SUPPLEMENTARY STUDY ON EMBANKMENT SLOPE STABILITY FOR SEDIMENTATION PONDS NO. 1, 3 and 5 STAR POINT MINE, CARBON COUNTY, UTAH

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS

4/30/82

Plateau Mine

Meeting Concerning UDOGM Stipulation #7
- Impoundments 1, 3, 5

Name	Affiliation
Jeff Saunders	Getty Mining Co. (CYCC)
Ben Grimes	PMC
Bill Snyder	PMC
Steve Rigby	"
George Young	Getty Mining (SLC)
D. Wayne Hedberg	DOGM (Reclam. Hydro.)
Bob Bamburg	OSM - Denver
David Darby	DOGM (Reclaimation Hydrologist)
Ken Lawyer	OSM Denver, Co
Sally Kefer	DOGM (SLC)
Floyd Tucker	PMC G manager

state of utah

DIVISION OF WILDLIFE RESOURCES

DOUGLAS F. DAY
Director

EQUAL OPPORTUNITY EMPLOYER

1596 West North Temple/Salt Lake City, Utah 84116/801-533-9333

January 25, 1982

Reply To SOUTHEASTERN REGIONAL OFFICE
455 West Railroad Avenue, Box 840, Price, Utah 84501
(801) 637-3310

RECEIVED
JAN 28 1982
PMC
FLOYD J. TUCKER

Mr. Floyd Tucker, General Manager
Plateau Mining Company
P.O. Drawer PMC
Price, Utah 84501

Attention: Mel Coonrod

Dear Floyd:

As per Plateau's request the Division has evaluated potential impacts on wildlife that could result from reconstruction of sediment ponds No. 1, 3 and 5 at locations other than where they now exist. The effluent leaving any of these ponds would have to flow in at least 9 miles of dry washes before it would reach Miller Creek which is a perennial stream. Miller Creek supports nongame fishes; segments of the stream are dewatered during the irrigation season through a series of diversions that serve the Miller Creek agricultural area. The return flow from irrigated areas recharges the stream channel.

The Division's concern is that adequate sediment pond capabilities be maintained by Plateau to keep industrial pollutants from reaching Miller Creek. If the now existing ponds are functional this need is considered to be satisfied. Redevelopment of the ponds at near-by locations would represent additional and unnecessary impacts from Plateau's mine or terrestrial habitats.

As you know there are unavoidable impacts on our wildlife resource associated with coal mining. Maintenance and continued use of the existing ponds will result in avoidance of unnecessary impacts on wildlife habitat that would result from construction of new ponds.

Floyd, the Division wants to take this opportunity to express our appreciation for your concern for the State's wildlife resources. Again thanks.

Sincerely,

John Livesay

John Livesay, Supervisor
Southeastern Region

JL:LBD:gp

cc: Darrell Nish

R&M CONSULTANTS, INC. BUSCH PARK • 5280 SOUTH 320 WEST, SUITE E-160 • MURRAY, UTAH 84107 • PHONE (801) 263-3419
ENGINEERS
GEOLOGISTS

February 24, 1982 R&M No. 261001

Plateau Mining Co.
P.O. Box P.M.C.
Price, UT 84501

Attn: Mr. Mel Coonrod

Gentlemen:

SUBJECT: Supplementary Embankment Slope Stability Study, Sedimentation Ponds No. 1, 3 & 5, Star Point Mine

Included herewith for your use are three copies of the report for the supplementary embankment slope stability study for the subject project as required by DOGM/OSM. This report was prepared in accordance with a purchase order authorized by Plateau Mining Co. on January 22, 1982.

We appreciate the opportunity of providing this geotechnical service to you on this project and will be glad to answer any questions you may have concerning this report.

Sincerely,

Larry Migliaccio, P.E.
Director

REGISTERED PROFESSIONAL ENGINEER
LARRY MIGLIACCIO
3595
STATE OF UTAH

CW

SUPPLEMENTARY STUDY ON
EMBANKMENT SLOPE STABILITY
FOR
SEDIMENTATION PONDS NO. 1, 3 and 5
STAR POINT MINE, CARBON COUNTY, UTAH

Prepared for

PLATEAU MINING CO.
Carbon County, Utah

By

R&M Consultants, Inc.
Salt Lake City, Utah

Proj. No. 261001

February, 1982

I. INTRODUCTION

This report presents our supplemental findings on the stability of the existing Sedimentation Ponds Nos. 1, 3 and 5 at Star Point Mines in Carbon County, Utah. The purpose of our analysis is to outline reasons for a grant of variance from the State of Utah's Division of Oil, Gas and Mining (DOGM) and the Federal Office of Surface Mining (OSM). This additional study was required by DOGM per its letter, dated January 28, 1982, from Mr. D.W. Hedberg of DOGM to Mr. F.J. Tucker of Plateau Mining Company (PMC). A stability analysis on each of the embankments of the above sedimentation ponds was previously accomplished by R&M with the results presented in a report entitled "Embankment Slope Stability Study for Sedimentation Ponds No. 1, 3 and 5, Plateau Mining Co., Wattis, Utah," dated November, 1981, and will be referred to hereinafter as the "previous report."

The additional study regarding the stability of these sedimentation ponds includes: 1) an evaluation of the results of the stability analysis presented in the previous report regarding total versus partial embankment failures; 2) alternatives to improve the safety factors of the sedimentation pond embankments against slope failure; and 3) probability analysis for specific seismic events related to the factors of safety of the pond embankments against slope failure.

II. TOTAL EMBANKMENT FAILURES

A further evaluation of the critical failure surfaces associated with the minimum factors of safety against slope failure for the embankment of Pond No. 1 presented in Table 1 of the previous report shows that these failure surfaces appear to be surficial and localized with little possibility of causing a total embankment failure. The potential failure surfaces most likely to bring about a total embankment failure would be deep-seated and are delineated on plots generated by the STABL2 Computer Program used for performing the slope stability analysis as shown in Figs. 1 through 4.

For each case, based on the number of failure surfaces specified to be analyzed, the STABL2 analysis computes and prints out the ten lowest factors of safety. The corresponding failure surfaces of these factors of safety are then plotted on computer printout as loci represented by digits 1 through 9 and 0, with 1 for the failure surface of the lowest factor of safety, up to 9 for the 9th lowest factor of safety, and 0 of the 10th lowest factor of safety. The factors of safety against total embankment failure for the sedimentation pond embankments are tabulated as follows:

		Pond No. 1	Pond No. 3	Pond No. 5
Full Pool	static	1.240	1.238	1.356
	w/seismic*	1.071	1.042	1.140
Rapid Drawdown	static	1.240	1.238	1.429
	w/seismic*	1.071	1.042	1.210
Dry Pool	static	1.240	1.238	1.577
	w/seismic*	1.071	1.042	1.294

*Based on a horizontal acceleration of 0.1g (Seismic Zone 2 of Uniform Building Code, 1979 Edition).

Note that the factors of safety for Ponds No. 3 and 5 are the same as those presented in the previous report, since their corresponding failure surfaces represent possible total embankment failure.

III. ALTERNATIVES FOR STABILITY IMPROVEMENT

Several alternatives have been studied to improve the factors of safety of the pond embankments against slope failure. These alternatives are discussed as follows:

A. Installing Impervious Liner

Seepage of the impounded water into the embankments may be substantially reduced or completely cut off by lining the ponds with a layer of compacted clay liner or with an impervious membrane, such as Hypalon. This would normally mitigate saturation of the embankment soil mass and reduce the possibility of pore water pressure build-up, and thus enhance stability of the pond embankments. However, since all three ponds are located on relatively steep hillsides with good drainage and the embankments are built primarily with granular soils, gravels and stones with good drainage characteristics, it is judged that complete saturation of the embankment soil masses would be very unlikely under any circumstances. Furthermore, after service for some time, the ponds would be partially lined with the sediment comprised fine soil particles and mine waste which would essentially act as the compacted clay or membrane liner discussed above, and thus impede the build-up of the pore water pressure.

Based on the above, we conclude that there would be little benefit gained in improving the stability of the pond embankments by installing impervious liner on the ponds.

B. Installing Piles

The stability of the pond embankments may also be increased by installing piles in the embankment soil mass on the downstream slopes. This would force the potential failure surfaces to cut below the tips of piles, and thus increase the factors of safety against slope failure.

A single row of piles installed along the crest of the pond embankment may not be very effective in improving the stability of the embankment since the piles can hardly intercept the full original critical failure surfaces, such as those shown on Figs. 1 through 4. Instead, multi-rows of piles, installed at suitable spacings and with pile tips extending beyond the original critical failure surfaces, in the downstream slopes of pond embankments are required to provide the desired resistance against slope failure.

The slopes of the downstream faces of the pond embankments are all very close to 1.4H:1V, which is excessively steep for pile installing operations. Furthermore, there are large blocks of rock in the pond embankments, such as those encountered during subsurface exploratory drilling on the embankment crests, which would make pile installation, whether by driving or drilling, very difficult. If the piles are to be installed by driving, the vibration due to pile driving could have adverse effects on the stability of the embankments, which would be difficult to assess. It is, therefore, concluded that installing piles to improve the stability of pond embankments would be impractical and uneconomical.

C. Modifying Existing Embankment

The stability of pond embankments may be enhanced by modifying their geometric configurations. Although the downstream slopes of the pond embankments can normally be sufficiently flattened to render desired factors of safety against slope failure, it is economically prohibitive since an enormous quantity of additional compacted fill would be required due to the steep natural terrain where the ponds are located.

One of the possible alternatives to modify the existing embankments and improve their stability is shown in Fig. 5. The existing crest of the pond embankment is lowered and the downstream slope flattened by excavating the embankment soil mass shown in the shaded area. The existing pond is deepened by lowering the pond floor and cutting into the upstream hill of more competent material to maintain the required retention capacity. The material thus excavated may be used to build a berm at the toe of the new downstream slope to provide additional stability of the modified embankment. This scheme appears to be more feasible and effective than the previous alternatives and additional analysis would be necessary to determine factors of safety against sliding for the new geometry.

D. Relocating Ponds

Relocating the ponds to lower elevations with properly designed embankments would obviously be another way to improve the stability of the pond embankments. This would reduce the required heights of the pond embankments and allow the embankments to be supported on more stable foundation material, and thus would increase the factors of safety against slope failure.

This alternative would, nevertheless, allow a greater area to be subjected to environmental disturbance due to mining operation and require a larger impoundment to contain the contaminated surface runoff. Furthermore, the existing pond embankments would still need to be modified for better stability. This alternative would seem to be economically prohibitive.

It is evident from the above discussion that although some of the alternatives may be effective in improving the stability of the pond embankment, none could be achieved economically or practically.

IV. SEISMIC ANALYSIS

The calculations in our previous report for seismic conditions were performed using a horizontal acceleration of 10% of gravity according to Seismic Zone 2, Uniform Building Code, 1979 Edition. This classification is a generalization in lieu of a site specific analysis and is, in general, conservative. A specific seismicity analysis has, therefore, been performed for the Wattis, Utah area and the results are presented below.

Our specific analysis of the seismicity of the site area has been confined to those events of Richter magnitude (M_L) 3.0 or greater reported to have occurred within a 100-kilometer radius of Wattis, Utah, between the period 1853 to 1982. Seismic events with $M_L < 3.0$ are considered microearthquakes. In general, seismic events with M_L 2½-3 result in the smallest ground movements perceptible to humans.

A summary of seismic events within the 100-km radius is presented in Table I, below. All events of $M_L \geq 3.0$ occurring within the 10-km radius and between the 10 to 25-km radii of the site are presented. Only those events of $M_L \geq 3.5$ occurring between the 25 to 50-km radii and those events of $M_L \geq 4.0$ between the 50 to 100-km radii are presented, due to the negligible affect of the smallest events with increasing distance from the site.

Seismic event totals and information on specific events were obtained from the University of Utah Seismograph Stations, Salt Lake City, Utah.

TABLE 1

Historic Seismicity Within 100-km Radius of Wattis, Utah

Description	M_L	Distance From Site (km)	Date
Events w/$M_L \geq 3.0$ within 10-km radius of site	3.7	1.8*	1958
	3.0	5.2*	1958
	3.5	6.2**	1968
	3.5	7.9**	1981
Events w/$M_L \geq 3.0$ between 10 to 25-km radii of site	3.0	23**	1970
	3.1	19**	1976
Events w/$M_L \geq 3.5$ between 25 to 50-km radii of site	5.0	47*	1876
	3.7	36*	1895
	3.7	47*	1919
Events w/$M_L \geq 4.0$ between 50 to 100-km radii of site	4.3	71*	1853
	4.3	94*	1853
	5.0	94*	1915
	4.3	53*	1942
	4.3	60*	1948

TABLE I (cont.)

Description	M_L	Distance From Site (km)	Date
Events w/$M_L \geq 4.0$ between 50 to 100-km radii of site	4.3	81*	1950
	4.3	94*	1951
	4.3	96*	1953
	4.3	71*	1958
	4.3	71*	1958
	4.3	71*	1958
	5.0	96*	1958
	4.3	73*	1961
	5.0	58*	1961
	4.4	91**	1981

*accuracy within ±25-50 km; based on regional seismograph coverage and/or historical accounts.

**accuracy within ±5 km; based on statewide instrumental coverage since 1962.

A. Seismic Occurrences

A total of 90 events of $M_L \geq 3.0$ have been reported to have occurred within a 100-km radius of the site in the interval between 1853 to 1982. The largest event within this radius were four $M_L = 5.0$ events. The nearest of these events to the site was 47 km* which occurred in 1876. The most recent of these four events occurred in 1961, and was 58 km* from the site. The most recent event of $M_L \geq 3.0$ within 25 km of the site was a M_L 3.5 event, occurring in May, 1982, 7.9 km** from the site. The nearest $M_L \geq 3.0$ event of the site was 1.8 km*, occurring in 1958. Of the 90 events reported, 4½% occurred within the 10-km radius, 2% between the 10 to 25-km radii, 13.5% between the 25 to 50-km radii and 80% between the 50 to 100-km radii.

B. Estimated Maximum Horizontal Accelerations (% acceleration of gravity)

Estimated maximum horizontal ground accelerations of bedrock at the site for various size seismic events at varying distances from the site are presented in

Table II below. These data are obtained from published information. Due to the near surface and exposed bedrock at the site, amplification of seismic energy due to the presence of unconsolidated material is considered negligible. An appreciable range in estimated accelerations presented in Table II is noted. This is due mainly to the scant data base of near source accelerations for small earthquake events.

TABLE II

Estimated Maximum Horizontal Accelerations (% of gravity) in Bedrock

Magnitude	Distance from source	acceleration of gravity
3.7	0	.05[1]
		.015-.02[2]
3.7	10	.04[1]
4.3	0	.08[1]
		.03-.04[2]
4.3	10	.06[1]
5.0	0	.15[1]
		.06-.07[2]
5.0	25	.06[1]
5.0	50	.02[1]
5.1-5.7	25	.075[3]
5.1-5.7	50	.04[3]

[1]Davenport, A.J., 1972, A statistics relationship between shock, amplitude, magnitude, and epicentral distance and its application to seismic zoning, W.O.T., Engr. Sci. Res. Rept. BLWT-4-72.

[2]Bolt, B.A., 1978, Earthquakes, A Primer, 1978, U. of Calif.-Berkeley, W.H. Freeman & Co.

[3]Boore, et al., 1978, Estimation of Ground Motion Parameters, U.S. Geol. Survey Circular 795.

A further discussion of the estimated maximum horizontal accelerations at the site is included in Section G of this report.

C. Recurrence Intervals

Recurrence intervals given below are based on the mean of the intervals between each event being considered which occurred within the 100-km radius during the period 1853 to 1982.

M_L 3.0-3.7	1 event/7.7 yrs within a 10-km radius of the site
M_L 4.3	1 event/11.6 yrs between the 10 to 100-km radii of the site
M_L 5.0	1 event/28.3 yrs between the 10 to 100-km radii of the site

D. Probability of Recurrence of Seismic Events

The following probability analysis is presented, based on: the historical record of seismic events reported within a 100-km radius of the site as shown in Table I; on published data on attenuation of seismic energy with increasing distance; on published estimates of maximum horizontal ground accelerations as shown in Table II; and on the assumption that larger seismic events than reported will not occur within the respective radii selected for this report.

Conservatively, there is a 100% probability that a M_L 3.0-3.7 event will occur within a 10-km radius of the site within the 20-year life of the project.

Conservatively, there is a 100% probability that a M_L 4.3 event will occur within a 100-km radius of the site within the 20-year life of the project.

There is a 70% probability that a M_L 5.0 event will occur within a 100-km radius of the site within the 20-year life of the project.

E. Probability of Recurrence of Seismic Events During 10-yr/24-hr Full Pond Conditions

Using the recurrence intervals in Section C and recurrence probabilities in Section D, the following probabilities are obtained for the occurrence of varying size seismic events during the 10-year/24-hr full pond condition:

M_L 3.0-3.7 within a 10-km radius of the site: 1/7.7 yrs X 1/365/10 yrs = 1/28105 = .0036%

M_L 4.3 within a 100-km radius of the site: 1/11.6 yrs X 1/365/10 yrs = 1/42340 = .0024%

M_L 5.0 within a 100-km radius of the site: 1/28.3 yrs X 1/365/10 yrs = 1/103295 = .001%

F. Uniform Building Code (UBC) Zone 2

A probability analysis of the occurrence of the 10% acceleration of gravity designated by Seismic Zone 2, UBC, 1979 Ed., is presented below.

The UBC classification is based on seismic research in the late 60's by Algermissen and Perkins and others. Algermissen and Perkins, in a more recent investigation of estimated probabilistic ground accelerations[4], categorize the site area as having a 90% probability that a slightly less than 10% acceleration of gravity will not be exceeded within any 50-yr period. They assign an M_L 5.5 event for this corresponding acceleration.

Using the above author's recurrence intervals, the probability of non-exceedence of 10% acceleration of gravity increases from 90% to 96% or, restated, there is a 4% probability that a 10% horizontal acceleration in bedrock will be exceeded with any 20-yr period. The probability of the 10% acceleration being exceeded within a 10-yr/24-hr full pond condition then reduces to (0.04)(1/365)(1/10) = 0.001%.

G. Summary

Based on the historical seismic record and published references on seismic energy attenuation with increasing distance, a horizontal acceleration in bedrock of 5% of gravity has not been exceeded at the site during the 129 year historical record. It is notable that the M_L 3.5 event, occurring in May 1981, 7.9 km (±5 km) from the site had no apparent affect on the embankments of Pond Nos. 1, 3 and 5.

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[4] Algermissen, S.T. and Perkins, D.M., 1976, A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States, U.S.G.S., Open File Report 76-416.

This event resulted in an estimated maximum horizontal acceleration of gravity ranging from .015 to .05 or 1½% to 5% (Table II).

The 10% acceleration of gravity assigned by Algermissen and Perkins (1974) is based on a M_L 5.5 seismic event. The recurrence interval for this size event for the entire State of Utah is roughly 55 years. Using the seismic attenuation rates as the authors and those referred to in this report, an event of M_L 5.5 creating a horizontal acceleration of 10% would be required at 20 to 25 km from the site. Since no events with $M_L > 5.0$ have been reported to have occurred within a 100-km radius of the site in the past 129 years, we conclude that a 5% horizontal acceleration of gravity is acceptable for future stability analysis at the site.

V. CONCLUSIONS

Our further evaluation of the data comprising the slope stability analysis in the previous report for a total versus a partial embankment failure has resulted in an increase in the factors of safety against embankment failure for Sedimentation Pond No. 1, which was considered the most critical among the three ponds.

None of the alternatives for improving the stability of the pond embankment appear to be both practical and economical. The most feasible alternative to further increase the factors of safety, Alternative C discussed in this report, would require the excavation and placement of considerable volumes of material, including bedrock, to appreciably increase the factors of safety for each of the three embankments.

In our previous report, a 10% horizontal acceleration of gravity was utilized in the slope stability for the analysis of seismic condition. This value, based on Seismic Zone 2, Uniform Building Code, 1979 Edition, was assigned in lieu of a specific study of the area seismicity.

Our analysis of the site specific seismicity has determined that a horizontal acceleration of 5% gravity is acceptable for future stability analysis at the site. Seismic loading with a horizontal acceleration of 5% gravity used in the stability analysis will result in approximately 9% increase over the factors of safety for the pond embankments when a horizontal acceleration of 10% gravity is used.

Our analysis of the probability of occurrence of future seismic events indicates that probabilities for the occurrence of any of the seismic events considered, for the 10-yr/24-hr full pond condition are very low, ranging from .001% to .0036%.

Based on the above analysis, we urge that the request for a variance for these sedimentation ponds be granted by DOGM/OSM.

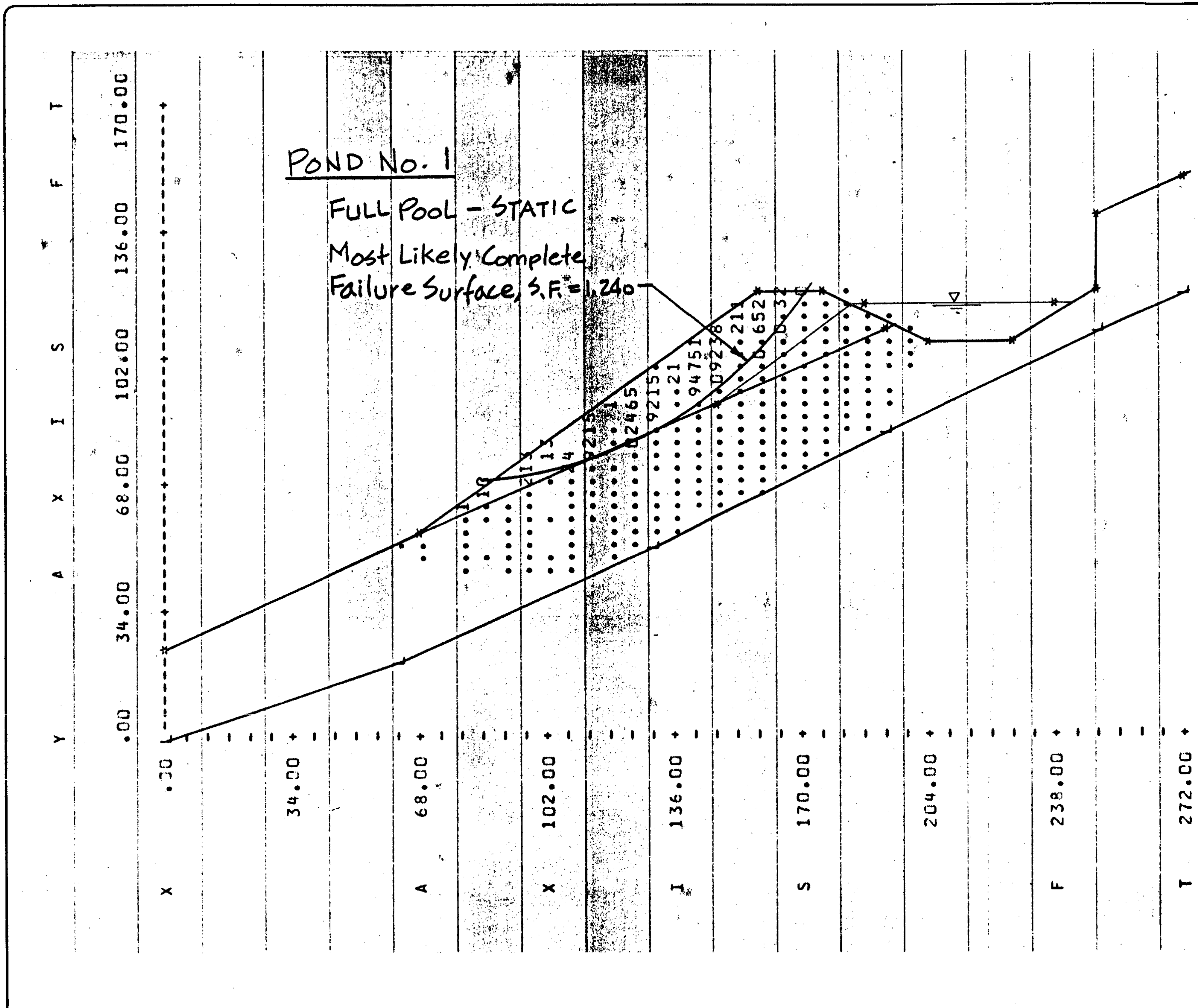
Prepared by:

J.S. Liu, Ph.D., P.E.
Senior Geotechnical Engineer

LaMonte Sorenson
Senior Engineering Geologist

Reviewed by:

Larry Migliaccio, P.E.
Director



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DATE. 2-19-82
SCALE. AS SHOWN

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SEDIMENTATION PONDS
STABILITY STUDY

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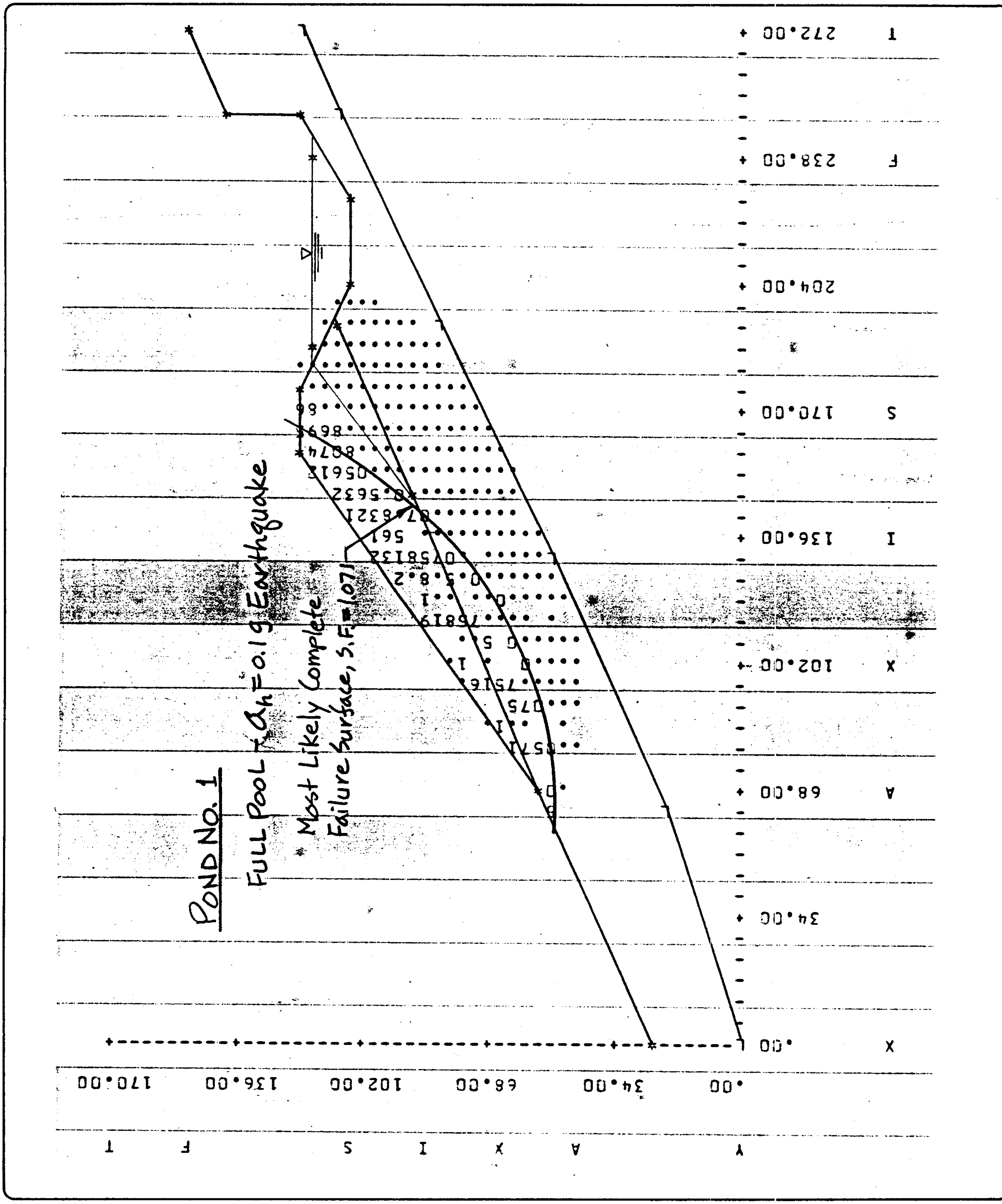

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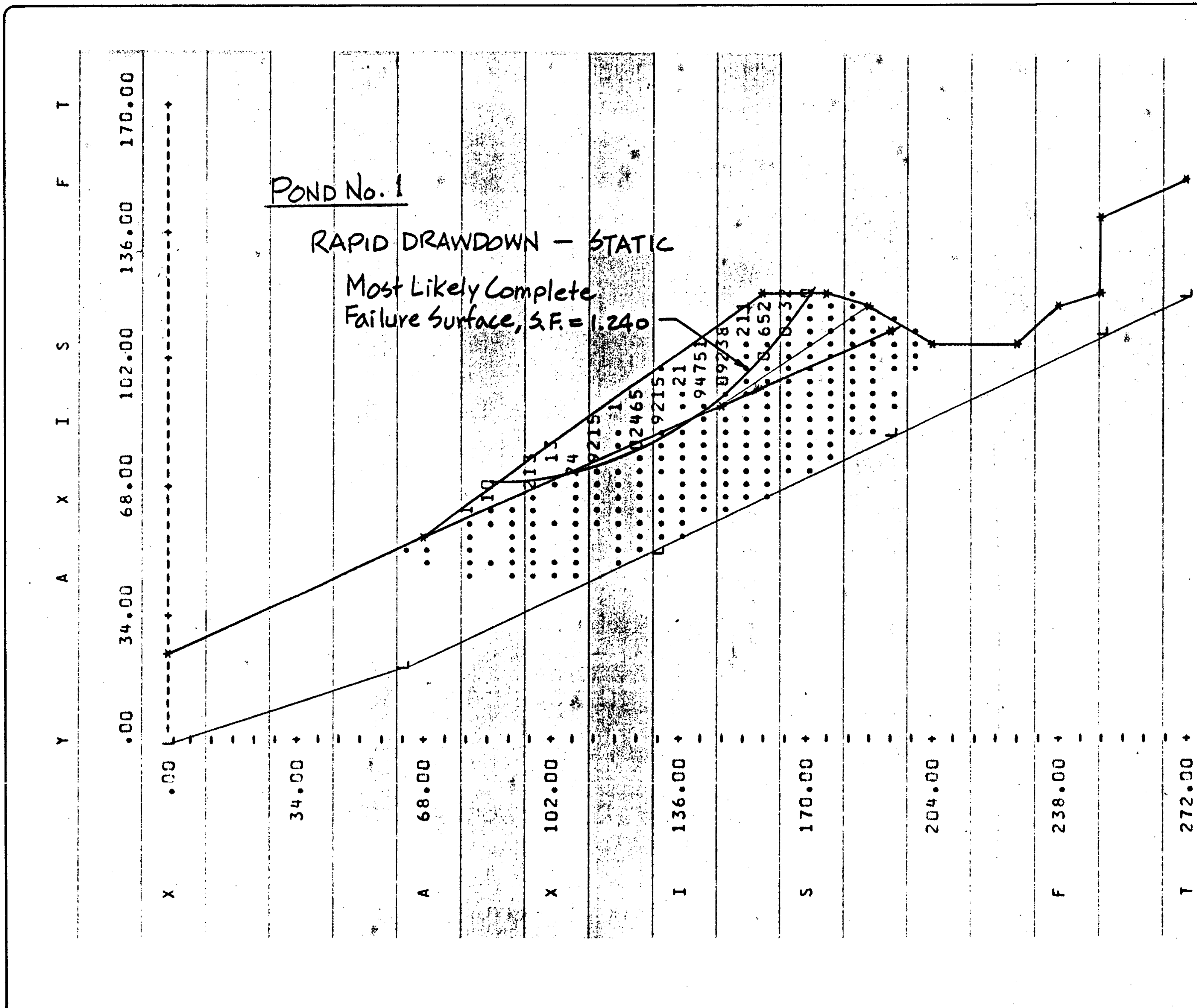

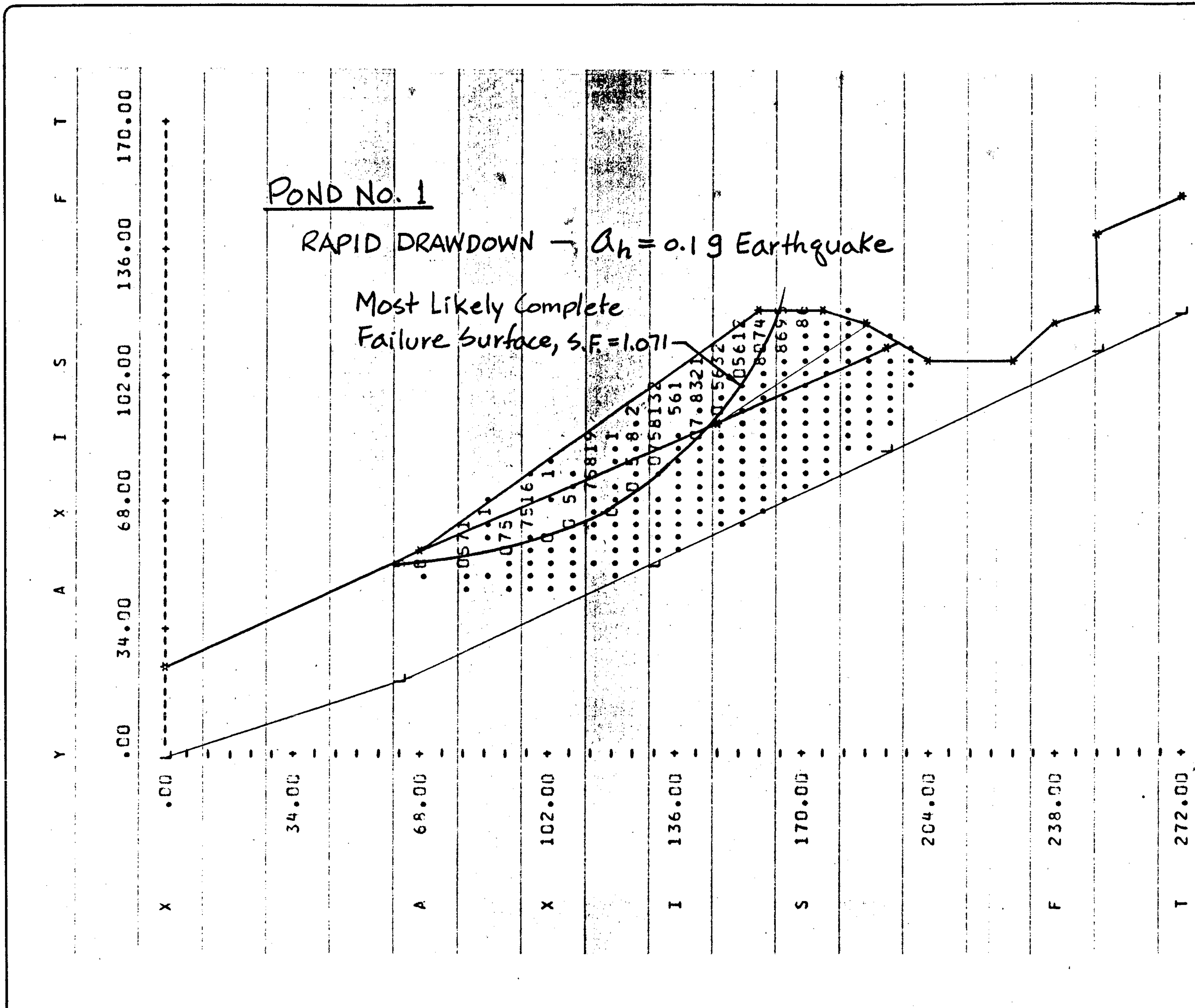

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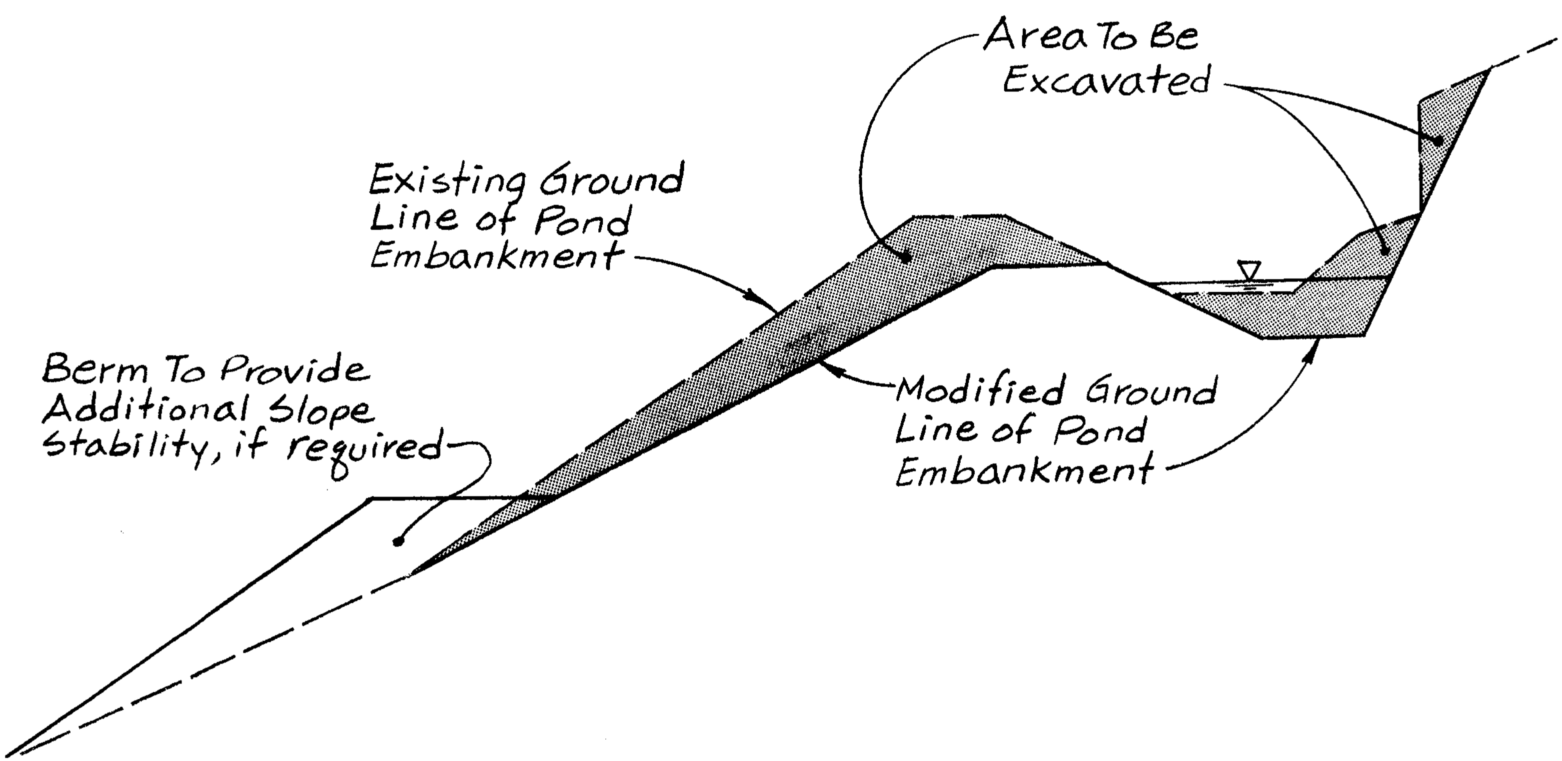

TYPICAL CROSS SECTION OF SCHEMATIC PRESENTATION FOR MODIFYING GEOMETRIC CONFIGURATION OF EXISTING POND EMBANKMENT TO IMPROVE SLOPE STABILITY

DWN.	JSL
CKD.	LGS
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SCALE.	NONE

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