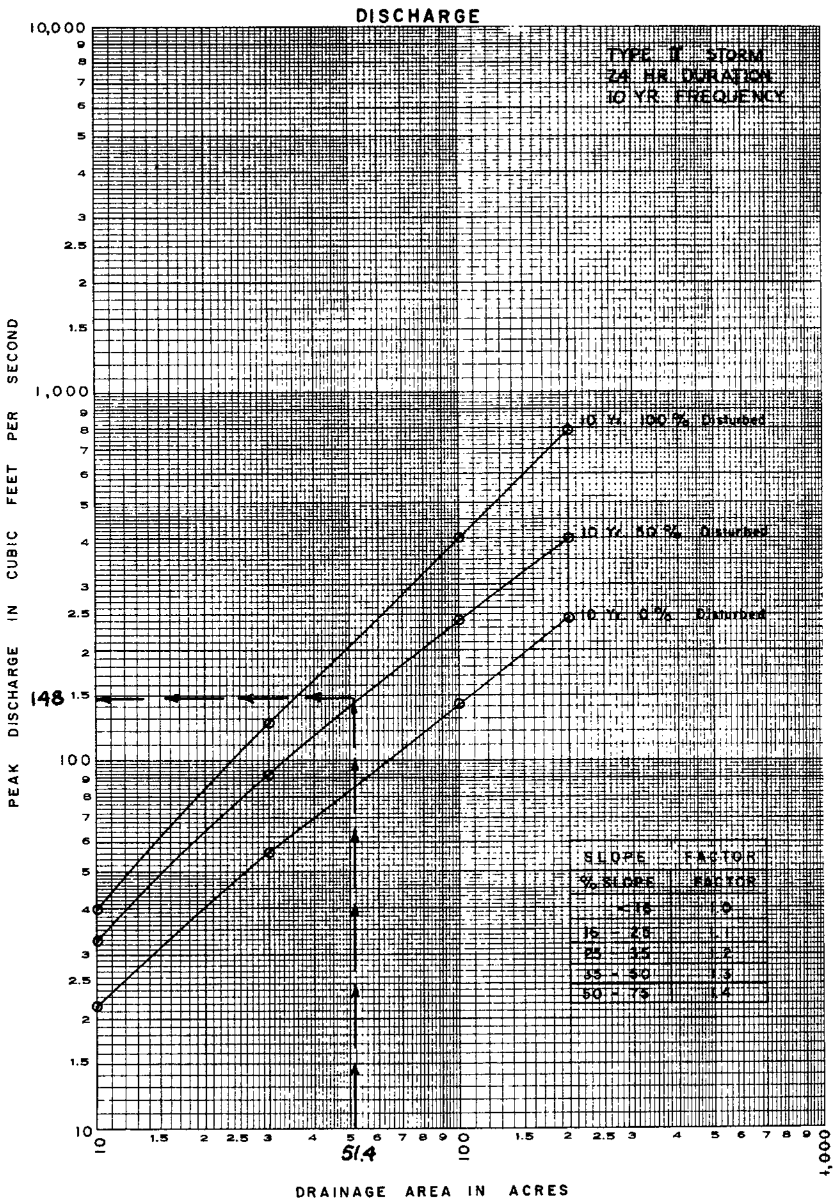

STAGE AREA STORAGE CURVES
Sample
STAGE (ELEV)
STORAGE (Ac. Ft.)
SURFACE AREA (Ac.)
97.1
3.35

FIGURE 1 **SAMPLE**

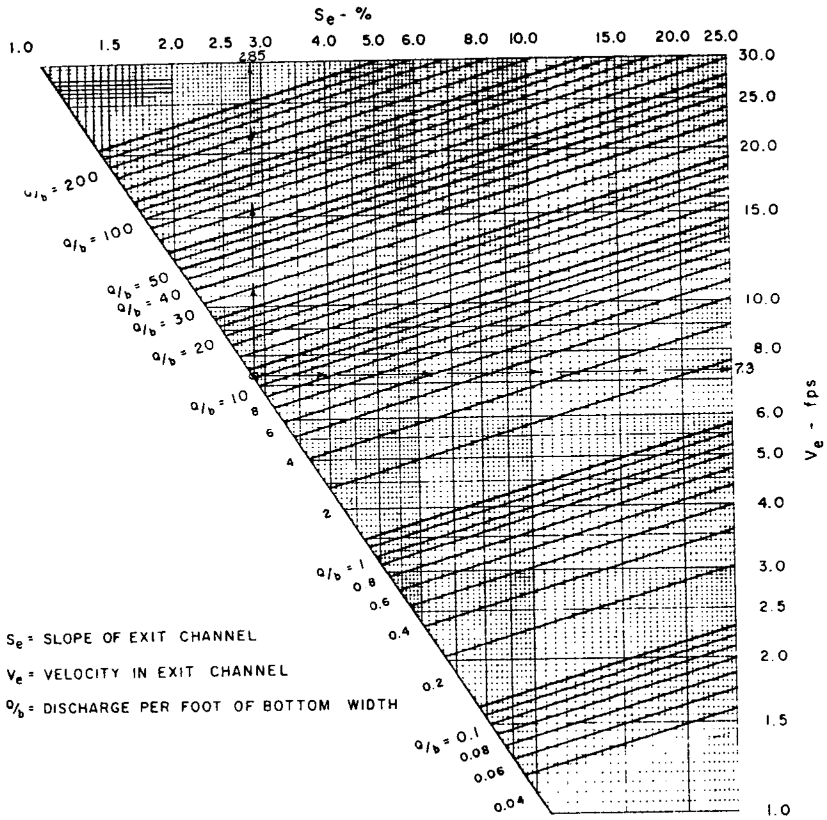
EMERGENCY SPILLWAY DESIGN PEAK



Sample

CHART NO. 1

EMERGENCY SPILLWAY VELOCITY CHART



Sample

TABLE 2

EMERGENCY SPILLWAY HYDRAULICS

b-Ft / Hp-Ft	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	DISCHARGE CFS													
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	6	9	12	15	18	21	24	27	30	33	36	39	42	45
1.0	20	30	40	50	60	70	80	90	100	110	120	130	140	150
1.5	39	59	78	98	118	137	157	176	196	216	235	255	274	294
2.0	64	96	128	160	192	224	256	288	320	352	384	416	448	480
2.5	94	141	188	235	282	329	376	423	470	517	564	611	658	705
3.0	129	194	258	323	387	452	516	581	645	710	774	839	903	968
3.5	169	254	338	423	507	592	676	761	845	930	1014	1099	1183	1268
4.0	212	318	424	530	636	742	848	954	1060	1166	1272	1378	1484	1590
4.5	258	387	516	645	774	903	1032	1161	1290	1419	1548	1677	1806	1935
5.0	305	458	610	763	915	1068	1220	1373	1525	1678	1830			
5.5	364	546	728	910	1092	1274	1456	1638	1820					
6.0	422	633	844	1055	1266	1477	1688	1899						
6.5	482	723	964	1205	1446	1687	1928							
7.0	550	825	1100	1375	1650	1925								
7.5	618	927	1236	1545	1854									
8.0	690	1035	1380	1735										
8.5	764	1146	1528	1910										
9.0	845	1268	1690											
9.5	924	1386	1848											
10.0	1010	1515												

Reference - SCS Technical Release No. 35 (Z=2, n=0.040, L=100 Ft.)

EXCAVATED SEDIMENT PONDS

DEFINITION

A water impoundment made by excavating a pit or "dugout". The use of an earth embankment is permissible to increase capacity; however, ponds resulting from both excavation and embankment are classified as SEDIMENT DAMS, EMBANKMENT TYPE where the depth of water impounded against the embankment at the emergency spillway elevation is 3 feet or more.

PURPOSE

To preserve the capacity of reservoirs, ditches, canals, diversions, waterways and streams and to prevent undesirable deposition on bottom lands, in channels or waterways, and other areas by providing basins for the deposition and storage of silt, sand, stone, gravel and other detritus.

SCOPE

This standard establishes the minimum acceptable quality for the design and construction of excavated sediment ponds in predominantly rural or agricultural areas in West Virginia.

LOCATION

Excavated sediment ponds fed by surface runoff may be located on almost any type of topography; however, they are most satisfactory in areas with relatively flat terrain. An excavated pond may be located in a natural or constructed drainway or to one side of a natural or constructed drainway if the runoff can be directed into the pond.

Site conditions shall be such that the following capacity requirements can be met.

CAPACITY REQUIREMENTS

The excavated sediment pond shall have a minimum capacity (from the lowest elevation in the dugout to the crest of the exit channel or emergency spillway) to store .125 acre-feet per acre of disturbed area in the watershed. The disturbed area includes all land affected by previous operations that is not presently stabilized and all land that will be affected during the surface mining and reclamation work. The sediment pond shall be cleaned out when the sediment accumulation approaches 60% of the design capacity. The design and construction drawings shall indicate the corresponding elevation.

When excavated sediment ponds are constructed in series, the required storage for sediment for any pond shall be based on the uncontrolled drainage area above that pond.

SEDIMENT POND DIMENSIONS

Excavated sediment ponds may be constructed to any desired shape that will meet sediment capacity requirements. The width and depth of sediment ponds are not limited.

Side slopes of excavated sediment ponds shall be such that they will be stable and shall not be steeper than 2 horizontal to 1 vertical in earth and ¼ horizontal to 1 vertical in rock.

ENTRANCE CHANNEL

The entrance channel shall have a minimum slope of 4 horizontal to 1 vertical, extending from the bottom of the excavated pond upstream to the original streambed. The entrance channel shall be protected with a 1.5 foot layer of rock riprap which shall have 25% of the material 18 inches in diameter or slightly larger and the remaining 75% well graded with sizes to fill the voids between the larger rocks. Minimum side slopes shall be 2 horizontal to 1 vertical and shall also be protected with rock riprap for a vertical height of 2'.

EXIT CHANNEL

Pipe principal spillways shall not be required for excavated ponds. The crest of the exit channel will be thoroughly protected with rock riprap to prevent erosion and scouring. The exit channel shall be located as far as possible from the inlet channel with a minimum distance of 50 feet.

EMBANKMENT AND EMERGENCY SPILLWAY

An earth embankment may be used to increase the capacity of an excavated sediment pond provided that the depth of water impounded against the embankment at the elevation of the emergency spillway is less than 3 feet. An emergency spillway will be required when earth embankments are used. The design of the emergency spillway shall conform to that given under Emergency Spillways in Sediment Dams, Embankment type. The emergency spillway may be waived when the height of the embankment is less than 5 feet and when the drainage area is 20 acres or less.

The earth embankment shall be high enough to have one foot of freeboard between the maximum design flow elevation in the emergency spillway and the top of the embankment. Earth embankments without emergency spillways shall have 2 feet of freeboard between the sediment pool elevation and the top of the embankment. The minimum top width shall be 14 feet.

The side slopes will be no steeper than 3 horizontal to 1 vertical on the upstream side and 2 horizontal to 1 vertical on the downstream side.

Embankments constructed without emergency spillways shall have an upstream slope of 3 horizontal to 1 vertical and a downstream slope of 5 horizontal to 1 vertical. The entire downstream slope shall be protected with a 1.5 foot layer of rock riprap which shall have 25% of the material 18 inches in diameter or slightly larger and the remaining 75% well graded with sizes to fill the voids between the larger rocks. A cutoff trench will not be required.

The design height of the embankment shall be increased by 10 percent to allow for settlement.

UTILITIES UNDER EMBANKMENTS

Utilities encountered at dam sites must be relocated away from the site according to the standard criteria and procedure of the utility company involved.

DISPOSAL OF WASTE MATERIAL

The waste material from the excavated sediment pond may be spread, used in the embankment or removed from the site as conditions warrant.

The waste material, when not removed from the site, shall be placed in a manner that its weight will not endanger the stability of the pond side slopes and the rainfall will not wash the material back into the pond. Not less than 12' should be left between the toe of the waste material and the edge of the pond.

If the waste material is spread, it should be to a height of no more than 3 feet with the surface graded to a uniform slope away from the pond. The pond side slope of the spread material should be no steeper than 2 horizontal to 1 vertical.

If the waste material is to be used in an embankment, it shall be free of all sod, roots, stones over 6 inches in diameter, and other objectionable material.

SAFETY

The embankment, pool area and vegetated spillway shall be fenced as needed to restrict accessibility for reasons of safety. All fences shall be constructed in accordance with good fencing practices. Warning signs of danger shall be installed where deemed necessary.

VEGETATIVE PROTECTION AGAINST EROSION

The waste material, spillway, embankment and any other area disturbed during construction shall be mulched and vegetated immediately upon completion of the pond in accordance with Reclamation Rules and Regulations for revegetation.

PLANS, DRAWINGS AND SPECIFICATIONS

In addition to the "Drainage Map", there shall also be submitted the following items concerning excavated sediment ponds:

1. A "Structure Proportioning Computations Sheet" to be completed for each proposed pond.
2. Construction plans showing a plan view and a cross-section view with entrance and exit channels.
3. A cross-section view of the embankment and emergency spillway, if used.
4. Cross-sections plotted at 50 foot intervals showing original ground ground line and the proposed excavation limits (Note: This requirement will be waived if sediment pond is to be constructed in a regular shape. See computations sheet).
5. Construction Specifications

CONSTRUCTION SPECIFICATIONS

I. SITE PREPARATION

The pond site and waste areas shall first be cleared of all woody vegetation. The limits of the excavation and spoil placement areas should be staked, and the depth of cut from the ground surface to the pond bottom should be indicated on the stakes.

If an embankment is to be constructed, the embankment site shall be cleared of all brush, trees, stumps, roots and other undesirable material. Sod and topsoil shall be stripped from the embankment site.

II. EXCAVATION

Excavation and placement of the waste material shall be done as near to the staked lines and grades as skillful operation of the equipment will permit. Side slopes of the excavated pond will be no steeper than 2 horizontal to 1 vertical in earth and ¼ horizontal to 1 vertical to rock.

III. SELECTION AND PLACEMENT OF EMBANKMENT MATERIALS

If an embankment is constructed, the most impervious material will be used in the center portion. When sandy gravelly material is encountered, it shall be placed in the outer shell, preferably in the downstream portion of the embankment. The fill material shall be taken from approved designated borrow areas. It shall be free of roots, woody vegetation, oversized stones, rocks, or other objectionable material. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material should contain sufficient moisture so that it can be formed into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction.

Fill material will be placed in 6- to 8-inch layers and shall be continuous over the entire length of the fill. Compaction will be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is traversed by at least one tread track of the equipment, or compaction shall be achieved by the use of a compactor. The embankment shall be constructed to an elevation 10 percent higher than the design height to allow for settlement if compaction is obtained with hauling equipment. If compactors are used for compaction, the overbuild may be reduced to 5 percent.

IV. VEGETATIVE PROTECTION AGAINST EROSION

The waste material, spillway, embankment and any other area disturbed during construction shall be mulched and vegetated immediately upon completion of the pond in accordance with Reclamation Rules and Regulations for revegetation.

V. EROSION AND POLLUTION CONTROL

Construction operations will be carried out in such a manner that erosion and water pollution will be minimized. State and local laws concerning pollution abatement shall be complied with.

EXCAVATED SEDIMENT POND

STRUCTURE PROPORTIONING COMPUTATIONS SHEET

Sediment Storage Requirements

Drainage Area = ______ Ac.
Disturbed Area = ______ Ac. = ______ % of Drainage Area
Sediment Volume = ______ .125 Ac. Ft./Ac. x Area Disturbed = ______ Ac. Ft.

Emergency Spillway Design (If Required)

(See EMERGENCY SPILLWAYS – SEDIMENT DAMS, EMBANKMENT TYPE)

Peak Discharge (Figure 1) = ______ c.f.s. x ______ (slope factor) = ______ c.f.s.

Emergency Spillway Proportions (Table 2)

Emergency Spillway Elevation = ______
Bottom Width, b = ______ ft.
Emergency Spillway Stage, Hp = ______ ft.
Peak Discharge / Bottom Width = $\frac{Q}{b}$ = ______ = ______
Slope of Exit Channel, S_e = ______ % (Chart 1)
Velocity in Exit Channel, V_e = ______ f.p.s. (Chart 1)
Spillway Material ______________
Allowable V_e = ______ f.p.s.
Top of Embankment Elevation = Emergency Spillway Elevation + Hp + 1.0 = ______ + ______ + ______ = ______
or
Top of Embankment = Sediment Pool Elevation + 2.0′ = ______ + ______ = ______

Note:

If pond is to be a regular shape and constructed on relatively flat terrain (less than 20% slope), fill in the following:

Bottom Length = ______ ft.
Bottom Width = ______ ft.
Water Depth = ______ ft.
Side Slopes = ______ ft.
Volume (in ft.^{3}, taking into account side slopes) = ______ ft.^{3} = ______ Ac. Ft.
(1 Ac. Ft. = 43560 Ft.^{3})

LOG AND POLE STRUCTURES

DEFINITION

A barrier composed of logs and poles constructed across a natural or constructed drainway.

PURPOSE

To retard stream flow and catch small sediment loads.

CONDITIONS WHERE PRACTICE APPLIES

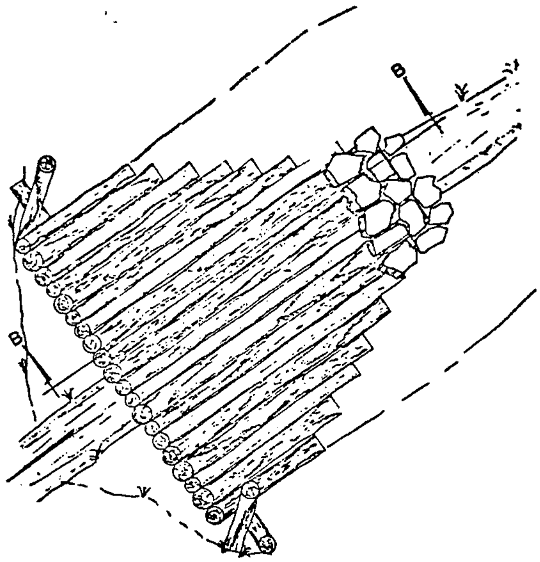
Log and pole structures are to be used only to assist in sediment control and ARE NOT SUBSTITUTES for sediment dams or excavated sediment ponds. When used above such structures, log and pole structures will in no way reduce the required sediment capacity (.125 ac. ft./acre of disturbed area) of sediment dams or excavated sediment ponds.

They may be used in locations such as:

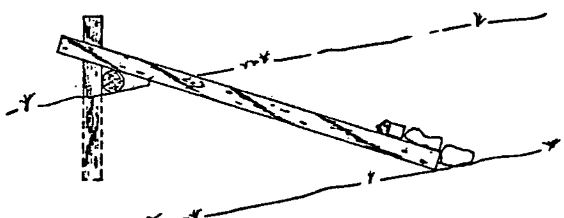
1. In natural drainways close to the disturbed area to catch initial sediment loads.
2. In channels carrying water off the bench toward a natural drainway.
3. Other locations where small localized sedimentation problems exist.

DESIGN CRITERIA

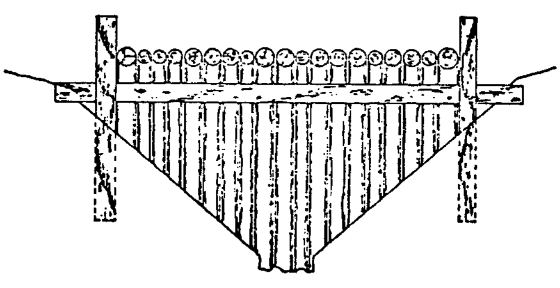
A design is not needed for log and pole structures. Generally they will follow the standard shown. Log and pole structures will not be used on a drainway whose normal discharge is greater than 5 feet per second.



LOG & POLE SILT STRUCTURE



SECTION B-B



UPSTREAM VIEW

STONE CHECK DAMS

DEFINITION

A barrier composed of large stone constructed across a drainway.

PURPOSE

To retard stream flow and form a small sediment basin in order to assist in sediment control.

CONDITIONS WHERE PRACTICE APPLIES

Stone check dams may be used only to assist in sediment control. They ARE NOT SUBSTITUTES for sediment dams or excavated sediment ponds. If used above such structures, stone check dams will in no way reduce the required sediment capacity (.125 ac. ft./acre of disturbed area) of sediment dams and excavated sediment ponds.

Stone check dams will not be used when the drainage area above them exceeds 50 acres. They may be used in locations such as:

1. In natural or constructed drainways close to the disturbed area in order to catch initial sediment loads.
2. In channels carrying water off the bench toward a natural drainway.
3. Other locations where small localized sedimentation problems exist.

DESIGN CRITERIA

A design is not required for stone check dams; however, the following standard criteria will be used:

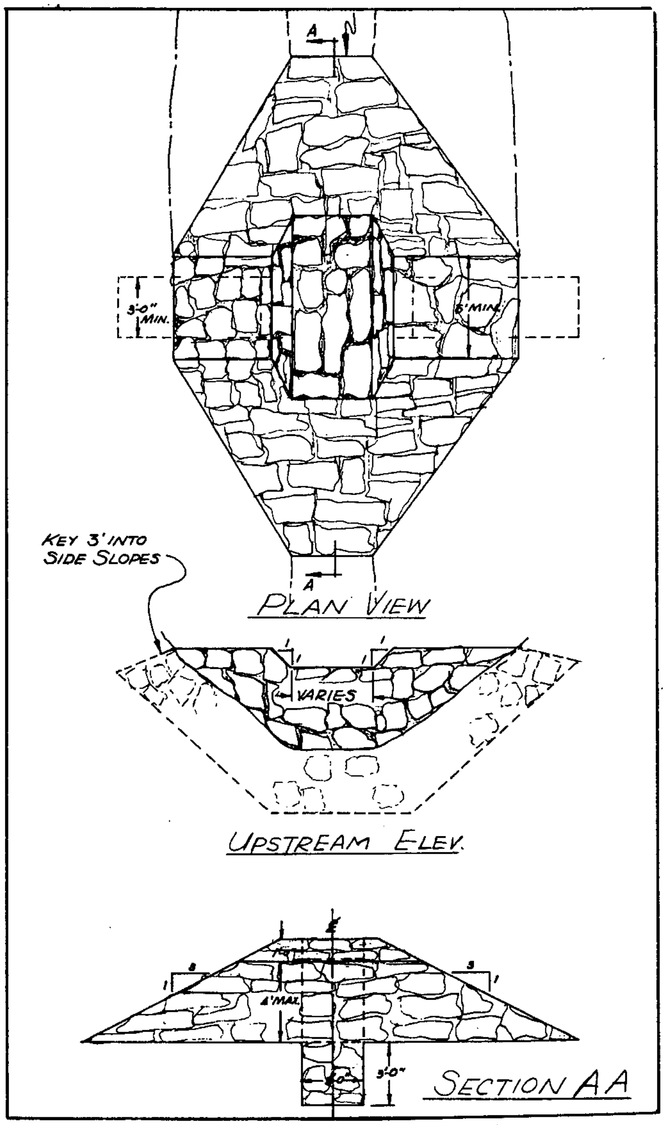
1. Twenty-five percent of the rock will be 18" or larger. The remaining 75% shall be well graded material consisting of sufficient rock small enough to fill the voids between the larger rocks.
2. The dam will be keyed into the sides and bottom of the channel a minimum depth of 3 feet. Minimum width of the key will be 3 feet.
3. Upstream slope and downstream slope will be 3 horizontal to 1 vertical.
4. A weir the width of the channel and a minimum of one foot deep will be positioned at the center of the dam.

5. Maximum height will be 4 feet (from lowest point along center-line of dam to crest of weir.

6. Minimum top width shall be 5 feet.

MAINTENANCE

Stone check dams shall be cleaned when sediment capacity is approached.



TOE BERM

DEFINITION

A berm or "bench" of compacted and vegetated soil constructed at the toe of the outer slope.

PURPOSE

To control sheet erosion from the outer spoil slope by diminishing the velocity of the runoff and making it possible for sediment to deposit.

CONDITIONS WHERE PRACTICE APPLIES

The toe berm is used at the toe of the outer spoil slope to control excessive erosion until the slope has been properly revegetated and stabilized. The toe berm should be constructed as soon as the toe of the outer spoil slope is established. This shall be done as mining progresses. The berm shall not be built where concentrated flows from the bench area occurs; it shall be built only where runoff is from spoil slope.

DESIGN CRITERIA

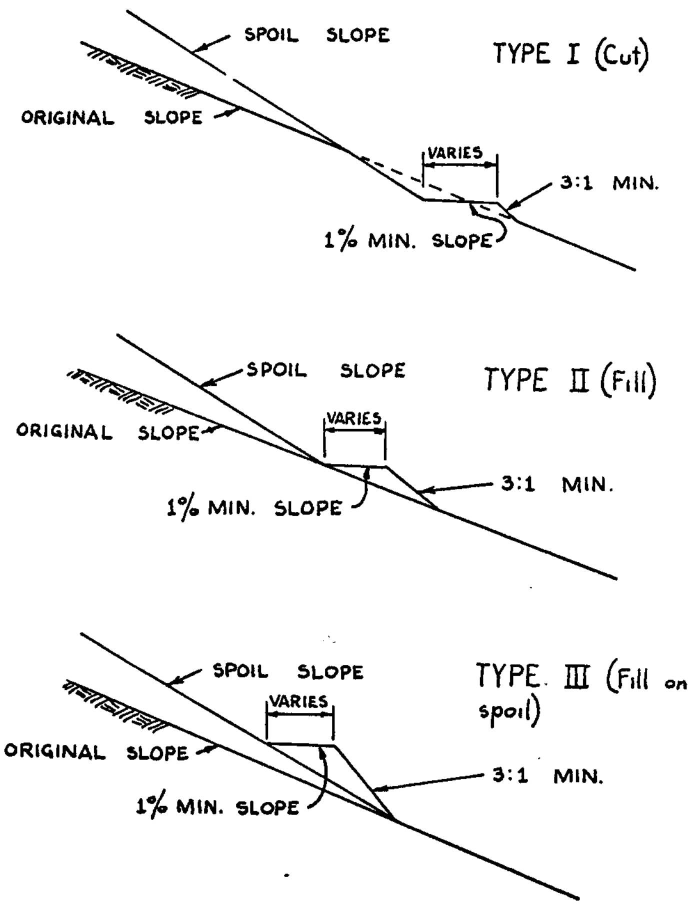
A design is not required for toe berms; however, the following standard criteria will be used:

1. Width of the toe berm will be 10 feet for every 100′ of spoil slope length.
2. Toe berm will be sloped a minimum of 1% and a maximum of 3% away from the toe of spoil.
3. Outer slope of the toe berm will be 3 horizontal to 1 vertical or flatter.
4. Toe berm will be vegetated immediately after construction and shall cover the outer slope, berm, and shall extend a minimum of 10′ up the spoil slope. The Ph and nutrient level of the soil shall be such that a vigorous stand of vegetation can be established.
5. Toe berm will be compacted using suitable construction equipment.

Refer to Figure 1 for different types of toe berm construction.

TOE BERM

FIGURE 1



NOTE: NO SCALE

LEVEL SPREADER

DEFINITION

An outlet constructed at zero percent grade across the slope where concentrated runoff may be spread at non-erosive velocities over undisturbed areas stabilized by existing vegetation.

PURPOSE

The purpose of the level spreader is to convert a concentrated flow of storm runoff into sheet flow and to outlet it onto areas stabilized by existing vegetation without causing erosion.

CONDITIONS WHERE PRACTICE APPLIES

Level spreaders may be used where storm runoff is concentrated and diverted from surface mined areas onto undisturbed stabilized areas (i.e., at diversion outlets, etc.). This practice applies only in those situations where the spreader can be constructed on undisturbed soil and where the area directly below the level lip is stabilized by existing vegetation.

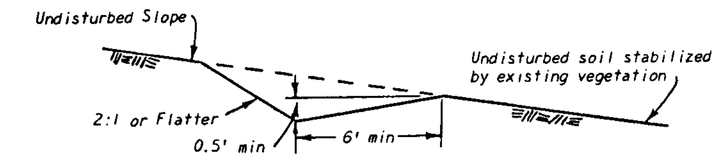
DESIGN CRITERIA

A specific design for level spreaders will not be required. However, spreader length will be determined by estimating Q_1 flow from the Diversion Peak Flow Chart No. 1 and selecting the appropriate length from Table 1, Level Spreader (L.S.-1).

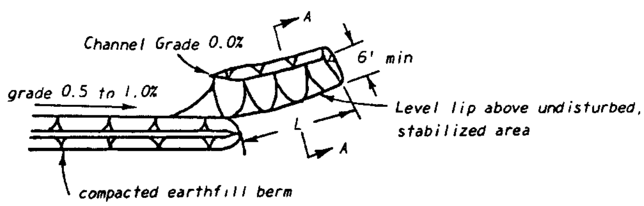
OUTLETS

Final discharge will be over the level lip onto an area already stabilized by existing vegetation.

LEVEL SPREADER



SECTION A-A



PLAN VIEW

Table 1

Designed Q (cfs)	Minimum Length ("L" in Feet)
up to 10	15
11 to 20	20
21 to 30	26
31 to 40	36
41 to 50	44

General Notes:

1. All drawings Not to Scale.
2. Construct level lip on zero percent grade to insure uniform spreading of storm runoff (converting channel flow to sheet flow).
3. Level spreaders must be constructed on undisturbed soil (not on fill).
4. Entrance to spreader must be graded in a manner to insure that runoff enters directly onto the zero percent graded channel.
5. Storm runoff converted to sheet flow must outlet onto areas already stabilized by existing vegetation.
6. Periodic inspection and maintenance must be provided to insure intended purpose is accomplished.

DIVERSION

DEFINITION

A graded channel constructed across the slope with or without a supporting ridge on the lower side.

PURPOSE

To divert water away from surface mined areas and thereby reduce acid water and sediment problems.

CONDITION WHERE PRACTICE APPLIES

Diversions may be used above the highwall to keep water out of the pit, below the spoil slopes to direct runoff to sediment ponds, and in other locations as needed.

DESIGN CRITERIA

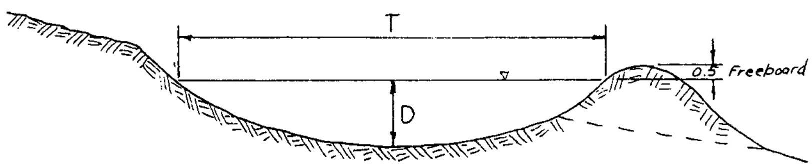
CAPACITY: Diversions shall have the capacity to carry at least the peak discharge from the contributing watershed for a one year frequency storm. This discharge shall be obtained from Figure 1, Diversion Design Peak Discharge. Table 1 and Chart 1 will be used to proportion trapezoidal and triangular shaped diversion ditches. Table 2 will be used to proportion parabolic shaped diversions. Trapezoidal or triangular shaped ditches are easier than parabolic to construct on slopes exceeding 20 per cent. All diversions constructed in earth will be vegetated immediately upon completion according to Reclamation Rules and Regulations for revegetation.

VELOCITY: Maximum permissible velocities of flow shall be as follows:

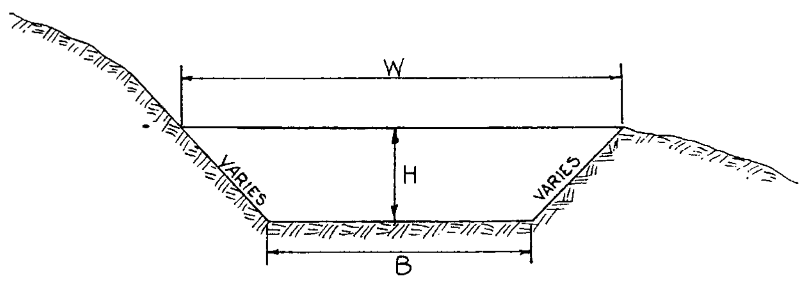
	MAXIMUM PERMISSIBLE VELOCITIES Feet per Second		
SOIL TEXTURE	Bare Channel	Vegetated Channel	Rock Rip Rap
Sand, silt, sandy loam and silty loam	1.5	2.5	12
Silty clay loam and sandy clay loam	2.0	3.5	12
Clay	2.5	4.5	12

Rock riprap, when required, will be placed in a 1.5 feet thick blanket on the bottom and sides of the channel. Twenty-five per cent of the rock will be 18 inches or slightly larger. The remaining 75% shall be well graded material consisting of sufficient rock small enough to fill the voids between the larger rocks.

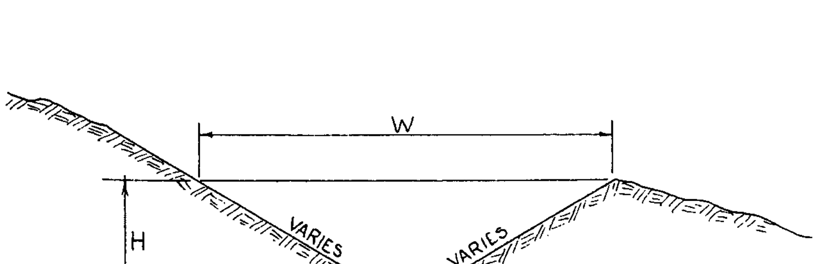
CROSS SECTION: The channel shall be approximately parabolic, triangular, or trapezoidal, with side slopes no steeper than 1.5:1. When a ridge is used it shall have a minimum width of four (4) feet at the design water elevation, and must provide a minimum 0.5 foot for freeboard and settlement above this elevation. Typical cross sections are shown below:



PARABOLIC



D-1, D-2, D-3, D-4 TRAPEZOIDAL



D-5, D-6, D-7 TRIANGULAR

GRADE: Channel grades may be uniform or variable. The allowable velocity for the particular soil type and vegetal cover will determine the maximum grade.

LOCATION: Diversion location shall be determined by outlet conditions, topography, soil type, and length of slope.

PROTECTION AGAINST SEDIMENTATION: When movement of sediment into the channel is a significant problem, a vegetated filter strip shall be used above the diversion.

OUTLETS: Each diversion must have an adequate outlet. The outlet may be a natural drainway, vegetated area, or other stable watercourse. In all cases, the outlet must convey runoff to a point where outflow will not cause damage. Vegetative outlets shall be installed before diversion construction, if needed, to insure establishment of vegetation cover in the outlet channels.

MAINTENANCE: All diversions shall be kept free of sediment and other debris so that the flow of water will remain uninterrupted.

PLANS, DESIGN DATA AND SPECIFICATIONS

In addition to the "Proposed Drainage Map", there shall also be submitted the following items concerning diversions:

1. A "Diversion Design Computation Sheet" to be completed for each proposed diversion.
2. Construction plans showing:

   a. A surveyed profile along the centerline of the diversion showing original ground line and proposed diversion bottom.

   b. Channel cross sections showing the bottom width, side slopes, and depth of flow.

   c. Type of soil in which diversion will be excavated. The soil shall be sampled and classified at intervals not exceeding 500 feet.
3. Construction and vegetation specifications.

CONSTRUCTION SPECIFICATIONS

I. SITE PREPARATION

Obstructions will be removed, as necessary for construction of the diversion.

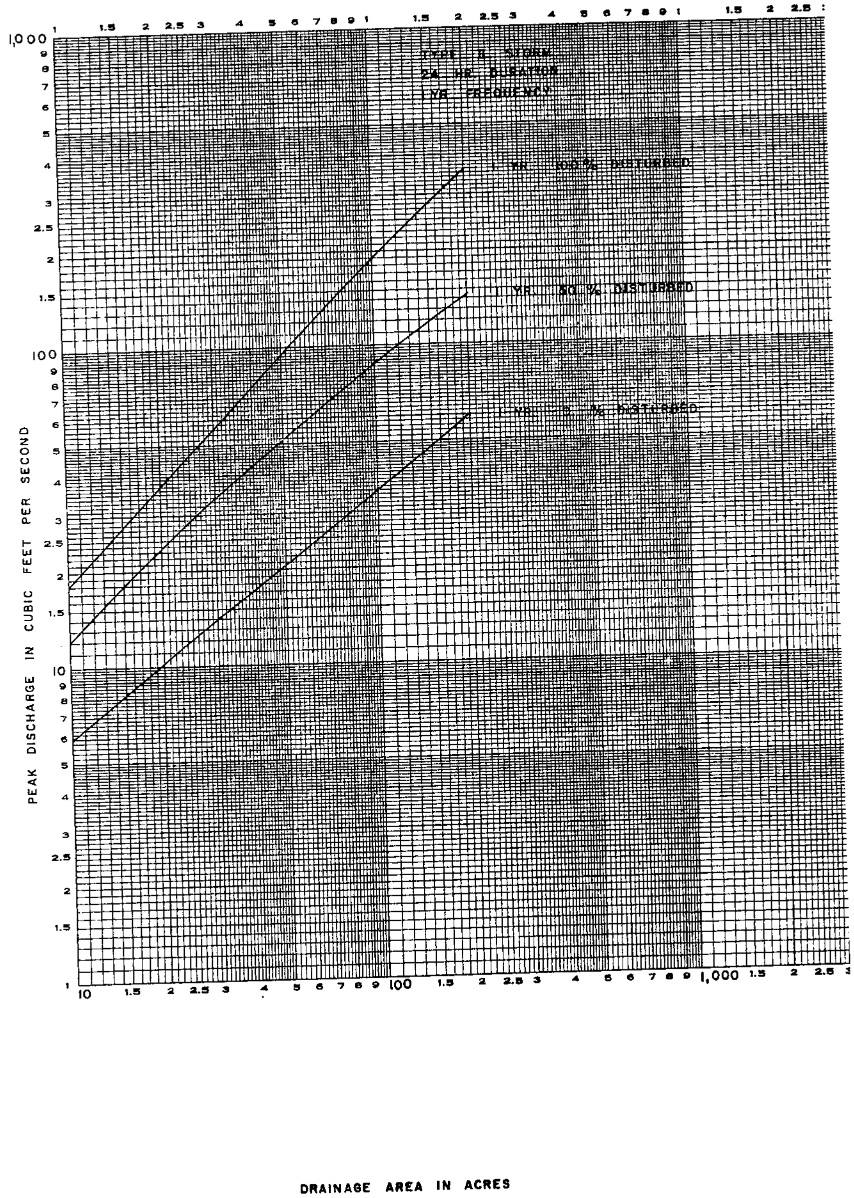
II. EXCAVATION AND SHAPING

The completed diversion shall conform to the line, grade, and cross section as shown on the plans. The top of the constructed ridge or low bank shall not be lower at any point than the designed elevation, including freeboard and the settlement factor. The constructed channel shall be generally free draining and low spots shall not exceed 0.2 foot in depth. All portions of the diversion shall be finished and smoothed as needed for the establishment of vegetative cover.

III. PROTECTION AGAINST EROSION

The completed diversion shall be mulched and vegetated in accordance with Reclamation Rules and Regulations for revegetation.

FIGURE I
DIVERSION DESIGN PEAK DISCHARGE



PARABOLIC WATERWAY DESIGN

GRADE %	Q cfs	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
		T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
.25	15																		
	20																		
	25	10	2.4																
	30	11	2.3																
	35	13	2.3																
	40	15	2.3	10	2.7														
	45	17	2.2	12	2.6														
	50	19	2.2	13	2.6														
	55	20	2.2	14	2.6														
	60	22	2.2	15	2.5														
	65	24	2.2	17	2.5														
	70	26	2.2	18	2.5	13	3.1												
	75	28	2.2	19	2.5	13	3.0												
	80	29	2.2	20	2.5	14	3.0												
	90	33	2.2	23	2.5	16	3.0												
	100	38	2.2	25	2.5	18	3.0												
.50	15	9	1.6																
	20	11	1.6																
	25	14	1.6	9	1.9														
	30	17	1.6	11	1.9	8	2.2												
	35	20	1.6	12	1.9	9	2.1												
	40	22	1.6	14	1.8	11	2.1												
	45	25	1.5	16	1.8	12	2.0												
	50	28	1.5	18	1.8	13	2.0	10	2.4										
	55	31	1.5	19	1.8	15	2.0	11	2.4										
	60	33	1.5	21	1.8	16	2.0	11	2.4										
	65	36	1.5	23	1.8	17	2.0	12	2.4										
	70	39	1.5	24	1.8	18	2.0	13	2.3										
	75	42	1.5	26	1.8	20	2.0	14	2.3	11	2.7								
	80	44	1.5	28	1.8	21	2.0	15	2.3	12	2.7								
	90	50	1.5	31	1.8	24	2.0	17	2.3	13	2.7								
	100	55	1.5	35	1.8	26	2.0	19	2.3	15	2.6	12	3.0						

Q = Flow in Cubic Feet per second V = Velocity in Feet per Second T = Top Width in Feet
D = Depth in Feet

PARABOLIC WATERWAY DESIGN

GRADE %	Q cfs	V = 2.0 T	V = 2.0 D	V = 2.5 T	V = 2.5 D	V = 3.0 T	V = 3.0 D	V = 3.5 T	V = 3.5 D	V = 4.0 T	V = 4.0 D	V = 4.5 T	V = 4.5 D	V = 5.0 T	V = 5.0 D	V = 5.5 T	V = 5.5 D	V = 6.0 T	V = 6.0 D
.75	15	12	1.3	7	1.6														
	20	16	1.3	9	1.5														
	25	19	1.3	11	1.5	8	1.7												
	30	23	1.3	13	1.5	10	1.7	8	1.9										
	35	27	1.3	15	1.5	11	1.7	9	1.9										
	40	31	1.3	18	1.5	13	1.7	10	1.9										
	45	35	1.3	20	1.5	14	1.7	11	1.8										
	50	38	1.3	22	1.5	16	1.6	13	1.8	9	2.2								
	55	42	1.3	24	1.5	18	1.6	14	1.8	10	2.1								
	60	46	1.3	26	1.5	19	1.6	15	1.8	11	2.1								
	65	50	1.3	28	1.5	21	1.6	16	1.8	12	2.1	10	2.1						
	70	53	1.3	30	1.5	22	1.6	17	1.8	13	2.1	11	2.4						
	75	57	1.3	33	1.5	24	1.6	19	1.8	14	2.1	11	2.3						
	80	61	1.3	35	1.5	25	1.6	20	1.8	15	2.1	12	2.3						
	90	68	1.3	39	1.5	28	1.6	22	1.8	16	2.1	13	2.3	11	2.6				
	100	76	1.3	43	1.5	32	1.6	25	1.8	18	2.1	15	2.3	12	2.6				
1.00	15	13	1.1	8	1.3														
	20	18	1.1	11	1.3	8	1.5												
	25	22	1.1	14	1.3	9	1.5	8	1.6										
	30	27	1.1	17	1.3	11	1.5	9	1.6										
	35	31	1.1	19	1.3	13	1.5	11	1.6	8	1.8								
	40	35	1.1	22	1.3	15	1.4	12	1.6	9	1.8								
	45	40	1.1	25	1.3	17	1.5	13	1.6	10	1.8								
	50	44	1.1	28	1.3	19	1.4	15	1.6	11	1.8	9	2.0						
	55	48	1.1	30	1.3	20	1.4	16	1.5	12	1.8	10	2.0						
	60	53	1.1	33	1.3	22	1.4	18	1.5	14	1.7	10	2.0						
	65	57	1.1	36	1.3	24	1.4	19	1.5	15	1.7	11	2.0	9	2.2				
	70	61	1.1	38	1.3	26	1.4	21	1.5	16	1.7	12	2.0	10	2.2				
	75	66	1.1	41	1.3	28	1.4	22	1.5	17	1.7	13	2.0	11	2.2				
	80	70	1.1	44	1.3	29	1.4	24	1.5	18	1.7	14	2.0	11	2.2				
	90	79	1.1	49	1.3	33	1.4	27	1.5	20	1.7	15	1.9	13	2.2	11	2.4		
	100	87	1.1	55	1.3	37	1.4	29	1.5	22	1.7	17	1.9	14	2.2	12	2.4		

Q = Flow in Cubic Feet per second   V = Velocity in Feet per Second   T = Top Width in Feet
D = Depth in Feet

D = Depth in Feet

PARABOLIC WATERWAY DESIGN

GRADE %	Q cfs	V = 2.0 T	V = 2.0 D	V = 2.5 T	V = 2.5 D	V = 3.0 T	V = 3.0 D	V = 3.5 T	V = 3.5 D	V = 4.0 T	V = 4.0 D	V = 4.5 T	V = 4.5 D	V = 5.0 T	V = 5.0 D	V = 5.5 T	V = 5.5 D	V = 6.0 T	V = 6.0 D
1.25	15	15	1.0	10	1.2	7	1.4												
	20	20	1.0	13	1.1	9	1.3	7	1.5										
	25	25	1.0	16	1.1	11	1.3	8	1.5	7	1.6								
	30	31	1.0	19	1.1	13	1.3	10	1.4	8	1.6								
	35	36	1.0	23	1.1	15	1.3	11	1.4	9	1.6	7	1.8						
	40	41	1.0	26	1.1	17	1.3	13	1.4	11	1.6	8	1.8						
	45	46	1.0	29	1.1	19	1.3	14	1.4	12	1.5	9	1.7						
	50	50	1.0	32	1.1	21	1.3	16	1.4	13	1.5	10	1.7	8	2.0				
	55	55	1.0	35	1.1	23	1.3	18	1.4	14	1.5	11	1.7	9	1.9				
	60	60	1.0	38	1.1	26	1.3	19	1.4	16	1.5	12	1.7	10	1.9				
	65	65	1.0	41	1.1	28	1.3	21	1.4	17	1.5	13	1.7	11	1.9	9	2.2		
	70	70	1.0	45	1.1	30	1.3	22	1.4	18	1.5	14	1.7	11	1.9	9	2.2		
	75	75	1.0	48	1.1	32	1.3	24	1.4	19	1.5	15	1.7	12	1.9	10	2.1		
	80	80	1.0	51	1.1	34	1.3	25	1.4	21	1.5	16	1.7	13	1.9	11	2.1	9	2.3
	90	90	1.0	57	1.1	38	1.3	29	1.4	23	1.5	18	1.7	15	1.9	12	2.1	10	2.3
	100	100	1.0	63	1.1	42	1.3	32	1.4	26	1.5	20	1.7	16	1.9	13	2.1	11	2.3
1.50	15	17	0.9	11	1.1	8	1.2												
	20	23	0.9	15	1.0	10	1.2	7	1.4	6	1.5								
	25	28	0.9	19	1.0	12	1.2	9	1.4	7	1.5								
	30	34	0.9	22	1.0	15	1.2	10	1.3	8	1.5	7	1.6						
	35	40	0.9	26	1.0	17	1.1	12	1.3	10	1.4	8	1.6						
	40	45	0.9	30	1.0	20	1.2	14	1.3	11	1.4	9	1.6	7	1.8				
	45	51	0.9	33	1.0	22	1.1	15	1.3	12	1.4	10	1.5	8	1.8				
	50	56	0.9	37	1.0	25	1.1	17	1.3	14	1.4	11	1.5	9	1.8				
	55	62	0.9	41	1.0	27	1.1	19	1.3	15	1.4	12	1.5	10	1.7	8	1.9		
	60	67	0.9	44	1.0	30	1.1	20	1.3	16	1.4	14	1.5	11	1.7	9	1.9		
	65	73	0.9	48	1.0	32	1.1	22	1.3	18	1.4	15	1.5	11	1.7	10	1.9		
	70	78	0.9	51	1.0	34	1.1	24	1.3	19	1.4	16	1.5	12	1.7	10	1.9	9	2.1
	75	83	0.9	55	1.0	37	1.1	25	1.3	21	1.4	17	1.5	13	1.7	11	1.9	9	2.1
	80	89	0.9	59	1.0	39	1.1	27	1.3	22	1.4	18	1.5	14	1.7	12	1.9	10	2.1
	90	100	0.9	66	1.0	44	1.1	30	1.3	25	1.4	20	1.5	16	1.7	13	1.9	11	2.0
	100	111	0.9	73	1.0	49	1.1	33	1.3	27	1.4	22	1.5	17	1.7	15	1.9	12	2.0

Q = Flow in Cubic Feet per second   V = Velocity in Feet per Second   T = Top Width in Feet
D = Depth in Feet

PARABOLIC WATERWAY DESIGN

GRADE	Q	V = 2.0		V = 2.5		V = 3.0		V = 3.5		V = 4.0		V = 4.5		V = 5.0		V = 5.5		V = 6.0	
%	cfs	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
1.75	15	19	0.9	12	1.0	9	1.1	6	1.3										
	20	25	0.9	16	1.0	11	1.1	8	1.3	7	1.3								
	25	31	0.9	20	1.0	14	1.1	10	1.2	8	1.3	7	1.5						
	30	37	0.9	24	1.0	17	1.1	12	1.2	10	1.3	8	1.4						
	35	43	0.9	28	1.0	20	1.1	13	1.2	11	1.3	9	1.4	7	1.6				
	40	49	0.9	32	1.0	22	1.1	15	1.2	13	1.3	10	1.4	8	1.6				
	45	55	0.9	36	1.0	25	1.1	17	1.2	14	1.3	12	1.4	9	1.6	8	1.7		
	50	61	0.9	40	1.0	28	1.1	19	1.2	16	1.3	13	1.4	10	1.4	8	1.7		
	55	67	0.9	44	1.0	31	1.1	21	1.2	17	1.3	14	1.4	11	1.5	9	1.7	8	1.9
	60	73	0.9	48	1.0	33	1.1	23	1.2	19	1.3	15	1.4	12	1.5	10	1.7	8	1.9
	65	78	0.9	52	1.0	36	1.1	25	1.2	21	1.3	17	1.4	13	1.5	11	1.7	9	1.9
	70	84	0.9	56	1.0	39	1.1	27	1.2	22	1.3	18	1.4	14	1.5	12	1.7	10	1.9
	75	90	0.9	59	1.0	42	1.1	29	1.2	24	1.3	19	1.4	15	1.5	12	1.7	10	1.9
	80	96	0.9	63	1.0	44	1.1	30	1.2	25	1.3	20	1.4	16	1.5	13	1.7	11	1.9
	90	108	0.9	71	1.0	50	1.1	34	1.2	28	1.3	23	1.4	18	1.5	15	1.7	12	1.9
	100	120	0.9	79	1.0	55	1.1	38	1.2	31	1.3	25	1.4	20	1.5	16	1.7	13	1.9
2.00	15	21	0.8	13	0.9	9	1.0	7	1.2										
	20	28	0.8	17	0.9	12	1.0	9	1.1	7	1.3	5	1.4						
	25	35	0.8	21	0.9	15	1.0	11	1.1	8	1.3	7	1.4						
	30	41	0.8	26	0.9	18	1.0	13	1.1	10	1.2	8	1.3	7	1.5				
	35	48	0.8	30	0.9	22	1.0	15	1.1	11	1.2	9	1.3	8	1.5				
	40	55	0.8	34	0.9	25	1.0	18	1.1	13	1.2	11	1.3	9	1.5	7	1.7		
	45	62	0.8	38	0.9	28	1.0	20	1.1	14	1.2	12	1.3	10	1.4	8	1.6		
	50	68	0.8	42	0.9	31	1.0	22	1.1	16	1.2	13	1.3	11	1.4	9	1.6	8	1.7
	55	75	0.8	46	0.9	34	1.0	24	1.1	17	1.2	14	1.3	12	1.4	10	1.6	8	1.7
	60	82	0.8	51	0.9	37	1.0	26	1.1	19	1.2	16	1.3	13	1.4	11	1.6	9	1.7
	65	88	0.8	55	0.9	40	1.0	28	1.1	21	1.2	17	1.3	14	1.4	11	1.6	10	1.7
	70	95	0.8	59	0.9	43	1.0	30	1.1	22	1.2	18	1.3	15	1.4	12	1.6	10	1.7
	75	101	0.8	63	0.9	46	1.0	32	1.1	24	1.2	20	1.3	16	1.4	13	1.6	11	1.7
	80	108	0.8	67	0.9	48	1.0	35	1.1	25	1.2	21	1.3	17	1.4	14	1.6	12	1.7
	90	121	0.8	75	0.9	54	1.0	39	1.1	28	1.2	23	1.3	19	1.4	16	1.6	13	1.7
	100	134	0.8	83	0.9	60	1.0	43	1.1	31	1.2	26	1.3	21	1.4	17	1.6	15	1.7

Q = Flow in Cubic Feet per second V = Velocity in Feet per Second T = Top Width in Feet
D = Depth in Feet

PARABOLIC WATERWAY DESIGN

GRADE %	Q cfs	V = 2.0 T	V = 2.0 D	V = 2.5 T	V = 2.5 D	V = 3.0 T	V = 3.0 D	V = 3.5 T	V = 3.5 D	V = 4.0 T	V = 4.0 D	V = 4.5 T	V = 4.5 D	V = 5.0 T	V = 5.0 D	V = 5.5 T	V = 5.5 D	V = 6.0 T	V = 6.0 D
3.0	15	24	0.7	16	0.8	11	0.8	9	0.9	7	1.0	5	1.2						
	20	31	0.7	22	0.8	15	0.8	12	0.9	9	1.0	7	1.1	6	1.2				
	25	39	0.7	27	0.8	19	0.8	15	0.9	11	1.0	8	1.0	7	1.2	6	1.3		
	30	47	0.7	32	0.8	23	0.8	17	0.9	13	1.0	10	1.1	9	1.2	7	1.2	6	1.4
	35	55	0.7	38	0.8	26	0.8	20	0.9	15	1.0	11	1.1	10	1.1	8	1.2	7	1.4
	40	62	0.7	43	0.8	30	0.8	23	0.9	17	1.0	13	1.1	12	1.1	9	1.2	8	1.4
	45	70	0.7	48	0.8	34	0.8	26	0.9	19	1.0	15	1.1	13	1.1	11	1.2	9	1.3
	50	77	0.7	54	0.8	38	0.8	29	0.9	21	1.0	16	1.1	14	1.1	12	1.2	9	1.3
	55	85	0.7	59	0.8	41	0.8	32	0.9	23	1.0	18	1.1	16	1.1	13	1.2	10	1.4
	60	93	0.7	64	0.8	45	0.8	35	0.9	26	1.0	19	1.1	17	1.1	14	1.2	11	1.3
	65	100	0.7	70	0.8	49	0.8	37	0.9	28	1.0	21	1.1	19	1.1	15	1.2	12	1.3
	70	107	0.7	74	0.8	52	0.8	40	0.9	30	1.0	22	1.1	20	1.1	16	1.2	13	1.3
	75	115	0.7	79	0.8	56	0.8	43	0.9	32	1.0	24	1.1	21	1.1	18	1.2	14	1.3
	80	122	0.7	85	0.8	59	0.8	46	0.9	34	1.0	26	1.1	23	1.1	19	1.2	15	1.3
	90	137	0.7	95	0.8	67	0.8	51	0.9	38	1.0	29	1.1	26	1.1	21	1.2	17	1.3
	100	152	0.7	105	0.8	74	0.8	57	0.9	42	1.0	32	1.1	28	1.1	23	1.2	19	1.3
4.0	15	28	0.6	20	0.7	14	0.7	10	0.8	8	0.9	6	0.9	5	1.1				
	20	37	0.6	27	0.7	19	0.7	14	0.8	11	0.8	8	0.9	6	1.0	6	1.1		
	25	46	0.6	33	0.7	23	0.7	17	0.8	13	0.8	11	0.9	8	1.0	7	1.1	6	1.2
	30	55	0.6	40	0.7	28	0.7	20	0.8	16	0.8	13	0.9	10	1.0	8	1.1	7	1.2
	35	64	0.6	46	0.7	32	0.7	24	0.8	18	0.8	15	0.9	11	1.0	10	1.1	8	1.2
	40	73	0.6	52	0.7	37	0.7	27	0.8	21	0.8	17	0.9	13	1.0	11	1.0	9	1.1
	45	82	0.6	59	0.7	41	0.7	30	0.8	23	0.8	19	0.9	14	1.0	12	1.1	10	1.1
	50	91	0.6	65	0.7	46	0.7	34	0.8	26	0.8	21	0.9	16	1.0	14	1.1	11	1.1
	55	100	0.6	72	0.7	50	0.7	37	0.8	29	0.8	23	0.9	17	1.0	15	1.0	12	1.1
	60	109	0.6	78	0.7	55	0.7	40	0.8	31	0.8	25	0.9	19	1.0	16	1.0	13	1.1
	65	117	0.6	84	0.7	59	0.7	44	0.8	34	0.8	27	0.9	20	1.0	18	1.0	14	1.1
	70	126	0.6	90	0.7	63	0.7	47	0.8	36	0.8	29	0.9	22	1.0	19	1.0	15	1.1
	75	135	0.6	97	0.7	68	0.7	50	0.8	39	0.8	31	0.9	24	1.0	20	1.0	17	1.1
	80	143	0.6	103	0.7	72	0.7	53	0.8	41	0.8	33	0.9	25	1.0	21	1.0	18	1.1
	90	161	0.6	115	0.7	81	0.7	60	0.8	46	0.8	37	0.9	28	1.0	24	1.0	20	1.1
	100	178	0.6	128	0.7	90	0.7	66	0.8	51	0.8	41	0.9	31	1.0	27	1.0	22	1.1

Q = Flow in Cubic Feet per second V = Velocity in Feet per Second T = Top Width in Feet
D = Depth in Feet

PARABOLIC WATERWAY DESIGN

GRADE %	Q cfs	V = 2.0 T	V = 2.0 D	V = 2.5 T	V = 2.5 D	V = 3.0 T	V = 3.0 D	V = 3.5 T	V = 3.5 D	V = 4.0 T	V = 4.0 D	V = 4.5 T	V = 4.5 D	V = 5.0 T	V = 5.0 D	V = 5.5 T	V = 5.5 D	V = 6.0 T	V = 6.0 D
5.0	15	29	0.6	21	0.6	15	0.7	12	0.7	9	0.8	7	0.8	6	0.9	5	1.0		
	20	39	0.6	28	0.6	20	0.7	16	0.7	12	0.8	10	0.8	8	0.9	6	1.0	5	1.1
	25	49	0.6	35	0.6	25	0.7	20	0.7	15	0.8	12	0.8	10	0.9	8	1.0	7	1.0
	30	58	0.6	42	0.6	30	0.7	24	0.7	18	0.8	14	0.8	11	0.9	9	1.0	8	1.0
	35	68	0.6	49	0.6	35	0.7	28	0.7	21	0.8	17	0.8	13	0.9	11	0.9	9	1.0
	40	77	0.6	56	0.6	40	0.7	32	0.7	24	0.8	19	0.8	15	0.9	12	0.9	10	1.0
	45	86	0.6	63	0.6	44	0.7	36	0.7	27	0.8	21	0.8	17	0.9	14	0.9	12	1.0
	50	96	0.6	69	0.6	49	0.7	49	0.7	39	0.8	24	0.8	19	0.9	15	0.9	13	1.0
	55	105	0.6	76	0.6	54	0.7	44	0.7	33	0.8	26	0.8	21	0.9	17	0.9	14	1.0
	60	114	0.6	83	0.6	59	0.7	48	0.7	36	0.8	28	0.8	22	0.9	18	0.9	15	1.0
	65	123	0.6	89	0.6	63	0.7	52	0.7	38	0.8	31	0.8	24	0.9	19	0.9	17	1.0
	70	132	0.6	96	0.6	68	0.7	56	0.7	41	0.8	33	0.8	26	0.9	21	0.9	18	1.0
	75	142	0.6	102	0.6	73	0.7	59	0.7	44	0.8	35	0.8	28	0.9	22	0.9	19	1.0
	80	151	0.6	109	0.6	78	0.7	63	0.7	47	0.8	37	0.8	30	0.9	24	0.9	20	1.0
	90	169	0.6	122	0.6	87	0.7	71	0.7	53	0.8	42	0.8	33	0.9	27	0.9	23	1.0
	100	187	0.6	136	0.6	97	0.7	79	0.7	59	0.8	47	0.8	37	0.9	30	0.9	26	1.0
6.0	15	35	0.5	23	0.6	17	0.6	13	0.7	10	0.7	8	0.8	7	0.8	5	0.9	4	1.0
	20	46	0.5	30	0.6	22	0.6	17	0.7	13	0.7	11	0.7	9	0.8	7	0.9	6	1.0
	25	57	0.5	37	0.6	28	0.6	21	0.7	17	0.7	13	0.7	11	0.8	9	0.9	7	0.9
	30	69	0.5	45	0.6	33	0.6	25	0.7	20	0.7	16	0.7	13	0.8	10	0.9	8	0.9
	35	80	0.5	52	0.6	38	0.6	29	0.7	23	0.7	19	0.7	15	0.8	12	0.9	10	0.9
	40	91	0.5	59	0.6	44	0.6	33	0.7	26	0.7	21	0.7	17	0.8	14	0.9	11	0.9
	45	102	0.5	67	0.6	49	0.6	37	0.7	30	0.7	24	0.7	19	0.8	16	0.9	13	0.9
	50	113	0.5	74	0.6	54	0.6	42	0.7	33	0.7	26	0.7	22	0.8	17	0.9	14	0.9
	55	123	0.5	81	0.6	60	0.6	46	0.7	36	0.7	29	0.7	24	0.8	19	0.8	15	0.9
	60	134	0.5	88	0.6	65	0.6	50	0.7	39	0.7	32	0.7	26	0.8	21	0.8	17	0.9
	65	145	0.5	95	0.6	70	0.6	54	0.7	42	0.7	34	0.7	28	0.8	22	0.9	18	0.9
	70	155	0.5	102	0.6	75	0.6	58	0.7	45	0.7	37	0.7	30	0.8	24	0.9	19	0.9
	75	166	0.5	109	0.6	81	0.6	62	0.7	49	0.7	39	0.7	32	0.8	26	0.8	21	0.9
	80	176	0.5	116	0.6	86	0.6	65	0.7	52	0.7	42	0.7	34	0.8	27	0.9	22	0.9
	90	198	0.5	130	0.6	96	0.6	73	0.7	58	0.7	47	0.7	38	0.8	31	0.8	25	0.9
	100	219	0.5	144	0.6	107	0.6	81	0.7	64	0.7	52	0.7	42	0.8	34	0.9	28	0.9

Q = Flow in Cubic Feet per second   V = Velocity in Feet per Second   T = Top Width in Feet
D = Depth in Feet

PARABOLIC WATERWAY DESIGN

GRADE %	Q cfs	V = 2.0 T	V = 2.0 D	V = 2.5 T	V = 2.5 D	V = 3.0 T	V = 3.0 D	V = 3.5 T	V = 3.5 D	V = 4.0 T	V = 4.0 D	V = 4.5 T	V = 4.5 D	V = 5.0 T	V = 5.0 D	V = 5.5 T	V = 5.5 D	V = 6.0 T	V = 6.0 D
8.0	15	37	0.5	27	0.5	19	0.5	15	0.6	12	0.6	9	0.7	8	0.8	6	0.7	5	0.8
	20	49	0.5	35	0.5	25	0.5	20	0.6	16	0.6	13	0.7	10	0.7	9	0.7	7	0.8
	25	61	0.5	44	0.5	31	0.5	25	0.6	19	0.6	16	0.7	13	0.7	11	0.7	9	0.8
	30	73	0.5	53	0.5	37	0.5	30	0.6	23	0.6	19	0.7	16	0.7	13	0.7	11	0.8
	35	85	0.5	61	0.5	43	0.5	35	0.6	27	0.6	22	0.6	18	0.7	15	0.7	12	0.8
	40	97	0.5	70	0.5	49	0.5	40	0.6	31	0.6	25	0.6	21	0.7	17	0.7	14	0.8
	45	109	0.5	78	0.5	55	0.5	45	0.6	35	0.6	28	0.6	23	0.7	19	0.7	16	0.8
	50	120	0.5	87	0.5	61	0.5	50	0.6	38	0.6	31	0.7	26	0.7	21	0.7	17	0.8
	55	132	0.5	95	0.5	67	0.5	55	0.6	42	0.6	34	0.7	28	0.7	23	0.7	19	0.8
	60	143	0.5	103	0.5	73	0.5	60	0.6	46	0.6	37	0.7	31	0.7	25	0.7	21	0.8
	65	155	0.5	111	0.5	79	0.5	65	0.6	50	0.6	40	0.7	33	0.7	27	0.7	23	0.8
	70	166	0.5	120	0.5	85	0.5	69	0.6	53	0.6	43	0.6	36	0.7	29	0.7	24	0.8
	75	177	0.5	128	0.5	91	0.5	74	0.6	57	0.6	46	0.7	38	0.7	31	0.7	26	0.8
	80	188	0.5	136	0.5	96	0.5	79	0.6	61	0.6	49	0.6	41	0.7	33	0.7	28	0.8
	90	211	0.5	152	0.5	108	0.6	88	0.6	68	0.6	55	0.7	46	0.7	37	0.7	31	0.8
	100	234	0.5	168	0.5	120	0.6	98	0.6	75	0.6	61	0.7	51	0.7	41	0.7	34	0.8
10.0	15	45	0.4	33	0.5	23	0.5	17	0.5	13	0.6	11	0.6	9	0.6	7	0.7	6	0.7
	20	60	0.4	43	0.5	30	0.5	22	0.5	18	0.6	14	0.6	12	0.6	10	0.7	8	0.7
	25	75	0.4	54	0.5	38	0.5	28	0.5	22	0.6	18	0.6	15	0.6	12	0.7	10	0.7
	30	89	0.4	64	0.5	45	0.5	33	0.5	27	0.6	21	0.6	18	0.6	15	0.6	12	0.7
	35	104	0.4	75	0.5	53	0.5	38	0.5	31	0.6	25	0.6	21	0.6	17	0.7	14	0.7
	40	118	0.4	85	0.5	60	0.5	44	0.5	35	0.6	28	0.6	24	0.6	20	0.7	16	0.7
	45	132	0.4	95	0.5	67	0.5	49	0.5	40	0.6	32	0.6	27	0.6	22	0.7	18	0.7
	50	146	0.4	105	0.5	74	0.5	54	0.5	44	0.6	35	0.6	30	0.6	24	0.7	20	0.7
	55	160	0.4	115	0.5	82	0.5	60	0.5	48	0.6	39	0.6	32	0.6	27	0.6	22	0.7
	60	174	0.4	124	0.5	87	0.5	65	0.5	52	0.6	42	0.6	35	0.6	29	0.7	24	0.7
	65	188	0.4	135	0.5	96	0.5	70	0.5	57	0.6	45	0.6	38	0.6	32	0.7	26	0.7
	70	201	0.4	145	0.5	103	0.5	75	0.5	61	0.6	49	0.6	41	0.6	34	0.7	28	0.7
	75	215	0.4	155	0.5	110	0.5	80	0.5	65	0.6	52	0.6	44	0.6	36	0.7	30	0.7
	80	228	0.4	164	0.5	116	0.5	85	0.5	69	0.6	55	0.6	47	0.6	39	0.7	32	0.7
	90	255	0.4	184	0.5	131	0.5	96	0.5	76	0.6	62	0.6	52	0.6	43	0.7	36	0.7
	100	282	0.4	204	0.5	145	0.5	106	0.5	86	0.6	69	0.6	58	0.6	48	0.7	40	0.7

Q = Flow in Cubic Feet per second V = Velocity in Feet per Second T = Top Width in Feet
D = Depth in Feet

DIVERSION DESIGN CHART

CHART NO. 1

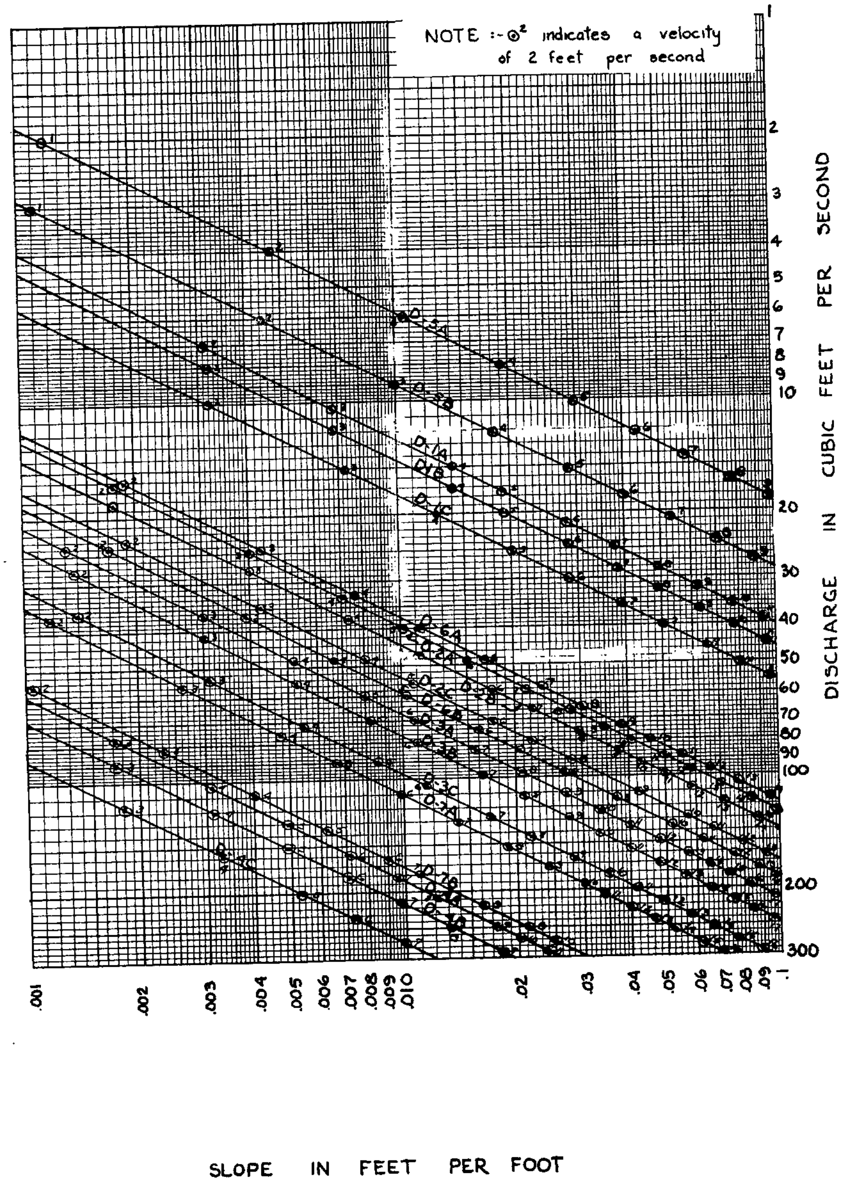


TABLE 1

NO.	SIDE SLOPES	BOT. WIDTH B	DEPTH H	TOP WIDTH W	AREA A (ft²)
D-1A	1½ : 1	2'-0"	1'-0"	5'-0"	3.50
D-1B	2 : 1	2'-0"	1'-0"	6'-0"	4.00
D-1C	3 : 1	2'-0"	1'-0"	8'-0"	5.00
D-2A	1½ : 1	3'-0"	1'-6"	7'-6"	7.88
D-2B	2 : 1	3'-0"	1'-6"	9'-0"	9.00
D-2C	3 : 1	3'-0"	1'-6"	12'-0"	11.25
D-3A	1½ : 1	3'-0"	2'-0"	9'-0"	12.00
D-3B	2 : 1	3'-0"	2'-0"	11'-0"	14.00
D-3C	3 : 1	3'-0"	2'-0"	15'-0"	18.00
D-4A	1½ : 1	4'-0"	3'-0"	13'-0"	25.50
D-4B	2 : 1	4'-0"	3'-0"	16'-0"	30.00
D-4C	3 : 1	4'-0"	3'-0"	22'-0"	39.00
D-5A	2 : 1	—	1'-0"	4'-0"	2.00
D-5B	3 : 1	—	1'-0"	6'-0"	3.00
D-6A	2 : 1	—	2'-0"	8'-0"	8.00
D-6B	3 : 1	—	2'-0"	12'-0"	12.00
D-7A	2 : 1	—	3'-0"	12'-0"	18.00
D-7B	3 : 1	—	3'-0"	18'-0"	27.00

DIVERSION DESIGN COMPUTATION SHEET

LINE	STATIONS	SOIL TYPE	DRAIN AREA (AC)	REQ'D CAP. (cfs)	GRADE (%)	DIMENSIONS		SIDE SLOPES	AVAIL. CAP. (cfs)	VELOCITY	
						DEPTH (FT.)	BOTTOM (FT.)			DESIGN (ft./sec.)	ALLOW. (ft./sec.)

SEEDING

MATERIALS	KIND	RATE	TOTAL (lbs.)
Seed			
Fertilizer			
Lime			
Mulch			

PROFILE ALONG CENTERLINE OF DIVERSION SHOWING CROSS SECTIONS

SLOPE PROTECTION STRUCTURE

ROCK RIPRAP FLUME

DEFINITION

A temporary rock riprap lined channel to conduct surface runoff from the top of a slope to the bottom of the slope.

PURPOSE

To convey storm runoff safely down steep slopes without scouring or erosion damage.

CONDITION WHERE PRACTICE APPLIES

Rock riprap flumes shall be used to convey surface water from the bench to a natural drainway and also in other locations where concentrated flows will produce erosion problems.

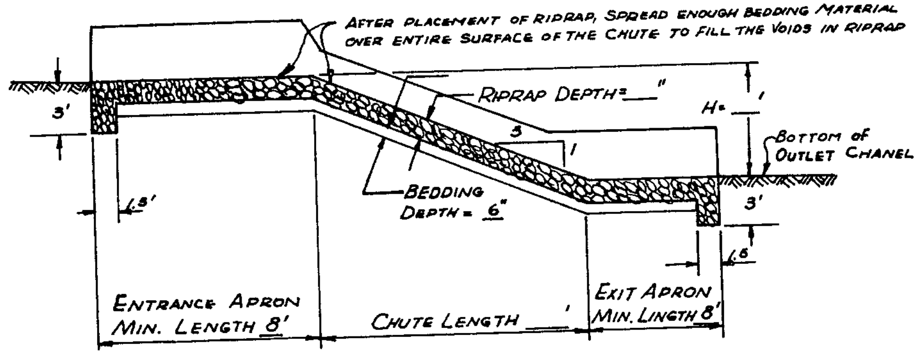
DESIGN CRITERIA

CAPACITY: The flume shall be designed to carry the expected peak flow from a one year frequency storm. This peak flow shall be obtained from Figure 1, Diversion Design Peak Discharge curves. The following table shall be used to determine the required dimensions:

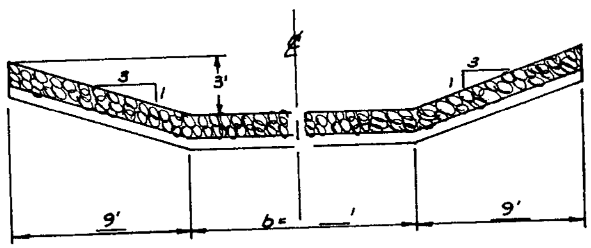
DISCHARGE (cfs)	BOTTOM (ft.)	SIDE SLOPE	CHUTE DEPTH (ft.)	INLET & EXIT DEPTH (ft.)
0 - 30	4	3:1	1.5	3.0
30 - 50	6	3:1	1.5	3.0
50 - 65	8	3:1	1.5	3.0
65 - 80	10	3:1	1.5	3.0
80 - 100	12	3:1	1.5	3.0

SLOPE: The maximum allowable slope shall be 20 per cent.

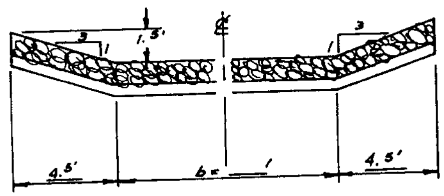
ROCK RIPRAP: A 1.5 foot thick blanket of durable rock riprap will be required. Twenty-five per cent of the rock will be 18 inches or slightly larger and the remaining 75% shall be well graded material consisting of sufficient rock small enough to fill the voids between the larger rocks. Shale shall not be used for riprap.



PROFILE ALONG CENTERLINE



ENTRANCE & EXIT APRON



CHUTE SECTION

PIPE FLOW

DEFINITION

An enclosed water-tight conduit.

PURPOSE

To convey storm runoff down steep slopes without scouring or erosion damage.

CONDITION WHERE PRACTICE APPLIES

Pipe shall be used to convey surface water from the bench to a natural drainway, to carry water beneath haulage roads, and in other locations where concentrated flows will produce erosion damage.

DESIGN CRITERIA

CAPACITY: The size of pipe used shall be adequate to carry the expected peak flow from a one year frequency storm. This peak flow shall be obtained from Figure 1, Diversion Design Peak Discharge curves. The following table shall be used to determine the required dimensions:

DISCHARGE cfs	PIPE DIAMETER inches
0 - 10	21"
10 - 20	24"
20 - 40	30"
40 - 60	36"
60 - 100	42"

BEDDING: All pipe shall be placed in a trench excavated in solid undisturbed ground or formed in compacted earth. The pipe shall be imbedded in a formed cradle to a depth no less than 1/10 times the outside diameter of the pipe. Backfill material shall be placed around and over the pipe in 4 inch layers and thoroughly compacted.

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