SOLDIER CANYON MINE
UTAH

PERMIT TO MINE COAL
APPLICATION PACKAGE

JANUARY, 1991

Volume 8

Soldier Creek Coal Company
Post Office Box I
Price, Utah 84501

PERMIT TRACKING FORM

Type of Proposal:

MRP AMENDMENT		TDN #	
MRP REVISION	X	NOV #N ___ ___ ___ ___, # ___ of ___	
EXPLORATION		CO #C ___ ___ ___ ___, # ___ of ___	

I. B. C. ______ (Incidental Boundary Change)

Title of Proposal: Road Relocation & Surface expansion

Company Name: Soldier Creek Coal

File #: (INA / PRO / ACT / CEP) 007 / 018 - ~~90~~ 91 - 1 # New Acres: ________

LEAD Reviewers: Randy

		Tech Memo Drafted Yes	No
HYDROLOGY	Sharon	( )	( )
BIOLOGY		( )	( )
ENGINEER	Randy	( )	( )
SOILS	Priscilla	( )	( )
GEOLOGY		( )	( )

Please Check Appropriate Box!!

Dates:

(1) Initial Plan Received 1/9/91
Tech Review Due 3/15/91
Tech Review Complete ______
DOGM Response Sent ______
Operator Response Due ______

(2) Operator Response Rc'd ______
Tech Review Due ______
Tech Review Complete ______
DOGM Response Sent ______
Operator Response Due ______

(3) Operator Response Rc'd ______
Tech Review Due ______
Tech Review Complete ______
DOGM Response Sent ______
Operator Response Due ______

(4) Operator Resubmission ______
Tech Review Due ______
Tech Review Complete ______
DOGM Response Sent ______
Operator Response Due ______

(5) Operator Response Rcd ______
Tech Review Due ______
Tech Review Complete ______
DOGM Response Sent ______
Operator Response Due ______

Conditional Approval ______
Stipulations Due ______
Stipulations Received ______
DOGM Response Sent ______
Final Approval ______
Filed in MRP ______
Author ______
Transmitted ______

COMMENTS: 2 copies recieved
Randy to do ICR

WMN10/1

SC3 SOLDIER CREEK COAL CO.
Telephone (801) 637-6360
P.O. Box I
Price, Utah 84501

January 8, 1991

RECEIVED
JAN 09 1991
DIVISION OF
OIL, GAS & MINING

Daron R. Haddock
Permit Supervisor
Division of Oil, Gas & Mining
355 North West Temple
3 Triad Center, Suite 350
Salt Lake City, UT 84180-1203

RE: Permit Revision Package, Surface Facilities Expansion
Soldier Canyon Mine, Carbon County, Utah
ACT/007/018

Dear Daron:

Soldier Creek Coal Company (Applicant) submits herewith a revision to the approved permit for Soldier Canyon Mine (SCM). The Applicant proposes to increase the bonded area at SCM from 32.2 acres to 37.8 acres. This revision package will incorporate the two previous permit amendments and provide the Applicant with the extra area needed to expand the facilities and realign the county road. This revision package describes the facilities that will be added to SCM, the realignment of the county road, the operations of said facilities, and reclamation procedures that shall occur during final/permanent reclamation.

The Applicant is planning to start the road relocation in early March of 1991 and there after, begin with the construction of the facilities. We request the Division favorably review the enclosed revision and issue an approval of the Surface Facilities Expansion at the Divisions earliest convenience.

If you have any questions concerning this revision, please contact me.

Sincerely,

SOLDIER CREEK COAL COMPANY

Johnny Pappas

Johnny Pappas
Environmental Coordinator

JP/sm

Enclosures

Soldier Canyon Mine Permit Application
Package Volume 8

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Part 10.0

PERMIT REVISION - SURFACE FACILITIES EXPANSION AND COUNTY ROAD RELOCATION

10.1 INTRODUCTION, LEGAL, FINANCIAL AND RELATED INFORMATION {R614-301-100}

10.1.1 INTRODUCTION {R614-301-111}

Soldier Creek Coal Company (Applicant) is planning to upgrade and expand the surface facilities at Soldier Canyon Mine (SCM) during the 1991 calendar year. The expansion proposed by Soldier Creek Coal Company (SC3) will provide the needed facilities and space to accommodate an increase in coal production and preparation for up to 3.5 million tons per year. The planned surface expansions are shown on Exhibit 10.1.1-1 and include the following:

1. Portals into the Rock Canyon Seam
2. 4th North #1 belt, transfer house and crusher
3. Silo conveyor belt
4. 2-6000 ton concrete silos
5. Reclaim tunnel and vibrating feeders
6. Reclaim belt
7. Coal preparation plant
8. Coal truck bin belt
9. Refuse truck bin belt
10. Coal truck bin facilities
11. Refuse truck bin facilities
12. Thickener
13. Coal ground storage
14. Stream culvert
15. Substation 46 KV
16. Power poles
17. Drainage control
18. Access roads
19. County road realignment at mine site for approximately 1235 feet
20. Miscellaneous support equipment

SCM's surface expansion and road relocation will require the Applicant to disturb approximately 6.40 acres, including the two previous incidental boundary changes, within the Applicant's permit area.

10.1.2 EFFECTS ON THE ENVIRONMENT

The effects on the environment due to the surface expansion will be identical to those listed in Section 1.2 of the approved permit for SCM, except that the stream channel of Soldier Creek will be altered by the placement of a culvert in Soldier Creek's natural channel and the county road will be realigned.

Adverse effects on the original environment, because of these changes and the remainder of the expansion, will be kept to a minimum through careful planning and adherence to the permit revision and the approved permit for SCM. The Applicant will strive to maintain the new surface expansion facilities in the same clean and environmental sound conditions, as they now maintain their constructed facilities.

10.1.3 ORGANIZATION OF PERMIT REVISION {R614-303-223}

This permit revision is organized to present the planned surface expansion in a clear and precise format that demonstrates compliance with the permanent regulatory program of OSM and DOGM. The permit revision has been written for direct insertion into the approved permit for SCM - ACT/007/018.

10.1.4 VERIFICATION OF APPLICATION {R614-301-123}

See Section 2.1, page 2-1 of the approved MRP.

10.1.5 IDENTIFICATION OF INTEREST {R614-301-112}

See Section 2.2, pages 2-1 through 2-14 of the approved MRP.

10.1.6 COMPLIANCE INFORMATION {R614-301-113}

See Section 2.3, pages 2-16 through 2-16a of the approved MRP.

10.1.7 RIGHT OF ENTRY AND OPERATION {R614-301-114}

The Applicant bases its right to enter and continue underground mining operations, including the new surface expansions, on the documents listed in Section 2.4, and an agreement with Questar Pipeline Company/Mountain Fuel Supply Company (Illustration 10.1.7-1), B.L.M. Right-of-way Permit (Illustration 10.2.1-1), Stream Alteration Permit (Illustration 10.1.7-2), B.L.M. Culvert Installation Approval (Illustration 10.1.7-3) and two approvals from Carbon County (Illustrations 10.2.1-2 and 10.2.1-3).

10.1.8 AREAS DESIGNATED UNSUITABLE FOR MINING {R614-301-115}

See Section 2.5, page 2-28 of the approved MRP.

10.1.9 PERMIT TERM {R614-301-116}

See Section 2.6, pages 2-29 through 2-30 of the approved MRP.

10.1.10 INSURANCE {R614-301-117}

See Section 2.7, pages 2-31 through 2-33a of the approved MRP.

10.1.11 OTHER LICENSES AND PERMITS {R614-300-113}

See Section 2.8, pages 2-34 through 2-36 of the approved MRP.

10.1.12 BONDING INFORMATION {R614-301-800}

See Section 10.3 of this document.

10.1.13 LOCATION AND FILING APPLICATION {R614-300-121.200}

This Permit Revision Package, when filed with the Division of Oil, Gas & Mining, 355 West North Temple, 3 Triad Center, Suite 350, Salt Lake City, Utah 84180-1203, will simultaneously be filed with the Carbon County Records Office, Carbon County Courthouse, Price, Utah 84501.

10.1.14 PROOF OF PUBLICATION {R614-301-117.200}

The following is a copy of the newspaper advertisement which will be published in a local newspaper of general circulation in the locality of the permit area once a week for four consecutive weeks. Proof of Publication will be filed with the Division within four weeks after the date of publication.

10.1.15 CORRESPONDENCE

Also see Section 2.12, pages 2-59 through 2-225.

10.2 OPERATION PLAN {R614-301-520}

Soldier Creek Coal Company's (SC3) new surface facilities expansion and road relocation will provide the needed facilities and space to accommodate an increase in coal production and preparation for up to 3.5 million tons/year. The anticipated total area of surface disturbance for the facility expansion and road relocation will be approximately 6.4 acres, including previously approved incidental boundary changes. The Applicant has increased the disturbed area boundary at the mine site from 10.03 acres to 18.5 acres (Exhibit 5.1-2), to accommodate the anticipated disturbance and any unanticipated disturbance associated with field fitting of the facilities. In any event, all unanticipated disturbances will abide by the R614 Coal Mining Rules. Perimeter markers will be used to designate the disturbed area boundary (Exhibit 5.1-2). Bonding for the facilities expansion and road relocation is discussed in Section 10.3

10.2.1 PUBLIC AND LANDOWNER PROTECTION {R614-301-521.133}

Measures have been taken by the Applicant to ensure the protection of the landowner and public. The BLM (landowner) has reviewed the road relocation project and has issued the Applicant the necessary right-of-way permit (Illustration 10.2.1-1). Carbon County has also reviewed the road relocation project and has given their approval (Illustration 10.2.1-2 and 3).

The facilities and yard expansion will be fenced for security purposes and access to the expansions will be controlled by roadside gates (Exhibit 10.1.1-1). The fence will be constructed in a similar fashion as the existing fence. The conveyor structure leaving the ROM transfer house will cross the county road totally enclosed, via a tube, and have a 58 foot clearance between it and the county road.

The Applicant will support and maintain all of the additional surface access openings to the underground operations, and secure all of the additional surface facilities associated with the opening during temporary cessation of operations. Notice will be given to the regulatory authority of any temporary cessation of operation that will last for a period of thirty days or more. Any permanent cessation of operations of SCM will initiate the final reclamation of the affected lands as required by the regulations.

The Applicant will notify DOGM of any slide occurring within the permit area that may have a potential adverse effect on public, property, health, safety or the environment. Also, the Applicant will comply with all remedial measures by DOGM.

10.2.2 MINE FACILITIES {R614-301-526}

Mine structures, facilities and relocation of the county road, associated with the planned surface facilities expansion, that will be used to facilitate underground coal mining activities are situated on federally owned property. All planned facilities are shown on Exhibit 10.1.1-1, except for the present conveyor which will be removed, once the new facilities are operational.

As depicted on Exhibit 10.1.1-1, the surface facilities will encroach upon the county road and Soldier Creek. In order to minimize the impact on the water quality, degradation of stream channel and facilitate the road relocation, the applicant has installed approximately 885 feet of culvert. The steam culvert was installed following DOGM's approval of two previously submitted permit amendments (Illustration 10.2.2-1 and 10.2.2-2). As stated in Section 10.2.1, the road relocation has been approved by the BLM and Carbon County and construction activities will begin as soon as the Applicant receives approval from the Division.

All of the facilities constructed as a result of the surface expansions will be designed for the life of the operation. The Applicant plans to use all facilities for the normal operation of SCM and will repair or replace the facilities with items of similar performance standards throughout the life of the operation. The structures that will be constructed will meet the performance standards and will provide adequate compliance so that no significant harm to the environment, public health or safety will result from the use of the structures.

10.2.3 SUPPORT FACILITIES {R614-301-526.220}

All support facilities incident to the operation of Soldier Canyon Mine will operate in accordance with a permit issued for the mine. Support facilities will be located, maintained, and used in a manner that prevents or controls erosion and siltation, water pollution, and damage to public or private property; and to the extent possible using the best technology currently available minimizes additional damage to fish, wildlife and related environmental values; and minimizes additional contributions of suspended solids to stream flow or runoff outside the permit area. Any such contributions will not be in excess of limitations of Utah or Federal law through adequate design and operation of appropriate water pollution control facilities.

A step-by-step progression through the coal conveyance facilities, potential waste material and water discharges is shown on figure 10.2.3-1.

1.0 <u>Liquid discharges from the facility during normal operations and maintenance operations are discussed below.</u>

1.1 <u>Washdown Effluent from the Covered Portion of the #1 Raw Coal Transfer Conveyor</u>

This will be routine maintenance operation to take care of any coal spillage that remains after the material has been shovel cleaned. The effluent will be collected in a catch pan fitted with a 1/2" aperture screen. +1/2" material will be shovel cleaned off the screen. Material and water passing through the screen will be directed to the yard drainage collection ditch below. Hose output would be 35 to 50 gallons per minute. → included in drainage w/ BD.

1.2 <u>Washdown Effluent from the Silo Reclaim Area Including the Conveyor Extension</u>

This will be a routine maintenance operation for coal spillage in the area that remains after shovel cleaning. The hose water and coal will be washed down to a collection sump at the rate of 35 to 50 gallons per minute. The collection sump will be fitted with a 1/2" aperture screen. Plus 1/2" material will be shovel cleaned off the screen. Material and water passing through the screen will be pumped via units (111A) and (111B) into the yard drainage collection ditch adjacent to the silo. Each pump is capable of 75 gallons per minute and only one pump should be operated at one time. Pump start-up and shut-down is controlled by high and low level float controls.

Any silo pad drainage water that may pass through the reclaim hopper together with any water drainage from the silo contents will also eventually end up in the collection sumps.

1.3 <u>Effluents from the Coal Preparation Plant</u>

There should be no discharges from the plant during normal operations as it uses a closed loop concept.

During coal washing operations the plant requires an addition of water to make-up for the losses contained in the moisture added to the refuse and cleaned coal product. These losses are in the order of 19 gallons per minute.

All water used inside the plant is reclaimed and recycled. Washdown water used both during washing hours and non-washing hours is also reclaimed.

Unless there is a simultaneous failure of both clean-up sump pumps in the plant, all liquids contained within the plant that pass onto the ground floor will pass to either the fine coal (jig) sump or in an emergency situation to the sediment pond via the yard area ditch.

In the event that a surplus of water exists in the plant due to operator error, the floor clean-up sumps are fitted with manually operated, valve by-pass pipes delivering the water to the sediment pond via the drainage ditch.

1.4 Drainage from Loadout Bins

Depending upon the length of time that the material is stored in the specification coal and refuse bins, there may be some drain down of the surface moisture.

This water will pass via the yard area into the drainage ditches. Extra dewatering capacity has been included in the preparation plant in the refuse circuit to minimize this problem.

2.0 Liquid Discharges from the Facility During Maintenance Operations

Other than the preparation plant, there should be no additional liquid discharges from the rest of the facilities that are not described in Section 1.0.

2.1 Preparation Plant

Most maintenance situations can be handled without any outside discharges of liquids.

There are, however, three major liquid storage vessels forming part of the preparation plant that may affect this:

1. The fine coal (jig) sump which contains approximately 43,000 gallons maximum
2. The clarified water sump containing 9,300 gallons.
3. The thickener containing approximately 90,000 gallons.

The thickener and the fine coal sump contain a mixture of water and fine coal (minus 100 mesh and 0.75 mm respectively) during normal washing operations.

The fine coal sump is fitted with high and low level drain connections, discharging to the floor. In the event that too much water was allowed to accumulate in that circuit due to operator error, the high level drain could be utilized to drain off excess liquid. If this was done during operations, the liquid would contain fine coal. During shut down periods the liquid would be "clear". The drainage would pass via the floor collection sump pump to either the fine coal sump for solids recovery or directly to the sediment pond via ditch if the liquid was "clear". The above scenario would also apply if ever the entire sump had to be drained in which case every effort would be made to recover the solids portion of the contents via the cyclone and disc filter circuit.

It should be noted that during normal operations, the jig itself retains approximately 27,000 gallons of the sump contents. This amount will always remain in the jig unless it is physically drained.

The jig would require draining to perform certain maintenance operations. The water would pass into the fine coal sump and any overflow of the sump would be dealt with as described earlier.

The clarified water sump is fitting with a low level drain that discharges onto the floor. The water would then pass into the floor collection sump pump for disposal to either the fine coal sump or sediment pond as described earlier.

The thickener is fitted with a variety of devices to ensure efficient operation and maintenance facilities. It has high and low level drains each piped to the yard area drainage ditch. The thickened sludge from the bottom discharge cone is extracted via dual outlet pipes and pumps (1 operating, 1 standby). Each pipe and pump system is equipped with high pressure water connections for preventative flushing to ensure optimum working conditions after shutdown.

The thickener tank has sludge level sensing device which tells the operator exactly where the separation is between the thickened sludge and clarified water.

For a planned thickener drain down (i.e. with all ancillary equipment working) the thickened sludge would be evacuated via the underflow pumps and recovered via the disc filter. The remaining "clear" water would then be drained via the ditch to the sediment pond. On a sludge worst case basis, approximately half the thickener contents could be sludge, leaving approximately 45,000 gallons of "clear" water to be directed to the pond.

For a worst case unplanned emergency thickener drain down (i.e. no thickener rake rotation availability), the following is one possible procedure.

1. Remove as much sludge as possible via the underflow pumps, disc filter, etc.
2. Drain the fine coal sump (recovering any solids) discharging "clear" liquid to the pond.
3. Use the high level drain on the thickener to discharge the "clear" liquid to the pond.
4. Bring in the external sludge pump and transfer material to the fine coal sump.
5. Repair/re-instate thickener
6. Pump transfer fine coal sump sludge back to thickener.

3.0 <u>Anticipated Oversize and Undersize Waste Material</u>

There is only one size of waste material produced by the preparation plant which is not added to the specification coal conveyor, this is the refuse product. The typical amount is shown on the flowsheet. This will vary depending on the raw coal quality.

10.2.4 TRANSPORTATION FACILITIES {R614-301-527.100}

The surface expansion will involve the relocation of the county road and the establishment of two primary roads. The county road will be constructed according to the County and BLM specifications. As shown by the County and BLM approvals, the road satisfies their requirements. Although the County will operate and maintain the new road, the Applicant will maintain reclamation liability for the area throughout the bond liability period.

The two primary roads will be constructed and maintained according to the regulations. The primary road leading into the yard will split in order to access the haulage facilities. The other primary road will access the new portals. Exhibit 10.1.1-1 and figure 10.4.2-1 show the new location of the roads and typical design. As-built drawings and certification of the primary roads will be submitted upon completion of construction of the new operations.

10.2.5 TRANSPORTATION FACILITIES {R614-301-527.200}

As shown on Exhibit 10.1.1-1, the coal haulage, storage, preparation and loadout facilities will be improved to accommodate any projected increase in coal production up to 3.5 million tons per year. The flow sheet (Figure 10.2.3-1), shows the flow of coal exiting the mine, via the 4th North conveyor, and the step-by-step progression through the coal conveyance system. Two ground storage stockpiling locations will be used in connection with the facility expansion (Exhibit 10.1.1-1). One, is located adjacent to the coal silos and will occur as a result of overspillage from #2 coal silo. The other ground storage is adjacent to the existing loadout bin and present coal stockpiling area. The coal stockpiling capacities will be approximately 3000 tons and 10,000 tons, respectively.

When the new facilities are operational, the present conveyor structure will no longer be used and eventually removed. The portion of the existing conveyor that conveys coal to the loadout bin will remain and may eventually be used to provide the operation with the facility to stockpile the approximate 10,000 tons of coal ground storage adjacent to the loadout bins.

10.2.6 HANDLING AND DISPOSAL OF COAL, OVERBURDEN, EXCESS SPOIL, AND COAL MINE WASTE {R614-301-528}

During the construction of the facilities and further development of the new portals, excavated and underground development material will be generated. The Applicant will temporarily store this material on site until the material can be utilized in the construction of pads and roads for the facilities. All underground development waste will be placed around the coal silos and properly shown on the soil recovery and reclamation map. During the backfilling of the culvert extension, underground development material was placed at least 8 feet up from the bottom of the culvert to minimize any chance of saturation. The material was analyzed (Illustration 10.2.6-1) and approved by the Division for use as backfill. This too, will be shown on the soil recovery map and used for backfilling of the highwalls during reclamation. All underground development materials used in backfilling and grading operations during construction of the new facilities will be accounted for in the reclamation plan.

The Applicant is presently gathering baseline information and developing designs for a permanent refuse disposal site. The Permit Revision Package for the refuse disposal site is forthcoming and the Applicant is hopeful to have the Division's approval for its construction and use during October 1991. In the event that weather conditions do not allow this site to be constructed by the time the preparation plant is operational or disposal of underground development waste is necessary, the Applicant would appreciate the cooperation of the Division to allow the temporary stockpiling of coal processing and underground development waste at the mine site, in a location that would best facilitate the needs of the operation. All runoff from the temporary stockpiling will report to a sediment pond and any interim sampling, according to the regulations, will be conducted for acid-toxic forming material. In the event that acid and toxic materials are identified, the storage burial or treatment practices will be consistent with other material handling and disposal provisions of the R614 rules.

Overburden material that will be used for pad and other construction at the mine site were sampled for possible toxic contaminants. Representative samples of the overburden and underburden were taken from a previously completed portal exploration cut. Initial samples were taken on 5/8/89 with subsequent resampling completed on 9/30/89. Respective analysis sheets are presented as Illustration 10.2.6-2. (Note: the second analysis was requested by DOGM due to unusually low values originally determined for neutralization are acid potential. Additional detail on % sulfur and % calcium carbonate were also requested).

Based on the 9/30/89 sample analysis, the following values have been determined.

Parameter	Overburden	Underburden
Total Sulfur as S,%	0.03	0.10
Calcium Carbonate as $CaCO_3$,%	20.3	18.8
Acid Potential*	0.94	3.12
Neutralization Potential*	203.00	188.00
Acid Base Potential*	202.06	184.88

*Reported as Tons $CaCO_3$/1000 Tons Material

10.2.7 NONCOAL WASTE {R614-301-528.330}

All noncoal waste will be handled as stated within our approved permit for SCM.

10.2.8 BLASTING AND EXPLOSIVES {R614-301-524}

The Applicant will comply with all state and federal laws in the use of explosives during the construction of the surface expansion at SCM. A certified blaster will direct all blasting operations with the help of at least one other person. The Applicant will make sure that all contractors working on the project are made aware of the blasting procedures. All blasting records will be kept on file at SCM for the required period of time.

10.2.9 METHODS FOR REMOVING AND STORING TOPSOIL {R614-301-231.100}

The following is a list of equipment to be used for removal of vegetation, boulders and topsoil and for loading the topsoil, substitute topsoil and landscape boulders/riprap.

1. Track Hydraulic Excavator
2. 966 Wheel Loader
3. D8 Dozer
4. 953 Track Loader
5. 12 yd^3 Dump Trucks

The safest and most efficient means of performing this operation will be used to ensure the safety of the equipment operators. Topsoil will be loaded into the dump trucks and hauled to the Applicant's topsoil storage site. Substitute topsoil will be sorted and hauled to the topsoil site and placed in its designated location at the topsoil site. Landscape boulders/riprap will also be hauled and placed in its designated location at the topsoil storage site.

10.2.10 TESTING PLAN FOR EVALUATING TOPSOIL HANDLING AND RECLAMATION PROCEDURES {R614-301-231.300}

The soil will be sampled prior to redistributing as per sections 5.5.3 and 5.5.4 of the approved MRP. Sampling techniques are described in detail in these sections. Soil nutrients and amendments will be added based on these tests.

10.2.11 NARRATIVE DESCRIPTION OF THE CONSTRUCTION, MODIFICATION AND MAINTENANCE OF TOPSOIL STORAGE AND HANDLING AREAS {R614-301-231.400}

The Applicant has received the Division's approval on their PRP to construct a Topsoil Storage site. The Applicant will construct the storage site and place all topsoil, substitute topsoil and a designated amount of landscape boulders/riprap. After placement, the material will be protected according to the R614 regulations as stated in the approved permit revision.

10.2.12 TOPSOIL AND SUBSOIL REMOVAL (R614-301-232}

The stripping depths and quantity of topsoil to be removed prior to any surface disturbances associated with the facilities expansion and road relocation was determined by EarthFax Engineering (Illustration 10.2.12-1). Three areas of potential disturbance (Area 1, Area 2, Area 3) that may arise, as a result of sight-fitting the facilities were also evaluated for their topsoil recovery potential.

A summary of the topsoil and substitute topsoil yardage previously salvaged, to be salvaged and possibly salvaged are shown below.

FROM	PRESENT LOCATION	YARDAGE
Steam Culvert Extension (substitute)	North of storage yard	4000 yd3
Topsoil removed during initial culvert installation	Topsoil Pile-east side of Soldier Creek	660 yd3
Streambank/Ridge Zone 1 Zone 2	South of #2 Fan-east of culvert extension	420 yd3 260 yd3
In-situ soils below & adjacent to Topsoil pile	East side of Soldier Creek-side slope	1420 yd3
Area 1-Topsoil from potential disturbance (0.35 Ac)	West and North of storage yard	735 yd3*
Area 2-Topsoil from potential disturbance (0.09 Acres)	West of storage yard	175 yd3*
Area 3-Potential disturbance for silos and pad construction (0.16 Ac)	North of storage yard	335 yd3*
TOTAL		8005 yd3
TOTAL excluding potential disturbances (Areas 1, 2 and 3)		6760 yd3

*Note: Of the total acreage within each area, topsoil will only be salvaged where the disturbance will occur. Therefore, the topsoil quantity may be much less. The quantities shown are a worst case, assuming the total area is disturbed. When the facilities are constructed, the actual areas of disturbance will be shown and the actual quantity of topsoil salvaged calculated.

The total disturbance, including two previous incidental boundary changes and the potential areas of disturbance is 6.4 acres. The following chart gives a break down of the total acreage requiring topsoil redistribution.

Description	Area	Acres	Yardage - 1 foot Replacement depth
Total disturbance Does not need topsoil replacement Does not need topsoil replacement Does not need topsoil replacement	 Pipeline Road County Road Stream Channel	6.40 0.56 0.83 2.25	
Total Acreage Requiring Topsoil		2.76	4453 yd3
Potential Limits of Disturbance Potential Limits of Disturbance Potential Limits of Disturbance	Area 1 Area 2 Area 3	0.35 0.09 0.16	
Total Area Requiring Topsoil if Area 1, Area 2 and Area 3 are not disturbed		2.16	3485 yd3

Using the 2.16 acres as the area in need of topsoil redistribution at a depth of 1 foot, 3485 yd^3s of topsoil will need to be stockpiled for reclamation. If all the potential areas of disturbance are disturbed (worst case), then 4453 yd^3s of topsoil will need to be stockpiled.

As can be seen from the two charts, the Applicant will stockpile more than enough topsoil and substitute topsoil to adequately reclaim any permitted disturbances, as a result of the facilities expansion and road relocation. The remaining topsoil material will be used in reclaiming pre-SMCRA disturbances (Exhibit 10.3.6-2), where topsoil was not salvaged. Placement of this material will be determined during the permit renewal of the Soldier Canyon Mine Permit.

During the road relocation, an excess amount of cut material may be generated. Much of this material will be used for grading purposes to achieve the proper elevations for the facilities. If there is an excess after site grading is completed, the Applicant will take soil samples to determine the excess material suitable for substitute topsoil. If the analyses determine the excess material as suitable, then the Applicant would, upon DOGM's approval, haul this material to the topsoil storage site for proper placement and protection. This material, the amount to be determined at that time, will also be used for reclamation of pre-SMCRA disturbances.

10.2.13 TOPSOIL SUBSTITUTES AND SUPPLEMENTS {R614-301-233 & 233.100}

The substitute topsoil material gained from the stream culvert extension (Approx. 4000 yd^3s) will be stored at the Applicant's topsoil storage site. There it will be stockpiled separately from the topsoil and revegetated with an interim seed mix. By placing the soil material in such a manner, it can be demonstrated to the Division that the resulting soil medium is equal to, or more suitable for, sustaining vegetation on non-prime farmland areas than the existing topsoil, and results in a soil medium that is the best available in the permit area to support revegetation.

10.2.14 ANALYSIS OF TOPSOIL SUBSTITUTES {R614-301-233.200}

Two composite samples were taken from the stream channel excavation material on 2/26/91 (Illustration 10.2.14-1). The results confirm that this soil has a sandy load texture, a low EC (less than 4.0 mmhos/cm), equal proportions of calcium and magnesium and an SAR valve between 7 and 10. Both samples are suitable for substitute topsoil material once the 10-12 inch rock fragments or greater size are reduced to only 10%.

To ensure that the material contains only 10% rock fragments of the 10-12 inch or greater size, the Applicant will sort the material and remove the rocks and boulders 10-12 inch or greater size.

All other soils previously sampled for use as substitute topsoil can no longer be considered for such use, because the soils have been used as backfill around the initial stream culvert. The placement of the soils as backfill negates their potential for substitute topsoil because of excessive compaction and degradation of the material. The placement of the portal bench/portal slope (Illustration 10.6.5-1) along with the yard expansion material (Illustration 10.2.14-2) as backfill around the culvert was done after the Division's approval. All material used as backfill will be removed during the stream culvert removal and used as backfill against the highwalls during reclamation.

10.2.15 TOPSOIL STORAGE {R614-301-234}

The Applicant has submitted and received Division approval to construct a Topsoil Storage Site (Volume 9). The site will facilitate the storage of topsoil, substitute topsoil and landscape boulders/riprap, and be constructed and maintained according to the R614 regulations.

10.3 RECLAMATION PLAN {R614-301-240, 340, 412, 540 AND 760}

The reclamation plan for the surface facilities expansion at SCM will correspond to the plan as stated in Part 5.0 of the approved permit, ACT/007/018, site specific information for the reclamation of the surface expansion will be listed within this section.

10.3.1 POSTMINING LAND USE {R614-301-413.100, 723, 542.600, 242.100 AND 341}

Specific information on land use is detailed in Section 3.12 of the approved permit. The postmining land use of the area to be disturbed during the construction and operation of the surface facilities expansion is wildlife habitat, rangeland and recreational use and the land will be returned to the pre-mining environment and postmining land use. The reclamation of the area will enhance the present environment by stabilizing the eroding stream channel and revegetating the area. This will insure the continued ability of the land to produce an environment capable of supporting the pre/postmining land use.

10.3.2 STRUCTURES REMOVAL AND SITE CLEANUP{R614-301-541.300, 542.700 AND 763}

The removal of structures from the site will begin when the Applicant permanently closes their operations. All equipment will be removed by the Applicant to other projects, sold as used equipment or sold to a local scrap dealer. This will include all conveyors, the transfer house, silos, reclaim tunnel, feeders, crushers, preparation plant, truck bins and all associated structures. The culvert that was placed into the stream channel will be the last structure removed from the expansion site. It will remain until the county road is relocated and traffic is able to travel through the site. A detailed timetable for the completion of each major step is given on Table 10.3.8-1.

All concrete, asphalt and debris associated with the facilities will be demolished and hauled to the reclaim tunnel area, shaft or portals for deposition. Any additional metal associated with the expansion will be sold to a local scrap dealer. All underground openings will be sealed as stated in Section 5.2, pages 5-3 through 5-6 and all fences will be removed during the structures removal.

10.3.3 BACKFILLING AND GRADING {R614-301-242, 553.100, 541.100, 542 AND 763.200}

All areas affected will be returned to a final surface configuration that closely resembles the existing terrain prior to mining. This configuration will conform to the drainage pattern of the surrounding terrain (Exhibit 10.3-1). Areas that are regraded and revegetated during construction of the facilities and are not disturbed during normal operations will not be disturbed during final backfilling and grading if they are stable and meet revegetation standards. General grading specifications are listed in Section 5.4 of the approved permit.

Material balance for the backfilling and grading is contained in Table 10.3.8-2. This indicates that all material will be used in the reclamation of the highwalls and slopes created during the surface expansions. As stated previously, all drainage control in-place during the operation of the facilities will be removed and replaced with silt fence dikes during the monitoring period of permanent reclamation.

10.3.4 DRAINAGE CONTROL {R614-301-761, 553, 140 AND 742}

Drainage controls that will be installed during construction of the site will be impossible to maintain during permanent reclamation because of the removal of the stream culvert. Drainage controls will be left in-place during structure removal and site cleanup. Following this phase of the reclamation, the controls will be removed until the site is backfilled, regraded and the culvert removed from the stream. Straw bale check dams shall be placed at appropriate locations down stream prior to the removal of the stream culvert. These check dams shall be maintained until final reclamation activities are completed. Silt fences shall then be installed at strategic locations for sediment control associated with the reclaimed area.

10.3.5 TOPSOIL REDISTRIBUTION AND SURFACE PREPARATION {R614-301-242, 542.200 AND 355}

Soils that were salvaged for use as substitute topsoil and placed over the in-stream culvert will be redistributed during permanent reclamation. Salvaged topsoil will also be redistributed during permanent reclamation. These soils will be placed on the graded areas in a manner that achieves: 1) approximate uniform thickness consistent with the postmining land use, contours and surface water drainage system; 2) minimal compaction and erosion of the fill material and substitute topsoil; 3) minimal contamination of the soil; 4) conservation of the soil moisture and promotes revegetation; and 5) minimal deterioration of the biological, chemical and physical properties of the resource.

Prior to the redistribution and during grading, the surficial area will be ripped along contour to produce proper seedbed conditions. Soil will be applied to a depth of approximately 1 foot over the roughen surfaces. Replacement will occur along the contour, where safety permits, to minimize erosion and instability of the seedbed. If any areas become compacted due to the reclamation activities, they will be disced along the contour to loosen the soil and improve the seedbed.

Samples of the soil will be taken prior to redistribution to determine the current requirements for soil nutrients and amendments. Section 5.5.3, 5.5.4 and 10.6 provide additional information on general redistribution, soil analysis and data concerning soil nutrients. Exhibits 10.3.4-1 through 10.3.4-6 depict the cross sections of the reclaimed areas.

10.3.6 REVEGETATION PLAN {R614-301-341, 412.100 AND 763.200}

The revegetation plan will follow Section 5.6 of the approved plan and will incorporate the use of the Permanent Seed Mixture-Central Mine Facilities Area, page 5-50. Revegetation success will be based on the reference area associated with the Central Mine Facilities Area (as per discussion with DOGM and the Applicant during the site selection process - Spring 1989). The revegetation of the riparian zone will follow the methodology described in Section 5.6.8 and will utilize the Permanent Seed Mixture - Riparian Area, page 5-51. Revegetation success will be based on the deciduous streambank reference area as described in Section 3.7.3 (also see Exhibit 10.3.6-1). Any intermediate (temporary) revegetation of disturbed areas will be in accordance with Section 5.6.9.

There will be no irrigation or supplementary water used during or after the revegetation of the area. There are no planned pest or disease control measures for the surface expansion facilities. Pest or disease control measures may be implemented if results from the test plots and/or reference area indicate a need. Any measures taken shall be consistent with proper rangeland and wildlife management and shall receive prior DOGM approval.

Pursuant to R614-301-342.200 and 342.400, pages 5-60 through 5-70d present the criterion for the determination of the revegetation success follow final/permanent reclamation. As identified within the revegetation plan, the Applicant will stabilize and revegetate the surface facilities expansion area consistent with all disturbed areas associated with mining operations. The primary intended postmining uses are wildlife habitat, rangeland and recreational use. The overall reclaimed topography reflects considerations of both primary/postmining land uses.

10.3.7 MONITORING AND MAINTENANCE {R614-301-244, 350, 413, 560 AND 761}

See Section 5.6.12, pages 5-69 through 5-75.

Table 10.3.8-1 is a detailed timetable for the completion of each major reclamation step for the surface facilities expansion. Table 10.3.8-3 presents a cost breakdown for each step of reclamation. Both tables take into consideration Figure 5.7-1 and Section 5-7 of the approved permit for SCM, ACT/007/018. The estimated reclamation costs in the section are to be added to the costs for reclamation in Section 5.7 for a total reclamation cost/bond liability.

10.3.8 COUNTY ROAD RELOCATION {R614-301-521.133.3, 542.600 AND 762}

The county road, upon final reclamation will be relocated as shown on Exhibit 10.3-1. Once traffic is able to travel through the site on the newly relocated road, the old road will be reclaimed and the stream culvert removed.

10.3.9 STREAM CHANNEL RECLAMATION DESIGN {R614-301.731.600 and 742.13}

During the reclamation activities, the fill material placed over the Soldier Creek by-pass culvert will be removed and used as back fill for the highwalls and portal areas. Once these areas are roughly graded, the stream channel by-pass culvert will be removed. Following the culvert removal, the entire length of the stream channel will be regraded and stabilized according to the reclamation design presented in Appendix F. Due to the configuration of the site area, it will not be possible to convey much of the regraded and stabilized channel areas to the sediment pond. As much area as possible will be directed to the sediment pond until the area has been adequately revegetated.

Following the construction of the reclaimed channel section, for those sections of the channel sideslopes, which cannot be directed to the sediment pond, will be provided with silt fences, at the anticipated mean annual flow depth, to provide temporary sediment control until the channel banks and sideslopes can be revegetated. Channel sideslopes will be seeded according to the revegetation plan described in section 10.3.6 and as shown on Exhibit 10.3.6-1.

To facilitate reclamation, a small coffer dam and by-pass pipe will be installed to convey the low flows through the reclamation area. This will minimize the sediment loading to the stream during the reclamation activities. Due to the large drainage area of Soldier Creek, the diversion will be designed only for low-flow events.

For those areas which drain to the sediment pond, the pond will remain in place until the areas draining to it have achieved an adequate vegetative cover.

TABLE 10.3.8-1

RECLAMATION TIMETABLE - PERMANENT/FINAL

ACTIVITY	JUL	AUG	SEP	OCT	NOV	DEC
Coal Removal		—				
Operation Closure	—					
Structure Removal		—	—			
Concrete & Asphalt Removal		—	—			
Road Relocation & Culvert Removal			—	—		
Backfilling & Grading			—	—	—	
Soil Reclamation & Revegetation				—	—	
Site Completion					—	
Mobilization & Demobilization					—	—
Coordination Staff	—	—	—	—	—	—

Table 10.3.8-2

EARTHWORK - CONSTRUCTION

Cross-Section*	Dist (ft)	End Areas (ft²) Cut	Fill	Volumes (ft³) Cut	Fill
0 + 00	0	0	0	0	0
0 + 50	50	0	0	0	0
1 + 00	50	199	387	4,975	2,902.5
1 + 50	50	620	824	20,475	30,275
2 + 00	50	756	577.5	34,400	27,537.5
2 + 50	50	269.5	562	25,637.5	28,487.5
3 + 00	50	140	747	10,237.5	32,725
3 + 50	50	38.5	556	4,462.5	32,575
4 + 00	50	244	199	7,062.5	18,875
4 + 50	50	265	968	12,725	29,175
5 + 00	50	506.5	1,469	19,287.5	60,925
5 + 50	50	552	1,268	26,462.5	68,425
6 + 00	50	207	1,444	18,975	67,800
6 + 50	50	1,816	1,078	50,575	63,050
7 + 00	50	2,016.5	311.5	95,800	34,725
7 + 50	50	1,312	714	83,212.5	25,637.5
8 + 00	50	738	2,228	51,250	73,550
8 + 50	50	603	2,534.5	33,525	119,062.5
9 + 00	50	702.5	728.5	32,637.5	81,759
9 + 50	50	76.5	151.5	19,475	22,000
10 + 00	50	0	0	1,912.5	3,787.5
TOTALS				553,090.0	823,275.0
Amount Excavated from New Portals				189,000.0	

Conclusion: Utilizing a swell factor of 12% for the cut material, results in a surplus of 7,866 cubic feet or 291 cubic yards of fill material.

EARTHWORK - RECLAMATION

Cross-Section*	Dist (ft)	End Areas (ft²) Cut	Fill	Volumes (ft³) Cut	Fill
0 + 00	0	0	0	0	0
0 + 50	50	0	0	0	0
1 + 00	50	1,495	1,603.5	37,375	40,087.5
1 + 50	50	1,994	2,212	87,225	95,387.5
2 + 00	50	1,627.5	2,171.5	90,537.5	109,587.5
2 + 50	50	1,405.5	2,130.5	75,825	107,550
3 + 00	50	1,277	1,729.5	67,062.5	96,500
3 + 50	50	1,103	1,561	59,500	82,262.5
4 + 00	50	879.5	1,613	49,562.5	79,350
4 + 50	50	1,107	1,562	49,662.5	79,375
5 + 00	50	813.5	1,662.5	48,012.5	80,612.5
5 + 50	50	750	1,527	39,087.5	79,737.5
6 + 00	50	834	1,541	39,600	76,700
6 + 50	50	1,054.5	1,786.5	47,212.5	83,187.5
7 + 00	50	1,103	1,485.5	53,937.5	81,800
7 + 50	50	1,013	719	52,900	55,112.5
8 + 00	50	2,651	462.5	91,600	29,537.5
8 + 50	50	2,969.5	580.5	140,512.5	26,075
9 + 00	50	555.5	662.5	88,125	31,075
9 + 50	50	178.5	153.5	18,350	20,400
10 + 00	50	0	0	0	0
TOTALS				1,136,088.0	1,254,337.5

Conclusion: Utilizing a swell factor of 12% for the cut material, results in a surplus of 18,080 cubic feet or 670 cubic yards of fill material.

Table 10.3.8-3

Equipment/Operator Costs

Equipment	Operator Cost/hr $	Total Cost/hr $
D8 Dozer Cat D8L Track/ripper	28.65	118.54
Cat 966C Loader	31.50	106.50
Cat 14G Grader	31.50	101.50
Dynapac W70 Compactor	28.65	73.65
MS 300 Mitsubishi Excavator	28.65	128.65
Water Truck	28.65	68.65
12 yd^3 Truck	25.25	59.73
Loader Cat 953	28.65	67.06
Farm Tractor Deere 301A	28.65	37.37
Disc attachment		1.71
Drill attachment		1.71
Crimper attachment		1.71
Loader Backhoe Deere 410B	28.65	49.13
Grove Model 68 Crane	31.00	130.00
Tractor-trailer 40 Ton Cap.	24.25	64.68
Mulch blower (w/3 laborers)	99.60	112.17
Hydro Seeder w/labor	70.95	100.26
Common Laborer	23.65	23.65
Foreman	33.65	33.65

Unit Cost for Specific Job

Job	Cost/Unit $
Steel Demolition and Removal	70.00/ton
Concrete Demolition	5.94/yd^3
Concrete Disposal (on site)	3.50/yd^3
Pavement	1.48/yd^3
Powerlines	3.62/ft
Fence Removal	1.22/ft
Backfilling and Grading	3.00/yd^3
Excavation	2.50/yd^3
Broadcast seed cost	550.00/AC
Drill seed cost	275.00/AC
Hydro mulch	140.00/ton
Fertilizer	.35/lb
Mulch Netting (incl. labor)	1,050.00/AC
Seedlings (incl. labor)	2.25/Stem
Cuttings (incl. labor)	1.50/Stem
Soil Analysis	100.00/sample
Filter Blanket	1.50/yd^2
9" riprap	7.00/yd^3
12" riprap	6.50/yd^3
3/4" minus	9.00/ton
Road Base	9.00/ton

Table 10.3.8-3 (Cont'd)

Reclamation Costs {R614-301-327 & 830}

I. Coal Removal (0.5 ac and 0.5 ft. thick)

Equipment	Quantity	Production	Cost/Unit $	Total
Cat D8L	400 yd^3	2 HR	118.54/hr	237.08
Cat 966C Loader	400 yd^3	2 HR	106.50/hr	213.00
Foreman	2 HR		33.65/hr	67.30
			Subtotal	517.38

II. Structure Removal

	Quantity	Cost/Unit $	Total
Steel Removal			
Surface Handling & Storage	354 Tons	70.00/ton	24,780.00
Coal Preparation Plant	650 Tons	70.00/ton	45,500.00
Culverts (Removal performed after County Road relocation)	240 Tons	70.00/ton	16,800.00
Sealing Mine Openings	4	1,800.00/opening	7,200.00
Concrete Removal			
Preparation Plant	559 yd^3	5.94/yd^3	3,320.46
Surface Handling & Storage	310 yd^3	5.94/yd^3	1,841.40
Culverts:			
Inlet	27 yd^3	5.95/yd^3	160.38
Headwall (OLD)	170 yd^3	5.94/yd^3	1,009.80
Outlet	124 yd^3	5.94/yd^3	736.56
Silos	1200 yd^3 ea	5.94/yd^3	14,256.00
Concrete Disposal			
On site	3590 yd^3	3.50/yd^3	12,565.00
Fence Removal	1400 ft	1.22/ft	1,700.00
Power Line Removal	800 ft	3.62/ft	2,896.00
		Subtotal	132,765.60

III. County Road Relocation (Gravel surface)

Equipment	Quantity	Production	Cost/Unit $	Total $
Construction (Post Mining)	1200 ft			
Cat D8L		3 hr	118.54/hr	355.62
Cat 966C Loader		6 hr	106.50/hr	639.00
Cat 14G Grader		8 hr	101.50/hr	812.00
Road Base 1" Minus (Delivery to site)	700 ton		9.00/ton	6,300.00
Dynapac Compactor W70		4 hr	73.65/hr	294.60
Water Truck (4000 gallon)		2 hr	68.65/hr	137.30
Foreman		8 hr	33.65/hr	269.20

Table 10.3.8-3 (Cont'd)

III. County Road Relocation (Gravel surface) cont'd

Equipment	Quantity	Production	Cost/Unit $	Total $
Demolition (Operation)				
Cat D8L w/ripper		10 hr	118.54/hr	1,185.40
Cat 966C Loader		10 hr	106.50/hr	1,065.00
Foreman		10 hr	33.65/hr	336.50
			Subtotal	11,394.62

IV. Backfilling and Grading - 42,077 yd^3

Equipment	Quantity	Production	Cost/Unit $	Total $
		1500 yd^3/8 hr	3.00/yd^3	
Cat D8L w/ripper	1			
Cat 966C Loader	2			
Cat 14G Grader	1			
MS300 Mitsubishi Excavator	1			
Cat 953 Track Loader	1			
Dynapac W70 compactor	1			
Water truck	1			
12 yd^3 Truck	3			
Foreman	1			
			Subtotal	126,231.00

V. Stream Channel

Activity	Equipment	Production	Cost/Unit $	Total $
Excavation 13,000 yd^3		1500yd^3/8 hrs	2.50/yd^3	32,500.00
	Cat D8L w/ripper			
	MS 300 Mitsubishi Excavator			
	Cat 966C Loader			
	Foreman			
Grading				
	Foreman	24 hr	33.65/hr	807.60
	MS 300 Excavator	24 hr	128.65/hr	3,087.60
	Cat 966C	24 hr	106.50/hr	2,556.00
	3 Laborers	10 hrs	23.65/hr	709.50
	Filter Fabric	4,667 yd^3	1.50/yd^2	7,000.00
	9" riprap	714 yd^3	7.00/yd^3	5,000.00
	12" riprap	846 yd^3	6.50/yd^3	5,500.00
	3/4" minus riprap	1,111 tons	9.00/ton	10,000.00
			Subtotal	67,160.70

VI. Soil Reclamation and Revegetation (5.6 acres)

Activity	Equipment	Production	Cost/Unit $	Total $
Ripping	Cat D8L w/ripper	2.33ac/hr	129.54/hr	311.34
Soil Sampling		1 sample/ac	100.00/ac	560.00
Discing	Deere 301A	3.33ac/hr	37.37/hr	62.84

Table 10.3.8-3 (Cont'd)

VI. Soil Reclamation and Revegetation (5.6 acres) cont'd

Activity	Equipment	Production	Cost/Unit $	Total $
Fertilizer		ac	55.00/ac	308.00
Seed		ac	390.00/ac	2,184.00
Hand Seeding	Hand	2 ac/hr	23.65/hr	66.22
Drill Seeding	301A	2 ac/hr	39.08/hr	109.42
Fertilizing	Hand	3 ac/hr	35.08/hr	65.48
Mulch		2 Ton/ac	140.00/ton	1,568.00
Mulching	Blower	2 ac/hr	112.17/hr	314.08
Crimping		2 ac/hr	39.08/hr	66.22
Foreman		16 hrs	33.65/hr	538.40
			Subtotal	6,154.00

VII.	Mobilization and Demobilization 10%	34,645.63
VIII.	Subtotal for All Activities	378,645.63
	- 10% Maintenance and Monitoring	37,864.56
	- 10% Contingency and Engineering	41,651.01
	- Subtotal 1989 Dollars	458,161.21
	- Escalation at 2.32 for 3 yrs (1994)	31,888.02
IX.	Total Bond Amount	490,000.00*

Note: Siaperas Construction, Inc. was the Applicant's source for the cost estimates and equipment usage.

* An interim bond amount has been prepared by the Division to include the existing mining facilities, the topsoil storage area, the sewage lagoons, and the proposed changes to the mine facilities area including the relocation of the public road. This interim bond amount is shown on Table 10.3.8-4 on the following page.

Table 10.3.8-4

I. Interim bond amount is based on the following:

Current Bond Amount	$ 577,000.00
New Portal Facilities	500,000.00
Topsoil Storage Area	50,000.00
Subtotal	$1,127,000.00
Contingency Factor (50%)	$ 563,000.00
Subtotal	$1,690,000.00
Engineering and Design (15%)	$ 250,000.00
Total Bond Amount	$1,940,000.00

Note- No escalation or other factors were added to the reclamation cost estimate due to the short term in which this interim amount will be utilized (1992). Sufficient contingency factors have been added to the bond amount to allow for escalation and adjustment of current bond amount such that in the event of bond forfeiture, adequate bond would be available to conduct reclamation.

10.4 ENGINEERING DESIGNS

10.4.1 ENVIRONMENTAL AND FACILITY DESCRIPTION {R614-301-521, 523, 521.133.2}

The construction of the surface facilities expansion will allow the Applicant the ability to continue their operation of SCM and improve the coal handling facilities. The initial construction drawings and plans are shown on Exhibits 10.1.1-1 and Exhibit 10.2.4-1. During the construction of the facilities, modifications to the drawings and plans may occur, but all modifications will be shown on the final as-built drawings sent to DOGM. Any modification that could alter or effect the design of the runoff controls or the stream culvert will be sent to the state prior to construction of the facilities.

Designs of the surface facilities expansions at SCM is based on present coal handling problems, ventilation requirements and long-term needs for both at SCM. The following facilities will be constructed during 1991/1992, except for the Portals that were started in 1989.

1. Three Portals into the Rock Canyon seam will provide additional intake air capacity and will allow SCM to change their underground conveyor facilities.

2. Fourth North #1 belt will connect the underground conveyor system to the surface facilities. This belt has been designed to carry coal from the mine at 3600 tons per hour. The belt will be covered for the total length that it is exposed on the surface.

3. The Transfer House with Crusher will be enclosed and equipped with water sprays. Coal will be transferred from the Fourth North #1 belt, crushed to 5"x 0 and then onto the silo conveyor belt.

4. Silo conveyor belt will accept coal from the Fourth North #1 belt and has been designed to handle 3600 tons per hour. This belt will be covered for the entire length. This belt will discharge coal into the silos. It will have a dribble pan/tube where the belt crosses the county road. The transfer points from the belt to the silos will be enclosed and equipped with water sprays.

5. The silos will accept coal from the silo conveyor belt. One silo will be equipped with an overflow chute to provide for emergency ground storage.

6. Vibrating feeders will be placed within the silos and ground storage facility to draw coal from the facilities and dump the coal onto the reclaim belt.

7. A Reclaim Tunnel will be placed beneath the silo pads. The vibrating feeders will be anchored to the tunnel and a reclaim belt will be placed within and anchored to the tunnel.

8. The Reclaim Conveyor Belt will accept coal from the vibrating feeders and convey the coal to the Preparation plant. This belt will be covered for the total length that it is outside the reclaim tunnel.

9. The Baum Jim Preparation Plant will be enclosed and house the equipment necessary for washing coal as needed. Two crushers will be enclosed within the preparation plant. Due to the location of the crushers, water springs are not anticipated. One crusher will be used to size coal to 2"x 0 when coal quality is such that washing is not necessary and the system is by-passed. The other crusher will be used for the cleaned coal at the end of the washing cycle. Processed coal will then be transferred to the truck

bin belt. Refuse from the washing process will be transferred to the refuse bin conveyor.

10. An Ash Analyzer, used in monitoring coal quality, will be located along the coal conveyor belt at the coal bins.

11. The Truck Bin Conveyor Belt will accept coal from the preparation plant and will convey and discharge coal to the truck bins. The transfer point from the belt to the truck bins will be enclosed and equipped with water sprays.

12. Two 600 ton Truck Bins will accept the coal from the truck bin belt and discharge the coal into coal haulage trucks. The bins will be equipped with sensors that will automatically open and close the dump gates of the bins.

13. The Refuse Conveyor Belt will accept refuse from the preparation plant and will convey and discharge refuse to the truck bin. The transfer point from the belt to the truck bin will be enclosed, but not equipped with water sprays.

14. The 300 ton Truck Bin will accept the refuse from the refuse conveyor belt and discharge the refuse into refuse haulage trucks. Refuse will be hauled to the waste rock disposal site.

15. Thickener Tank is used in the recovery of coal fines from the washing process. These fines settle out through the use of polymers and are then sent to a filtering disc where the caked fines are discharged onto the truck bin conveyor and blended with the coal.

16. Power Poles will be repositioned and several new poles added to provide electrical power to the facilities.

17. A culvert has to be placed into the natural channel of Soldier Creek to allow for the construction of the facilities and to protect this water resource. The culvert was designed for the 100-year, 6-hour storm event.

18. County Road will be relocated eastward to facilitate SCM's expansion. The new road will be built using current and prudent engineering practices. The road will be a county road and maintained by the County.

19. Access Roads into the expansion will provide an access to the mine portal area and haulage facilities. These access roads will be classified as primary roads and constructed to meet all prudent regulations.

20. A Concrete Protection Pad has been placed over the gas line to permit haulage of men and material over the gas line and into the portal area.

21. Drainage controls will be placed within the expansion to provide runoff control for the surface facilities, yard expansion, and undisturbed drainage. Additionally, several operational drainage controls may be upgraded to provide the necessary facilities to handle the design event.

22. Fences and Gates will be placed along the county road and across the culvert in the stream to limit any unauthorized access to the surface facilities expansion. Also, the fence enclosing the present storage yard will be removed and relocated to accommodate the new facilities.

23. Other miscellaneous items may be added to the design to improve the overall operation of the facilities, but all such items will be listed and shown on the as-built drawing that will be submitted to DOGM.

10.4.2 DETAILED DESIGNS AND CALCULATIONS {R614-301-412.100, 520, 133.2, 530, 736, 740 AND 830}

All detailed designs and calculations for the expansion are contained within the specific environmental sections within this document. Engineering design and calculations for the mine surface facilities were performed by Norwest Resource Consultants, Inc. A geotechnical investigation of the area was performed by Rollins, Brown and Gunnell Inc. and supervised by Norwest. The mine surface expansion is shown on Exhibit 10.1.1-1.

The surface expansion will have two primary roads. These roads will be constructed and maintained according to the regulations. The primary road leading into the yard will split in order to access the haulage facilities. The other primary road will access the portal area. Exhibit 10.1.1-1 and Figure 10.4.2-1 show the location of the roads and typical design. The area not designated as a primary road will be the pad area. The pad areas will be used for mine related storage and activities. Due to the storage of mine related material, the travel paths in these areas will be ever changing in response to the amount of material at the site.

The county road will be realigned for approximately 1235 ft. (Exhibit 10.1.1-1) to accommodate the surface expansion. The Applicant will assume the relocation cost and thereafter, the County will assume the operation and maintenance of the new county road. Upon reclamation, the county road will be relocated as shown on Exhibit 10.3-1.

Reclamation costs needed for bond estimates are given on Table 10.3.8-3 and this includes a breakdown of the specific manpower, equipment and material costs. Costs were calculated for the removal of all facilities, relocation of the county road and recontouring the disturbed area to the final postmining contours (Exhibits 10.3-1, 10.3.4-1 through 10.3.4-6). Exhibits 10.3.4-1 through 10.3.4-6 illustrate the operational and final contour cross sections of the permit area. These exhibits show adequate material balance and help in the determination of the reclamation costs.

Reclamation efforts of all lands disturbed by the Applicant's operation will occur as contemporaneously as practical with mining operations. Backfilling and grading work performed during reclamation will cover all coal or toxic-forming materials and stabilize the backfilled and graded materials. Rills or gullies that form in reclaimed areas will be filled, graded or otherwise stabilized and reseeded or replanted.

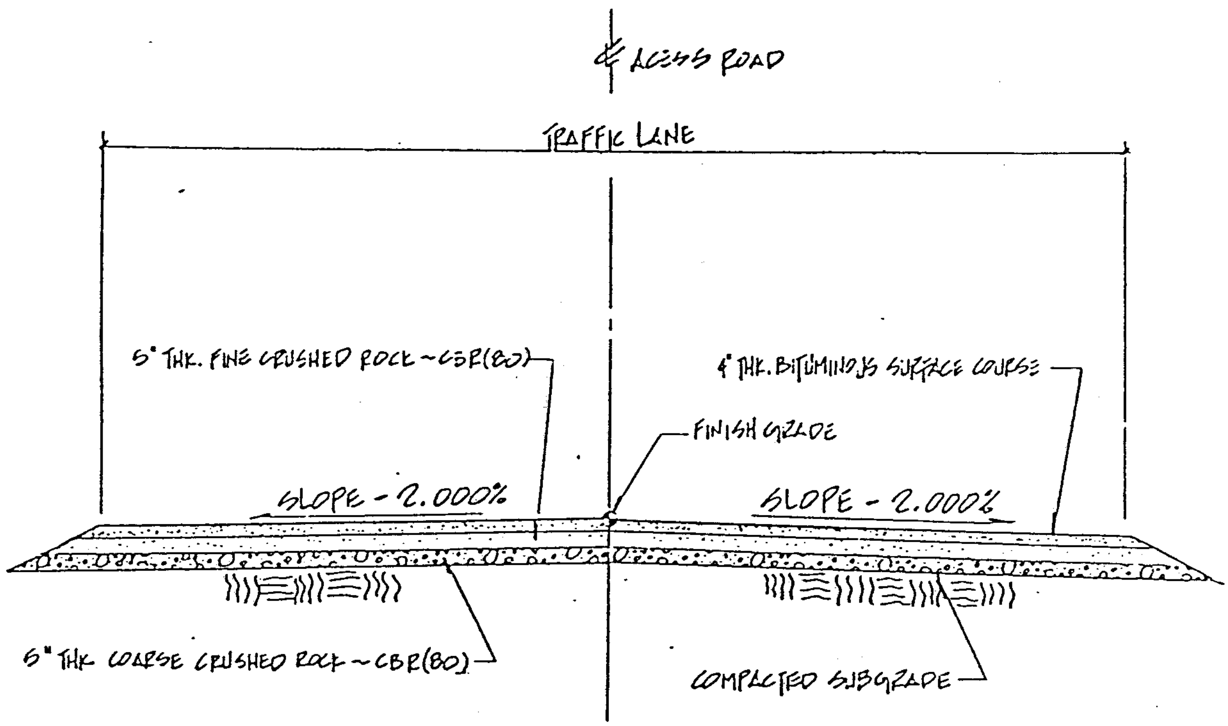
10.4.3 COMPLIANCE {R614-301-560}

The Applicant will conform to all state and federal regulations on the use of explosives and the methods for surface blasting activities if there is a need for the use of explosives at the site. A record of the surface explosives use will be kept on file at SCM.

Historically, the areas within and adjacent to the proposed surface facilities expansions have been used as a route for a natural gas pipeline, electrical transmission line, county road, coal mine and coal mine exploration. The exact location of some of the structures is shown on Exhibit 10.1.1-1.

All facilities and roads will be designed and constructed under the guidance of a professional engineer. As-built drawings will be submitted to DOGM following construction of the facilities and roads.

Drainage from creek



TYPICAL ACCESS ROAD CROSS-SECTION

NO SCALE

FIGURE 10.4.2-1

10.5 HYDROLOGY

The information contained in this section was prepared by the staff of the Applicant and by Thomas J. Suchoski, Carol A. Bjork, and Richard B. White of EarthFax Engineering, Inc. located in Midvale, Utah.

10.5.1 GENERAL HYDROLOGIC DESCRIPTION {R614-301-720}

The surface hydrology of the area within and adjacent to SCM is detailed within Section 3.3 and the information presented in Section 10.5.3. Groundwater information for the permit area is detailed within Section 3.2.

10.5.2 SURFACE WATER - SOLDIER CREEK {R614-301-731.610, 742.300}

DOGM and the Applicant, during initial discussions and site visits to SCM in early 1989, tentatively agreed that a culvert placed in Soldier Creek would provide the most environmentally sound method to acquire the needed surface area for mine expansion. The Applicant has designed a culvert that will handle the flow and provide the required stability. DOGM approved the initial plans in 1989. This culvert has been installed and is being extended to the north.

10.5.3 RUNOFF CONTROL - DETAILED DESIGN AND CALCULATIONS {R614-301-740}

The existing runoff- and sediment-control facilities at the Soldier Canyon Mine were examined to determine their capacity to adequate handle the existing flow from the portal and yard expansion areas. Results of these analyses are contained in Appendices A, B, C, and D.

Sediment Pond

As indicated in Appendix A, the existing facilities and the proposed expansion areas will contribute 1.49 acre-foot of runoff to the sedimentation pond during the 10-year, 24-hour storm. Additionally, the pond will handle 0.44 acre-feet of process water, in the event of a worst-case shut down of the preparation plant.

The total disturbed area contributing to the pond totals 14.3 acres. The sediment storage required to be provided in the pond for this area of disturbance is 1.43 acre-feet. This will result in the maximum sediment storage being at an elevation to 6649.5 feet. The sediment collected in the pond will be removed when 60 percent of the maximum storage volume (0.86 acre-feet) has been deposited. This cleanout level corresponds to an elevation of 6647.55 feet. With the decant elevation at 6649.5 feet, the clean out level will be at least 2.0 feet below the decant level, thus meeting previous requirements of the Utah Bureau of Water Pollution Control placed on operation of the pond.

To accommodate the runoff and process water and the sediment volumes, the primary and emergency spillways of the sedimentation pond will be at an elevation of 6654.5 feet. The runoff peak flow to the sedimentation pond during the 25-year, 6-hour storm (10.34 cfs) can be adequately passed by the combined principal and emergency spillways. With the risers and conduits of the spillways being 18-inches in diameter, calculations presented in Appendix A indicate that, at peak flow the head over the spillway will be 0.62 feet. This head corresponds to an elevation of 6655.12 feet. Based on the crest elevation of the pond at 6656.2 feet, this leaves 1.08 feet of freeboard between the water surface and the top of the embankment.

A trash rack and oil skimmer has been provided on the spillway. This appurtenance is constructed of 30-inch diameter CMP and extends 1.0 feet below and 1.0 feet above the spillway elevation.

Riprap currently exists at the outfall of the pond spillway. Based on a visual examination, this riprap is generally in the size range of 1.5 feet to 3.0 feet in diameter, with smaller and larger rocks also present at low percentages. Analyses presented in Appendix A indicate that this riprap is adequate for controlling erosion at the outfall.

Diversions and Culverts

Analyses contained in Appendix A indicate that the existing runoff conveyance system is adequate to handle the additional flow expected from the proposed expansion areas during a 10-year, 6-hour storm. In the existing half-round conveyance culvert, the freeboard is slightly less than the arbitrarily selected design value of 0.3 foot. However, site-specific rainfall data documented by Soldier Creek Coal Company in their "Sedimentation Pond Modification, Final Construction Report" (dated February 24, 1987) indicate that runoff from the design event is actually less than predicted by the rainfall runoff models. Thus, given the conservative nature of the runoff predictions, the system has adequate capacity to convey the design flow and the freeboard of 0.25 feet is considered adequate.

The existing ditches in the storage yard will be connected to the proposed plant yard/portal expansion area runoff control structures. Four new ditches and culverts are proposed. Ditches 1 and 2 are proposed to be half-round culverts. These are sized to be a minimum of 18-inch diameter half-round culverts. Larger diameter half-round culverts may be used if materials are readily available. Ditches 3 and 4 are proposed to be triangular earthen ditches. These ditches are sized with 3H:1V sideslopes and with an approximate depth of 1 foot. Analyses presented in Appendix A indicate that these ditches will adequately convey the additional runoff from the expansion area.

Runoff generated on the new plant yard/portal area will be conveyed under the access roads via culverts. Four culverts are proposed for the expansion area. Culverts 1, 2, and 3, which drain under the access roads in the plant area, are proposed to be 18-inch minimum diameter culverts, though larger diameter culverts can be used if materials are readily available (see calculations in Appendix A). Culvert 4 is proposed to convey runoff from the portal area and from the surface of the county road under the road to the existing ditch system via an at-grade culvert. Design details for this culvert, including location and joining with the existing system, are contained in Appendix B. The inlet of these culverts will be projecting end culverts. No other protection is planned as these culverts are inlet controlled and the flow entering the culverts will be subcritical in nature. All undisturbed area runoff will be diverted around the new portal area as indicated in Appendix C.

The diversions and their appurtenant structures will be designed, located, constructed, maintained and used to be stable, protect to the extent possible using the best technology currently available, additional contributions of suspended solids to streamflow outside the permit area and comply with all applicable local, Utah, and federal laws and regulations.

Soldier Creek By-pass Culvert

Design details are provided in Appendix D for the culvert installed in Soldier Creek extending beneath the new portal pad. The structure was originally designed to adequately convey the peak flow resulting from the 100-year, 24-hour storm. With the new regulations, the peak flow has been reduced to the 100-year, 6-hour storm. As indicated, the structure consists of a 19'-11"x12'-10" pipe-arch culvert. The beveled inlet and riprapped headwall have been constructed to improve the inlet hydraulics and to provide erosion protection to the limited area of the inlet. Outlet protection is provided in the form of a riprap basin. Details of the proposed inlet and outlet conditions are contained in Appendix D.

Information contained in Appendix D indicates that the exit velocity from the riprap basin will be approximately 16.2 feet per second. Previous water-surface profile analyses of Soldier Creek presented in Appendix E indicate that, under natural conditions, velocities near the proposed culvert outlet are in excess of 18 feet per second. Thus, the outflow from the riprap basin will be less than the stream would experience during the design event under natural conditions, indicating that the basin design is adequate.

10.6 SOILS {R614-301-200}

10.6.1 ENVIRONMENTAL DESCRIPTION {R614-301-220}

The soil range type is Mountain Loam. The slopes in this area range from 10-30%. Elevation is 6700 to 6850 feet. At streamside, the vegetation was oakbrush/grass. Where new portals are being developed, the slope was vegetated with firs, sagebrush, and oak.

The soils adjacent to the topsoil pile are deep, well-drained, sandy loams. These soils have formed from alluvial and colluvial action over a stony layer found two to six feet down.

Adjacent to these soils on the easterly bench were soils that had been previously disturbed by Questar's pipeline installation. These soils are well mixed to a depth of three feet. They have a sandy loam to loam texture with less than 22% cobbles and gravel. Much of this soil along with the yard expansion soils were used as backfill in the initial placement of the culvert in Soldier Creek.

10.6.2 PRIME FARMLAND INVESTIGATION {R614-301-221}

This area is located at the Soldier Canyon Mine site. As determined by the SCS on 12/5/85, the area is not considered prime farmland (see section 3.9 of the approved permit.)

10.6.3 MAP DELINEATING DIFFERENT SOILS {R614-301-222.100}

Illustration 10.2.12-1 shows the topsoil depths at the locations of the road realignment and potential disturbances associated with the facilities expansion.

On May 23, 1991, the Applicant had the SCS map and describe the soils outside the disturbed area that are subject to be and may potentially be disturbed, as a result of the road relocation and surface facilities expansion. Five different types of soils were found and described (Illustration 10.6.3-1). One was previously described by Carol Franks, SCS, (Illustration 10.6.3-2), therefore Illustration 10.6.3-1 only describes four soil types.

10.6.4 SOIL IDENTIFICATION {R614-301-222.200}

LOCATION	DATE SAMPLED	SAMPLE I.D.	ILLUSTRATION
Disturbed Soil (Pipeline)	11/11/89 and submitted for analyses on 1/5/89	#3	10.6.5-1 and 10.6.5-4
Slope below pipeline	11/11/89 and submitted for analyses on 1/5/89	#4	10.6.5-1 and 10.6.5-4
Undisturbed Soils	11/11/89 and submitted for analyses on 1/5/89	1-1, 1-2 & 2-1 2-2	10.6.5-2 10.6.5-3 and 10.6.5-5 and 10.6.5-6
Exploration Cut	5/8/89	Overburden Underburden	10.2.6-2
Yard Expansion	5/11/89	#1 (0-6") #1 (0-12")	10.2.14-2
Exploration Cut	9/30/89	Overburden Underburden	10.2.6-2
Soil below topsoil pile	10/16/89 5/23/91	SCS Field Evaluation	10.6.3-2 and 10.6.3-1
Soil Thickness Survey (steam bank/ridge)	12/10/90 5/23/91	15 auger holes to determine topsoil depth	10.2.12-1 (revised 5/1/91) and 10.6.3-1
Stream Channel	2/26/91	#1, #2 Composites	10.2.14-1
Portal Development	2/26/91	#3 Composite	10.2.6-1
Soil below and adjacent to topsoil pile	5/1/91 5/23/91	9 auger holes to determine topsoil depth	10.2.12-1 and 10.6.3-1
Potent. areas of disturbance Area 1 Area 2 Area 3	5/1/91 5/23/91	14 auger holes to determine topsoil depth and SCS field evaluation	10.2.12-1 and 10.6.3-1

10.6.5 SOIL DESCRIPTION {R614-301-222.300}

The soils portion of this text was prepared by Randolph B. Gainer and Rhett Brooks of EarthFax Engineering, Inc. located in Midvale, Utah.

On November 11, 1988, soil samples were collected from test pits (#1, #2 #3 & #4) as shown on Exhibit 10.3.6-2. Inspection of test pits (#3 and #4) conclusively proved that the soil in the area was previously disturbed by activities associated with the installation of a buried gas line. Therefore, it was not possible to identify or log any distinct soil profiles or horizons. The soil appeared to be well mixed from the surface down to bedrock (0.0' to 3.0'). Thus only the upper foot of soil was sampled and submitted to ChemTech on January 5, 1989 for analysis of the required physical and chemical parameters (Illustration 10.6.5-1). Inspection of test pits (#1 and #2) show a definite break in the soil horizons with the appropriate soil samples submitted for analyses (Illustration 10.6.5-2 and 10.6.5-3).

The soils in the area of the portal expansion are a sandy loam to loam with up to 22% gravel and cobble fragments. Field notes for test pits #3 and #4 are shown on Illustration 10.6.5-4. The undisturbed soils (#1 and #2) are a gravelly sandy loan with up to 20%-25% gravel in the A Horizon with a gravelly sandy loam with up to 20% cobbles in the B Horizon. Field notes for (#1 and #2) are shown on Illustration 10.6.5-5 and 10.6.5-6. Soil samples #1 and #2 were taken when the Applicant had originally made plans to place the new portals southeast of their present locations. Because of the geologic conditions of the coal seam in that area, the Applicant was forced to relocate the portals.

Due to the decision to realign the County road, the Applicant had additional studies performed on the soils to be disturbed. On October 16, 1989, Carol Franks (Soil Scientist) for the SCS examined the topsoil material adjacent to the present topsoil stockpile. From her examination of the topsoil material, the Applicant should save the material down to the very stony layer (Illustration 10.6.3-2), since this material is similar to the topsoil already stockpiled. On May 23, 1991 Leland Sasser (Soil Scientist) for the SCS examined additional soils outside the disturbed area that are subject to be and may be disturbed as a result of the road relocation and surface facilities. (Illustration 10.6.3-1)

As per discussions and agreements with Priscilla Burton of DOGM, a topsoil thickness survey was performed by Rhett Brooks on a small area to be disturbed by the road alignment located a short distance away from the above sampled areas. Because this area is located within the same soil mapping unit and is of similar material, only a thickness survey was needed and the results are shown in Illustration 10.2.12-1

Additional information on the soils within this area can be found in Section 3.6 of the approved permit.

10.6.6 SOILS CHARACTERISTICS {R614-301-223}

The investigation performed by Carol Franks and Leland Sasser (SCS) satisfies this requirement (Illustration 10.6.3-2 and 10.6.3-1).

10.6.7 SUBSTITUTE TOPSOIL {R614-301-224}

During the culvert extension project, approximately 4800 yd^3s of material was excavated for placement of the stream culvert. This material was placed on the west side of the County road and a berm was constructed at the toe of the stockpile. On 2/26/91, #1 and #2 composite samples were taken and sent to Intermountain Labs for analysis. The results (Illustration 10.2.14-1) shows the material to be suitable for use as substitute topsoil. The material must be sorted to ensure that the topsoil contains only 10% rock fragments of the 10-12 inch or greater size. By sorting this material, approximately 4000 yd^3s will be substitute topsoil and the boulders larger than 10-12 inches will be stored as landscape boulders/riprap.

Soils designated as substitute topsoil from the portal expansion, yard expansion and initial stream culvert installation can no longer be considered for use as substitute topsoil. This material was used as backfill around the stream culvert, thereby, negating its use as potential topsoil. This material will now be used in backfilling of highwalls during reclamation.

10.7 VEGETATION

The vegetation communities that will be disturbed during the construction of the surface facilities are the Mountain Brush, Pinion/Juniper and Sagebrush. The elevation of the disturbance area lies between 6,700 feet and 6,800 feet above sea level.

As requested by the Bureau of Land Management, the Applicant shall conduct a clearance for Hydesarum occidentale var canone prior to any disturbance. Results shall be forwarded to the proper agencies.

10.7.1 ENVIRONMENTAL DESCRIPTION {R614-301-321}

A general description of the communities was done on 22 November 1988, and 28 June 1990 by Patrick D. Collins, Ph.D, Mt. Nebo Scientific (Illustration 10.7.1-1 and 10.7.1-2). Additional information listed in Section 3-7 of the approved permit details additional descriptions of the overall vegetation communities throughout the permit area of SCM.

10.7.2 DETAILED DESIGNS AND CALCULATIONS {R614-301-353, 354, 355 and 356}

As per discussions and agreements with Mr. Lynn Kunzler of DOGM, the Applicant will use the Central Mine Facilities Reference Area for the revegetation comparator for the 6.4 ac surface facilities expansion. Designs and information on the vegetation communities reference areas and test plots is included in the approved permit, Section 3.7.

10.7.3 COMPLIANCE {R614-301-350}

The Applicant will continue all monitoring programs that are listed in the approved plan for SCM. Monitoring of the surface facilities expansion areas following final/permanent reclamation will coincide with the program as stated in Sections 3.7 and 5.6 of the approved permit for SCM, ACT/007/018.

10.8 WILDLIFE

10.8.1 ENVIRONMENTAL DESCRIPTION {R614-301-322}

Description of the wildlife habitats that exist within the permit area of SCM are listed in Section 3.10 of the approved permit.

10.8.2 PROTECTION OF WILDLIFE AND RELATED ENVIRONMENTAL VALUES {R614-301-358}

The surface facilities expansion at SCM will disturb approximately 6.4 ac of additional ground. The major impacts to the wildlife in and around the area are loss of stream use for 885 feet and displacement of wildlife during construction and operation of the facilities. The Applicant will minimize, to the extent possible, all of the impacts through environmentally sound construction practices and by following the mitigative measures described in Section 3.10.4 and 4.4.6 of the approved plan. Along with the mitigative measures in the approved plan, the Applicant participated in a wildlife mitigation plans as detailed in Illustration 10.8.2-1, thus providing an additional 79.2 acres of improved rangeland. This plan to mitigate the loss of critical valued deer winter range was developed by the Utah Division of Wildlife Resources (Illustration 10.2.8-2). This plan would mitigate the loss of winter range due to the construction of the sewage lagoons as well as the yet to be constructed refuse disposal site and the proposed expansion of the surface facilities.

All power lines that are reconstructed or constructed during the expansion will follow the DWR and FWS guidelines for raptor protection. All threatened or endangered wildlife sighted within or adjacent to the permit area will be reported to the appropriate state and/or federal agency.

10.9 CLIMATE, AIR QUALITY, CULTURAL RESOURCES AND LAND USE

10.9.1 CLIMATE - AIR QUALITY {R614-301-420-724.400}

The Applicant's surface facilities expansion is shown on Exhibit 10.1.1-1 and borders the present facilities of SCM. The climate of this area is the same as that presented for SCM and contained in Section 3.5 of the approved plan, ACT/007/018. The Applicant will collect precipitation data from a rain gauge at SCM and will keep this data on file at the mine site.

Air Quality information for the area in and around SCM is contained in Section 3.5.3. The Applicant's air quality approval order is presently in the public comment phase (Illustration 10.9.1-2). The new approval order is based on a projected tonnage of 3.5 million tons. The Applicant has designed the new facilities to provide the best available control technology for the economic feasibility of the expansions. Any changes to the designed facilities will be reported to DOGM and the Utah Bureau of Air Quality prior to construction.

10.9.2 CULTURAL RESOURCES - LAND USE {R614-301-411.140 AND 410}

Information on the cultural resources within the permit area, including the expansion, is contained in Section 3.11. As stated, the ridgetop and valley bottom terrain was sampled and the results indicate that no resources were formed within the surface expansion sites. The Applicant will traverse the entire surface expansion site prior to construction to insure no cultural resource site may have been overlooked during sampling. If a potential site is discovered the BLM and DOGM will be notified immediately. No construction will occur around the site until the Applicant receives permission from both agencies.

Land use information is contained in Section 3-13. The expansion will have only a minor effect on the area and that effect will be reduction of wildlife habitat by 6.4 ac. This habitat will be replaced during final reclamation of the surface facilities at SCM.

APPENDIX A

Evaluation of Existing Facilities and Design of New Structures for Proposed Portal Expansion

REGISTERED PROFESSIONAL ENGINEER
No. 7102
RICHARD B. WHITE
STATE OF UTAH

Richard B. White
8 Mar 1991

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Attachment

A Design of New and Evaluation of Existing Runoff and Sediment Control Facilities for Expansion Area

Evaluation Existing Facilities and Design of
New Structures for Proposed Portal Expansion Area

1.0 GENERAL

This appendix presents a discussion of the hydrologic conditions associated with the existing runoff control facilities of the Soldier Canyon Mine and the proposed facilities for the portal expansion areas for the mine.

Computations are based upon a field reconnaissance of the area, proposed operations area topography provided by Soldier Creek Coal Company (SCCC), and published hydrologic information. In addition, the designs are based on the assumption that the culverts and diversions are temporary structures which will be removed upon cessation of mining.

2.0 STORM RUNOFF CALCULATIONS

Watershed boundaries used to determine runoff conditions for the watersheds contributing to the sediment pond are shown on Exhibit 10.2.4-1. Table 2-1 presents the watershed characteristics for the drainages contributing to the sediment pond. Of the existing drainages, only watersheds 4, 6, and ASCA #5 will be affected by the facility modifications, the drainage areas of these watersheds will be slightly reduced. Details for ASCA #5 are addressed in the MRP for the Soldier Canyon Mine (see pg. 4-14f). To facilitate drainage from the new portals, on the east side of the canyon, and the additional drainage area for the Soldier Creek culvert extension, four watersheds have been added to the runoff control plan. As indicated in Exhibit 10.2.4-1, Watershed 11 has an area of 1 acre and will drain to proposed diversion Ditch #1. Watershed 12 has an area of 3.6 acres and will drain into the proposed diversion Ditch #3, which conveys runoff to the south along the county road (see Figure 2-1 and Plate 10.2.4-2). Watershed 13 has a drainage area of 2.8 acres and contributes runoff to the portal area undisturbed runoff diversion (see Appendix C for design). Watershed 14 drains the new portal area and has a drainage area of 0.8 acres. For those watersheds not affected by the facilities modifications, watershed parameters

Table 2-1

Summary of Runoff Calculations
Upstream of Sedimentation Pond

Watershed	Area (acres)	Curve No.	T_c (hours)	10 yr-6 hr Individual Peak Flows (cfs)	10 yr-6 hr Routed Peak Flows (cfs)
3	6.50	75	.050	0.76	0.76
4	9.10	75	.060	1.16	1.16
5	3.10	75	.050	0.36	0.36
6	4.00	90	.310	1.71	4.84
7	3.50	90	.080	2.34	8.30
8	0.90	80	.020	0.24	0.24
9	1.50	90	.140	0.80	0.80
10	1.00	75	.000	0.56	9.91
11	1.00	90	.090	0.67	0.67
12	3.60	80	.090	0.94	0.94
14	0.80	85	.080	0.36	1.30
Total	34.50				

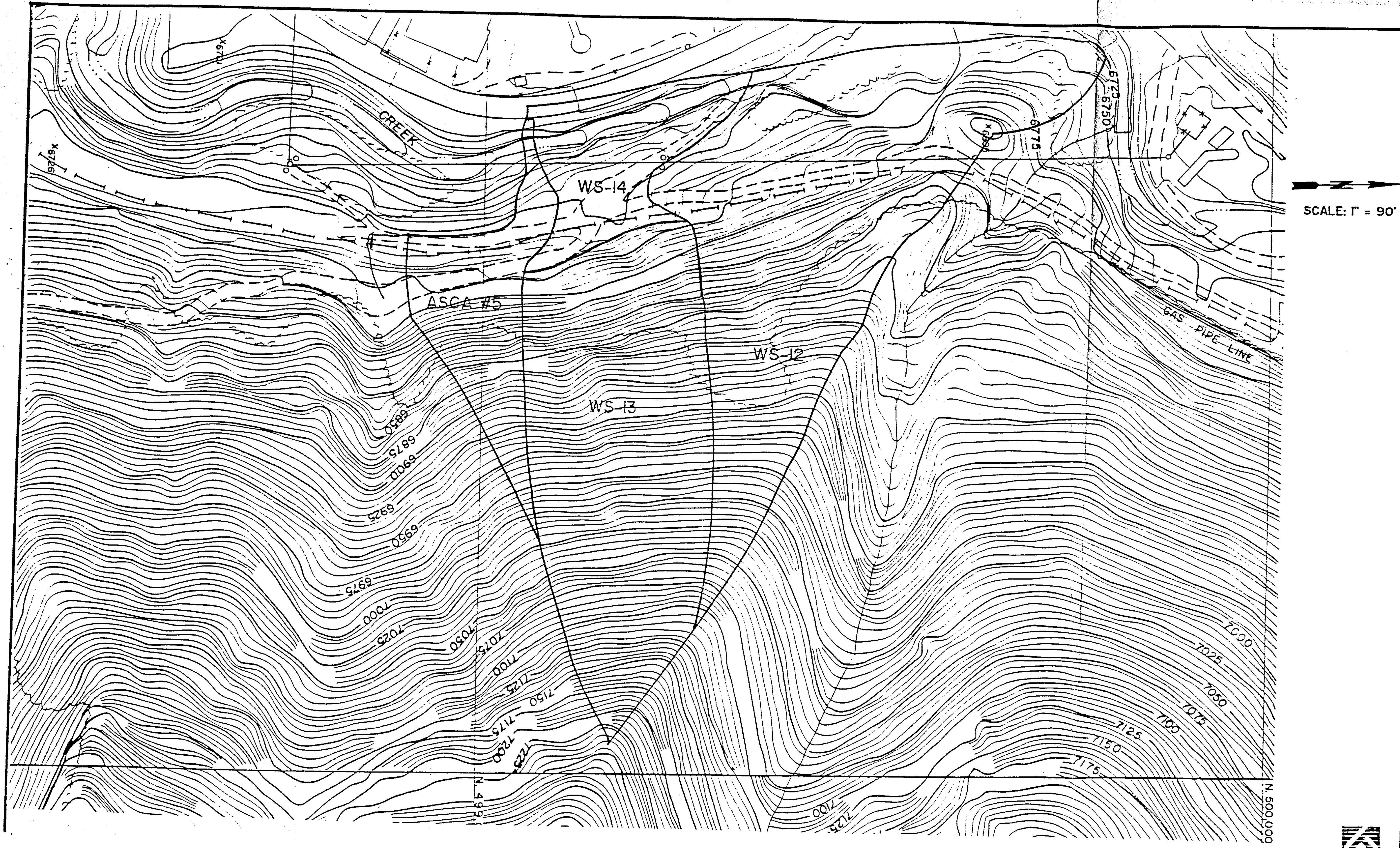

FIGURE 2-1. PORTAL AREA WATERSHEDS FOR RUNOFF CONTROL DESIGN.

EarthFax

from the Division of Oil, Gas, and Mining - Memorandum to File by Kent Wheeler dated October 21, 1987 were used.

Data obtained from the watersheds draining to the sediment pond were input into the SEDIMOT II computer program developed by Warner, et.al. (1980) to generate runoff hydrographs for the 10 year-6 hour and 25 year-6 hour storms required by the Division of Oil, Gas, and Mining (1989) for evaluation of existing and design of new temporary runoff control structures. The SEDIMOT II program models runoff using the rainfall-runoff function of the U.S. Soil Conservation Service (1972) and the unit hydrograph of Haan (1970).

According to the U.S. Soil Conservation Service (1972), the algebraic and hydrologic relations between storm rainfall, soil moisture storage, and runoff can be expressed by the equations:

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \qquad (2\text{-}1)$$

and

$$S = \frac{1000}{CN} - 10 \qquad (2\text{-}2)$$

where:

Q = direct runoff volume (inches)

S = watershed storage factor (inches)

P = rainfall depth (inches)

CN = runoff curve number (dimensionless)

The average curve number for the Watersheds 12 and 14 were chosen from professional judgement and tabulated values presented by the U.S. Soil Conservation Service (1972). Accordingly, a value of 75 was used for the undisturbed areas and a value of 90 was used for the disturbed areas. For those watersheds with a mixture of disturbed and undisturbed areas, the curve numbers were determined by weighting by area of each type.

The time of concentration for the watersheds may be estimated by several formulas. For this report, T_c was determined from the following equations (U.S. Soil Conservation Service, 1972):

$$L = \frac{\lambda^{0.8}\ (S+1)^{0.7}}{1900\ Y^{0.5}} \tag{2-3}$$

and

$$T_p = L + d/2 \tag{2-4}$$

and

$$T_c = 1.67L \tag{2-5}$$

where:

L = watershed lag (hours)

λ = hydraulic length of the watershed, or distance along the main channel to the watershed divide (feet)

S = watershed storage factor defined in equation (2-2)

Y = average watershed slope (percent)

T_p = time to peak (hours)

d = duration of effective or incremental rainfall (hours)

T_c = time of concentration (hours)

The translation of the runoff depth to an outflow hydrograph is accomplished by the program using the curvilinear unit hydrograph of Haan (1970). It is characterized by the equations:

$$\frac{q(t)}{q_p} = \left[\frac{t}{t_p} e^{(1-t/t_p)}\right]^{C_3 t_p} \tag{2-6}$$

where:

$q(t)$ = unit hydrograph ordinate at time t,

q_p = peak flow rate, and

C_3 is a parameter defined by the equation:

where:

$$V = q_p t_p \left[\frac{e}{C_3 t_p}\right]^{C_3 t_p} \Gamma(C_3 t_p) \qquad (2\text{-}7)$$

V = runoff volume (one inch for unit hydrograph),

Γ = gamma function,

and other parameters have been previously defined.

The SEDIMOT II computer program was run for the watersheds contributing to the sediment pond. The input calculations and results are presented in Attachments A, B, and C. Table 2-1 summarizes the input and resulting peak flows for the watersheds.

3.0 EVALUATION OF EXISTING RUNOFF STRUCTURES

3.1 SEDIMENTATION POND

The sedimentation pond will receive water from runoff from watersheds 3 through 12 and 14 and from process water from the preparation plant. As shown in Table 2-1, the total drainage area contributing to the pond is 34.50 acres. Based on this area, the weighted curve number to be used in the runoff calculations is 80. Using these values and the 1.90 inches for 10 year-24 hour precipitation depth (Miller et.al., 1973), the anticipated runoff volume to be handled in the pond is 1.49 acre-feet (see Attachment A).

The process water volume is based on a worst-case condition where all water from the thickner tank, jig sump, and clarification tank were able to be discharged to the pond. This would result in a volume of 142,300 gallons of water (0.44 ac-ft). If such a discharge were to occur from the plant, the discharge would be conveyed via the proposed and existing ditches to the sediment pond where it would be treated prior to discharge in accordance with the existing NPDES permit.

The sediment volume to be handled in the sedimentation pond is based on the 0.1 acre-foot per acre disturbed sediment volume factor. Using the areas of the watersheds presented in Table 2-2, the total disturbed drainage area is 14.30

0.1 AF /acre /yr

Table 2-2

Summary of Sediment Volume Calculations

Disturbed Watersheds	Disturbed Area (acres)	Sediment Volume (ac-ft)
6	4.00	0.40
7	3.50	0.35
8	0.90	0.09
9	1.50	0.15
10	0.50	0.05
11	1.00	0.10
12	2.10	0.21
14	0.80	0.08
Total	14.30	1.43

acres. Therefore, the sediment volume required to be handeled in the pond is 1.43 acre-feet. Assuming the pond will be cleaned when 60 percent of the sediment capacity is reached, the cleanout volume is calculated to be 0.86 acre-foot.

The elevation-capacity curve of the sedimentation pond is presented in Attachment A. This indicates that the pond will have adequate capacity to handle the required sediment and process and runoff water volumes with the spillway at 6654.5 feet, the decant at 6649.5 feet, and the sediment cleanout elevation at 6647.55 feet.

The sedimentation pond spillway was evaluated for its capacity to handle the peak flow from the 25 year-6 hour storm. Based on calculations in Attachments A and C, the design flow for this event was 10.34 cfs. The existing 18-inch CMP drop inlet spillway will be able to handle this flow under weir conditions with 0.62 feet of head. The freeboard from the pond embankment crest to the head on the spillway flowing at design depth will be 1.48 feet.

3.2 DITCHES

The existing diversion from the new portal/plant expansion area to the sedimentation pond consists of a combination of:

- o Half-round Culvert (24-inch)
- o Concrete ditch
- o Concrete ditch with cobblestones.

The capacities of each of these ditch sections were determined, assuming 0.3 foot of freeboard, to be: 15.7 cfs in the concrete ditch; 14.0 cfs in the concrete/cobblestone ditch; and 4.1 cfs in the half-round culvert section (see Attachment A and Drawing B-134 of the SCCC permit, Volume 2, page 4-21a). The half-round culvert section is the limiting flow section of the runoff conveyance system. The peak flow of runoff in the half-round culvert section is calculated to be 4.8 cfs. Based on calculations presented in Attachment A, the freeboard remaining to handle the design flow is 0.25 feet. Although this is minimally less than the design freeboard of 0.3 foot, the half-round culvert will not overtop during the design event and therefore, is considered adequate.

The peak flow calculated for the downstream end of the concrete and concrete/cobblestone ditch section is 8.3 cfs. As indicated above, the capacity of these ditches is sufficient to convey this flow with greater than 0.3 feet of freeboard.

3.3 CULVERTS

The conveyance culvert from the end of the concrete ditch sections to the sedimentation pond consists of a 24-inch CMP culvert. The design flow calculated for this structure is 8.5 cfs (see Attachments A and B). The capacity of the 24-inch culvert is 12.8 cfs (see Drawing B-134 of the SCCC permit, Volume 2, page 4-21a). Thus, the culvert section is adequate to convey the design flow.

4.0 DESIGN OF NEW RUNOFF CONTROL STRUCTURES

4.1 DIVERSIONS

To convey the collected runoff from the portal and plant expansion areas diversion ditches will be constructed adjacent to the proposed county road realignment to convey the runoff to the existing diversion structures. As shown on Exhibit 10.2.4-1, four new diversion ditches will be installed. The design and sizing calculations for these diversions are presented in Attachment A. It is proposed that Ditches #1 and #2 be constructed using half-round culvert. As indicated in Attachment A, the minimum size of the half-round culvert should be 18-inches. SCCC has some 24-inch half-round culvert materials on site. This material could be used for the ditches until the supply is depleted then the ditches can be transitioned to 18-inch half-round culverts.

Ditches #3 and #4 are proposed to be constructed as triangular earthen ditches. As indicated in Attachment A, the ditches will be constructed with 2H:1V sideslopes and will be approximately 1 foot deep. This will provide adequate capacity for the 10 year-6 hour design peak flow.

4.2 CULVERTS

Four culverts will be installed associated with the new expansion area. One will be installed under the county road (see Appendix B) and one each under the three access roads to the plant and portal areas. Culverts 1, 2, and 3 were sized based on the peakflows from the contributing ditches. Based on calculations presented in Attachment A, it is recommended that these culverts have a minimum size of 18-inches. Culvert #4's design and sizing is addressed in Appendix B.

5.0 REFERENCES

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ATTACHMENT A

Design of New and Evaluation of Existing Runoff and Sedimentation Control Facilities for Expansion Area

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SOLDIER CREEK COAL COMPANY

DESIGN OF NEW AND EVALUATION OF EXISTING RUNOFF AND SEDIMENT CONTROL FACILITIES FOR EXPANSION AREA

DRAINAGE CHARACTERISTICS

AS INDICATED ON EXHIBITS 4.2-5 + 4.2-6, THE ONLY AREAS AFFECTED BY THE PORTAL EXPANSION ARE WS-4, WS-6, & ASCA#5.

NEW DRAINAGE AREAS - (BASED ON EXHIBIT 4.2-6, DRAWING EØ3Ø, AND FIG. 4.2-)

WATERSHED	AREA
WS-4	9.9 AC
WS-6	4.0 AC
WS-11	1.0 AC
WS-12	2.6 AC
WS-13a	2.8 AC
WS-13b	0.6 AC
WS-14	0.8 AC
ASCA#5	0.4 AC

No longer Applicable

WATERSHED AREAS FOR ALL OTHER DRAINAGES WERE TAKEN FROM DOGM MEMO TO FILE BY KENT WHEELER DATED OCT. 21, 1987. PRESENTED ON PAGES I-78k THROUGH I-78o OF SOLDIER CANYON MINE PERMIT, VOL. 3, APPENDIX I.

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HYDRAULIC LENGTH

W.S. ID	LENGTH (FT)
WS-4	900
WS-6	2550
WS-11	1040
WS-12	1050
WS-13a	825
WS-13b	475
WS-14	775
ASCA #5	350

WATERSHED SLOPE

WATERSHED I.D.	SLOPE (%)
WS-4	84.5
WS-6	6.4
WS-11	17.3
WS-12	34.1
WS-13a	62.5
WS-13b	63.1
WS-14	20.8
ASCA #5	26.8

@ J3, B2, S1 → J2, B2, S2 WS 9

$T_t = \frac{D}{V} = \frac{520^{FT}}{3.4} = 152.9\,s = 2.6\,m = 0.04\,hr$

V = 3.4 FT/S BASED ON: 2.9% SLOPE ON PAVED SURFACE.
(SEE FIG. 4.15 - ATTACHED)

MUSKINGUM K = 0.04

MUSKINGUM X = .5 V/(1.7 + V) = 0.5 (3.4)/(1.7 + 3.4) = 0.33

@ J2 → J3, B1, S1

$T_t = \frac{D}{V} = \frac{360}{3.4} = 106\,s = 0.03\,hr$

V = 3.4 BASED ON: 2.9% SLOPE; PAVED AREA

14, 12, 11, 6, 4

MUSKINGUM K = 0.03 hr

MUSKINGUM X = 0.33

@ J3, B2, SWS1 → J3, B2, S1

$T_t = \frac{D}{V} = \frac{515}{6.3} = 81.7\,s = 1.36\,m = .002\,hrs$

V = 6.3 F/S BASED ON: 9.7% SLOPE; PAVED SURFACE

MUSKINGUM K = 0.02 hrs

MUSKINGUM X = 0.39

@ J3, B2, SWS2 → J3, B2, S1

$T_t = \frac{D}{V} = \frac{300}{7.0} = 42.9\,s = 0.71\,m = 0.01\,hrs$

V = 7.0 F/S BASED ON: 11.7% SLOPE; PAVED SURFACE

MUSKINGUM K = 0.01 hr

MUSKINGUM X = 0.40

12a / 35
2/23/91

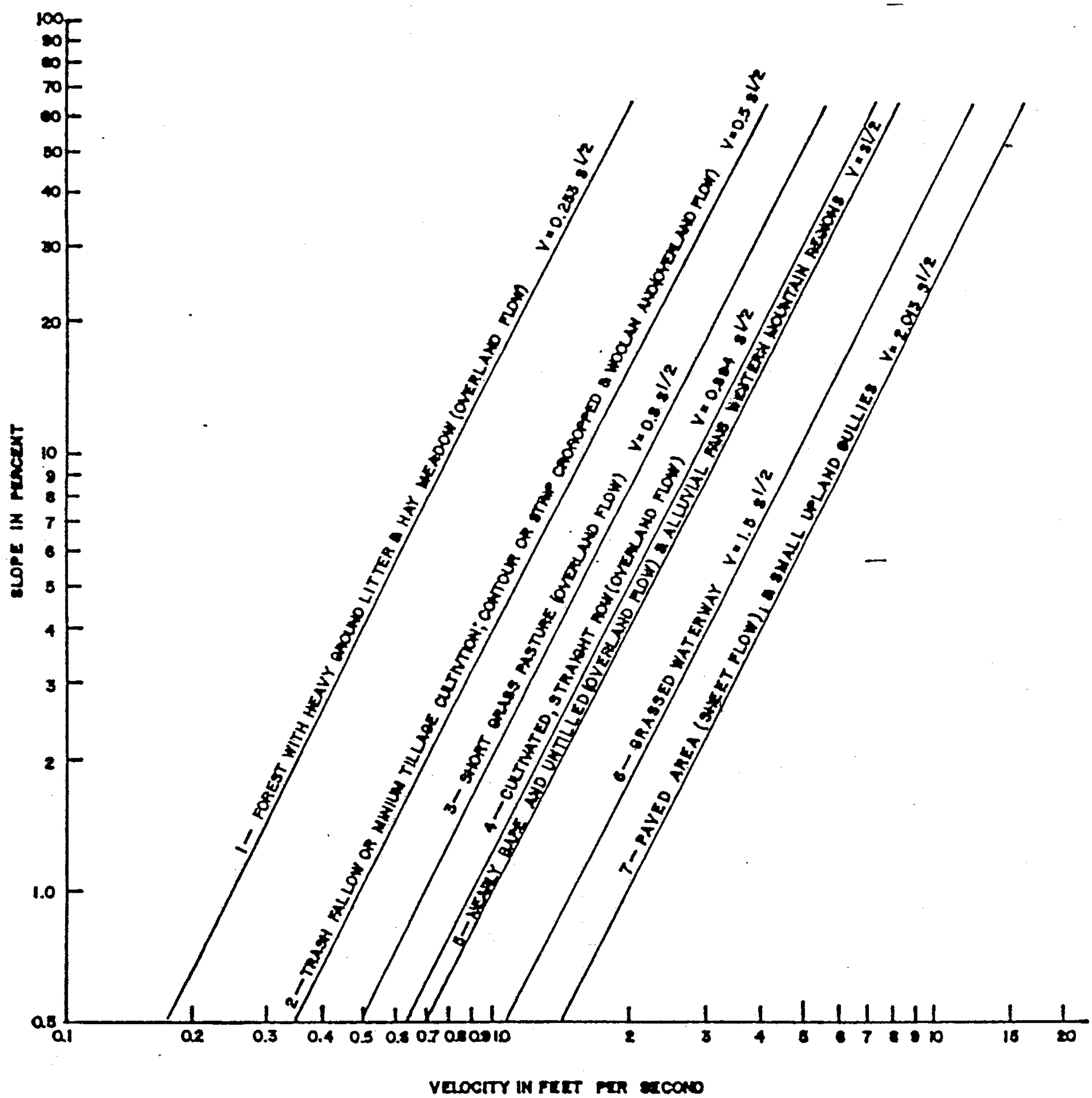

Figure 4.13 SCS's Upland Curves (SCS, 1972)

SEDIMOT II - MODELLING TECHNIQUES (1980).

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CURVE NUMBERS

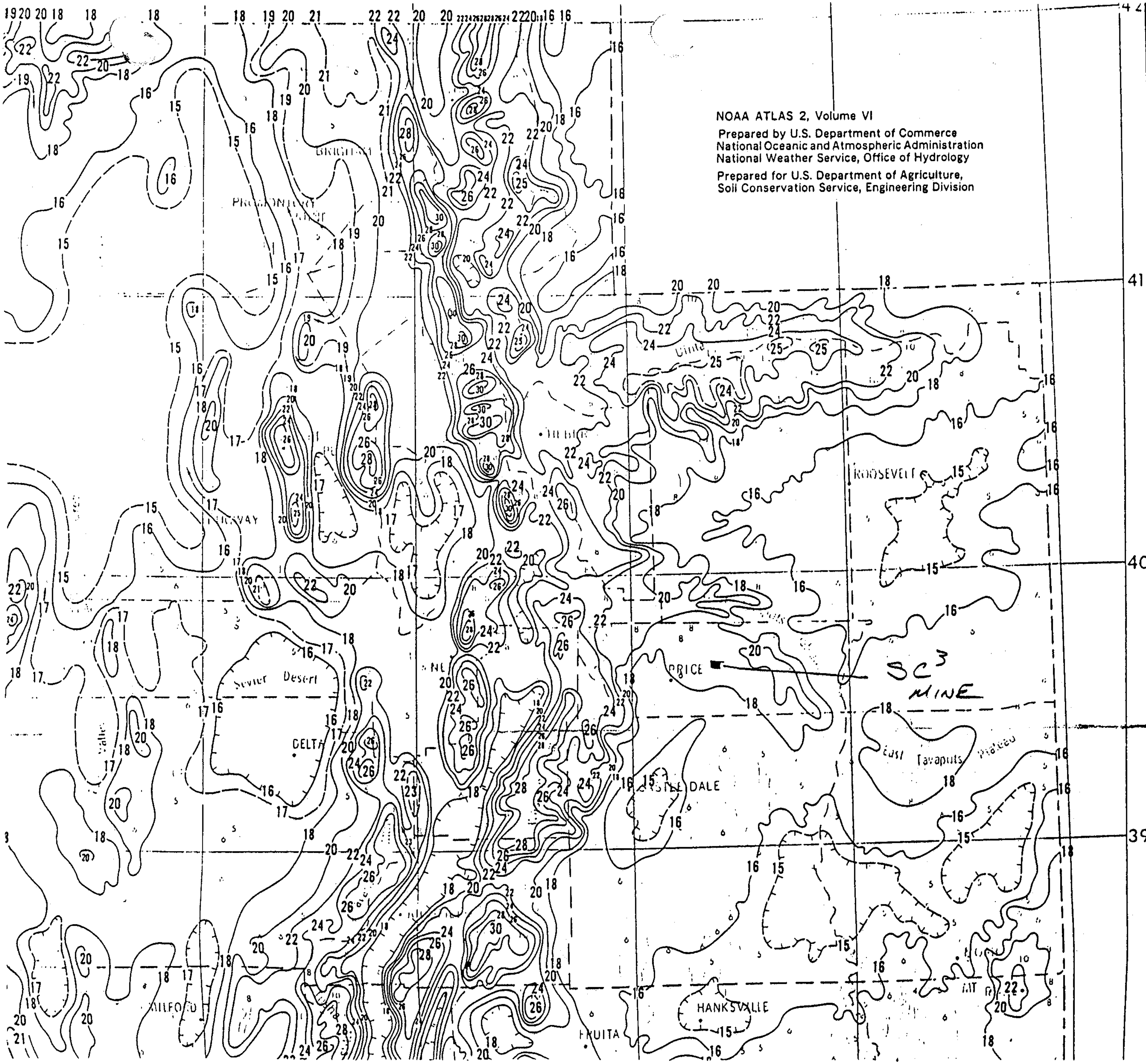
WATERSHED I.D.	CN VALUE	COMMENTS
WS-4	75	UNDISTURBED
WS-6	90	DISTURBED
WS-11	90	"
WS-12	80	MOSTLY UNDISTURBED
WS-13a	75	UNDISTURBED
WS-13b	75	UNDISTURBED
WS-14	85	DISTURBED
ASCA #5	75	RECLAIMED

TIME OF CONCENTRATION

WATERSHED ID	HYDRALIC LENGTH	CURVE NUMBER	AWS (%)	LAG TIME	Tc (hrs)
WS-4	900	75	34.5	0.04	0.06
WS-6	2550	90	6.4	0.19	0.31
WS-11	1040	90	17.3	0.06	0.09
WS-12	1050	80	34.1	0.06	0.09
WS-13a	825	75	62.5	0.04	0.07
WS-13b	475	75	63.1	0.03	0.04
WS-14	775	85	20.8	0.05	0.08
ASCA #5	350	75	26.8	0.03	0.05

Check these ✓ ✓ ✓

TIME OF CONCENTRATIONS FOR OTHER W.S.'S TAKEN FROM DOGM MEMO DATED OCT. 21, 1987 FROM KEITH WHEELER.


NOAA ATLAS 2, Volume VI
Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology
Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division
Sevier Desert
DELTA
PRICE
SC3 MINE
HANKSVILLE
FRUITA
ROOSEVELT
East Tavaputs Plateau
Uinta
39
40
41

TOTAL DRAINAGE AREA CONTRIBUTING TO SED. POND

WATERSHED ID	AREA (AC)	CURVE NUMBER
WS-3	6.5	75
WS-4	9.9	75
WS-5	3.1	75
WS-6	4.0	90
WS-7	3.5	90
WS-8	0.9	30 ?
WS-9	1.5	90
WS-10	0.5 0.5	75 100
WS-11	1.0	90
WS-12	3.6	80
WS-14	0.8	85
TOTAL	35.80	AVE. WT. CN. = 80.4 ≈ 80

Round up

RUNOFF VOLUME TO SED. POND

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} = \frac{(1.9 - 0.2(2.5))^2}{1.9 + 0.8(2.5)} = 0.50 \text{ in}$$

CN = 80 ⇒ S = 2.50

P = 1.90 in (MILLER, ET. AL., 1973)

$$Vol = Q * A = 0.5/12 * 35.8 = 1.49 \text{ AC-FT}$$

SEDIMENT VOLUME

CALCULATED BASED ON 0.1 AC-FT/AC-DIST.:

DISTURBED WATERSHEDS	DISTURBED AREA (AC)	SED. VOLUME (AC-FT)
WS-6	4.0	0.4
WS-7	3.5	0.35
WS-8	0.9	0.09
WS-9	1.5	0.15
WS-10	0.5	0.05
WS-11	1.0	0.10
WS-12	2.1	0.21
WS-14	0.8	0.08
TOTAL	14.30	1.43 AC-FT

SEDIMENT CLEANOUT VOLUME

- SET @ 60% OF SED. STORAGE VOLUME

CLEANOUT VOL = 1.43 AC-FT * 0.6
= 0.86 AC-FT

NOTE: ACCORDING TO THE SC^3 SEDIMENTATION POND MODIFICATION FINAL RECONSTRUCTION REPORT (REVISED 2/24/87), THE FOLLOWING CURVE DOES NOT ACCOUNT FOR 0.3 AC-FT OF SEDIMENT STORAGE THAT WAS PRESENT AT THE TIME OF SURVEY. THUS, IN THE DESIGN EVALUATION 0.3 AC-FT WAS ADDED TO THE STORAGE VOLUMES.

PROCESS WATER VOLUME

- IN THE EVENT OF A WORST-CASE PREP. PLANT SHUTDOWN:

✓ 90,000 gALS THICKNER
✓ 43,000 gALS JIG SUMP IN PREP. PLANT
✓ 9,300 gALS CLARIFICATION TANK

142,300 gALS TOTAL WATER COULD BE DISCHARGED.

THIS WATER WOULD BE CONVEYED BY THE CONTAINMENT DITCHES TO THE SED. POND.

STORAGE VOLUME

142,300 gAL = 0.44 AC-FT ✓

DETERMINE CAPACITY OF POND:

1 MAY '91 SURVEY + INFORMATION FROM DRAWINGS:

B-125 thru 127

D 202

WHERE USED TO DETERMINE CAPACITY.

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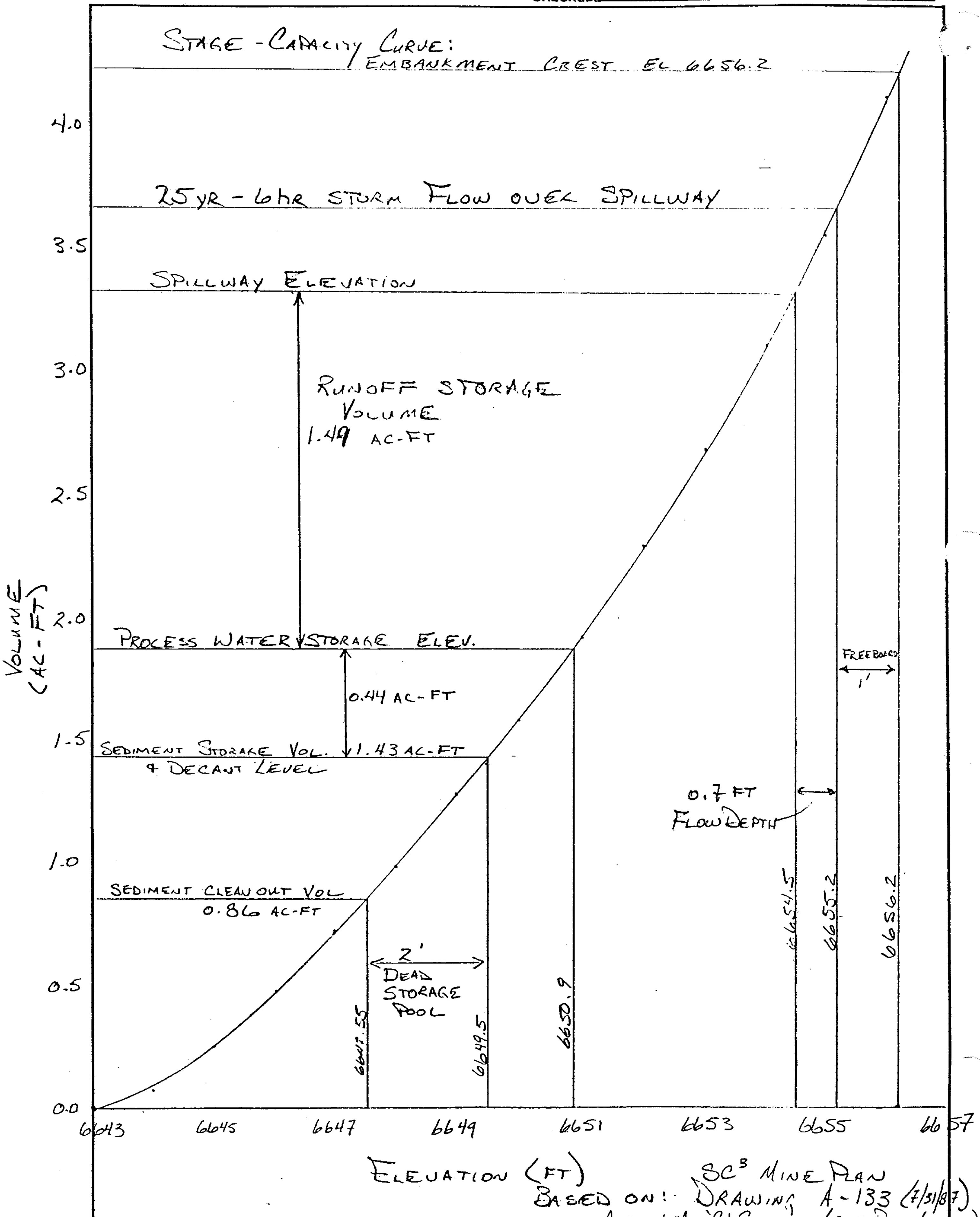

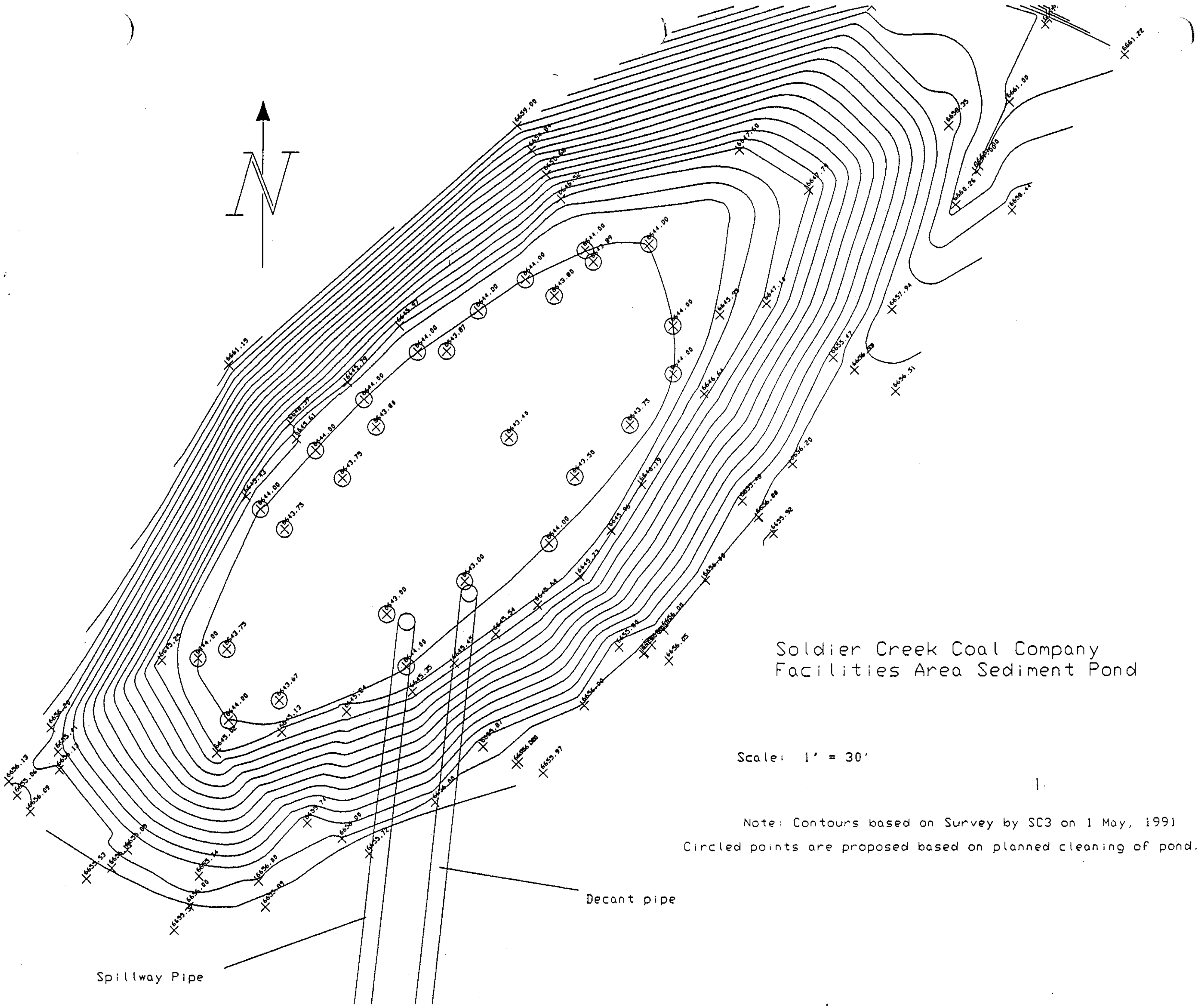

Soldier Creek Coal Company
Facilities Area Sediment Pond

Scale: 1' = 30'

Note: Contours based on Survey by SC3 on 1 May, 1991
Circled points are proposed based on planned cleaning of pond.

6a/35

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ELEV.	AREA (FT^2)	AVERAGE AREA (FT^2)	CONTOUR INCR. (FT)	VOLUME (AC-FT)	CUM. VOLUME (AC-FT)
6643	0				
		3367	1	0.08	0.08
6644	6733				
		7844	1	0.18	0.26
6645	8954				
		9488	1	0.22	0.48
6646	10021				
		10585	1	0.24	0.72
6647	11148				
		11682	1	0.27	0.99
6648	12215				
		12718	1	0.29	1.28
6649	13221				
		13744	1	0.32	1.59
6650	14266				
		14812	1	0.34	1.93
6651	15358				
		15926	1	0.37	2.30
6652	16494				
		17081	1	0.39	2.69
6653	17667				
		18275	1	0.42	3.11
6654	18882				
		19511	1	0.45	3.56
6655	20139				
		20602	1.2	0.57	4.13
6656.2	21065				

SEDIMENT POND CONCLUSIONS:

1) THE POND IS ADEQUATELY SIZED TO HOLD THE REQUIRED VOLUME OF SEDIMENT, PROCESS WATER, AND RUNOFF FROM THE DISTURBED AND UNDISTURBED AREAS CONTRIBUTING TO THE POND.

2) TO ADDRESS THE CONCERNS RAISED BY THE DOGM, BY THE REGULATION CHANGES, THE EXISTING SPILLWAY WILL BE RAISED TO ELEVATION 6654.50 AND BE RE-DESIGNATED AS THE EMERGENCY SPILLWAY.

THE EXISTING DECANT WILL BE RAISED TO ELEVATION 6654.50 AND BE DESIGNATED AS THE PRINCIPAL SPILLWAY.

THE COMBINED CAPACITY OF THESE PIPES CAN HANDLE THE 25 YR-6 HR PEAK FLOW W/ 0.7 FT OF HEAD AND 1 FT OF FREEBOARD.

3) WITH CHANGE IN DECANT PIPE, A NEW DECANT MUST BE PROVIDED. A 3-INCH VALVE WILL BE INSTALLED AT AN ELEVATION OF 6649.50. THIS WILL PROVIDE ADEQUATE VOLUME FOR THE 10 YR-24 HR RUNOFF AND PROCESS-WATER AND WILL BE LOCATED 2 FT. ABOVE THE SEDIMENT CLEAN-OUT LEVEL AS REQUESTED BY STATE HEALTH.

EVALUATION OF CONVEYANCE TO POND

DETERMINE PEAK FLOWS FROM WATERSHEDS CONTRIBUTING TO SED. POND.

- CALCULATIONS BASED ON:
  - METHODOLOGY: SEDIMOT II
  - ← DESIGN STORM: 10 yr, 6 hr = 1.52 in (MILLER, ET AL, 1973)
  - STORM DIST.: SCS TYPE "B" (SEE ATTACHED CALC.)
  - TIME INCREMENT OF OUTFLOW HYDROGRAPH: 0.1 hr (min. VALUE)
  - COMPUTATION MODE: HYDROLOGY ONLY
  - MODEL STRUCTURE: (SEE ATTACHED SCHEMATIC)

- ROUTING PARAMETERS

@ J1, B1 SWS1 → J1, B1, S1   WS11, 4, Portable

$T_t = \frac{D}{V} = \frac{450 \text{ FT}}{4.7 \text{ Ft/s}} = 95.7 s = 1.6 \text{ min} = 0.03 \text{ hrs}$

V = 4.7 @ 5.3% CHANNEL SLOPE; PAVED AREA - SHEET FLOW

V = 0/A

MUSKINGUM K = 0.03 hrs

MUSKINGUM X = 0.37

@ J1 → J2, B1   S1 Y

$T_t = \frac{D}{V} = \frac{300 \text{ FT}}{2 \text{ F/s}} = 150 s = 2.5 m = 0.04 hr$

V = 2 F/s   BASED ON: 1% SLOPE ON PAVED SURFACE

MUSKINGUM K = 0.04

MUSKINGUM X = 0.27

SCS TYPE "B" RAINFALL DIST.

TIME PERCENTAGE	RAINFALL PERCENTAGE	TIME (HRS)	10 YR-6 HR CUMMULATIVE RAINFALL (IN)	25 YR-6 HR CUMMULATIVE RAINFALL (IN)
0	0	0	0	0
8.33	3.5	0.5	0.05	0.06
16.67	8.0	1.0	0.12	0.22
25.00	13.5	1.5	0.21	0.36
33.33	23.0	2.0	0.35	0.62
41.67	60.0	2.5	0.91	1.06
50.00	70.0	3.0	1.07	1.23
58.33	78.0	3.5	1.19	1.37
66.67	83.5	4.0	1.27	1.47
75.00	88.5	4.5	1.35	1.56
83.33	92.5	5.0	1.41	1.63
91.67	96.5	5.5	1.47	1.70
100.00	100.0	6.0	1.52	1.76

SOURCE: U.S. SCS, 1972. NEH-4, CHAP. 21

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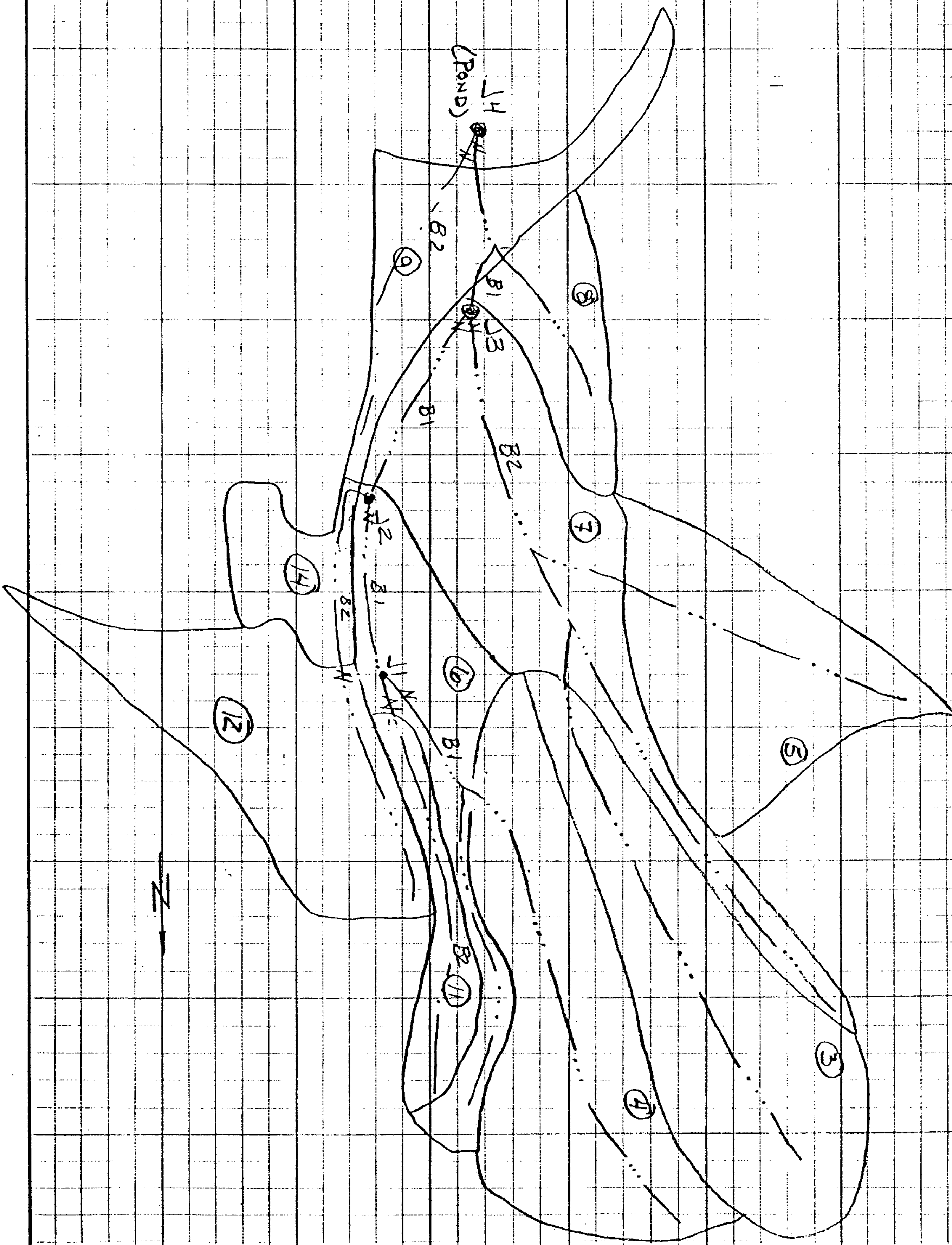

@ J3 → J4, B1, S1

$T_t = \frac{D}{V} = \frac{620}{4.8} = 129.2\ s = 2.15\ m = 0.04\ hr$

V = 4.8 FPS BASED ON: 5.6 % SLOPE; PAVED SURFACE

MUSKINGUM K = 0.04 hrs

MUSKINGUM X = 0.37

@ J4B1,SWS1 → J4

$T_t = \frac{D}{V} = \frac{270}{6.2} = 43.5\ s = 0.73\ m = 0.01\ hrs$

V = 6.2 FPS BASED ON: 9.3 % SLOPE; PAVED SURFACE

~~MUSKINGUM K = 0.01 hrs~~

MUSKINGUM X = 0.39

NO. OF SUBWATERSHEDS:

JUNCTIONS	BRANCHES	STRUCTURES	SUBWATERSHEDS	
1	1	1 (NULL)	1	WS-4
1	2	1 (CULVERT)	1	WS-11
2	1	1 (NULL)	1	WS-6
2	2	2 (CULVERTS)	2	WS-12+14
3	1	1 (NULL)	1	WS-7
3	2	1 (NULL)	2	WS-3+5
4	1	1 (NULL)	1	WS-8
4	2	1 (NULL)	1	WS-9

10yr-6hr SEDIMOT II OUTPUT PRESENTED IN ATTACHMENT A.

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SUMMARY OF SEDIMOT II OUTPUT

WATERSHED I.D.	INDIVIDUAL WATERSHED PEAK FLOW (CFS)	ROUTED PEAK FLOW (CFS)
WS-3	0.76	0.76
WS-4	1.16	1.16
WS-5	0.36	0.36
WS-6	1.71	4.84
WS-7	2.34	8.30
WS-3	0.24	0.24
WS-9	0.80	0.80
WS-10	0.56	9.91
WS-11	0.67	0.67
WS-12	0.94	0.94
WS-14	0.36	1.30

PRINTOUT FOR SEDIMOT II RUN IS PRESENTED IN ATTACHMENT B.

EVALUATION OF EXISTING STRUCTURES

DITCHES

Jct 2, WS-6 → indicative of the upstream end of the concrete ditch and the concrete/cobblestone ditch as well as the downstream end of the half-round culvert.

Design $q_p = 4.8$ cfs

Ditch capacities (w/ 0.3' freeboard - see Drawing B-134 [7/24/87]):

Concrete → $q_d = 15.7$ cfs

Concrete / cobblestone → $q_d = 14.0$ cfs

Half-round culvert → $q_d = 4.1$ cfs

Thus, concrete and concrete/cobblestone ditches are adequate with at least 0.3 ft freeboard. Calculate freeboard that remains in half-round culvert when $q_p = 4.8$ cfs.

See hydraulic table on pg. 16 of this calc. Assume $n = 0.024$, $S = 0.017$ (minimum value on Drawing B-134).

d (ft)	d/D	$\frac{Qn}{d^{8/3} S^{1/2}}$	Q (cfs)
0.70	0.35	2.000	4.2
0.75	0.375	1.895	4.8
0.80	0.40	1.797	5.4
0.90	0.45	1.622	6.7
1.00	0.50	1.471	8.0

Freeboard is slightly less than 0.25 ft. Although this is less than the 0.3 ft value for ENGINEERING DESIGN, site-specific rainfall data documented by SC3 ("Sedimentation Pond Modification, Final Construction Report", revised 2/24/87) indicate that runoff from the design event is actually less than calculated above. Thus, given the fact that the half-round will not overtop as shown above and the fact that runoff during the design event has been shown to be less at the mine site than predicted, the half-round is considered adequate.

Table 21.—*Uniform flow in circular sections flowing partly full*

d=Depth of flow
D=Diameter of pipe
A=Area of flow
R=Hydraulic radius
Q=Discharge in second-feet by Manning's formula
n=Manning's coefficient
S=Slope of the channel bottom and of the water surface

$\frac{d}{D}$	$\frac{A}{D^2}$	$\frac{R}{D}$	$\frac{Qn}{D^{8/3}S^{1/2}}$	$\frac{Qn}{d^{8/3}S^{1/2}}$	$\frac{d}{D}$	$\frac{A}{D^2}$	$\frac{R}{D}$	$\frac{Qn}{D^{8/3}S^{1/2}}$	$\frac{Qn}{d^{8/3}S^{1/2}}$
0.01	0.0013	0.0066	0.00007	15.04	**0.51**	0.4027	0.2531	0.239	1.442
0.02	0.0037	0.0132	0.00031	10.57	**0.52**	0.4127	0.2562	0.247	1.415
0.03	0.0069	0.0197	0.00074	8.56	**0.53**	0.4227	0.2592	0.255	1.388
0.04	0.0105	0.0262	0.00138	7.38	**0.54**	0.4327	0.2621	0.263	1.362
0.05	0.0147	0.0325	0.00222	6.55	**0.55**	0.4426	0.2649	0.271	1.336
0.06	0.0192	0.0389	0.00328	5.95	**0.56**	0.4526	0.2676	0.279	1.311
0.07	0.0242	0.0451	0.00455	5.47	**0.57**	0.4625	0.2703	0.287	1.286
0.08	0.0294	0.0513	0.00604	5.09	**0.58**	0.4724	0.2728	0.295	1.262
0.09	0.0350	0.0575	0.00775	4.76	**0.59**	0.4822	0.2753	0.303	1.238
0.10	0.0409	0.0635	0.00967	4.49	**0.60**	0.4920	0.2776	0.311	1.215
0.11	0.0470	0.0695	0.01181	4.25	**0.61**	0.5018	0.2799	0.319	1.192
0.12	0.0534	0.0755	0.01417	4.04	**0.62**	0.5115	0.2821	0.327	1.170
0.13	0.0600	0.0813	0.01674	3.86	**0.63**	0.5212	0.2842	0.335	1.148
0.14	0.0668	0.0871	0.01952	3.69	**0.64**	0.5308	0.2862	0.343	1.126
0.15	0.0739	0.0929	0.0225	3.54	**0.65**	0.5404	0.2882	0.350	1.105
0.16	0.0811	0.0985	0.0257	3.41	**0.66**	0.5499	0.2900	0.358	1.084
0.17	0.0885	0.1042	0.0291	3.28	**0.67**	0.5594	0.2917	0.366	1.064
0.18	0.0961	0.1097	0.0327	3.17	**0.68**	0.5687	0.2933	0.373	1.044
0.19	0.1039	0.1152	0.0365	3.06	**0.69**	0.5780	0.2948	0.380	1.024
0.20	0.1118	0.1206	0.0406	2.96	**0.70**	0.5872	0.2962	0.388	1.004
0.21	0.1199	0.1259	0.0448	2.87	**0.71**	0.5964	0.2975	0.395	0.985
0.22	0.1281	0.1312	0.0492	2.79	**0.72**	0.6054	0.2987	0.402	0.965
0.23	0.1365	0.1364	0.0537	2.71	**0.73**	0.6143	0.2998	0.409	0.947
0.24	0.1449	0.1416	0.0585	2.63	**0.74**	0.6231	0.3008	0.416	0.928
0.25	0.1535	0.1466	0.0634	2.56	**0.75**	0.6319	0.3017	0.422	0.910
0.26	0.1623	0.1516	0.0686	2.49	**0.76**	0.6405	0.3024	0.429	0.891
0.27	0.1711	0.1566	0.0739	2.42	**0.77**	0.6489	0.3031	0.435	0.873
0.28	0.1800	0.1614	0.0793	2.36	**0.78**	0.6573	0.3036	0.441	0.856
0.29	0.1890	0.1662	0.0849	2.30	**0.79**	0.6655	0.3039	0.447	0.838
0.30	0.1982	0.1709	0.0907	2.25	**0.80**	0.6736	0.3042	0.453	0.821
0.31	0.2074	0.1756	0.0966	2.20	**0.81**	0.6815	0.3043	0.458	0.804
0.32	0.2167	0.1802	0.1027	2.14	**0.82**	0.6893	0.3043	0.463	0.787
0.33	0.2260	0.1847	0.1089	2.09	**0.83**	0.6969	0.3041	0.468	0.770
0.34	0.2355	0.1891	0.1153	2.05	**0.84**	0.7043	0.3038	0.473	0.753
0.35	0.2450	0.1935	0.1218	2.00	**0.85**	0.7115	0.3033	0.477	0.736
0.36	0.2546	0.1978	0.1284	1.958	**0.86**	0.7186	0.3026	0.481	0.720
0.37	0.2642	0.2020	0.1351	1.915	**0.87**	0.7254	0.3018	0.485	0.703
0.38	0.2739	0.2062	0.1420	1.875	**0.88**	0.7320	0.3007	0.488	0.687
0.39	0.2836	0.2102	0.1490	1.835	**0.89**	0.7384	0.2995	0.491	0.670
0.40	0.2934	0.2142	0.1561	1.797	**0.90**	0.7445	0.2980	0.494	0.654
0.41	0.3032	0.2182	0.1633	1.760	**0.91**	0.7504	0.2963	0.496	0.637
0.42	0.3130	0.2220	0.1705	1.724	**0.92**	0.7560	0.2944	0.497	0.621
0.43	0.3229	0.2258	0.1779	1.689	**0.93**	0.7612	0.2921	0.498	0.604
0.44	0.3328	0.2295	0.1854	1.655	**0.94**	0.7662	0.2895	0.498	0.588
0.45	0.3428	0.2331	0.1929	1.622	**0.95**	0.7707	0.2865	0.498	0.571
0.46	0.3527	0.2366	0.201	1.590	**0.96**	0.7749	0.2829	0.496	0.553
0.47	0.3627	0.2401	0.208	1.559	**0.97**	0.7785	0.2787	0.494	0.535
0.48	0.3727	0.2435	0.216	1.530	**0.98**	0.7817	0.2735	0.489	0.517
0.49	0.3827	0.2468	0.224	1.500	**0.99**	0.7841	0.2666	0.483	0.496
0.50	0.3927	0.2500	0.232	1.471	**1.00**	0.7854	0.2500	0.463	0.463

Source: "Hydraulic and Excavation Tables"
U.S. Bureau of Reclamation

JUNCTION 3 → INDICATIVE of the downstream end of THE CONCRETE AND CONCRETE/COBBLESTONE DITCHES.

DESIGN q_p = 8.3 CFS

DITCH CAPACITIES w/ 0.3 FT FREEBOARD - SEE DRAWING B-134 (7/24/87):

CONCRETE → q_p = 15.7 CFS

CONCRETE/COBBLESTONE → q_p = 14.0 CFS

THUS, CONCRETE AND CONCRETE/COBBLESTONE DITCHES ARE ADEQUATE WITH AT LEAST 0.3 FEET FREEBOARD.

CULVERT TO POND

JUNCTION 3 FLOW + FLOW FROM WS-8 (J4, B1, SWS1) IS INDICATIVE OF INFLOW TO 24-INCH CULVERT TO SED. POND.

DESIGN q_p = 8.3 CFS + 0.24 CFS ≈ 8.5 CFS

CULVERT CAPACITY (24-INCH CMP) = 12.8 CFS
(SEE DRAWING B-134)

THUS, 24-INCH CULVERT IS ADEQUATE TO CONVEY DESIGN FLOW TO SED. POND UNDER INLET CONTROL CONDITIONS.

Determine spillway hydraulics using SEDIMOT II. Use watershed data presented previously.

Design storm → 25-yr 6-hr = 1.76 in (Miller et al., 1973)

Storm type → SCS Type "B"

Time increment = 0.1 hr

Computation mode → hydro.

MODEL STRUCTURE: → see schematic on pg. 11 of this calc.

No. JUNCTIONS:

No. BRANCHES:

No. STRUCTURES:

No. SUB WATERSHEDS:

} SEE SCHEMATIC DATA PAGES 9 TO 13 OF THIS CALC. SUMMARY ON PAGE 13 THIS CALC.

SEDIMOT II RESULTS: (ATTACHMENT C)

DESIGN qp = 10.34 CFS

EVALUATION OF POND HYDRAULICS

EXISTING SPILLWAY CAPACITY:

- 18-INCH RISER PIPE
- 18-INCH BARREL PIPE
- HYDRAULIC EQUATIONS: (BARFIELD, ET.AL., 1981)

  - WEIR FLOW

$$Q = C L H^{3/2}$$

$$C = 3.27 + 0.4\ H/w$$

H = HEAD OVER WEIR
W = HEIGHT OF RISER

L = CIRCUMFERENCE OF RISER PIPE

H = HEAD OVER WEIR.

  - ORIFICE FLOW

$$Q = C' a \sqrt{2gH}$$

C' = 0.80 (ORIFICE COEFF. FOR LARGE DIA.)

a = AREA OF RISER

H = HEAD OVER INLET

g = 32.2 FT/SEC²

  - PIPE FLOW

$$Q = \frac{a(2gH')^{1/2}}{(1 + K_e + K_b + K_c L)^{1/2}}$$

a = AREA

H' = HEAD OVER INLET + HEIGHT FROM INLET CREST TO OUTLET + OUTLET CORRECTION

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K_e = ENTERANCE LOSS

K_b = BEND LOSS

K_c = FRICTION LOSS

L = LENGTH OF RISER + LENGTH OF BARREL

RESULTS: PRESENTED ON COMPUTER PRINTOUT p 21

→ GRAPH OF DISCHARGE - HEAD CURVE
FIGURE 1 SHOWS THAT THE
DESIGN PEAK FLOW CAN BE PASSED
AT A HEAD OF 0.62 FT (SEE ATTACHED
PLOT p 22)

CHECK FREEBOARD:

TOP OF EMBANKMENT = 6656.2 FT

CREST OF SPILLWAY = (6654.1 FT

DESIGN FLOW DEPTH = + 0.62 FT)

DESIGN FLOW ELEVATION = 6654.72 FT

FREEBOARD = 1.48 FT

└ MORE THAN 1 FT, OK.

OUTLET VELOCITY:

ASSUMING NO PRESSURE:
MANNING'S n = 0.024
BARREL SLOPE = $\frac{6645.6 - 6643.7}{87}$ = 0.022 FT/FT
" DIAMETER = 1.5 FT

Q_{MAX} = 8.44 CFS

AS SHOWN ON PAGES 21 + 22 OF THIS CALC., HIGHER FLOWS ARE POSSIBLE DUE TO THE HEAD AT THE INLET INDICATING THAT THE FLOW IS UNDER SLIGHT PRESSURE AND PIPE IS FLOWING FULL.

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Spillway outlet

Comment: Sed. Pond Spillway Outlet

Solve For Actual Depth

Given Input Data:

Diameter..........	1.50 ft
Slope.............	0.0220 ft/ft
Manning's n.......	0.024
Discharge.........	10.34 cfs

Computed Results:

Worksheet does not have calculated results...

DISCHARGE GREATER THAN PIPE CAN HANDLE.

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

DROP INLET FOR FACILITIES AREA SED. POND

- THE PRINCIPLE AND EMERGENCY SPILLWAYS WILL BE LOCATED AT THE SAME ELEVATION
- EACH WILL CONSIST OF A 1.5 FT DIAMETER PIPE.
- CALCULATIONS FOR A SINGLE PIPE ARE ATTACHED
- FOR TWO PIPES THE FLOWS ARE DOUBLED. THESE ARE:

HEAD (FT)	WEIR FLOW	ORIFICE FLOW	PIPE FLOW
0.0	0.0	0.0	0.0
0.1	0.67	5.47	31.24
0.2	1.90	7.74	31.38
0.3	3.48	9.48	31.52
0.4	5.36	10.94	31.66
0.5	7.40	12.23	31.80
0.6	9.80	13.40	31.94
0.7	12.42	14.47	32.08
0.8	15.17	15.47	32.21
0.9	18.11	16.41	32.35
1.0	21.21	17.30	32.49

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Circular Drop-inlet Spillway
Flow Determination

Calculation inputs for:
Soldier Creek - Facilities Pond Spillway - Single Pipe

Weir flow:

Weir coefficient:	3.00
Diameter of riser:	1.50 ft

Orifice flow:

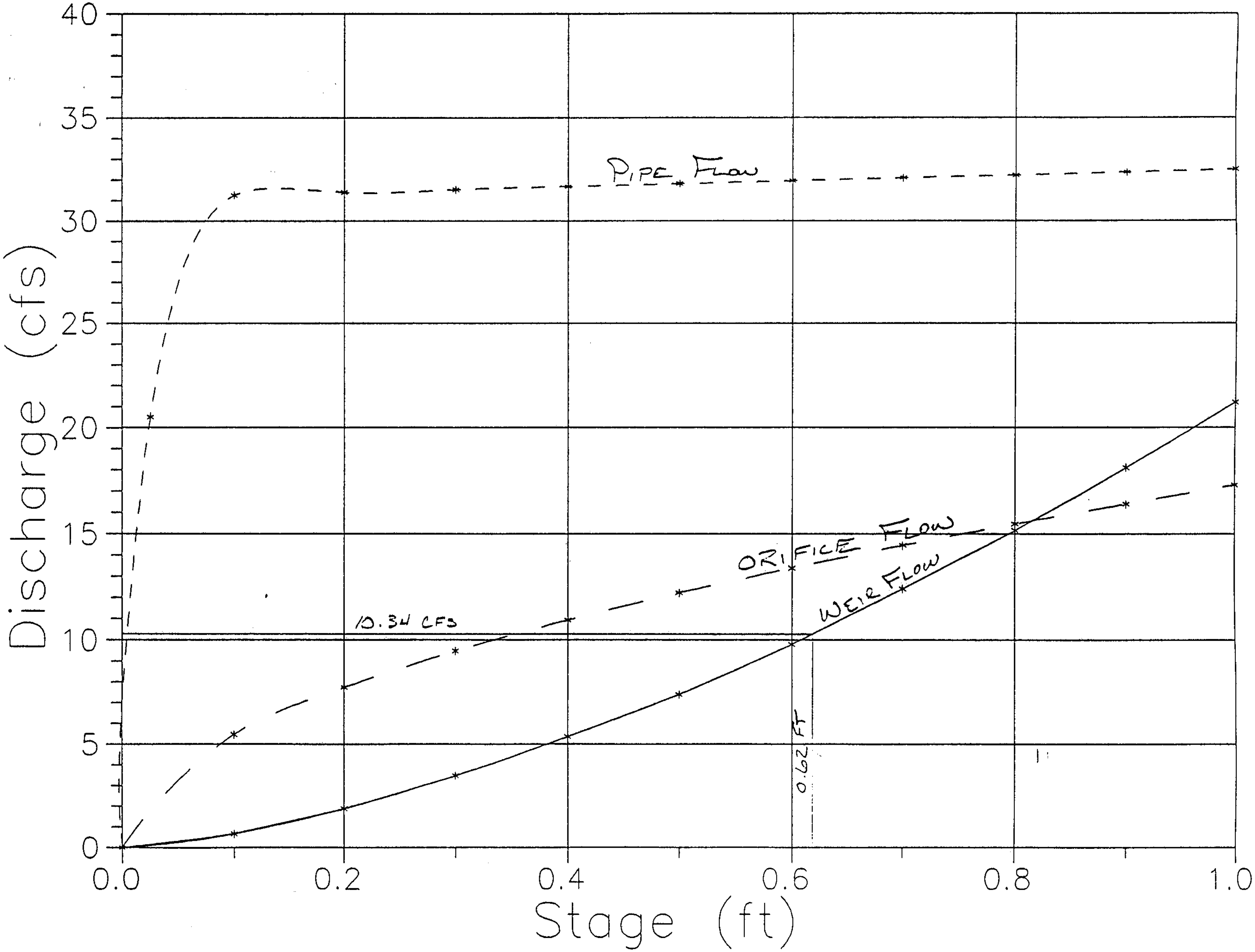
Orifice coefficient:	0.61

Pipe flow:

Length of horizontal pipe:	97.00 ft
Height of the riser:	10.00 ft – 9.0
Total length of pipe:	107.00 ft
Height from inlet to bottom of outlet:	11.00 ft
Diameter of horizontal pipe:	1.50 ft
Manning's n for pipe:	0.024
Head loss coefficient:	0.062
Entrance factor (Ke) for pipe:	1.00
Bend factor (Kb) for pipe:	0.50

Head	Weir flow	Orifice flow	Pipe flow
0.00	0.000	0.000	0.000
0.10	0.335	2.735	15.622
0.20	0.948	3.869	15.692
0.30	1.742	4.738	15.762
0.40	2.682	5.471	15.832
0.50	3.749	6.117	15.901
0.60	4.928	6.701	15.970
0.70	6.210	7.237	16.039
0.80	7.587	7.737	16.107
0.90	9.053	8.206	16.175
1.00	10.603	8.650	16.243

Figure 1. – Stage – Disharge Curve for SCCC Spillway



DETERMINE FULL FLOW OUTLET VELOCITY

PEAK DISCHARGE THRU SPILLWAY:

→ 10.34 CFS

AREA OF PIPE:

$A = 1.5^2 \pi = 1.767 \text{ FT}^2$

$\text{VELOCITY} = \frac{10.34}{1.77} = 5.85 \text{ FT/S}$

CHECK OUTLET RIPRAP ADEQUECY

THE CURVE ON PAGE 22b OF THIS CALC. INDICATES THAT THE d_{50} OF THE RIPRAP AT THE OUTLET MUST BE ATLEAST 0.5" IF THE SLOPE IS 1H:1V (STEEPEST SLOPE MEASURED ON EXISTING RIPRAP). SINCE THE EXISTING RIPRAP d_{50} IS IN EXCESS OF 2.0 FEET (VISUAL INSPECTION), EXISTING CONDITIONS ARE ADEQUATE TO CONTROL EROSION.

Riprap size vs. velocity (from Searcy, 1967):

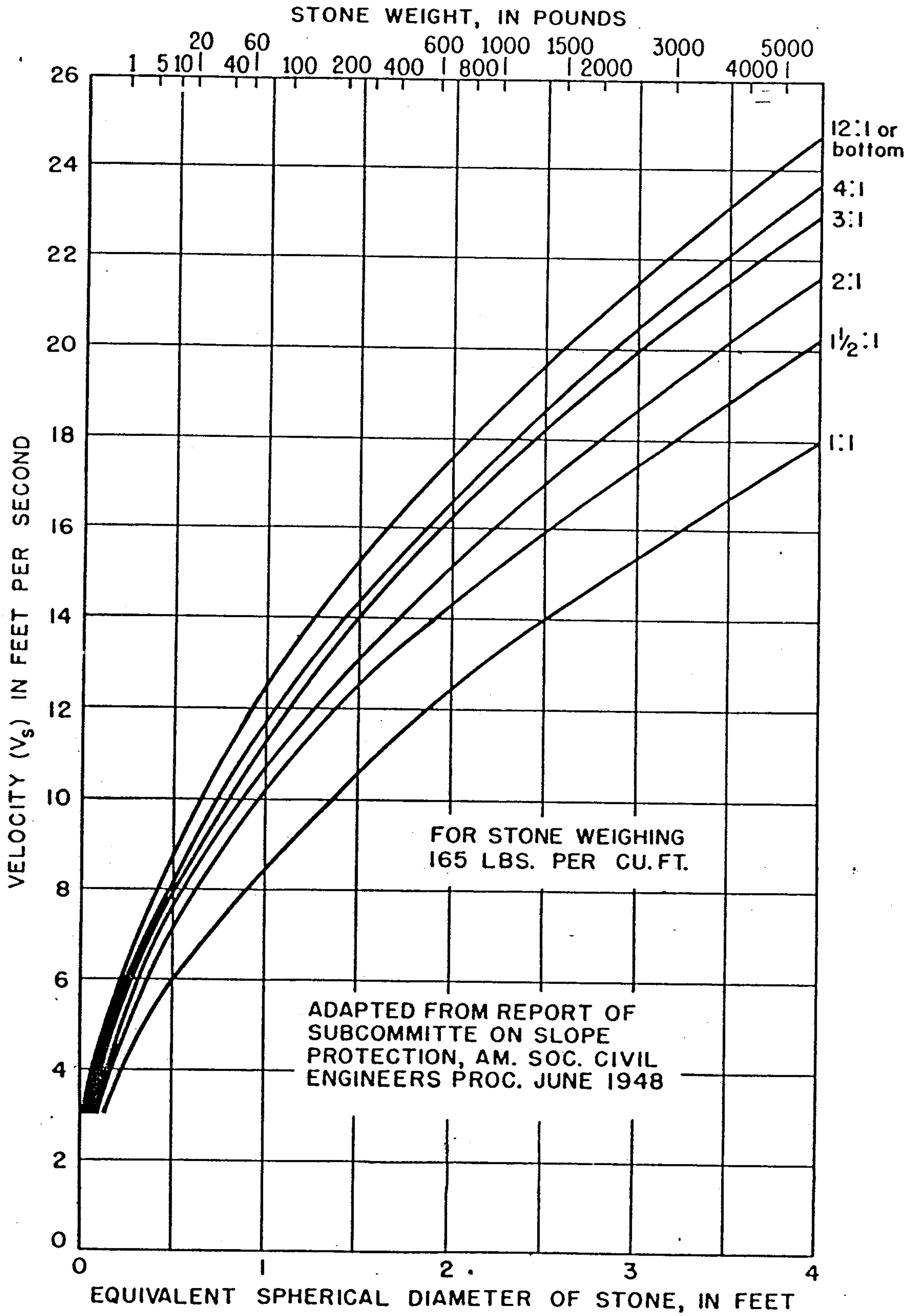


FIG. 2–SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

DESIGN OF NEW STRUCTURES FOR EXPANSION AREA.

DIVERSION DITCHS - EVALUATED FOR 18 + 24-INCH HALF-ROUND CULVERTS.

EVALUATION OF DRAINAGE DITCH 1 (SEE LOCATION p24)

- HANDLES RUNOFF FROM WS-11
- DESIGN q_p = 0.67 CFS

ASSUME:

HALF ROUND SHAPE

CHANNEL SLOPE = $\frac{(40-18)}{500 FT}$ = 0.044 FT/FT (SEE EXHIBIT 10.2.4-1)

DIAMETER = 18" + 24"

MANNING'S n = 0.024 CMP CULVERTS

RESULT: (SEE FLOW MASTER OUTPUT p. 28a + b)

	18"	24"
DEPTH:	0.24 FT	0.22 FT
VELOCITY:	3.64 FPS	3.51 FPS

USING 0.3 FT FREE BOARD:

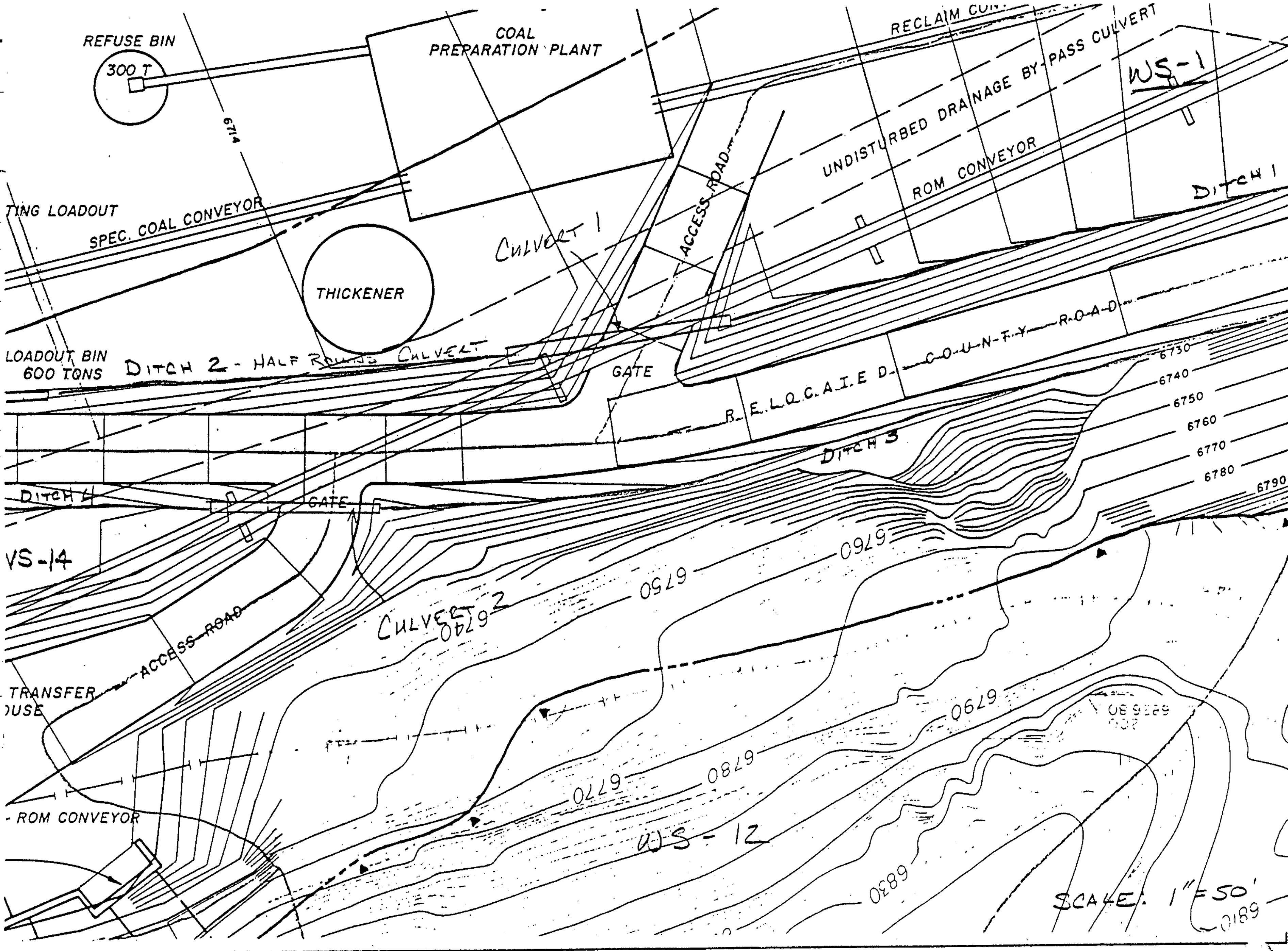
CHANNEL DEPTH: 0.54 FT. 0.52 FT
< 0.75 FT OK < 1.0 FT OK

EVALUATION OF DRAINAGE DITCH 2 (UPPER SECTION) (ABOVE CULVERT #3; SEE LOCATION p25)

- HANDLES RUNOFF FROM WS-11 + WS-4
- DESIGN q_p = 0.67 + 1.16 = 1.83 CFS

ASSUME:

HALF-ROUND SHAPE (SEE EXHIBIT 10.4.2-6)
CHANNEL SLOPE = 16-10/310 FT = 6/310 = 0.019 FT/FT
DIAMETER = 18" + 24"
MANNINGS n = 0.024 CMP CULVERT.



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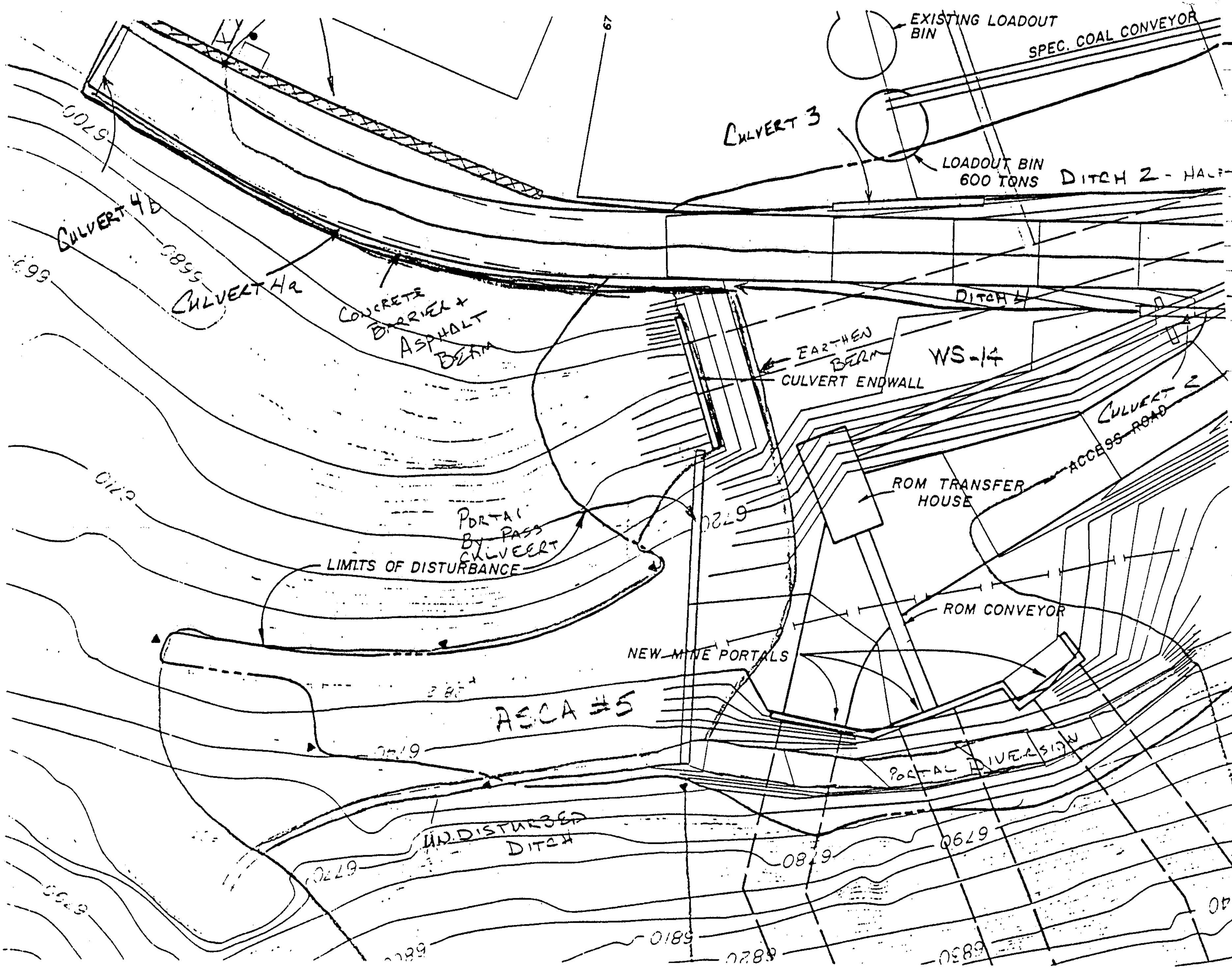

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RESULT: (SEE FLOW MASTER OUTPUT p 29a+b)

	18"	24"
DEPTH:	0.49 FT	0.44 FT
VELOCITY:	3.62 FPS	3.52 FPS

MINIMUM CHANNEL DEPTH (USING 0.3 FT FREEBOARD)

	FT	0.74 FT
	< 0.75 FT NO	< 1.0 FT OK

EVALUATION OF DRAINAGE DITCH - 5 (SEE LOCATION p 24)

- HANDLES RUNOFF FROM WS-12
- DESIGN q_p = 0.94 CFS

ASSUME (FOR FILL SECTIONS):

TRIANGULAR SHAPE

CHANNEL SLOPE = 8/310 = 0.026 FT/FT (SEE EXHIBIT 4.2-6)

CHANNEL SIDESLOPES = 3H:1V ON BOTH SIDES

MANNING'S n = 0.03 EARTH DITCH

RESULTS: (SEE FLOWMASTER OUTPUT p 30a)

DEPTH = 0.36 FT

VELOCITY = 2.45 FPS

MIN. CHANNEL DEPTH (USING 0.3 FT FREEBOARD):
0.66 FT < 1.0 FT OK

FOR CUT SECTION EVERYTHING IS THE SAME EXCEPT CHANNEL SIDE SLOPE:

RIGHT SIDESLOPE 1.25:1
LEFT SIDESLOPE 5.0:1

RESULTS: (SEE FLOWMASTER OUTPUT p 30b)
DEPTH = 0.41 FT
VELOCITY = 2.59 FPS
MIN. CHANNEL DEPTH = 0.71 FT < 1.0 FT OK!

EVALUATION OF DRAINAGE DITCH 4 (SEE LOCATION p25)

- HANDLES RUNOFF FROM WS-12 + WS-14
- DESIGN qp = 0.94 + 0.36 = 1.30 CFS

ASSUME:

TRIANGULAR SHAPE

CHANNEL SLOPE = 7/190 = 0.037 FT/FT

CHANNEL SIDESLOPES = 3H : 1V

MANNING'S n = 0.03 EARTH DITCH

RESULTS: (SEE FLOWMASTER OUTPUT p 31)

DEPTH = 0.38 FT

VELOCITY = 3.03 FPS

MIN. CHANNEL DEPTH = 0.68 FT < 1 FT OK.

EVALUATION OF DRAINAGE DITCH 2 (LOWER SECTION, BELOW CULVERT #3; SEE LOCATION p25)

- HANDLES RUNOFF FROM DITCH 2 UPPER SECTION & WS-6

- DESIGN qp = 1.83 + 1.71 = 3.54 CFS

ASSUME:

HALF-ROUND SHAPE

CHANNEL SLOPE = 1.5/70 = 0.021 FT/FT

DIAMETER = 18" + 24"

MANNING'S n = 0.024 CMP CULVERT

RESULTS: (FLOWMASTER OUTPUT p 32a+b)

	18	24"
DEPTH =	0.68 FT	0.60 FT
VELOCITY =	4.57 FPS	4.48 FPS
MIN. CHANNEL DEPTH =	0.98 FT	0.9 FT

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Ditch-1-18

Comment: Expansion Area - Ditch-1 18-inch Half Round

Solve For Actual Depth

Given Input Data:

Diameter..........	1.50 ft
Slope.............	0.0440 ft/ft
Manning's n.......	0.024
Discharge.........	0.67 cfs

Computed Results:

Depth.............	0.24 ft
Velocity..........	3.64 fps
Flow Area.........	0.18 sf
Critical Depth....	0.30 ft
Critical Slope....	0.0172 ft/ft
Percent Full......	16.09 %
Full Capacity.....	11.94 cfs
QMAX @.94D........	12.84 cfs
Froude Number.....	1.57 (flow is Supercritical)

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Ditch-1-24

Comment: Expansion Area - Ditch-1 24-inch Half round

Solve For Actual Depth

Given Input Data:

Diameter..........	2.00 ft
Slope.............	0.0440 ft/ft
Manning's n.......	0.024
Discharge.........	0.67 cfs

Computed Results:

Depth.............	0.22 ft
Velocity..........	3.51 fps
Flow Area.........	0.19 sf
Critical Depth....	0.28 ft
Critical Slope....	0.0166 ft/ft
Percent Full......	11.12 %
Full Capacity.....	25.70 cfs
QMAX @.94D........	27.65 cfs
Froude Number.....	1.59 (flow is Supercritical)

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Ditch-2-18

Comment: Expansion Area - Ditch-2 18-inch Half Round

Solve For Actual Depth

Given Input Data:

Diameter..........	1.50 ft
Slope.............	0.0190 ft/ft
Manning's n.......	0.024
Discharge.........	1.83 cfs

Computed Results:

Depth.............	0.49 ft
Velocity..........	3.62 fps
Flow Area.........	0.51 sf
Critical Depth....	0.51 ft
Critical Slope....	0.0168 ft/ft
Percent Full......	32.86 %
Full Capacity.....	7.84 cfs
QMAX @.94D........	8.44 cfs
Froude Number.....	1.06 (flow is Supercritical)

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: ditch-2-24

Comment: Expansion Area - Ditch-2 24-inch Half Round

Solve For Actual Depth

Given Input Data:

Diameter..........	2.00 ft
Slope.............	0.0190 ft/ft
Manning's n.......	0.024
Discharge.........	1.83 cfs

Computed Results:

Depth.............	0.44 ft
Velocity..........	3.52 fps
Flow Area.........	0.52 sf
Critical Depth....	0.47 ft
Critical Slope....	0.0153 ft/ft
Percent Full......	22.23 %
Full Capacity.....	16.89 cfs
QMAX @.94D........	18.17 cfs
Froude Number.....	1.11 (flow is Supercritical)

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Ditch 3

Comment: Expansion Area Ditch #3 - Fill Sections

Solve For Depth

Given Input Data:

Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.030
Channel Slope....	0.0260 ft/ft
Discharge........	0.94 cfs

Computed Results:

Depth............	0.36 ft
Velocity.........	2.45 fps
Flow Area........	0.38 sf
Flow Top Width...	2.15 ft
Wetted Perimeter.	2.26 ft
Critical Depth...	0.36 ft
Critical Slope...	0.0249 ft/ft
Froude Number....	1.02 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Ditch 3 - cs

Comment: Expansion Area Ditch #3 - Cut Section

Solve For Depth

Given Input Data:

Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	1.25:1 (H:V)
Manning's n......	0.030
Channel Slope....	0.0260 ft/ft
Discharge........	0.94 cfs

Computed Results:

Depth............	0.41 ft
Velocity.........	2.59 fps
Flow Area........	0.36 sf
Flow Top Width...	1.76 ft
Wetted Perimeter.	1.97 ft
Critical Depth...	0.41 ft
Critical Slope...	0.0258 ft/ft
Froude Number....	1.00 (flow is Critical)

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Ditch 4-fs

Comment: Expansion Area Ditch #4 - Fill Section

Solve For Depth

Given Input Data:

Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.030
Channel Slope....	0.0370 ft/ft
Discharge........	1.30 cfs

Computed Results:

Depth............	0.38 ft
Velocity.........	3.03 fps
Flow Area........	0.43 sf
Flow Top Width...	2.27 ft
Wetted Perimeter.	2.39 ft
Critical Depth...	0.41 ft
Critical Slope...	0.0239 ft/ft
Froude Number....	1.23 (flow is Supercritical)

32a/35
3/1/91

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Ditch-2-18-1

Comment: Expansion Area - Ditch-2 18-inch Half Round

Solve For Actual Depth

Given Input Data:

Diameter..........	1.50 ft
Slope.............	0.0220 ft/ft
Manning's n.......	0.024
Discharge.........	3.54 cfs

Computed Results:

Depth.............	0.68 ft
Velocity..........	4.57 fps
Flow Area.........	0.78 sf
Critical Depth....	0.72 ft
Critical Slope....	0.0180 ft/ft
Percent Full......	45.18 %
Full Capacity.....	8.44 cfs
QMAX @.94D........	9.08 cfs
Froude Number.....	1.12 (flow is Supercritical)

32 b/35
3/1/91

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Ditch-2-24-1

Comment: Expansion Area - Ditch-2 24-inch Half Round

Solve For Actual Depth

Given Input Data:

Diameter..........	2.00 ft
Slope.............	0.0220 ft/ft
Manning's n.......	0.024
Discharge.........	3.54 cfs

Computed Results:

Depth.............	0.60 ft
Velocity..........	4.48 fps
Flow Area.........	0.79 sf
Critical Depth....	0.66 ft
Critical Slope....	0.0152 ft/ft
Percent Full......	29.92 %
Full Capacity.....	18.18 cfs
QMAX @.94D........	19.55 cfs
Froude Number.....	1.20 (flow is Supercritical)

CULVERTS

EVALUATION OF CULVERT 1 (SEE LOCATION p24)

- CONVEYS FLOW UNDER PLANT PAD ACCESS ROAD FROM DITCH 1 TO DITCH 2
- DESIGN q_p = 0.67 CFS

ASSUME:

- MINIMUM SIZE CULVERT = 18-INCH CMP

ASSUMING INLET CONTROL W/ PROJECTING INLET

18-INCH CULVERT WITH HW/D RATIO OF 1.0

CAPACITY = 5.75 CFS (SEE ATTACHED NOMOGRAPH)

THUS, a minimum culvert diameter of 18 inches is adequate to handle the design flow at culvert 1 location.

EVALUATION OF CULVERT 2 (SEE LOCATION p25)

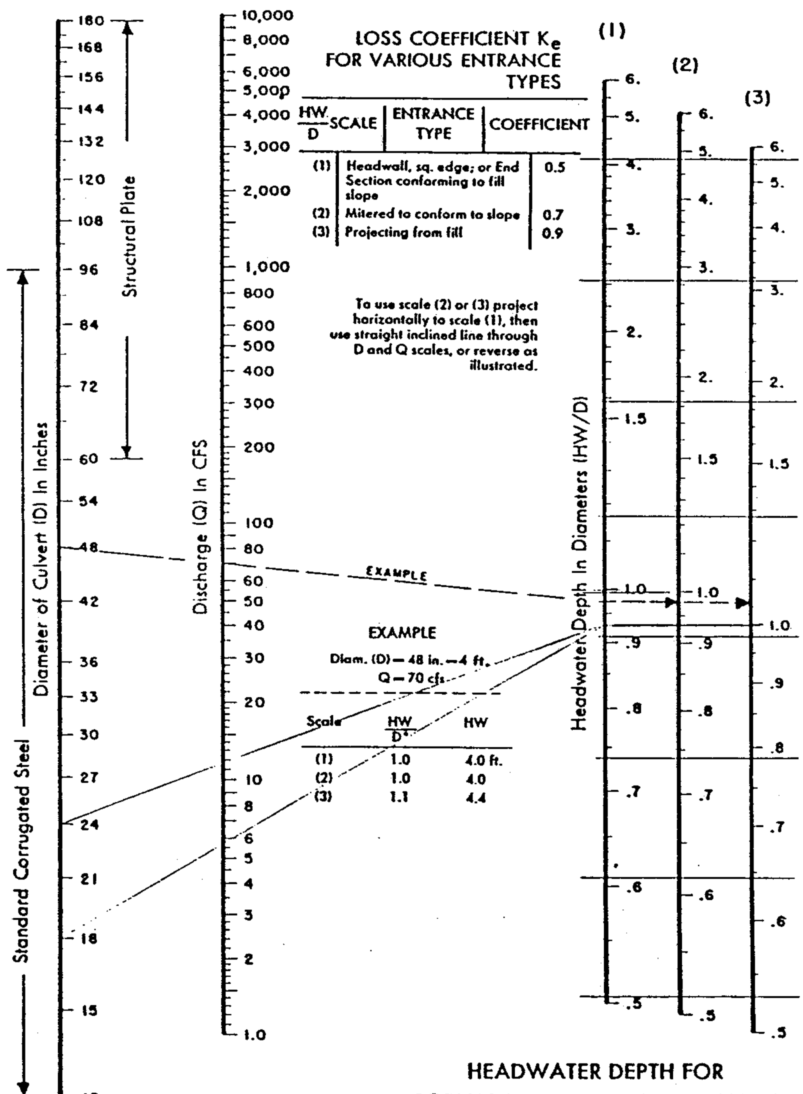
- CONVEYS FLOW UNDER PORTAL PAD ACCESS ROAD FROM DITCH 3 TO DITCH 4
- DESIGN q_p = 0.94 CFS

ASSUME:

- USING MINIMUM SIZE CULVERT (18-INCH)

CAPACITY = 5.75 CFS (SEE ABOVE CALC.)

THUS, a minimum culvert diameter of 18 inches is adequate to handle the design flow at Culvert 2 Location.



HEADWATER DEPTH FOR
CORRUGATED STEEL PIPE CULVERTS
WITH INLET CONTROL

Fig. 4-18. *Inlet control* nomograph for corrugated steel *pipe* culverts. The manufacturers recommend keeping *HW/D* to a maximum of 1.5 and preferably to no more than 1.0.

SOURCE: AMERICAN IRON & STEEL INSTITUTE, 1971. HANDBOOK STEEL DRAINAGE & HIGHWAY CONSTRUCTION PRODUCTS.

EVALUATION OF CULVERT # 3 (SEE LOCATION p25)

- CONVEYS FLOW UNDER PLANT PAD ACCESS ROAD FROM DITCH 2 - UPPER SECTION TO DITCH 2 - LOWER SECTION.
- DESIGN qp = 1.83 + 1.71 = 3.54 cfs
- USING 18-INCH CMP CULVERT UNDER INLET CONTROL CONDITIONS W/ HW/D = 1.0

CAPACITY = 5.75 CFS

THUS: a minimum culvert diameter of 18 inches is adequate to handle the design flow at Culvert Location 3.

CULVERT 4a & b are ADDRESSED in APPENDIX B.

REFERENCES

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EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT C-159-04 PAGE ___ OF ___
COMPUTED TJS DATE 12/19/90
CHECKED ___ DATE ___

ATTACHMENT B

10 YR - 6 HR STORM
RUNOFF CONTROL
EVALUATION
USING
SEDIMOT II

```
*****************************************************************
                          -- SEDPC --
              SEDIMOT II MODEL FOR THE IBM PC/XT
              CONVERTED BY TECH ENGINEERING INC.
                 VERSION 1.10 NOVEMBER 17, 1983
*****************************************************************


*****************************************************************
*****************************************************************

       UNIVERSITY OF KENTUCKY COMPUTER MODEL
       OF SURFACE MINE HYDROLOGY AND SEDIMENTOLOGY
       FOR MORE INFORMATION CONTACT THE AGRICULTURAL
       ENGINEERING DEPARTMENT

       THE UK MODEL IS A DESIGN MODEL DEVELOPED TO PREDICT
       THE HYDRAULIC AND SEDIMENT RESPONSE FROM SURFACE
       MINED LANDS FOR A SPECIFIED RAINFALL EVENT (SINGLE STORM)

       VERSION DATE 9-23-83

       DISCLAIMER: NEITHER THE UNIVERSITY NOR ANY OF ITS EMPLOYEES
       ACCEPT ANY RESPONSIBILITY OR LEGAL LIABILITY FOR THE
       CONCLUSIONS DRAWN FROM THE RESULTS OF THIS MODEL

*****************************************************************
*****************************************************************


*****************************************************************
*                                                               *
*     THE FOLLOWING VALUES ARE NOW PREDICTED BY SEDIMOT II.     *
*     THEY CAN BE FOUND IN SUMMARY TABLES.                      *
*      1. PERIOD OF SIGNIFICANT CONCENTRATION                   *
*      2. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      3. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PEAK 24 HOUR PERIOD                            *
*      4. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      5. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PEAK 24 HOUR PERIOD                            *
*                                                               *
*     ALL CONCENTRATIONS ARE IN ML/L.                           *
*                                                               *
*****************************************************************
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****

WATERSHED IDENTIFICATION CODE

SCCC - FACTILITIES AREA RUNOFF CONTROL - 10 YR-6 HR STORM

****

******************** INPUT RAINFALL PATTERN ********************

VALUE	DEPTH	TIME
1	.05	.50
2	.12	1.00
3	.20	1.50
4	.35	2.00
5	.91	2.50
6	1.06	3.00
7	1.19	3.50
8	1.27	4.00
9	1.35	4.50
10	1.41	5.00
11	1.47	5.50
12	1.52	6.00

********************INPUT VALUES********************

STORM DURATION = 6.00 HOURS
PRECIPITATION DEPTH = 1.52 INCHES

New Submittal
Loost

* *
JUNCTION 1, BRANCH 1, STRUCTURE 1
* *

***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.000
2.20	.000	*	2.30	.011
2.40	.486	*	2.50	1.156
2.60	.415	*	2.70	.458
2.80	.499	*	2.90	.540
3.00	.579	*	3.10	.533
3.20	.562	*	3.30	.590
3.40	.617	*	3.50	.643
3.60	.409	*	3.70	.419
3.80	.428	*	3.90	.438
4.00	.447	*	4.10	.457
4.20	.466	*	4.30	.475
4.40	.484	*	4.50	.493
4.60	.375	*	4.70	.380
4.80	.385	*	4.90	.390
5.00	.395	*	5.10	.399
5.20	.404	*	5.30	.409
5.40	.413	*	5.50	.418
5.60	.352	*	5.70	.355

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	9.90	75.00	.060	.030	.030	.37	.0

☆ ☆ ☆ COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS ☆ ☆ ☆

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	1.16	.17

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.1435	ACRE-FT
PEAK DISCHARGE	=	1.1556	CFS
AREA	=	9.9000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆

NULL STRUCTURE

☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆

* *

JUNCTION 1, BRANCH 2, STRUCTURE 1

* *

***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*******	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.012
1.80	.027	*	1.90	.040
2.00	.053	*	2.10	.296
2.20	.424	*	2.30	.524
2.40	.605	*	2.50	.670
2.60	.189	*	2.70	.193
2.80	.196	*	2.90	.199
3.00	.203	*	3.10	.178
3.20	.180	*	3.30	.182
3.40	.184	*	3.50	.186
3.60	.116	*	3.70	.116
3.80	.117	*	3.90	.118
4.00	.118	*	4.10	.119
4.20	.120	*	4.30	.120
4.40	.121	*	4.50	.121
4.60	.091	*	4.70	.092
4.80	.092	*	4.90	.092
5.00	.093	*	5.10	.093
5.20	.093	*	5.30	.093
5.40	.094	*	5.50	.094
5.60	.079	*	5.70	.079

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	1.00	90.00	.090	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.67	.70

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0583	ACRE-FT
PEAK DISCHARGE	=	.6699	CFS
AREA	=	1.0000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

* * * * * * * * * * * *
NULL STRUCTURE
* * * * * * * * * * * *

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JUNCTION 2, BRANCH 1, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.013	*	1.90	.037
2.00	.072	*	2.10	.150
2.20	.366	*	2.30	.736
2.40	1.130	*	2.50	1.495
2.60	1.712	*	2.70	1.623
2.80	1.315	*	2.90	1.106
3.00	1.014	*	3.10	1.000
3.20	.968	*	3.30	.923
3.40	.883	*	3.50	.847
3.60	.804	*	3.70	.729
3.80	.637	*	3.90	.575
4.00	.544	*	4.10	.531
4.20	.519	*	4.30	.510
4.40	.502	*	4.50	.496
4.60	.487	*	4.70	.463
4.80	.431	*	4.90	.410
5.00	.399	*	5.10	.394
5.20	.390	*	5.30	.386
5.40	.384	*	5.50	.381
5.60	.377	*	5.70	.365
5.80	.349	*	5.90	.338
6.00	.332	*	6.10	.315
6.20	.259	*	6.30	.178
6.40	.121	*	6.50	.088
6.60	.070	*	6.70	.055
6.80	.041	*	6.90	.030
7.00	.020	*	7.10	.013
7.20	.007	*	7.30	.003

****

BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

****

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	4.00	90.00	.310	.000	.000	.00	2.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	1.71	.70

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.2331	ACRE-FT
PEAK DISCHARGE	=	1.7119	CFS
AREA	=	4.0000	ACRES
TIME OF PEAK DISCHARGE	=	2.60	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.27	
PREVIOUS MUSKINGUM ROUTING K	=	.0400	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	1.83	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	14.90	ACRES
TOTAL RUNOFF VOLUME	=	.4348	AC-FT
PEAK RUNOFF DISCHARGE	=	3.54	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

* * * * * * * * * * * *
NULL STRUCTURE
* * * * * * * * * * * *

* *
JUNCTION 2, BRANCH 2, STRUCTURE 1
* *

***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.000
2.20	.077	*	2.30	.390
2.40	.685	*	2.50	.945
2.60	.293	*	2.70	.310
2.80	.325	*	2.90	.340
3.00	.355	*	3.10	.319
3.20	.330	*	3.30	.340
3.40	.350	*	3.50	.359
3.60	.226	*	3.70	.229
3.80	.233	*	3.90	.236
4.00	.240	*	4.10	.243
4.20	.246	*	4.30	.249
4.40	.253	*	4.50	.256
4.60	.194	*	4.70	.196
4.80	.197	*	4.90	.199
5.00	.201	*	5.10	.202
5.20	.204	*	5.30	.206
5.40	.207	*	5.50	.209
5.60	.175	*	5.70	.176

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	3.60	80.00	.090	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.94	.30

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0887	ACRE-FT
PEAK DISCHARGE	=	.9448	CFS
AREA	=	3.6000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

* * * * * * * * * * * *
NULL STRUCTURE
* * * * * * * * * * * *

* *

JUNCTION 2, BRANCH 2, STRUCTURE 2

* *

***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*******	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.051
2.20	.147	*	2.30	.228
2.40	.297	*	2.50	.355
2.60	.104	*	2.70	.107
2.80	.111	*	2.90	.114
3.00	.117	*	3.10	.104
3.20	.106	*	3.30	.108
3.40	.110	*	3.50	.112
3.60	.070	*	3.70	.071
3.80	.071	*	3.90	.072
4.00	.073	*	4.10	.074
4.20	.074	*	4.30	.075
4.40	.075	*	4.50	.076
4.60	.057	*	4.70	.058
4.80	.058	*	4.90	.058
5.00	.059	*	5.10	.059
5.20	.059	*	5.30	.060
5.40	.060	*	5.50	.060
5.60	.051	*	5.70	.051

****

BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

****

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	.80	85.00	.080	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.36	.46

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0310	ACRE-FT
PEAK DISCHARGE	=	.3551	CFS
AREA	=	.8000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.33	
PREVIOUS MUSKINGUM ROUTING K	=	.0400	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	.94	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	4.40	ACRES
TOTAL RUNOFF VOLUME	=	.1196	AC-FT
PEAK RUNOFF DISCHARGE	=	1.30	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

* * * * * * * * * * * *
NULL STRUCTURE
* * * * * * * * * * * *

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JUNCTION 3, BRANCH 1, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.042
1.80	.094	*	1.90	.142
2.00	.186	*	2.10	1.037
2.20	1.483	*	2.30	1.835
2.40	2.116	*	2.50	2.345
2.60	.661	*	2.70	.674
2.80	.686	*	2.90	.698
3.00	.709	*	3.10	.623
3.20	.631	*	3.30	.638
3.40	.645	*	3.50	.652
3.60	.405	*	3.70	.407
3.80	.409	*	3.90	.412
4.00	.414	*	4.10	.416
4.20	.418	*	4.30	.420
4.40	.423	*	4.50	.425
4.60	.320	*	4.70	.321
4.80	.322	*	4.90	.323
5.00	.324	*	5.10	.325
5.20	.326	*	5.30	.327
5.40	.328	*	5.50	.329
5.60	.275	*	5.70	.276

****

BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

****

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	3.50	90.00	.080	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	2.34	.70

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.2039	ACRE-FT
PEAK DISCHARGE	=	2.3446	CFS
AREA	=	3.5000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.33	
PREVIOUS MUSKINGUM ROUTING K	=	.0300	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	4.84	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	22.80	ACRES
TOTAL RUNOFF VOLUME	=	.7584	AC-FT
PEAK RUNOFF DISCHARGE	=	7.18	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE

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JUNCTION 3, BRANCH 2, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.000
2.20	.000	*	2.30	.000
2.40	.319	*	2.50	.759
2.60	.273	*	2.70	.301
2.80	.328	*	2.90	.354
3.00	.380	*	3.10	.350
3.20	.369	*	3.30	.387
3.40	.405	*	3.50	.422
3.60	.269	*	3.70	.275
3.80	.281	*	3.90	.288
4.00	.294	*	4.10	.300
4.20	.306	*	4.30	.312
4.40	.318	*	4.50	.324
4.60	.246	*	4.70	.250
4.80	.253	*	4.90	.256
5.00	.259	*	5.10	.262
5.20	.265	*	5.30	.268
5.40	.271	*	5.50	.274
5.60	.231	*	5.70	.233

***** RESULTS FROM SUBWATERSHED 2 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.000
2.20	.000	*	2.30	.000
2.40	.152	*	2.50	.362
2.60	.130	*	2.70	.143
2.80	.156	*	2.90	.169
3.00	.181	*	3.10	.167
3.20	.176	*	3.30	.185
3.40	.193	*	3.50	.201
3.60	.128	*	3.70	.131
3.80	.134	*	3.90	.137
4.00	.140	*	4.10	.143
4.20	.146	*	4.30	.149
4.40	.152	*	4.50	.154
4.60	.118	*	4.70	.119
4.80	.121	*	4.90	.122
5.00	.124	*	5.10	.125
5.20	.127	*	5.30	.128
5.40	.129	*	5.50	.131
5.60	.110	*	5.70	.111

****

BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

****

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	6.50	75.00	.050	.020	.020	.39	.0
2	3.10	75.00	.050	.010	.010	.40	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.76	.17
2	.36	.17

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.1391	ACRE-FT
PEAK DISCHARGE	=	1.1206	CFS
AREA	=	9.6000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE

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JUNCTION 4, BRANCH 1, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.000
2.20	.019	*	2.30	.098
2.40	.171	*	2.50	.236
2.60	.073	*	2.70	.077
2.80	.081	*	2.90	.085
3.00	.089	*	3.10	.080
3.20	.082	*	3.30	.085
3.40	.087	*	3.50	.090
3.60	.056	*	3.70	.057
3.80	.058	*	3.90	.059
4.00	.060	*	4.10	.061
4.20	.062	*	4.30	.062
4.40	.063	*	4.50	.064
4.60	.048	*	4.70	.049
4.80	.049	*	4.90	.050
5.00	.050	*	5.10	.051
5.20	.051	*	5.30	.051
5.40	.052	*	5.50	.052
5.60	.044	*	5.70	.044

****

BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

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*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	.90	80.00	.020	.010	.010	.39	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.24	.30

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0222	ACRE-FT
PEAK DISCHARGE	=	.2362	CFS
AREA	=	.9000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.37	
PREVIOUS MUSKINGUM ROUTING K	=	.0400	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	8.30	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	33.30	ACRES
TOTAL RUNOFF VOLUME	=	.9197	AC-FT
PEAK RUNOFF DISCHARGE	=	8.54	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE
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JUNCTION 4, BRANCH 2, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*******	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.022
2.00	.039	*	2.10	.070
2.20	.216	*	2.30	.407
2.40	.568	*	2.50	.711
2.60	.803	*	2.70	.626
2.80	.464	*	2.90	.417
3.00	.385	*	3.10	.355
3.20	.318	*	3.30	.291
3.40	.282	*	3.50	.283
3.60	.279	*	3.70	.241
3.80	.210	*	3.90	.199
4.00	.193	*	4.10	.188
4.20	.184	*	4.30	.182
4.40	.182	*	4.50	.183
4.60	.182	*	4.70	.166
4.80	.154	*	4.90	.149
5.00	.147	*	5.10	.144
5.20	.143	*	5.30	.142
5.40	.142	*	5.50	.143
5.60	.142	*	5.70	.134
5.80	.127	*	5.90	.125
6.00	.124	*	6.10	.117
6.20	.074	*	6.30	.039
6.40	.025	*	6.50	.016
6.60	.010	*	6.70	.005

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	1.50	90.00	.140	.000	.000	.00	2.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.80	.70

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0874	ACRE-FT
PEAK DISCHARGE	=	.8030	CFS
AREA	=	1.5000	ACRES
TIME OF PEAK DISCHARGE	=	2.60	HRS

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NULL STRUCTURE

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JUNCTION 5, BRANCH 1, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.252	*	.10	.000
.20	.000	*	.30	.071
.40	.071	*	.50	.071
.60	.071	*	.70	.071
.80	.071	*	.90	.071
1.00	.071	*	1.10	.081
1.20	.081	*	1.30	.081
1.40	.081	*	1.50	.081
1.60	.151	*	1.70	.151
1.80	.151	*	1.90	.151
2.00	.151	*	2.10	.565
2.20	.565	*	2.30	.565
2.40	.565	*	2.50	.565
2.60	.151	*	2.70	.151
2.80	.151	*	2.90	.151
3.00	.151	*	3.10	.131
3.20	.131	*	3.30	.131
3.40	.131	*	3.50	.131
3.60	.081	*	3.70	.081
3.80	.081	*	3.90	.081
4.00	.081	*	4.10	.081
4.20	.081	*	4.30	.081
4.40	.081	*	4.50	.081
4.60	.061	*	4.70	.060
4.80	.061	*	4.90	.060
5.00	.061	*	5.10	.061
5.20	.061	*	5.30	.060
5.40	.061	*	5.50	.060
5.60	.050	*	5.70	.050

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	.50	100.00	.000	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.56	1.52

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0633	ACRE-FT
PEAK DISCHARGE	=	.5647	CFS
AREA	=	.5000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.00	
PREVIOUS MUSKINGUM ROUTING K	=	.0000	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	9.34	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	35.30	ACRES
TOTAL RUNOFF VOLUME	=	1.0704	AC-FT
PEAK RUNOFF DISCHARGE	=	9.91	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

* * * * * * * * * * * *
NULL STRUCTURE
* * * * * * * * * * * *

*** RUN COMPLETED ****

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT C-159.04 PAGE ____ OF ____
COMPUTED TJS DATE 12/19/90
CHECKED ____ DATE ____

ATTACHMENT C

25 YR - 6 HR STORM

SPILLWAY EVALUATION

USING

SEDIMOT II

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**********************************************************************
                        -- SEDPC --
            SEDIMOT II MODEL FOR THE IBM PC/XT
            CONVERTED BY TECH ENGINEERING INC.
              VERSION 1.10 NOVEMBER 17,1983
**********************************************************************


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**********************************************************************

       UNIVERSITY OF KENTUCKY COMPUTER MODEL
       OF SURFACE MINE HYDROLOGY AND SEDIMENTOLOGY
       FOR MORE INFORMATION CONTACT THE AGRICULTURAL
       ENGINEERING DEPARTMENT

       THE UK MODEL IS A DESIGN MODEL DEVELOPED TO PREDICT
       THE HYDRAULIC AND SEDIMENT RESPONSE FROM SURFACE
       MINED LANDS FOR A SPECIFIED RAINFALL EVENT (SINGLE STORM)

       VERSION DATE 9-23-83

       DISCLAIMER: NEITHER THE UNIVERSITY NOR ANY OF ITS EMPLOYEES
       ACCEPT ANY RESPONSIBILITY OR LEGAL LIABILITY FOR THE
       CONCLUSIONS DRAWN FROM THE RESULTS OF THIS MODEL

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**********************************************************************
*                                                                    *
*     THE FOLLOWING VALUES ARE NOW PREDICTED BY SEDIMOT II.          *
*     THEY CAN BE FOUND IN SUMMARY TABLES.                           *
*      1. PERIOD OF SIGNIFICANT CONCENTRATION                        *
*      2. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION                 *
*      3. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PEAK 24 HOUR PERIOD                                 *
*      4. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION                *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION                 *
*      5. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION                *
*         DURING PEAK 24 HOUR PERIOD                                 *
*                                                                    *
*     ALL CONCENTRATIONS ARE IN ML/L.                                *
*                                                                    *
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WATERSHED IDENTIFICATION CODE

SCCC - SEDIMENT POND SPILLWAY PEAKFLOW - 25 YR-6 HR STORM

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******************** INPUT RAINFALL PATTERN ********************

VALUE	DEPTH	TIME
1	.06	.50
2	.22	1.00
3	.36	1.50
4	.62	2.00
5	1.06	2.50
6	1.23	3.00
7	1.37	3.50
8	1.47	4.00
9	1.56	4.50
10	1.63	5.00
11	1.70	5.50
12	1.76	6.00

*********************INPUT VALUES*********************

STORM DURATION	=	6.00	HOURS
PRECIPITATION DEPTH	=	1.76	INCHES

* *
JUNCTION 1, BRANCH 1, STRUCTURE 1
* *

***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*******	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.051
2.20	.432	*	2.30	.846
2.40	1.230	*	2.50	1.587
2.60	.703	*	2.70	.751
2.80	.798	*	2.90	.844
3.00	.889	*	3.10	.764
3.20	.793	*	3.30	.821
3.40	.849	*	3.50	.876
3.60	.642	*	3.70	.655
3.80	.668	*	3.90	.681
4.00	.694	*	4.10	.635
4.20	.645	*	4.30	.655
4.40	.665	*	4.50	.675
4.60	.531	*	4.70	.537
4.80	.543	*	4.90	.548
5.00	.554	*	5.10	.559
5.20	.565	*	5.30	.570
5.40	.575	*	5.50	.581
5.60	.502	*	5.70	.506

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	9.90	75.00	.060	.030	.030	.37	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	1.59	.27

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.2228	ACRE-FT
PEAK DISCHARGE	=	1.5865	CFS
AREA	=	9.9000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

* * * * * * * * * * * *
NULL STRUCTURE
* * * * * * * * * * * *

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JUNCTION 1, BRANCH 2, STRUCTURE 1

* *

***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.019	*	1.30	.031
1.40	.043	*	1.50	.054
1.60	.126	*	1.70	.157
1.80	.184	*	1.90	.208
2.00	.230	*	2.10	.433
2.20	.480	*	2.30	.521
2.40	.555	*	2.50	.585
2.60	.233	*	2.70	.237
2.80	.241	*	2.90	.244
3.00	.247	*	3.10	.206
3.20	.208	*	3.30	.210
3.40	.211	*	3.50	.213
3.60	.153	*	3.70	.154
3.80	.155	*	3.90	.156
4.00	.157	*	4.10	.142
4.20	.142	*	4.30	.143
4.40	.143	*	4.50	.144
4.60	.112	*	4.70	.113
4.80	.113	*	4.90	.113
5.00	.114	*	5.10	.114
5.20	.114	*	5.30	.114
5.40	.115	*	5.50	.115
5.60	.099	*	5.70	.099

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	1.00	90.00	.090	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.59	.89

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0744	ACRE-FT
PEAK DISCHARGE	=	.5853	CFS
AREA	=	1.0000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE

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JUNCTION 2, BRANCH 1, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***

(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.024
1.40	.052	*	1.50	.086
1.60	.132	*	1.70	.214
1.80	.330	*	1.90	.446
2.00	.553	*	2.10	.682
2.20	.904	*	2.30	1.198
2.40	1.459	*	2.50	1.673
2.60	1.777	*	2.70	1.674
2.80	1.427	*	2.90	1.262
3.00	1.184	*	3.10	1.160
3.20	1.111	*	3.30	1.047
3.40	.995	*	3.50	.954
3.60	.914	*	3.70	.848
3.80	.770	*	3.90	.717
4.00	.689	*	4.10	.674
4.20	.653	*	4.30	.629
4.40	.612	*	4.50	.601
4.60	.589	*	4.70	.562
4.80	.527	*	4.90	.502
5.00	.489	*	5.10	.482
5.20	.477	*	5.30	.472
5.40	.468	*	5.50	.466
5.60	.461	*	5.70	.449
5.80	.432	*	5.90	.420
6.00	.414	*	6.10	.394
6.20	.323	*	6.30	.223
6.40	.151	*	6.50	.110
6.60	.088	*	6.70	.068
6.80	.052	*	6.90	.037
7.00	.026	*	7.10	.016
7.20	.009	*	7.30	.004

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BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

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*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	4.00	90.00	.310	.000	.000	.00	2.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	1.78	.89

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.2976	ACRE-FT
PEAK DISCHARGE	=	1.7770	CFS
AREA	=	4.0000	ACRES
TIME OF PEAK DISCHARGE	=	2.60	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.27	
PREVIOUS MUSKINGUM ROUTING K	=	.0400	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	2.17	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	14.90	ACRES
TOTAL RUNOFF VOLUME	=	.5948	AC-FT
PEAK RUNOFF DISCHARGE	=	3.95	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE
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JUNCTION 2, BRANCH 2, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*******	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.062
2.00	.134	*	2.10	.380
2.20	.558	*	2.30	.718
2.40	.865	*	2.50	.999
2.60	.419	*	2.70	.437
2.80	.454	*	2.90	.471
3.00	.487	*	3.10	.413
3.20	.423	*	3.30	.433
3.40	.443	*	3.50	.452
3.60	.329	*	3.70	.333
3.80	.338	*	3.90	.343
4.00	.347	*	4.10	.316
4.20	.319	*	4.30	.323
4.40	.326	*	4.50	.330
4.60	.259	*	4.70	.261
4.80	.262	*	4.90	.264
5.00	.266	*	5.10	.268
5.20	.270	*	5.30	.272
5.40	.274	*	5.50	.275
5.60	.237	*	5.70	.239

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	3.60	80.00	.090	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	1.00	.42

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.1267	ACRE-FT
PEAK DISCHARGE	=	.9991	CFS
AREA	=	3.6000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE
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JUNCTION 2, BRANCH 2, STRUCTURE 2

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*******	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.015	*	1.70	.038
1.80	.058	*	1.90	.077
2.00	.095	*	2.10	.197
2.20	.237	*	2.30	.274
2.40	.306	*	2.50	.335
2.60	.136	*	2.70	.140
2.80	.144	*	2.90	.147
3.00	.150	*	3.10	.126
3.20	.128	*	3.30	.130
3.40	.132	*	3.50	.134
3.60	.097	*	3.70	.098
3.80	.099	*	3.90	.100
4.00	.100	*	4.10	.091
4.20	.092	*	4.30	.092
4.40	.093	*	4.50	.094
4.60	.073	*	4.70	.074
4.80	.074	*	4.90	.074
5.00	.075	*	5.10	.075
5.20	.075	*	5.30	.076
5.40	.076	*	5.50	.076
5.60	.066	*	5.70	.066

****

BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

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*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	.80	85.00	.080	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.33	.62

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0416	ACRE-FT
PEAK DISCHARGE	=	.3347	CFS
AREA	=	.8000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.33	
PREVIOUS MUSKINGUM ROUTING K	=	.0400	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	1.00	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	4.40	ACRES
TOTAL RUNOFF VOLUME	=	.1683	AC-FT
PEAK RUNOFF DISCHARGE	=	1.33	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE

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JUNCTION 3, BRANCH 1, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.021
1.20	.067	*	1.30	.110
1.40	.151	*	1.50	.188
1.60	.441	*	1.70	.548
1.80	.643	*	1.90	.728
2.00	.805	*	2.10	1.514
2.20	1.681	*	2.30	1.822
2.40	1.943	*	2.50	2.048
2.60	.817	*	2.70	.830
2.80	.842	*	2.90	.853
3.00	.865	*	3.10	.720
3.20	.727	*	3.30	.734
3.40	.740	*	3.50	.746
3.60	.537	*	3.70	.540
3.80	.542	*	3.90	.545
4.00	.548	*	4.10	.495
4.20	.497	*	4.30	.500
4.40	.502	*	4.50	.504
4.60	.393	*	4.70	.394
4.80	.395	*	4.90	.396
5.00	.397	*	5.10	.398
5.20	.400	*	5.30	.401
5.40	.402	*	5.50	.403
5.60	.346	*	5.70	.347

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BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

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*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	3.50	90.00	.080	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	2.05	.89

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.2604	ACRE-FT
PEAK DISCHARGE	=	2.0485	CFS
AREA	=	3.5000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.33	
PREVIOUS MUSKINGUM ROUTING K	=	.0300	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	5.28	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	22.80	ACRES
TOTAL RUNOFF VOLUME	=	1.0234	AC-FT
PEAK RUNOFF DISCHARGE	=	7.33	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE
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JUNCTION 3, BRANCH 2, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.033
2.20	.283	*	2.30	.555
2.40	.807	*	2.50	1.042
2.60	.462	*	2.70	.493
2.80	.524	*	2.90	.554
3.00	.583	*	3.10	.502
3.20	.521	*	3.30	.539
3.40	.557	*	3.50	.575
3.60	.421	*	3.70	.430
3.80	.439	*	3.90	.447
4.00	.456	*	4.10	.417
4.20	.424	*	4.30	.430
4.40	.437	*	4.50	.443
4.60	.349	*	4.70	.353
4.80	.356	*	4.90	.360
5.00	.364	*	5.10	.367
5.20	.371	*	5.30	.374
5.40	.378	*	5.50	.381
5.60	.329	*	5.70	.332

***** RESULTS FROM SUBWATERSHED 2 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.016
2.20	.135	*	2.30	.265
2.40	.385	*	2.50	.497
2.60	.220	*	2.70	.235
2.80	.250	*	2.90	.264
3.00	.278	*	3.10	.239
3.20	.248	*	3.30	.257
3.40	.266	*	3.50	.274
3.60	.201	*	3.70	.205
3.80	.209	*	3.90	.213
4.00	.217	*	4.10	.199
4.20	.202	*	4.30	.205
4.40	.208	*	4.50	.211
4.60	.166	*	4.70	.168
4.80	.170	*	4.90	.172
5.00	.173	*	5.10	.175
5.20	.177	*	5.30	.178
5.40	.180	*	5.50	.182
5.60	.157	*	5.70	.158

****

BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

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*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	6.50	75.00	.050	.020	.020	.39	.0
2	3.10	75.00	.050	.010	.010	.40	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	1.04	.27
2	.50	.27

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.2160	ACRE-FT
PEAK DISCHARGE	=	1.5384	CFS
AREA	=	9.6000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE

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JUNCTION 4, BRANCH 1, STRUCTURE 1
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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*******	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.015
2.00	.034	*	2.10	.095
2.20	.139	*	2.30	.180
2.40	.216	*	2.50	.250
2.60	.105	*	2.70	.109
2.80	.114	*	2.90	.118
3.00	.122	*	3.10	.103
3.20	.106	*	3.30	.108
3.40	.111	*	3.50	.113
3.60	.082	*	3.70	.083
3.80	.085	*	3.90	.086
4.00	.087	*	4.10	.079
4.20	.080	*	4.30	.081
4.40	.082	*	4.50	.082
4.60	.065	*	4.70	.065
4.80	.066	*	4.90	.066
5.00	.067	*	5.10	.067
5.20	.067	*	5.30	.068
5.40	.068	*	5.50	.069
5.60	.059	*	5.70	.060

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BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

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*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	.90	80.00	.020	.010	.010	.39	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.25	.42

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0317	ACRE-FT
PEAK DISCHARGE	=	.2498	CFS
AREA	=	.9000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.37	
PREVIOUS MUSKINGUM ROUTING K	=	.0400	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	8.87	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	33.30	ACRES
TOTAL RUNOFF VOLUME	=	1.2711	AC-FT
PEAK RUNOFF DISCHARGE	=	9.12	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

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NULL STRUCTURE

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JUNCTION 4, BRANCH 2, STRUCTURE 1

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***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.015
1.40	.029	*	1.50	.044
1.60	.063	*	1.70	.113
1.80	.169	*	1.90	.214
2.00	.256	*	2.10	.307
2.20	.443	*	2.30	.575
2.40	.662	*	2.50	.736
2.60	.777	*	2.70	.630
2.80	.502	*	2.90	.461
3.00	.434	*	3.10	.408
3.20	.368	*	3.30	.339
3.40	.329	*	3.50	.328
3.60	.323	*	3.70	.290
3.80	.263	*	3.90	.254
4.00	.249	*	4.10	.244
4.20	.232	*	4.30	.224
4.40	.222	*	4.50	.221
4.60	.218	*	4.70	.201
4.80	.187	*	4.90	.182
5.00	.179	*	5.10	.177
5.20	.175	*	5.30	.174
5.40	.174	*	5.50	.175
5.60	.174	*	5.70	.165
5.80	.159	*	5.90	.156
6.00	.155	*	6.10	.147
6.20	.093	*	6.30	.048
6.40	.032	*	6.50	.021
6.60	.012	*	6.70	.006

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	1.50	90.00	.140	.000	.000	.00	2.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.78	.89

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.1116	ACRE-FT
PEAK DISCHARGE	=	.7767	CFS
AREA	=	1.5000	ACRES
TIME OF PEAK DISCHARGE	=	2.60	HRS

* * * * * * * * * * * *
NULL STRUCTURE
* * * * * * * * * * * *

*
JUNCTION 5, BRANCH 1, STRUCTURE 1
*

***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.302	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.161
.60	.161	*	.70	.161
.80	.161	*	.90	.161
1.00	.161	*	1.10	.141
1.20	.141	*	1.30	.141
1.40	.141	*	1.50	.141
1.60	.262	*	1.70	.262
1.80	.262	*	1.90	.262
2.00	.262	*	2.10	.444
2.20	.444	*	2.30	.444
2.40	.444	*	2.50	.444
2.60	.171	*	2.70	.171
2.80	.171	*	2.90	.171
3.00	.171	*	3.10	.141
3.20	.141	*	3.30	.141
3.40	.141	*	3.50	.141
3.60	.101	*	3.70	.101
3.80	.101	*	3.90	.101
4.00	.101	*	4.10	.091
4.20	.091	*	4.30	.091
4.40	.091	*	4.50	.091
4.60	.071	*	4.70	.071
4.80	.071	*	4.90	.071
5.00	.071	*	5.10	.071
5.20	.071	*	5.30	.071
5.40	.071	*	5.50	.071
5.60	.060	*	5.70	.061

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	.50	100.00	.000	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.44	1.76

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0733	ACRE-FT
PEAK DISCHARGE	=	.4437	CFS
AREA	=	.5000	ACRES
TIME OF PEAK DISCHARGE	=	2.30	HRS

SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.00	
PREVIOUS MUSKINGUM ROUTING K	=	.0000	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	9.90	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	35.30	ACRES
TOTAL RUNOFF VOLUME	=	1.4560	AC-FT
PEAK RUNOFF DISCHARGE	=	10.34	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

* * * * * * * * * * * *

NULL STRUCTURE

* * * * * * * * * * * *

*** RUN COMPLETED ****

APPENDIX B

Design of Conveyance Culvert under Highway
for Proposed Portal Expansion

REGISTERED PROFESSIONAL ENGINEER
No. 7102
RICHARD B. WHITE
STATE OF UTAH

Richard B. White
29 Mar 1991

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LIST OF ATTACHMENTS

Attachment

A Culvert Design and Runoff Calculations

APPENDIX B

Design of Conveyance Culvert under Highway
for Proposed Portal Expansion

1.0 GENERAL

This appendix presents a discussion of the hydrologic conditions associated with the conveyance culverts along and under the county road from the portal expansion areas to the existing diversions and sediment control structures.

Computations are based upon a field reconnaissance of the area, proposed operations area topography provided by Soldier Creek Coal Company (SCCC), and published hydrologic information. In addition, the designs are based on the assumption that the culvert is a temporary structure which will be removed upon cessation of mining.

2.0 STORM RUNOFF CALCULATIONS

Watershed boundaries used to determine runoff conditions above Culverts #4a and b are shown on Exhibit 10.2.4-1. Watershed 12 has an area of 3.6 acres and will drain into the proposed diversion Ditch #3, which conveys runoff to the south along the county road (see Figure 2-1 and Plate 10.2.4-2). Watershed 14 drains the portal area and has a drainage area of 0.8 acres.

Data obtained from Watersheds 12 and 14 were input into the SEDIMOT II computer program developed by Warner, et.al. (1980) to generate runoff hydrographs for the 10-year, 6-hour storm required by the Division of Oil, Gas, and Mining (1989) for design of temporary culvert structures. The program models runoff using the rainfall-runoff function of the U.S. Soil Conservation Service (1972) and the unit hydrograph of Haan (1970).

According to the U.S. Soil Conservation Service (1972), the algebraic and hydrologic relations between storm rainfall, soil moisture storage, and runoff can be expressed by the equations:

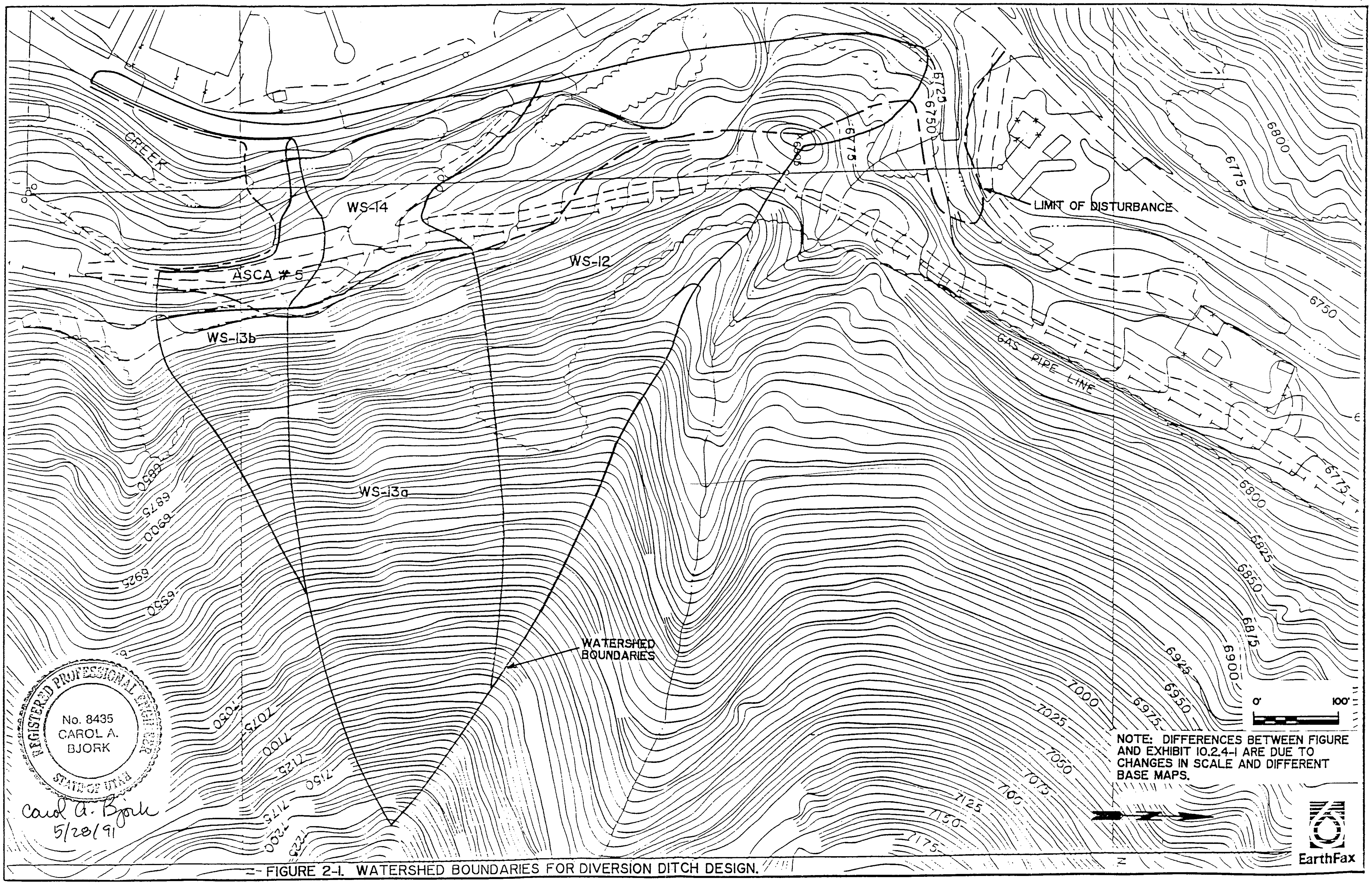


FIGURE 2-1. WATERSHED BOUNDARIES FOR DIVERSION DITCH DESIGN.

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \tag{2-1}$$

and

$$S = \frac{1000}{CN} - 10 \tag{2-2}$$

where:

Q = direct runoff volume (inches)

S = watershed storage factor (inches)

P = rainfall depth (inches)

CN = runoff curve number (dimensionless)

The average curve number for the Watersheds 12 and 14 were chosen from professional judgement and tabulated values presented by the U.S. Soil Conservation Service (1972). Accordingly, a value of 80 was used for the undisturbed areas of Watershed 12 and a value of 85 was used for the disturbed areas of Watershed 14.

The time of concentration for the watersheds may be estimated by several formulas. For this report, T_c was determined from the following equations (U.S. Soil Conservation Service, 1972):

$$L = \frac{\lambda^{0.8} (S+1)^{0.7}}{1900 Y^{0.5}} \tag{2-3}$$

and

$$T_p = L + d/2 \tag{2-4}$$

and

$$T_c = 1.67L \tag{2-5}$$

where:

L = watershed lag (hours)

λ = hydraulic length of the watershed, or distance along the main channel to the watershed divide (feet)

S = watershed storage factor defined in equation (2-2)

Y = average watershed slope (percent)

T_p = time to peak (hours)

d = duration of effective or incremental rainfall (hours)

T_c = time of concentration (hours)

The translation of the runoff depth to an outflow hydrograph is accomplished by the program using the curvilinear unit hydrograph of Haan (1970). It is characterized by the equations:

$$\frac{q(t)}{q_p} = \left[\frac{t}{t_p} e^{(1-t/t_p)}\right]^{C_3 t_p} \tag{2-6}$$

where:

q(t) = unit hydrograph ordinate at time t,

q_p = peak flow rate, and

C_3 is a parameter defined by the equation:

$$V = q_p t_p \left[\frac{e}{C_3 t_p}\right]^{C_3 t_p} \Gamma(C_3 t_p) \tag{2-7}$$

where:

V = runoff volume (one inch for unit hydrograph),

Γ = gamma function,

and other parameters have been previously defined.

The SEDIMOT II computer program was run for the watersheds and the input calculations and results are presented in Attachment A. Table 2-1 summarizes the input and resulting peak flows for the watersheds.

3.0 CULVERT DESIGN

To convey the collected runoff from diversion Ditch #4 adjacent to the proposed road realignment to the existing 18"x18" diversion ditch, it will be necessary to install two drainage culverts. The proposed locations of these culverts are shown on Exhibit 10.2.4-1. It is proposed that these culverts be a 24-inch "Class C" steel pipe culvert in the upper section along the east side

Table 2-1

Summary of Runoff Calculations

Watershed	Area (acres)	Curve No.	T_c (hours)	Runoff Depth (inches)	Peak Flow (cfs)
12	3.60	80	.090	.300	0.94
14	0.80	85	.110	.460	0.36
Total					1.30

of the road, and an at-grade concrete reinforced 18-inch steel Schedule 80 pipe under the road. It is planned that the culvert will be installed during the proposed road realignment and will be field fit to ensure that the junction with the existing ditch is made at an angle of no more than 30 degrees. The culvert along the road, Culvert 4a, will collect runoff from Ditch #4 and the road barrier ditch. The runoff from ditch #4 will enter the pipe above the headwall for the Soldier Creek By-pass Culvert Outlet, while runoff from the road barrier ditch will be collected using two drop-inlets as indicated in Exhibit 10.2.4-1. The design and sizing calculations for these culverts are presented in Attachment A.

4.0 REFERENCES

Chow, V.T. 1959. Open Channel Hydraulics. McGraw-Hill. New York, New York.

Haan, C.T. 1970. A dimensionless hydrograph equation. File Report, Agricultural Engineering Department. University of Kentucky. Lexington, Kentucky.

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-Frequency Atlas of the Western United States. Volume VI - Utah. U.S. Department of Commerce. Silver Spring, Maryland.

U.S. Soil Conservation Service. 1972. National Engineering Handbook, Section 4: Hydrology. U.S. Government Printing Office. Washington, D.C.

Utah Division of Oil, Gas and Mining. 1989. Utah Coal Mining and Reclamation Regulatory Program. R-614, Rules Pertaining to Underground Coal Mining Activities. Salt Lake City, Utah.

Warner, R.C., B.N. Wilson, B.J. Barfield, D.S. Logsdon, and P.J. Nebgen. 1980. A Hydrology and Sedimentology Watershed Model. Department of Agricultural Engineering. University of Kentucky. Lexington, Kentucky.

ATTACHMENT A

Culvert Design and Runoff Calculations

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT C-159-04 PAGE 1 OF 19
COMPUTED DJS DATE 3/28/91
CHECKED ______ DATE ______

DESIGN OF CONVEYANCE CULVERT UNDER THE HIGHWAY (CULVERTS #4a & b:)

HYDROLOGIC CALCULATIONS:

INPUT TO SEDIMOT II:

	AREA	CN	Tc	Qp
WATERSHED 12:	3.6 AC	80	0.09	0.94
WATERSHED 14:	0.8 AC	85	0.08	0.36

OUTPUT FROM SEDIMOT II IS ATTACHED.

TOTAL DISCHARGE = 1.30 CFS

HYDRAULIC CALCULATIONS:

CULVERT DIVIDED INTO TWO SECTIONS.

- UPPER SECTION - ALONG ROAD
  - 24-INCH "CLASS C" CULVERT W/ DROP DRAINS ALONG LENGTH OF CONCRETE BARRIER DIVERSION.
- LOWER SECTION - UNDER ROAD
  - 18-INCH SCHEDULE 80 STEEL PIPE REINFORCED W/ CONCRETE.

CONFIGURATION OF CULVERTS + ROAD DIVERSION AND DROP DRAINS IS PRESENTED ON FIGURE (SEE PAGE 6).
- TYPICAL DETAILS FROM ROAD SPECIFICATIONS FOR BARRIER PLACEMENT & DROP DRAINS (CATCH BASIN TYPE B) ARE ATTACHED (CREAMER & NOBLE, 1991). (SEE PAGES 7 THRU 10 OF).

* *
JUNCTION 2, BRANCH 2, STRUCTURE 1
* *

***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	******* *	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.000
2.20	.077	*	2.30	.390
2.40	.685	*	2.50	.945
2.60	.293	*	2.70	.310
2.80	.325	*	2.90	.340
3.00	.355	*	3.10	.319
3.20	.330	*	3.30	.340
3.40	.350	*	3.50	.359
3.60	.226	*	3.70	.229
3.80	.233	*	3.90	.236
4.00	.240	*	4.10	.243
4.20	.246	*	4.30	.249
4.40	.253	*	4.50	.256
4.60	.194	*	4.70	.196
4.80	.197	*	4.90	.199
5.00	.201	*	5.10	.202
5.20	.204	*	5.30	.206
5.40	.207	*	5.50	.209
5.60	.175	*	5.70	.176

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	3.60	80.00	.090	.000	.000	.00	.0

3/19

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.94	.30

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0887	ACRE-FT
PEAK DISCHARGE	=	.9448	CFS
AREA	=	3.6000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

* * * * * * * * * * * *
NULL STRUCTURE
* * * * * * * * * * * *

* *

JUNCTION 2, BRANCH 2, STRUCTURE 2

* *

***** RESULTS FROM SUBWATERSHED 1 *****

*** HYDROGRAPH AND SEDIMENT GRAPH ***
(TWO CONSECUTIVE VALUES PER LINE)

TIME (HR)	DISCHARGE (CFS)	*******	TIME (HR)	DISCHARGE (CFS)
.00	.000	*	.10	.000
.20	.000	*	.30	.000
.40	.000	*	.50	.000
.60	.000	*	.70	.000
.80	.000	*	.90	.000
1.00	.000	*	1.10	.000
1.20	.000	*	1.30	.000
1.40	.000	*	1.50	.000
1.60	.000	*	1.70	.000
1.80	.000	*	1.90	.000
2.00	.000	*	2.10	.051
2.20	.147	*	2.30	.228
2.40	.297	*	2.50	.355
2.60	.104	*	2.70	.107
2.80	.111	*	2.90	.114
3.00	.117	*	3.10	.104
3.20	.106	*	3.30	.108
3.40	.110	*	3.50	.112
3.60	.070	*	3.70	.071
3.80	.071	*	3.90	.072
4.00	.073	*	4.10	.074
4.20	.074	*	4.30	.075
4.40	.075	*	4.50	.076
4.60	.057	*	4.70	.058
4.80	.058	*	4.90	.058
5.00	.059	*	5.10	.059
5.20	.059	*	5.30	.060
5.40	.060	*	5.50	.060
5.60	.051	*	5.70	.051

****

BETA IS NEGATIVE WHICH INHERENTLY INDICATES THAT THE STREAM SYSTEM TRANSPORT CAPACITY EXCEEDS THE SEDIMENT LOAD, AS EVALUATED BY WILLIAMS' TECHNIQUE. SEDIMOTII DOES NOT CONSIDER ERODIBLE CHANNELS SO BETA IS SET .EQ. TO .01. IF THE USER WISHES TO EVALUATE THE TRANSPORT CAPACITY OF THE STREAM DIRECTLY HE/SHE SHOULD USE SUBROUTINE SLOSS.

****

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	.80	85.00	.080	.000	.000	.00	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)
1	.36	.46

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.0310	ACRE-FT
PEAK DISCHARGE	=	.3551	CFS
AREA	=	.8000	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS

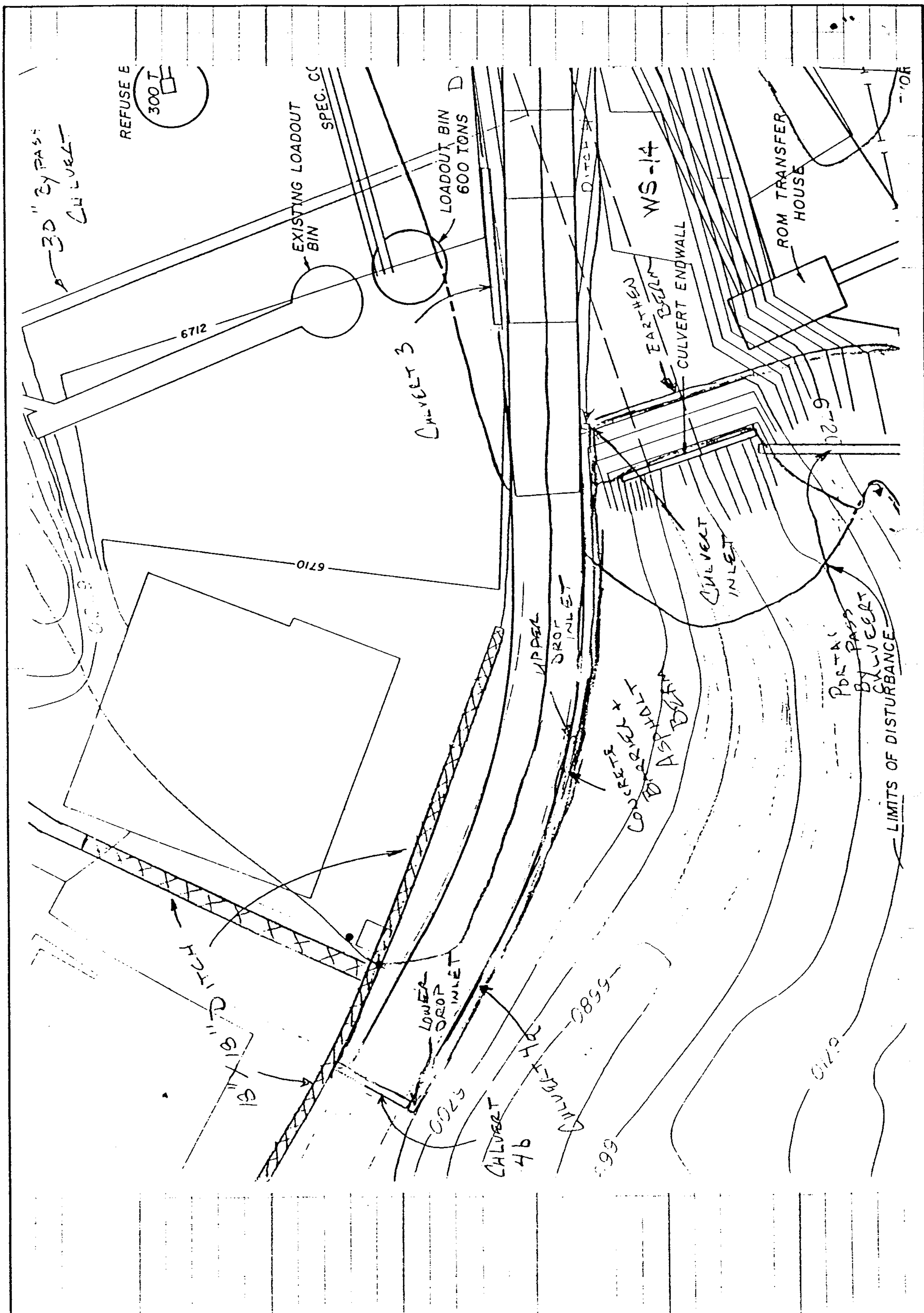
SUMMARY TABLE OF COMBINED HYDROGRAPH AND SEDIGRAPH VALUES

PREVIOUS MUSKINGUM ROUTING X	=	.33	
PREVIOUS MUSKINGUM ROUTING K	=	.0400	HRS
PREVIOUS ROUTED PEAK DISCHARGE	=	.94	CFS
TIME OF ROUTED PEAK DISCHARGE	=	2.50	HRS
TOTAL DRAINAGE AREA	=	4.40	ACRES
TOTAL RUNOFF VOLUME	=	.1196	AC-FT
PEAK RUNOFF DISCHARGE	=	1.30	CFS
TIME TO PEAK DISCHARGE	=	2.50	HRS

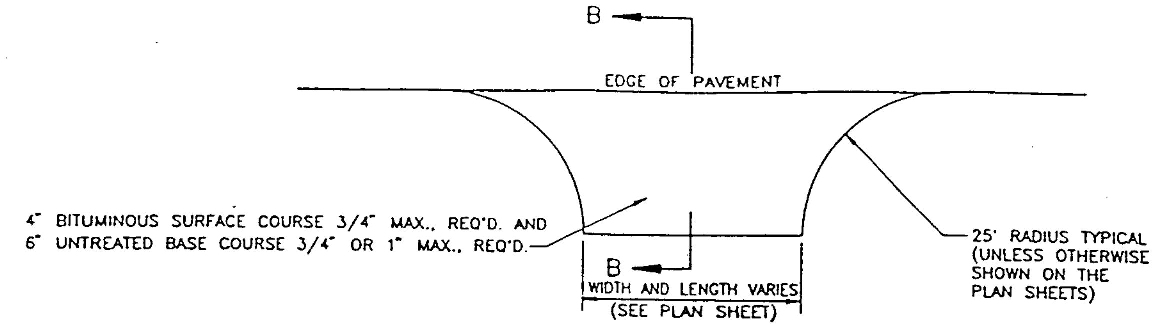
* * * * * * * * * * * *
NULL STRUCTURE
* * * * * * * * * * * *

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

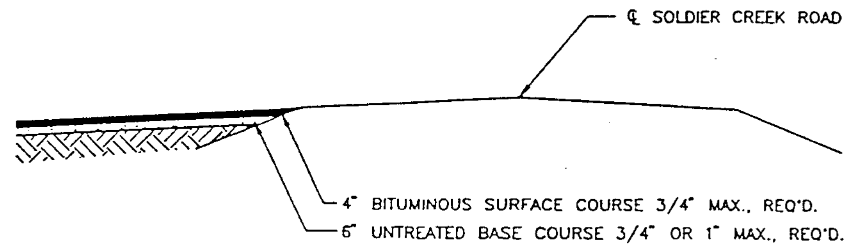
PROJECT C-159-04 PAGE 6 OF 19
COMPUTED TJS DATE 3/28/91
CHECKED ______ DATE ______



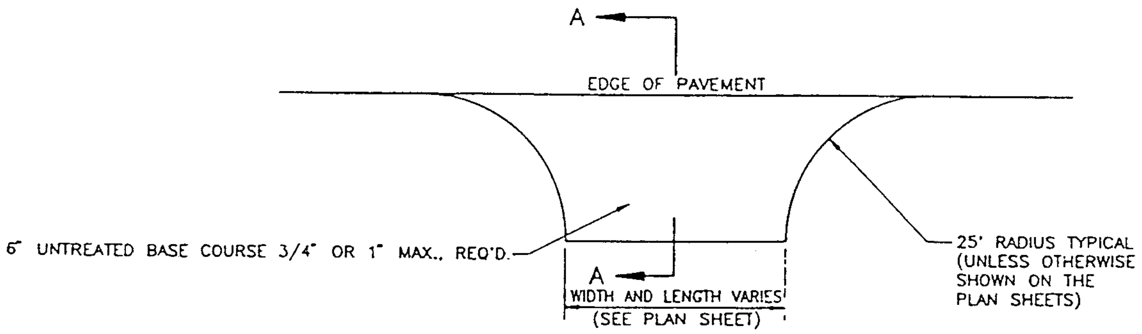
7/19



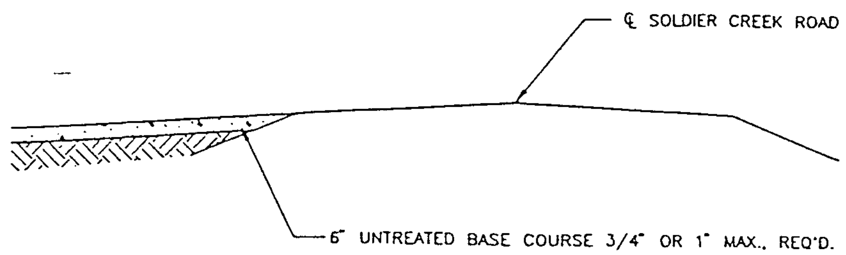
PAVED ACCESS ROAD



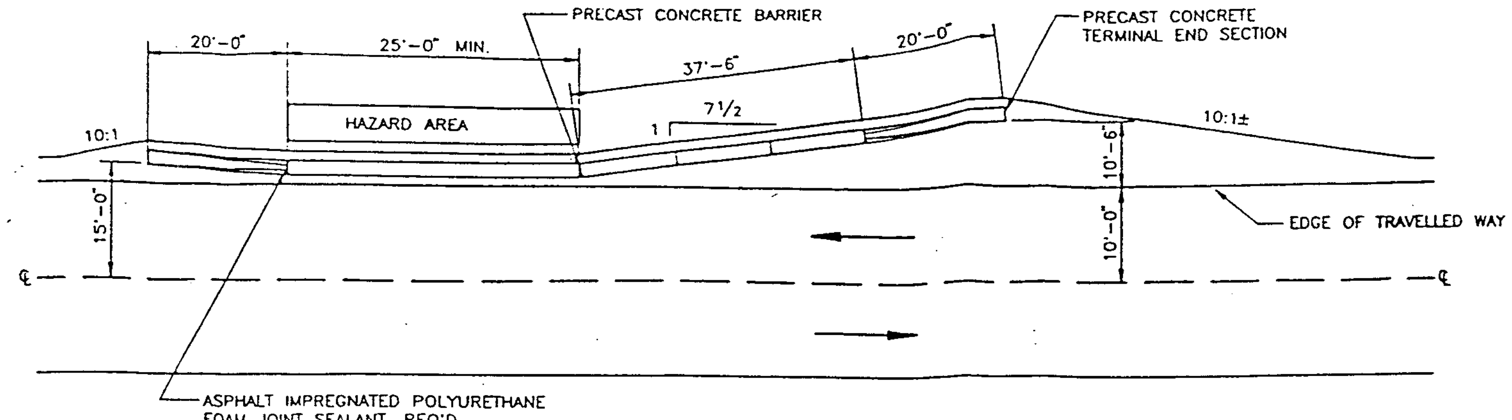
DETAIL B–B



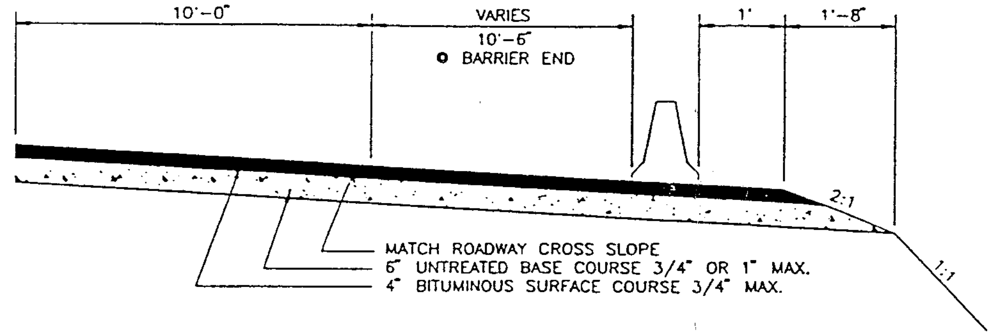
UNPAVED ACCESS ROAD



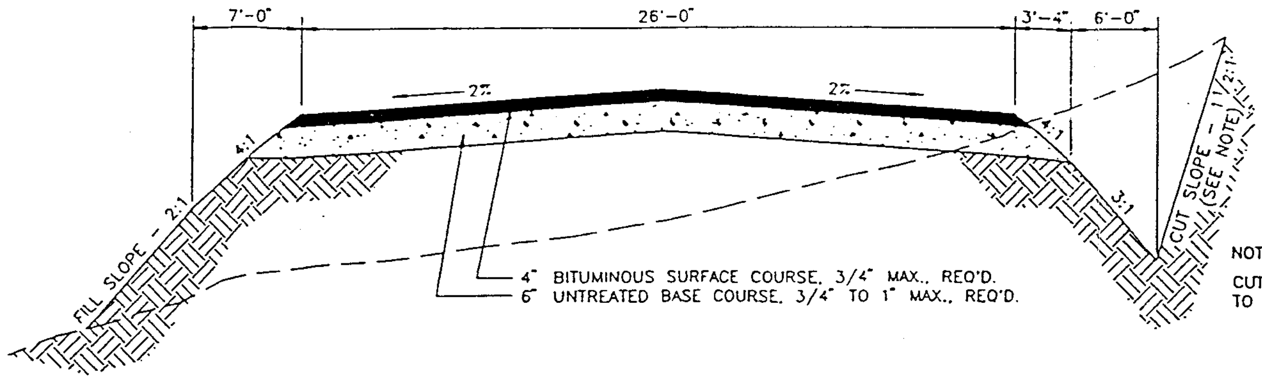
DETAIL A–A



TYPICAL BARRIER INSTALLATION PLAN



BARRIER PLACEMENT DETAIL



NOTE:
CUT SLOPE FROM STA. 16+10 TO STA. 18+90 IS 1.25:1.

TYPICAL SECTION
DESIGN SPEED 30 M.P.H.
STA. 10+00 TO STA. 22+33.50

NO. | DATE | REMARKS
ORIGINAL SUBMISSION FOR AUTHORIZATION
REVISIONS

SOLDIER CREEK COAL COMPANY
SOLDIER CREEK ROAD
ROADWAY DESIGN

REVIEW

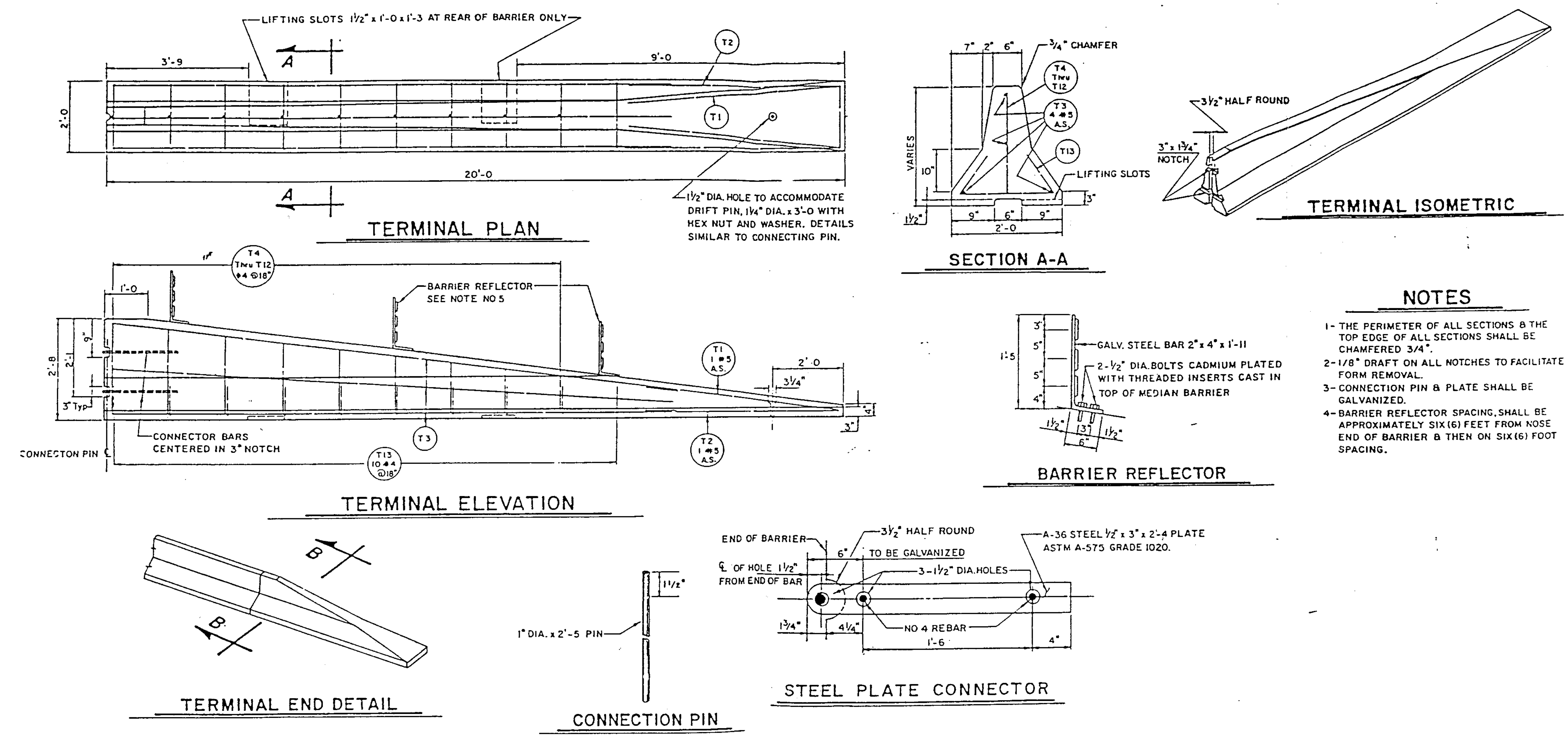
APPROVAL RECOMM. DATE
APPROVED DATE

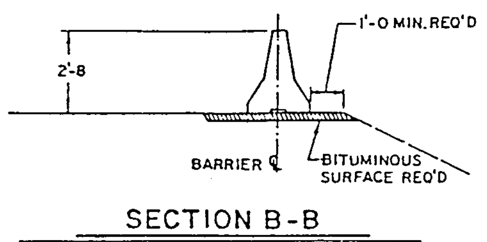
CREAMER & NOBLE ENGINEERS

DESIGNED SEL
CHECKED KRN
DRAWN DRL
PROJECT NUMBER

CARBON
COUNTY

SHEET NO. 2





NOTE: Reinforcing Steel dimensions are out to out of bar unless otherwise specificed.

REINFORCING STEEL FOR TERMINAL

MARK	LOCATION	SIZE NO.	NO. BARS	LENGTH	TOTAL LENGTH	SKETCH
T1	TERMINAL	5	1	15'-7	15'-7	7'-0, 1'-7
T2	TERMINAL	5	1	15'-7	16'-7	7'-0, 1'-7
T3	TERMINAL	5	4	15'-0	60'-0	
T4	TERMINAL	4	1	2'-4	2'-4	
T5	TERMINAL	4	1	2'-2	2'-2	
T6	TERMINAL	4	1	2'-0	2'-0	
T7	TERMINAL	4	1	1'-10	1'-10	
T8	TERMINAL	4	1	1'-8	1'-8	
T9	TERMINAL	4	1	1'-6	1'-6	
T10	TERMINAL	4	1	1'-4	1'-4	
T11	TERMINAL	4	1	1'-2	1'-2	
T12	TERMINAL	4	1	1'-0	1'-0	
T13	TERMINAL	4	10	3'-8	36'-8	6", 9", 1'-0, 1'-8

2-07-89 REMOVED WIRE LOOP CONNECTOR DETAIL
3-15-88 CHANGED DIM. TO 3" ON CONNECTOR BAR
REMOVED HEX NUT & WASHER FROM CONNECTION PIN
DELETED NOTE 1 & CHANGED NOTE 3 – RENUMBERED

UTAH DEPARTMENT OF TRANSPORTATION

SUPERSEDES

REVISIONS

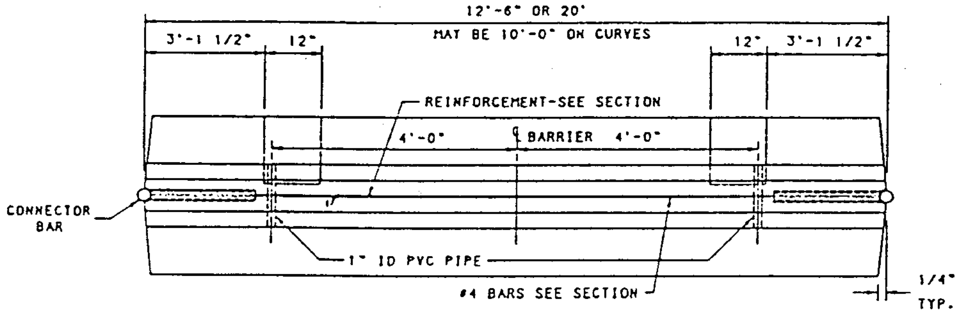
Date	Appr.
3-15-88	
2-07-89	

PRECAST CONCRETE BARRIER AND TERMINAL SECTION

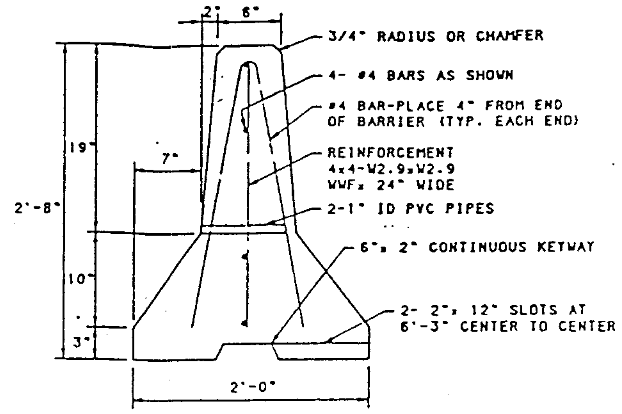
RECOMMENDED FOR APPROVAL: Blaine J. Kay, CHAIRMAN STANDARDS COMMITTEE — MAR 4 19 86

APPROVED: [signature], ASSISTANT DIRECTOR — MAR 4 19 86

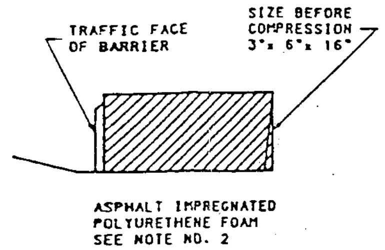
STD. DWG. NO. 735-1B



PLAN

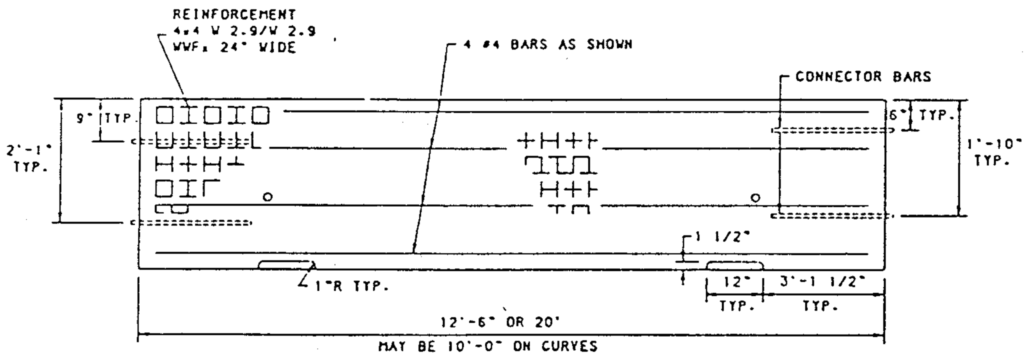


SECTION

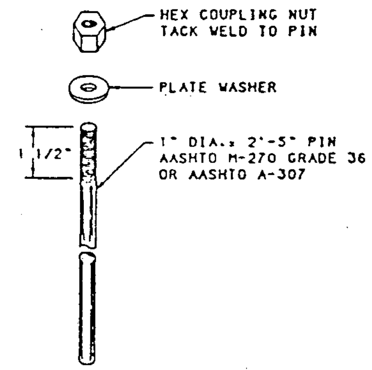


NOTES

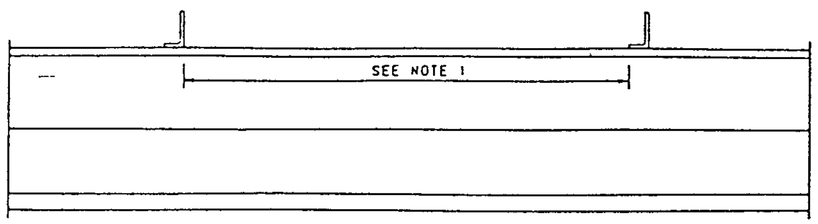
1. SPACING OF BARRIER REFLECTORS SHALL BE IN ACCORDANCE WITH STANDARD DRAWING 726-2.
2. USE POLYESTER POLYURETHANE OPEN CELL FOAM IMPREGNATED WITH ASPHALT. THE FOAM SHALL BE 100% IMPREGNATED WITH ASPHALT. WEIGH 68±10 POUNDS PER CUBIC YARD, AND 254±10 POUNDS PER CUBIC YARD AFTER BEING IMPREGNATED WITH ASPHALT. WHEN RELEASED, AFTER BEING COMPRESSED TO 25% OF ITS VOLUME, THE MATERIAL SHALL RETURN TO 95% OF ITS ORIGINAL VOLUME AND IT SHALL NOT SPREAD SIDEWAYS WHEN COMPRESSED. THE MATERIAL SHALL REMAIN STABLE AT TEMPERATURE FROM -40° TO +150° FAHRENHEIT. THE MATERIAL SHALL MAINTAIN A PERMANENT BOND WHEN THERE IS A CONSTANT EXERTION AGAINST THE JOINT SURFACES.
3. ALL REINFORCING STEEL & WIRE FABRIC SHALL BE EPOXY COATED.
4. 1/8" DRAFT ON ALL NOTCHES TO FACILITATE FORM REMOVAL.
5. CONNECTION PIN, HEX NUT & PLATE WASHER SHALL BE GALVANIZED; AASHTO M-111.
6. THREAD HEX NUT HALF WAY ONTO PIN AND TACK WELD THE NUT AND PLATE WASHER. PLACE AN ADEQUATE AMOUNT OF SILICONE ADHESIVE ON BOTTOM OF WASHER BEFORE INSERTING PIN TO HOLD PIN IN PLACE AND PREVENT EASY HAND REMOVAL.



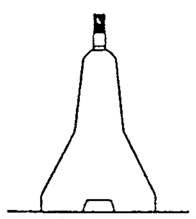
ELEVATION



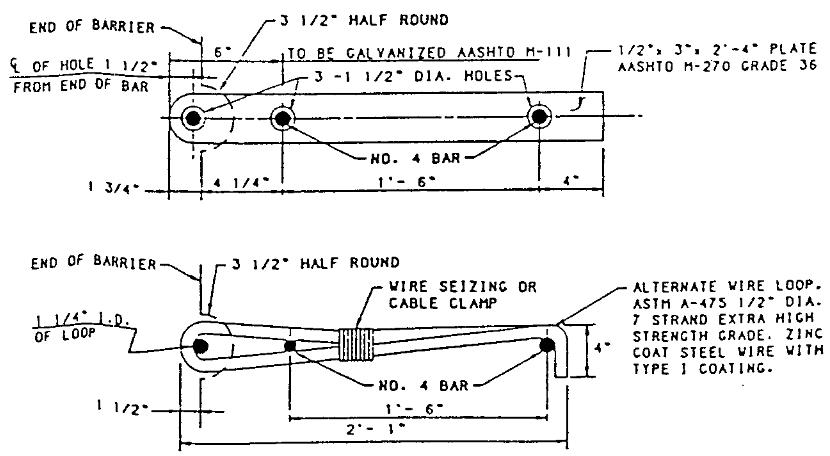
CONNECTION PIN



BARRIER REFLECTOR

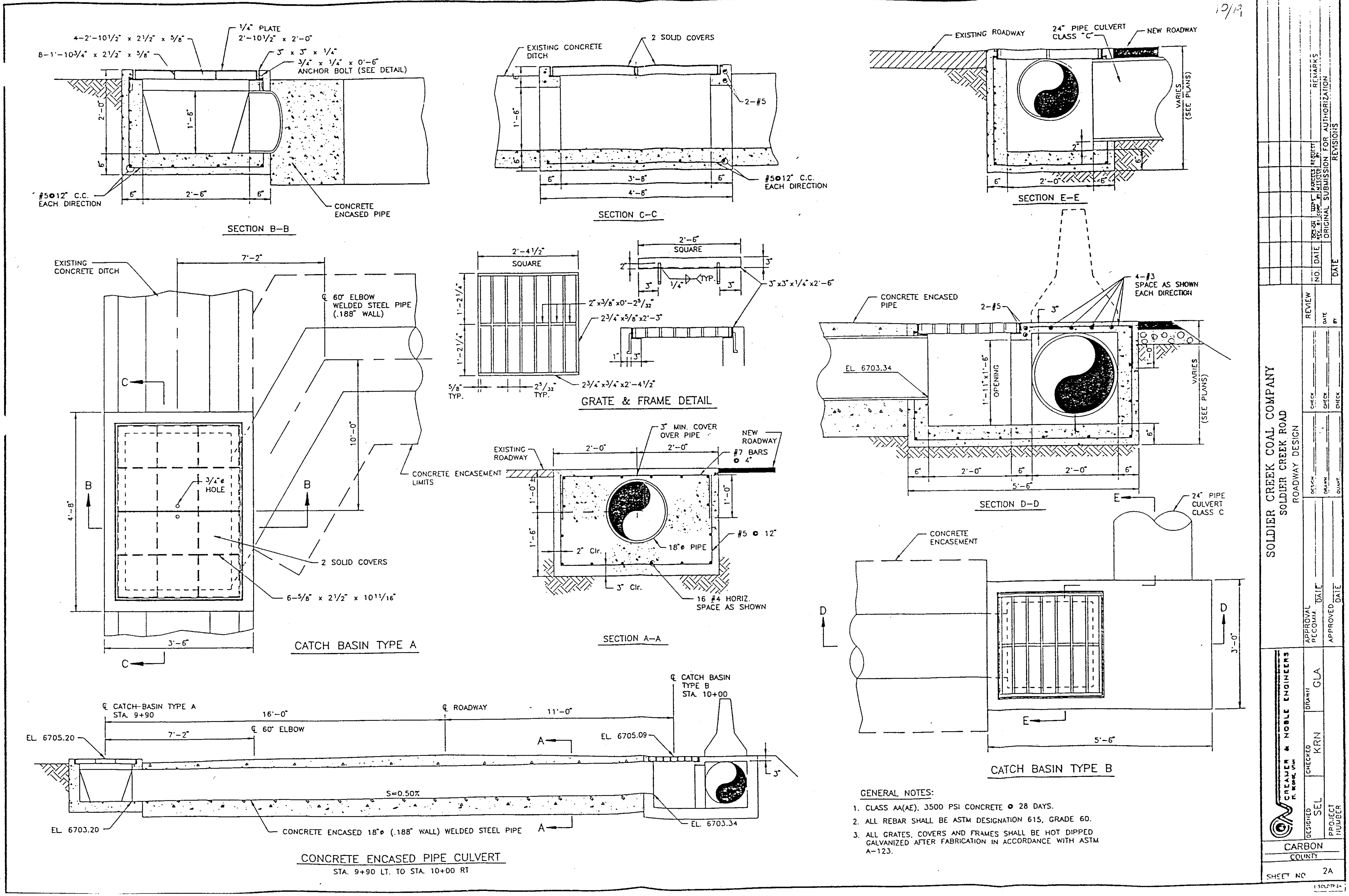


ELEVATION



CONNECTOR BAR

UTAH DEPARTMENT OF TRANSPORTATION	
SUPERCEDES	PRECAST CONCRETE BARRIER STANDARD SECTIONS
REVISIONS (Date, Appr.)	
RECOMMENDED FOR APPROVAL: [signature] CHAIRMAN STANDARDS COMMITTEE	6-14 19 90 Date
APPROVED: [signature] ASSISTANT DIRECTOR	6-15 19 90 Date
STD. DWG. NO. 735-1C	



GENERAL NOTES:

1. CLASS AA(AE), 3500 PSI CONCRETE @ 28 DAYS.
2. ALL REBAR SHALL BE ASTM DESIGNATION 615, GRADE 60.
3. ALL GRATES, COVERS AND FRAMES SHALL BE HOT DIPPED GALVANIZED AFTER FABRICATION IN ACCORDANCE WITH ASTM A-123.

CULVERT 4a:

- DETERMINE CAPACITY OF 24-INCH CULVERT

UPPER SECTION -

DIAMETER - 2.0 FT

SLOPE - 0.0231 FT/FT

MANNING'S n - 0.015 → .012 - .016

DISCHARGE - 1.30 CFS

RESULT - (SEE FLOW MASTER OUTPUT p 12)

DEPTH - 0.28 FT OK

Δ in slope max V VELOCITY - 4.75 FPS

LOWER SECTION

DIAMETER - 2.0 FT 18"

SLOPE - 0.0078 FT/FT

MANNING'S n - 0.015

DISCHARGE - 1.30 CFS

RESULT - (SEE FLOWMASTER OUTPUT p12)

max DEPTH - 0.37 FT OK

VELOCITY - 3.24 FPS

12/19

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: 24-inch pipe-maxsec

Comment: 24-inch Pipe along County Road @ max. slope

Solve For Actual Depth

Given Input Data:

Diameter..........	2.00 ft
Slope.............	0.0231 ft/ft
Manning's n.......	0.015
Discharge.........	1.30 cfs

Computed Results:

Depth.............	0.28 ft
Velocity..........	4.75 fps
Flow Area.........	0.27 sf
Critical Depth....	0.39 ft
Critical Slope....	0.0061 ft/ft
Percent Full......	14.24 %
Full Capacity.....	29.80 cfs
QMAX @.94D........	32.05 cfs
Froude Number.....	1.89 (flow is Supercritical)

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: 24-inch Pipe-minsec

Comment: 24-inch Pipe along County Road - min. slope

Solve For Actual Depth

Given Input Data:

Diameter..........	2.00 ft
Slope.............	0.0078 ft/ft
Manning's n.......	0.015
Discharge.........	1.30 cfs

Computed Results:

Depth.............	0.37 ft
Velocity..........	3.24 fps
Flow Area.........	0.40 sf
Critical Depth....	0.39 ft
Critical Slope....	0.0061 ft/ft
Percent Full......	18.54 %
Full Capacity.....	17.32 cfs
QMAX @.94D........	18.63 cfs
Froude Number.....	1.12 (flow is Supercritical)

CULVERT 4b:

INPUTS

DIAMETER	1.5 FT
SLOPE	0.005 FT/FT
MANNING'S n	0.015
DISCHARGE	1.30 CFS

RESULTS (SEE FLOWMASTER OUTPUT p 15)

DEPTH	0.46 FT	OK
VELOCITY	2.85 FPS	

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Culvert 4b

Comment: Culvert 4b - 18-inch under County Road

Solve For Actual Depth

Given Input Data:

Diameter..........	1.50 ft
Slope.............	0.0050 ft/ft
Manning's n.......	0.015
Discharge.........	1.30 cfs

Computed Results:

Depth.............	0.46 ft
Velocity..........	2.85 fps
Flow Area.........	0.46 sf
Critical Depth....	0.43 ft
Critical Slope....	0.0065 ft/ft
Percent Full......	30.48 %
Full Capacity.....	6.44 cfs
QMAX @.94D........	6.92 cfs
Froude Number.....	0.87 (flow is Subcritical)

DROP DRAINS:

AS INDICATED ON SHEET 2A (SEE PAGE 10), THE DROP DRAINS CONSIST OF A 2'X2' OPENING COVERED WITH A GRATE.

THE PEAK FLOW TO BE HANDLED BY A SINGLE DROP DRAIN IS A PORTION OF THE 1.3 CFS FROM WATERSHEDS 12 + 14. TO ENSURE THESE STRUCTURES ARE ADEQUATE THEY WERE DESIGNED ASSUMING THAT THE FULL 1.3 CFS HAD TO BE HANDLED INDIVIDUALLY.

THE CAPACITY OF THE DRAINS WAS DETERMINED BY CALCULATING THE WEIR & ORIFICE FLOW FOR THE DRAIN OPENING ADJUSTED FOR THE GRATE AREA.

AREA OF GRATE:

TOP BARS, CENTER BAR

$6\,(24'' \times 3/8'') + (24'' \times 3/8) = 63\ in^2$

AREA OF DRAIN $= 0.44\ FT^2$

$2' \times 2' = 4\ FT^2$

OPEN AREA OF DRAIN

$4 - 0.44 = 3.56\ FT^2$

LENGTH OF WEIR

$(2(2') + 2(2')) - (14 \times (3/8''/12)) = 7.56\ FT$

FLOW CAPACITY

WEIR

$Q = K L H^{3/2}$

L = LENGTH OF WEIR (FT)

H = HEAD (FT)

K = WEIR COEFFICIENT $= 3.27$

ORIFICE

$$Q = C' A (2gH)^{0.5}$$

$C' = 0.80$

A = AREA OF ORIFICE (FT^2)

$g = 32.2$

H = HEAD (FT)

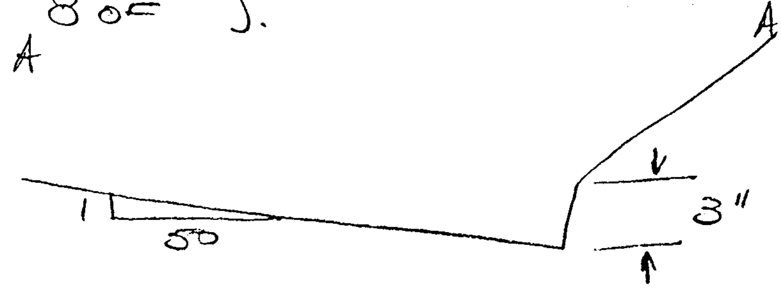
FLOW CAPACITY

HEAD (FT)	WEIR FLOW (CFS)	ORIFICE FLOW (CFS)
0	0	0
0.1	0.78	7.23
0.2	2.21	10.22
0.3	4.06	12.52
0.4	6.25	14.45
0.5	8.74	16.16

∴ FLOW OF 1.3 CFS CAN BE HANDLED WITH ≈ 0.15 FT OF HEAD.

DITCH ALONG CONCRETE BARRIERS:

- DITCH IS FORMED BY ASPHALT ROAD SURFACE + CONCRETE BERM. (SEE PAGE 8 OF).



ASSUME:

TRIANGULAR SHAPE

LEFT SIDESLOPE 50:1

RIGHT SIDESLOPE 0.1:1

MANNING'S n = 0.021

CHANNEL SLOPE = 0.019 FT/FT

DISCHARGE = 1.5 CFS

RESULTS: (SEE FLOWMASTER OUTPUT)

DEPTH = 0.17 FT 2" < 0.25' OK

VELOCITY = 1.85 FPS

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Road barrier

Comment: Road Barrier Ditch

Solve For Depth

Given Input Data:

Left Side Slope..	0.10:1 (H:V)
Right Side Slope.	50.00:1 (H:V)
Manning's n......	0.021
Channel Slope....	0.0190 ft/ft
Discharge........	1.30 cfs

High but overdesigned

Computed Results:

Depth............	0.17 ft
Velocity.........	1.85 fps
Flow Area........	0.70 sf
Flow Top Width...	8.40 ft
Wetted Perimeter.	8.55 ft
Critical Depth...	0.18 ft
Critical Slope...	0.0148 ft/ft
Froude Number....	1.12 (flow is Supercritical)

APPENDIX C

Design of Undisturbed Area Diversion
Above Proposed Portal Expansion

REGISTERED PROFESSIONAL ENGINEER
No. 7102
RICHARD B. WHITE
STATE OF UTAH

Richard B. White
8 Mar 1991

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Attachment	
A	Diversion Ditch and Runoff Calculations

Design of Undisturbed Area Diversion
Above Proposed Portal Expansion

1.0 GENERAL

This appendix presents a discussion of the hydrologic conditions associated with the portal diversion areas. The method of diverting runoff from the undisturbed watershed above the portal area is defined.

Computations are based upon a field reconnaissance of the area and published hydrologic information. In addition, the designs are based on the assumption that the diversion ditch is a temporary structure which will be reclaimed.

2.0 STORM RUNOFF CALCULATIONS

Watershed boundaries used to determine runoff conditions above the portal is shown on Figure 2-1. Watershed 13a has an area of 2.8 acres and will drain into the proposed diversion ditch which conveys runoff to the south around the portal area (see Figure 2-1 and Exhibit 10.2.4-1). Watershed 13b has a drainage area of 0.6 acres and will also drain to a proposed diversion ditch which will convey the runoff to the north as shown on Exhibit 10.2.4-1. The drainage from these two ditches will be conveyed around the disturbed area through a by-pass culvert.

Data obtained from Watersheds 13a and 13b were input into the computer program developed by Hawkins and Marshall (1979) to generate runoff hydrographs for the 10-year, 6-hour storm required (Division of Oil, Gas, and Mining, 1987) for designing the temporary diversion structures. The program models runoff using the rainfall-runoff function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972).

According to the U.S. Soil Conservation Service (1972), the algebraic and hydrologic relations between storm rainfall, soil moisture storage, and runoff can be expressed by the equations,

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \tag{2-1}$$

and

$$S = \frac{1000}{CN} - 10 \tag{2-2}$$

where:

- Q = direct runoff volume (inches)
- S = watershed storage factor (inches)
- P = rainfall depth (inches)
- CN = runoff curve number (dimensionless)

The average curve number for the undisturbed Watershed 13 was chosen from professional judgement and tabulated values presented by the U.S. Soil Conservation Service (1972). Accordingly, a value of 75 was used for the undisturbed areas.

The translation of the runoff depth to an outflow hydrograph is accomplished in the code using the triangular unit hydrograph of the U.S. Soil Conservation Service (1972). This unit hydrograph is shown on Figure 2-2 along with a typical curvilinear hydrograph. It is characterized by its time to peak (T_p), recession time (T_r), time of base (T_b), and the relations between these parameters (i.e., T_r=1.67T_p; T_b=2.67$_p$). Thus, from the geometry of a triangle, the incremental runoff (Q) can be defined by the equation,

$$Q = \frac{(2.67T_p)(q_p)}{2} \tag{2-3}$$

or

$$q_p = \frac{0.75Q}{T_p} \tag{2-4}$$

where q_p = peak flow rate (dimensioned according to Q and T) and other parameters have been previously defined.

When Q is expressed in inches and T_p in hours, q_p will be in inches per hour. The flow at any time $0 < t < T_r$ may be determined by simple linear proportioning

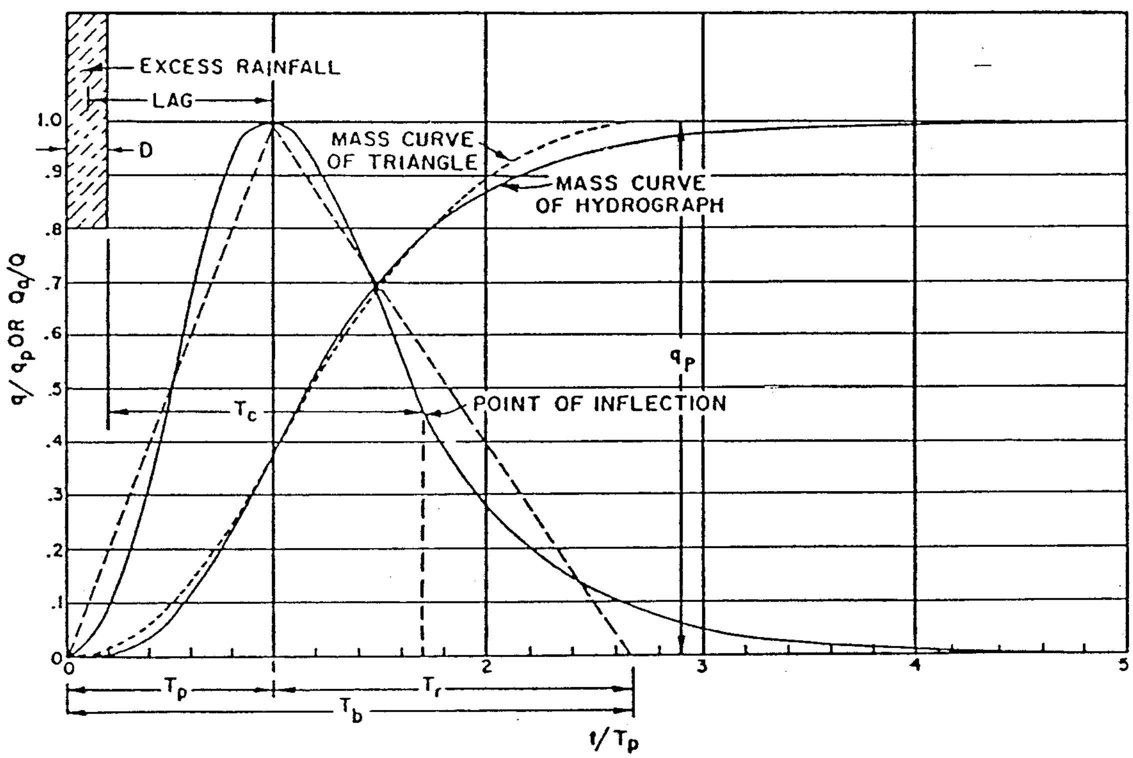


FIGURE 2-2. DIMENSIONLESS UNIT HYDROGRAPH AND MASS-CURVE.

EarthFax

of the triangular unit hydrograph. The time to peak is related to the familiar expression time of concentration (T_c) by the equation,

$$T_c + t = 1.7T_p \qquad (2\text{-}5)$$

in which the factor 1.7 is an empirical finding cited by the U.S. Soil Conservation Service (1972).

The time of concentration may be estimated by several formulas. For this report, T_c was determined from the following equations (U.S. Soil Conservation Service, 1972):

$$L = \frac{\lambda^{0.8}\ (S+1)^{0.7}}{1900\ Y^{0.5}} \qquad (2\text{-}6)$$

and

$$T_c = 1.67L \qquad (2\text{-}7)$$

where:

- L = watershed lag (hours)
- λ = hydraulic length of the watershed, or distance along the main channel to the watershed divide (feet)
- S = watershed storage factor defined in equation (2-2)
- Y = average watershed slope (percent)
- T_c = time of concentration (hours)

The computer program developed by Hawkins and Marshall (1979) was run for the watersheds and the input calculations and results are presented in Attachment A. Table 2-1 summarizes the input and resulting peak flow volume for the watersheds.

3.0 DIVERSION DITCH DESIGN

The diversion ditches were designed to convey runoff from the undisturbed watershed above the portals away from the disturbed site. The Manning and continuity equations were used to determine the required sizing of the ditches. These equations are:

Table 2-1

Summary of Runoff Calculations

Watershed	Area (acres)	Curve No.	T_c (hours)	Runoff Depth (inches)	Peak Flow (cfs)
13a	2.80	75	.070	.173	0.34
13b	0.60	75	.040	.173	0.08

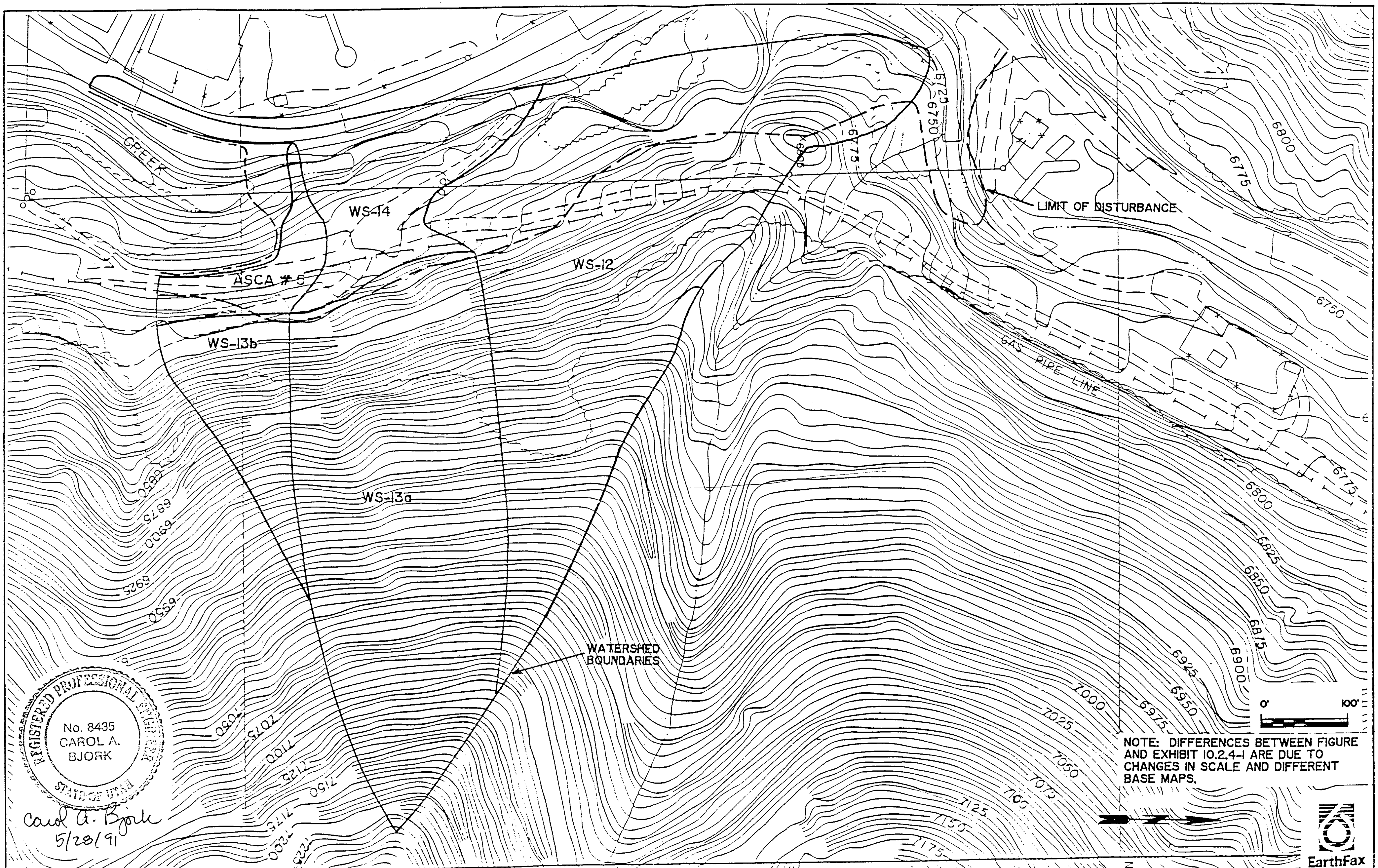


FIGURE 2-1. WATERSHED BOUNDARIES FOR DIVERSION DITCH DESIGN.

$$V = \frac{1.49}{n} R^{2/3} S^{1/2} \qquad (3\text{-}1)$$

and

$$Q = AV \qquad (3\text{-}2)$$

where:

- V = velocity (feet per second)
- R = hydraulic radius (feet)
- S = hydraulic slope (feet per foot)
- n = roughness coefficient
- Q = discharge (cubic feet per second)
- A = flow area (square feet)

Values of the roughness coefficient required for the solution of equation (3-1) were obtained by comparing local conditions with tabulated values provided by Chow (1959). The portal diversion ditch will be excavated in rock and, therefore, a roughness coefficient of 0.04 was chosen as being appropriate for jagged or irregular rock cuts. The road diversion ditch will be excavated in earth and a roughness coefficient of 0.035 was chosen as being appropriate for the earthen ditch. high OK

Calculations with equations (3-1) and (3-2) were performed using the FLOWMASTER I computer program developed by Haested Methods (1990). The results of these design calculations are presented in Attachment A.

The location of the portal diversion and road diversion ditches are identified on Exhibit 10.2.4-1. Typical cross sections of the ditches are presented in Attachment A of this appendix.

When excavation occurs, the diversions will be constructed as modified V-shaped ditches. The portal diversion ditch will be constructed with a vertical side wall adjacent to the undisturbed area and a gently sloping (15 horizontal to 1 vertical) side slopes above the portal area. The average slope of the rock cut diversion is 0.057 ft/ft. Based on the anticipated peak flow of 0.33 cfs, the resulting depth of flow is 0.17 feet and the flow velocity is approximately 1.6 feet per second. In order to incorporate adequate freeboard, the diversion will be constructed with a 0.3 foot freeboard resulting in a minimum diversion depth of 0.56 feet.

The road diversion ditch will be excavated in soil as a triangular shaped ditch with 1H:1V side slopes. The average slope of the earthen ditch is anticipated to be 0.04 ft/ft. Based on the expected peak flow of 0.08 cfs, the resulting depth of flow is 0.23 feet and the flow velocity is approximately 1.6 feet per second. To include the 0.3 foot freeboard, the triangular section shall be excavated to a minimum depth of 0.53 feet. Because the diversion ditch velocities will be less than 3.0 feet per second, riprap is not required.

4.0 DROP BY-PASS CULVERT

To convey the undisturbed runoff from the ditches to the Soldier Creek Channel it will be necessary to install a by-pass culvert. This culvert, shown on Exhibit 10.2.4-1, will have a minimum size of 12-inch CMP culvert. Larger culverts can be installed if desired for maintenance reasons. It is planned that the culvert will be buried through the upper section of its length and will be secured on the surface for the lower section, below the portal pad elevation. The design and sizing calculations for this culvert are presented in Attachment A.

5.0 REFERENCES

Chow, V.T. 1959. Open Channel Hydraulics. McGraw-Hill. New York, New York.

Hawkins, R.H. and K.A. Marshall. 1979. Storm Hydrograph Program. Final Report to the Utah Division of Oil, Gas & Mining. Utah State University Foundation. Logan, Utah.

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-Frequency Atlas of the Western United States. Volume VI - Utah. U.S. Department of Commerce. Silver Spring, Maryland.

U.S. Soil Conservation Service. 1972. National Engineering Handbook, Section 4: Hydrology. U.S. Government Printing Office. Washington, D.C.

Utah Division of Oil, Gas and Mining. 1987. Utah Coal Mining and Reclamation Regulatory Program. Chapter I, Rules Pertaining to Underground Coal Mining Activities. Salt Lake City, Utah.

ATTACHMENT A

Diversion Design and Runoff Calculations

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

DETERMINE PEAK FLOW FROM AREAS ABOVE PORTAL

WATERSHED	13 a	13 b
AREA (AC)	2.8	0.6
HYDRAULIC LENGTH (FT)	325	475
WATERSHED SLOPE (%)	62.5	63.1
CURVE NUMBER	75	75
TIME OF CONCENTRATION	0.07 hrs	0.04 hrs

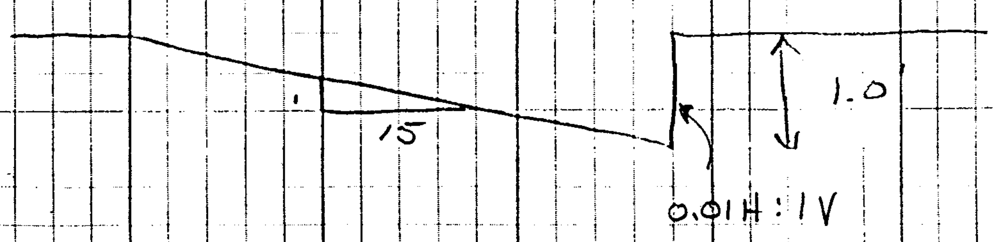
PEAK FLOW – FROM SCS HYDRO PROGRAM

Qp (cfs) =	0.33	0.08

DIVERSION DESIGN: (USING FLOWMASTER I)

PORTAL DITCH:

ROCK SECTION:



EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENRATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: Watershed 13a - SC3 Expansion area

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 2.80 acres
Depth = 1.52 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.070 hrs

OUTPUT SUMMARY

Runoff depth 0.17393 inches
Initial abstr 0.66667 inches
Peak flow = 0.33 cfs (0.11849 iph)
at time 2.520 hrs

INPUT FOR: Watershed 13b - SC3 Expansion area

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 0.60 acres
Depth = 1.52 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.040 hrs

OUTPUT SUMMARY

Runoff depth 0.17393 inches
Initial abstr 0.66667 inches
Peak flow = 0.08 cfs (0.13048 iph)
at time 2.507 hrs

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: portal

Comment: Portal Diversion - ROCK SECTION

Solve For Depth

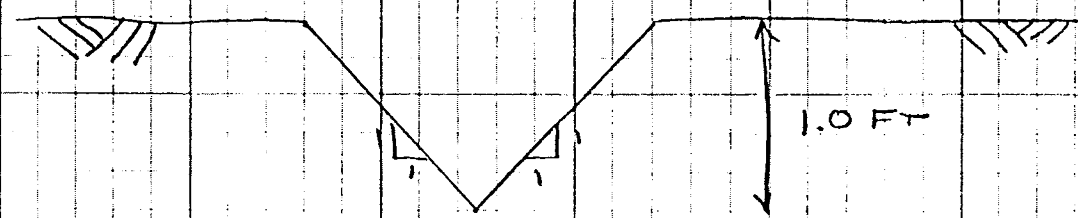
Given Input Data:

Left Side Slope..	0.01:1 (H:V)
Right Side Slope.	15.00:1 (H:V)
Manning's n......	0.040
Channel Slope....	0.0570 ft/ft
Discharge........	0.33 cfs

Computed Results:

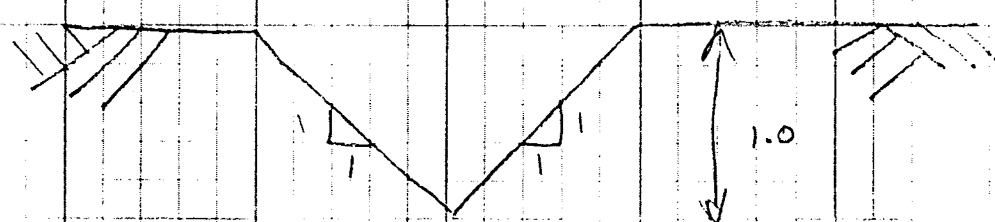
Depth............	0.17 ft < 1.0 OK
Velocity.........	1.61 fps
Flow Area........	0.20 sf
Flow Top Width...	2.48 ft
Wetted Perimeter.	2.65 ft
Critical Depth...	0.16 ft
Critical Slope...	0.0586 ft/ft
Froude Number....	0.99 (flow is Subcritical)

SOIL SECTION:



SEE FLOW MASTER CALC'S OK

ROAD DIVERSION:



SEE FLOW MASTER CALC'S OK

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: portal-soil

Comment: Portal Ditch - Soil Section

Solve For Depth

Given Input Data:

Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n......	0.035
Channel Slope....	0.0570 ft/ft
Discharge........	0.33 cfs

Computed Results:

Depth............	0.36 ft	< 1.0 OK
Velocity.........	2.56 fps	< 3.0 OK
Flow Area........	0.13 sf	
Flow Top Width...	0.72 ft	
Wetted Perimeter.	1.02 ft	
Critical Depth...	0.37 ft	
Critical Slope...	0.0498 ft/ft	
Froude Number....	1.06 (flow is Supercritical)	

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Road

Comment: Road Ditch

Solve For Depth

Given Input Data:

Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n......	0.035
Channel Slope....	0.0400 ft/ft
Discharge........	0.08 cfs

Computed Results:

Depth............	0.23 ft	< 1.0 OK
Velocity.........	1.57 fps	< 3.0 OK
Flow Area........	0.05 sf	
Flow Top Width...	0.45 ft	
Wetted Perimeter.	0.64 ft	
Critical Depth...	0.21 ft	
Critical Slope...	0.0602 ft/ft	
Froude Number....	0.83 (flow is Subcritical)	

PORTAL BYPASS CULVERT:

REQUIRED CAPACITY:

0.33 CFS + 0.08 CFS = 0.41 CFS

ASSUME 12-INCH CMP CULVERT W/ INLET CONTROL AND PROJECTING END.

(SEE ATTACHED NOMOGRAPH)

CAPACITY = 2.1 CFS

THUS, A 12-INCH OR LARGER CULVERT IS ADEQUATE.

NOTE: ACTUAL CULVERT LOCATION SHALL BE FIELD FIT TO ALLOW EASIEST INSTALLATION. DISCHARGE FROM CULVERT SHALL BE DIRECTED ON TO EXISTING RIPRAP APRON OF SOLDIER CREEK BY-PASS CULVERT.

V = 4.4 cfs

= .5'

outlet Riprap size?

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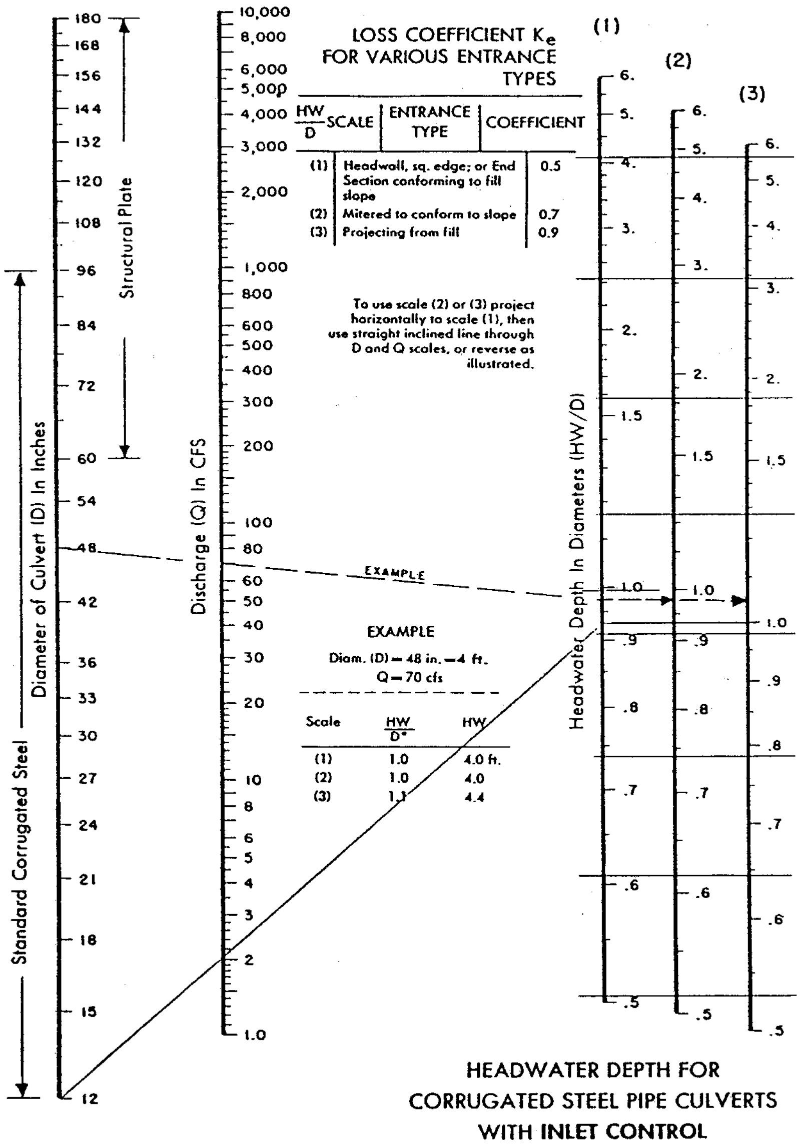

Fig. 4-18. *Inlet control* nomograph for corrugated steel *pipe* culverts. The manufacturers recommend keeping *HW/D* to a maximum of 1.5 and preferably to no more than 1.0.

APPENDIX (D)

Design of Proposed Soldier Creek
Bypass Culvert

REGISTERED PROFESSIONAL ENGINEER
No. 7102
RICHARD B. WHITE
STATE OF UTAH

Richard B. White
18 May 1989

DESIGN OF SOLDIER CREEK ~~CULVERT~~ BYPASS
– SOLDIER CANYON MINE PORTAL EXPANSION –

Hydrology

Design flow ⟶ Peak from 100-yr, 24-hr event
q_p = 2900 cfs (Vaughn Hansen Assoc., 1982)

Hydraulics

Culvert length = 550 ft (from site plan)
Culvert slope = 4.0% (from site cross sections)

$$\frac{L}{100 S_o} = \frac{550}{(100)(0.04)} = 137.5$$

Maximum available headwater:
HW_{max} = 15 ft (site cross sections)

Possible options:

① 180" structural plate circular CMP (see pg. 2 of this calc.)
HW = 20 ft ⟹ Exceeds current plans for HW

② 16.6' × 10.1' structural plate CMP pipe arch (see pg. 3 of this calc.)
HW = 27 ft ⟹ Exceeds desired HW

③ 16.6' × 10.1' structural plate pipe arch with headwall, bevel, and 18" radius corner plate (see pg. 4 of this calc.)
HW = 20.2 ft ⟹ Exceeds desired HW

④ The following structural plate pipe arch culverts with headwall, bevel, and 31" radius corner plate (see pg. 5 of this calc.):

20.6 × 13.2 ⟶ HW/D = 1.09 HW = 14.4 ft
19.9 × 12.9 ⟶ HW/D = 1.14 HW = 14.7 ft
19.3 × 12.3 ⟶ HW/D = 1.25 HW = 15.4 ft
17.4 × 11.5 ⟶ HW/D = 1.53 HW = 17.6 ft

(first two) ⟶ Examine exit velocities of these two culverts for Q = 2900 cfs. Calculations based on Manning's equation with S = 0.04 and n = 0.028 (see AISI, 1983). Cross-sectional data provided on pg. 6 of this calc.

$$Q = A \frac{1.486}{n} R^{2/3} S^{1/2}$$

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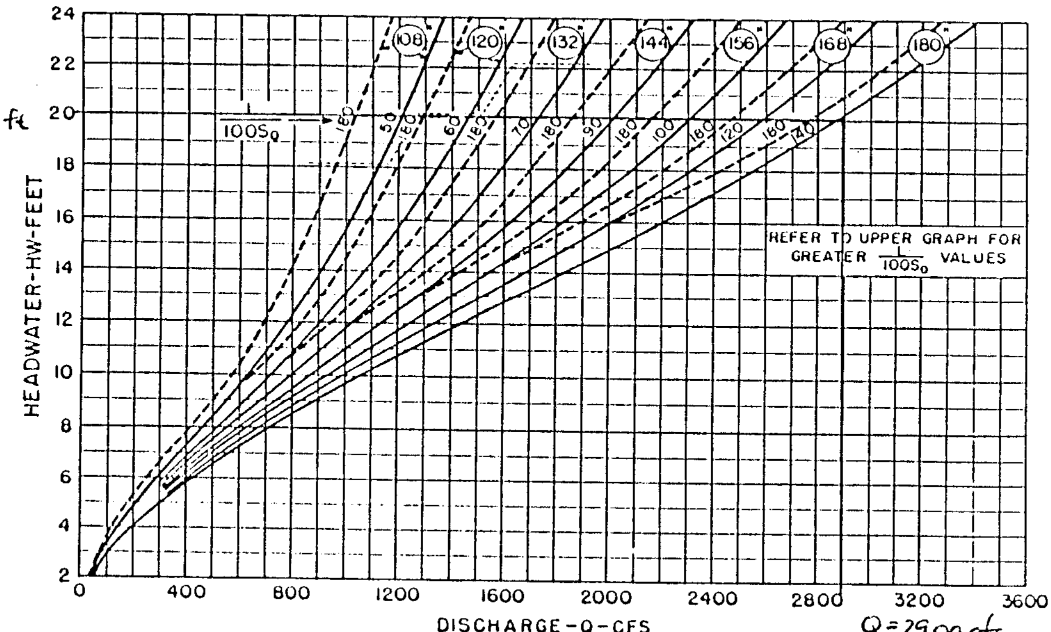
HW = 20 ft



Q = 2900 cfs

EXAMPLE

⊗ GIVEN
1500 CFS., AHW = 17.6 FT
L = 180 FT., S_0 = 0.006

SELECT 144"
HW = 16.5 FT

BUREAU OF PUBLIC ROADS JAN. 1963

CULVERT CAPACITY
STRUCTURAL PLATE
CIRCULAR CORR. METAL PIPE
HEADWALL ENTRANCE
108" TO 180" ○

Source: HEC-10

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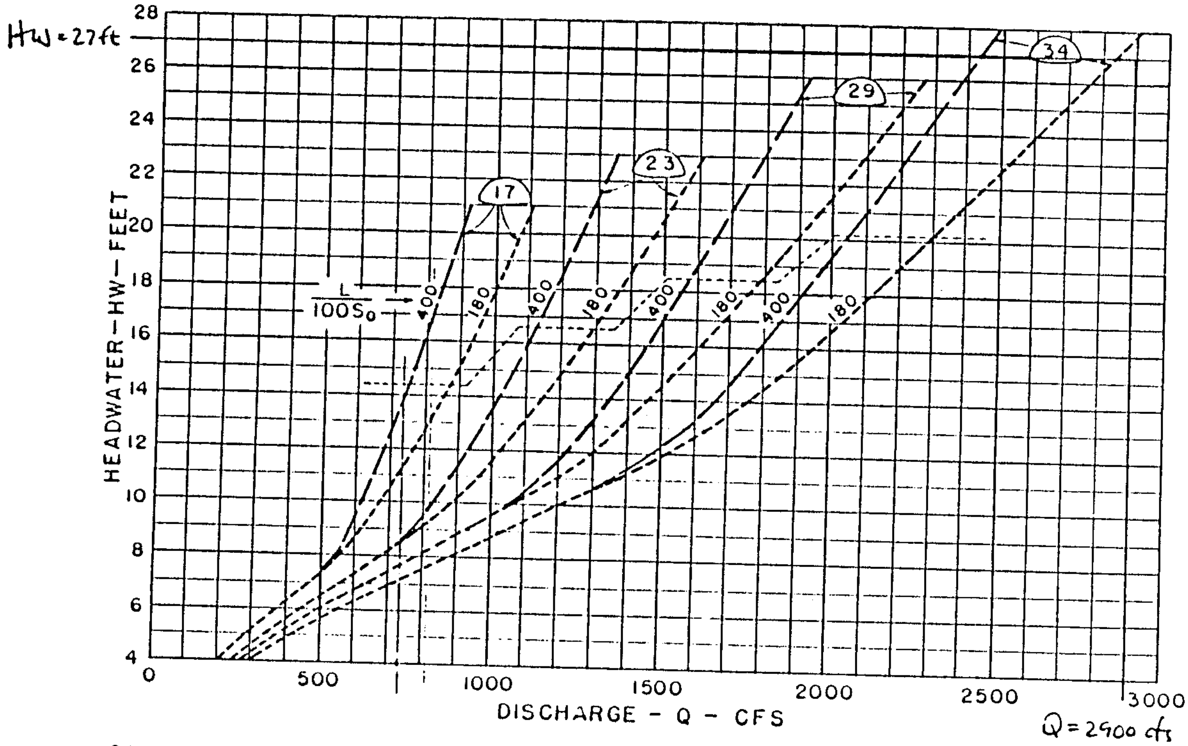

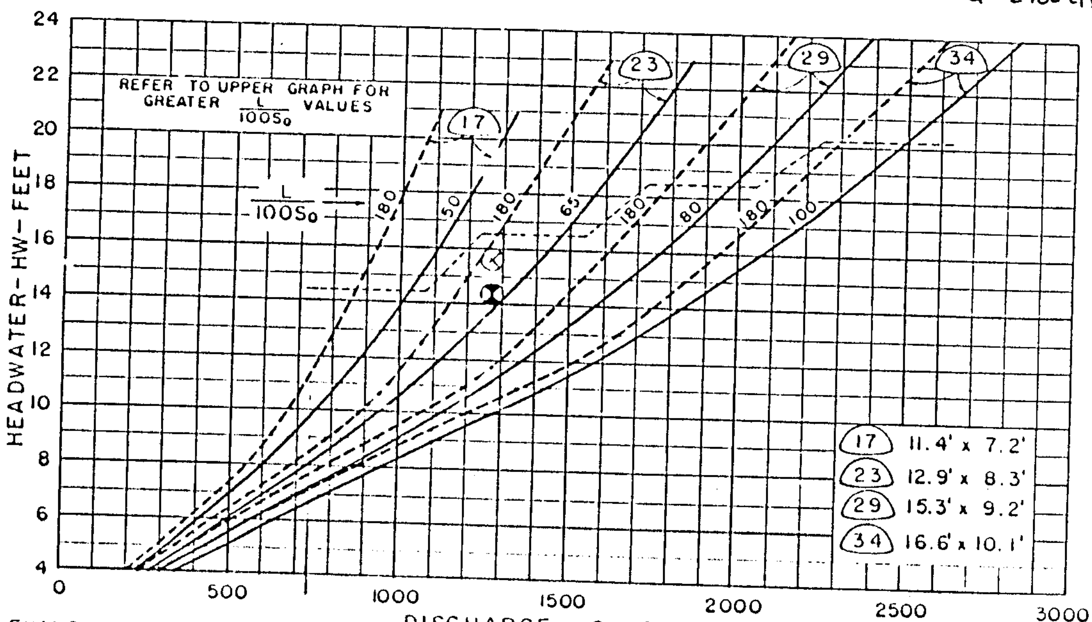

EXAMPLE

⊗ GIVEN
1270 CFS, AHW = 15.6 FT.
L = 126 FT, S = 0.013

SELECT No 23
12.9' x 8.3'
HW = 14.4 FT
(OR 12.7' x 8.1' HW = 15.3 FT)

BUREAU OF PUBLIC ROADS JAN 1963

CULVERT CAPACITY STRUCTURAL PLATE CORR. METAL PIPE-ARCH HEADWALL ENTRANCE 7.2' TO 10.1' RISE

Source: HEC-10

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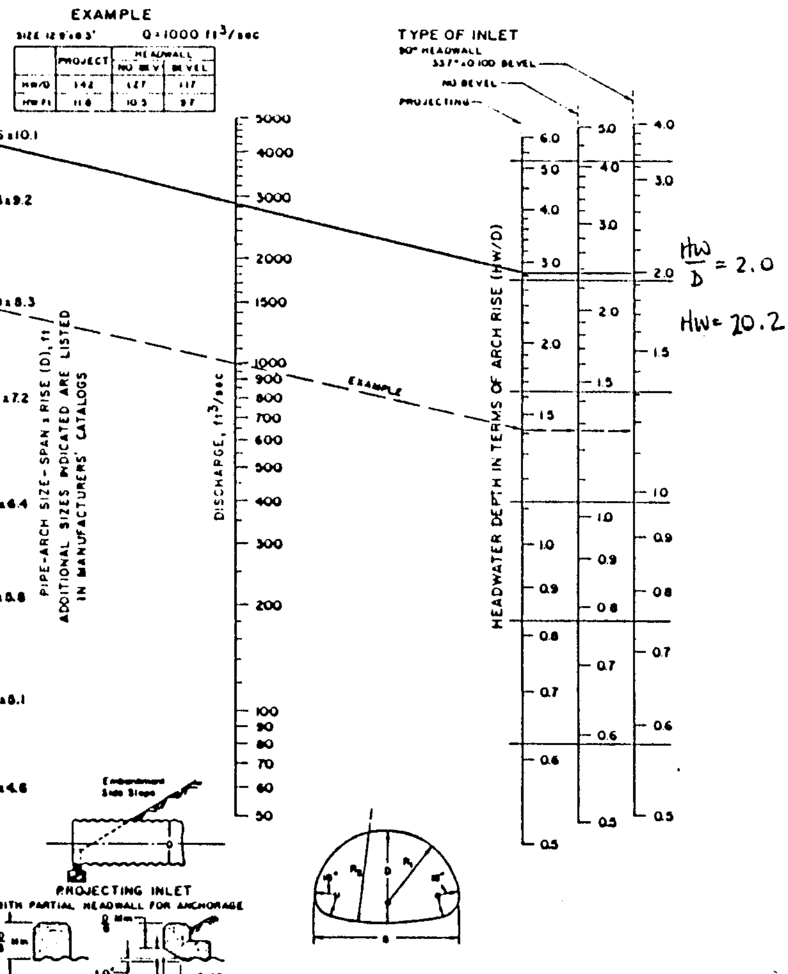

HEADWATER DEPTH FOR INLET CONTROL
STRUCTURAL PLATE PIPE-ARCH CULVERTS

18-IN. RADIUS CORNER PLATE
PROJECTING OR HEADWALL INLET
HEADWALL WITH OR WITHOUT EDGE BEVEL

BUREAU OF PUBLIC ROADS
OFFICE OF R&D JULY 1968

Source: AISI Handbook
3rd Edition (1983)

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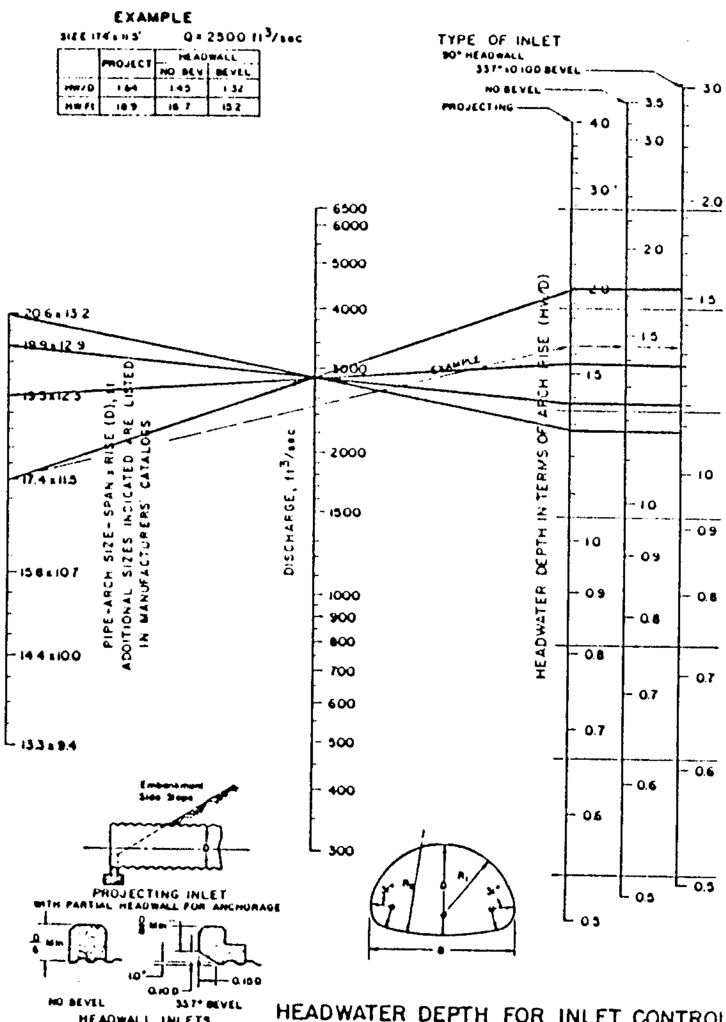


HEADWATER DEPTH FOR INLET CONTROL
STRUCTURAL PLATE PIPE-ARCH CULVERTS

31-IN. RADIUS CORNER PLATE.
PROJECTING OR HEADWALL INLET
HEADWALL WITH OR WITHOUT EDGE BEVEL

BUREAU OF PUBLIC ROADS
OFFICE OF R&D JULY 1968

Source: AISI (1983)

Table 4-17 Full-Flow Data for Corrugated Steel Pipe-Arches
Corrugations 6 × 2 in.
Corner Plates 15 pl Radius (Rc) = 31 in.

Span, ft-in.	Rise, ft-in.	Area, ft²	Hydraulic Radius, ft
13-3	9-4	97	2.68
13-6	9-6	102	2.74
14-0	9-8	105	2.78
14-2	9-10	109	2.83
14-5	10-0	114	2.90
14-11	10-2	118	2.94
15-4	10-4	123	2.98
15-7	10-6	127	3.04
15-10	10-8	132	3.10
16-3	10-10	137	3.14
16-6	11-0	142	3.20
17-0	11-2	146	3.24
17-2	11-4	151	3.30
17-5	11-6	157	3.36
17-11	11-8	161	3.40
18-1	11-10	167	3.45
18-7	12-0	172	3.50
18-9	12-2	177	3.56
19-3	12-4	182	3.59
19-6	12-6	188	3.65
19-8	12-8	194	3.71
19-11	12-10	200	3.77
20-5	13-0	205	3.81
20-7	13-2	211	3.87

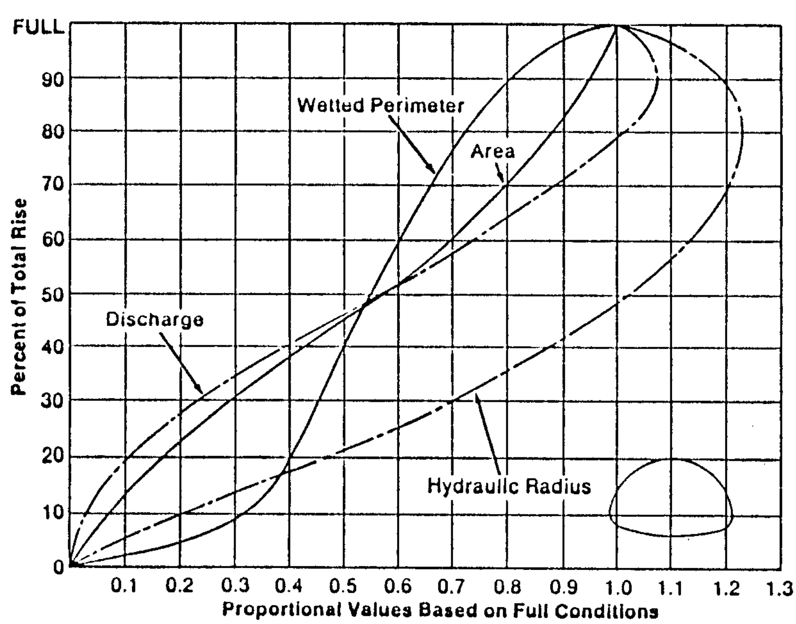


Figure 4-38 Hydraulic properties of corrugated steel and structural plate pipe-arches.

Source: AISI (1989)

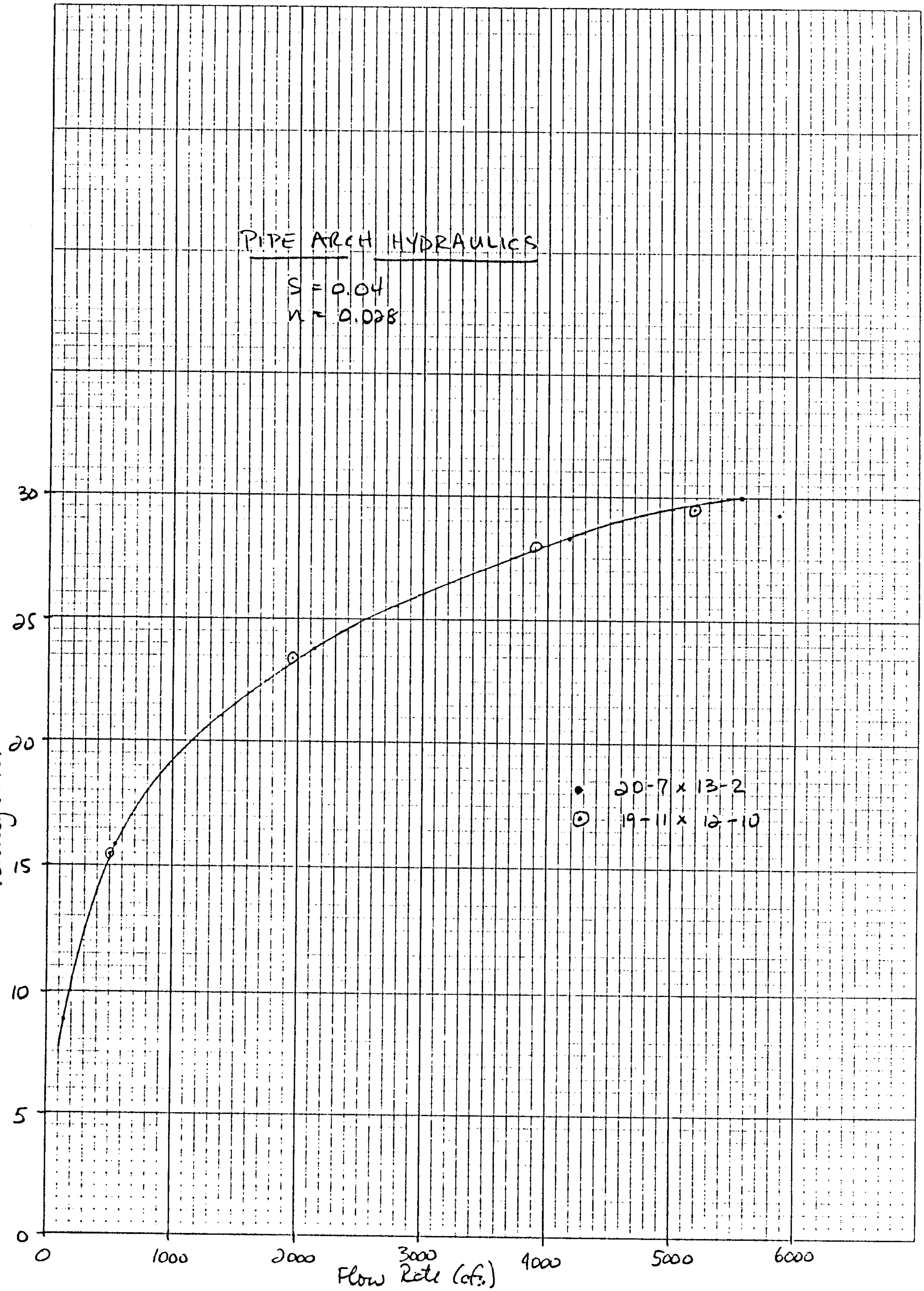
Percent of Rise	Depth of Flow (ft)	Area (ft²)[a]	Hydraulic Radius (ft)[a]	Velocity (ft/s)[b]	Flow Rate (cfs)[b]
20-7 × 13-2 PIPE ARCH					
10	1.3	12.9	0.77	8.9	115
20	2.6	34.0	1.82	15.8	538
40	5.3	89.1	3.37	23.9	2126
60	7.9	147.7	4.37	28.4	4190
80	10.5	185.7	4.76	30.0	5578
90	11.9	200.4	4.61	29.4	5892
100	13.2	211.0	3.87	26.2	5521
19-11 × 12-10 PIPE ARCH					
10	1.3	12.2	0.75	8.8	107
20	2.6	32.2	1.77	15.5	500
40	5.1	84.4	3.28	23.4	1978
60	7.7	140.0	4.26	27.9	3905
80	10.3	176.0	4.64	29.5	5197
90	11.6	190.0	4.49	28.9	5489
100	12.8	200.0	3.77	25.7	5142

(a) From Table 4-17 and Figure 4-38 on pg. 6 of this calc.
(b) From Manning's equation

Velocity at Q = 2900 cfs (see pg. 8 of this calc.):

20-7 × 13-2 ⟶ V = 25.8 ft/s
19-11 × 12-10 ⟶ V = 25.8 ft/s

} Energy dissipator req'd


PIPE ARCH HYDRAULICS
S = 0.04
n = 0.028
● 20-7 x 13-2
⊙ 19-11 x 12-10
Velocity (ft/s)
Flow Rate (cfs)
0
5
10
15
20
25
30
0
1000
2000
3000
4000
5000
6000

⑤ Steel box culvert (see AISI, 1983 and pg. 10 of this calc.). Determine stage-discharge relations for culverts indicated on pg. 10 of this calc. Assume corrugated steel floor.

Percent of Rise	Proportional Full $AR^{2/3}$ (a)	Flow Rate (cfs) (b)						
		7-11 x 18-7	8-5 x 17-8	8-7 x 20-9	8-11 x 16-10	9-1 x 19-9	9-6 x 18-10	10-2 x 20-9
10	0.05	137	140	176	142	181	184	232
20	0.15	411	421	529	425	543	552	697
40	0.42	1151	1179	1482	1191	1521	1544	1950
60	0.75	2055	2105	2647	2126	2716	2758	3483
80	1.01	2768	2834	3565	2863	3658	3714	4690
90	1.08	2960	3031	3812	3062	3911	3971	5015
100	1.00	2741	2806	3529	2835	3622	3677	4644
HW @ Q=2900 cfs (c)		6.9	7.0	5.6	7.2	5.8	5.9	5.2

(a) See Figure 4-46 on pg. 10 of this calc.
(b) Based on Manning's equation and $S = 0.04$, $n = 0.028$. Values for $AR^{2/3}$ under full conditions taken from Table 4-23 on pg. 10 of this calc.
(c) See pg. 11 of this calc.

Exit velocity calculations at Q = 2900 cfs

Culvert Size	HW (ft)	Percent of Rise	Proportional R	Actual $R^{2/3}$	Velocity (ft/s)
7-11 x 18-7	6.9	87	1.27	2.29	24.3
8-5 x 17-8	7.0	83	1.28	2.34	24.9
8-7 x 20-9	5.6	65	1.17	2.30	24.5
8-11 x 16-10	7.2	81	1.28	2.37	25.2
9-1 x 19-9	5.8	64	1.16	2.33	24.8
9-6 x 18-10	5.9	62	1.14	2.34	24.8
10-2 x 20-9	5.2	51	1.01	2.28	24.2

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Table 4-23 Hydraulic Data for Structural Plate Box Culverts

Rise × Span (D × B) ft-in.	Full Flow Data				Discharge — (Q), ft³/sec					
					Critical Depth					
	Area, ft²	WP, ft	R, ft	$AR^{2/3}$	0.4D	0.5D	0.6D	0.7D	0.8D	0.9D
2-7 × 9-8	20.8	21.9	0.95	20.1	58	81	106	134	166	207
2-11 × 12-6	31.1	27.9	1.12	33.5	93	129	169	213	264	334
3-5 × 15-3	43.8	33.8	1.29	51.9	138	193	254	323	405	540
3-6 × 11-6	34.5	26.9	1.28	40.7	111	154	202	255	316	393
3-11 × 14-2	48.2	32.7	1.47	62.3	163	226	297	376	467	598
3-11 × 18-0	59.1	39.7	1.49	77.0	207	288	379	483	619	824
4-2 × 10-7	36.4	25.9	1.40	45.6	127	172	227	288	359	448
4-6 × 13-2	51.2	31.7	1.61	70.5	178	251	330	419	520	650
4-6 × 16-10	64.4	38.6	1.67	90.6	223	315	418	533	670	898
4-7 × 20-8	77.6	45.6	1.70	110.7	291	409	542	701	903	1194
5-0 × 15-9	68.3	37.5	1.82	101.9	249	348	460	586	731	949
5-1 × 12-3	52.9	30.8	1.72	75.9	198	275	362	458	569	708
5-1 × 19-5	83.4	44.3	1.88	127.1	313	441	586	750	966	1291
5-6 × 14-9	71.0	36.5	1.94	110.6	270	383	502	636	790	992
5-7 × 18-3	88.0	43.2	2.04	141.5	335	473	628	802	1011	1359
6-1 × 17-2	91.4	42.1	2.17	153.2	367	505	668	852	1066	1399
6-2 × 20-8	110.6	48.8	2.27	190.9	459	644	853	1092	1406	1879
6-5 × 11-10	62.2	32.0	1.94	96.9	268	372	486	615	760	947
6-8 × 19-6	114.5	47.7	2.40	205.4	480	670	888	1135	1434	1931
6-10 × 14-2	83.3	37.5	2.22	141.8	356	495	648	825	1020	1270
7-4 × 16-5	106.5	43.0	2.48	195.1	462	644	854	1079	1341	1688
7-5 × 13-5	82.8	36.8	2.25	142.2	379	526	688	862	1063	1321
7-11 × 15-7	106.8	42.1	2.53	198.5	490	681	892	1116	1383	1727
★ 7-11 × 18-7	132.1	48.4	2.73	258.2	590	824	1092	1388	1735	2274
8-0 × 12-8	81.1	36.1	2.25	139.3	398	552	720	901	1103	1371
8-5 × 14-10	106.0	41.4	2.56	198.4	508	706	923	1161	1429	1774
★ 8-5 × 17-8	133.0	47.5	2.80	264.4	613	854	1120	1428	1776	2254
★ 8-7 × 20-9	160.3	53.7	2.99	332.5	748	1046	1378	1761	2224	2996
★ 8-11 × 16-10	132.9	46.6	2.85	267.1	634	883	1156	1470	1819	2276
★ 9-1 × 19-9	161.6	52.7	3.07	341.2	773	1079	1406	1790	2245	2973
★ 9-6 × 18-10	162.0	51.8	3.13	346.4	786	1096	1438	1834	2284	2936
★ 10-2 × 20-9	193.5	56.9	3.40	437.5	965	1348	1779	2263	2842	3792

Determine hydraulics for starred culvert.

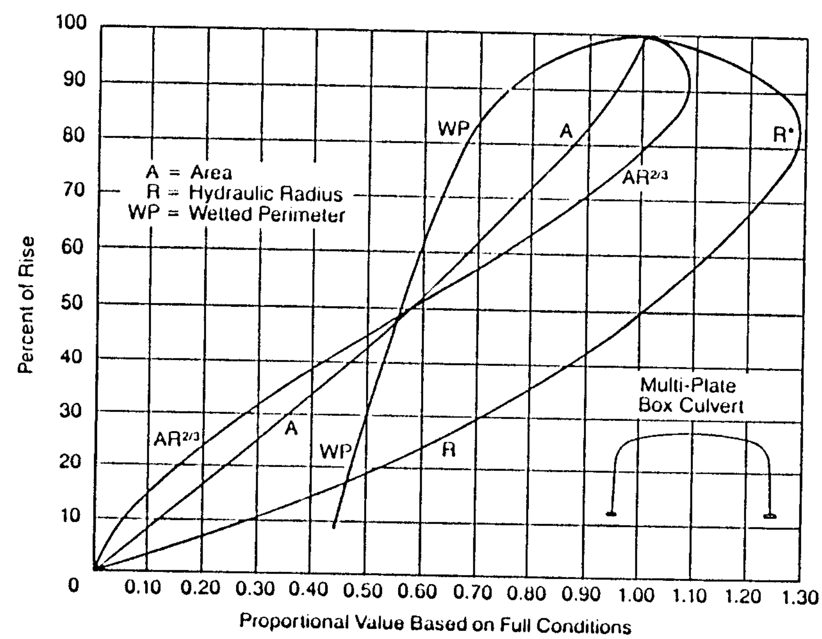
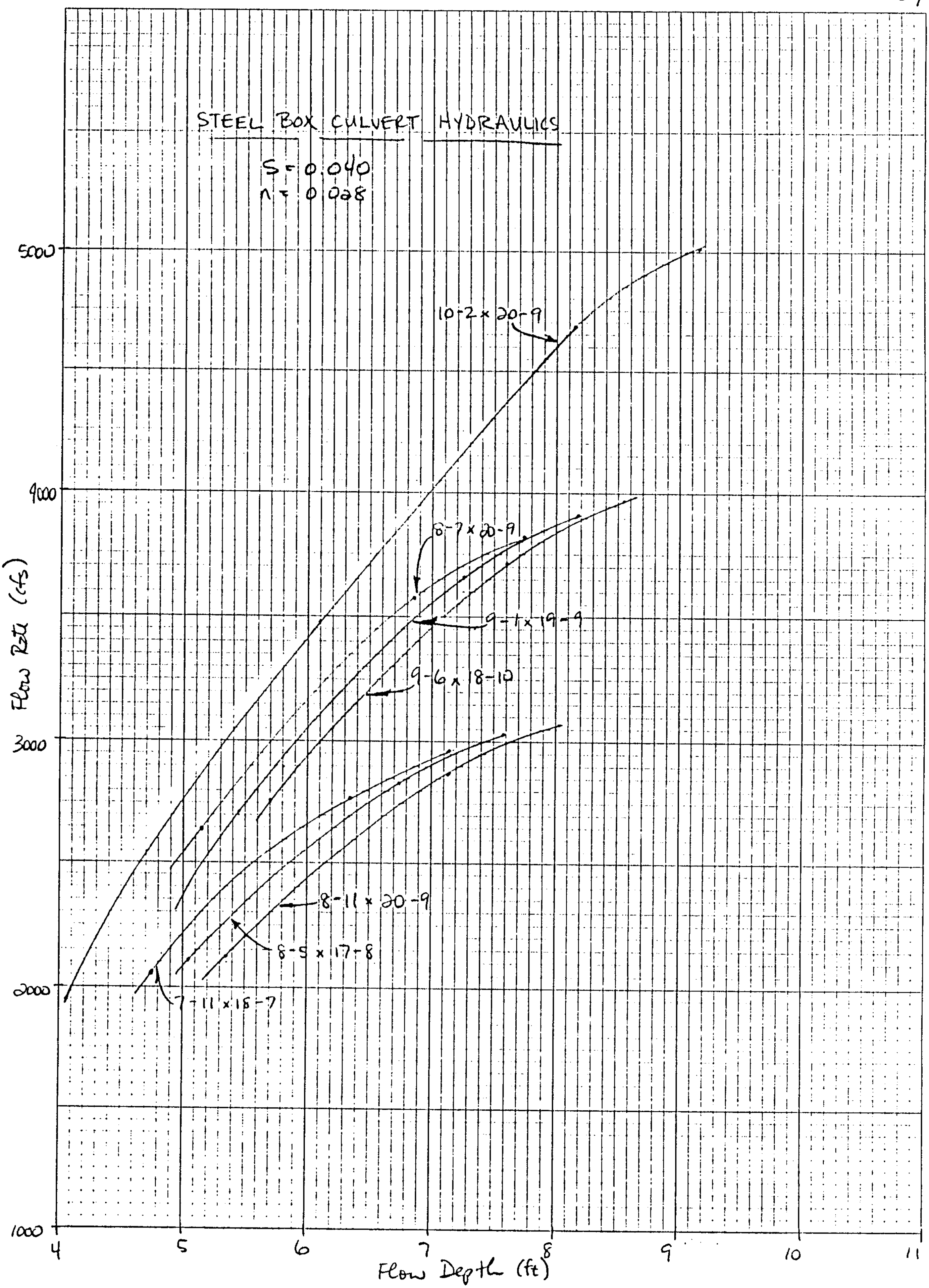


Figure 4-46 Hydraulic properties of structural plate box culverts.

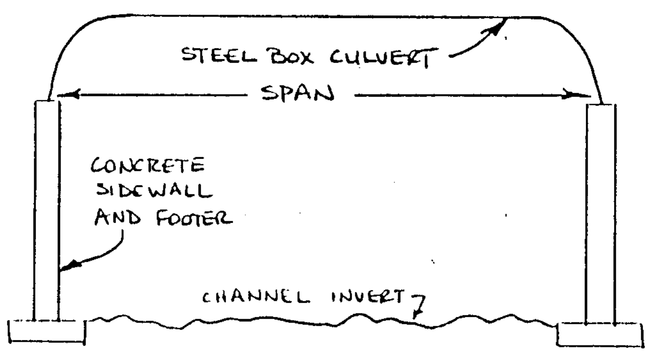
Source: AISI, 3rd ed, 1983


STEEL BOX CULVERT HYDRAULICS
S = 0.040
n = 0.028
10-2 x 20-9
8-7 x 20-9
9-1 x 19-9
9-6 x 18-10
8-11 x 20-9
8-5 x 17-8
7-11 x 18-7
5000
4000
3000
2000
1000
4
5
6
7
8
9
10
11
Flow Rate (cfs)
Flow Depth (ft)

⑥ Steel box culvert with natural channel invert and concrete footings. Assume all flow contained within concrete wall. Calculate barrel capacity then inlet requirements. Use Manning's equation, weighting the roughness coefficient between the channel bottom and the sides.

n_{bottom} = 0.048 (previous channel hydraulic estimate)

n_{sides} = 0.015 (typical concrete value).



Assume S = 0.04

Flow Depth (ft)	$\bar{n}$	Wetted Perimeter (ft)	Flow Area (ft²)	Hydraulic Radius (ft)	Velocity (ft/s)	Discharge (cfs)
— SPAN = 18'-0" — (Rise = 3'-11")						
1	0.045	20	18.0	0.90	6.2	111
2	0.042	22	36.0	1.64	9.8	354
4	0.038	26	72.0	2.77	15.4	1111
6	0.035	30	108.0	3.60	19.9	2154
8	0.032	34	144.0	4.24	24.3	3504
— SPAN = 16'-0" — (Rise = 3'-6")						
2	0.041	20	32.0	1.60	9.9	317
4	0.037	24	64.0	2.67	15.5	989
6	0.034	28	96.0	3.43	19.9	1909
8	0.032	32	128.0	4.00	23.4	2996

Flow Depth (ft)	n	Wetted Perimeter (ft)	Flow Area (ft²)	Hydraulic Radius (ft)	Velocity (ft/s)	Discharge (cfs)
— SPAN = 13'-11" — (Rise = 3'-2")						
2	0.041	17.9	27.8	1.56	9.8	271
4	0.036	21.9	55.7	2.54	15.4	856
6	0.033	25.9	83.5	3.22	19.6	1640
8	0.030	29.9	111.3	3.72	23.8	2647
10	0.029	33.9	139.2	4.10	26.3	3654

Stage - capacity curves → pg. 14 of this calc.

Stage - velocity curves → pg. 15 of this calc.

Flow depth and velocity at Q = 2900 cfs:

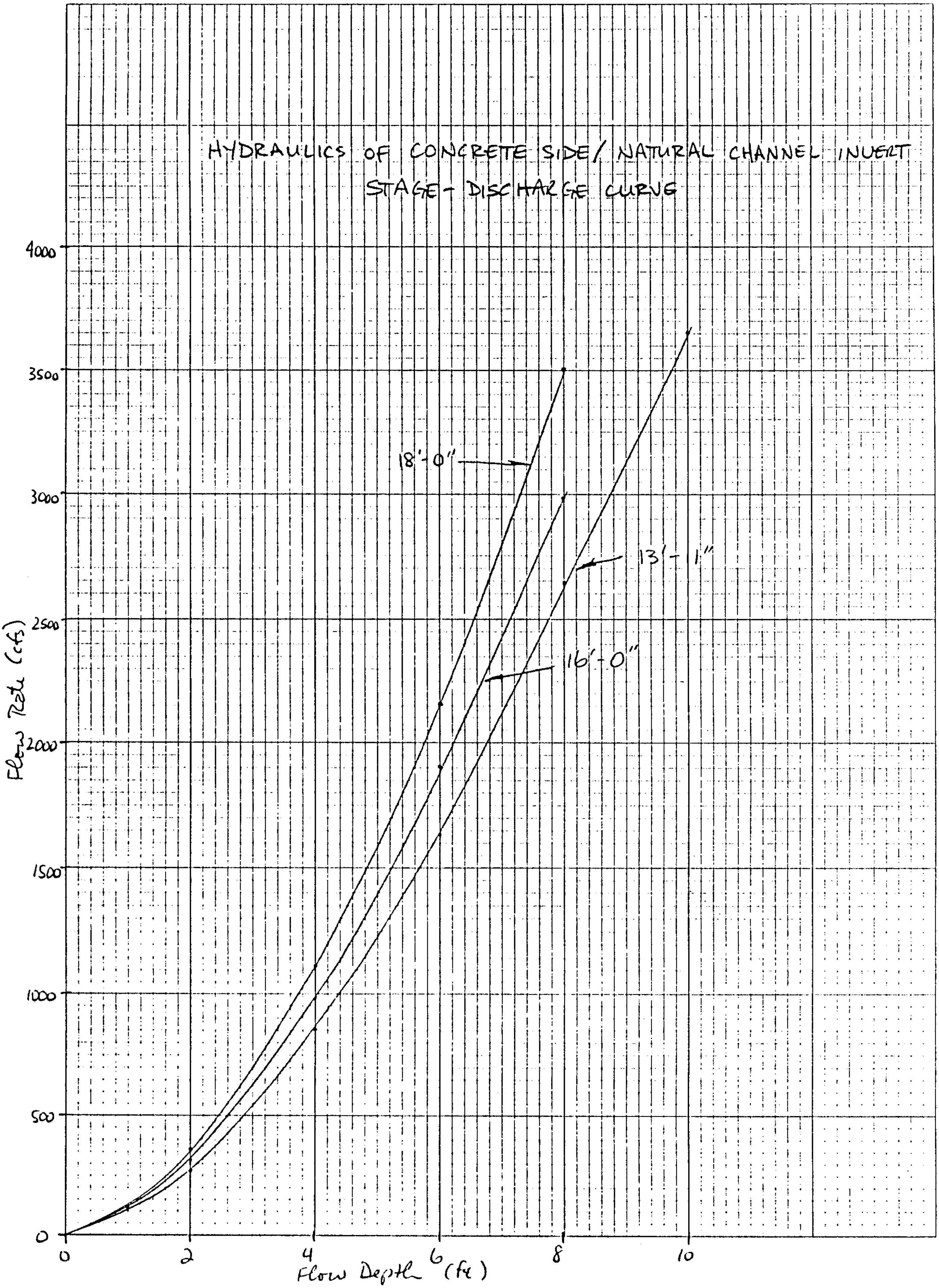
Box Span	Flow Depth (ft)	Velocity (ft/s)
18'-0"	6.6	21.3
16'-0"	6.9	22.0
13'-11"	7.3	22.8

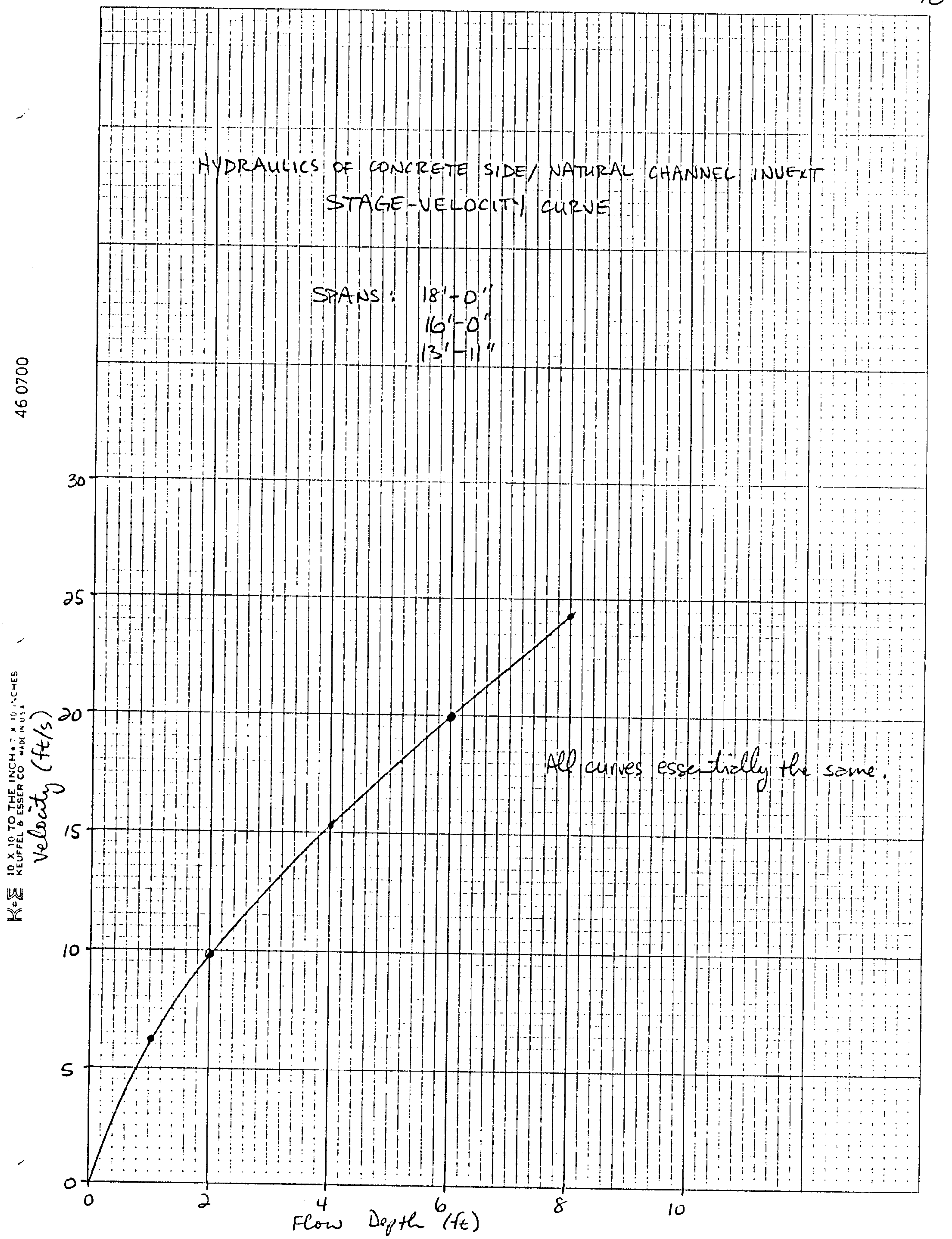
Economic Considerations

Cost data are provided on pg. 16 of this calc. for selected culverts. Costs were obtained from Big R Manufacturing (via Syro Steel):

Pipe Arch costs → 20'-7" x 13'-2" (7 ga.) - $350/ft
19'-11" x 12'-10" (8 ga.) - $314/ft
19'-3" x 12'-4" (8 ga.) - $299/ft
17'-5" x 11'-6" (8 ga.) - $282/ft
} Materials Costs

Steel Box Culverts → Typically twice the price of pipe arch culverts (generally $600 - $700/ft). Steel box culverts also have lower strength than pipe arch culverts and may not provide sufficient support in areas loaded by coal adjacent to the tipple.


HYDRAULICS OF CONCRETE SIDE/ NATURAL CHANNEL INVERT
STAGE - DISCHARGE CURVE
18'-0"
13'-1"
16'-0"
Flow Rate (cfs)
Flow Depth (ft)
0
500
1000
1500
2000
2500
3000
3500
4000
0
2
4
6
8
10


HYDRAULICS OF CONCRETE SIDE/ NATURAL CHANNEL INVERT
STAGE-VELOCITY CURVE
SPANS: 18'-0"
16'-0"
13'-11"
All curves essentially the same.
Velocity (ft/s)
30
25
20
15
10
5
0
0
2
4
6
8
10
Flow Depth (ft)
46 0700
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Conclusion → Utilize pipe arch culvert. Due to minimal excess headwater requirement and lower cost, use

19'-11" x 12'-10" ⇒ HW = 14.7 ft

Final Design – Inlet

Minimum crest dimensions of headwall → see pg. 5 of this calc.
Cutoff wall → see AISI (1983)

AISI (1983) recommends a minimum headwall height of D/8 over the crest of the culvert, where D = culvert rise (12'-10" or 12.83'). Thus,

$$\frac{D}{8} = \frac{12.83'}{8} = 1.60 \text{ ft}$$

Minimum headwall height = 12.83 ft + 1.60 ft
≈ 14.4 ft above top of bevel

Bevel → Angle = 33.7°
Drop = 0.10 D = 1.3 ft
Extension = 0.15 D = 1.9 ft
} See design recommendations on nomograph provided on pg. 5 of this calc.

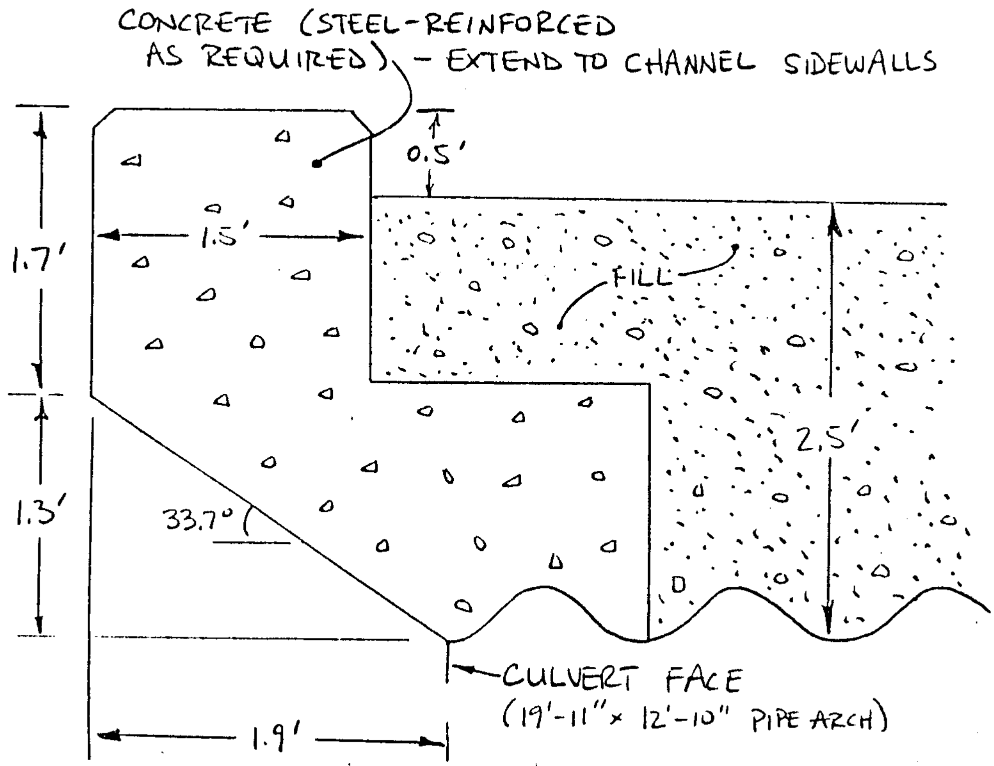
Minimum headwall height above channel invert:

12.8 ft (culvert) + 1.6 ft (headwall) + 1.3 ft (bevel) = 15.7 ft

Round this value to 16.0 ft for ease of construction. This provides a freeboard of 1.3 ft, which is considered adequate.

Minimum cover depth = 1/8 of span (see AISI, 1983)
= 19'-11" / 8
= 2.5 ft ⇒ provide this amount, resulting in a cover elevation of approx 15.5 ft above the channel invert.

Upper headwall and bevel detail → see pg. 17 of this calc.
Inlet cutoff wall detail → see pg. 18 of this calc.
Wingwall → not required since span approximates channel width (≈ 20')



UPPER HEADWALL AND BEVEL DETAIL

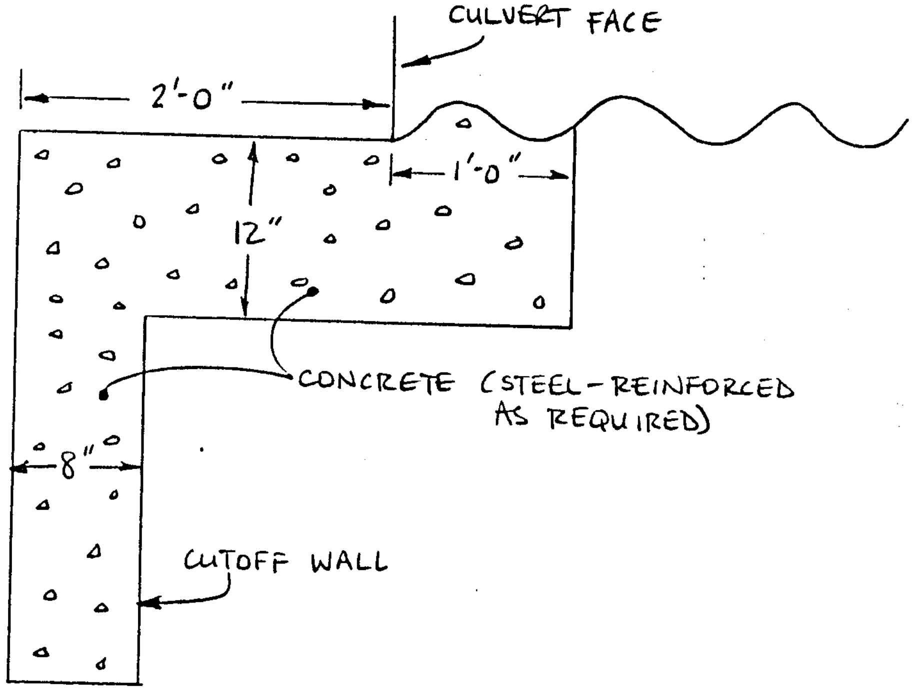
SCALE: 1"=1'

NOTES:

① Steel reinforcing to be determined following selection of fill and final determination of loads.

② Minimum cover of 2.5' to be maintained over culvert. If additional loads are anticipated during construction, it shall be the responsibility of the contractor to provide additional temporary cover.

③ Anchor culvert to headwall with hook bolts.



INLET CUTOFF WALL DETAIL
SCALE: 1" = 1'

NOTES:

① Steel reinforcing to be designed following selection of fill and final determination of loads.

② Dimensions shown are minima.

③ Anchor culvert to concrete with hook bolts.

Final Design – Outlet

Outlet velocity = 25.8 ft/s (see pg. 7 of this calc.)

Froude number at this velocity:

$$F_r = \frac{V}{\sqrt{gy}}$$

where V = velocity = 25.8 ft/s
g = acceleration due to gravity = 32.2 ft/s
y = flow depth = 6.2 ft (interpolation from data on pg. 7 of this calc.)

$$= \frac{25.8}{\sqrt{(32.2)(6.2)}}$$

$$= 1.8$$

Since $F_r < 3$, use the design procedures of HEC-14 (Corry et al, 1975).

Reduce the outlet velocity using roughness elements (section VII-C of HEC-14). Since the methodology presented in HEC-14 is strictly applicable only to box culverts and circular CMP culverts, the design approach will be modified by examining a circular CMP with the same end area as the proposed pipe arch culvert. Based on the similarity of the dimensionless area and hydraulic radius curves presented on the attached hydraulic elements graphs (pp 20 & 21 of this calc.), this modification is considered valid.

Proposed culvert ⟶ 19'-11" × 12'-10" pipe arch
A = 200 ft² } Full-flow data (see pg 20)
R = 3.77 ft

Equivalent CMP ⟶ 192" (16') CMP
A = 201.1 ft² } Full-flow data (see pg. 21)
R = 4.0 ft

Subsequent calculations will be based on the 16' diameter CMP culvert. Roughness elements will need to be field fitted to ensure conformance to the shape of the pipe-arch culvert.

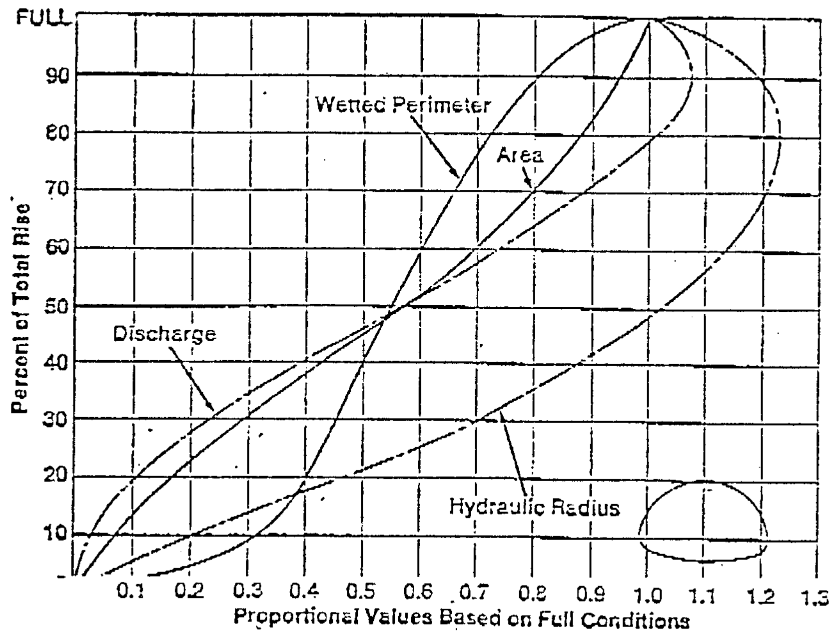


Figure 4-38 Hydraulic properties of corrugated steel and structural plate pipe-arches.

Table 4-17 Full-Flow Data for Corrugated Steel Pipe-Arches
Corrugations 6 × 2 in.
Corner Plates 15 pi **Radius (Rc) = 31 in.**

Span, ft-in.	Rise, ft-in.	Area, ft²	Hydraulic Radius, ft
13-3	9-4	97	2.68
13-6	9-6	102	2.74
14-0	9-8	105	2.78
14-2	9-10	109	2.83
14-5	10-0	114	2.90
14-11	10-2	118	2.94
15-4	10-4	123	2.98
15-7	10-6	127	3.04
15-10	10-8	132	3.10
16-3	10-10	137	3.14
16-6	11-0	142	3.20
17-0	11-2	146	3.24
17-2	11-4	151	3.30
17-5	11-6	157	3.36
17-11	11-8	161	3.40
18-1	11-10	167	3.45
18-7	12-0	172	3.50
18-9	12-2	177	3.56
19-3	12-4	182	3.59
19-6	12-6	188	3.65
19-8	12-8	194	3.71
19-11	12-10	200	3.77
20-5	13-0	205	3.81
20-7	13-2	211	3.87

Source: AISI, 1983

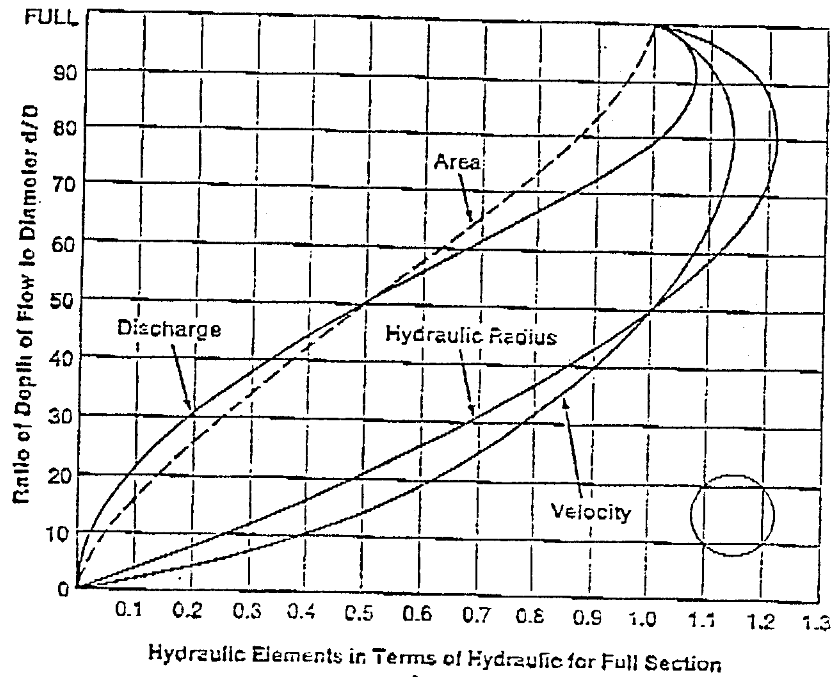


Figure 4-37 Hydraulic elements graph for circular corrugated steel pipe.

Table 4-14 Full Flow Data for Round Pipe

Diameter, in.	Area, ft^2	Hydraulic Radius, ft	Diameter, in.	Area, ft^2	Hydraulic Radius, ft
12	0.785	0.250	156	132.7	3.25
15	1.227	0.3125	162	143.1	3.375
18	1.767	0.375	168	153.9	3.5
21	2.405	0.437	174	165.1	3.625
24	3.142	0.50	180	176.7	3.75
30	4.909	0.625	186	188.7	3.875
36	7.069	0.75	192	201.1	4.0
42	9.621	0.875	198	213.8	4.125
48	12.566	1.0	204	227.0	4.25
54	15.904	1.125	210	240.5	4.375
60	19.635	1.25	216	254.5	4.5
66	23.758	1.375	222	268.8	4.625
72	28.27	1.5	228	283.5	4.75
78	33.18	1.625	234	298.6	4.875
84	38.49	1.75	240	314.2	5.0
90	44.18	1.875	246	330.1	5.125
96	50.27	2.0	252	346.4	5.25
108	63.62	2.25	258	363.1	5.375
114	70.88	2.375	264	380.1	5.5
120	78.54	2.5	270	397.6	5.625
126	86.59	2.625	276	415.5	5.75
132	95.03	2.75	282	433.7	5.875
138	103.87	2.875	288	452.4	6.0
144	113.10	3.00	294	471.4	6.125
150	122.7	3.125	300	490.9	6.25

Source: AISI, 1983

Design procedure:

- n (for smooth culvert) = 0.028; D = 16 ft (equivalent) } $n/D^{1/6} = 0.0176$

- Assume $L/D_i = 1.0$ (recommended in HEC-14)

- Assume $h/D_i = 0.08$ (between HEC-14 recommended values of 0.05 & 0.10)

- Flow regime → isolated roughness (value falls above the curve for $n/D^{1/6} = 0.0176$) – see pg. 23 of this calc.

- Roughess pipe resistence:

$$n_r = n_{IR} = n\,(D_i/D)^{1/6}\,[1 + 67.2\,C_D\,(L_r/P)\,(h/L)]^{1/2}$$

According to HEC-14, h/D should be between 0.06 and 0.09 (where h = roughness element height). For D = 16.0 ft, h = 1.0 ft to 1.4 ft. Use h = 1.25 ft (1'-3"). Under this configuration:

$h = 1.25$ ft

$D_i = 13.5$ ft

Other values required to solve the above equation:

$n = 0.028$

$D = 16.0$ ft

$C_D = 1.9$ (see HEC-14 — assumes sharp-edged elements)

L_r/P → Assume that a 2.0 ft gap exists in the bottom of the roughness elements (i.e., at the center of the culvert invert) to permit free drainage of the culvert, allow sediment to be washed out, and permit fish passage. Assume that roughess elements extend up the sides of the culvert to 75% of the culvert height. Based on these assumptions:

$L_r = (A/R)_{0.75} - 2.0$ ← bottom gap

$= [(201.1)(0.82)/(4.0)(1.21)] - 2.0$

$= 32.1$ ft

} See hydraulic elements graph on pg. 21

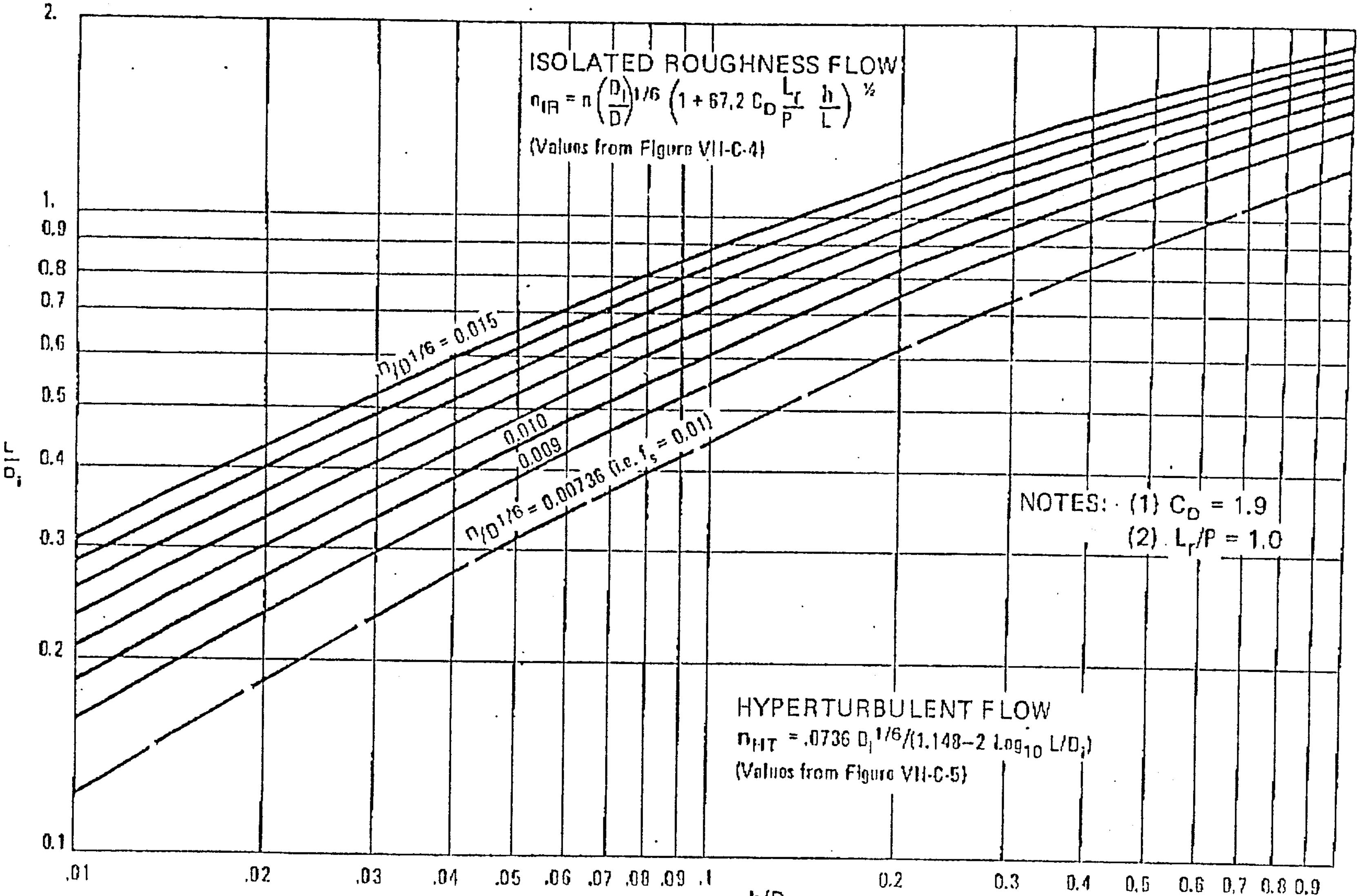


Figure VII-C-6 FLOW REGIME BOUNDARY CURVES

Source: HEC-14

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$P = (A/R)_{full}$
$= 201.1/4.0$
$= 50.3$ ft

See hydraulic elements graph on pg. 21

$L_r/P = 32.1/50.3$
$= 0.64$

$L = D_i = 13.5$ ft

$n_r = n_{IR} = (0.028)(13.5/16.0)^{1/6}\,[1 + (67.2)(1.9)(0.64)(1.25/13.5)]^{1/2}$
$= 0.080$

- $D_i = 13.5$ ft
- Modified full-flow discharge and velocity:

$Q_{full} = (0.46/n_r) D_i^{8/3} S_0^{1/2}$ $(S_0 = 0.04)$
$= (0.46/0.080)(13.5^{8/3})(0.04^{1/2})$
$= 1188$ cfs < 2900 cfs (design flow). Reduce h & L_r. Recalculate roughness pipe resistence.

- Recalculate roughness pipe resistence:

Assume $h = 1.0$ ft
$D_i = 14.0$ ft
Elements extend to 60% of full depth:
$L_r = (A/R)_{0.60} - 2.0$
$= [(201.1)(0.67)/(4.0)(1.12)] - 2.0$
$= 28.1$ ft

All other factors remain unchanged

$n_r = n_{IR} = (0.028)(14.0/16.0)^{1/6}\,[1 + (67.2)(1.9)(28.1/50.3)(1.0/14.0)]^{1/2}$
$= 0.068$

- Modified full-flow discharge and velocity:

$$Q_{full} = (0.46/0.068)(14.0^{8/3})(0.04^{1/2})$$
$$= 1540 \text{ cfs} < 2900 \text{ cfs} \quad \text{— redo}$$

- Recalculate resistance:

Assume elements extend to 30% of full depth:

$$L_r = (A/R)_{0.30} - 2.0$$
$$= [(201.1)(0.25)/(4.0)(0.68)] - 2.0$$
$$= 16.5 \text{ ft}$$

All other factors remain unchanged,

$$n_r = n_{IR} = (0.028)(14.0/16.0)^{1/4}\,[1 + (67.2)(1.9)(16.5/50.3)(1.0/14.0)]^{1/2}$$
$$= 0.055$$

- Modified flow:

$$Q_{full} = (0.46/0.055)(14.0^{8/3})(0.04^{1/2})$$
$$= 1904 \text{ cfs} < 2900 \text{ cfs} \quad \text{— redo}$$

- Recalculate resistance:

Assume elements extend to 10% of full depth:

$$L_r = (A/R)_{0.10} - 2.0$$
$$= [(201.1)(0.05)/(4.0)(0.25)] - 2.0$$
$$= 8.1 \text{ ft}$$

$$n_r = n_{IR} = (0.028)(14.0/16.0)^{1/4}\,[1 + (67.2)(1.9)(8.1/50.3)(1.0/14.0)]^{1/2}$$
$$= 0.043$$

- Modified flow:

$$Q_{full} = (0.46/0.043)(14.0^{8/3})(0.04^{1/2})$$
$$= 2436 \text{ cfs} < 2900 \text{ cfs} \quad \text{— redo}$$

- Recalculate resistance:

Assume gap at bottom is increased to 8.0 ft and elements extend to 20% of full depth.

$$L_r = (A/R)_{0.20} - 8.0$$
$$= [(201.1)(0.14)/(4.0)(0.49)] - 8.0$$
$$= 6.4 \text{ ft}$$

$$n_r = n_{IR} = (0.028)(14.0/16.0)^{1/6}[1+(67.2)(1.9)(6.4/50.3)(1.0/14.0)]^{1/2}$$
$$= 0.040$$

- Modified flow:

$$Q_{full} = (0.46/0.040)(14.0^{8/3})(0.04^{1/2})$$
$$= 2619 \text{ cfs}$$

- Recalculate resistance:

Assume gap at bottom is increased to 10.0 ft.

$$L_r = (6.4 \text{ ft} + 8.0 \text{ ft}) - 10.0 \text{ ft} = 4.4 \text{ ft}$$

$$n_r = n_{IR} = (0.028)(14.0/16.0)^{1/6}[1+(67.2)(1.9)(4.4/50.3)(1.0/14.0)]^{1/2}$$
$$= 0.037$$

- Modified flow:

$$Q_{full} = (0.46/0.037)(14.0^{8/3})(0.04^{1/2})$$

= 2831 cfs. Since the full flow discharge is only slightly less than the maximum capable discharge (see pg 21), these conditions are assumed adequate.

$$V_{full} = (0.59/n_r)\, D_i^{2/3}\, S_0^{1/2}$$
$$= (0.59/0.037)(14.0^{2/3})(0.04^{1/2})$$
$$= 18.5 \text{ ft/s}$$

- Design flow = 2900 cfs $\Rightarrow$ $Q_{Design}/Q_{Full} = 2900/2831$

$$= 1.02$$

From the hydraulic elements graph (pg. 21):

For $Q_D/Q_F = 1.02$, $V_D/V_F = 1.13$ ($d/D_i = 0.80$)

$V_{Design} = (1.13)(18.5)$

$= 20.9$ ft/s

- Required downstream riprap:

$d/D_i = 0.80 \implies d = (0.80)(14.0) = 11.2$ ft

Based on nomographs presented on pp. 28 and 29A of this calc.:

Assume $d_{50} = 1.0$ ft

$\frac{d_{50}}{d_f} = \frac{1.0}{11.2} = 0.09 \implies \frac{V_s}{V} = 0.50$

$V_s = (0.50)(20.9) = 10.4$ ft/s

$d_{50} = 0.71$ ft (channel bottom)
$= 0.94$ ft (2:1 side)
$= 1.25$ ft ($1\frac{1}{4}$:1 side)

Assume $d_{50} = 0.9$ ft

$\frac{d_{50}}{d_f} = \frac{0.9}{11.2} = 0.08 \implies \frac{V_s}{V} = 0.48$

$V_s = (0.48)(20.9) = 10.0$ ft/s

$d_{50} = 0.65$ ft (bottom)
$= 0.88$ ft (2:1 side) → OK

$d_{50} = 0.9$ ft (on 2:1 side)

Assume $d_{50} = 0.5$ ft

$\frac{d_{50}}{d_f} = \frac{0.5}{11.2} = 0.04$

$V_s = (0.42)(20.9) = 8.8$ ft/s

$d_{50} = 0.5$ ft (bottom) → OK

Assume $d_{50} = 1.5$ ft

$\frac{d_{50}}{d_f} = \frac{1.7}{11.2} = 0.13 \Rightarrow \frac{V_s}{V} = 0.54$

$V_s = (0.54)(20.9) = 11.3$ ft/s

$d_{50} = 1.5$ ft OK

$d_{50} = 1.5$ ft (on $1\frac{1}{4}$:1 side)