REPLACED
PAGES FROM
SKYLINE'S
5/10/89
SUBMITTAL.

The groundwater situation is complicated by the ~~present~~ presence of underground workings of the old Union Pacific Mine. The present condition of these workings is unknown and unobtainable due to an underground smoldering fire.

2.3.5 Uses of Water in the Aquifers

2.3.5.1 Surface Water Rights

The water rights on and adjacent to the Skyline property which were on record with the Utah Division of Water Rights as of December, 1986 are listed in Volume 4. The locations of these water rights can be found on Plate 2.3.5.1-1.

Surface water rights in the area are primarily for stockwatering and irrigation. Stockwatering rights are almost entirely directly on the stream. Irrigation rights are centered around the town of Scofield and in Flat Canyon, southwest of the center of the property. Irrigated lands consist almost entirely of pasture. Only stockwatering rights are present on the lease area.

2.3.5.2 Ground Water Rights

Ground water rights on and adjacent to the Skyline Property, on record with the Utah Division of Water Rights as of December, 1986, are listed in Volume 4 and presented on Plate 2.3.5.2-1. Again, rights are primarily for stockwatering and irrigation (mainly lawns and gardens). Only one spring on the lease area has a filed water right. Only a limited number of wells are located in the area.

Also shown on Plate 2.3.5.2-1 are exchanges of Scofield Reservoir water for ground water in Pleasant Valley Creek Basin. These are also listed in Volume 4. All exchanges are wells, with the exception of 91-940. Most of the exchanges serve the industrial and domestic needs for mining companies in the area.

TABLE 2.4-1
SURFACE WATER INFORMATION - AVERAGED FROM SKYLINE DATA
STATION VC-9, MOUTH OF ECCLES CREEK
(MAY 1978 - MARCH 1986)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Flow-cfs	2.8	--	2.2	5.3	20.0	12.2	5.4	3.3	2.8	2.4	2.5	2.4
TDS-mg/l	332	367	--	427	247	235	267	324	308	325	352	379
TSS-mg/l	57	33	127	6.7	1060	26	34	62	26	36	24	20
pH-std units	8.0	8.1	8.2	8.1	8.1	8.1	8.0	8.0	7.8	8.0	7.7	7.9
Iron-total mg/l	1.48	2.45	1.17	5.59	10.44	0.70	0.40	0.63	0.64	0.56	0.51	0.69
Iron-Dis. mg/l	--	--	--	--	0.033	0.036	0.016	0.050	0.020	--	0.010	--
Manganese-mg/l	0.13	0.11	0.14	0.22	0.28	0.06	0.06	0.08	0.07	0.10	0.10	0.10

TABLE 2.4-2
SURFACE WATER INFORMATION - AVERAGED FROM SKYLINE DATA
STATION UPL-10 - HUNTINGTON CREEK ABOVE ELECTRIC LAKE
(NOVEMBER 1978 - MARCH 1986)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Flow-cfs	6	--	6.6	7.6	11.9	33.5	6.37	3.00	3.62	2.92	1.40	4.50
TDS-mg/l	185	--	--	226	123	122	165	195	180	192	182	212
TSS-mg/l	3	--	--	1	13	6	4	14	6	2	12	2
pH-std units	7.3	--	7.7	7.8	7.9	8.1	8.1	8.0	7.8	7.7	7.7	8.0
Iron-total mg/l	0.423	--	0.144	--	0.350	0.037	0.450	0.440	0.370	0.550	0.440	0.270
Iron-dis. mg/l	--	--	--	--	0.076	0.011	0.080	0.110	0.060	--	--	--
Manganese mg/l	0.027	--	0.022	0.014	0.022	0.020	0.024	0.012	0.005	0.035	0.035	0.017

of sampling. The Permittee commits to the following surface water monitoring program when surface flow is present.

1. Four monitoring stations will be established: two stations on the drainage from the east and two sites on the drainage from the south. Stations will be located both above and below the rock waste disposal site in each of the drainages. (See Drawing 2.6.6-1.)

2. When flow is present, these stations will be monitored, when accessible, at the same frequency and for the same constituents as the stations in Eccles Creek. The data will be tabulated and reported in the same manner as the Skyline water quality data.

3. The data from these stations will be evaluated for non-point source contribution from ground water aquifers. This procedure offers the best potential for detection of ground water contamination.

The Upper O'Connor seam required a breakout to improve ventilation. The breakout is on a south facing slope in a side canyon of the South Fork of Eccles Creek (see map no. 3.1.2-1).
* A new road was built across this canyon to gain access to the breakout area. The canyon flows water in all but the driest of years. If the canyon was flowing water, the creek was sampled above and below the construction site on a daily basis during the active construction period. The samples will be tested for total suspended solids and settleable solids.

of sampling. The Permittee commits to the following surface water monitoring program when surface flow is present.

* 1. Four monitoring stations will be established: two stations on the drainage from the east and two sites on the drainage from the south. Stations will be located both above and below the rock waste disposal site in each of the drainages. (See Drawing 2.6.6-1.)

2. When flow is present, these stations will be monitored, when accessible, at the same frequency and for the same constituents as the stations in Eccles Creek. The data will be tabulated and reported in the same manner as the Skyline water quality data.

3. The data from these stations will be evaluated for non-point source contribution from ground water aquifers. This procedure offers the best potential for detection of ground water contamination.

* The Upper O'Connor seam will require a breakout to improve ventilation. The breakout will be on a south facing slope in a side canyon of the South Fork of Eccles Creek (see map no. 3.1.2-1). A new road will need to be built across this canyon to gain access to the breakout area. The canyon flows water in all but the driest of years. If the canyon is flowing water, the creek will be sampled above and below the construction site on a daily basis during the active construction period. The samples will be tested for total suspended solids and settleable solids.

2.8 AQUATIC WILDLIFE RESOURCES

Introduction

Both Huntington Creek and Eccles Creek flow through the project area and both provide habitat for reproducing resident populations of cutthroat trout. Cutthroat trout from Electric Lake use upper Huntington Creek for spawning and nursery activities. Scofield Reservoir, although stocked with rainbow trout exclusively, has numerous cutthroat trout which have been produced in Eccles Creek and other tributary streams such as Winter Quarters, Woods Creek, Lost Creeks, Pleasant Valley Creek and possibly Boardinghouse Creek.

Eccles Creek

Eccles Creek is a small mountain stream draining west to east into Pleasant Valley Creek which flows north approximately 3 miles where it empties into Scofield Reservoir. Discharges in Eccles Creek are frequently as low as 2 cfs during late summer, fall and winter months; and high flows seldom exceed 50 cfs, even at the creek mouth. Water temperatures of streams such as Eccles Creek fluctuate because of turbulence from the rough channels. During November to March, water temperatures remain between 0-2°C. In the summer, water temperatures often fluctuate from 12-15°C daily although high temperatures seldom exceed 20°C.

Through natural erosion of mudstone, sandstone and shale deposits, Eccles Creek has periods of high total suspended solids (sedimentation). This occurs, however, during periods of high runoff when the stream waters have sufficient energy (velocity) to carry the fine sediments out of the canyon rather than depositing them on the
* coarser substrate materials. During normal runoff years, there are numerous clean trout spawning gravel beds in Eccles Creek. Maintenance of this resource is dependent upon a continuation of adequate substrate, food base and water quality conditions.

The existing aquatic species of Eccles Creek, fish and macroinvertebrates, have adapted to tolerate natural temperature fluctuations and sediment loads. The macroinvertebrate communities of Eccles Creek have a high diversity of species representing all major trophic groups. There are species found only in high quality water streams indicating the high water quality of Eccles Creek. There are also environmentally resistant taxa present. This high diversity represents a resiliency to environmental change, especially short term changes.

Upper Eccles Creek above the Valley Camp Mine Road (at sampling stations ECO3, ECO2, UPMF, UPSF, Figure 2.8-A), have numerous taxa of macroinvertebrates found only in high quality waters and stable habitats. Lower Eccles Creek (Stations ECO4 and ECO5) has a more tolerant macroinvertebrate community with taxa tolerant to sedimentation dominating the community.

Cutthroat trout maintain naturally reproducing populations in Eccles Creek from the National Forest boundary downstream to the creek mouth. The fish have upstream migration access to a point just above Whiskey Gulch where a series of beaver dams frequently block upstream movement. There are no fish in the upper forks of Eccles Creek.

* Construction activities caused sufficient sediment loading into Eccles Creek resulting in a significant reduction in fish populations. Cooperative efforst with DWR, however, resulted in habitat improvement by 1986 sufficient for near recovery of these populations.

Huntington Creek

Huntington Creek above Electric Lake is a small mountain stream draining north to south into Electric Lake. Discharges are

habitat affinities and high-interest species status. These results are reported in tabular form (Tables 2.9-1 through 2.9-3). They are listed according to their various ecological classifications (Dalton et al. 1978; Durrant 1952; Hall and Kelson 1959; Hayward 1967; and Hayward et al 1958). All species whose ranges appear to overlap any or all of the potential area of impact are listed. Generally speaking, the proposed project area could potentially be inhabited by about 57 mammalian, 6 amphibian and 15 reptilian species. Some of these are considered high interest species for the habitats and local area of concern and 48 percent are protected species.

Terms used in Tables 2.9-1 through 2.9-3 are defined as follows:

1. Plant communities (discussed in detail in another portion of this report): (a) spruce-fir; (b) aspen; (c) sage brush; (d) mixed shrubs and grasses; and (e) riparian habitat.

2. Resident species: (R) Any species that inhabits the area during reproduction activities.

3. Casual or Rare: (Ca) Any species that is only observed occasionally over a period of several years but whose status has not been determined as "threatened" or endangered".

4. High-interest: (X) Any species that is endangered, threatened, game or of economic or recreation value.

* TABLE 2.11-1

Seeded Vegetation	Acres	Minimum Inches	Yards^3	Recommended Depth/in.	Yards^3
Grass/Forb	17.7	6	14,278	12	28,556
Spruce/Fir	15.30	12	24,683	12	24,683
Aspen/Snowberry	15.0	24	48,700	30	60,500
TOTAL	48.0		87,661		113,739

REPLACES	TEXT
Table 2.11-1 Page 2-115	Table 2.11-1 Page 2-115 Date 10/15/88

* Denotes change or addition

* TABLE 2.11-2 (continued)
TOPSOIL VOLUMES

Area	Mapping Unit	Vegetation	Acreage	Good (Ave Depth/ft)	Poor (Ave Depth/ft)	Useable Soil, yd^3	Unsuitable Soil, yd^3
Conveyor Route	2	Grass/Forb	0.8	4.5	0.5	5,808	645
	5	Sagebrush/ Grass	2.1	0.5	0.-	1,694	--
	6	Aspen/ Snowberry	0.1	2.5	2.5	403	403
	7	Sagebrush/ Grass	0.3	--	--	--	--
	8	Aspen	.3	2.0	3.0	968	1,452
	9	Rock Outcrops	0.3	--	--	--	--
	10	Aspen	0.5	2.5	1.0	2,017	807
	11	Aspen	0.8	2.5	1.5	3,227	1,936
	12	Grass/forb Elderberry	0.3	2.5	--	1,210	--
	13	Spruce/fir	0.5	1.0	2.5	806	2,016
Total - Conveyor			6.0			16,133	7,259
Waste Rock Disposal		Sagebrush/ Grass	1.3	0	0	0	0
Water Tank & Wells		Aspen	.2				
South Fork Breakout		Aspen	.3	4.5	4.4	2,242	2,133
		Spruce/Fir	.1	4.5	4.4	747	74
	GRAND TOTAL		48.0			134,731	127,535

REPLACES TEXT
Table 2.11-2 Page 2-117 Table 2.11-2 Page 2-117 Date 10/15/88

* TABLE 2.11-2 (continued)
TOPSOIL VOLUMES

Area	Mapping Unit	Vegetation	Acreage	Good (Ave Depth/ft)	Poor (Ave Depth/ft)	Useable Soil, yd^3	Unsuitable Soil, yd^3
Conveyor Route	2	Grass/Forb	0.8	4.5	0.5	5,808	645
	5	Sagebrush/ Grass	2.1	0.5	0.-	1,694	--
	6	Aspen/ Snowberry	0.1	2.5	2.5	403	403
	7	Sagebrush/ Grass	0.3	--	--	--	--
	8	Aspen	.3	2.0	3.0	968	1,452
	9	Rock Outcrops	0.3	--	--	--	--
	10	Aspen	0.5	2.5	1.0	2,017	807
	11	Aspen	0.8	2.5	1.5	3,227	1,936
	12	Grass/forb Elderberry	0.3	2.5	--	1,210	--
	13	Spruce/fir	0.5	1.0	2.5	806	2,016
Total - Conveyor			6.0			16,133	7,259
Waste Rock Disposal		Sagebrush/ Grass	1.3	0	0	0	0
Water Tank & Wells		Aspen	.2				
South Fork Breakout		Aspen	.3	4.5	4.4	2,242	2,133
		Spruce/Fir	.1	4.5	4.4	747	74
	GRAND TOTAL		48.0			134,731	127,535

REPLACES TEXT
Table 2.11-2 Page 2-117 Table 2.11-2 Page 2-117 Date 10/15/88

Recreation

Recreational use of the lease area affected by surface operations consists primarily of hunting big game, game birds, and small game species; fishing in Eccles Canyon below the portal area; from the south fork to the mouth of the canyon sightseeing, snowmobiling, and cross country skiing. Limited camping and picnicking also occurred in the mouth of Eccles Canyon (U.S. geological Survey, 1979).

Eccles Canyon Road provides the only direct access from Scofield Reservoir to Huntington Canyon and is used as an access route from the Scofield Reservoir recreation area to the recreational use areas at higher elevations in the northern end of the Wasatch Plateau (U.S. Geological Survey, 1979).

Forestry

Forest uses are limited primarily to cutting firewood and fenceposts. Occasional timber sales from National Forest lands are made to salvage insect-killed spruce timber. One such sale, totalling 2.5 million board feet, was made in the Kitchen Creek drainage basin on the west side of the coal lease area in 1977.

2.12.2 Capability and Productivity of the Permit Area Affected by Surface Operations and Facilities

Portions of the permit area affected by surface operations and facilities of the underground Skyline Mines are capable of supporting limited forestry, grazing, and recreational uses. Farming in the area is prohibited by the steep and rocky terrain of Eccles Canyon.

FORESTRY AND GRAZING

Land-Use Capability

Data concerning resource availability for forestry and grazing

uses within the permit area affected by surface operations and facilities were collected and assimilated by Dr. Joseph R. Murdock, professor of Botany and Range Science at Brigham Young University, Provo, Utah (1979). Vegetative plot studies were made in the affected permit area within five general area classifications: the spruce-fir timber type, the aspen timber type, the sagebrush type, the riparian type and the unrecovered disturbed area type, composed of existing roads and the unrecovered site of an abandoned gas well and the abandoned Eccles Mine located on the proposed portal site. From these specific vegetative plot studies, the productivity and capability of supporting grazing and forestry uses were determined for each general area. The plot studies revealed that both the spruce-fir timber type and the unrecovered disturbed area type contained no significant herbage usable for grazing purposes.

The number of animal units and animal unit months that the other three areas are capable of supporting was determined by converting the available green plant species desirable by sheep to a dry weight basis and assuming that one 1,100 pound cow having one calf, which constitutes an animal unit, consumes 27 pounds per day. The results of this analysis are presented in Table 2.12.2-1 for the yard area, the conveyor corridor and the bypass road.

The capability of the area affected by surface operations and facilities to support forestry uses was determined from the total land area in the spruce-fir and aspen timber types and the available timber volume per area as published by the U.S. Forest Service in the "Land Management Plan" for the Manti-LaSal National Forest, "Management Unit A-1", (1979). The spruce-fir timber type contained approximately 10,000 board-feet per acre and the aspen timber type contains 5,300 board-feet per acre. Therefore, within the affected area, there were approximately 201,000 board-feet of the spruce-fir timber and 93,800 board-feet of aspen timber.

Farming in the lease and permit areas would be impractical due to the steep terrain (50 - 80 percent slopes).

PREVIOUSLY MINED AREAS

Underground Mined Areas

The abandoned Eccles Canyon coal mine, located in the southwest quarter of the southwest quarter of section 13 of T13S and R6E, is the only mine located in the proposed mine plan area. The Eccles Canyon mine, operated intermittently from 1899 to 1952, mined the Lower O-Connor "A" seam using the room and pillar method. The mine covered an area of approximately 500 feet south of the portal and 700 feet west of the National Forest boundary (Doelling, 1972 and Heath, 1979). Doelling (1972) states, "Little is known about the Eccles Canyon mine....Production figures are incomplete but estimated to be small." The Eccles Canyon Mine portals have been covered and sealed by SR-264 and the Skyline Mine benches.

No other known minerals of value have been mined within the lease and permit area. There are two producing and two abandoned gas wells located in Eccles Canyon. These gas wells are not classified as "mining". Therefore, no other minerals have been mined within the Skyline coal lease area.

Surface Mined Areas

There have been no previous surface mines located within the mine plan or adjacent areas.

LOCAL LAND-USE CLASSIFICATIONS

Both the county zoning ordinances and the "Land Management Plan" for the Manti-LaSal National Forest, prepared by the U.S. Forest Service (1987), classify local land-use for the lease area of the Skyline Mine as recreation, forestry and mining.

County Zoning Ordinances

The Emery County zoning map dated 1970 and the Carbon County zoning ordinance amended February 15, 1977 with a revised zoning map dated 1974 have zoned the Skyline property for recreation, forestry, and mining (RF&M). Section 8-7-1 of the Carbon County zoning ordinance states:

> "Recreation, forestry, and mining zone has been established as a district in which the primary use of the land is for recreation, forestry, grazing, wildlife, and mining purposes. In general this zone....is characterized by...high grazing lands interspersed by ranches, recreational camps and resource outdoor recreational facilities and mines and facilities related thereto."

U.S. Forest Service Land Management Plan

All but approximately seventy acres of the lease area lie within the boundary of the National Forest, and are therefore subject to the "Land Management Plan" for the Manti-LaSal National Forest prepared by the U.S. Forest Service (1987). All of the lease area located within the National Forest boundary is designated in the land management plan as "Coal Lands Management Area A". In the "Land Management Plan" the Forest Service lists management objectives pertaining to the lease area. The management objectives (U.S. Forest Service, 1979) and the impacts from the Skyline Mine pertaining to these objectives are described in the following sections.

GROUNDWATER

Management Objective

"Improve and maintain watershed conditions to reduce overland flows and to recharge the underground aquifer. Reduce soil

losses from the unit where feasible. Protect perennial springs and ground water, and maintain or improve water quality to meet the standards for existing or possible future use of the water".

Impacts

Approximately 46.1 acres of soil were disturbed within Eccles Canyon, which include the portal and yard area of the mine, the railroad laodout area and the conveyor corridor. Though on-site erosion will increase, it will not reach the stream and significantly impact the water quality of Eccles Creek due to required sediment control measures. Therefore, the water quality of Eccles Creek will not be degraded. In fact, dissolved solids concentrations in the area should be improved downstream as a result of removal of good quality water from the ground water system through the mines prior to mixing with poorer quality ground water in the lowlands (Southeastern Utah Association of Governments. 1977).

VEGETATION, RANGE MANAGEMENT AND SOILS

Vegetation Management Objective

"Improve desirable vegetative cover to protect watersheds, decrease erosion, and maintain soil stability."

Range Management Objective

"Improve desirable plant species composition and increase forage production on suitable livestock range. Maintain livestock numbers and capacities at a level which is compatible with watershed values, wildlife uses, and other resource uses."

Soil Management Objective

"Maintain soil productivity and minimize soil loss through sound resource management."

The simultaneous production of both oil and gas and coal should present no major conflicts. The log of an oil and gas well, located in the mouth of Eccles Canyon and developed by Three States National Gas company in 1953, indicates that oil and gas zones were first discovered at an elevation of approximately 4,200 feet above sea level. Doelling (1972) shows one coal outcrop in Eccles Canyon at an elevation of approximately 8,500 feet above sea level, which is 4,300 feet higher than the shallowest oil and gas find. Though other mineable coal seams may be at greater depths, the oil and gas zones are at sufficient depths to result in no overlap between oil and gas zones and coal seams. Therefore, the production of both oil and gas and coal should be compatible.

ARCHEOLOGY AND PALEONTOLOGY

Management Objective

"Manage and protect important archeological, historical and paleontological resources to preserve scientific and interpretive values in accordance with applicable laws and regulations."

Impacts

To date there are no known archeological or paleontological sites within the proposed disturbed areas.

TIMBER AND FIRE

Timber Management Objective

"Harvest timber and forest products on a sustained yield basis where environmental effects to resource uses and activities are acceptable and where regeneration can be assured. Improve timber growth and yield on productive sites."

reasonable proximity to railroad transportation facilities available in Pleasant Valley and the availability of at least some relatively flat acreage adjacent to the outcrop. The Lower O'Conner "B" seam will be reached via underground rock slopes from entries in the Upper O'Conner or Lower O'Conner "A" seams.

Two to four entry portals will be used at each mine drift entry location for the intake of air and the transportation of mining crews and materials, and one to three portals will be used to exhaust air. The number of entries will increase within the mine in order to reduce the velocity of the air and to facilitate a reduction of air resistance losses. One additional entry portal in each mine will be used for the conveyance of coal from the mine.

* The Upper O'Connor seam will also require a breakout to improve the ventilation. The Breakout will be on a south facing slope in a side canyon of the South Fork of Eccles Creek (see map no. 3.1.2-1). No exhaust fans or permanent activity is planned for this area once construction is finished.

The size of portals vary to conform to the mineable height of the Upper O'Connor seam and the Lower O'Connor "A" seam.

A series of parallel underground openings called entries, separated by blocks of coal providing support, called pillars, are driven from the portal location and are called "main entries", or "mains". These entries are comparable to the main avenues of a city, and allow access for the provision of power, piping, haulage, ventilation, and support services. The design of the mains and the layout of the mines for the Skyline project have been engineered after careful review of the many conditions that can affect the mining operations.

A large number of parallel headings has been determined necessary to maintain air velocities within required acceptable limits (usually less than 800 ft/min. for the 4-6 tons of air required to be circulated through the mine for every ton of coal mined). The final number of developed entries will be based on the requirements of the mine area to be accessed.

Since the Permittee considers five feet to be the minimum seam height which can be economically extracted, maps show mining

3.2 COMPONENTS OF OPERATION

3.2.1 Ponds, Impoundments, and Dams

Two sedimentation ponds are included in the design of the Skyline Mine plan. Each retention pond has been designed to provide adequate volume for sediment containment and also adequate volume for a theoretical 24-hour detention of run-off resultant of a 24-hour, 10-year rainstorm. The minesite sedimentation pond also contains additional volume to adequately treat mine water
* discharge. An engineers certification of proper construction for these ponds may be found on page 3-17A. The location and design characteristics for each of these two ponds are described in the following:

Mine Site Sediment Pond

A detention pond is located at the mine site adjacent to the crushing and truck loading station. It will detain surface run-off from the 31.1 acre disturbed mine site shown on Map 3.2.1-1. Precipitation from a 10-year, 24-hour rainstorm is expected to be 2.45 inches. After infiltration, surface run-off from a storm of this intensity should be 1.50 inches, based on the assumption that the land surface will be similar to gravel and dirt roads with SCS run-off curve numbers of about 90.

The required volume for providing a theoretical detention of the run-off from a 10-year, 24-hour storm is estimated as: 1.50 inches per acre x 31.1 acres = 169,340 cubic feet. The required volume for sediment storage is estimated as (0.10 acre-feet) x (31.1 acres) = 135,472 cubic feet. The combined volumes for 24-hour retention and sediment storage equal 304,812 cubic feet. The pond contains a volume of approximately 421,505 cubic feet from the spillway elevation of 8,579.6 to a depth of 20.4 feet. The difference between the total pond volume of 421,505 cubic

SKYLINE MINE SEDIMENT PONDS

I certify that the sediment ponds at the Skyline mining project were constructed under the supervision of a registered, professional engineer. They were constructed in a prudent manner and field-fitted to meet design specifications.

The final construction of the minesite sediment pond actually exceeded design requirements for holding capacity.

Roland Heath
Professional Engineer
Aug. 1, 1982

feet and that required for surface run-off retention of 169,340 cubic feet plus sediment storage of 135,472 cubic feet is 116,693 cubic feet and is for retention and treatment of mine water discharge (See Map 3.2.1-2). The pond volume dedicated to mine water discharge will contain the average inflow from the mine based on a 30-day averaging period. This 30-day period is consistent with reporting conditions of the NPDES Discharge Permit. The pond will be decanted only after retaining the
* runoff event for the required 24-hour period or in accordance with the NPDES discharge permit conditions.

A minimum of three feet have been added to the pond embankments for freeboard. Slopes are 3h:1v for backwater impoundments (pressure slope) except on the southeast side where solid rock is located. In the area of solid rock, slopes are near vertical.

The combined emergency and principal spillway pipe utilizes an oil skimmer collar. This pipe will safely pass any run-off from a 24-hour, 100-year storm plus mine water discharge. The pipe is sized to pass a one-foot head of pressure which will allow a flow of 80 cfs. The maximum run-off inflow rate expected from the
* disturbed 31.1 acre portal site during a 24-hour, 10-year storm is 49.41 cfs.

The plan view with contours of the pond is shown on Map 3.2.1-2B. The detailed design of the mine site sedimentation pond and the pond cross-section with detailed construction notes are shown in Map 3.2.1-2. A walkway providing access to the sediment pond dewatering device control valve is shown on Map 3.2.1-1. Detailed design of the spillway pipe and dewatering structure is shown on Map 3.2.1-2A.

Coal Loadout Sediment Pond

A detention pond is located adjacent to the storage silos at the coal loadout site. It detains surface run-off and associated

sediment from the disturbed site. Precipitation from a 24-hour,10-year rainstorm has been calculated to be 2.45 inches. After infiltration, the surface runoff is estimated at 1.50 inches.

The required volume for providing a theoretical 24-hour detention of the calculated runoff has been estimated as: 1.50 inches per
* acre x 7.35 acres = 40,020 cubic feet. The required volume for
* sediment storage has been estimated as: 0.10 acre-feet x 7.35
* acres = 32,016 cubic feet. The combined volumes equal 72,036 cubic feet.

The coal load-out sediment pond contains a volume of 76,212 cubic feet. Two feet have been added for freeboard. Berm width at the top of the embankments (7,928-foot level) will be eight feet. Embankment slopes were constructed at 2h:1v.

A single pipe is used for both the emergency and principal spillway with its inlet at the 7,926-foot level. Using an anti-seep collar, this pipe will safely pass any runoff from a 24-hour, 100-year storm. The pipe is sized to pass 30 second-feet of water with a one-foot head of pressure. This is more than the maximum runoff inflow rate expected from the seven acre mine site during a 24-hour, 100-year storm.

Functioning as principal spillway, the pipe will release runoff at a rate that will allow a 24-hour detention of the runoff resultant of a 24-hour, 10-year rainstorm. A riprapped section along the pond embankment crest, similar to that described previously, is provided to prevent overtopping should the principal emergency spillway pipe become blocked during an extreme precipitation event.

The plan view of the load-out sediment pond is shown on Map 3.2.1-3, and the pond cross section with detailed construction notes is shown in Map 3.2.1-4. Engineering calculations

with four vibrating feeders at a variable controlled rate of 100 to 1,800 tons/hour. These feeders will deliver loads to an 84 inch wide conveyor transporting coal to the train loading system.

Two ground storage areas at the mine site have been established. (Location shown on Map 3.2.3-4). They will be used on an as needed basis. The south storage area will hold approximately 37,500 tons and the north storage area will hold approximately 75,000 tons. Actual capacity will depend upon such factors as height, compaction, fill slope and safe working practices. It is planned for the piles to encroach onto one of the adjacent cut slopes that do not have vegetation on them. Volumes will be consistent with and in compliance with PSD regulations. Drainage will be provided on both sides of the south storage pile and will direct run-off water into the established surface drainage system. Drainage on the north storage area will always be provided along one side of the pile. This drainage system will be of sufficient size to handle the entire 50 year 24 hour storm runoff for the middle fork drainage. This provision is for emergency use in the event of flood resulting in the plugging of the Middle Fork trash rack (see map 3.2.3-4).

The haul route from the truck tipple to the stockpiles includes a section of Utah State Highway SR-264. To mitigate potential traffic hazards, the following actions have been taken: 1) Warning signs have been placed along the highway above and below the Truck Loadout tipple; 2) A traffic pattern has been implemented to allow for the best and safest traffic approach to the highway; and 3) Training sessions are required for contract truck drivers handling stockpile coal on safe driving procedures to be followed on the haul route.

Coal hauled by trucks from the mine site permit area creates the possibility of coal spilling and coal being moved onto the non-permitted highway area. To help reduce the possibility of spillage, the permittee will: 1) Load trucks so as to prevent spills and overloading; 2) apply dust pallative to unpaved haul roads; and 3) Clean up accidental coal spills on SR-264 promptly.

bench facilities through a system of large diameter culverts. This system has been designed to handle the runoff from the 100-year, 24-hour precipitation event.

Natural water runoff from the surrounding hillsides is intercepted by a system of diversion channels and directed around the site. These channels are lined or riprapped where necessary to reduce erosion and to provide energy dissipation. These constructed channels have all been seeded and have well established vegetation in them. No observations have been made of any overland flow entering these ditches since initial construction seven years ago. These observations are further validated by numerous inspections by Utah Fuel Company environmental personnel, Utah Department of Oil, Gas and Mining personnel, and Office of Surface Mining personnel who have observed these channels being lined with grass and forb vegetative litter, conifer needle fall and small twigs from adjacent aspen trees, conifer trees and browse plants. These observations conclude that no perceptive flows have occurred in these channels although there has been significent above average precipitation during the past several years. The Permittee does commit to continue inspection and to maintain these channels in an operational state.

All runoff from disturbed areas is directed to the sedimentation pond for settling through a collection system of surface ditches, paved swales and culverts. Engineering design calculations for these collection ditches are included in the Engineering Calculation section of Appendix Volume A-3. The drainage from the upper pads are collected and directed to a buried culvert. The entrance to this culvert is by the main entrance gate to the mine maintenance complex area and is shown on Map 3.2.1-1. This buried culvert is underneath Utah State Highway SR-264 to an outfall above the sediment pond. No drainage from the Utah State Highway system enters the mine drainage system.

*

There are several exempt areas that do not report to a sediment
* pond. At the railroad loadout area there are four areas, as shown on Map 3.2.1-3, that do not report to the sediment pond. The first area is on the north side of the disturbed area. This area has been reseeded and has a well established cover of grass and forbs. The toe of the slope is lined with straw bales to intercept any sediment. Part of the area also has a collection ditch below the straw bales. The ditch has a series of straw bales across the drainage at 15-20 feet intervals. Much of the ditch has become well grassed-in and is almost indistinguishable from the adjacent undisturbed areas. The ditch empties into a flat, naturally grassed area and no sediment has been observed to
* reach this area during the past six years. The second area (.30 acre) is south of the track dump area and is the fill slope of the access road. The ditch at the toe of the fill slope has a
* series of straw bales to control sediment. The third area (.30 acre) is adjacent to the sediment pond. This area is lower in elevation than the pond and therefore cannot be drained into the pond. Part of this area is a roadway and has been paved. The rest of the area has been seeded and grass and forbs are becoming established. The unpaved area is lined with straw bales to intercept sediments, and two drainage collection basins have been constructed to collect drainage water. No measurable amounts of
* sediment have left this area. The fourth area (.2 acre) is adjacent to the railroad loadout structure. There are two
* parcels to this area, a north parcel and a south parcel. The north and south parcels are covered with 4 inches of clean 2 inch material. No measurable amounts of sediment have left either of these two parcels.

There are five other exempt areas along the Eccles Canyon Highway which do not report to a sediment pond. There are three well houses (.25 acre), a water storage tank area (.3 acre) and the conveyor bench area (6.0 acres), shown on Map 3.2.3-2. The three well houses and the water storage tank area all have straw bales

to intercept any sediment. No measurable amounts of sediment have left any of these areas. The conveyor bench is located at the top of the cut slope for Utah State Highway SR-264. The drainage pattern for this conveyor bench was field located and fitted through a cooperative effort of Utah Fuel Company and Utah Department of Oil, Gas & Mining.

Map 3.2.5-1 illustrates the water and wastewater flow diagram.

Sanitary sewage from the mine surface facility is routed through a system of gravity pipes below grade to the collection tank. The sewage is removed by truck for disposal at a municipal facility. No sewage effluent will be discharged into Eccles Creek. Oil and water separators are used within the maintenance complex building for separation of oils from wash-down water. Skimmed oil is then discharged to the waste oil storage tank for disposal. Waste oil is pumped from the tank and sold to a waste oil dealer for refining. The remaining water is discharged to the sedimentation pond.

As mining progresses, underground storage sumps are developed for storage of mine drainage water. This water is pumped to these underground sumps for later reuse within the mine as process water. Quantities in excess of that necessary for this purpose will be discharged to the sedimentation pond for further clarification prior to discharge. Oil skimmers have been installed to remove oil and grease residue from mine discharge water. Should the mine water drainage be either high or low pH or high in concentrations of heavy metals, treatment will be provided to reduce these values to acceptable levels prior to discharge from the permit area. Water quality data collected to date indicate that additional treatment will not be necessary. Table 3.2-2 lists five parameter measurements and applicable NPDES Standards. This table also summarizes mine water discharges collected in compliance with NPDES Discharge Permit No. UT-0023540. As illustrated in the table, levels of pH, TDS, oil and grease, suspended solids and iron were normally well within NPDES standard limits. The Permittee's installation of oil skimmers has prevented any occurrences of oil or grease levels exceeding permit limitations.

TABLE 3.2-2

RESULTS OF WATER QUALITY MEASUREMENTS OF THE NPDES-001 DISCHARGE

	Number of Measurements	Minimum	Average	Maximum	NPDES Permit Standard
PH	32	6.8	7.66	8.3	6.5-9.0
Iron, mg/l	32	0.12	0.81	3.13	Maximum 2.0 Daily Maximum 7.0
Oil & Grease, mg/l	32	.1	0.12	0.8	10
Total Suspended Solids mg/l	16	5	26.8*	171*	Maximum 35 Daily Maximum 70 Average 25
Total Dissolved Solids mg/l	32	140	348	695	700
Settleable Solids mg/l (as applicable)	17	.1	.12	0.4	Maximum 0.5

*After this maximum, the option of measuring settleable solids in lieu of suspended solids during precipitation or runoff events was initiated. Average without this maximum is 17.1 mg/l.

compacted to ensure culvert stability during subsequent mine bench construction.

The culvert inlets of the North Fork and Middle Fork were reconstructed in 1984 after being plugged by debris flows. These inlets are shown on Maps 3.2.6-1A, 3.2.6-1B and 3.2.6-1C. The culvert in the south west fork was extended by UDOT in 1986 approximately 300 feet off of the permit area and the inlet is now within their jurisdiction.

The culvert system was designed to allow easy maintenance access. Manholes were placed at each directional change point as additional access points. The culverts were constructed of
* plastic coated galvanized metal to ensure that the culverts do not rust. Culverts will be inspected periodically throughout the life of the mines.

* The culverts will be plugged and left in place and the stream channel restored following completion of the mining operations. The channel will be riprapped in erosional areas.

Eccles Canyon Road

The Eccles Canyon road is part of the State Road collector system.

Mine Site Sediment Pond

The initial construction phase of the mine site sediment pond structure involved the removal of topsoil and vegetation. As the pond was being constructed, lift heights were maintained to ensure maximum compaction. The final lift, which achieved the proposed elevation of the pond bottom, is of an impermeable material, capable of preventing seepage. Following this construction operation, the bank and spillway pipe construction was begun. The bank was constructed in lift heights to ensure maximum compaction and was constructed of impermeable material to prevent seepage. A spillway pipe was added during construction

of the bank. The pond is shown in plan view (Map 3.2.1-1) and in cross section (Map 3.2.1-2).

Surface runoff will enter the pond via gravitational flow.

Other than sediment removal when 60 percent of the design sediment storage volume is exceeded, only limited maintenance of the pond will be required.

Following cessation of mining operations, the sedimentation pond will remain in place to receive upslope runoff, where possible, until the mine site is revegetated, stabilized and surface runoff is demonstrated to meet the applicable water quality standards.
* After these conditions have been met, water will then be permanently diverted from the pond and residual pond water allowed to evaporate. When the residual water has evaporated and the mud dried, the pond will be backfilled, covered with topsoil and revegetated.

Coal Load-out Sediment Pond

Prior to construction of the coal load-out sediment pond, topsoil and vegetation were removed from the pond site area. The pond was excavated to the proposed bottom elevation and the excavated material used to construct the dam. The dam was constructed in lifts of heights which ensured maximum compaction. A spillway pipe was added during the construction of the dam. After the dam was completed, a principal emergency spillway was constructed. The pond is shown in plan view (Map 3.2.1-4) and in cross section (Map 3.2.1-2). The pond requires only limited maintenance, i.e., sediment removal to an approved disposal site when 60% of the design sediment storage volume is exceeded.

After mining operations are completed, the site will be revegetated. The sedimentation pond will remain until surface

runoff from the site is demonstrated to meet the applicable water quality standards. Water will then be permanently diverted from the pond and residual pond water allowed to evaporate. When the residual water has evaporated and the mud dried, the pond will be backfilled, covered with topsoil and revegetated.

No hydrologic information is available for the quality and quantity of the ground water of the area due to the existence of coal fires. Coastal believes that the proper sealing of the rock waste containment area, as outlined in the Development and Operations Plan, will prevent the communication of any accidental ignitions of the rock/coal waste into the adjacent coal seams, thereby eliminating degradation of the ground water resources beyond the effects of the existing underground coal fires.

No surface water information is presented herein due to the intermittent surface water flows in the disposal site area. Coastal proposed to redirect any surface runoff waters around the site into the original pre-strip mining drainage system in order to prevent contamination of the surface runoff by the disposal activities. Coastal will also contain all runoff water from within the area to be affected in a catchment basin. Therefore, no surface water will discharge from within the disposal site.

Site Development

The development of the rock disposal site required upgrading the existing unpaved access road to the abandoned pit as well as the development work required to convert the abandoned strip pit into a disposal site.

Access Road

The access road to the disposal site follows the alignment of an existing unimproved access road shown on Map 3.2.8-1. Approximately 3,158 feet of the unimproved pre-existing road were upgraded to comply with the standards set forth for Class II roads in UMC 817.170 to 817.164, inclusive. The gravelled surface road is approximately 16 feet wide (see Figure 3.2.8-A).

Near-surface portions of the UP coal seams which were mined and then burned have subsided at the intersection of entries. Other

areas have developed subsidence cracks which transfer the coal fire combustion products to the surface, generally leaving coal-like condensates which are readily apparent in field examinations. No evidence of subsidence or of coal fires has been observed under or within ten or more feet from either side of the exising road. The anticipated infrequent need to use the rock waste disposal site once there is sufficient underground development for the material to be permanently stored underground will minimize the potential for subsidence due to truck traffic over the road. Truck drivers have been trained to look for the surface evidence of subsidence and, should subsidence occur, good engineering practices will be employed in backfilling depressions and compacting the subsided area. A subsidence monitoring program is not needed due to the absence of current mining and the inferred low density of underground development beneath the access road alignment.

Disposal Site

The preparation of the disposal site entailed:

1. Emplacment of drainage controls to redirect surface waters around the site and into the original, pre-strip mining drainage system.

2. The emplacement of non-combustible fill material to form a barrier across the floor and along the walls of the abandoned strip pit where coal seams were exposed during prior mining activities and where cracks or fissures are venting from adjacent coal fires.

3. The construction of a fence and gate to control access to the disposal site.

4. Some shrubs will be removed from near the top of the north side of the pit just prior to the time the area

they occupy will be covered with waste rock. The sparse grass and weeds will not be removed.

The previous course of the drainage from the canyon to the east of the abandoned strip pit was rerouted around the abandoned strip pit in order to redirect the flow into the original stream course, and therefore, around rather than into the disposal site. An open channel and dip are used to redirect the water flow (Maps 3.2.8-1 and 4.16.1-1B).

The dip to redirect the drainage across the access road and into the original stream channel was rip-rapped with a blanket of reasonably well graded, hard, durable native rock approximately 4" x 4" or larger in size, compacted in a layer approxiamtely two feet deep and no less than 30 feet wide. The surface of the rip-rap blanket was graded such that water is directed into the orignal stream channel to the south of the road.

The compacted non-combustible fill is being emplaced along the floor and walls of the pit in order to isolate the coal seams and venting cracks or fissures in the highwall from the material disposed of in the pit. Approximately two feet of compacted material was placed on the floor and three feet along the wall. The material to isolate exposed coal and venting cracks or fissures along the walls is being built up and compacted in lifts during normal rock disposal operations after an initial 3 to 4 feet high barrier is constructed. Any new venting cracks or fissures will be reported. Drainage onto the floor of the pit is directed to a pre-existing sump at the east end of the abandoned strip pit (Map 4.16.1-1B). Cross sections through the pit and sump are shown in Maps 3.2.8-2 and 4.16.1-1B. A fence and gate were installed in order to prevent unauthorized access to the rock disposal site (Map 3.2.8-1).

There are two locations in the pit where coal is exposed. These exposures of the coal seam are shown in Map 4.16.1-1B. The exposure in the west end of the pit required sealing before any

B. Disposal Site

The underground development waste rock and excess fill material from the unit train loadout area will be emplaced and compacted in layers not exceeding two feet in thickness. As layers of compacted material are added to the floor of the pit, the three-feet thick noncombustible barrier, where required to

isolate any exposed coal seams and venting cracks and fissures, will be added.

The compacted layers of fill will be sloped at an angle of 2-3 percent to the east in order to direct any drainage from the pit floor into the sump at the east end of the pit. The sump will be pumped out if filled and the water will be hauled to the loadout sedimentation pond.

Shrubs that are along the north side of the pit will be removed just prior to the time the area they occupy will be covered with waste rock.

The spreading and compaction of the rock waste will be accomplished through the use of a dozer and dump trucks. The dozer will be used to spread and level the material and both the dozer and the dump truck will be used to compact the material. Repeated, long-term operation of the equipment on each lift of material will ensure adequate compaction of the fill.

The Permittee cannot commit to the size of the dozer or the number of trucks to be used during the infrequent use of the pit. The Permittee will use its 10-ton capacity truck that may be supplemented by others which, in addition to the dozer, will be used as the need occurs.

The rock waste disposal site will be regularly inspected during configuration and at least quarterly after disposal operations begin.

The Permittee's registered engineer or other qualified professional specialist will provide the Division a certified report within two weeks after each quarterly inspection and after the completion of construction. The reports will describe the activities during the reporting period and will certify that the site has been constructed and operated as specified in the design approved by the Division.

3.2.11 South Fork Breakout Area

The Upper O'Connor seam required a breakout to improve ventilation. The breakout is on a south facing slope in a side canyon of the South Fork of Eccles Creek (see map 3.1.2-1).

Access to the breakout area is via an existing road up the South Fork of Eccles Creek to the Manti-LaSal National Forest boundary. From the Forest boundary on, the road had been water barred and was reopened. Where the road leaves the main South Fork tributary, it crosses two side drainages. Temporary 18" culverts were installed in these drainages during the construction period. The Forest Service road then continues up the side drainage. Approximately 600 feet up the side drainage a new class III life of project road was constructed for a distance of 75' across the drainage to the breakout area (see map 3.2.11-1). During installation of the culverts silt fence and/or straw bales, dikes were placed downstream to control sediment in the stream.

As construction started on the project, the trees and brush were cleared from the road location. The topsoil was then stripped from the road location and stored on the abandoned temporary Forest Service road above the construction area and on the small
* opening at the mouth of the canyon where the knob was removed. All of the topsoil was stored in lifts not to exceed 2' deep, and then seeded to the approved seed mixture and fertilized. After the topsoil from the road location was removed, a 36" culvert was placed in the stream bed to provide a life of project crossing. The initial fill material over the culvert was hauled in from the mouth of the side canyon where a small knob was partially removed to help dress up an area. This also created a safe open area to burn slash created by the breakout construction. After the slash has been burned, the area will be dressed up and seeded with the approved seed mixture and fertilized. No further activity is planned for this

* 3.2.11 South Fork Breakout Area

The Upper O'Connor seam will require a breakout to improve ventilation. The breakout will be on a south facing slope in a side canyon of the South Fork of Eccles Creek (see map 3.1.2-1).

Access to the breakout area will be via an existing road up the South Fork of Eccles Creek to the Manti-LaSal National Forest boundary. From the Forest boundary on, the road had been water barred and will need to be reopened. Where the road leaves the main South Fork tributary, it crosses two side drainages. Temporary 18" culverts will be installed in these drainages during the construction period. The Forest Service road then continues up the side drainage. Approximately 600 feet up the side drainage a new class III life of project road will need to be constructed for a distance of 75' across the drainage to the breakout area (see map 3.2.11-1). During installation of the culverts silt fence and/or straw bales, dikes will be placed downstream to control sediment in the stream.

As construction starts on the project, the trees and brush will be cleared from the road location. The topsoil will then be stripped from the road location and stored on the abandoned temporary Forest Service road above the construction area. All of the topsoil will be stored on this abandoned road in a lift not to exceed 2' deep, and then seeded to the approved seed mixture. After the topsoil from the road location has been removed, a 36" culvert will be placed in the stream bed to provide a life of project crossing. The initial fill material over the culvert will be hauled in from the mouth of the side canyon where a small knob will be removed to help dress up an area (see map no. 3-2-11-1). This will also create a safe open area to burn slash created by the breakout construction. After the slash has been burned, the area will be dressed up and seeded

area unless there is fill material that was not used and is needed for final reclamation. The fill slopes of the fill covering the 36" culvert were seeded, fertilized, and covered with excelsior mats to help prevent erosion until the vegetation is established. A flared inlet and a trash rack were installed on the culvert. The fill slope was rocked up to the high water line to also help protect the inlet and outlet. The culvert was bedded in washed gravel at the slope of the natural channel of 14.3%.

A track hoe removed the topsoil from the breakout area so it could be stored in the storage area. As the subsoils were encountered, they were used to bring the new road up to grade.
* The new road was built with a 1-2% adverse grade from the existing road to the breakout area. Subsoil not used as road fill was stored on the small opening at the mouth of the canyon where the knob was removed. All of the stored soil was then seeded with the approved seed mix, and then a layer of straw mulch was applied.

The new road and the breakout area disturbed .42 acres, and the area where the knob was partially removed disturbed .19 acres, for a total new disturbance of .61 acres. The road that was reopened for access and to provide topsoil storage disturbed an additional .35 acres.

The breakout pad will be constructed so that the surface drainage will drain into the mine where it will enter the normal mine drainage and will eventually enter the portal area sedimentation pond. A small seep was encountered during construction. A French drain was constructed to drain this seep into the creek drainage system.

A combination of silt fences and strawbales was used to treat the surface run-off from the disturbed area of the new road, the breakout pad and the topsoil and subsoil storage areas. The silt

with the approved seed mixture. No further activity is planned for this area. The fill slopes of the fill covering the 36" culvert will be seeded and covered with excelsior mats to help prevent erosion until the vegetation is established. A flared inlet will be installed on the culvert. The fill slope will be rocked up to the high water line to also help protect the inlet. The culvert will be bedded in washed gravel at the slope of the natural channel of 14.3%.

A track hoe will then start removing the topsoil from the breakout area so it can be stored in the storage area. As the subsoils are encountered, they will be used to bring the new road up to grade. The new road will be built with a 1-2% adverse grade from the existing road to the breakout area. Subsoil not used as road fill will also be stored on the abandoned temporary Forest Service road below the topsoil storage area. All of the stored soil will then be seeded with the approved seed mix, and then a layer of straw mulch will be applied.

It is estimated that the new road will disturb .11 acres and the breakout area .29 acres, for a total new disturbance of .40 acres.

The breakout pad will be constructed so that the surface drainage will drain into the mine where it will enter the normal mine drainage and will eventually enter the portal area sedimentation pond.

A combination of silt fences and strawbales will be used to treat the surface run-off from the disturbed area of the new road, the breakout pad and the topsoil and subsoil storage areas. The silt fences and strawbales will be located as needed between the disturbed and undisturbed areas to treat run-off from the disturbed area. These silt fences and strawbales will be maintained until adequate vegetation is established.

fences and strawbales were located as needed between the disturbed and undisturbed areas to treat run-off from the disturbed area. These silt fences and strawbales will be maintained until adequate vegetation is established.

The breakout portals are screened to prevent humans or animals from entering the mine. No exhaust fans or permanent activity is planned for this area once construction is finished.

Once the breakout portals were established, all of the disturbed areas were seeded and all of the roads on National Forest land were water barred and seeded. All seeding was done with the
* approved seed mixtures and then fertilized. One of the temporary 18" culverts was removed but left on site in case emergency access is needed back into the breakout area.

All slash created by the project was piled so it can be burned at a later date. All brush disposal will be in accordance with standard U.S. Forest Service requirements.

Once the breakout area has been faced up and the portals established, no further activities are planned or anticipated at the area until final reclamation begins, except for periodic inspections. The culvert trash rack and portal high wall will be inspected at a minimum of three times a year: (1) early spring; (2) mid-summer at the beginning of the thunderstorm season, and (3) late fall before freeze-up.

The breakout portals will be screened to prevent humans or animals from entering the mine. No exhaust fans or permanent activity is planned for this area once construction is finished.

Once the breakout portals have been established, all of the disturbed area will be seeded and all of the roads on National Forest land will be water barred and seeded. All seeding will be done with the approved seed mixtures. One of the temporary 18" culverts will be removed but left on site in case emergency access is needed back into the breakout area.

All slash created by the project will be piled so it can be burned at a later date. All brush disposal will be in accordance with standard U.S. Forest Service requirements.

Once the breakout area has been faced up and the portals established, no further activities are planned or anticipated at the area until final reclamation begins.

3.4 AREA AFFECTED BY EACH PHASE OF OPERATIONS

The area affected by the Skyline Mines project can be divided into two major categories:

(a) Surface acreage disturbed by construction/installation of coal handling and associated facilities, and

(b) Surface acreage overlying underground mine workings.

Disturbed Surface Acreage

The offices, bathhouse, workshop, portal, fans, and other necessary facilities utilize a site of 31.1 acres. Approximately .26 acres is used for water tank bench. The coal loading and handling facility at the mouth of Eccles Canyon utilizes
* approximately 9.0 acres, of which a sedimentation pond requires 0.6 acres. The enclosed conveyor belt, transporting material from the mining portals to loading points, has disturbed 6.0 acres. The Scofield waste rock disposal site utilizes 1.3 acres. The South Fork breakout area has disturbed approximately .96 acre. In total, the surface acres disturbed is 48.6 acres. The disturbed and permitted area and bonded area for the mine portal area and loadout area are shown on Maps 3.2.1-1 and 3.2.1-3, respectively.

The pre-mining phase of earth work and dirt removal commenced in the spring of 1980 and was completed in 1981. The actual construction and installation of facilities necessary for coal mining and handling began in early 1981.

Area Overlying Underground Mining

Interpretation of the available geological data and bore holes information indicates that certain portions of all three seams within the leasehold are non-mineable. Total acreage values for mineable acreage do not include such areas. Surface area to be affected by underground mining is shown in Section 4.17 Subsidence Control Plan.

3.4 AREA AFFECTED BY EACH PHASE OF OPERATIONS

The area affected by the Skyline Mines project can be divided into two major categories:

(a) Surface acreage disturbed by construction/installation of coal handling and associated facilities, and

(b) Surface acreage overlying underground mine workings.

Disturbed Surface Acreage

The offices, bathhouse, workshop, portal, fans, and other necessary facilities utilize a site of 31.1 acres. Approximately .26 acres is used for water tank bench. The coal loading and handling facility at the mouth of Eccles Canyon utilizes approximately 9.0 acres, of which a sedimentation pond requires 0.6 acres. The enclosed conveyor belt, transporting material from the mining portals to loading points, has disturbed 6.0 acres. The Scofield waste rock disposal site utilizes 1.3 acres. The
* South Fork breakout area has disturbed approximately .4 acre. In total, the surface acres disturbed is 48.0 acres. The disturbed permitted area and bonded area for the mine portal area and loadout area are shown on Maps 3.2.1-1 and 3.2.1-3 respectively.

The pre-mining phase of earth work and dirt removal commenced in the spring of 1980 and was completed in 1981. The actual construction and installation of facilities necessary for coal mining and handling began in early 1981.

Area Overlying Underground Mining

Interpretation of the available geological data and bore holes information indicates that certain portions of all three seams within the leasehold are non-mineable. Total acreage values for mineable acreage do not include such areas. Surface area to be affected by underground mining is shown in Section 4.17 Subsidence Control Plan.

intervals. The area around Mine No. 3 portals is overlain by thin (1 to 2 feet thickness) sandstones, shales and siltstones. Final cut slopes in this area will be contoured to a one horizontal to one vertical slope (1h:1v) with 8-foot-wide benches provided at 30-foot height intervals. The described specifications have been determined to be stable and safe by analysis of the geotechnical core drilling. Stability and designated postmining landuse will be achieved without extensive backfilling and therefore the mine site will not be returned to the original contours. The sedimentation
* pond at the portal area will be backfilled, covered with topsoil and revegetated. All drainage diversion ditches will not be reclaimed as they will already be fully revegetated and in stable condition.

The reclamation plan is shown on in maps 4.4.2-1A and 4.4.2-1B. Costs and mass balance data associated with reclamation may be found in the Engineering Calculations, Volume 5.

The cut slopes will be constructed in a manner which will achieve the necessary physical stability. The Permittee will develop cutslopes with 1h:2v slopes in competent rock only and will develop cutslopes with 1h:1v (maximum) slopes in less competent materials such as soil and colluvium. This design will prevent slides and reduce other related erosional damage from occurring. The operational bench slopes will be reduced to the approximate original contour (2h:1v) upon abandonment, utilizing a bulldozer working along the slopes. The only steeper slope (1h:1v) will be the area between the benches at the portal area. A geotechnical analysis will be made of this slope at the time of reclamation and design adjustment made as necessary to insure slope stability.

Grading operations will be possible at the railroad load-out site which will be returned to the approximate original contour and

shown on Maps 4.4.2-1C and 4.4.2-1D. Water tank final reclamation contours are shown on Map 4.4.2-1E. The waste rock disposal site final reclamation contours are shown on Map 4.16.1-1B.

4.4.3 Soil Stabilization

In addition to the vegetative stabilization discussed in Section 4.7 - REVEGETATION PLAN, physical stabilization of the soil is also planned. The specific methods to be implemented will be defined on the basis of additional soil analyses at the time of reclamation. An example of the soil stabilization methodology that might be used includes the placement of crushed and heavier material at the toe of road fill slopes and along stream banks.

4.4.4 Stabilization of Rills and Gullies

All rills and gullies which erode to a depth of nine inches or more will be filled, regraded and reseeded.

4.4.5 Acid and Toxic-Forming Materials

* Extensive testing of soil material near the coal seams failed to identify the presence of any materials capable of causing acidity or toxicity problems. (Refer to Hydrology Section of Volume A-1 for test results. These test, however, were conducted using different procedures than those currently requested by the Division. More recent tests on waste material removed from the mine have given mixed signals, particularly on acid forming potential. (Recent test data are appended to this section.)

* Material placed at the waste disposal site will be compositely sampled on a quarterly basis during periods of deposition at the site. Composite samples will also be taken during recontouring prior to final reclamation at the waste rock disposal site and on

the waste material to be left at the loadout facility site. Operational test data will be submitted to the Division annually. However, should acidity or toxicity problems be defined either during operation or reclamation, the Division will be notified immediately and mutually acceptable remedial action will be taken.

* Waste material temporarily stored in the mine site gob pile will be tested for each accumulation of approximately 2,000 tons. The location from which the sample is taken will be identified. Materials found to be toxic will be removed to the permanent disposal site within 30 days or as soon thereafter as weather conditions permit. Drainage from the temporary storage site reports to the sedimentation pond where the discharge is tested in accordance with NPDES Discharge Permit conditions.

4.5 SOIL PREPARATION AND FERTILIZATION PLAN

Prior to redistribution, the topsoil stockpile will be loosened by ripping, disking, or other reclaiming means to break up the topsoil.

Following redistribution, the topsoil will be fertilized. Fertilizer application and rate to be applied to the redistributed topsoil will be based on and established by analysis of stockpiled topsoil and/or by analyses conducted on topsoil that has been disturbed prior to revegetation. The topsoil will be analyzed for N, P, K, Fe, Mg, Mn, Zn, Ca, and pH to determine the fertilizer formulation and application. The fertilizer will be applied when there is suitable moisture in the soil; and initial application will be done at the time of seeding by the same method as the seeding, i.e., drilling, broadcasting or with the hydromulch. If follow up applications are needed, they will be applied by broadcasting.

Chemical analyses for micro-nutrients on the permit areas was conducted by testing soil extracts with DTPA solution and measured by use of an atomic absorption analyzer. Ammonium acetate was used to extract potassium, calcium and magnesium for atomic absorption analysis. Phosphorous determination was made by using sodium bicarbonate extraction and colorimetric analysis. The Kjeldahl method was used for determination of
* total nitrogen. Soil texture was determined by using a Bouyoucus hydrometer method (sodium herametaphosphate dispersing agent). Soil pH was determined on a 1:1 soil/water mixture tested with an electrode pH meter. Salinity was analyzed by using a Wheatstone conductivity cell on an extract of each soil sample. These analyses correlated with the consultant's recommendation that 100 pounds per acre of available nitrogen be applied during initial seeding on all areas for seedling establishment and to assist in the breakdown of straw that may be used for mulch. Additional fertilization will be determined on a case-by-case basis. After seedlings are established, additional fertilizer will not be used to increase production.

Addition to	Text
Section 4.5 p. 4-20	Sec. 4.5, p. 4-20, dtd 4/10/89

4.5 SOIL PREPARATION AND FERTILIZATION PLAN

Prior to redistribution, the topsoil stockpile will be loosened by ripping, disking, or other reclaiming means to break up the topsoil.

Following redistribution, the topsoil will be fertilized. Fertilizer application and rate to be applied to the to redistributed topsoil will be based on and established by analysis of stockpiled topsoil and/or by analyses conducted on topsoil that has been disturbed prior to revegetation. The topsoil will be analyzed for N, P, K, Fe, Mg, Mn, Zn, Ca, and pH to determine the fertilizer formulation and application. The fertilizer will be applied when there is suitable moisture in the soil; and initial application will be done at the time of seeding by the same method as the seeding, i.e., drilling, broadcasting or with the hydromulch. If follow up applications are needed, they will be applied by broadcasting.

TIME PARAMETERS

CONCENTRATION TIME

$$t_c = .0078\ L^{0.77} (L/H)^{0.385}$$

$L = 10{,}200$

$H = 1200$

$$t_c = .0078\ (10{,}200)^{0.77} (10{,}200/1200)^{.385}$$

$$= .0078\ (1220.74)(2.28)$$

$= 21.70$ MIN 22 MINS

LAG TIME

$$t_L = L^{0.8} (S+1)^{0.7} / 1900\ Y^{0.5}$$

$Y = \Sigma C_i \times i / \text{AREA IN } \square'$

$i = 80$

$A = 49{,}106{,}930.4$ SQ FT

ΣC_i	CONTOUR
2,100	9600
10,000	9520
14,800	9440
18,800	9360
21,400	9280
24,860	9200
25,800	9120
23,200	9040
19,375	8960
16,000	8880
16,000	8800
8,800	8720
6,250	8640
3,900	8560
1,000	8480
1,000	8400
213,285	

$y = 213{,}285 \times 80 / 49{,}106{,}930.4$ SQ FT.

$= .35$ OR 35%

$t_L = (10{,}200)^{.8} (6.39+1)^{.7} / 1900 (35)^{.5}$

$= (1610.20)(4.06) / 11{,}240.55$

$= 6\,532.40 / 11{,}240.55$

$= 1.58$ HRS

$= 34.87$ OR $\underline{35 \text{ MINS}}$

$t_L = .6\, t_c$

$35 \text{ MINS} = .6\, t_c$

$t_c = 58.33$

$t_c = .969$ HRS

PEAK FLOW USING SCS CURVE METHOD

EVENT	PEAK FLOW
2 YR - 24 HR	
10 YR - 24 HR	45.92 CFS
25 YR - 24 HR.	109.95 CFS
50 YR - 24 HR.	179.89 CFS
100 YR. - 24 HR	264.26 CFS

DETERMINE IF PRESENT CULVERT WILL HANDLE FLOW OF 264 CFS

$Q = A \; 1.486/n \; R^{2/3} S^{1/2}$

$A = 38$ SQ FT.

$n = .024$

$R = 1.67$

$S = .03$

$$q = 38 \text{ SQ FT.} \; 1.486/.024 \; (1.67)^{.66} (.03)^{.5}$$

$$= (38)(61.92)(1.40)(.17)$$

$$= 559.97 \text{ CFS}$$

THE 8'-2" x 5'-9" STR. PLATE PIPE ARCH WILL WORK

REFERENCES

1. BARFIELD, B. J., R.C. WARNER AND C.T. HAAN, 1985 APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS OKLAHOMA TECHNICAL PRESS, STILLWATER, OKLAHOMA

2. HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION, PRODUCTS AMERICAN IRON AND STEEL INSTITUTE, WASHINGTON D.C. THIRD EDITION

3. SOIL SURVEY OF CARBON AREA, UTAH, UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

HYDROLOGY STUDY
CULVERT WEST IN OR
TRAIN LOADOUT

SOIL TYPE	PERCENT	TYPE	CN
CURRCANTI FAMILY LOAM	24%	B	66
PATHEAD EXTREMELY BOULDERY FINE SANDY LOAM	19%	C	77
PATHEAD EXTREMELY STONY LOAM	19%	C	77
PERMA FAMILY	8%	B	66
MIDFORK FAMILY BOULDERY LOAM	3%	B	55
TRAG STONY LOAM	7%	C	77
CROYDON LOAM	4%	B	66
FALCON STONY SANDY LOAM	1%	C	77
UINTA FAMILY LOAM	5%	B	55
TOZE FAMILY FINE SANDY LOAM	4%	B	55
COMODORE BOULDERY LOAM	2%	D	77
ROCK OUTCROP	4%	D	83

CN = [.24(66) + .19(77) + .19(77) + .08(66) + .03(55) + .07(77) + .04(66) + .01(77) + .05(55) + .04(55) + .02(77) + .04(83)] / .24 + .19 + .19 + .08 + .03 + .07 + .04 + .01 + .05 + .04 + .02 + .04

= 15.84 + 14.63 + 14.63 + 5.28 + 1.65 + 5.39 + 2.64 + .77 + 2.75 + 2.20 + 1.54 + 3.37 / 1

= 70.64 USE 71

S = 1000/CN - 10

= 1000/71 - 10

= 14.08 - 10

= 4.08

AREA OF THE WATER SHED

6,686 × .0149 IN² = 99.62 IN² × 22.96 ACRES / IN² = 2,287.31 ACRES

2,287.31 ACRES × 43,560 SQ. FT / ACRES = 99,635,107.90

TIME PARAMETERS

CONCENTRATION TIME

$t_c = .0078\, L^{0.77} (L/H)^{0.385}$

$L = 15,400$ FT

$H = 1,760$ FT

$t_c = .0078\ (15,400)^{.77}\ (15,400/1760)^{.385}$

$= .0078\ (1,676.45) \cdot (2.31)$

$= 30.14$ MINS USE 30 MINS.

LAG TIME

$t_L = L^{0.8} (S+1)^{0.7} / 1900\ Y^{0.5}$

$Y = \Sigma C_i\, i / \text{AREA}$

$i = 80$

$A = 99,635,107.90$

Σc_i	Contour
400	9920
800	9840
1100	9760
1700	9680
4500	9600
9300	9520
17200	9440
26250	9360
33350	9280
40250	9200
40250	9120
40250	9040
38250	8960
30000	8880
32250	8800
28000	8720
24700	8640
23500	8560
22,300	8480
17,700	8400
13,450	8320
8400	8240
4200	8160
458,100	

$y = 458{,}100 \times 80 / 99{,}635{,}107.90$

$= .37$ or 37%

$t_L = (15{,}400)^{.8} (4.08 \times 1)^{.7} / 1900 (37)^{.5}$

$= (2{,}238.01)(3.12) / 1{,}900 (6.08)$

$= 6{,}985.09 / 11{,}557.25$

$= .60$ HRS

$= .36.26$ nms use 36 MINS.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

$t_L = .6\, t_c$

$36 = .6\, t_c$

$60 = t_c$

60 mins $= t_c$

$t_c = 1.008$ hrs

PEAK FLOW USING SCS CURVE METHOD

EVENT	PEAK FLOW
2 YR - 24 HR	
10 YR - 24 HR	392.3 CFS
25 YR - 24 HR	669.85 CFS
50 YR - 24 HR	921.32 CFS
100 YR - 24 HR	1186.47 CFS

DETERMINE MAXIMUM FLOW OF THE PIPE

$Q = A = 1.486/n \; R^{2/3} S^{1/2}$

$n = .035$

$R \quad .83$

$S = .03$

$A = 15.69$ SQ FT

$Q = 15.69 \text{ SQ FT} \left(1.486/.035\right) (.83)^{.66} (.03)^{.5}$

$= (15.69 \text{ sq ft})(42.46)(.88)(.17)$

$= 99.35$ CFS

Hydrometrics, Inc.
2727 Airport Road • Helena, Montana 59601 • (406) 443-4150

November 17, 1988

Gary E. Taylor
Senior Mining Engineer
Utah Fuel Company
P. O. Box 719
Helper, UT 84526

Dear Gary,

Attached are flow capacity computations for the 72-inch diameter half-round CMP culvert with gravel invert at the Skyline Mine. Based on our telephone conversation, I assumed that inlet rather than outlet conditions controlled the flow. Flow capacities for various water depths above the top of the culvert are:

Depth of Water Above Top of Pipe - Feet	Discharge Capacity - CFS
0	125
2	150
6	190
10	225

Please let me know if you have any questions.

Sincerely,

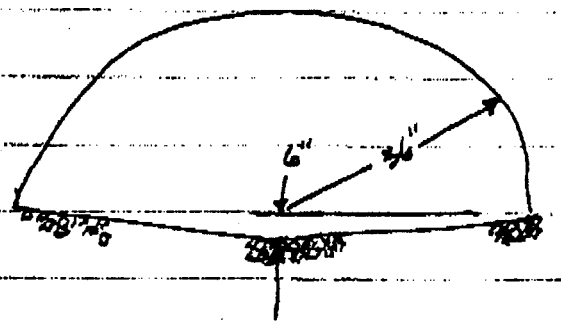
Bob

Robert D. Braico, P. E.
Civil/Environmental Engineer

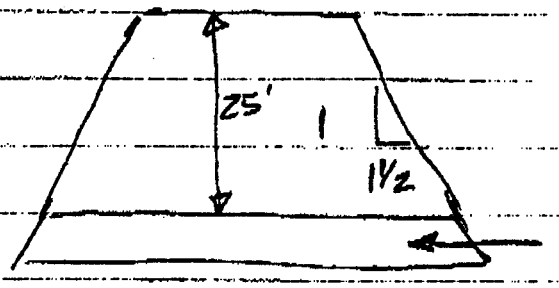
RDB:jy

Enclosures

Utah Fuel Co. - Skyline Mine



half-round CMP w/ gravel invert. Inlet is flared concrete with total width of 32'. Culvert is 161' long and installed on 3% slope. Discharge is to natural drainage w/o obstructions.



Need to calculate maximum discharge when:

ⓐ Water surface at inlet is at top of pipe
Q = 125 cfs

ⓑ Water surface is 2' ab. top of inlet
Q = 150 cfs

ⓒ 6' ab. inlet
Q = 190 cfs

ⓓ 10' ab. inlet
Q = 225 cfs

Answers From Smyant 11-17-88 Comps

7/11

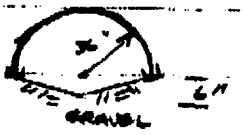
2/6

UTAH FUEL. CO. SKYLINE MINE

S.M.Y 11-17-88 p.2

CULVERT HYDRAULICS OF HORSESHOE STRUCTURAL PLATE ARCH SPAN = 6'-0" R = 36" RISE = 36" + 6" = 42"

INLET CONTROL (ASSUME THIS CONDITION EXISTS)



FIND HW/D FOR GIVEN CONDITIONS

L = 161'
S = 3%

a.) HW = D ∴ HW/D = 1.0

FOR CMPA ↓ FOR CMP ↓ for ... add 3 to HW

b.) HW = D + 2 D = 3.5' ∴ HW = 5.5'

HW/D = 5.5/3.5 = 1.57 $\frac{8.5}{6}$ = 1.42

c.) HW = D + 6 D = 3.5 ∴ HW = 9.5 $\frac{12.5}{6}$ = 2.0

$\frac{HW}{D} = \frac{9.5}{3.5} = 2.71$

d.) HW = D + 10 D = 3.5 HW = 13.5 $\frac{16.5}{6}$ = 2.75

$\frac{HW}{D} = \frac{13.5}{3.5} = 3.86$

FIND ENTRANCE LOSS COEF. FOR INLET SECTION

INLET IS FLARED CONCRETE W/ TOTAL WIDTH = 32'

→ ASSUME SIMILAR TO PIPE WITH HEADWALL, 45° WINGWALL & GROOVED EDGE INLET (SOCKET END) $K_e = 0.2$

$K_o = 1.0$

8/11

UTAH FUEL C. 3/6
SKYLINE MINE Co.
SMY 11-17-88
p. 3

Adjustments to use nomographs

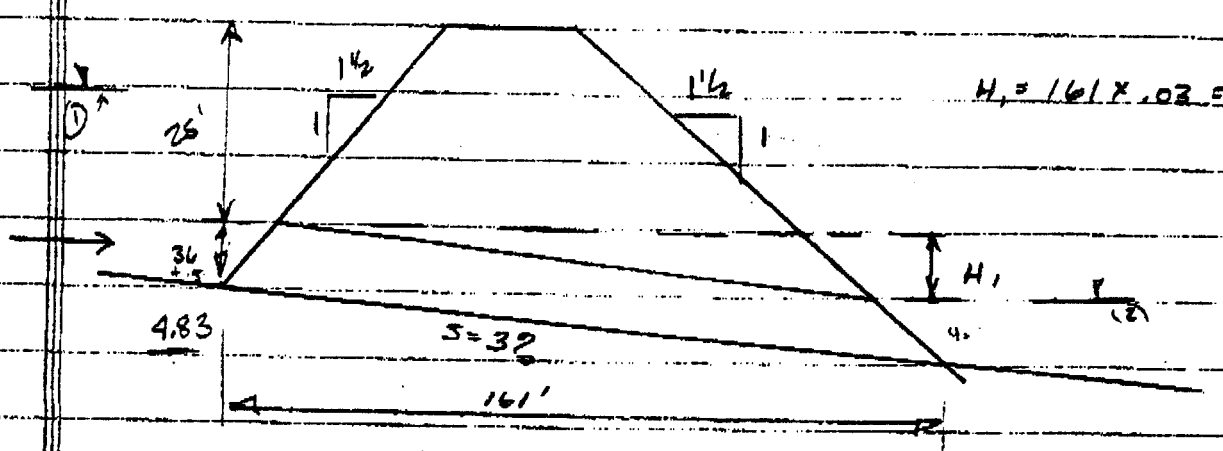
Dia. or Equiv. Dia.	Dimensions	Area ft^2	
60"	44" x 72"	17.6	
54"	40" x 65"	14.3	.82
66"	round	23.8	
72"	"	28.3	14.14
78"	"	33.2	16.59

FIND AREA
GIVEN PIPE:

$$A = \frac{\pi 3^2}{2} + \frac{1}{2} D^{3}(.5) = \frac{28.27}{2} + .25 = 14.89\ ft^2$$

(See Nomographs p. 5 & 6)

X-SECTION



$H_1 = 161 \times .03 = 4.83$

USING NOMOGRAPHS		a)	b)	c)	d)
1) CMPA	18% above 40" x 65"	83 cfs	130	175	210
2) CMP ½	30% above 72" ø	108	160	210	250
Q new →		95 cfs	145 cfs		

UTAH FUEL CO.
SKYLINE MINE
11-17-88 smyost

Bernolli Equation

$$\frac{V_1^2}{2g} + y_1 + z_1 = \frac{V_2^2}{2g} + y_2 + z_2 + \sum h_L$$

$$S \times L + H = \sum H_L \quad \text{where } H = \Delta \text{ above pipe}$$

$$(.03)(161) + H = \sum H_L$$

$$4.83 + H = \sum H_L$$

$$\sum H_L = \text{entrance loss} + \text{outlet loss} + \text{friction loss}$$

$$= K_e \frac{V^2}{2g} + K_o \frac{V^2}{2g} + \frac{2.87\, n^2 l V^2}{d^{4/3}}$$

$K_e = 0.2$

$K_o = 1.0$

$n = .027$

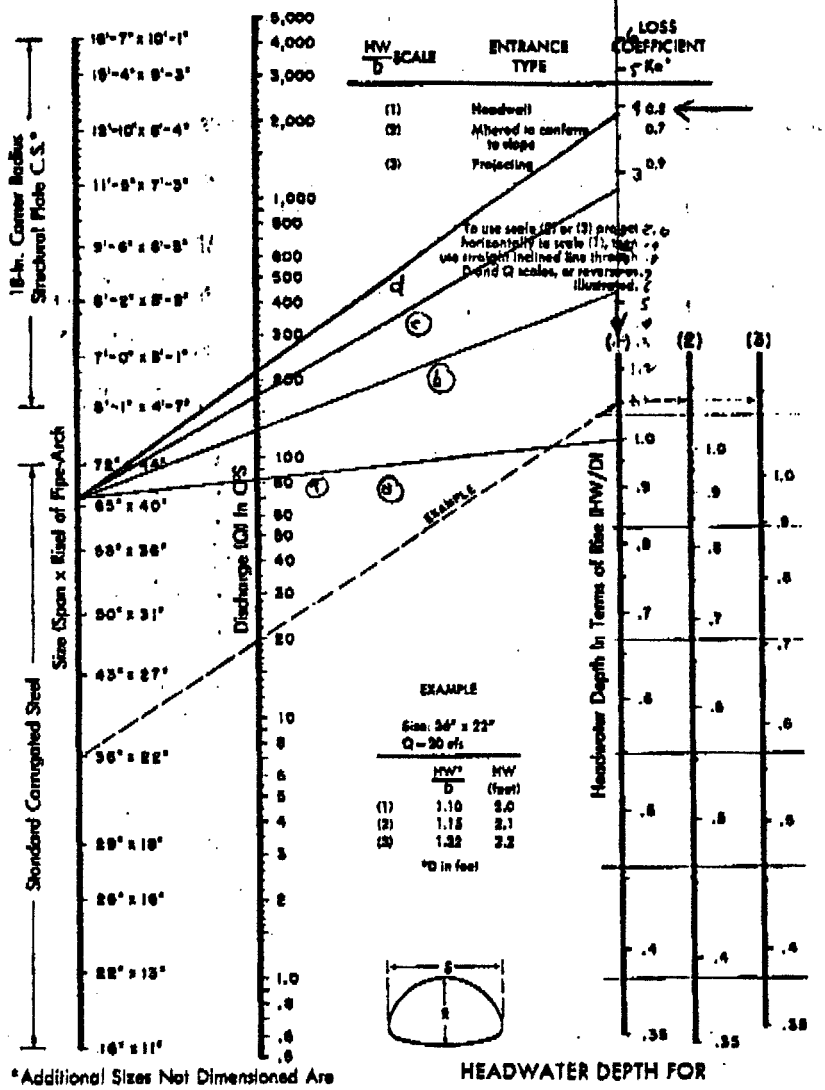
$l = 161$

$$d = \sqrt{\frac{A \cdot 4}{\pi}} = \sqrt{\frac{14.89 \cdot 4}{\pi}} = 4.354' = 52.25''$$

$$\therefore \sum H_L = V^2(.0660) \rightarrow V = \sqrt{\frac{\sum H_L}{(.0660)}}$$

	H	$\sum H_L$	V	Q = A·V = 14.89 × V		
a)	0	4.83 ft	8.55 fps	127.35 cfs	Use	125 ←
b)	2	6.83	10.17	151.44		150 ←
c)	6	10.83	12.81	190.70		190 ←
d.	0	14.83	14.99	223.15		225 ←

these do check w/ nomographs.
fairly closed.



*Additional Sizes Not Dimensioned Are Listed In Fabricator's Catalog

Bureau of Public Roads Jan. 1963

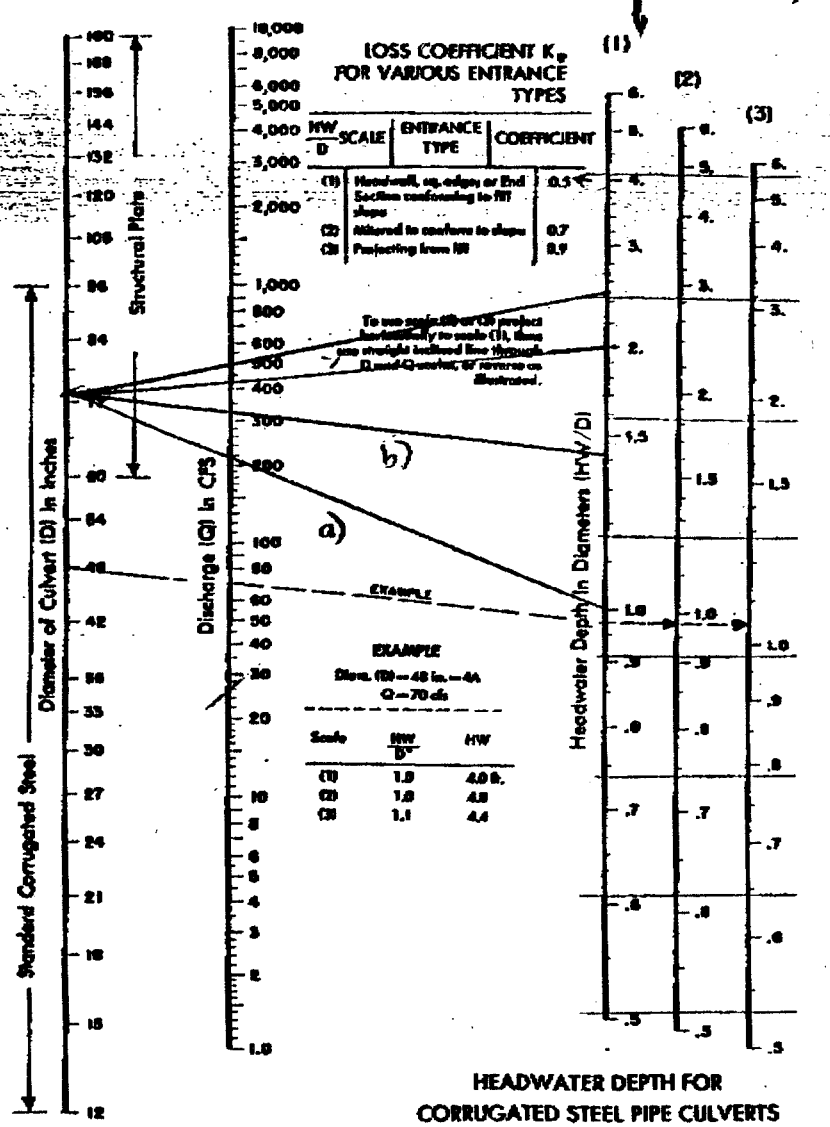
HEADWATER DEPTH FOR CORRUGATED STEEL PIPE-ARCH CULVERTS WITH INLET CONTROL

Fig. 4-20. *Inlet control* and headwater depths for corrugated steel *pipe-arch* culverts. Headwater depth should be kept low because pipe-arches are generally used where headroom is limited.

Reference: Handbook of Steel Drainage & Highway Construction Products, 1971.

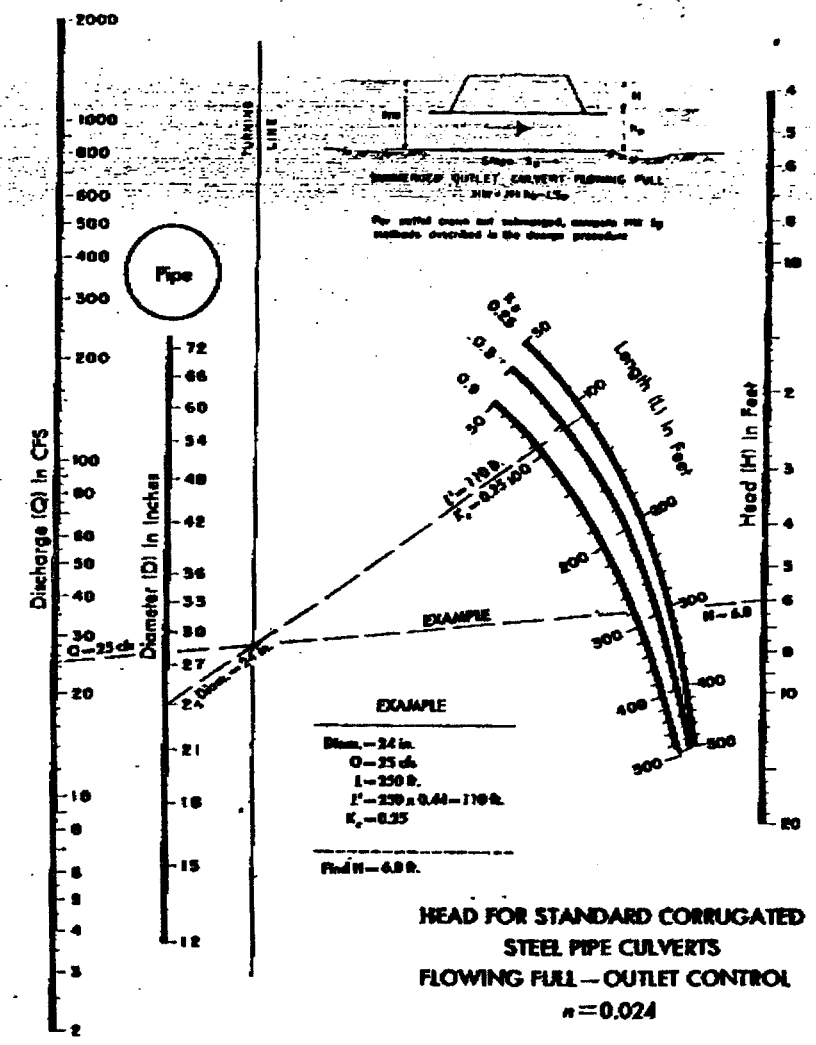
FIG. 2

2)



HEADWATER DEPTH FOR CORRUGATED STEEL PIPE CULVERTS WITH INLET CONTROL

Fig. 15. Inlet Control Nomograph for corrugated steel pipe culverts.



HEAD FOR STANDARD CORRUGATED STEEL PIPE CULVERTS FLOWING FULL — OUTLET CONTROL
$n = 0.024$

Fig. 16. Outlet Control Nomograph for corrugated steel pipe culverts with submerged outlet and flowing full.

60" 23.8
72" 28.3
78" 33.2

LENGTH ADJUSTMENT FOR IMPROVED HYDRAULICS

Pipe Diameter in Inches	Roughness Factor n' for Helical Corr.*	Length Adjustment Factor $\left(\frac{n'}{n}\right)^2$
12	.011	.21
24	.016	.44
36	.019	.61
48	.020	.70

*Other values of roughness, n, are applicable to paved pipe, lined pipe and pipe with 3 x 1 in. corrugations. See page 31. To use the above chart for these types of pipe and pipe-arches, use "adjusted length factors" computed per the equation, page 29.

Sky line mine

Smy p.6

p.8

6/6

DRAINAGE CONTROL
WASTE ROCK DISPOSAL SITE

WASTE DISPOSAL SITE
CHANNEL DESIGN

1. DRAINGE BASIN CHARACTERISTICS

AREA - 270. ACRES

L = 4800 FT

S = .36

H = 1,040 FT.

ϕ = 19.80

$\cos\phi$ = .9404

$D = L/\cos\phi$ = 5,104.04

2. DRAINAGE BASIN DISCHARGE

RATIONAL DESIGN METHOD

Q = C i A

C = RUNOFF COEFFICIENT = .1 TRAC SOILS

i = INTENSITY, IN/HR

A = AREA IN ACRES

$T_c = 1.8(1.1-C)\sqrt{D} / 3\sqrt{S}$

3 CALCULATE T_c

$T_c = 1.8(1.1-.1)\sqrt{5104.04} / \sqrt[3]{.36}$

$= 1.80(71.44 / 3.26$

$= 128.60 / 3.26$

= 39.42 MINUTES USE 40 MINUTES

I = 1.02 IN/HR 10 YR - 24 HR

4. CALCULATE Q

$Q = CiA$ $\qquad C = .1$

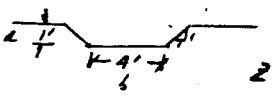
$= (.1)(1.02)(.270)$ $\qquad i = 1.02$ in/hr

$= 27.54$ CFS $\qquad A = 270$ acres

5. EVALUATION OF DITCH DESIGN

USING MANNING FORMULA

$V = 1.486/n \; R^{2/3} S^{1/2}$



$Z = \frac{1}{1} : 1$

V = VELOCITY

n = COEFFICIENT OF ROUGHNESS = .035

R = HYDRAULIC RADIUS = $bd + 2d^2 / b + 2d\sqrt{Z^2+1}$

S = SLOPE = .03

$R = (4)(1) + 2(1)^2 / 4 + 2(1)\sqrt{(1)^2+1}$

$= 6/7.41$

$= .81$

$V = 1.486/.035 \; (.81)^{2/3} (.03)^{1/2}$

$= 6.39$ FPS

$A = bd + Zd^2$

$= (4)(1) + (1)(1)^2$

$= 5$ ft²

$Q = VA$

$= (6.39 \text{ fps})(5 \text{ ft}^2)$

$= 31.98$ CFS

THE DITCH WILL HANDLE THE FLOW BUT THE VELOCITY IS

ABOUT THE MAXIMUM DESIGN LIMITS. RIPRAP WILL BE NEED.

6. DETERMINE RIPRAP D_{50} AND FOR S.F. = 1.20

$Q = 27.54$ CFS

$S = .03$

$n = .035$

$Q = VA = 1.486/n \; R^{2/3} \; A$

$= 1.486/n \left[\frac{bd + .25d^2}{b + 2d\sqrt{1.1}}\right]^{2/3} (.03)^{1/2} \left[bd + z d^2\right]$

$27.54 = 1.486/.035 \left[\frac{4d + .25d^2}{4 + 2.83d}\right]^{2/3} (.03)^{1/2} \left[4d + d^2\right]$

$3.75 = \left[4d + d^2/4 + 2.83d\right]^{2/3} \left[4d + d^2\right]$

TRIAL d FT	Q
.50	1.08
.60	1.71
.70	2.22
.80	2.78
.90	3.40
.92	3.47
.94	3.66
.96	3.79

$d = .96$ FT.

ASSUME STONE D_{50} = 7.5 IN OR .63 FT

CHECK n VALUE

$n = .0395 \; D_{50}^{.17}$

$= .0395 \; (.63)^{.17} = .037$

CHECK FOR STABILITY

$\tau = \gamma d s$

d: DEPTH - .96

s: SLOPE - .03

γ: DENSITY - 62.4

$\tau = (62.4)(.96)(.03) = 1.80$ lb/FT²

$\eta_b = 21\tau/\gamma\,(SG-1)\,D_{50}$ SG = 2.36

$= (21)(1.80)/62.4\,(2.36-1)\,.63 = .70$

SF MUST BE > 1

$\phi = 42°$ ANGULAR RIPRAP

3% SLOPE

$\theta = 1.72$

$SF_b = \cos\theta \tan\phi / \sin\theta + \eta_b \tan\phi$

$= \cos 1.72 \tan 42 / \sin 1.72 + .70(\tan 42)$

$= (.9996)(.9004) /$

$= .9000/.603$

$SF_b = 1.36$

$D_{50} = .63$ FT WILL WORK

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

7 DETERMINE RIPRAP FOR BANK SF = 1.2

$D_{50} = .63$ FT., $n = .035$, $\theta = 1.72$ $d = .96$ FT

ASSUME

$\tau_{MAX} = .76 \gamma d s$

$= (.76)(62.4)(.96)(.03) = 1.37$ LB/FT^2

$n = 21 \tau_{MAX} / \gamma (SG-1) D_{50}$

$= (21)(1.37)/62.4 (2.36-1)(.63)$

$= 28.98 / 53.46$

$= .54$

ASSUME UNIFORM FLOW

$\lambda = \theta = 1.72$

SLIDE SLOPE

$\alpha = \tan^{-1} \frac{1}{1} = 45°$

$\beta = \tan^{-1} \left[\cos\lambda / 2\sin\alpha / n \tan\phi + \sin\lambda \right]$

$= \tan^{-1} \left[.9995 / 2(.7071) / .54(.9004) + .03 \right]$

$= \tan^{-1} (.3401)$

$\beta = 18.78$

$n' = n \left[\frac{1 + \sin \lambda + \beta}{2} \right]$

$= .54 \left[\frac{1 + \sin (1.72 + 18.78)}{2} \right]$

$= .3646$

7 DETERMINE RIPRAP FOR BANK SF = 1.2

$D_{50} = .63$ FT., $n = .035$, $\theta = 1.72$ $d = .97$ FT

ASSUME

$\tau_{MAX} = .76 \gamma d s$

$= (.76)(62.4)(.97)(.03) = 1.38$ lb/ft²

$n = 21 \tau_{MAX} / \gamma (SG-1) D_{50}$

$= (21)(1.38)/62.4 (2.36-1)(.63)$

$= 28.98 / 53.46$

$= .54$

ASSUME UNIFORM FLOW

$\lambda = \theta = 1.72$

SLIDE SLOPE

$\alpha = \tan^{-1} \frac{1}{1} = 45°$

$\beta = \tan^{-1} \left[\cos\lambda / 2\sin\alpha / n \tan\phi + \sin\lambda \right]$

$= \tan^{-1} \left[.9995 / 2(.7071) / .54(.9004) + .03 \right]$

$= \tan^{-1} (.3401)$

$\beta = 18.78$

$\eta' = n \left[\frac{1 + \sin \lambda + \beta}{2} \right]$

$= .54 \left[\frac{1 + \sin (1.72 + 18.78)}{2} \right]$

$= .3646$

$$S.F. = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos 45 \tan 42 / .3646 \tan 42 + \sin 45 \cos 18.78$$

$$= .6367 / .9977$$

$$= .6381$$

D_{50}	η	β	η'	S.F.
.63	.5421	18.78°	.3646	.6381
.70	.4979	17.0995	.3226	.6589
1.00	.3415	12.1843	.1947	.7348
1.5	.2277	8.21	.1335	.7781
2.0	.1707	6.1799	.0971	.8055
3.0	.1138	4.1343	.0627	.8377
4.0	.0854	3.1048	.0463	.8515
5.0	.0683	2.4855	.0367	.8611
6.0	.0569	2.0721	.0293	.8689
8.0	.0427	1.5548	.0226	.8756
10.0	.0341	1.2442	.0179	.8805

RIPRAP FOR SIDE BANK WOULD BE LARGE THAN THE CHANNEL

BASED ON THE CALCULATIONS THE BOTTOM AND SIDESLOPES RIPRAP WILL BE .63 FT = D_{50}

RIPRAP GRADATION

	$2D_{50}$	$1D_{50}$	$.5D_{50}$	$.2D_{50}$
Size	1.26 FT	.63 FT	.32 FT	.13 FT
%	100	50	20	0

FILTER BLANKET DESIGN

BASE MATERIAL

D_{50} = .600 mm

D_{85} = 2.36 mm

D_{15} = .150 mm

RIPRAP

D_{100} = 1.26 ft = 384.048 mm

D_{50} = .63 ft = 192.024 mm

D_{85} = 1.07 ft = 326.440 m

D_{15} = .19 ft = 57.61 mm

D_5 = .063 ft 19.202 mm

FILTER BLANKET WITH RESPECT TO BASE MATERIALS

(1) D_{50} Filter / D_{50} Base < 40

D_{50} (Filter) < 40 x .6 = 24 mm

(2) D_{15} (Filter) / D_{15} (Base) > 5

D_{15} (Filter) > 5 x .15 = .75 mm

D_{15} (Filter) / D_{15} (Base) < 40

D_{15} (Filter) < 40 x .15 = 6 mm

(3) D_{15} (Filter) / D_{85} (Base) < 5

D_{15} Filter < 5 x 2.36 = 11.80 mm

∴ WITH RESPECT TO THE BASE THE FOLLOWING MUST BE SATISFIED

$.75\ mm < D_{15}\ (FILTER) < 6.00\ mm$

$D_{50}\ (FILTER) < 24\ mm$

FILTER BLANKET MUST BE SIZED TO THE RIPRAP

(1) $D_{50}\ (RIPRAP) / D_{50}\ (FILTER) \leq 40$

$D_{50}\ (FILTER) > 192.024/40 = 4.8\ mm$

(2) $D_{15}\ (RIPRAP) / D_{15}\ (FILTER) \geq 5$

$D_{15}\ (FILTER) \leq 57.61/5 = 11.52\ mm$

$D_{15}\ (RIPRAP) / D_{15}\ (FILTER) < 40$

$D_{15}\ (FILTER) > 57.61/40 = 1.44\ mm$

(3) $D_{15}\ (RIPRAP) / D_{85}\ (FILTER) < 5$

$D_{85}\ (FILTER) > 57.61/5 = 11.52\ mm$

∴ $D_{50}\ (FILTER) > 4.8\ mm$

$1.44\ mm < D_{15}\ (FILTER) < 11.52\ mm$

$D_{85}\ (FILTER) > 11.52\ mm$

FILTER BLANKET MUST BE SIZED AS FOLLOWS:

$4.8\ mm < D_{50}\ (FILTER) < 24\ mm$

$.75 < D_{15}\ (FILTER) < 11.52\ mm$

$D_{85}\ (FILTER) > 11.52\ mm$

THE FILTER BLANKET WILL BE AT LEAST 6 INCHES IN THICKNESS

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

RECLAIMED CHANNEL DESIGNS

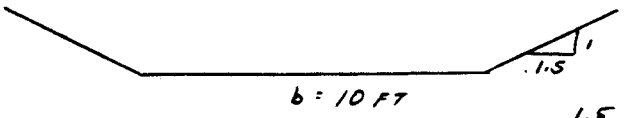
RECLAIM CHANNEL
WEST STREAM → (above)

100 YR - 24 HR.

$Q = 85$ CFS

$S = .03$ FT/FT

$n = .04$



$Z = \frac{1.5}{1} = 1.5$

USING MANNING FORMULA

$$Q = VA = \frac{1.49}{n} R^{2/3} A S^{1/2} \qquad R = \frac{bd + 2d^2}{b + 2d\sqrt{(Z^2+1)}}$$

$$A = bd + Zd^2$$

$$Q = \frac{1.49}{.n}\left(\frac{bd + Zd^2}{b + 2d\sqrt{Z^2+1}}\right)^{2/3} S^{1/2}\,(bd + Zd^2)$$

$$= \frac{1.49}{.04}\left(\frac{10d + 1.5d^2}{10 + 2d\sqrt{(1.5)^2+1}}\right)^{2/3} (.03)^{1/2}\,(10d + 1.5d^2)$$

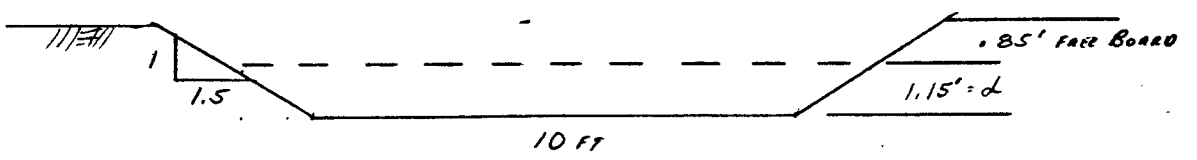
$$85 \text{ CFS} = 37.15\left[\frac{10d + 1.5d^2}{10 + 3.61d}\right]^{2/3}(.17)\,(10d + 1.5d^2)$$

$$13.21 = \left[\frac{10d + 1.5d^2}{10 + 3.61d}\right]^{2/3}(10d + 1.5d^2)$$

TRAIL d

d FT	Q
2	34.13
1	10.29
1.1	12.10
1.2	14.05
1.15	13.06
1.17	13.45

$\underline{d = 1.15 \text{ FT}}$ OR rd 85 cfs is 7



22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F. = 1.20

$V = 1.486/n \; R^{2/3} \; S^{1/2}$

$n = .04$

$S = .03$ ft/ft

$R = bd + zd^2 / b + 2d\sqrt{z^2+1} = 10(1.15) + 1.5(1.15)^2 / 10 + 2(1.15)\sqrt{1.5^2+1} = .95$

$V = 1.486/.04 \; (.95)^{.66} \; (.03)^{.5}$

$= 37.15 \; (.97)(.17)$

$= 6.23$ FPS

STONE D_{50} = 7 IN = .58 FT

CHECK n

$n = .0395 \; D_{50}^{.17}$

$= .0395 \; (.9)$

$= .04$

CHECK FOR STABILITY

$\tau = \gamma d s$

$d = 1.15$ ft
$s = .03$
$\gamma = 62.4$

$\tau = (62.4)(1.15)(.03) = 2.15$ lb/ft²

$n_b = 21\tau / \gamma (SG-1) D_{50}$ SG = 2.36

$= 21(2.15) / 62.4(2.36-1) .58$

$= 45.21/49.22$

$= .92$

SF MUST BE >1

$\phi = 42°$ ANGULAR RIPRAP

3 %

$\theta = 1.72°$

$$SF_b = \cos\theta \tan\phi / \sin\theta + \eta_b \tan\phi$$

$$= \cos(1.72) \tan(42) / \sin(1.72) + .92 (\tan 42)$$

$$= .9000 / .8584$$

$$= 1.04$$ UNDER DESIGNED

D_{50}	MANNING η	ANGLE OF RIPRAP (DEG)	DEPTH ON CONVEY FLOW	TRACTIVE FORCE	STABILITY FACTOR	SAFETY FACTOR
.58	.04	42	1.15	2.15	.92	1.04
.75	.0376	42	1.15	2.15	.71	1.34

$D_{50} = .75$ FT.

DETERMINE RIPRAP FOR BANK S.F. = 1.20

$D_{50} = .75$ FT, $\eta = .0376$, $\theta = 1.72$, $d = 1.15$ FT.

ASSUME

$$\tau_{max} = .76 \gamma d s$$

$$= .76 (62.4)(1.15)(.03)$$

$$= 1.64 \text{ lb/ft}^2$$

$$\eta = 21 (\tau_{max}) / \gamma (S.G. - 1) D_{50}$$

$$= 21(1.64) / \gamma (2.36 - 1) .75$$

$$= 39.36 / 63.65$$

$$= .54$$

ASSUME UNIFORM FLOW

$\lambda = \theta = 1.72°$

SIDESLOPE

$\alpha = \tan^{-1} 1/1.5 = 33.69°$

$\beta = \tan^{-1} \left[\cos\lambda / 2 \sin\alpha / \eta \tan\phi + \sin\lambda \right]$

$= \left[.9995 / 1.1094 / .4862 + .03 \right]$

$= \tan^{-1} (.4324)$

$\beta = 23.38°$

$\eta_1 = \eta \left[1 + \sin \lambda + \beta/2 \right]$

$= .54 \left[1 + \sin (1.72 + 23.38)/2 \right]$

$= .54 \left[1.4241/2 \right]$

$= .3845$

$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$

$= \cos(33.69) \tan(42) / .3845 \tan\phi + \sin(33.69) \cos(23.38)$

$= .7492 / .8554$

$= .8759$ UNDER DESIGNED

D_{50}	n	B	n'	SF
.75	.54	23.38	.3845	.8759
1.50	.2706	12.30	.1681	1.08
1.70	.2387	10.89	.1454	1.11
1.90	.2136	9.78	.1281	1.13
2.1	.1933	8.86	.1144	1.15
2.5	.1623	7.47	.0941	1.18
2.7	.1503	6.92	.0880	1.19
2.9	.1399	6.45	.0799	1.20

USE <u>2.9 FT</u>

BASED ON THE CALCULATIONS THE BOTTOM AND SIDESLOPES RIPRAP WILL BE .75 FT · D_{50}

RIPRAP GRADATION

	SIZE FT	%
$2D_5$	1.5	100
D_{50}	.75	50
$.5D_{50}$	.38	20
$.2D_{50}$	.15	0

AVG. SUMMER FLOW

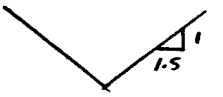
$Q = .10$ CFS

$S = .03$

$n = .04$

USING MANNING FORMULA

$Q = 1.486/n \; A \; R^{2/3} \; S^{1/2}$



$Z = \frac{1.5}{1} = 1.5$

$R = Zd / 2\sqrt{Z^2+1}$

$A = Zd^2$

$Q = 1.486/n \; (Zd^2) \left(Zd / 2\sqrt{Z^2+1} \right)^{2/3} S^{1/2}$

$= 1.486/.04 \; (1.5d^2) \left(1.5d / 2\sqrt{(1.5)^2+1} \right)^{2/3} (.03)^{1/2}$

$.10 = 37.15 \; 1.5d^2 \; (.41d)^{2/3} (.17)$

$1.55 = 1.5d^2 \; (.41d)^{2/3}$

TRAIL d

d	Q
1	.83
2	57.26
1.5	2.45
1.25	1.51

$\underline{d = 1.25 \text{ FT}}$

DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F. = 1.20

$V = 1.486/n \; R^{2/3} \; S^{1/2}$

$n = .04$

$S = .03$

$R = Zd / 2\sqrt{Z^2+1} = 1.5(1.25) / 2\sqrt{(1.5)^2+1} = .52$

$V = 1.486/.04 \; (.52)^{.66} \; (.03)^{.5}$

$= 37.15 \; (.64) \; (.17)$

$= 4.18$ FPS

STONE $D_{50} = 3$ IN $= .25$ FT.

$D_{50} = 1.25$ FT, $n = .04$, $\theta = 1.72$, $d = 1.25$ FT.

ASSUME

$\tau_{MAX} = .76 \, \gamma d s$

$= .76(62.4)(1.25)(.03) = 1.78$ LB/FT²

$\eta = 21 \, \tau_{MAX} / \gamma (S.G. - 1) D_{50}$

$= 21 \, (1.78) / 62.4 \, (2.36 - 1)(1.25)$

$37.34^{\#} / 106.08$

$= .3521$

ASSUME UNIFORM FLOW

$\lambda = \theta = 1.72°$

SIDE SLOPE $= \tan^{-1} \frac{1}{1.5} = 33.69 = \alpha$

$\beta = \tan^{-1} \left[\cos\lambda / \; 2 \sin\alpha / \eta \tan\phi + \sin\lambda \right]$

$= \left[\cos 1.72 / \; 2 \sin 33.69 / .3521 \tan 42 + \sin 1.72 \right]$

$= .9995 / 3.597$

$\beta = \tan^{-1} [.28321]$

$\beta = 15.81$

$$\eta' = \eta\left[1 + \sin(\lambda + \beta)/2\right]$$

$$= .7722\left[1 \sin(1.72 + 30.27)/2\right]$$

$$= .7722\ 1.5295/2$$

$$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos(33.69)\ \tan(42) / .2291\ \tan(42) + \sin(33.69)\cos 15.81$$

$$= .7496 / .7400$$

$$= 1.01$$

D_{50}	η	β	η'	SF
1.25	.3521	15.81	.2291	1.01
1.75	.2515	11.46	.1544	1.09
2.25	.1956	8.97	.1159	1.15
2.75	.1600	7.37	.0926	1.18
3.00	.1467	6.76	.0842	1.20

BASED ON THE CALCULATIONS THE SIDESLOPES RIPRAP WILL BE .75 FT = D_{50}

UNDERLYING FILTER

ASSUME

BASE MATERIAL

$D_{50} = .600\ mm$

$D_{85} = 2.36\ mm$

$D_{15} = .150\ mm$

RIPRAP

D_{100}	=	1.5	=	457.20
D_{50}	=	.75	=	228.60
D_{85}	=	1.36	=	414.34
D_{15}	=	.34	=	120.87
D_0	=	.15	=	97

FILTER BLANKET WITH RESPECT TO BASE MATERIAL

(1) $D_{50}F / D_{50B} < 40$

$D_{50}(F) < 40 \times .6 = 24\ mm$

(2) $D_{15}(F) / D_{15B} > 5$

$D_{15}(F) > 5 \times .150 = .75\ mm$

$D_{15}F / D_{15B} < 40$

$D_{15}(F) < 40 \times .15 = 6\ mm$

(3) $D_{15}(F) / D_{85}(B) < 5$

$D_{15}(F) < 5 \times 2.36 = 11.8\ mm$

∴ WITH RESPECT TO BASE MATERIAL

$.75\,mm < D_{15}(\text{FILTER}) < 6\,MM$

$D_{50}(\text{FILTER}) < 24\,mm$

FILTER SIZE FOR RIPRAP

(1) $D_{50}(R)/D_{50}(F) < 40$

$D_{50} > 228.60/40 = 5.72\,mm$

(2) $D_{15}(R)/D_{15}(F) > 5$

$D_{15}(F) < 120.87/5 = 24.17\,mm$

$D_{15}(R)/D_{15}(F) < 40$

$D_{15}(F) > 120.87/40 = 3.02\,mm$

(3) $D_{15}(R)/D_{85}(F) < 5$

$D_{85}(F) > 120.87/5 = 24.17\,mm$

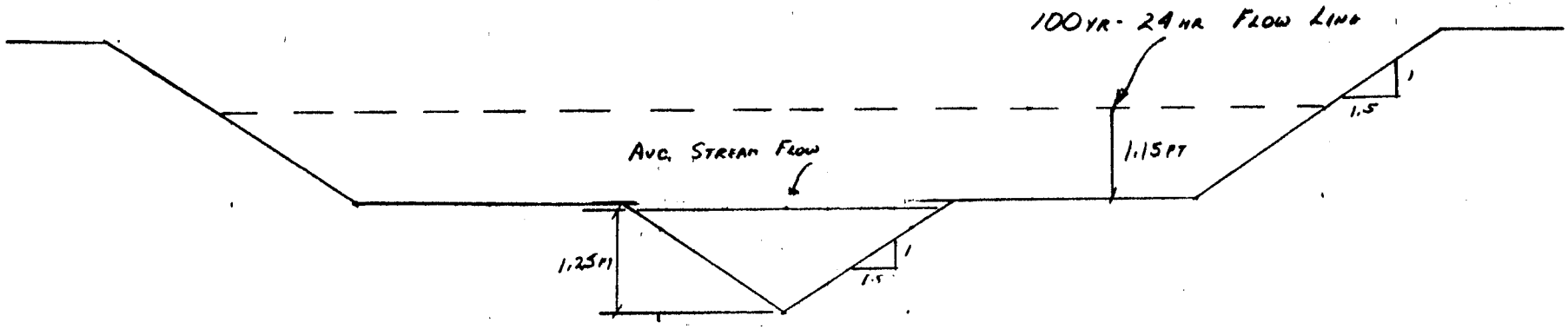
FILTER BLANKET MUST BE SIZED AS FOLLOWS

$D_{50}(\text{FILTER}) > 5.72\,mm$

$.75\,mm < D_{15}(\text{FILTER}) < 24.17\,mm$

$D_{85}(\text{FILTER}) < 24.17\,mm$

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD



SECTION D,

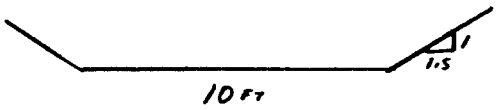
AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

RECLAIM CHANNEL
WEST STREAM
FROM UPPER BENCH TO MIDDLE BENCH

$Q = 85$ CFS

$n = .04$

$S = .079$



USING MANNING FORMULA

$R = bd + zd^2 / b + 2d\sqrt{z^2+1}$

$Q = 1.486/n \; A R^{2/3} S^{1/2}$

$A = bd + zd^2$

$= 1.486/n \; (bd + zd^2)\left(bd + zd^2 / b + 2d\sqrt{z^2+1}\right)^{2/3} S^{1/2}$

$= 1.486/.04 \; (10d + 1.5d^2)\left(10d + 1.5d^2 / 10 + 3.61d\right)^{2/3} (.079)^{1/2}$

$85 \text{ CFS} = 10.49 (10d + 1.5d^2)\left(10d + 1.5d^2 / 10 + 3.61d\right)^{2/3}$

$8.14 = (10d + 1.5d^2)\left(10d + 1.5d^2 / 10 + 3.61d\right)^{2/3}$

TRAIL d

d	Q
.75	6.32
1.0	10.29
.9	8.60
.88	8.28
.87	8.12

$\underline{d = .87}$

DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F. = 1.20

$V = 1.486/n \; R^{2/3} S^{1/2}$

$n = .04$

$S = .079$

$R = bd + zd^2 / b + 2d\sqrt{z^2+1} = 10(.87) + 1.5(.87)^2 / 10 + 2(.87)\sqrt{1.5^2+1} = .75$

$V = 1.486/.04 \; (.75)^{.66} (.079)^{.5}$

$= (37.15)(.83)(.28)$

$= 8.63$ FPS

STONE $D_{50} = .9$ IN $= .75$ FT

CHECK n

$n = .0395 \; D_{50}^{.17}$
$= .0376$

CHECK FOR STABILITY

$\tau = \gamma d s$

$d = .87$
$s = .079$
$\gamma = 62.4$

$\tau = (62.4)(.87)(.079) = 4.28$ lb/FT²

$n_b = 21 \tau_{max} / 62.4 (S.G. - 1) D_{50}$

SG = 2.36

$= 21(4.28) / 62.4(2.36-1)(.75)$

$= 90.06 / 63.68$

$= 4.415$

S.F. MUST BE 7/

$\phi = 42°$ ANGULAR RIPRAP

7.92
$\theta = 4.517$

$SF_b = \cos\theta \tan\phi / \sin\theta + \eta_b \tan\phi$

$= \cos(4.517) \tan(42) / \sin 4.517 + 1.415 \tan 42$

$= .8976 / 1.3526$

$= .66$

D_{50}	Manning η	Angle of Repose	Depth of Convey Flow	Tracting Force	Stability Factor	Safety Factor
.75	.0376	42	.87	4.289	1.415	.66
1.0	.0395	42	.86	4.2395	1.049	.87
1.5	.0423	42	.90	4.4366	.7319	1.21

$\therefore D_{50} = 1.5$ ft

Determine Riprap for Bank S.F. = 1.20

$D_{50} = 1.5$, $\eta = .0423$, $\theta = 4.517$, $d = .9$

Assume

$\tau_{max} = .76 \gamma d s$

$= .76 (62.4)(.9)(.079) = 3.37$ lb/ft²

$\eta = 21 \tau_{max} / \gamma (S_s - 1) D_{50}$

$= 21(3.37) / 62.4 (2.36-1)(1.5)$

$= 70.8084 / 127.2960$

$= .5563$

Assume Uniform Flow

$\lambda = \theta = 4.517$

Side slope

$\alpha = \tan^{-1} \frac{1}{1.5} = 33.69°$

$$\beta = \tan^{-1}\left[\cos\lambda \Big/ 2\sin\alpha/\eta \tan\phi + \sin\lambda\right]$$

$$= \left[\cos(4.517) \Big/ 2\sin 33.69/.5563 \tan 42 + \sin 4.517\right]$$

$$= \tan^{-1}\left[.9969/2.2938\right]$$

$$= \tan^{-1}\left[.4346\right]$$

$$\beta = 23.49$$

$$\eta_1 = \eta\left[1 + \sin\lambda + \beta/2\right]$$

$$= .5563\left[1 + \sin 4.517 + 23.49/2\right]$$

$$= .5563\ (.7348)$$

$$= .4088$$

$$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos(33.69)\tan(42) / .4088 \tan 42 + \sin 33.69 \cos 23.49$$

$$= .7492/.8768$$

$$= .8544$$

D_{50}	η	β	η'	SF
1.5	.5563	23.49	.4088	.8544
2.0	.4172	18.20	.2892	.9516
2.5	.3338	14.81	.2249	1.0141
3.0	.2781	12.47	.1797	1.0651
3.5	.2384	10.76	.1506	1.10
4.0	.2086	9.46	.1295	1.12
4.5	.1854	8.43	.1135	1.15
5.5	.1517	6.93	.0909	1.18
6.0	.1391	6.36	.0827	1.20

USE 6.0 ft

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

BASED ON THE CALCULATIONS THE BOTTOM AND SIDE SLOPES RIPRAP WILL BE 1.5 FT : D_{50}

RIPRAP GRADATION

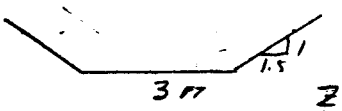
$2\ D_{50}$	:	3.0 FT	100
D_{50}	:	1.5 FT	50
$.5\ D_{50}$	:	.75 FT	20
$.2\ D_{50}$	:	.30 FT	0

AVG SUMMER FLOW

$Q_1 = .10$ CFS

$S = .079$

$n = .04$



$Z = \frac{1.5}{1} = 1.5$

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}$

$A = bd + z^2d^2$

USING MANNING EQUATION

$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

$Q = \frac{1.486}{n}(bd + zd^2)\left(\frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}\right)^{2/3} S^{1/2}$

$= \frac{1.486}{.04}(3d + 1.5d^2)\left(\frac{3d + 1.5d^2}{3 + 3.61d}\right)^{2/3}(.079)^{1/2}$

$10 = 37.15(3d + 1.5d^2)\left(\frac{3d + 1.5d^2}{3 + 3.61d}\right)^{2/3}(.28)$

$.95 = (3d + 1.5d^2)\left(\frac{3d + 1.5d^2}{3 + 3.61d}\right)^{2/3}$

TRIAL d

d	Q
1	3.49
.5	1.01
.49	.97
.48	.94

$\underline{d = .48 \text{ FT}}$

DETERMINE RIPRAP D_{50} AND DESIGN FOR SF = 1.20

$V = 1.486/n \; R^{2/3} \; R^{1/2}$

$n = .04$

$S = .079$

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}} = \frac{3(.48) + 1.5(.48)^2}{3 + 2(.48)\sqrt{(1.5)^2+1}} = .38$

$V = 1.486/.04 \; (.38)^{.66} \; (.079)^{.5}$

$= 37.15 \; (.53)(.28)$

$= 5.49$ FPS

STONE $D_{50} = 1.5$ FT

ASSUME

$\tau_{max} = .76 \, \gamma d S$

$= .76 \, (62.4)(.48)(.079) = 1.7983$ LB/FT²

$\eta = 21 \, \tau_{max} / 62.4 \, (S.G.-1) \, D_{50}$

$= 21(1.7983) / 62.4 \, (2.36-1) \, 1.5$

$= 37.7643 / 127.2960$

$= .2967$

ASSUME UNIFORM FLOW

$\lambda = \theta = 4.517°$

SIDE SLOPE $= \tan^{-1} \frac{1}{1.5} = 33.69 = \alpha$

$\beta = \tan^{-1} \left[\cos\lambda / 2 \sin\alpha / \eta \tan\phi + \sin\lambda \right]$

$= \tan^{-1} \left[\cos 4.517 / 2 \sin 33.69 / .7169 \tan 42 + \sin 4.517 \right]$

$= \tan^{-1} (.9969 / 4.2319)$

$\beta = \tan^{-1} (.2356)$

$\beta = 13.26$

$$\eta' = \eta \left(1 + \sin \lambda + \beta/2\right)$$

$$= .2967 \left[1 + \sin\left(4.517 + 13.2553/2\right)\right]$$

$$= .2967 \left(.6526\right)$$

$$= .1936$$

$$SF = \cos\alpha \tan\phi \Big/ \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos(33.69) \tan(42) \Big/ .1936 \tan 42 + \sin(33.69) \cos 13.2553$$

$$= .7492 \Big/ .7143$$

$$= 1.05$$

D_{50}	η	β	η'	SF
1.5	.2967	13.26	.1936	1.05
2.0	.2225	10.07	.1393	1.12
2.5	.1780	8.10	.1084	1.16
3.0	.1483	6.78	.0887	1.19

D_{50} = 3.0

BASED ON THE CALCULATIONS THE BOTTOM AND SIDESLOPE RIPRAP WILL BE 1.5 FT D_{50}

UNDERLYING FILTER

ASSUME

BASE MATERIAL

D_{50} = .600 mm

D_{85} = 2.36 mm

D_{15} = .150 mm

RIPRAP

D_{100}	=	3.0 FT	=	914 mm
D_{50}	=	1.5 FT	=	457.2 mm
D_{85}	=	1.275 FT	=	388.62
D_{15}	=	.6750	=	205.74
D_0	=	.3.00 FT	=	91.44

FILTER BLANKET WITH RESPECT TO BASE MATERIAL

(1) $D_{50}(F)/D_{50}(B) < 40$

$D_{50}(F) < 40 \times .6 = \underline{24\ mm}$

(2) $D_{15}(F)/D_{15}(B) > 5$

$D_{15}(F) > 5 \times .150 = \underline{.75\ mm}$

$D_{15}(F)/D_{15}(B) < 40$

$D_{15}(F) < 40 \times .15 = \underline{6\ mm}$

(3) $D_{15}(F)/D_{85}(B) < 5$

$D_{15}(F) < 5 \times 2.36 = \underline{11.80\ mm}$

∴ WITH RESPECT TO BASE MATERIAL

$.75 < D_{15}(\text{FILTER}) < 6\,mm$

D_{50} FILTER $< 24\,mm$

FILTER SIZE FOR RIPRAP

(1) $D_{50}(R)/D_{50}(F) < 40$

$D_{50}(F) > 457.2/40 = \underline{11.43\,mm}$

(2) $D_{15}(R)/D_{15}(F) > 5$

$D_{15}(F) < 205.74/5 = \underline{41.15\,mm}$

$D_{15}(R)/D_{15}(F) < 40$

$D_{15}(F) > 205.74/40 = \underline{5.14\,mm}$

(3) $D_{15}(R)/D_{85}(F) < 5$

$D_{85}(F)\ 205.74/5 = \underline{41.15\,mm}$

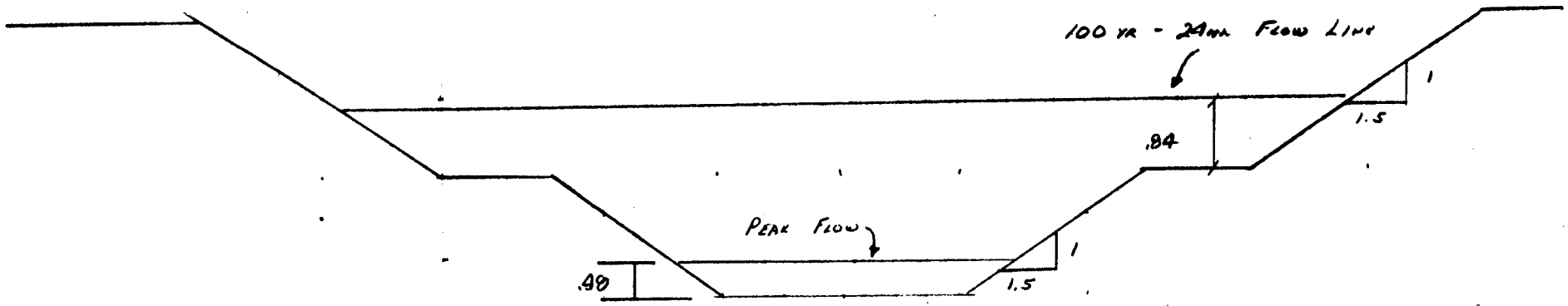
FILTER BLANKET MUST BE SIZED AS FOLLOWS:

$D_{50}(\text{FILTER}) > 11.43\,mm$

$.75\,mm < D_{15}(\text{FILTER}) < 41.15\,mm$

$D_{85}(\text{FILTER}) < 41.15\,mm.$

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD



SECTION D_2

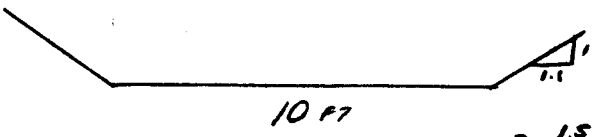
AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

RECLAIM CHANNEL
SOUTHWEST STREAM

$Q = 110$ CFS

$S = .0474$

$n = .04$



$z = \frac{1.5}{1} = 1.5$

USING MANNING FORMULA

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}$

$Q = VA = \frac{1.486}{n} R^{2/3} S^{1/2} A$

$A = bd + zd^2$

$$Q = \frac{1.486}{n}\left(\frac{bd+zd^2}{b+2d\sqrt{z^2+1}}\right)^2 (bd+zd^2)\, S^{1/2}$$

$$= \frac{1.486}{.04}\left(\frac{10d+1.5d^2}{10+2d\sqrt{(1.5)^2+1}}\right)^{2/3}(10d+1.5d^2)\,(.0474)^{1/2}$$

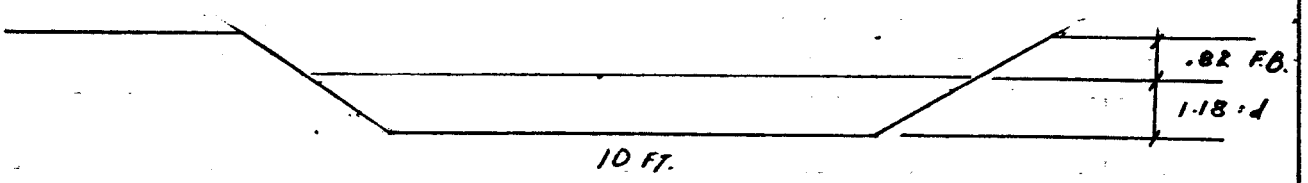
$$110 = 37.15\left[\frac{10d+1.5d^2}{10+3.61d}\right]^{2/3}(10d+1.5d^2)\,(.2177)$$

$$13.60 = \left(\frac{10d+1.5d^2}{10+3.61d}\right)^{2/3}(10d+1.5d^2)$$

TRAIL d

d	Q
.80	6.22
1.1	11.75
1.5	26.11
1.4	19.06
1.2	13.99
1.17	13.30
1.18	13.52

$d = \underline{1.18 \text{ FT}}$



DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F. = 1.20

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

$n = .04$

$S = .0474$

$$R = \frac{bd + 2d^2}{b + 2d\sqrt{z^2+1}} = \frac{10(1.18) + 1.5(1.18)^2}{10 + 2(1.18)\sqrt{(1.5)^2+1}} = .97$$

$$V = \frac{1.486}{.04} (.97)^{.66} (.0474)^{.5}$$

$= 37.15 \ (.98)(.22)$

$= 7.95$ FPS

STONE $D_{50} = 12$ IN $= 1$ FT

CHECK n

$n = .0395 \ D_{50}^{.17} = .0395$

CHECK FOR STABILITY

$\tau = \gamma d s$

$\gamma = 62.4$
$d = 1.18$
$s = .0474$

$\tau = (62.4)(1.18)(.0474) = 3.49$ KN/m²

$$\eta_b = \frac{21\tau}{\gamma (SG-1) D_{50}}$$

$$= \frac{21(3.4902)}{62.4(2.36-1)(1)}$$

$$= \frac{73.2933}{84.9690}$$

$= .8637$

SF MUST BE > 1

$\phi = 42°$ ANGULAR RIPRAP

4.79%
$\theta = 2.71°$

$$SF_b = \cos\theta \tan\phi / \sin\theta + \eta \tan\phi$$

$$= \cos(2.71) \tan 42 / \sin 2.71 + .8637 \tan(42)$$

$$= .8994 / .8250$$

$$= 1.09$$

D_{50}	Manning n	Angle of Repose (ϕ_{rc})	Depth on Convex Flow	Tractive Force	Stability Factor	Safety Factor
1	.0395	42	1.18	3.49	.8637	1.09
1.5	.0423	42	1.21	3.58	.5904	1.55
1.3	.0413	42	1.21	3.58	.6812	1.36
1.2	.0407	42	1.20	3.55	.7319	1.27

$D_{50} = 1.2$ ft

Determine Riprap for Bank S.F. = 1.2

$D_{50} = 1.2$ ft $n = .0407$ $\theta = 2.71$ $d = 1.2$ ft

Assume

$$\tau_{max} = .76 \gamma d s = .76 (62.4)(1.2)(.0474) = 2.70 \text{ lb/ft}^2$$

$$\eta = 21 \tau_{max} / \gamma (SG - 1) D_{50}$$

$$= 21 (2.6975) / 62.4 (2.36 - 1) 1.2$$

$$= 56.6970 / 101.8368$$

$$= .5563$$

Assume Uniform Flow

$$\lambda = \theta = 2.71°$$

Side slope

$$\alpha = \tan^{-1} \frac{1}{1.5} = 33.69°$$

$$\beta = \tan^{-1}\left[\cos\lambda / 2\sin\alpha / \eta \tan\phi + \sin\lambda\right]$$

$$= \tan^{-1}\left(\cos(2.71) / 2\sin(33.69) / .5563 \tan 42 + \sin 2.71\right)$$

$$= \tan^{-1}\left[.9989 / 2.2502\right]$$

$$= \tan^{-1}(.4439)$$

$$\beta = 23.94°$$

$$\eta' = \eta\left[1 + \sin(\lambda + \beta)/2\right]$$

$$= .5563\left[1 + \sin(2.71 + 23.94)/2\right]$$

$$= .4029$$

$$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos(33.69) \tan(42) / .4029 \tan 42 + \sin(33.69) \cos(23.94)$$

$$= .7492 / .8697$$

$$= .8697$$

D_{50}	η	β	η'	SF
1.2	.5563	23.9369	.4029	.87
2.0	.3338	14.96	.2176	1.02
3.0	.2225	10.14	.1360	1.12
4.0	.1669	7.66	.0985	1.17
4.5	.1483	6.8189	.0864	1.20

USE 4.5 FT

BASED ON THE CALCULATIONS THE BOTTOM AND SIDE SLOPES RIPRAP WILL BE 1.2 FT • D_{50}

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

RIPRAP GRADATION

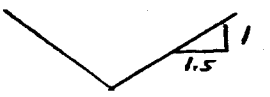
SIZE FT			PERCENT
2.0_{50}	-	2.4 FT	100
D_{50}	-	1.2	50
$.5D_{50}$	-	.6 FT	20
$.20_{50}$	-	.24	0

PEAK FLOW

$Q = 3.31$ CFS

$S = .0474$

$n = .0407$



$z = \frac{1.5}{1} = 1.5$

$A = zd^2$

$R = zd / 2\sqrt{z^2+1}$

USING MANNING FORMULA

$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

$= \frac{1.486}{.0407} (zd^2) \left(\frac{zd}{2\sqrt{z^2+1}} \right)^{2/3} (.0474)^{1/2}$

$3.31 = 36.51 \; 1.5d^2 (.416d)^{2/3} (.2177)$

$.42 = 1.5d^2 (.416d)^{2/3}$

TRIAL d

d	Q
1	.84
.5	.13
.75	.39
.80	.46
.78	.43

$\underline{d = .78 \text{ FT}}$

DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F. = 1.20

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

$n = .0907$

$S = .0474$

$$R = \frac{2d}{2\sqrt{2d}} = \frac{1.5(.78)}{2\sqrt{1.5(.78)}} = .32$$

$$V = \frac{1.486}{.0407} (.32)^{2/3} (.0474)^{1/2}$$

$= (36.51)(.4758)(.2177)$

$= 3.78$ FPS

STONE $D_{50} = 12$ IN $= 1$ FT.

$D_{50} = 1$ F, $n = .0907$ $\theta = 2.71$ $d = .78$

ASSUME

$$\tau_{max} = .76 \gamma d S$$
$$= .76(62.4)(.78)(.0474) = 1.75 \text{ lb/ft}^2$$

$$\eta = \frac{21 \tau_{max}}{\gamma (SG-1) D_{50}}$$

$$= \frac{21(1.75)}{62.4(2.65-1)(1)}$$

$$= \frac{36.8206}{84.8640}$$

$= .4339$

ASSUME UNIFORM FLOW

$\lambda = \theta = 2.71$

SIDE SLOPE $= \tan^{-1} 1/1.5 = 33.69 = \alpha$

$$\beta = \tan^{-1}\left[\frac{\cos\lambda}{2\sin\alpha/n \tan\alpha z + \sin\lambda}\right]$$

$$= \tan\left[\frac{\cos(2.71)}{2\sin 33.69/.4339 \tan 42 + \sin(2.71)}\right]$$

$$= \tan^{-1}\left(\frac{.9989}{2.8870}\right)$$

$= \tan^{-1}(.3460)$

$\beta = 19.0850$

$$\eta' = \eta \left[1 + \sin (\eta + \beta)/2\right]$$

$$= .4339 \left[1 + \sin (2.71 + 19.0850)/2\right]$$

$$= .2975$$

$$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos(33.69) \tan(42) / .2975 \tan(42) + \sin(33.69) \cos(19.085)$$

$$= .7492 / .7921$$

$$= .95$$

D_{50}	η	β	η'	SF
1	.4339	19.0850	.2975	.95
2	.2169	9.8943	.1321	1.13
3	.1446	6.6509	.0841	1.20

BASE ON THE CALCULATION THE SIDESLOPE RIPRAP WILL BE 1.2 FT = D_{50}

UNDERLYING FILTER

ASSUME

BASE MATERIAL

D_{50} = .600 mm

D_{85} = 2.36 mm

D_{15} = .150 mm

RIPRAP

D_{100}	= 2.4 FT	=	731.52 mm
D_{50}	= 1.2 FT	=	365.76 mm
D_{85}	= 2.16 FT	=	658.37 mm
D_{15}	= .54 FT	=	164.59 mm
D_0	= .24 FT	=	73.15 mm

FILTER BLANKET WITH RESPECT TO BASE MATERIAL

(1) $D_{50}(F)/D_{50}(B) < 40$

$D_{50}(F) < 40 \times .6 = 24\ mm$

(2) $D_{15}(F)/D_{15}(B) > 5$

$D_{15}(F) > 5 \times .15 = .75\ mm$

$D_{15}(F)/D_{15}(B) < 40$

$D_{15}(F) < 40 \times .15 = 6\ mm$

(3) $D_{15}(F)/D_{85}(B) < 5$

$D_{15}(F) < 5 \times 2.36 = 11.80\ mm$

∴ WITH RESPECT TO BASE MATERIAL

$.75 < D_{15} < 11.80\ mm$

$D_{50} < 24\ mm.$

FILTER BLANKET SIZED FOR RIPRAP

(1) $D_{50}(R)/D_{50}(F) < 40$

$D_{50}(F) > 365.76/40 = 9.14\ mm$

(2) $D_{15}(R)/D_{15}(F) > 5$

$D_{15}(F) < 164.59/4 = 32.92\ mm$

$D_{15}(R)/D_{15}(F) > 40$

$D_{15}(F) < 164.59/40 = 4.11\ mm$

(3) $D_{15}(R)/D_{85}(F) < 5$

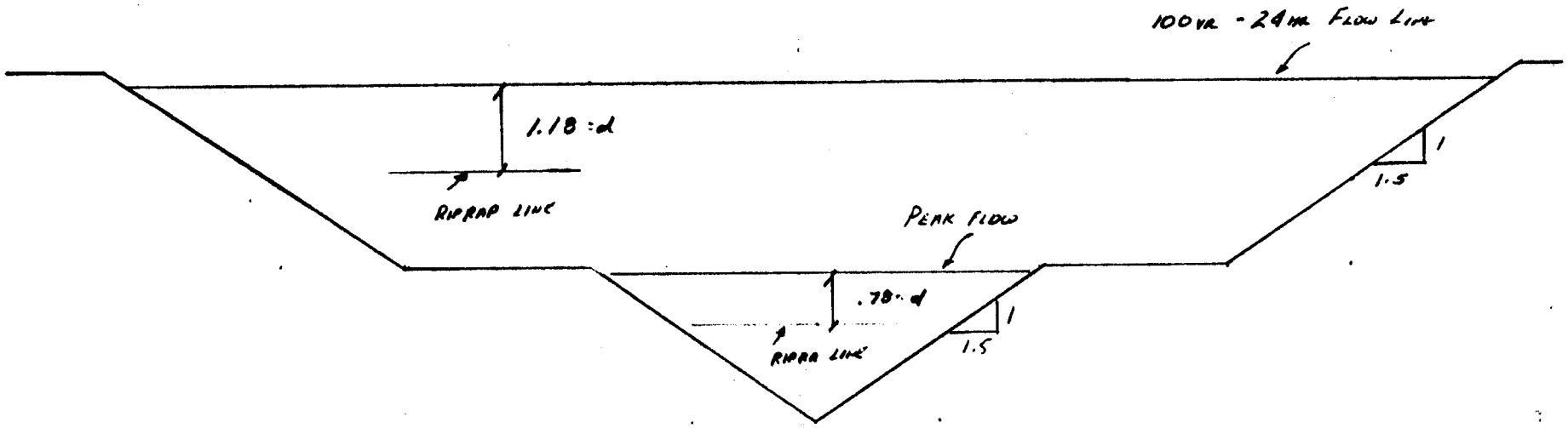
$D_{85}(F) > 164.59/5 = 32.92\ mm.$

FILTER BLANKET MUST BE SIZED AS FOLLOWS

D_{50} (FILTER) $> 9.14\ mm$

$.75\ mm < D_{15}$(FILTER) $< 32.92\ mm$

D_{85} (FILTER) $< 32.92\ mm.$



SECTION D3

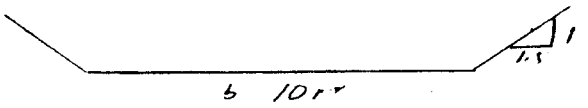
AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

RECLAIM - CHANNEL 2

$Q = 195$ CFS

$S = .0833$

$n = .040$



$Z = \frac{1.5}{1} = 1$

USING MANNING FORMULA

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}$

$Q = VA = \frac{1.486}{n} A R^{2/3} S^{1/2}$

$A = bd + zd^2$

$Q = \frac{1.486}{n}(bd + zd^2)\left(\frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}\right)^{2/3} S^{1/2}$

$= \frac{1.486}{.04}(10d + 1.5d^2)\left(\frac{10d + 1.5d^2}{10 + 2d\sqrt{(1.5)^2+1}}\right)^{2/3}(.0833)^{1/2}$

$195 = 3715(10d + 1.5d^2)\left(\frac{10d + 1.5d^2}{10 + 3.61d}\right)^{2/3}(.2886)$

$18.19 = (10d + 1.5d^2)\left(\frac{10d + 1.5d^2}{10 + 3.61d}\right)^{2/3}$

TRAIL d

d	Q
1.2	14.05
1.4	19.31
1.39	18.09

$\underline{d = 1.39}$

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F. = 1.20

$$V = \frac{1.486}{.04} R^{2/3} S^{1/2}$$

$$n = .04$$

$$S = .0833$$

$$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}} = \frac{10(1.39) + 1.5(1.39)^2}{10 + 2(1.39)\sqrt{1.5^2+1}} = 1.119$$

$$V = \frac{1.486}{.04} (1.119)^{2/3} (.0833)^{1/2}$$

$$= 37.15 \ (1.077)(.2886) =$$

$$= 11.55 \text{ FPS}$$

STONE D_{50} = 24 IN = 2 FT

CHECK n

$$n = .0395 \ D_{50}^{.17}$$
$$= .0395 \ (1.13)$$
$$= .0444$$

CHECK FOR STABILITY

$$\tau = \gamma d S$$

$\gamma = 62.4$
$d = 1.39$
$S = .0833$

$$\tau = (62.4)(1.39)(.0833) = 7.2251 \text{ lb/ft}^2$$

$$n_b = \frac{21\tau}{\gamma(S.G.-1) D_{50}}$$

$$= \frac{21(7.2251)}{62.4(2.36-1)\ 2}$$

$$= \frac{151.7273}{169.7280}$$

$$= .8939$$

SF MUST BE >1

$\phi = 42°$ ANGULAR RIPRAP

8.33%
$\theta = 4.7617$

$SF_b = \cos\theta \tan\phi / \sin\theta + \eta_b \tan\phi$

$= \cos(4.7617) \tan(42) / \sin(4.7617) + .8939 \tan(42)$

$= .8973 / .8879$

$= 1.01$

D_{50}	Manning n	Angle of Repose (Deg)	Depth of Convey Flow	Tractive Force	Stability Factor	SF
2.0	.0444	42	1.39	7.2251	.8939	1.01
3.0	.0476	42	1.55	8.0560	.6646	1.31
2.8	.0471	42	1.52	7.9008	.6983	1.26
2.6	.0465	42	1.52	7.9008	.7520	1.18

$D_{50} = 2.617$

Determine Riprap for Bank SF = 1.20

$D_{50} = 2.6$ ft, $n = .0465$, $\theta = 4.7617$, $d = 1.52$ ft

Assume

$\tau_{max} = .76 \gamma d s$

$.76 (62.9)(1.52)(.0833) = 6.0096$

$n = 21 \tau_{max} / 62.9 (SG-1) D_{50}$

$= 21 (6.0096) / 62.9 (2.56-1) 2.6$

$= 126.0979 / 220.6961$

$= .5715$

Assume Uniform Flow

$\lambda = \theta = 4.7617$

Side slope

$\alpha = \tan^{-1} 1/1.5 = 33.69$

$$\beta = \tan^{-1}\left[\cos\lambda / 2\sin\alpha / \eta \tan\phi + \sin\lambda\right]$$

$$= \tan\left[\cos(4.7617) / 2\sin 33.69 / .5715 \tan(45) + \sin 4.7617)\right]$$

$$= \tan^{-1}\left(.9965 / 2.2399\right)$$

$$= \tan^{-1}(.4451)$$

$$\beta = 23.99$$

$$\eta' = \eta\left[1 + \sin\lambda + \beta/2\right]$$

$$= .5715\left[1 + \sin(4.7617 + 23.99)/2\right]$$

$$= .5715\,(.7405)$$

$$= .4232$$

$$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos(33.69) \tan(45) / .4232 \tan(45) + \sin(33.69) \cos(23.99)$$

$$= .7496 / .8878$$

$$= .8436$$

D_{50}	η	β	η'	SF
2.6	.5715	23.99	.4232	.8436
5.2	.2857	12.7752	.1859	1.05
7.0	.2123	9.6066	.1325	1.12
9.0	.1651	7.5228	.1001	1.17
11.0	.1351	6.1790	.0809	1.20

USE 11.0 FT

BASED ON THE CALCULATIONS THE BOTTOM AND SIDESLOPES RIPRAP WILL BE 2.6 FT = D_{50}

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

RIPRAP GRADATION

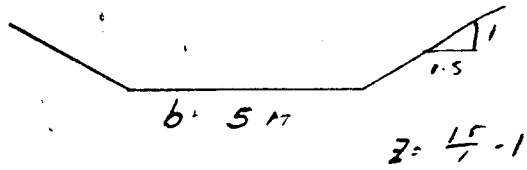
SIZE FT		PERCENT
$2D_{50}$	5.2	100
D_{50}	2.6	50
$.5D_{50}$	1.3	20
$.2D_{50}$	.52	0

PEAK FLOW

$Q = 13.31$

$S = .0833$

$n = .09$



$z = \frac{1.5}{1} = 1$

USING MANNING FORMULA

$Q = VA = \frac{1.486}{n} A R^{2/3} S^{1/2}$

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}$

$A = bd + zd^2$

$Q = \frac{1.486}{n}(bd + zd^2)\left(\frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}\right)^{2/3} S^{1/2}$

$= \frac{1.486}{.09}(5d + 1.5d^2)\left(\frac{5d + 1.5d^2}{5 + 2d\sqrt{0.5^2+1}}\right)^{2/3}(.0833)^{1/2}$

$13.31 = 37.15\,(5d + 1.5d^2)\left(\frac{5d + 1.5d^2}{5 + 3.61d}\right)^{2/3}(.2886)$

$1.2419 = (5d + 1.5d^2)\left(\frac{5d + 1.5d^2}{5 + 3.61d}\right)^{2/3}$

TRIAL d

d	Q
1.0	5.39
.5	1.60
.4	1.11
.42	1.21
.43	1.26

$d = .43$ FT

DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F = 1.20

$V = 1.486/n \; R^{2/3} \; S^{1/2}$

$n = .04$

$S = .0833$

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}} = \frac{5(.93) + 1.5(.93)^2}{5 + 2(.93)\sqrt{1.5^2+1}} = .3706$

$V = 1.486/.04 \; (.3706)^{2/3} \; (.0833)^{1/2}$

$= 37.15 \; (.5193) \; (.2886)$

$= 5.5684$ FPS

STONE $D_{50} = 1.5$ FT.

CHECK n

$n = .0395 \; D_{50}^{1/6}$

$= .0395 \; (1.0714)$

$= .0423$

CHECK FOR STABILITY

$\tau = \gamma d S$ $\qquad \gamma = 62.4$, $d = .93$, $S = .0833$

$\tau = 62.4 \; (.93) \; (.0833) = 2.251$ LB/FT^2

$\eta_D = 21\tau / \gamma (S_s - 1) D_{50}$

$= 21(2.251)/62.4 \; (2.2 - 1) \; 1.5$

$= 46.9372 / 127.2960$

$= .3687$

S.F. MUST BE > 1

$\phi = 42°$ ANGULAR RIPRAP

8.332

$\theta = 4.767$

$$SF = \cos\theta \tan\phi / \sin\theta + n \tan\phi$$

$$= \cos(4.7617) \tan(40) / \sin(4.7617) + .3687 \tan(40)$$

$$= .8973 / .4150$$

$$= 2.1621$$

D_{50}	Manning n	Angle of Riprap (Deg)	Depth of Comer Flow	Tractive Force	Stability Factor	SF
1.5	.0423	42	.43	2.251	.3687	2.16
1.0	.0395	42	.42	2.1831	.5402	1.57
.75	.0376	42	.50	2.5990	.8575	1.09
.9	.0388	42	.42	2.1831	.5402	1.67

$D_{50} = .9$ ft

Deter Riprap for Bank S.F = 1.20

$D_{50} = .9$ ft, $n_1 = .0388$, $\theta = 4.7617$ $d = .9217$

Assume

$$\tau_{max} = .76 \gamma d s$$
$$= .76(62.4)(.42)(.0833) = 1.6592$$

$$n = 21 \tau_{max} / \gamma (G.E.-1) D_{50}$$

$$= 21(1.6592) / 62.4(2.36-1).9$$

$$= 34.8427 / 76.3776$$

$$= .4562$$

Assume Uniform Flow

$\lambda = \theta = 4.7617$

Side slope

$\alpha = \tan^{-1} \frac{1}{1.5} = 33.69$

$$\beta = \tan^{-1}\left[\cos\lambda / 2\sin\phi / \eta \tan\phi + \sin\lambda\right]$$

$$= \tan^{-1}\left[\cos(4.7617) / 2\sin(32.69) / .4562 \tan(42) + \sin(4.7617)\right]$$

$$= \tan\left(.9965 / 2.7939\right)$$

$$= \tan^{-1}(.3580)$$

$$\beta = 19.6959$$

$$\eta' = \eta\left(1 + \sin(\lambda + \beta/2)\right)$$

$$= .4562\left(1 + \sin(4.7616 + 19.6959/2)\right)$$

$$= .4562\,(1.7070)$$

$$= .3225$$

$$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos(32.69)\tan(42) / .3225 \tan(42) + \sin(32.69)\cos(19.6959)$$

$$= .7492 / .8127$$

D_{50}	η	β	η'	SF
.9	.4562	19.6959	.3225	.92
1.3	.3158	14.0411	.1597	1.10
1.7	.2415	10.8791	.1533	1.10
2.5	.1642	7.4891	.0995	1.17
3.0	.1369	6.2589	.0815	1.20

BASED ON THE CALCULATION THE BOTTOM AND SIDE SLOPES RIPRAP WILL BE ~.9 FT = D50

RIPRAP GRADATION

SIZE FT		PERCENT
$2D_{50}$	1.8 FT	100
D_{50}	.9 FT	50
$.5D_{50}$	.45 FT	20
$.2D_{50}$	.18 FT	0

UNDERLYING FILTER .3

ASSUME

BASE MATERIAL

D_{50} = .600 MM

D_{85} = 2.36 MM

D_{15} = .150 MM

RIPRAP

D_{100}	=	1.8 FT	=	548.64
D_{50}	=	.9 FT	=	274.32
D_{85}	=	1.28 FT	=	390.14 MM
D_{15}	=	.40 FT	=	121.92 MM
D_0	=	.18 FT	=	54.86 MM

FILTER BLANKET WITH RESPECT TO BASE MATERIAL

(1) $D_{50}(F)/D_{50}(B) < 40$

$D_{50}(F) < 40 \times .6 = \underline{24\ mm}$

(2) $D_{15}(F)/D_{15}(B) < 5$

$D_{15}(F) < 5 \times .150 = \underline{.75\ mm}$

$D_{15}(F)/D_{15}(B) < 40$

$D_{15}(F) < 40 \times .15 = \underline{6\ mm}$

(3) $D_{15}(F)/D_{85}(B) < 5$

$D_{15}(F) < 5 \times 2.36 = \underline{11.80\ mm}$

FILTER BLANKET WITH RESPECT TO RIPRAP

(1) $D_{50}(R)/D_{50}(F) < 40$

$D_{50}(F) > 274.32/40 = 6.86$ mm

(2) $D_{15}(R)/D_{15}(F) > 5$

$D_{15}(F) < 274.32/5 = 54.86$ mm

$D_{15}(R)/D_{15}(F) < 40$

$D_{15}(F) > 274.32/40 = 6.86$ mm

(3) $D_{15}(R)/D_{85}(F) < 5$

$D_{85}(F) > 274.32/5 = 54.86$ mm

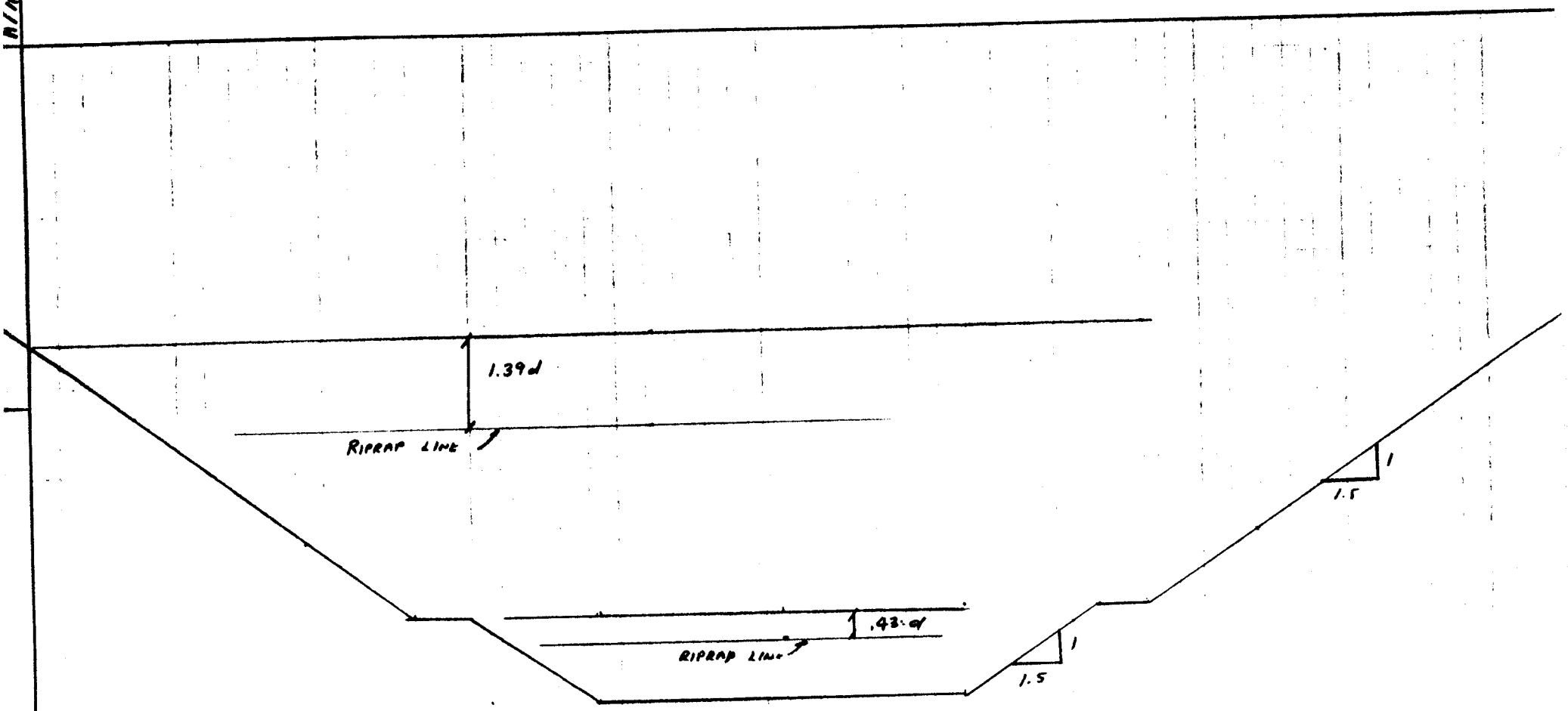
FILTER BLANKET MUST BE SIZED AS FOLLOWS

$D_{50}(\text{FILTER}) > 6.86$ mm

$.75\text{mm} < D_{15}(\text{FILTER}) < 54.86$ mm

$D_{85}(\text{FILTER}) < 54.86$ mm.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD



SECTION D_4

AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

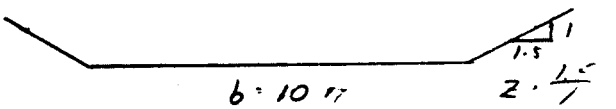
RECLAIM CHANNEL
NORTH STREAM

$Q = 100$ CFS

$S = .02$

$n = .04$

from Sec 7



$R = bd + zd^2 / b + 2d\sqrt{z^2+1}$

$A = bd + zd^2$

USING MANNING FORMULA

$Q = VA = 1.486/n \; A R^{2/3} S^{1/2}$

$Q = 1.486/n \, (bd + zd^2) \left(bd + zd^2 / b + 2d\sqrt{z^2+1} \right)^{2/3} S^{1/2}$

$= 1.486/.04 \, (10d + 1.5d^2) \left(10d + 1.5d^2 / 10 + 2d\sqrt{(1.5)^2+1} \right)^{2/3} (.02)^{1/2}$

$100 = 37.15 \, (10d + 1.5d^2) \left(10d + 1.5d^2 / 10 + 3.61d \right)^{2/3} (.141)$

$19.03 = (10d + 1.5d^2) \left(10d + 1.5d^2 / 10 + 3.61 \right)^{2/3}$

TRIAL d

d	Q
1.5	20.63
1.4	18.31
1.42	18.77
1.44	19.23
1.43	18.99

$d = 1.44$ ft

DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F. = 1.20

$V = 1.486/n \; R^{2/3} S^{1/2}$

$n = .04$

$S = .02$

reference 3.2.6-1A SHOWS ~11.7%

$R = \frac{bd + z^2d^2}{b + 2d\sqrt{z^2+1}} = \frac{10(1.44) + 1.5(1.44)^2}{10 + 2(1.44)\sqrt{(2.5)^2+1}} = 1.15$

$V = 1.486/.04 \; (1.15)^{2/3} \; (.02)^{1/2}$

$= 37.15 \; (1.0983) \; (.1414)$

$= 5.77$ FPS

STONE $D_{50} = .9$ in $= .75$ ft

CHECK n

$n = .0395 \; D_{50}^{.17}$

$= .0395 \; (.75)^{.17} = .0376$

CHECK FOR STABILITY

$\tau = \gamma d S$

$d = 1.44$
$S = .02$
$\gamma = 62.4$

$\tau = 62.4 \; (1.44)(.02) = 1.7971$

$\eta_s = 21\tau / \gamma (SG-1) D_{50}$

$= 21(1.7971) / 62.4 \; (2.36-1) .75$

$= 37.7395 / 63.6490$

$= .5929$

S.F. MUST BE > 1

$\phi = 42°$ ANGULAR RIPRAP

$2\eta_s$
$\theta = 1.1858$

$$SF = \cos\theta \tan\phi / \sin\theta + \eta_b \tan\theta$$

$$= \cos(1.145E) \tan(42) / \sin(1.145E) + .5939 \tan(42)$$

$$= .9002 / .5539$$

$$= 1.62$$

D_{50}	Manning N	Angle of Repose Deg	Depth of Convey Flow	Tractive Force	Stability Factor	Safety Factor
.75	.0376	42	1.44	1.7971	.5925	1.62
.5	.0351	42	1.33	1.6598	.8215	1.19
.52	.0353	42	1.34	1.6723	.7958	1.22

$D_{50} = .52$ ft

Determine Riprap for Bank S.F. = 1.20

$D_{50} = .52$ ft, $n = .0353$, $\theta = 1.1458$ $d = 1.34$ ft.

Assume

$$\tau_{max} = .76 \gamma d s$$
$$= .76(62.4)(1.34)(.02) = 1.2710 \text{ lb/ft}^2$$

$$\eta = 21 \tau / \gamma (SG-1) D_{50}$$

$$= 21(1.2710) / 62.4(2.36-1)(.52)$$

$$= 26.6902 / 44.1293$$

$$= .6048$$

Assume Uniform Flow
$\lambda = \theta = 1.1458$

Side slope
$\alpha = \tan^{-1} 1.5 = 33.69$

$$\beta = \tan^{-1}\left(\cos\lambda / 2\sin\alpha / \eta \tan\phi + \sin\lambda\right)$$

$$= \tan^{-1}\left(\cos(1.1456) / 2\sin 33.69 / .6098 \tan 42 + \sin(1.1456)\right)$$

$$= \tan^{-1}\left(.9998 / 2.0572\right)$$

$$= \tan(.4860)$$

$$\beta = 25.92$$

$$\eta' = \eta\left(1 + \sin(\lambda + \beta)/2\right)$$

$$= .6098\left(1 + \sin(1.1456 + 25.92)/2\right)$$

$$= .6098\,(.7271)$$

$$= .4400$$

$$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos(33.69) \tan(42) / .4400 \tan(42) + \sin(33.69) \cos 25.92$$

$$= .7492 / .8931$$

$$= .8370$$

D_{50}	η	β	η'	SF
.52	.6098	25.92	.4400	.8370
1.0	.3145	14.2467	.1990	1.05
1.5	.2097	9.6236	.1244	1.14
2.0	.1573	7.2535	.0901	1.19

$D_{50} = 2.0$

BASED ON THE CALCULATIONS THE BOTTOM AND SIDESLOPES RIPRAP WILL BE $.54 = D_{50}$

RIPRAP GRADATION

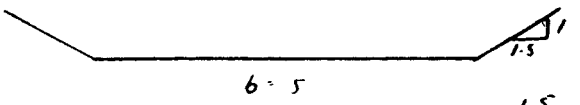
			Percent
$2D_{50}$	=	1.09 ft	100
D_{50}	=	.54	50
$.5D_{50}$	=	.27	20
$.2D_{50}$	=	.11	0

PEAK FLOW ? what is this

$Q = 8.8$ cfs

$s = .02$

$n = .04$



$z = \frac{1.5}{1} = 1.5$

USING MANNING FORMULA

$Q = VA = \frac{1.486}{n} A R^{2/3} s^{1/2}$

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}$

$A = bd + zd^2$

$Q = \frac{1.486}{n}(bd + zd^2)\left(\frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}\right)^{2/3} s^{1/2}$

$= \frac{1.486}{.04}(5d + 1.5d^2)\left(\frac{5d + 1.5d^2}{5 + 2d\sqrt{(1.5)^2+1}}\right)^{2/3}(.02)^{1/2}$

$8.8 = 37.15(5d + 1.5d^2)\left(\frac{5d + 1.5d^2}{5 + 3.61d}\right)^{2/3}(.1414)$

$1.6750 = (5d + 1.5d^2)\left(\frac{5d + 1.5d^2}{5 + 3.61d}\right)^{2/3}$

TRIAL d

d	Q
.5	1.6281
.	

$d = .5$ FT.

DETERMINE RIPRAP D_{50} AND DESIGN IN S.F. = 1.20

$V = \frac{1.486}{n} R^{2/3} s^{1/2}$

$n = .04$

$s = .02$

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}} = \frac{5(.5) + 1.5(.5)^2}{5 + 2(.5)\sqrt{1.5^2+1}} = .4226$

$V = 1.486/.04 \; (.4228^{2/3}) \; (.02)^{1/2}$

$= 37.15 \; (.5224) \; (.1414)$

$= 2.98$ FPS

STONE $D_{50} = 3$ IN $= .25$ FT

CHECK n

$n = .0395 \; (D_{50})^{1/6}$

$= .0395 \; (.7900) = .0312$

CHECK FOR STABILITY

$\tau = \gamma d s$ $\qquad \gamma = 62.4$, $d = .5$, $s = .02$

$\tau = (62.4)(.5)(.02) = .6240$

$n_b = 21\tau / \gamma (s_s - 1) D_{50}$

$= 21(.6240)/62.4 \; (2.36 - 1) \; .25$

$= 13.1040 / 21.2160$

$= .6176$

S.F. MUST BE > 1

$\phi = 42°$ ANGULAR RIPRAP

2%

$\theta = 1.1458$

$SF = \cos\theta \tan\phi / \sin\theta + n \tan\phi$

$= \cos(1.1458) \tan(42) / \sin(1.1458) + .6176 \tan(42)$

$= .9002 / .3761$

$= 1.5$

D_{50}	Manning n	Angle of Repose (Deg)	Depth of Comp. Flow	Tractive Force	Stability Factor	SF
.25	.0312	42	.5	.6240	.6176	1.56
.20	.0300	42	.43	.5366	.6640	1.45
.15	.0286	42	.40	.4992	.8835	.98
.17	.0292	42	.43	.5366	.7811	1.03
.18	.0295	42	.44	.5491	.7549	1.07
.19	.0298	42	.43	.5366	.6989	1.15

$D_{50} = .19$ FT.

DETERMINE RIPRAP FOR BANK S.F. = 1.20

$D_{50} = 1$, $n = .0298$, $\theta = 1.1458$ $d = .43'$

ASSUME

$$\tau_{max} = .76 \gamma d s$$
$$= .76 (62.4)(.43)(.02) = .4078$$

$$n = 21 \tau_{max} / \gamma (SG-1) D_{50}$$
$$= 21(.4078) / 62.4 (2.36-1)(1)$$
$$= 8.5646 / 84.8640$$
$$= .1009$$

ASSUME UNIFORM FLOW
$\lambda = \theta = 1.1458$

SIDE SLOPE
$\alpha = \tan^{-1} 1/1.5 = 33.69$

$$\beta = \tan^{-1}\left(\cos\lambda / 2\sin\alpha / n\tan\phi + \sin\lambda\right)$$

$$= \tan^{-1}\left(\cos(1.1456) / 2\sin(33.69) / .1009\tan(42) + \sin(1.1456)\right)$$

$$= \tan^{-1}\left(.9996 / 12.2284\right)$$

$$= \tan^{-1}(.0818)$$

$$\beta = 4.6791$$

$$n' = n\left(1 + \sin\lambda + \beta/2\right)$$

$$= .1009\left(1 + \sin(1.1456 + 4.6791)/2\right)$$

$$= .0556$$

$$SF = \cos\alpha\tan\phi / n'\tan\phi + \sin\alpha\cos\beta$$

$$= \cos(33.69)\tan(42) / .0556\tan(42) + \sin(33.69)\cos(4.679)$$

$$= .7796 / .6029$$

$$= 1.29$$

$$D_{50} = 1\ ft$$

BASED ON THE CALCULATIONS THE BOTTOM AND SIDE SLOPE RIPRAP WILL BE $.19 - D_{50}$

RIPRAP GRADATION

	SIZE	PERCENT
$2D_{50}$	.38	100
D_{50}	.19	50
$.5D_{50}$	.09	20
$.2D_{50}$	.04	0

UNDERLYING FILTER

ASSUME

BASE MATERIAL

D_{50} = .600 mm

D_{85} = 2.36 mm

D_{15} = .150 mm

RIPRAP

D_{100}	=	1.04	=	316.99 mm
D_{50}	=	.54	=	164.59 mm
D_{85}	=	.97	=	296.27 mm
D_{15}	=	.24	=	74.07 mm
D_0	=	.11	=	32.92 mm

FILTER BLANKET WITH RESPECT TO BASE MATERIAL

(1) $D_{50}(F)/D_{50}(B) > 40$

$D_{50}(F) = 40 \times .6 = 24$ mm

(2) $D_{15}(F)/D_{15}(B) < 5$

$D_{15}(F) < 5 \times .15 = .75$ mm

$D_{15}(F)/D_{15}(B) < 40$

$D_{15}(F) < 40 \times .15 = 6$ mm

(3) $D_{15}(F)/D_{85}(B) < 5$

$D_{15}(F) < 5 \times 2.36 = 11.8$ mm

∴ WITH RESPECT TO BASE MATERIAL

$.75\ mm < D_{15}(\text{FILTER}) < 6\ mm$

$D_{50}(\text{FILTER}) < 24\ mm.$

FILTER SIZE FOR RIPRAP

(1) $D_{50}(R)/D_{50}(F) < 40$

$D_{50}(F) > 164.59/40 = 4.11\ mm$

(2) $D_{15}(R)/D_{15}(F) < 5$

$D_{15}(F) > 164.59/5 = 32.92\ mm$

$D_{15}(R)/D_{15}(F) < 40$

$D_{15}(F) > 164.59/40 = 4.11\ mm$

(3) $D_{15}(R)/D_{85}(F) < 5$

$D_{85}(F) > 164.59/5 = 32.92\ mm$

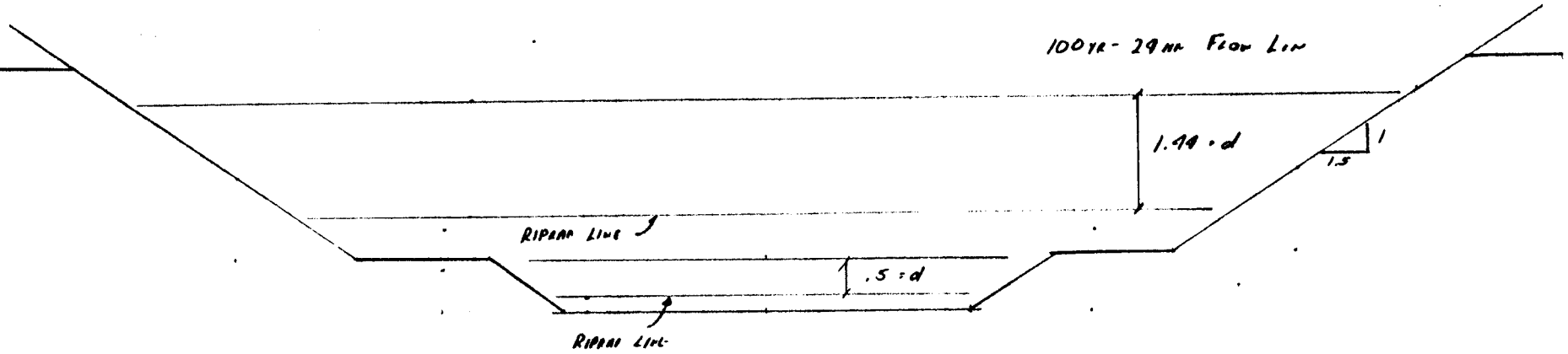
FILTER BLANKET MUST BE SIZED AS FOLLOWS

$D_{50}(\text{FILTER}) > 4.11\ mm$

$.75\ mm < D_{15}(\text{FILTER}) < 32.92\ mm$

$D_{85}(\text{FILTER}) < 32.92\ mm.$

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD



SECTION D_5

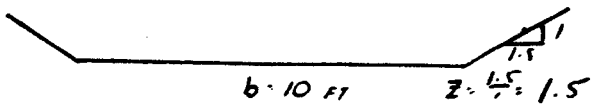
AMPAD
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS

RECLAIM CHANNEL

$Q = 295$ CFS

$S = .1163$

$n = .04$



USING MANNING FORMULA

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}$

$Q = VA = \frac{1.486}{n} A R^{2/3} A$

$A = bd + zd^2$

$$Q = \frac{1.486}{n}(bd + zd^2)\left(\frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}\right)^{2/3} S^{1/2}$$

$$= \frac{1.486}{.04}(10d + 1.5d^2)\left(\frac{10d + 1.5d^2}{10 + 2d\sqrt{(1.5)^2+1}}\right)^{2/3}(.1163)^{1/2}$$

$$295 = 37.15\,(10d + 1.5d^2)\left(\frac{10d + 1.5d^2}{10 + 3.61d}\right)^{2/3}(.3410)$$

$$23.29 = (10d + 1.5d^2)\left(\frac{10d + 1.5d^2}{10 + 2.61d}\right)^{2/3}$$

TRAIL d

d	Q
2.0	39.13
1.5	20.63
1.7	25.65
1.6	23.08
1.62	23.58
1.61	23.33

$d = 1.61$ FT.

DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F. = 1.20

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

$n = .04$

$S = .1163$

$$R = \frac{bd + zd^2}{bd + 2d\sqrt{z^2+1}} = \frac{10(1.61) + 1.5(1.61)^2}{10 + 2(1.61)\sqrt{(1.5)^2+1}} = 1.26$$

$$V = \frac{1.486}{.04}(1.26)^{2/3}(.1163)^{1/2}$$

$= 37.15\ (1.1676)\ (.3410)$

$= 14.79$ FPS

STONE $D_{50} = 24$ IN $= .2$ FT

CHECK n

$n = .0395\ D_{50}^{.17}$

$= .0395\ (2)^{.17} = .0439$

CHECK FOR STABILITY

$\tau = \gamma d s$ $\qquad \gamma = 62.4$, $d = 1.61$, $s = .1163$

$\tau = (62.4)(1.61)(.1163) = 11.4830$

$$n_b = \frac{21\tau}{\gamma (S_G - 1) D_{50}}$$

$$= \frac{21(11.4830)}{62.4(2.36-1)(2)}$$

$$= \frac{241.1430}{169.7280}$$

$= 1.4208$

S.F. MUST BE > 1

$\phi = 42°$ ANGULAR RIPRAP

11.63%

$\theta = 6.6337$

$$SF = \cos\theta \tan\phi / \sin\theta + \eta_b \tan\theta$$

$$= \cos(6.6377) \tan(42) / \sin(6.6377) + 1.4208 \tan 42$$

$$= .8944 / 1.3948$$

$$= .6412$$

D_{50}	Manning n	Angle of Repose (Φ)	Depth of Convey Flow	Tractive Force	Stability Factor	Safety Factor
2	.0439	42	1.61	11.4930	1.4208	.6412
4.5	.0510	42	1.85	13.4257	.7383	1.15
5.0	.0519	42	1.88	13.6434	.6752	1.23

D_{50} = 5.0 FT THIS WILL ERROR - $2D_{50}$

BASE ON THE CALCULATIONS THE RIPRAP WILL BE $5 \cdot D_{50}$. THIS WILL BE USED TO CREATE WATER FALLS.

RIPRAP GRADATION

	Size	Percent
$2D_{50}$	50	100
D_{50}	2.5	50
$.5D_{50}$	1.25	20
$.2D_{50}$	.45	0

UNDERLYING FILTER

ASSUME

BASE MATERIAL

D_{50} = .600 mm

D_{85} = 2.36 mm

D_{15} = .150 mm

RIPRAP

D_{100}	=	5.0 FT	=	1524 mm
D_{50}	=	2.5 FT	=	762 mm
D_{85}	=	4.63 FT	=	1411.22 mm
D_{15}	=	1.13 FT	=	344.42 mm
D_0	=	.5 FT	=	152.40 mm

FILTER BLANKET WITH RESPECT TO BASE MATERIAL

(1) $D_{50}(F)/D_{50}(B) > 40$

$D_{50}(F) > 40 \times .6 = 24$ mm

(2) $D_{15}(F)/D_{15}(B) < 5$

$D_{15}(F) < 5 \times .15 = .75$ mm

$D_{15}(F)/D_{15}(B) < 40$

$D_{15}(F) < 40 \times .15 = 6$ mm

(3) $D_{15}(F)/D_{85}(B) < 5$

$D_{15} < 5 \times 2.36 = 11.8$ mm

∴ WITH RESPECT TO BASE MATERIAL

$.75 < D_{15}(\text{FILTER}) < 6$ mm

$D_{50}(\text{FILTER}) < 24$ mm

FILTER SIZE FOR RIPRAP

(1) $D_{50}(R)/D_{50}(F) < 40$

$D_{50}(F) > 762/40 = 19.05$ mm

(2) $D_{15}(R)/D_{15}(F) < 5$

$D_{15}(F) > 344.42/5 = 68.88$ mm

$D_{15}(R)/D_{15}(F) < 40$

$D_{15}(F) > 344.42/40 = 8.61$ mm

(3) $D_{15}(R)/D_{85}(F) < 5$

$D_{85}(F) > 344.42/5 = 68.88$ mm

FILTER BLANKET MUST BE SIZED AS FOLLOW:

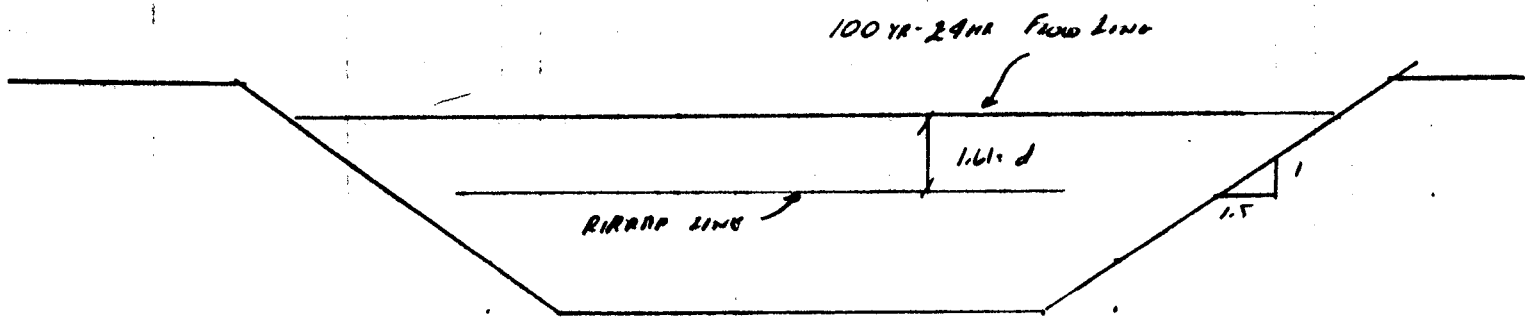
D_{50} (FILTER) > 19.05 mm

.75 mm < D_{15} (FILTER) < 68.88 mm

D_{85} (FILTER) < 68.88 mm

A MAT WILL BE INSTALLED IN THE CHANNEL TO INSURE THAT THE FILTER BLANKET WILL REMAIN AND NOT WASH OUT. THIS WILL BE INSTALL BECAUSE OF THE STEEPNESS OF THE SLOPE.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD



SECTION D6

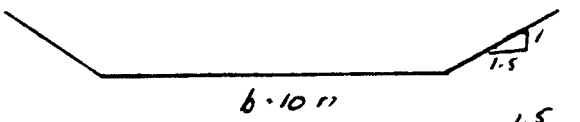
AMPAD
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS

RECLAIM CHANNEL

$Q = 295$ cfs

$n = .04$

$S = .017$



$z = \frac{1.5}{1} = 1.5$

USING MANNING FORMULA

$R \quad bd + zd^2 / b + 2d\sqrt{z^2+1}$

$Q = AV = \frac{1.486}{n} A R^{2/3} S^{1/2}$

$A = bd + zd^2$

$Q = \frac{1.486}{n}(bd + zd^2)\left(\frac{bd+zd^2}{b+2d\sqrt{z^2+1}}\right)^{2/3} S^{1/2}$

$= \frac{1.486}{.04}(10d + 1.5d^2)\left(\frac{10d + 1.5d^2}{10 + 2d\sqrt{1.5^2+1}}\right)^{2/3}(.017)^{1/2}$

$295 = 37.15(10d + 1.5d^2)\left(\frac{10d + 1.5d^2}{10 + 3.61d}\right)^{2/3}(.130)$

$60.90 = (10d + 1.5d^2)\left(\frac{10d + 1.5d^2}{10 + 3.61d}\right)^{2/3}$

TRAIL d

d	Q
3	70.72
2.8	62.35
2.6	59.55
2.7	58.37
2.72	59.16
2.74	59.94
2.76	60.74

$d = 2.76$

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

DETERMINE RIPRAP D_{50} AND DESIGN FOR S.F. 1:20

$V = 1.486/n \; R^{2/3} \; S^{1/2}$

$n = .04$

$S = .017$

$R = bd + zd^2 / b + 2d\sqrt{z^2+1} = 10(2.76) + 1.5(2.76)^2 / 10 + 2(2.76)\sqrt{1.5^2+1} = 1.9561$

$V = 1.486/.04 \; (1.9561)^{2/3} \; (.017)^{1/2}$

$= 37.15 \; (1.5571) \; (.1304)$

$= 7.54$ FPS

STONE $D_{50} = 12$ IN $= 1$ FT.

CHECK n

$n = .0395 \; D_{50}^{.17}$

$= .0395 \; (1) = .0395$

CHECK FOR STABILITY

$\tau = \gamma d s$

$\gamma = 62.4$

$d = 2.76$

$s = .017$

$\tau = (62.4)(2.76)(.017) = 2.9278$ lb/ft²

$\eta_b = 21\tau / \gamma(S_s - 1) D_{50}$

$= 21(2.9278) / 62.4(2.36-1)1$

$= 61.4640 / 84.8640$

$= .7245$

S.F. MUST BE > 1

$\phi = 42°$ ANGULAR RIPRAP

1.7%

$\theta = .9739$

$$SF = \cos\theta \tan\phi / \sin\theta + \eta_b \tan\theta$$

$$= \cos(.9739)\tan(42) / \sin(.9739) + .7245 \tan(42)$$

$$= .9003 / .6693$$

$$= 1.3450$$

D_{50}	Manning's n	Angle of Repose (deg)	Depth on Curved Flow	Tractive Force	Stability Factor	Safety Factor
1	.0395	42	2.76	2.9278	.7245	1.35
.9	.0388	42	2.72	2.8854	.7933	1.23

$D_{50} = .9$ FT.

DETERMINE RIPRAP FOR BANK S.F. = 1.20

$D_{50} = .9$ FT, $n = .0388$, $\theta = .9739$, $d = 2.72$

ASSUME

$$\tau_{max} = .76\,\gamma d S$$
$$= .76(62.4)(2.72)(.017) = 2.1929$$

$$\eta = 21\tau_{max} / \gamma(SG-1)D_{50}$$
$$= 21(2.1929) / 62.4(2.36-1).9$$
$$= 46.0506 / 76.3776$$
$$= .6029$$

ASSUME UNIFORM FLOW

$\lambda = \theta = .9739$

SIDESLOPE

$\alpha = \tan^{-1} 1/1.5 = 33.69$

$$\beta = \tan^{-1}\left[\cos\lambda / 2\sin\alpha / \eta \tan\phi + \sin\lambda\right]$$

$$= \tan^{-1} \cos(.9739) / 2\sin 33.69 / .6029 \tan(42) + \sin .9739$$

$$= \tan(.9999 / 2.8866)$$

$$= \tan^{-1}(.3852)$$

$\beta = 25.8841$

$$\eta' = \eta\left(1 + \sin\lambda + \frac{\beta}{2}\right)$$

$$= .6029\left(\frac{1 + \sin .9739 + 14.9452}{2}\right)$$

$$= .6029\,(.6371)$$

$$= .3841$$

$$S.F = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\phi$$

$$= \cos(33.60)\tan\phi / .3841 \tan(\phi) + \sin(33.6)\cos(.9739)$$

$$= .7492 / .9005$$

$$= .8320$$

D_{50}	η	β	η'	SF
.9	.6029	25.8999	.9376	.8389
1.5	.3618	16.2860	.2346	1.0075
2.0	.2713	12.3727	.1670	1.0824
2.5	.2171	9.9608	.1291	1.1307
3.0	.1809	8.3303	.1051	1.1643
3.5	.1550	7.1561	.0885	1.1892

$D_{50} = 3.5$ ft

BASED ON THE CALCULATIONS THE BOTTOM AND SIDE SLOPES RIPRAP WILL BE $D_{50} = .9$ ft

RIPRAP GRADATION

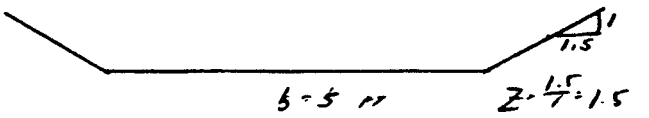
	Size	Percent
$2\,D_{50}$	1.8	100
D_{50}	.9	50
$.5\,D_{50}$	.45	20
$.2\,D_{50}$	.18	0

PEAK FLOW

$Q = 22$ cfs

$n = .40$

$S = .017$



USIN MANNING FORMULA

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}$

$Q = VA = \frac{1.486}{n} A R^{2/3} S^{1/2}$

$A = bd + zd^2$

$$Q = \frac{1.486}{n}(bd + zd^2)\left(\frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}\right)^{2/3} S^{1/2}$$

$$= \frac{1.486}{.04}(5d + 1.5d^2)\left(\frac{5d + 1.5d^2}{5 + 2d\sqrt{(1.5)^2+1}}\right)^{2/3}(.017)^{1/2}$$

$$22 = 37.15(5d + 1.5d^2)\left(\frac{5d + 1.5d^2}{5 + 3.61d}\right)^{2/3}(.1304)$$

$$4.54 = (5d + 1.5d^2)\left(\frac{5d + 1.5d^2}{5 + 3.61d}\right)^{2/3}$$

TRAIL d

d	Q
1	5.40
.9	4.99
.92	4.66

$d = .92$ FT.

DETERMINE RIPRAP D_{50} AND DESIGN IN S.F. = 1.20

$V = \frac{1.486}{n} R^{2/3} S^{1/2}$

$n = .04$

$S = .017$

$R = \frac{bd + zd^2}{b + 2d\sqrt{z^2+1}} = \frac{5(.92) + 1.5(.92)^2}{5 + 2(.92)\sqrt{1.5^2+1}} = .7057$

$V = \frac{1.486}{.04}(.7057)^{2/3}(.017)^{1/2}$

$= 37.15(.7945)(.1304)$

$= 3.85$ FPS

STONE D_{50} = .4 IN = .3 FT

CHECK n

$n = .0395\, D_{50}^{.17}$

$= .0395\,(.8140)$

$= .0322$

CHECK FOR STABILITY

$\tau = \gamma d s$ $\gamma = 62.4$, $d = .92$, $s = .017$

$\tau = (62.4)(.92)(.017) = .9759$

$\eta_g = 27\tau / \gamma(SG-1) D_{50}$

$= 21(.9759) / 62.4(2.36-1)(.5)$

$= 20.4951 / 42.4320$

$= .8050$

S.F. MUST BE > 1

ϕ = 42° ANGULAR RIPRAP

1.7 %

$\theta = .9739$

S.F. = $\cos\theta \tan\phi / \sin\theta + n \tan\phi$

$= \cos(.9739) \tan 42 / \sin .9739 + .8050 \tan 42$

$= .9003 / .7418$

$= 1.21$

$D_{50} = .3$ FT

DETERMINE RIPRAP FOR BANK S.F. = 1.20

$D_{50} = 1.5$, $n = .0322$, $\theta = .9739$ $d = .92$ FT

ASUME

$\tau_{max} = .76\, \gamma d s$

$= .76(62.4)(.92)(.017) = .7417$

$\eta = 21\tau_{max} / \gamma(SG-1) D_{50}$

$= 21(.7417) / 62.4(2.36-1)(1.5)$

$= 15.5769 / 127.7960$

$= .1224$

ASSUME UNIFORM FLOW

$\lambda = \theta = .9739$

SIDE SLOPE

$\alpha = \tan^{-1} \frac{1}{1.5} = 33.69$

$\beta = \tan^{-1} \left[\cos\lambda / 2\sin\alpha / \eta \tan\phi + \sin\lambda \right]$

$= \tan^{-1} \left[\cos(.9739) / 2\sin 33.69 / .1224 \tan(45) + \sin(.9739) \right]$

$= \tan^{-1} (.9999 / 10.0911)$

$\beta = \tan^{-1} (.0992)$

$\beta = 5.6629$

$\eta' = \eta \left(1 + \sin\lambda + \beta/2 \right)$

$= .1224 \left(1 + \sin .9739 + \frac{5.6629}{2} \right)$

$= .1224 \ (.5576)$

$= .0683$

$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$

$= \cos(33.69) \tan(45) / .0683 \tan(45) + \sin(33.69) \cos(5.6629)$

$= .7492 / .6134$

$= 1.22$

$D_{50} = 1.5$

BASE ON THE CALCULATIONS THE BOTTOM AND SIDE SLOPE RIPRAP WILL BE $D_{50} = .3$ FT

RIPRAP GRADATION

	Size	Percent
$2D_{50}$	.60	100
D_{50}	.30	50
$.5D_{50}$	.15	20
$.2D_{50}$	.06	0

UNDERLYING FILTER

ASSUME

BASE MATERIAL

D_{50} = 600 mm

D_{85} = 2.36 mm

D_{15} = .150 mm

RIPRAP

D_{100}	1.8 FT	=	548.64 mm
D_{50}	.9 FT	=	274.32 mm
D_{85}	1.67 FT	=	509.02 mm
D_{15}	.39 FT	=	118.87 mm
D_0	.18 FT	=	54.86 mm

FILTER BLANKET WITH RESPECT TO BASE MATERIAL

(1) $D_{50}(F)/D_{50}(B) < 40$

$D_{50}(F) < 40 \times .6 = 24$ mm

(2) $D_{15}(F)/D_{15}(B) < 5$

$D_{15}(B) < 5 \times .15 = .75$ mm

$D_{15}(F)/D_{15}(B) < 40$

$D_{15}(B) < 40 \times .15 = 6$ mm

(3) $D_{15}(F)/D_{85}(B) < 5$

$D_{15}(F) < 5 \times 2.36 = 11.8$ mm

∴ WITH RESPECT TO THE BASE

$.75 < D_{15}(\text{Filter}) < 6$ mm

$D_{50}(\text{Filter}) < 24$ mm.

FILTER SIZE FOR RIPRAP

(1) $D_{50}(R)/D_{50}(F) < 40$

$D_{50}(F) > 274.37/40 = 6.86$ mm

(2) $D_{15}(R)/D_{15}(F) > 5$

$D_{15}(F) < 118.87/5 = 23.77$ mm

$D_{15}(R)/D_{15} < 40$

$D_{15}(F) > 118.87/40 = 2.97$ mm

(3) $D_{15}(R)/D_{85}(F) < 5$

$D_{85}(F) > 118.87/5 = 23.77$ mm

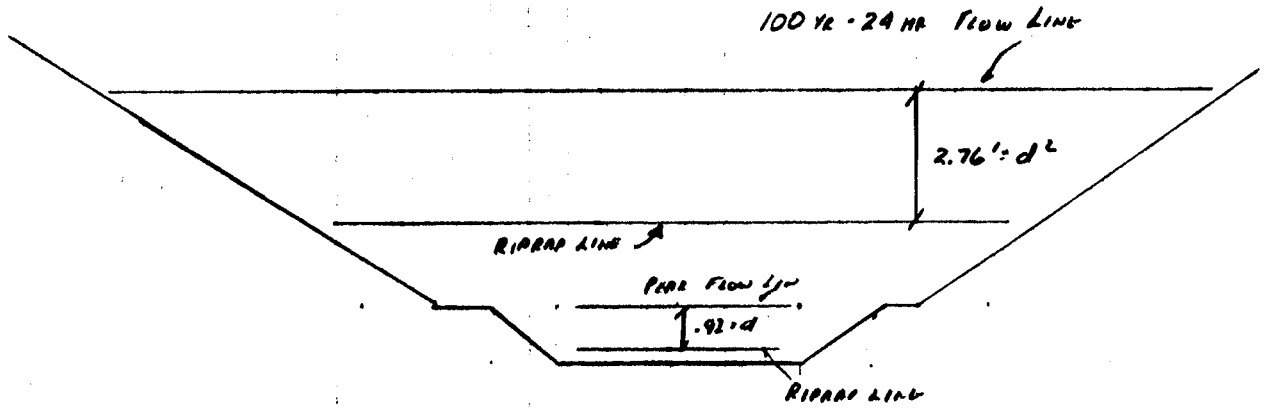
FILTER BLANKET MUST BE SIZED AS FOLLOWS

D_{50} (FILTER) > 6.86 mm

.75 mm < D_{15} (FILTER) < 23.77 mm

D_{85} (FILTER) < 23.77 mm

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD



SECTION D7

AMPAD
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS

HYDROLOGY STUDY
SOUTH FORK BREAKOUT
AREA

SOIL TYPES

	PERCENT	TYPE	CN
VINTA FAMILY LOAM	50%	B	55
TOZE FAMILY FINE SANDY LOAM	35%	B	55
COMODORE BOULDERY LOAM	10%	D	77
MIDFORK FAMILY BOULDERY LOAM	5%	B	55

LAND USE IS WOOD AND FOREST LAND WITH GOOD COVER

$$CN = [.5(55) + .35(55) + .10(77) + .05(55)]/(.5 + .35 + .10 + .05)$$

$$= (27.50 + 19.25 + 7.70 + 2.75)/(1)$$

$$= \underline{57.20}$$

$$S = 1000/CN - 10$$

$$= 1000/57.20 - 10$$

$$= 17.48 - 10$$

$$= \underline{7.48}$$

AREA OF THE WATER SHED

PLANIMETER READING - 3.228

443 x .0149 in² = 6.60 in² x 22.96 acre/in² = 151.55 acre

151.55 acres x 43,560 sq ft/acre = 6,601,608.26 sq ft

Time Parameters

Concentration Time

$$t_c = .0078\, L^{0.77} (L/H)^{0.385}$$

$L = 3,850$ FT.

$H = 828$ FT.

$$t_c = .0078\,(3,850)^{0.77}\,(3850/828)^{.385}$$

$$= .0078\,(576.51)\,(1.81)$$

$= 8.13$ MIN. USE 8.00 MIN.

Lag Time

$$t_L = L^{0.8}(S+1)^{0.7} / 1900\, Y^{0.5}$$

$Y = \Sigma c_i \times i$ / AREA IN SQ.FT

$i = 80$ FT

$A = 6,601,608.26$ SQ.FT.

ΣC_i		Contour
600	-	8,720
1,400	-	8,800
2,300	-	8,880
2,875	-	8,960
3,400	-	9,040
3,650	-	9,120
3,700	-	9200
3,300	-	9280
3,000	-	9360
2,200	-	9440
460	-	9,520
650	-	9,520
27,525 FT		

$y = 27{,}525 \text{ ft} \times 80 \text{ ft} / 6{,}601{,}608.26$

$= 2{,}202{,}000 / 6{,}601{,}608.26$

$= 33\%$

$t_L = (3{,}850)^{.8} (7.48+1)^{.7} / 1900 (33)^{.5}$

$= (738.53)(4.47) / 1900 (5.74)$

$= 3{,}301.23 / 10{,}906$

$= .30$

$= 18.16$ MIN. USE 18 MINS.

$t_L = 0.6\, t_c$

$18. = .6 (t_c)$

$t_c = 0.494$ HRS

PEAK FLOW USING SCS CURVE METHOD

EVENT	PEAK FLOW
2YR - 24 HR	7/CFS
10YR - 24 HR	2.8 CFS
25YR - 24 HR	12.5 CFS
50YR - 24 HR	24.6 CFS
100YR - 24 HR	39.1 CFS

CULVERT SELECTION[2]

USE 100 YR - 24 HR EVENT - 39.1 CFS = Q

SIZE OF CULVERT - FLAT SLOPE

$Q = 2.58\ D^{2.5}$ [2]

$D = (Q/2.58)^{1/2.5}$

$= (39.1/2.58)^{.4}$

$= 2.97$ FT $\times 12$ IN/FT

$= 35.6$ IN

USE A 36 IN CULVERT

EFFECT OF SLOPE

$S = 2.04/D^{1/3}$ $\qquad S = .14$

$.14 = 2.04/D^{.33}$

$D^{.33} = 2.04/.14$

$D^{.33} = 14.57$

$= 2.42$ FT $\times 12$ IN/FT

$= 29.05$ IN

USE 30 IN CULVERT

USE A 36 IN CULVERT TO HANDLE PEAK FLOW.

DESIGN

GIVEN

PIPE DIA. - 36"
COVER - 15"
LIVE LOAD - 0
WEIGHT OF SOIL - 100 lb/ft³

DETERMINE WALL THICKNESS AND CORRUGATION

1 BACKFILL SOIL DENSITY
90% COMPACTION

2 DESIGN PRESSURE

$P_V = DL + LL$ $\quad DL = H \times w$
$= 15ft \times 100 lb/ft^3 + 0$ $\quad LL$ = NEGLIGIBLE FOR COVER
$= 1500 lb/ft^2$

3 RING COMPRESSION

$C = P_V \times S/2$ $\quad S$ = SPAN IN FT = 3FT
$= 1,500 lb/ft^2 \times 3/2$
$= 1,500 lb/ft^2 \times 1.5 ft$
$= 2,250 lb/ft$

4 ALLOWABLE WALL STRESS
FIG 3-6 $f_c = 22,500 lb/in^2$
FOR $2\frac{2}{3} \times \frac{1}{2}$ IN. CORRUGATION

5 WALL CROSS-SECTIONAL AREA

$A = C/f_c$

$= 2,250 lb/ft / 22,500 lb/in^2$

$= .10 in^2/ft$

FROM TABLE 3-2, A SPECIFIED THICKNESS OF 0.064 IN. PROVIDES AN WALL AREA OF .775

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

6. $FF = D^2/EI$ = FLEXIBILITY FACTOR $\leq .0433$ MAX

D = DIA. = 36 in
E = 30×10^6 lb/in^2
I = .00189 in^2/FT

$$FF = (36)^2 / 30 \times 10^6 \times .00189$$

$$= 1{,}296 / 56{,}700$$

$$= .02286$$

$.02286 < .0433$ THEREFORE $2\frac{2}{3} \times \frac{1}{2}$ in. CORRUGATION IS OK

PURCHASE A 36 in. DIA. PIPE WITH $2\frac{2}{3} \times \frac{1}{2}$ in CORRUGATIONS.

TEMPORARY CULVERT SELECTION

Q = >1 CFS USE 1 CFS 2 YR - 24 HR

SIZE OF CULVERT - FLAT SLOPE

$Q = 2.58 \; D^{2.5}$

$D = (Q/2.58)^{1/2.5}$

$= (1\,cfs/2.58)^{.4}$

$= .684\,ft \times 12\,in/ft$

$= 8.21\,in.$

NEED A 12 in CULVERT

<u>USE A 18 IN. DIA. CULVERT</u>

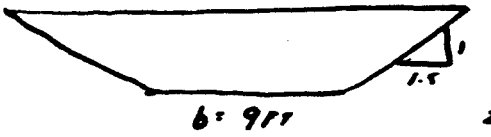
CHANNEL RECONSTRUCTION

TRAPEZOIDAL TYPE CHANNEL DESIGN

$Q = 39.1$ CFS

$S = .143$ FT/FT

$n = .04$



$Z = \frac{1.5}{1} = 1.5$

$$Q = VA = \frac{1.49}{n} R^{2/3} A$$

$$= \frac{1.49}{n}\left[\frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}\right]^{2/3} S^{1/2}(bd + zd^2)$$

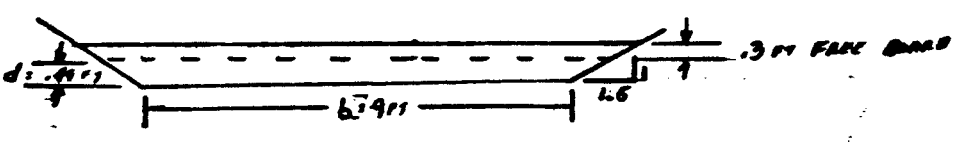
$$39.1 = \frac{1.49}{.04}\left[\frac{9d + 1.5d^2}{9 + 3.61d}\right]^{2/3}(.143)^{.5}(9d + 1.5d^2)$$

$$2.78 = \left[\frac{9d + 1.5d^2}{9 + 3.61d}\right]^{2/3}(9d + 1.5d^2)$$ 1.0 4.14

$b = 9$ FT

TRIAL d FT	Q
.2	.63
.3	.80
.35	1.08
.4	1.98
.42	2.15
.44	2.33
.46	2.51
.48	2.69
.49	2.79

$\therefore d = .49$ FT.



DETERMINE RIPRAP D_{50} AND DESIGN FOR SF = 1.20

$V = \frac{1.49}{n} R^{2/3} S^{1/2}$

$n = .04$

$S = .143$ FT/FT

$R = \frac{bd + 2d^2/b + 2d\sqrt{Z^2+1}}{} = \frac{9(.49) + 1.5(.49)^2}{9 + (.49)(2)\sqrt{(1.5)^2+1}} = \frac{4.77}{10.767} = .443$

$V = \frac{1.49}{.04} (.443)^{.66} (.143)^{.5}$

$= (37.25)(.568)(.38)$

$= 8.27$ FT/SEC.

STONE $D_{50} = 7.5$ in $= .625$ FT.

CHECK n VALUE

$n = .0395 \; D_{50}^{.17}$

$= .0395 \; (.625)$

$= .036$

CHECK FOR STABILITY

$d = .49$ FT $\quad S = 14.3 \quad \gamma = 62.4$

$\tau = \gamma d s$

$= (62.4)(.49)(.143) = 4.372$ lb/ft²

$n_b = \frac{21\tau}{\gamma(G-1) D_{50}} \qquad SG = 2.36$

$n_b = \frac{21(4.372)}{(62.4)(2.36-1)(.63)}$

$= \frac{91.820}{53.464}$

$= 1.72$

SF MUST BE > 1

$\phi = 42°$ ANGULAR RIPRAP

14.3 % SLOPE

$\theta = .8°$

$SF_\theta = \cos\theta \tan\phi / \sin\theta + n_\theta \tan\phi$

$= (\cos .8°)(\tan 42) / (\sin .8°) + (1.72)(\tan 42)$

$= (.994)(.9004) / (.139) + 1.999$

$= .896 / 1.682$

$= .521$ UNDER DESIGNED RESKA STREAM CHANNEL

D_{50} (FT)	MANNING'S n	ANGLE OF REPOSE (DEG)	DEPTH OF CONVEY FLOW	TRACTIVE FORCE	STABILITY FACTOR	SAFETY FACTOR
.63	.036	42°	.49	4.372	1.72	.521
1.26	.041	42°	.49	4.372	.859	.982
1.6	.043	42°	.49	4.372	.676	1.192

$D_{50} = 1.6$ FT.

DETERMINE RIPRAP FOR BANK SF = 1.2

$D_{50} = 1.6$ FT, $n = .043$, $\theta = 8°$, $d = .49$ FT.

ASSUME

$$\tau_{max} = .76\,\gamma\,d\,s$$

$$= .76(62.4)(.49)(.043) = 3.323 \text{ lb/ft}^2$$

$$n = (21)(\tau_{max}) / \gamma(SG-1)D_{50}$$

$$= (21)(3.323) / 62.4(2.36-1)1.6$$

$$= 69.783 / 135.782$$

$$= .514$$

ASSUME UNIFORM FLOW

$$\lambda = \theta = 8°$$

SLIDE SLOPE

$$\alpha = \tan^{-1} 1/1.5$$

$$= 33.69°$$

$$\beta = \tan^{-1}\left[\cos\lambda / \frac{2\sin\alpha}{n\tan\phi} + \sin\lambda\right]$$

$$= \tan^{-1}\left[.990 / 2(.555)/.514(.900) + .139\right]$$

$$= \tan^{-1}(.390)$$

$$= 21.32°$$

$$\eta' = n\left[\frac{1+\sin(\lambda+\beta)}{2}\right]$$

$$= .514\left[\frac{1+\sin(8+21.32)}{2}\right]$$

$$= .514\left[1.819/2\right]$$

$$= .383$$

$$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos 33.69 \tan 42 / (.383)(\tan 42) + (\sin 33.69)(\cos 21.32)$$

$$= (.832)(.900) / .345 + (.555)(.932)$$

$$= .749 / .862$$

$$= .869$$

D_{50}	n	β	η'	SF
1.6	.514	21.32°	.383	.869
1.8	.456	19.21	.332	.90
2.0	.411	17.52	.294	.944
2.2	.374	16.09	.263	.979
2.5	.329	14.304	.227	1.009
2.7	.305	13.327	.208	1.03
3.0	.274	12.059	.184	1.06
3.5	.235	10.426	.155	1.09
4.0	.206	9.17	.133	1.12
5.0	.164	7.391	.104	1.17
5.5	.150	6.737	.094	1.18
6.0	.137	6.189	.085	1.19

USE 6 FT D_{50} FOR BOTH CHANNEL BOTTOM AND SIDES

BASED ON THE CALCULATION THE BOTTOM AND SIDESLOPE RIPRAP WILL BE 1.6 FT = D_{50}

RIPRAP GRADATION

	SIZE FT	PERCENT
$2D_{50}$	3.2	100
$1D_{50}$	1.6	50
$.5D_{50}$	.8	20
$.2D_{50}$	.32	0

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

UNDERLYING FILTER

BASE MATERIAL

D_{50} = .600 MM

D_{85} = .15 MM

D_{15} = .236 MM

RIPRAP

D_{100} : 3.2 FT : 975.36 MM

D_{50} : 1.6 FT : 487.68 MM

D_{85} : 2.9 FT : 883.92 MM

D_{15} : .24 FT : 73.15 MM

D_0 : .10 FT : 30.48 MM

FILTER BLANKET WITH RESPECT TO BASE MATERIAL

(1) D_{50} (FILTER) / D_{50} BASE < 40

D_{50} (FILTER) < 40 × .6 = 24 MM

(2) D_{15} (FILTER) / D_{15} (BASE) > 5

D_{15} (FILTER) > 5 × .236 = 1.18 MM

D_{15} (FILTER) / D_{15} (BASE) < 40

D_{15} (FILTER) < 40 × .236 = 9.44 MM

(3) D_{15} (FILTER) / D_{85} (BASE) < 5

D_{15} (FILTER) < 5 × .15 = .75 MM

∴ WITH RESPECT TO THE BASE THE FOLLOWING MUST BE SATISFIED

$1.18\ mm < D_{15}\ (FILTER) < 9.44\ mm$

$D_{50}\ (FILTER) < 24\ mm$

FILTER MUST BE SIZED TO THE RIPRAP

(1) $D_{50}\ (RIPRAP) / D_{50}\ (FILTER) < 40$

$D_{50}\ FILTER > 487.60/40 = 12.19\ mm$

(2) $D_{15}\ (RIPRAP) / D_{15}\ FILTER > 5$

$D_{15}(FILTER) < 73.15\ mm/5 = 14.63\ mm$

$D_{15}\ (RIPRAP) / D_{15}\ (FILTER) < 40$

$D_{15}\ (FILTER) > 73.15\ mm/40 = 1.83\ mm$

(3) $D_{15}\ (RIPRAP) / D_{85}\ (FILTER) < 5$

$D_{85}\ (FILTER) > 73.15/5 = 14.63\ mm$

∴ FILTER MUST MEET THESE

$D_{50}(FILTER) > 12.19\ mm$

$1.83\ mm < D_{15}(FILTER) < 14.65\ mm$

$D_{85}(FILTER) > 14.65\ mm$

FILTER BLANKET MUST BE SIZED AS FOLLOWS

$12.19\ mm < D_{50}\ (FILTER) < 24\ mm$

$1.18\ mm < D_{15}\ (FILTER) < 14.65\ mm$

$D_{85}\ (FILTER) > 14.65\ mm$

ENERGY DISSIPATOR FOR DISCHARGE END OF CULVERT.

$Q = VA$

$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$

$39.1 = \frac{1.49}{n} \left(\frac{.5768\,D}{1.9576}\right)^{2/3} (.143)^{1/2} \frac{\pi D^2}{4}$

$D = TW$ = TAILWATER DEPTH
$n = .024$
$S = .143$

$39.1 = 62.08\,(.295\,D)^{2/3}(.143)(.785\,D^2)$

$39.1 = 8.877\,(.295\,D)^{2/3}(.785\,D^2)$

$4.4 = (.295\,D)^{2/3}(.785\,D^2)$

D	Q
1 ft	.351
2 ft	2.317
3 ft	6.518
2.5 ft	4.01
2.6 ft	4.45

$D = 2.6$ ft $= TW$

DESIGN FOR MINIMUM TAILWATER CONDITION

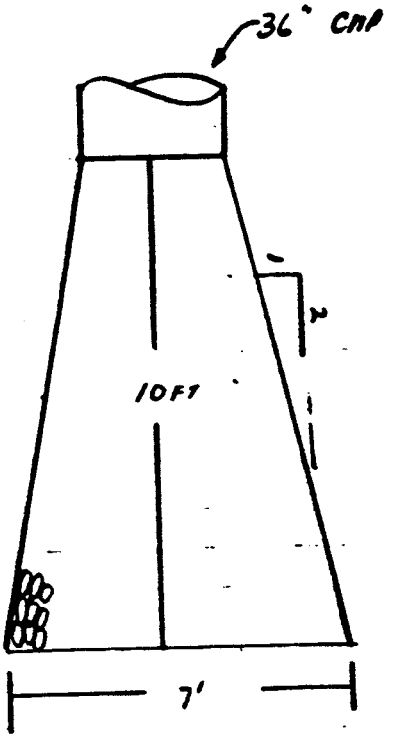
MAX ROCK SIZE $1.5 \times D_{50}$

$D_{50} \cong .33$ ft

$Q = 39.1$ cfs $\quad D = 3$ ft $\quad d_{50} = .33$ ft $\quad L_A = 10$ ft

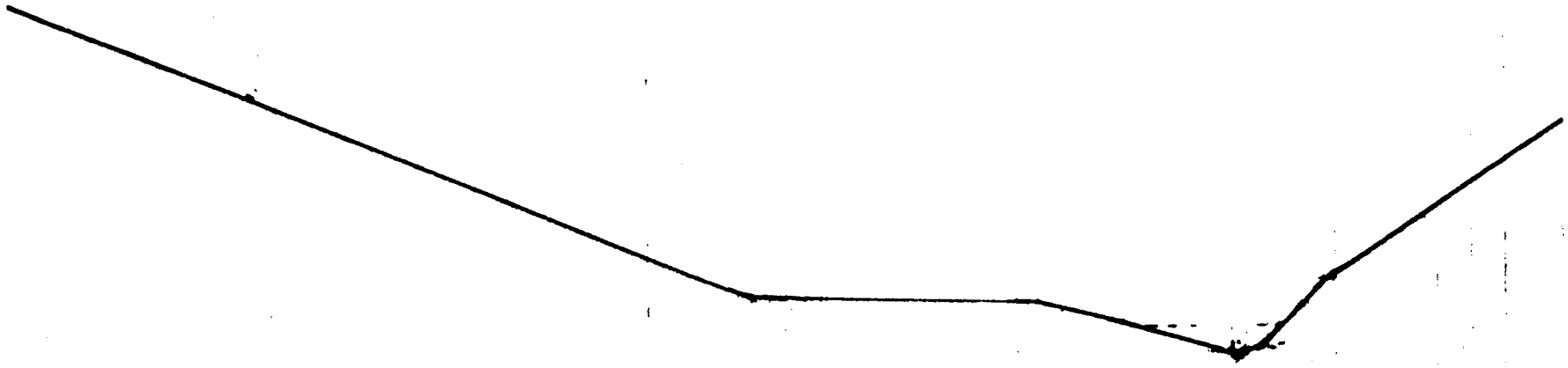
$W_A = D + L_A = 3 + 10 = 13$ ft $\quad d_{max} = 1.5 \times d_{50} = 1.5 \times .33 = .5$ ft

ENERGY DISSIPATOR



d_{50} = 4 IN.

d_{MAX} = 6 IN.



TYPICAL STREAM BED PROFILE

SCALE 1" = 6'

AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

REFERENCE

1. BARFIELD, B.J., R.C. WARNER AND C.T. HAAN, 1985 APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS. OKLAHOMA TECHNICAL PRESS, STILLWATER, OKLAHOMA.

2. HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS. AMERICAN IRON AND STEEL INSTITUTE. WASHINGTON D.C. THIRD EDITION

3. HYDRAULIC DESIGN OF STILLING BASINS AND ENERGY DISSIPATORS UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION.

4. SOIL SURVEY OF CARBON AREA, UTAH, UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE.

4/27/89

HYDROLOGY STUDY
SOUTH FORK BREAKOUT AREA

SOIL TYPES

	PERCENT	TYPE	CN
VINTA FAMILY LOAM	50%	B	55
TOZE FAMILY FINE SANDY LOAM	35%	B	55
COMODORE BOULDERY LOAM	10%	D	77
MIDFORK FAMILY BOULDERY LOAM	5%	B	55

LAND USE IS WOOD AND FOREST LAND WITH GOOD COVER

$$CN = [.5(55) + .35(55) + .10(77) + .05(55)]/(.5 + .35 + .10 + .05)$$

$$= (27.50 + 19.25 + 7.70 + 2.75)/(1)$$

$$= \underline{57.20}$$

$$S = 1000/CN - 10$$

$$= 1000/57.20 - 10$$

$$= 17.49 - 10$$

$$= \underline{7.48}$$

AREA OF THE WATER SHED

PLANIMETER READING - 3,228

443 x .0149 in² = 6.60 in² x 22.96 acres/in² = 151.55 acre

151.55 acres x 43,560 sq ft/acre = 6,601,608.26 sq ft

TIME PARAMETERS

CONCENTRATION TIME

$$t_c = .0078\, L^{0.77} (L/H)^{0.385}$$

$L = 3,850$ FT.

$H = 828$ FT.

$$t_c = .0078\,(3,850)^{0.77}\,(3850/828)^{.385}$$

$$= .0078\,(576.51)\,(1.81)$$

$= 8.13$ MIN. USE 8.00 MIN.

LAG TIME

$$t_L = L^{0.8}(S+1)^{0.7} / 1900\, Y^{0.5}$$

$Y = \Sigma c_i \times i$ / AREA IN SQ.FT

$i = 80$ FT

$A = 6,601,608.26$ SQ.FT.

ΣC_i		CONTOUR
600	-	8,720
1,400	-	8,800
2,300	-	8,880
2,875	-	8,960
3,400	-	9,040
3,650	-	9,120
3,700	-	9200
3,300	-	9280
3,000	-	9360
2,200	-	9440
450	-	9,520
650	-	9,520
27,525 FT		

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

$y = 27,525 \text{ FT} \times 80 \text{ FT} / 6,601,608.26$

$= 2,202,000 / 6,601,608.26$

$= 33\%$

$t_L = (3,850)^{.8} (7.48+1)^{.7} / 1900 (33)^{.5}$

$= (738.53)(4.47) / 1900 (5.74)$

$= 3,301.23 / 10,906$

$= .30$

$= 18.16$ MIN. USE 18 MINS.

$t_L = 0.6\, t_c$

$18. = .6 (t_c)$

$t_c = 0.494$ HRS

PEAK FLOW USING SCS CURVE METHOD

EVENT	PEAK FLOW
2YR - 24 HR	7/CFS
10YR - 24 HR	3.8 CFS
25YR - 24 HR	12.5 CFS
50YR - 24 HR	24.6 CFS
100YR - 24 HR	39.1 CFS

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

CULVERT SELECTION

USE 100 YR - 24 HR EVENT - 39.1 CFS = Q

SIZE OF CULVERT - FLAT SLOPE

$Q = 2.58\ D^{2.5}$

$D = (Q/2.58)^{1/2.5}$

$= (39.1/2.58)^{.4}$

$= 2.97$ FT $\times 12$ IN/FT

$= 35.6$ IN

USE A 36 IN CULVERT

EFFECT OF SLOPE

$S = 2.04/D^{1/3}$ $\qquad S = .14$

$.14 = 2.04/D^{.33}$

$D^{.33} = 2.04/.14$

$D^{.33} = 14.57$

$= 2.42$ FT $\times 12$ IN/FT

$= 29.05$ IN

USE 30 IN CULVERT

USE A 36 IN CULVERT TO HANDLE PEAK FLOW.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

DESIGN

GIVEN

PIPE DIA. - 36"
COVER - 15"
LIVE LOAD - 0
WEIGHT OF SOIL - 100 lb/ft³

DETERMINE WALL THICKNESS AND CORRUGATION

1 BACKFILL SOIL DENSITY
90% COMPACTION

2 DESIGN PRESSURE

$P_V = DL + LL$ $\qquad DL = H \times w$
$= 15 ft \times 100 lb/ft^3 + 0$ $\qquad LL$ = NEGLIGIBLE FOR COVER
$= 1500 lb/ft^2$

3 RING COMPRESSION

$C = P_V \times S/2$ $\qquad S$ = SPAN IN FT = 3 FT
$= 1,500 lb/ft^2 \times 3/2$
$= 1,500 lb/ft^2 \times 1.5 ft$
$= 2,250 lb/ft$

4 ALLOWABLE WALL STRESS
FIG 3-6 $f_c = 22,500 lb/in^2$
FOR $2\frac{2}{3} \times \frac{1}{2}$ IN. CORRUGATION

5 WALL CROSS - SECTIONAL AREA

$A = C/f_c$

$= 2,250 lb/ft / 22,500 lb/in^2$

$= .10 in^2/ft$

FROM TABLE 3-2, A SPECIFIED THICKNESS OF 0.064 IN. PROVIDES AN WALL AREA OF .775

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

6. $FF = D^2/EI$ = FLEXIBILITY FACTOR = .0433 MAX

D = DIA. = 36 in

E = 30×10^6 lb/in^2

I = .00189 in^2/FT

$$FF = (36)^2 / 30 \times 10^6 \times .00189$$

$$= 1{,}296 / 56{,}700$$

$$= .02286$$

.02286 < .0433 THEREFORE $2\frac{2}{3} \times \frac{1}{2}$ in. CORRUGATION IS OK

PURCHASE A 36 in. DIA. PIPE WITH $2\frac{2}{3} \times \frac{1}{2}$ in CORRUGATIONS.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

TEMPORARY CULVERT SELECTION

Q = >1 CFS USE 1 CFS 2 YR - 24 HR

SIZE OF CULVERT - FLAT SLOPE

$Q = 2.58 \; D^{2.5}$

$D = (Q/2.58)^{1/2.5}$

$= (1\,cfs/2.58)^{.4}$

$= .684\,ft \times 12\,in/ft$

$= 8.21\,in.$

NEED A 12 in CULVERT

<u>USE A 18 IN. DIA. CULVERT</u>

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

CHANNEL RECONSTRUCTION

TRAPEZOIDAL TYPE CHANNEL DESIGN

$Q = 39.1$ CFS

$S = .143$ FT/FT

$n = .04$

$b = 9$ FT $\qquad Z = \frac{1.5}{1} = 1.5$

$$Q = VA = \frac{1.49}{n} R^{2/3} A$$

$$= \frac{1.49}{n}\left[\frac{bd + zd^2}{b + 2d\sqrt{z^2+1}}\right]^{2/3} S^{1/2}(bd + zd^2)$$

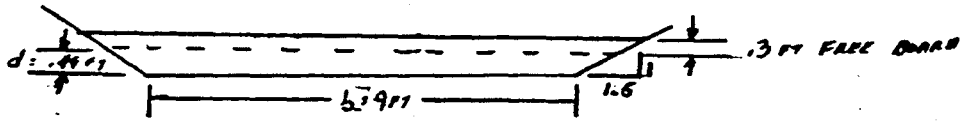
$$39.1 = \frac{1.49}{.04}\left[\frac{9d + 1.5d^2}{9 + 3.61d}\right]^{2/3}(.143)^{.5}(9d + 1.5d^2)$$

$$2.78 = \left[\frac{9d + 1.5d^2}{9 + 3.61d}\right]^{2/3}(9d + 1.5d^2) \qquad 1.0 \qquad 1.24$$

$b = 9$ FT

TRIAL d FT	Q
.2	.63
.3	.80
.35	1.08
.4	1.98
.42	2.15
.44	2.33
.46	2.51
.48	2.69
.49	2.79

$d = .49$ FT.



DETERMINE RIPRAP D_{50} AND DESIGN FOR SF = 1.20

$V = \frac{1.49}{n} R^{2/3} S^{1/2}$

$n = .04$

$S = .143$ FT/FT

$R = \frac{bd + 2d^2}{b + 2d\sqrt{2^2+1}} = \frac{9(.49) + 1.5(.49)^2}{9 + (.49)(2)\sqrt{1.5^2+1}} = \frac{4.77}{10.767} = .443$

$V = \frac{1.49}{.04} (.443)^{.66} (.143)^{.5}$

$= (37.25)(.588)(.38)$

$= 8.27$ FT/SEC.

STONE $D_{50} = 7.5$ in $= .625$ FT.

CHECK n VALUE

$n = .0395 \, D_{50}^{.17}$

$= .0395 (.625)$

$= .036$

CHECK FOR STABILITY

$d = .49$ FT $\quad S = 14.3 \quad \gamma = 62.4$

$\tau = \gamma d S$

$= (62.4)(.49)(.143) = 4.372$ lb/ft²

$n_s = \frac{21\tau}{\gamma(SG-1) D_{50}}$ $\quad SG = 2.36$

$n_s = \frac{21(4.372)}{(62.4)(2.36-1)(.63)}$

$= \frac{91.812}{53.464}$

$= 1.72$

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

SF MUST BE > 1

$\phi = 42°$ ANGULAR RIPRAP

14.3 % SLOPE

$\theta = .8°$

$$SF_b = \cos\theta \tan\phi / \sin\theta + n_b \tan\phi$$

$$= (\cos .8)(\tan 42) / (\sin .8) + (1.72)(\tan 42)$$

$$= (.999)(.904) / (.139) + 1.549$$

$$= .896 / 1.688$$

$$= .521$$ UNDER DESIGNED RESIGN STREAM CHANNEL

D_{50} (FT)	MANNING'S n	ANGLE OF REPOSE (DEG)	DEPTH OF CONVEY FLOW	TRACTIVE FORCE	STABILITY FACTOR	SAFETY FACTOR
.63	.036	42°	.49	4.372	1.72	.521
1.26	.041	42°	.49	4.372	.859	.982
1.6	.043	42°	.49	4.372	.676	1.192

$D_{50} = 1.6$ FT.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

DETERMINE RIPRAP FOR BANK SF = 1.2

$D_{50} = 1.6$ FT, $n = .043$, $\theta = 8°$, $d = .49$ FT.

ASSUME

$$\tau_{max} = .76 \gamma d s$$

$$= .76 (62.4)(.49)(.043) = 3.323 \text{ lb/FT}^2$$

$$n = (21)(\tau_{max}) / \gamma (SG - 1) D_{50}$$

$$= (21)(3.326) / 62.4 (2.36 - 1) 1.6$$

$$= 69.783 / 135.782$$

$$= .514$$

ASSUME UNIFORM FLOW

$$\lambda = \theta = 8°$$

SLIDESLOPE

$$\alpha = \tan^{-1} 1/1.5$$

$$= 33.69°$$

$$\beta = \tan^{-1} \left[\cos\lambda / \frac{2 \sin\alpha}{n \tan\phi} + \sin\lambda \right]$$

$$= \tan^{-1} \left[.990 / 2(.555)/.514(.900) + .139 \right]$$

$$= \tan^{-1} (.390)$$

$$= 21.32°$$

$$\eta' = \eta \left[\frac{1 + \sin(\lambda + \beta)}{2} \right]$$

$$= .514 \left[\frac{1 + \sin(8 + 21.32)}{2} \right]$$

$$= .514 \left[1.819/2 \right]$$

$$= .383$$

$$SF = \cos\alpha \tan\phi / \eta' \tan\phi + \sin\alpha \cos\beta$$

$$= \cos 33.69 \tan 42 / (.383)(\tan 42) + (\sin 33.69)(\cos 21.32)$$

$$= (.8327)(.900) / .345 + (.555)(.932)$$

$$= .749 / .862$$

$$= .869$$

D_{50}	n	β	η'	SF
1.6	.514	21.32°	.383	.869
1.8	.456	19.21	.332	.90
2.0	.411	17.52	.294	.944
2.2	.374	16.09	.263	.979
2.5	.329	14.304	.227	1.009
2.7	.305	13.327	.208	1.03
3.0	.274	12.059	.184	1.06
3.5	.235	10.426	.155	1.09
4.0	.206	9.17	.133	1.12
5.0	.164	7.391	.104	1.17
5.5	.150	6.737	.094	1.18
6.0	.137	6.189	.085	1.19

USE 6 FT D_{50} FOR BOTH CHANNEL BOTTOM AND SIDES

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

BASED ON THE CALCULATION THE BOTTOM AND SIDESLOPE RIPRAP WILL BE 1.6 FT = D_{50}

RIPRAP GRADATION

	SIZE FT	PERCENT
$2D_{50}$	3.2	100
$1D_{50}$	1.6	50
$.5D_{50}$	.8	20
$.2D_{50}$	.32	0

AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

UNDERLYING FILTER

BASE MATERIAL

D_{50} = .600 MM

D_{85} = .15 MM

D_{15} = .236 MM

RIPRAP

D_{100} : 3.2 FT : 975.36 MM

D_{50} : 1.6 FT : 487.68 MM

D_{85} : 2.9 FT : 883.92 MM

D_{15} : .24 FT : 73.15 MM

D_0 : .10 FT : 30.48 MM

FILTER BLANKET WITH RESPECT TO BASE MATERIAL

(1) D_{50} (FILTER) / D_{50} BASE < 40

D_{50} (FILTER) < 40 × .6 = 24 MM

(2) D_{15} (FILTER) / D_{15} (BASE) > 5

D_{15} (FILTER) > 5 × .236 = 1.18 MM

D_{15} (FILTER) / D_{15} (BASE) < 40

D_{15} (FILTER) < 40 × .236 = 9.44 MM

(3) D_{15} (FILTER) / D_{85} (BASE) < 5

D_{15} (FILTER) < 5 × .15 = .75 MM

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

∴ WITH RESPECT TO THE BASE THE FOLLOWING MUST BE SATISFIED

$1.18\ mm < D_{15}\ (FILTER) < 9.44\ mm$

$D_{50}\ (FILTER) < 24\ mm$

FILTER MUST BE SIZED TO THE RIPRAP

(1) $D_{50}\ (RIPRAP) / D_{50}\ (FILTER) < 40$

$D_{50}\ FILTER > 487.66/40 = 12.19\ mm$

(2) $D_{15}\ (RIPRAP) / D_{15}\ FILTER > 5$

$D_{15}\ (FILTER) < 73.15\ mm/5 = 14.63\ mm$

$D_{15}\ (RIPRAP) / D_{15}\ (FILTER) < 40$

$D_{15}\ (FILTER) > 73.15\ mm/40 = 1.83\ mm$

(3) $D_{85}\ (RIPRAP) / D_{85}\ (FILTER) < 5$

$D_{85}\ (FILTER) > 73.15/5 = 14.63\ mm$

∴ FILTER MUST MEET THESE

$D_{50}\ (FILTER) > 12.19\ mm$

$1.83\ mm < D_{15}\ (FILTER) < 14.65\ mm$

$D_{85}\ (FILTER) > 14.65\ mm$

FILTER BLANKET MUST BE SIZED AS FOLLOWS

$12.19\ mm < D_{50}\ (FILTER) < 24\ mm$

$1.18\ mm < D_{15}\ (FILTER) < 14.65\ mm$

$D_{85}\ (FILTER) > 14.65\ mm$

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

ENERGY DISSIPATOR FOR DISCHARGE END OF CULVERT.

$Q = VA$

$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$

$39.1 = \frac{1.49}{n} \left(\frac{.5768\,D}{1.9578}\right)^{.66} (.143) \frac{\pi D^2}{4}$

D = TW = TAILWATER DEPTH
n = .024
s = .143

$39.1 = 62.08\ (.295\ D)^{.66} (.143)(.785\ D^2)$

$39.1 = 8.877\ (.295\ D)^{.66} (.785\ D^2)$

$4.404 = (.295\ D)^{.66} (.785\ D^2)$

D	Q
1 ft	.351
2 ft	2.317
3 ft	6.518
2.5 ft	4.01
2.6 ft	4.45

D = 2.6 ft = TW

DESIGN FOR MINIMUM TAILWATER CONDITION

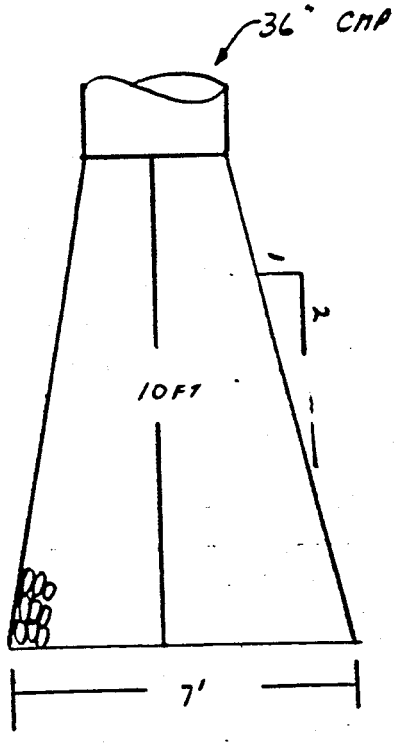
MAX ROCK SIZE $1.5 \times D_{50}$

$D_{50} \cong .33$ ft

$Q = 39.1$ cfs $D = 3$ ft $d_{50} = .33$ ft $L_A = 10$ ft

$W_A = D + L_A = 3 + 10 = 13$ ft $d_{max} = 1.5 \times d_{50} = 1.5 \times .33 = .5$ ft

ENERGY DISSIPATOR

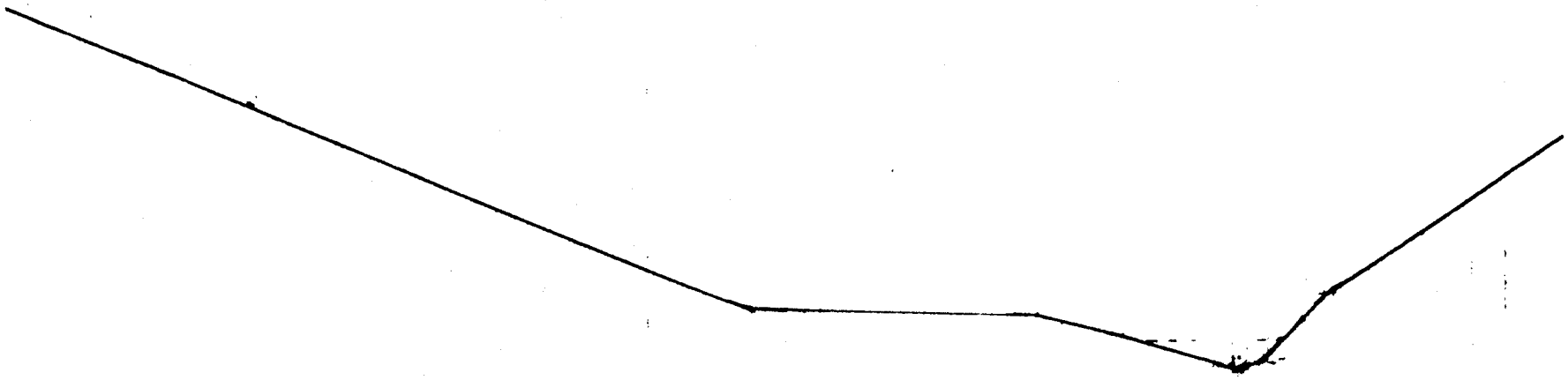


d_{50} = 4 IN.

d_{MAX} = 6 IN.

AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

STREAM RECLAMATION



TYPICAL STREAM BED PROFILE

SCALE 1" = 6'

AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

REFERENCE

1. BARFIELD, B. J., R.C. WARNER AND C.T. HAAN, 1985 APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS. OKLAHOMA TECHNICAL PRESS, STILLWATER, OKLAHOMA.

2. HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS. AMERICAN IRON AND STEEL INSTITUTE. WASHINGTON D.C. THIRD EDITION

3. HYDRAULIC DESIGN OF STILLING BASINS AND ENERGY DISSIPATORS UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION.

4. SOIL SURVEY OF CARBON AREA, UTAH, UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD