APPENDIX

APPENDIX A STABILITY ANALYSIS MEMO

TO: File

FROM: Bill Horne

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FILE: 1100060.004

SUBJECT: **Stability Analysis of East and South Dams**
Jericho Diamond Mine, Nunavut

1.0 INTRODUCTION

This memo describes an update to the stability analysis EBA's report "Jericho Project East and Southeast Dam Design Report" dated August 2005. An update was required as the liner material for the dam was changed from a polypropylene liner to an HDPE liner. Additional analyses are also presented as requested by INAC 2005.

2.0 ANALYSES METHODOLOGY

Limit equilibrium analyses have been carried out to determine the factors of safety for slope stability during construction and operation of the East and Southeast Dams.

All analyses were conducted using the commercial, two-dimensional, slope stability computer program, SLOPE-W. The factors of safety have been computed using the Morgenstern - Price Method.

The dams are designed to meet Canadian Dam Association guidelines (CDA, 1999). The design criteria for computed minimum factors of safety are given in Table 1.

TABLE 1: SLOPE STABILITY DESIGN CRITERIA

Loading Conditions	Minimum Factor of Safety	Slope
Static Loading, full reservoir	1.5	Downstream and Upstream
Full or partial rapid drawdown	1.2 to 1.3	Upstream
Earthquake, full reservoir	1.1	Downstream and Upstream

The stability analyses were carried out for the deepest dyke cross-section, which is considered to be the worst cases in evaluating intermediate dyke stability.

3.0 MATERIAL PROPERTIES

The material properties chosen for the embankment and foundation materials in the stability analysis are presented in Table 2. The properties for granular materials were selected based on experience with similar materials used and encountered by EBA in dam designs at other sites across the Arctic.

TABLE 2: MATERIAL PROPERTIES USED IN STABILITY ANALYSES			
Material	Angle of Internal Friction (°)	Cohesion (kPa)	Unit Weight (kN/m³)
Run-of-Mine	42	--	20
200 mm Material	35	--	21
20 mm Material	32	--	20
Composite Liner System (Interface)	8	--	18
Ice-Poor Till Foundation	30	--	18.5
Ice-Rich Till Foundation	0	75	16.5
Upstream Till Fill	30	0	18.5
Coarse Processed Kimberlite	30	--	18.5
Fine Processed Kimberlite	0	0	15.0

The friction angle presented in Table 2 for the run-of-mine material is conservative for shallow depths where confining stresses are low (Jansen, 1988). The friction angle presented in Table 2 for rockfill is applicable for higher confining stresses that would be found at depth below the dam crest. The friction angle for similar rockfill under low confining stresses may approach 55°. The interface friction angle between the HDPE geomembrane and the nonwoven geotextile was based on published test results (Koerner, 1990).

3.1 PORE WATER PRESSURE CONDITIONS

Pore water conditions for individual analyses are shown on the attached analyses schematics (Figures A.1 through A.17). The following further describes the assumed pore water conditions.

3.1.1 Coarse Tailings

The pore pressures assigned to the coarse tailings on the upstream face of the dam correspond to the pool level. It was assumed that phreatic surface would drop approximately 0.5 m from the dam face during rapid drawdown.

3.1.2 Till

The pore water pressures assigned to the till on the upstream side of the liner corresponded to the pond elevation for the static and seismic full reservoir stability analyses. Intermediate water levels were also analyzed to determine the minimum factor of safety for the upstream analyses. Pore pressures were conservatively assumed to remain approximately at the original level during rapid drawdown situations.

3.1.3 Rockfill

Pore water pressures assigned to the downstream rockfill equalled the original ground elevation. The liner is not expected to leak significant volumes of water and, furthermore, the rockfill is free draining and will not sustain a rising water level within it.

3.1.4 Liner System

The pore water pressures assigned to the nonwoven geotextile/HDPE interfaces corresponded to the maximum pond levels for the static, seismic, and rapid drawdown stability analyses.

3.1.5 Foundation Till

It was assumed that negligible excess pore water pressures would be generated due to thaw of the till under the upstream or downstream portions of the dams. This is considered to be appropriate for the following reasons:

- thaw progresses relatively slowly into the foundation, and
- the till is non-plastic and has a significant sand and gravel content, which increases permeability.

Given these conditions, the thaw consolidation parameter (Morgenstern and Nixon, 1971) will be low, indicating that excess pore water pressures generated in the till during thaw will be negligible. Furthermore, the permeability of the coarse-grained till is expected to prevent the build-up of excess pore water pressures during rapid drawdown.

3.2 SEISMICITY

The project area lies in a region of low seismicity, but magnitude 4+ earthquakes have recently occurred within a similar part of the shield. NRCan (NRCan 2003a and NRCan 2003b) recommends that a probabilistic approach should be adopted to estimate the peak ground accelerations (PGA).

The CDA indicates that the usual minimum criterion for the design earthquake for a dam, which coincides with the "low" consequence category, would be an earthquake with an annual exceedance with return periods of 100 to 1,000 years. NRCan (2003a and 2003b) indicates that the 1,000-year event has a peak acceleration of 0.016 g. However, in conjunction with proposed changes to the NBCC, NRCan indicates that performance of the Jericho dams be designed for an earthquake with a 2,475 year return period which has a peak ground acceleration of 0.06 g. This has been adopted as the design earthquake.

3.3 ANALYSES RESULTS

Table 3 summarizes the factors of safety under static, rapid drawdown and seismic conditions for different failure surfaces on the upstream and downstream slopes.

TABLE 3: SUMMARY OF STABILITY ANALYSIS RESULTS					
Slip Surface	Location	Factor Safety			
		Static	Static, Rapid Drawdown of Reservoir	Seismic	End of Construction (No Coarse Tailings or Water)
1	Upstream, rotational	1.5	1.2	1.2	1.9
2	Upstream, along liner	2.0	1.4	1.5	1.4
3	Downstream rotational	1.6	1.6	1.4	1.6
4	Downstream along the liner	2.1	2.1	1.6	2.9
5	Downstream Overall Stability – Full Tailings Level	2.7	-	-	-

The computed minimum factors of safety exceed the design criteria of 1.5, 1.2 and 1.1 for static, rapid drawdown and seismic loading conditions, respectively, in accordance with the CDA, Dam Safety Guidelines (CDA 1999).

FIGURES

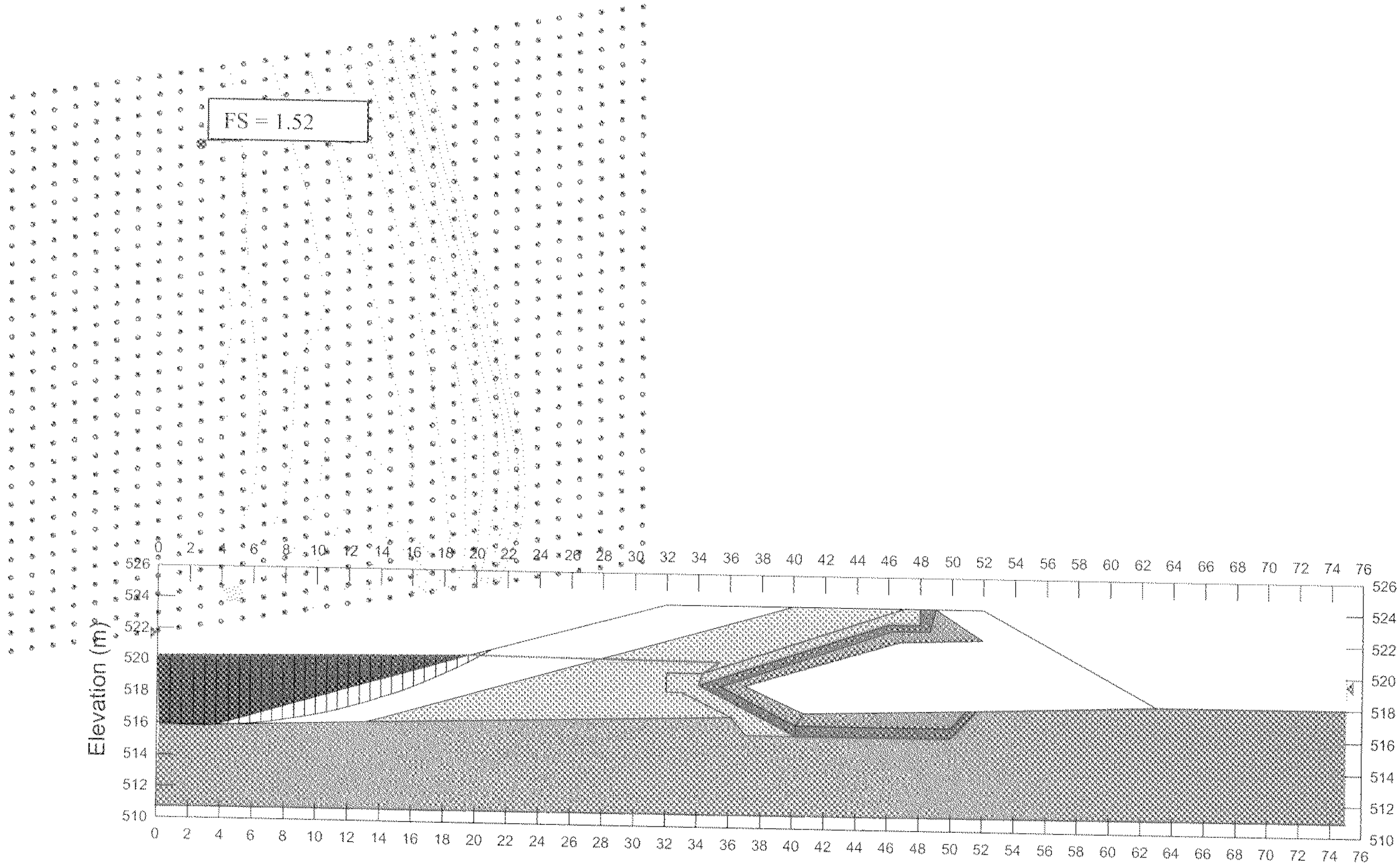


Figure A1
Stability Analysis - Upstream, Static – Rotational Slip Surface

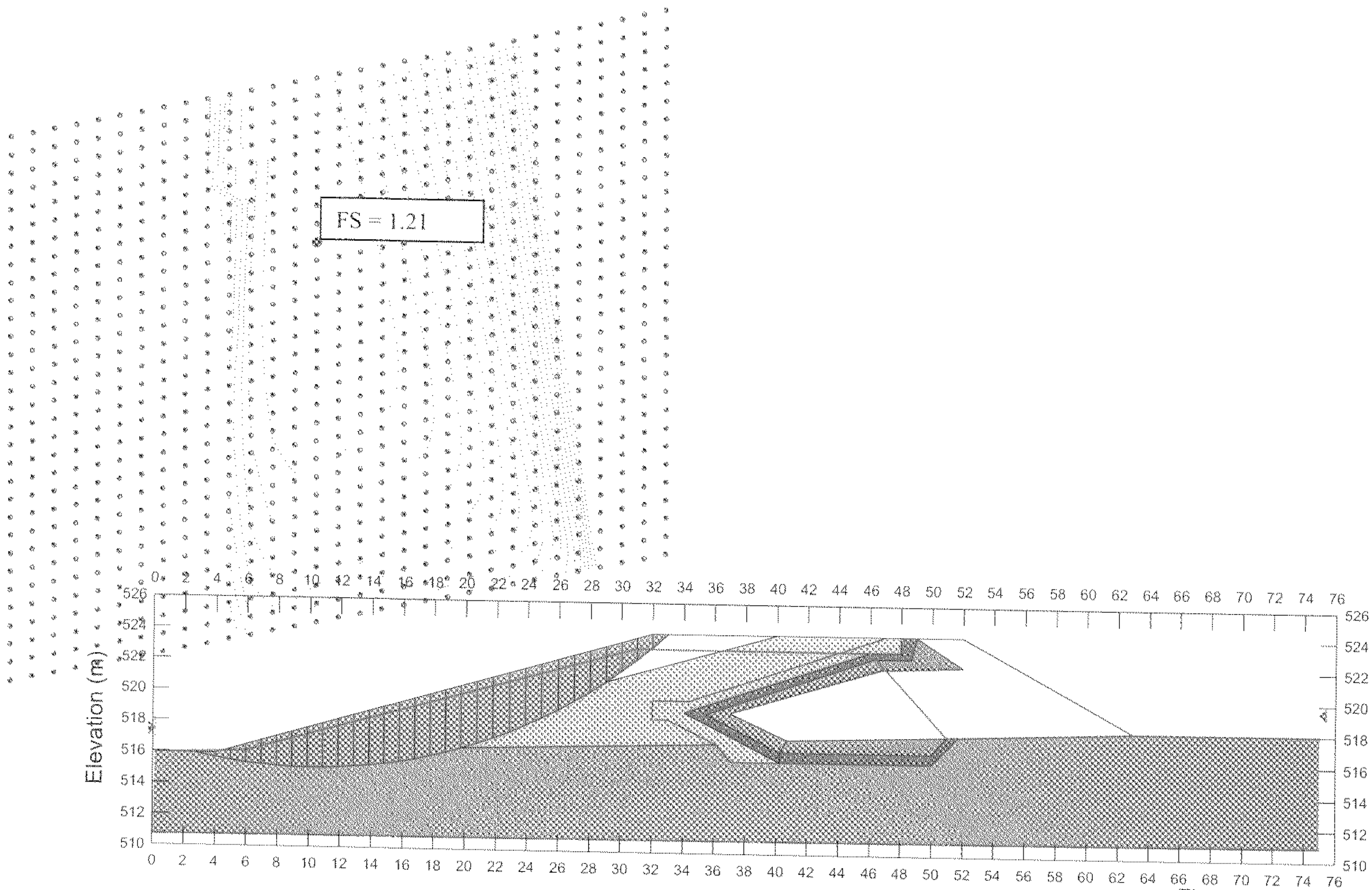


Figure A2
Stability Analysis - Upstream, Rapid Drawdown – Rotational Slip Surface

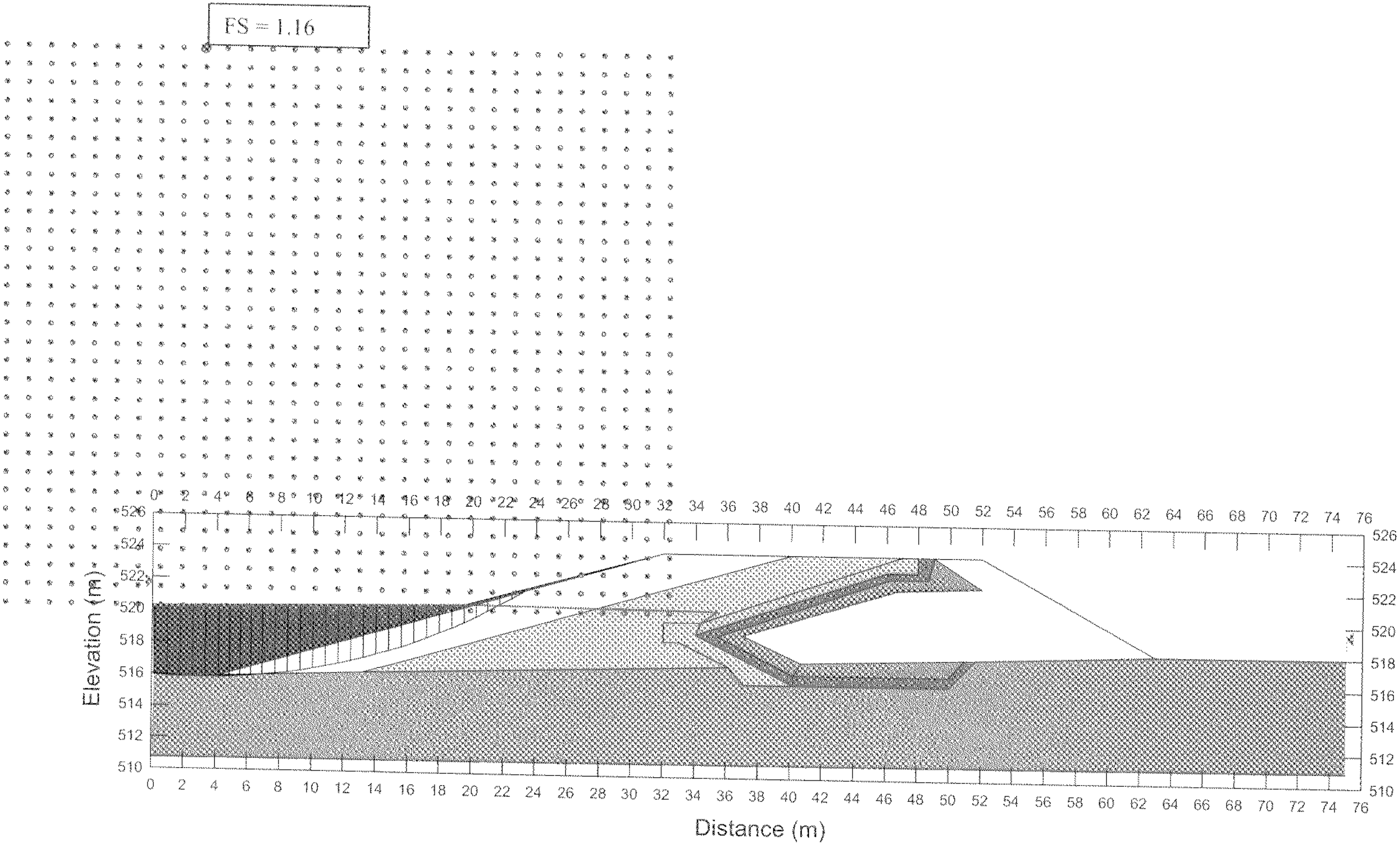


Figure A3
Stability Analysis - Upstream, Seismic Analysis – Rotational Slip Surface

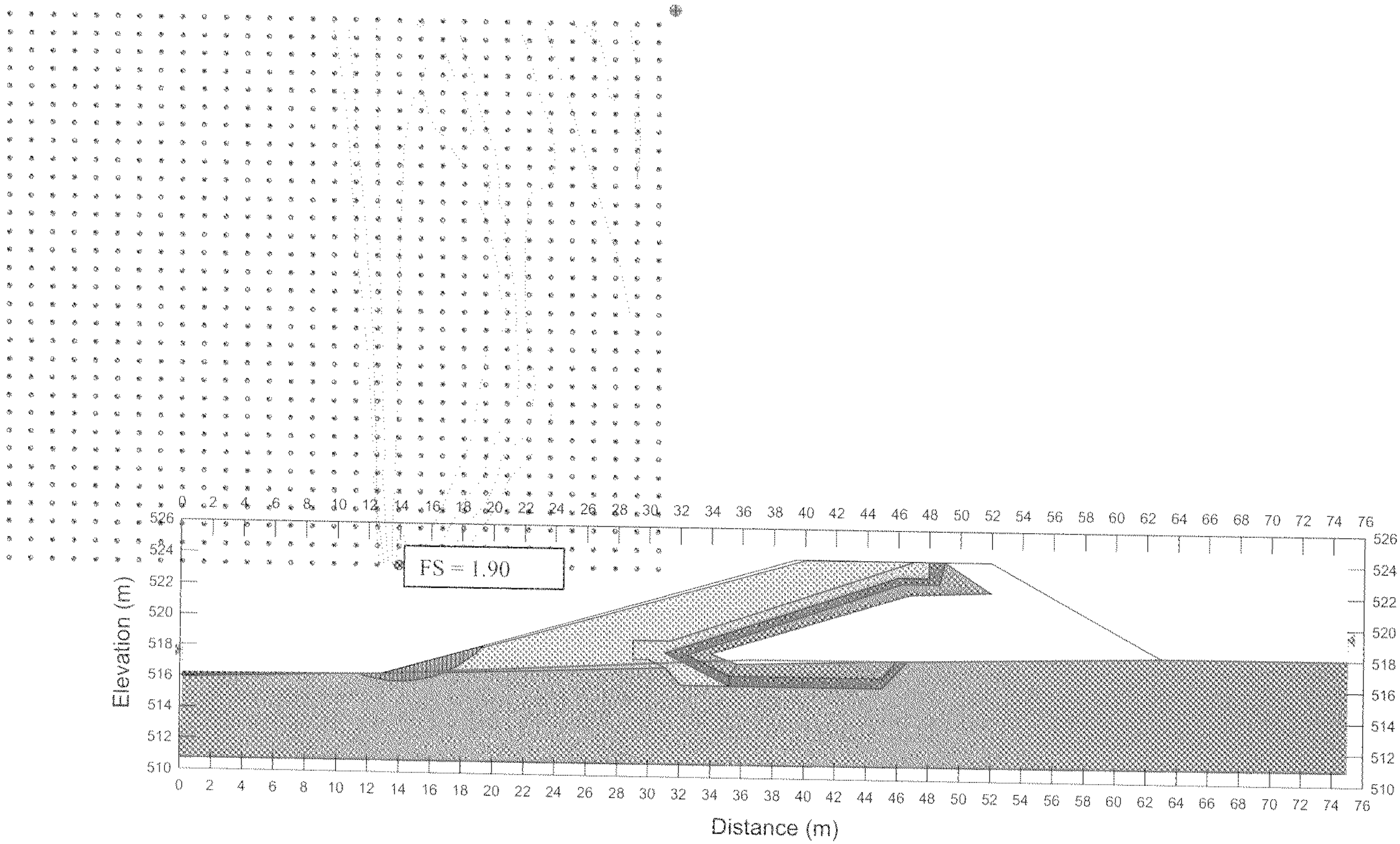


Figure A4
Stability Analysis - Upstream End of Construction – Rotational Slip Surface

FS = 2.00

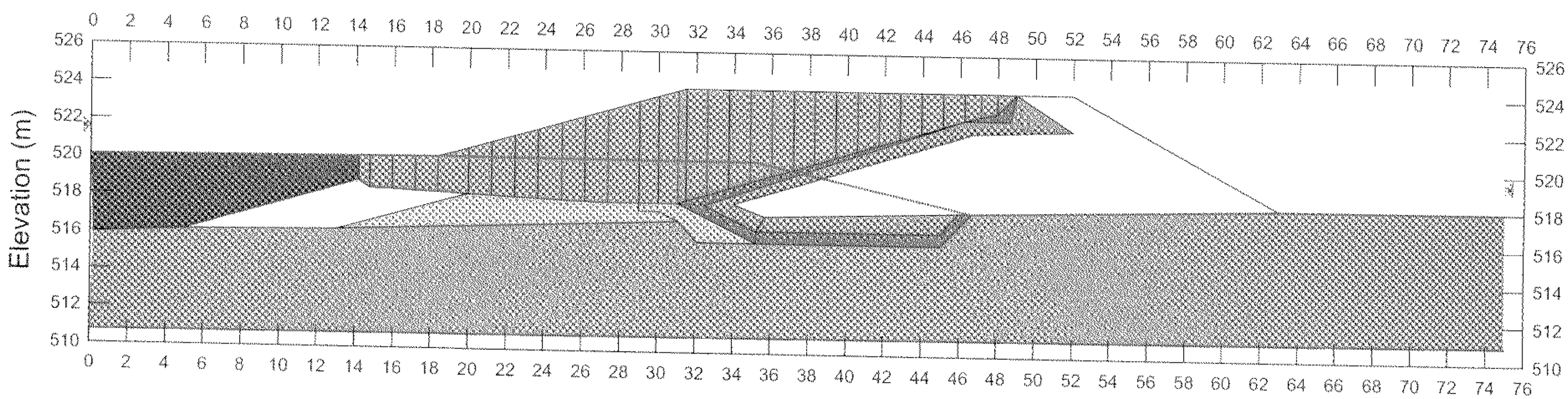


Figure A5
Stability Analysis - Upstream, Static -- Slip Surface Along Liner

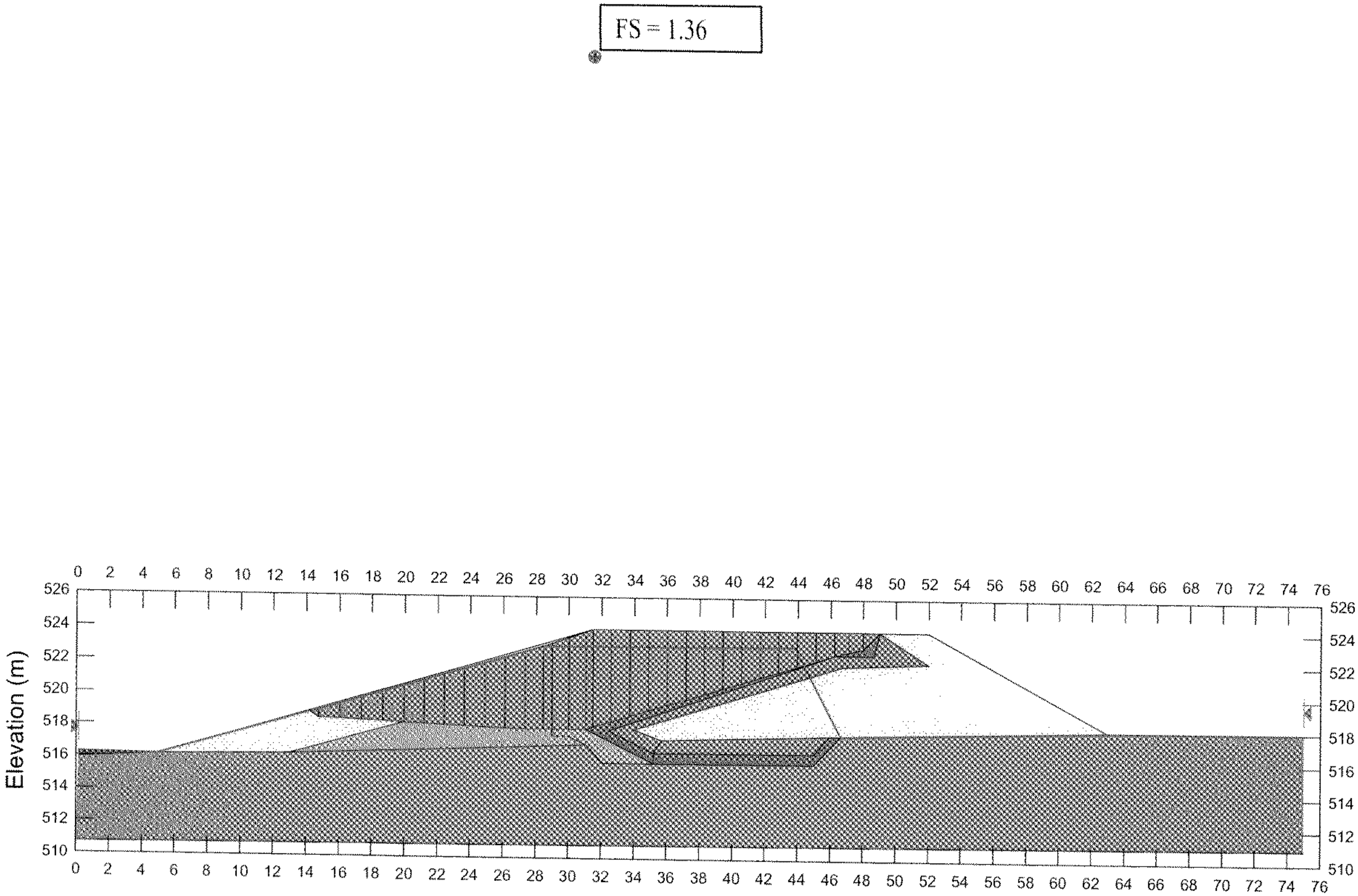


Figure A6
Stability Analysis - Upstream, Rapid Drawdown – Slip Surface Along Liner

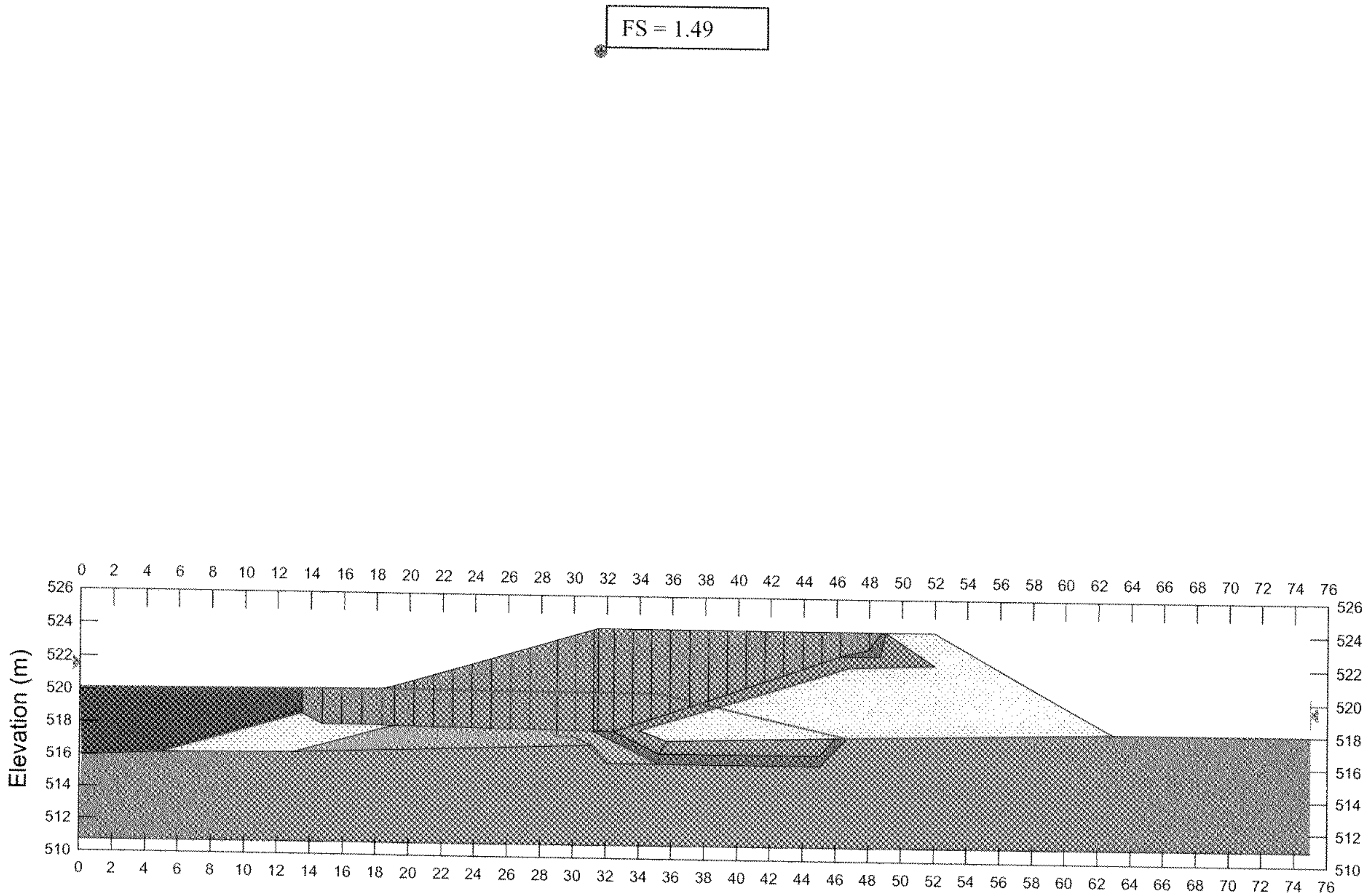


Figure A7
Stability Analysis - Upstream, Seismic Analysis – Slip Surface Along Liner

eba

FS = 1.44

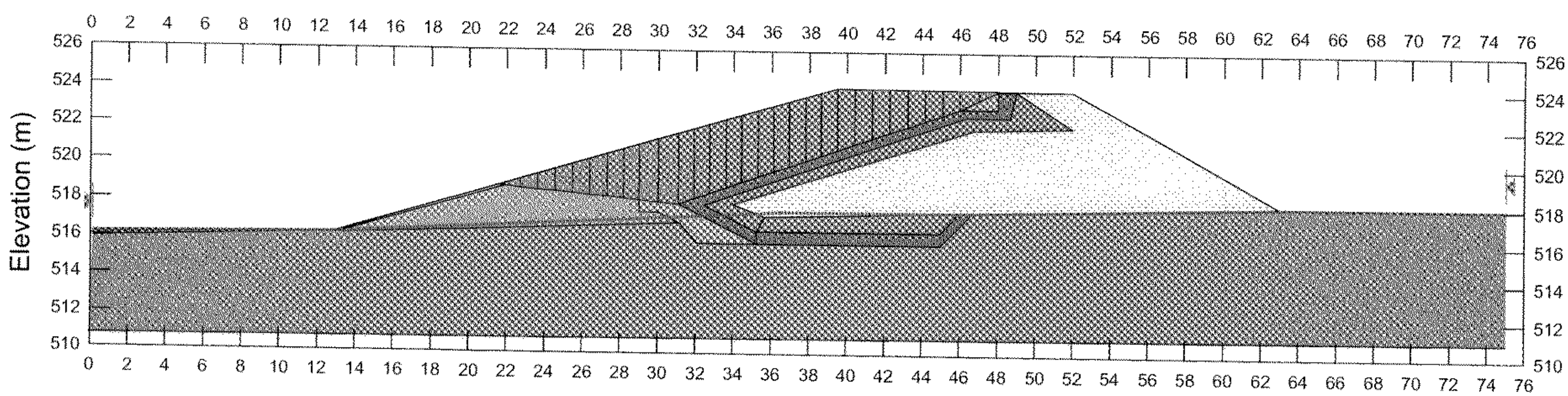


Figure A8

Stability Analysis - Upstream, Static, End of Construction – no coarse tailings

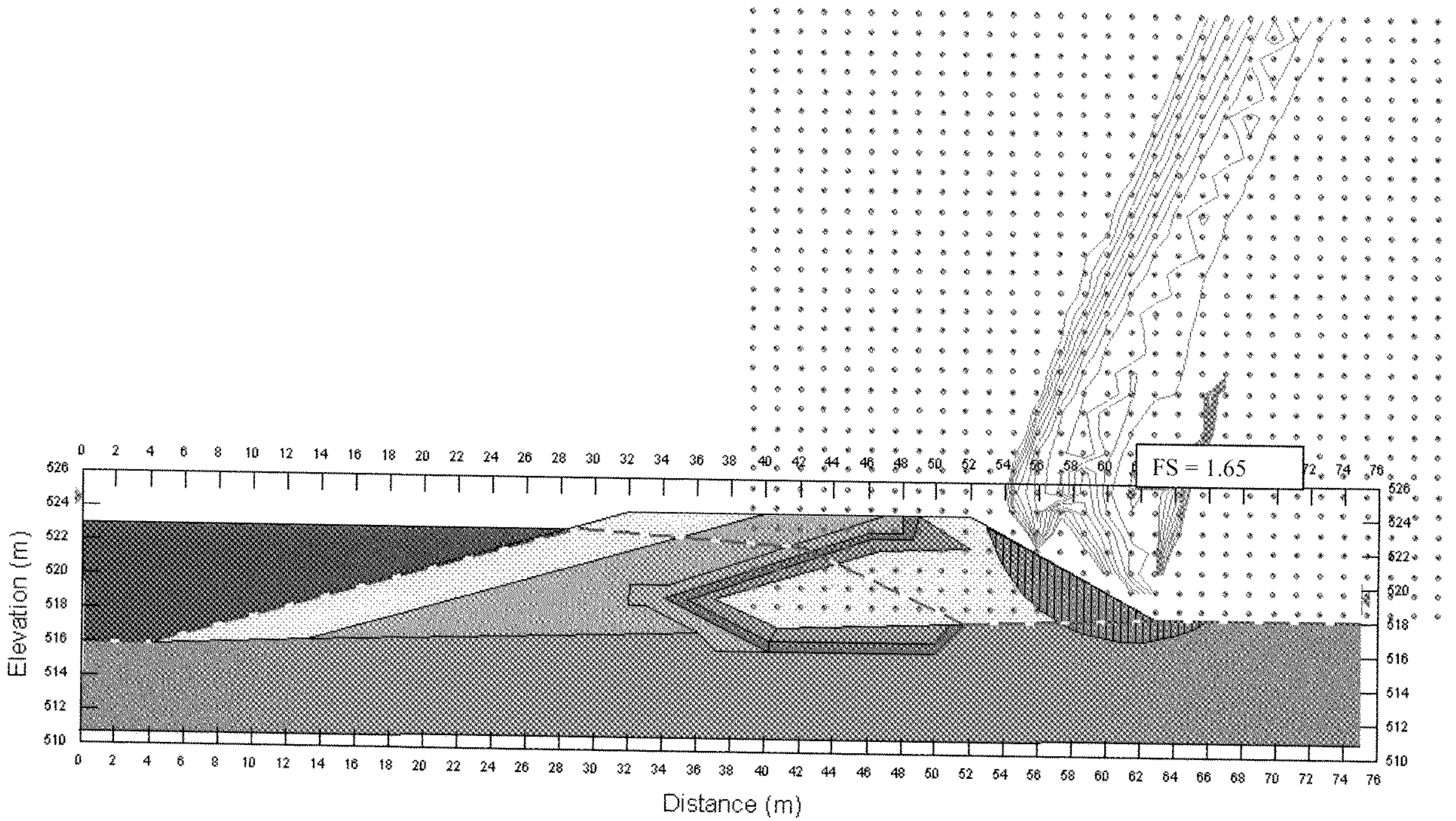


Figure A9
Stability Analysis - Downstream, Static – Rotational Slip Surface

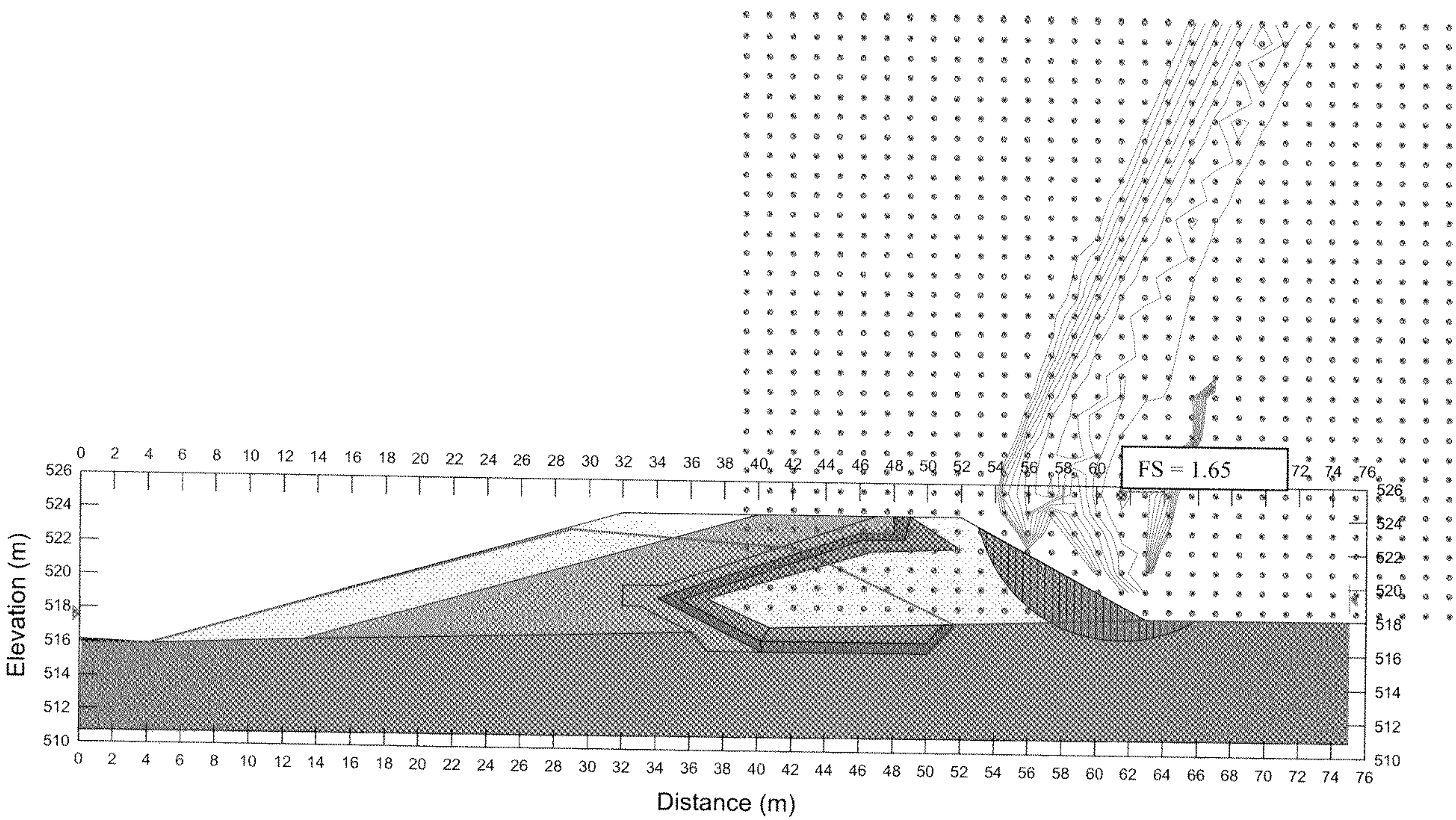


Figure A10
Stability Analysis - Downstream, Rapid Drawdown – Rotational Slip Surface

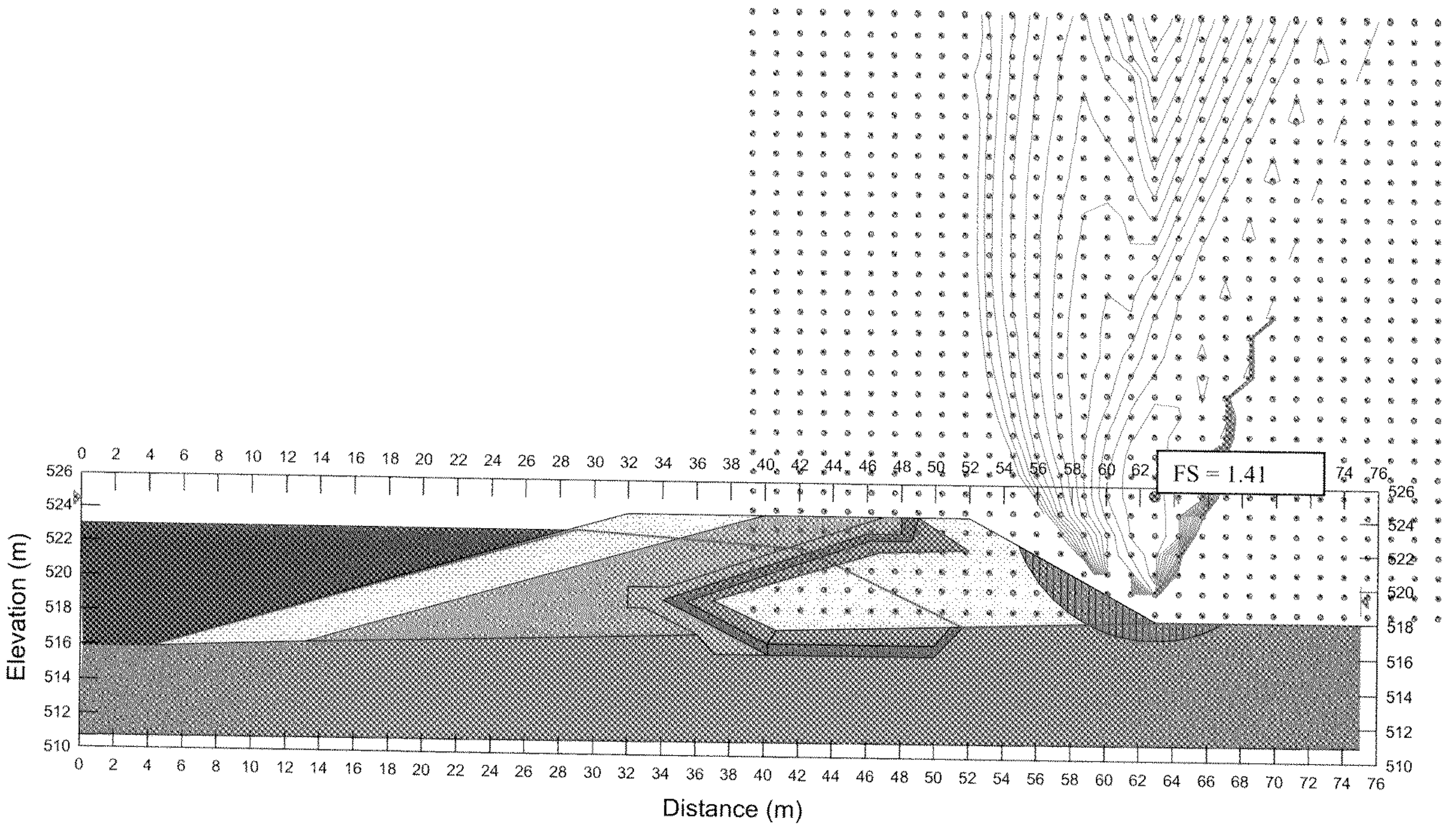


Figure A11
Stability Analysis - Downstream, Siesmic – Rotational Slip Surface

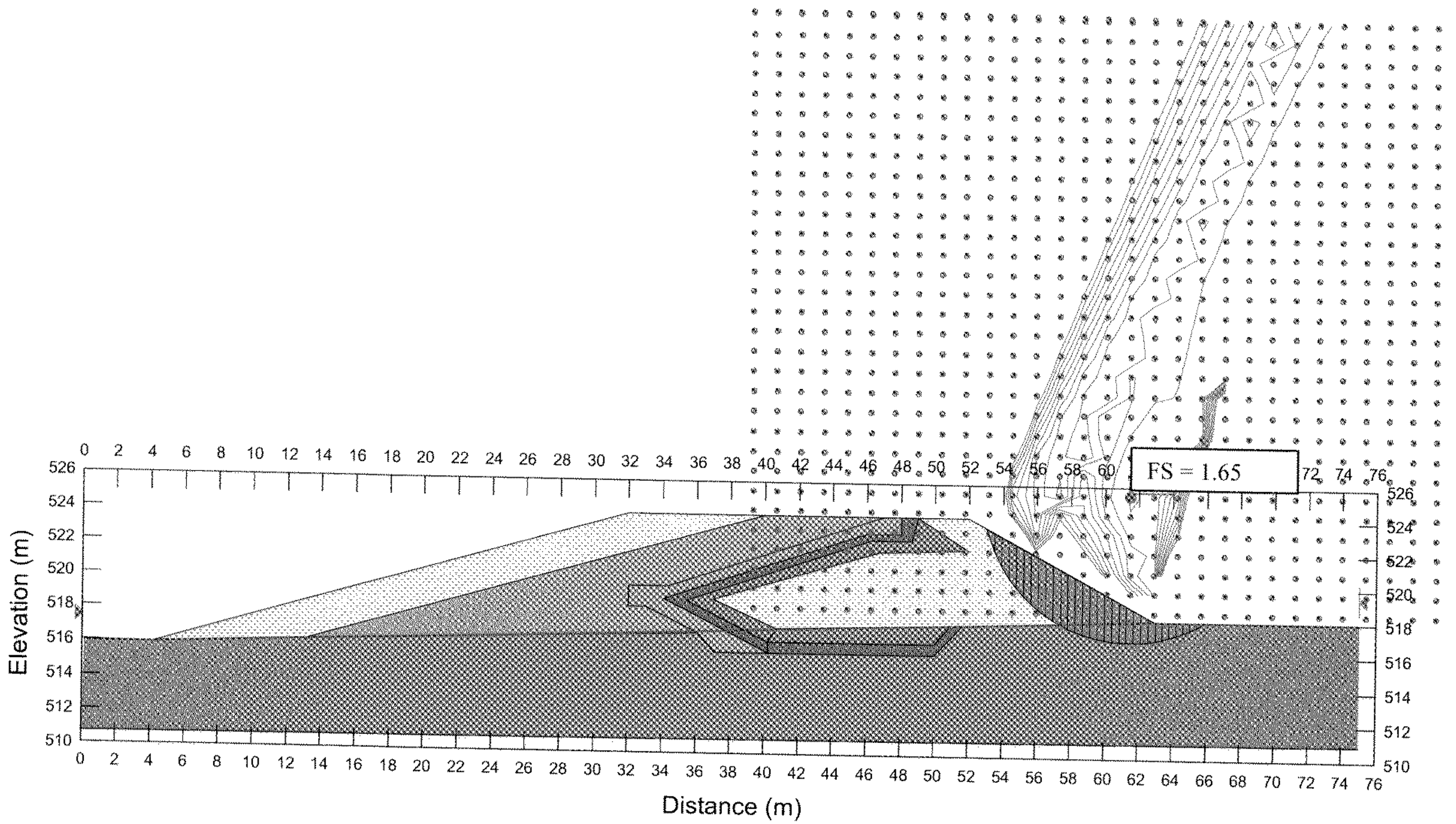


Figure A12
Stability Analysis - Downstream, End of Construction – Rotational Slip Surface

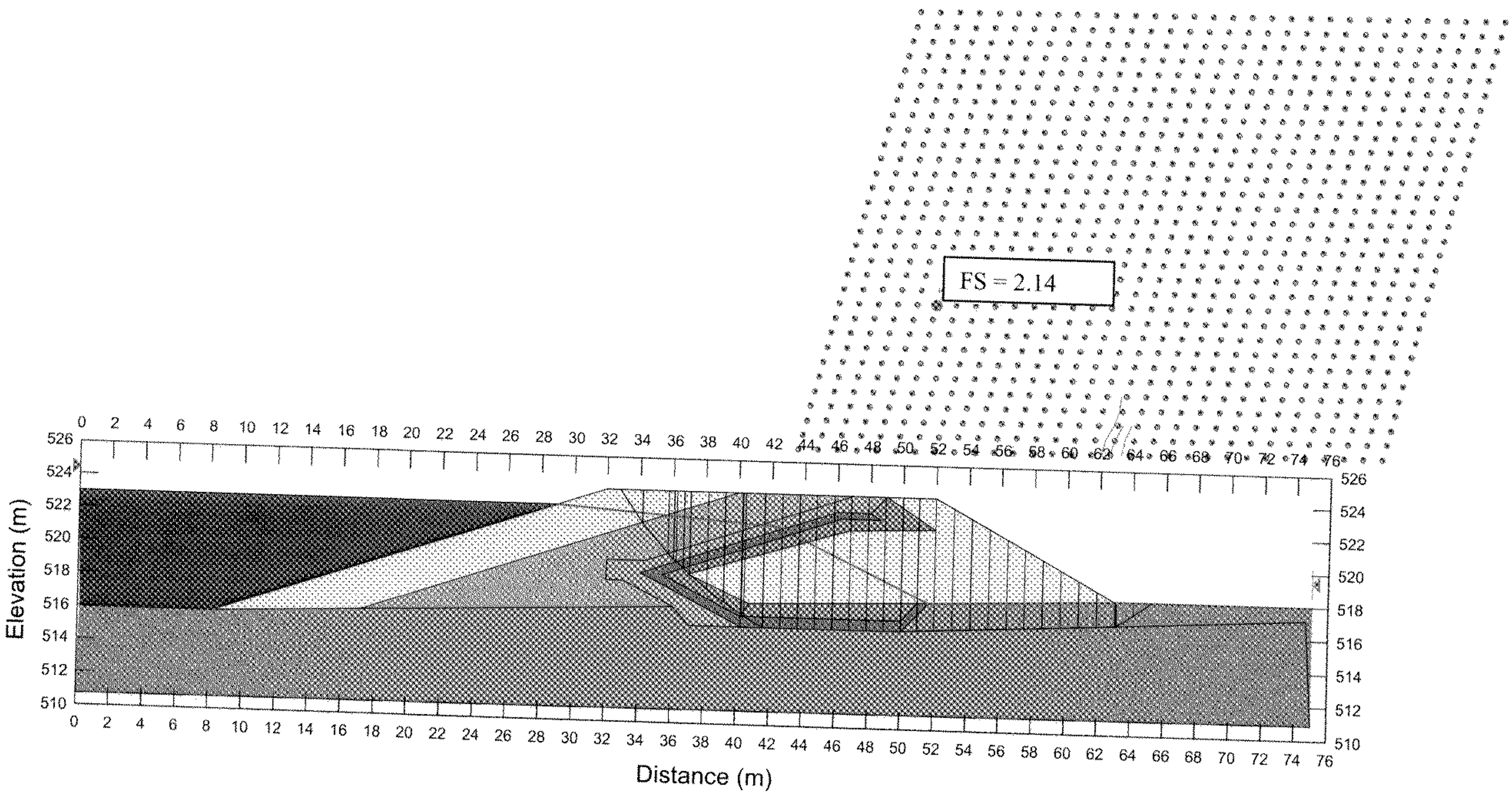


Figure A13
Stability Analysis - Downstream, Static Analysis –Slip Surface along Liner

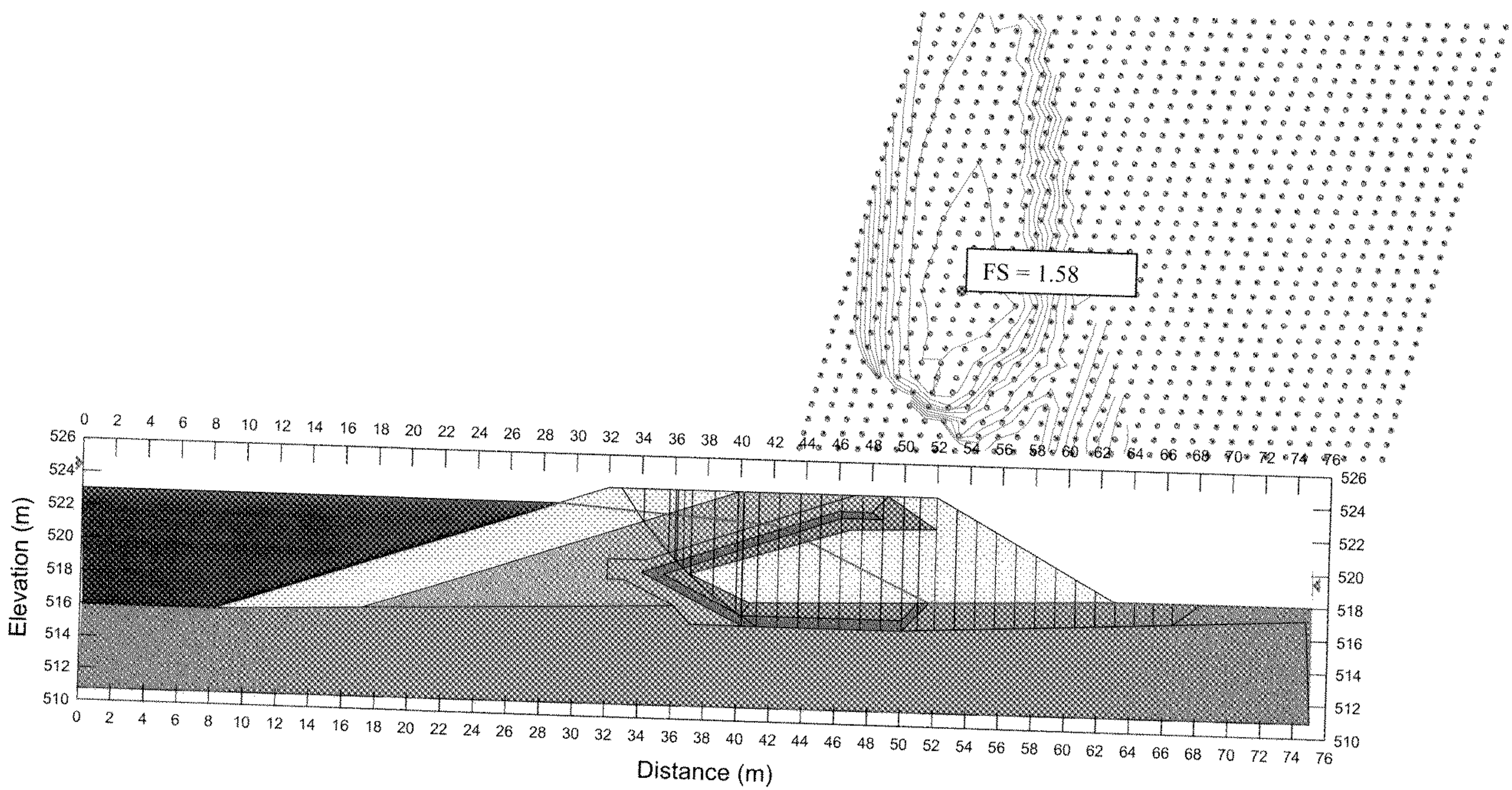


Figure A14
Stability Analysis - Downstream, Seismic Analysis –Slip Surface along Liner

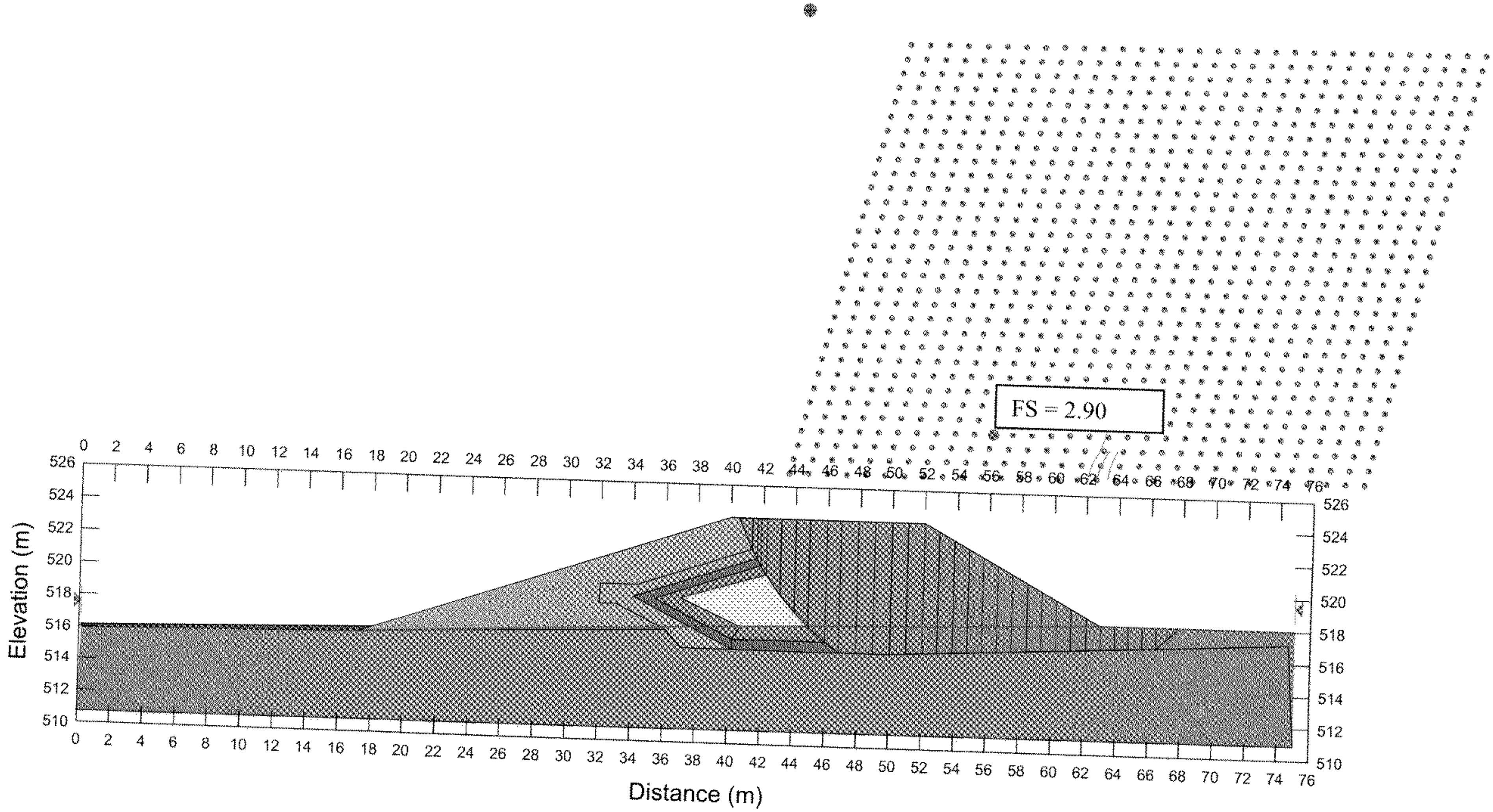


Figure A15
Stability Analysis - Downstream, End of Construction –Slip Surface along Liner

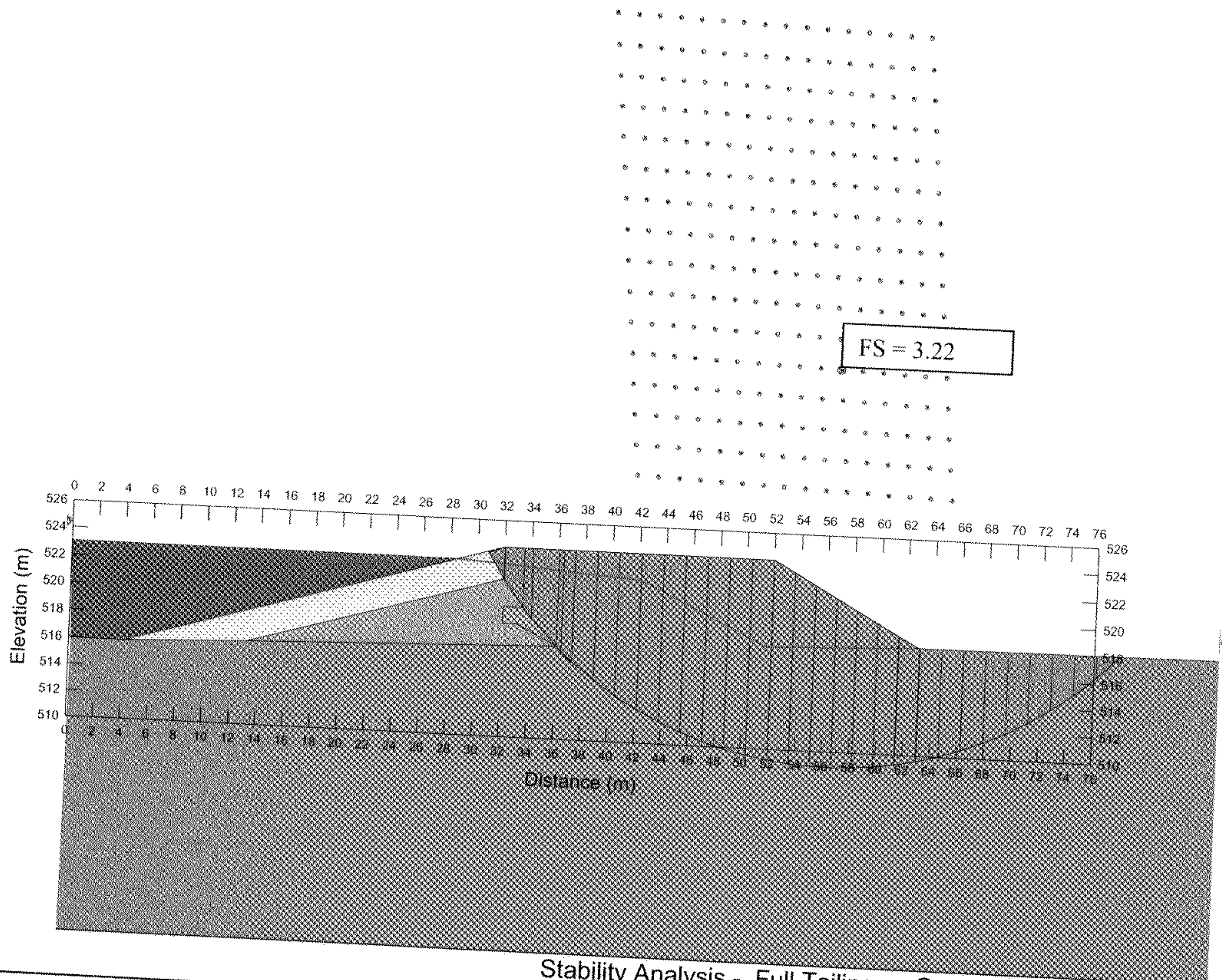
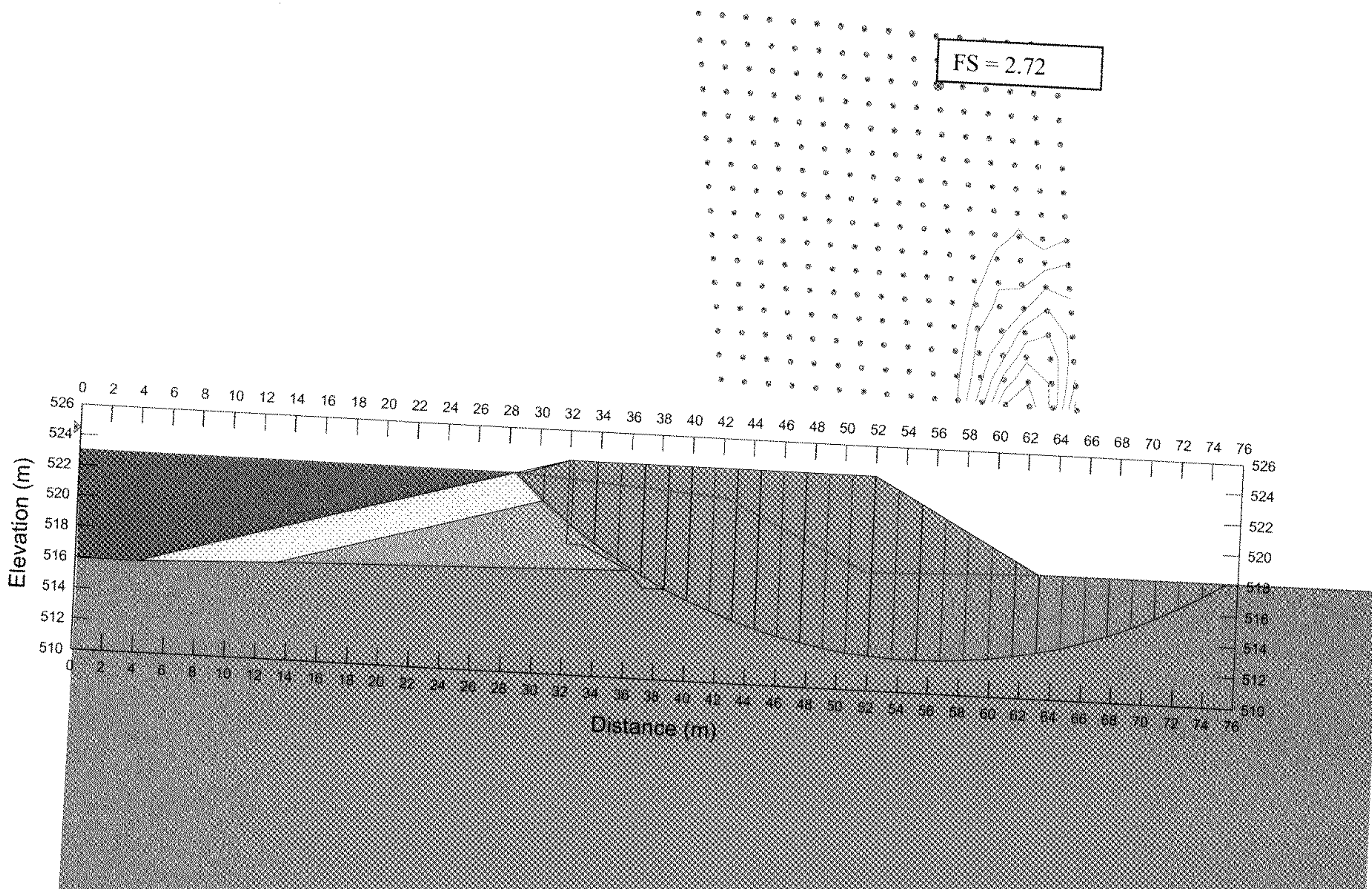


Figure A16
Stability Analysis - Full Tailings – Overalll Stability – Ice Rich Foundation



Stability Analysis - Downstream, Full Tailings –Overall Stability – Ice Poor Foundation

Figure A17