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TREATMENT OF UNDERFLOW FROM THICKENER TANK USING SETTLING PONDS

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Prepared For

Plateau Mining Company
Price, Utah

Prepared By

Vaughn Hansen Associates, Inc.
Salt Lake City, Utah

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TREATMENT OF UNDERFLOW FROM THICKENER TANK USING SETTLING PONDS

Plateau Coal Company presently operates a coal preparation plant at Wattis, Utah to remove waste materials from coal extracted at their Star Point Mines (see Figure 1). Water used in washing the coal in the coal preparation process is treated and recycled through a thickener tank in which flocculant is added to promote settling of suspended solids. The thickener concentrates suspended solids in the bottom of the tank, which periodically must be flushed to provide space for settling out additional suspended solids.

In the past the thickener underflow from flushing the thickener tank has been discharged in the flat area southwest of the general office buildings, which is within the contributing drainage area to sediment pond No. 5. However, recently Plateau received a violation from the Division of Oil, Gas, and Mining (DOGM) for discharging the thickener underflow at the location described above, with the requirement that the underflow be treated by an alternative means.

Vaughn Hansen Associates, Inc. (VHA) of Salt Lake City was retained by Plateau Mining Company to develop the design for treatment of the thickener underflow via settling ponds. VHA was to analyze both the option of discharging the treated water either back into the natural channel or the option of recycling the water for use as makeup water in the coal preparation plant. However, based on communications with the Utah State Department of Health, at the present time the Colorado River Authority has placed a limitation of 723 mg/l on the TDS concentration for discharge of processed water into a natural channel. TDS concentrations of both the make-up water to the plant (which is obtained from ground water inflow into the mines) as well as the thickener underflow from the thickener tank exceed this limitation, the minimum concentration of the thickener underflow having been measured at 822 mg/l. Therefore, in order to discharge from the thickener underflow treatment ponds directly into the natural channel, a variance would have to be granted by EPA. Obtaining a variance may take considerable time and since Plateau must abate the violation received from DOGM in a timely manner, option 1 will be abandoned for now and option 2 (that of recycling the treated water) is considered the only viable option.

Plateau may make application for a variance to discharge into the natural channel at a later date, once the ponds have been constructed and the violation abated. This application would be accompanied by sufficient quality data on outflow from the thickener underflow treatment ponds to present a valid case for requesting a variance from EPA.

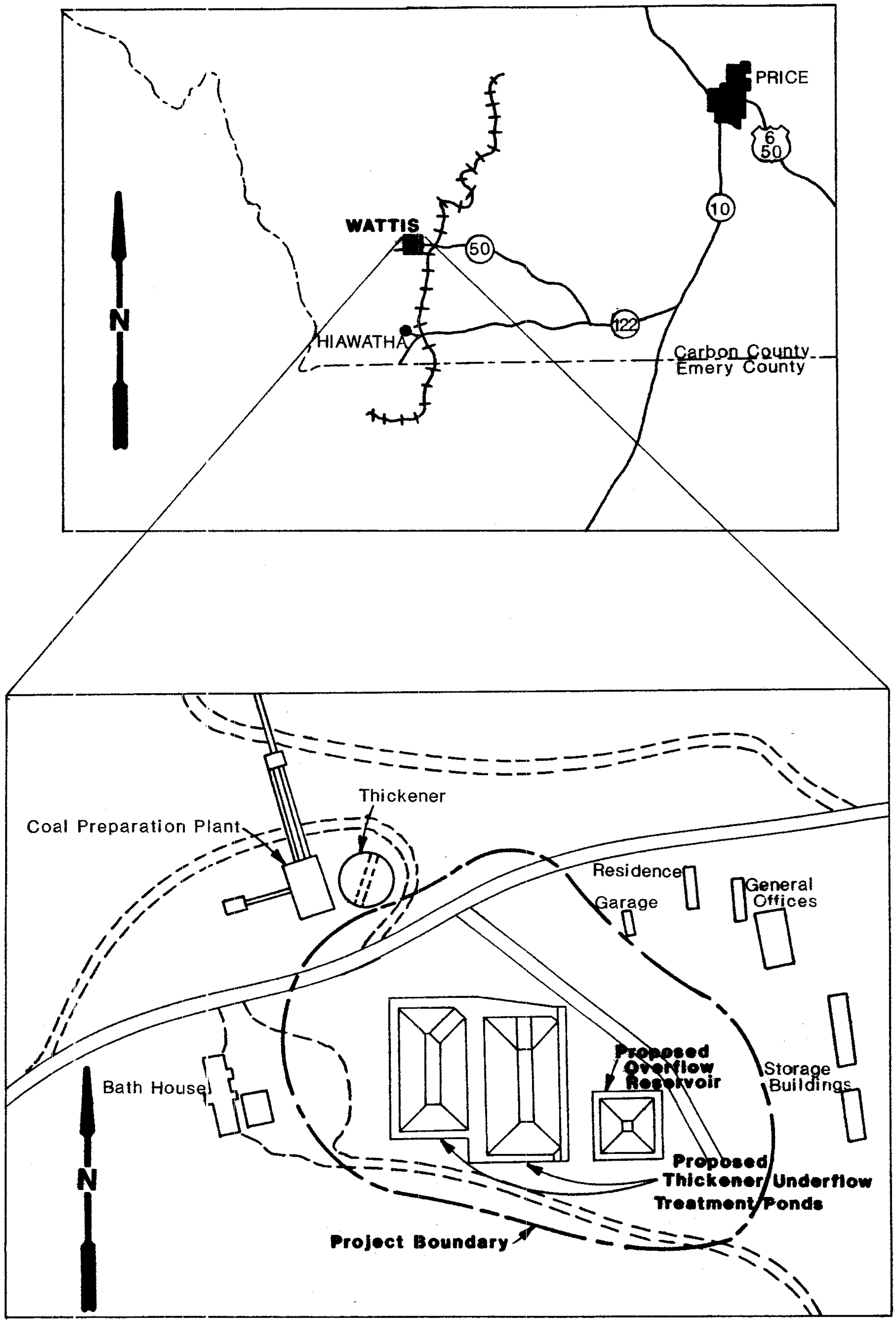


Figure 1. Vicinity Map for Proposed Thickener Underflow Treatment Ponds

The proposed treatment ponds for the thickener underflow are to be located approximately 200 feet southeast of thickener tank, in the area between the general office building and the bath house. The ponds will be constructed entirely within the existing mining permit lease area held by Plateau Mining Company.

The scope of this report is to present design and construction criteria for the proposed thickener underflow treatment ponds for review by both DOGM and the Utah State Department of Health.

Existing Conditions at the Site

Climatic Conditions

The coal processing plant and proposed thickener underflow treatment ponds are located at an approximate elevation of 7500 feet above mean sea level. Latitude and longitude of the mine site are approximately 30° 30' North and 111° 03' West. Being a mountainous area in south central Utah, limited climatic data are available. Available records are discussed in the following paragraphs.

Temperature data have been collected by Plateau at the mine site for the period from July 1981 to November 1983. Copies of these records were made available to Vaughn Hansen Associates for this study. Analysis of these data reveals a period from December through April when modification to the normal operations plan and/or coal preparation plant will be required due to freezing.

Precipitation records for the mine site are of insufficient length for determination of average annual or average monthly values. Therefore, records at the following stations were averaged by the Theissen Method to determine average precipitation over the mine site: 1) Price, 2) Castledale, 3) Hiawatha, 4) Scofield Dam, 5) Electric Lake and 6) Scofield. By this analysis precipitation for the year averages 14.2 inches. A summary of these data is provided in Appendix A.

A specific monthly distribution of average annual evaporation at the site is not available. Total annual evaporation at the proposed site for the thickener underflow treatment ponds was found using the NOAA Evaporation Atlas. The yearly total for a free water surface was distributed through the year using equivalent percentages at Scofield, Strawberry and Joe's Valley reservoirs. Evaporation for the year from the NOAA Atlas is 37 inches on a free water surface. A summary of these data and calculations are contained in Appendix A.

Site Conditions

As indicated previously, the proposed thickener underflow treatment ponds are to be located within the Plateau mine permit area at Wattis, Utah. The ponds will be located south and east of the thickener tank in the area between the general office building and the bathhouse. The site in which the proposed ponds may be located is roughly triangular in shape encompassing an area of approximately 2 acres (see Figure 1). Running diagonally through the east and north portions of the site is an access haul road to the coal refuse pile. Topographic relief from west to east across the site is approximately 70 feet.

The proposed site is located in an ephemeral watershed with is tributary to Serviceberry Creek. The nearest major stream channel in the ephemeral watershed is located due north approximately 350 feet. However surface drainage from the proposed site is to an ephemeral channel to the southwest, located some 1400 feet from the proposed ponds. The proposed water surface elevation in the ponds is 7483 and 7480 which compares with the ephemeral channel invert elevation to the north of approximately 7465 feet and the ephemeral channel invert elevation to the southwest of 7400 feet.

Characteristics of Natural Water In Vicinity of the Site

Both surface and ground water data in the vicinity of the proposed treatment ponds are limited. VHA monitored the ephemeral channel north of the proposed ponds monthly from October of 1980 to December of 1981. Flow was encountered in the channel only three out of the 14 times the sampling station was checked. From the three water quality samples collected, TDS concentrations varied from 689 mg/l to 2600 mg/l, demonstrating that natural TDS concentrations of surface waters in the area are often in excess of the 723 mg/l limitation imposed by the Colorado River Authority.

Ground water usage in the vicinity of the treatment ponds is limited to two deep wells drilled by Plateau Mining Company to obtain an occasional water supply for dust suppression or makeup water to the coal preparation plant. The closest well to the ponds is located 180 feet due east of the ponds. This well was drilled to a depth of 1280 feet, the bottom of which extends into the Emery Sandstone. The pump and perforations in the well casing were set at approximately 800 feet in the Emery Sandstone. Ground water was first encountered in drilling this well at approximately 74 feet. The second well is located some 2000 feet further east and a little north of the first well. This well was drilled to a depth of 2040 feet with the pump again set in the Emery Sandstone at a depth of 1140 feet. Ground water was first encountered at a depth of approximately 100 feet. Productivity of the wells is meager, the first well yielding approximately 45 gpm and the second well yielding less than 10 gpm.

Characteristics of Makeup Water to the
Coal Preparation Plant and the
Thickener Underflow

Makeup water from the coal preparation plant comes from seepage of ground water in the mine. Small amounts are occasionally added from well located approximately 180 feet due east of the site. VHA was given data for two sets of samples of the makeup water and thickener underflow. TDS (total dissolved solids) concentrations for the first set of samples taken for the make water to the plant and resultant thickener underflow were 963 mg/l and 925 mg/l, respectively. TDS concentrations from the second set of samples for the makeup water and thickener underflow were 1024 mg/l and 822 mg/l, respectively. From these data, two points were observed:

1. Average TDS of makeup water is 1000 mg/l which precludes discharge to the natural channel (unless a variance is granted) due to Colorado River Authority limitations of 723 mg/l TDS.

2. Flocculation added within the process of the coal preparation plant appears to reduce the concentration of TDS in process water, and it appears from the limited data available to have a more pronounced effect at higher TDS concentrations.

The concentration of TSS (total suspended solids) in the thickener underflow to be treated is extremely high. The two samples mentioned above contained a TSS concentration of 239,190 and 296,120 mg/l, respectively. A gradation analysis of the suspended solids was provided by Plateau. This analysis showed 26.67 percent smaller than a number 325 sieve (opening .045 mm). A sieve and hydrometer analysis was subsequently conducted by Chen and Associates which showed the gradation of these smaller particles. Results from the Chen and Associates' sieve and hydrometer analysis are presented in Table 1. Chen and Associates reported a specific gravity of 1.49 for the suspended solids.

Copies of tests mentioned above as received by VHA appear in Appendix B.

Design and Construction Criteria

As indicated previously, water to be treated in the proposed treatment ponds comes from the periodic flushing of the thickener tank used in the coal preparation plant for recycling water within the plant. The peak daily discharge of underflow from the thickener tank and therefore design flow rate for the proposed treatment ponds is on the order of 30,000 gallons per day. The peak flow rate to be used as a basis for design of transport facilities was assumed to result from flushing 15,000 gallons from the thickener tank over a 2 hour period, which yields a

Table 1. Results of Gradation Analysis on Thickener Underflow

Sieve Size	Particle Diameter (millimeters)	Percent of Total Passing
No. 16	1.190	100
No. 30	0.590	99
No. 50	0.297	93
No. 100	0.149	78
No. 200	0.074	62
	0.037	37
	0.019	29
	0.009	21
	0.005	15
	0.002	10
	0.001	2.8

peak design flow rate through the thickener underflow treatment ponds of 125 gpm.

Site Restrictions

As stipulated by Plateau with reference to the proposed site, the treatment ponds must be located within the area bounded by the fuel dispensing area to the north, a drainage control ditch to the east-northeast, and a drainage control ditch to the south. In addition, the existing haul road must be maintained through the site. Plateau also indicated that if possible the ponds were to be totally incised ponds.

Due to the above outlined physical restrictions at the site, there is insufficient area in which to locate evaporation type ponds for removing the suspended sediments at the peak design flow rate. Therefore, the ponds must be designed as continuous flow-through ponds with the treated water pumped back to the preparation plant for reuse, or discharge to the ponds must be maintained at a rate significantly less than the peak design flow rate.

Settling Rates of Suspended Solids

Settling rates of the suspended solids to be removed through the thickener underflow treatment ponds were determined in order to size the ponds with a sufficient detention time to promote settling of most if not all settleable solids in solution and meet desired effluent limitations. When concentrations of suspended solids are such that the settling rate of a given particle is not hindered by neighboring particles, Stokes Law is used to calculate particle fall velocities. However, settling rates of the suspended solids in the thickener underflow will be significantly affected due to the high concentration of suspended solids (having TSS concentrations of from 200,000 to 300,000 mg/l), and Stokes Law is not applicable. Anticipated settling rates were therefore determined by laboratory testing, using thickener underflow obtained from the thickener tank of the coal preparation plant.

Samples were collected from the underflow of the thickener tank and delivered to Chen and Associates for determining the particle size gradation of the suspended solids, the results of which were previously presented. In addition to the results of the gradation analysis, another interesting point was determined from the hydrometer test conducted as part of Chen's analysis. The hydrometer test (which is a method for determining particle size based on fall velocities of a particle suspended in a liquid) required approximately 5 days to determine that there was still 2.8% of the suspended solids finer by weight than the 0.001 mm particle diameter. This represents a suspended sediment concentration still remaining in solution after 5 days of approximately 8200 mg/l. Therefore, it was determined that without flocculation at peak design flow there is insufficient area within the designated area of the proposed site to construct a flow through type treatment pond of adequate detention time to remove the fine clay size particles with diameters less than 0.001 mm.

A sample of the thickener underflow was sent to American Cyanamid (the company presently supplying flocculant for the coal preparation plant) to determine expected settling rates of suspended solids in the underflow after flocculation. Since at the time of the test it had not been determined whether or not the thickener underflow would have to be pumped to the treatment ponds, tests were conducted on both pumped and unpumped samples. Results of these tests with American Cyanamid's recommendations are included in Appendix C. Using two separate flocculant products, settling rates to obtain a crystal clear clarity varied from 0.0001 feet per second to 0.00093 feet per second.

Assuming a treatment pond 10 feet deep with a bottom width of 20 feet and the minimum fall velocity indicated above of 0.0001 feet per second after flocculation, the required flow length to create sufficient detention time in the ponds for suspended sediments to fall a vertical height of 5 feet (one half of the total pond depth) is 95 feet. See Appendix D for calculations.

<u>Pond Layout</u>

Combining the conditions, requirements, and results previously discussed a pond configuration was prepared, the plan view of which is illustrated on Drawing No. 1. With the addition of a flocculant, one pond will provide sufficient detention time at peak design flow to remove suspended solids from the thickener underflow. The second pond (identical to the first pond) is provided for backup and is intended to be used as an alternate to the other pond to facilitate cleaning of the pond. The option presented on Drawing No. 1 illustrates ponds that are primarily incised with minimal embankments. This option would allow flow of the underflow from the thickener tank to the ponds by gravity, rather than having to pump.

Discharge from the treatment ponds will be stored in a small open reservoir located on the east side of the treatment ponds (see Drawing No. 1) until makeup water at the coal preparation plant is required. The proposed storage reservoir will have a capacity of 0.37 acre-feet which based on a peak daily discharge of 30,000 gallons is equivalent to a 4 day storage volume. Under the option of recycling the water, operation of the treatment ponds will require that makeup water for the coal preparation plant first be taken from the reservoir and secondly from within the mines.

The thickener underflow treatment ponds are nearly identical and have a capacity of approximately 1.5 acre-feet at a stage of 10 feet. This leaves 2.0 feet of free board. The reservoir has a capacity of 0.37 acre-feet at a stage of 8.0 feet again allowing 2.0 feet of freeboard. The ponds have a capacity to contain 1 acre-foot of solids. At a flow rate of 30,000 gpd and a suspended solids concentration of 200,000 to 300,000 mg/l, the daily sediment loading to the ponds would be approximately 0.02 acre-feet. Assuming an even sediment distribution across the pond, the pond in use would require cleaning approximately every 50 working days at the peak flow rate.

Underflow from the thickener tank will be conveyed to the proposed treatment ponds by gravity via a 6-inch supply line. The 6-inch line will be laid on a minimum of a 5% grade to prevent settling out of the suspended solids in the line.

Under and operation at peak design flow and if it is decided to add flocculant, from the proposed 6-inch supply line the thickener underflow would be discharged into a mixing tank where flocculant would be added. The underflow would be retained in the mixer for approximately 20 minutes which would provide sufficient time to achieve a thorough mixing of the flocculant into the underflow solution.

From the mixer, the underflow is directed to either pond via a gate system located in a manhole immediately downstream of the mixing tank. Treated water exits the proposed ponds via a 12-inch diameter cast iron stand pipe which at the design flow rate will operate under weir flow conditions with 1-inch of surcharge. From the storage reservoir, the treated water will be pumped back to the coal preparation plant. An emergency overflow pipe has been located at a level of 1.5 feet below the embankment crest to prevent overtopping of the pond in the event that the principal overflow should become clogged.

Water Budget of Ponds

Requirements for lining of the proposed thickener underflow treatment ponds are based on anticipated concentrations of TDS. As indicated by personnel of the State Department of Health, a liner would be required if TDS concentrations are expected to exceed 5000 mg/l. If TDS concentrations are expected to approach 2000 mg/l, then the ponds should be designed with the same criteria as is imposed on a sanitary lagoon, i.e. designed to allow a maximum rate of seepage out of the pond of 1/8 inch per day.

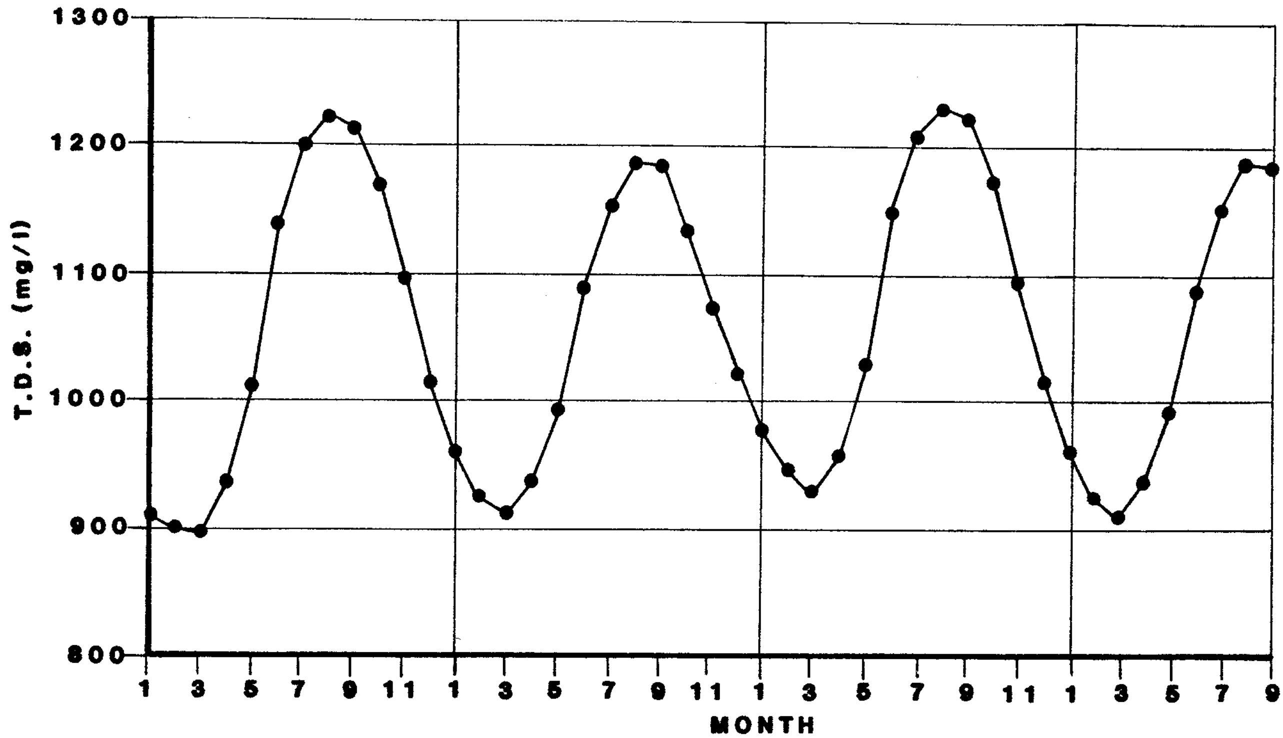
Based on the above outlined criteria for determination of lining requirements, a water budget analysis was conducted for the treatment ponds to estimate maximum anticipated concentrations of TDS due to concentration of salts by evaporation, particularly through the summer months. Water budget analyses were conducted assuming 1/4 to 1/2 time operation of the design flow. Since evaporation exceeds precipitation (37 inches versus 14.2 inches, respectively) it was assumed that this would represent a worse case scenario from a water quality standpoint than if the ponds were operated at the full design capacity. Results showed a cyclical behavior in TDS concentrations of treatment pond outflow with no gradual worsening of TDS concentrations (see Figure 2). As illustrated on Figure 2, the maximum expected TDS concentration for quarter time operation (operation at 1/4 of the design flow rate of 30,000 gpd which when analyzed on a monthly basis is equivalent to operating the plant one quarter of the time period) is between 1200 to 1300 mg/l and maximum concentrations for half time operation are between 1050 to 1100 mg/l. Water budget calculations and methodology are presented in Appendix E.

Geotechnical Evaluation

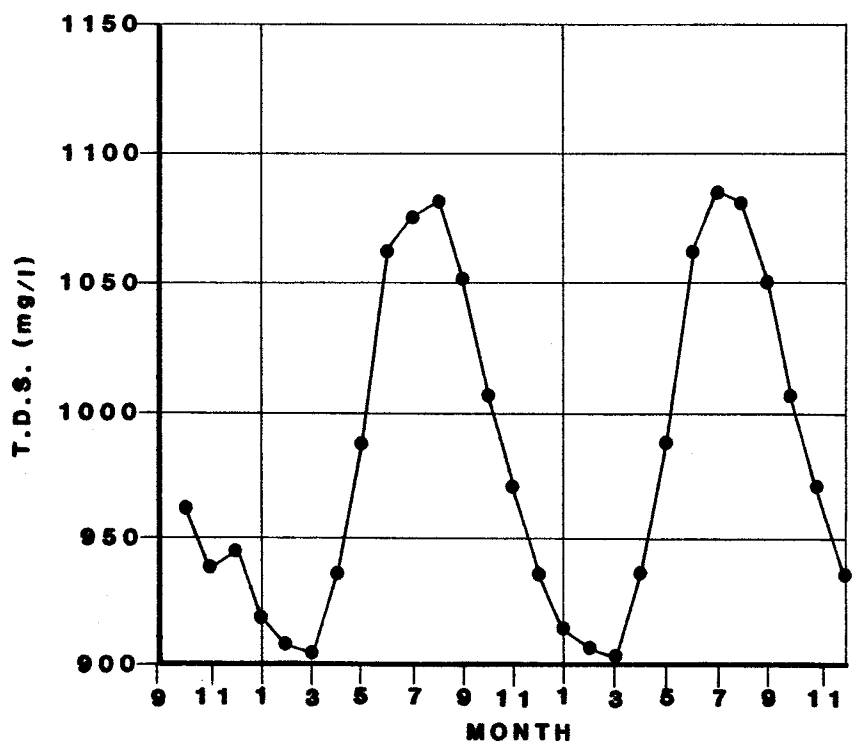
A geotechnical investigation of the proposed treatment pond site was conducted by Chen and Associates, Inc. of Salt Lake City, Utah. The conclusions reached by Chen and Associates will be summarized in this section. Chen's report with supporting data is contained in its entirety in Appendix F.

Seven exploratory borings were drilled in the vicinity of the proposed treatment ponds. "Subsurface conditions encountered within the exploratory borings consist generally of fill material overlying clays, sands or gravels." Actually, as identified by the logs in Appendix F, the principal fill area is the flat to the west of the ponds designated as "parking lot." "Generally within the northern portion of the area investigated, granular soils were encountered...with natural clay soils being encountered on the southern portion."

Also, as noted on the logs of the borings in Appendix F, no free water was encountered in the borings at the time of the investigation. Borings #5 and #6 were extended to a depth



Quarter Time Operation



Half Time Operation

Predicted T.D.S. concentration in Thickener Underflow Treatment Ponds as Determined from Water Budget Analysis

Figure 2

of 16 to 17 feet below the proposed bottom elevation of the eastern most treatment pond.

Conclusions reached by Chen and Associates based on their geotechnical investigation and testing at the site are as follows:

1. The natural soils at the site are suitable for the proposed thickener underflow treatment pond construction.

2. Excavation slopes in natural material on the order of 1.5H:1V for clays and 1.75H:1V for sands and gravels should be incorporated in the design of the proposed ponds.

3. Interior slopes of the ponds should be constructed on 3H:1V slopes to facilitate placement of the clay liner.

4. Fill slopes for pond embankment should be constructed on 3H:1V.

5. The natural clay soils removed during excavation are suitable for use as a pond lining material.

Construction Requirements

The proposed thickener underflow treatment ponds are to be nearly totally incised ponds. Only a small embankment (less than 4 feet) will be required along the east side of the eastern most pond. Construction details for the treatment ponds and associated facilities are illustrated on Drawings No. 1 through 8.

With the exception of the flocculator with mixing tank and pump house on the return line, Plateau intends to construct all facilities as indicated on the details, during 1984. The flocculator and pumping facilities may be constructed during the 1985 construction season depending upon the operations procedure for the ponds that Plateau determines to be practical under the present rate of discharge from the thickener tank, which is well below the peak design discharge for which the ponds were designed. Potential operation schemes for the ponds will be discussed in a subsequent section of this report. Until the flocculator and pumping facilities are installed Plateau intends to operate the coal preparation plant in such a manner that no discharge from the treatment ponds will occur.

As illustrated by the pond cross-section on Drawing No. 2, the ponds will be excavated into natural soil materials. Excavated slopes extending into the clay soils on the southern portion of the site will be maintained at a 1.5H:1V slope. Excavated slopes in the granular soils on the northern portion of the site will be maintained at a slope no steeper than 1.75H:1V.

Interior slopes of the ponds will be maintained on a 3H:1V slope to facilitate placement of the clay liner.

Since the TDS concentrations in the ponds are not expected to exceed 2000 mg/l (see the "Water Budget of Ponds" section of this report), in keeping with requirements outlined by personnel of the Department of Health the ponds have been designed to allow a maximum rate of seepage of 1/8 inch per day. The rate of seepage will be restricted to 1/8 inch per day or less by the placement of a clay liner on all interior slopes to the ponds and reservoir. The natural clay soils excavated from the site will provide sufficient resistance to seepage to be used as the clay liner material. Based on laboratory permeability test results conducted on the remolded on-site clay soils ($3x10^{-7}$ cm/sec), a liner 12-inches thick of compacted clay would result in seepage on the order of 1/8 of an inch per day with a 10-foot head.

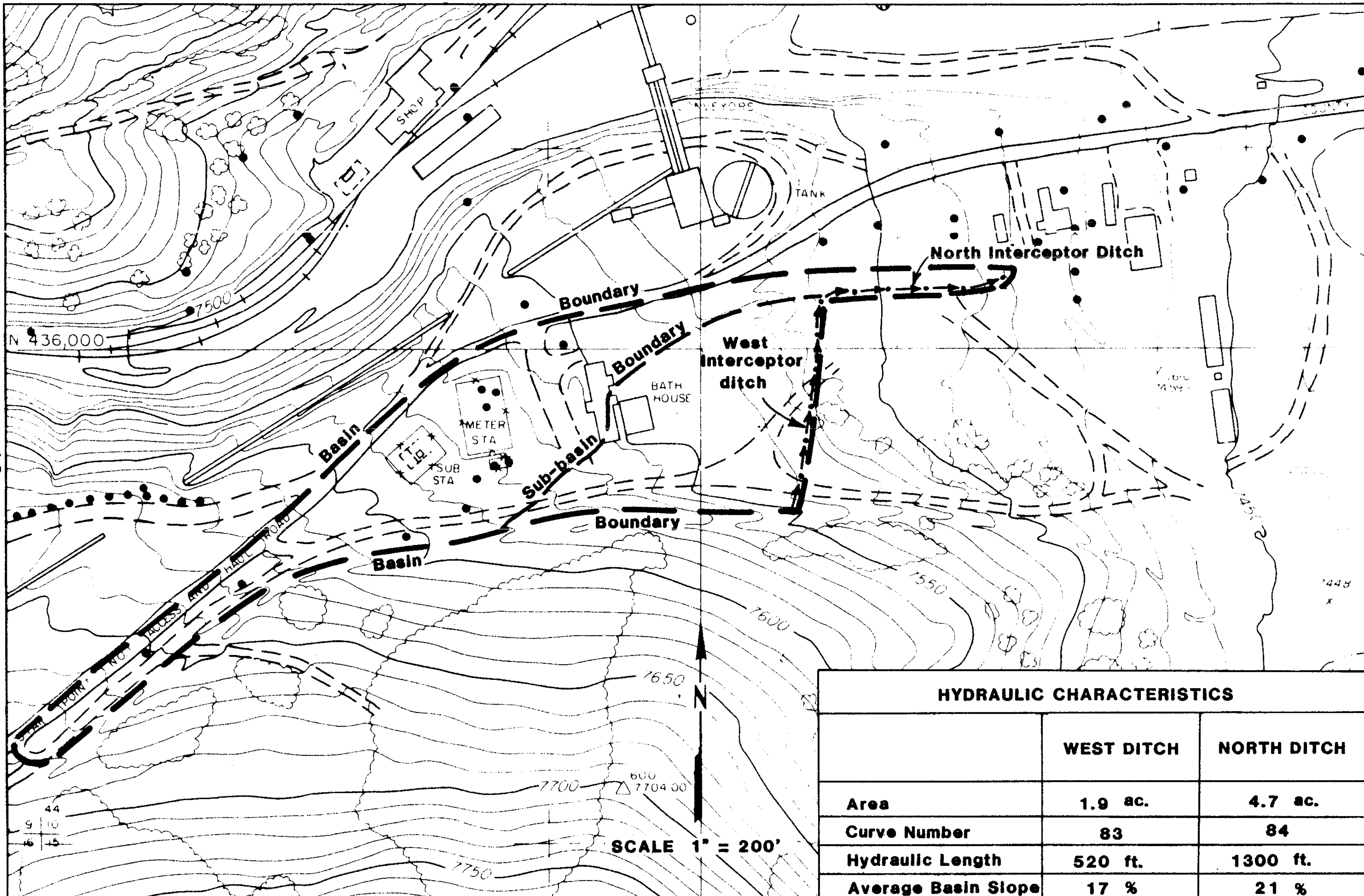
The liner will be constructed to a thickness of 2-feet to allow a margin of safety for cleaning operations of the pond. The liner will be placed in lifts not to exceed 6-inches and will be compacted to at least 95 percent Standard Proctor density at a moisture content of from optimum to 3 percent above optimum. Prior to placement of the clay liner, existing soils will be scarified, compacted to at least 90 percent Standard Proctor, and smoothed.

In addition to the clay lining material, concrete slabs will be placed on the pond bottoms and extended up one slope to facilitate cleaning of the ponds. The concrete slab will be reinforced to provide for a distribution of anticipated wheel loadings. Concrete lips or curbs will be provided around all edges to be used as an indicator for machinery used in cleaning the ponds as to where the concrete stops and the slopes begin. This will aid in preventing the machinery from gouging into the clay liner material while cleaning the ponds.

The natural excavated soils will also be used as construction materials for the limited embankment that must be constructed on the east side of the east pond and reservoir. Prior to placement of the fill, all existing fill material, topsoil, or other deleterious materials will be removed down to natural soils. Natural soils will then be prepared by scarifying and compaction to at least 90 percent Standard Proctor density. The fill material will be compacted to a minimum of 95 percent Standard Proctor density within plus or minus 2 percent of optimum moisture content.

Thickener Underflow Treatment Ponds Runoff Control Plan

An interception ditch shall be placed along the west and north sides of the thickener underflow treatment ponds (see Drawing No. 1) to intercept surface runoff prior to entering the cut slopes associated with the ponds. Small dike top ditches



HYDRAULIC CHARACTERISTICS	WEST DITCH	NORTH DITCH
Area	1.9 ac.	4.7 ac.
Curve Number	83	84
Hydraulic Length	520 ft.	1300 ft.
Average Basin Slope	17 %	21 %

Figure 3. Contributary Drainage Area to the Proposed Runoff Control Diversion Ditch

TABLE 2

Hydrologic Characteristics of Area Tributary to Interception Ditch

Reach	Disturbed Area (acres)	Undisturbed Area (acres)	Total Area (acres)	Weighted CN	25-year 24-hour Rainfall (inches)	Hydraulic Length (feet)	Average Watershed Slope %	Tp (hrs)	Peak Flow (cfs)
West	0.9	1.0	1.9	83	2.6	520	17	0.05	2.3
*North	2.2	2.5	4.7	84	2.6	1300	21	0.08	5.7

* Basin tributary to north side of interception ditch includes sub-basin tributary to west side.

TABLE 3

Design Criteria and Calculation Results for Interception Ditch

Reach	Design Flow (cfs)	Mannings n	Maximum Channel Slope Smax (ft/ft)	Channel Side Slope M	Bottom Width B (ft)	Flow Depth D at Smax (ft)	Velocity at Smax (fps)	Minimum Slope Smin (ft/ft)	Flow Depth D at Smin (ft)	*Required Channel Depth (ft)	**Riprap D_{50} (ft)
West	2.3	.038	0.29	2	3	0.13	5.5	0.12	0.2	1.2	0.75
North	5.7	.035	0.115	2	2	0.35	6.0	0.06	0.42	1.4	0.5

* Required channel depth includes one foot of freeboard
** Reference U.S. Department of Transportation (1978) for riprap sizing

around each pond are utilized at the base of the cut slopes to stop surface water from the cut slopes from entering the ponds.

The areas tributary to the interception ditch are delineated on Figure 3. The hydrologic characteristics of the tributary areas are given in Table 2. Runoff volumes and flowrates were computed using the Soil Conservation Service unit hydrograph procedure (see Appendix G for details of methodology). A curve number (CN) of 90 was assumed for disturbed areas and a CN of 74 for undisturbed areas. Interception ditch design data are tabulated on Table 3 (also see cross sections on Drawing No. 6).

The small dike top ditches (see Drawing No. 2) receive only minor amounts of runoff from the cut slopes. The dike top ditches are triangular with 1.5 horizontal to 1 vertical side slopes, 0.3 foot depth, and graded with a minimum slope of 0.1%.

Quality Control During Construction

During construction, an inspector will be employed at the site under the direction of a professional engineer. The inspector and professional engineer will be responsible for the administration and satisfactory completion of the project in accordance with plans and specifications. The inspector will keep a daily log and fill out a daily construction report. Copies of the daily construction report will be maintained at the site for review at all times during construction.

A representative of the soils engineer will be on site to inspect foundation soils prior to the placement of fill materials to distinguish any irregularities or changes in foundation conditions that might affect design consideration. The representative of the soils engineer will ensure that proper materials are used in the construction of embankments, liners, etc.; that designated maximum lift thicknesses are not exceeded; and that compaction density requirements are met. A Standard Proctor Test will be conducted at the time of construction for each representative soil type used in the embankment. The Standard Proctor tests will be used as standards for comparison with in-place compaction density tests taken during construction.

Monitoring

Ground water monitoring requirements associated with the proposed thickener underflow treatment ponds were discussed with personnel of the Utah State Department of Health. It was indicated that monitoring of ground water seepage in any nearby drainage channel (should seepage occur) would be sufficient for the ponds. Should no seepage be noted, then ground water monitoring would not be required as long as TDS concentrations in the ponds do not become excessive (greater than 5000 mg/l).

Since TDS concentrations in the treatment ponds are not expected to exceed 2000 mg/l, the proposed ground water monitoring plan shall consist of monitoring seepage (should seepage occur) in any nearby ephemeral stream channels. Chemical parameters to be included in the monitoring schedule are listed in Table 4.

Table 4

Required Chemical Analysis Parameters
by
State of Utah
Department of Health
Division of Environmental Health
Bureau of Water Pollution Control

1.	Ammonia	12.	Sodium
2.	Barium	13.	Zinc
3.	Boron	14.	Bicarbonate
4.	Cadmium	15.	Carbonate
5.	Calcium	16.	Chloride
6.	Chromium	17.	Fluoride
7.	Chromium (+6)	18.	Hydroxide
8.	Copper	19.	Sulfate
9.	Iron, soluble	20.	pH
10.	Magnesium	21.	Total Dissolved Solids
11.	Potassium	22.	Oil and Grease

In addition to the above parameters a chemical cation and anion balance will be computed for each sample and reported with the analyses.

Disposal of Settleable Solids

Solids settled out in the treatment ponds will be removed periodically (as required) by use of a front end loader. The concrete pad on the bottom of the ponds and ramp have been included in the design to facilitate cleaning of the ponds. Material cleaned from the ponds will be placed on the coal refuse pile located 500 feet east of the treatment pond site.

Operation Plan for the Ponds

As indicated previously, the thickener underflow treatment ponds are proposed as a means to abate the violation given by DOGM which indicated that the thickener underflow must be contained and not discharged as in the past in the flat area above sediment pond No. 5. At the present time Plateau Mining Company has some flexibility in determining how to operate the treatment ponds to ensure no discharge since presently the coal preparation plant is operated well below the capacity that would produce the peak thickener underflow rate for which the treatment ponds were designed. In order to abate the violation Plateau proposes to construct the ponds and commits to no discharge.

In the operation of the treatment ponds Plateau is considering three modes of operation. Plateau intends to experiment with these various modes of operation to determine which mode is most practical under present loading conditions from the thickener tank to the treatment ponds.

The first mode of operation which will also be the initial mode of operation after the ponds are constructed will include simply discharging the thickener underflow into one of the ponds without flocculation, allowing the pond to fill and the suspended solids to settle. Once the pond fills the water will be drawn from the filled pond and emptied into the second pond so that the first pond can be cleaned. Under this initial mode of operation the thickener underflow will be neither flocculated nor pumped back to the coal preparation plant for reuse. Plateau commits that there will be no discharge under this first mode of operation. As indicated previously, Plateau does not intend to construct the flocculator unit or the return pumping facility this year.

The second mode of operation consists of adding flocculant to the thickener underflow and recirculating the clarified water back to the plant for reuse. Plateau has budgeted to construct the flocculator unit and pumping return facilities to initiate operation mode No. 2 in 1985 if they find it to be necessary.

The third mode of operation consists of adding a flocculant if necessary and discharging clarified effluent from the pond to a natural channel if a variance to do so can be obtained from EPA. This third mode of operation will not be attempted until sufficient data from the ponds as to their efficiency in clarifying the water and water quality data from the ponds can be obtained to provide justification for the requested variance.

REFERENCES

Craig, G.D., and J.G. Rankle. 1977. Analysis of Runoff from Small Drainage Basins in Wyoming. USGS Open File Report 77-727. Cheyenne, Wyoming.

Haan, C.T. 1970. A Dimensionless Hydrograph Equation. File Report, Agricultural Engineering Department, University of Kentucky, Lexington, Kentucky.

U.S. Department of Transportation. 1978. Design of Stable Channels with Flexible Linings - Hydraulic Engineering Circular No. 15, Federal Highway Administration, Washington, D.C.

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

APPENDIX A

Climatic Data

VAUGHN HANSEN ASSOCIATES
CONSULTANTS / ENGINEERS

COMPUTED BW CLIENT Plateau
CHECKED PROJECT
DATE 6/14/84 FEATURE Precip Dist.

Precip at Wattis Represented By the Theissen average over the following stations.
Scofeild Dam, Scofeild, Electric Lake, Price, Hiawatha, and Castle Dale.

Months average Precip '73'-'83'

Station	% Cont.	1	2	3	4	5	6	7	8	9	10	11	12
Price warehouse	13.06	0.91	0.97	0.96	0.29	0.73	0.36	0.98	0.78	1.12	1.12	0.87	0.47
Castle Dale	23.62	0.83	0.58	0.89	0.38	0.62	0.22	0.89	0.72	0.67	0.55	0.61	0.35
Hiawatha	36.89	1.32	1.19	1.58	0.99	1.37	0.46	1.44	1.11	1.47	1.20	1.33	0.84
Scofeild Dam	0.14	0.96	0.67	1.05	0.75	1.34	0.54	1.00	1.30	1.23	1.00	0.94	0.68
☆Electric Lake	13.97	2.24	1.77	3.98	1.55	2.59	0.61	1.15	1.73	2.65	2.42	2.73	3.83
Scofeild	12.32	1.87	1.64	1.94	1.37	1.77	0.56	0.99	1.38	1.37	1.44	1.68	1.64
Avg. Precip at Wattis		1.35	1.15	1.71	0.88	1.33	0.42	1.15	1.09	1.39	1.24	1.34	1.19

☆ Electric Lake records only Back to 1980

Total yearly Precip = 14.24 inches

VAUGHN HANSEN ASSOCIATES
CONSULTANTS / ENGINEERS

COMPUTED BW CLIENT Plateau
CHECKED PROJECT
DATE 6/13 FEATURE

NOAA Evap:

Free Water Surface

yearly ~37 inches. = 3.083 ft.

Distribution of this total is by, the average percentage of Strawberry, Scofield and Joes Valley from the Info Supplied By UPL (USBR Emery Co Proj Report)

Mo	Avg %	Evap (FWS) ft
Jan	.34	.0108
Feb	.34	.0108
Mar	2.59	.08
Apr	6.72	.207
May	13.56	.418
June	17.58	.542
July	17.84	.55
Aug	15.57	.48
Sept	13.45	.415
Oct	8.26	.255
Nov	3.41	.105
Dec	.34	.0108
		3.083 ft

APPENDIX B

Characteristics of Makeup and Thickener Underflow

CERTIFICATE OF ANALYSIS

STANDARD LABORATORIES, INC.
P.O. Box 1140, Huntington, Utah 84528 801-653-2314

Client: Plaetau Mining Co.
P. O. Drawer PMC
Price, Utah 84501

Sample ID: Plant Make Up Water

Lab. No. 5459
Date Rec'd 5-23-84
Date Sampled 5-22-84
Time Sampled 1239

Acidity	< 1.0	mg/l $CaCO_3$
Alkalinity, Total	297	mg/l $CaCO_3$
Alkalinity, Bicarbonate	362	mg/l ~~$CaCO_3$~~ HCO_3
Alkalinity, Carbonate	< 1.0	mg/l $CaCO_3$
Chloride	244	mg/l
Coliform, Fecal		MPN/100 ml
Coliform, Total		MPN/100 ml
Conductivity	1750	umhos/cm
Fluoride		mg/l
Hardness, Total		mg/l $CaCO_3$
.trogen, Ammonia		mg/l
Nitrogen, Nitrate		mg/l
Nitrogen, Nitrite		mg/l
Oil & Grease		mg/l
pH	7.85	Units
Phosphorus, Ortho		mg/l
Phosphorus, Total		mg/l
Solids, Total Dissolved	963	mg/l
Solids, Total Suspended	55.5	mg/l
Sulfate	210	mg/l
Sulfide		mg/l
Turbidity		NTU
Cation, Total	16.00	meq/l
Anion, Total	17.20	meq/l

Aluminum		mg/l
Arsenic		mg/l
Barium		mg/l
Beryllium		mg/l
Boron		mg/l
Cadmium		mg/l
Calcium	68	mg/l
Chromium		mg/l
Copper	< 0.02	mg/l
Iron	0.16	mg/l
Lead		mg/l
Magnesium	37	mg/l
Manganese	0.03	mg/l
Mercury		ug/l
Nickel	< 0.04	mg/l
Potassium	10	mg/l
Selenium		mg/l
Silica		mg/l
Sodium	215	mg/l
Vanadium		mg/l
Zinc	0.015	mg/l
Iron, Dissolved	< 0.05	mg/l
Manganese, Dissolved	0.03	mg/l

Analyst: [signature]

Respectfully submitted [signature]

CERTIFICATE OF ANALYSIS

STANDARD LABORATORIES, INC.
P. O. Box 1140, Huntington, Utah 84528 801-653-2314

Lab. No. 5460

Date Rec'd 5-23-84

Date Sampled 5-22-84

Time Sampled 1245

Client: Plateau Mining Co.
P. O. Drawer PMC
Price, Utah 84501

Sample ID: Thickener Underflow

Acidity	< 1.0	mg/l $CaCO_3$
Alkalinity, Total	267	mg/l $CaCO_3$
Alkalinity, Bicarbonate	326	mg/l ~~$CaCO_3$~~ HCO_3
Alkalinity, Carbonate	< 1.0	mg/l $CaCO_3$
Chloride	238	mg/l
Coliform, Fecal		MPN/100 ml
Coliform, Total		MPN/100 ml
Conductivity	1700	umhos/cm
Fluoride		mg/l
Hardness, Total		mg/l $CaCO_3$
Nitrogen, Ammonia		mg/l
Nitrogen, Nitrate		mg/l
Nitrogen, Nitrite		mg/l
Oil & Grease		mg/l
pH	7.45	Units
Phosphorus, Ortho		mg/l
Phosphorus, Total		mg/l
Solids, Total Dissolved	925	mg/l
Solids, Total Suspended	239,190	mg/l
Sulfate	190	mg/l
Sulfide		mg/l
Turbidity		NTU
Cation, Total	15.75	meq/l
Anion, Total	16.03	meq/l

Aluminum		mg/l
Arsenic		mg/l
Barium		mg/l
Beryllium		mg/l
Boron		mg/l
Cadmium		mg/l
Calcium	62	mg/l
Chromium		mg/l
Copper	0.05	mg/l
Iron	0.80	mg/l
Lead		mg/l
Magnesium	37	mg/l
Manganese	1.78	mg/l
Mercury		ug/l
Nickel	0.21	mg/l
Potassium	12	mg/l
Selenium		mg/l
Silica		mg/l
Sodium	215	mg/l
Vanadium		mg/l
Zinc	0.230	mg/l
Iron, Dissolved	< 0.05	mg/l
Manganese, Dissolved	0.04	mg/l

Analyst: David A Janusz

Respectfully submitted [signature]

Certified Environmental Laboratory

Ford Chemical
LABORATORY, INC.
Bacteriological and Chemical Analysis
40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 466-8761

DATE: 06/24/83

CERTIFICATE OF ANALYSIS

PLATEAU MINING
P.O. BOX PMC
PRICE, UTAH
84501

83-004985

SAMPLE: WATER SAMPLE COLLECTED 6-9-83 RECEIVED 6-13-83 FOR ANALYSIS UNDER P.O. W-31209.

	THICKENER TANK
ttleable Solids ml/l SM209F	<.1
Suspended Solids mg/l SM 209D	17.0
Total Solids mg/l	1,772

FORD CHEMICAL LABORATORY, INC.

Data as received by telephone from Ben Grimes for second set of makeup water and thickener underflow samples.

Constituent	Makeup Water	Thickener Underflow
TDS	1024	822
TSS	3.5	296,120 mg/1

Table A-2

SIEVE ANALYSIS DATA SHEET

Media Description: THICKENER U/F COMPOSITE

Media Source: PLATEAU MINING/NORWEST

Date: 3/28/83 **Investigator:** JOHN YINGST

SIEVE PAN + SAMPLE	SIEVE PAN WT. (gms)	SIEVE NUMBER	SIEVE OPENING (mm)	WEIGHT RETAINED (gms)	PERCENT RETAINED	PERCENT SMALLER THAN STATED SIZE
415.07	404.78	28		10.29	10.10	89.90
411.66	386.40	48		25.26	24.80	65.10
403.92	390.80	80	Sand ↑	13.12	12.88	52.22
361.43	356.36	100	0.147 mm	5.07	4.98	47.24
404.58	387.65	200	0.074 mm	16.93	16.62	30.62
331.74	326.70	325	0.045	5.04	4.95	25.67
391.87	365.72	-325		26.15	25.67	
		PAN				
		TOTAL		101.86	100% ✓	

Calculations:

$$\text{Percent Retained} = \frac{\text{Wt. Retained on Sieve}}{\text{Total Wt. of Sample}} \times 100$$

Remarks: ORIG SAMPLE SIZE: 279.15 GMS

$$\frac{101.86}{279.15} \times 100\% = 36.4\%$$

CALCULATED DRY SAMPLE WT: $(38.6)\frac{279.15}{100} = 107.75$

SOLIDS YIELD = 94.5%

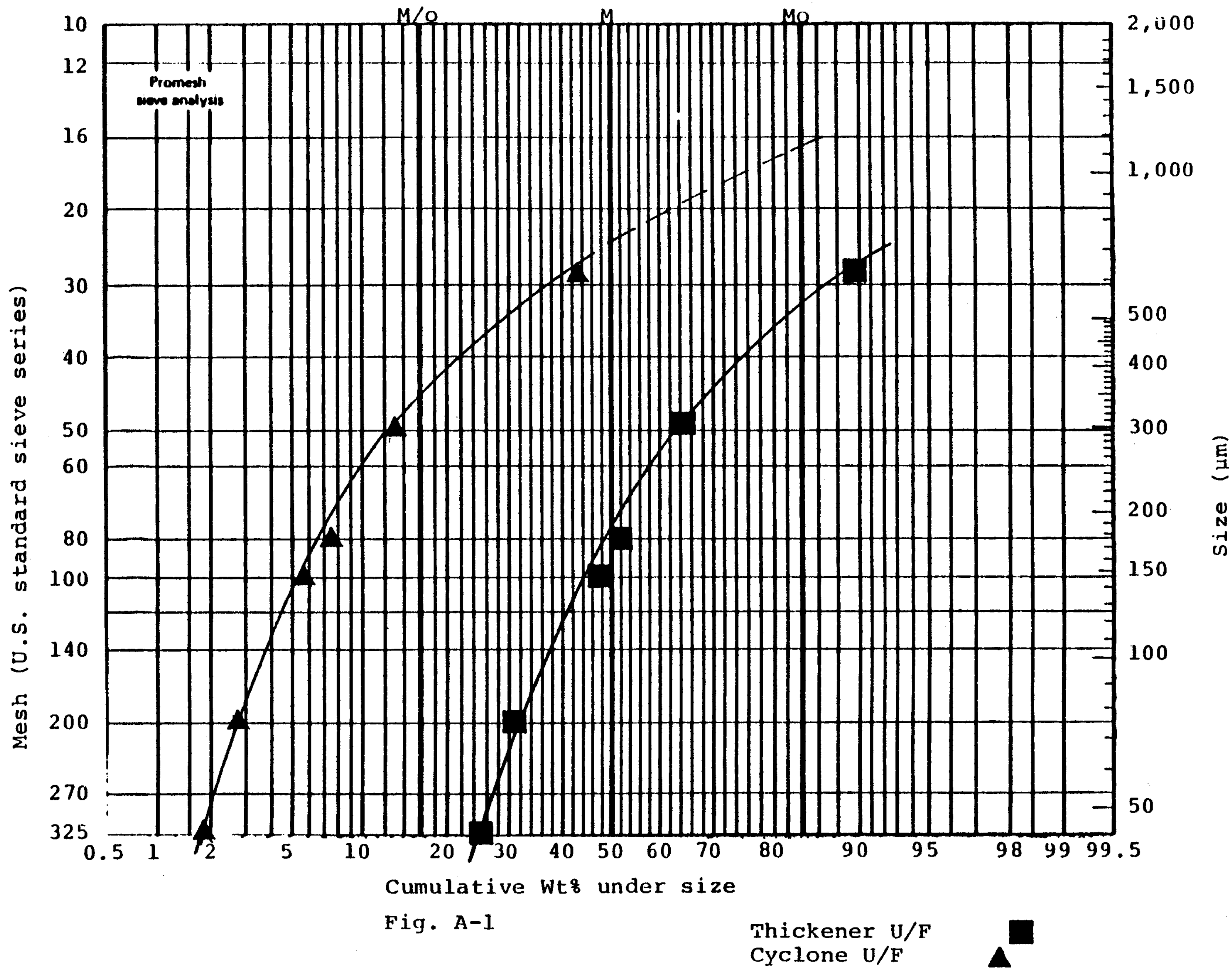

M/o
M
Mo
Promesh
sieve analysis
Mesh (U.S. standard sieve series)
10
12
16
20
30
40
50
60
80
100
140
200
270
325
Size (μm)
2,000
1,500
1,000
500
400
300
200
150
100
50
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.5
Cumulative Wt% under size
Thickener U/F
Cyclone U/F

Fig. A-1

chen and associates, inc.
CONSULTING ENGINEERS

SOIL & FOUNDATION
ENGINEERING
401 IRONWOOD DR. • SALT LAKE CITY, UTAH 84115 • 801/487-3661

July 2, 1984

Subject: Gradation and Hydrometer Testing, Plateau Mine Sample

Job No. 525484

Vaughn Hansen Associates
Waterbury Plaza Suite A
5620 South 1475 East
Salt Lake City, Utah 84121

Attention: Marv Allen

Gentlemen:

Chen and Associates, Inc. was requested to conduct additional gradation-hydrometer analyses on a sample of thickener underflow submitted to our office. On June 12, 1984 preliminary gradation and hydrometer results were transmitted which were found to require modification due to the specific gravity of the material tested. Listed below are the results of the gradation and hydrometer analyses after incorporating the specific gravity of the material.

Sieve Size	Particle Diameter (millimeters)	Percent of Total Passing
No. 16	1.190	100
No. 30	0.590	99
No. 50	0.297	93
No. 100	0.149	78
No. 200	0.074	62
	0.037	37
	0.019	29
	0.009	21
	0.005	15
	0.002	10
	0.001	2.8

The results listed above reflect a specific gravity of 1.49 and required approximately 5 days to conduct the test to obtain percent finer than the 0.001 (mm) size.

Should additional testing be requested, we could conduct similar tests on the new sample of thickener underflow provided to us on June 14, 1984.

Vaughn Hansen Associates
July 2, 1984
Page 2

If you have any questions or if we can be of further service, please call.

Sincerely,

CHEN AND ASSOCIATES, INC.

REGISTERED PROFESSIONAL ENGINEER
NO. 6153
JAMES E.
NORDQUIST
State of Utah

James E. Nordquist, P.E.

JEN/tc

APPENDIX C

Flocculation Tests

CYANAMID

American Cyanamid Company
Industrial Products Division
Mining Chemicals Sales Office and Laboratory
2002 North Forbes Blvd. Suite 103
Tucson, AZ 85745

July 3, 1984

Mr. Marvin Allen
VAN ALLEN & ASSOCIATES
5620 South 1475 East
Salt Lake City, Utah 84121

Dear Mr. Allen:

Attached is the data from our recent laboratory testing at Plateau Mining in which, at your request, we reprocessed thickener underflow. The results indicate that wash plant refuse thickener underflow can be resettled and clarified at low dosage. The Cyanamid products tested were ACCOAL-FLOC® 1202 and ACCOAL-FLOC® 360 anionic and cationic polymers respectively. These products were tested as they are currently used and inventoried at the wash plant.

Thickener underflow was sampled both before and after the underflow pump. As anticipated, the sample taken after the underflow pump required slightly more polymer to achieve equivalent performance due to pump shear. Dosage requirements were in the 0.05-0.20 lb./ton range. We project a consumption of 0.10 lb./ton will be enough to effectively settle and clarify the slurry.

Thickener underflow discharge does not appear difficult to treat. If you have any further questions please contact myself or Jerry Fahey.

Very truly yours,

AMERICAN CYANAMID COMPANY

Shane D. Fleming
Technical Sales Representative

cc: Mr. Dan Grimes
Plateau Mining

SDF/jw
encl.

CYANAMID LAB SETTLING TESTS

Plateau Coal

Wattis Utah

6/21/84

Thickener Underflow

19% solids

Non pumped slurry

test no.	flocculant	DOSAGE ml's 0.5%	lb/ton	Interface drop [inches] 5 mins	10 mins	Clarity
1	none	none	none	0.20	0.35	Dark Haze
2	SF-1202	1.0	0.049	0.45	0.95	Sligt Haze
3	SF-1202	2.0	0.098	1.10	2.50	Crystal Clear
4	SF-1202	4.0	0.196	3.15	5.25	Crystal Clear
5	SF-360	1.0	0.049	0.30	0.55	Slight Haze
6	SF-360	2.0	0.098	0.40	0.75	Crystal Clear
7	SF-360	4.0	0.196	0.75	1.55	Crystal Clear

Pumped slurry

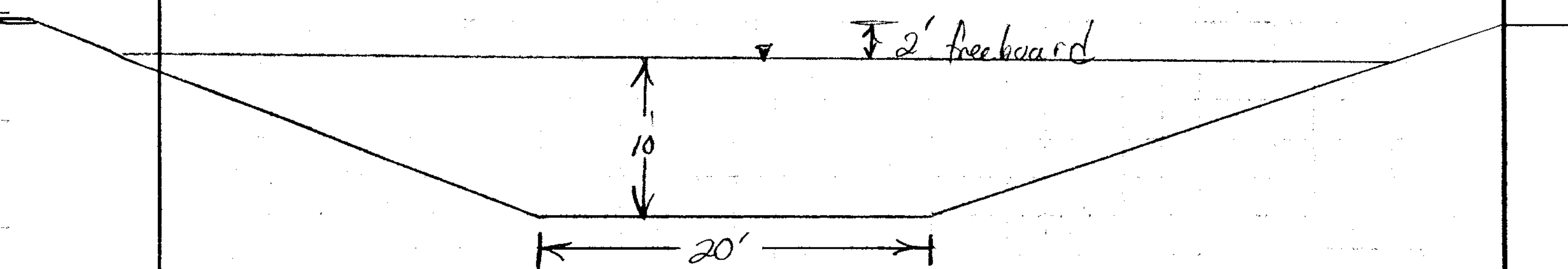
test no.	flocculant	DOSAGE ml's 0.5%	lb/ton	Interface drop [inches] 5 mins	10 mins	Clarity
8	none	none	none	0.20	0.30	Dark Haze
9	SF-1202	1.0	0.049	0.35	0.75	Medium Haze
10	SF-1202	2.0	0.098	1.00	2.05	Sligt Haze
11	SF-1202	4.0	0.196	3.35	5.55	Crystal Clear
12	SF-360	1.0	0.049	0.20	0.40	Medium Haze
13	SF-360	2.0	0.098	0.35	0.80	Sligt Haze
14	SF-360	4.0	0.196	0.65	1.30	Crystal Clear

APPENDIX D

Pond Efficiency Calculations

I- Proposed pond configuration

- Bottom dimensions: 20' x 98'
- Typical cross-section:



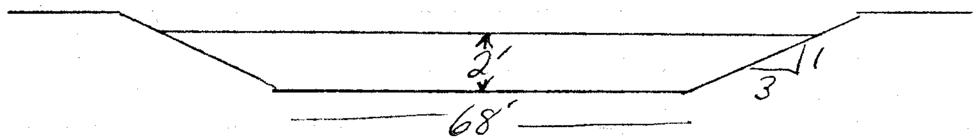
- Depth Capacity Curve for Pond #1

Stage ft	Area ft²	Volume ac-ft	Acc Volume ac-ft
0	1977	0.025	0
0.5	2330	0.029	0.025
1.0	2699	0.033	0.054
1.5	3084	0.038	0.087
2.0	3484	0.042	0.125
2.5	3900	0.047	0.167
3.0	4332	0.052	0.214
3.5	4779	0.058	0.266
4.0	5243	0.063	0.324
4.5	5722	0.069	0.387
5.0	6217	0.074	0.456
5.5	6727	0.080	0.530
6.0	7254	0.086	0.610
6.5	7796	0.093	0.696
7.0	8354	0.099	0.789
7.5	8927	0.106	0.888
8.0	9517	0.113	0.994
8.5	10,121	0.120	1.107
9.0	10742	0.127	1.227
9.5	11379	0.134	1.354
10.0	12031		1.488

VAUGHN HANSEN ASSOCIATES
CONSULTANTS / ENGINEERS

COMPUTED MA. CLIENT Plateau
CHECKED PROJECT Thickener Underflow
DATE 8/10/84 FEATURE Pond Eff. Calculations

– Assuming 1ac-ft of sediment storage in each pond, the stage corresponding to 1ac-ft is 8 feet, which would leave 2 feet for a flow path – or a corresponding flow cross-section of:



Length at 2' depth = 146 feet.

Peak Q = 125 gpm (0.28 cfs)

Flow Area = 148 ft^2

$$V = \frac{Q}{A} = \frac{0.28}{148} = 0.0019 \text{ fps.}$$

At the above indicated flowrate the flow through the above illustrated cross section would have the following characteristics assuming a Manning's n of 0.02:

Slope S = 2.9×10^{-10} ft/ft
Area = 148 ft^2
Wetted Perimeter = 80.7 ft
Hydraulic Radius = 1.8 ft
Velocity = 0.0019 fps
Depth = 2 ft
Flow = 0.28 cfs
Froude No = 2.4×10^{-4}

II – Required length of cell to produce clear water using a flocculant.

Criteria = time it takes particles to fall say half of the depth of the cell (5') must equal the time it takes the water to traverse the pond.

Fall velocity assuming the minimum velocity reported by American Cyanamid = 0.0001 fps with flocculant.

Based on this velocity the required length of the pond is –

Time required to fall 5' = $\frac{5}{0.0001 \text{ fps}}$ = 50,000 sec.

Required Length = 0.0019 fps * 50,000 sec = 95 ft

APPENDIX E

Water Budget Methodology and Calculations

Methodology of Water Balance Calculations

Due to the limited area available for construction of the slurry treatment ponds, it became evident the construction of evaporation ponds to treat the slurry underflow was impractical. Based on this fact, VHA became concerned with the impact that an increase in TDS concentration would have on the coal processing plant if the water was recycled, or the environment if the water was discharged. Therefore, a water balance analysis was completed by using the following methodology and based on the assumptions listed below. The water balance calculations are also included in this Appendix.

Water balance calculations are based on the equations:

1. $Q_{I1} C_{I1} + Q_s C_s + Q_p C_p - Q_e C_e + Q_f C_f = (Q_d + Q_{I2}) C_d$

2. $Q_{I1} - Q_{I2} + Q_s + Q_p - Q_e + Q_f = Q_d$

3. $Q_d C_d + Q_m C_m = Q_t C_t$

4. $Q_d + Q_m = Q_t$

Where:

Q = flow volume in ac-ft/month.
C = TDS concentration.

Subscripts

s	-	slurry
p	-	precipitation
e	-	evaporation
f	-	flushing water to pump seals (see assumption 3)
d	-	discharge from pond
I1	-	storage at the beginning of the analysis period
I2	-	storage at the end of the analysis period
m	-	makeup water
t	-	thickener inflow

Water balance calculations were based on the following assumptions and operational procedures:

1. All evaporation and precipitation for the test period are at monthly norms as calculated for this report.

2. TDS concentrations in the evaporation and precipitation equal 0.

3. At this time gravity flow is possible. However, slurry may have to be pumped to the ponds. Therefore, VHA assumed that the slurry must be pumped. The pump

was assumed to have a mechanical seal that requires flushing to protect the seal, at a rate of 1/8 gpm. Water used for flushing is discharged into the slurry treatment ponds.

4. Seepage out of the ponds equals 0.

5. The TDS concentration is determined by the following following relationship:

$$C_S = 1511 - 0.5922 (C_T)$$

This relationship was determined by using the data from the two sets of water quality analyses on makeup water and slurry underflow (see Appendix B) provided to VHA from Plateau. The calculation of this relationship appears at the beginning of the water balance tables. It should be noted that based on this relationship all predicted TDS concentrations fall between the two sets of data points. In order to improve the accuracy of this relationship, additional data would be required.

6. Operation time is measured in 16 hour days at design flows.

Slurry underflow (Q_S) 30,000 gpd - 0.09208 ac-ft/day
Make-up water 150 gpm - 0.0442 ac-ft/day
Flushing water through seals of pump 1/8 gpm- 0.00037 ac-ft/day

7. Operation begins October 1, 1984 with the ponds empty.

8. Make-up water averages 1000 mg/l TDS. Make-up is added to pond discharge to obtain flows in 6. Flushing water comes from the same source as make-up.

9. At the end of the month when the 1 ac-ft of solids storage is reached, operation is switched to the other pond with slurry above the solids storage level pumped to the other pond.

10. Both slurry treatment ponds have a capacity of approximately 2 ac-ft.

11. The TDS concentration of liquid storage is assumed equal to TDS concentration of discharge.

Selected headings on the water balance tabulation sheet are described below.

Inflow refers to slurry inflow to the treatment ponds.

Volume refers to ac.ft./month (Q in equations).

Outflow refers to discharge from the treatment ponds to the reservoir (see Figure 1) in text.

Outflow TDS is the end of the month TDS concentration of the pond contents (and discharge). These are the values plotted on Figure 2 in text.

Thickener Outflow is slurry inflow for the next month.

VAUGHN HANSEN ASSOCIATES
CONSULTANTS / ENGINEERS

COMPUTED BW CLIENT Plateau
CHECKED PROJECT
DATE 6/21 FEATURE Water Budget

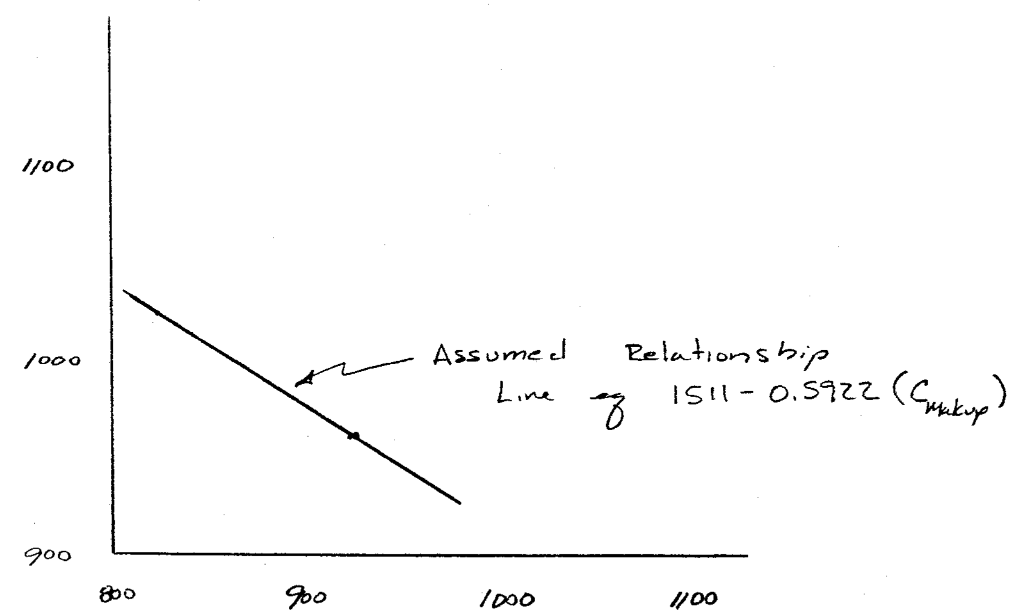
Water Budget of Slurry Treatment Ponds at Wattas Mine Site.

TDS Balance

Data

	Make up water		Slurry Underflow	
	Q (gpm)	TDS	Q (gpm)	TDS
	150	1024	31	822
	150	963	31	925

Avg Make up 1000 TDS.



Assumed Relationship Between TDS Concentrations of Make up and Slurry Due to Flocculant Addition.

Eqs $$Q_S C_{Slurry} + Q_p C_{precip} - Q_e C_{evap} + Q_f C_{flush} = Q_D C_{Discharge}.$$

$$Q_s + Q_p - Q_e + Q_f = Q_d$$

Plinkage Water quality ½ & ¼ operation time.

Assumptions.

1. Operation Begins Oct 1 1989 with ponds empty
2. Evap & Precip at 0 TDS
3. Vols as follows. 16 hr days.

   31 gpm = 0.09208 acft/day

   150 gpm = 0.442 acft/day

   ⅛ gpm = 0.00037 acft/day

4. TDS Eq for Thickner Outflow

   $1511 - 0.5922(I)$

   I = inflow

5. Seepage = 0
6. Vol ponds = 2 ac ft
7. When 1 acft Solids is reached operations switches to other pond. 1 acft water is emidiatly transfered with the rest made up By inflow
8. Inflow TDS at Start Based on following

   $1511 - .5922(1000) = 919$

YR	MO	INFLOW			PRECIP (Total Month)		EVAP (Total Month)		Flush		END Solid STO	END Total STO	OUT FLOW			MAKE UP		Thickner IN FLOW		Thickner OUT Flow	Comments
		DAYS	VOL	TDS	In	VOL	In	Vol	Vol	TDS	STO	STO	DAYS	Vol	TDS	Vol	TDS	Vol	TDS	TDS	
	Jan				1.35	0.046	0.13	0.004		1000							1000				
	Feb				1.15	.04	0.13	0.004		1000							1000				
	Mar				1.71	0.06	.96	.033		1000							1000				
	Apr				0.88	0.03	2.48	.085		1000							1000				
	May				1.33	.046	5.02	.173		1000							1000				
	June				0.42	.014	6.5	.224		1000							1000				
	July				1.15	.04	6.6	.227		1000							1000				
	Aug				1.09	.038	5.76	.198		1000							1000				
	Sept				1.39	.048	4.98	.171		1000							1000				
84	Oct	7	.645	919	1.24	.043	3.06	.105	.003	1000	.129	.586	0	–	1044	3.094	1000	3.094	1000	919	
	Nov	7	.645	919	1.34	.046	1.26	.043	.003	1000	.258	1.237	0	–	975	3.094	1000	3.094	1000	919	
	Dec	7	.645	919	1.19	.041	0.13	.004	.003	1000	.387	1.922	0	–	933	3.094	1000	3.094	1000	919	

Mass Balance on Slurry Treatmen Ponds.

1/4 time operation.

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5

YR	Mo	INFLOW			TOTAL MONTH PRECIP		EVAP		Flush		END Solid	Total	OUT FLOW			MAKE UP		Thickner IN FLOW		OUT Flow	Comments
		DAYS	VOL	TDS	In	VOL	In	Vol	Vol	TDS	STO	STO	DAYS	Vol	TDS	Vol	TDS	Vol	TDS	TDS	
85	Jan	7	.645	919	1.35	0.046	0.13	0.004	.003	1000	.516	2	6.6	.612	911	2.482	1000	3.094	982	929	
	Feb	7	.645	929	1.15	.04	0.13	0.004	.003	1000	.645	2	7	.684	900	2.41	1000	3.094	978	932	
	Mar	7	.645	932	1.71	0.06	.96	.033	.003	1000	.774	2	7	.675	896	2.419	1000	3.094	977	932	
	Apr	7	.695	932	0.88	0.03	2.48	.085	.003	1000	.903	2	7	.593	936	2.501	1000	3.094	988	926	
	May	7	.695	926	1.33	.046	5.02	.173	.003	1000	1.032	2	7	.521	1012	2.573	1000	3.094	1002	918	
	June	7	.645	918	0.42	.014	6.5	.224	.003	1000	.129	1.406	0	—	1,140	3.094	1000	3.099	1000	919	switch Ponds.
	July	7	.645	919	1.15	.04	6.6	.227	.003	1000	.258	1.867	0	—	1,202	3.094	1000	3.094	1000	919	
	Aug	7	.645	919	1.09	.038	5.76	.198	.003	1000	.387	2	3.86	.355	1,225	2.739	1000	3.094	1026	904	
	Sept	7	.645	904	1.39	.048	4.98	.171	.003	1000	.516	2	7	.525	1,217	2.569	1000	3.094	1037	897	
	Oct	7	.645	897	1.24	.043	3.06	.105	.003	1000	.645	2	7	.586	1,170	2.508	1000	3.094	1032	900	
	Nov	7	.645	900	1.34	.046	1.26	.043	.003	1000	.774	2	7	.651	1,094	2.443	1000	3.099	1020	907	
	Dec	7	.645	907	1.19	.041	0.13	.004	.003	1000	.903	2	7	.685	1017	2.409	1000	3.094	1004	917	

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2/3

YR	MO	INFLOW DAYS	INFLOW VOL	INFLOW TDS	TOTAL MONTH PRECIP In	PRECIP Vol	EVAP in	EVAP Vol	Flush Vol	Flush TDS	END Solid STO	END Total STO	OUTFLOW DAYS	OUTFLOW Vol	OUTFLOW TDS	MAKE UP Vol	MAKE UP TDS	Thickner INFLOW Vol	Thickner INFLOW TDS	Thickner OUTFLOW TDS	Comments
86	Jan	7	.645	917	1.35	0.046	0.13	0.004	.003	1000	1.032	2	7	.69	960	2.404	1000	3.094	991	924	
	Feb	7	.645	924	1.15	.04	0.13	0.004	.003	1000	.129	1.652	0	—	925	3.094	1000	3.094	1000	919	Switch ponds
	Mar	7	.645	919	1.71	0.06	.96	.033	.003	1000	.258	2	3.55	.327	912	2.767	1000	3.094	991	924	
	Apr	7	.645	924	0.88	0.03	2.48	.085	.003	1000	.387	2	7	.593	938	2.501	1000	3.094	988	926	
	May	7	.645	926	1.33	.046	5.02	.173	.003	1000	.516	2	7	.521	994	2.573	1000	3.094	999	919	
	June	7	.645	919	0.42	.014	6.5	.224	.003	1000	.645	2	7	.438	1,089	2.656	1000	3.094	1013	911	
	July	7	.645	911	1.15	.04	6.6	.227	.003	1000	.774	2	7	.461	1,155	2.633	1000	3.094	1023	905	
	Aug	7	.645	905	1.09	.038	5.76	.198	.003	1000	.903	2	7	.488	1,190	2.606	1000	3.094	1030	901	
	Sept	7	.645	901	1.59	.048	4.98	.171	.003	1000	1.032	2	7	.525	1,188	2.569	1000	3.094	1032	900	
	Oct	7	.645	900	1.24	.043	3.06	.105	.003	1000	.129	1.554	0	—	1,135	3.094	1000	3.094	1000	919	Switch Ponds
	Nov	7	.645	919	1.34	.046	1.26	.043	.003	1000	.258	2	2.23	.205	1,076	2.889	1000	3.094	1005	916	
	Dec	7	.685	916	1.19	.041	0.13	.004	.003	1000	.387	2	7	.685	1,023	2.409	1000	3.094	1005	916	

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3/5

Yr	Mo	INFLOW			PRECIP (Total Month)		EVAP (Total Month)		Flush		End Solid	Total	OUT FLOW			MAKE UP		Thickner Inflow		Thickner Outflow	Comments
		DAYS	VOL	TDS	In	Vol	in	Vol	Vol	TDS	Sto.	Sto	DAYS	Vol	TDS	Vol	TDS	Vol	TDS	TDS	
87	Jan	7	.645	916	1.35	0.046	0.13	0.004	.003	1000	.516	2	7	.69	977	2.404	1000	3.094	995	922	
	Feb	7	.645	922	1.15	.04	0.13	0.004	.003	1000	.645	2	7	.684	946	2.41	1000	3.094	988	926	
	Mar	7	.645	926	1.71	0.06	.96	.033	.003	1000	.774	2	7	.675	927	2.419	1000	3.094	984	928	
	Apr	7	.645	928	0.88	0.03	2.48	.085	.003	1000	.903	2	7	.593	958	2.501	1000	3.094	992	924	
	May	7	.645	924	1.33	.046	5.02	.173	.003	1000	1.032	2	7	.521	1028	2.573	1000	3.094	1005	916	
	June	7	.645	916	0.42	.014	6.5	.224	.003	1000	.129	1.406	0	—	1,149	3.094	1000	3.094	1000	919	Switch ponds
	July	7	.645	919	1.15	.04	6.6	.227	.003	1000	.258	1.867	0	—	1,209	3.094	1000	3.094	1000	919	
	Aug	7	.645	919	1.09	.038	5.76	.198	.003	1000	.387	2	3.86	.355	1,231	2.739	1000	3.094	1026	903	
	Sept	7	.645	903	1.39	.048	4.98	.171	.003	1000	.516	2	7	.525	1,222	2.569	1000	3.094	1038	897	
	Oct	7	.645	897	1.24	.043	3.06	.105	.003	1000	.645	2	7	.586	1,174	2.508	1000	3.094	1033	899	
	Nov	7	.645	899	1.34	.046	1.26	.043	.003	1000	.774	2	7	.651	1096	2.443	1000	3.094	1020	907	
	Dec	7	.645	907	1.19	.041	0.13	.004	.003	1000	.903	2	7	.685	1018	2.409	1000	3.094	1004	916	

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4/5

YR	Mo	INFLOW DAYS	INFLOW VOL	INFLOW TDS	TOTAL MONTH PRECIP In	TOTAL MONTH PRECIP VOL	TOTAL MONTH EVAP in	TOTAL MONTH EVAP Vol	Flush Vol	Flush TDS	END Solid STO	END Total STO	OUT FLOW DAYS	OUT FLOW Vol	OUT FLOW TDS	MAKE UP Vol	MAKE UP TDS	Thickner IN FLOW Vol	Thickner IN FLOW TDS	Thickner OUT Flow TDS	Comments
	Jan	7	,695	916	1.35	0.046	0.13	0.004	,003	1000	1.032	2	7	.69	960	2.404	1000	3.094	991	924	
	Feb	7	,695	924	1.15	,04	0.13	0.004	.003	1000	.129	1.652	0	–	925	3.094	1000	3.094	1000	919	Switch ponds
	Mar	7	.695	919	1.71	0.06	.96	,033	.003	1000	,258	2	3.55	.3.27	912	2,767	1000	3.094	991	924	
	Apr	7	.695	924	0.88	0.03	2.48	,085	.003	1000	.387	2	7	.593	938	2.501	1000	3.094	988	926	
	May	7	.695	926	1.33	.046	5.02	.173	,003	1000	.516	2	7	,521	994	2.573	1000	3.094	999	919	
	June	7	,695	919	0.42	,014	6.5	,224	,003	1000	.645	2	7	,438	1089	2.656	1000	3.094	1013	911	
	July	7	,695	911	1.15	,04	6.6	,227	.003	1000	.774	2	7	.461	1155	2,633	1000	3.094	1023	905	
	Aug	7	,695	905	1.09	,038	5.76	,198	.003	1000	.903	2	7	.488	1190	2606	1000	3.094	1030	901	
	Sept	7	.695	901	1.39	,048	4.98	.171	.003	1000	1.032	2	7	,525	1188	2569	1000	3.094	1032	900	
	Oct	7	.695	900	1.24	,043	3.06	,105	.003	1000	,129	1,554	0	–	1135	3,094	1000	3.094	1000	919	Switchponds
	Nov	7	.695	919	1.34	,046	1.26	.043	,003	1000	,258	2	2[illegible]	.205	1076	2889	1000	3.094	1005	916	
	Dec	7	.695	916	1.19	.041	0.13	,004	,003	1000	.387	2	7	.685	1023	2409	1000	3.094	1005	916	

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YR	MO	INFLOW DAYS	INFLOW VOL	INFLOW TDS	TOTAL MONTH PRECIP In	PRECIP VOL	EVAP In	EVAP Vol	Flush Vol	Flush TDS	END Solid STO.	END Total STO	OUTFLOW/Stg DAYS	OUTFLOW Vol	OUTFLOW TDS	MAKE UP Vol	MAKE UP TDS	Thickner InFlow Vol	Thickner InFlow TDS	Thickner OUT Flow TDS	Comments
	Jan				1.35	0.046	0.13	0.004		1000							1000				
	Feb				1.15	.04	0.13	0.004		1000							1000				
	Mar				1.71	0.06	.96	.033		1000							1000				
	Apr				0.88	0.03	2.48	.085		1000							1000				
	May				1.33	.046	5.02	.173		1000							1000				
	June				0.42	.014	6.5	.229		1000							1000				
	July				1.15	.04	6.6	.227		1000							1000				
	Aug				1.09	.038	5.76	.198		1000							1000				
	Sept				1.39	.048	9.98	.171		1000							1000				
84	Oct	15	1.381	919	1.24	.043	3.06	.105	.006	1000	.276	1.325	0	0	962	6.63	1000	6.63	1000	919	
	Nov	15	1.381	919	1.34	.046	1.26	.043	.006	1000	.552	2	7.76	.715	939	5.195	1000	6.63	885	987	
	Dec	15	1.381	987	1.19	.041	0.13	.004	.006	1000	.828	2	15	1.424	946	5.206	1000	6.63	988	926	

MASS Balance on Slurry Treatment Ponds

½ time operation.

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1/3

YR	MO	INFLOW DAYS	INFLOW VOL	INFLOW TDS	TOTAL MONTH PRECIP In	TOTAL MONTH PRECIP VOL	TOTAL MONTH EVAP In	TOTAL MONTH EVAP Vol	Flush Vol	Flush TDS	END Solid STO	END Total STO	OUT FLOW DAYS	OUT FLOW Vol	OUT FLOW TDS	MAKE UP Vol	MAKE UP TDS	Thickner INFLOW Vol	Thickner INFLOW TDS	Thickner OUT Flow TDS	Comments
85	Jan	15	1.381	926	1.35	0.046	0.13	0.004	.006	1000	1.104	2	15	1.429	919	5.201	1000	6.63	983	929	Finish month on first cell
	Feb	15	1.381	929	1.15	.04	0.13	0.004	.006	1000	.276	2	3.46	.319	908	6.311	1000	6.63	996	921	move to 2nd cell add .9 acft at 914 TDS from prev.
	Mar	15	1.381	921	1.71	0.06	.96	.033	.006	1000	.552	2	15	1.414	905	5.216	1000	6.63	980	931	
	Apr	15	1.381	931	0.88	0.03	2.48	.085	.006	1000	.828	2	15	1.332	937	5.298	1000	6.63	987	926	
	May	15	1.381	926	1.33	.046	5.02	.173	.006	1000	1.104	2	15	1.26	987	5.37	1000	6.63	997	920	
	June	15	1.381	920	0.42	.014	6.5	.224	.006	1000	.276	2	.79	.073	1,061	6.557	1000	6.63	1001	918	Switch panels
	July	15	1.381	918	1.15	.04	6.6	.227	.006	1000	.552	2	15	1.2	1,076	5.43	1000	6.63	1014	911	
	Aug	15	1.381	911	1.09	.038	5.76	.198	.006	1000	.828	2	15	1.231	1,071	5.403	1000	6.63	1013	911	
	Sept	15	1.381	911	1.39	.048	4.98	.171	.006	1000	1.104	2	15	1.264	1,050	5.366	1000	6.63	1010	913	
	Oct	15	1.381	913	1.24	.043	3.06	.105	.006	1000	.276	2	2.4	.221	1,005	6.409	1000	6.63	1000	919	Switch panels
	Nov	15	1.381	919	1.34	.046	1.26	.043	.006	1000	.552	2	15	1.39	970	5.24	1000	6.63	994	922	
	Dec	15	1.381	922	1.19	.041	0.13	.004	.006	1000	.828	2	15	1.422	936	5.208	1000	6.63	986	927	

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YR	MO	INFLOW			TOTAL MONTH PRECIP		EVAP		Flush		END Solid STO	Total STO	OUTFLOW			MAKE UP		Thickner INFLOW		OUT Flow	Comments
		DAYS	VOL	TDS	IN	VOL	IN	Vol	Vol	TDS	STO	STO	DAYS	Vol	TDS	Vol	TDS	Vol	TDS	TDS	
86	Jan	15	1.381	927	1.35	0.046	0.13	0.004	.006	1000	1.104	2	15	1.429	915	5.201	1000	6.63	982	930	
	Feb	15	1.381	930	1.15	.04	0.13	0.004	.006	1000	.276	2	3.46	.319	907	6.311	1000	6.63	996	921	Switch ponds
	Mar	15	1.381	921	1.71	0.06	.96	.033	.006	1000	.552	2	15	1.414	904	5.216	1000	6.63	980	931	
	Apr	15	1.381	931	0.88	0.03	2.48	.085	.006	1000	.828	2	15	1.332	936	5.298	1000	6.61	987	926	
	May	15	1.381	926	1.33	.046	5.02	.173	.006	1000	1.104	2	15	1.26	986	5.37	1000	6.63	997	920	
	June	15	1.381	920	0.42	.014	6.5	.224	.006	1000	.276	2	.79	.073	1,061	6.557	1000	6.63	1001	918	Switch ponds.
	July	15	1.381	918	1.15	.04	6.6	.227	.006	1000	.552	2	15	1.2	1,076	5.43	1000	6.63	1014	911	
	Aug	15	1.381	911	1.09	.038	5.76	.198	.006	1000	.828	2	15	1.227	1,071	5.403	1000	6.63	1013	911	
	Sept	15	1.381	911	1.39	.048	4.98	.171	.006	1000	1.104	2	15	1.264	1,050	5.366	1000	6.63	1010	913	
	Oct	15	1.381	913	1.24	.043	3.06	.105	.006	1000	.276	2	2.4	.221	1,005	6.409	1000	6.63	1000	919	Switch ponds.
	Nov	15	1.381	919	1.34	.046	1.26	.043	.006	1000	.552	2	15	1.39	970	5.24	1000	6.63	994	922	
	Dec	15	1.381	922	1.19	.041	0.13	.004	.006	1000	.828	2	15	1.422	936	5.208	1000	6.63	986	927	

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APPENDIX F

GEOTECHNICAL INVESTIGATION
THICKENER UNDERFLOW TREATMENT PONDS
PLATEAU MINE
WATTIS, UTAH

Prepared by:

Chen and Associates, Inc.
Salt Lake City, Utah

chen and associates, inc.
CONSULTING ENGINEERS

SOIL & FOUNDATION ENGINEERING

401 IRONWOOD DR. • SALT LAKE CITY, UTAH 84115 • 801/487-3661

GEOTECHNICAL INVESTIGATION
THICKENER UNDERFLOW TREATMENT PONDS
PLATEAU MINE
WATTIS, UTAH

Service Contract #1058

PREPARED FOR:

Plateau Mining Company
P.O. Drawer PMC
Price, Utah 84501

Job No. 527484 August 2, 1984

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FIGURE 1 - SITE MAP AND LOCATION OF EXPLORATORY BORINGS

FIGURES 2 & 3 - LOGS OF EXPLORATORY BORINGS

FIGURE 4 - LEGEND AND NOTES OF EXPLORATORY BORINGS

FIGURES 5 & 6 - DIRECT SHEAR TEST RESULTS

FIGURE 7 - COMPACTION TEST RESULTS

FIGURE 8 - GRADATION TEST RESULTS

TABLE I - SUMMARY OF LABORATORY TEST RESULTS

CONCLUSIONS

(1) The natural soils at the site are suitable for the proposed thickener underflow treatment pond construction.

(2) Excavation slopes in natural material on the order of 1.5:1 to 1.75:1 (horizontal to vertical) should be incorporated in design of the proposed ponds.

(3) Interior slopes should be constructed on 3:1 (horizontal to vertical) slopes to facilitate placement of clay liner material.

(4) Fill slopes for pond embankment should be constructed on 3:1 (horizontal to vertical).

(5) The natural clay soils removed during excavation are suitable for use as pond lining material.

(6) Excavation for the proposed ponds may be conducted with conventional excavation euipment. Some areas will require heavy duty excavation equipment.

(7) Further design details and construction precautions are contained within the text of the report.

SCOPE

This report presents the results of a geotechnical investigation for proposed Thickener Underflow Treatment Ponds for the Plateau Mine located at the Plateau Mine site, Wattis, Utah.

This investigation has been conducted in accordance with our proposal dated June 19, 1984 under service contract No. 1058.

This report has been prepared to summarize the data obtained and to present our conclusions and recommendations based on the proposed construction and subsurface conditions encountered. Design and construction considerations related to the geotechnical engineering aspects are included.

PROPOSED CONSTRUCTION

We understand it is proposed to construct two thickener underflow treatment ponds and an overflow reservoir at the Plateau Mine Facility as located and shown on Figure 1. We understand that thickener underflow material removed from the coal preparation plant thickener will be piped to the ponds. The ponds will facilitate sedimentation of the underflow materials, separation of and removal of liquid and sediment. Removal of the sediment will be conducted using front end loaders. To facilitate removal of the sediment, the ponds will be constructed with a concrete bottom and access ramps. Pond interior side slopes will be constructed on the order of 3:1 (horizontal to vertical). Liner material will be placed inside the ponds to keep seepage less than 1/8 of an inch per day.

Overall dimensions of each pond will be approximately 100 by 190 feet. Maximum elevation difference between the base and the top of the pond is planned at approximately 115 feet. Construction of the proposed ponds will require an excavated slope on the order of 82 feet deep.

The reservoir area will have a plan dimension of approximately 75 feet by 75 feet with an elevation difference of approximately 10 feet.

The configuration of the treatment ponds has changed since the field investigation. The general configuration at the time of report preparation is shown on Figure 1.

SITE CONDITIONS

At the time of the field investigation, the area proposed for the ponds was vacant of permanent structures. Several roads were observed within the area of the ponds. One road which crosses through the central portion of the ponds appears to be fairly new and is supported on approximately 4 to 5 feet of fill material.

Fill material was observed at the surface across a large portion of the site. It appears that the majority of fill has been placed in the north and west portions of the site. It appears that this fill has been placed to provide flatter areas within the site.

Grass and small trees cover the slope southwest of the site. Sparce grass coverage was observed in the southeast portion of the site. The remainder of the site was void of vegetation at the time of the investigation.

FIELD INVESTIGATION

The field investigation for the project was conducted on June 28 through 30, 1984. A total of seven exploratory borings were drilled at locations for proposed ponds. Subsequent to the field investigation, the pond configuration has changed. Location of the borings in respect to the proposed facilities and existing facilities are shown on Figure 1.

Exploratory borings were advanced using 7-inch diameter hollow stem power augers. Samples of the subsurface materials were obtained with a 2-inch diameter California spoon sampler. The samplers were driven into the various subsoils with blows from a 140 pound hammer falling 30 inches. This test is comparable to the standard penetration test described by ASTM Method D-1586. Penetration resistance values when properly evaluated provide an indication of relative density or consistency of the soils encountered. Depths at which the samples were taken and their penetration resistance values are shown on Figures 2 and 3.

SUBSOIL CONDITIONS

Subsurface conditions encountered within the exploratory borings consist generally of fill material overlying clays, sands or gravels. Generally within the northern portion of the area investigated, granular soils were encountered immediately beneath the fill material with natural clay soils being encountered on the southern portion. A large amount of fill material was encountered in Boring 1 extending to a depth of approximately 20 1/2 feet.

No free water was encountered in the borings at the time of the investigation.

Graphic logs of the soils encountered in the exploratory borings are shown on Figures 2 through 4.

Fill Material:

Fill material was encountered from the ground surface extending down to depths ranging from 1 to 20 1/2 feet below existing grade. Two general types of fill material were encountered within the borings. These fills consisted of a carbonaceous type fill and a fill consisting of clay, sand and gravel.

The carbonaceous fill material was observed to contain some shale. Moisture content of the fill ranged from dry to very moist and color ranged from black to brown.

The clay, sand and gravel fill was observed to contain some carbonaceous material. Moisture content ranged from dry to slightly moist with a brown to black color.

Natural Soils:

Natural soils encountered at the site generally ponsisted of clay or sand and gravel. The clay material was generally encountered in the southern portion of the site with the granular materials on the northern portion of the site.

The natural clay soils were observed to be sandy with occasional gravel and silty sand layers. Consistency of the material ranged from stiff to hard with the consistency increasing with depth. Moisture content was generally dry to moist. Samples of the clay material were observed to be porous, calcareous and were brown in color.

The silty sand soil encountered was observed to contain occasional clay layers and gravel. Some carbonaceous materials were encountered within this deposit. Density of the material ranged from medium dense to very dense. Moisture content ranged from slightly moist to moist and the color of the material was brown.

The sand and gravel material encountered was found to be silty with occasional cobbles. Layers of silty sand and clay were also encountered. Density ranged from medium dense to very dense with a dry to moist moisture condition. Color of this material was found to be brown.

LABORATORY TESTING

The subsoils obtained from the exploratory borings were examined and classified in the laboratory by the project engineer. Selected samples of the subsoils were tested in the laboratory for natural moisture contents, dry unit weights, grain size analysis, liquid and plastic limits, permeability, compaction and strength testing. The results of these tests are included on Figures 5 through 8 and are summarized on Table I.

Selected samples of the carbonaceous fill material and silt and sand soils were tested in direct shear tests. Test results are shown on Figures 5 and 6.

Selected samples of the soils were tested in the laboratory in unconfined compressive strength tests. Tests indicate unconfined compressive strengths ranging from 790 to 22,900 pounds per square foot.

A compaction test was conducted on a sample of the clay material which may be potentially used as pond liner material. Test results are shown on Figure 7.

Permeability tests were conducted on relatively undisturbed samples of the carbonaceous fill material, natural clay soils and a remolded sample of the clay soils. Permeability test results are shown on Figures 2, 3 and Table I. Permeability test results on relatively undisturbed samples obtained from Boring 4 at a depth of 30 feet and from Boring 7 at a depth of 5 feet were not complete at the time of report preparation. These test results will be forwarded upon completion.

EMBANKMENT CONSIDERATIONS

Excavation from an elevation of approximately 7555 feet to 7473 feet will be required to construct the proposed ponds. This constitutes an elevation difference of approximately 82 feet.

Excavation will extend into clay, and sand and gravel soils. In the areas of clay soils, excavation should be conducted on slopes no steeper than 1.5:1 (horizontal to vertical). In areas where granular soils are encountered (the sand and gravel soils), excavation should be conducted at slopes no steeper than 1.75:1. With the excavation depths and the slopes given, calculations indicte a safety factor on the order of 1.5 under long term conditions. A safety factor greater than 1.1 is calculated under earthquake conditions. Based on the site location and a Zone 2 earthquake hazard potential, a seismic coefficient of 0.1 was used for the earthquake analysis

These slopes may require maintenance to repair surficial raveling and erosion of the slopes.

Positive measures should be taken to prevent surface water from migrating into the soils behind the slopes and seeping out on the face of the excavation. Precautions should also be taken to reduce surface flow on the excavated slopes.

POND SLOPES

Interior slopes for the proposed ponds may be constructed with the criteria mentioned above for excavation in the granular and clay soils. If a clay liner is placed within the pond, consideration should be given to flattening the slopes to approximately 3:1 (horizontal to vertical). Slopes on this order would facilitate placement, compaction and future repair of clay material.

Consideration should be given to flattening the slopes in the area of access ramps to facilitate equipment traffic.

EMBANKMENT FILL

Placement of up to 4 feet of fill will be required in the northwest portion of the eastern pond embankment. Prior to fill placement, all existing fill material, topsoil or other deleterious material should be removed down to natural soils. Fill material should be placed and compacted to at least 95 percent standard Proctor (ASTM D-698) density near optimum moisture content. Prior to fill placement, the natural soils should be prepared by scarifying and compacting the natural soils. Compaction of the natural soils should be to at least 90 percent standard Proctor density. The natural excavated soils may be used for embankment fill.

POND LINER MATERIAL

We understand that seepage from the ponds should be limited to no more than 1/8 of an inch per day. The natural clay soils would provide sufficient resistance to seepage if precautions are taken to mitigate discontinuities observed during construction. The sand and gravel soil would require some type of lining material to reduce seepage quantities.

Based on the laboratory premeability test results on the remolded on-site clay soils, a liner of compacted clay, approximately 12 inches thick, would result in seepage on the order of 1/8 of an inch per day with a 10 foot head. Consideration should be given to increasing the liner to approximately 2 feet thick. This would allow a margin of safety for disturbance of the liner from construction and operation. The liner material should be placed and compacted to at least 95 percent standard Proctor (ASTM D-68) density from optimum to 3 percent above optimum moisture content.

Prior to placing liner material, the existing soils should be prepared by scarifying, compacting and smoothing the base soils. Compaction of the natural soils should be to at least 90 percent standard Proctor density.

Consideration should be given to placing concrete on the access ramps to maintain the integrity of the pond slopes.

CONCRETE POND BCTTOM

The pond bottoms will be provided with concrete slabs to facilitate removal of sediment. The natural soils at the base of the ponds will likely consist of clay and sand-gravel soils. Consideration may be given to placing compacted clay cn the entire bottom of the pond prior to concrete placement. This would reduce potential seepage and provide a uniform base for support of the concrete slab. Clay material placed and compacted to at least 95 percent standard Proctor density will provide a support for the concrete slab with a modulus of subgrade reaction of approximately 100 pounds per suare inch. The clay should be placed at or up to 3 percent above optimum moisture content. The concrete slab should be reinforced to provide distribution of wheel loads.

LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in this area for the use of the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings drilled at the locations indicated on the exploratory boring plan. The nature and extent of variations between exploratory borings may not become evident until excavation is performed. If during construction, soil and groundwater conditions appear to be different from those described herein, this office should be advised at once so that re-evaluation of the recommendations may be made. We recommend on site observation of excavations and frequent testing of fill placement by a representative of the soils engineer.

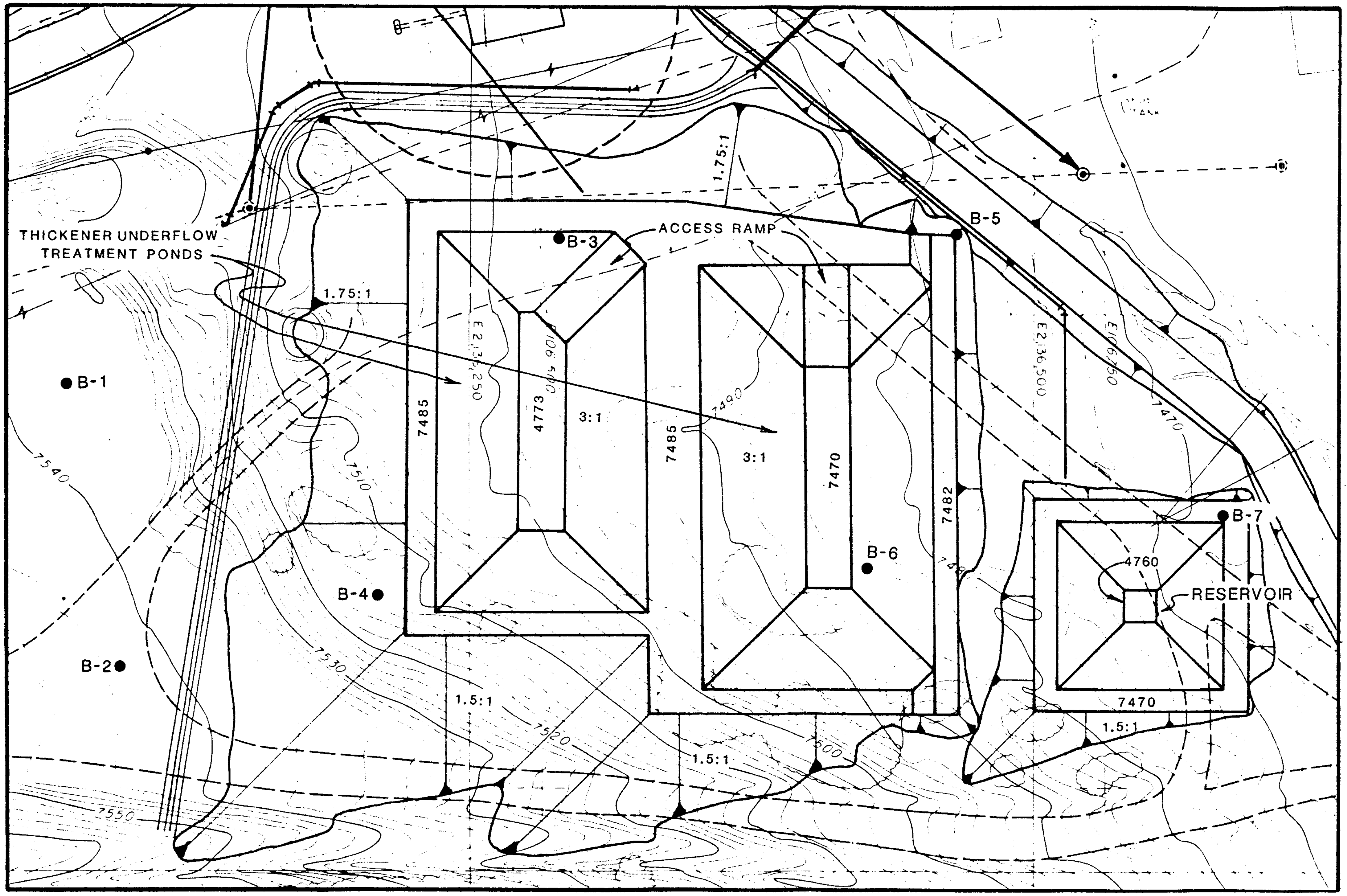
REGISTERED PROFESSIONAL ENGINEER
NO. 6153
JAMES E.
NORDQUIST
State of Utah

CHEN AND ASSOCIATES, INC.

James E. Nordquist, P.E.

Reviewed by Donald E. Bressler, P.E.

JEN/tc



#527484	chen and associates, inc.	LOCATION OF EXPLORATORY BORINGS	Figure 1

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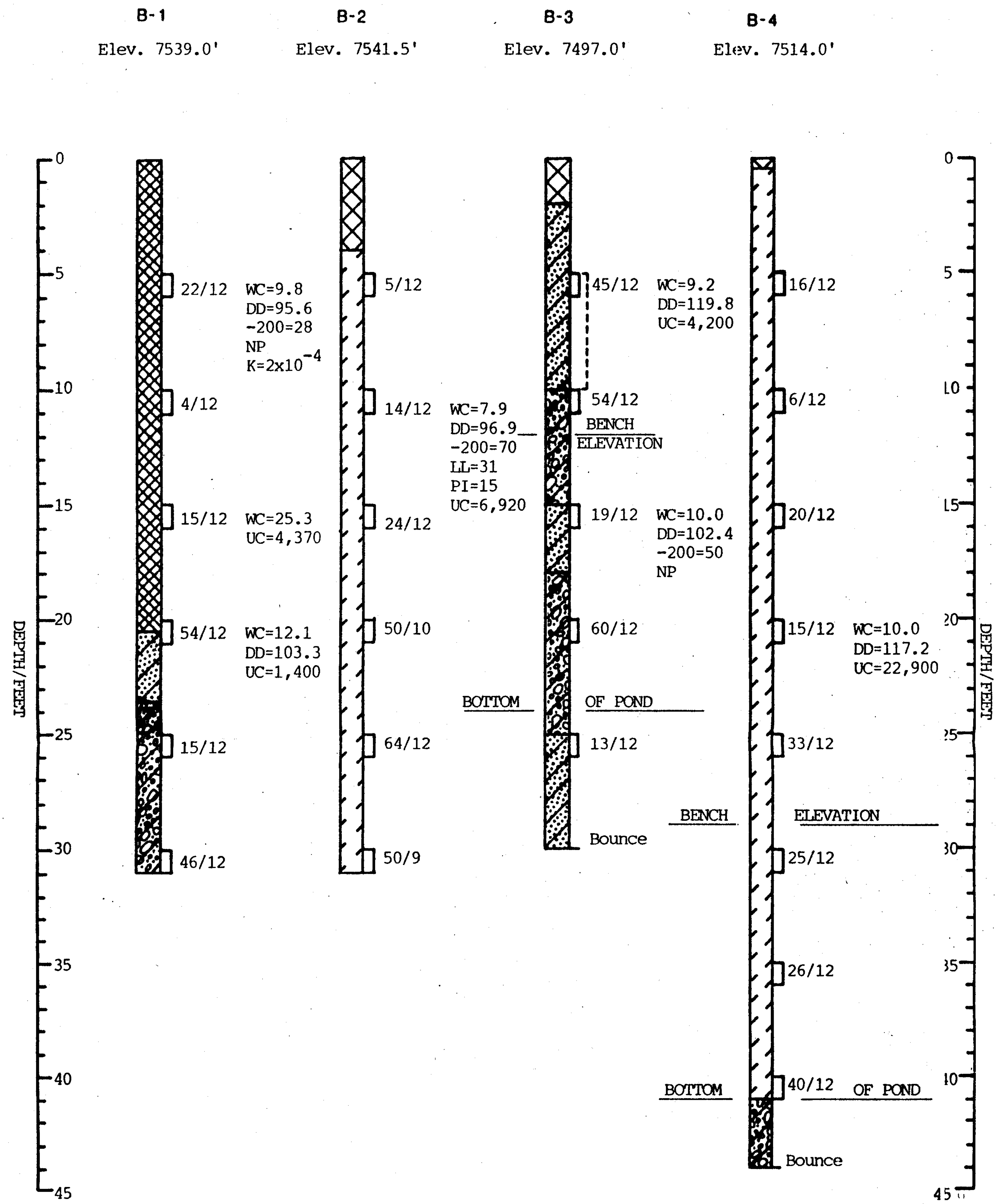

SEE FIGURE 4 FOR LEGEND AND NOTES

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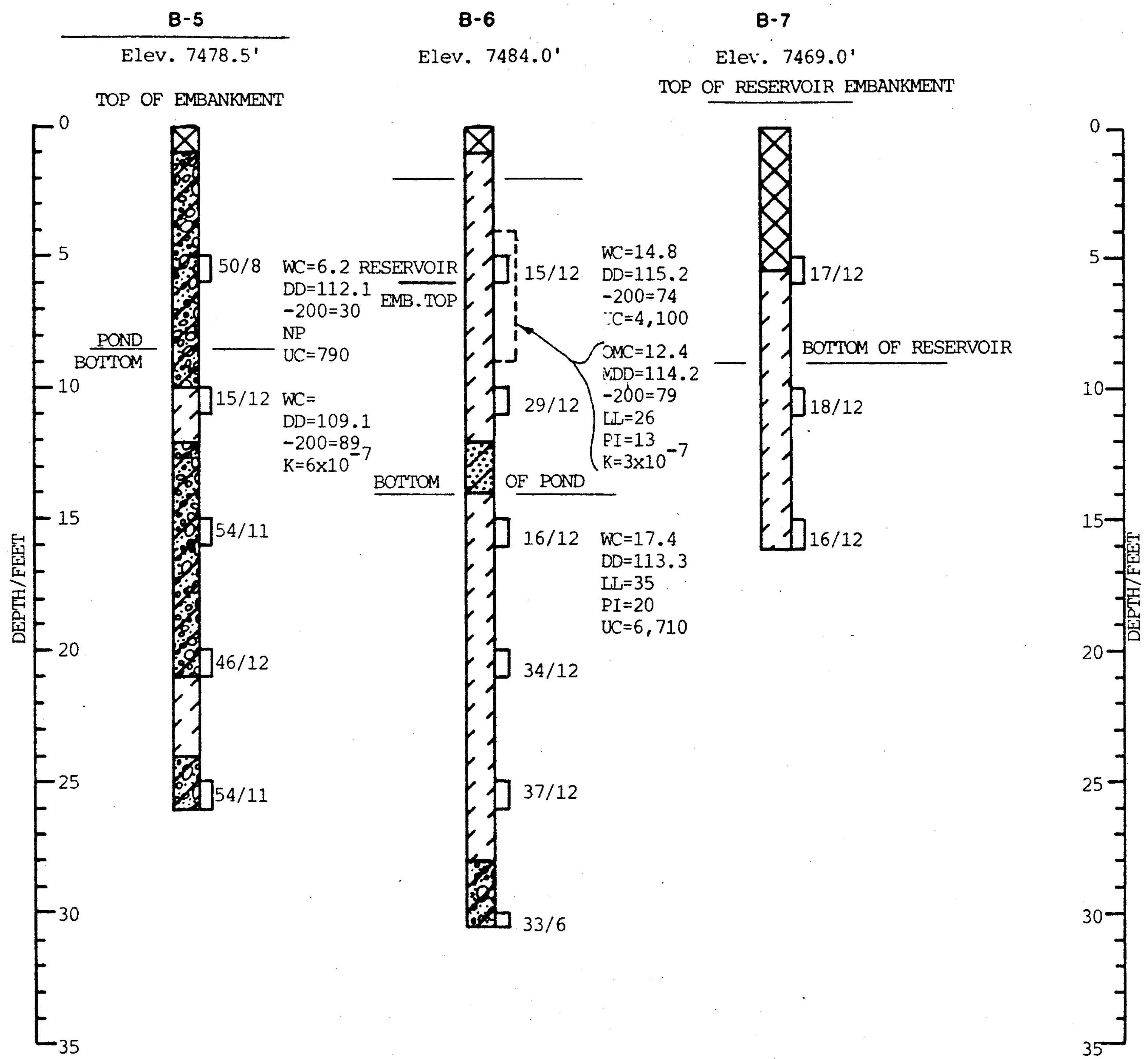
LOGS OF EXPLORATORY BORINGS

Figure 2



SEE FIGURE 4 FOR LEGEND AND NOTES

527484	chen and associates, inc.	LOGS OF EXPLORATORY BORINGS	Figure 3

NOTES

1. Exploratory borings were drilled on June 28, 1984 with a 7-inch diameter continuous flight hollow stem power auger.
2. Locations of exploratory borings were measured approximately by pacing from features shown on site plan provided.
3. Elevations of exploratory borings were taken from contours on the Figure provided.
4. The exploratory boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.
6. No free water was encountered in the borings at the time of the investigation.
7. WC = Water Content (%);
   DD = Dry Density (pcf);
   OMC = Optimum Moisture Content (%);
   MDD = Maximum Dry Density (pcf);
   -200 = Percent Passing No. 200 Sieve;
   LL = Liquid Limit (%);
   PI = Plasticity Index (%);
   UC = Unconfined Compressive Strength (psf);
   K = Permeability (cm/sec);
   NP = Non-Plastic.

LEGEND

Fill, carbonaceous material, some shale, dry to very moist, black to brown.

Fill, clay, sand and gravel, some carbonaceous material, dry to slightly moist, brown to black.

Clay (CL), sandy, occasional gravel and silty sand layers, stiff to hard, dry to moist, porous, calcareous, brown.

Sand (SM), silty, occasional clay layers and gravel, some carbonaceous material, medium dense to very dense, slightly moist to moist, brown.

Sand and Gravel (GM), silty, occasional cobbles, silty sand and clay layers, medium dense to very dense, dry to moist, brown.

Undisturbed Drive Sample. The symbol 10/12 indicates that 10 blows of a 140 pound hammer falling 30 inches were required to drive the sampler 12 inches.

Disturbed Bulk Sample.

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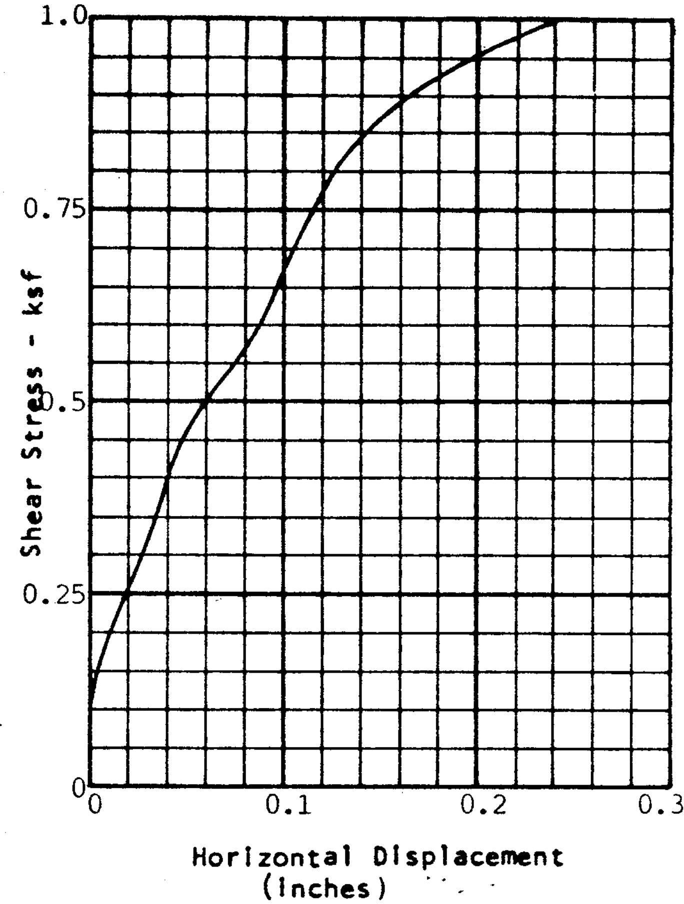
TEST NUMBER	1	2	3	4
LOCATION	B-1 @ 5.0'			
HEIGHT-INCH	0.5			
DIAMETER-INCH	1.93			
WATER CONTENT - %	30.9			
DRY DENSITY - pcf	95.6			
CONSOL. LOAD - ksf	--			
NORMAL LOAD - ksf	1.0			
SHEAR STRESS - ksf	1.0			



TYPE OF SPECIMEN: California Liner

SOIL DESCRIPTION: Fill - Carbonaceous Material

TYPE OF TEST: Unconsolidated - Saturated

TAN Ø:

Ø: --

Shear Strength - ksf at 1 kip confining pressure: 1.0

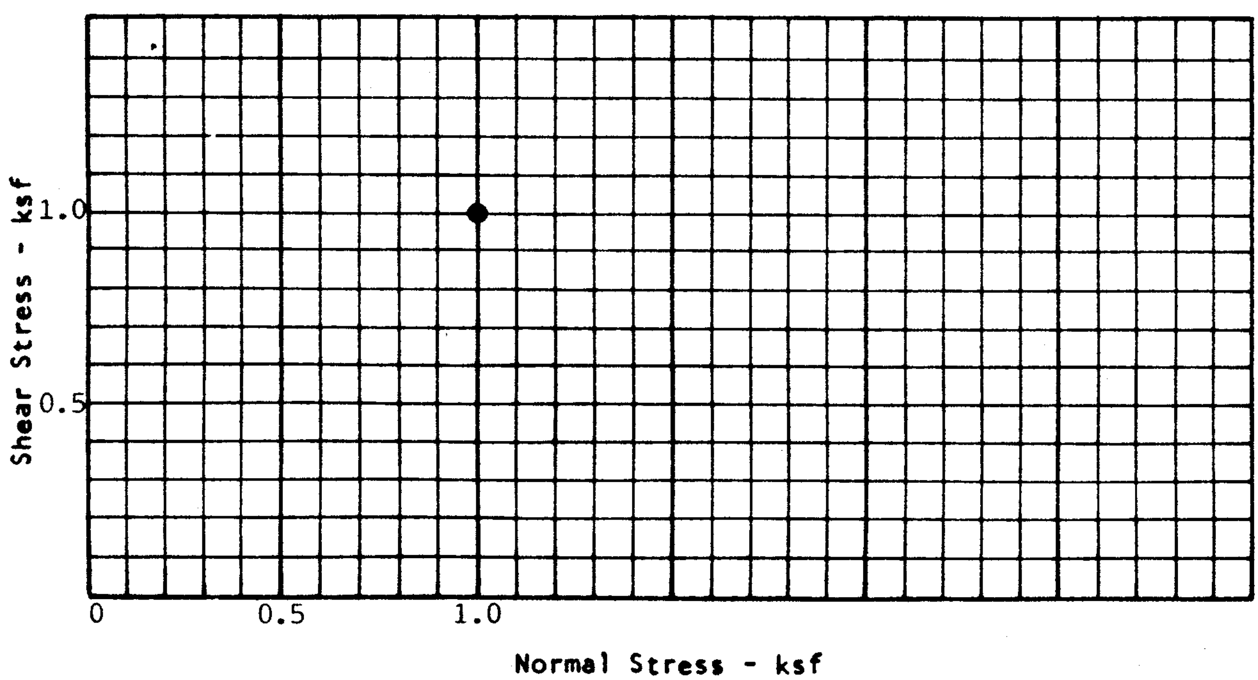


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Figure 5

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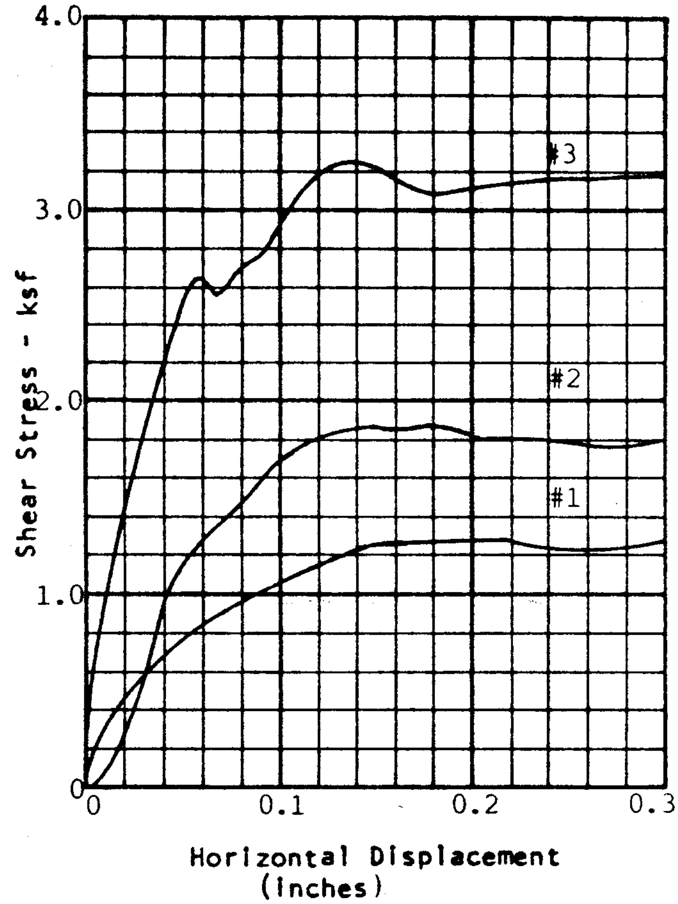
TEST NUMBER	1	2	3	4
LOCATION	B-3 @	15.0'		
HEIGHT-INCH	0.5	0.5	0.5	
DIAMETER-INCH	1.93	1.93	1.93	
WATER CONTENT - %	18.9	21.0	22.6	
DRY DENSITY - pcf	102.4	102.4	102.4	
CONSOL. LOAD - ksf	--	--	--	
NORMAL LOAD - ksf	1.0	2.0	4.0	
SHEAR STRESS - ksf	1.3	1.9	3.2	



TYPE OF SPECIMEN: California Liner

SOIL DESCRIPTION: Silt and Sand

TYPE OF TEST: Unconsolidated - Saturated

Strain Rate = 0.09 in/min

TAN Ø: 0.65

Ø: 33

COHESION - ksf: 0.6

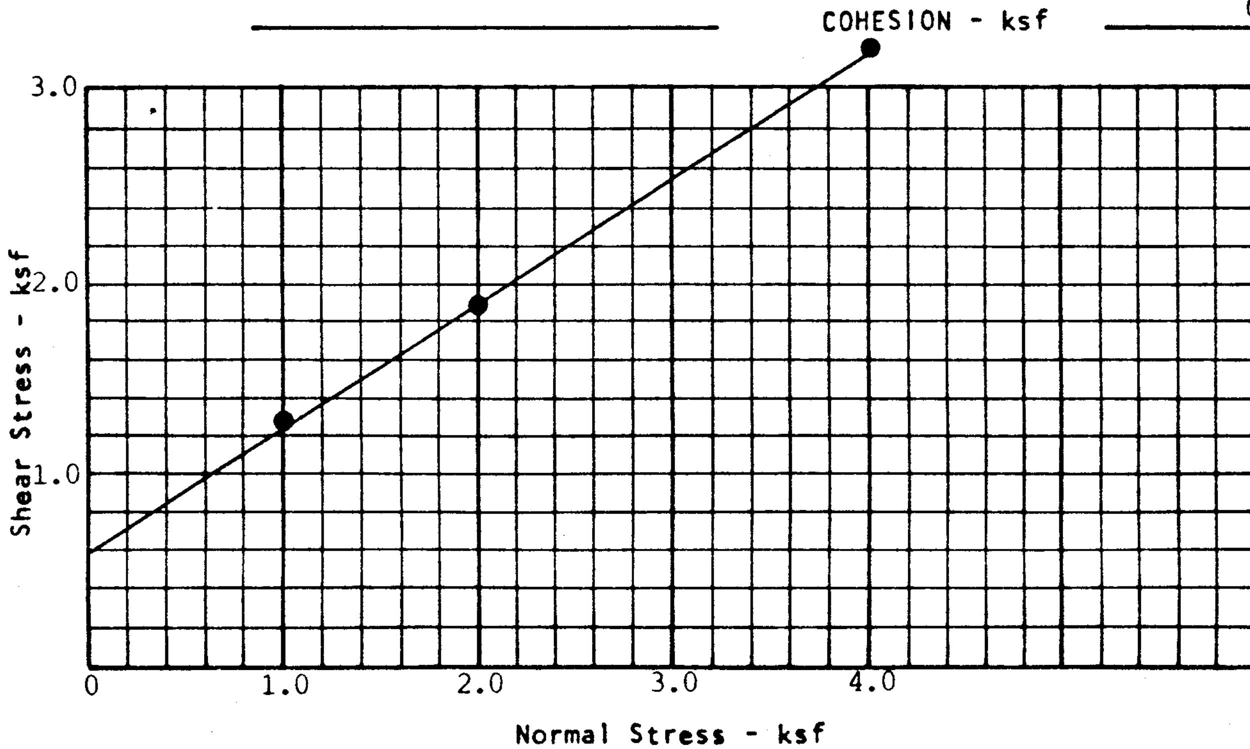


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Figure 6

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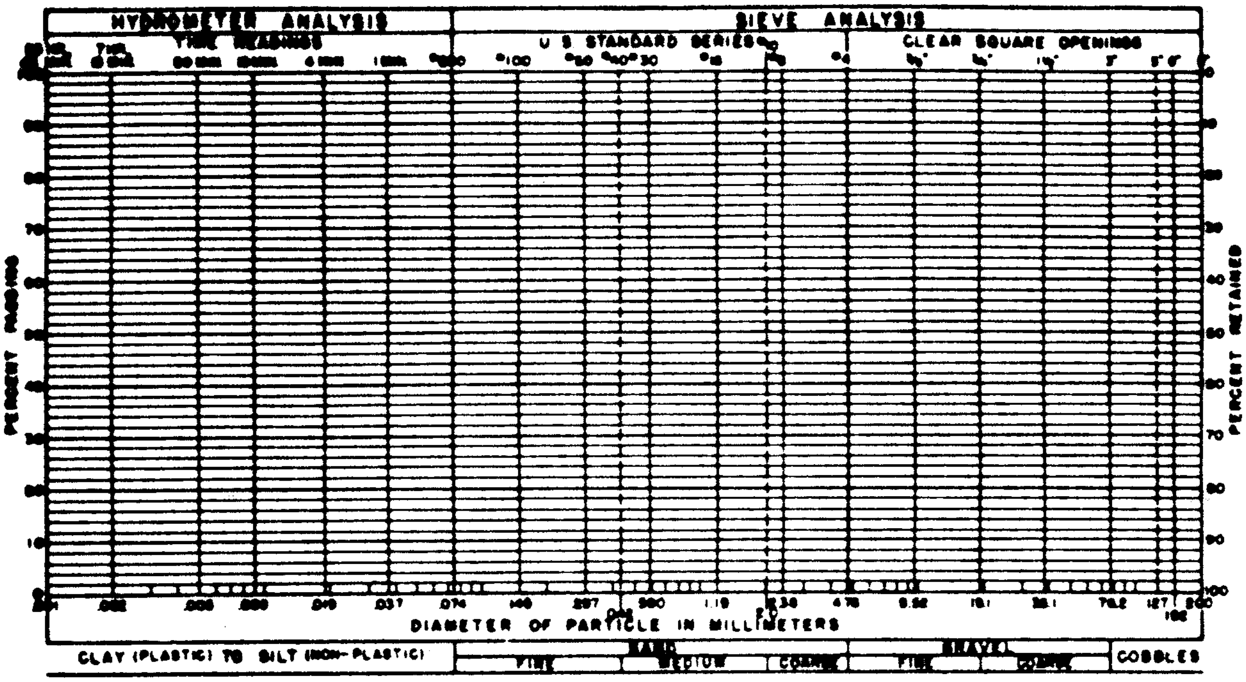
Consulting Engineers

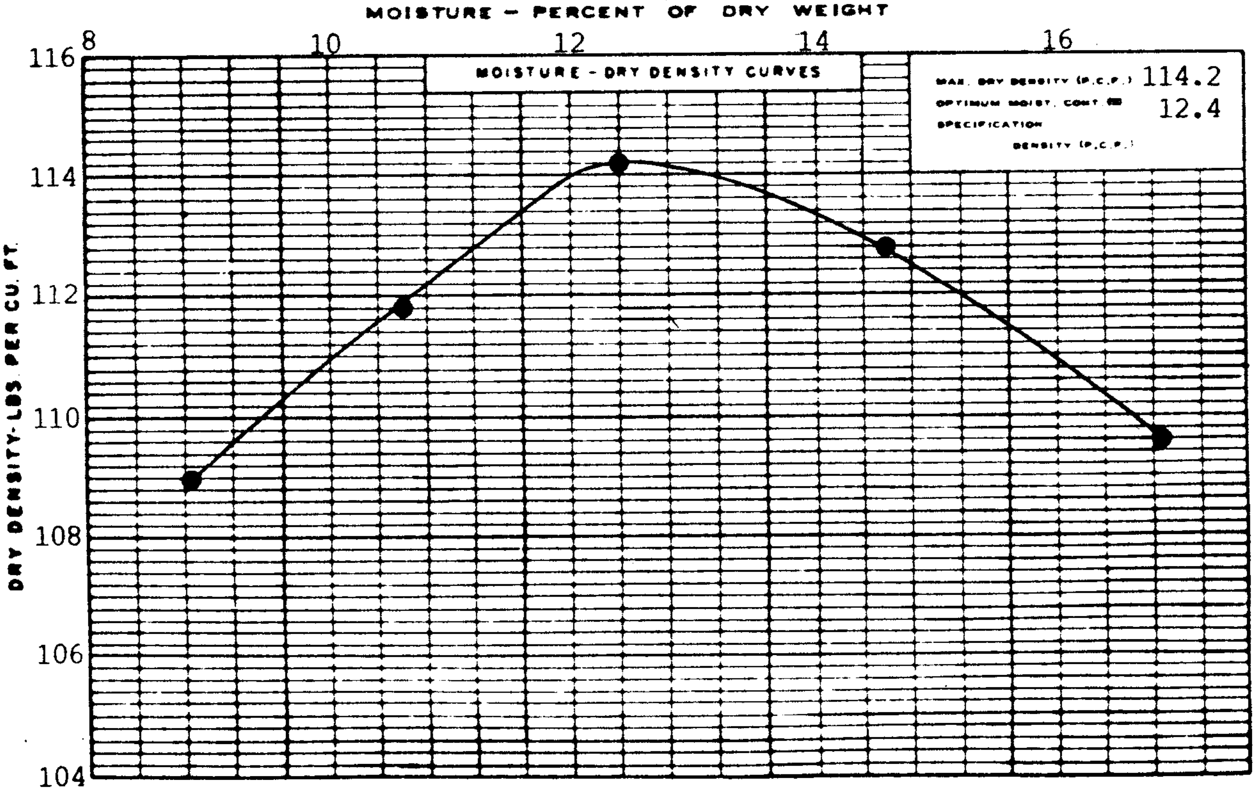
Soil and Foundation Engineering



GRADATION TEST RESULTS

GRAVEL % SAND % SILT AND CLAY 79 %

LIQUID LIMIT 26 % PLASTICITY INDEX 13 %



COMPACTION TEST RESULTS

COMPACTION TEST PROCEDURE ASTM D-698 Method A

SAMPLE OF Sandy Clay

#527484 FROM B-6 DEPTH From 4.0 to 9.0 feet Figure 7

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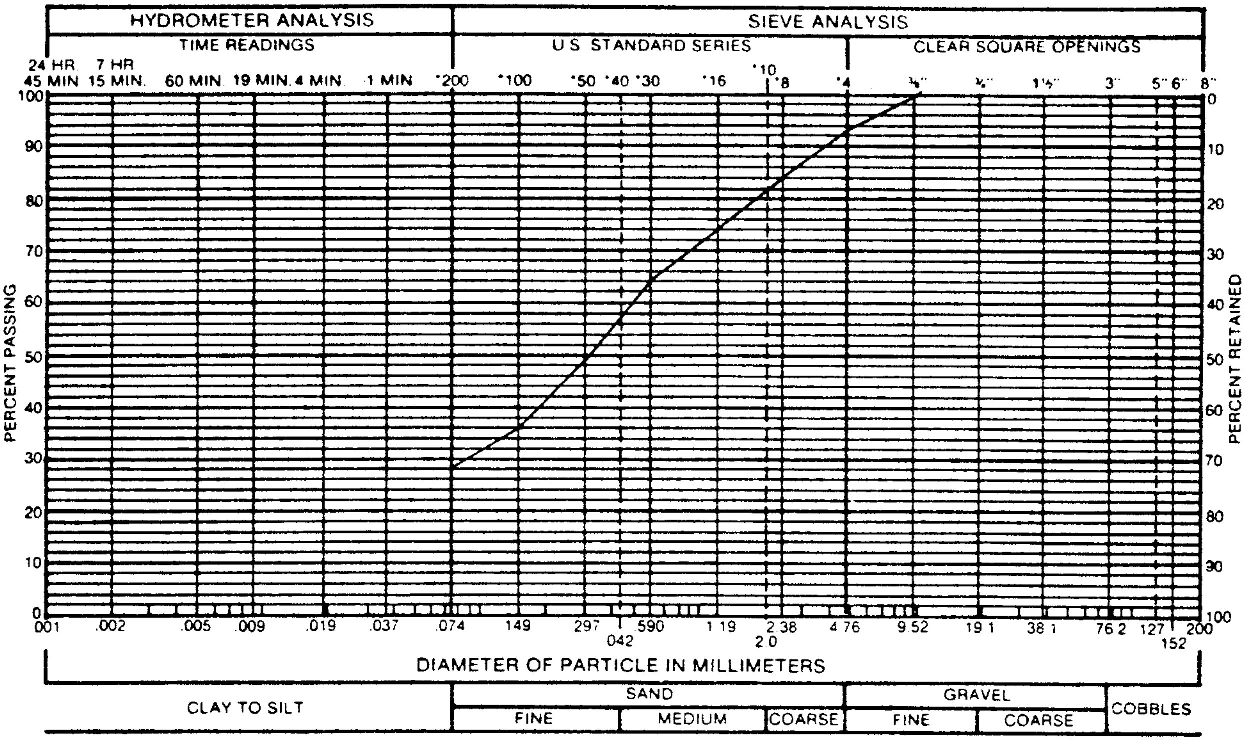
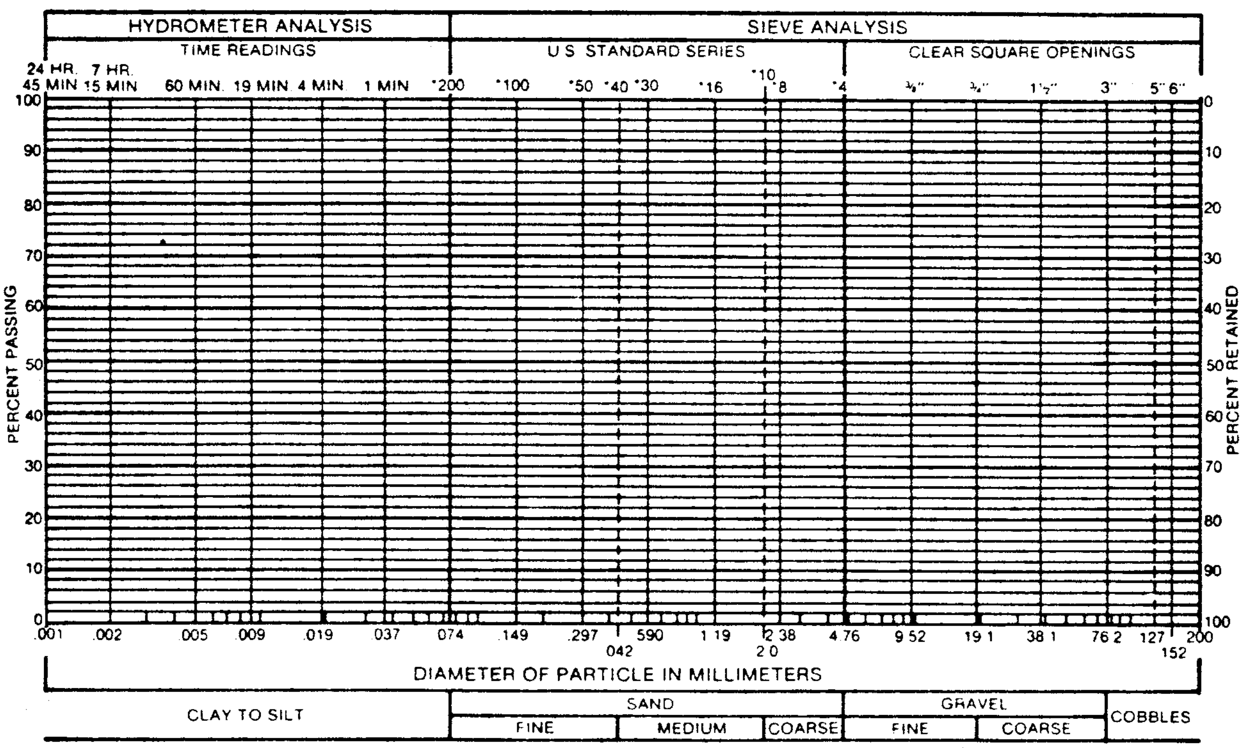


GRAVEL 7 % SAND 65 % SILT AND CLAY 28 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Fill FROM B-1 @ 5.0'



GRAVEL % SAND % SILT AND CLAY %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM

#527484 GRADATION TEST RESULTS Fig. 8

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	PERMEABILITY (cm/sec)	SOIL OR BEDROCK TYPE
HOLE	DEPTH (FEET)			GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
1	5.0	9.8	95.6	7	65	28		NP		2×10^{-4}	Fill, Carbonaceous Material
	15.0	25.3							4,370		Fill, Carbonaceous Material
	20.0	12.1	103.3						1,400		Sandy Clay
2	10.0	7.9	96.9			70	31	15	6,920		Sandy Clay
3	5.0	9.2	119.8						4,200		Sandy Clay
	15.0	10.0	102.4			50		NP			Sand and Silt
4	20.0	10.0	117.2						22,900		Clay
	30.0										Clay
5	5.0	6.2	112.1			30		NP	790		Silty Sand & Gravel
	10.0	17.9*	109.1			89				6×10^{-7}	Sandy Clay
6	4.0-9.0	+14.0	+108.3			79	26	13		3×10^{-7}	Sandy Clay
	5.0	14.8	115.2			74			4,100		Sandy Clay
	15.0	17.4	113.3				35	20	6,710		Sandy Clay
7	5.0										Sandy Clay

* Moisture content after permeability testing.
+ Remolded moisture and density

APPENDIX G

Methodology- Runoff Control

The runoff volume resulting from a particular rainfall depth was determined using the runoff curve number technique, as defined by the U.S. Soil Conservation Service (1972). According to the curve number methodology, the algebraic and hydrologic relationship between storm rainfall, soil moisture storage, and runoff can be expressed by the equations

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

and

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

where Q is the direct runoff volume, in inches, P is the storm rainfall depth, in inches; S is a watershed storage factor, in inches, defined as the maximum possible difference between P and Q; and CN is a dimensionless expression of S referred to as the curve number.

Equation 1 is based upon the assumption that $I_a = 0.2S$, where I_a is the initial abstraction from storm rainfall, defined as the rainfall which must fall before runoff begins (i.e. to satisfy interception, evaporation, and soil-water storage). Therefore, determination of runoff from Equation 1 is valid only when $P \geq I_a$ or $P \geq 0.2S$. Below this point, no runoff can occur.

Estimates of the peak discharge to be expected from various rainfall events were made using the dimensionless unit hydrograph procedure developed by the U.S. Soil Conservation Service (1972). Figure A-1 shows a runoff hydrograph and the associated terminology. In the upper portion of this figure, a hyetograph of a single block of rainfall excess with duration D is shown. The lower portion of the figure contains the resultant runoff hydrograph. For runoff from excess rainfall, the area under the hydrograph curve and the area enclosed by the rainfall hyetograph represent the same volume of water (Q). The peak flow rate for the hydrograph is represented by q_p, while T_p represents the time to peak, which is defined as the flow from the start of the hydrograph to q_p. The base time (T_b) is the duration of the hydrograph. The time from the center of mass of rainfall excess to the peak of the runoff hydrograph is the lag time (T_L).

The time of concentration (T_c), (not shown on Figure A-1) is defined as the time for flow from the hydraulically most remote point in a basin to reach the basin outlet.

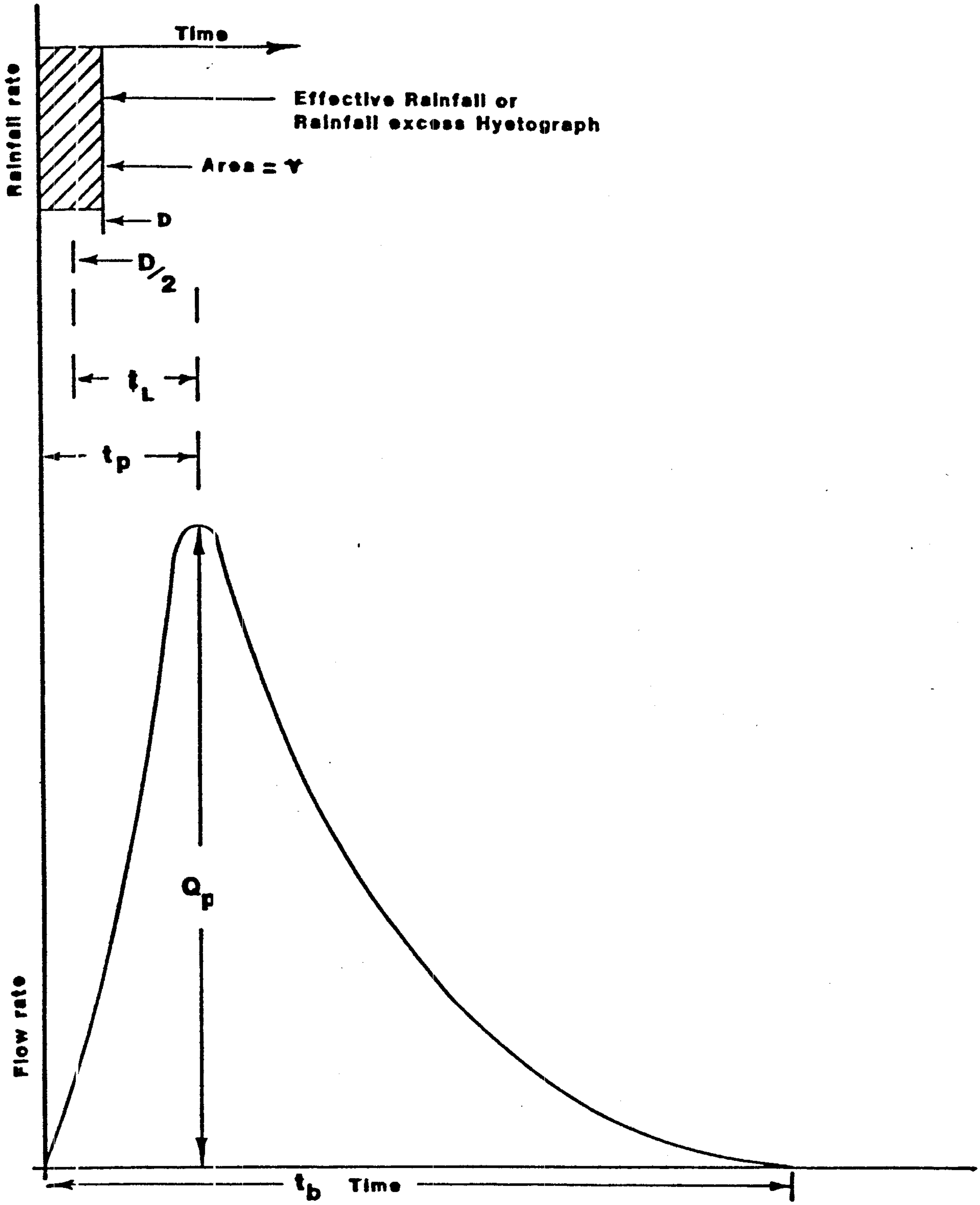


FIGURE A-1. UNIT HYDROGRAPH TERMINOLOGY.

Time to peak, T_p, is assumed to be a function of watershed lag (T_L) which is determined according to the equation

$$T_L = \frac{l^{0.8} \ (S+1)^{0.7}}{1900\sqrt{Y}} \qquad (3)$$

where T_L is the watershed lag, in hours; l is the hydraulic length, or the length of the mainstream to the farthest divide, in feet; S is as previously defined; and Y is the average watershed slope, in percent. Values of Y were obtained by using methods outlined by Craig and Rankl (1977). The hydraulic length was taken from an appropriate topographic map while S was determined from Equation 2 once the runoff curve number was estimated.

According to the U.S. Soil Conservation Service (1972), the watershed lag is equal to 0.6 T_c and the time of concentration (T_c) is equal to 1.5 T_p. Combining these two expressions it can be seen that

$$T_p = 1.11 \ T_L \qquad (4)$$

where both variables are as previously defined.

The peak discharge constant used in the dimensionless unit hydrograph method is determined according to the equation

$$q_p = \frac{484 \ AQ}{T_p} \qquad (5)$$

where q_p is the peak discharge constant, in cfs; A is the drainage area, in square miles; Q is the runoff volume, in inches (as determined by Equation 1); 484 is a conversion factor, and T_p is the time lapsed from the beginning of runoff to the hydrograph peak, in hours.

Dimensionless unit hydrographs are developed by simulating many natural unit hydrographs using the time to peak and the peak discharge constant. Haan (1970) proposed a dimensionless unit hydrograph based on the gamma function

$$\frac{q(t)}{q_p} = \left[\frac{t}{T_p} e^{(-t/Tp)}\right]^{(C_3 T_p)} \qquad (6)$$

where q(t) is the hydrograph ordinate at time t in cfs, the parameters q_p and T_p are as previously defined, and C_3 is a parameter defined by the equation

$$Q = q_p \; T_p \left[\frac{e}{C_3 T_p}\right]^{C_3 T_p} \Gamma(C_3 T_p) \qquad (7)$$

where Q is the runoff volume in inches (one inch for a unit hydrograph) and Γ is the gamma function.

Figure A-2 shows how shape of the hydrograph defined by Equation 6 changes as C_3T_p changes. The higher the value of C_3T_p, the sharper the peak of the hydrograph.

The dimensionless unit hydrograph method involves the development of a runoff hydrograph from a complex rainstorm. The storm is divided into blocks of duration D. Values of D must be less than or equal to T_p. Practically, the selection of D as a multiple of T_p will ensure that the peak will be encountered. The rainfall distribution for the 24-hour storm is generated from the theoretical NOAA Type II storm distribution shown in Figure A-3.

Rainfall excess is generated from the rainfall depths of duration D, and the rainfall excess from each time increment of duration D is then multiplied by the unit hydrograph ordinates to produce a component hydrograph. Each of the component hydrographs are then lagged by a time increment D and are concurrently summed to produce the synthetic runoff hydrograph.

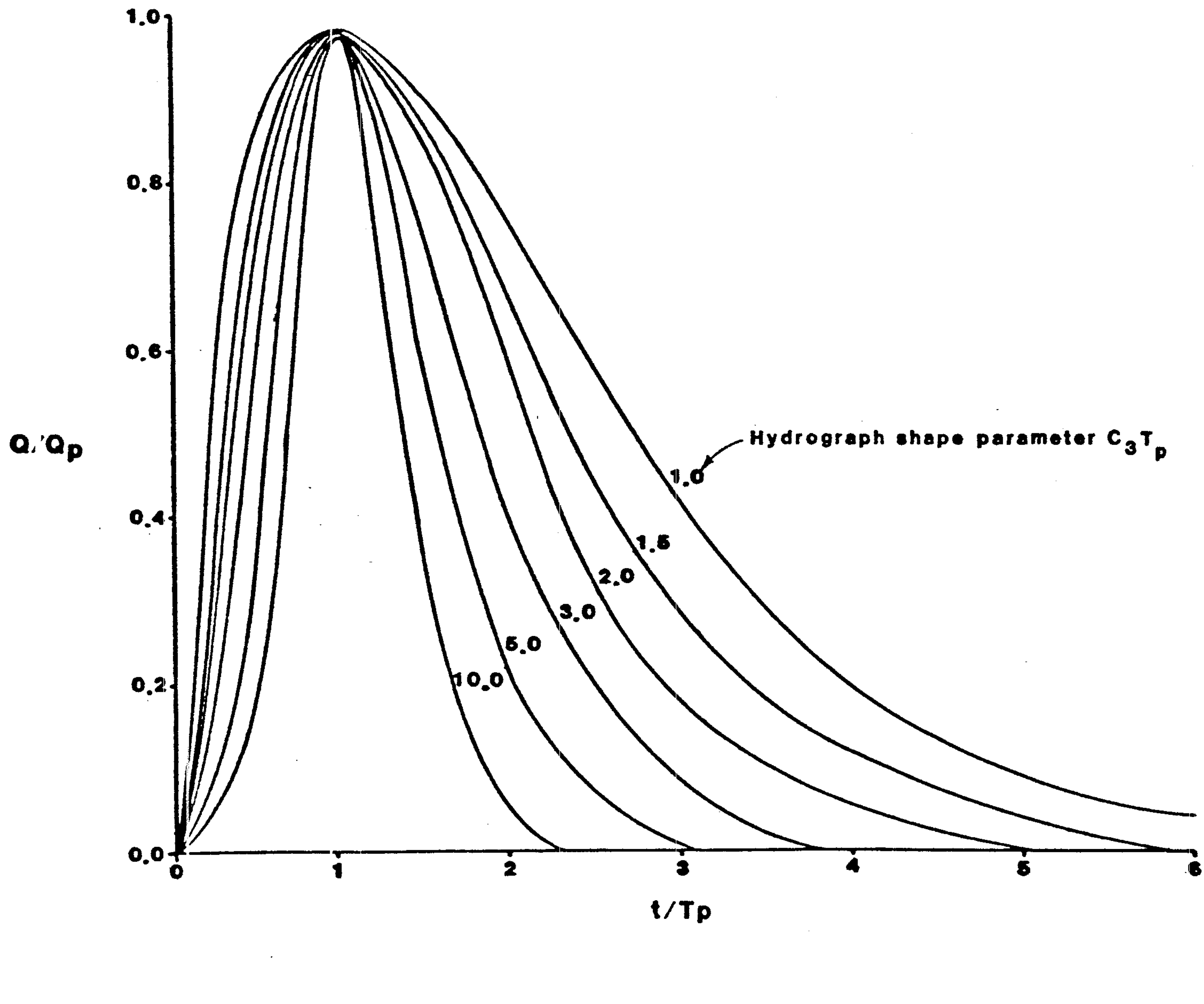


FIGURE A-2 VARIATION IN HYDROGRAPH SHAPE WITH VARIATION IN C_3T_p (TAKEN FROM HAAN, 1970).

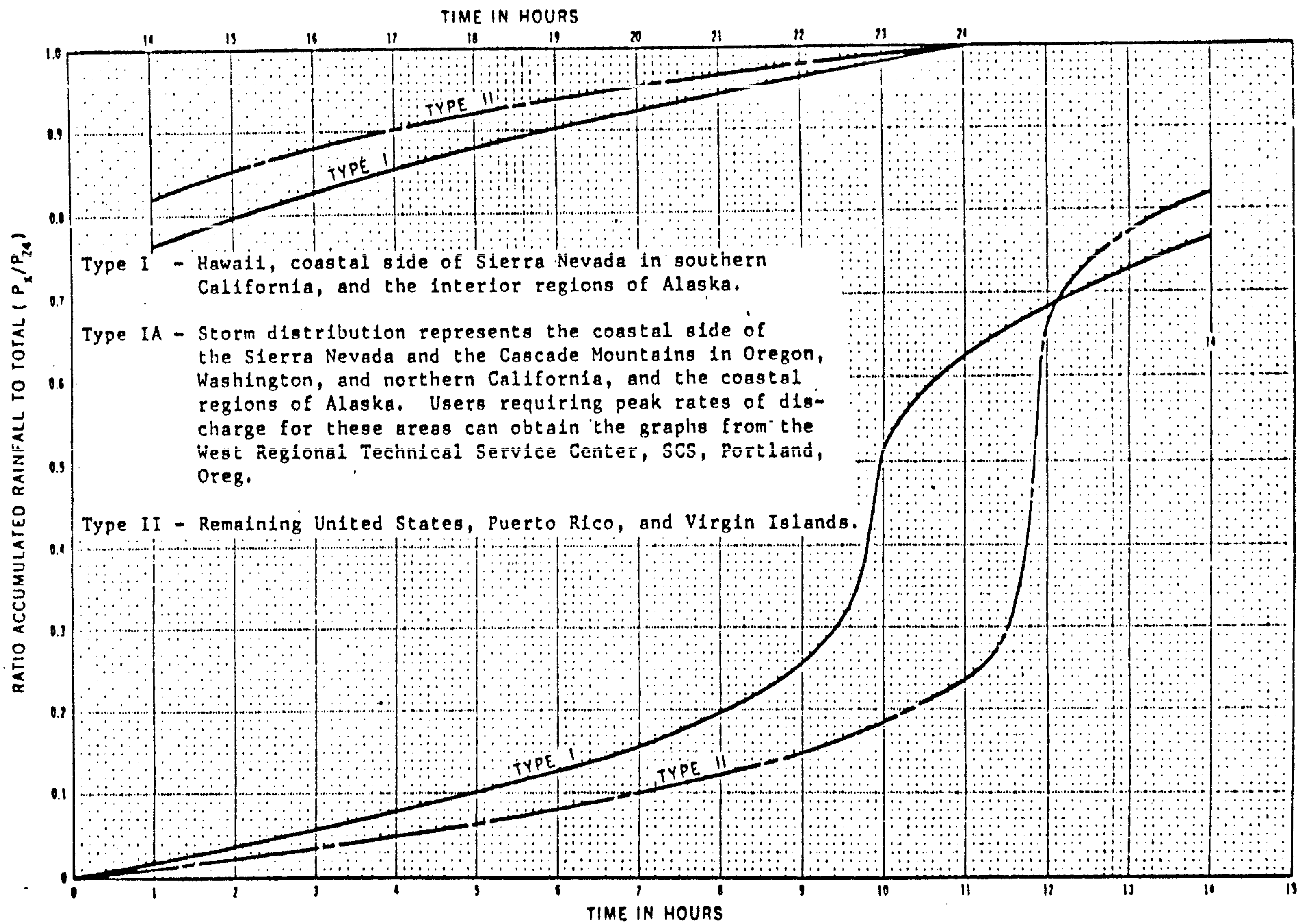


FIGURE TWENTY-FOUR-HOUR RAINFALL DISTRIBUTIONS (FROM KENT, 1973).

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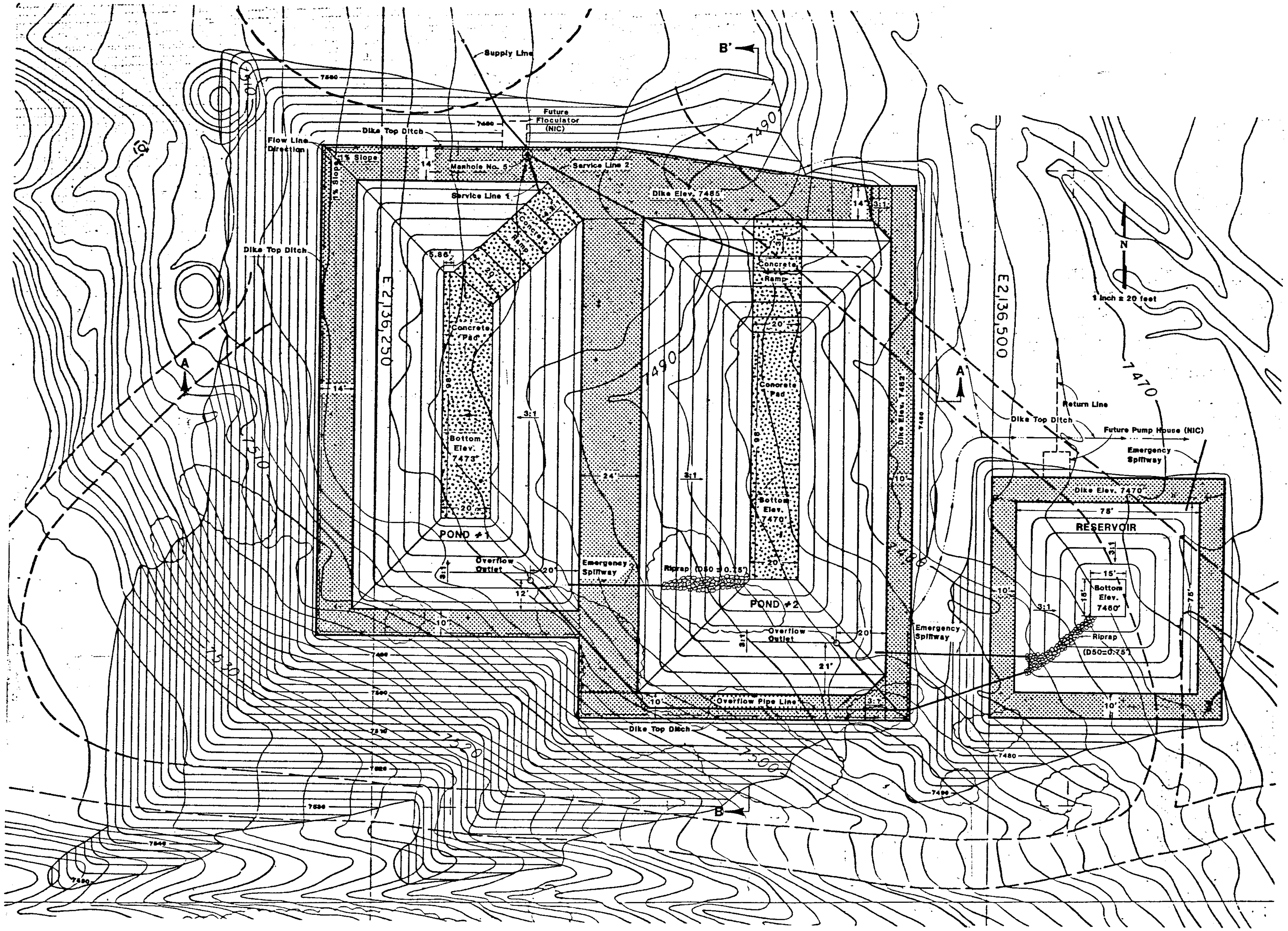
CONSULTANTS / ENGINEERS
VAUGHN HANSEN ASSOCIATES
INCORPORATED
SALT LAKE CITY, UTAH

Registered Professional Engineer
MARVIN E. ALLEN
#6292
State of Utah

PLATEAU MINING COMPANY
P.O. DRAWER PMC PRICE, UTAH 84501
PHONE (801) 637 - 2875

TITLE THICKENER UNDERFLOW TREATMENT PONDS SITE PLAN

REVISIONS BY	DATE	ENGINEERING BY	APPROVED BY	DATE
		REVIEWED BY		
		DRAWN BY		
		SCALE 1 inch = 50 feet	Drawing 1 of 8	



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CONSULTANTS/ENGINEERS
VAUGHN HANSEN ASSOCIATES
INCORPORATED
SALT LAKE CITY, UTAH

Registered Professional Engineer
MARVIN E. ALLEN
#6292
State of Utah

PLATEAU MINING COMPANY
P.O. DRAWER PMC PRICE, UTAH 84501
PHONE (801) 637 - 2875

TITLE THICKENER UNDERFLOW TREATMENT PONDS

PLAN

REVISIONS BY	DATE		APPROVED BY	DATE
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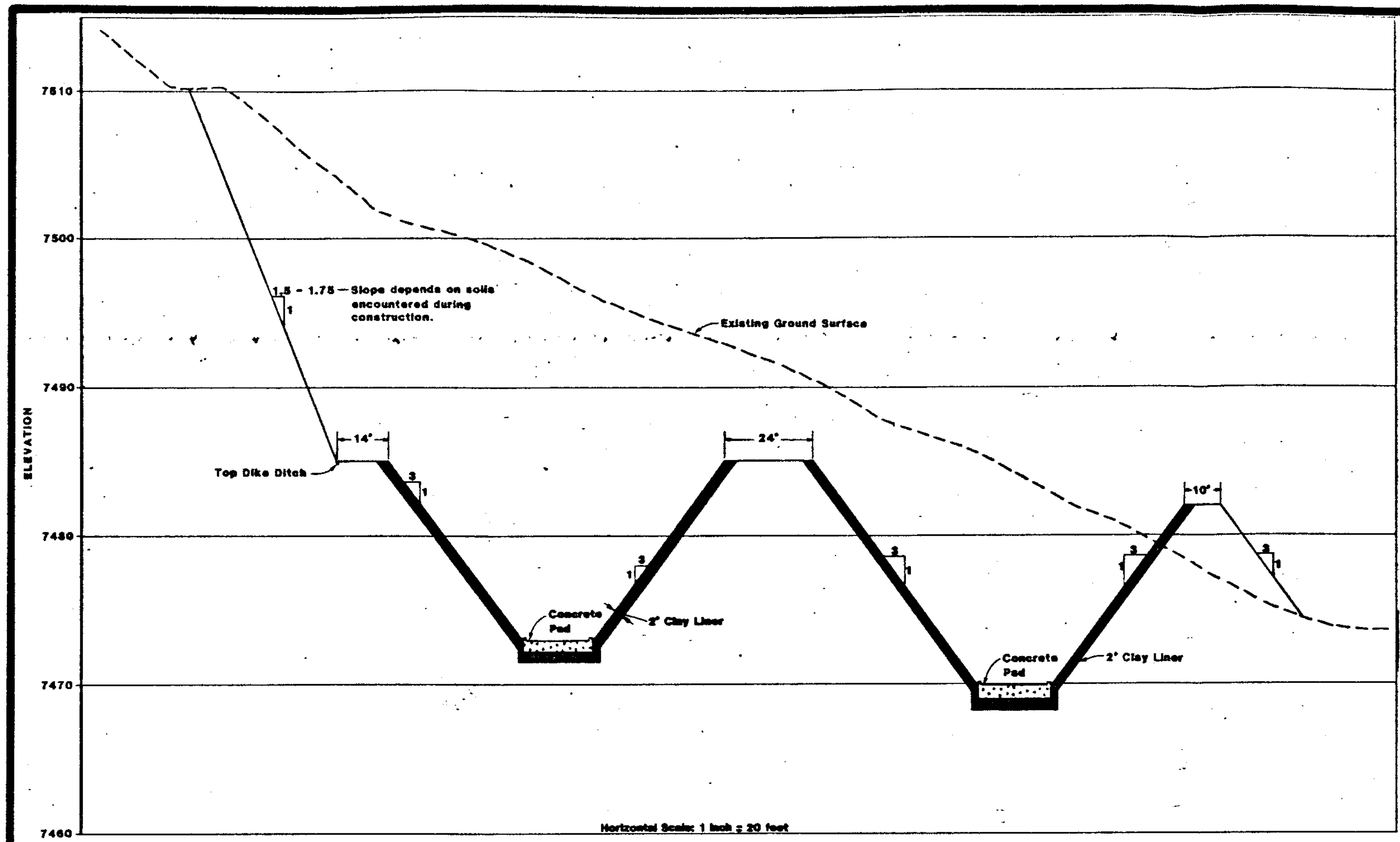
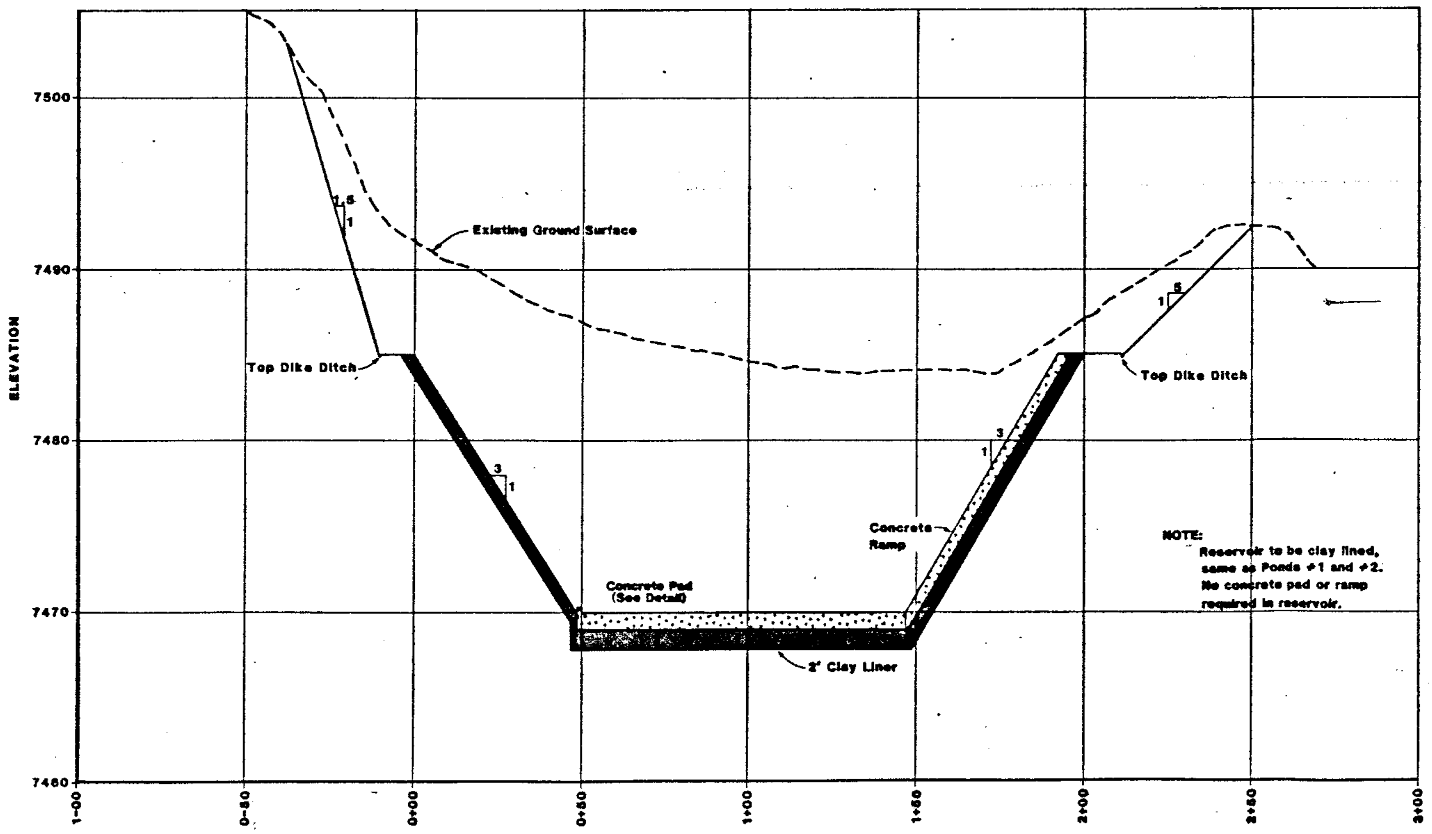
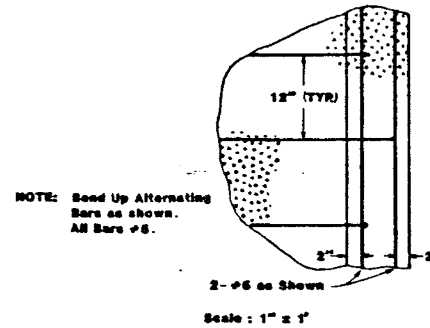
		REVIEWED BY		
		DRAWN BY		
		SCALE	Drawing 2 of 8	



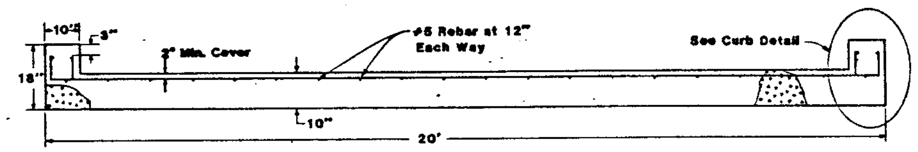
Section A - A'
(See Drawing 2 of 8)



Section B - B'
(See Drawing 2 of 8)



Curb Detail



Concrete Pad /Ramp Section

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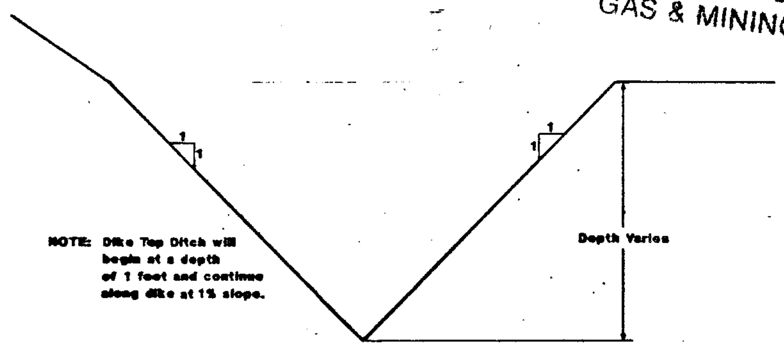

Dike Top Ditch Typical
No Scale

PRELIMINARY

APPROXIMATELY 1/2 SCALE

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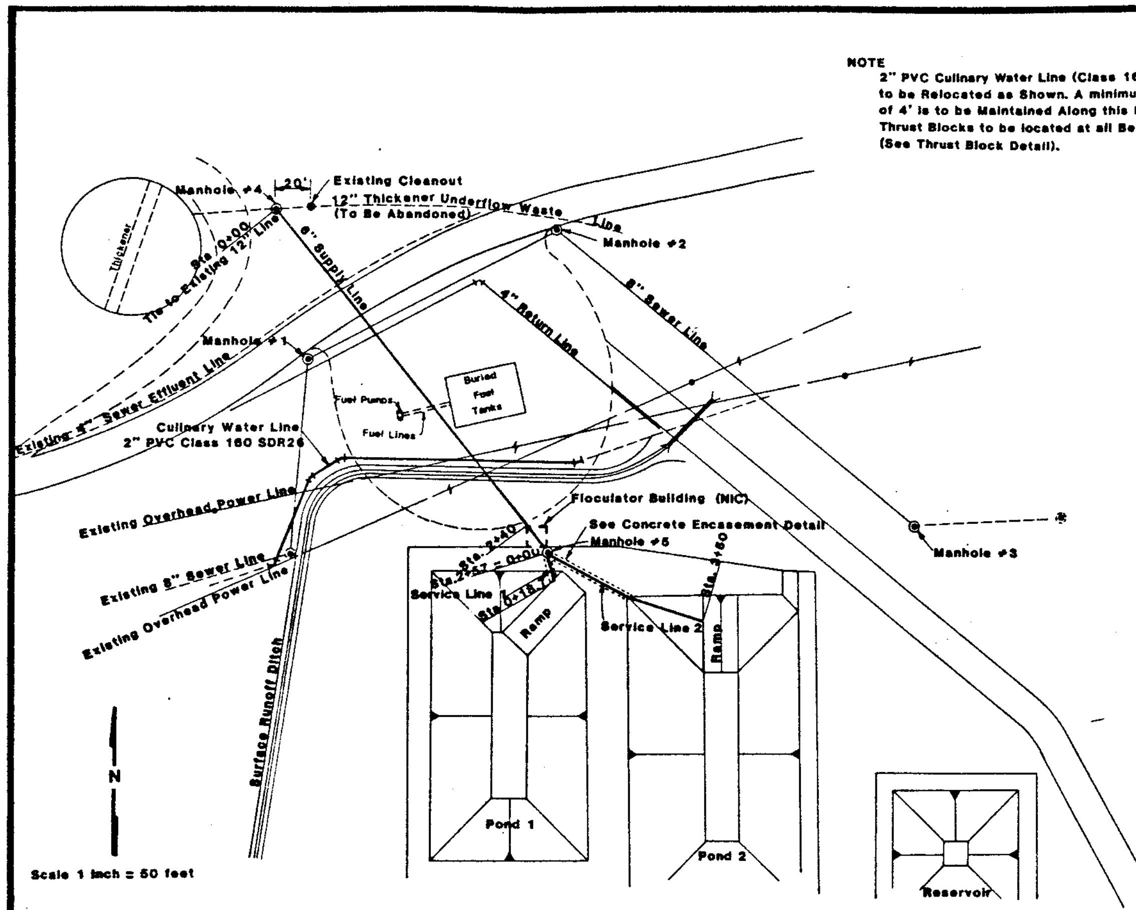
VAUGHN HANSEN ASSOCIATES
INCORPORATED
SALT LAKE CITY, UTAH

Registered Professional Engineer — MARVIN E. ALLEN #6292 — State of Utah

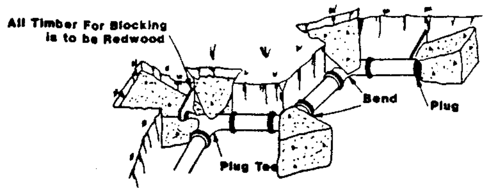
PLATEAU MINING COMPANY
P.O. DRAWER PMC PRICE, UTAH 84501
PHONE (801) 637 - 2875

TITLE
THICKENER UNDERFLOW TREATMENT PONDS
TREATMENT POND CROSS-SECTIONS AND DETAILS

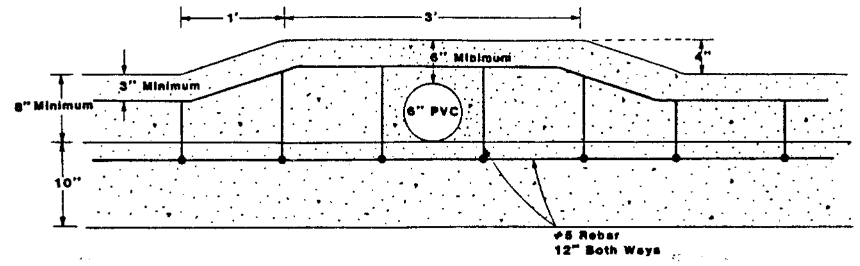
REVISIONS BY	DATE		APPROVED BY	DATE
		ENGINEERING BY		
		REVIEWED BY		
		DRAWN BY		
		SCALE	Drawing 3 of 8	



NOTE
Concrete shall not be placed around joints and bolts.



THRUST BLOCK DETAIL
No Scale



SECTION A - A'
No Scale

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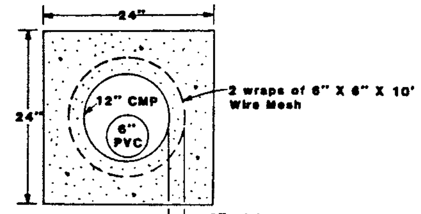
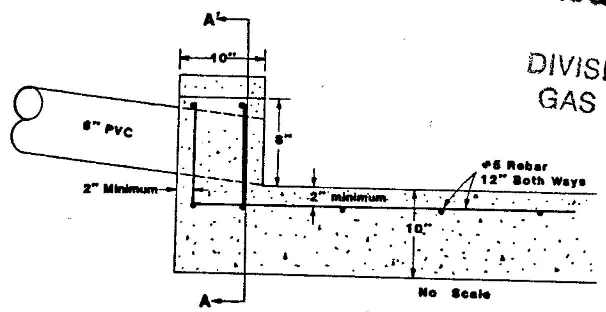
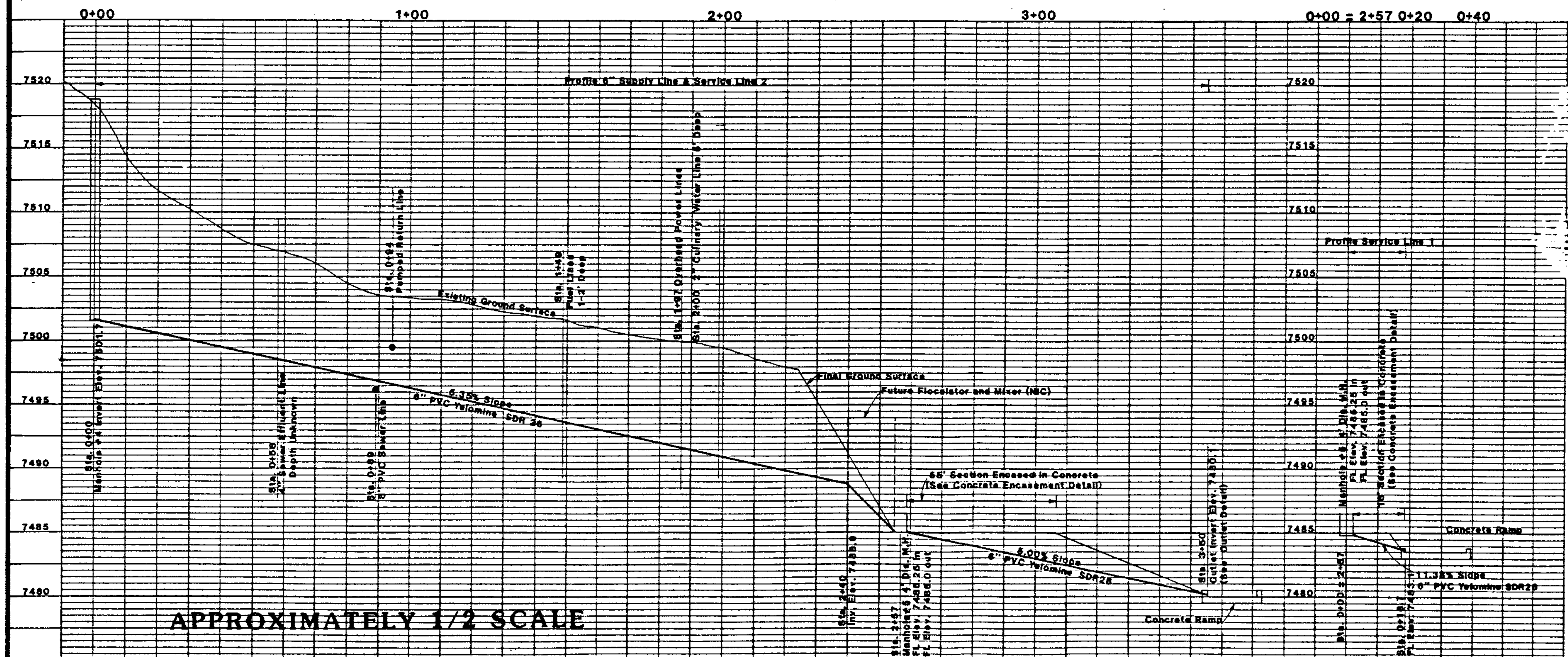
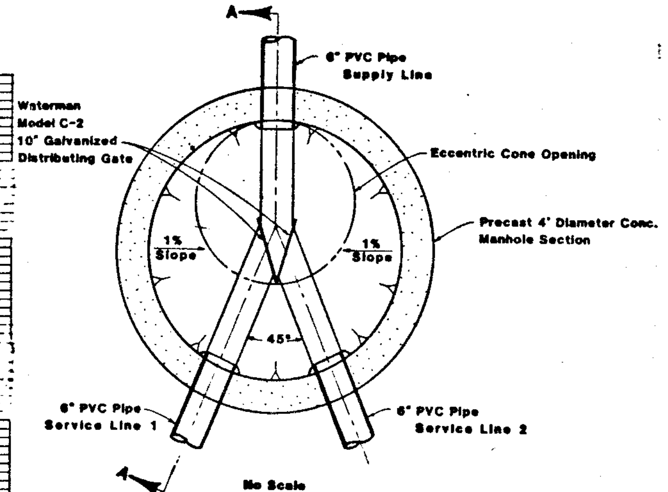


CONCRETE ENCASEMENT DETAIL
No Scale

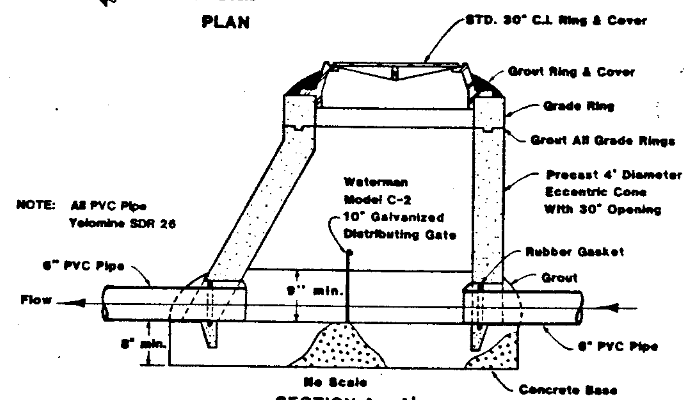


No Scale
OUTLET DETAIL





No Scale
PLAN



No Scale
SECTION A - A'
MANHOLE NO. 5 DETAIL

DATE	DRAWN BY	REVISIONS	DESCRIPTION	APPD

PRELIMINARY

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VAUGHN HANSEN ASSOCIATES
INCORPORATED
SALT LAKE CITY UTAH

Registered Professional Engineer MARTIN E. ALLEN #6292 State of Utah

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TITLE THICKENER UNDERFLOW TREATMENT PONDS SUPPLY LINE PLAN, PROFILE, AND DETAILS

SCALE

Drawing 4 of 8

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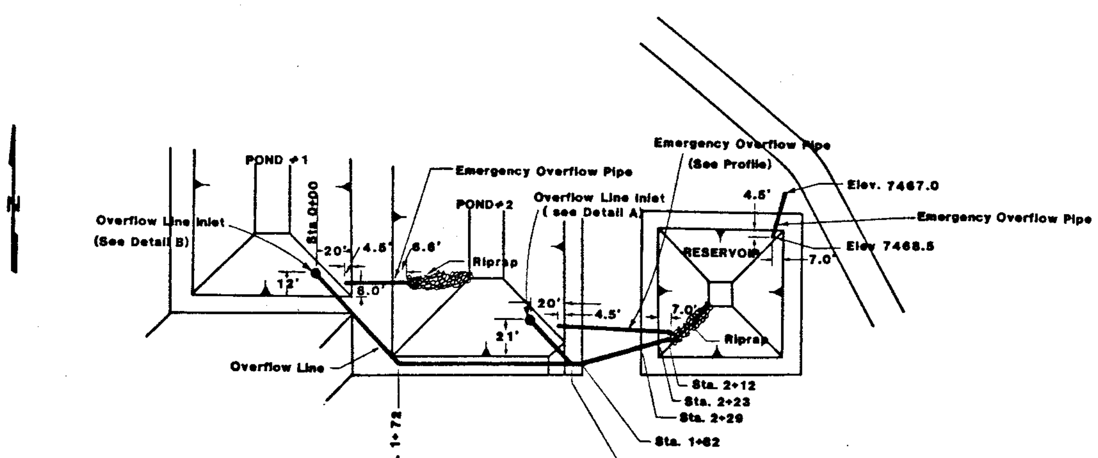
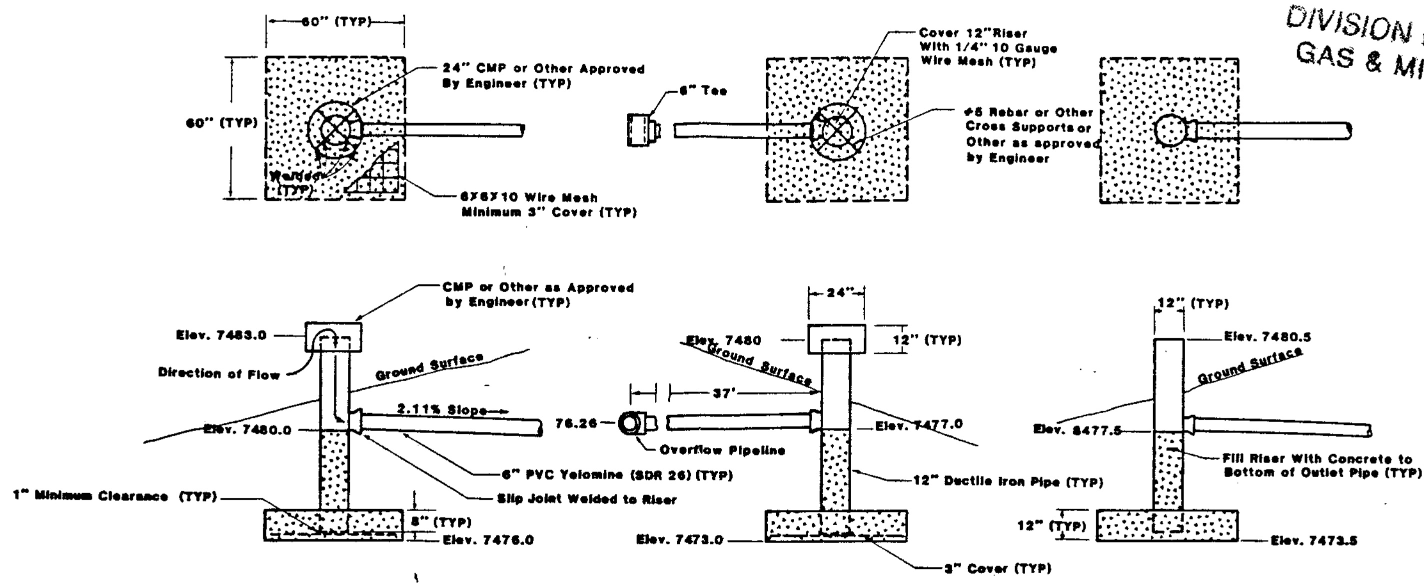


Scale 1" = 50'

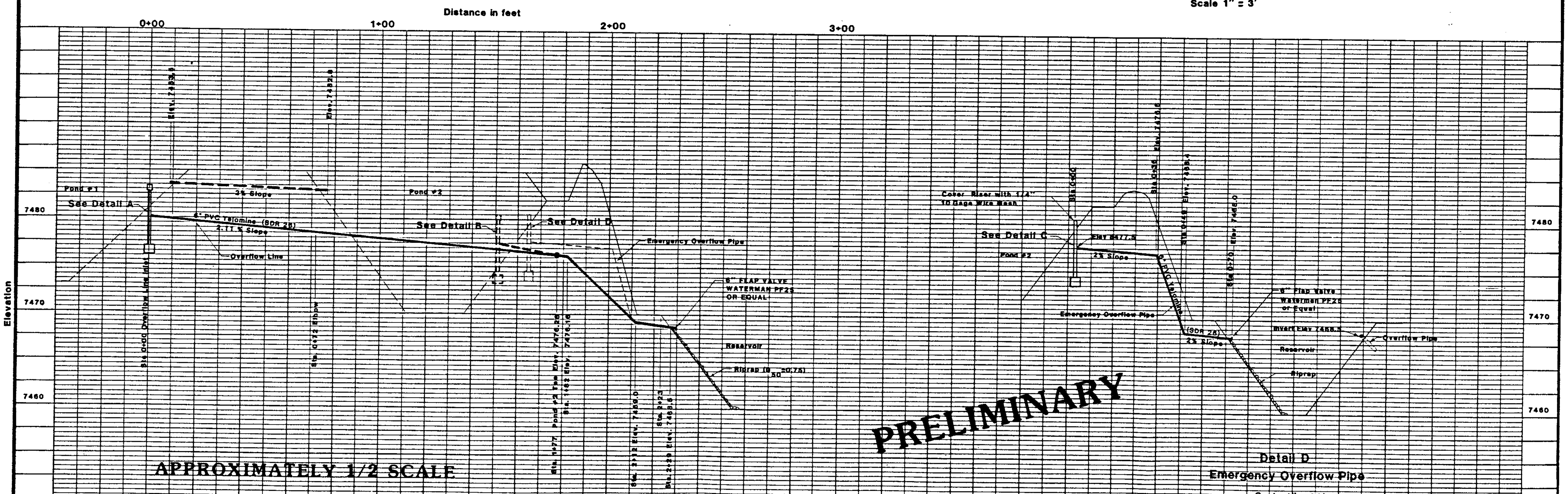


Detail A
Overflow Line Inlet

Detail B
Overflow Line Inlet

Detail C
Emergency Overflow Pipe Inlet

Scale 1" = 3'



Detail D
Emergency Overflow Pipe

Scale 1" = 20'

DATE	DRAWN BY	REVISIONS	DESCRIPTION	APPD

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MARVIN E. ALLEN
#6292
State of Utah

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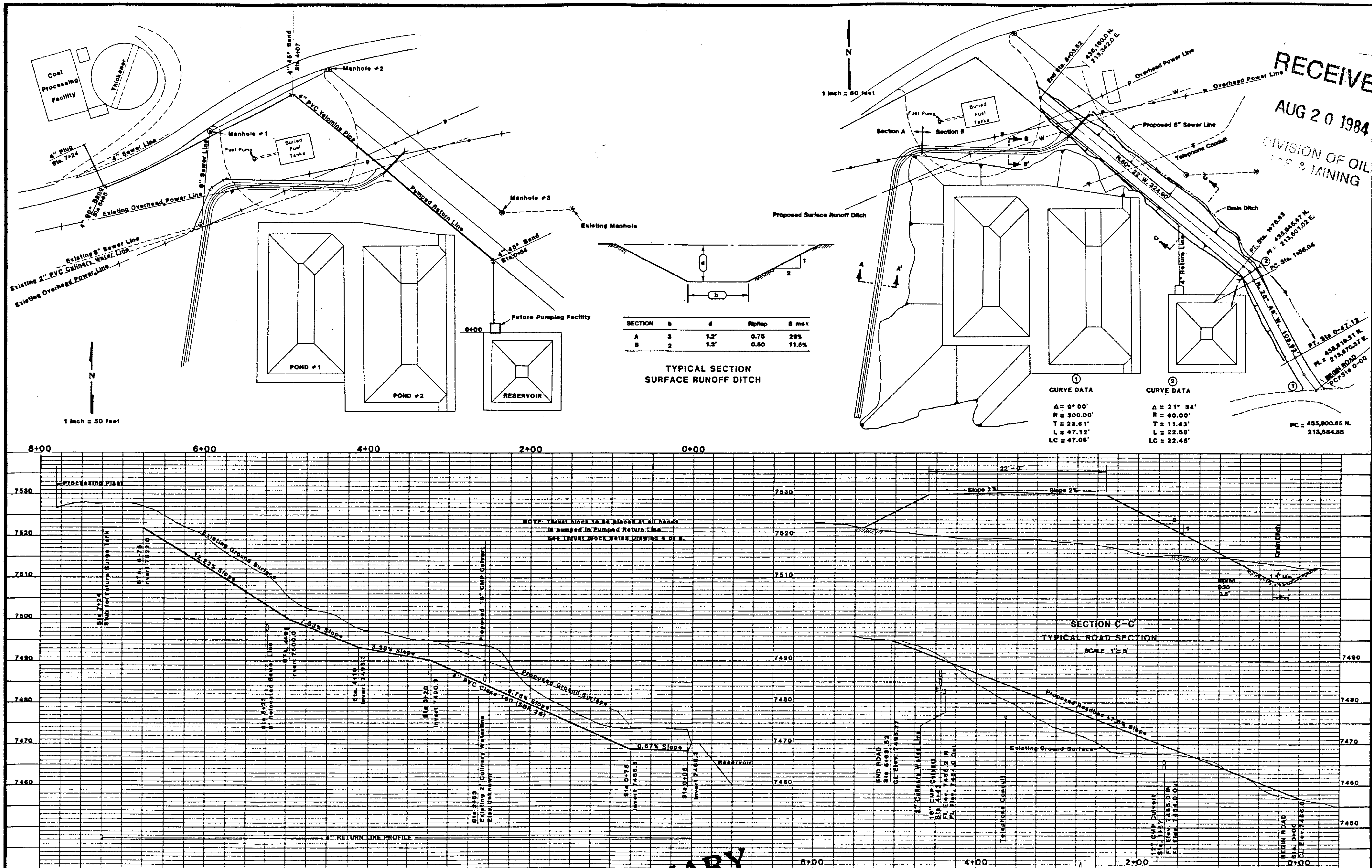
TITLE
THICKENER UNDERFLOW TREATMENT PONDS
OVERFLOW PLAN, PROFILE, AND DETAILS

SCALE
Drawing 5 of 8



TYPICAL SECTION
SURFACE RUNOFF DITCH

SECTION	b	d	RipRap	S max
A	3	1.2'	0.75	29%
B	2	1.3'	0.50	11.5%

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PRELIMINARY
APPROXIMATELY 1/2 SCALE

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#6292
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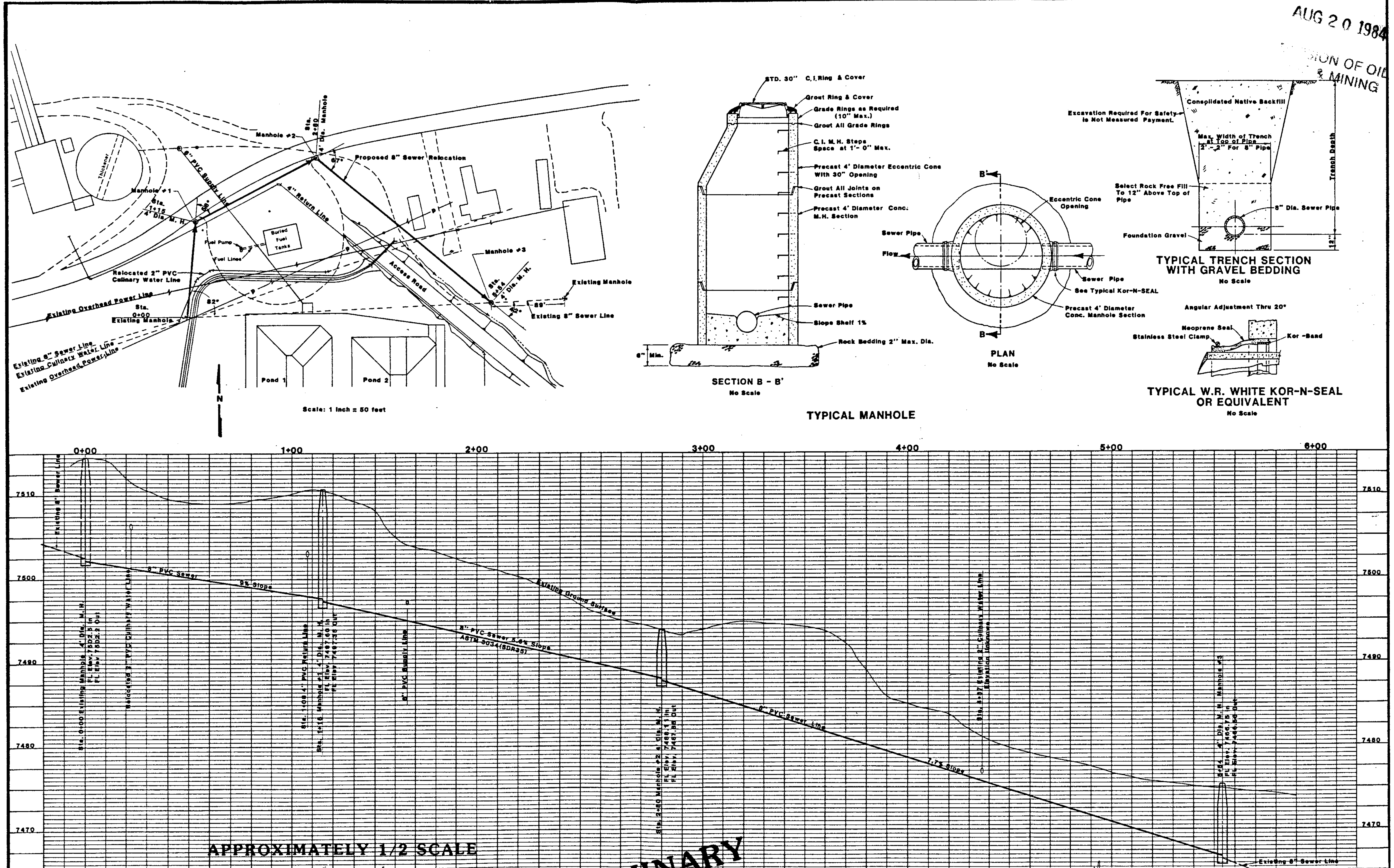
TITLE
THICKENER UNDERFLOW TREATMENT PONDS
RETURN LINE AND ROAD PLAN AND
PROFILE RUNOFF DITCH DETAILS

SCALE

Drawing 6 of 8



DATE	DRAWN BY	REVISIONS	DESCRIPTION	APP'D

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TITLE: THICKENER UNDERFLOW TREATMENT PONDS SEWER LINE RELOCATION PLAN PROFILE AND DETAILS

SCALE

Drawing 7 of 8

Sheet 8 of 8

PUMPING FACILITIES DETAIL

To be Provided

Note: Pumping facility to be constructed
in construction year 1985 if required.