CHAPTER 5

ENGINEERING

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Refer to Record No. 0086
in C00170039, 2006, Incoming
for additional information

The county road ends at the BLM/State property boundary, which is located approximately 300 feet northeast of the southwest edge of the proposed disturbed area boundary (i.e., near the upstream edge of the sedimentation pond). Those operations to be conducted within 100 feet of the county road include construction and operation of the sedimentation pond with its associated inflow and outflow structures, construction and operation of the downstream end of culvert UC-6 with its associated energy dissipator, construction and operation of sewer pipeline and storage of materials, snow, or equipment. The owner of the land in this area is the United States of America, as administered by the U.S. Bureau of Land Management. The interests of the public and the landowner will be protected by:

- Complying with the requirements of the BLM land lease.
- Conducting the mining and reclamation operations in compliance with the permit issued by the State of Utah.
- Maintaining a guardrail along the south edge of the road at the outlet of culvert UC-6 and the energy dissipator, whose height will be equal to at least the axle height of the vehicles which frequent the road.
- Maintaining a guardrail along the north edge of the road adjacent to the sedimentation pond, whose height will be equal to at least the axle height of the vehicles which frequent the road.

Plates 4-1 and 5-2 depict the location of an existing UP&L distribution line that will be improved and activated to provide electrical service to the mine. It is unknown when the original distribution line was initially constructed. This line will be upgraded as necessary to provide power to the mine. Generally, all support facilities will be located within or in close proximity to the associated operations areas. It is currently anticipated that mine support buildings will generally be steel-frame buildings with concrete floors, spread footings, or slab foundations, with metal exterior walls. Buildings of this design have been used extensively in the region and allow for ease of erection, long-term structural integrity, and minimal maintenance.

current location with an approximate grade of 10 to 14%. The primary water tank access road and the ancillary survey-monument access road will be graded and maintained as a dirt road.

Drainageway Alterations. Alterations of Dugout Creek are planned to accommodate the needs of transportation systems. These alterations consist of installation of culverts in two locations - one on the eastern tributary of Dugout Creek and one along Dugout Creek, beginning approximately 150 feet upstream from the confluence with the eastern tributary and extending downstream to near the sedimentation pond (culverts UC-5 and UC-6, respectively, as noted on Plate 7-5). Pace Creek will not be impacted by the Pace Canyon Fan Portal Site.

Culverts UC-5 and UC-6 provide several advantages, including: allowing coal haulage trucks to enter and leave the surface facilities area, protecting Dugout Creek from coal fines and sediment which may be generated on the adjacent disturbed areas, providing space for equipment and material storage, providing a location for snow to be stacked away from the operations area during winter months, providing additional parking space, and increasing the safety of vehicular traffic by eliminating the drop off into the channel area. These advantages are discussed in further detail below.

Coal haulage trucks will enter and leave the surface facilities area in the loop shown on Plate 5-2 immediately upstream from the sedimentation pond. Culverting of the stream allows a sufficient turning angle for the coal trucks to access and safely maneuver in this area.

The surface facilities at the Dugout Canyon Mine have been designed to adequately control sediment which is generated from those facilities. However, as indicated in Section 521.100 and Plate 5-4 of this M&RP, past mining at the site has resulted in previous disturbance of the surface area. As a result, several areas along the banks of Dugout Creek which may otherwise had not been disturbed by SCM (if the Dugout Creek culvert was not installed) contain overcast, disturbed soils which would have continued to erode into Dugout Creek (see, particularly, the area of "OB" soils noted on Plate 2-2). Culverting of the creek protects it from this sediment as well as from wind-blown coal fines which could otherwise be transported to the stream throughout its length within the disturbed area.

- 0.5 acre immediately northeast of the office/bath house building;
- 0.1 acre in the storage area on the north side of the substation access road; and
- 0.2 acre adjacent to the fan portal.

Given the relatively small area of the Dugout Canyon surface facilities, and with space at a premium, installation of the Dugout Creek culvert is an important part of providing the storage and parking space that will be needed at the mine.

A final advantage of installing the Dugout Creek culvert throughout the disturbed area is the improved safety for surface operations that the culvert affords. In several areas of the site, the embankments into the stream have been over steepened by past activities, with vertical slopes present in selected areas where deep down cutting has occurred from past blockage of an old culvert at the site. Installation of the Dugout Creek culvert has eliminated the safety hazard associated with most of these steep slopes.

R645-301-358.400 requires that coal mining and reclamation operations be conducted in a manner that "will avoid disturbance to, enhance where practicable, restore, *or* replace, wetlands and riparian vegetation along rivers and streams . . ." (emphasis added). Installation of culverts UC-5 and UC-6 can unfortunately not be accomplished in a manner that will avoid disturbance to the riparian vegetation along Dugout Creek. However, as noted in Section 322.200 of this M&RP, the lost riparian vegetation will be replaced within the Dugout Creek watershed during the operational period at a ratio of three feet of replacement for every one foot of lost vegetation. This action will also immediately enhance the riparian vegetation in the areas where the mitigation is implemented.

Furthermore, during reclamation of the site, the riparian vegetation within the disturbed area will be both enhanced and restored. Enhancement of the riparian vegetation will be facilitated through the construction of reclaimed Dugout Creek channels which, as indicated in Section 762.100 of this M&RP, have been specifically designed to improve the geomorphological stability of the stream. By increasing this stability, the riparian vegetation will be enhanced and restored along the stream to a condition

which more closely mimics that which probably existed prior to disturbance of the site. Hence, through installation of culverts UC-5 and UC-6, the requirements of R645-301-358.400 will be met by immediately replacing and enhancing riparian vegetation in the Dugout Canyon watershed, and by ultimately (upon reclamation) restoring the riparian vegetation within the disturbed area. The enhancement, restoration, and replacement activities will result in an improvement of the riparian system to a condition which greatly exceeds that which is present prior to installation of the culverts.

Information regarding the design of these culverts is presented in Section 732.300 of this M&RP. Prior to installation of the culverts on Dugout Creek, silt fences were emplaced in the stream channel perpendicular to the flow direction in accordance with Figure 5-4. A minimum of four such silt fences were installed in the creek downstream from the county culvert outlet but within the disturbed area. The downstream-most silt fence was installed in the stream at the downstream end of the disturbed-area boundary, downstream from the location of the county culvert. The silt fences were located in an area convenient for maintenance and cleanout. The silt fences were removed after completion of all initial site construction activities. During culvert installation, the silt fences were periodically inspected and accumulated sediment removed from behind the silt fences when required to minimize downstream impacts.

No bridges are currently planned for the site.

Road Maintenance. The road which will access the disturbed area will be owned and maintained by Carbon County. SCM will pay a toll for use of the road, with this toll being used by the County for repayment of upgrade costs and maintenance. In the event of a catastrophic event that causes damage to the county road, SCM will cooperate with the County to promote rapid repair of the road as soon as practical following the catastrophic damage. For all primary roads within the permit area that are not owned by the county, SCM will itself repair the road (or cause it to be repaired) as soon as practical following the catastrophic damage.

The roads within the surface-facilities area will be maintained by SCM as necessary to permit access to the respective facilities. The remaining roads in the permit area are private roads and will be

creek downstream from the by-pass culvert (UC-6) outlet but within the disturbed area prior to removal of the culvert. The downstream-most silt fence will be installed in the stream at the downstream end of the disturbed-area boundary, downstream from the location of the energy dissipater. The silt fences will be located in an area convenient for maintenance and cleanout. The silt fences will be removed when reclamation construction activities are completed. During reclamation activities, the silt fences will be periodically inspected and accumulated sediment will be removed from behind the silt fences when required to minimize downstream impacts.

The sedimentation pond and sediment trap in Pace Canyon will be retained for as long as practical during reclamation. Once backfilling and grading operations proceed to the location of the pond, it will be removed. Because the pond is designed primarily as an excavated structure, removal of the pond will consist primarily of backfilling. This removal will be accomplished using backhoes, loaders, dozers, and other appropriate earthmoving equipment.

As soon as regrading of an area no longer allows that area to drain to the sedimentation pond or sediment trap, silt fences will be installed along the base of the slopes adjacent to Dugout Creek and Pace Creek and its tributaries to control erosion on an interim basis prior to revegetation success. These silt fences will be installed using a supportive backing and burying the toe of the filter fabric as noted in Figure 5-4.

On a temporary basis, straw-bale dikes may also be installed as necessary to control localized erosion prior to the establishment of revegetation efforts. If installed, locations of the straw-bale dikes will be selected to reduce sediment contributions to runoff based on field observations. Straw-bale dikes will be installed by keying the bales into the ground as noted in Figure 5-4.

542.300 Final Surface Configuration Maps and Cross Sections

Final surface configuration maps and cross sections for the Dugout Canyon site are provided on Plates 5-5 and 5-6, respectively. The final surface configuration map and cross sections for the Pace Canyon Fan Portal Site can be found on Plate PC5-5 in Appendix 5-10. Roads which access the

CHAPTER 7

HYDROLOGY

Potential Hydrocarbon Contamination. Diesel fuel, oils, greases, and other hydrocarbon products will be stored and used at the site for a variety of purposes. Diesel and oil stored in above-ground tanks at the mine surface facilities may spill onto the ground during filling of the storage tank, leakage of the storage tank, or filling of vehicle tanks. Similarly, greases and other oils may be spilled during use in surface and underground operations.

The probable future extent of the contamination caused by diesel and oil spillage is expected to be small for three reasons. First, because the tanks will be located above ground, leakage from the tanks will be readily detected and repaired. Second, spillage during filling of the storage or vehicle tanks will be minimized to avoid loss of an economically valuable product.

Finally, the Spill Prevention Control and Countermeasure Plan which will be developed for the site will provide inspection, training, and operation measures to minimize the extent of contamination resulting from the use of hydrocarbons at the site. This plan is not required to be submitted. However, a copy will be maintained at the mine site as required by the Utah Division of Water Quality.

Road Salting. When necessary for safety purposes, salt and/or ice melting compounds will be used on paved road areas. The paved road areas report to the sediment pond for treatment.

Coal Haulage. Coal will be hauled over the county road from the mine portal area to the Soldier Creek Road and thence to its ultimate destination. In the event of an accident which causes coal to spill from the trucks, residual coal following cleanup of the spill may wash into local streams during a runoff event. Possible impacts to the surface water are increased total suspended solids concentrations and turbidity from the fine coal particulates. The probability of a spill occurring in an area sufficiently close to a stream channel to introduce coal to the stream bed is considered small.

In addition to spills, wind may carry coal dust or small pieces of coal from the open top of the coal trucks into creeks near the roads. The impact from fugitive coal dust is considered to be insignificant due to the small amounts lost during haulage in the permit and adjacent areas.

Water Replacement. The water consumed in operating underground equipment, dust suppression, and evaporation is obtained from ground water sources. These underground water sources are not connected to the surface waters in the area. Research has been performed by the mine to verify that water currently entering the mine is not coming from the surface or depleting surface waters. Continued monitoring by the mine of the surface waters and seeps and springs flows in the permit and adjacent areas have shown no discernable impacts due to mining activities. It is the operator's position that the water consumed in operating Dugout Canyon Mine is not depleting surface water sources. In fact, there is an overall net gain to local river systems discharging to the Colorado River as a result of the mine's discharge.

The Permittee will replace the water supply of any land owner if such a water supply proves to be contaminated, diminished or interrupted as a result of the mining operations. First, a determination will be made by the Division in accordance with R645 - 301- 731.800 as to whether or not material damage has occurred. Then, in accordance with Regulation R645-301-525.510, Dugout Canyon Mine will correct any material damage resulting from subsidence caused to surface lands (which includes water rights), to the extent technologically and economically feasible, by restoring the land to a condition capable of maintaining the value and reasonably foreseeable uses that it was capable of supporting before subsidence damage. Negotiations will be held with the water right holders to determine the best plan of action and implementation of water replacement.

729 Cumulative Hydrologic Impact Assessment (CHIA)

A Cumulative Hydrologic Impact Assessment to include the permit and adjacent areas is to be prepared by the Division.

730 OPERATION PLAN

731 General Requirements

This permit application includes an operation plan which addresses the following:

- Groundwater and Surface Water Protection and Monitoring Plan;
- Design Criteria and Plans;
- Performance Standards; and
- Reclamation Plan.

731.100 Hydrologic-Balance Protection

Groundwater Protection. To protect the hydrologic balance, coal mining and reclamation operations will be conducted to handle earth materials and runoff in a manner that minimizes acidic, toxic, or other harmful infiltration to the groundwater system. Additionally, the permittee will manage excavations and disturbances to prevent or control discharges of pollutants to the groundwater.

As indicated in Section 728.300, it is anticipated that an average of approximately 190 gallons per minute of groundwater encountered in the mine will eventually be discharged to Dugout Creek or Pace Creek. This water will be discharged in a controlled manner, in accordance with an approved UPDES permit, via a pipeline from the mine to the creek. The Dugout Creek discharge point is anticipated to be located at the upstream inlet to the Dugout Canyon culvert, UC-6. If the discharge occurs to a point outside of the culvert, riprap will be placed at the outlet of the pipe to prevent erosion. The Pace Creek discharge point will be located southeast of the fan shaft. The pipe will discharge directly to the

- Allowing all upstream runoff in Dugout Creek to bypass the disturbed area through the use of culverts;
- Routing runoff from the adjacent undisturbed areas above the facilities through culverts and diversion ditches where feasible to bypass the disturbed area; and
- Routing any runoff from undisturbed areas which enters the disturbed area into the sediment control system.

The location of each diversion ditch or culvert for the main facility area is presented on Plate 7-5 or in Addendum A to Appendix 7-9. Details regarding design of the diversions are presented in Appendix 7-9. A brief list of the proposed diversion structures follows (refer to Plates 7-6 through 7-8 for the location of each watershed boundary):

Diversion Ditches:

- Interception ditch UD-1 along the southeast border of the disturbed area will collects runoff from adjacent undisturbed watersheds and direct the runoff into Dugout Creek.
- Disturbed drainage ditches DD-1a through DD-3care located within the main portion of the facility pad, directing disturbed-area runoff from this pad toward the sedimentation pond.
- Disturbed drainage ditch DD-3a through DD-3c are located along the north edge of the road that accesses the large and small substation pads. Runoff from ditches DD-3a through DD-3c is conveyed to the sedimentation pond via culvert DC-5 and ditches DD-2a through DD-2d.
- Disturbed drainage ditches DD-4 through DD-7 are located along the west side of the water-tank access road. These ditches convey runoff from the water tank access road to culverts DC-7 through DC-9. Culverts DC-8 and DC-9 discharge to the slope above Dugout Creek because crests in the road prevent runoff from reaching the sedimentation pond. Ditch DD-4 and Culvert DC-7 also discharge to the slope above Dugout Creek. Although runoff in DD-4 could reach the sediment pond it has been diverted because the runoff was creating large puddles and mud holes in front of the principle access portal. Alternate sediment control is provided for discharge from these ditches and culverts (see Section 742.200 of this M&RP).

Diversion Culverts:

- Culvert DC-4is located along the northwest portion of the main facility pad. This culvert conveys runoff from DD-2e to DD-2d and to the sedimentation pond.

- Culvert DC-6 will convey runoff from the portal pad via a drop inlet to the lower facility pad. This runoff will ultimately discharge to the sedimentation pond via ditches DD-9 and DD-2 and culvert DC-5.
- Culvert DC-1 will convey water from ditches located on the south side of the facility pad to the sedimentation pond.
- Culvert DC-5 will convey water from the substation access road into ditch DD-2 and then to the sedimentation pond. A drop inlet is used on this culvert.
- Culverts DC-7 DC-8 and DC-9 are located along the water-tank access road, conveying runoff from the roadside ditches to Dugout Creek. Because of the presence of the crest in the road between the facility pad and these culverts, this runoff cannot be conveyed to the sedimentation pond. Hence, alternate sediment control has been provided as noted in Section 742.200 of this M&RP.
- Culverts DC-2 and DC-3 convey runoff from the parking area and truck loop to ditches DD-2b and DD-2c respectively. Both culverts have drop inlets.
- Culverts UC-1 through UC-4convey undisturbed-area runoff from undisturbed watersheds to the Dugout Creek bypass culvert (UC-6). Culvert UC-4 conveys undisturbed-area runoff from ditch UD-1 to the Dugout Creek culvert (UC-6).
- Culvert UC-5 is located on the eastern tributary of Dugout Creek. Containing this tributary in a culvert will prevent uncontrolled sediment from the adjacent disturbed area from impacting this water during the operational period. Gabion baskets will be installed adjacent to the culvert as shown on Dwg. No. B101 in Appendix 7-9.
- Culvert UC-6 is located on the main branch of Dugout Creek, containing the creek through the disturbed area and allowing coal-haul trucks to enter and leave the loadout pad and mine access/haul road. Installation of this culvert will protect Dugout Creek from sediment which may be generated from the adjacent disturbed areas.
- Culvert DC-10 conveys runoff from the sediment basin beneath the storage racks west of the office/warehouse building into ditch DD-1a.
- Culvert DC-11 conveys runoff from the sediment trap to the sediment pond.

All diversion ditches will be maintained with adequate riprap or alternative erosion protection in the ditch sections where flow velocities are predicted to be sufficiently high to require a ditch lining. Adequate ditch capacities will be maintained in all ditch sections. Culverts will be kept free of debris and each outlet will be protected with riprap where deemed necessary. Detailed diversion design is presented in Section 742.

732.400 Road Drainage

Road drainage facilities will include diversion ditches, culverts, and containment berms. The road drainage diversion ditches and culverts for the mine site are included in the list of diversions presented in Section 732.300 above. Additional road drainage design information is presented in Section 742.

All road drainage diversions will be maintained and repaired to original condition following the occurrence of a large storm event. Culvert inlets and outlets will be kept clear of sediment and other debris. Culverts to be installed on Dugout Creek to permit turning of the coal haul trucks are discussed in Section 742.300.

- Provision of silt fences, riprap, contemporaneous revegetation, vegetative sediment filters, a sedimentation pond, and other measures that reduce overland flow velocities, reduce runoff volumes or trap sediment; and
- Treatment of mine drainage in underground sumps.

742.200 Siltation Structures

General Requirements. Additional contributions of suspended solids and sediment to stream flow or runoff outside the permit area will be prevented to the extent possible using a sedimentation pond. The pond will be constructed before mining operations begin. The structures will be certified by a qualified registered professional engineer.

The sedimentation pond has been designed and will be constructed and maintained as described in Chapter 5 and Sections 733 and 743.

Some areas within the disturbed area boundary will not flow to the sedimentation pond. Areas not contributing runoff to the sedimentation pond would be impractical, if not impossible, to divert to the sedimentation pond due to their location. The proposed disturbed areas which will not flow to the sedimentation pond can be generally described as areas downstream from the sedimentation pond, areas along the water-tank access road, and the area occupied by the water tanks.

Areas of alternate sediment control (ASCAs) are shown on Plate 7-8 and in Addendum A to Appendix 7-9. These include ASCA-1 (a small portion of the primary haul road downstream from the sedimentation pond), ASCA-2 (the water-tank access road upstream from the crest in the road below watershed WS-9 and upstream of culvert DC-8), ASCA-3 (the water-tank access road upstream from culvert DC-9 including the water tank area), ASCA-4 (the water-tank access road upstream of culvert DC-7), and ASCA-5 (the topsoil storage area) .

ASCA-1 consists of a small portion of the primary haul road adjacent to and downstream from the sedimentation pond. Sediment control in this area is provided by paving the road, thus precluding the production of sediment from the ASCA.

Runoff from ASCA-2 is precluded from flowing to the sedimentation pond because of a crest in the water-tank access road at the downstream edge of this ASCA. Instead, runoff from this area flows to Dugout Creek via culvert DC-8 (see Plate 7-5). Sediment generated from this ASCA is controlled

by installing silt fences or straw-bale dikes in ditch DD-5 immediately upstream from the inlet to culvert DC-8. These sediment-control devices have been installed in accordance with Figure 5-4. Sediment which accumulates behind these devices will be periodically removed and either spread on the adjacent road or disposed of with waste-rock generated from the mine.

Runoff from ASCA-3 is precluded from flowing to the sedimentation pond for the reasons outlined above. This runoff will flow to Dugout Creek via culvert DC-9 (see Plate 7-5). Sediment generated from this ASCA will be controlled by installing silt fences or straw-bale dikes in ditch DD-6 immediately upstream from the inlet to culvert DC-9. These sediment-control devices were installed in accordance with Figure 5-4. Sediment which accumulates behind these devices will be periodically removed and either spread on the adjacent road or disposed of with waste-rock generated from the mine.

ASCA-3 also includes the water-tank area and the adjacent cut slope. Sediment yield from this area will be controlled by placing a layer of gravel around the water tanks and the explosives magazines. The cut slope west of the water tanks will also be contemporaneously reclaimed using the interim seed mix identified in Section 341.200 of this M&RP. Runoff which is generated from this ASCA will also flow through culvert DC-9, with additional sediment control being provided at the inlet to this culvert as discussed above.

An additional alternate sediment control measure (ASCA-5) is implemented at the topsoil storage area. Sediment contributions from this stockpile will be controlled by placing a berm around the stockpile to prevent both runoff from the pile and run-on to the pile. The location of this berm is indicated on Plate 2-3 and the design of the berm is noted in Appendix 7-9. Furthermore, erosion from the stockpile will be minimized through the establishment of a vegetative cover on the pile, as indicated in Section 234.200 of this M&RP.

Runoff from ASCA-4 is on the water-tank access road. Instead of runoff flowing to the sediment pond, runoff from this area will flow to Dugout Creek via culvert DC-7 . Sediment generated from this ASCA will be controlled by installing silt fences or straw-bale dikes in the ditch immediately upstream from the inlet to culvert DC-7. These sediment-control devices were installed in accordance with Figure 5-4. Sediment which accumulates behind these devices will be periodically removed and either spread on the adjacent road or disposed of with waste-rock generated from the mine.

Sediment-control measures were implemented during the relocation of the west fork of Dugout Creek. These measures will include installation of three straw-bale dikes and/or reinforced silt fences in appropriate locations within the creek channel below the relocation site to minimize potential contributions of sediment to Dugout Creek. The straw-bale dikes/silt fences will remain in-place until channel relocation and pad construction is completed.

Pace Canyon Fan Portal Facilities

The entire site is an ASCA area. Sediment from the site will be controlled by a combination of contemporaneous reclamation, revegetation, gravel, and the use of a sediment trap. Plate PC7-5A identifies the various alternative sediment control methods that will be used and where the methods will be implemented. Other than the realigned road and a small area on the outslope of the sediment trap embankment the entire site will drain to the sediment trap. Although calculations in Appendix 7-12, Attachment 2 demonstrate that the contemporaneous reclamation, gravel, and revegetation will reduce the sediment yield to less than pre-mining conditions a sediment trap will be constructed to contain sediment generated by the site.

Sedimentation Ponds. A single sedimentation pond has been designed for the Dugout Canyon Mine facilities. The sedimentation pond is located in the southwest corner of the disturbed area. This pond will function individually.

The sedimentation pond will be located as near as possible to the disturbed areas as indicated on Plates 7-4 and 7-5. The pond will not be located within a perennial stream channel.

Design, Construction, and Maintenance

Sediment Storage Volume. The sedimentation pond has been designed to control sediment from disturbed and undisturbed areas. The disturbed area contributing runoff to the sedimentation pond contains 16.9 acres from watersheds DWS-1 through DWS-7 (portions of which will be undisturbed or contemporaneously reclaimed - see Appendix 7-9). The undisturbed area contributing runoff to the sedimentation pond contains 33.7 acres from watersheds WS-1, -3, -5, -6, -7, -8, -9a, and -11. Refer to Plates 7-7 and 7-8 for a delineation of watershed boundaries.

TABLE 7-6
SUMMARY OF WATERSHED DATA

Watershed[a]	Curve Number	Area (acres)	Time of Concentration (hours)
WS-1	72	1.96	0.051
WS-2A	71	6.68	0.103
WS-2B	92	1.03	0.079
WS-3	70	4.87	0.071
WS-4	73	4.63	0.055
WS-5	70	15.9	0.119
WS-6	74	2.09	0.046
WS-7A	70	11.97	0.082
WS-7B	88	1.05	0.016
WS-8	71	5.45	0.072
WS-9	71	4.42	0.068
WS-10	70	47.77	0.198
WS-11	71	11.91	0.075
WS-12A	60	4.48	0.107
WS-12B	88	2.35	0.048
WS-13	67	15.31	0.123
WS-14	67	13.11	0.147
WS-15A	67	5.58	0.067
WS-15B	91	3.2	0.075
WS-16	95	0.56	0.059
WS-17	97	1.32	0.085
ODCWS-1a	66	1794.7	1.069
ODCWS-1b	66	1794.9	1.223

(a) See Plates 7-6, 7-7, and 7-8 for watershed boundaries

TABLE 7-7

STAGE-CAPACITY CURVE FOR THE SEDIMENTATION POND

ELEVATION (FT)	AREA (FT^2)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
6,947	724		0
		3,668	
6,950	1,721		3,668
		15,180	
6,955	4,351		18,848
		30,225	
6,960	7,739		49,073
		48,500	
6,965	11,661		97,573

Prevent, to the extent possible, additional contributions of suspended solids to stream flow outside the permit area; and
Comply with all applicable local, state, and federal laws and regulations.

All diversions within the permit area will removed when no longer needed. The diversions will be reclaimed in accordance with the reclamation plan defined in Chapter 5.

Peak discharge rates from the undisturbed and disturbed area drainages within the permit area were calculated for use in designing diversion ditches and culverts. With the exception of the culverts on Dugout Creek, the storm runoff calculations for the temporary diversion structures were based on the 10-year, 24-hour precipitation event of 1.95 inches. For the design of the Dugout Creek culverts, a 100-year, 6-hour precipitation event was used, with a storm depth of 2.05 inches.

Curve numbers were based on those defined in Appendix 7-9 and professional judgement. A description of the methods used to determine the peak discharge rates is presented in Appendix 7-10.

A precipitation gauge will be installed at the mine site in the summer of 2001 to monitor and assess the types of precipitation events occurring at the mine site. The information will be used to determine if precipitation events exceed design parameters.

The disturbed and undisturbed drainage areas within and above the facilities area are presented on Plates 7-6 through 7-8. A summary of the characteristics of watersheds contributing to the diversions is presented in Table 7-6.

All proposed diversions are presented on Plate 7-5 or in Addendum A to Appendix 7-9. The minimum capacity and freeboard of each diversion ditch and culvert was determined based on the minimum ditch slope. The maximum velocity and need for a channel lining or outlet protection was calculated based on the maximum ditch or culvert slope. Slopes were measured from a contour map with a scale of 1" = 50'. A description of the methods used to determine diversion capacities, flow velocities, and riprap sizes is presented in Appendix 7-10. All diversion calculations are presented in Appendix 7-9.

Diversion of Perennial and Intermittent Streams. Dugout Creek will be diverted through culverts within the disturbed area. UC-6 and UC-5 consist of 60-inch diameter CMPs with mitered inlets. Both culverts are designed to pass the peak flow, of approximately 90 cfs with a combined flow of approximately 180 cfs below their confluence, from a 100-year, 6-hour storm event without creating a excess headwater above the top of the culvert. The justification for diverting the creek with respect to the stream buffer zones is discussed in Section 731.600. To the extent feasible, these culverts will be installed during a season of the year other than the high-flow season.

Culvert UC-5 is located on the eastern tributary of Dugout Creek. This culvert will have a constant slope of 4.9% and an approximate length of 160 feet. This culvert will merge with UC-5 approximately 115 feet downstream from the inlet of UC-6.

Culvert UC-6 is installed on the main branch of Dugout Creek, with a slope that varies from about 2.2% to 8.0% and an approximate length of 2140 feet. This culvert will also consist of a 60-inch diameter CMP. To reduce the velocity at the culvert outlet below the velocities under natural conditions, a riprap basin was constructed in the channel immediately downstream from the outlet. This riprap basin will extend a minimum of 56.25 feet downstream from the culvert outlet and will be underlain with a geofabric to prevent piping of the soil beneath the riprap (see Appendix 7-9). This riprap section will be periodically monitored and modified if necessary to prevent erosion.

Detailed design calculations for culverts UC-6 and UC-5 can be found in Appendix 7-9. All designs have been prepared by or under the direction of, and certified by a qualified registered, professional engineer. The location of each culvert can be found on Plate 7-5 or in Addendum A to Appendix 7-9.

Calculations presented in Appendix 7-9 indicate that the capacity of Dugout Creek upstream and downstream of culverts UC-6 and UC-5 is in excess of 3,000 cfs. This high natural capacity of the stream channel has been caused by a combination of factors, including steep natural gradients, narrow valleys which preclude the development of flood plains, and erosion of the channels due to headcutting following failure of an old culvert located near the center of the operational facility prior to construction of the Dugout Canyon Mine. Hence, although UC-6 and UC-5 have been designed with a capacity of 180 cfs (see Appendix 7-9), the combined conditions of the stream channel noted above indicate that it is not feasible to design these culverts to have a capacity at least equal to that of the natural channel up- and downstream from the culverts.

The west fork of Dugout Creek near the Gilson water well will be relocated for approximately 50 feet. This will be necessary to protect the retaining wall that stabilizes the well site and other support facilities for the well, mainly the well house. Refer to Appendix 7-11 design calculations and typical channel drawing for RD-4, the relocated portion of Dugout Creek will mimic this design.

Diversion of Miscellaneous Flows. Diversion ditches and culverts have been utilized within the permit area to divert miscellaneous flows from disturbed and undisturbed area drainages.

Diversion Ditches. A summary table of the minimum channel geometry, channel slope, peak discharge, minimum riprap requirements, maximum flow velocity and minimum freeboard values for each diversion ditch within the facilities area is presented in Table 7-8. All calculations are contained in Appendix 7-9. Within the main facility area, diversion ditches will generally be lined with concrete if required for erosion protection, thereby aiding long-term maintenance of the ditches. Each ditch has adequate capacity and erosion protection to safely pass the peak flow resulting from the 10-year, 24-hour precipitation event. A description of the diversion ditches within the facilities area is presented in Section 732.300.

Diversion Culverts. A summary table of the culvert size, slope, peak discharge, outlet riprap, and outlet flow velocity for each culvert within the facilities area is presented in Table 7-9.

All calculations are contained in Appendix 7-9. Except for culverts UC-6 and UC-5, each culvert has adequate capacity and outlet erosion protection to safely pass the peak flow resulting from the 10-year, 24-hour precipitation event. Culverts UC-6 and UC-5 were designed to convey the peak runoff resulting from the 100-year, 6-hour precipitation event. A description of the diversion culverts within the facilities area is presented in Section 732.300.

Diversion Berms. Although several berms are noted on Plate 7-5, these will be installed primarily to meet MSHA requirements for safety concerns adjacent to slopes. However, these berms may also locally convey runoff from higher-elevation pads to lower-elevation pads, where it will be conveyed via diversion ditches to the sedimentation pond. Since none of the berms have been designed specifically to convey runoff, no calculations concerning the hydraulic characteristics of these berms are provided in Appendix 7-9.

742.400 Road Drainage

All Roads. The proposed roads within the facilities area are the county road which accesses the mine site and the additional roads noted on Plate 5-2. All of the roads will be constructed to include adequate drainage control with the use of diversion ditches and culverts. None of these roads are located in the channel of an intermittent or perennial stream. Control

TABLE 7-8
SUMMARY OF DIVERSION DITCHES - 10-YEAR 6-HOUR STORM EVENT

Diversion Ditch	Design Flow (cfs)	Minimum Existing Conditions (c)						Calculation Results		Suggested Channel Depth (ft)[a]	Freeboard (ft)[a]
		Bottom Width (ft)	Side Slopes (ft)	Max. Bottom Slope (%)	Min. Bottom Slope (%)	Channel Depth (ft)	Riprap D_{50} (in)	Max. Velocity (ft/s)	Max. Flow Depth (ft)		
DD-1a	3.1	1.5	1:1	10.0	1.7	1.2	Rocky soil	5.25	0.54	1.04	0.66
DD-1b	1.4	0	1.9:1	20.0	1.7	1.0	Concrete	11.78	0.40	0.90	0.60
DD-2a	3.0	2.0	1.4:1	33.3	10.0	0.8	Grouted 6"	5.60	0.29	0.79	0.51
DD-2b	3.0	0	1.9:1	11.6	0.9	1.0	Concrete	11.62	0.60	1.10	0.40 (b)
DD-2c	1.5	1.0	1.9:1	1.4	0.9	0.83	Concrete	4.22	0.27	0.77	0.56
DD-2d	1.4	0	1.9:1	14.3	3.6	1.0	Concrete	10.39	0.34	0.84	0.66
DD-2e	0.7	0	1.9:1	13.3	3.1	1.0	Concrete	8.50	0.27	0.77	0.73
DD-3a	0.2	0.83	0.7:1	20.2	4.2	1.17	Bedrock	3.07	0.12	0.62	1.05
DD-3b	0.2	1.0	5:1	4.2	1.6	0.65	None	1.64	0.11	0.61	0.54
DD-3c	0.2	0.83	0.7:1	20.0	4.8	1.17	Bedrock	3.06	0.11	0.61	1.06
DD-4	0.2	0	1:1 20:1	25.4	0.8	0.75	None	2.90	0.15	0.65	0.60
DD-5	0.1	0	1:1 20:1	0.9	0.5	0.75	None	0.70	0.13	0.63	0.62
DD-6	0.3	0	1:1 20:1	9.1	2.5	0.75	None	2.19	0.15	0.65	0.60
DD-7	0.1	0	1:1 30:1	3.1	1.3	0.6	None	1.01	0.09	0.59	0.51
DD-8	0.5	4	1.5:1	35.7	12.2	0.7	6	2.35	0.06	0.56	0.64
DD-9	0.1	0	2:1	33.3	14.3	0.75	3	2.84	0.15	0.65	0.6
UD-1	0.2	0.75	1.2:1	25.8	9.6	1.0	Rocky soil	3.35	0.10	0.60	0.90

Note: The ditches described above represent the section of ditch with the least capacity to handle runoff. It does not indicate the ditch configuration everywhere.
(a) According to Barfield et.al., (1994) a freeboard of 0.2* (flow depth) or 0.5', whichever is greater should be an adequate freeboard.
(b) Ditch has slightly less than 0.5' of freeboard. However, the ditch can handle up to 12 cfs, which is over four times the design flow. Thus, this channel is adequate.
(c) Minimum existing conditions represent the minimum depth and bottom width and steepest side slopes measured at any point in the channel. For example the minimum bottom width does not occur where the side slopes are steepest. Thus, making calculations more conservative.

structures have been located to minimize downstream sedimentation and flooding. Diversion ditches and culverts for all roads are described in Section 732.300.

A generic cross section showing a typical diversion ditch adjacent to a road is provided in Figure 5-1. This cross section is typical of the ditches to be installed at the Dugout Canyon Mine. As noted in Table 7-8, each of the ditches to be installed at the site will have positive freeboard when flowing at the design rate. Hence, the ditches have been designed to avoid spreading of water on the adjacent roads during the design event.

Primary Roads. The location of primary roads is discussed in Section 527 and presented on Plate 5-2 of this M&RP. The county road which accesses the mine site will be located by Carbon County, where practical, along the alignment of the existing dirt road to minimize erosion and be on stable ground. The access road will not ford Dugout Creek. However, prior to entering the disturbed area, the county road will cross Dugout Creek using a 10' diameter circular corrugated metal pipe culvert with headwalls. As this culvert is located outside the disturbed area boundary and part of the county road, design of this structure was handled by Carbon County. Within the disturbed area, Dugout Creek will be diverted through culverts UC-5 and UC-6 to prevent uncontrolled sediment from reaching the stream and to allow for efficient use of the site. A riprap-lined energy dissipater will be constructed downstream from the outlet of culvert UC-6 to withstand the peak flow from a 100-year, 6-hour storm event. Calculations regarding the design of the energy dissipater can be found in Appendix 7-9.

The drainage control system for the primary roads within the permit area includes diversion ditches and culverts. Except for culverts UC-5 and UC-6, the diversions will adequately pass the peak runoff from the 10-year, 24-hour precipitation event. Culverts UC-6 and UC-5 have been designed to convey the peak flow resulting from the 100-year, 6-hour precipitation event. Culverts will be constructed to avoid plugging or collapse and erosion at the inlet or outlet. Drainage details for the access road are presented in Section 732.300.

Pace Canyon Road

Runoff and erosion on the road will be controlled by the use of water bars. The water bars will divert any runoff from the road before an erosive volume of water can accumulate. Three water bars will be placed approximately 200 feet apart on the road. The water bars will be placed as shown on Plate PC7-5. The first water bar will be placed approximately 5 feet upgradient of the start of the realigned road to prevent any runoff rom the existing road from flowing onto the road. The other two water bars will divert any runoff that has fallen on the realigned road off the road into well vegetated areas. Due to the berm running parallel to the road only precipitation falling directly on the realigned road could impact the road. Therefore, very little runoff is expected to be generated. The little runoff generated by the realigned road will be controlled by the water bars.

TABLE 7-9

SUMMARY OF DIVERSION CULVERTS

Culvert	Existing Pipe Diameter (in)	Inlet Type	Average Pipe Slope (%)	Maximum Allowable HW/D*	Inlet Control Capacity (cfs)	Design Discharge (cfs)	Minimum Allowable Culvert Size (in)	Design Status
DC-1	24	Headwall	4.0	1.5	18	2.3	12	OK
DC-2	12	Projecting	6.9	1.3	2.6	0.8	<12	OK
DC-3	12	Projecting	10.2	1.5	3.2	0.5	<12	OK
DC-4	24	Headwall	5.6	1.1	14.2	1.0	<12	OK
DC-5	18	Drop Inlet	14.6	2.4	15.5	0.2	<6	OK
DC-6	12 and 6	Drop Inlet	17.8	2.0	3.5	0.1	<6	OK
DC-7	22	Projecting	5.6	1.5	14	0.2	<6	OK
DC-8	18	Projecting	5.6	1.8	10	0.1	<6	OK
DC-9	30	Projecting	5.6	2.1	41	1.2	<12	OK
DC-10	22	Projecting	4.1	1.3	12	2.1	12	OK
DC-11	24	Headwall	4.4	1.0	13.0	3.1	15	OK
DC-12	18	Projecting	3.5	1.0	5.5	0.2	<6	OK
UC-1	18	Projecting	32.0	1.2	7	0.1	<6	OK
UC-2	18	Mitre	17.0	2.3	13	0.2	<6	OK
UC-3	18	Projecting	18.0	2.4	13	0.4	<12	OK
UC-4	18	Drop Inlet	25.0	2.0	11	0.2	<6	OK
UC-5	60	Headwall	2.0 +	1.8	230	89.2 @	<48	OK
UC-6 (inlet)	60	Headwall	2.0 +	2.6	300	90.4@	<48	OK
UC-6 (barrel)	60	NA	2.0 +	NA	NA	185.48 @	60	OK

* HW/D = Ratio of the maximum headwater depth and the culvert diameter

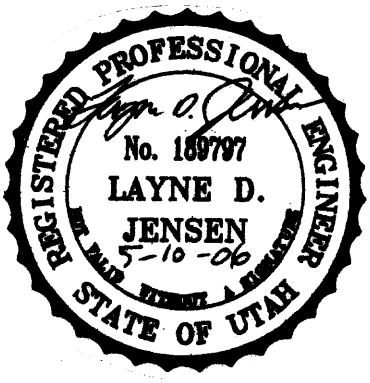
\+ Values are for the minimum pipe slope to insure adequate capacity.

@ 100-year 6-hour storm event

For a drop inlet the inlet control capacity is determined assuming a projecting culvert since the area of the grated inlet is greater than the area of the culvert.

APPENDIX 7-9

Diversion and Culvert Design Calculations



Dugout Canyon Mine
As-Built Hydrology

Rainfall depths

10-yr	6-hr	1.35 in
10-yr	24-hr	1.95 in
25-yr	6-hr	1.65 in
100-yr	6-hr	2.05 in

Miller, J. F., 1973

Curve Numbers.

The Curve numbers are determined by using the vegetation type and density and soil type for each watershed.

The vegitation report (Richardson, 1980) identifies 7 different vegitation types in the mine area. However, in the undisturbed watersheds above the mine two vegitation communities dominate, Douglas Fir, and Mixed conifer.

Mixed Conifer

According to the vegitation report the cover density is approximately 60% (Cover density is the sum of vegitation and litter densities) A hydrologic soil group of C is assumed since good data is not available. Although it is likely to be a Hydrologic soil group B.

The closest match for mixed conifer in an available graph is the Juniper-grass line on Figure 9.6 on pg 5. This should also be a conservative estimate since aspens have a larger canopy than Junipers and grass communities are usually better established.

CN = 70

Curve number (cont.)

Douglas fir → According to the SCS soil survey of the area (Jensen and Borchert, 1988), soils within the Douglas fir vegetative community generally consist of the Midfork family - Comodore complex. The SCS soil survey indicates that the Midfork family is a Hydrologic Soil Group B soil, while pg 7 of this calc. indicates that the Comodore is also a Hydrologic Soil Group B soil.

Logging has occurred within the Douglas fir vegetative community in the Dugout Creek watershed (see Exhibit B of Appendix 4-3 of this M&RP). This logging has been selective and has resulted in an estimated removal of 40-50 percent of the Douglas fir within the logged areas. No aspen were removed. Areas of slash, together with numerous local depressions and other surface disturbances, will continue to retain runoff prior to establishment of revegetation efforts.

As a result of logging, it is estimated that the condition of the watershed in the logged areas of Douglas fir has been downgraded from good to fair. Hence, based on the information provided on pg. 7a of this calc., it is estimated that the average curve number for the Douglas fir vegetative community is 60 (see "Woods", fair condition, Hydrologic Soil Group B).

Disturbed Area Curve Numbers

Four categories for the disturbed area has been Identified. Impermiable (100% runoff. i.e. the sed. pond), Paved, Fill/Gravel, and Reclaimed.

- Impermiable CN = 100

- Paved

Using Table 2-2 on pg 6 for paved parking lots, driveways, etc.

CN = 98

- Compacted Fill / Gravel

Using Table 2.2 on pg 6 and averaging the CN for a gravel and dirt road and assuming a Hydrologic soil group C

CN = 88

- Reclaimed

Areas of contemporaneous reclamation will be assumed to have a CN = 75 although after establishment of the vegitation the CN would likely be closer to 60

CN = 75

Dugout Canyon Mine Curve Numbers

Watershed	Impermiable		Paved		Fill/Gravel		Reclaimed		Mixed Conifer		Douglas Fir		Weighted
Area a	Area (ac.)	CN	Area (ac.)	CN	Area (ac.)	CN	Area (ac.)	CN	Area (ac.)	CN	Area (ac.)	CN	CN b
WS-1	0.08	100	0	98	0	88	0.11	75	1.77	70	0	60	72
WS-2A	0	100	0	98	0	88	1.18	75	5.5	70	0	60	71
WS-2B	0.12	100	0.29	98	0.62	88	0	75	0	70	0	60	92
WS-3	0	100	0	98	0	88	0	75	4.87	70	0	60	70
WS-4	0	100	0	98	0.72	88	0	75	3.9	70	0	60	73
WS-5	0	100	0	98	0	88	0	75	15.9	70	0	60	70
WS-6	0	100	0	98	0.44	88	0	75	1.65	70	0	60	74
WS-7A	0	100	0	98	0	88	0	75	11.97	70	0	60	70
WS-7B	0	100	0	98	1.05	88	0	75	0	70	0	60	88
WS-8	0	100	0	98	0.3	88	0	75	5.15	70	0	60	71
WS-9	0	100	0	98	0.16	88	0	75	4.26	70	0	60	71
WS-10	0	100	0	98	0	88	0	75	47.77	70	0	60	70
WS-11	0	100	0	98	0.56	88	0	75	11.34	70	0	60	71
WS-12A	0	100	0	98	0	88	0	75	0	70	4.48	60	60
WS-12B	0	100	0	98	2.35	88	0	75	0	70	0	60	88
WS-13	0	100	0	98	0.17	88	0	75	9.84	70	5.3	60	67
WS-14	0	100	0	98	0	88	0	75	8.72	70	4.39	60	67
WS-15A	0	100	0	98	0	88	0	75	3.63	70	1.95	60	67
WS-15B	0.16	100	0.62	98	2.42	88	0	75	0	70	0	60	91
WS-16	0.12	100	0.24	98	0.2	88	0	75	0	70	0	60	95
WS-17	0	100	1.2	98	0.17	88	0	75	0	70	0	60	97

Notes

a See Plate 7-7 for watershed locations

b Weighted CN = (CN1)(A1)+(CN2)(A2)+(CN3)(A3)+(CN4)(A4) / (A1+A2+A3+A4)

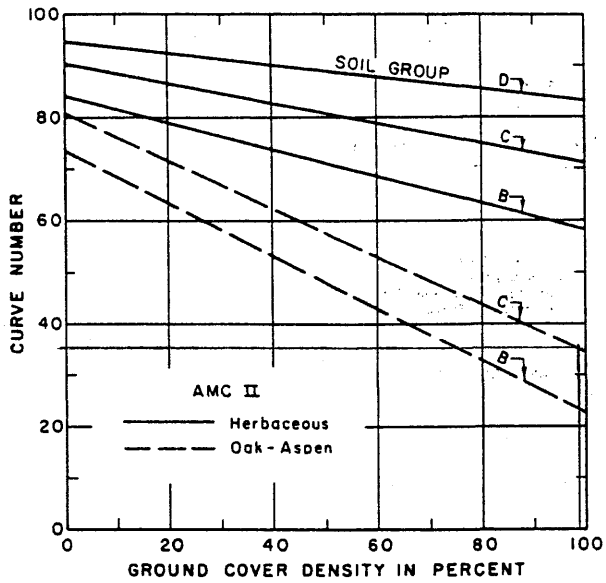


Figure 9.5.--Graph for estimating runoff curve numbers of forest-range complexes in western United States: herbaceous and oak-aspen complexes.

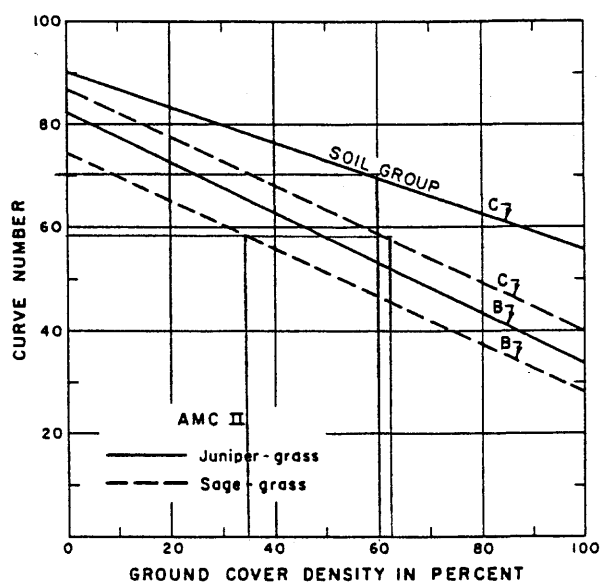


Figure 9.6.--Graph for estimating runoff curve numbers of forest-range complexes in western United States: juniper-grass and sage-grass complexes.

Ref. U.S. Dept. of Agriculture, 1972

Table 2-2.--Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and $I_a = 0.2S$)

LAND USE DESCRIPTION		HYDROLOGIC SOIL GROUP			
		A	B	C	D
Cultivated land[1]: without conservation treatment		72	81	88	91
: with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious).		81	88	91	93
Residential:[3]					
Average lot size	Average % Impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers[5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

1/ For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

2/ Good cover is protected from grazing and litter and brush cover soil.

3/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

4/ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

5/ In some warmer climates of the country a curve number of 95 may be used.

Ref. U.S. Dept of Agriculture, 1977

Table 7.1-Continued

CARYVILLE	B	CENTRAL POINT	B	CHILGREN	C	CLARESON	C	COKEDALE	B/C
CASA GRANDE	C	CERESCO	A	CHILHOWIE	C	CLAREVILLE	C	COKEL	B
CASCADE	C	CERRILLOS	B	CHILI	B	CLARINDA	D	COKER	D
CASCAJO	B	CERRO	C	CHILKAT	C	CLARION	B	COKESBURY	D
CASCILLA	B	CHACRA	C	CHILLICOTHE	C	CLARITA	D	COKEVILLE	B
CASCO	B	CHAFFEE	C	CHILLISQUAQUE		CLARK	B	COLBATH	C/D
CASE	B	CHAGRIN	B	CHILLUM	B	CLARK FORK	A	COLBERT	D
CASEBIER	D	CHAIX	B	CHILMARK	B	CLARKSBURG	C	COLBURN	B
CASEY	C	CHALFONT	C	CHILO	B/D	CLARKSDALE	C	COLBY	B
CASHEL	C	CHALMERS	C	CHILOQUIN	B	CLARKSON	B	COLCHESTER	B
CASHION	D	CHAMA	B	CHILSON	D	CLARKSVILLE	B	COLDCREEK	B
CASHMERE	B	CHAMBER	C	CHILTON	B	CLARNO	B	COLDEN	D
CASHMONT	B	CHAMBERINO	C	CHIMAYO	D	CLARY	B	COLD SPRINGS	C
CASINO	A	CHAMISE	B	CHIMNEY	B	CLATO	B	COLE	B/C
CASITO	D	CHAMOKANE	B	CHINA CREEK	B	CLATSOP	D	COLEBROOK	B
CASPAR	B	CHAMPION	B	CHINCHALLO	B/D	CLAVERACK	C	COLEMAN	C
CASPIANA	B	CHANCE	B/D	CHINIAK	A	CLAWSON	C	COLEMANTOWN	D
CASS	A	CHANDLER	B	CHINO	B/C	CLAYBURN	B	COLETO	A
CASSADAGA		CHANEY	C	CHINOOK	B	CLAYSPRINGS	D	COLFAX	C
CASSIA	C	CHANNAHON	B	CHIPETA	D	CLAYTON	B	COLIBRO	B
CASSIRO	C	CHANNING	B	CHIPLEY	C	CLEARFIELD	C	COLINAS	B
CASSOLARY	B	CHANTA	B	CHIPMAN	D	CLEAR LAKE	D	COLLAMER	C
CASSVILLE		CHANTIER	D	CHIPPENY	D	CLEEK	C	COLLARD	B
CASTAIC	C	CHAPIN	C	CHIPPEWA	B/D	CLE ELUM	B	COLLBRAN	C
CASTALIA	C	CHAPMAN		CHIQUITO	C/D	CLEGG	B	COLLEEN	C
CASTANA	B	CHAPPELL	B	CHIRICAHUA	D	CLEMAN	B	COLLEGIATE	C
CASTELL	C	CHARO	B	CHISPA	B	CLEMS	B	COLLETT	C
CASTILE	B	CHARGO	D	CHITINA	B	CLEMVILLE	B	COLLIER	A
CASTINO	C	CHARITON	D	CHITTENDEN	C	CLEORA	B	COLLINGTON	B
CASTLE	D	CHARITY	D	CHITWOOD	C	CLERF	C	COLLINS	C
CASTLEVALE	D	CHARLEBOIS	C	CHIVATO	D	CLERMONT	D	COLLINSTON	C
CASTNER	C	CHARLESTON	C	CHIWAWA	B	CLEVERLY	B	COLLINSVILLE	C
CASTO	C	CHARLEVOIX	B	CHO	C	CLICK	A	COLMA	B
CASTRO	C	CHARLOS	A	CHOBEE	D	CLIFFDOWN	B	COLMOR	B
CASTROVILLE	B	CHARLOTTE	A/D	CHOCK	B/D	CLIFFHOUSE	C	COLO	B
CASUSE	D	CHARLTON	B	CHOCOLOCCO	B	CLIFFORD	B	COLOCKUM	B
CASWELL	D	CHASE	C	CHOPAKA	C	CLIFFWOOD	C	COLOMA	A
CATALINA	B	CHASEBURG	B	CHOPTANK	A	CLIFTERSON	B	COLOMBO	B
CATALPA	C	CHASEVILLE	A	CHOPTIE	D	CLIFTON	C	COLONA	C
CATANO	A	CHASKA	C	CHORALMONT	B	CLIFTY	B	COLONIE	A
CATARINA	D	CHASTAIN	D	CHOSKA	B	CLIMARA	D	COLORADO	B
CATAULA	C	CHATBURN	B	CHOTEAU	C	CLIMAX	D	COLOROCK	D
CATAWBA	B	CHATFIELD	C	CHRISTIAN	C	CLIME	C	COLOSO	D
CATH	D	CHATHAM	B	CHRISTIANA	B	CLINTON	B	COLOSSE	A
CATHCART	C	CHATSWORTH	D	CHRISTIANBURG	D	CLIPPER	B/C	COLP	D
CATHEDRAL	D	CHAUNCEY	C	CHRISTY	B	CLODINE	D	COLRAIN	B
CATHERINE	B/D	CHAVIES	B	CHROME	C	CLONTARF	B	COLTON	A
CATHRO	D	CHAWANAKEE	C	CHUALAR	B	CLOQUALLUM	C	COLTS NECK	B
CATLETT	C/D	CHEADLE	C	CHUBBS	C	CLOQUATO	B	COLUMBIA	B
CATLIN	B	CHECKETT	D	CHUCKAWALLA	B	CLOQUET	B	COLUMBINE	A
CATNIP	D	CHEDEHAP	B	CHUGTER	B	CLOUD	D	COLUSA	C
CATOCTIN	C	CHEEKTOWAGA	D	CHULITNA	B	CLOUDCROFT	D	COLVILLE	B/C
CATOOSA	B	CHEESEMAN	C	CHUMMY	C/D	CLOUD PEAK	C	COLVIN	C
CATSKILL	A	CHEHALEM	C	CHUMSTICK	C	CLOUD RIM	B	COLWOOD	B/D
CATTARAUGUS	C	CHEHALIS	B	CHUPADERA	C	CLOUGH	D	COLY	B
CAUDLE	B	CHEHULPUM	D	CHURCH	D	CLOVERDALE	D	COLYER	C/D
CAVAL	B	CHELAN	B	CHURCHILL	D	CLOVER SPRINGS	B	COMER	B
CAVE	D	CHELSEA	A	CHURCHVILLE	D	CLOVIS	B	COMERIO	B
CAVELT	D	CHEMAWA	B	CHURN	B	CLUFF	C	COMETA	D
CAVE ROCK	A	CHEMUNG		CHURNDASHER	B	CLUNIE	D	COMFREY	C
CAVO	D	CHEN	D	CHUTE	A	CLURDE	C	COMITAS	A
CAVODE	C	CHENA	A	CIALES	D	CLURO	C	COMLY	C
CAVOUR	D	CHENANGO	A	CIBEQUE	B	CLYDE	D	COMMERCE	C
CAWKER	B	CHENEY	B	CIBO	D	CLYMER	B	COMO	A
CAYAGUA	C	CHENNEBY	C	CIBOLA	B	COACHELLA	B	COMODORE	B
CAYLOR	B	CHENOWETH	B	CICERO	D	COAD	B	COMORO	B
CAYUGA	C	CHEQUEST	C	CIDRAL	C	COAL CREEK	D	COMPTCHE	B
CAZADERO	C	CHEREETE	A	CIENEBA	C	COALMONT	C	COMPTON	C
CAZADOR	B	CHERIONI	D	CIMA	C	COAMO	C	COMSTOCK	C
CAZENOVIA	B	CHEROKEE	D	CIMARRON	C	COARSEGOLD	B/C	COMUS	B
CEBOLIA	C	CHERRY	C	CINCINNATI	C	COATICOOK	C	CONALB	B
CEBONE	C	CHERRYHILL	B	CINCO	A	COATSBURG	D	CONANT	C
CECIL	B	CHERRY SPRINGS	C	CINDERCONE	B	COBB	B	CONASAUGA	C
CEDA	B	CHESAW	A	CINEBAR	B	COBEN	D	CONATA	D
CEDARAN	D	CHESHIRE	B	CINTRONA	D	COBEY	B	CONBOY	D
CEDAR BUTTE	C	CHESHNINA	C	CIPRIANO	D	COBURG	C	CONCHAS	C
CEDAREDGE	B	CHESNIMNUS	B	CIRCLE	C	COCHETOPA	C	CONCHO	C
CEDAR MOUNTAIN	D	CHESTER	B	CIRCLEVILLE	C	COCOA	A	CONCONULLY	B
CEDARVILLE	B	CHESTERTON	C	CISNE	D	COCOLALLA	C	CONCORD	D
CEDONIA	B	CHETCO	D	CISPUS	A	CODORUS	C	CONCREEK	B
CEDRON	C/D	CHETEK	B	CITICO	B	CODY	A	CONDA	C
CELAYA	B	CHEVELON	C	CLACKAMAS	C	COE	A	CONDIT	D
CELETON	D	CHEWACLA	C	CLAIBORNE	B	COEBURN	C	CONDON	C
CELINA	C	CHEWELAH	B	CLAIRE	A	COEROCK	D	CONE	A
CELIO	A/D	CHEYENNE	B	CLAIREMONT	B	COFF	D	CONEJO	C
CELLAR	D	CHIARA	D	CLALLAM	C	COFFEEK	B	CONESTOGA	B
CENCOVE	B	CHICKASHA	B	CLAM GULCH	D	COGGON	B	CONESUS	B
CENTER	C	CHICOPEE	B	CLAMO	C	COGSWELL	C	CONGAREE	B
CENTER CREEK	B	CHICOTE	D	CLANTUN	C	COHASSET	B	CONGER	B
CENTERFIELD	B	CHIGLEY	C	CLAPPER	B	COHOCTAH	D	CONI	D
CENTERVILLE	D	CHILCOTT	C	CLAREMORE	D	COHOE	B	CONKLIN	B
CENTRALIA	B	CHILDS	B	CLARENCE	D	COIT	C	CONLEN	B

NOTES A BLANK HYDROLOGIC SOIL GROUP INDICATES THE SOIL GROUP HAS NOT BEEN DETERMINED
TWO SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION

9.2

Table 9.1.--Runoff curve numbers for hydrologic soil-cover complexes

(Antecedent moisture condition II, and $I_a = 0.2\ S$)

Land use	Cover: Treatment or practice	Cover: Hydrologic condition	Hydrologic soil group A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		---	74	84	90	92

1/ Close-drilled or broadcast.
2/ Including right-of-way.

Ref. (U.S Dept of Agriculture, 1972)

Dugout Canyon Mine

Watershed Area	Drainage Area (ac)	Curve Number	S (in)	Y (%)	I (ft)	L (hr)	Time of Conc. (hr)	Peak Flow (cfs)
WS-1	1.96	72	3.889	76	600	0.031	0.051	0.05
WS-2A	6.68	71	4.085	57	1160	0.062	0.103	0.15
WS-2B	1.03	92	0.870	8.3	600	0.047	0.079	0.66
WS-3	4.87	70	4.286	76.1	840	0.042	0.071	0.09
WS-4	4.63	73	3.699	61	600	0.033	0.055	0.15
WS-5	15.9	70	4.286	72.7	1560	0.071	0.119	0.31
WS-6	2.09	74	3.514	67.1	520	0.027	0.046	0.09
WS-7A	11.97	70	4.286	89.2	1120	0.049	0.082	0.23
WS-7B	1.05	88	1.364	16.1	100	0.010	0.016	0.51
WS-8	5.45	71	4.085	77	900	0.043	0.072	0.12
WS-9	4.42	71	4.085	73.8	820	0.041	0.068	0.1
WS-10	47.77	70	4.286	47	2260	0.119	0.198	0.91
WS-11	11.91	71	4.085	77.1	950	0.045	0.075	0.26
WS-12A	4.48	60	6.667	49.1	780	0.064	0.107	0.01
WS-12B	2.35	88	1.364	17.3	420	0.029	0.048	1.1
WS-13	15.31	67	4.925	59.3	1300	0.074	0.123	0.19
WS-14	13.11	67	4.925	55.5	1560	0.088	0.147	0.16
WS-15A	5.58	67	4.925	58.5	600	0.040	0.067	0.07
WS-15B	3.2	91	0.989	8.7	550	0.045	0.075	1.9
WS-16	0.56	95	0.526	9.5	540	0.035	0.059	0.45
WS-17	1.37	97	0.309	4.8	640	0.051	0.085	1.25
ODCWS-1A	1794.7	66	5.152	42.2	15200	0.640	1.069	90.4
ODCWS-1B	1794.9	66	5.152	37.7	16750	0.732	1.223	89.2

Notes

S = 1000/CN - 10

Y = average watershed slope = (length of contour lines)(contour interval)/(watershed area)

I = hydraulic length

L = watershed lag =(I^0.8(S+1)^0.7) / (1900(Y)^0.5)

Time of Concentration + 1.67L

Peak Flow is based on a 10-yr 6-hr storm event except for ODCWS-1A and AB which are for the 100-yr 6-hr storm

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-1 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 1.96 acres
Depth = 1.35 inches	CN = 72.00
Duration = 6.0 hrs	Time conc.= 0.05 hrs

OUTPUT SUMMARY

Runoff depth:	0.073 inches
Initial abstr:	0.778 inches
Peak flow:	0.05 cfs (0.027 iph)
at time:	3.509 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-2A 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 6.68 acres
Depth = 1.35 inches	CN = 71.00
Duration = 6.0 hrs	Time conc.= 0.10 hrs

OUTPUT SUMMARY

Runoff depth:	0.062 inches
Initial abstr:	0.817 inches
Peak flow:	0.15 cfs (0.022 iph)
at time:	3.529 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-2B 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 1.03 acres
Depth = 1.35 inches	CN = 92.00
Duration = 6.0 hrs	Time conc.= 0.08 hrs

OUTPUT SUMMARY

Runoff depth: 0.676 inches
Initial abstr: 0.174 inches
Peak flow: 0.66 cfs (0.637 iph)
at time: 2.507 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-3 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 4.87 acres
Depth = 1.35 inches	CN = 70.00
Duration = 6.0 hrs	Time conc.= 0.07 hrs

OUTPUT SUMMARY

Runoff depth:	0.051 inches
Initial abstr:	0.857 inches
Peak flow:	0.09 cfs (0.019 iph)
at time:	5.510 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-4 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 4.63 acres
Depth = 1.35 inches	CN = 73.00
Duration = 6.0 hrs	Time conc.= 0.06 hrs

OUTPUT SUMMARY

Runoff depth:	0.086 inches
Initial abstr:	0.740 inches
Peak flow:	0.15 cfs (0.032 iph)
at time:	3.505 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-5 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 15.90 acres
Depth = 1.35 inches	CN = 70.00
Duration = 6.0 hrs	Time conc.= 0.12 hrs

OUTPUT SUMMARY

Runoff depth:	0.051 inches
Initial abstr:	0.857 inches
Peak flow:	0.31 cfs (0.019 iph)
at time:	5.522 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-6 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 2.09 acres
Depth = 1.35 inches	CN = 74.00
Duration = 6.0 hrs	Time conc.= 0.05 hrs

OUTPUT SUMMARY

Runoff depth: 0.101 inches
Initial abstr: 0.703 inches
Peak flow: 0.09 cfs (0.042 iph)
at time: 2.515 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-7A 10-YEAR 6-HOUR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 11.97 acres
Depth = 1.35 inches	CN = 70.00
Duration = 6.0 hrs	Time conc.= 0.08 hrs

OUTPUT SUMMARY

Runoff depth: 0.051 inches
Initial abstr: 0.857 inches
Peak flow: 0.23 cfs (0.019 iph)
at time: 5.510 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-7B 10-YEAR 6-HOUR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 1.05 acres
Depth = 1.35 inches	CN = 88.00
Duration = 6.0 hrs	Time conc.= 0.02 hrs

OUTPUT SUMMARY

Runoff depth: 0.475 inches
Initial abstr: 0.273 inches
Peak flow: 0.51 cfs (0.478 iph)
at time: 2.500 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-8 10-YEAR 6-HOUR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 5.45 acres
Depth = 1.35 inches	CN = 71.00
Duration = 6.0 hrs	Time conc.= 0.07 hrs

OUTPUT SUMMARY

Runoff depth: 0.062 inches
Initial abstr: 0.817 inches
Peak flow: 0.12 cfs (0.022 iph)
at time: 3.514 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-9 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 4.42 acres
Depth = 1.35 inches	CN = 71.00
Duration = 6.0 hrs	Time conc.= 0.07 hrs

OUTPUT SUMMARY

Runoff depth:	0.062 inches
Initial abstr:	0.817 inches
Peak flow:	0.10 cfs (0.022 iph)
at time:	3.509 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-10 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 47.77 acres
Depth = 1.35 inches	CN = 70.00
Duration = 6.0 hrs	Time conc.= 0.20 hrs

OUTPUT SUMMARY

Runoff depth:	0.051 inches
Initial abstr:	0.857 inches
Peak flow:	0.91 cfs (0.019 iph)
at time:	5.544 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-11 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 11.91 acres
Depth = 1.35 inches	CN = 71.00
Duration = 6.0 hrs	Time conc.= 0.08 hrs

OUTPUT SUMMARY

Runoff depth:	0.062 inches
Initial abstr:	0.817 inches
Peak flow:	0.26 cfs (0.022 iph)
at time:	3.510 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-12A 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 4.48 acres
Depth = 1.35 inches	CN = 60.00
Duration = 6.0 hrs	Time conc.= 0.11 hrs

OUTPUT SUMMARY

Runoff depth:	0.000 inches
Initial abstr:	1.333 inches
Peak flow:	0.00 cfs (0.000 iph)
at time:	6.049 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-12B 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 2.35 acres
Depth = 1.35 inches	CN = 88.00
Duration = 6.0 hrs	Time conc.= 0.05 hrs

OUTPUT SUMMARY

Runoff depth:	0.475 inches
Initial abstr:	0.273 inches
Peak flow:	1.10 cfs (0.463 iph)
at time:	2.502 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-13 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 15.31 acres
Depth = 1.35 inches	CN = 67.00
Duration = 6.0 hrs	Time conc.= 0.12 hrs

OUTPUT SUMMARY

Runoff depth:	0.025 inches
Initial abstr:	0.985 inches
Peak flow:	0.19 cfs (0.012 iph)
at time:	5.527 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-14 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 13.11 acres
Depth = 1.35 inches	CN = 67.00
Duration = 6.0 hrs	Time conc.= 0.15 hrs

OUTPUT SUMMARY

Runoff depth:	0.025 inches
Initial abstr:	0.985 inches
Peak flow:	0.16 cfs (0.012 iph)
at time:	5.547 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-15A 10-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 5.58 acres
Depth = 1.35 inches	CN = 67.00
Duration = 6.0 hrs	Time conc.= 0.07 hrs

OUTPUT SUMMARY

Runoff depth:	0.025 inches
Initial abstr:	0.985 inches
Peak flow:	0.07 cfs (0.013 iph)
at time:	5.512 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-15B 10-YEAR 6-HOUR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 3.20 acres
Depth = 1.35 inches	CN = 91.00
Duration = 6.0 hrs	Time conc.= 0.08 hrs

OUTPUT SUMMARY

Runoff depth: 0.620 inches
Initial abstr: 0.198 inches
Peak flow: 1.90 cfs (0.590 iph)
at time: 2.510 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-16 10-YEAR 6-HOUR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 0.56 acres
Depth = 1.35 inches	CN = 95.00
Duration = 6.0 hrs	Time conc.= 0.06 hrs

OUTPUT SUMMARY

Runoff depth: 0.875 inches
Initial abstr: 0.105 inches
Peak flow: 0.45 cfs (0.802 iph)
at time: 2.502 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-17 10-YEAR 6-HOUR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 1.37 acres
Depth = 1.35 inches	CN = 97.00
Duration = 6.0 hrs	Time conc.= 0.09 hrs

OUTPUT SUMMARY

Runoff depth: 1.039 inches
Initial abstr: 0.062 inches
Peak flow: 1.25 cfs (0.902 iph)
at time: 2.505 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-3 100-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 4.87 acres
Depth = 2.05 inches	CN = 70.00
Duration = 6.0 hrs	Time conc.= 0.07 hrs

OUTPUT SUMMARY

Runoff depth:	0.260 inches
Initial abstr:	0.857 inches
Peak flow:	0.93 cfs (0.190 iph)
at time:	2.518 hrs

* Watersheds WS-3, WS-5, WS-13 and WS-14 runoff has been calculated Assuming a 100-yr 6-hr storm event to verify the adequacy of the main Bypass culvert which must be able to handle the 100-yr 6-hr storm event

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-5 100-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 15.90 acres
Depth = 2.05 inches	CN = 70.00
Duration = 6.0 hrs	Time conc.= 0.12 hrs

OUTPUT SUMMARY

Runoff depth:	0.260 inches
Initial abstr:	0.857 inches
Peak flow:	2.66 cfs (0.166 iph)
at time:	2.555 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-13 100-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 15.31 acres
Depth = 2.05 inches	CN = 67.00
Duration = 6.0 hrs	Time conc.= 0.12 hrs

OUTPUT SUMMARY

Runoff depth:	0.189 inches
Initial abstr:	0.985 inches
Peak flow:	1.28 cfs (0.083 iph)
at time:	2.575 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-14 100-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 13.11 acres
Depth = 2.05 inches	CN = 67.00
Duration = 6.0 hrs	Time conc.= 0.15 hrs

OUTPUT SUMMARY

Runoff depth:	0.189 inches
Initial abstr:	0.985 inches
Peak flow:	1.01 cfs (0.076 iph)
at time:	2.587 hrs

Ditch Verification

The following represents the minimum cross-section for the existing ditches as measured at the site. The purpose is to verify that the minimum cross-section can contain the flows generated by the 10-yr 6-hr storm event. In general the ditches have larger cross-sections than is described in the summary table.

Assumptions :

Mannings $n = 0.030$ for ditches with smooth earthen sides and bottom with no significant obstructions.

Mannings $n = 0.035$ for ditches cut in rocky soils or into bedrock (Not for riprapped channels)

Mannings n will be determined by using the following equation

$$n = 0.0456 \, (D_{50} \cdot S)^{0.159}$$

where D_{50} = median riprap size (in)
S = slope (ft/ft)

Abt et al. (1987)

Design ditches based on

- maximum slope to determine erosional stability
- minimum slope to determine capacity

Design Summary → pg. 36

Flowmaster Output → pgs 37-74

Riprap is generally not necessary if the maximum flow velocity is less than 5 ft/sec.

The maximum allowable velocity for a riprapped channel is based on the method presented by Searcy (1967) see graph on pg 36a

DUGOUT CANYON MINE
DIVERSION DITCH DESIGN FLOWS

Diversion Ditch	Contributing Watersheds	Design Flow (cfs)
DD-1a	12a, 12b, 15a, 15b	3.1
DD-1b	12a, 12b, 15% of 15b	1.4
DD-2a	2a, 2b, 4, 6, 7a, 7b, 17	3.0
DD-2b	2a, 2b, 4, 6, 7a, 7b, 17	3.0
DD-2c	20% 2a, 70% 2b, 4, 6, 7a, 7b	1.5
DD-2d	20% 2a, 60% 2b, 4, 6, 7a, 7b	1.4
DD-2e	7a, 7b	0.7
DD-3a	4	0.2
DD-3b	4	0.2
DD-3c	4	0.2
DD-4	8	0.2
DD-5	9	0.1
DD-6	11	0.3
DD-7	30% 11	0.1
DD-8	16	0.5
DD-9	6	0.1
UD-1	13	0.2

Note: When only part of a watershed contributes runoff to a ditch or culvert the runoff will be determined by multiplying the total flow by the percentage of the watershed area flowing to the ditch or culvert. In some cases the total watershed runoff may be used.

Design flows are rounded up to the nearest tenth of a cfs.

All design flows are for a 10-year, 6-hour storm event.

TABLE 7-8
SUMMARY OF DIVERSION DITCHES
10-YEAR 6-HOUR STORM EVENT

Diversion Ditch	Design Flow (cfs)	Minimum Existing Conditions (c)						Calculation Results		Suggested Channel Depth (ft)[a]	Freeboard (ft)[a]
		Bottom Width (ft)	Side Slopes (ft)	Max. Bottom Slope (%)	Min. Bottom Slope (%)	Channel Depth (ft)	Riprap D_{50} (in)	Max. Velocity (ft/s)	Max. Flow Depth (ft)		
DD-1a	3.1	1.5	1:1	10.0	1.7	1.2	Rocky soil	5.25	0.54	1.04	0.66
DD-1b	1.4	0	1.9:1	20.0	1.7	1.0	Concrete	11.78	0.40	0.90	0.60
DD-2a	3.0	2.0	1.4:1	33.3	10.0	0.8	Grouted 6"	5.60	0.29	0.79	0.51
DD-2b	3.0	0	1.9:1	11.6	0.9	1.0	Concrete	11.62	0.60	1.10	0.40 (b)
DD-2c	1.5	1.0	1.9:1	1.4	0.9	0.83	Concrete	4.22	0.27	0.77	0.56
DD-2d	1.4	0	1.9:1	14.3	3.6	1.0	Concrete	10.39	0.34	0.84	0.66
DD-2e	0.7	0	1.9:1	13.3	3.1	1.0	Concrete	8.50	0.27	0.77	0.73
DD-3a	0.2	0.83	0.7:1	20.2	4.2	1.17	Bedrock	3.07	0.12	0.62	1.05
DD-3b	0.2	1.0	5:1	4.2	1.6	0.65	None	1.64	0.11	0.61	0.54
DD-3c	0.2	0.83	0.7:1	20.0	4.8	1.17	Bedrock	3.06	0.11	0.61	1.06
DD-4	0.2	0	1:1 20:1	25.4	0.8	0.75	None	2.90	0.15	0.65	0.60
DD-5	0.1	0	1:1 20:1	0.9	0.5	0.75	None	0.70	0.13	0.63	0.62
DD-6	0.3	0	1:1 20:1	9.1	2.5	0.75	None	2.19	0.15	0.65	0.60
DD-7	0.1	0	1:1 30:1	3.1	1.3	0.6	None	1.01	0.09	0.59	0.51
DD-8	0.5	4	1.5:1	35.7	12.2	0.7	6	2.35	0.06	0.56	0.64
DD-9	0.1	0	2:1	33.3	14.3	0.75	3	2.84	0.15	0.65	0.6
UD-1	0.2	0.75	1.2:1	25.8	9.6	1.0	Rocky soil	3.35	0.10	0.60	0.90

Note: The ditches described above represent the section of ditch with the least capacity to handle runoff. It does not indicate the ditch configuration everywhere.

(a) According to Barfield et.al., (1994) a freeboard of 0.2* (flow depth) or 0.5', whichever is greater should be an adequate freeboard.
(b) Ditch has slightly less than 0.5' of freeboard. However, the ditch can handle up to 12 cfs, which is over four times the design flow. Thus, this channel is adequate.
(c) Minimum existing conditions represent the minimum depth and bottom width and steepest side slopes measured at any point in the channel. For example the minimum bottom width does not occur where the side slopes are steepest. Thus, making calculations more conservative.

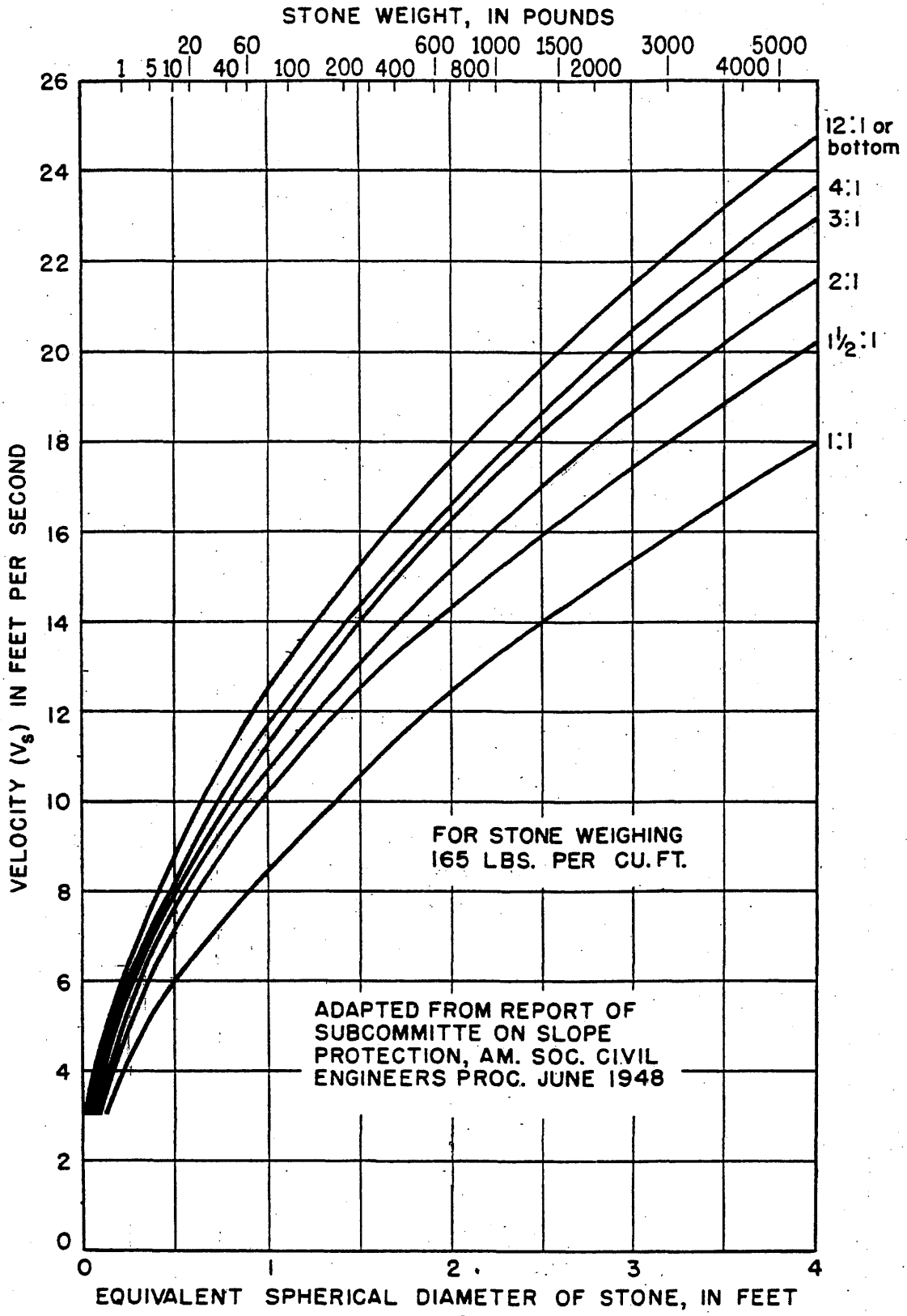


FIG. 2-SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

Searcy, J.K. 1967. Use of Riprap for Bank Protection. U.S. Dept. of Transportation, Bureau of Public Roads, U.S Government Printing Office, Washington D.C.

DD-1A MINIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	very rocky earth
Slope	017000	ft/ft
Left Side Slope	1.00	V : H
Right Side Slope	1.00	V : H
Bottom Width	1.50	ft
Discharge	3.10	cfs

Results		
Depth	0.54	ft <1.2' ∴ ok
Flow Area	1.1	ft²
Wetted Perim	3.03	ft
Top Width	2.58	ft
Critical Depth	0.46	ft
Critical Slope	0.030170	ft/ft
Velocity	2.82	ft/s
Velocity Head	0.12	ft
Specific Energ	0.66	ft
Froude Numb	0.76	
Flow Type	Subcritical	

Note: this calculation assumes that DC-11 is plugged and that the lower portion of this Ditch must still be able to handle the entire design flow.

DD-1A MAXIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	very rocky earth
Slope	100000	ft/ft
Left Side Slope	1.00	V : H
Right Side Slope	1.00	V : H
Bottom Width	1.50	ft
Discharge	3.10	cfs

Results		
Depth	0.32	ft
Flow Area	0.6	ft²
Wetted Perim	2.42	ft
Top Width	2.15	ft
Critical Depth	0.46	ft
Critical Slope	0.030170	ft/ft
Velocity	5.25	ft/s > 5.0 fps
Velocity Head	0.43	ft
Specific Energ	0.75	ft
Froude Numb	1.76	
Flow Type	Supercritical	

slightly over 5.0 fps. However, this channel should still be stable under these conditions because the channel is D_{50} = 6" rock with a little soil. Also this represents the minimum channel X-sec and assumes that the smallest X-sec occurs in the area of greatest slope, which it does not. Therefore, this is a conservative estimate in addition to the natural armoring of the channel (D_{50} = 6")

DD-1B MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	smooth concrete
Slope	0.017000 ft/ft	
Left Side Slope	1.90 H : V	
Right Side Slope	1.90 H : V	
Bottom Width	0.00 ft	
Discharge	1.40 cfs	

Results		
Depth	0.40 ft	< 1.0' ok
Flow Area	0.3 ft²	
Wetted Perimeter	1.70 ft	
Top Width	1.51 ft	
Critical Depth	0.51 ft	
Critical Slope	0.004578 ft/ft	
Velocity	4.67 ft/s	
Velocity Head	0.34 ft	
Specific Energy	0.74 ft	
Froude Number	1.85	
Flow Type	Supercritical	

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DD-1B MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	smooth Concrete
Slope	0.200000 ft/ft	
Left Side Slope	1.90 H : V	
Right Side Slope	1.90 H : V	
Bottom Width	0.00 ft	
Discharge	1.40 cfs	

Results		
Depth	0.25 ft	
Flow Area	0.1 ft²	
Wetted Perimeter	1.07 ft	
Top Width	0.95 ft	
Critical Depth	0.51 ft	
Critical Slope	0.004578 ft/ft	
Velocity	11.78 ft/s	concrete ∴ ok
Velocity Head	2.16 ft	
Specific Energy	2.41 ft	
Froude Number	5.87	
Flow Type	Supercritical	

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DD-2A MINIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.042	D_{50} = 6" Slope = 10 %
Slope	100000	ft/ft
Left Side Slope	1.40	H : V
Right Side Slope	1.40	H : V
Bottom Width	2.00	ft
Discharge	3.00	cfs

Results		
Depth	0.29	ft < 0.8' ∴ ok
Flow Area	0.7	ft²
Wetted Perim	3.01	ft
Top Width	2.82	ft
Critical Depth	0.38	ft
Critical Slope	0.041988	ft/ft
Velocity	4.25	ft/s
Velocity Head	0.28	ft
Specific Energ	0.57	ft
Froude Numb	1.50	
Flow Type	Supercritical	

DD-2A MAXIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.051	D_{50} = 6" Slope = 33.3%
Slope	333330	ft/ft
Left Side Slope	1.40	H : V
Right Side Slope	1.40	H : V
Bottom Width	2.00	ft
Discharge	3.00	cfs

Results		
Depth	0.23	ft
Flow Area	0.5	ft²
Wetted Perim	2.79	ft
Top Width	2.65	ft
Critical Depth	0.38	ft
Critical Slope	0.061910	ft/ft
Velocity	5.60	ft/s grouted riprap ∴ ok
Velocity Head	0.49	ft
Specific Energ	0.72	ft
Froude Numb	2.19	
Flow Type	Supercritical	

DD-2B MINIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.013	Concrete
Slope	009000	ft/ft
Left Side Slope	1.90	H : V
Right Side Slope	1.90	H : V
Bottom Width	0.00	ft
Discharge	3.00	cfs

Results		
Depth	0.60	ft < 1.0' ok
Flow Area	0.7	ft²
Wetted Perim	2.56	ft
Top Width	2.26	ft
Critical Depth	0.69	ft
Critical Slope	0.004135	ft/ft
Velocity	4.46	ft/s
Velocity Head	0.31	ft
Specific Energ	0.90	ft
Froude Numb	1.44	
Flow Type	Supercritical	

DD-2B MAXIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data			
Mannings Coeffic	0.013		Concrete
Slope	116000	ft/ft	
Left Side Slope	1.90	H : V	
Right Side Slope	1.90	H : V	
Bottom Width	0.00	ft	
Discharge	3.00	cfs	

Results			
Depth	0.37	ft	
Flow Area	0.3	ft²	
Wetted Perim	1.58	ft	
Top Width	1.40	ft	
Critical Depth	0.69	ft	
Critical Slope	0.004135	ft/ft	
Velocity	11.62	ft/s	concrete ∴ ok
Velocity Head	2.10	ft	
Specific Energ	2.47	ft	
Froude Numb	4.77		
Flow Type	Supercritical		

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DD-2C MINIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.013	Concrete
Slope	009000	ft/ft
Left Side Slope	1.90	H : V
Right Side Slope	1.90	H : V
Bottom Width	1.00	ft
Discharge	1.50	cfs

Results		
Depth	0.27	ft < 0.83' ∴ ok
Flow Area	0.4	ft²
Wetted Perim	2.18	ft
Top Width	2.04	ft
Critical Depth	0.33	ft
Critical Slope	0.004355	ft/ft
Velocity	3.60	ft/s
Velocity Head	0.20	ft
Specific Energ	0.48	ft
Froude Numb	1.41	
Flow Type	Supercritical	

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DD-2C MAXIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.013	Concrete
Slope	014000	ft/ft
Left Side Slope	1.90	H : V
Right Side Slope	1.90	H : V
Bottom Width	1.00	ft
Discharge	1.50	cfs

Results		
Depth	0.24	ft
Flow Area	0.4	ft²
Wetted Perim	2.04	ft
Top Width	1.92	ft
Critical Depth	0.33	ft
Critical Slope	0.004355	ft/ft
Velocity	4.22	ft/s Concrete ∴ ok
Velocity Head	0.28	ft
Specific Energ	0.52	ft
Froude Numb	1.73	
Flow Type	Supercritical	

DD-2D MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	Concrete
Slope	0.036000	ft/ft
Left Side Slope	1.90	H : V
Right Side Slope	1.90	H : V
Bottom Width	0.00	ft
Discharge	1.40	cfs

Results		
Depth	0.34	ft < 1.0 ∴ ok
Flow Area	0.2	ft²
Wetted Perimeter	1.48	ft
Top Width	1.31	ft
Critical Depth	0.51	ft
Critical Slope	0.004578	ft/ft
Velocity	6.19	ft/s
Velocity Head	0.60	ft
Specific Energy	0.94	ft
Froude Number	2.63	
Flow Type	Supercritical	

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DD-2D MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	concrete
Slope	0.143000 ft/ft	
Left Side Slope	1.90 H : V	
Right Side Slope	1.90 H : V	
Bottom Width	0.00 ft	
Discharge	1.40 cfs	

Results	
Depth	0.27 ft
Flow Area	0.1 ft²
Wetted Perimeter	1.14 ft
Top Width	1.01 ft
Critical Depth	0.51 ft
Critical Slope	0.004578 ft/ft
Velocity	10.39 ft/s concrete ∴ ok
Velocity Head	1.68 ft
Specific Energy	1.94 ft
Froude Number	5.02
Flow Type	Supercritical

DD-2E MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	Concrete
Slope	0.031000	ft/ft
Left Side Slope	1.90	H : V
Right Side Slope	1.90	H : V
Bottom Width	0.00	ft
Discharge	0.70	cfs

Results		
Depth	0.27 ft	< 1.0' ok
Flow Area	0.1	ft²
Wetted Perimeter	1.17	ft
Top Width	1.04	ft
Critical Depth	0.38	ft
Critical Slope	0.005021	ft/ft
Velocity	4.92	ft/s
Velocity Head	0.38	ft
Specific Energy	0.65	ft
Froude Number	2.35	
Flow Type	Supercritical	

DD-2E MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	concrete
Slope	0.133000	ft/ft
Left Side Slope	1.90	H : V
Right Side Slope	1.90	H : V
Bottom Width	0.00	ft
Discharge	0.70	cfs

Results		
Depth	0.21	ft
Flow Area	0.1	ft²
Wetted Perimeter	0.89	ft
Top Width	0.79	ft
Critical Depth	0.38	ft
Critical Slope	0.005021	ft/ft
Velocity	8.50	ft/s concrete ∴ ok
Velocity Head	1.12	ft
Specific Energy	1.33	ft
Froude Number	4.65	
Flow Type	Supercritical	

DD-3A MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	rocky soil or bedrock
Slope	0.042000 ft/ft	
Left Side Slope	0.70 H : V	
Right Side Slope	0.70 H : V	
Bottom Width	0.83 ft	
Discharge	0.20 cfs	

Results		
Depth	0.12 ft	< 1.17' ok
Flow Area	0.1 ft²	
Wetted Perimeter	1.12 ft	
Top Width	1.00 ft	
Critical Depth	0.12 ft	
Critical Slope	0.043775 ft/ft	
Velocity	1.84 ft/s	
Velocity Head	0.05 ft	
Specific Energy	0.17 ft	
Froude Number	0.98	
Flow Type	Subcritical	

DD-3A MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	Rocky soil or bedrock.
Slope	0.202000 ft/ft	
Left Side Slope	0.70 H : V	
Right Side Slope	0.70 H : V	
Bottom Width	0.83 ft	
Discharge	0.20 cfs	

Results		
Depth	0.07 ft	
Flow Area	0.1 ft²	
Wetted Perimeter	1.01 ft	
Top Width	0.93 ft	
Critical Depth	0.12 ft	
Critical Slope	0.043772 ft/ft	
Velocity	3.07 ft/s	< 5 fps ok
Velocity Head	0.15 ft	
Specific Energy	0.22 ft	
Froude Number	2.05	
Flow Type	Supercritical	

DD-3B MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	soil
Slope	0.016000	ft/ft
Left Side Slope	5.00	H : V
Right Side Slope	5.00	H : V
Bottom Width	1.00	ft
Discharge	0.20	cfs

Results		
Depth	0.11 ft	< 0.65 ok
Flow Area	0.2 ft²	
Wetted Perimeter	2.12 ft	
Top Width	2.10 ft	
Critical Depth	0.09 ft	
Critical Slope	0.032271 ft/ft	
Velocity	1.17 ft/s	
Velocity Head	0.02 ft	
Specific Energy	0.13 ft	
Froude Number	0.72	
Flow Type	Subcritical	

DD-3B MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	soil
Slope	0.042000	ft/ft
Left Side Slope	5.00	H : V
Right Side Slope	5.00	H : V
Bottom Width	1.00	ft
Discharge	0.20	cfs

Results		
Depth	0.09	ft
Flow Area	0.1	ft²
Wetted Perimeter	1.87	ft
Top Width	1.85	ft
Critical Depth	0.09	ft
Critical Slope	0.032267	ft/ft
Velocity	1.64	ft/s < 5 fps ok
Velocity Head	0.04	ft
Specific Energy	0.13	ft
Froude Number	1.13	
Flow Type	Supercritical	

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DD-3C MIN SLOPE
Worksheet for Trapezoidal Channel

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Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	rocky earth or bedrock
Slope	0.048000	ft/ft
Left Side Slope	0.70	H : V
Right Side Slope	0.70	H : V
Bottom Width	0.83	ft
Discharge	0.20	cfs

Results		
Depth	0.11	ft <1.17 ok
Flow Area	0.1	ft²
Wetted Perimeter	1.11	ft
Top Width	0.99	ft
Critical Depth	0.12	ft
Critical Slope	0.043775	ft/ft
Velocity	1.92	ft/s
Velocity Head	0.06	ft
Specific Energy	0.17	ft
Froude Number	1.04	
Flow Type	Supercritical	

DD-3C MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.035 rocky earth or bedrock
Slope	0.200000 ft/ft
Left Side Slope	0.70 H : V
Right Side Slope	0.70 H : V
Bottom Width	0.83 ft
Discharge	0.20 cfs

Results	
Depth	0.07 ft
Flow Area	0.1 ft²
Wetted Perimeter	1.01 ft
Top Width	0.93 ft
Critical Depth	0.12 ft
Critical Slope	0.043777 ft/ft
Velocity	3.06 ft/s <5 fps ok
Velocity Head	0.15 ft
Specific Energy	0.22 ft
Froude Number	2.04
Flow Type	Supercritical

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DD-4 MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout Canyon Mine
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.008000	ft/ft
Left Side Slope	1.00	H : V
Right Side Slope	20.00	H : V
Bottom Width	0.00	ft
Discharge	0.20	cfs

Results		
Depth	0.15	ft
Flow Area	0.3	ft^2
Wetted Perimeter	3.32	ft
Top Width	3.25	ft
Critical Depth	0.12	ft
Critical Slope	0.034664	ft/ft
Velocity	0.79	ft/s
Velocity Head	0.01	ft
Specific Energy	0.16	ft
Froude Number	0.50	
Flow Type	Subcritical	

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DD-4 MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout Canyon Mine
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.254000	ft/ft
Left Side Slope	1.00	H : V
Right Side Slope	20.00	H : V
Bottom Width	0.00	ft
Discharge	0.20	cfs

Results		
Depth	0.08	ft
Flow Area	0.1	ft^2
Wetted Perimeter	1.74	ft
Top Width	1.70	ft
Critical Depth	0.12	ft
Critical Slope	0.034664	ft/ft
Velocity	2.90	ft/s
Velocity Head	0.13	ft
Specific Energy	0.21	ft
Froude Number	2.54	
Flow Type	Supercritical	

DD-5 MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout Canyon Mine
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.005000	ft/ft
Left Side Slope	1.00	H : V
Right Side Slope	20.00	H : V
Bottom Width	0.00	ft
Discharge	0.10	cfs

Results		
Depth	0.13	ft
Flow Area	0.2	ft²
Wetted Perimeter	2.80	ft
Top Width	2.74	ft
Critical Depth	0.09	ft
Critical Slope	0.038017	ft/ft
Velocity	0.56	ft/s
Velocity Head	4.87e-3	ft
Specific Energy	0.14	ft
Froude Number	0.39	
Flow Type	Subcritical	

DD-5 MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout Canyon Mine
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.009000	ft/ft
Left Side Slope	1.00	H : V
Right Side Slope	20.00	H : V
Bottom Width	0.00	ft
Discharge	0.10	cfs

Results		
Depth	0.12	ft
Flow Area	0.1	ft^2
Wetted Perimeter	2.50	ft
Top Width	2.45	ft
Critical Depth	0.09	ft
Critical Slope	0.038020	ft/ft
Velocity	0.70	ft/s
Velocity Head	0.01	ft
Specific Energy	0.12	ft
Froude Number	0.51	
Flow Type	Subcritical	

DD-6 MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout Canyon Mine
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.025000	ft/ft
Left Side Slope	1.00	H : V
Right Side Slope	20.00	H : V
Bottom Width	0.00	ft
Discharge	0.30	cfs

Results		
Depth	0.15	ft
Flow Area	0.2	ft²
Wetted Perimeter	3.12	ft
Top Width	3.06	ft
Critical Depth	0.14	ft
Critical Slope	0.032841	ft/ft
Velocity	1.35	ft/s
Velocity Head	0.03	ft
Specific Energy	0.17	ft
Froude Number	0.88	
Flow Type	Subcritical	

DD-6 MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout Canyon Mine
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.030
Slope	0.091000 ft/ft
Left Side Slope	1.00 H : V
Right Side Slope	20.00 H : V
Bottom Width	0.00 ft
Discharge	0.30 cfs

Results	
Depth	0.11 ft
Flow Area	0.1 ft²
Wetted Perimeter	2.45 ft
Top Width	2.40 ft
Critical Depth	0.14 ft
Critical Slope	0.032838 ft/ft
Velocity	2.19 ft/s
Velocity Head	0.07 ft
Specific Energy	0.19 ft
Froude Number	1.61
Flow Type	Supercritical

DD-7 MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	soil
Slope	0.013000	ft/ft
Left Side Slope	1.00	H : V
Right Side Slope	30.00	H : V
Bottom Width	0.00	ft
Discharge	0.10	cfs

Results		
Depth	0.09	ft < 0.6 ft ok
Flow Area	0.1	ft²
Wetted Perimeter	2.96	ft
Top Width	2.92	ft
Critical Depth	0.08	ft
Critical Slope	0.039680	ft/ft
Velocity	0.73	ft/s
Velocity Head	0.01	ft
Specific Energy	0.10	ft
Froude Number	0.59	
Flow Type	Subcritical	

DD-7 MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	soil
Slope	0.031000	ft/ft
Left Side Slope	1.00	H : V
Right Side Slope	30.00	H : V
Bottom Width	0.00	ft
Discharge	0.10	cfs

Results		
Depth	0.08	ft
Flow Area	0.1	ft²
Wetted Perimeter	2.51	ft
Top Width	2.48	ft
Critical Depth	0.08	ft
Critical Slope	0.039677	ft/ft
Velocity	1.01	ft/s < 5.0 fps ok
Velocity Head	0.02	ft
Specific Energy	0.10	ft
Froude Number	0.89	
Flow Type	Subcritical	

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DD-8 MINIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.043	D_{50} = 6" 12.2% slope
Slope	122000	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	4.00	ft
Discharge	0.50	cfs

Results		
Depth	0.06	ft < 0.7 ft ∴ ok
Flow Area	0.3	ft²
Wetted Perim	4.23	ft
Top Width	4.19	ft
Critical Depth	0.08	ft
Critical Slope	0.064643	ft/ft
Velocity	1.90	ft/s
Velocity Head	0.06	ft
Specific Energ	0.12	ft
Froude Numb	1.33	
Flow Type	Supercritical	

DD-8 MAXIMUM SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout As-built
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.052	D_{50} = 6" 35.7 % slope
Slope	357000	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	4.00	ft
Discharge	0.50	cfs

Results		
Depth	0.05	ft
Flow Area	0.2	ft²
Wetted Perim	4.19	ft
Top Width	4.16	ft
Critical Depth	0.08	ft
Critical Slope	0.094535	ft/ft
Velocity	2.35	ft/s < 5.0 fps ok
Velocity Head	0.09	ft
Specific Energ	0.14	ft
Froude Numb	1.83	
Flow Type	Supercritical	

DD-9 MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.040	$D_{50} = 3''$ Slope = 14.3%
Slope	0.143000 ft/ft	
Left Side Slope	2.00 H : V	
Right Side Slope	2.00 H : V	
Bottom Width	0.00 ft	
Discharge	0.10 cfs	

Results		
Depth	0.15 ft	< 0.75' ok
Flow Area	4.3e-2 ft²	
Wetted Perimeter	0.66 ft	
Top Width	0.59 ft	
Critical Depth	0.17 ft	
Critical Slope	0.060548 ft/ft	
Velocity	2.30 ft/s	
Velocity Head	0.08 ft	
Specific Energy	0.23 ft	
Froude Number	1.50	
Flow Type	Supercritical	

DD-9 MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.046 D_{50} = 3" Slope = 33.3%
Slope	0.333333 ft/ft
Left Side Slope	2.00 H : V
Right Side Slope	2.00 H : V
Bottom Width	0.00 ft
Discharge	0.10 cfs

Results	
Depth	0.13 ft
Flow Area	3.5e-2 ft²
Wetted Perimeter	0.59 ft
Top Width	0.53 ft
Critical Depth	0.17 ft
Critical Slope	0.080888 ft/ft
Velocity	2.84 ft/s < 5.0 fps ok
Velocity Head	0.13 ft
Specific Energy	0.26 ft
Froude Number	1.94
Flow Type	Supercritical

UD-1 MIN SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.035 rocky soil
Slope	0.096000 ft/ft
Left Side Slope	1.20 H : V
Right Side Slope	1.20 H : V
Bottom Width	0.75 ft
Discharge	0.20 cfs

Results	
Depth	0.10 ft <1.0 ft ok
Flow Area	0.1 ft²
Wetted Perimeter	1.05 ft
Top Width	0.98 ft
Critical Depth	0.12 ft
Critical Slope	0.042213 ft/ft
Velocity	2.42 ft/s
Velocity Head	0.09 ft
Specific Energy	0.19 ft
Froude Number	1.47
Flow Type	Supercritical

UD-1 MAX SLOPE
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Dugout ditches
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	rocky soil
Slope	0.258000 ft/ft	
Left Side Slope	1.20 H : V	
Right Side Slope	1.20 H : V	
Bottom Width	0.75 ft	
Discharge	0.20 cfs	

Results		
Depth	0.07 ft	
Flow Area	0.1 ft²	
Wetted Perimeter	0.97 ft	
Top Width	0.92 ft	
Critical Depth	0.12 ft	
Critical Slope	0.042215 ft/ft	
Velocity	3.35 ft/s	< 5.0 fps ok
Velocity Head	0.17 ft	
Specific Energy	0.25 ft	
Froude Number	2.32	
Flow Type	Supercritical	

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Culvert Verification

The following represents the evaluation of existing culverts. This calculation verifies that the culverts can handle the flows generated by the the 10-yr 6-hr storm event.

The limiting factor on a culverts is generally the inlet. With the exception of culverts with a low slope (slope < 3%)

If pipe slope is less than 3% the pipe capacity will be evaluated. Otherwise the inlet will be the limiting factor and therefore the inlet capacity will be evaluated.

Design Summary → pg. 73

Flow Master Output. → pgs. 74 - 81.

The culvert outlet Erosion protection should also be evaluated.

With the exception of UC-6 all undisturbed culverts empty into another culvert. Thus requiring no outlet protection

The energy dissipation basin for UC-6 is discussed on pgs 83-89. The design presented on pgs 83-89 represents the minimum requirements for the energy dissipation basin assuming a 72" culvert at the outlet. The 60" culvert transitions to a 72" culvert prior to reaching the outlet making this the appropriate design. The constructed energy dissipation basin is over 17' wide and 30' long thus far exceeding the minimum design.

Disturbed Area culverts DC-2, DC-3, DC-4, DC-5, and DC-6 all discharge to concrete lined ditches, concrete drop inlets, or concrete headwalls. Thus outlet protection is more than adequate.

The remaining culverts, DC-1, DC-8, DC-6, DC-9 to DC-12 have been evaluated on pages 75-80b

All Culverts can easily handle the runoff generated by the 10-yr 6-hr storm event.

DUGOUT CANYON MINE
CULVERT DESIGN FLOWS

Culvert	Contributing Watersheds	Design Flow (cfs)
DC-1	12a, 12b, 15a, 15b	3.1
DC-2	17	1.3
DC-3	50% 2b	0.5
DC-4	7a, 7b	0.7
DC-5	4, 6	0.2
DC-6	6	0.1
DC-7	8	0.2
DC-8	9	0.1
DC-9	10, 11	1.2
DC-10	12a, 12b, 60% 15b, 10% 15a	2.3
UC-1	3	0.1
UC-2	14	0.2
UC-3	5	0.4
UC-4	13	0.2
UC-5	OOCWS-1B	89.2
UC-6	OOCWS-1A, 1B, WS-3, 5, 13, 14	185.48
	See Watersheds OOCWS-1A + 1B on Plate 7-6	
DC-11	12a, 12b, 15a, 15b	3.1
DC-12	4	0.2

Note: When only part of a watershed contributes runoff to a ditch or culvert the runoff will be determined by multiplying the total flow by the percentage of the watershed area flowing to the ditch or culvert. In some cases the total watershed runoff may be used.

Design flows are rounded up to the nearest tenth of a cfs.

All design flows are for a 10-year, 6-hour storm event except UC-5 and UC-6 which are for a 100-year, 6-hour storm event.

TABLE 7-9
SUMMARY OF DIVERSION CULVERTS

Culvert	Existing Pipe Diameter (in)	Inlet Type	Average Pipe Slope (%)	Maximum Allowable HW/D*	Inlet Control Capacity (cfs)	Design Discharge (cfs)	Minimum Allowable Culvert Size (in)	Design Status
DC-1	24	Headwall	4.0	1.5	18	2.3	12	OK
DC-2	12	Projecting	6.9	1.3	2.6	0.8	<12	OK
DC-3	12	Projecting	10.2	1.5	3.2	0.5	<12	OK
DC-4	24	Headwall	5.6	1.1	14.2	1.0	<12	OK
DC-5	18	Drop Inlet	14.6	2.4	15.5	0.2	<6	OK
DC-6	12 and 6	Drop Inlet	17.8	2.0	3.5	0.1	<6	OK
DC-7	22	Projecting	5.6	1.5	14	0.2	<6	OK
DC-8	18	Projecting	5.6	1.8	10	0.1	<6	OK
DC-9	30	Projecting	5.6	2.1	41	1.2	<12	OK
DC-10	22	Projecting	4.1	1.3	12	2.1	12	OK
DC-11	24	Headwall	4.4	1.0	13.0	3.1	15	OK
DC-12	18	Projecting	3.5	1.0	5.5	0.2	<6	OK
UC-1	18	Projecting	32.0	1.2	7	0.1	<6	OK
UC-2	18	Mitre	17.0	2.3	13	0.2	<6	OK
UC-3	18	Projecting	18.0	2.4	13	0.4	<12	OK
UC-4	18	Drop Inlet	25.0	2.0	11	0.2	<6	OK
UC-5	60	Headwall	2.0 +	1.8	230	89.2 @	<48	OK
UC-6 (inlet)	60	Headwall	2.0 +	2.6	300	90.4@	<48	OK
UC-6 (barrel)	60	NA	2.0 +	NA	NA	185.48 @	60	OK

* HW/D = Ratio of the maximum headwater depth and the culvert diameter
\+ Values are for the minimum pipe slope to insure adequate capacity.
@ 100-year 6-hour storm event
For a drop inlet the inlet control capacity is determined assuming a projecting culvert since the area of the grated inlet is greater than the area of the culvert.

DC-1 OUTLET VELOCITY
Worksheet for Circular Channel

Project Description	
Worksheet	DUGOUT AS-E
Flow Element	Circular Chann
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.024	
Slope	040000	ft/ft
Diameter	24	in
Discharge	3.10	cfs

This assumes that DC-11 is plugged and all of the runoff in DD-1a must reach the pond through this culvert.

Results		
Depth	0.48	ft
Flow Area	0.6	ft²
Wetted Perime	2.05	ft
Top Width	1.71	ft
Critical Depth	0.62	ft
Percent Full	24.0	%
Critical Slope	0.015150	ft/ft
Velocity	5.34	ft/s
Velocity Head	0.44	ft
Specific Energ:	0.92	ft
Froude Numbe	1.62	
Maximum Disc	26.36	cfs
Discharge Full	24.51	cfs
Slope Full	0.000640	ft/ft
Flow Type	Supercritical	

This culvert discharges into the sediment pond. The water in the pond will dissipate the energy. Any riprap at the culvert outlet would be quickly covered by sediment. Thus, No Riprap is needed.

DC-6 OUTLET VELOCITY
Worksheet for Circular Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.024	
Slope	0.178000	ft/ft
Diameter	22	in
Discharge	0.10	cfs

Results		
Depth	0.07	ft
Flow Area	3.1e-2	ft²
Wetted Perimeter	0.70	ft
Top Width	0.69	ft
Critical Depth	0.11	ft
Percent Full	3.6	%
Critical Slope	0.021124	ft/ft
Velocity	3.24	ft/s < 5.0 fps
Velocity Head	0.16	ft
Specific Energy	0.23	ft
Froude Number	2.70	
Maximum Discharge	44.09	cfs
Discharge Full	40.99	cfs
Slope Full	0.000001	ft/ft
Flow Type	Supercritical	

No outlet protection required
D_{50} = 3" more than adequate.

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DC-7 OUTLET VELOCITY
Worksheet for Circular Channel

Project Description	
Worksheet	DUGOUT CANYON MINE
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.015	
Slope	0.056000	ft/ft
Diameter	22	in
Discharge	0.20	cfs

Results		
Depth	0.10	ft
Flow Area	0.1	ft²
Wetted Perimeter	0.85	ft
Top Width	0.82	ft
Critical Depth	0.16	ft
Percent Full	5.3	%
Critical Slope	0.007524	ft/ft
Velocity	3.72	ft/s < 5.0 fps no outlet protection required
Velocity Head	0.21	ft
Specific Energy	0.31	ft
Froude Number	2.56	
Maximum Discharge	39.57	cfs
Discharge Full	36.79	cfs
Slope Full	0.000002	ft/ft
Flow Type	Supercritical	

DC-8 OUTLET VELOCITY
Worksheet for Circular Channel

Project Description	
Worksheet	Dugout Canyon Mine
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.024	
Slope	0.056000	ft/ft
Diameter	18	in
Discharge	0.10	cfs

Results		
Depth	0.09	ft
Flow Area	4.5e-2	ft²
Wetted Perimeter	0.75	ft
Top Width	0.72	ft
Critical Depth	0.12	ft
Percent Full	6.1	%
Critical Slope	0.021061	ft/ft
Velocity	2.24	ft/s < 5 fps ∴ no outlet protection required
Velocity Head	0.08	ft
Specific Energy	0.17	ft
Froude Number	1.58	
Maximum Discharge	14.48	cfs
Discharge Full	13.46	cfs
Slope Full	0.000003	ft/ft
Flow Type	Supercritical	

DC-9 OUTLET VELOCITY
Worksheet for Circular Channel

Project Description	
Worksheet	Dugout Canyon Mine
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.024	
Slope	0.056000	ft/ft
Diameter	30	in
Discharge	1.20	cfs

Results		
Depth	0.26	ft
Flow Area	0.3	ft²
Wetted Perimeter	1.64	ft
Top Width	1.53	ft
Critical Depth	0.36	ft
Percent Full	10.4	%
Critical Slope	0.015354	ft/ft
Velocity	4.41	ft/s
Velocity Head	0.30	ft
Specific Energy	0.56	ft
Froude Number	1.84	
Maximum Discharge	56.55	cfs
Discharge Full	52.57	cfs
Slope Full	0.000029	ft/ft
Flow Type	Supercritical	

< 5 fps ∴ no outlet protection is required

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DC-10 OUTLET VELOCITY
Worksheet for Circular Channel

Project Description	
Worksheet	DUGOUT AS-E
Flow Element	Circular Chann
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.015	
Slope	041000	ft/ft
Diameter	22	in
Discharge	2.30	cfs

Results		
Depth	0.34	ft
Flow Area	0.3	ft²
Wetted Perime	1.62	ft
Top Width	1.42	ft
Critical Depth	0.54	ft
Percent Full	18.3	%
Critical Slope	0.006102	ft/ft
Velocity	6.95	ft/s
Velocity Head	0.75	ft
Specific Energ	1.09	ft
Froude Numbe	2.54	
Maximum Disc	33.86	cfs
Discharge Full	31.48	cfs
Slope Full	0.000219	ft/ft
Flow Type	Supercritical	

The outlet for this culvert is placed directly on bedrock. Thus, no outlet protection is needed.

DC-11 OUTLET VELOCITY
Worksheet for Circular Channel

Project Description	
Worksheet	DUGOUT AS-E
Flow Element	Circular Chann
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.024	
Slope	044000	ft/ft
Diameter	24	in
Discharge	3.10	cfs

Results		
Depth	0.47	ft
Flow Area	0.6	ft²
Wetted Perime	2.02	ft
Top Width	1.69	ft
Critical Depth	0.62	ft
Percent Full	23.5	%
Critical Slope	0.015150	ft/ft
Velocity	5.53	ft/s
Velocity Head	0.47	ft
Specific Energ:	0.94	ft
Froude Numbe	1.69	
Maximum Disc	27.65	cfs
Discharge Full	25.70	cfs
Slope Full	0.000640	ft/ft
Flow Type	Supercritical	

Culvert discharges into the pond. Water in the pond will dissipate energy. No riprap necessary

Note: this culvert can handle the full flow from Ditch DD-1a. However, if the culvert is plugged the overflow from the sediment Trap allows the runoff to return to Ditch DD-1a and flow to the pond through Culvert DC-1. Thus, this culvert does not need to be maintained in the winter if it freezes up since Ditch DD-1a and Culvert DC-1 can still safely convey the runoff to the pond.

80a

DC-12 OUTLET VELOCITY
Worksheet for Circular Channel

Project Description	
Worksheet	DUGOUT AS-E
Flow Element	Circular Chann
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.024	
Slope	035000	ft/ft
Diameter	18	in
Discharge	0.20	cfs

Results		
Depth	0.14	ft
Flow Area	0.1	ft²
Wetted Perime	0.94	ft
Top Width	0.88	ft
Critical Depth	0.16	ft
Percent Full	9.5	%
Critical Slope	0.019385	ft/ft
Velocity	2.34	ft/s < 5.0 no riprap needed.
Velocity Head	0.09	ft
Specific Energ	0.23	ft
Froude Numbe	1.32	
Maximum Disc	11.45	cfs
Discharge Full	10.64	cfs
Slope Full	0.000012	ft/ft
Flow Type	Supercritical	

UC-6 MINIMUM SLOPE
Worksheet for Circular Channel

Project Description	
Worksheet	DUGOUT CANYON
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.024	
Slope	0.020000 ft/ft	
Diameter	60 in	
Discharge	185.50 cfs	100-yr 6-hr storm.

Results		
Depth	3.81 ft	
Flow Area	16.1 ft²	
Wetted Perimeter	10.62 ft	
Top Width	4.25 ft	
Critical Depth	3.90 ft	
Percent Full	76.3 %	ok
Critical Slope	0.019073 ft/ft	
Velocity	11.54 ft/s	
Velocity Head	2.07 ft	
Specific Energy	5.88 ft	
Froude Number	1.05	
Maximum Discharge	214.60 cfs	
Discharge Full	199.50 cfs	> 185.5 cfs.
Slope Full	0.017292 ft/ft	
Flow Type	Supercritical	

Note the slope of 2% used for this calculation is likely much lower than is actually installed and thus this is a conservative estimate.

Design of energy dissipator at the downstream end of UC-6:

Combined flow = 89.2 cfs + 90.4 cfs
= 179.6 cfs

Design for a flow of 200 cfs. This will account for additional flow added to the culvert from potential undisturbed-area diversions that may be constructed in the future. (see page 89)

Natural channel at outlet:

Bottom width = 6 ft
Side slopes = 1.5:1
Manning's n = 0.040
Slope = 0.065 ft/ft

Velocity = 11.49 ft/s (see pg 84 of this calc.). Design the energy dissipator to ensure that the velocity exiting the dissipator is less than this value.

Exit velocity for 72-inch outlet = 18.7 ft/s (see pg 84)

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Natural Channel Condition at ~~DC-2~~ UC-6 Outlet
Worksheet for Trapezoidal Channel

Project Description	
Project File	untitled.fm2
Worksheet	Dugout Canyon Energy Dissipator Design
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.040	
Channel Slope	0.065000	ft/ft
Left Side Slope	1.500000	H : V
Right Side Slope	1.500000	H : V
Bottom Width	6.00	ft
Discharge	200.00	cfs

Results		
Depth	1.95	ft
Flow Area	17.41	ft^2
Wetted Perimeter	13.03	ft
Top Width	11.85	ft
Critical Depth	2.60	ft
Critical Slope	0.021867	ft/ft
Velocity	11.49	ft/s ← Design energy dissipator to this value
Velocity Head	2.05	ft
Specific Energy	4.00	ft
Froude Number	1.67	
Flow is supercritical.		

84

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uc-6 ~~DC-2~~ Outlet Velocity for 72-inch Culvert
Worksheet for Circular Channel

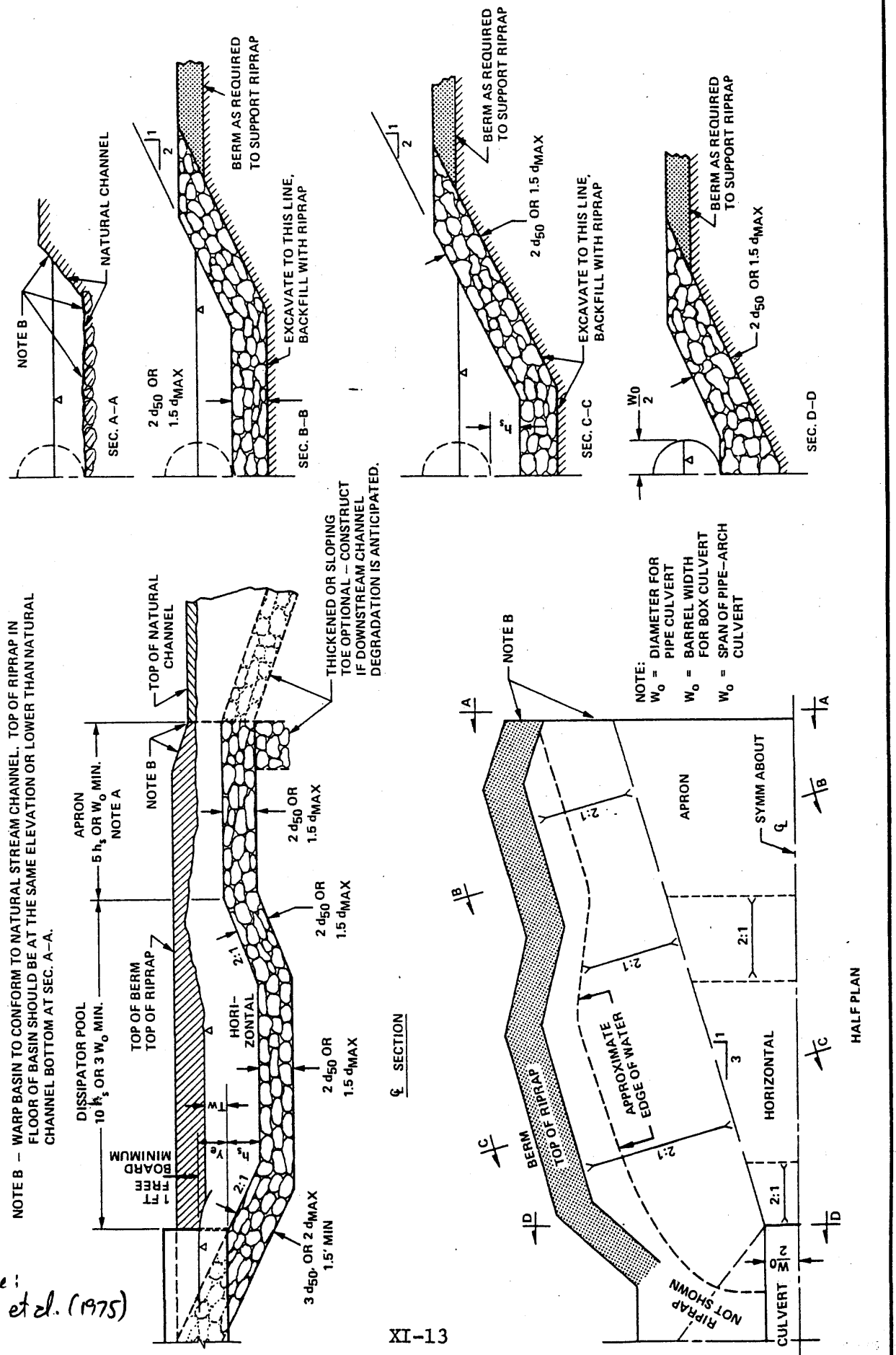
Project Description	
Project File	untitled.fm2
Worksheet	Dugout Canyon Culvert Design
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.024	
Channel Slope	0.065000	ft/ft
Diameter	72.00	in
Discharge	200.00	cfs

Results		
Depth	2.42	ft
Flow Area	10.68	ft²
Wetted Perimeter	8.26	ft
Top Width	5.89	ft
Critical Depth	3.87	ft
Percent Full	40.32	
Critical Slope	0.013628	ft/ft
Velocity	18.73	ft/s
Velocity Head	5.45	ft
Specific Energy	7.87	ft
Froude Number	2.45	
Maximum Discharge	629.10	cfs
Full Flow Capacity	584.83	cfs
Full Flow Slope	0.007602	ft/ft
Flow is supercritical.		

NOTE A – IF EXIT VELOCITY OF BASIN IS SPECIFIED, EXTEND BASIN AS REQUIRED TO OBTAIN SUFFICIENT CROSS–SECTIONAL AREA AT SECTION A–A SUCH THAT Q_{des}/CROSS SECTION AREA AT SEC. A–A) = SPECIFIED EXIT VELOCITY.

NOTE B – WARP BASIN TO CONFORM TO NATURAL STREAM CHANNEL. TOP OF RIPRAP IN FLOOR OF BASIN SHOULD BE AT THE SAME ELEVATION OR LOWER THAN NATURAL CHANNEL BOTTOM AT SEC. A–A.



Source: Corry et al. (1975)

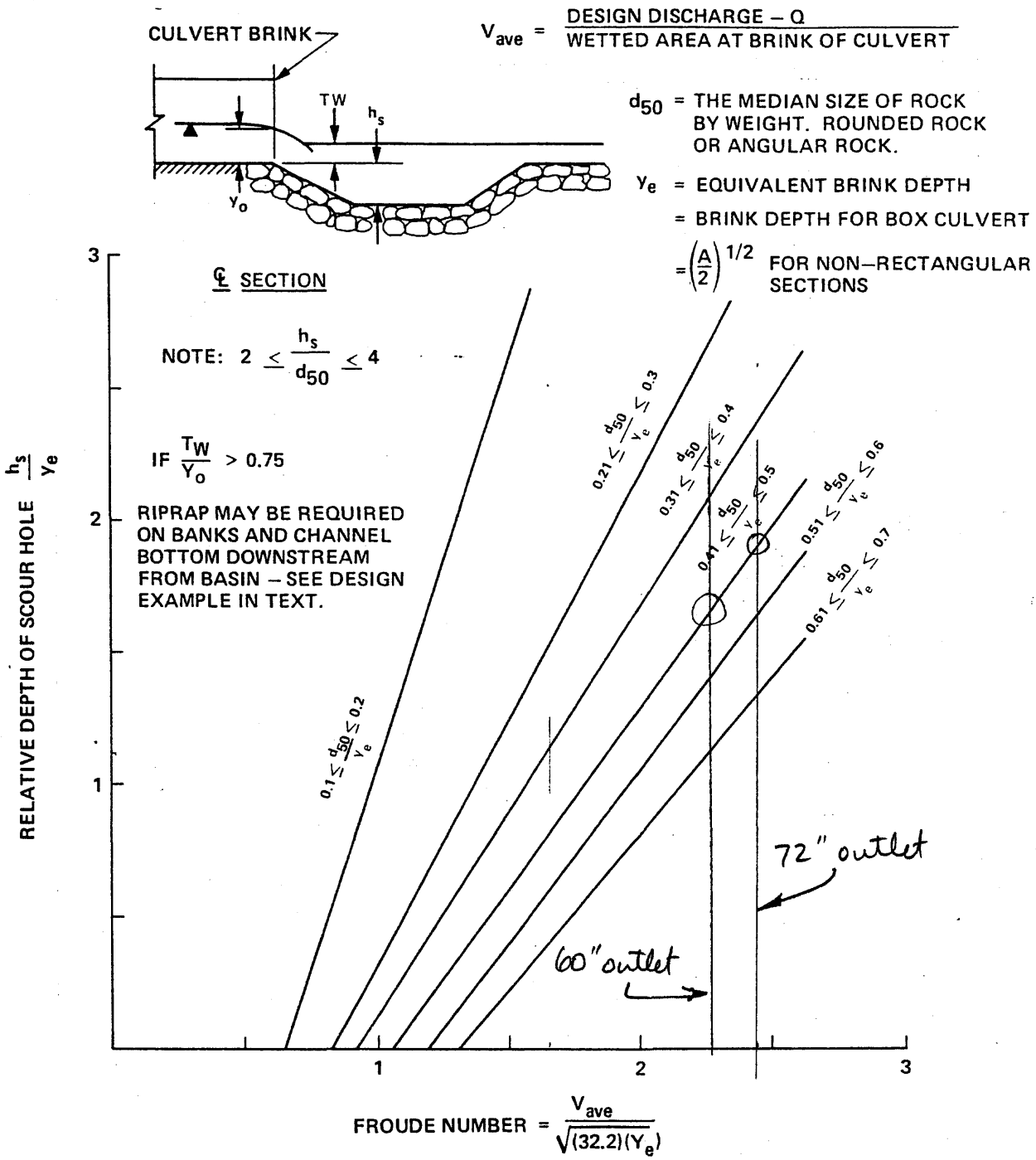


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

Source: Corry et al. (1975)

Assuming a culvert outlet diameter of 72 inches:

Brink depth = 2.42 ft (supercritical flow - see pg 89)
Outlet velocity = 18.73 ft/s
Froude number = 2.45
Assume $d_{50}/y_e = 0.41$

$d_{50} = (0.41)(2.42) = 0.99$ ft ~ 12"

$h_s/y_e = 1.90$ (see pg 86)

$\frac{h_s}{d_{50}} = \frac{1.90}{0.41} = 4.63$ — Too high (not acceptable)

Increase d_{50}/y_e to 0.50 and evaluate.

$\frac{h_s}{d_{50}} = \frac{1.90}{0.50} = 3.8$ Acceptable $(2 < \frac{h_s}{d_5} < 4)$

$d_{50} = (0.50)(2.42') = 1.21' \sim 15''$
$h_s = (1.90)(2.42') = 4.60' \sim 4'8''$

Basin dimensions:

Length of dissipator pool (min):
$(10)(h_s) = (10)(4.60\text{ ft}) = 46.0$ ft ⇐ pool length
$3W_0 = (3)(6) = 18$ ft

Length of dissipator apron (min):
$(5)(h_s) = (5)(4.60\text{ ft}) = 23.0$ ft ⇐ apron length
$W_0 = 6$ ft

Required apron width = 9'-0" (see pg 88)

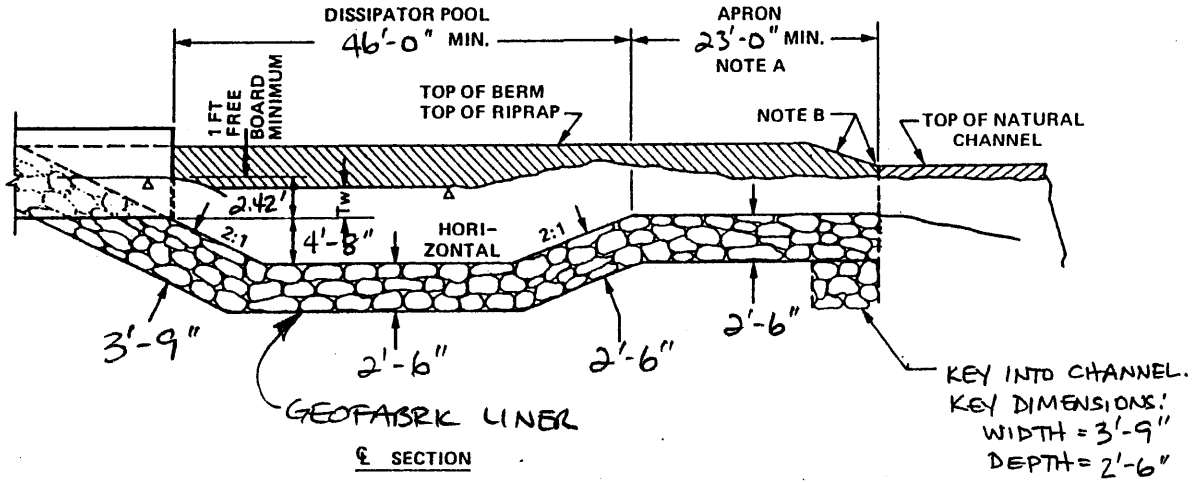
See cross section on pg 88 of this calc.

Note → According to Corry et.al. (1975), either angular or rounded riprap will be stable in the basin. Angularity of riprap does not affect basin design.

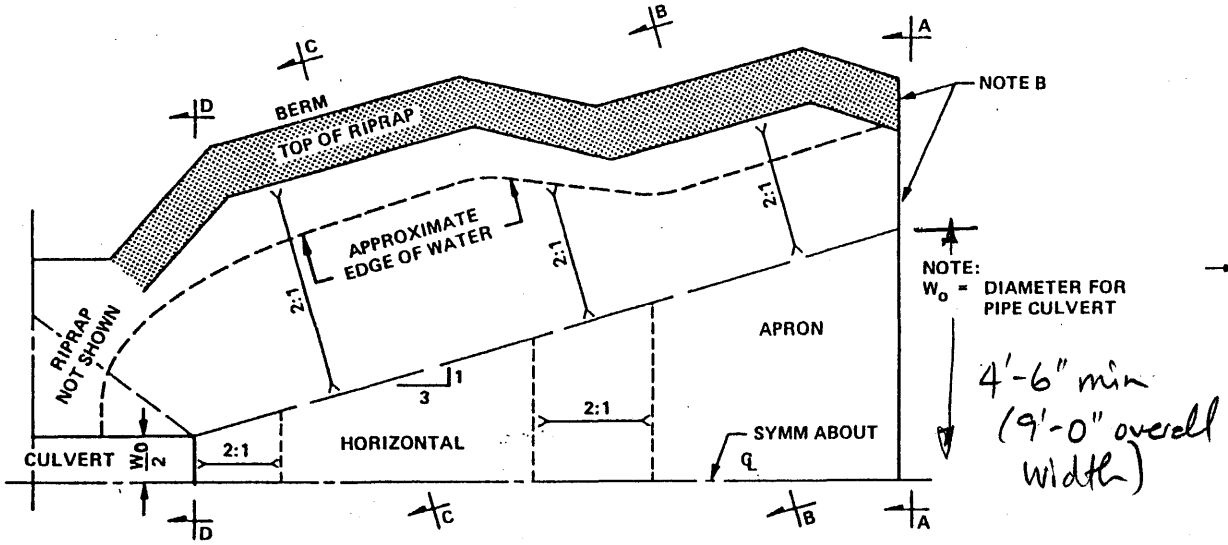
DIMENSIONS FOR 72 CULVERT OUTLET

NOTE A – IF EXIT VELOCITY OF BASIN IS SPECIFIED, EXTEND BASIN AS REQUIRED TO OBTAIN SUFFICIENT CROSS–SECTIONAL AREA AT SECTION A–A SUCH THAT Q_{des}/(CROSS SECTION AREA AT SEC. A–A) = SPECIFIED EXIT VELOCITY.

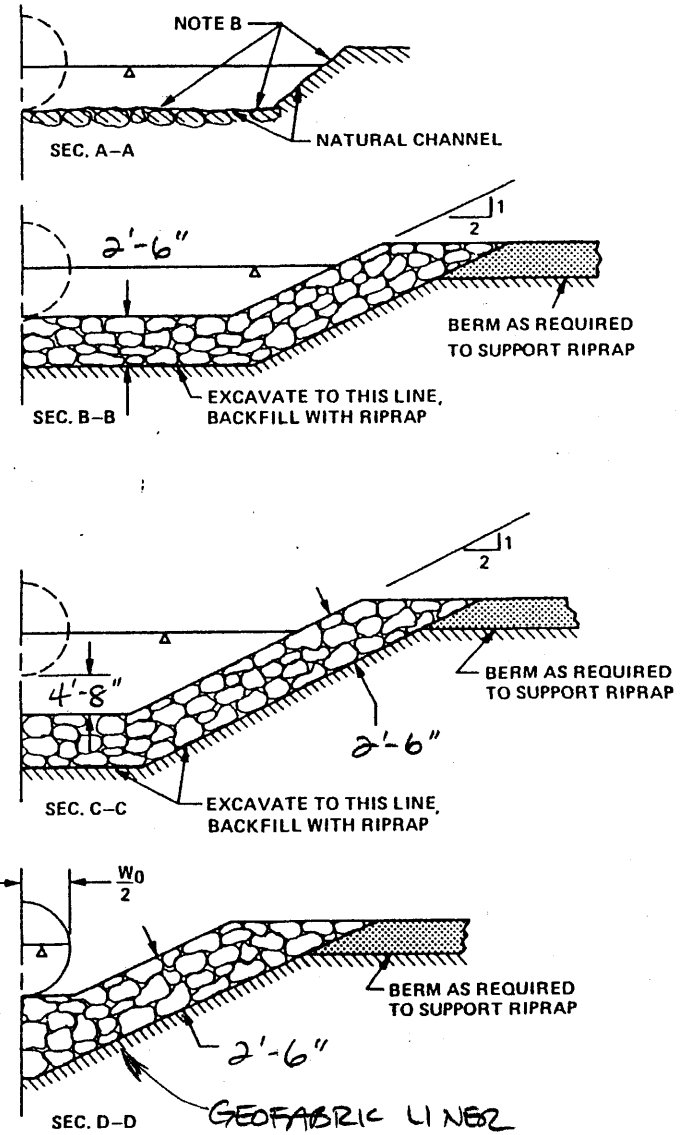
NOTE B – WARP BASIN TO CONFORM TO NATURAL STREAM CHANNEL. TOP OF RIPRAP IN FLOOR OF BASIN SHOULD BE AT THE SAME ELEVATION OR LOWER THAN NATURAL CHANNEL BOTTOM AT SEC. A–A.



℄ SECTION



HALF PLAN



DETAILS OF RIPRAPPED CULVERT ENERGY BASIN

As mentioned on page 82 additional flow may be added to UC-5 from undisturbed-area diversions.

(3) undisturbed watersheds have been diverted into UC-5: WS-3, WS-5, WS-13 and WS-14 They have added the following to UC-5.

WS-3	0.93 cfs	(pg 91)
WS-5	2.66 cfs	(pg 92)
WS-13	1.28 cfs	(pg 93)
WS-14	1.01 cfs	(pg 94)
	5.88 cfs	

Total design flow prior to diversion = 179.6 cfs (pg 83)

Total flow with diversions = 179.6 + 5.88 = 185.5 cfs

All design work was done for a flow of 200 cfs

185.9 < 200 cfs

∴ The design is still valid.

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-3 100-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 4.87 acres
Depth = 2.05 inches	CN = 70.00
Duration = 6.0 hrs	Time conc.= 0.07 hrs

OUTPUT SUMMARY

Runoff depth: 0.260 inches
Initial abstr: 0.857 inches
Peak flow: 0.93 cfs (0.190 iph)
at time: 2.518 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-5 100-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 15.90 acres
Depth = 2.05 inches	CN = 70.00
Duration = 6.0 hrs	Time conc.= 0.12 hrs

OUTPUT SUMMARY

Runoff depth: 0.260 inches
Initial abstr: 0.857 inches
Peak flow: 2.66 cfs (0.166 iph)
at time: 2.555 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-13 100-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 15.31 acres
Depth = 2.05 inches	CN = 67.00
Duration = 6.0 hrs	Time conc.= 0.12 hrs

OUTPUT SUMMARY

Runoff depth: 0.189 inches
Initial abstr: 0.985 inches
Peak flow: 1.28 cfs (0.083 iph)
at time: 2.575 hrs

Triangular Hydrograph Calculations using

SCSHYDRO Program

Watershed I.D.:
WS-14 100-YR 6-HR

INPUT SUMMARY

STORM :	WATERSHED :
Dist.= SCS Type `b'	Area = 13.11 acres
Depth = 2.05 inches	CN = 67.00
Duration = 6.0 hrs	Time conc.= 0.15 hrs

OUTPUT SUMMARY

Runoff depth: 0.189 inches
Initial abstr: 0.985 inches
Peak flow: 1.01 cfs (0.076 iph)
at time: 2.587 hrs

ALTERNATE SEDIMENT CONTROL AREAS

ASCA-5 (topsoil storage area, as indicated on Plate 2-3) →
Berm to be constructed around stockpile to control runoff from the pile and runon to the pile. Design to contain the 10-yr, 24-hr event.

Area within berm (Plate 2-3) = 1.9 ac

10-yr, 24-hr precip = 1.95 in

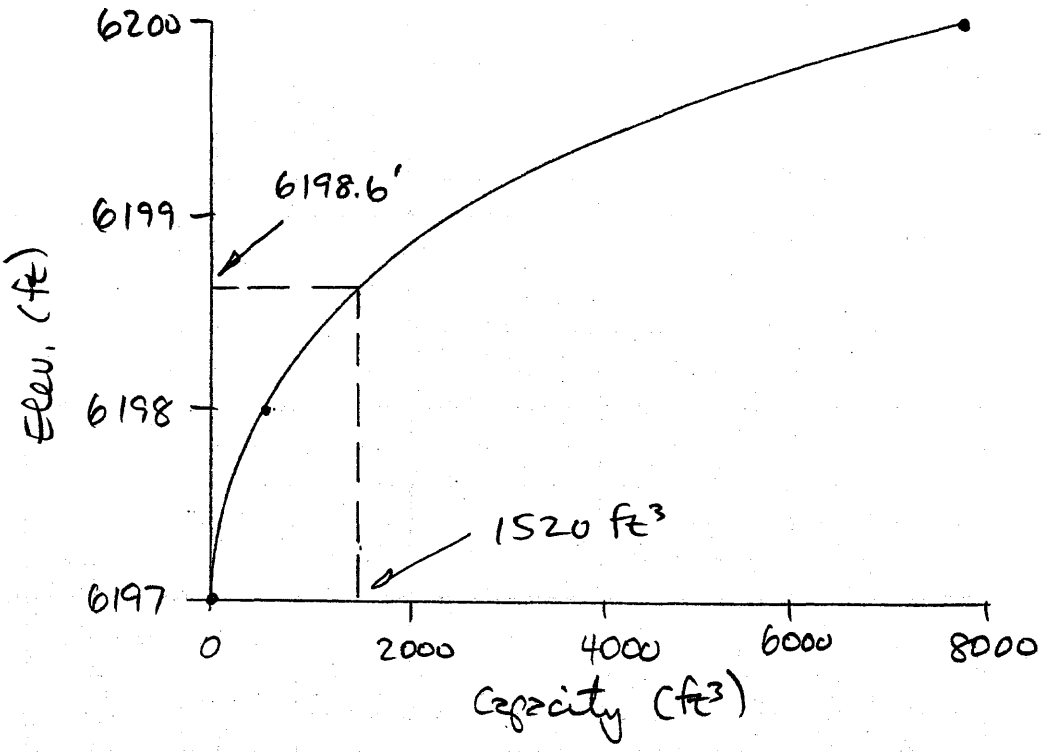
CN = 70 (based on low compaction of soil when placed, large percentage of stockpile which will be occupied by a relatively flat top, and revegetation of the stockpile — equivalent to pasture, fair condition, Hydrologic Soil Group B [compare with pg 7a of this calc.]).

Q = 0.22 in
= 1520 ft³

Assume that the berm is constructed with a minimum height of 1', which height is increased at the downstream (southwest) corner of the stockpile area to a minimum of 3'. At this SW corner, the elevation of the berm will be maintained at 6200! Based on this elevation, the following capacity can be stored behind the embankment:

Elev. (ft)	Area (ft²)	Volume (ft³) Incremental	Volume (ft³) Cumulative
6197	0	0	0
6198	1025	513	513
6200	6200	7225	7738

Stage-capacity curve for berm:



From the above curve, less than 2' of water will temporarily impound behind the berm during the design event. Hence, the berm as designed is adequate to control the runoff.

SEDCAD 4.0
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Civil Software Design

Attachment A Dugout Creek
Riprap Calculations

Material: Riprap

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
15.00	1.0:1	1.0:1	1.1			

Simons/OSM Method - Mild Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	179.00 cfs	
Depth:	1.88 ft	
Top Width:	18.75 ft	
Velocity:	5.66 fps	
X-Section Area:	31.65 sq ft	
Hydraulic Radius:	1.559	
Froude Number:	0.77	
Manning's n:	0.0377	
Dmin:	2.00 in	
D50:	9.00 in	
Dmax:	12.00 in	

INCORPORATED
EFFECTIVE:
MAY 06 1999
UTAH DIVISION OIL, GAS AND MINING

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Number/Designation Comparison for Ditches and Culverts 2006 with 1998			
2006 Diversion Ditch	1998 Diversion Ditch	2006 Culvert	1998 Culvert
DD-1a	DD-4	DC-1	DC-6
DD-1b	DD-3	DC-2	DC-10
DD-2a	DD-7	DC-3	-
DD-2b	DD-7	DC-4	DC-5
DD-2c	DD-7	DC-5	DC-7
DD-2d	DD-7	DC-6	-
DD-2e	DD-6	DC-7	-
DD-3a	DD-8	DC-8	DC-8
DD-3b	DD-8	DC-9	DC-9
DD-3c	DD-8	DC-10	-
DD-4	DD-11 &12	DC-11	-
DD-5	DD-13	DC-12	-
DD-6	DD-14, 15 &16	UC-1	UC-6
DD-7	DD-17	UC-2	UC-2
DD-8	-	UC-3	UC-1
DD-9	-	UC-4	UC-3
UD-1	UD-1	UC-5	UC-4
		UC-6	UC-5

Note: The ditches and culvert numbering designation was revised in 2006. This chart has been prepared for ease of comparison in incidences where a document has not been updated to the 2006 numbering system.

ATTACHMENT A TO APPENDIX 7-11

Riprap Calculations for DD-7 Outlet and
Stream Bank Directly Downstream of the County Culvert

Note: Information in this Attachment A to Appendix 7-9 is included here rather than modifying existing pages within Appendix 7-9. The affixed Professional Engineer's Stamp certifies the calculations contained only within this attachment.

The ditch number was changed from DD-7 to DD-2a in May of 2006. All information referenced for DD-7 refers to DD-2a in this attachment.