Midnite Mine Superfund Site
100 Percent Design

Appendix E – Water Management Ponds

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LIST OF ACRONYMS

BMP	Best Management Practice
BODR	Basis of Design Report
CD	Consent Decree
EPA	U.S. Environmental Protection Agency
FOS	Factor of Safety
gpad	gallons per acre per day
gpm	gallons per minute
GSR	Green and Sustainable Remediation
HDPE	high density polyethylene
MA	Mine Area
Mgal	million gallons
NPDES	National Pollutant Discharge Elimination System
PCP	Pollution Control Pond
RA	Remedial Action
RAO	Remedial Action Objective
RD	Remedial Design
SOW	Statement of Work
SWMP	Stormwater Management Plan
SWRP	South Waste Rock Pile
WMS	Water Management System
WSDE	Washington State Department of Ecology
WTP	Water Treatment Plant

E.1.0 INTRODUCTION

This appendix to the *Midnite Mine Superfund Site Basis of Design Report* (BODR) presents the design information for the temporary water management ponds. The Midnite Mine Superfund Site (Site) remedial action (RA) requires consolidation of the mine wastes into Pit 3 and Pit 4 and isolation of the wastes from groundwater and surface water infiltration. Under the current water management system (WMS), Pit 3, Pit 4, and the Pollution Control Pond (PCP) are used to store mine-impacted surface and groundwater prior to water treatment and discharge from the Site (see Figure E-1). Temporary water management ponds (aka, storage ponds) will be needed during RA construction to control and store the impacted water when the pits and PCP are no longer available for water storage.

Proposed locations for these temporary storage ponds have been discussed with the Spokane Tribe and the EPA. During those discussions, the Tribe expressed its desire that the storage ponds be constructed within the existing fenced mine area (MA) boundary. This limits the number of suitable locations for these temporary water management ponds. This appendix describes the proposed sequence for construction, location, sizing, stability, and other considerations for the temporary water management ponds.

E1.1 BACKGROUND

The RA will be performed in three main phases as described in Appendix D, during which time mine impacted surface water and groundwater will be captured and stored pending treatment at the operating WTP. Estimates of the water storage requirements during each RA phase are presented in Attachment E-1 (Storage Pond Water Balance). As proposed, water storage will occur at five different locations during the phased RA construction. These phases and locations are shown schematically on Figures E-2 through E-5, and include the existing Pit 3, the existing PCP, the new South Pond, the new West Pond, and the new Water Treatment Plant (WTP) Ponds.

During Phase 1 construction, mine wastes will be consolidated in Pit 4 and impacted water from the Site will be collected and stored in the PCP and Pit 3 as shown on Figure E-2. The major change to the current WMS during and upon completion of Phase 1 construction is that Pit 4 will no longer be used as a storage pond so that it can be backfilled with mine waste. The South Pond will be constructed during Phase 1 so that it is available to store water during Phase 2 as described below.

Phase 2 will commence with the backfilling of Pit 3, at which time Pit 3 will not be available for water storage. During Phase 2, impacted water will be stored in the PCP and in a new lined, temporary storage pond to be built immediately south of Pit 3 on the South Waste Rock Pile (i.e., the South Pond; see Figure E-3 and Drawing 5-1). Upon completion of Phase 2 the only significant volume of mine waste requiring excavation and consolidation will be that located in the Central Drainage portion of the South Waste Rock Pile in the vicinity of the South Pond and the PCP. As a result, necessary water-storage volumes at the end of Phase 2 will be significantly reduced because much of the Site surface water runoff can be shed from the remediated areas as clean water and discharged via local drainages to Blue Creek. The West Pond will be constructed during Phase 2 after completion of cleanup of the upper and central portions the Western Drainage so that it is available to store water during Phase 3 as described below.

The South Pond will be removed at the start of Phase 3 so that the underlying and adjacent wastes can be excavated and backfilled in Pit 3, and mine-impacted water will be stored in the PCP and in a new smaller West Pond (see Figure E-4 and Drawing 5-1). The PCP and associated mine wastes underlying and in the vicinity will be removed near the end of Phase 3 and consolidated in Pit 3. At the end of Phase 3, all the mine-impacted water will be stored in the West Pond. .

Upon completion of Phase 3, all stormwater will be shed from the remediated areas as clean water, and the only mine-impacted water requiring storage prior to treatment will be from the Alluvial Groundwater Controls and from the dewatering wells installed in the consolidated wastes in Pit 3, Pit 4, and the Backfilled Pits Area (BPA). It is anticipated that these flows will gradually decrease as steady-state base flow (groundwater inflow) levels are reached in the pit dewatering systems. The West Pond will remain operational until the volumes of mine impacted water have reduced to the point where the equalization ponds at the new WTP are sufficient for temporary water storage prior to treatment. Once flows have decreased to where the West Pond is no longer necessary, it will be decommissioned and any impacted sediments that may have accumulated within the West Pond and its liner system will be disposed of in a separate cell on top of the Pit 3 waste containment area as described in Appendix D.

The designs for the South Pond and West Pond are shown in Section 5 of the drawings contained in Volume II of this report, and are summarized in this appendix. Designs for the WTP equalization ponds are shown in Section 9 of the 60% design drawings. Section 9

drawings have not been progressed past the 60% level as the WTP design is on hold until the National Pollutant Discharge Elimination System (NPDES) permit is reissued.

The remainder of this appendix contains the following information:

- Demonstration that the design will attain the Performance Standards identified in the Consent Decree (CD) that are relevant to the storage ponds.
- Design calculations, assumptions, and parameters including:
    - Water balance calculations, estimates of required storage capacities, and analysis of storage of construction water
    - Embankment stability analyses
    - Pond configurations and capacities
    - Calculation of pond liner anchorage requirements
    - Emergency overflow spillway requirements
- Green and Sustainable Remediation (GSR) considerations

E2.0 PERFORMANCE STANDARDS

The Performance Standards presented herein are defined in the Consent Decree Statement of Work (CD SOW; EPA, 2011), and were developed to define attainment of the Remedial Action Objectives (RAOs) of the Selected Remedy. The performance standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. All of the Performance Standards for the Midnite Mine RA, as well as a summary of where or how they are addressed in the RD, are summarized on Table 4-6 of the BODR. The general and specific Performance Standards related to the Storage Ponds are listed below.

Table E-1 – Performance Standards Applicable to Temporary Storage Ponds

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Performance Standard No. in CD SOW	Performance Standard	Comments
2.3 General Standards Applicable to All Work Elements and Components of Work		
2.3.15. E	Removals and other excavations conducted as part of the construction activities shall be performed in a manner that allows for proper drainage from the excavated area. Drainage from Work Areas that may have come into contact with contaminants shall be captured and conveyed to the WTP for treatment. No drainage from Work Areas that may have come into contact with contaminants shall be allowed to infiltrate or discharge to natural drainages where water treatment collection and conveyance controls are not in place and operating.	The RA will be performed such that all water that potentially contacts mining wastes is captured and treated. To the extent practical, mine waste excavations will be completed beginning at the upstream (northern) end of the Western, Central, and Far Eastern Drainages and continued in a downstream direction. Excavation areas will be graded in a manner that contains surface water runoff from excavation areas wholly within the excavation areas, from where it will either drain by gravity, or be pumped initially into Pit 3, and as construction progresses, into various storage ponds (described in this Appendix E) that will be constructed and ultimately to the WTP for treatment. Topography will be maintained throughout the RA construction activities such that clean water sheds away from the work areas, and mine-affected water is captured before it can discharge to the downstream drainages. These details are described in the following design appendices: Appendix D – Mine Waste Excavation and Containment describes how excavations will be performed in a manner to capture and contain potentially mine-affected surface water. Appendix E – Water Management Ponds describes how the pits and temporary surface water impoundments will be used to capture and store mine-affected water. Appendix F – Surface Water and Sediment Controls – provides the analysis and design of the surface water (SW) and sediment controls for post-closure conditions and for temporary channels installed during the RA construction phases. Appendix I – Water Treatment Plant describes how the mine-affected water will be treated and discharged. Appendix J – Influent and Effluent Pipelines describes how the mine affected water will be conveyed to the WTP and how the treated water will be conveyed to the discharge location.
2.3.18 B.iv	Any dewatering or diversion of surface water and groundwater shall be performed in a manner that minimizes the release of sediments to the extent practicable beyond the Work Area and limits harm to	The majority of excavation activities are expected to occur above the water table. If groundwater is encountered or if stormwater accumulates in the excavations, the water will be contained and transferred to temporary surface water impoundments (as described in this Appendix E) and ultimately treated at the WTP. All sediments potentially contaminated by Site COCs will be captured and consolidated in the pits with the mining

Table E-1 – Performance Standards Applicable to Temporary Storage Ponds

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Performance Standard No. in CD SOW	Performance Standard	Comments
	wetlands and surface water.	wastes. The surface water and sediment control structures to be constructed in the excavation areas are described in Appendix F. Sediment migration in the remediated areas will be managed in accordance with the Master SWMP (Appendix O).
2.3.24	All water requiring treatment shall be conveyed to and treated at the water treatment plant operating at the time of conveyance.	**Surface Water** – During the RA, surface water that contacts mine wastes will drain to the mine pits or temporary surface water impoundments (described in this Appendix E) that will store the mine-impacted water. The water in the impoundments will be conveyed to the operating WTP via conveyance channels and pipelines. The topography of the reclaimed areas will shed clean water away from any wastes that are pending excavation (i.e., during the phased RA construction activities), and away from the consolidated wastes (upon remedy complete). **Groundwater** – During the RA, groundwater discharging from seeps in the mine wastes will be captured and conveyed the temporary surface water impoundments (described in this Appendix E), and ultimately treated by the operating WTP. Groundwater that accumulates in the consolidated wastes in the pits and BPA will be captured by groundwater extraction wells, and treated at the WTP. These details are described in the following design appendices: Appendix D – Mine Waste Excavation and Containment describes how excavation of mine waste will occur such that potentially mine-impacted surface water is contained within the excavations and transferred to the impoundments. Appendix E – Water Management Ponds describes how the mine pits and temporary impoundments will be used to capture and store potentially mine-impacted water. Appendix F – Surface Water and Sediment Controls describes the temporary and permanent structures that will convey surface water and control sediments. Appendix J - Influent and Effluent Pipelines describes how mine-affected water will be conveyed to the storage ponds, to the operating WTP, and discharged from the WTP through the effluent pipeline to Lake Roosevelt.
2.4.2.3 B. Surface Water and Stormwater Management and Controls During Excavation		
2.4.2.3.2 B.v.	The Settling Defendants shall develop a monitoring program to ensure that the concentrations of	To the extent practicable, all surface water that contacts mining wastes within the MA will continue to be captured during the RA activities and conveyed to the operating WTP. These details are described in Appendix D – Mine

Table E-1 – Performance Standards Applicable to Temporary Storage Ponds

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Performance Standard No. in CD SOW	Performance Standard	Comments
	contaminants in surface water leaving the MA are below those listed in Table 4-3. If concentrations are greater than those listed in Table 4-3, the water shall be collected and conveyed to the water treatment plant for treatment.	Waste Excavation and Containment, in this Appendix E – Water Management Ponds, Appendix F – Surface Water and Sediment Controls. and Appendix J – Influent and Effluent Pipelines, However, as noted in the ROD, achievement of the surface water cleanup levels down gradient of the MA will require a period for natural attenuation to occur after the remedy is completed. Therefore, the design does not include provisions to capture and treat surface water down gradient of the MA. The Site-Wide Monitoring Plan (SMP) in Appendix Q defines the monitoring program that will be implemented both during and following the RA to evaluate contaminant concentrations in surface water down gradient of the MA. The SMP defines the action levels that will be used during the RA to evaluate if mine-related contaminants are being released to surface water as a result of the RA activities. The SMP also describes how surface water will be monitored following the RA for comparison with the cleanup levels listed on Table 4-3.
2.4.2.4 A. Temporary Facilities during Construction Activities		
2.4.2.4.2 A.	During performance of the Pits 3 and 4 Component of Work, temporary facilities, such as covers, runoff controls, temporary sumps, and water capture and removal systems, shall be provided, as determined in the SWMP and RD. Water requiring treatment shall be conveyed as soon as practicable to the WTP for storage and treatment.	Design sections contained in this Appendix E (Water Management Ponds), Appendix F (Surface Water and Sediment Controls), Appendix J (Influent and Effluent Pipelines); and the associated design drawings in sections 5, 6, and 10 of Volume II describe/illustrate how surface water and impacted site water will be managed upon completion of each major phase of construction. Water will be transferred to the WTP as soon as practicable in order to maintain capacity in the impoundments for future storm events. In addition, the Master SWMP included in Appendix O describes the over-arching framework for how stormwater and surface water will be managed to limit the release of sediment, pollutants, and deleterious debris to downstream areas during RAs.
2.4.2.4.2 C.iv.	Contaminated surface water shall be captured and treated in the WTP.	Excavation activities will be performed such that drainage patterns are maintained to shed potentially contaminated surface water to diversion channels and temporary impoundments (described in this Appendix E), and ultimately to the operating WTP. Appendix D (Mine Waste Excavation and Containment) describes the excavation activities. Appendix F - Surface Water and Sediment Controls contains text, calculations, and references drawings in Volume II that show the

Table E-1 – Performance Standards Applicable to Temporary Storage Ponds

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Performance Standard No. in CD SOW	Performance Standard	Comments
.		temporary engineering controls (e.g., temporary drainage channels) that will be constructed to capture and convey contaminated water to the Water Management Ponds described in this Appendix E. Water from these ponds will be conveyed to the WTP for treatment.
2.4.3.3 Water Collection and Conveyance Work Component		
2.4.3.3.2 A.	All water requiring treatment, as described both above in this table and in this Component of Work, shall be collected and then conveyed to and treated at the WTP operating at the time of conveyance.	The temporary water management ponds described in this appendix will be used to store potentially mine-impacted water. This water will be conveyed to these impoundments and then to/from the operating WTP as described in Appendix J – Influent and Effluent Pipelines.
2.4.3.4 Water Storage and Treatment Work Component		
2.4.3.4.2 B.	Water treatment shall minimize the need for water storage, as determined during RD.	Water storage ponds for attenuation of peak flows will be required during RA construction and for some period of time after construction while the hydrologic system equilibrates to the remediated configuration. Sizing of these temporary storage ponds are discussed in Attachment E-1 to this Appendix. The impacts of WTP flow capacity on the required water storage during construction are also discussed in Attachment E-1.

E3.0 DESIGN CRITERIA

E3.1 STORAGE CAPACITY CRITERIA

As part of the RA, a new WTP has been proposed with the ability to operate year-round at a maximum average daily rate of 500 gallons per minute (gpm). Prior to the start of Phase 2 construction when mine-impacted water will be stored in the South Pond, either the new WTP will be operating, or the existing WTP will be winterized so that storage of water during a winter shutdown period will not be necessary. This will significantly reduce the peak volume of water stored at the Site from the levels currently reporting to the WMS. However, even with continuous operation of either the existing or the new WTP, some storage capacity will be required for Site water during RA construction when inflows temporarily exceed WTP capacity.

In addition, it is necessary to provide storage for impacted waters collected during maintenance or unscheduled WTP shutdowns.

In order to provide a high degree of confidence that sufficient storage capacity exists to accommodate mine-impacted waters during RA construction activities, the water management ponds have been sized to accommodate:

1) The 100-year peak storage event. Based upon analysis of historical records, these peak storage events are associated with wet periods during winter and early springtime.
2) Storage that would be required if the WTP experienced a complete shutdown and was inoperable for six weeks during the peak storage event (Item #1 above).

The water balance calculations presented in Attachment E-1 discuss these design criteria and their implications for water storage requirements. The assumption of a catastrophic six-week shutdown period is considered to be an extreme event scenario. Although it is highly unlikely that this would occur during the 100-year peak storage period, this level of conservatism provides a high degree of confidence in the estimated storage volumes presented in this appendix.

E3.2 SLOPE STABILITY CRITERIA

In addition to meeting the performance standards listed in Section E.2, the South Pond will be designed in substantive compliance with criteria from the Washington State Department of Ecology (WSDE) Dam Safety Program to the extent that they are applicable to a synthetically-lined storage pond, which intermittently impounds water. Regulations governing jurisdictional dams are provided at: http://www.ecy.wa.gov/programs/wr/dams/Regulations.html. Engineering guidance for design and construction are outlined in guidance documents which are available for download at: http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs.html.

Under the WSDE Dam Safety Program rules, both the proposed South and West Ponds will be considered large, high-hazard structures. Both ponds, as currently designed, will have maximum embankment heights of 50 feet or more. Although no permanently inhabited structures exist downstream, a release of the impounded water to downstream areas could result in significant economic and environmental damage. In addition, the CD SOW presents guidance on factors of safety for geotechnical stability.

Specifically, the required minimum factors of safety against slope failure presented in Table E-2 were used in the evaluation of slope stability analysis results discussed in Attachment E-2 and E-4.

Table E-2 – Design Criteria – Minimum Required Factors of Safety for Stability Analyses

Condition	Minimum Factor of Safety from Consent Decree	Minimum Factor of Safety based upon Dam Safety Guidelines	Minimum Factor of Safety Selected for Design
Static	1.3	1.5	1.5
Pseudostatic	1.0	1.0 to 1.1	1.1
Post-seismic Stability	N/A	1.0 to 1.1	1.1

E3.3 ADDITIONAL DESIGN CRITERIA

Additional design criteria needed to substantially comply with requirements of the WSDE Dam Safety Program, including emergency overflow spillway capacity and freeboard requirements for flood routing during extreme precipitation events have been considered in design of the pond configurations and accounted for when making capacity calculations. In accordance with WSDE requirements, an emergency overflow spillway capable of passing water flows associated with the 10,000 year storm was considered in the design of the South and West Ponds. The intent is to provide assurance, in the extremely unlikely precipitation scenario which results in the ponds being overtopped, that the overflows occur in controlled locations such that a breach of the ponds within the impoundment will not occur and release stored water.

The emergency overflow spillway configurations shown for the South Pond and West Pond design drawings are open-channel-type spillways with 5-foot-deep trapezoidal sections and a 10-foot bottom width. The South Pond is an off-channel impoundment and will have a relatively small contributing area reporting to it during most of Phase 2 construction. Although the West Pond is situated in-channel in the Western Drainage, clean runoff from the Pit 4 cover and other upland areas will be diverted around the West Pond via the West Pond Diversion Channel and the West Pond Diversion Berm as shown on Drawing 6-4 and described in Appendix F. These upland diversions have been designed in accordance with criteria specified in the CD SOW such that they can convey storm flows associated with the 100-year storm event without suffering damage, and have the capacity to convey the 500-year storm event without

overtopping. As a result, although the West Pond will be an in-channel impoundment, it also will have a relatively small contributing area under all but the most extreme storm events.

Since the West Pond emergency overflow spillway is designed for an extremely large storm event (approximately the 10,000 year storm), it was conservatively assumed that the clean water diversion channel and berm will not be functional and all upland water will report to the West Pond. Although the designed spillway dimensions are not needed to satisfy hydraulic requirements to pass design flows, WSDE also requires a minimum spillway depth of 5 feet to provide a minimum embankment freeboard of 5 feet above the spillway invert for a high-hazard dam. Likewise, a spillway bottom width of 10 feet is not required to pass design flows, but was selected based upon constructability considerations assuming the spillway excavation will be performed using a medium-sized (e.g. Caterpillar D-8 or D-9) dozer.

E4.0 ENGINEERING DESIGN DRAWINGS

The engineering design drawings are contained in Volume II of the BODR. The drawings related to Storage Ponds include:

Table E-3 –Design Drawings – Section 5, Water Management Ponds

Sheet Number	Description
5-1	Storage Ponds General Layout
5-2	South Pond Grading Plan
5-3	South Pond Sump Plan
5-4	South Pond Sections
5-5	South Pond Emergency Spillway Grading Plan
5-6	South Pond Emergency Spillway Profile
5-7	West Pond Grading Plan
5-8	West Pond Sump Plan
5-9	West Pond Sections
5-10	West Pond Emergency Spillway Grading Plan
5-11	West Pond Emergency Spillway Profile
5-12	Typical Detail and Section (1 of 4)
5-13	Typical Detail and Section (2 of 4)
5-14	Typical Detail and Section (3 of 4)
5-15	Typical Detail and Section (4 of 4)
5-16	South Pond Details (1 of 4)
5-17	South Pond Details (2 of 4)
5-18	South Pond Details (3 of 4)
5-19	South Pond Details (4 of 4)
5-20	West Pond Details (1 of 3)
5-21	West Pond Details (2 of 3)
5-22	West Pond Details (3 of 3)

E5.0 STORAGE POND DESIGN CRITERIA AND FINDINGS

Below design criteria and findings for each of the proposed water management ponds are discussed. These discussions include the following elements:

- Pond Location
- Pond Storage Requirements
- Pond Configuration and Capacity
- Stability
- Construction Details
- Operational Considerations

E5.1 SOUTH POND

The proposed location of the temporary South Pond is shown on Drawing 5-1 and Drawing 5-2. The South Pond will be used for water storage during the Phase 2 construction (possibly 5

years). The configuration of the South Pond is shown in plan view on Drawing 5-2 and sections are included on Drawing 5-4. Although seepage from this area is currently being collected in the Pollution Control Pond (PCP) (where it is collected, transferred to Pit 3, then pumped to the WTP for treatment), the South Pond will be constructed as a synthetically lined pond with double containment and leak detection. The liner system will significantly reduce the potential for increasing the saturation levels of the waste rock and foundation soils that could result in reduced embankment stability.

E5.1.1 South Pond Storage Requirements

The results of water balance analyses performed to estimate the storage required during the 5 years of Phase 2 of construction when the South Pond will be operational are included in Attachment E-1. A schematic of the WMS, showing flow components considered in the Phase 2 water balance analyses is included as Figure E-3. With the exception that Pit 3 will no longer be available for water storage, the flow components are very similar to those shown on Figure E-2 for Phase 1. These flow components and the water balance analyses are discussed in greater detail in Attachment E-1. The water balance analyses indicate that approximately 59,100,000 gallons of pond volume is needed to provide storage during the 100-year wet period, assuming that the WTP is inoperable for six weeks during the peak pond inflow period. The water balance analyses also indicate that under normal operating conditions, the pond will contain very small volumes of water. If the plant is operational during the 100-year wet period, less than half of the South Pond capacity (23,400,000 gallons) would be utilized.

E5.1.2 South Pond Configuration and Capacity

The South Pond is shown on Drawings 5-1 through 5-6. The pond will be constructed by excavating waste rock from the SWRP to a crest elevation of 2,683 ft. The South Pond configuration includes an emergency overflow spillway on the east side of the pond as shown on Drawing 5-2. Assessment of the design storm used and estimation of design flows for the emergency overflow spillway design followed WSDE Dam Safety guidelines and are provided in Attachments E-8 and E9, respectively. The design calculations for the spillway are provided in Attachment E-10. The emergency overflow spillway is an open-channel-type spillway with an invert elevation at elevation 2,678 ft and a trapezoidal cross-section with a depth of 5 ft (as required by WSDE) and a bottom width of 10 ft as shown on Drawing 5-15.

The pond will include a divider berm in the pond bottom at elevation 2,636 ft that effectively forms two cells at low-water levels, allowing for maintenance of the pond while still maintaining

the ability to operate in the other cell. The pond bottom in each cell will be sloped toward sumps areas, with sump bottoms located at elevation 2,619 ft and 2,620 ft for the east and west sumps, respectively. Figure E-6 depicts the stage-storage curve for the South Pond (shown on Drawings 5-1 thru 5-4) and illustrates that:

- The "maximum capacity" (defined by WSDE as the storage capacity at the embankment crest) for the configuration of the South Pond as designed is 80.3 million gallons (Mgal).
- The available capacity at the spillway inlet level located 5 feet below the crest is 66.9 Mgal.
- The effective storage volume of the South Pond is 63.8 Mgal assuming that 3.1 Mgal of dead storage (corresponding to a pond elevation of 2,633 ft or a minimum pool depth of 14 feet) will be maintained in the pond bottom to accommodate variations in operational flows and to provide ballast to prevent liner lift-out during high wind events. Calculations were performed to estimate makeup water quantities needed to offset evaporation losses and maintain dead storage. These calculations indicate that estimated low flows from the WMS during Phase 2 of construction will be sufficient to maintain the water levels needed for dead storage in the South Pond. These calculations were submitted as an interim submittal to EPA on April 30, 2014 and are included as Attachment E-7.

Thus, the capacity of the current South Pond configuration shown in the figure is greater than needed to achieve the design criteria of 59.1 Mgal.

E5.1.3 South Pond Stability

The input parameters and procedures used for, and results of slope stability analyses are presented in detail in Attachment E-2. Safety-factor calculations against slope failure were made for deeper-seated failures that had the potential to break back to within 20 feet of the pond crest. Potential shallow failure surfaces, especially in the steeper portion of the lower SWRP slope would have lower factors of safety, but would not impact the South Pond at the proposed setback from the SWRP crest shown on Drawing 5-2. Post-earthquake analyses using post-seismic strength parameters to represent loose, saturated materials were performed for Cross Section 1 in Attachment E-2 as this was the only location where a significant amount of this type of material exists at the waste rock foundation contact. The results of the stability analyses are summarized in Table E-4. These results show that the minimum factor-of-safety

design criteria for slope stability presented in Table E-2 are met in all cases for the proposed South Pond configuration.

Table E-4 – South Pond Factors of Safety for Against Deep-Seated Slope Failures

	Factor of Safety (FOS)					
	Static 1.5 Minimum FOS		Pseudo-Static 1.1 Minimum FOS		Post-Earthquake 1.1 Minimum FOS	
Failure Surface	**Circular**	**Wedge**	**Circular**	**Wedge**	**Circular**	**Wedge**
Cross-Section 1	1.6	1.8	1.1	1.1	1.2	1.2
Cross-Section 2	1.5	1.8	1.2	1.4	n/a	n/a
Cross-Section 3	2.0	2.3	1.5	1.6	n/a	n/a

E5.1.4 South Pond Construction Details

Design details for the South Pond are included on Drawings 5-3 to 5-6 and 5-12 to 5-19. It is proposed that the South Pond be constructed immediately upslope from the PCP by excavating into the SWRP waste. Prior to excavation of the South Pond, existing Ore and Protore Piles 5 and 8 will be removed from the SWRP surface in the South Pond area and placed in Pit 4 as part of Phase 1 construction. After removal of the Protore in this area, additional excavation of SWRP material to depths of up to 70 feet will occur to create the pond. This will result in significant unloading of the waste rock and foundation soils in the South Pond area.

The South Pond will be a double-lined with leak detection between the primary and secondary geomembranes. The primary liner will consist of a textured 60-mil high density polyethylene (HDPE) geomembrane overlying a synthetic geonet leak detection layer. The leak detection layer will overlie a secondary liner constructed of a second HDPE geomembrane liner. Drawing 5-12 depicts typical construction details for this liner system. In order to comply with WSDE Dam Safety guidelines, the South Pond will include and emergency overflow spillway configured as shown on Drawing 5-2. Calculations associated with the spillway design are included as Attachments E-9, E-10, and E-11.

As discussed in Sections E5.1.1 and E5.1.2, the South Pond will contain very little water beyond the 14 feet of water maintained for liner ballast in each cell for most years when the WTP is operating normally. Under these low-water operating conditions, wind uplift and anchor trench capacity can become a concern. In order to address this concern, evaluations were conducted

of the anchor trench capacity for the anchor trench configuration shown on Drawing 5-12, and of potential wind uplift for both construction and low-water (dead-storage pool) conditions. The analysis of anchor trench capacity is summarized in Attachment E-5 and the wind uplift analysis is summarized in Attachment E-6.

These analyses indicate the proposed anchor trench design is more than adequate, and the proposed 60-mil HDPE primary (upper) geomembrane has adequate strength to withstand stresses induced by wind uplift. Although not accounted for in the design calculations, suction vents are included in the design as shown on Drawing 5-14 to reduce uplift stresses on the primary geomembrane liner due to wind-induced suction and/or high air temperatures developing in the leak detection layer. In addition, ballast in the form of sand-filled HDPE piping placed in the corners of the ponds is included in the design details to reduce the potential for uplift, curve reversal, and excessive flexure at these critical locations. Details for the in-pond ballasts are provided on Drawing 5-14. Due to the relatively short anticipated life of the South Pond (approximately 5 years), additional protection for the HDPE geomembrane systems is not warranted.

E5.1.5 South Pond Operational Considerations

The South Pond will be used for water storage during the 5-year Phase 2 construction period. During Phase 2, water from the South Pond will be transferred to the WTP, treated, and either discharged to Lake Roosevelt via the Blue Creek pipeline, or used for construction water as needed for construction as described in the Water Source Identification and Development Plan (Appendix T). Analyses were performed of potential scenarios for storing some portion of impacted water during the spring inflow season for later use as on-Site construction water during drier parts of the year. These analyses and their results are provided in Attachment E-1.

The results indicate that on-Site construction water during Phase 2 can be supplied by WTP effluent if sufficient impacted water from the spring meltoff is stored in the South Pond prior to beginning of the dry-season. Storage of impacted water for later treatment and use during the dry-season construction will not affect the required active storage capacity of the ponds since the water levels within the pond will be reduced to dead storage levels prior to the onset of the next late winter/early spring high flow period.

Action leakage rates through the primary liner for the South Pond during operation were proposed in an interim submittal to the EPA (MWH, 2014). A four-level system for action

leakage rates and appropriate responses were proposed based upon a review of standards of practice as defined by existing state regulations across the United States regarding action leakage rates from surface impoundments, with particular emphasis placed on impoundments containing mine-impacted waters or constructed for groundwater protection. The four levels, based upon leakage rates measured in individual leak detection sumps, are:

- Level 1 Operating Leakage Rate (OLR) : <20 gallons per acre per day (gpad)
- Level 2 Increased Leakage Monitoring and Reporting (MR): >20 gpad, but <200 gpad
- Level 3 Leak Investigation and Action Plan (LIAP): >200 gpad, but <500 gpad and enhanced inspection of downstream slopes of embankments for signs of saturations or seepage.
- Level 4 Immediate Response Level (IRL): >500 gpad. Immediately implement enhanced inspection of downstream slopes of embankments for signs of saturation or seepage, determine the source of leakage, and prepare work plans and repair the pond, as needed.

Additional discussion and information regarding the operation, maintenance, and monitoring of the West Pond is provided in Appendix P.

E5.2 WEST POND

The location proposed West Pond is shown on Drawing 5-1 and Drawing 5-7. The West Pond will be used for water storage beginning in Phase 3 of the RA and remain operational until post-RA water management flows subside to the point where the equalization ponds adjacent to the new WTP provide sufficient storage for the overall WMS. The configuration of the West Pond is shown in plan view on Drawing 5-7 and sections are shown on Drawing 5-9. The West Pond will be a double-lined pond with leak detection as discussed above for the South Pond in Section E5.1.4. The West Pond will include and emergency overflow spillway configured as shown on Drawing 5-7 and designed in accordance with WSDE Dam Safety guidelines. Calculations associated with the spillway design are included as Attachments E-9, E-10, and E-11.

The West Pond Diversion Channel will be constructed to route clean surface water flow from upstream areas in the Western Drainage around the east side of the West Pond and route it to the West Pond emergency spillway, as shown on Drawing 5-7. This diversion channel has

been designed and sized to convey flows up to, and including those associated with the 500-year, 24-hour storm event and is described in Appendix F. The West Pond Diversion Berm also will be constructed uphill and to the north and west of the West Pond. This diversion berm will divert clean surface water flows to the south of the West Pond and into the lower Western Drainage. This berm is shown on Drawing 6-4 and described in Appendix F.

An emergency overflow spillway is included in the West Pond embankment at the left abutment (i.e. the contact of the embankment crest with the east slope of the Western Drainage).

E5.2.1 West Pond Storage Requirements

Water balance analyses were performed to estimate the storage required during the years when the West Pond is operational (assumed to be 10 to 15 years) and are described in detail in Attachment E-1. A schematic of the WMS at the start of Phase 3 construction, which represents the period of maximum flow to the West Pond, is shown on Figure E-4. A schematic of the WMS upon decommissioning of the West Pond is shown on Figure E-5. The flow components at these two stages are described in detail in Attachment E-1.

Operation of the West Pond is expected to be approximately 10 to 15 years. However, there is a potential that the West Pond or some other water storage mechanism will be needed more than 15 years after completion of RA construction. The West Pond is designed to be in substantive compliance with WSDE Dam Safety Guidelines which were been developed for permanent water retention structures. As such, there is nothing inherent in the design that would limit the life span of the West Pond to 15 years if it is necessary to keep it in service for a longer period of time. Regardless, if it appears that flows are stabilizing at a rate greater than 50 gpm and the WTP equalization ponds will not be able to provide sufficient contingency storage, other longer-term storage measures will have to be considered.

The water balance analyses for the West Pond indicate that approximately 22,100,000 gallons of storage volume will be needed at the start of Phase 3 when the West Pond is needed and becomes operational. This volume includes storage of inflow from the 100-year wet period assuming that the WTP is inoperable for six weeks during the peak pond inflow period. After the first few years of operation, when the remaining mine waste in the Central Drainage has been removed, all soil cleanup is completed, and additional stormwater can be shed clean from those remediated areas, the storage volume requirement of the West Pond will decrease. Under typical climate conditions and normal WTP operations, the West Pond will contain very small volumes of water.

E5.2.2 West Pond Configuration and Capacity

The West Pond is shown on Drawings 5-1, and 5-7 through 5-9. The pond will be constructed using an embankment of compacted fill consisting of native soils excavated from the impoundment footprint. The West Pond's embankment crest elevation is 2,660 ft. The design includes an emergency overflow spillway at the left abutment of the embankment as shown on Drawing 5-7. Assessment of the design storm used and estimation of flows for the emergency spillway design followed WSDE Dam Safety guidelines and are provided in Attachments E-8 and E9, respectively. The design calculations for the spillway are provided in Attachment E-10. The emergency overflow spillway will be an open-channel-type spillway, with an invert elevation at elevation 2,655 feet, and a trapezoidal cross-section with a depth of 5 feet (as required by WSDE) and a bottom width of 10 feet as shown on drawing 5-15.

The pond bottom will be sloped toward a sump area, with sump bottom located at elevation 2,605 ft. Figure E-7 depicts the stage-storage curve for the West Pond (shown on Drawings 5-7 through 5-9) and illustrates that:

- The "maximum impoundment capacity" (defined by WSDE as the storage capacity at the embankment crest level) is 32.5 Mgal.
- The available capacity at the spillway inlet level located 5 feet below the crest is 25.4 Mgal.
- The effective storage volume of the West Pond is 24 MGal assuming that 1.4 MGal of dead storage (corresponding to a pond elevation of 2,619 ft, of a minimum pool depth of 14 feet) will be maintained in the pond to accommodate variations in operational flows and provide ballast against liner liftout during high-wind events. Calculations were performed to estimate makeup water quantities needed to offset evaporation losses and maintain dead storage. These calculations indicate that estimated low flows from the WMS during Phase 3 of construction will be sufficient to maintain the water levels needed for dead storage in the West Pond. These calculations were submitted as an interim submittal to EPA on April 30, 2014 and are included as Attachment E-7.

Thus, as depicted in Figure E-7 and the drawings referenced above, the capacity of the West Pond as designed is greater than needed to meet the design criteria of 22.1 MGal.

E5.2.3 West Pond Preliminary Stability

The input parameters and procedures used for, and results of slope stability analyses for the West Pond are presented in Attachment E-4. These analyses were based upon borehole information in the vicinity of the proposed West Pond site (which is currently buried under waste rock of the SWRP), and pre-mine topographic mapping. Safety-factor calculations against slope failure were made for deeper-seated failures that included the pond crest. Post-earthquake analyses using post-seismic strength parameters to represent loose, saturated materials were not performed for the West Pond. This is because any loose, saturated material that might exist within the embankment footprint will be removed and replaced with suitably moisture-conditioned compacted fill during construction.

The results of the stability analyses are summarized in Table E-5. These results show that the minimum factor-of-safety design criteria for slope stability presented in Table E-2 are met in all cases for the proposed West Pond configuration. It is recommended that the assumptions made regarding foundation conditions and embankment and impoundment geometry be reevaluated as waste rock removal exposes the native ground surface during Phase 1 and the early stages of Phase 2 construction.

Table E-5 – West Pond Factors of Safety for Against Deep-Seated Slope Failures

	Factor of Safety (FOS)	
	Static	Pseudostatic
	(1.5 Minimum FOS)	(1.1 Minimum FOS)
Cross-Section 1	1.8	1.4
Cross Section 2	1.8	1.4

E5.2.4 West Pond Construction Details

Design details for the West Pond are included on Drawings 5-8 to 5-15, and 5-20 to 5-22. The West Pond will be constructed by excavating soils from the impoundment area immediately upstream of the West Pond and using them for construction of the West Pond embankment across the Western Drainage. Use of material from the upstream impoundment area as a borrow source will increase the West Pond capacity and reduce the required embankment height and volume.

The West Pond will be synthetically lined with two geomembranes and a leak-detection layer located between the primary and secondary geomembranes. The primary liner will consist of a 60-mil high density polyethylene (HDPE) geomembrane overlying a synthetic geonet leak

detection layer. The leak detection layer will overlie a secondary 60-mil HDPE geomembrane liner. Drawing 5-12 depicts typical construction details for this liner system.

As discussed in Sections E5.2.1 and E5.2.2, the West Pond will contain very little water, beyond the minimum 14 feet of dead storage needed for liner ballast, when the WTP is operating normally. As with the South Pond, wind uplift and anchor trench capacity can become a concern under these low-water conditions. In order to address this concern, evaluations were made of anchor trench capacity for the anchor trench design shown on Drawing 5-12, and of potential wind uplift for both construction and low-water (dead-storage pool) conditions. These anchor trench analyses are summarized in Attachment E-5 and the wind uplift analyses summarized in Attachment E-6.

These analyses indicate the proposed anchor trench design is more than adequate, and the proposed 60-mil HDPE primary (upper) geomembrane has adequate strength to withstand stresses induced by wind uplift. Although not accounted for in the design calculations, suction vents have been included in the design as shown on Drawing 5-14 to reduce uplift stresses on the primary geomembrane liner due to high air temperatures developing in the leak detection layer. In addition, ballast tubes in the form of sand-filled HDPE piping placed in the corners of the ponds is included in the design details to reduce the potential for wind uplift, curve reversal, and excessive flexure at these critical locations. Details of the in-pond ballast tubes are provided on Drawing 5-14. Due to the relatively short anticipated life of the West Pond (approximately 10 to 15 years), additional protection for the HDPE geomembrane systems is not warranted. If the West Pond is required to remain operational significantly longer than anticipated, replacement of the HDPE geomembrane liner system, or possibly even redesign and replacement of the entire West Pond may become necessary.

E5.2.5 West Pond Operational Considerations

The West Pond will be used for water storage during the Phase 3 construction and following the RA while the inflows of mine-affected water stabilize. The period of operation for the West Pond is assumed to be approximately 10 to 15 years. During Phase 3, water from the West Pond will be transferred to the WTP, treated, and either discharged to Lake Roosevelt via the Blue Creek pipeline, or used as needed for construction as described in Appendix T. Analyses were performed of potential scenarios for storing some portion of impacted water during the spring inflow season for later use as on-site construction water during drier parts of the year. These analyses and their results are provided in Attachment E-1.

The results indicate water captured by the WMS during the Phase 3 dry-season construction period will be sufficient to meet construction water needs, and additional storage prior to the onset of the dry season will not be needed during Phase 3.

Action leakage rates through the primary liner for the West Pond during operation were proposed in an interim submittal to the EPA (MWH, 2014). A four-level system for action leakage rates and appropriate responses were proposed based upon a review of standards of practice as defined by existing state regulations regarding allowable leakage rates from surface impoundments, with particular emphasis placed on impoundments containing mine-impacted waters or constructed for groundwater protection. The four levels, based upon leakage rates measured in individual leak detection sumps, are:

- Level 1 Operating Leakage Rate (OLR) : <20 gpad
- Level 2 Increased Leakage Monitoring and Reporting (MR): >20 gpad, but <200 gpad
- Level 3 Leak Investigation and Action Plan (LIAP): >200 gpad, but <500 gpad and enhanced inspection of downstream slopes of embankments for signs of saturations or seepage.
- Level 4 Immediate Response Level (IRL): >500 gpad. Immediately implement enhanced inspection of downstream slopes of embankments for signs of saturations or seepage, determine the source of leakage, and prepare work plans and repair the pond, as needed.

Additional discussion and information regarding the operation, maintenance, and monitoring of the West Pond is provided in Appendix P.

E6.0 GREEN AND SUSTAINABLE REMEDIATION CONSIDERATIONS

Below are green and sustainable remediation (GSR) considerations for Appendix E – Water Management Pond. GSR considerations were evaluated for: 1) Construction Materials (characteristics and manufacturing considerations), 2) Construction Methods, and 3) Low Impact/Sustainability measures undertaken during construction.

E6.1 CONSTRUCTION MATERIAL CONSIDERATIONS

The ponds will be double-lined with a leak detection system. The primary liner material is a 60-mil HDPE geomembrane which is chemically compatible with the pond water and resistant to

punctures and stress/strain conditions. These characteristics and the double-lined design will help ensure the liners viability and protect the environment from release of impacted mine water.

Site grading for these temporary storage ponds will be minimized to the extent possible to reduce the required construction equipment operating time, greenhouse gas emissions, and fill material.

E6.2 CONSTRUCTION METHODS

The construction equipment used for the storage ponds will be appropriately sized to reduce fuel consumption and greenhouse gas emissions, and to minimize stormwater erosion during these activities. Dust suppression also will be conducted in the work areas and on the access roads to decrease visible dust related emissions.

The Stormwater Management Plan (SWMP; included in Appendix O) identifies Best Management Practices (BMPs) and specific sediment control measures that will be employed before, during, and after construction for both sediment and stormwater control. Aspects of these BMPs support the green and sustainable features of the RA by effectively:

- Minimizing the transport of potentially contaminated surface water and sediments from the MA
- Limiting damage to existing vegetation, wetlands, and surface water
- Diverting clean water around and away from the temporary storage ponds and remediation activities (by regrading and contouring the surface, using stormwater control BMPs, and temporary channels) thus preventing its potential contamination
- Segregating contaminated water from clean water to minimize the volume of stormwater requiring treatment at the WTP

All of these activities decrease the impacts of the RA construction on the surrounding environment and serve to limit short-term treatment of potentially contaminated stormwater.

The South Pond will be excavated into the mine wastes of the SWRP, and these materials are scheduled for backfilling into Pit 4. Because this material has to be moved for the RA, the only extra expenditure of resources is in placing and removing the liner when the pond is dismantled at the end of Phase 2 operations. This will save significant fuel and labor expenditures over excavation at an alternative unimpacted location where there would be environmental impacts.

The West Pond will replace the South Pond and clean waters running off remediated areas (e.g., the Pit 4 cover), will be channeled around this pond so that the new WTP only has to treat impacted waters. Construction of the South and West Ponds reduce greenhouse gas emissions by placing these storage areas within the mine area close to the sources of water, and by segregating clean from dirty water so the WTP operations can be reduced.

E6.3 LOW IMPACT DEVELOPMENT/SUSTAINABILITY

A thoughtful approach was taken to determine the volume required for each temporary pond. The storage ponds are a key component to the RA because they have the capacity to store fluctuations in flow from maximum precipitation events, electrical disruptions and/or major equipment malfunctions at the WTP inoperable. Grading will be conducted and channels constructed to divert clean stormwater from entering the ponds and subsequently being treated at the WTP. The SWMP (included in Appendix O) identifies BMPs and specific sediment control measures that will be employed before, during, and after construction for both sediment and storm water control so that contaminated media do not leave the Site during construction. The Surface Water and Sediment Controls described in Appendix F will be used to shed clean water away from contaminated areas thereby reducing the volume of mine-impacted water requiring treatment. In addition, contaminated water will be retained in these double-lined temporary ponds within the contaminated areas, thereby preventing recontamination of remediated areas.

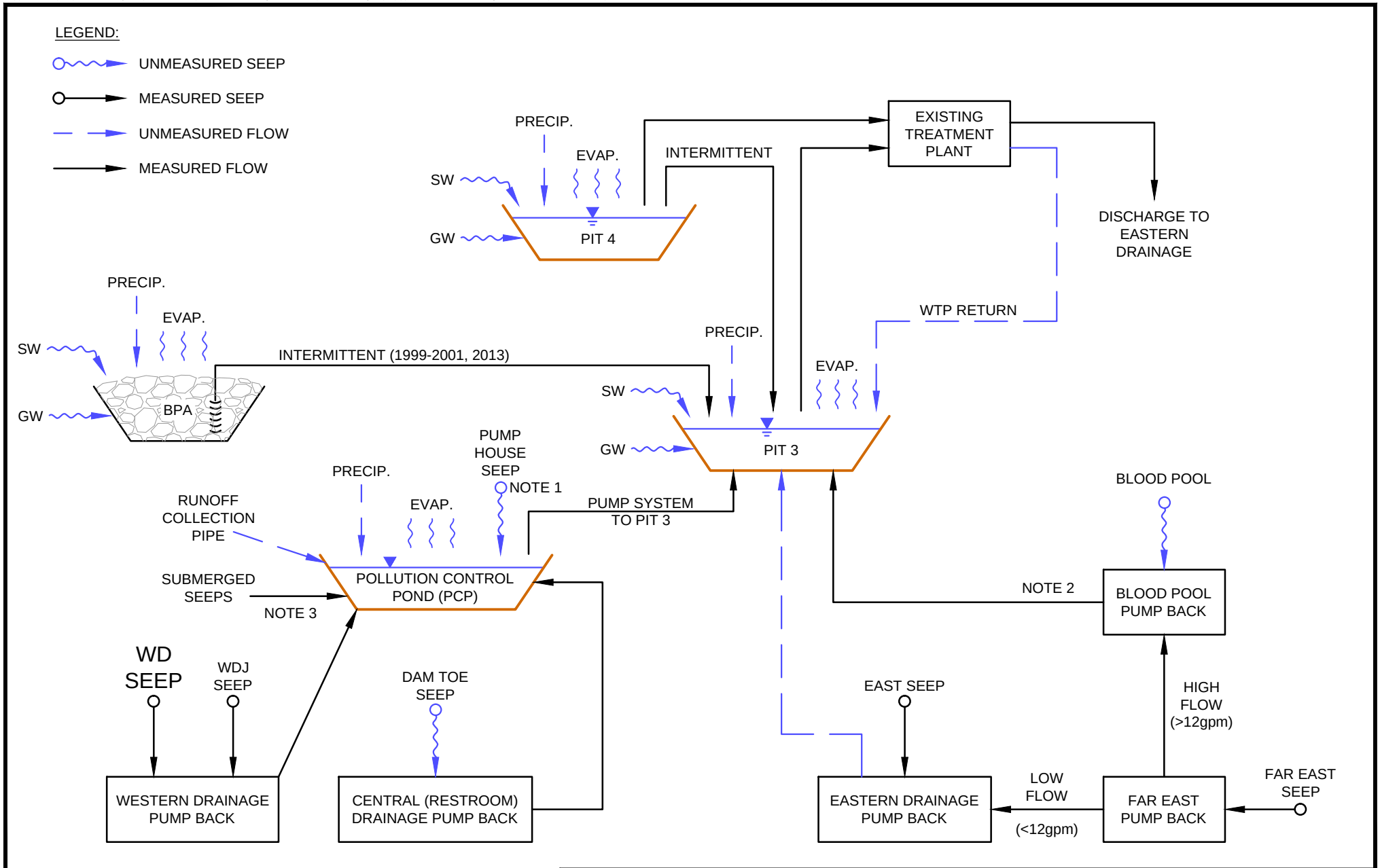
E.7.0 REFERENCES

U.S. Environmental Protection Agency (EPA), 2011. Consent Decree Statement of Work for the Remedial Action for the Midnite Mine Superfund Site, Spokane Indian Reservation, Washington. Civil Action No. CV-05-020-JLQ. United States of America, Plaintiff v. Dawn Mining Company, LLC and Newmont USA Limited, Defendants. August.

MWH Americas, Inc. (MWH), 2014. Technical Memorandum: Midnite Mine, Interim Submittal for 90% Design - Action leakage levels for Water Management Pond Primary Liners, Revision 0. Prepared for Worthington Miller Environmental and Newmont USA Limited. April 7.

Figures

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E – Water Management Ponds\90% Submittal\Att E-1 Water Balance\Schematics\MM_Schematics60%_AppE



NOTES:

1. NOT MEASURED AFTER 2004.
2. NOT MEASURED PRIOR TO 2010.
3. NOT MEASURED PRIOR TO JULY, 2011.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR CURRENT CONDITIONS

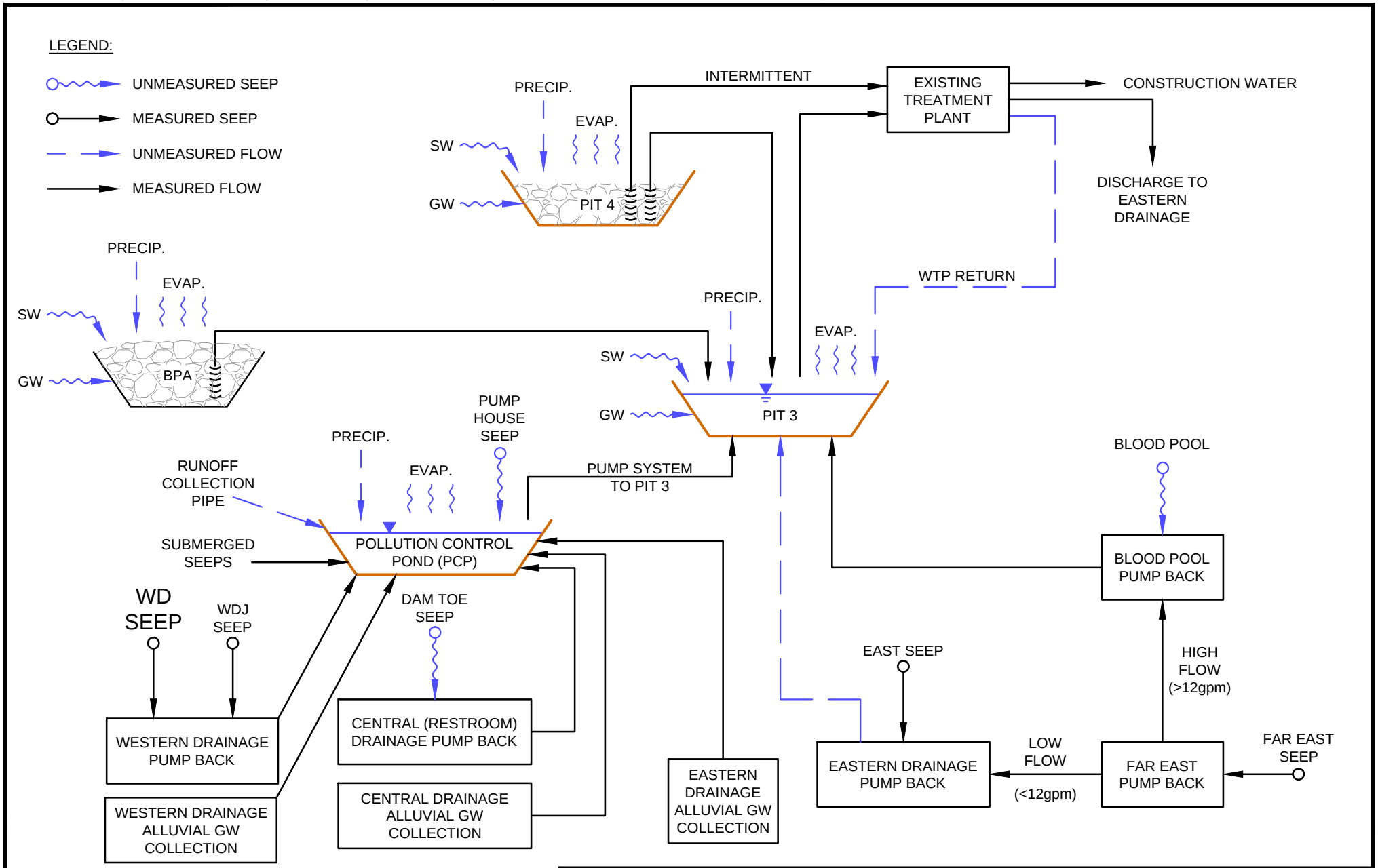
MWH

DATE: JUL 2014

FIGURE E-1

FILE NAME: MM_Schematics60%_AppE

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E – Water Management Ponds\90% Submittal\Att E-1 Water Balance\Schematics\MM_Schematics60%_AppE



NOTE:
1. PIT 4 WILL BE DEWATERED, AND BACKFILLED WITH MINE WASTE IN PHASE 1.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR PHASE 1

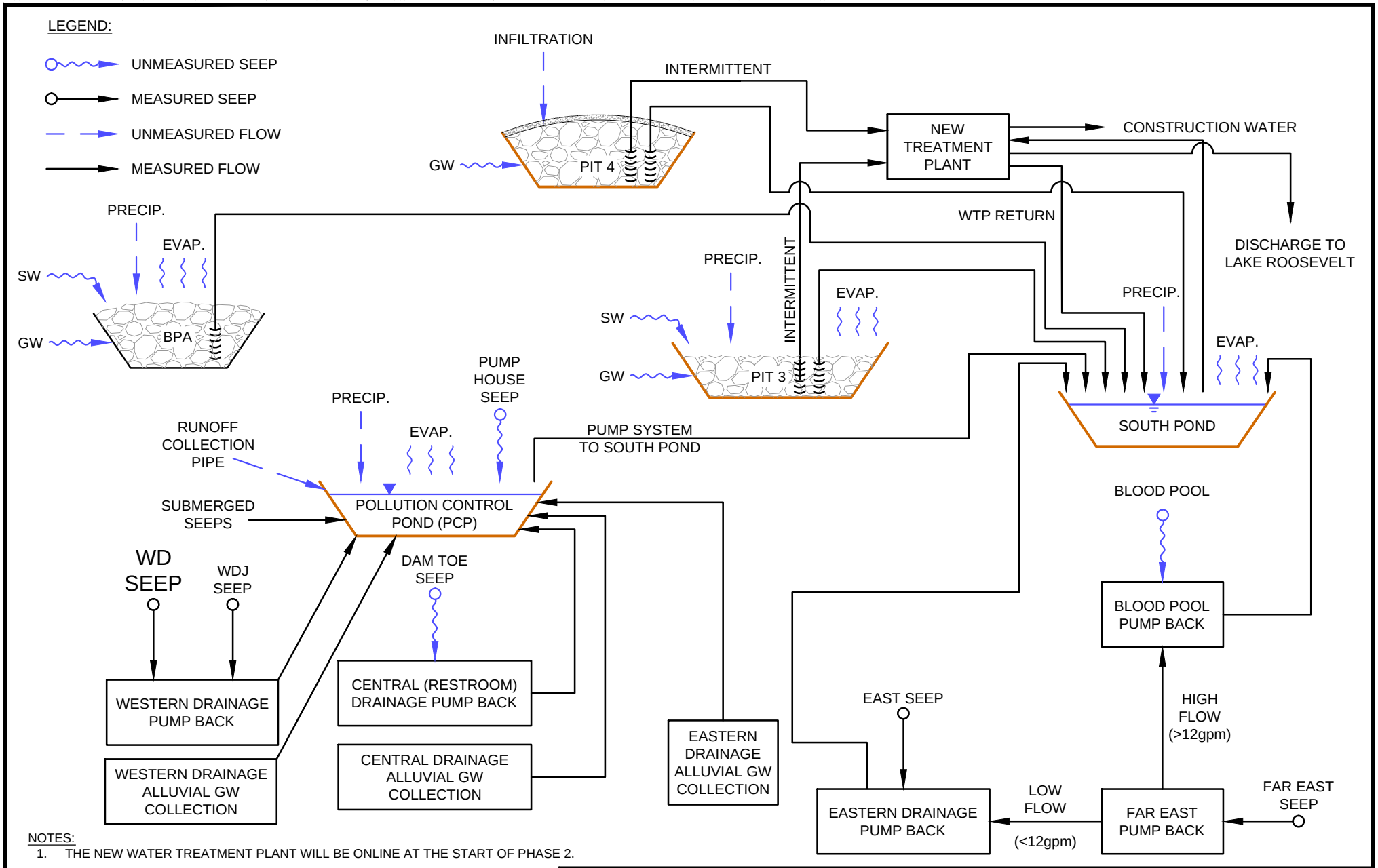
MWH

DATE: JUL 2014

FIGURE E-2

FILE NAME: MM_Schematics60%_AppE

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E – Water Management Ponds\90% Submittal\Att E-1 Water Balance\Schematics\MM_Schematics60%_AppE



NOTES:

1. THE NEW WATER TREATMENT PLANT WILL BE ONLINE AT THE START OF PHASE 2.
2. PIT 4 WILL BE COVERED AT START OF PHASE 2.
3. SOUTH POND WILL BE IN OPERATION AT THE START OF PHASE 2.
4. PIT 3 WILL BE DEWATERED, AND BACKFILLED WITH MINE WASTE IN PHASE 2.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR PHASE 2

MWH

DATE: JUL 2014

FIGURE E-3

FILE NAME: MM_Schematics60%_AppE

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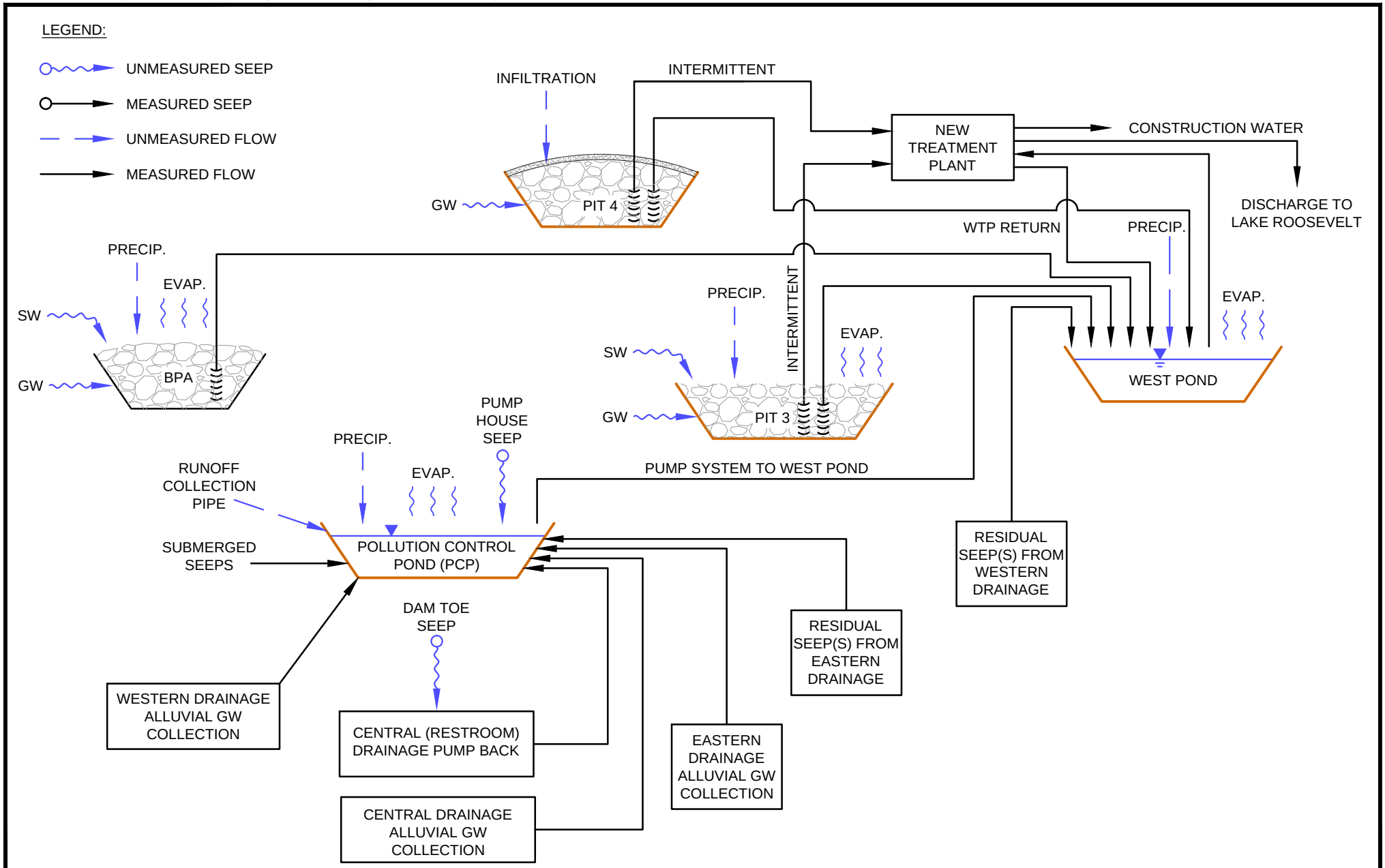


NOTES:

1. SOUTH POND WILL BE DECOMMISSIONED AT START OF PHASE 3.
2. WEST POND WILL BE IN OPERATION AT START OF PHASE 3.
3. PIT 3 WILL CONTINUE TO BE BACKFILLED WITH MINE WASTE IN PHASE 3.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR PHASE 3

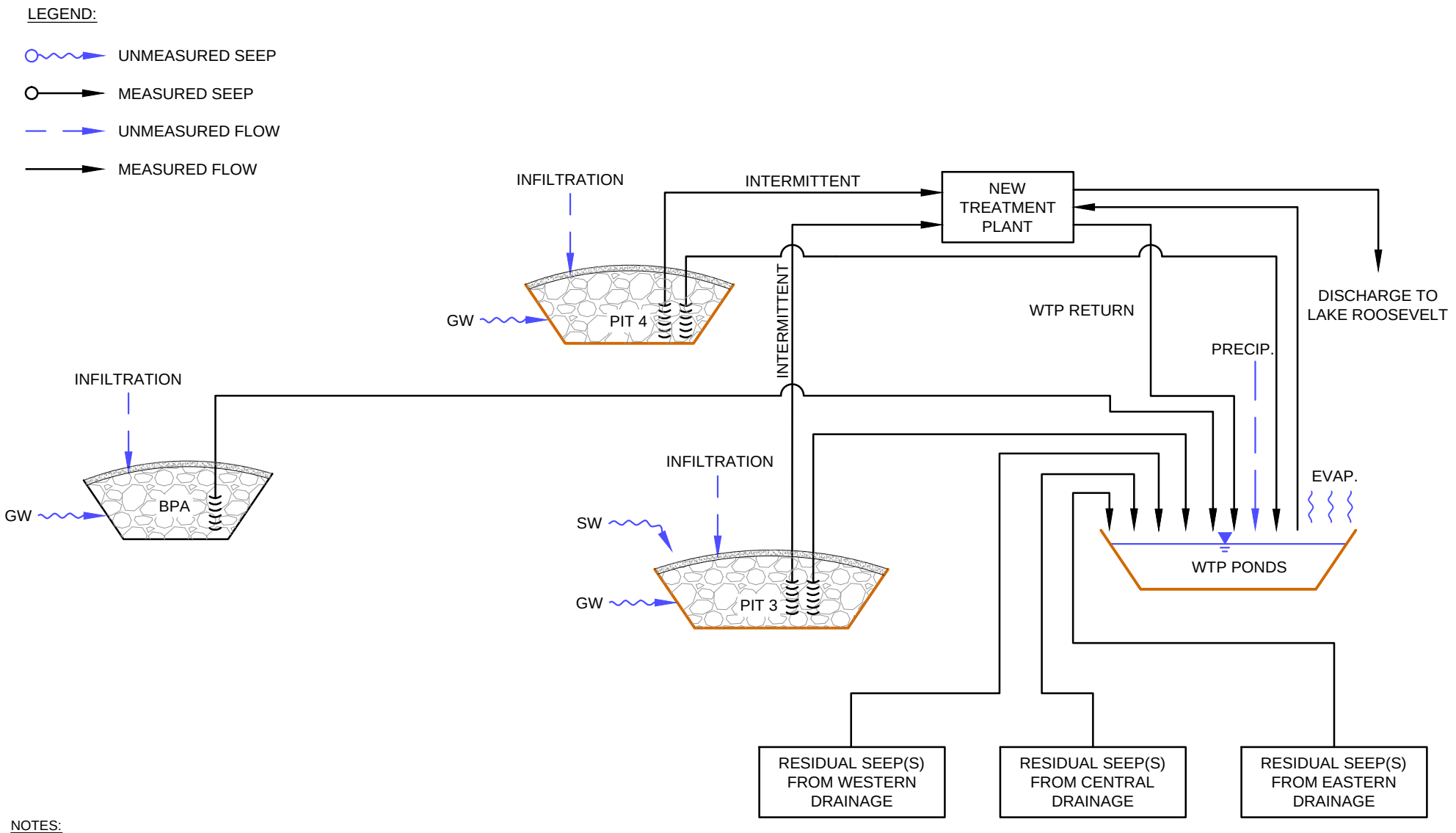
MWH

DATE: JUL 2014

FIGURE E-4

FILE NAME: MM_Schematics60%_AppE

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E – Water Management Ponds\90% Submittal\Att E-1 Water Balance\Schematics\MM_Schematics60%_AppE



NOTES:

1. PCP AND WEST POND WILL BE DECOMMISSIONED AT THE END OF PHASE 3.
2. THE WTP EQUALIZATION PONDS WILL BE USED FOR STORAGE OF IMPACTED WATER.

NEWMONT

PROJECT: MIDNITE MINE

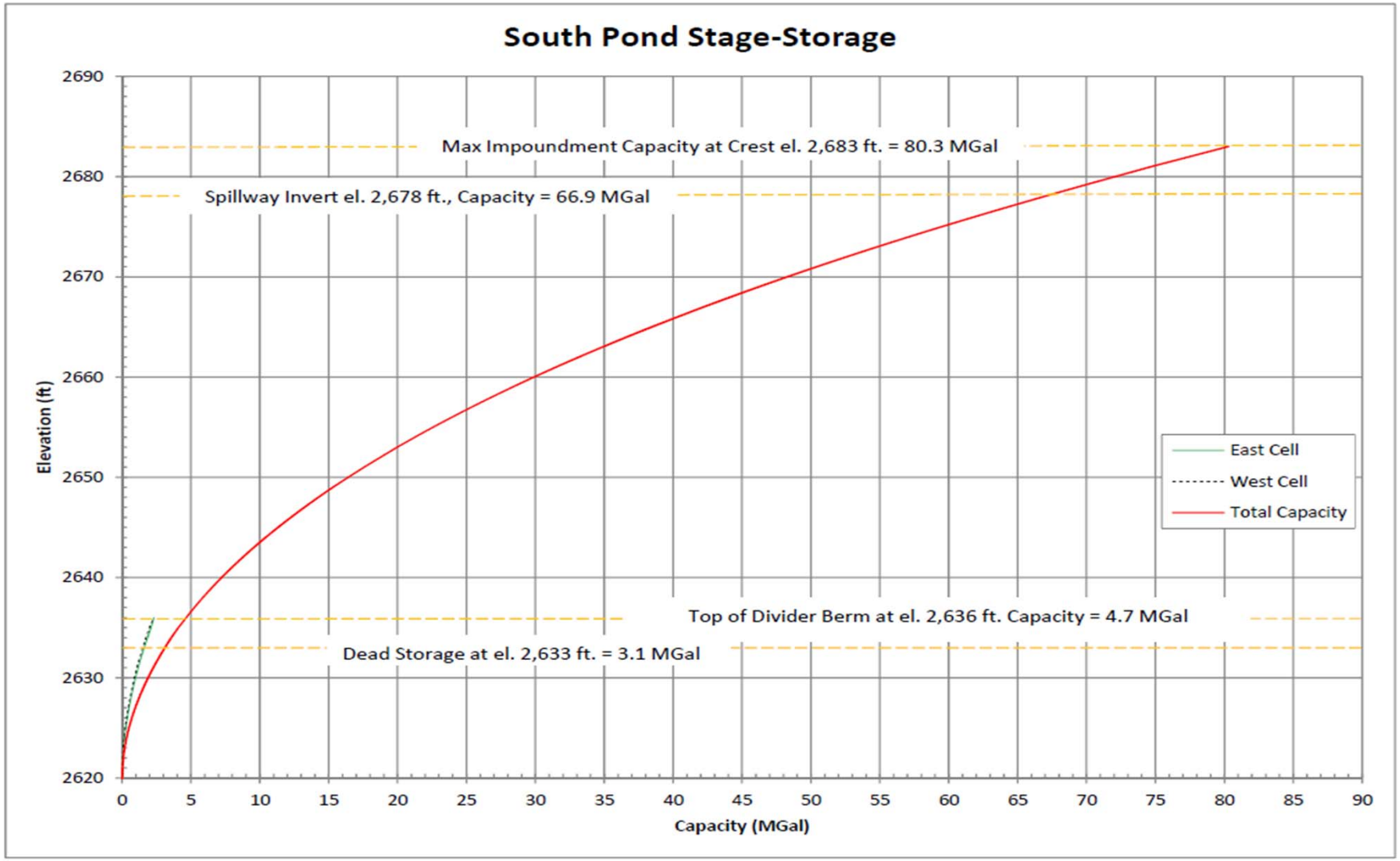
TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR FUTURE CONDTIONS

MWH

DATE: JUL 2014

FIGURE E-5

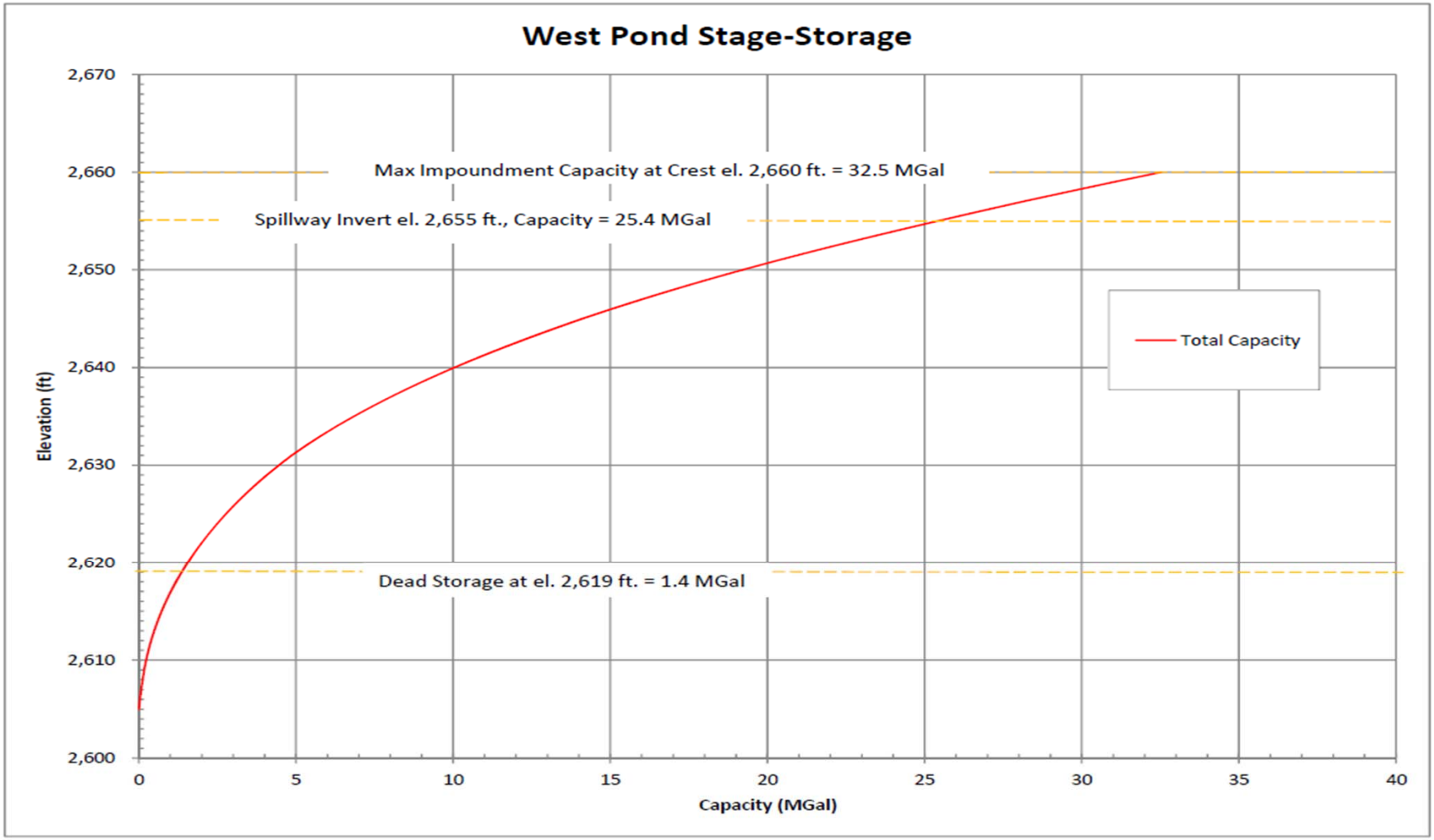
FILE NAME: MM_Schematics60%_AppE



NEWMONT

PROJECT	MIDNITE MINE
TITLE	South Pond Stage-Storage Curve
DATE	July 2014
	FIGURE E-6
FILENAME	Figures 6 & 7.pptx

MWH



NEWMONT

PROJECT: MIDNITE MINE

TITLE: West Pond Stage-Storage Curve

MWH

DATE: July 2014

FIGURE E-7

FILENAME: Figures 6 & 7.pptx

Attachment E-1

Storage Pond Water Balance

ATTACHMENT E-1

MIDNITE MINE REMEDIAL DESIGN STORAGE POND WATER BALANCE

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*08-Dec-12*	*30% Design*	*Tom Kelley*	*Steve McManus*	*08-Dec-12*	*Tom Kelley*
1	*3-Dec-13*	*60% Design*	*Christin Kapatayes/ Zygi Zurakowski*	*Melanie Davis*	*06-Dec-13*	*Tom Kelley*
2	*08-July-14*	*90% Design*	*Christin Kapatayes*	*Melanie Davis*	*20-July-14*	*Tom Kelley*
2	*15-May-15*	*100% Design – no changes*				

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E - Water Management Ponds\90% Submittal\Att E-1 Water Balance

The following calculations were generated using the following software:

Microsoft Office Professional Plus 2010 (Microsoft Excel)
GoldSim Version 10.5, SP3

Supplements

Supplement E-1.1 - Analysis of Storage Under Existing Conditions, 1997 through 2013

Supplement E-1.2 - Analysis of Storage with New Water Treatment Plant

Supplement E-1.3 - Analysis of Alternative WTP Operations
Supplement E-1.4 – Analysis of Phase 2 Construction Water Availability
Supplement E-1.5 – Analysis of Phase 3 Construction Water Availability

1.0 INTRODUCTION

This calculation brief presents the water balance analysis that has been prepared for the Midnite Mine Superfund Site (Site) Remedial Design (RD). The purpose of the water balance analysis is to provide estimates of water storage requirements during various phases of the Remedial Action (RA) so that storage needed during the RA construction can be evaluated and designed early in the Site RD effort.

1.1 BACKGROUND

This water balance was prepared using historical climate data and historical records from the existing water management system (WMS). The water balance model was developed using the commercially available dynamic systems simulation software, GoldSim 10.5 by the GoldSim Technology Group (2011). The site-wide water balance model was developed to assess the WMS for existing site conditions and determine storage capacity requirements at key phases of RA construction activities.

Climate data are available from the Midnite Mine climate station (NWS Station No. 452913). This station is a Remote Automated Weather Station (RAWS) that was installed by the U.S. Department of Interior, Bureau of Land Management in approximately 1990. The period of record for the Midnite Mine climate station is 1991 through 2013 (23 years). Climate data used in the analyses included daily precipitation and daily evaporation from the Midnite Mine RAWS climate station and was obtained from the Western Regional Climate Center (WRCC, 2012). The WRCC manages data for RAWS climate stations for the western United States. Historical records for the WMS operations were obtained from the Dawn Mining Company.

A schematic of the existing WMS at the site is shown on Figure 1. This schematic shows the major sources of impacted water that are collected and transmitted to the existing Water Treatment Plant (WTP). The existing WMS is discussed in more detail below.

1.1.1 Current Water Management and Flow Measurement Systems

In addition to showing the major sources of impacted water at the Site, the Figure 1 schematic also indicates which flows are currently measured, and which flows are being collected, but are not directly measured. The locations of flow meters are shown on Figure 1 and flow meter information is provided in Table 1. Minimum, average, and maximum flow volumes over the peak 6-week time period for key flow components are also shown on Figure 1. Generally, the unmeasured flows at the Site are minor components in terms of their effect on total water storage volumes.

Table 1. List of Flow Meters for Existing WMS

Flow Meter Designation on Figure 1	Flow Meter Name	Comments
1	Western Drainage Seep (WD)	
2	Western Drainage Junior Seep (WDJ)	
3	Pump Green	Totalizing flow meter for flow from Western Drainage Pump Back to PCP
4	Pump Yellow	Totalizing flow meter for flow from Western Drainage Pump Back to PCP
5	Pump Red	Totalizing flow meter for flow from Western Drainage Pump Back to PCP
6	GW-53	Pit 2 BPA pumping well flow meter, intermittent flow measured 1999 - 2000, well abandoned in 2000
7	GW-54	Boyd Pit BPA pumping well flow meter, intermittent flow measured 1999 – 2001 and 2013 - 2014
8	GW-58	Pit 2 BPA replacement pumping well flow meter, intermittent flow measured 2000 - 2001, and 2014
9	Pump House Seep (PHS)	Not measured after 2004
10	Dam Toe Seep (RS)	Flow from Central (Restroom) Drainage Pump Back to PCP
11	PCP-1 (East)	Totalizing flow meter for flow from PCP to Pit 3
12	PCP-2 (West)	Totalizing flow meter for flow from PCP to Pit 3
13	Pit 4 to Pit 3	Intermittent flow
14	Pit 4 to WTP	Totalizing flow meter
15	Pit 3 to WTP	Totalizing flow meter
16	Blood Pool Pump Back	Totalizing flow meter for flow from Blood Pool to Pit 3, not measured prior to 2010
17	East Seep (ES)	
18	WTP Discharge (Effluent)	Totalizing Flow Meter
19	Far East Seep (FES)	Flows greater than 12 gpm are pumped to the Blood Pool Pump Back and flows less than 12 gpm are pumped to the Eastern Drainage Pump Back

The majority of the flow meters at the site are totalizing meters which report the volume of water that has reported through the meter at any given point in time. For the purposes of the water balance analyses, the total volume that has reported through the meters since the previous measurement was is assumed to report on the day of the measurement, rather than assuming the flow is distributed uniformly over the time interval between measurements. Although this treatment of totalizing meter data causes some spikes in estimated storage volume and can result in overestimation of daily flow rates, especially when a large increment of time has elapsed between measurements, it can generally be expected to be slightly conservative as loss terms (e.g. evaporation) from the storage ponds tend to be underestimated.

The components of the existing WMS at the Site include:

1. The Pollution Control Pond (PCP). The PCP is a relatively small (5.9 Mgal), unlined storage pond located below (south) of the toe of the South Waste Rock Pile (SWRP) in the Central Drainage. Impacted water that is intercepted in the Western and Central Drainages is routed to the PCP, from where it is pumped to Pit 3 for storage prior to being transferred to the existing WTP for treatment. The volume of water transferred from the PCP to Pit 3 has been measured on an intermittent (approximately weekly) basis since April 1999 using totalizing flow meters. Water levels in the PCP are not measured and recorded.
2. The Western Drainage, including the Western Drainage (WD) and Western Drainage Junior (WDJ) seeps. These seep flow rates have been monitored on an intermittent (approximately weekly) basis since April 1992. These seeps are collected and pumped to the PCP in the Central Drainage.
3. The Dam Toe Seep. This seep emerges from the toe of the unlined PCP in the Central Drainage, where it is collected and pumped back to the PCP. As such, it is a closed system within the PCP and is not included in the water balance. The pumpback flow rate has been monitored on an intermittent (approximately weekly) basis since April 1992.
4. The Submerged Seep. The pre-mine topography indicates the Central Drainage channel originally bifurcated in the vicinity of the PCP, with the westerly fork extending up into the Backfilled Pit Area (BPA) and the easterly fork extending to the Pit 3 area. This Submerged Seep appears to emanate from the westerly fork of the Central Drainage. Under normal operating water levels, the Submerged Seep emerges below the PCP water surface (in this unlined pond) and the flow rate of this seep is not monitored. However, this flow is indirectly accounted for in that it is a portion of the PCP water that is pumped to Pit 3.
5. The Pumphouse Seep appears to emanate from the easterly fork of the Central Drainage that extends toward the Pit 3 area. The flow rate of this seep is not monitored on a regular basis.
6. Other miscellaneous flows associated with the PCP include precipitation, evaporation, and a surface water runoff collection. These flows are not measured.
7. The East, Far East, and Blood Pool Seeps emerge in the East and Far East Drainages and are pumped directly to Pit 3. The flow rates of the Far East and East Seep are monitored on an irregular basis. The flow rate of the Blood Pool Seep is not monitored.
8. Three wells in the BPA (GW-53, GW-54, and GW-58) were pumped as part of a hydrologic investigation of the BPA in 1999 and 2000. Well GW-53 was abandoned in 2000 and replaced with GW-58. Water extracted from these wells was routed to Pit 3. Although flow rate records were not available for the transfer of water to Pit 3, the total volume of water pumped over the dewatering period is available and was included in the water balance model. BPA dewatering of the Boyd Pit in the BPA (by pumping from well GW-54) was restarted during the summer of 2013 and dewatering of the Pit 2 in the BPA (by pumping from GW-58) was restarted in the spring of 2014 as part of design investigations for the BPA dewatering system and will be continued in the future. Flows measured in 2013 from GW-54 were incorporated into the water balance since these flows were measured during the time period covered by these analyses. Flows measured after 2013 from GW-54 and GW-58 will be incorporated into subsequent updates to the water balance analyses.
9. Pit 3 is the primary water storage unit for the Site. The primary outflow from Pit 3 is due to pumping to the existing WTP. The volume of water in Pit 3 has been recorded by a variety of means.

- The volume of water pumped from Pit 3 to the existing WTP is measured on a daily basis when the WTP is in operation with a totalizing flow meter. The existing WTP typically operates four days per week, between early April and the end of October on any given year, although this schedule varies greatly depending on the volume of water requiring treatment.
- Historically, the water surface elevation in Pit 3 was measured on a daily basis when the existing WTP was in operation using a series of staff gages. However, the rate of water level rise is not available during the winter and early spring period when the WTP is not operating.
- In 2010, a pressure transducer and data recorder were installed to provide water-level data on a more continuous basis. These measured water levels were used in conjunction with LIDAR and bathymetric topographic data obtained as part of the *Survey Design Investigation Report* (Tetra Tech, 2010) to calculate the water storage volumes associated with the pit water level measurements.

10. Other miscellaneous flows contributing to the volume of water in Pit 3 include: direct precipitation, evaporation, surface water run-on, groundwater, and intermittent return water from the existing WTP during startup of operations and plant upset conditions. These flows are not measured.
11. Unlike Pit 3, Pit 4 has not been used to store impacted water collected at other areas on site. Contributions of water to Pit 4 include groundwater flow, surface water run-on, and direct precipitation. These sources are not measured directly. Outflows from Pit 4 include evaporation and pumping to the existing WTP. The volume of water transferred to the existing WTP is measured on a daily basis when the WTP is in operation with a totalizing flow meter. Water from Pit 4 also was pumped intermittently to Pit 3, primarily in 1999, and also in 2010 as part of pit dewatering for hydrologic and pit-bottom sediment investigations.
12. Historically, the water surface elevation in Pit 4 was measured on a daily basis at times when the existing WTP was in operation using a series of staff gages. As with Pit 3, this manual system of water level monitoring was replaced in 2010 with a pressure transducer and data recorder to provide water-level data on a more continuous basis. These measured water levels were used in conjunction with bathymetric data to calculate the water storage volumes associated with the pit water level measurements.
13. The existing WTP receives water from Pit 3 and Pit 4 for treatment and following treatment this water is released into the Eastern Drainage. The plant influent and the effluent to the Eastern Drainage are measured on a daily basis using totalizing flow meters. During startup and during upset periods of plant operation, water is returned to Pit 3 from the existing WTP. The return water flow rate is not measured.

1.1.2 Existing Water Treatment Plant Operating Schedule

The existing WTP typically operates from early April through the end of October each year. During operations, the WTP typically is run for 24-hours/day, four days per week at a maximum average daily flow rate of approximately 500 gpm. The WTP is not operated for the remaining three days per week. The annual WTP shutdown date can vary considerably depending on the volume of water to be treated each year, with final water surface elevations at the end of the treatment season ranging from 2,530 ft. to 2,566 ft. in Pit 3 and from 3,001 ft. to 3,007 ft. in Pit 4. During the winter shutdown period, water inflow to the pits is stored as described in the preceding section until the following spring, when water treatment resumes.

1.1.3 Proposed New Water Treatment Plant

The proposed new WTP will operate year-round and will be capable of treating water 24 hours per day, 7 days per week. The capability of year-round water treatment will significantly reduce the need for storage of impacted Site waters. Although it is assumed in the water balance calculations presented in this appendix that the new WTP will have a capability to treat water at an average daily rate of 500 gpm and operate on a seven-day-per week basis, there will not be sufficient water available to treat at these rates for many parts of the year under typical hydrologic conditions. In addition, as RA construction progresses and sources of impacted water are remediated the total amount of water to be treated will be reduced from currently existing conditions. Thus, WTP operations at 500 gpm under a 24 hour-per-day, 7-day-per-week schedule will not be needed year-round for either currently existing or future conditions. The necessary treatment capacity and storage requirements, once the new WTP is in operation, are discussed in detail in the Section 2.0.

1.1.4 Water Storage Pond Volume Design Criteria

Even with continuous operation of either the existing or the new WTP at an average daily flow rate of 500 gpm, some storage capacity will be required for Site water under existing hydrologic conditions and during RA construction when inflows may temporarily exceed WTP capacity. In addition, it is necessary to provide storage for impacted waters collected during maintenance or unscheduled plant shutdowns.

In order to provide a high degree of confidence that sufficient storage capacity exists to accommodate impacted Site waters during RA construction activities, the water management ponds (also known as the storage ponds) have been sized to accommodate:

1. The 100-year peak storage event. Based upon analysis of historical records, these peak storage events are associated with wet periods during winter and early springtime.
2. Additional storage that would be required if the WTP experienced a complete shutdown and was inoperable for six weeks during the peak storage period.

The assumption of a catastrophic six-week shutdown period is considered to be a worst-case scenario. Although it is highly unlikely that this would occur during the 100-year peak storage period, this level of conservatism provides a high degree of confidence that the calculated storage volume presented in this appendix will provide sufficient storage capacity for impacted waters.

1.1.5 Proposed Phasing of RA Construction

The phasing of waste excavation and consolidation activities at the Site are discussed in detail in Appendix D. The following discussion of construction phasing is in the context of its effect on water management at the Site as RA construction progresses. Schematics showing the WMS during the early stages of the various phases of RA construction and upon completion of RA construction are presented in Figure 2 to Figure 5. Minimum, average, and maximum flow volumes over the peak 6-week period for key flow component are also presented in Figure 2 to Figure 5.

Mine waste excavation and placement within the waste containment areas are divided into three phases:

- Phase 1 – Work will include excavation and placement of mine wastes in Pit 4. Primary objectives for this phase of work include:

  (1) Preparation and construction of the site access road and construction support facilities, including the WTP site. The construction support zone and WTP footprints will require soil cleanup prior to construction of these facilities.
  (2) Initial processing of drain materials from the HSWRP
  (3) Consolidation of Ore/Protore Piles within Pit 4
  (4) Excavation of the South Pond and parts of the SWRP, with consolidation of excavated materials in Pit 4.

  Impacted water from the Site will be collected and stored in Pit 3 during this phase. There will be little change in the current WMS during and upon completion of Phase 1 construction except for the addition of groundwater collection from alluvial groundwater collection systems, pumping of water directly from the BPA to Pit 3, and transfer of water from Pit 3 to the WTP for treatment and use as construction water as needed for Phase 1 construction. Alluvial groundwater will be collected from the Western, Central, and Eastern Drainage groundwater control systems that will be constructed at the start of Phase 1, and will be stored in the PCP until the PCP is decommissioned at the end of Phase 3. These alluvial controls systems are described in Appendix G. Historically, water from the BPA overflowed the limits of the pits and is thought to flow at the waste rock – native soil contact and contribute to flow in the submerged Seep, and possibly the Western Drainage and Pump House Seeps (WME, 2013). With the onset of dewatering in the BPA, water from the BPA will now report directly to Pit 3, rather than to Pit 3 by way of seepage into the PCP. As such, BPA pumping is not expected to affect the volume of water requiring storage, but rather the pathway it takes to get to the storage pond. Water in Pit 4 will continue to be removed during Phase 1 via the underdrain dewatering system and a waste dewatering system described in Appendix D. Water removed from Pit 4 during this phase will be transferred to Pit 3 or will be intermittently transferred directly to the WTP, treated, then discharged. Upon completion of Phase 1, Pit 4 will be completely covered and revegetated.

  Although it is likely that the surface water runoff from the completed Pit 4 surface cover will be routed around the waste areas and released to surface water drainages down gradient of the Site, this potential reduction to the impacted water storage requirement at the completion of Phase 1 has been neglected in water balance calculations of Phase 2 storage requirements. For water balance modeling purposes, this reduction in flow is conservatively assumed to not occur until the beginning of Phase 3.

- Phase 2 –Work includes regrading the Backfilled Pits Area (BPA) and Area 5 (located between Pit 3 and Pit 4), and excavation and placement of mine wastes in Pit 3. Pit 3 will be dewatered at the start of Phase 2 and will no longer be available for water storage. Impacted water from the Site will then be stored in a lined, temporary storage pond located immediately south of Pit 3 on the South Waste Rock Pile (i.e., the South Pond). During Phase 2, water from the South Pond will be transferred to the WTP, treated, and either discharged to Lake Roosevelt via the Blue Creek pipeline, or used for construction water as needed for construction as described in the Water Source Identification and Development Plan (Appendix T). A primary objective of the Phase 2 work is to remove all waste from, and meet soil and sediment cleanup standards in the Western and Eastern Drainages so that surface water runoff in these drainage basins

can be released to Blue Creek without retention and treatment at the new WTP, which will replace the existing WTP at the start of Phase 2. This timing for the new WTP assumes that the NPDES permitting will occur in a timely manner to allow for the construction of the new WTP during Phase 1. If that is not the case, the existing WTP will be winterized so it can operate year around. In addition, the final surface cover will be completed over portions of the BPA, Area 5, part of the Pit 3 catchment area, and other portions of the Central Drainage catchment area.

Upon completion of Phase 2, the only significant volume of mine waste requiring excavation and consolidation will be that located in the Central Drainage portion of the South Waste Rock Pile in the vicinity of the South Pond and Pollution Control Pond (PCP). At that point, the South Pond can be decommissioned and replaced with a smaller, temporary, lined retention pond in the Western Drainage (the West Pond) while Phase 3 of the remedial construction proceeds in the remaining areas in the Central Drainage.

- Phase 3 – Work will include excavation and relocation of remaining mine wastes in the Central Drainage to the upper portion of the Pit 3 waste containment area. Demolition and removal of temporary support facilities in the construction support zone (CSZ) and other areas of the Site will occur near the end of Phase 3.

  During Phase 3, impacted water collected at the Site will be stored in the West Pond. Water stored in the West Pond during Phase 3 will be transferred to the WTP, treated, and either discharged to Lake Roosevelt via the Blue Creek pipeline, or used for construction water as needed for construction as described in Appendix T.

  It is possible that shallow groundwater may interact with surface water within the drainages after removal of mine waste and contaminated surface material in some areas. Prior to completion of a remediation area, shallow groundwater will be evaluated by excavating a series of shallow test pits in areas where there appears to be potential for near-surface groundwater or seeps. If groundwater is observed in a trench, samples will be collected and assessed relative to cleanup levels as discussed in Appendix O. If shallow groundwater is identified that does not meet cleanup standards, it will be collected and conveyed for treatment to minimize the co-mingling of contaminated water with clean water to the extent practicable. Although the extent of shallow groundwater needing collection and treatment cannot be known with certainty until waste removal operations have removed mine waste from the surface, flow components for residual seeps from the Eastern and Western Drainage have been added to the water balance for Phase 3, as shown on Figure 4, to account for potential seep flows from these areas after mine wastes have been removed. Residual seeps from the Eastern and Western Drainage will be collected and stored in the PCP and West Pond respectively.

  Upon completion of Phase 3, it is anticipated that flows to the water management system will gradually decrease as steady-state base flow (groundwater inflow) levels are reached, at which point the PCP and West Pond will be decommissioned and only the equalization ponds at the WTP plant site will be needed for storage of impacted water. In the long term, it is possible that flushing of the alluvial aquifer will improve water quality in the Western Drainage, Central Drainage, and Far East Seep Drainage to the point where collection and treatment of this water will no longer be necessary. Residual seeps that may require long-term collection and treatment in the Eastern, Central, and

Western Drainage have been included in the water balance for future conditions (i.e. after completion of Phase 3) to account for potential future seep flows from these areas. The West Pond will remain in operation until flows in the water management system have reduced to the point where there is no longer a need for this storage facility. Once flows have decreased to where the West Pond is no longer needed, it will be decommissioned. Contaminated material from the West Pond, including any impacted sediment that may have accumulated within the West Pond and the West Pond liner system will be disposed of in a separate cell on top of the Pit 3 waste containment area.

2.0 DESCRIPTION OF ANALYSES

The inflow hydrograph of impacted Site waters to Pits 3 and 4 is a key component for calculating the required storage capacity. As discussed in Section 1.1.1, pit water level measurements have historically been made while the WTP is in operation, but not during the shut-down period which typically lasts 5 months or more. As a result, although it is possible to calculate the amount of water that has accumulated during the shutdown (using existing bathymetric and LIDAR topographic data of the pits), it is not possible to calculate inflow rates based upon water level measurements. Therefore, a water balance model was prepared for the Site that uses, to the extent possible, measured flow rates from major water sources. Other key water sources are estimated from site-specific meteorological data and from groundwater inflow estimates that were made as part of previous investigations (URS, 2002, MGC, 2011). Specific design scenarios analyzed as part of storage pond water balance modeling include:

1. An analysis of variations in water storage under historic operating conditions.
2. Analyses of storage requirements using the proposed capacity and operating schedule for the new WTP.
3. An analysis of the sensitivity of water storage requirements for alternate WTP operating schedules and plant capacities.
4. An analysis of the effect of key impacted water sources on water storage volume requirements. The results of this analysis were used to evaluate the change in storage requirements at the end of each phase of RA construction as the source areas are remediated. At that point the impacted water sources from the remediated areas are assumed to be clean and no longer contribute to the impacted water stream requiring storage, except for potential future residual seeps.

5. Analyses of potential scenarios for storing some portion impacted water during the spring inflow season for subsequent treatment and use as construction water during drier parts of the year.

2.1 ANALYSIS OF HISTORICAL CONDITIONS - WATER INPUTS AND WITHDRAWALS

An analysis of estimated and measured inflow rates, and the effects on the temporal variation in calculated water storage in Pits 3 and 4 was made using historical WMS operating records including pumping records to and from the pits, and climatic records. The results of the analysis were compared to actual storage volumes (as calculated from water surface level measurements) to evaluate the ability of the water balance model to simulate inflows to the water storage components of the WMS (i.e. Pits 3 and 4) under existing conditions. This analysis was performed to “calibrate” the model to existing site conditions prior to using it to estimate the effects of modifications that will occur during the RA, on the required storage capacity.

The analysis of historical operations was performed on an “operating year” basis, which corresponds to the period beginning at shutdown in operations of the WTP in one year, and extending to shutdown of the WTP the following year. The period of analysis includes operating years 1997 through 2013. Prior to 1999, the record of flow rates in the WMS is less complete and water balance calculations are considered less reliable. However, due to the historic high flows that occurred in the WMS in 1997, flows during this time period were estimated based upon assumption discussed below, and this time period (1997-1998) was added to the analysis of historical operating conditions.

The individual flow components included in the analysis of historical operating conditions are:

Measured Water Contribution Sources:

1. PCP pumping - Records of water volume pumped from the PCP to Pit 3 were used in the water balance analyses. Use of the PCP pumping record avoided the need to estimate unmeasured flow components to the PCP (discussed in Section 1.1.1 above), as well as the need to account for varying storage levels in the PCP, which also are not part of the record. As discussed in Section 1.1.1, pumping records from the PCP to Pit 3 were not available prior to the spring of 1999. Pumping records from the Western Drainage to the PCP were available back to 1992. For analyses prior to the spring of 1999, PCP pumping rates were estimated by multiplying the Western Drainage pumping rates by a scale factor of 1.5, which represents the historical average ratio of total PCP pumping rate to Pit 3 to total pumping rate from the Western Drainage to the PCP.
2. BPA pumping - As discussed in Section 1.1, BPA pumping to Pit 3 occurred during 1999, 2000, and restarted again in 2013. Although no records for pumping rates are available for 1999 - 2000, the total volume pumped during this period is available. The pumping rate was estimated assuming a uniform flow rate during this period. Pumping records for 2013 were used in the updated water balance analysis that included this year.
3. East Seep and Far East Seep pumping records were used in the water balance calculations.
4. Pit 4 to Pit 3 pumping occurs intermittently as described in Section 1.1. Records of pumping rates are not available, however the total volume pumped during periods of operation are available. The pumping rates were estimated assuming a uniform flow rate during the periods of operation.
5. Precipitation inflows were estimated using daily precipitation data from the Midnite Mine RAWS meteorological station. Precipitation inflows to Pit 3 and Pit 4 were estimated assuming the entire precipitation volume falling inside the pit crests reported instantaneously to the ponds in Pit 3 and Pit 4.
6. Groundwater Inflow - Groundwater inflows to Pit 3 and Pit 4 were assumed to be at a uniform rate corresponding to the average of the estimates presented in previous groundwater investigation reports (URS, 2002 and MGC, 2011).

Measured Water Outflow or Withdrawal Components:

1. Pit 3 and Pit 4 Pumping to WTP - Pumping records were used in the water balance calculations.
2. Evaporation - These water losses were estimated using daily evaporation data from the Midnite Mine RAWS meteorological station and the pit water surface areas calculated based upon the estimated storage volume and site topographic data.

The results of the water balance analysis for combined storage on Pit 3 and Pit 4 under existing conditions are presented in Supplement E-1.1 and are summarized in Table 2. In addition, the minimum, average, and maximum flow volumes over the peak 6-week time period for key flow components for the existing WMS are shown on Figure 1. The results indicate that prior to 2001 the storage volumes predicted by the water balance model typically are less than that estimated from the recorded water surface elevation measurements. In the years after 2001, the results from the water balance model typically are greater than those estimated from the water surface elevation measurements, but the differences between calculated and estimated storage volumes were consistently less than in prior years. The average difference over the entire period modeled was relatively minor (3.3 Mgal) and suggests that a systematic bias does not exist in the water balance results.

The results in Table 1 show higher maximum combined storage prior to 2000 than in years after 2000. Prior to 1996 water levels in Pit 3 and Pit 4 were allowed accumulate to the point where maximum water surface water elevations at the start of the winter shutdown ranged from 2650 to 2670 in Pit 3 and from approximately 3025 to 3030 in Pit 4. Subsequent to that time, annual flow through the WTP was increased to draw down the pit water levels and provide better hydraulic control at the site. Recently, water levels at the start of the winter plant shutdown have ranged from approximately 2550 to 2555 in Pit 3 and from approximately 2999 to 3007 in Pit 4.

Table 2. Comparison of Measured vs. Modeled Maximum Storage by Year

Operating Year	Maximum Combined Storage- Calculated using Measured Water Elevations (Mgal)	Maximum Combined Storage- Calculated using Water Balance Model (Mgal)	Difference in Calculated Maximum Combined Storage Volumes (Mgal)
1997	355	339	-16
1998	246	251	5
1999	190	168	-22
2000	137	127	-10
2001	54	59	5
2002	75	84	9
2003	79	90	11
2004	61	74	12
2005	47	62	15
2006	108	114	6
2007	98	97	-1
2008	77	77	0
2009	81	78	-3
2010	43	57	14
2011	86	95	9
2012	**59**	**73**	**14**
2013	**67**	**75**	**8**
Average Difference			**3.3**

Note: Combined Storage includes storage occurring in Pit 3 and Pit 4.

2.2 PHASE 2 OPERATIONS - ANALYSIS OF STORAGE REQUIREMENTS

In order to estimate storage requirements for the Phase 2 South Pond, a water balance analysis was performed assuming that, with the exception that a WTP will be operating on a year-round basis and the addition of collection of alluvial groundwater flows from the Western, Central, and Eastern Drainage, there will be little change in the existing WMS and no significant flow diversions will be in place at the time the South Pond is brought into service (i.e., shedding of precipitation off of the Pit 4 cover as clean water was neglected). The analysis was performed using the existing inputs described in the previous section to estimate inflows and outflows, except for the WTP outflow from the system and estimates of the alluvial groundwater flows. The minimum, average and maximum flow volumes over the peak 6-week period used for water balance analysis for key flow components are shown on Figure 3. The WTP outflow was modeled at a continuous, 500-gpm flow rate. At times when there was no water accumulated storage in the pond and inflows were less than 500 gpm, the pumping rate from the storage pond to the WTP was assumed to equal the storage pond inflow. Flows collected by the Groundwater Controls in the Western Drainage, Central Drainage, and Far East Seep Drainage were assumed to range from a continuous 1-gpm to 15-gpm flow rate based on estimates of flows presented in Appendix G.

The results of the water balance analysis for Phase 2 storage with continuous WTP operation at 500 gpm is presented in Supplement E-1.2 and summarized in Table 3. Analyses were performed using the historical records discussed in the previous section and alluvial groundwater inflows assuming continuous WTP operations. Analyses were performed of storage requirements assuming both 1) continuous WTP operation assuming average (7.5-gpm) inflows for the alluvial groundwater inflows, and 2) that the WTP was shut down with no storage pond outflow to the WTP during the six weeks immediately prior to the date of maximum storage accumulation identified in the analysis of continuous WTP operations. Sensitivity of the alluvial groundwater inflows to storage requirements of the South Pond during the 6-week shutdown were evaluated by calculating storage requirements for an upper bound (15-gpm flow rate), average (7.5-gpm flow rate), and lower bound (1-gpm) flow rate for the alluvial groundwater collection of each drainage area.

The results for maximum necessary storage capacity were evaluated using a Gumbel-Type probability distribution for analysis of extreme-value to provide an estimate of the 100-year storage requirements under both continuous WTP operations at 500 gpm and the six-week shutdown scenarios, and the anticipated range of flows from alluvial groundwater collection systems (AGCS). These results are presented in Supplement E-1.2 and summarized in Table 3.

Table 3. Phase 2 - Storage Requirement by Year for a 500 gpm WTP

Operating Year	Storage Requirement (Mgal)			
	Average AGCS flow (24-7 Plant Operation)	Lower Bound AGCS flow (6-Week Plant Shutdown)	Average AGCS flow (6-Week Plant Shutdown)	Upper Bound AGCS flow (6-Week Plant Shutdown)
1997	22.8	48.4	52.8	55.0
1998	1.6	9.3	10.5	11.9
1999	4.1	25.1	26.4	27.7
2000	8.1	31.0	35.6	40.5
2001	1.0	10.5	11.7	13.1
2002	3.5	13.4	14.6	16.1
2003	2.5	14.2	15.4	16.8
2004	1.7	11.6	12.8	14.2
2005	1.8	8.1	9.3	10.7
2006	12.5	39.8	42.2	43.8
2007	12.7	17.7	18.9	20.3
2008	4.7	15.3	16.5	17.9
2009	2.7	21.5	22.7	24.1
2010	7.2	15.1	16.3	17.7
2011	3.5	23.8	25.0	26.4
2012	**18.3**	**22.4**	**23.6**	**25.0**
2013	**11.8**	**13.4**	**14.6**	**16.0**
100-year Peak Storage Requirement	**23.4**	**54.7**	**59.1**	**62.2**

2.3 ANALYSIS OF SENSITIVITY TO PLANT OPERATING SCHEDULE AND CAPACITY

Two additional analyses were conducted of alternative WTP capacities and/or operating schedules to evaluate the sensitivity of water storage requirements to the proposed WTP operations. In the first scenario, a plant with a continuous operation at 286 gpm was evaluated. This flow rate also is representative of a WTP that runs intermittently much like the current WTP (i.e., a 500 gpm capacity operating on a 24-hour-per-day, 4-day-per-week schedule throughout the year).

The results are presented in Supplement E-1.3 and summarized in Table 4. The estimates of the 100-year storage requirements under both continuous operations and for the six-week shutdown conditions are also presented in Table 4. The results indicate that a significantly larger volume of water will accumulate (18.4 Mgal) in the Phase 2 storage pond under a reduced operating capacity.

Table 4. Phase 2 - Storage Requirement by Year using a 286 gpm WTP

Operating Year	Storage Requirement (Mgal)			
	Average AGCS flow (24-7 Plant Operation)	Lower Bound AGCS flow (6-Week Plant Shutdown)	Average AGCS flow (6-Week Plant Shutdown)	Upper Bound AGCS flow (6-Week Plant Shutdown)
1997	47.9	62.4	65.6	70.3
1998	13.0	21.1	30.7	41.8
1999	8.6	25.1	26.4	28.1
2000	29.6	42.8	47.3	53.9
2001	1.3	10.6	11.8	27.5
2002	6.0	20.4	21.6	23.0
2003	7.1	21.4	24.8	29.0
2004	2.4	11.8	13.1	14.6
2005	2.6	9.0	10.2	18.6
2006	34.6	49.1	52.3	56.1
2007	13.0	17.7	18.9	35.4
2008	7.0	19.9	21.1	22.5
2009	5.6	22.0	23.3	24.8
2010	8.1	15.1	16.4	17.8
2011	16.4	31.3	34.1	37.3
2012	**6.2**	**22.7**	**23.9**	**25.4**
2013	**4.5**	**15.9**	**17.1**	**18.5**
100-year Peak Storage Requirement	**53.0**	**69.6**	**74.6**	**80.6**

The second alternative operating scenario evaluated was for a plant with a continuous operation at 750 gpm. A summary of the results for this scenario are presented in Supplement E-1.3 and in Table 5. The estimated 100-year storage requirements under both continuous operations and for the six-week shutdown conditions are also presented in Table 5. The results indicate that a moderate (6.5 Mgal) reduction in the necessary storage pond volume will occur using the 750 gpm when compared to the 500 gpm treatment rate (refer to Table 3).

Table 5. Phase 2 - Storage Requirement by Year using a 750 gpm WTP

Operating Year	Storage Requirement (Mgal)			
	Average AGCS flow (24-7 Plant Operation)	Lower Bound AGCS flow (6-Week Plant Shutdown)	Average AGCS flow (6-Week Plant Shutdown)	Upper Bound AGCS flow (6-Week Plant Shutdown)
1997	16.0	48.4	49.6	51.0
1998	1.2	9.3	10.5	11.9
1999	3.1	25.1	26.4	27.7
2000	5.1	36.1	37.3	38.7
2001	0.6	10.5	11.7	13.1
2002	3.1	13.4	14.6	16.0
2003	2.1	14.2	15.4	16.8
2004	1.4	11.6	12.8	14.2
2005	1.3	8.8	10.1	11.4
2006	7.4	32.7	33.9	35.3
2007	12.3	17.7	18.9	20.3
2008	4.4	15.3	16.5	17.9
2009	1.6	20.1	22.7	24.1
2010	6.4	14.7	15.9	17.3
2011	2.6	20.9	22.8	24.2
2012	**2.1**	**14.8**	**16.0**	**17.4**
2013	**2.7**	**13.4**	**14.6**	**16.0**
100-year Peak Storage Requirement	**17.5**	**52.9**	**54.3**	**55.7**

2.4 PHASE 3 OPERATIONS - EVALUATION OF WMS FLOWS COMPONENTS AND STORAGE REQUIREMENTS

An evaluation of the storage requirements necessary during Phase 3 was conducted by performing a water balance analysis in conjunction with an evaluation of contributions from individual flow components upon the completion of Phase 2 (and beginning of Phase 3) construction.

The average relative contributions of each flow component were calculated and effects of RA construction and assumed clean water diversions on flow were used to estimate the maximum required storage capacity required during Phase 3 of the RA construction. The estimates of reductions in flow contributions due to RA construction assume that once waste cleanup and soil covering is completed in an area, that surface water can then be released from these areas without storage or treatment. The estimated reductions in inflows are based upon the anticipated reductions in contributing areas for each flow component and are presented in Table 6 below.

Estimated reductions were then incorporated into the water balance model to determine the contributing inflows at the beginning of Phase 3 activities, which represents the maximum disturbed area that will exist while the West Pond will be in operation. All inflows, with the exception of precipitation inflow and reductions placed on these inflows were assumed constant during Phase 3 operations. The six-weeks of highest historical precipitation for each operation year for the time period of 1997-2013 were evaluated. A sensitivity analysis was conducted to

evaluate storage requirements based on bounding estimates for alluvial groundwater collection flows and residual seeps.

The results for maximum required storage capacity were evaluated using a Gumbel-Type probability distribution for analysis of extreme-value to provide an estimate of the 100-year storage requirements under a WTP operation of 500 gpm and a six-week shutdown scenario. These results are presented in Supplement E-1.2 and summarized in Table 7.

Specific flow components and the flow reductions at the completion of Phase 2 were estimated based on the reduction of contributing areas due to RA construction. These flow components and reductions were used in estimation of storage requirements upon the completion of Phase 2 as follows:

1. Blood Pool Seep - It is assumed that upon removal of all waste and contaminated soil from the East Waste Rock Pile that this flow component will become insignificant.
2. Western Drainage Seeps - It is assumed that upon removal of all waste and contaminated soil from the Western Drainage that water currently reporting as seepage will report as surface water runoff in the Western Drainage and that this water can be released without treatment.
3. Submerged Seep - In addition to the Western Drainage Seep, the Submerged Seep, Pump House Seep, and the Runoff Collection Pipe are three major sources contributing to the total PCP flow. The flow associated with each of these additional sources has not historically been monitored, and because little is known about their individual contributions, each source was assumed to make an equal contribution to PCP flow. It is assumed that, upon completion of Phase 2 construction, the Submerged Seep flow will be reduced by 50 percent due to regrading and capping that will occur in the west fork (BPA) area of the Central Drainage.
4. Pump House Seep - It is assumed that, the Submerged Seep flow will be reduced by 20 percent due to regrading and capping that will occur in the east fork (Pit 3 area) portion of the Central Drainage upon completion of Phase 2 construction.
5. Runoff Collection Pipe - It is assumed that approximately half of the flow reporting to the runoff collection pipe is the result of runoff from areas in the Western Drainage, with the remainder from the Central Drainage. It is assumed cleanup of the Western Drainage during Phase 2 construction will result in a 70 percent reduction in this flow component.
6. Pit 3 Groundwater - It is assumed that the Pit 3 Groundwater flow component will remain unchanged after Phase 2 construction.
7. East and Far East Seeps - As with the Blood Pool Seep, the East and Far East Seeps are assumed to become insignificant upon removal of all waste and contaminated soil from the East Waste Rock Pile during Phase 2.
8. Precipitation to Pit 3 - This estimated component is assumed to be reduced by 20 percent due to grading and capping of portions of Pit 3 during Phase 2.
9. BPA pumping - Flow from the BPA wells is assumed to be directly linked with the submerged seep, with water extracted from the BPA wells resulting in a 1 to 1 reduction in submerged seep flow. Since the effect of BPA pumping on the submerged seep is not accounted for in the WB, this flow component is neglected in the storage requirement calculation at the end of Phase 2.
10. Pit 4 Groundwater - As with Pit 3, the groundwater flow component to Pit 4 is assumed to be unaffected by RA construction.
11. Pit 4 Precipitation - This component is assumed to be completely eliminated due to capping and covering of Pit 4 during Phase 1 construction.

12. Alluvial GW Collection – Flows collected from each of the Western Drainage, Central Drainage, and Far East Seep Drainage alluvial groundwater collection systems are assumed to range from 1 to 15 gpm based on estimates of groundwater flow rates to the alluvial groundwater collection trenches provided in Attachment G-1 of Appendix G.
13. Residual Seep(s) – After the completion of waste cleanup in the Eastern and Western Drainage during Phase 2 construction, it is possible that there will be residual seeps from these areas which will require collection and treatment. It is assumed flows from the Eastern Drainage could range between 1 to 5 gpm and flows from the Western Drainage could range from 1 to 15 gpm.

The estimated contribution of each of these flow components to the total storage requirement, and the effects of RA construction at the start of Phase 3 are summarized in Table 6. The minimum, average and maximum flow volumes over the peak 6-week period used for water balance analysis for key flow components are shown on Figure 4. The results indicate the estimated water storage requirement during wetter years, and during a 6-week WTP shutdown, will be reduced by approximately 70 percent upon completion of Phase 2 RA construction, and that the required West Pond storage capacity is approximately 22 million gallons.

Table 6. Flow Components and Estimated Phase 3 Storage Requirement

Component	Reduction of Components Contributing to Storage Requirements at End of Phase 2 (%)
Blood Pool	0
Western Drainage	0
Submerged Seeps	35.9
Pump House Seep	78.4
Surface Water Pipe	32.4
Pit 3 Groundwater	n/a
East Seep	0
Far East Seep	0
Precipitation to Pit 3	80.7
BPA Pumping	0
Pit 4 Groundwater	n/a
Pit 4 Precipitation	0

Table 7. Phase 3 - Storage Requirement by Year using a 500 gpm WTP

Operating Year	Storage Requirement (Mgal)		
	Lower Bound	Average	Upper Bound
1997	9.5	10.8	12.3
1998	7.2	8.5	10.0
1999	7.0	8.3	9.8
2000	9.5	10.8	12.3
2001	5.0	6.2	7.7
2002	10.5	11.8	13.2
2003	10.2	11.5	13.0
2004	8.1	9.3	10.8
2005	5.5	6.8	8.2
2006	19.0	20.3	21.8
2007	4.6	5.9	7.3
2008	6.0	7.2	8.7
2009	5.9	7.2	8.7
2010	6.6	7.8	9.3
2011	9.6	10.9	12.4
2012	**10.0**	**11.4**	**12.7**
2013	**4.9**	**6.3**	**7.7**
100-year Peak Storage Requirement	**19.5**	**20.6**	**22.1**

2.5 ANALYSIS OF STORAGE OF CONSTRUCTION WATER

Construction water will be required during RA in the following areas:

1. For construction within the area of mine disturbance (on-site)
2. For construction in off-site areas including during access road construction and Rhoads Property Borrow Area operations
3. Potable water usage within the construction support zone.

Of these water uses, the on-site construction will require the largest volumes of water, and methods for providing storage to meet the on-site water needs is the focus of this evaluation. On-site construction water usage for on-site construction will includes dust suppression during crushing and screening of drain materials, dust suppression during mine waste excavation, haulage, and placement, and vehicle decontamination. For this analysis it is assumed that ware to meet on-site construction needs will be treated water from the WTP.

During most of the year, flows to the WMS will be more than sufficient to meet the on-site construction water needs. However, during drier parts of the year (primarily during the third quarter of each year), when WMS inflow rates will be low and dust suppression water requirements will be at their highest, additional construction water will be required. Rather than constructing an additional large water storage facility to store treated on-site construction water, it is proposed that some portion of untreated water from the spring runoff period be retained in the Water Management Ponds (Pit 3, South Pond and the West Pond, depending on construction phase) and treated on an as-needed to meet construction-water demands. At the end of the high-water-demand construction season, the treatment plant would then be operated on a continuous basis to draw the water management pond down to its dead-storage level to

ensure the full contingency storage is available before the onset of the next spring meltoff season.

Details of the estimated quantities of construction water needed during RA construction are provided in the Water Source Identification and Development Plan presented in Appendix T. During Phase 1, the WMS will be operated in a similar manner as has occurred historically and a sufficient volume of water will have accumulated in Pit 3 over the winter shutdown to meet anticipated construction-water requirements for this phase. For Phase 2, the maximum quarterly volume of water that will be needed for dry-season on-site construction water is estimated to be approximately 13.8 Mgal. This water will need to be stored in the South Pond prior to being transferred to the WTP for treatment and use during the dry season. It is anticipated that a maximum quarterly volume of approximately 7.4 Mgal of water will be required for Phase 3 construction for dry-season on-site construction water needs. This volume of water will need to be stored in the West Pond prior to treatment and use during dry-season construction. An analysis was conducted to evaluate the amount of water that would be stored in the South and West Ponds for use during dry-season construction.

2.5.1 Phase 2 – Analysis of Construction Water Availability

The potential volume of water that is expected to accumulate in the South Pond was calculated for varying dates when water withdrawals from the pond is halted and the WTP is shut down in order to store water for use as dry-season construction water. The water-availability analysis assumed the WTP is shut down for durations ranging from 1 day to 56 days (8 weeks) prior to the date. For the purposes of this analysis, it was (somewhat conservatively) assumed that dry-season construction water from will be required starting June 1 and hence water withdrawals from the South Pond will begin on this date. The analysis was performed using the existing historical inputs to the WMS described in the previous section to estimate inflows and outflows for each operating year (1997 – 2013), with the exception that estimated inflows from the alluvial groundwater collection system. As with the analyses described previously, flows collected by the Groundwater Controls in the Western Drainage, Central Drainage, and Far East Seep Drainage were assumed to range from a continuous 1-gpm to 15-gpm flow rate. The minimum, average and maximum accumulated volumes for varying WTP shutdown dates for the operating year between 1997 and 2013 are provided in Supplement E-1.4.

The results indicate that a minimum accumulated volume of 10 Mgal will be available for construction water purposes by June 1st if the WTP is shutdown on April 20th (i.e. the plant is shut down for six weeks prior to June 1st) to allow water to accumulate in the South Pond. In addition, an average inflow of 200,000 gal/day (including average estimates for Alluvial Groundwater Control inflows) is expected to report to the South Pond based on historical flows during an assumed dry-season construction period extending from the first of June to the end of August. This additional inflow would result in an additional 18 Mgal of water being available during the assumed dry-season construction period. The inflows calculated for the South Pond for each operating year for the time period of the beginning of June through the end of August are provided in Supplement E-1.5.

2.5.2 Phase 3 – Analysis of Construction Water Availability

The potential volume of water that is expected to accumulate in the West Pond for use as construction water during Phase 3 construction also was evaluated. The analysis was performed assuming inflows from Pit 3 groundwater, Pit 4 groundwater, and groundwater from the Central, Eastern, and Western Drainage Alluvial Groundwater Collections systems would

still report to the WMS. Additional West Pond inflows which will be reduced due to RA construction were neglected in this analysis, due to the uncertainty in the magnitude of flows, in order to provide a conservative estimate on the total amount of water available during construction.

The results of the analysis indicate that the WTP will need to shut down during the last week of February if the entire volume of water needed to meet the construction water needs during the peak Phase 3 construction year (i.e., approximately 14 weeks prior June 1st) is to be available at the start of the assumed dry-season construction period. As described in the preceding paragraph, this estimate is based upon conservative assumptions that only groundwater inflows from Pit 3, Pit 4, and average flow estimates for the Alluvial Groundwater Collection Systems will be available at that time. However, it appears that approximately 109,000 gal/day is expected to report to the West Pond during the assumed dry-season construction period, which equates to 9.8 Mgal during the assumed dry-season construction period between the beginning of June and end of August. As a result, it does not appear that a WTP shutdown period will be needed to accumulate additional water prior to the peak Phase 3 dry-season construction period in order to meet the peak Phase 3 construction water requirement of 7.4 Mgal.

3.0 CONCLUSIONS

For the proposed WTP operating conditions which include the capability to treat water 24 hours per day, 7 days per week, and year-round operations at up to 500 gpm, the recommended storage pond capacities are as shown in Table 9.

Table 9. Required Storage Pond Capacities

Pond	RA Construction Phase	Required Capacity (Mgal)
South Pond	Phase 2	59.1
West Pond	Phase 3	22.1

These storage capacities are based upon the assumption that the WTP will not be able to operate for 6 weeks during the time period that 100-year storage volume is accumulating.

On-site construction water during Phase 2 can be supplied by WTP effluent if impacted water is stored in the South Pond prior to start of the dry-season construction period as well as from water that will report to the WMS during the dry-season construction period. It appears the water captured by the WMS during the Phase 3 dry-season construction period will be sufficient to meet construction water needs and additional storage prior to the onset of the dry season will not be needed during Phase 3. Table 10 summarizes the estimated volumes of water that could be available from the South Pond for Phase 2 for dry-season construction water. The accumulated volume prior to the construction was estimated assuming a start date of dry-season construction of June 1 and assuming the WTP is shut down for six weeks (beginning April 20th) prior to the start of dry-season construction. The estimated volume of water volume that would accumulate during the assumed dry-season construction period extending from June 1st through August 31st during both Phase 2 and Phase 3 construction also is summarized in Table 10.

Table 10. Construction Water Availability

Pond	RA Construction Phase	Average Accumulated Water Volume Prior to Start Date of Construction (Mgal)	Average Accumulated Water Volume During Construction - June to End of August (Mgal)
South Pond	Phase 2	Minimum 10 Mgal (6 week shutdown)	18 Mgal
West Pond	Phase 3	Not needed	9.8 Mgal

The assumptions regarding the effects of RA construction on the required storage pond capacities and accumulated volumes available for construction water demands should continue to be evaluated as the project design is finalized and during RA construction. This water balance should be updated to account for additional information as it becomes available.

4.0 REFERENCES

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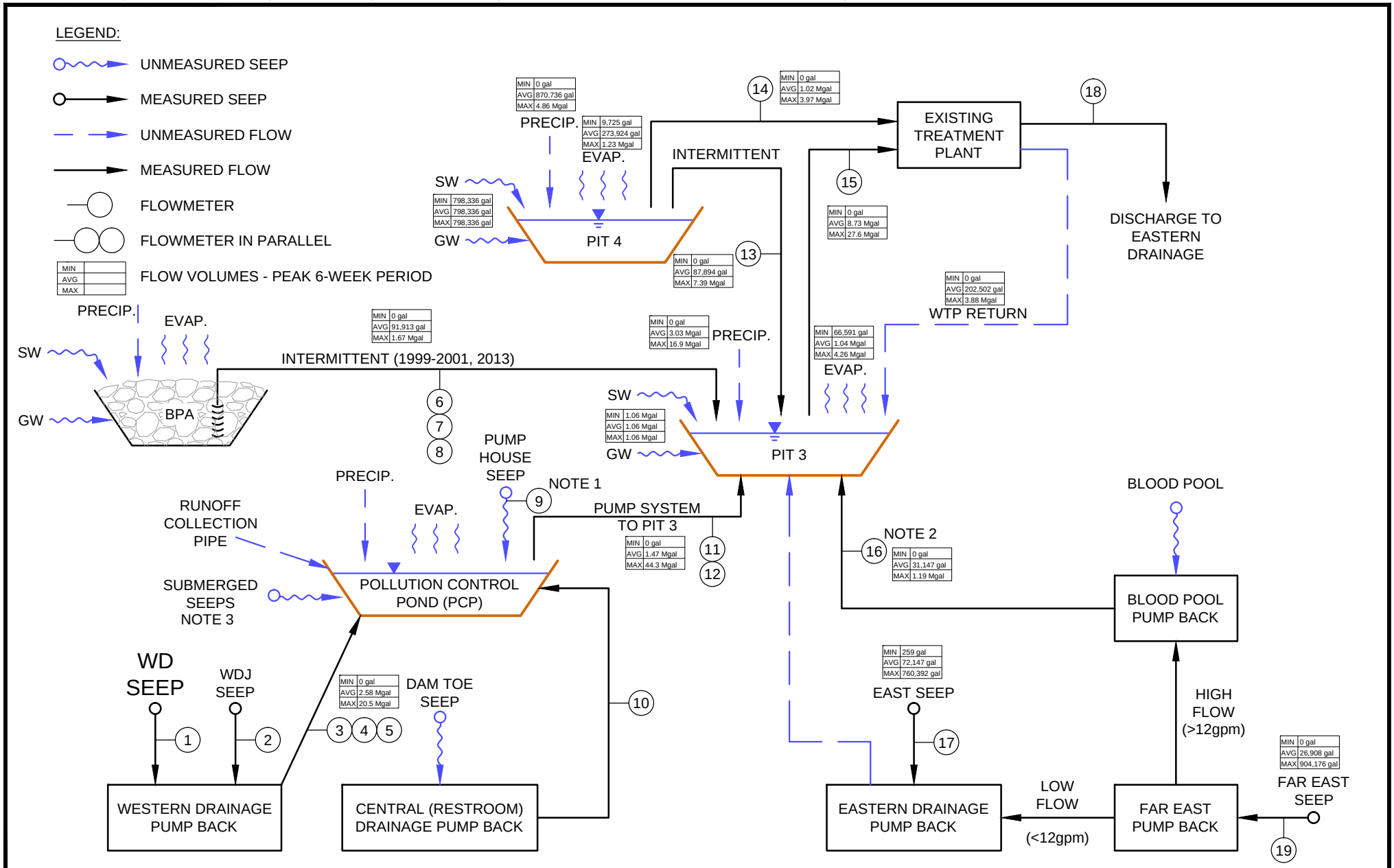
FIGURES

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E – Water Management Ponds\90% Submittal\Att E-1 Water Balance\Schematics\MM_Schematics_90% Design



NOTE:
1. NOT MEASURED AFTER 2004.
2. NOT MEASURED PRIOR TO 2010.
3. NOT MEASURED PRIOR TO JULY, 2011

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR CURRENT CONDITIONS

MWH

DATE: JULY 2014

FIGURE 1

FILE NAME: MM_Schematics_90% Design

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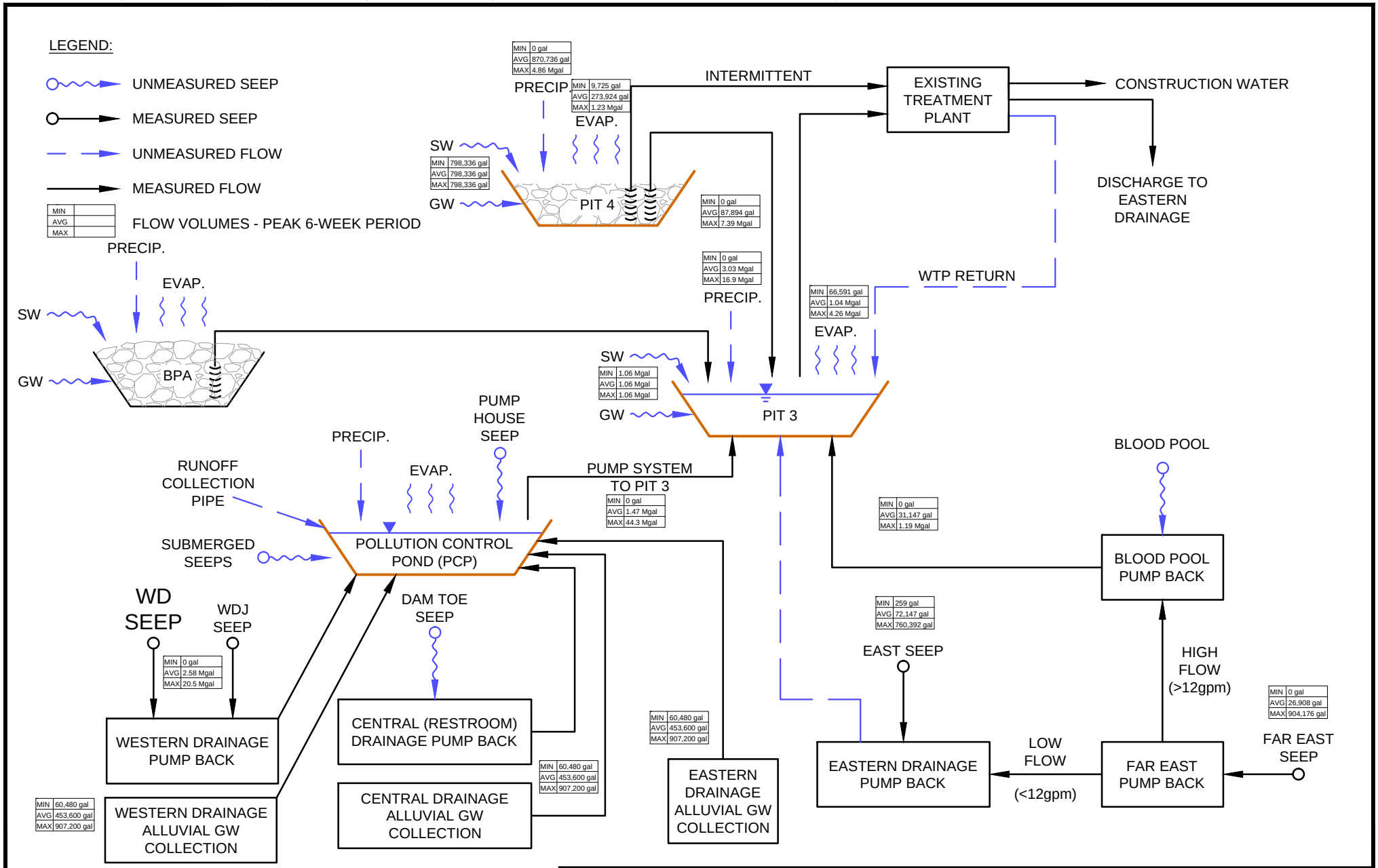

NOTE:

1. PIT 4 WILL BE DEWATERED, AND BACKFILLED WITH MINE WASTE IN PHASE 1.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR PHASE 1

MWH

DATE: JULY 2014

FIGURE 2

FILE NAME: MM_Schematics_90% Design

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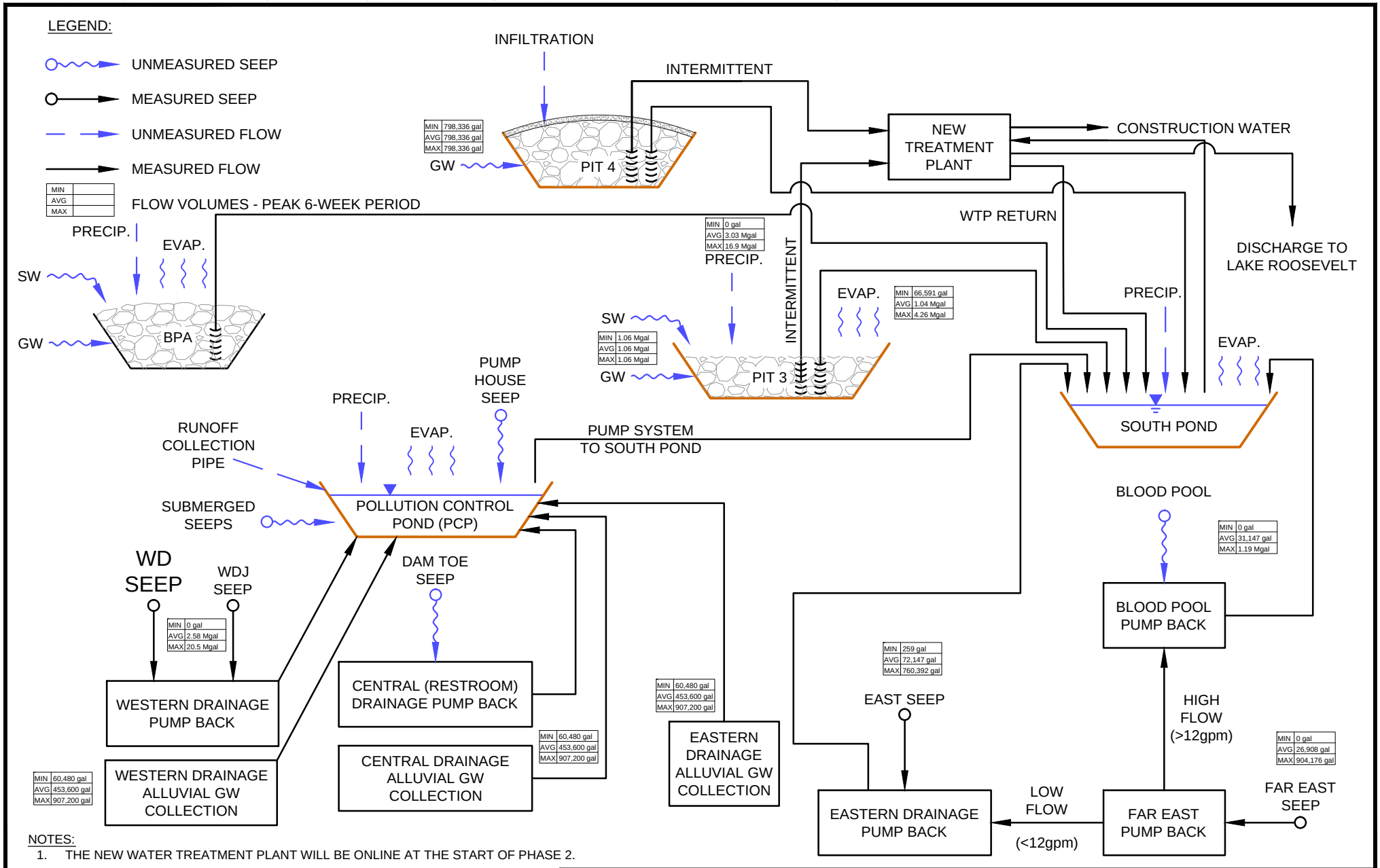

NOTES:

1. THE NEW WATER TREATMENT PLANT WILL BE ONLINE AT THE START OF PHASE 2.
2. PIT 4 WILL BE COVERED AT START OF PHASE 2.
3. SOUTH POND WILL BE IN OPERATION AT THE START OF PHASE 2.
4. PIT 3 WILL BE DEWATERED, AND BACKFILLED WITH MINE WASTE IN PHASE 2.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR PHASE 2

MWH

DATE: JULY 2014

FIGURE 3

FILE NAME: MM_Schematics_90% Design

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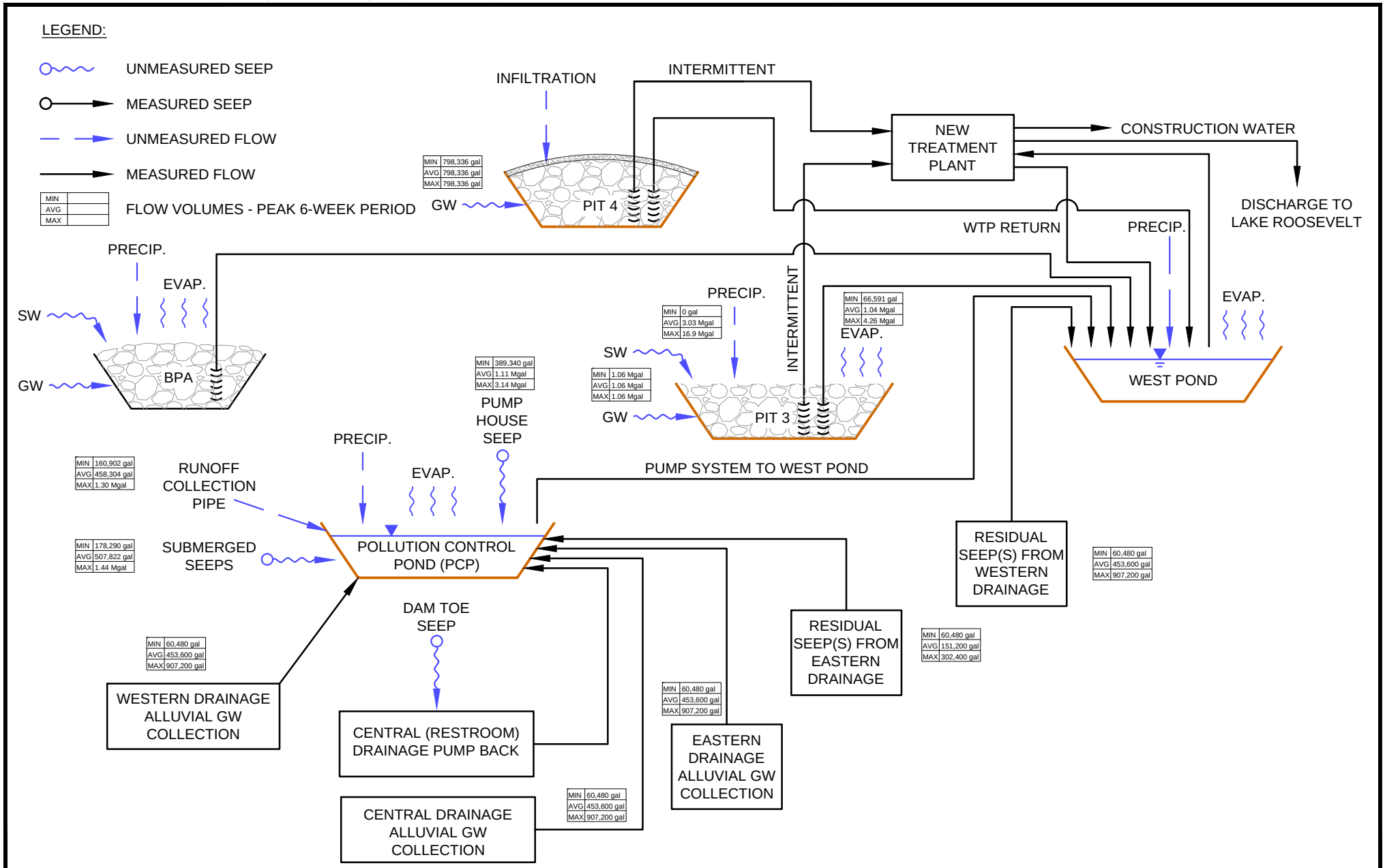

NOTES:

1. SOUTH POND WILL BE DECOMMISSIONED AT START OF PHASE 3.
2. WEST POND WILL BE IN OPERATION AT START OF PHASE 3.
3. PIT 3 WILL CONTINUE TO BE BACKFILLED WITH MINE WASTE IN PHASE 3.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR PHASE 3

MWH

DATE: JULY 2014

FIGURE 4

FILE NAME: MM_Schematics_90% Design

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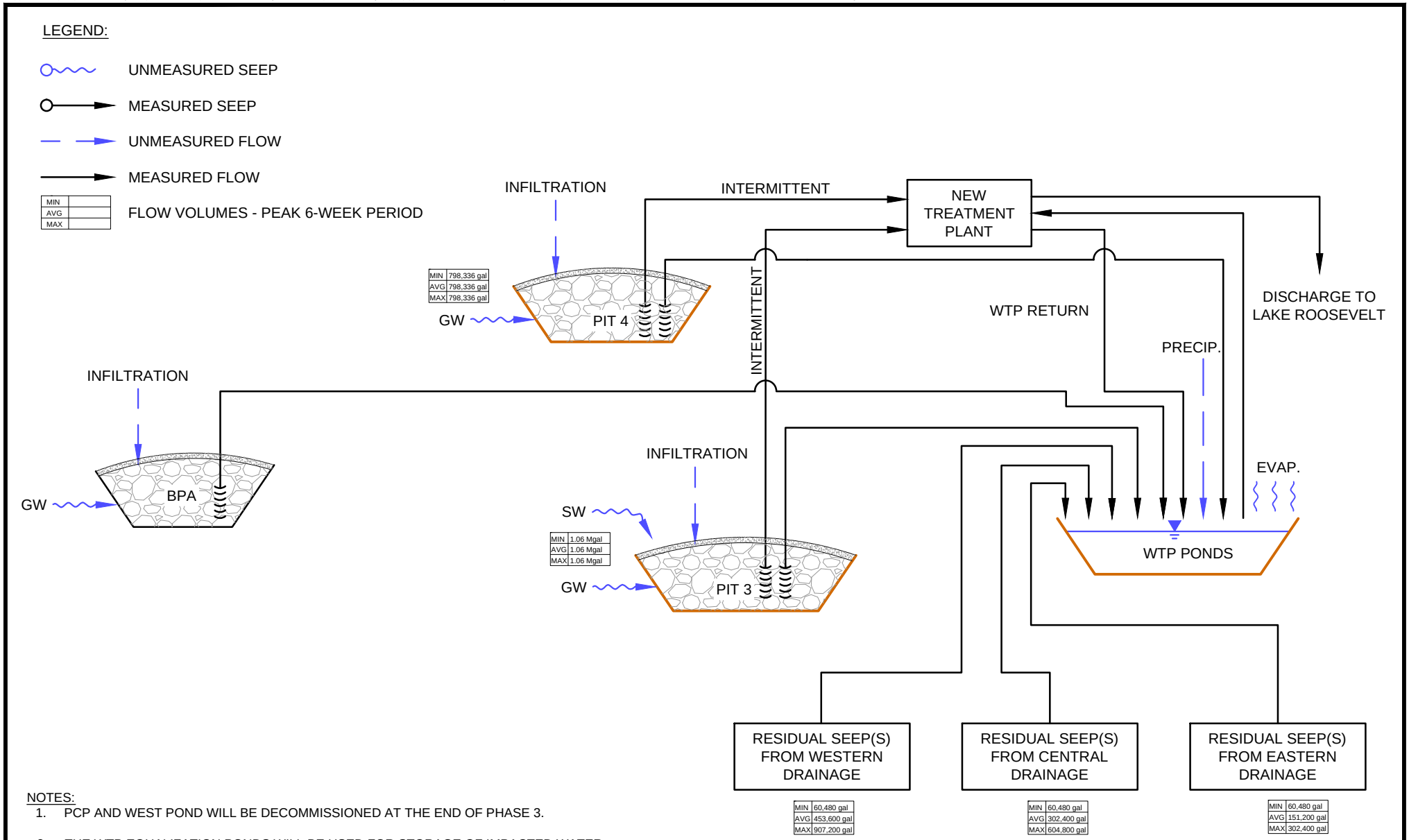


NOTES:

1. PCP AND WEST POND WILL BE DECOMMISSIONED AT THE END OF PHASE 3.
2. THE WTP EQUALIZATION PONDS WILL BE USED FOR STORAGE OF IMPACTED WATER.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR FUTURE CONDITIONS

MWH

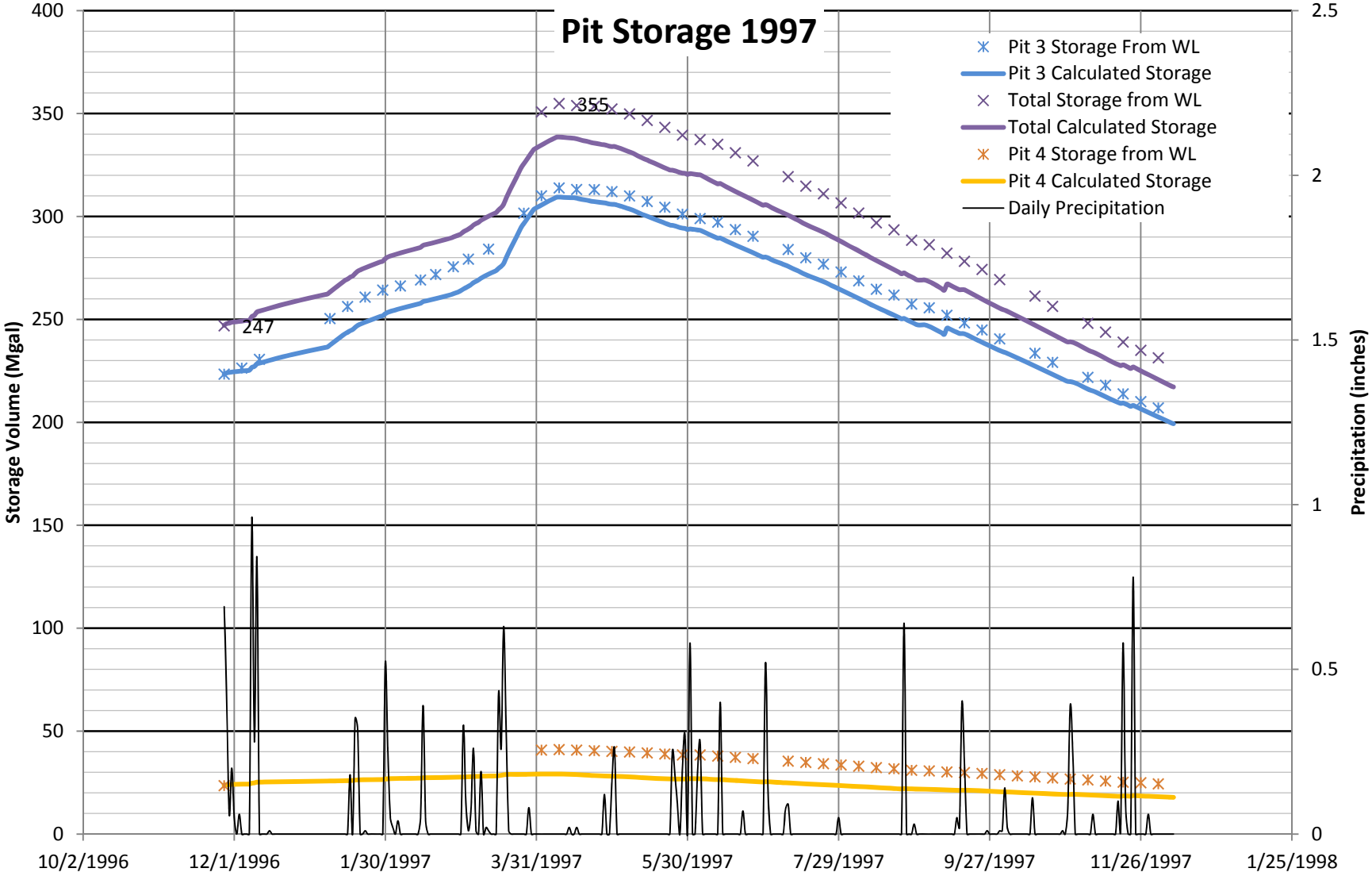
DATE: JULY 2014

FIGURE 5

FILE NAME: MM_Schematics_90% Design

Supplement E-1.1

Analysis of Storage Under Existing Conditions, 1997 through 2013



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PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
1997 Operating Year

MWH

DATE
July 2014

FIGURE 1

FILENAME
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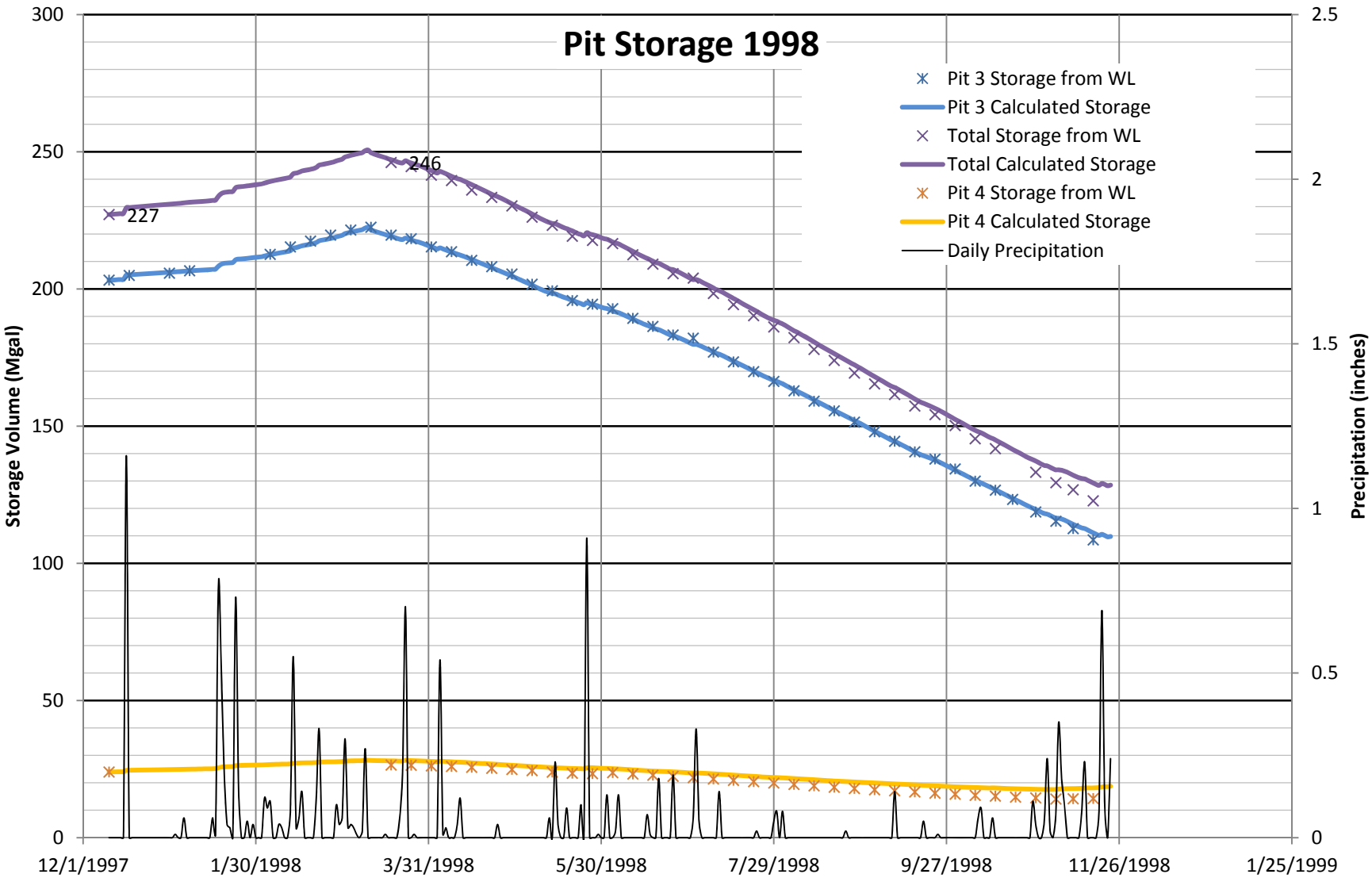

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MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
1998 Operating Year

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DATE
July 2014

FIGURE 2

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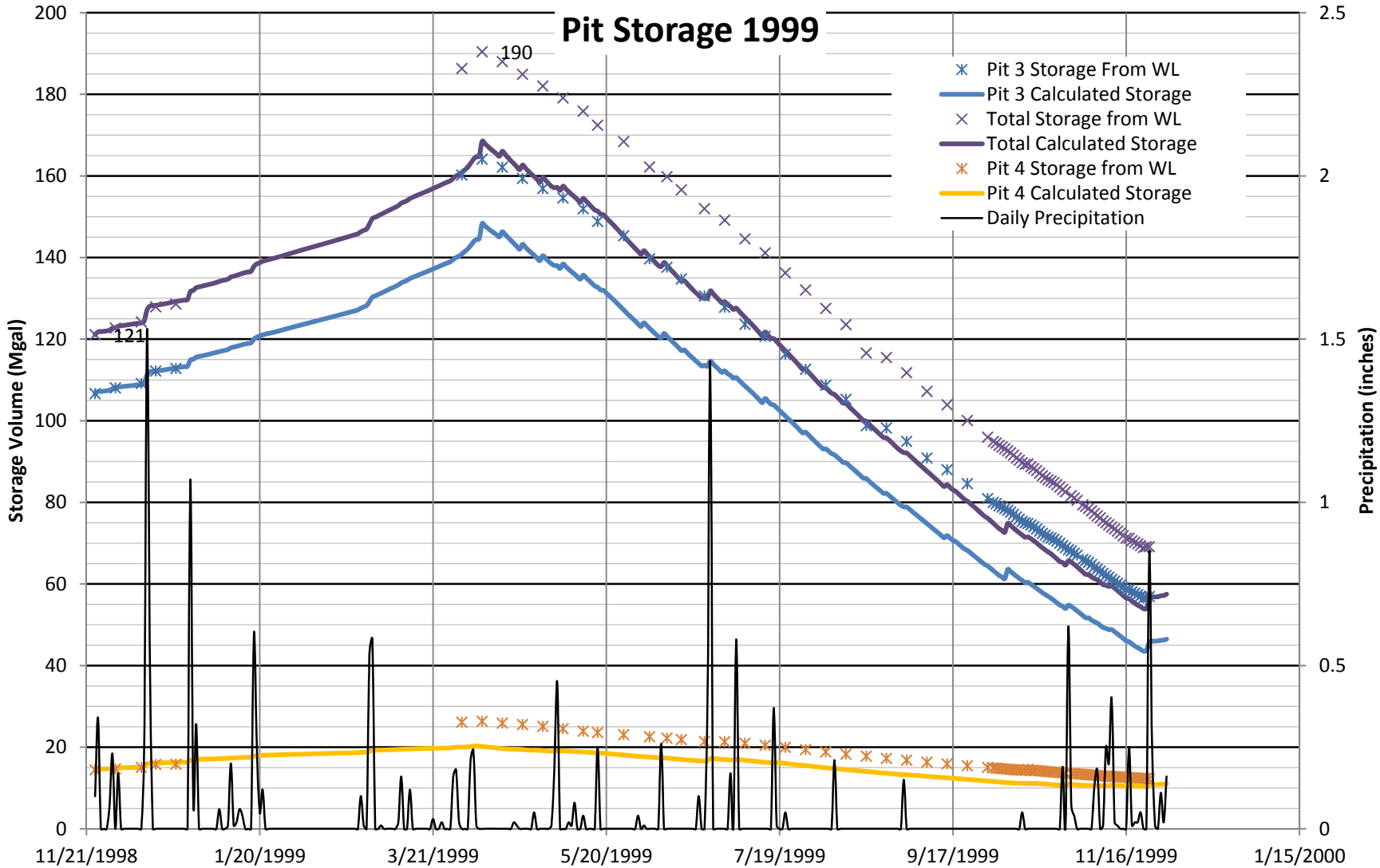

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PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
1999 Operating Year

MWH

DATE
July 2014

FIGURE 3

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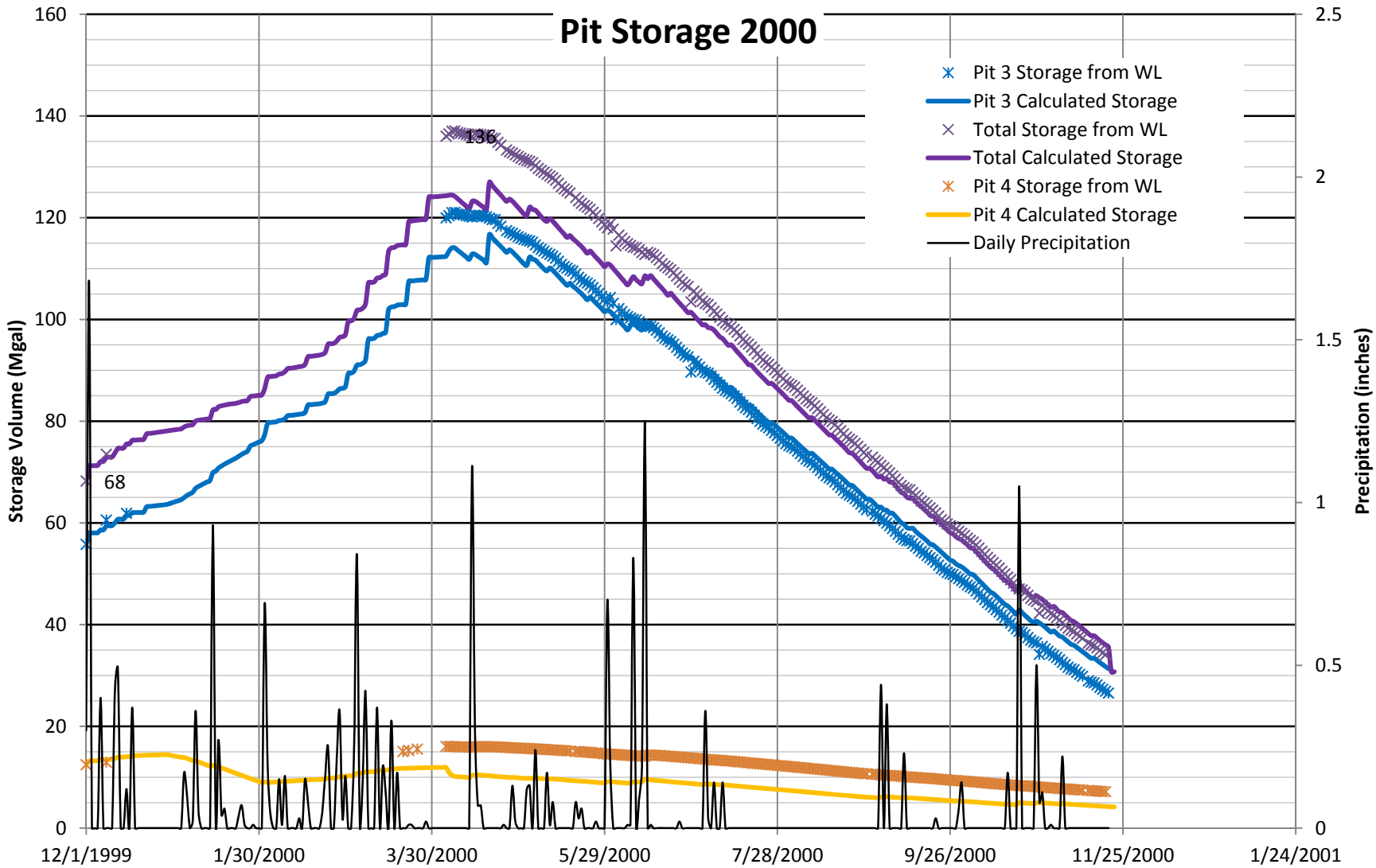

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PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
2000 Operating Year

MWH

DATE
July 2014

FIGURE 4

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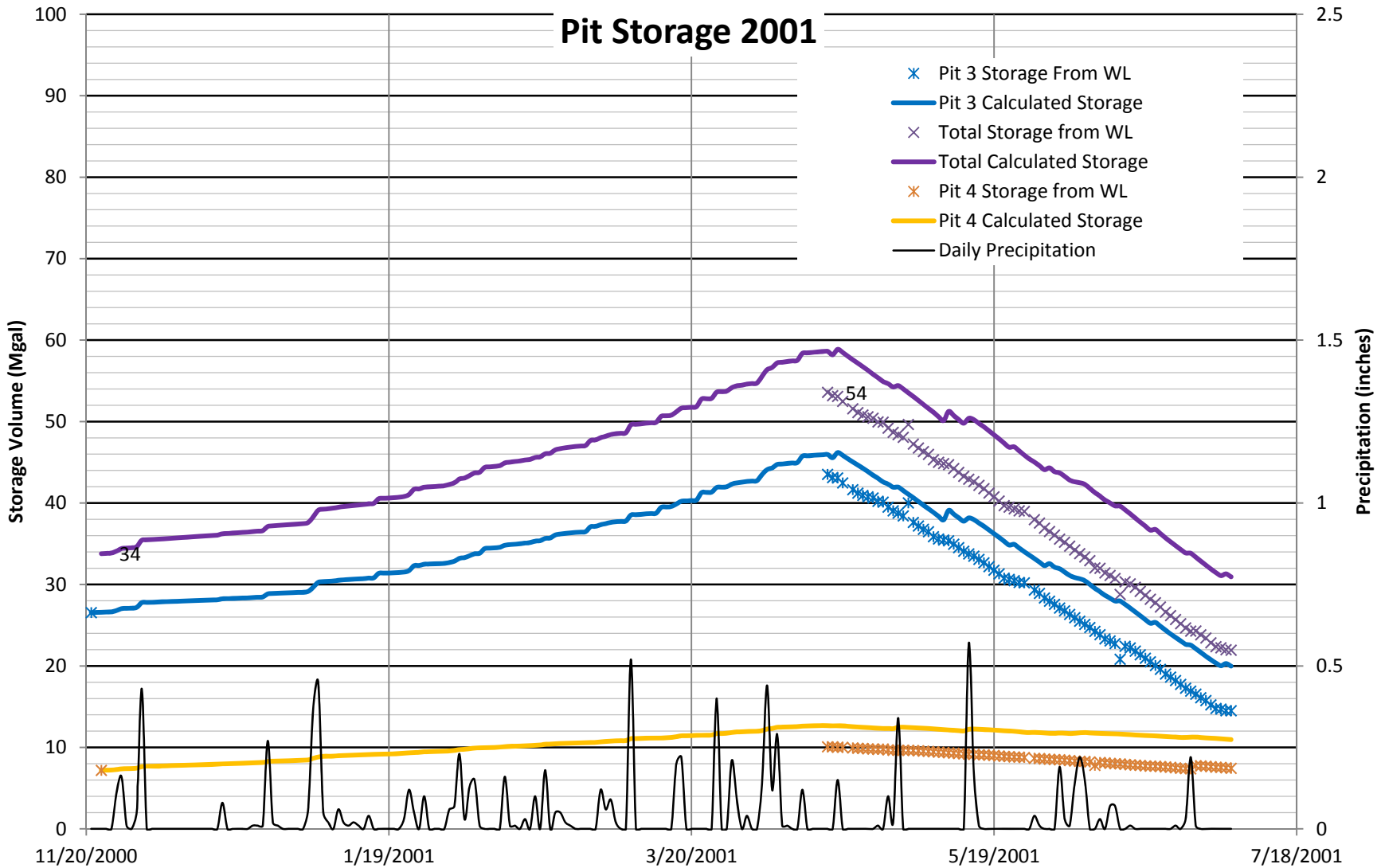

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PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
2001 Operating Year

MWH

DATE
July 2014

FIGURE 5

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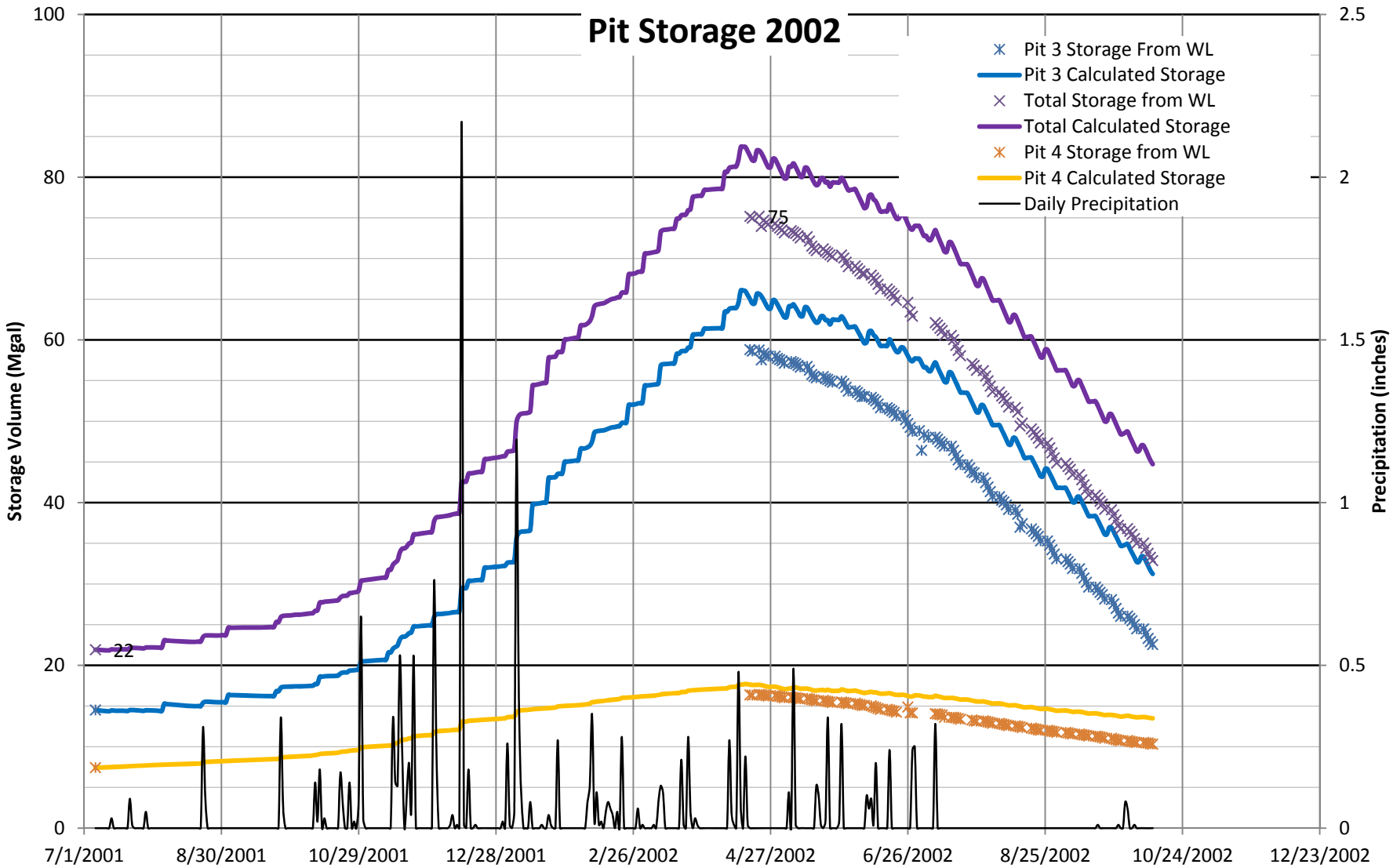

NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
2002 Operating Year

MWH

DATE
July 2014

FIGURE 6

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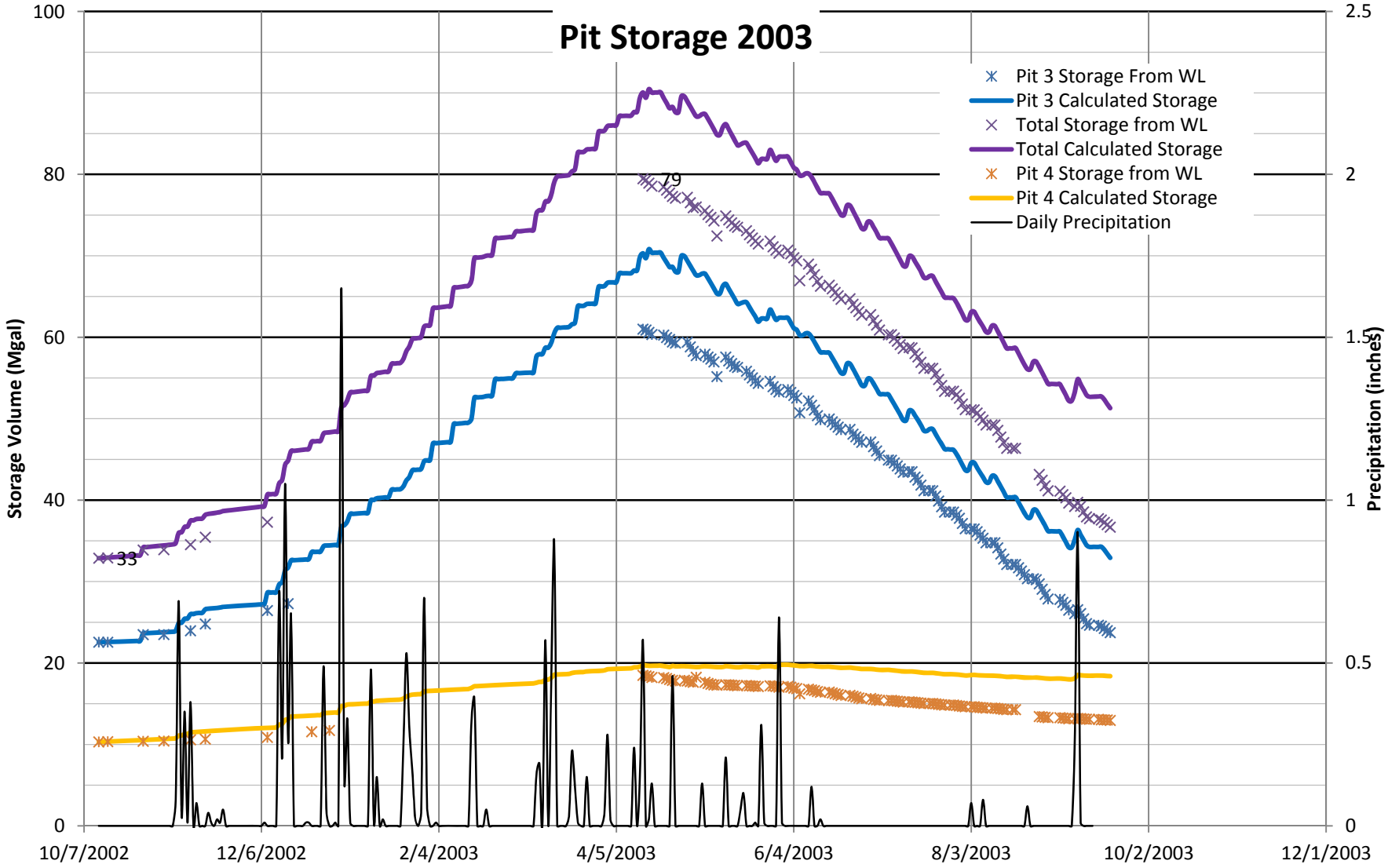
Supplement E-1-1_90% Design.pptx



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PROJECT: MIDNITE MINE

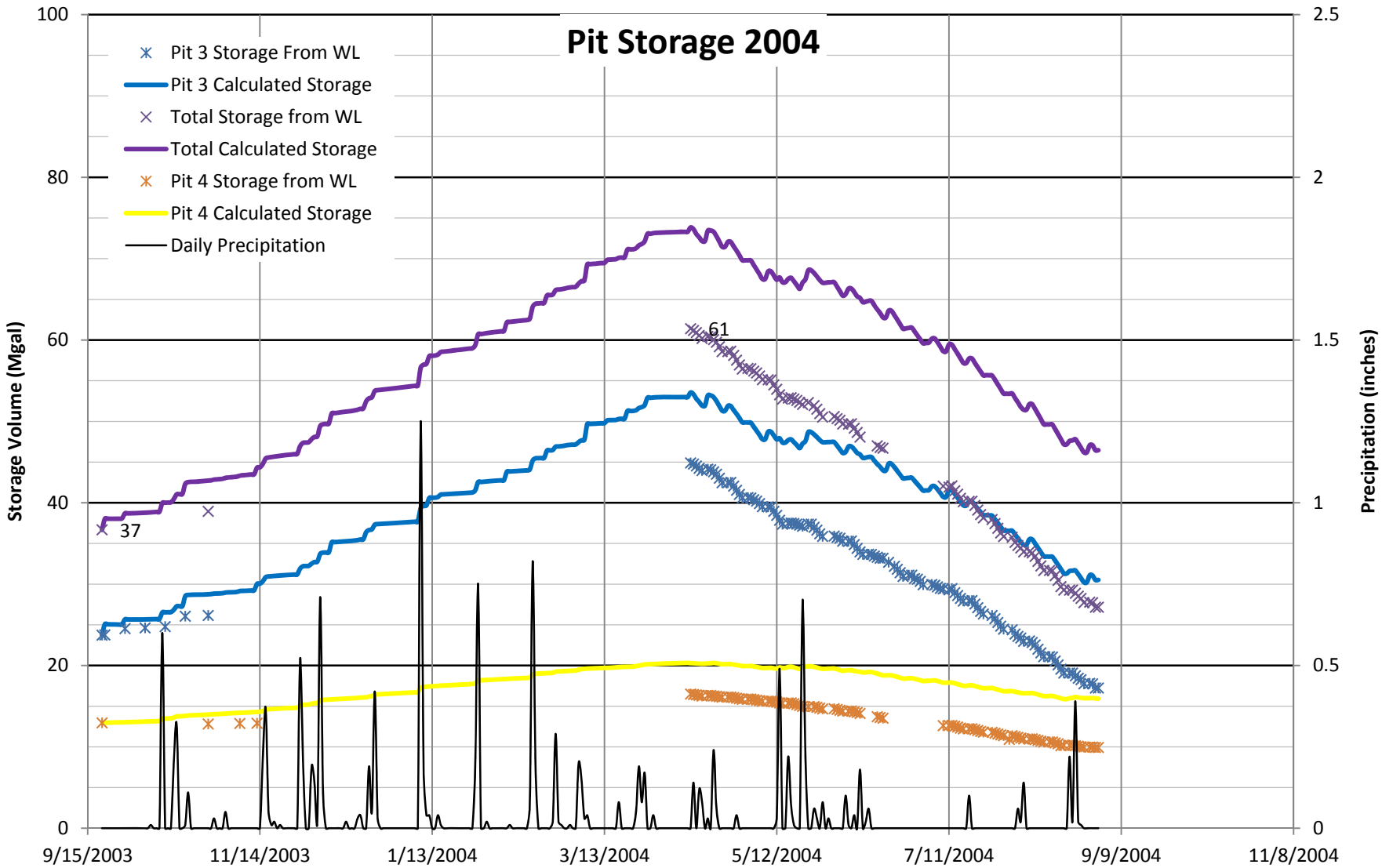
TITLE: Water Balance Analysis - Historic Conditions 2003 Operating Year

MWH

DATE: July 2014

FIGURE 7

FILENAME



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PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
2004 Operating Year

MWH

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FIGURE 8

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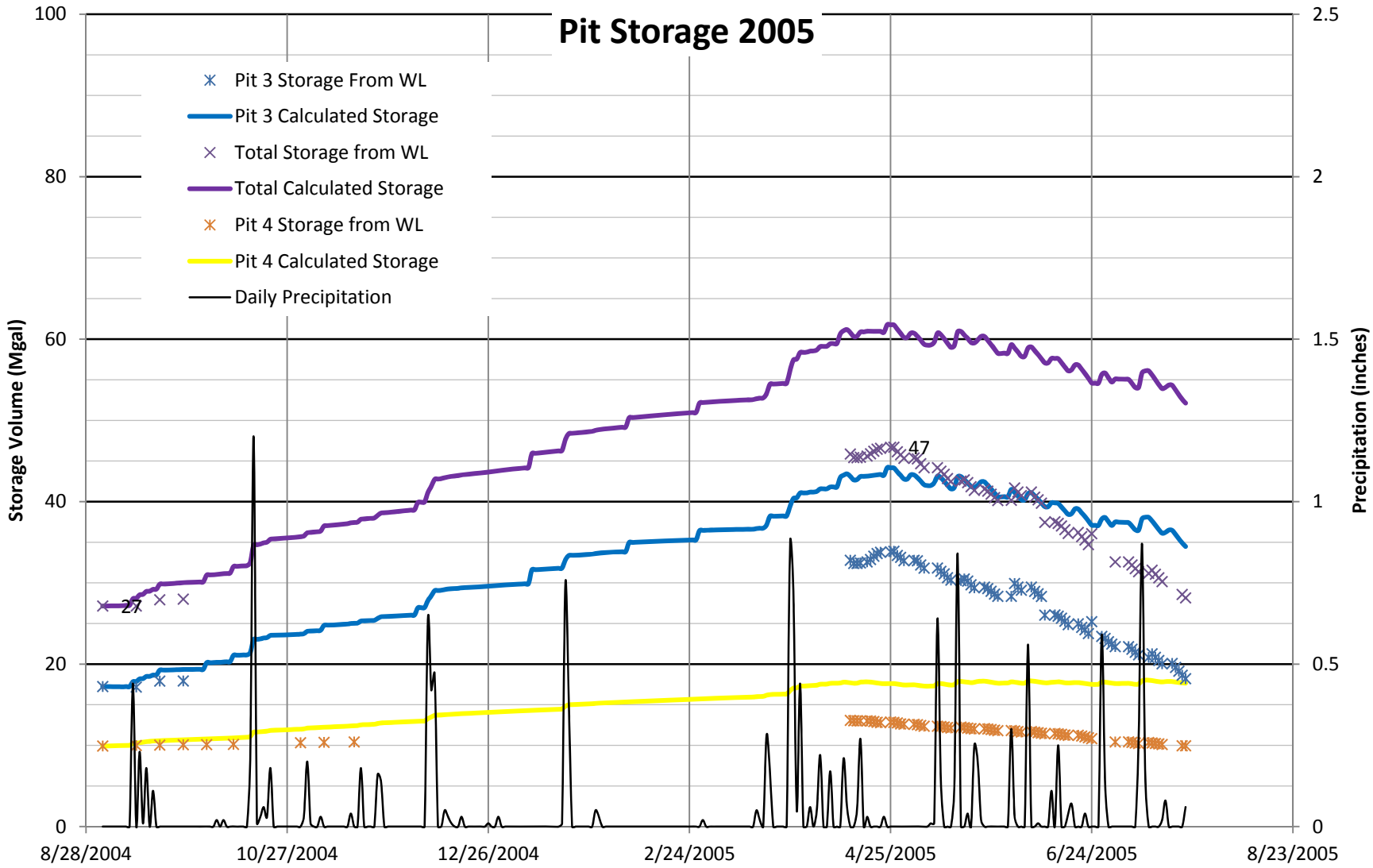


NEWMONT

PROJECT
MIDNITE MINE

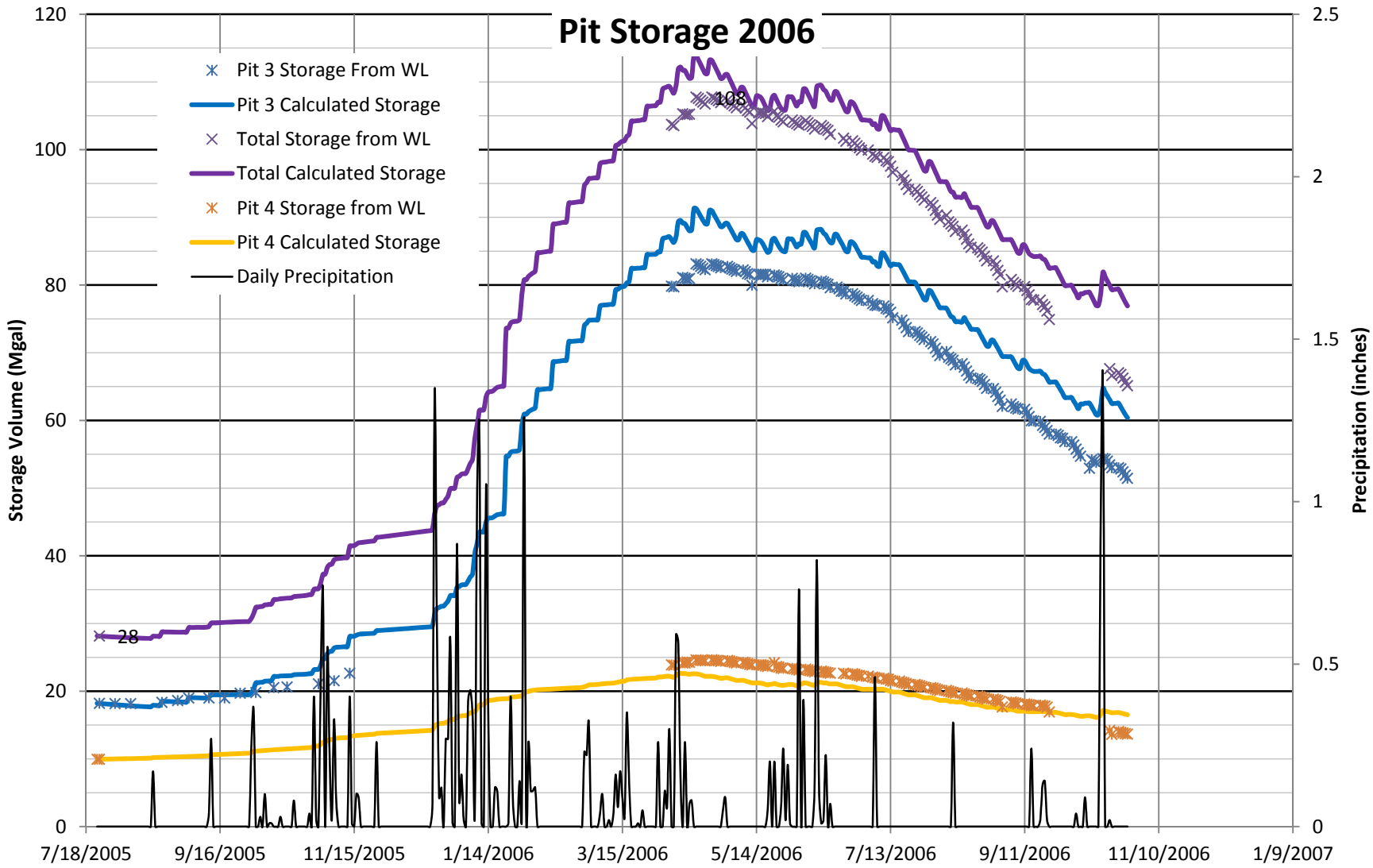
TITLE
Water Balance Analysis - Historic Conditions
2005 Operating Year

MWH

DATE
July 2014

FIGURE 9

FILENAME
Supplement E-1-1_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

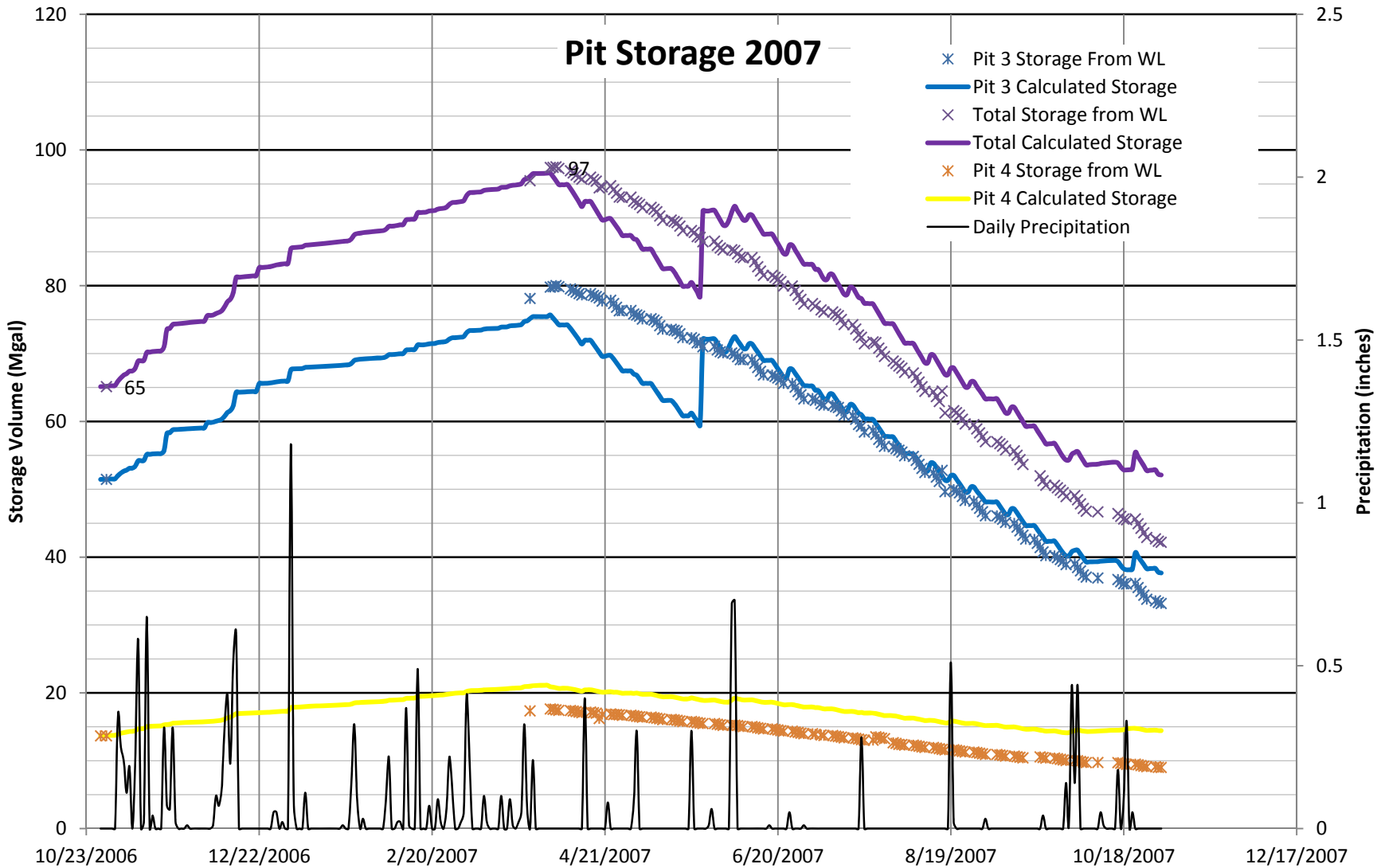
TITLE
Water Balance Analysis - Historic Conditions
2006 Operating Year

MWH

DATE
July 2014

FIGURE 10

FILENAME
Supplement E-1-1_90% Design.pptx



NEWMONT

PROJECT: MIDNITE MINE

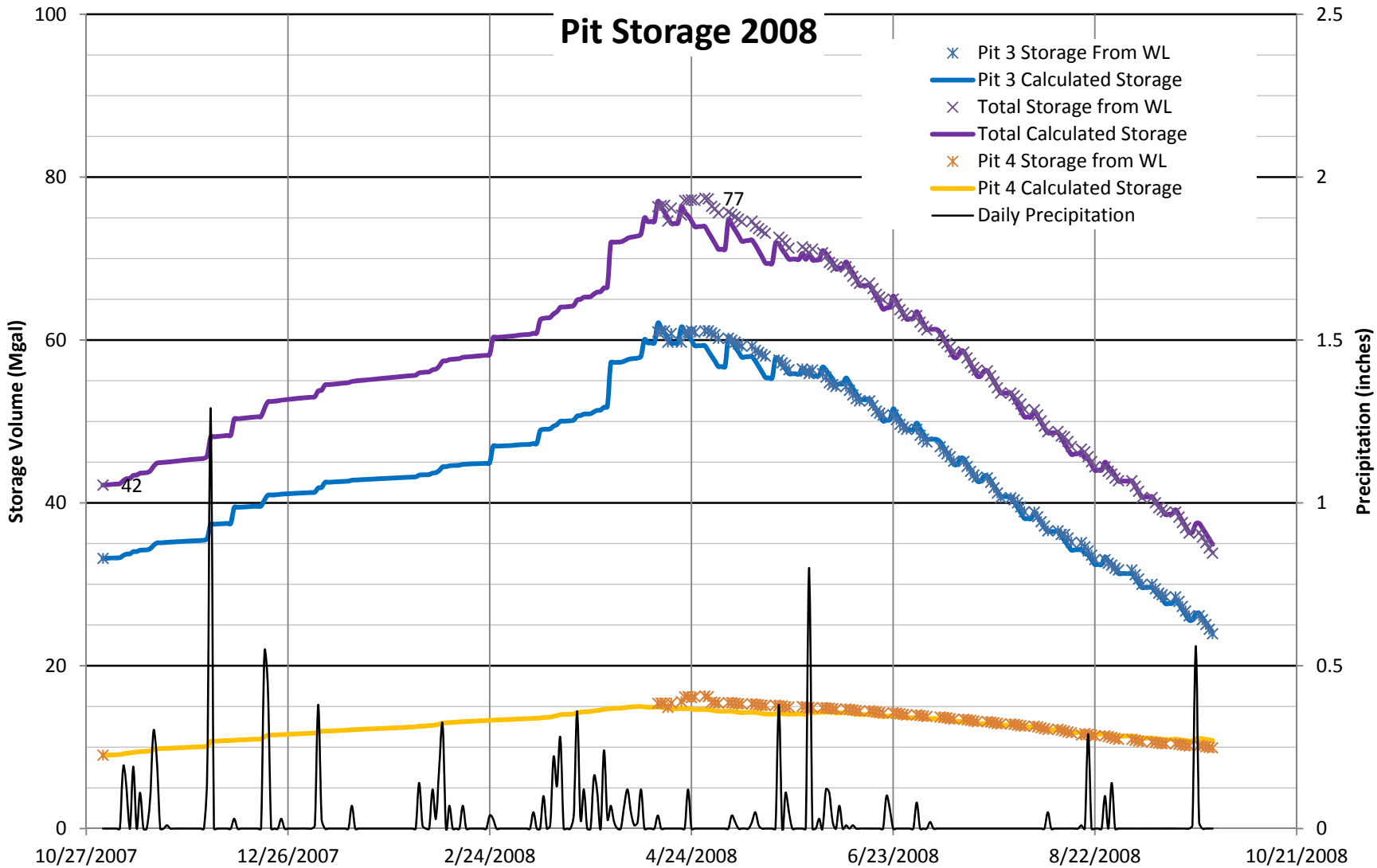
TITLE: Water Balance Analysis - Historic Conditions
2007 Operating Year

MWH

DATE: July 2014

FIGURE 11

FILENAME: Supplement E-1-1_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

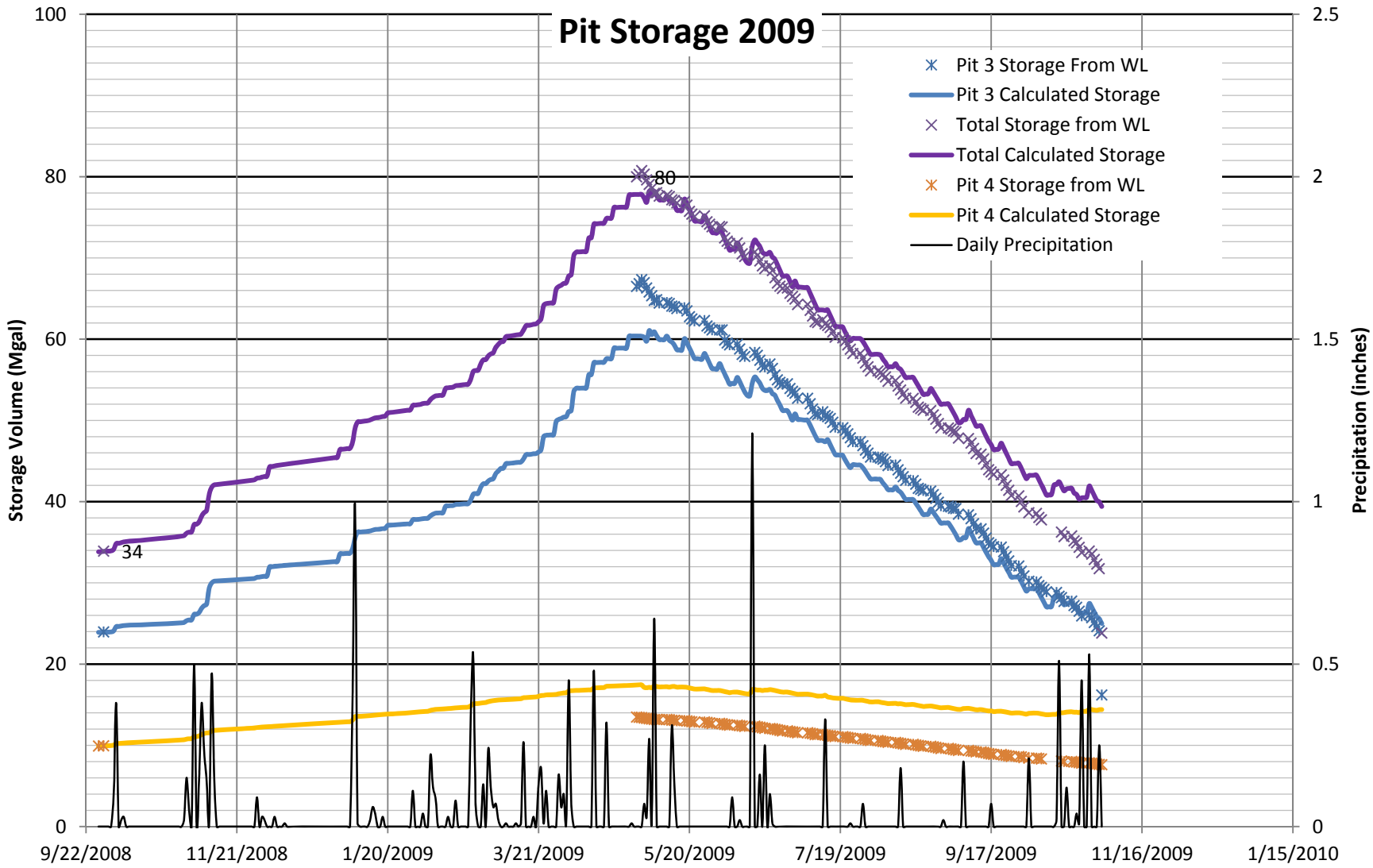
TITLE
Water Balance Analysis - Historic Conditions
2008 Operating Year

MWH

DATE
July 2014

FIGURE 12

FILENAME
Supplement E-1-1_90% Design.pptx



NEWMONT

PROJECT: MIDNITE MINE

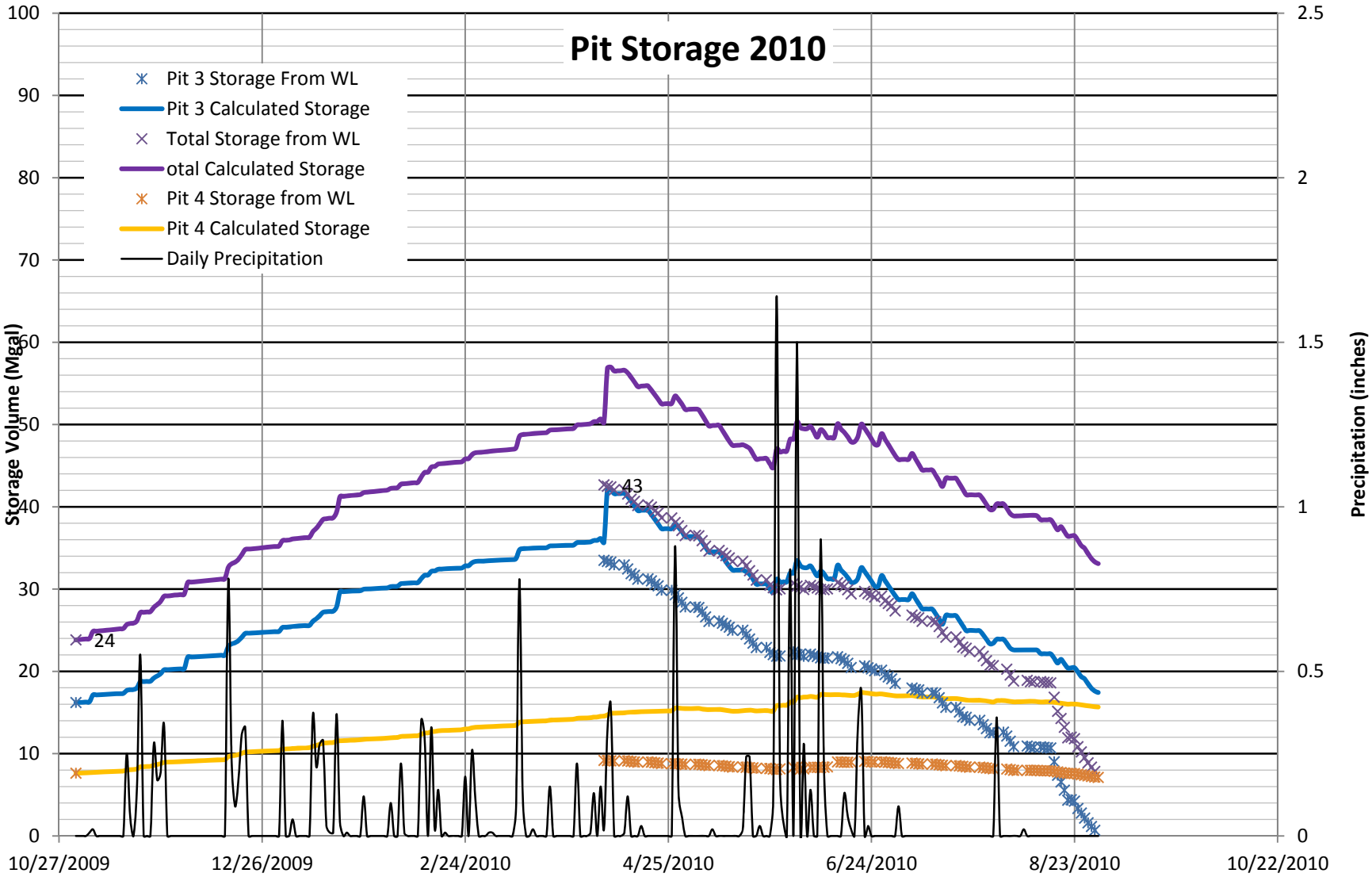
TITLE: Water Balance Analysis - Historic Conditions
2009 Operating Year

MWH

DATE

FIGURE 13

FILENAME: Supplement E-1-1_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

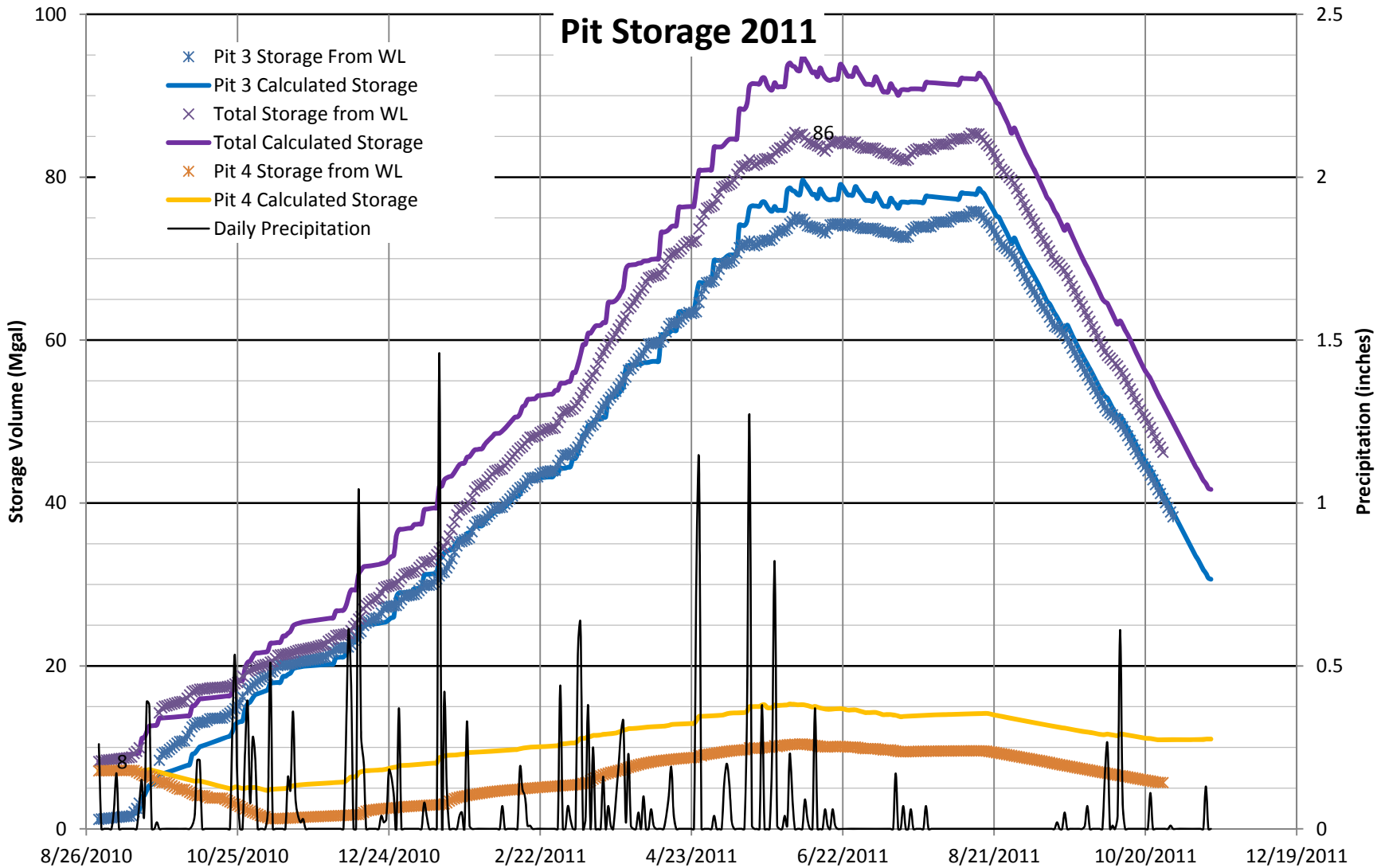
TITLE
Water Balance Analysis - Historic Conditions
2010 Operating Year

MWH

DATE
July 2014

FIGURE 14

FILENAME
Supplement E-1-1_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
2011 Operating Year

MWH

DATE
July 2014

FIGURE 15

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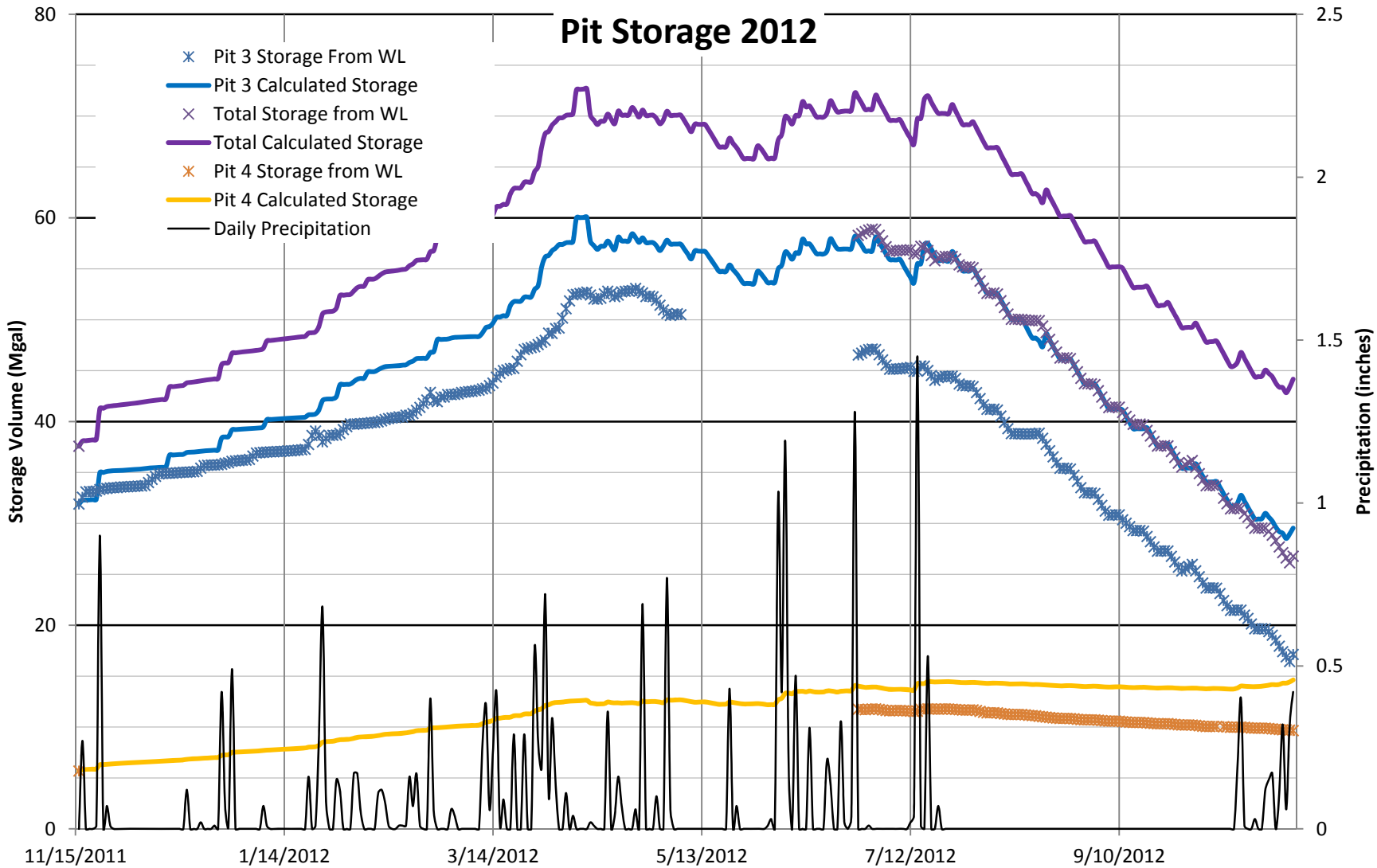

NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
2012 Operating Year

MWH

DATE
July 2014

FIGURE 16

FILENAME
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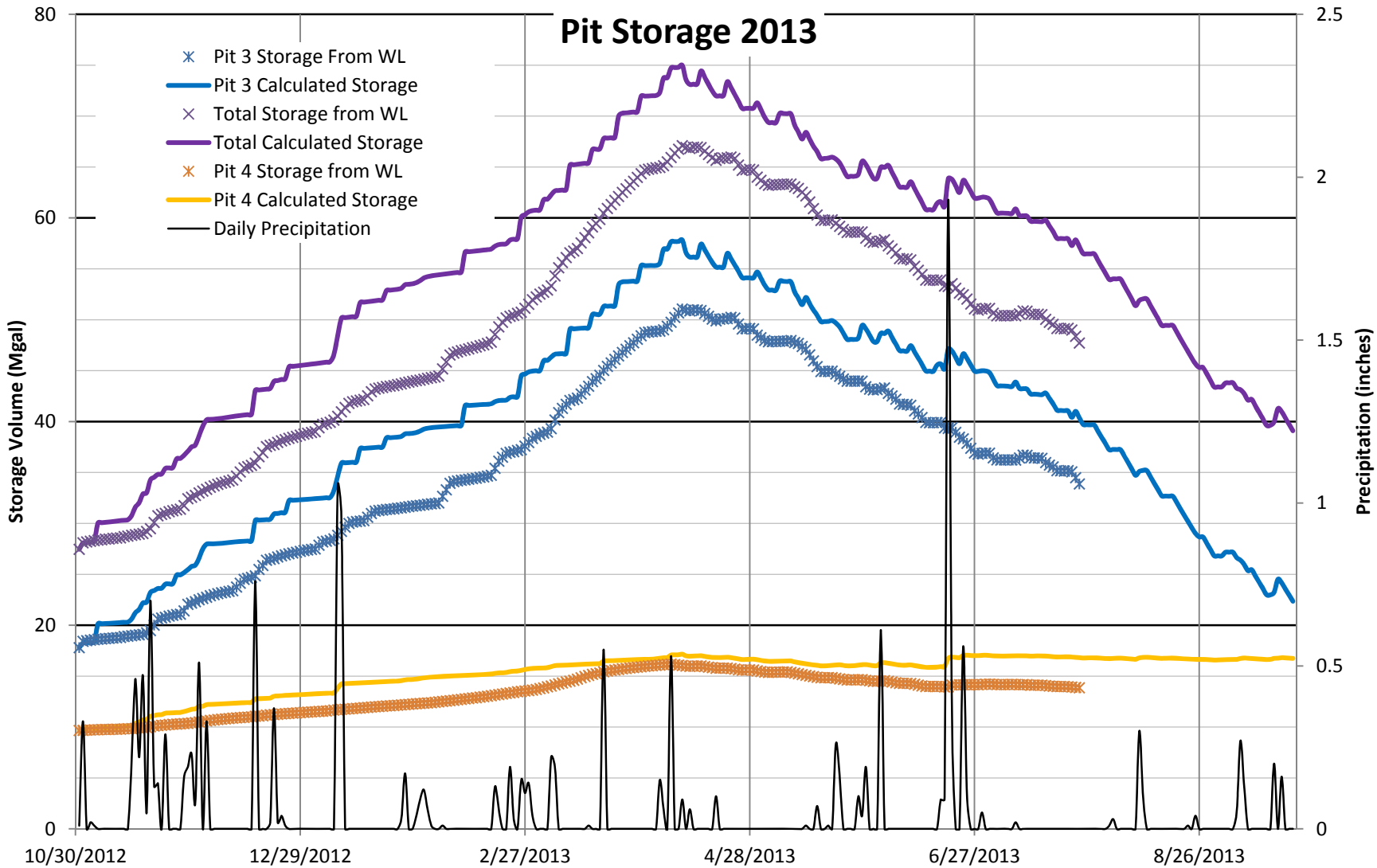


NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - Historic Conditions
2013 Operating Year

MWH

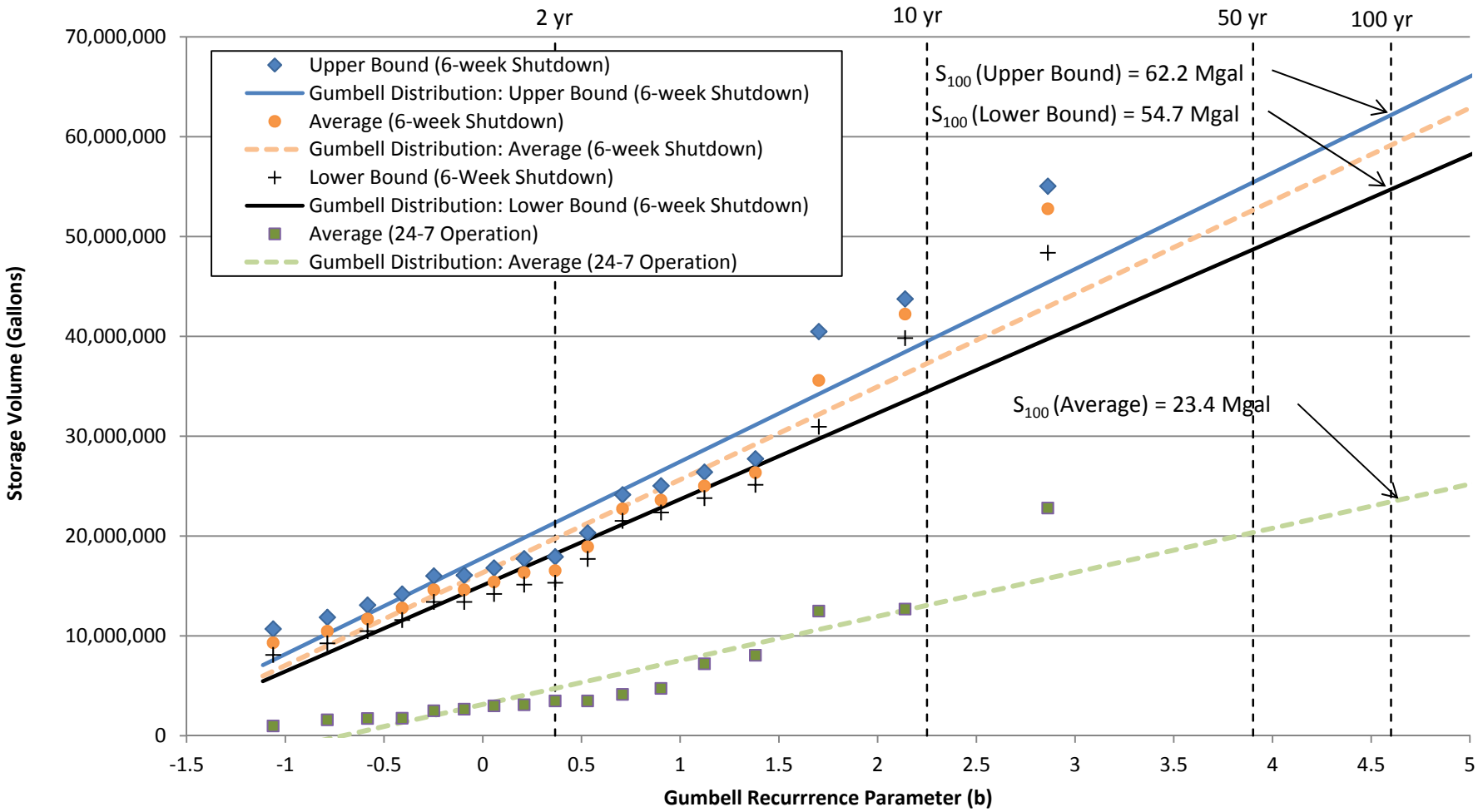
DATE
July 2014

FIGURE 17

FILENAME
Supplement E-1-1_90% Design.pptx

Supplement E-1.2

Analysis of Storage with New Water Treatment Plant



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Recurrence Relationship for Phase 2 Required Storage 500gpm Operations

MWH

DATE: July 2014

FIGURE 1

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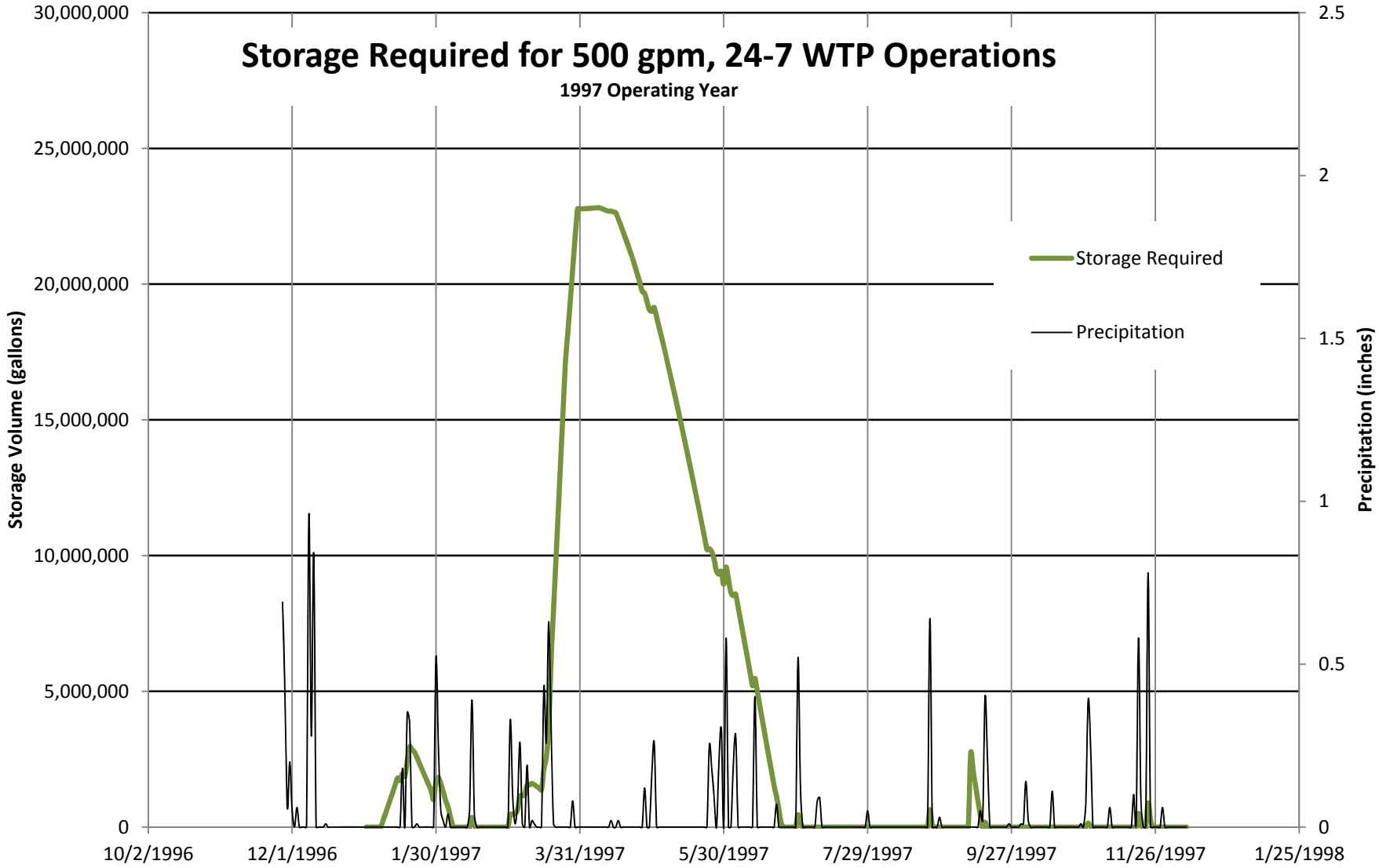


NEWMONT

PROJECT
MIDNITE MINE

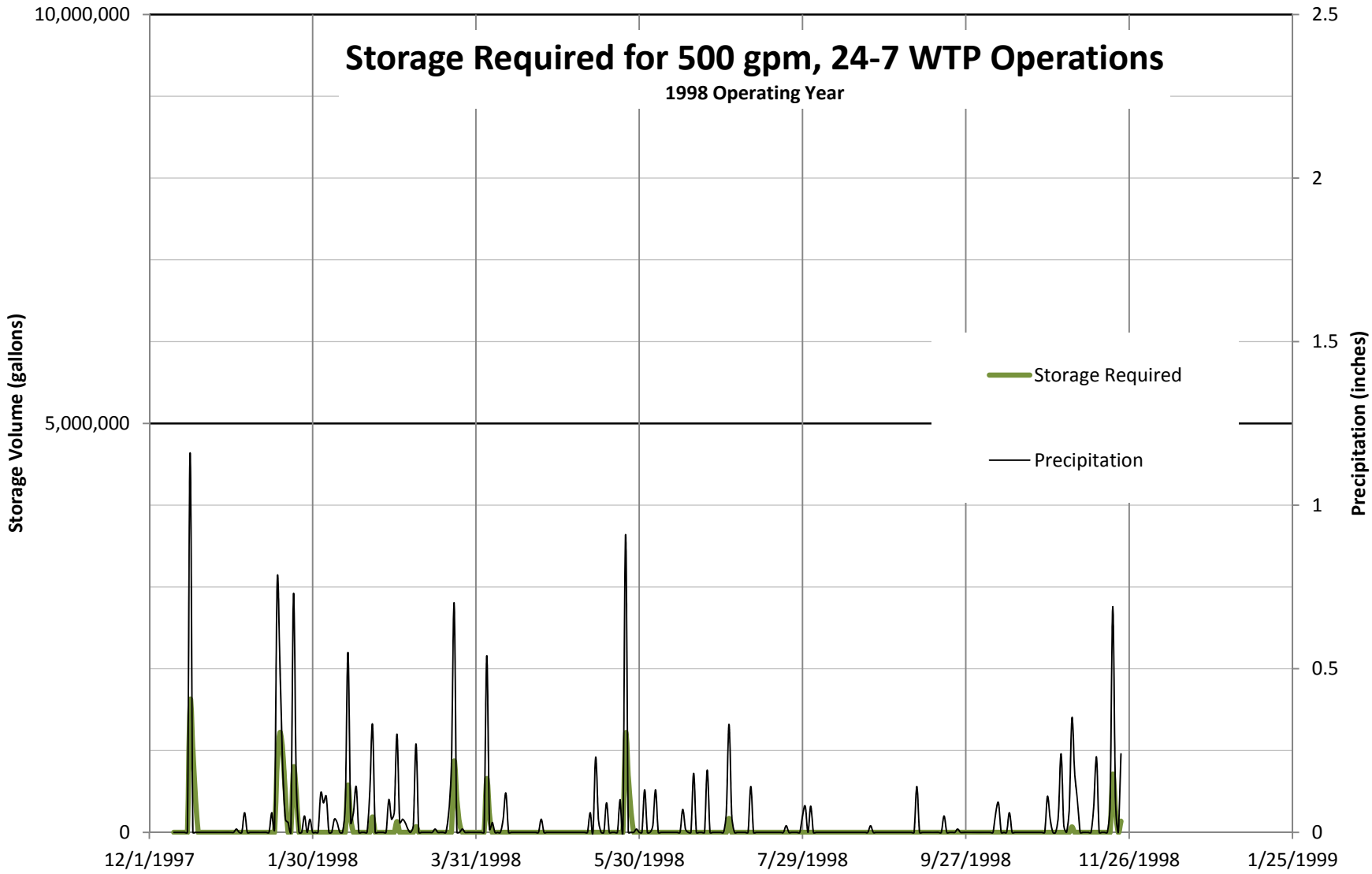
TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 1997 Operating Year

MWH

DATE
July 2014

FIGURE 2

FILENAME
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

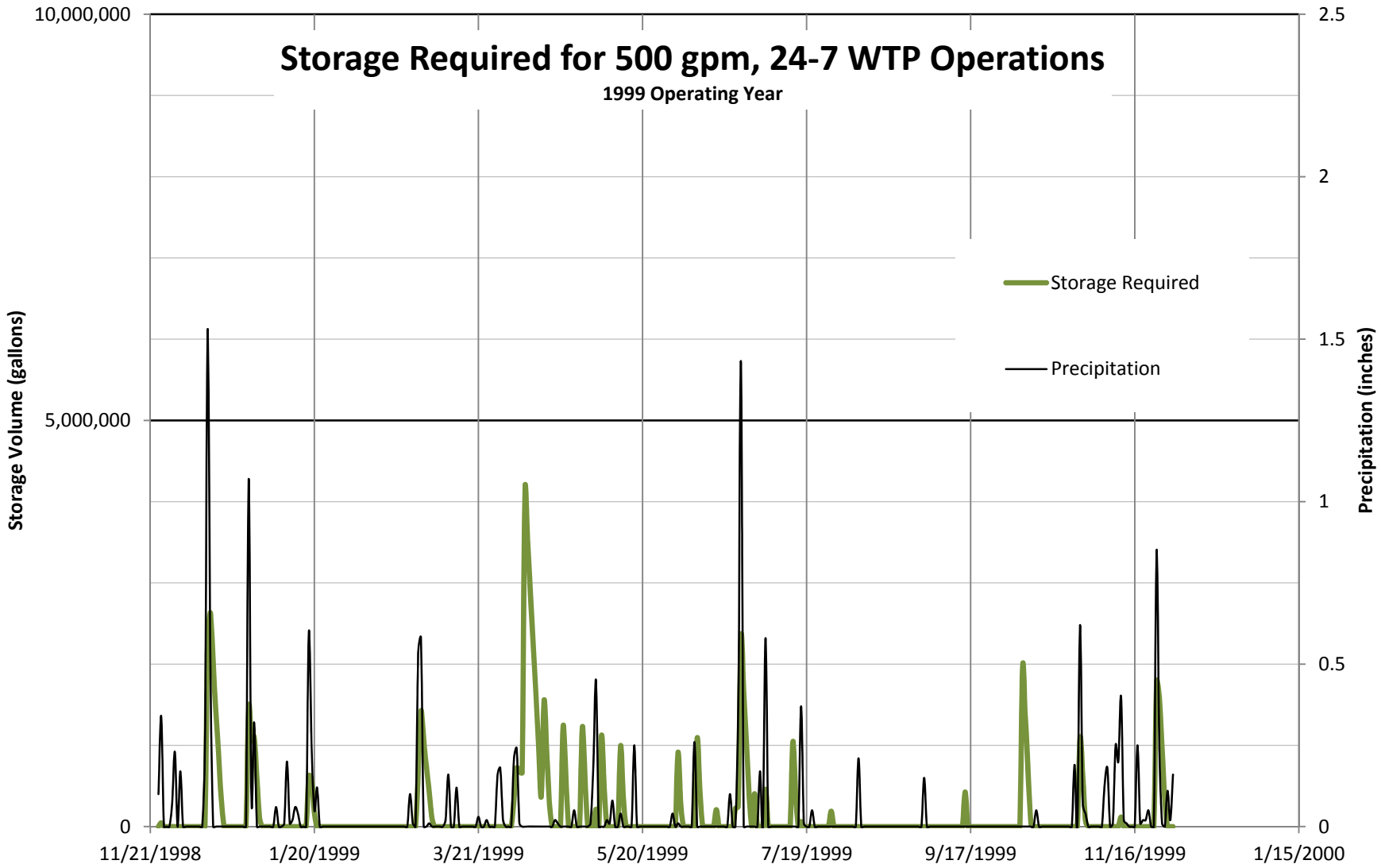
TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations - 1998 Operating Year

MWH

DATE
July 2014

FIGURE 3

FILENAME
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

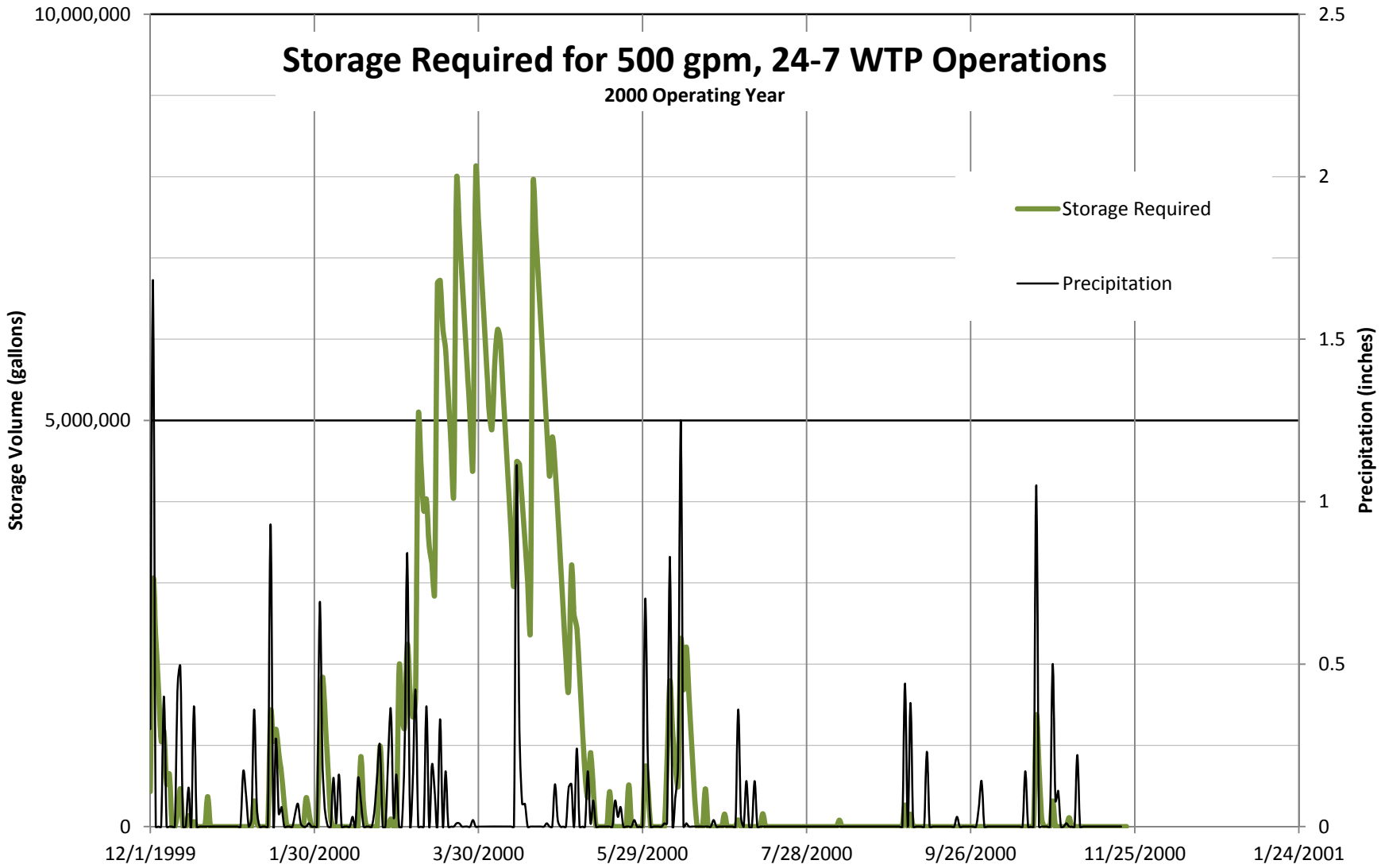
TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 1999 Operating Year

MWH

DATE
July 2014

FIGURE 4

FILENAME
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

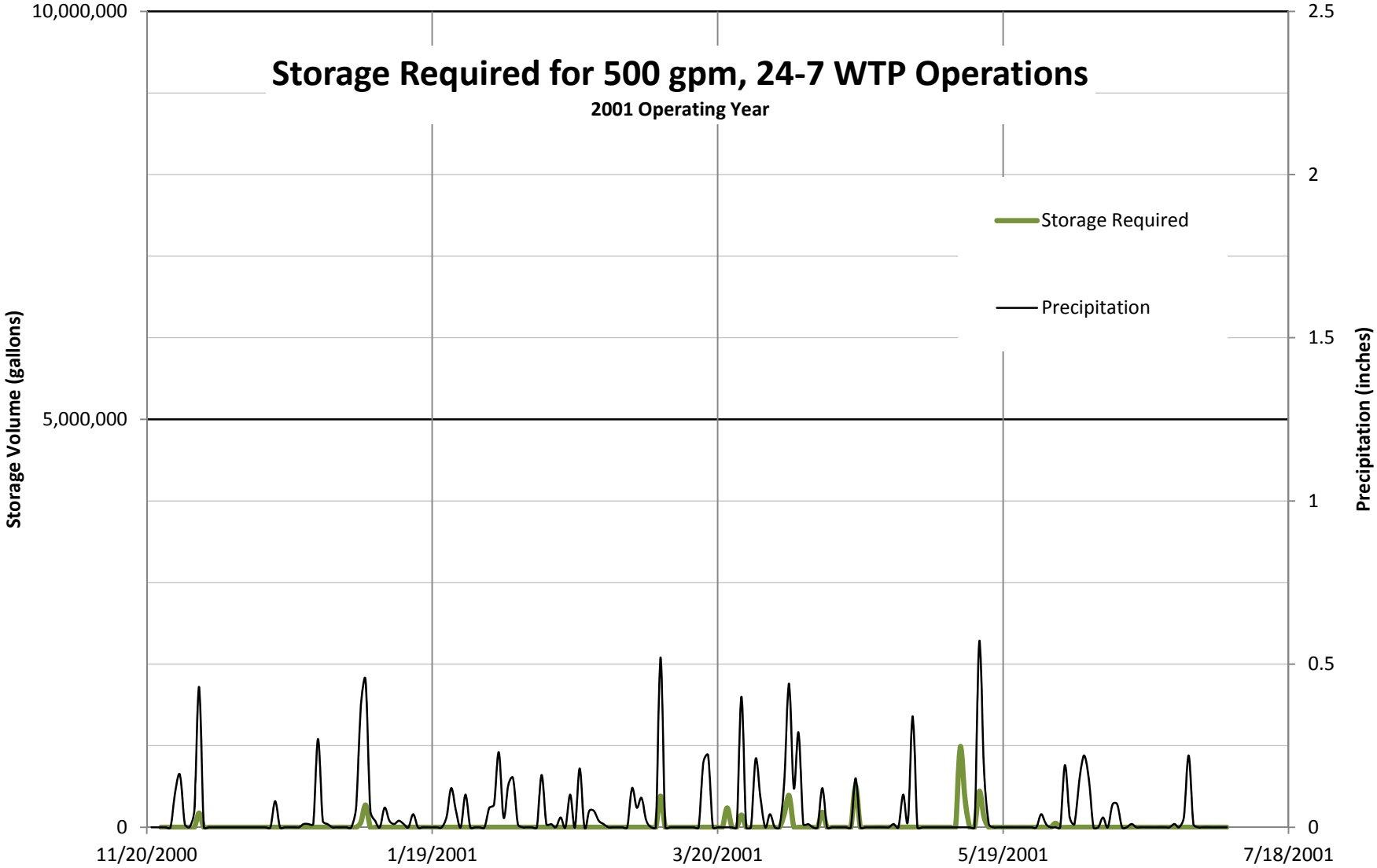
TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 2000 Operating Year

MWH

DATE
July 2014

FIGURE 5

FILENAME
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

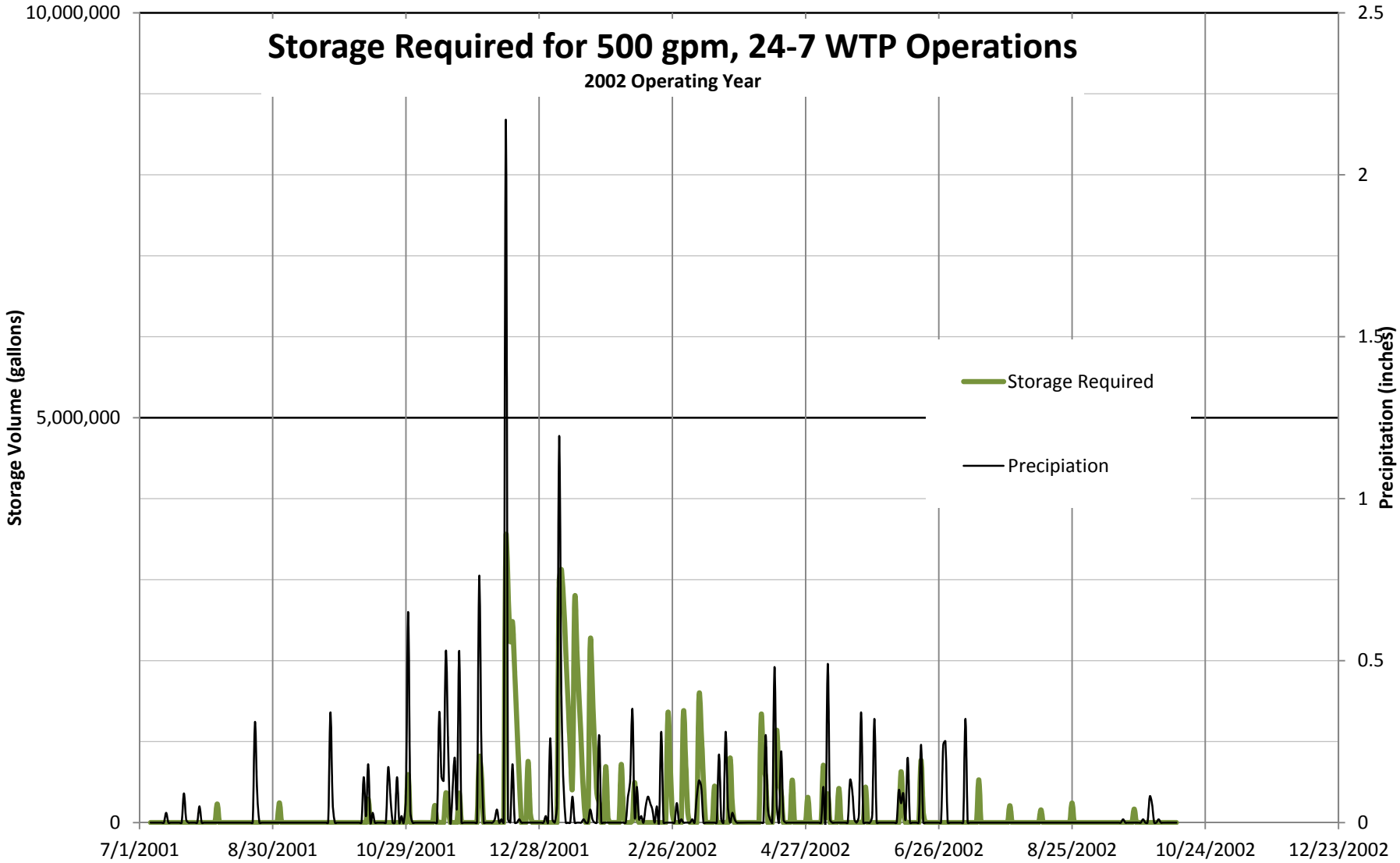
TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations - 2001 Operating Year

MWH

DATE
July 2014

FIGURE 6

FILENAME
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

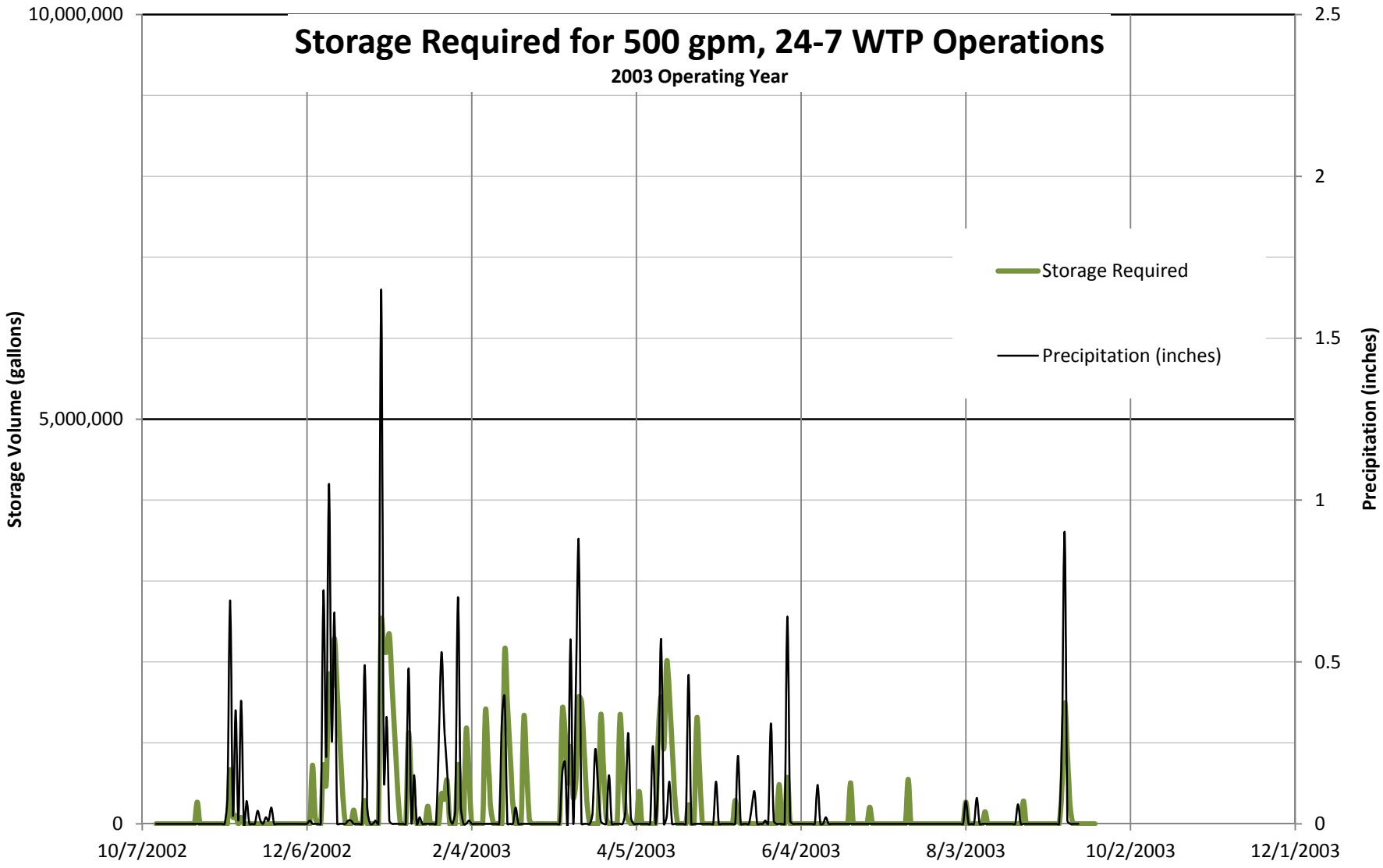
TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 2002 Operating Year

MWH

DATE
July 2014

FIGURE 7

FILENAME
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 2003 Operating Year

MWH

DATE
July 2014

FIGURE 8

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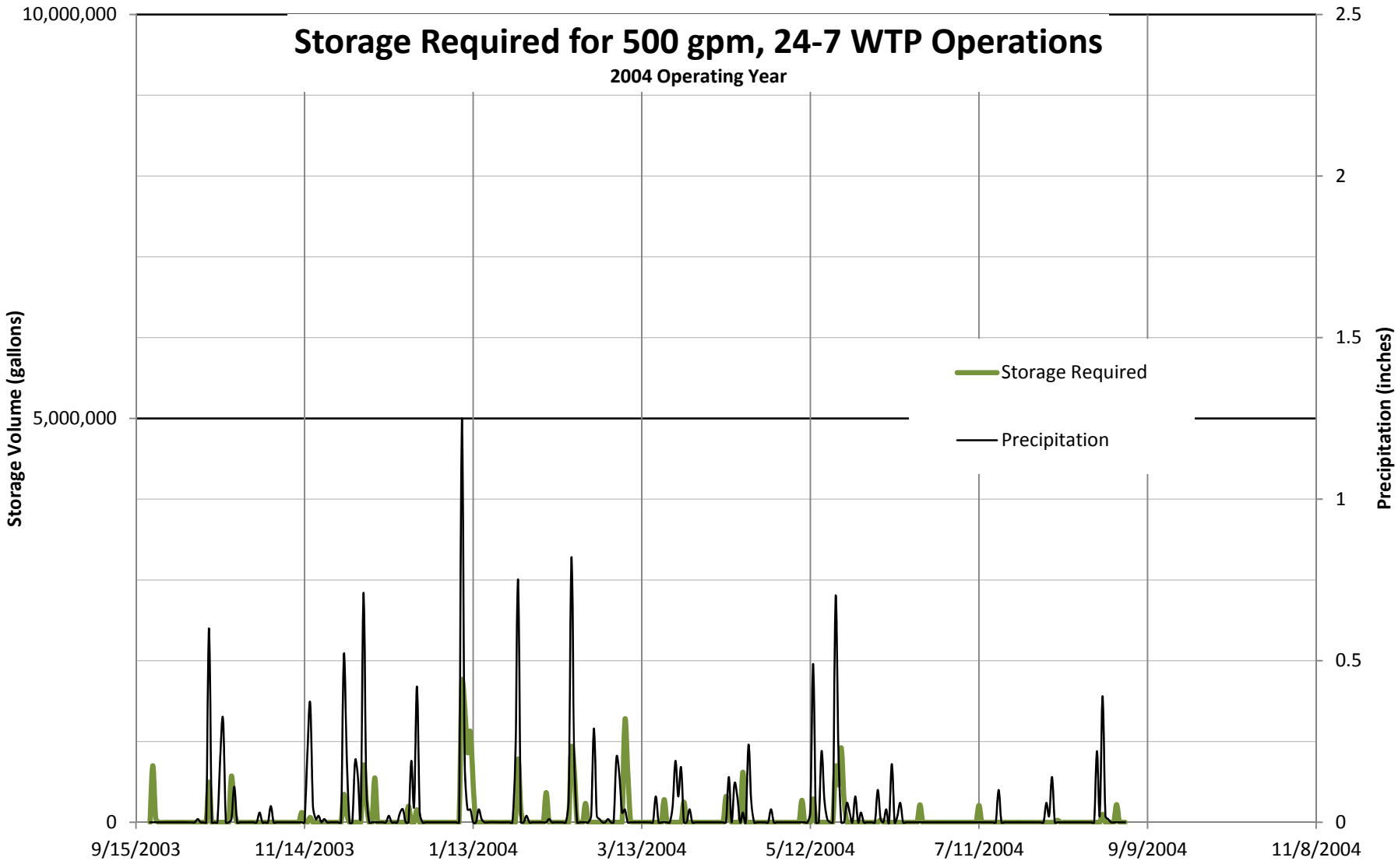
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations - 2004 Operating Year

MWH

DATE
July 2014

FIGURE 9

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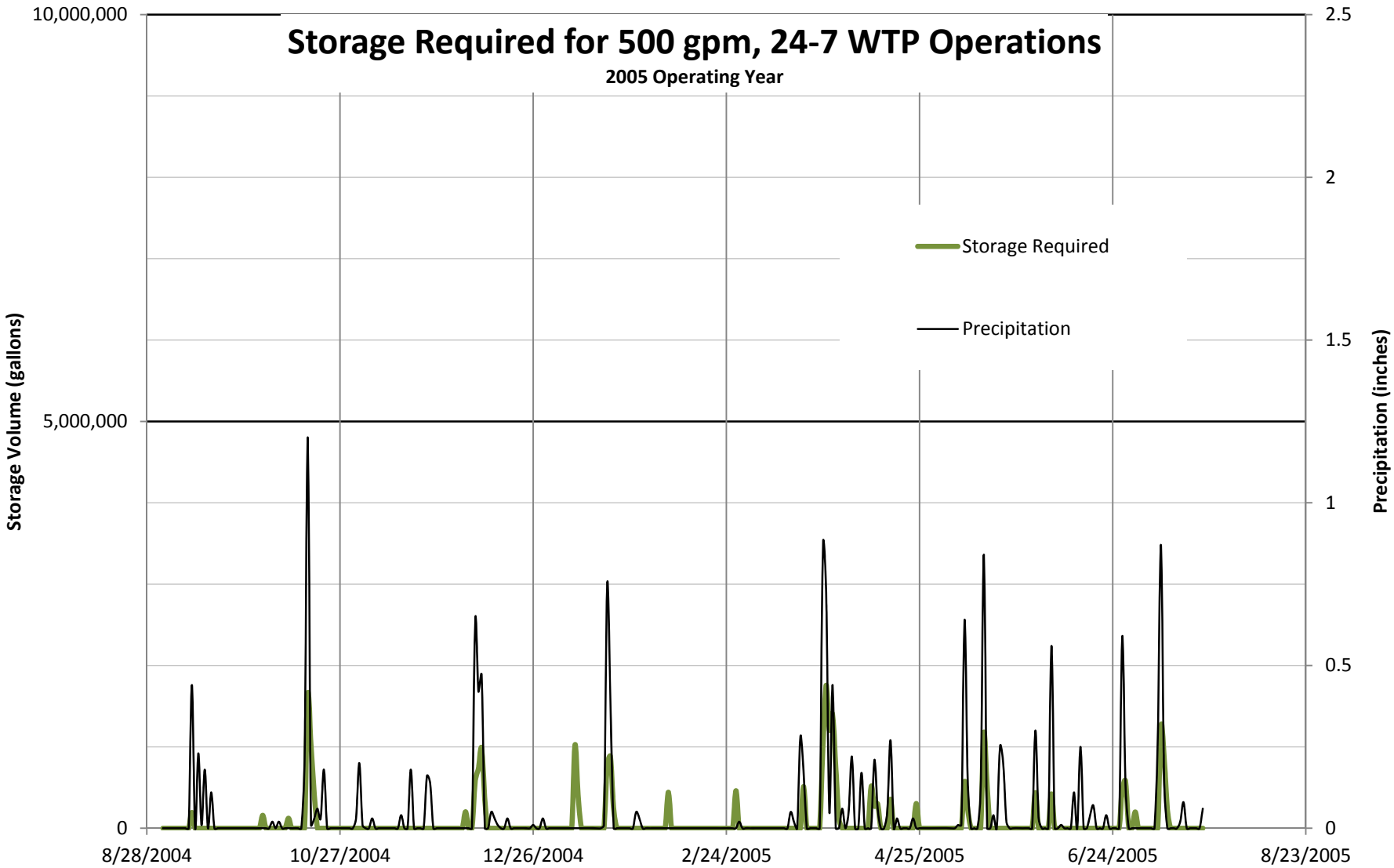
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations - 2005 Operating Year

MWH

DATE
July 2014

FIGURE 10

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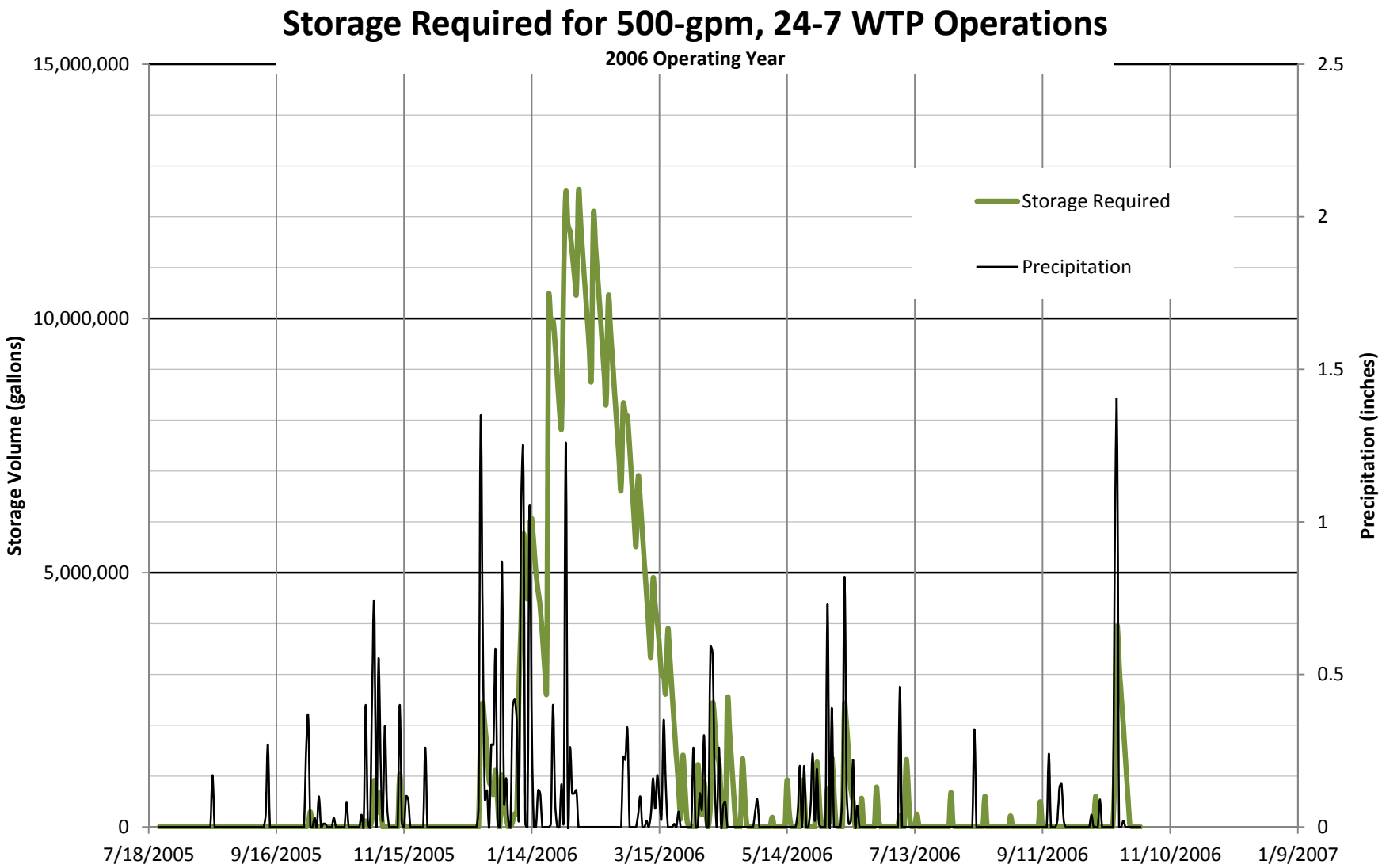
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations - 2006 Operating Year

MWH

DATE
July 2014

FIGURE 11

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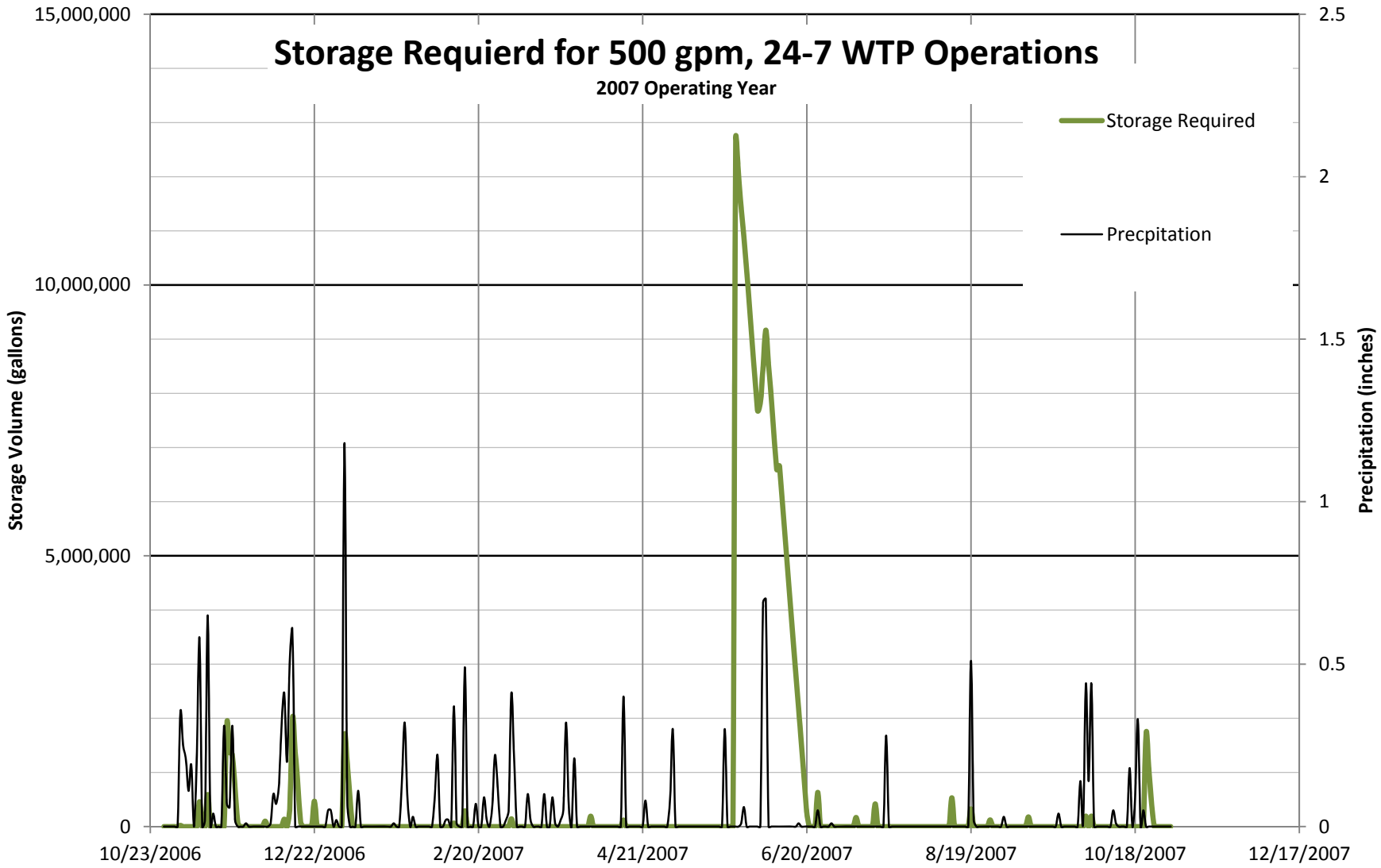
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations - 2007 Operating Year

MWH

DATE
July 2014

FIGURE 12

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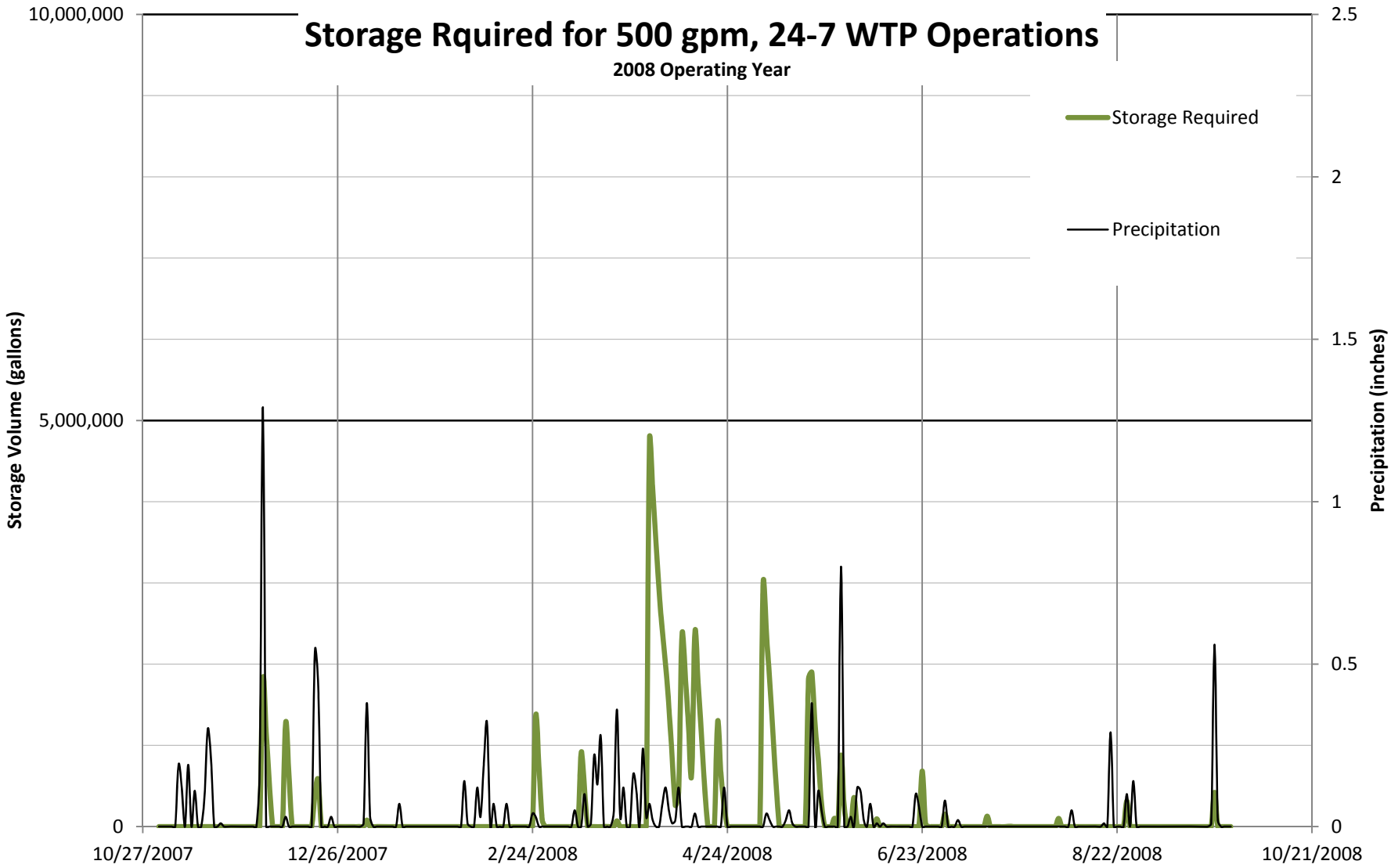
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

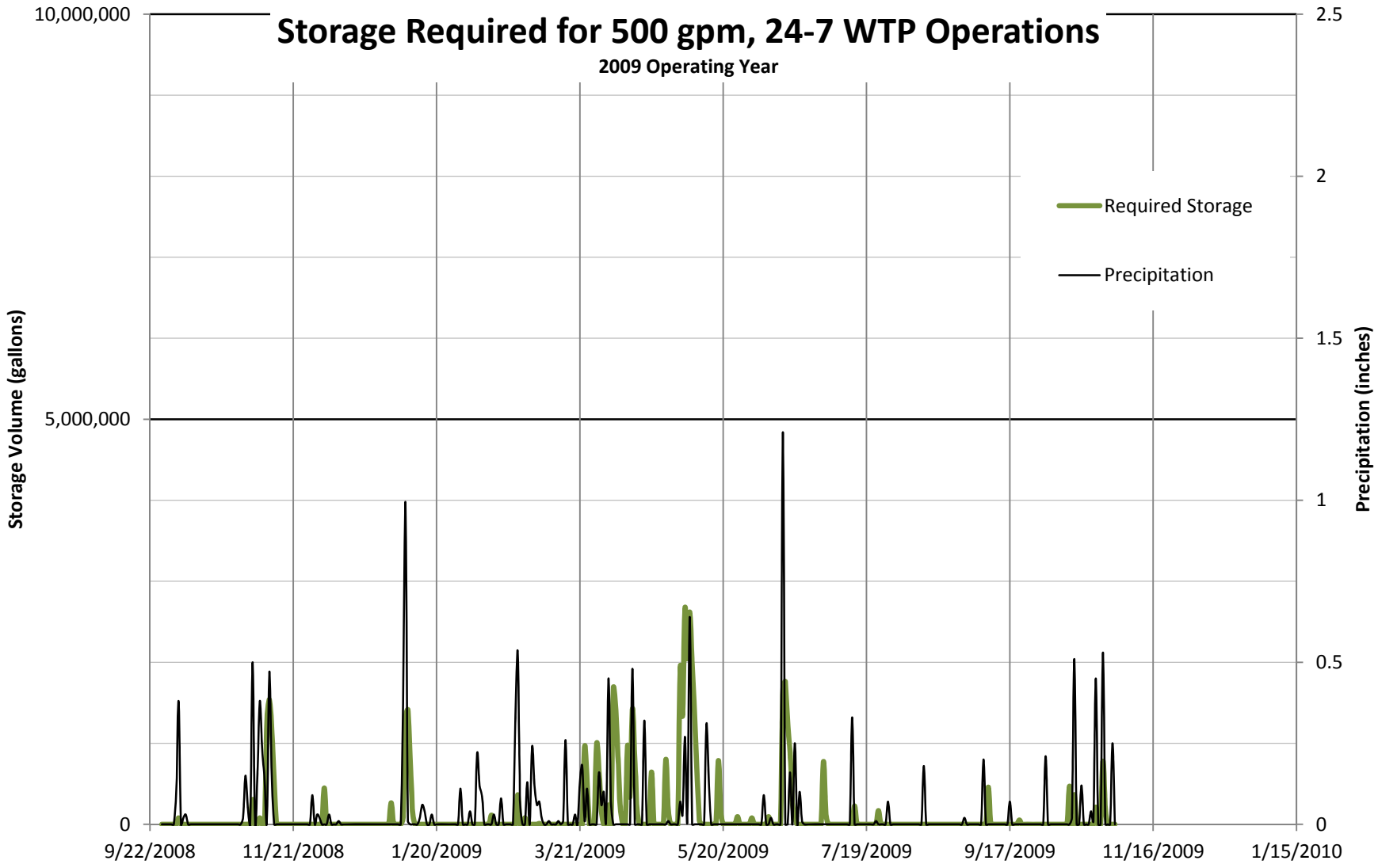
TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 2008 Operating Year

MWH

DATE
July 2014

FIGURE 13

FILENAME
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

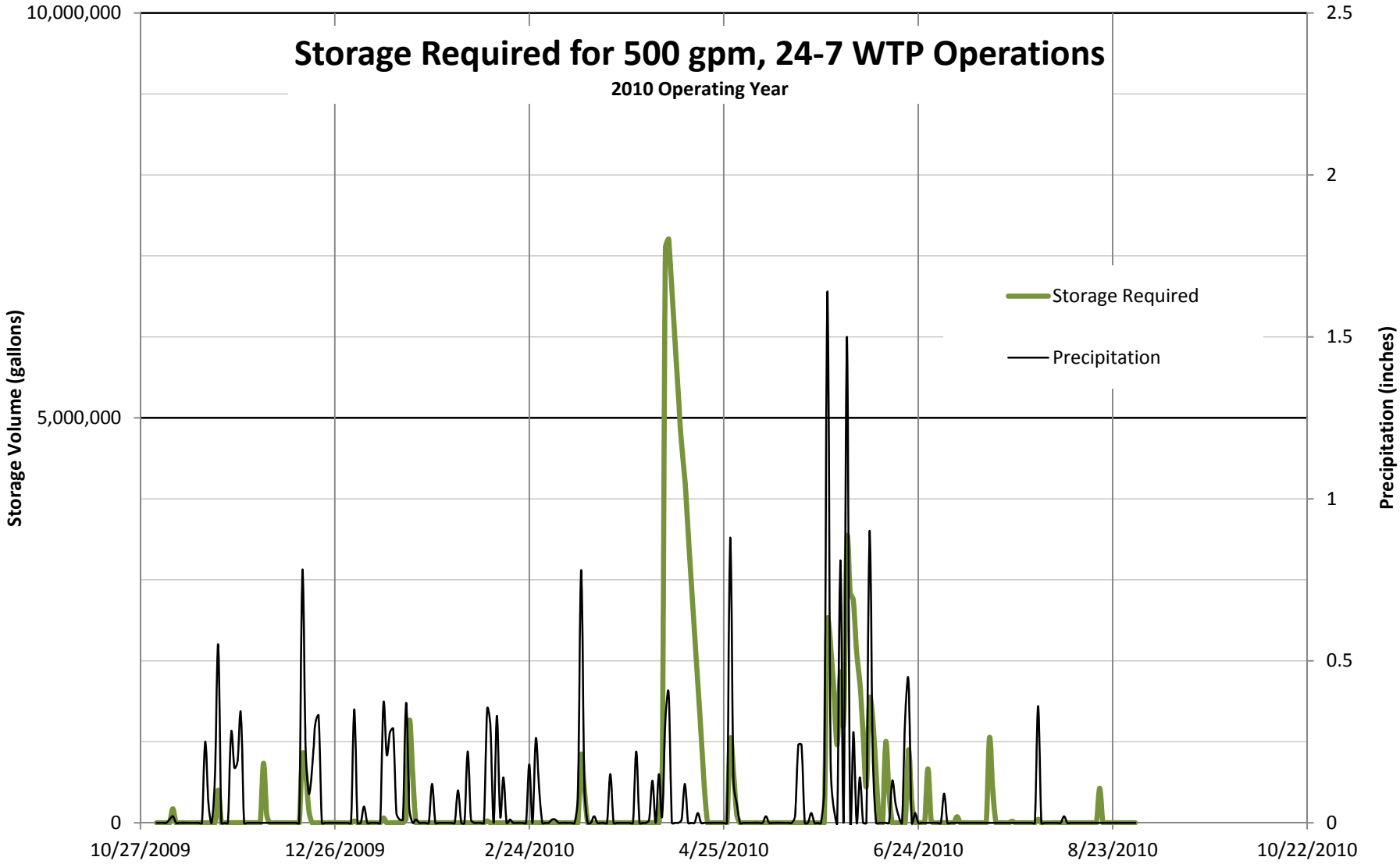
TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 2009 Operating Year

MWH

DATE
July 2014

FIGURE 14

FILENAME
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations - 2010 Operating Year

MWH

DATE
July 2014

FIGURE 15

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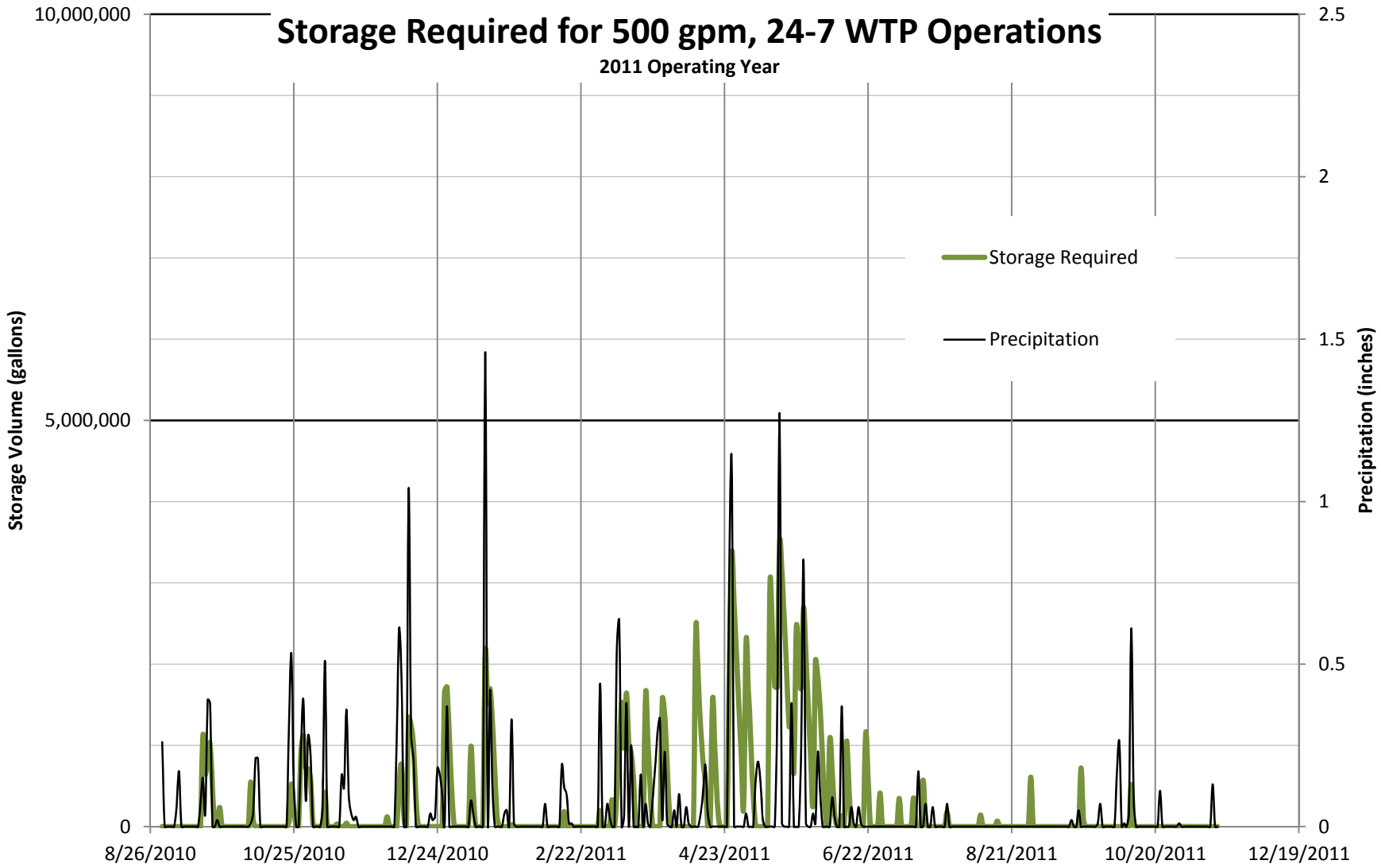
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 2011 Operating Year

MWH

DATE
July 2014

FIGURE 16

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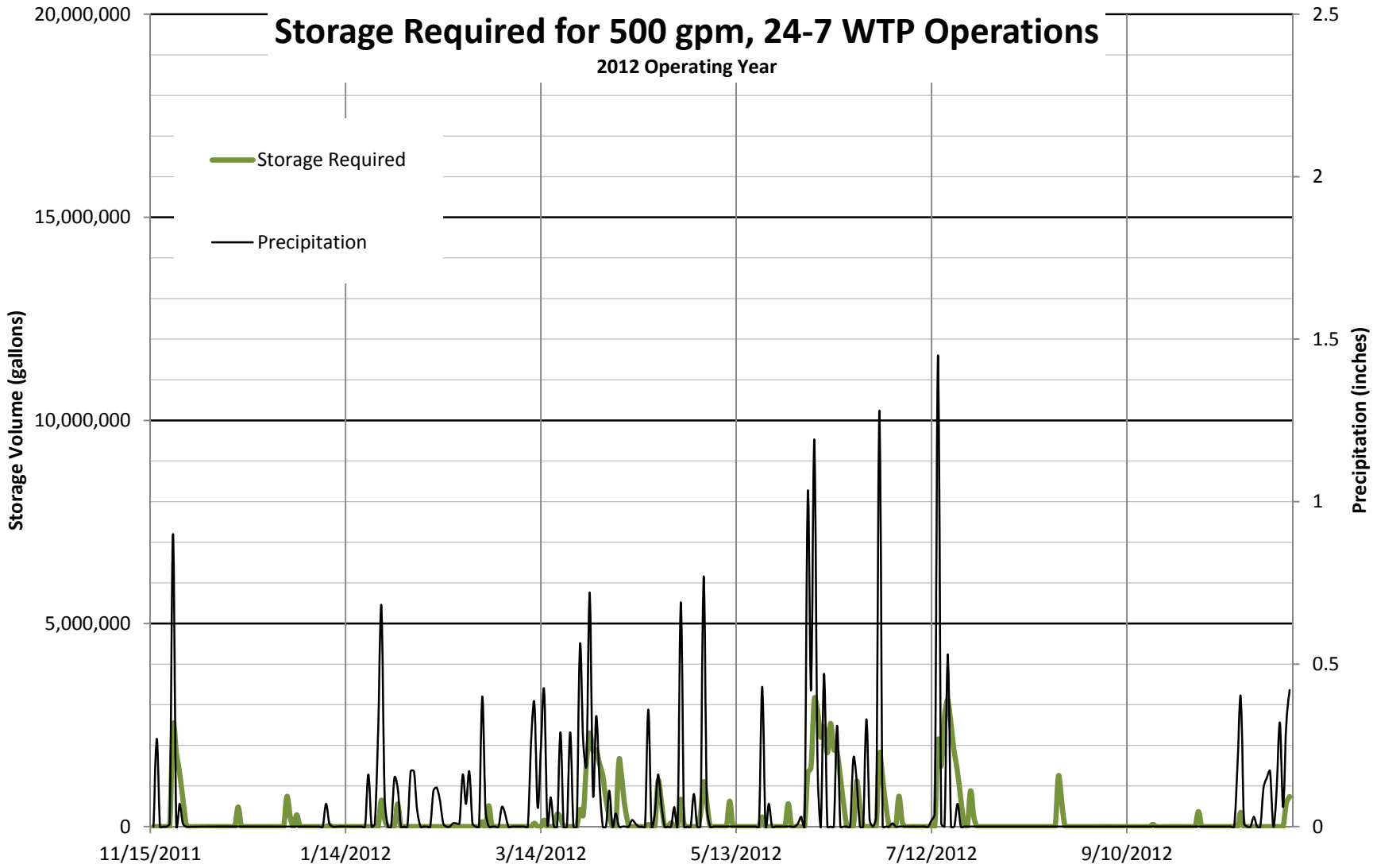
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 2012 Operating Year

MWH

DATE
July 2014

FIGURE 17

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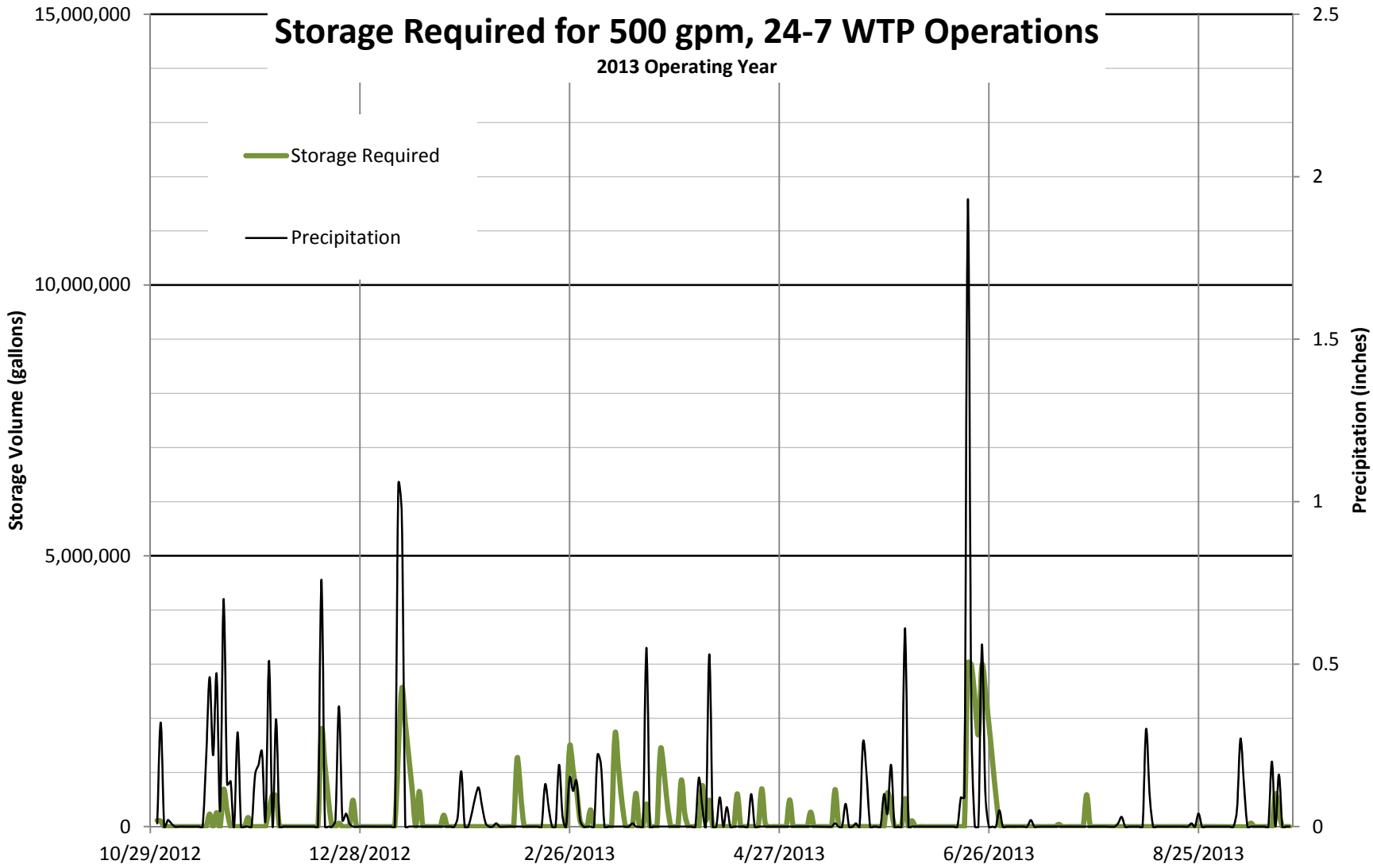
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 500 gpm, 24 hr/day, 7day/week Operations – 2013 Operating Year

MWH

DATE
July 2014

FIGURE 18

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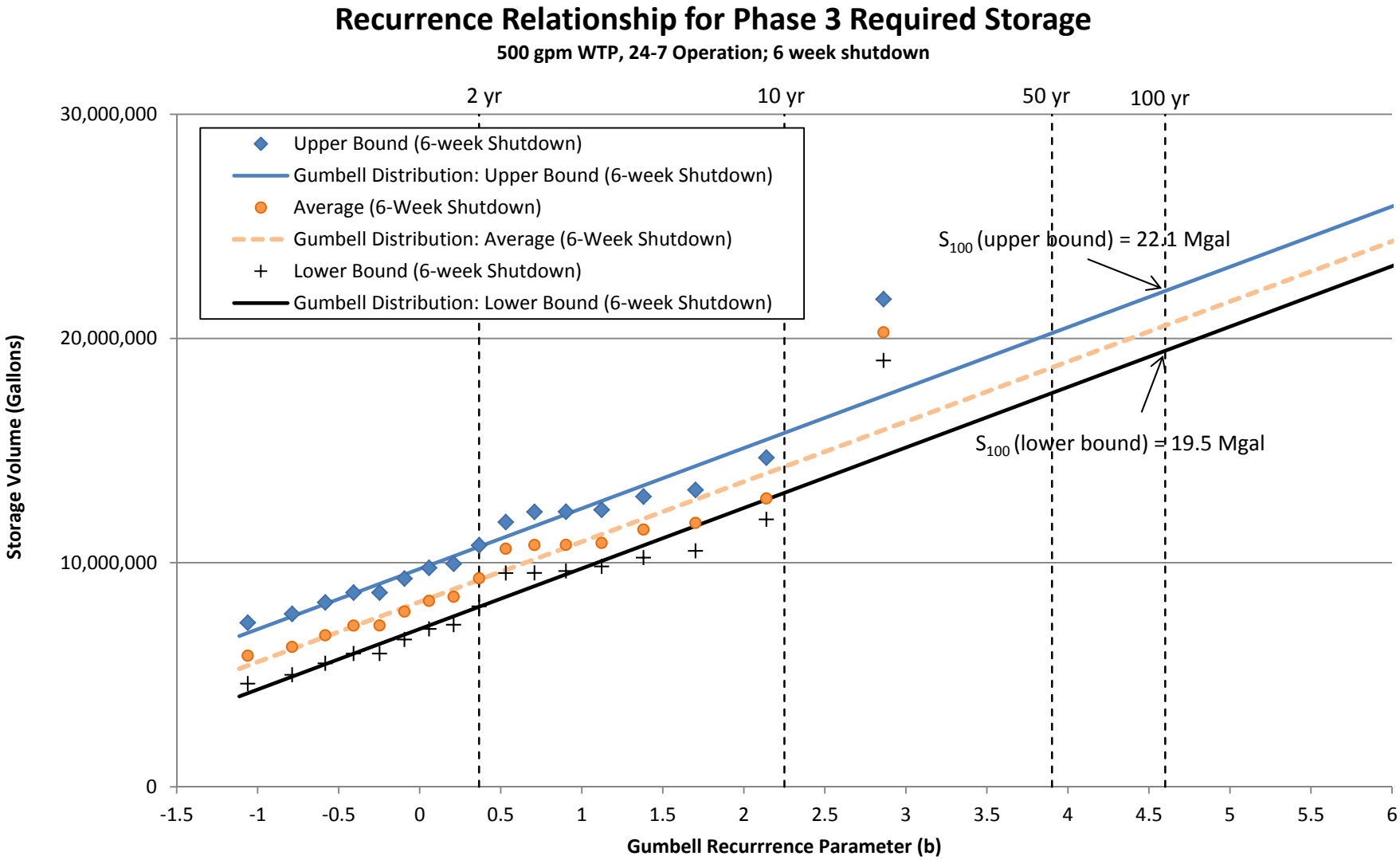
Supplement E-1-2_90%Design.pptx



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Recurrence Relationship for Phase 3 Required Storage 500gpm Operations

MWH

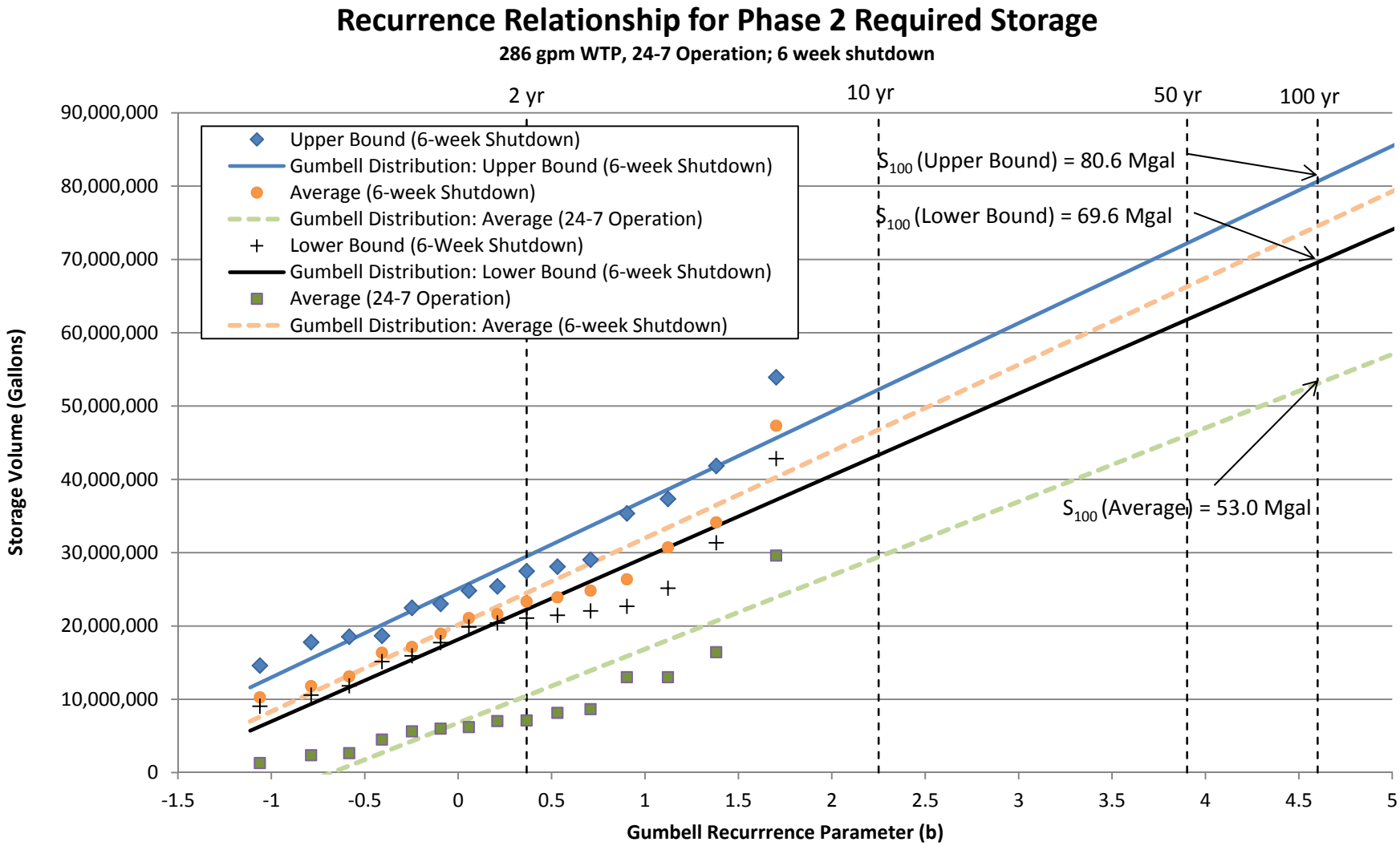
DATE: July 2014

FIGURE 19

FILENAME: Supplement E-1-2_90%Design.pptx

Supplement E-1.3

Analysis of Alternative WTP Operations



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Recurrence Relationship for Required Storage 286gpm, 24 hr/day, 7day/week Operations

MWH

DATE: July 2014

FIGURE 1

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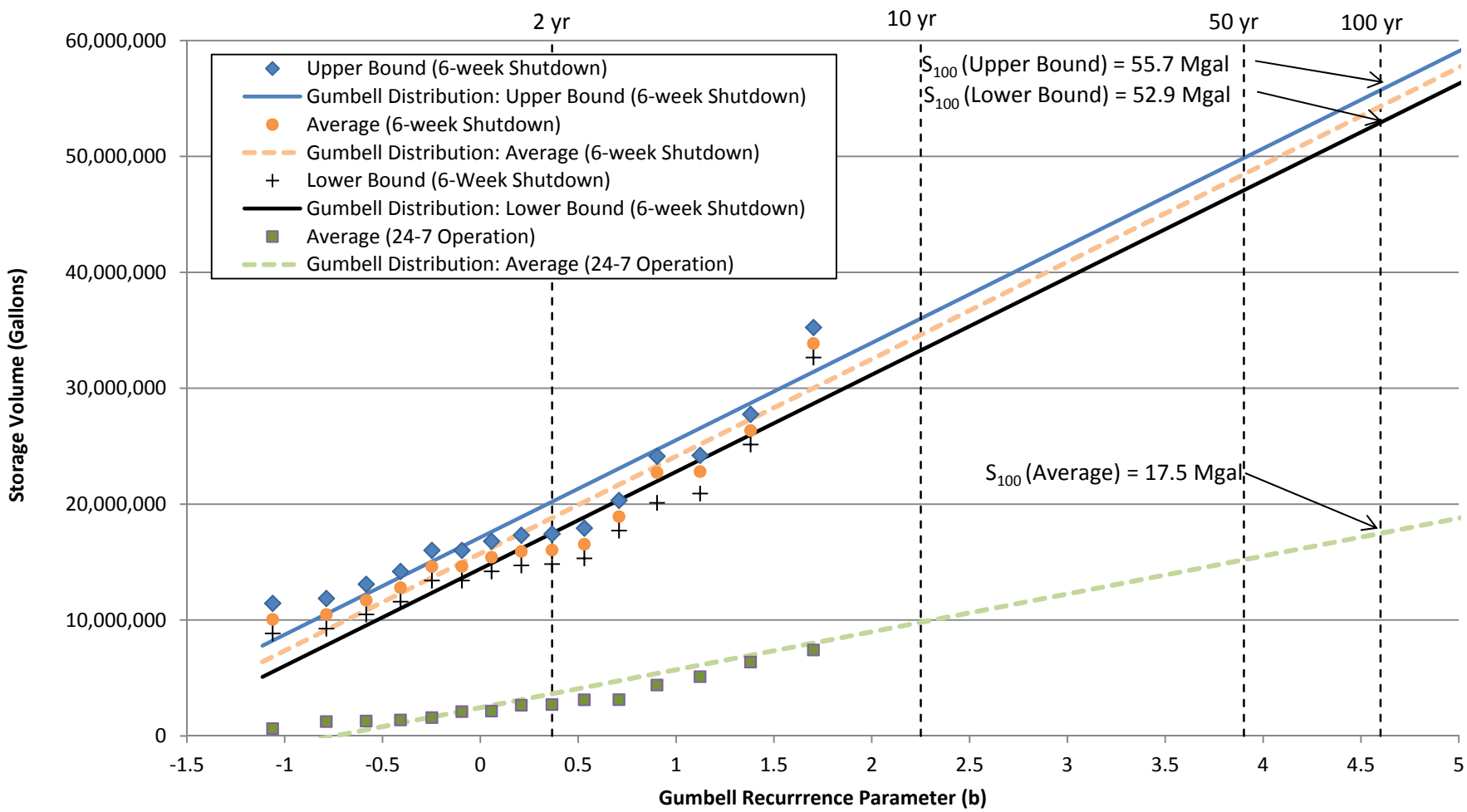

NEWMONT

PROJECT: MIDNITE MINE

TITLE: Recurrence Relationship for Required Storage 750gpm, 24 hr/day, 7day/week Operations

MWH

DATE: July 2014

FIGURE 2

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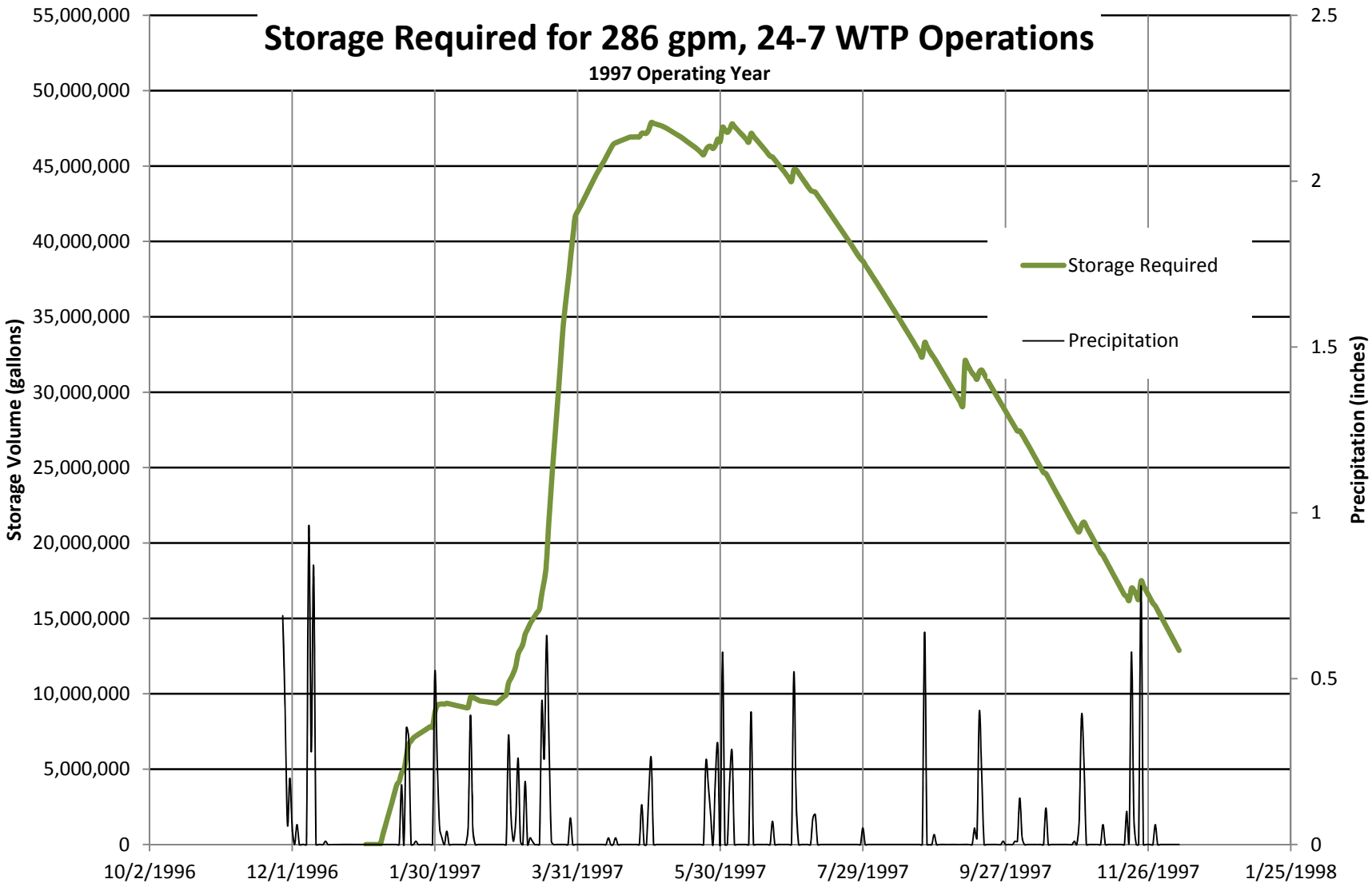


NEWMONT

PROJECT
MIDNITE MINE

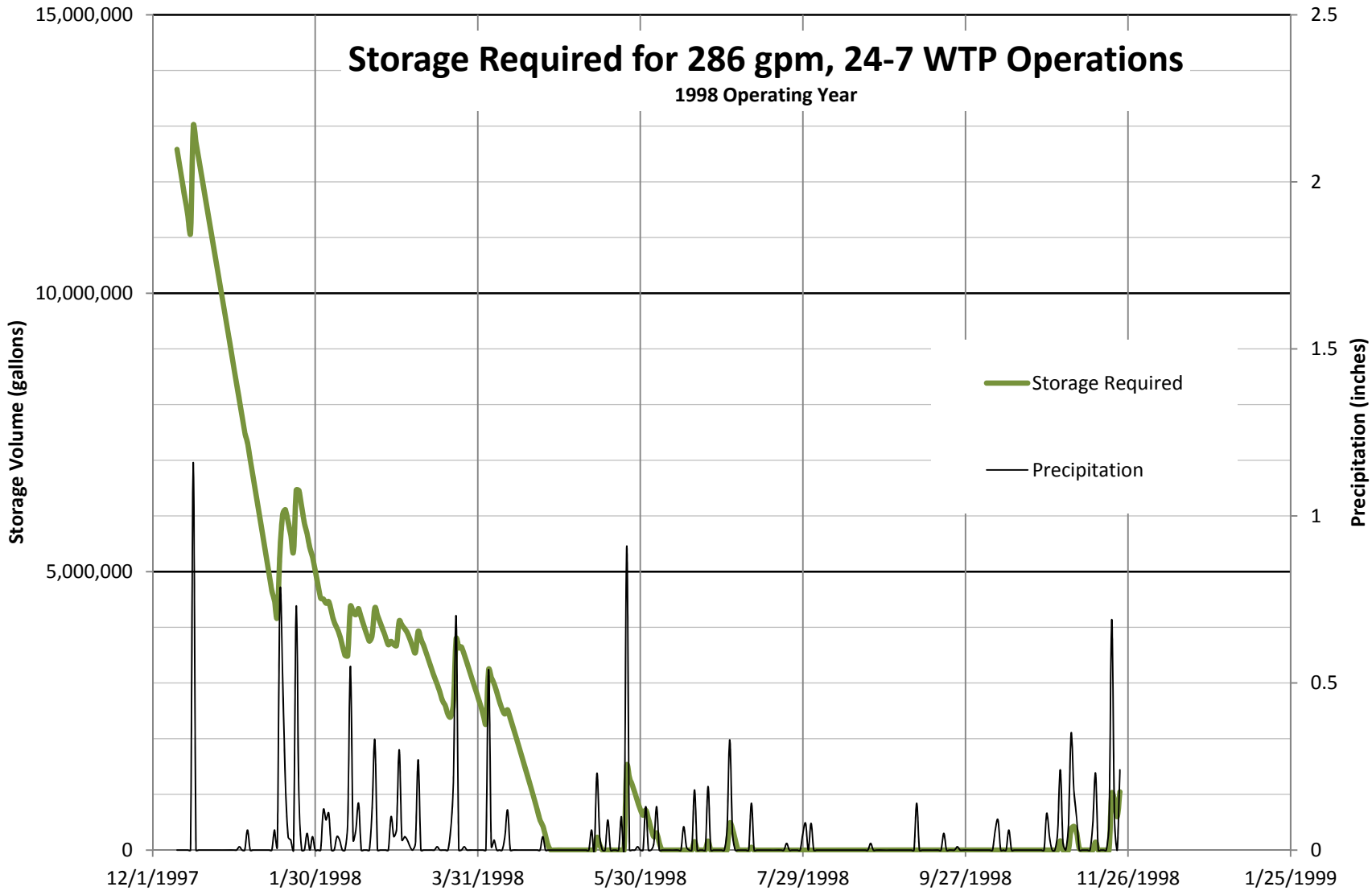
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 1997 Operating Year

MWH

DATE
July 2014

FIGURE 3

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

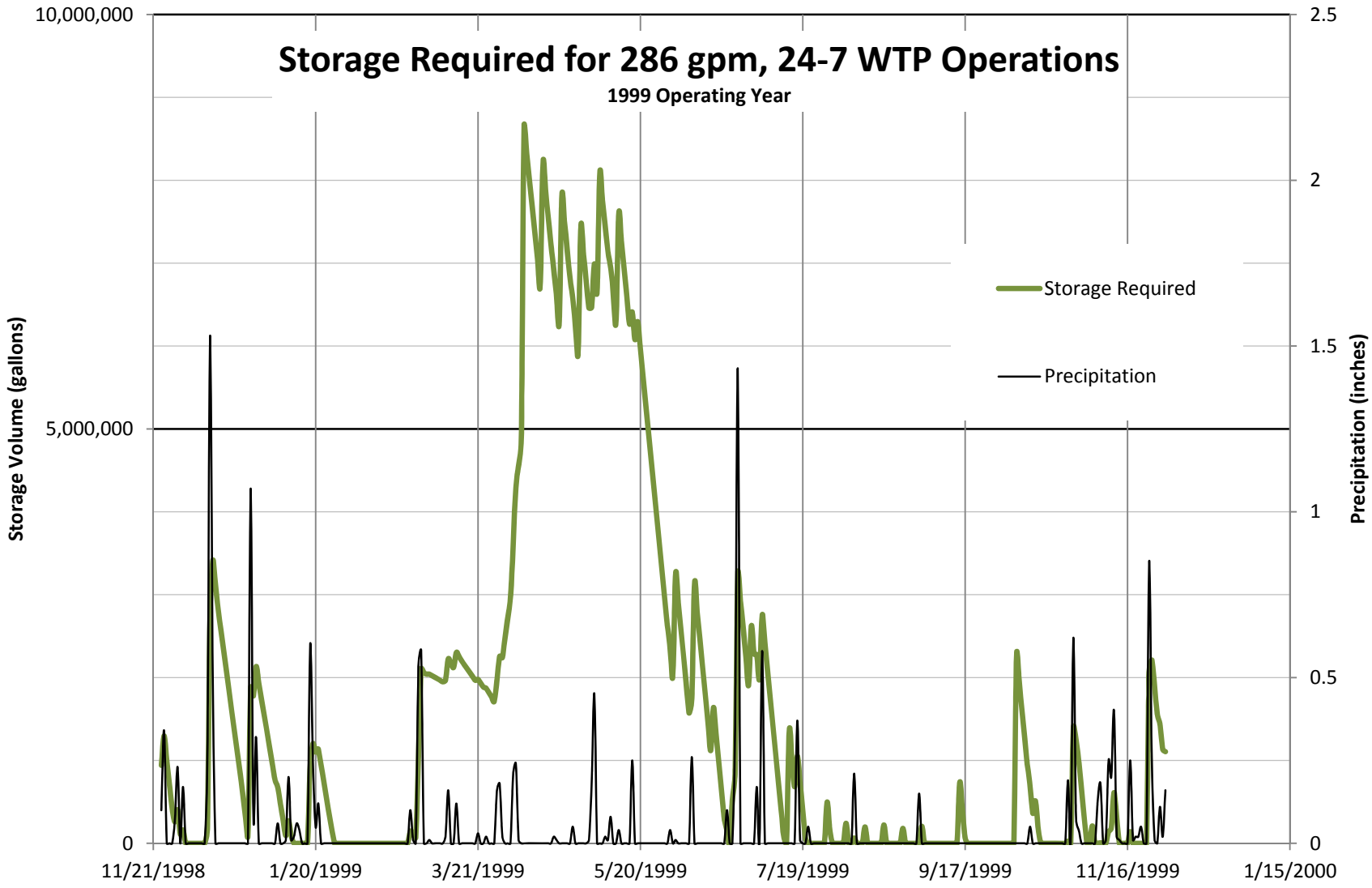
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 1998 Operating Year

MWH

DATE
July 2014

FIGURE 4

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

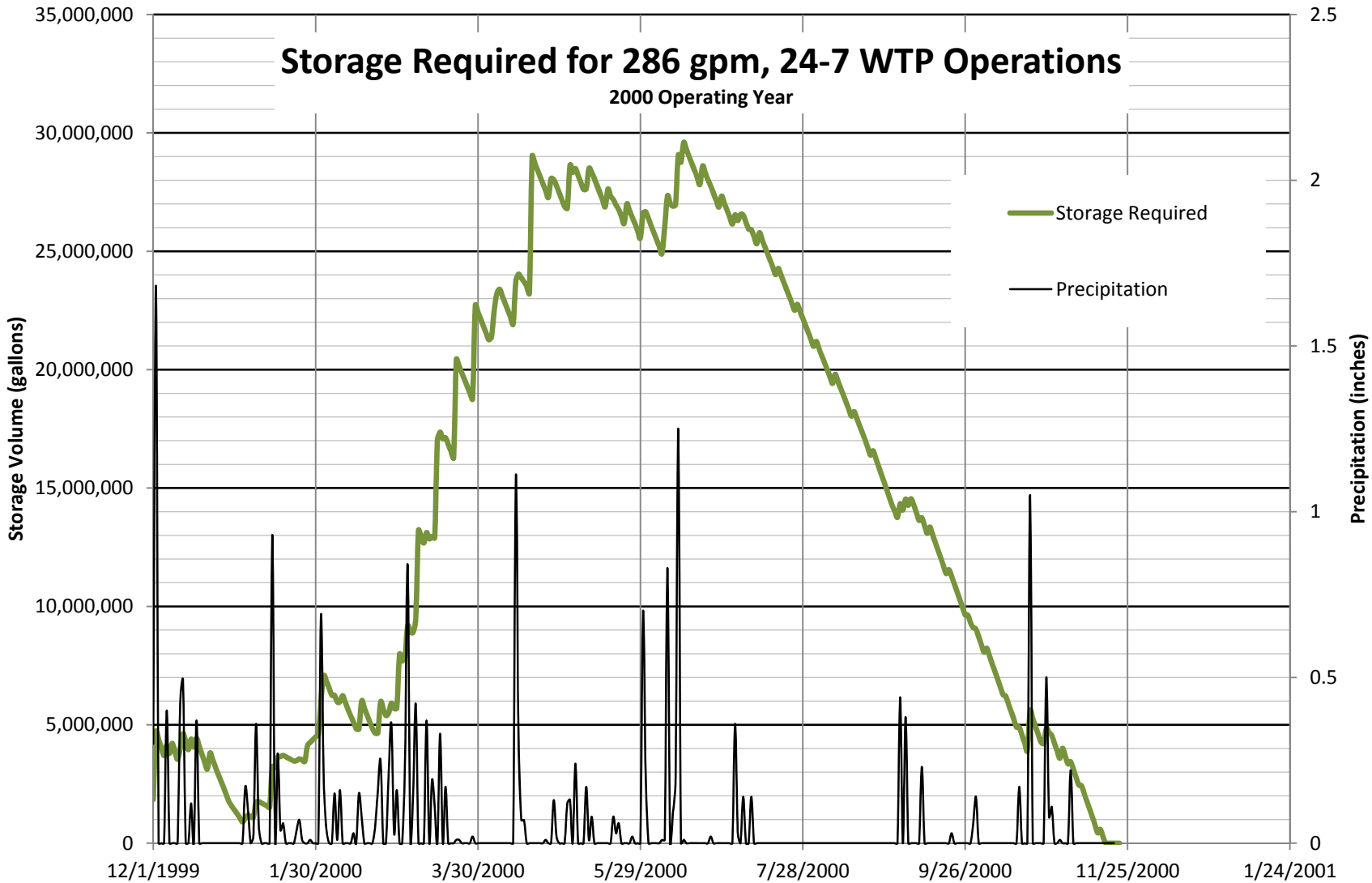
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 1999 Operating Year

MWH

DATE
July 2014

FIGURE 5

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

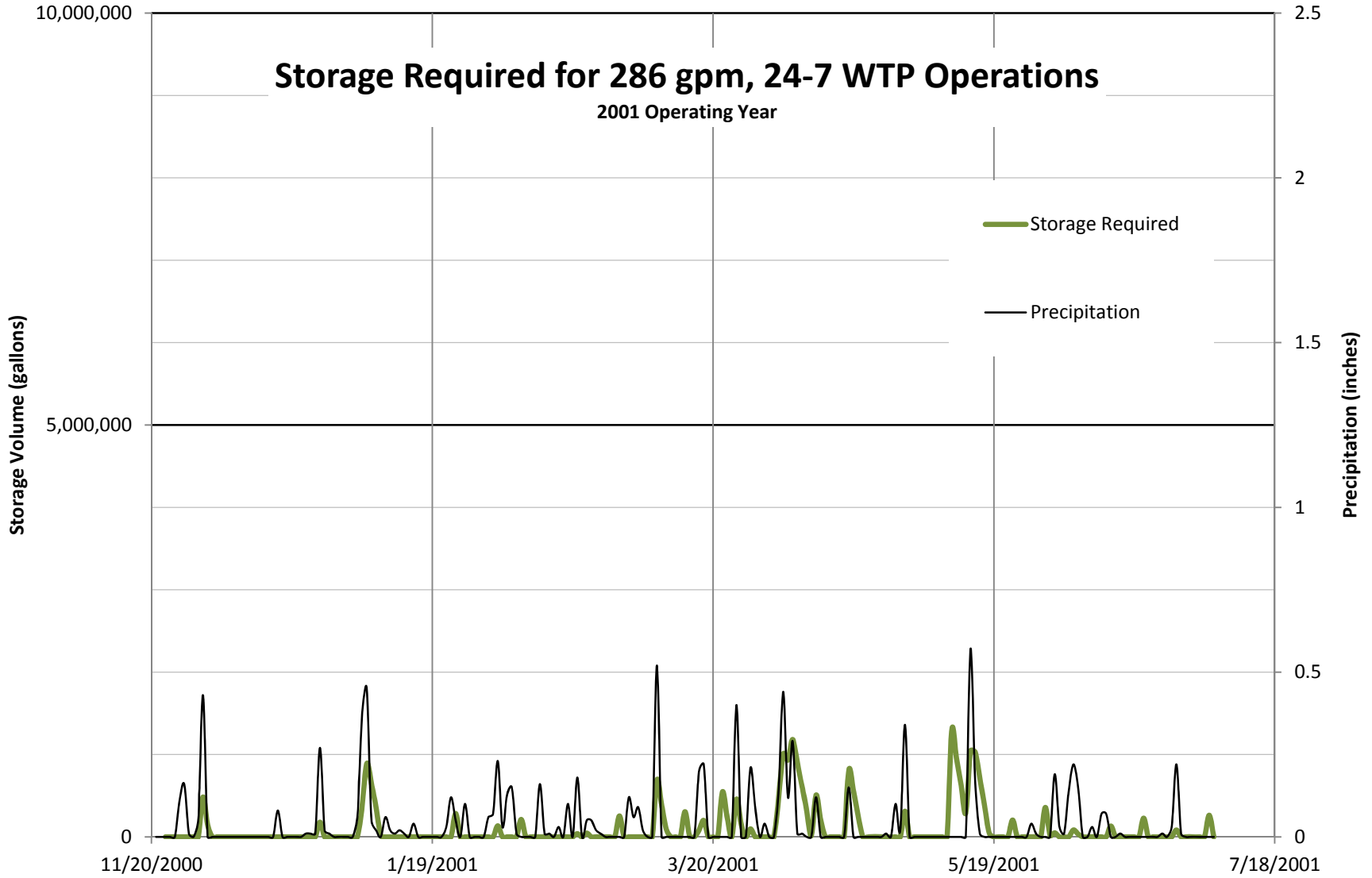
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations – 2000 Operating Year

MWH

DATE
July 2014

FIGURE 6

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

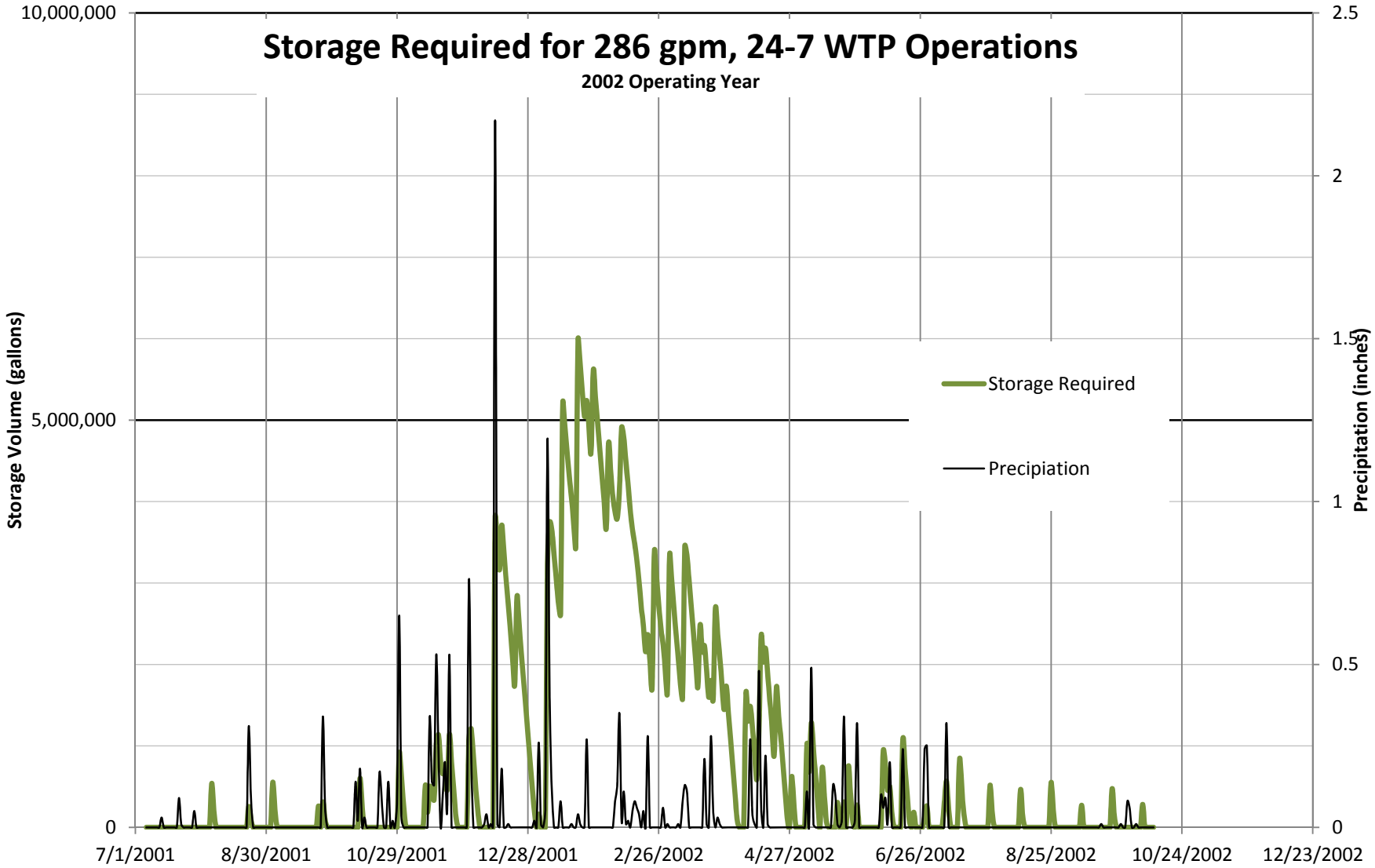
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2001 Operating Year

MWH

DATE
July 2014

FIGURE 7

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT: MIDNITE MINE

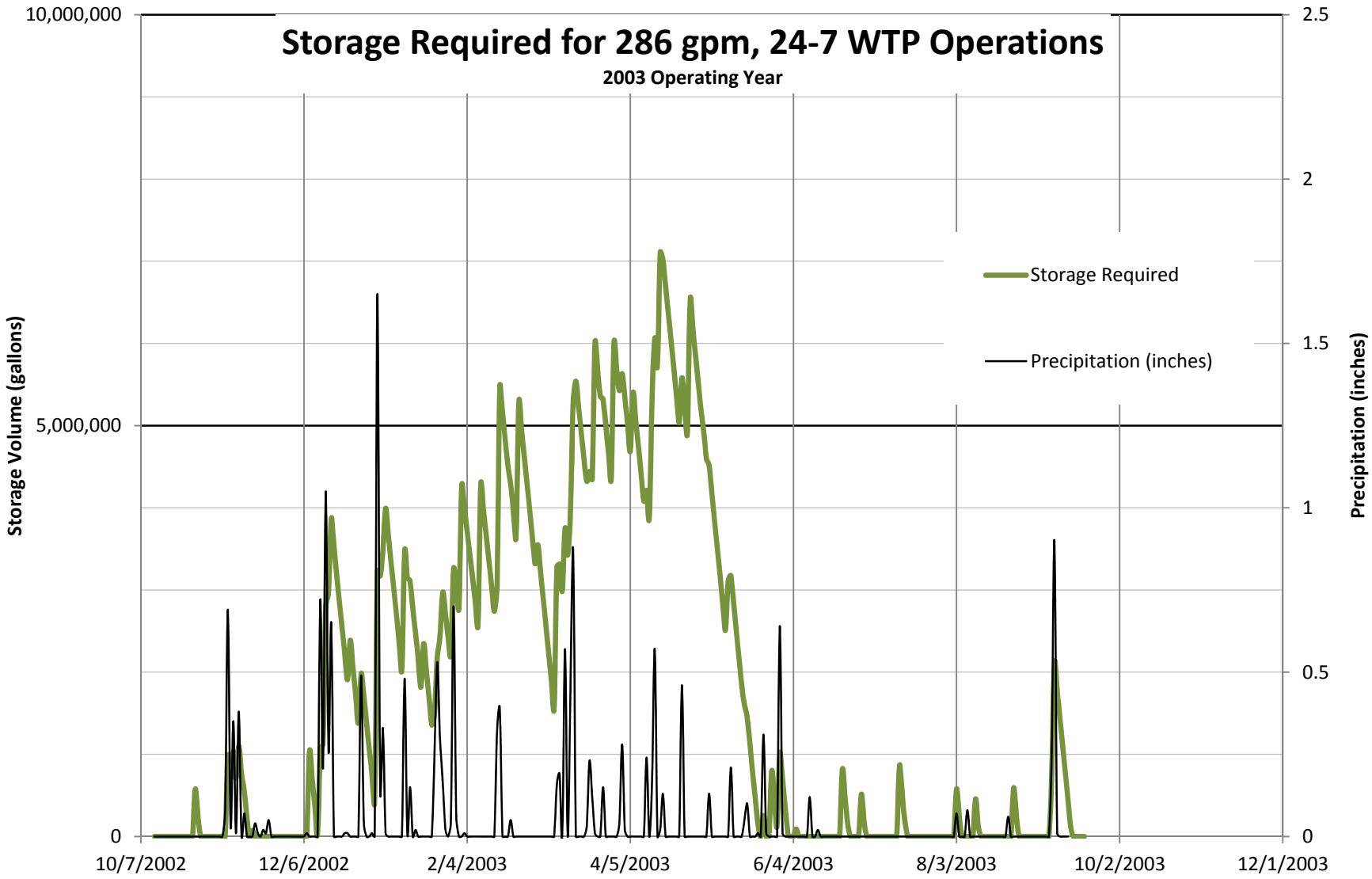
TITLE: Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations – 2002 Operating Year

MWH

DATE: July 2014

FIGURE 8

FILENAME: Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

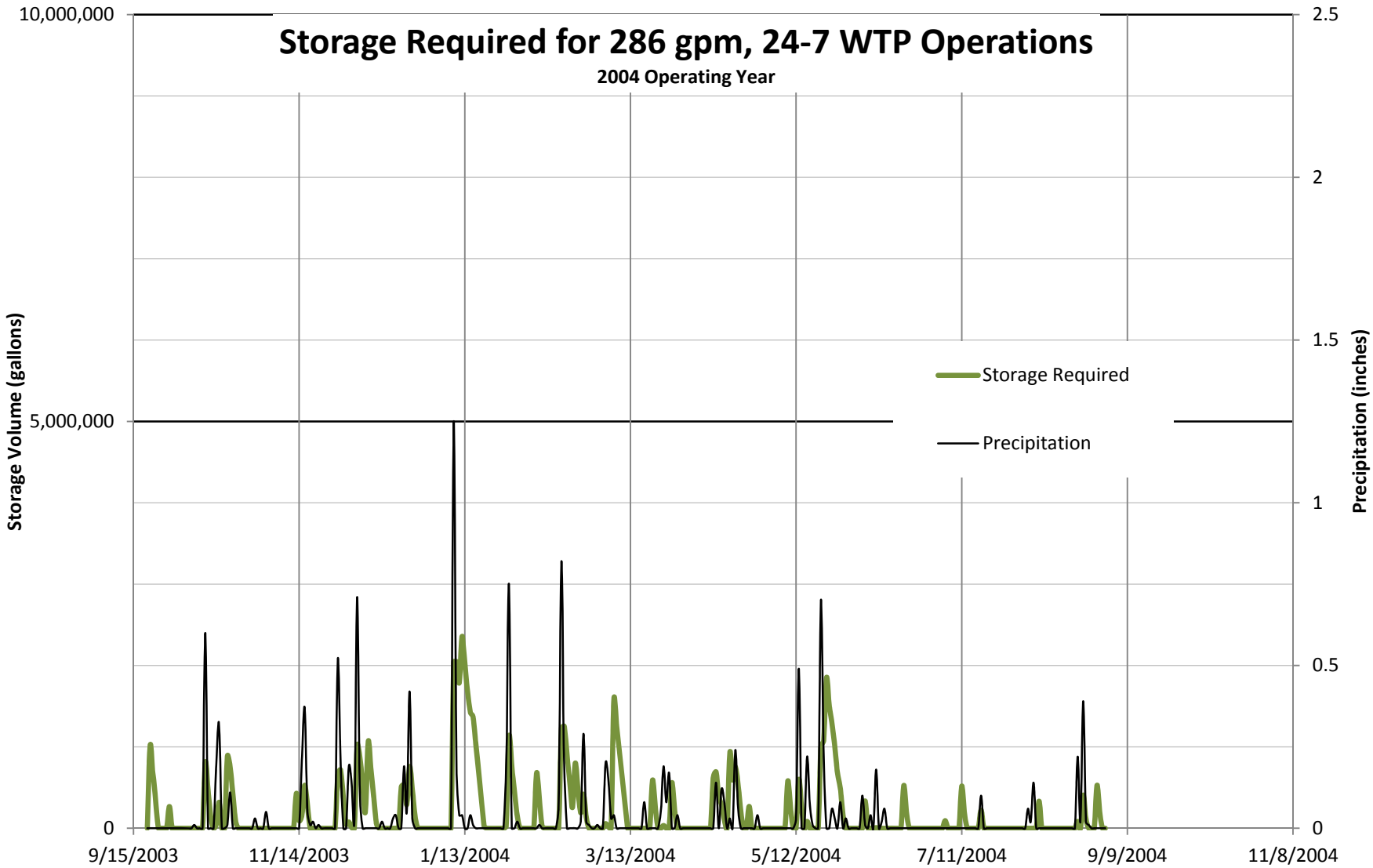
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations – 2003 Operating Year

MWH

DATE
July 2014

FIGURE 9

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT: MIDNITE MINE

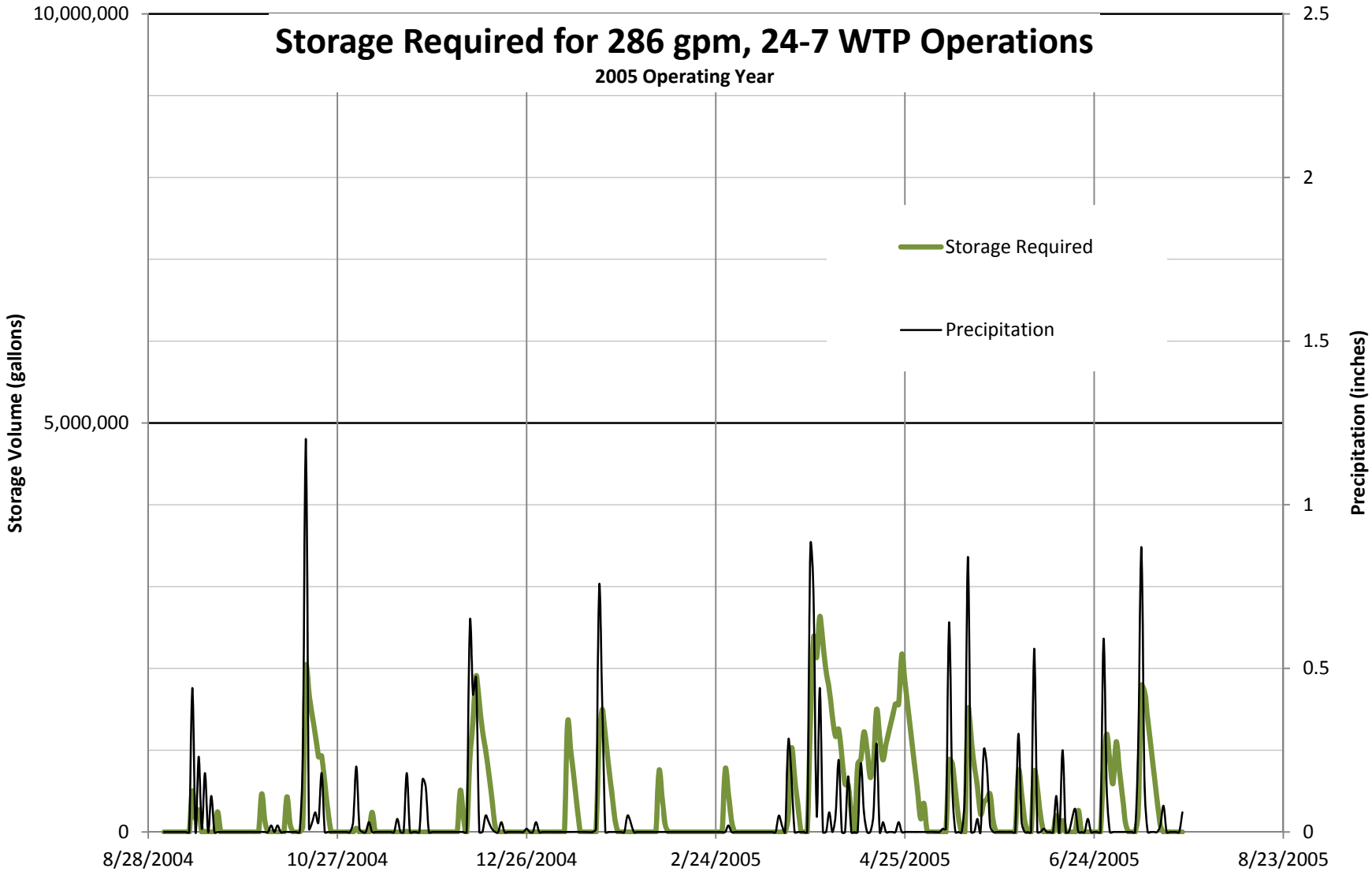
TITLE: Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2004 Operating Year

MWH

DATE: July 2014

FIGURE 10

FILENAME: Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT: MIDNITE MINE

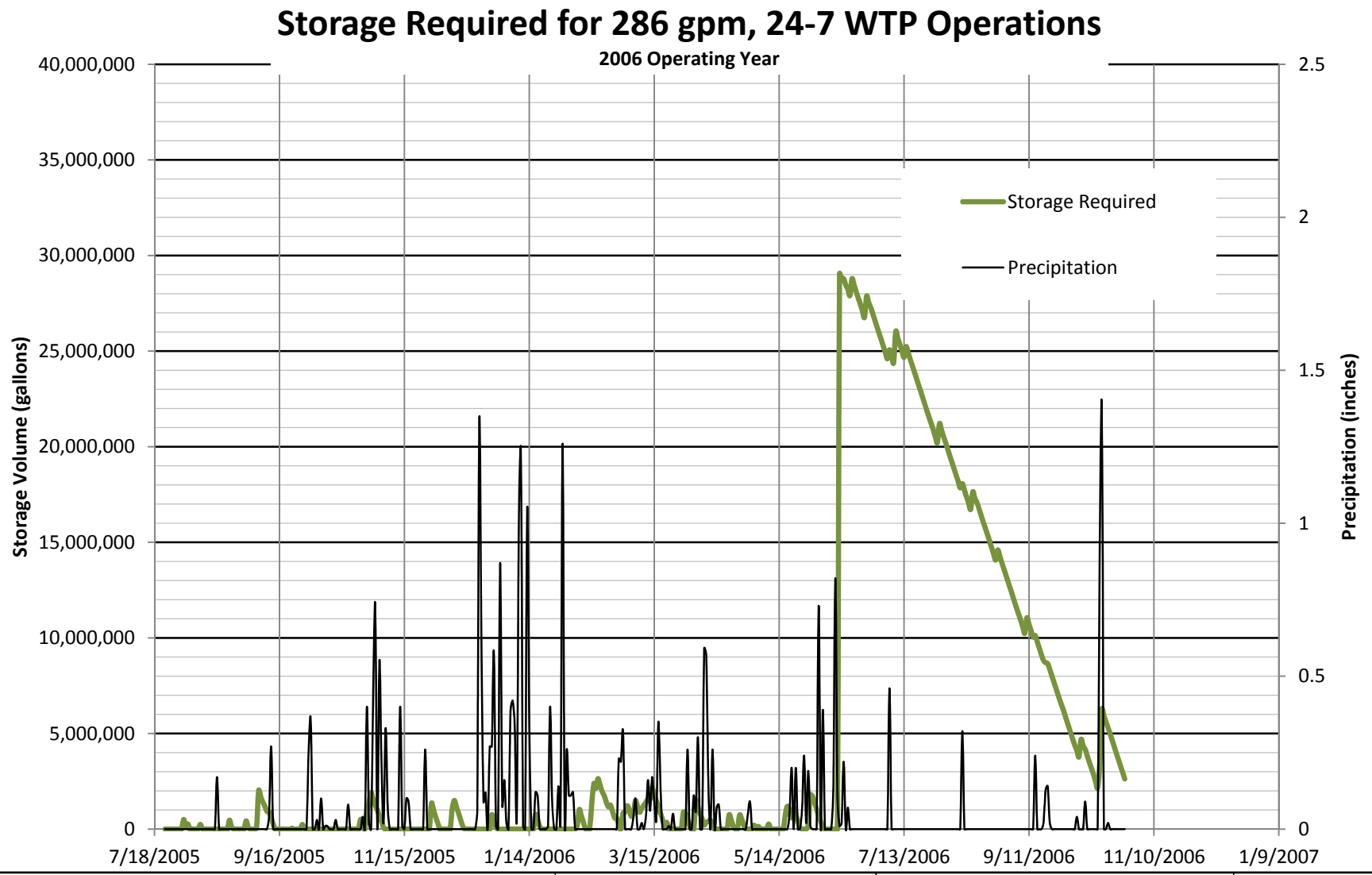
TITLE: Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2005 Operating Year

MWH

DATE: July 2014

FIGURE 11

FILENAME: Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

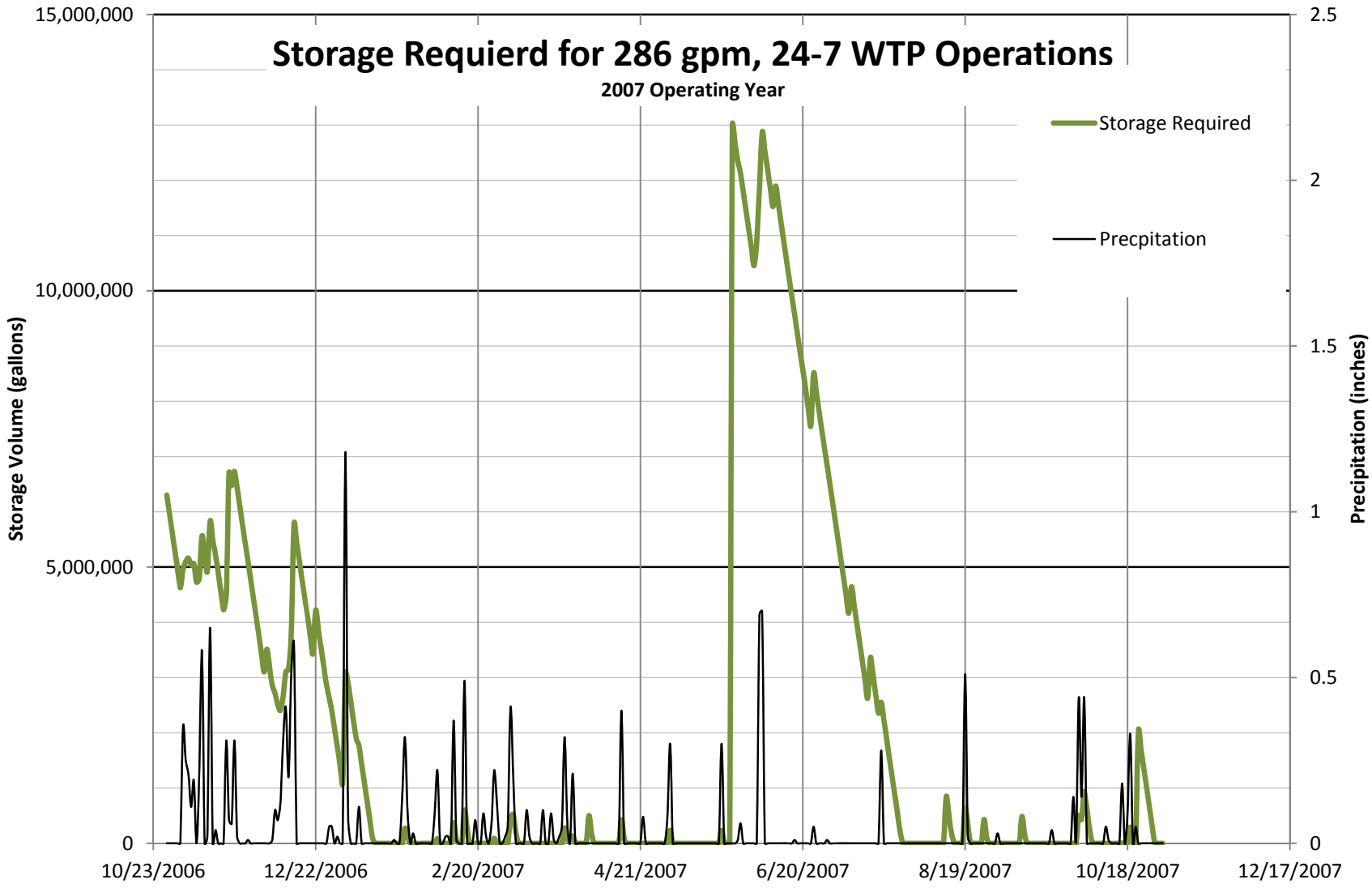
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2006 Operating Year

MWH

DATE
July 2014

FIGURE 12

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

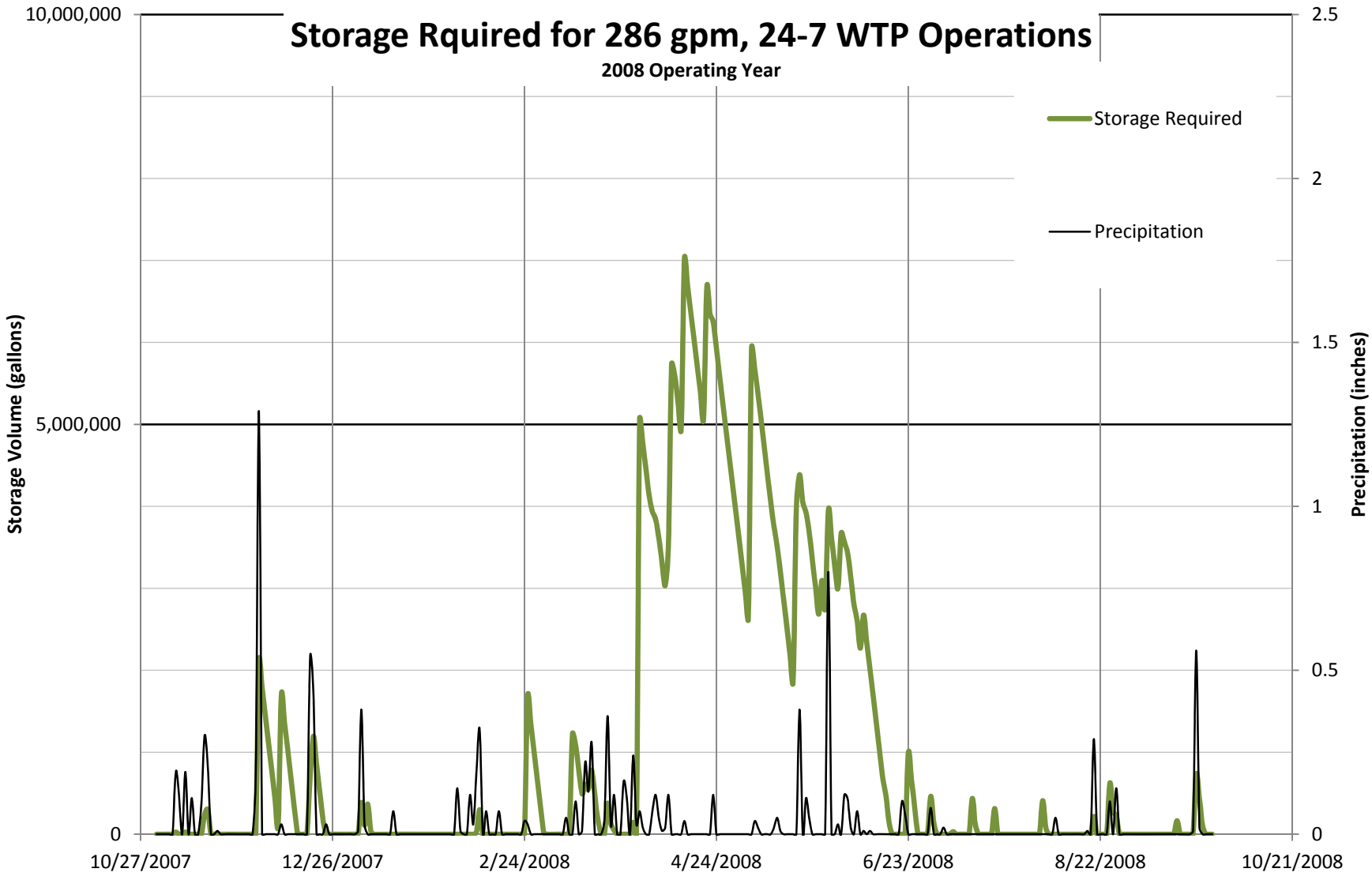
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2007 Operating Year

MWH

DATE
July 2014

FIGURE 13

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

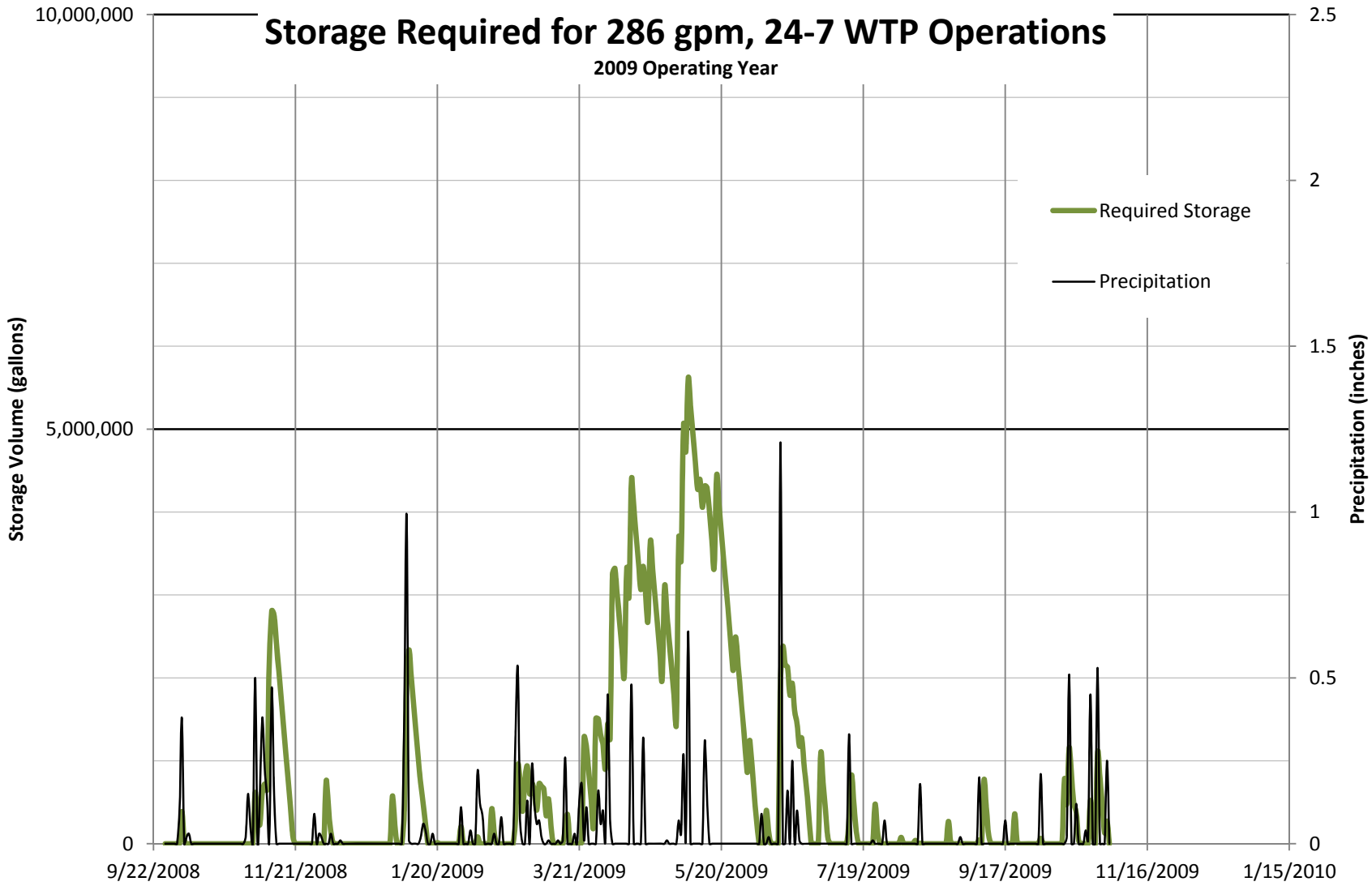
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations – 2008 Operating Year

MWH

DATE
July 2014

FIGURE 14

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT: MIDNITE MINE

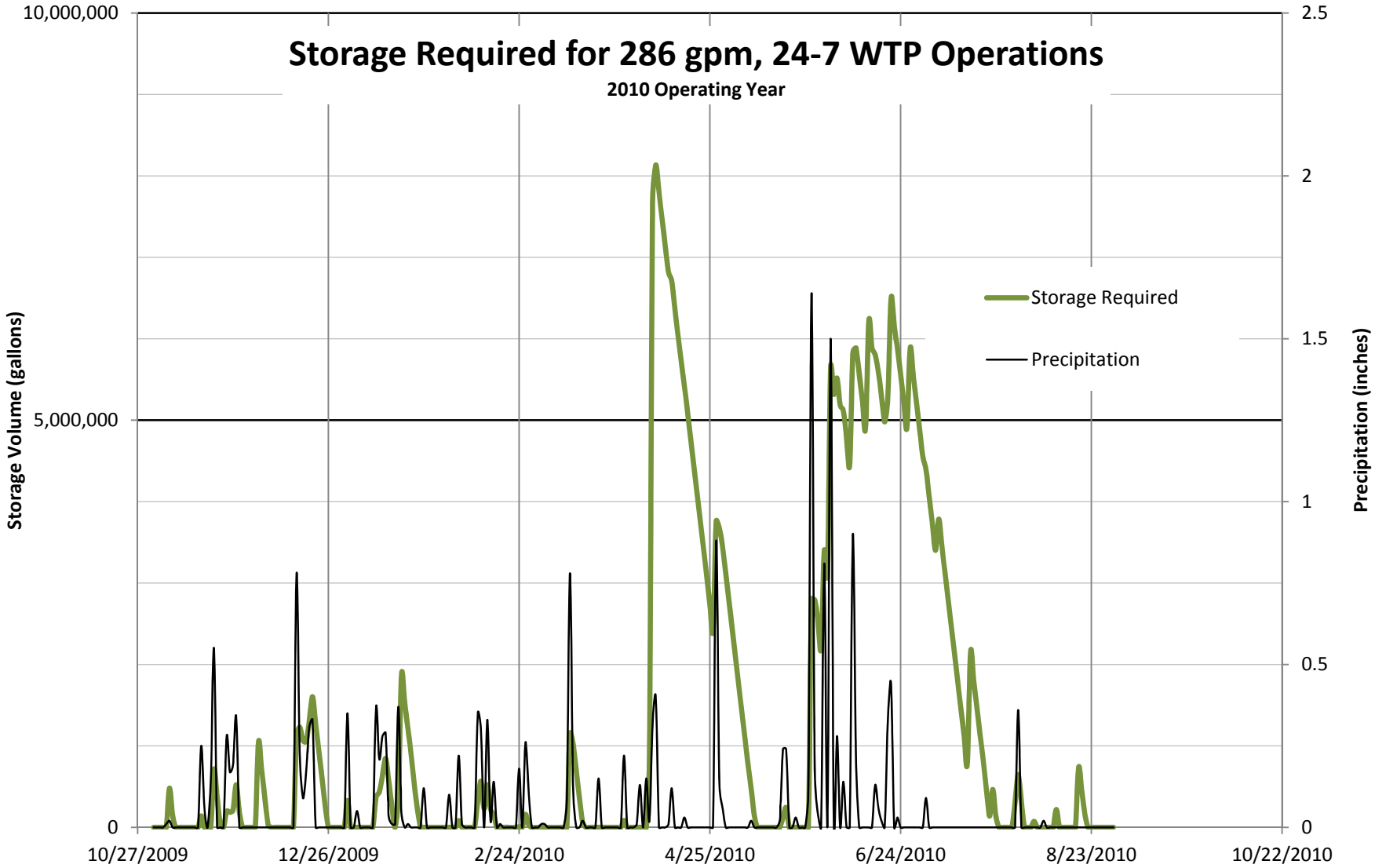
TITLE: Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2009 Operating Year

MWH

DATE: July 2014

FIGURE 15

FILENAME: Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT: MIDNITE MINE

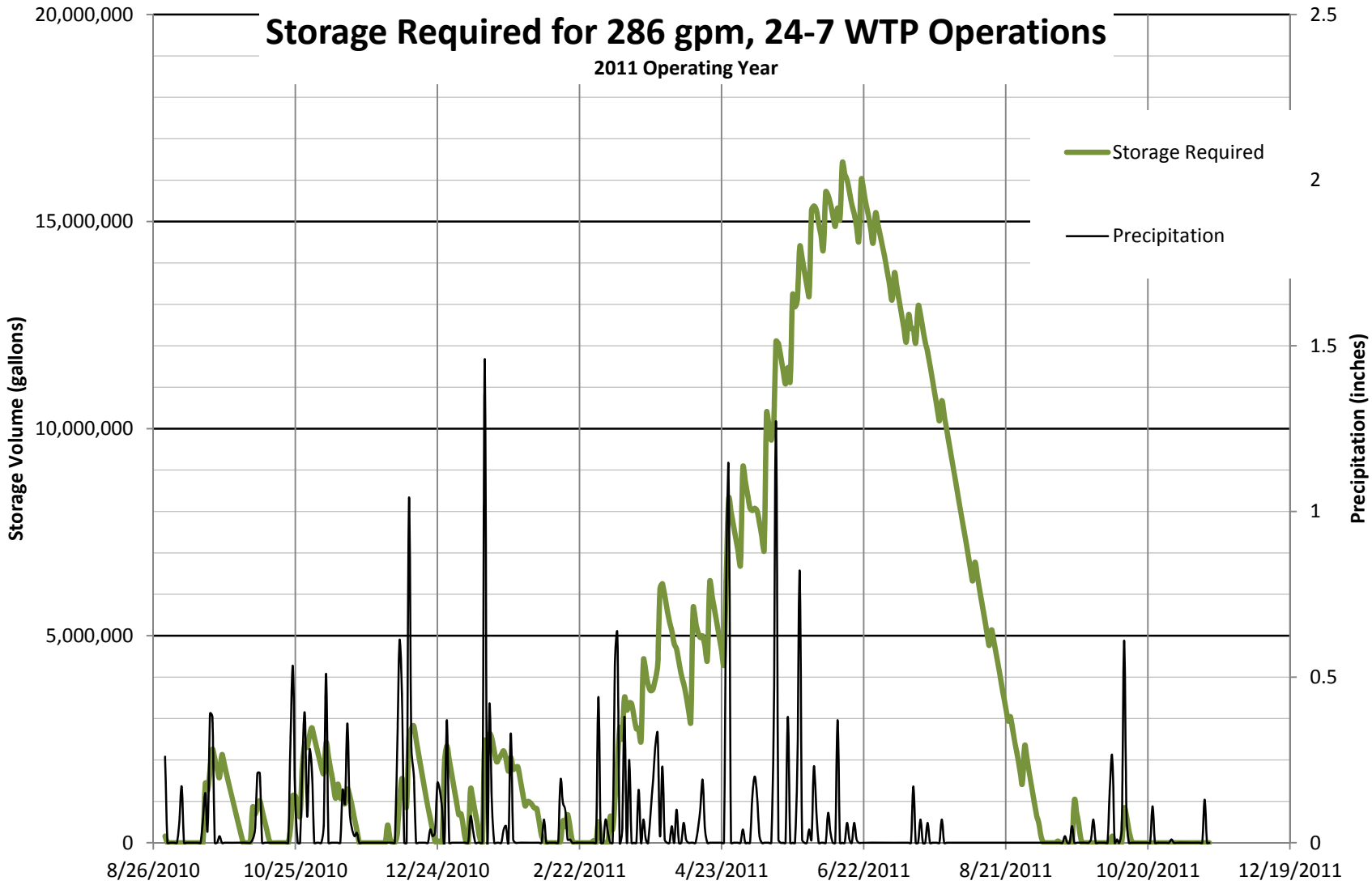
TITLE: Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2010 Operating Year

MWH

DATE: July 2014

FIGURE 16

FILENAME: Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

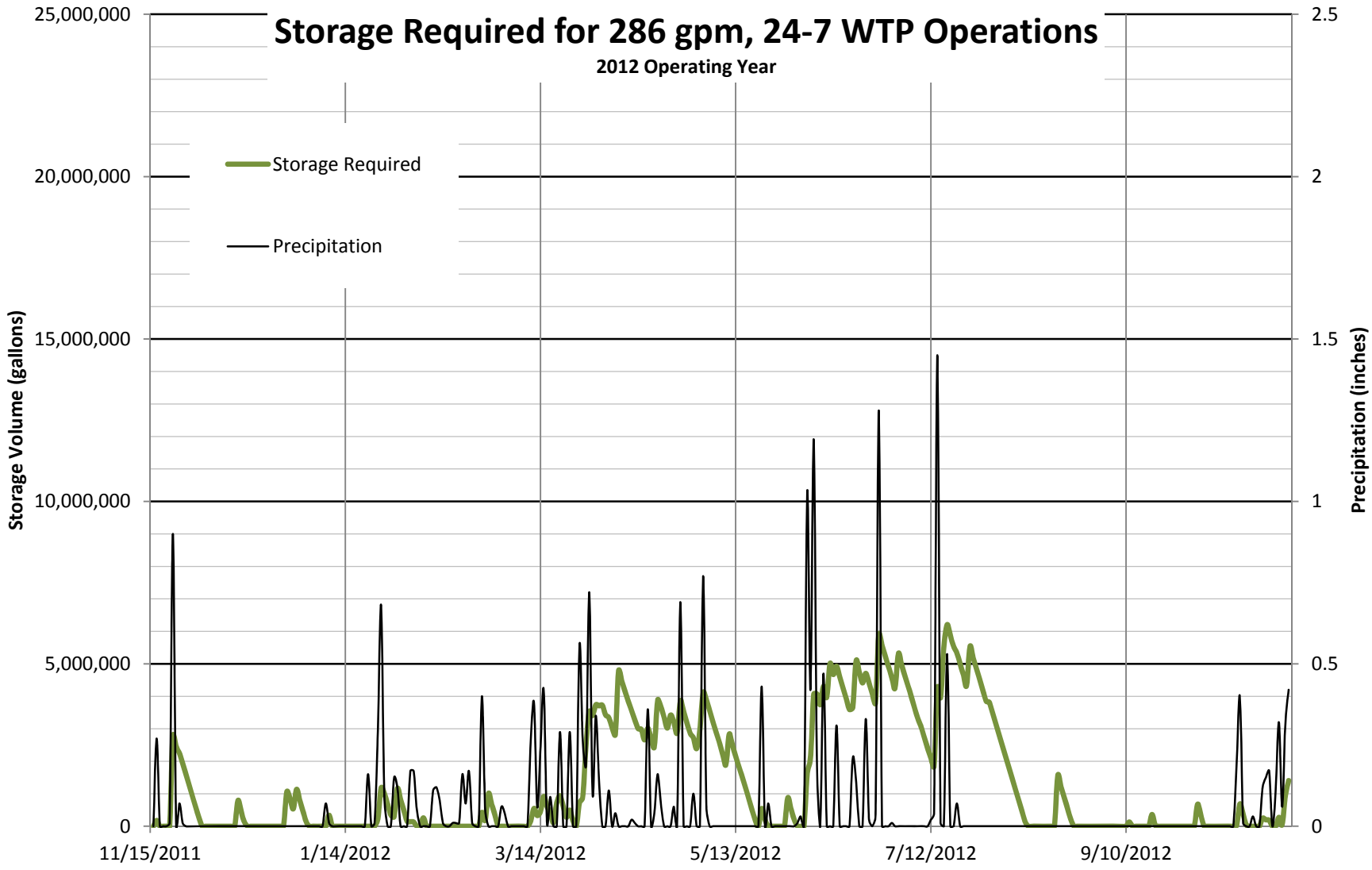
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2011 Operating Year

MWH

DATE
July 2014

FIGURE 17

FILENAME
Supplement E-1-3_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

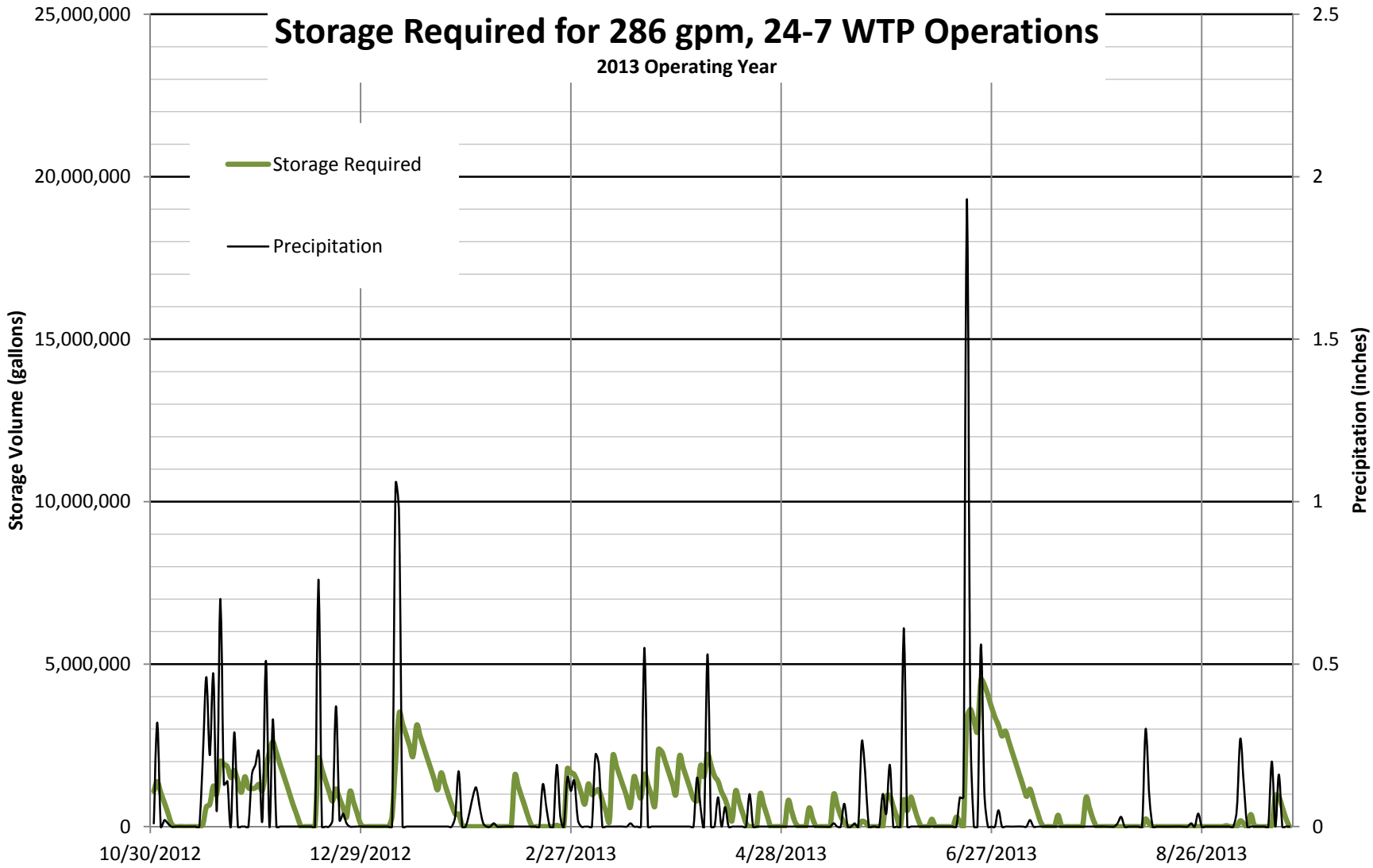
TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2012 Operating Year

MWH

DATE
July 2014

FIGURE 18

FILENAME
Supplement E-1-3_90% Design.pptx



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PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - 286 gpm, 24 hr/day, 7day/week Operations - 2013 Operating Year

MWH

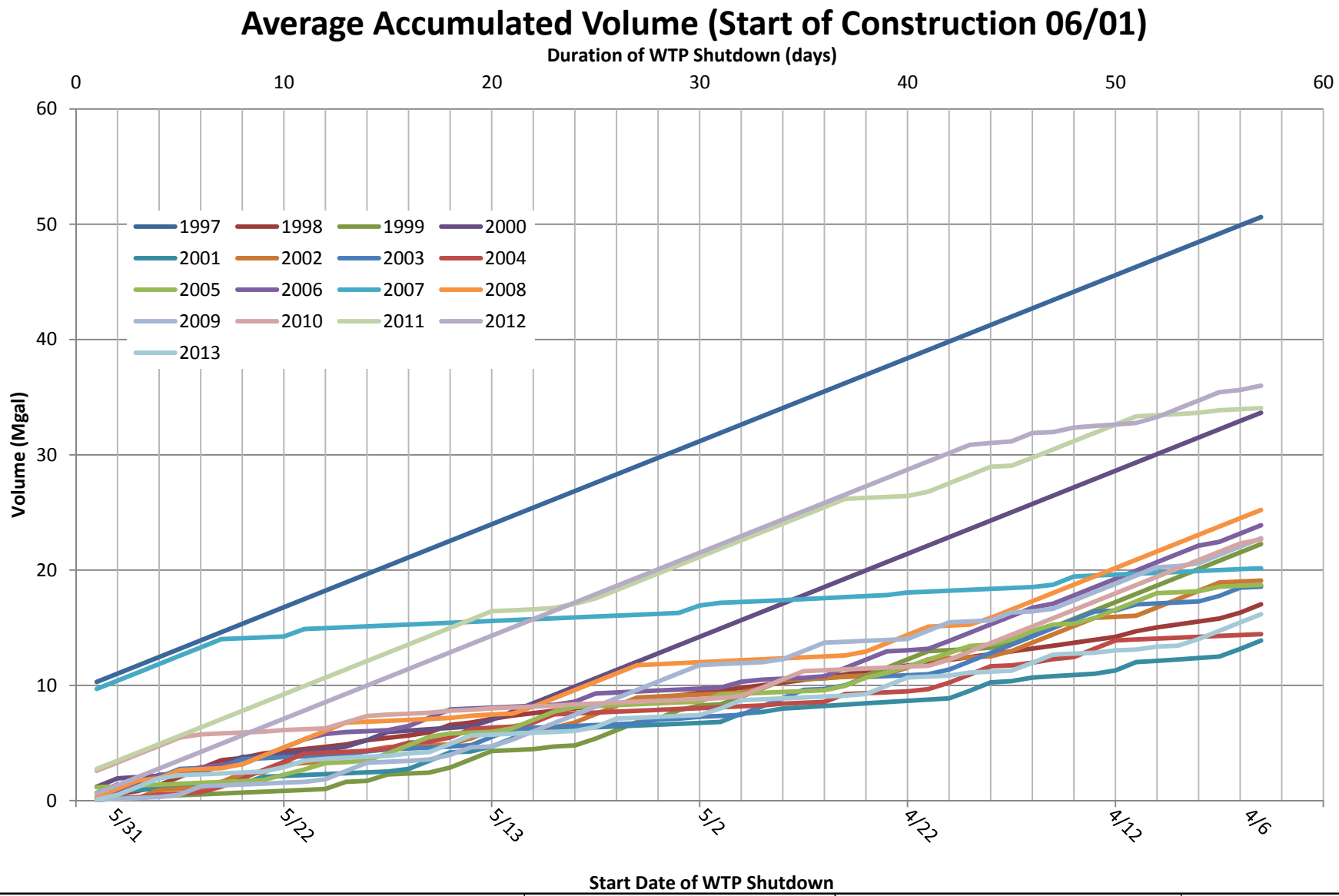
DATE
July 2014

FIGURE 19

FILENAME
Supplement E-1-3_90% Design.pptx

Supplement E-1.4

Analysis of Phase 2 Construction Water Availability



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Water Balance Analysis - South Pond Average Construction Water Volume

MWH

DATE: July 2014

FIGURE 1

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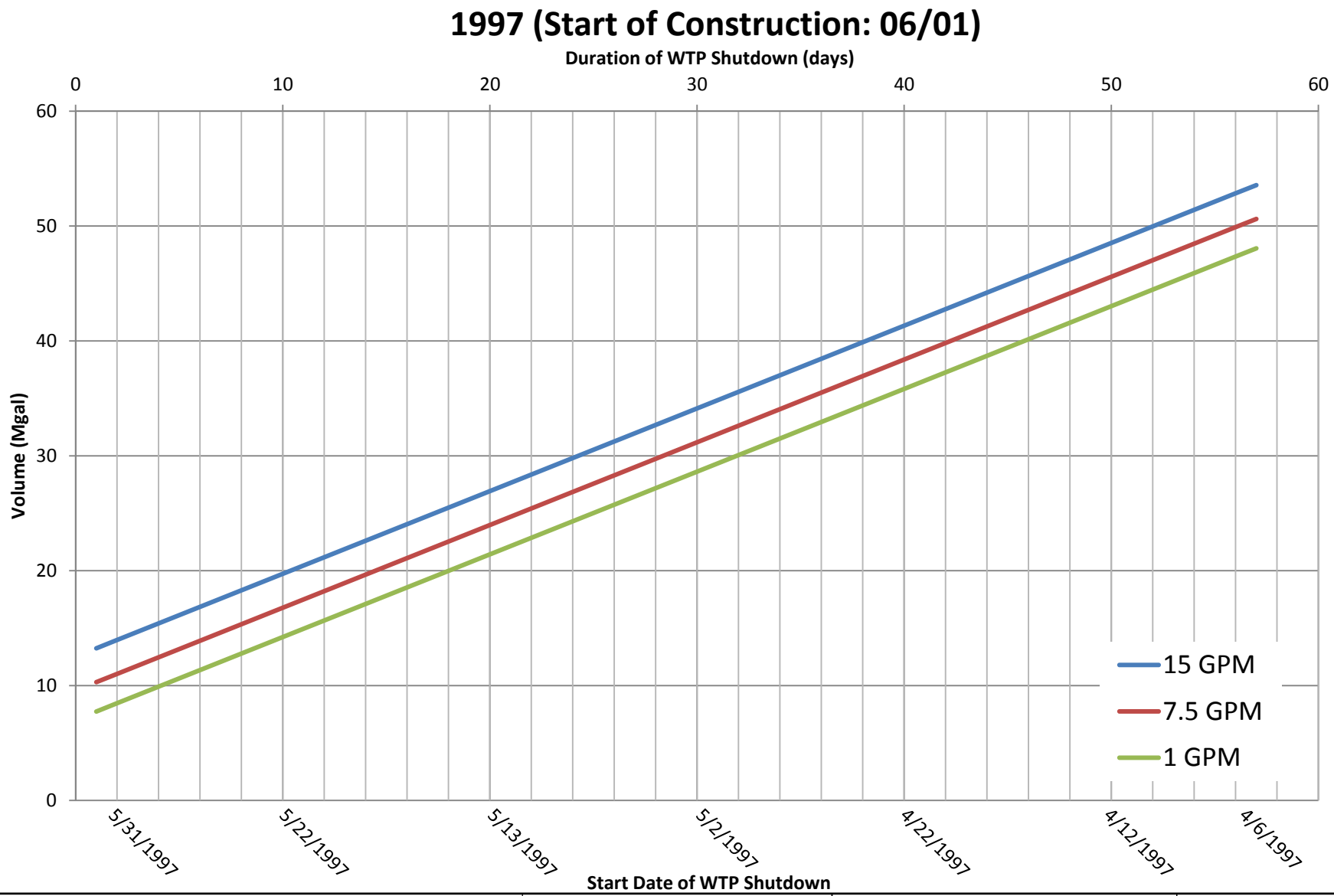

NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 1997 Operating Year

MWH

DATE
July 2014

FIGURE 2

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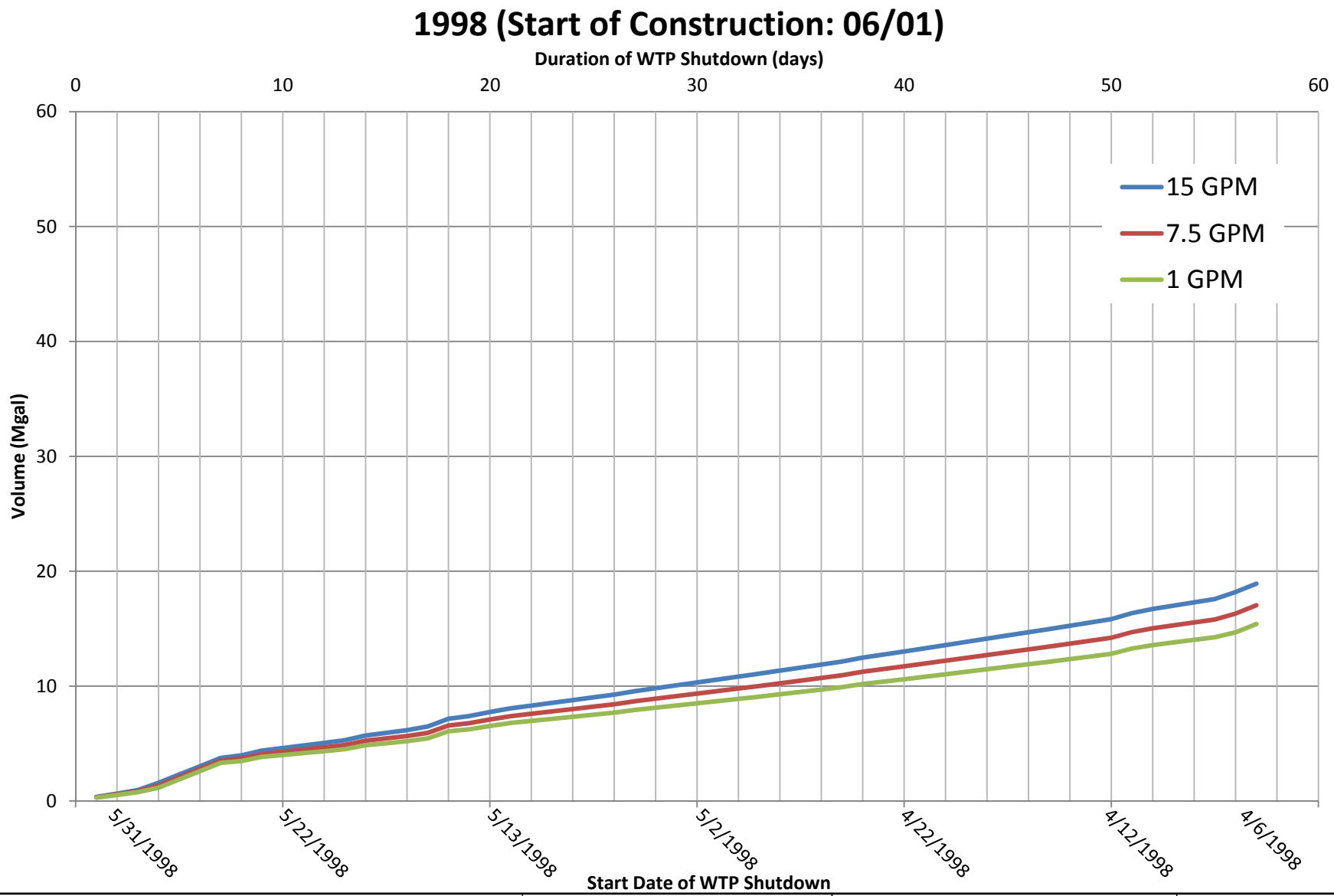

NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 1998 Operating Year

MWH

DATE
July 2014

FIGURE 3

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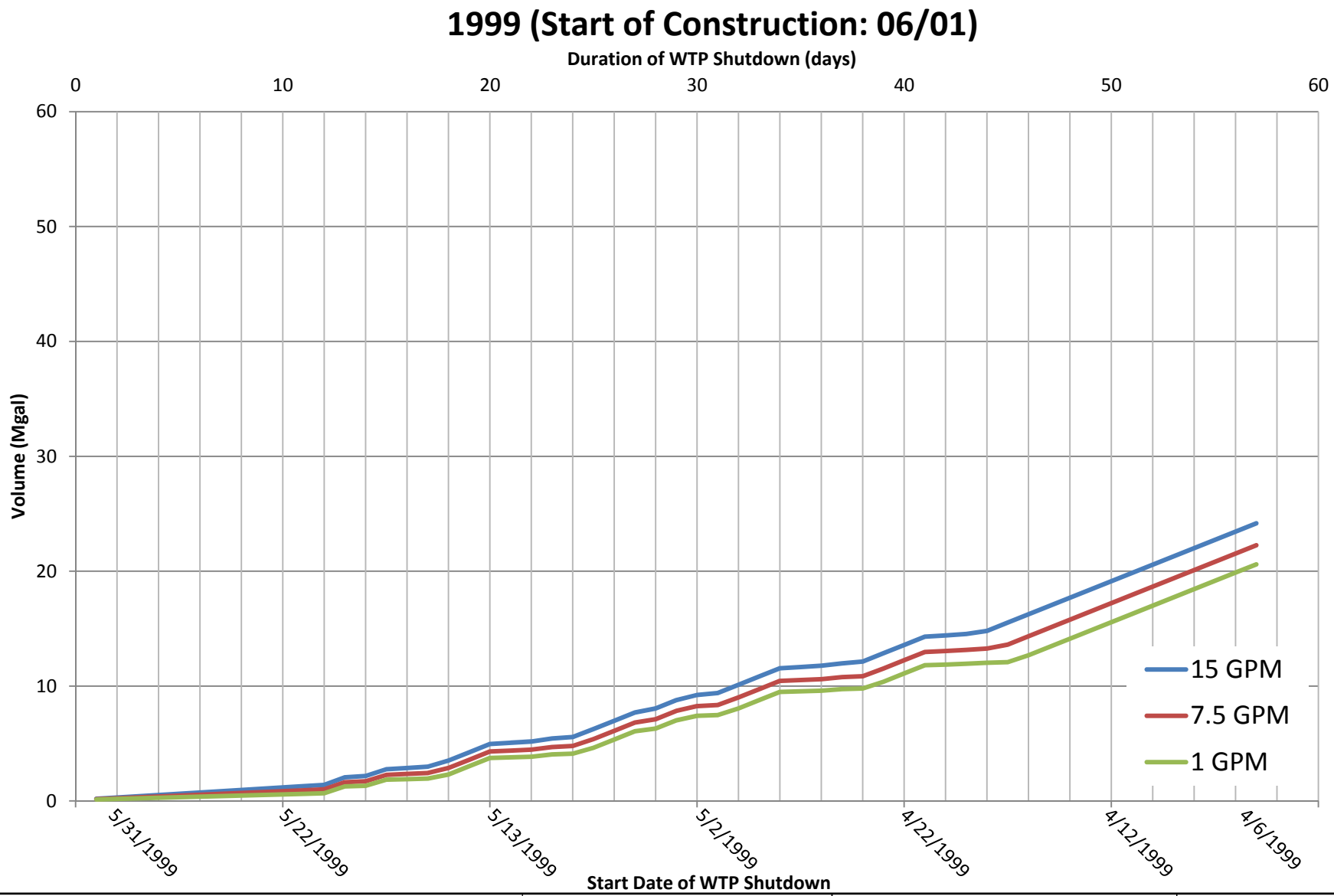
Supplement E-1-4_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 1999 Operating Year

MWH

DATE
July 2014

FIGURE 4

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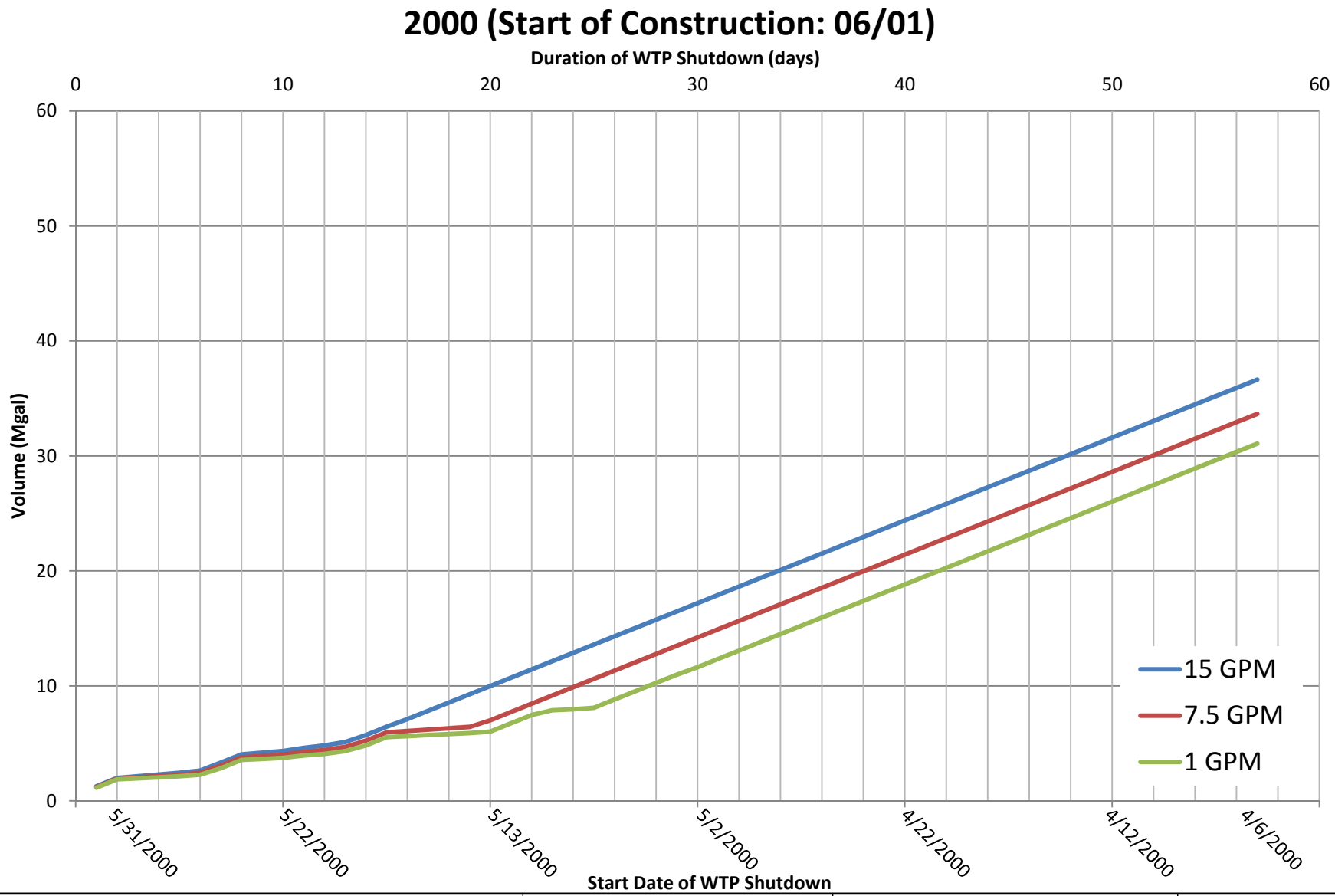
Supplement E-1-4_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2000 Operating Year

MWH

DATE
July 2014

FIGURE 5

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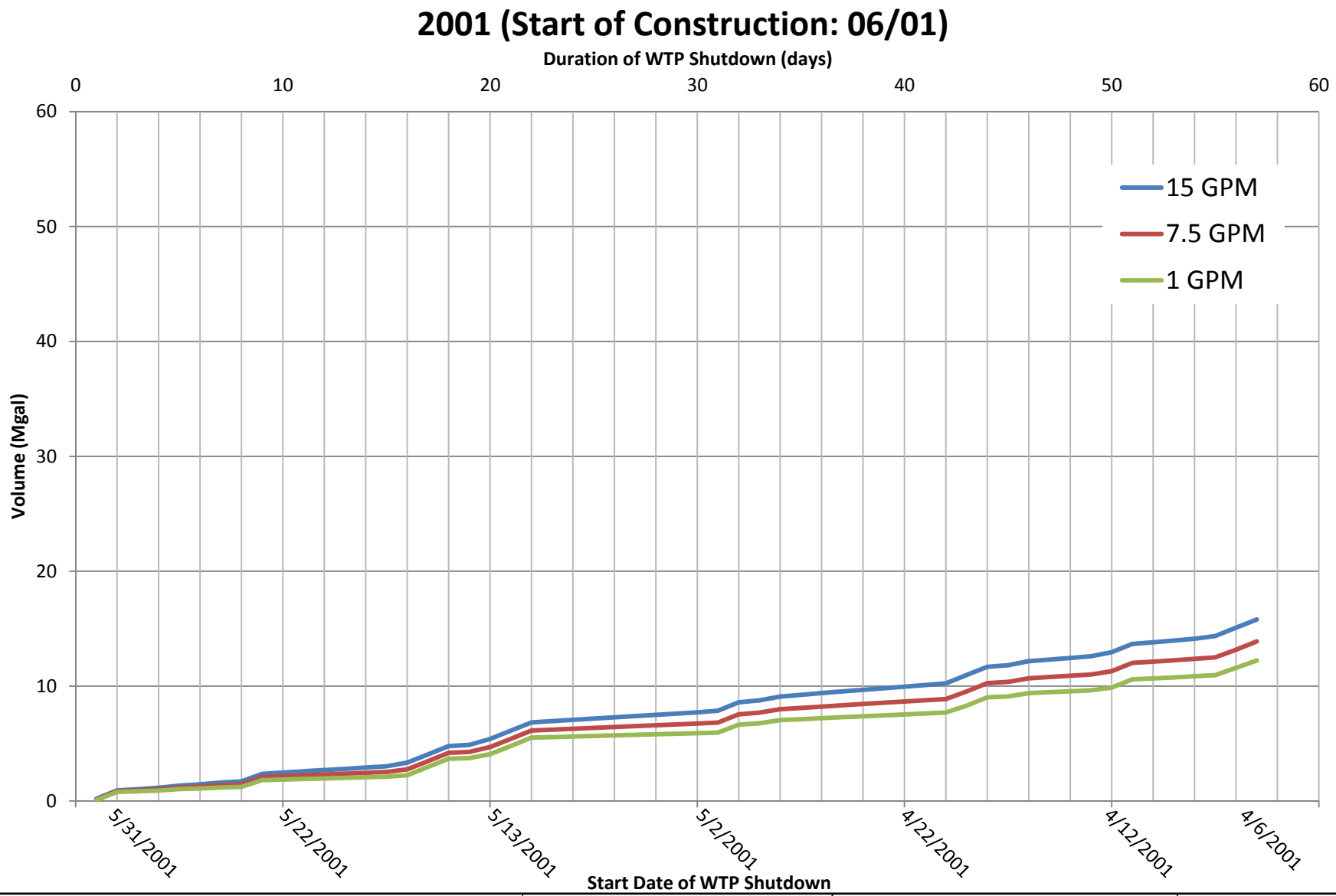
Supplement E-1-4_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2001 Operating Year

MWH

DATE
July 2014

FIGURE 6

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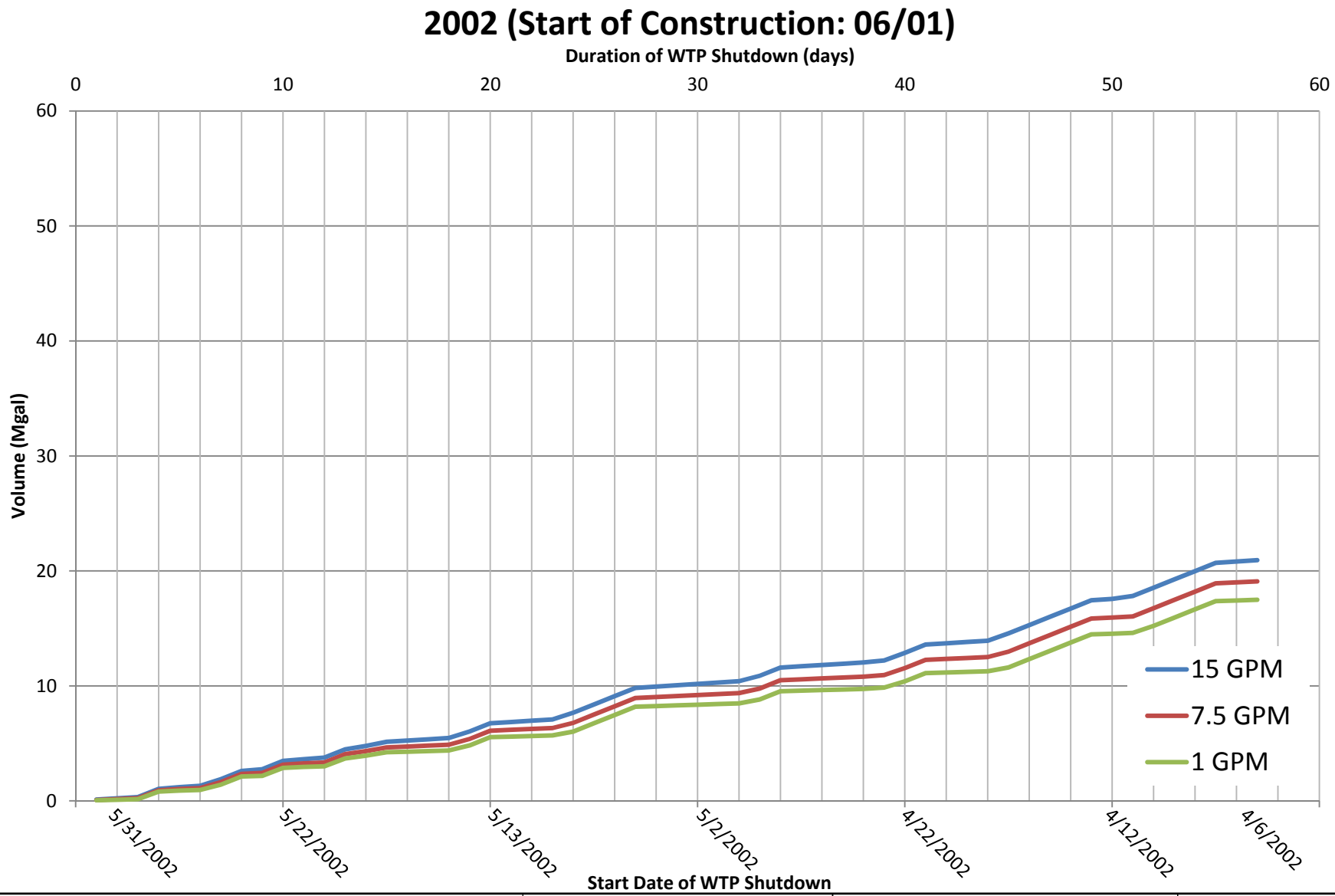
Supplement E-1-4_90% Design.pptx



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Water Balance Analysis - South Pond Construction Water Volume 2002 Operating Year

MWH

DATE: FIGURE 7

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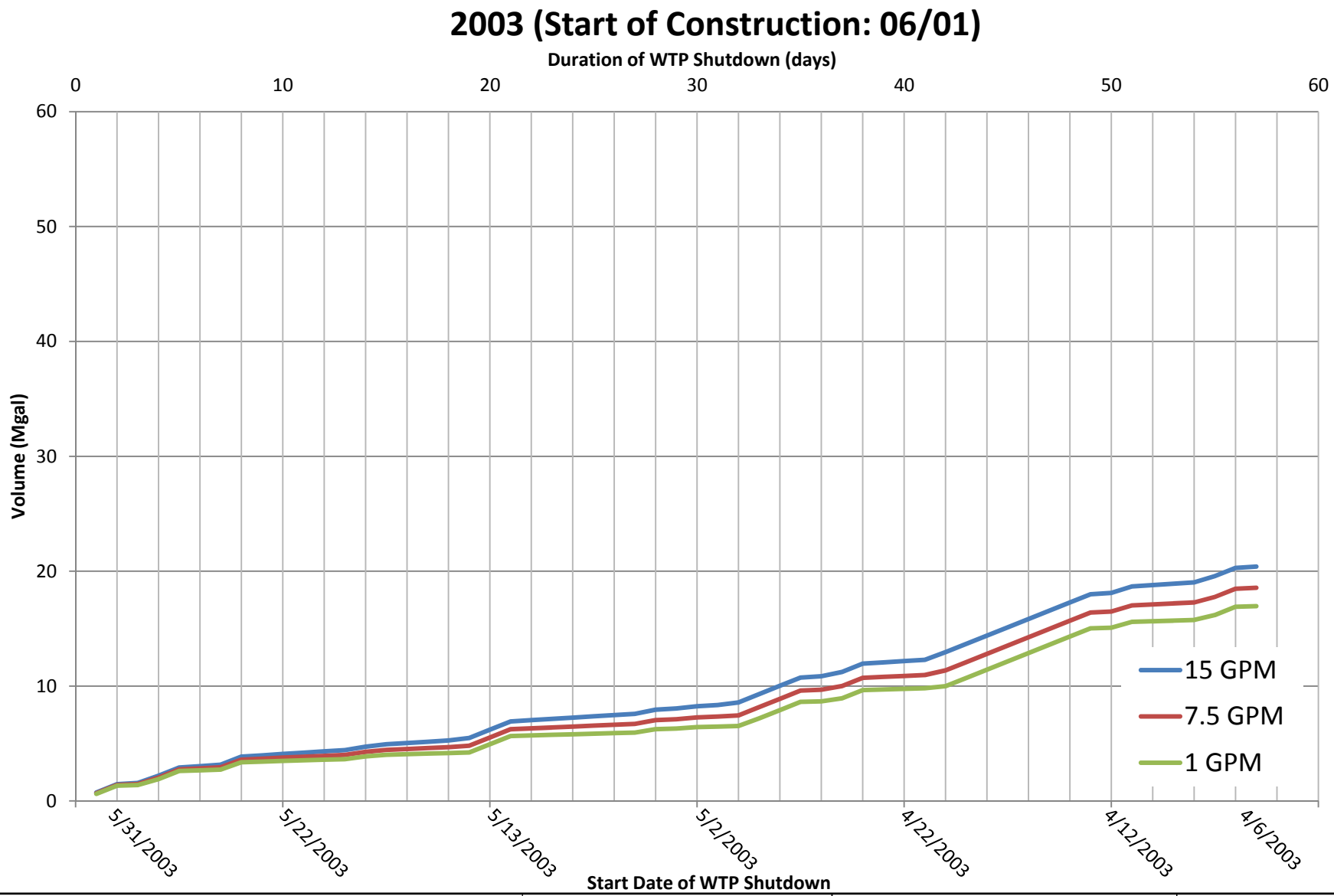


NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2003 Operating Year

MWH

DATE
July 2014

FIGURE 8

FILENAME
Supplement E-1-4_90% Design.pptx

NEWMONT

PROJECT
MIDNITE MINE

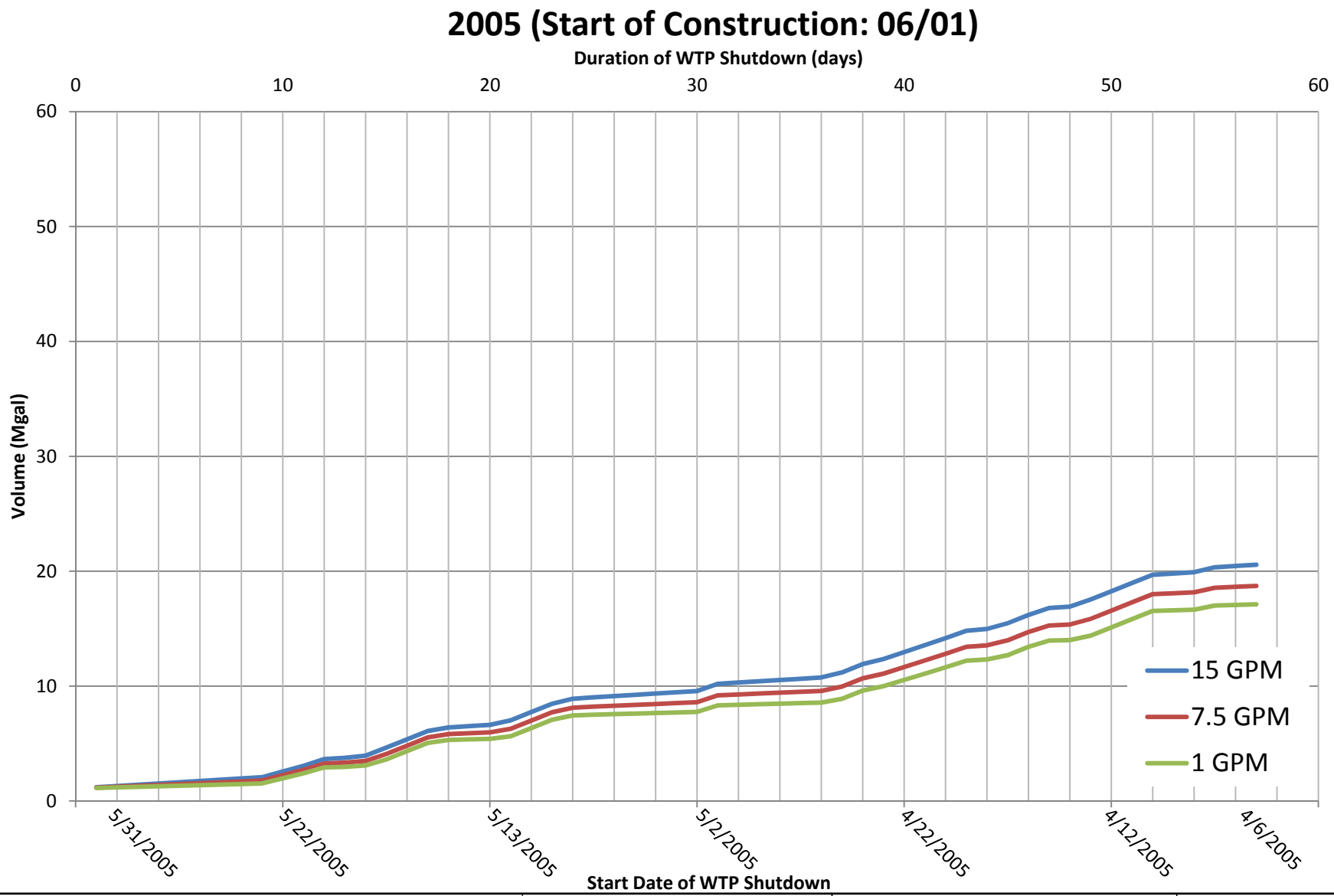
TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2004 Operating Year

MWH

DATE
July 2014

FIGURE 9

FILENAME
Supplement E-1-4_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2005 Operating Year

MWH

DATE
July 2014

FIGURE 10

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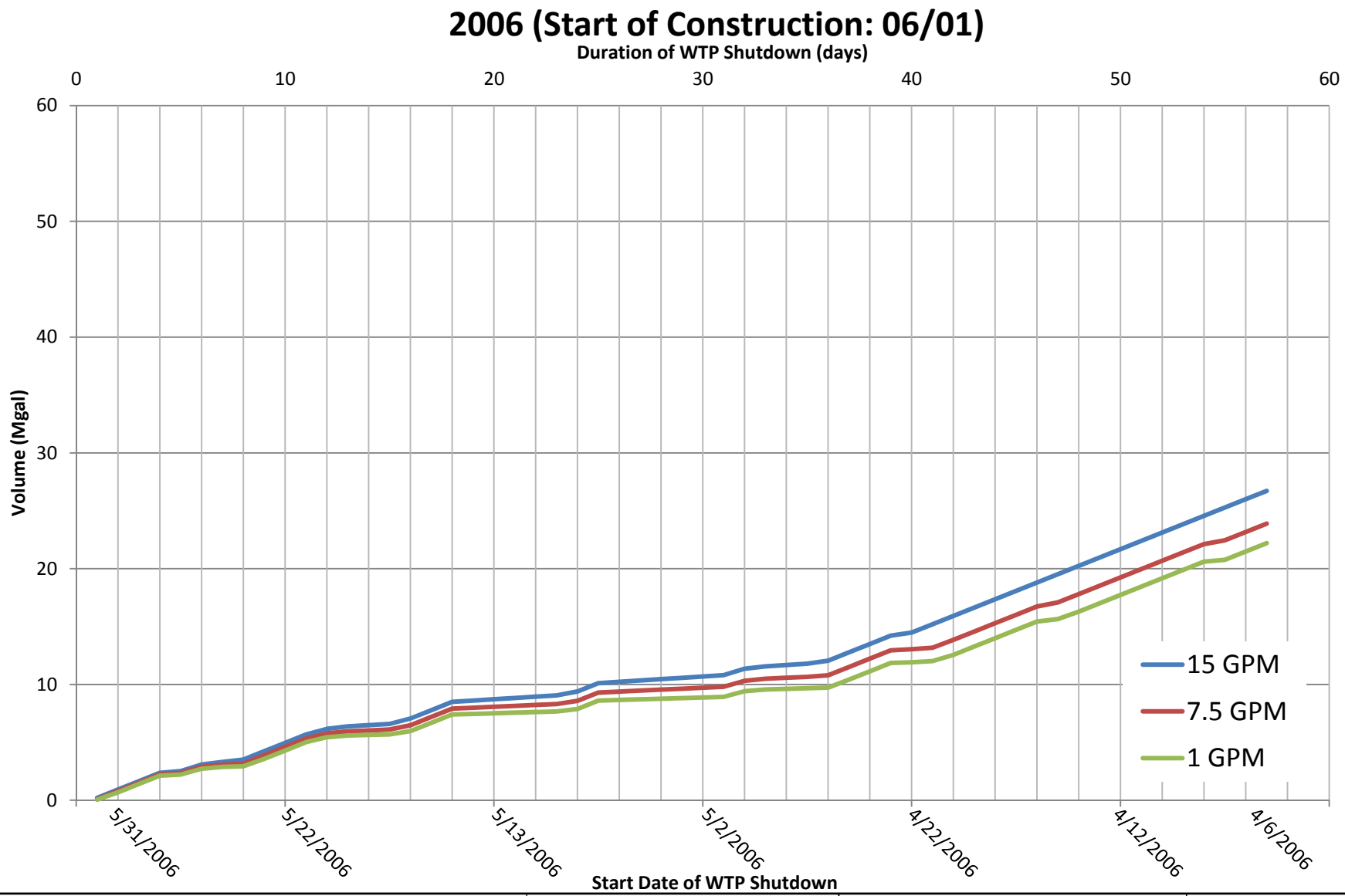
Supplement E-1-4_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2006 Operating Year

MWH

DATE
July 2014

FIGURE 11

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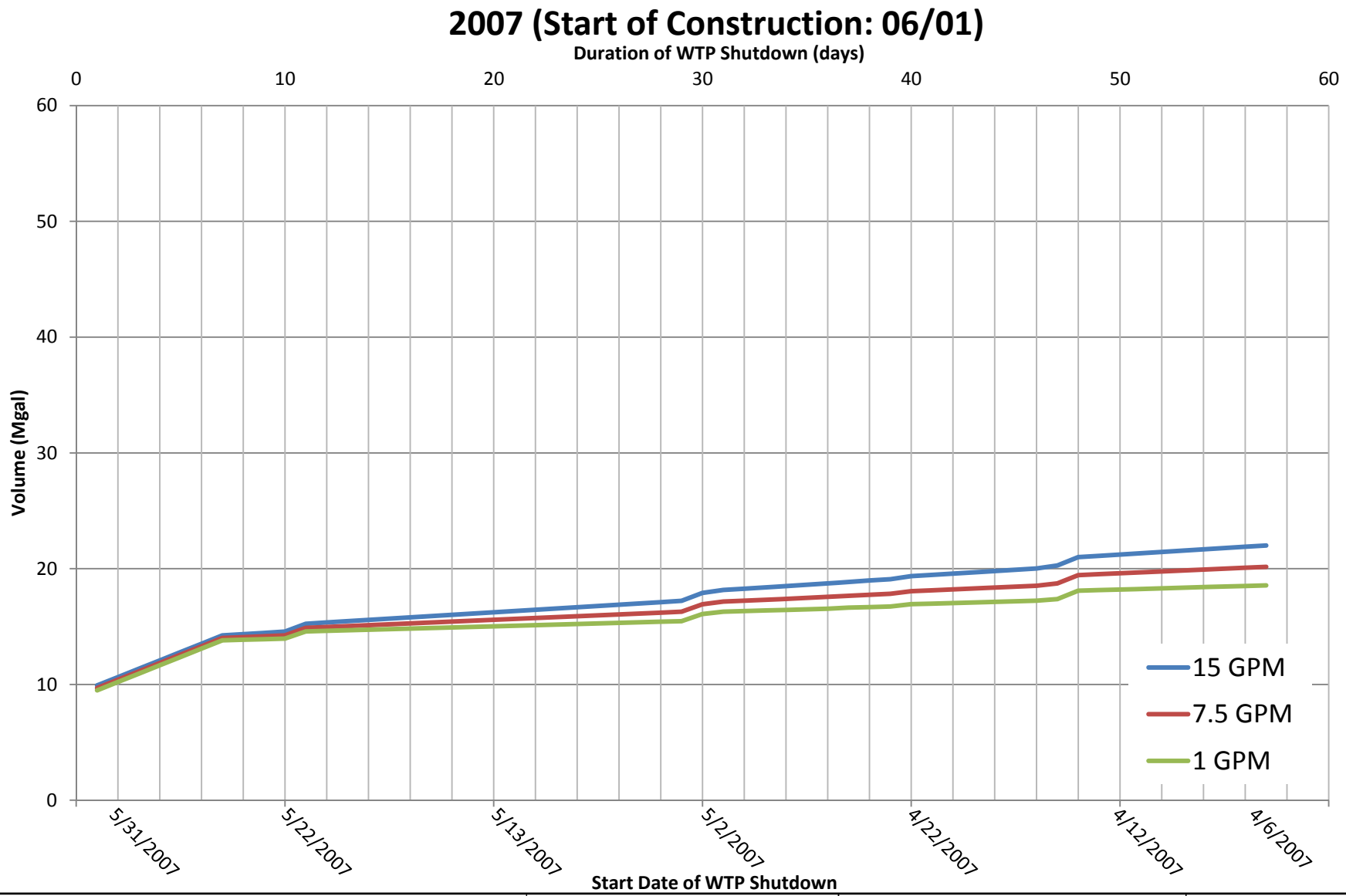
Supplement E-1-4_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2007 Operating Year

MWH

DATE
July 2014

FIGURE 12

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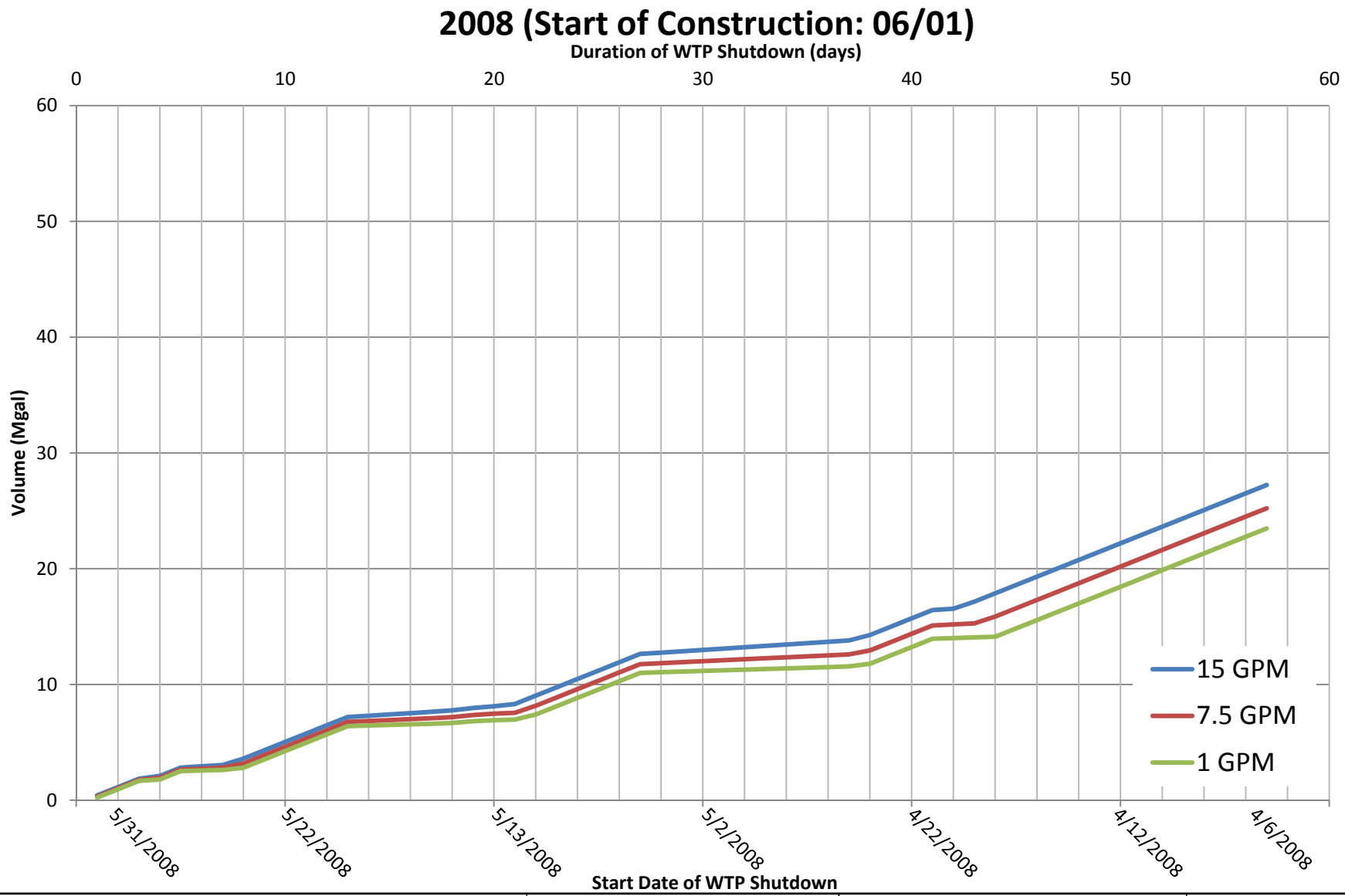
Supplement E-1-4_90% Design.pptx



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PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2008 Operating Year

MWH

DATE
July 2014

FIGURE 13

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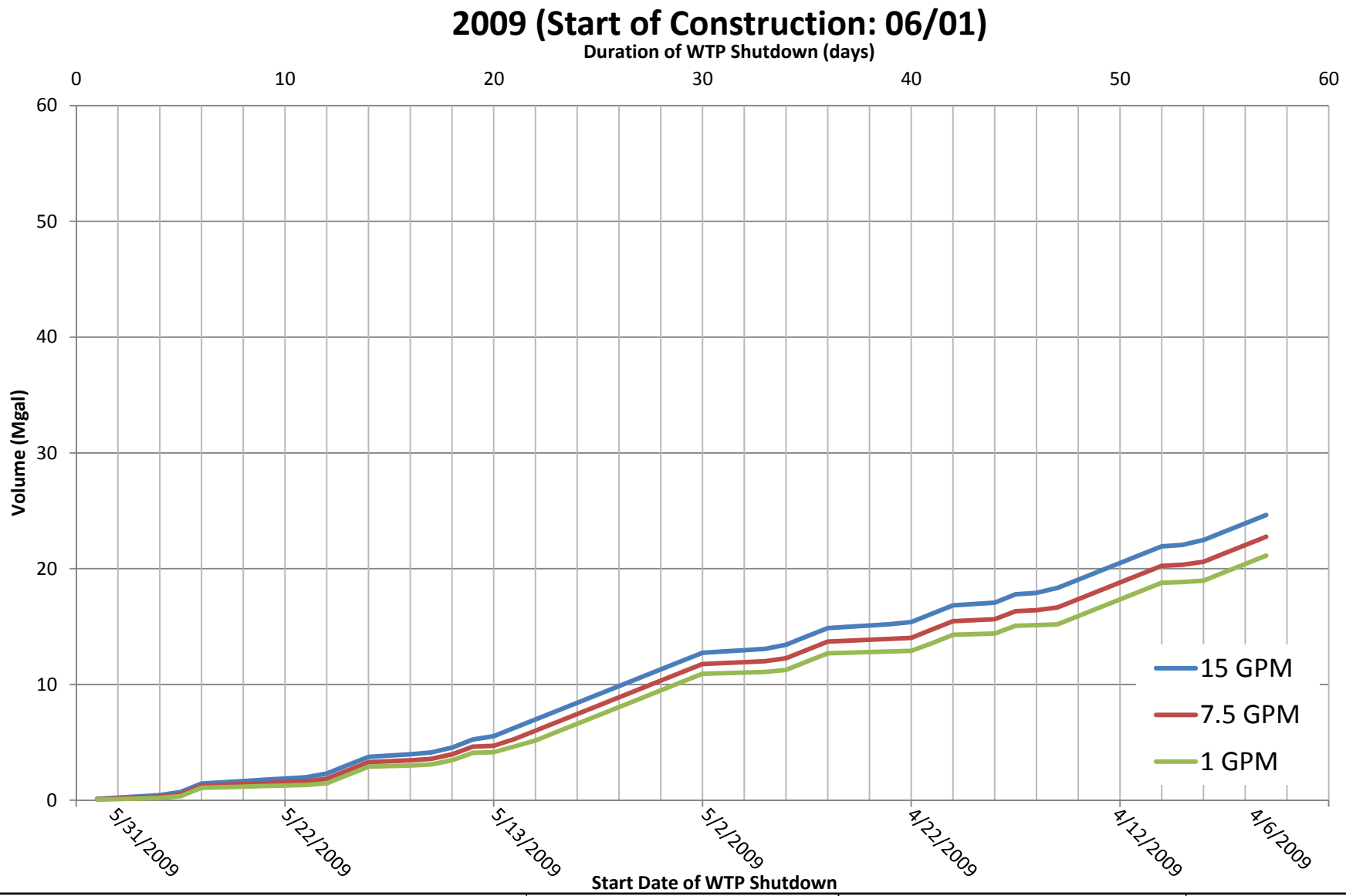
Supplement E-1-4_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2009 Operating Year

MWH

DATE
July 2014

FIGURE 14

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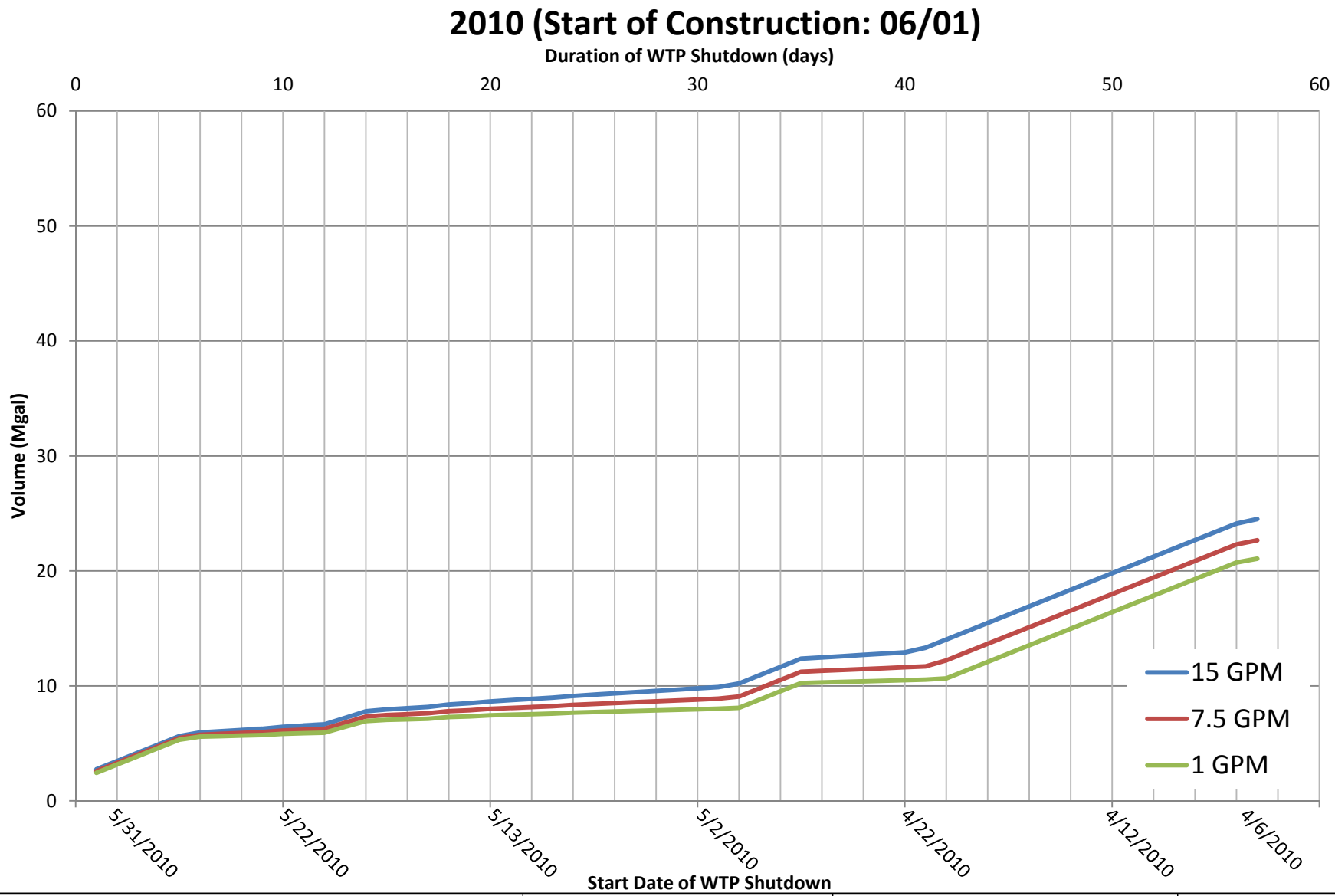
Supplement E-1-4_90% Design.pptx



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PROJECT: MIDNITE MINE

TITLE: Water Balance Analysis - South Pond Construction Water Volume 2010 Operating Year

MWH

DATE: July 2014

FIGURE 15

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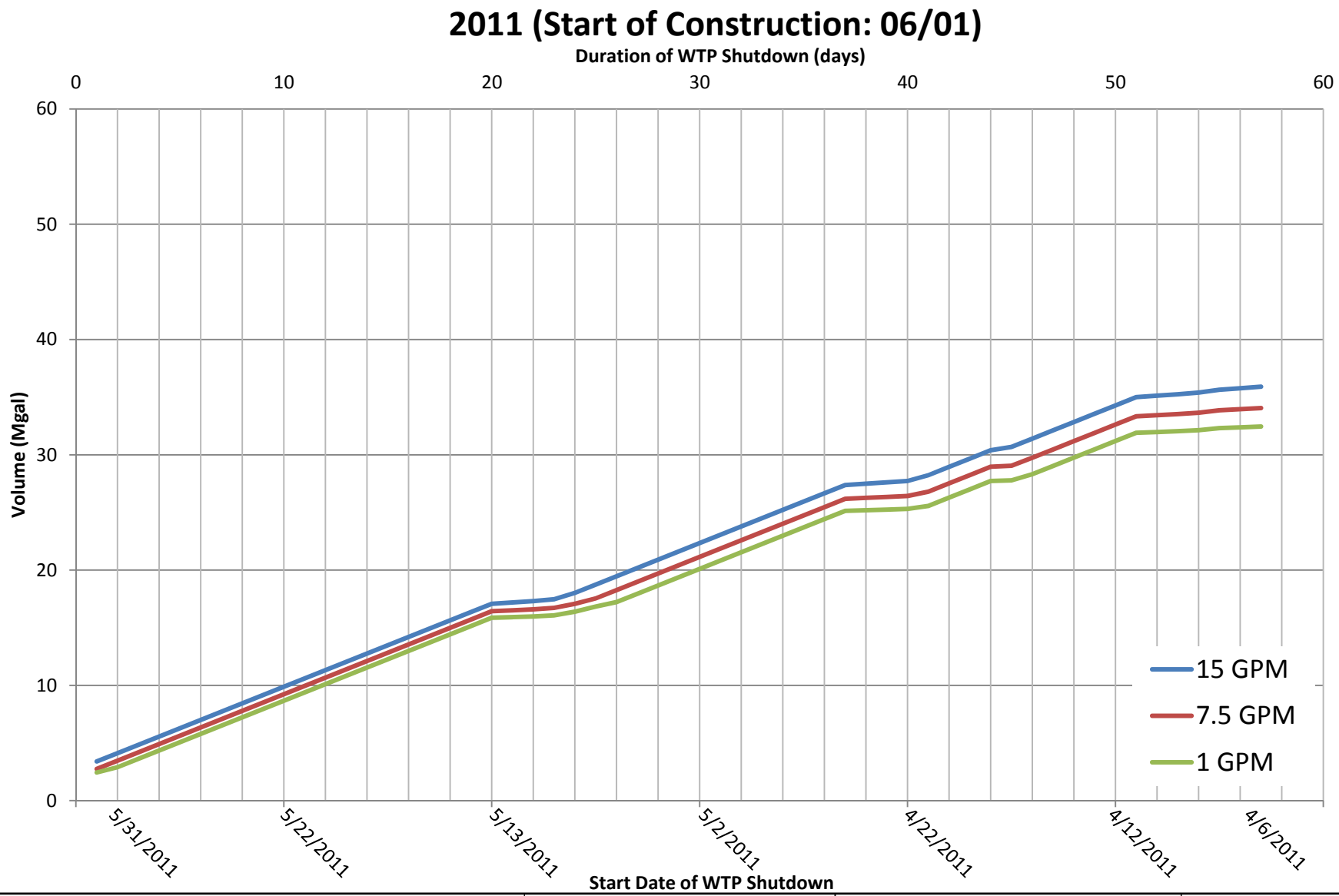

NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2011 Operating Year

MWH

DATE
July 2014

FIGURE 16

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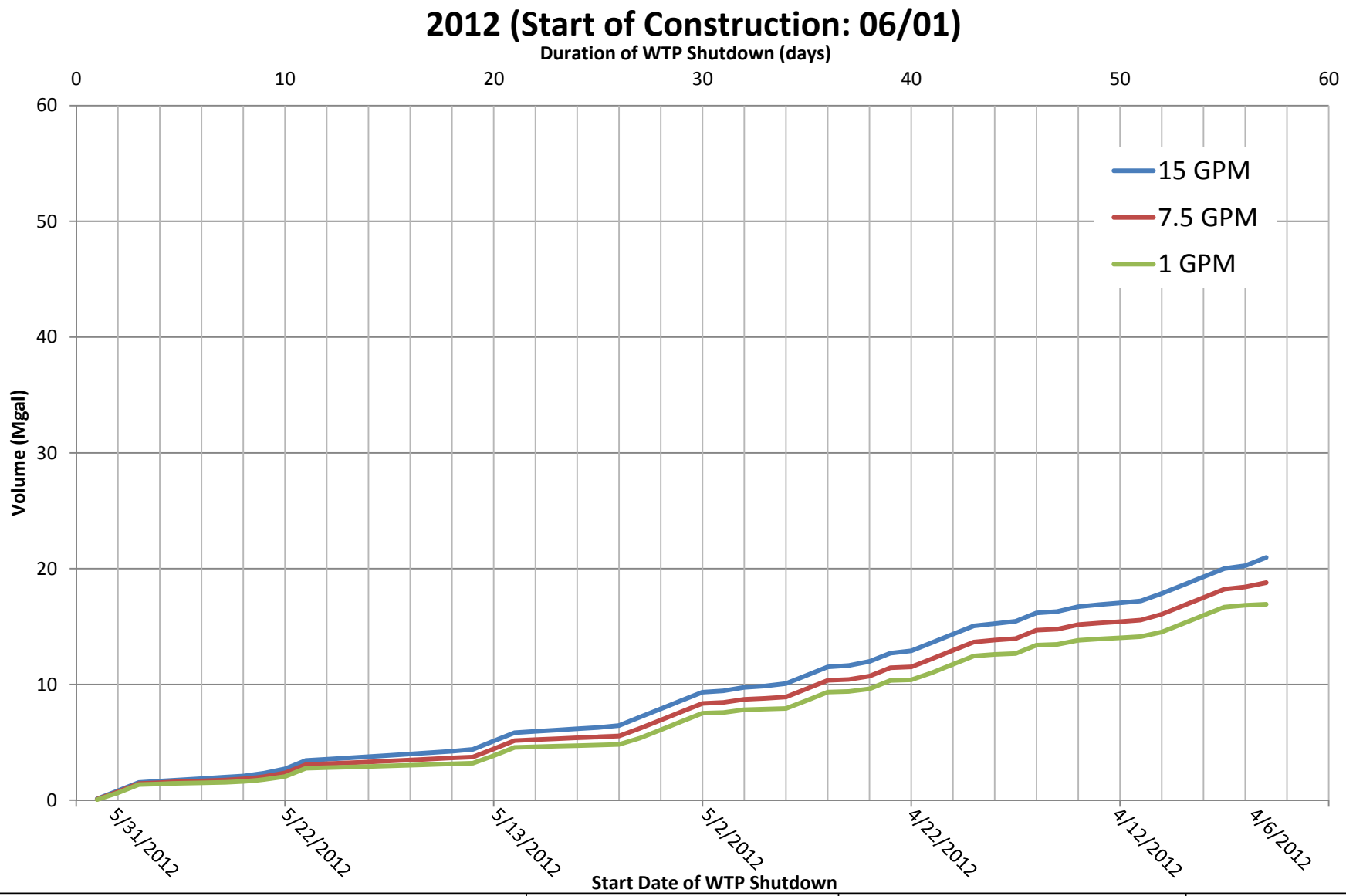

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PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2012 Operating Year

MWH

DATE
July 2014

FIGURE 17

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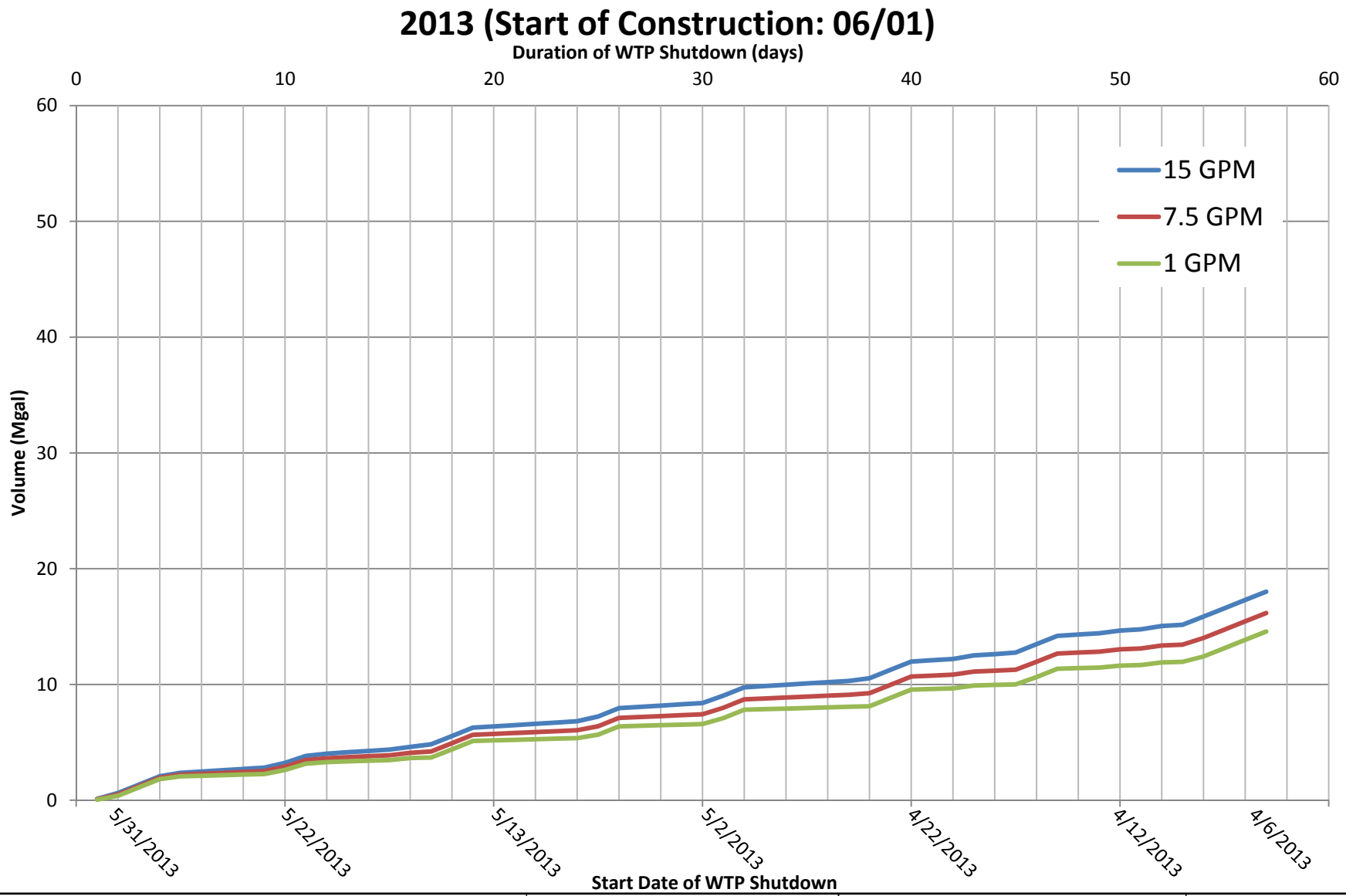
Supplement E-1-4_90% Design.pptx



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PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond
Construction Water Volume 2013 Operating Year

MWH

DATE
July 2014

FIGURE 18

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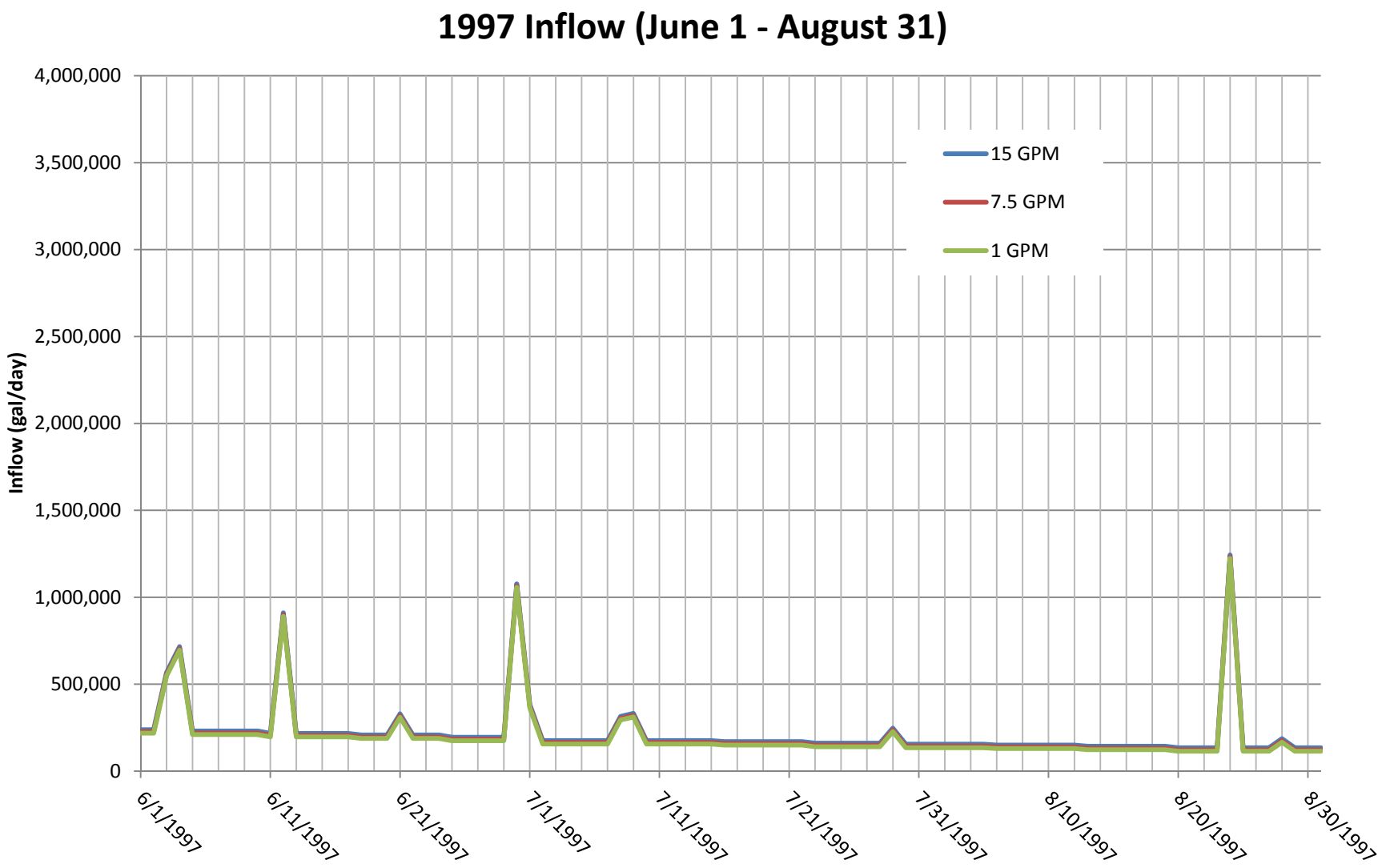
Supplement E-1-4_90% Design.pptx

Supplement E-1.5

Analysis of Phase 3 Construction Water Availability



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 1997 Operating Year

MWH

DATE
July 2014

FIGURE 1

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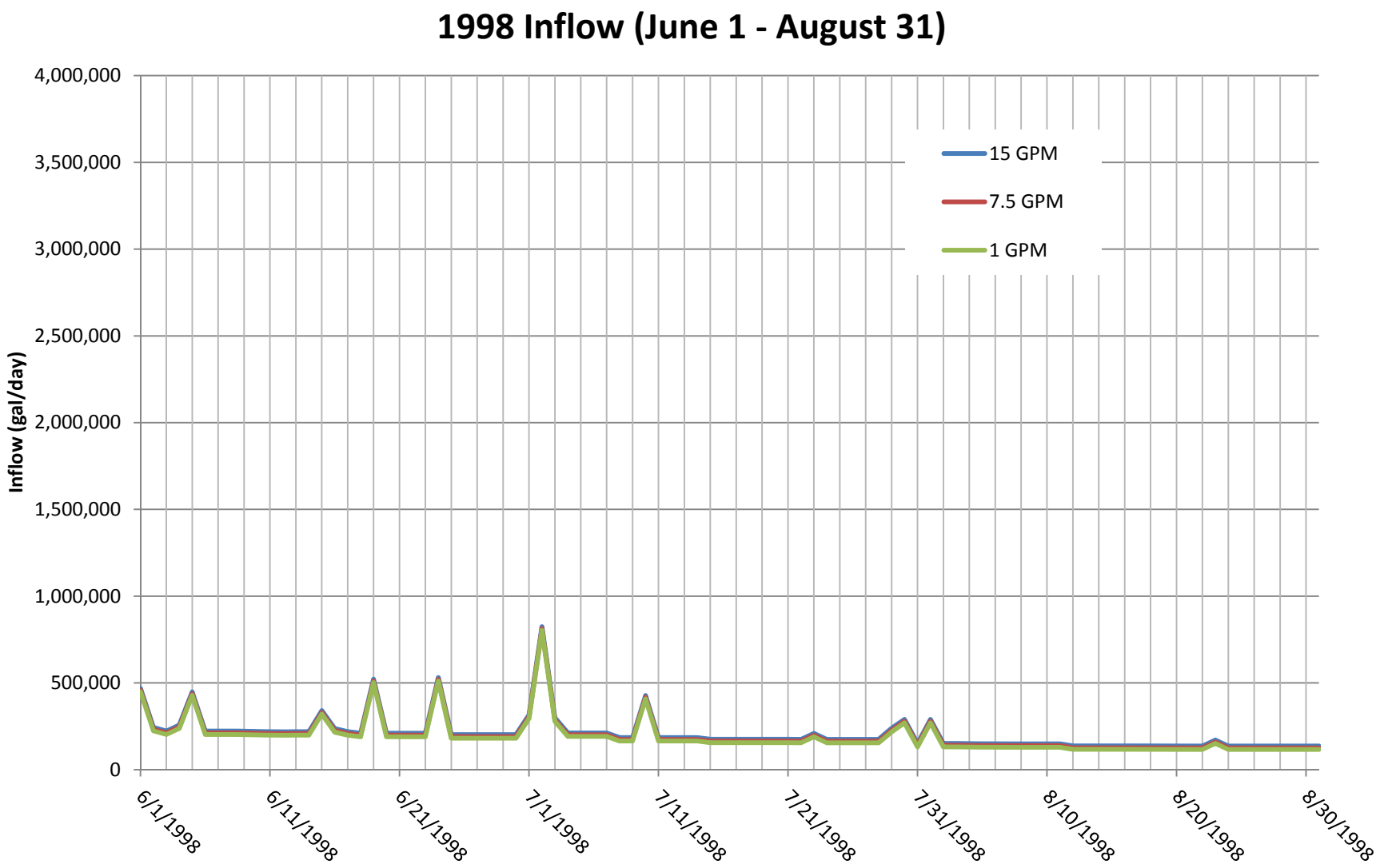
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 1998 Operating Year

MWH

DATE
July 2014

FIGURE 2

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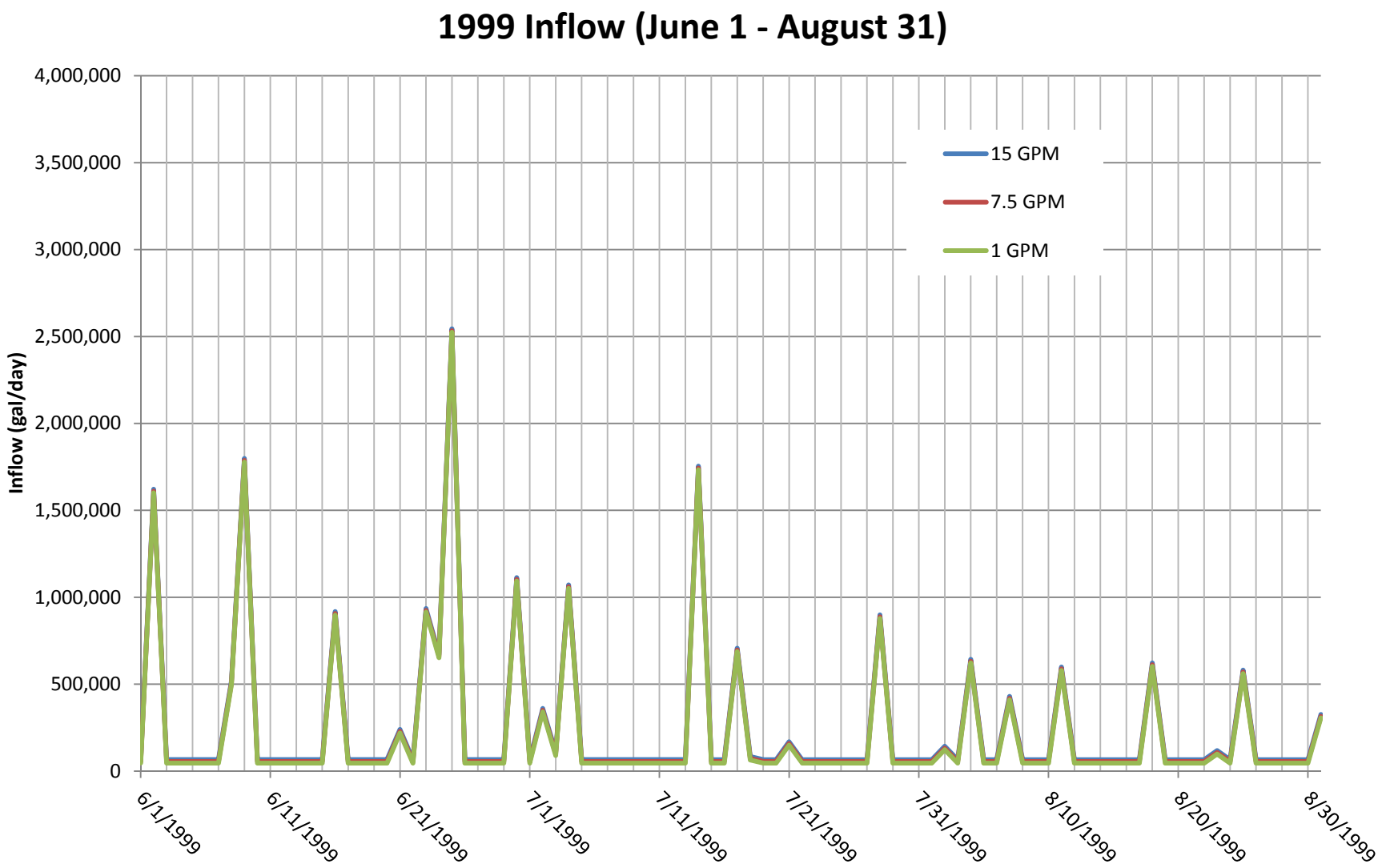
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 1999 Operating Year

MWH

DATE
July 2014

FIGURE 3

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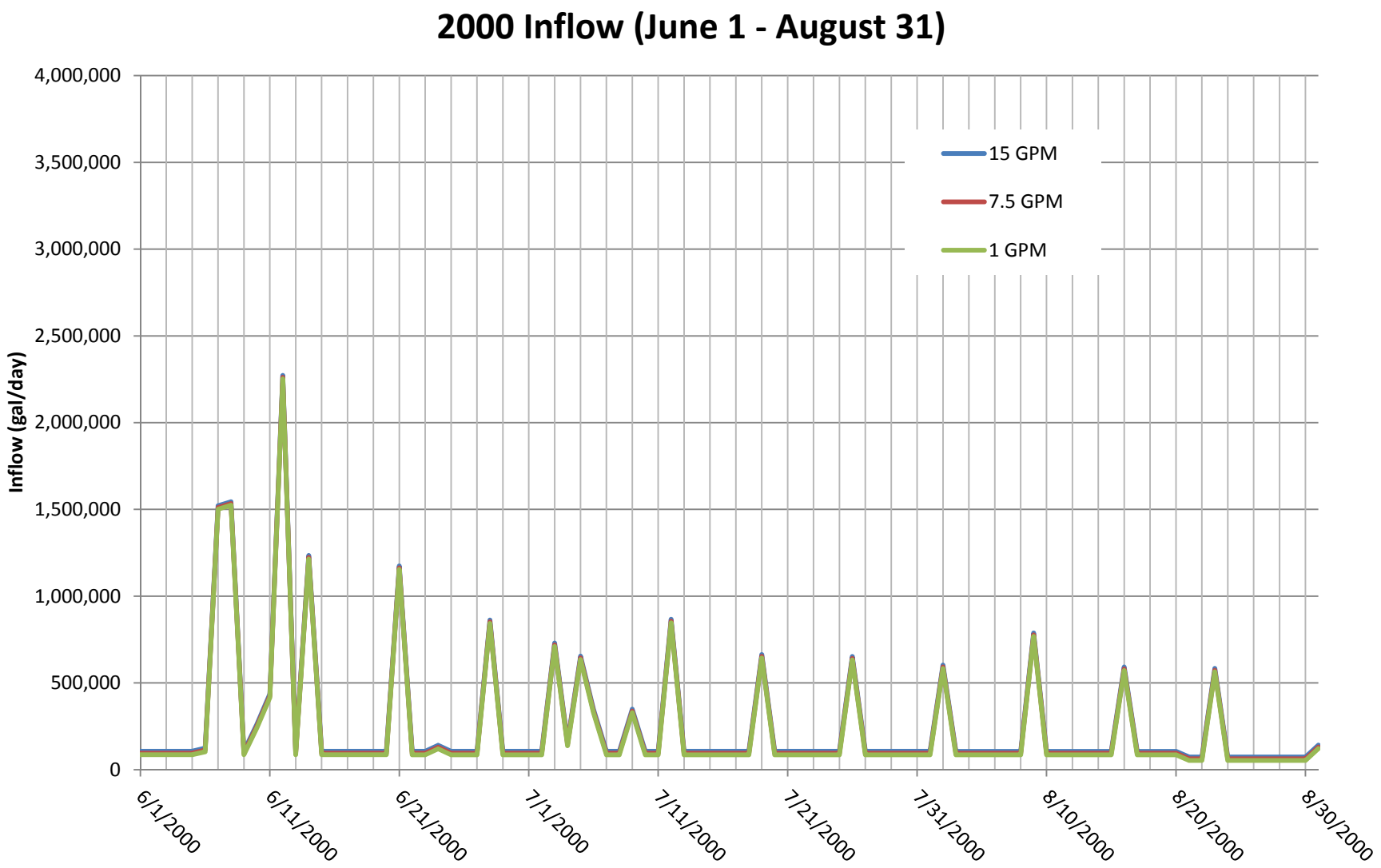
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2000 Operating Year

MWH

DATE
July 2014

FIGURE 4

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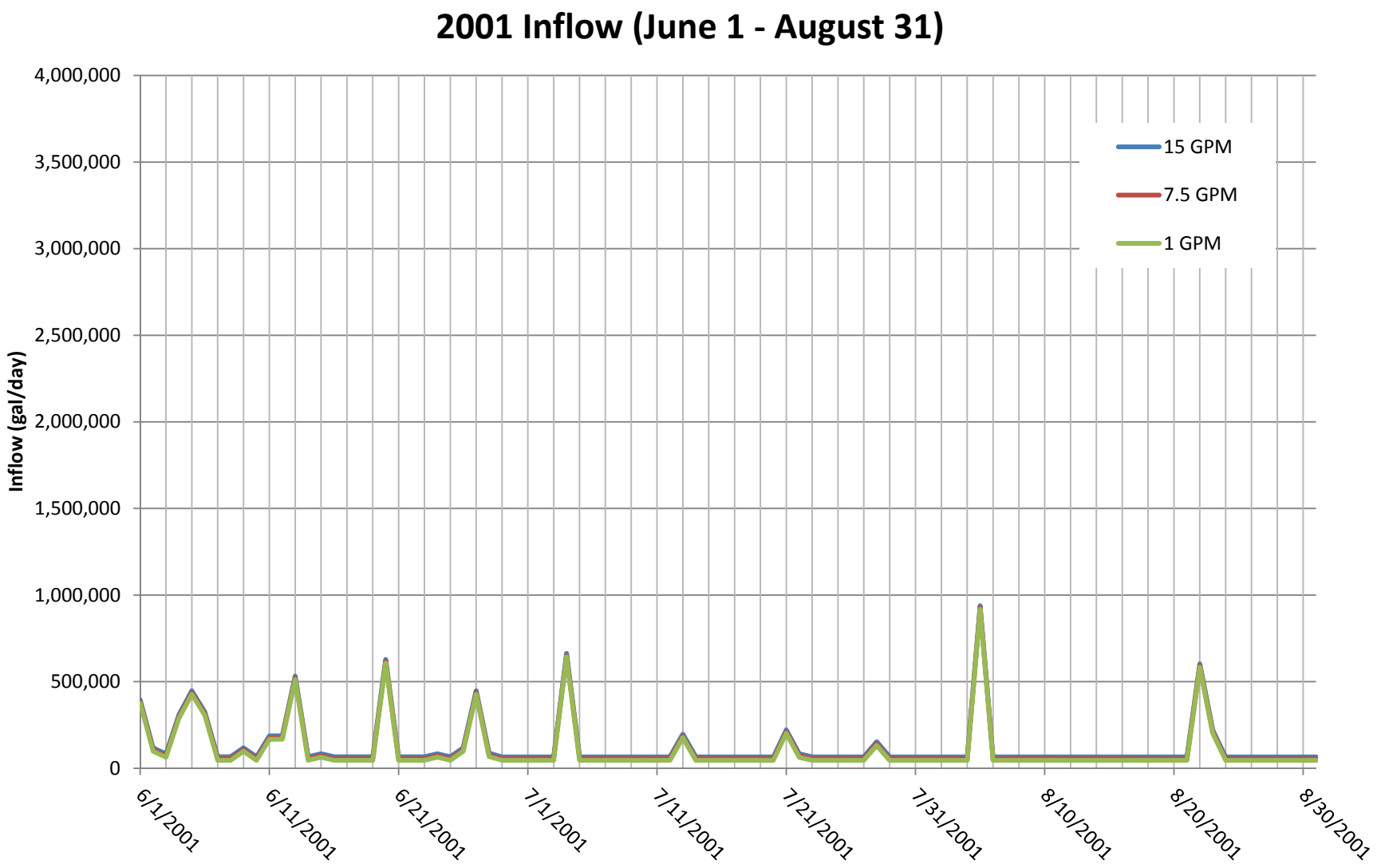
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2001 Operating Year

MWH

DATE
July 2014

FIGURE 5

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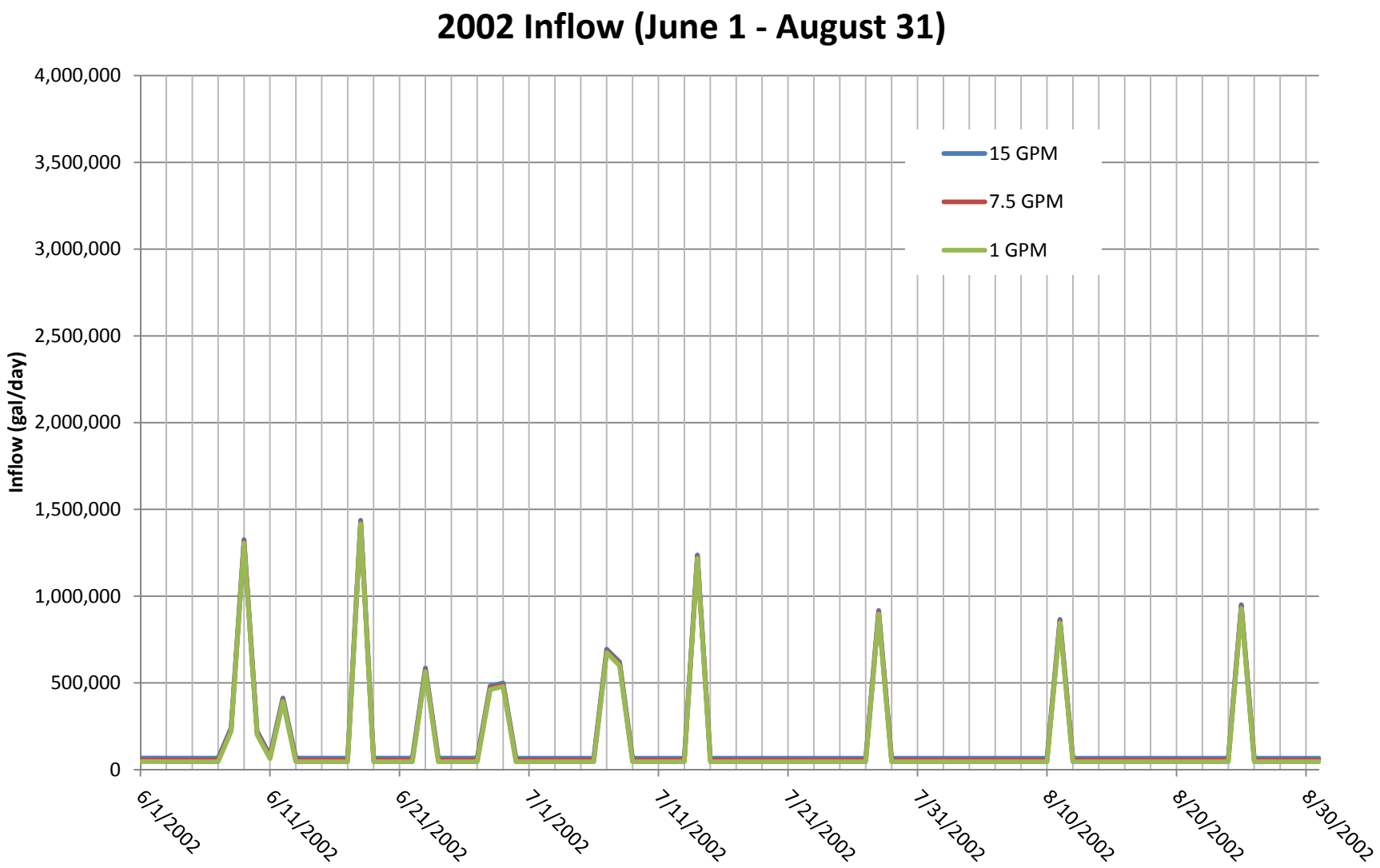
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2002 Operating Year

MWH

DATE
July 2014

FIGURE 6

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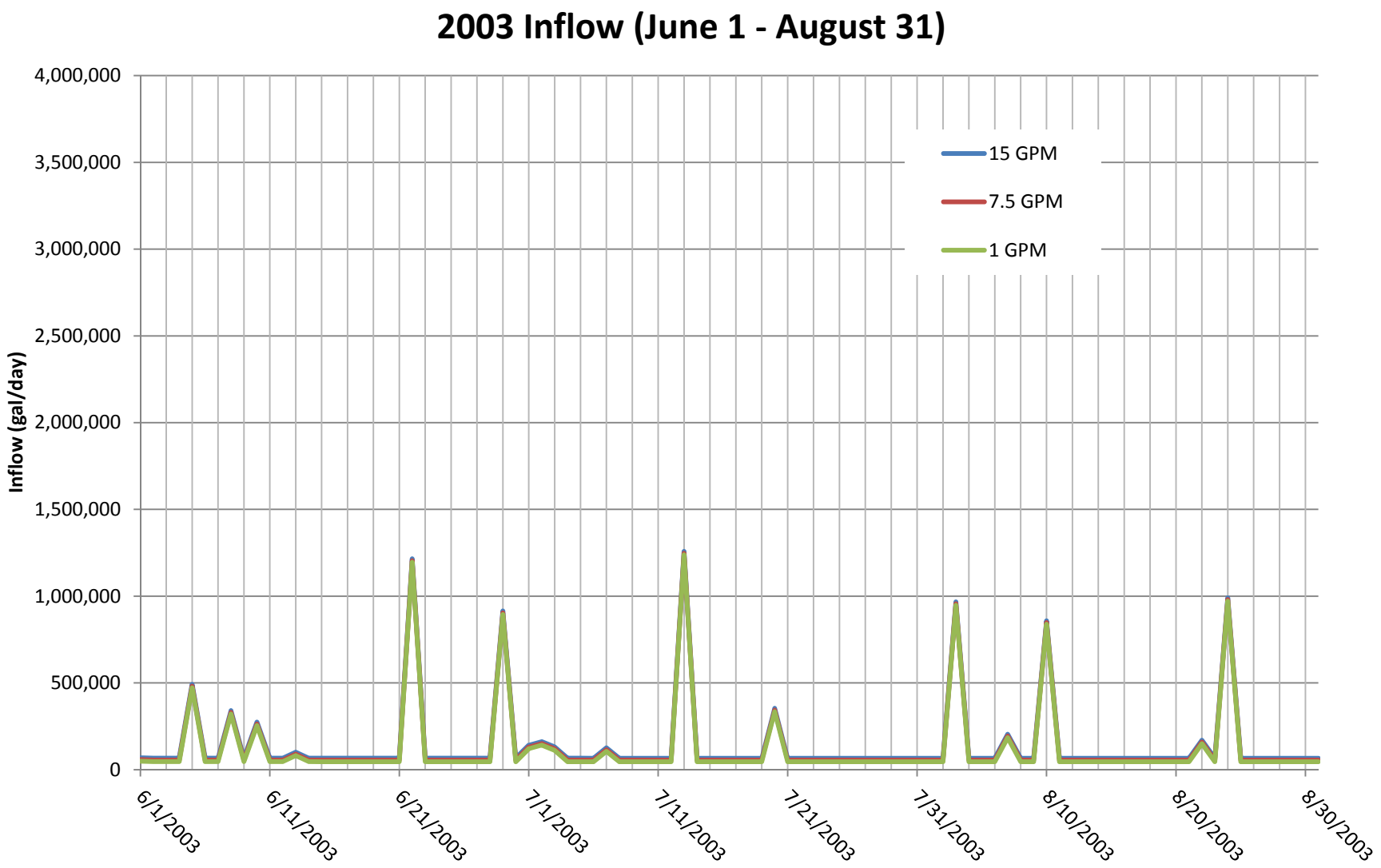
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2003 Operating Year

MWH

DATE
July 2014

FIGURE 7

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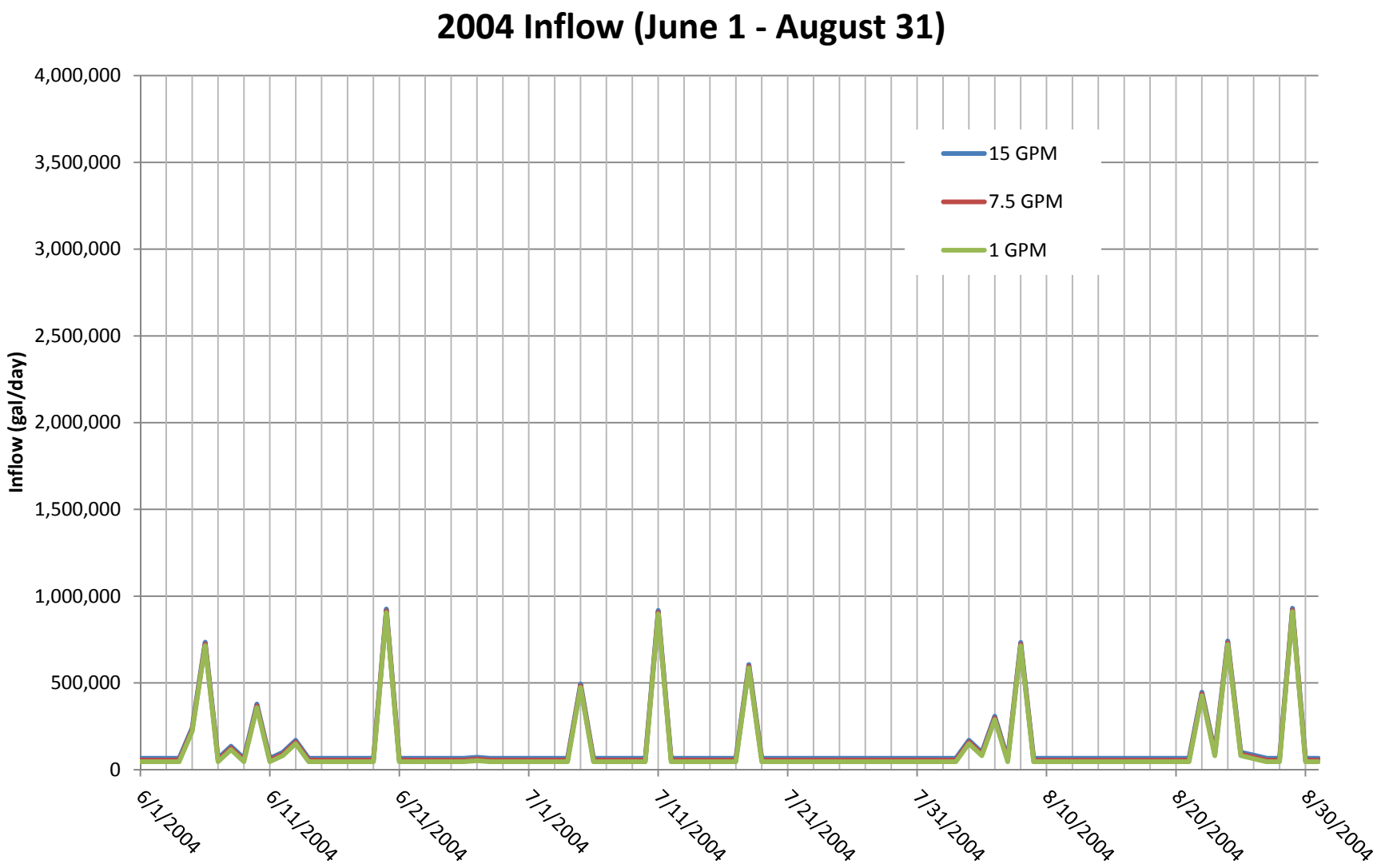
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2004 Operating Year

MWH

DATE
July 2014

FIGURE 8

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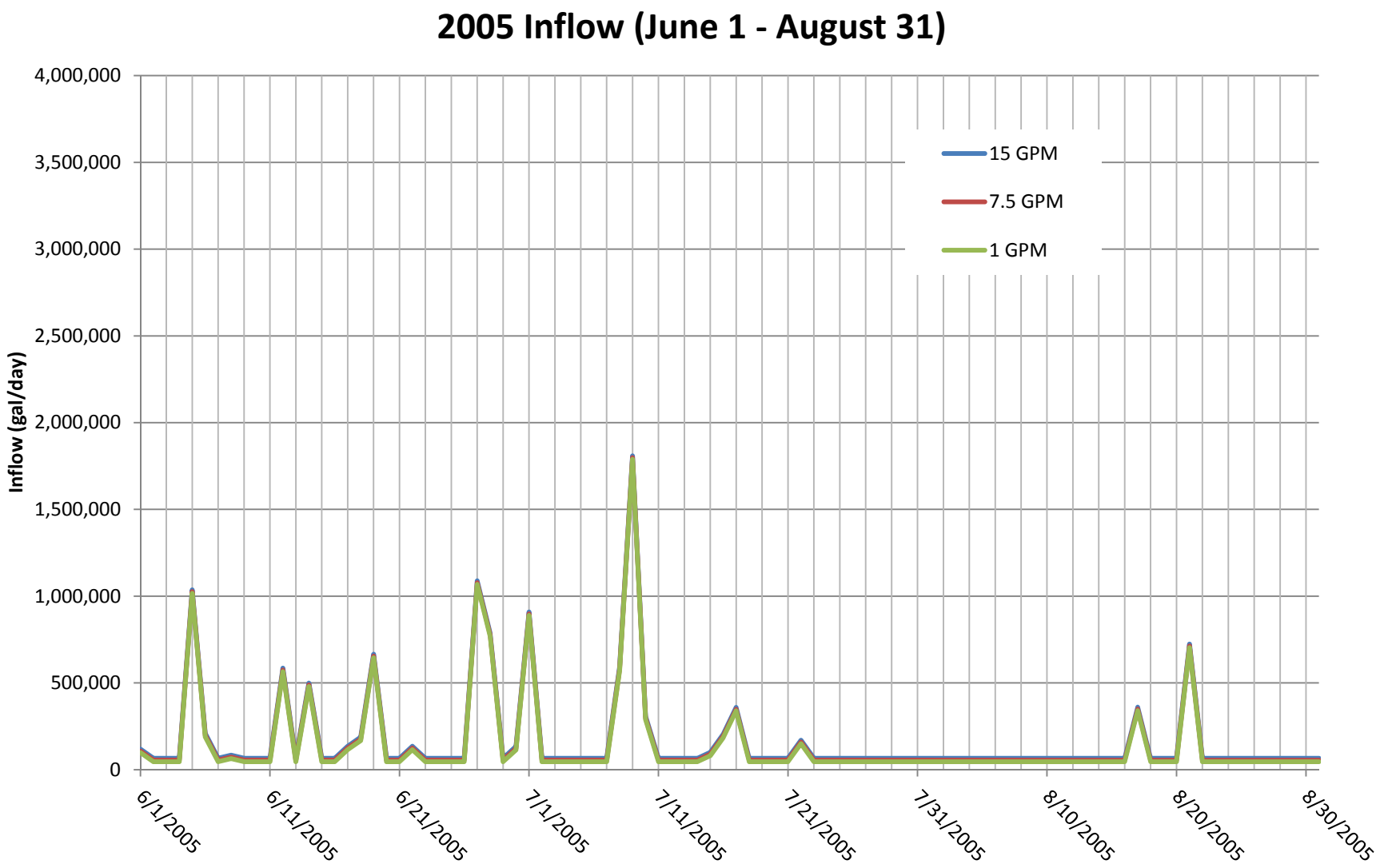
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

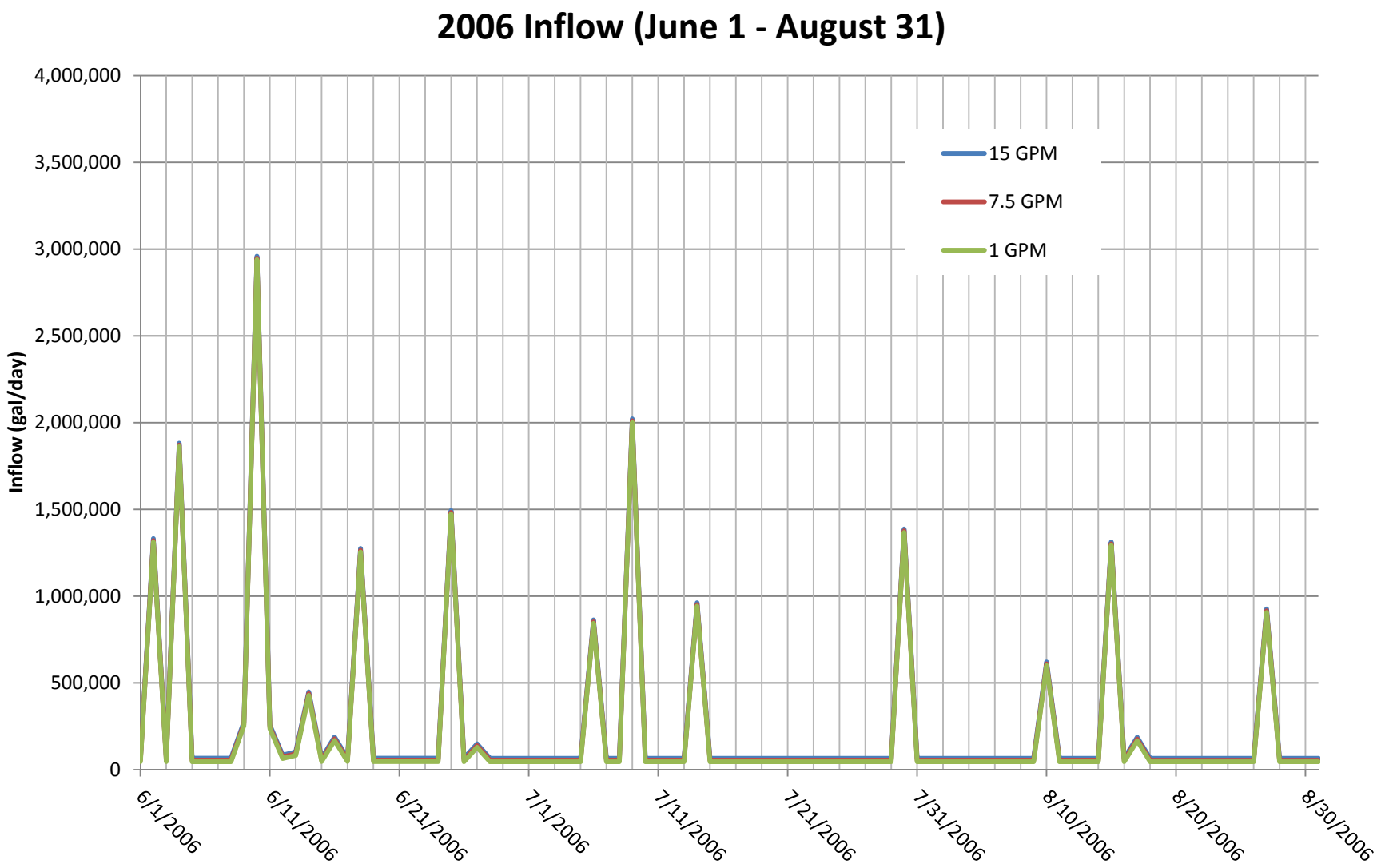
TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2005 Operating Year

MWH

DATE
July 2014

FIGURE 9

FILENAME
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2006 Operating Year

MWH

DATE
July 2014

FIGURE 10

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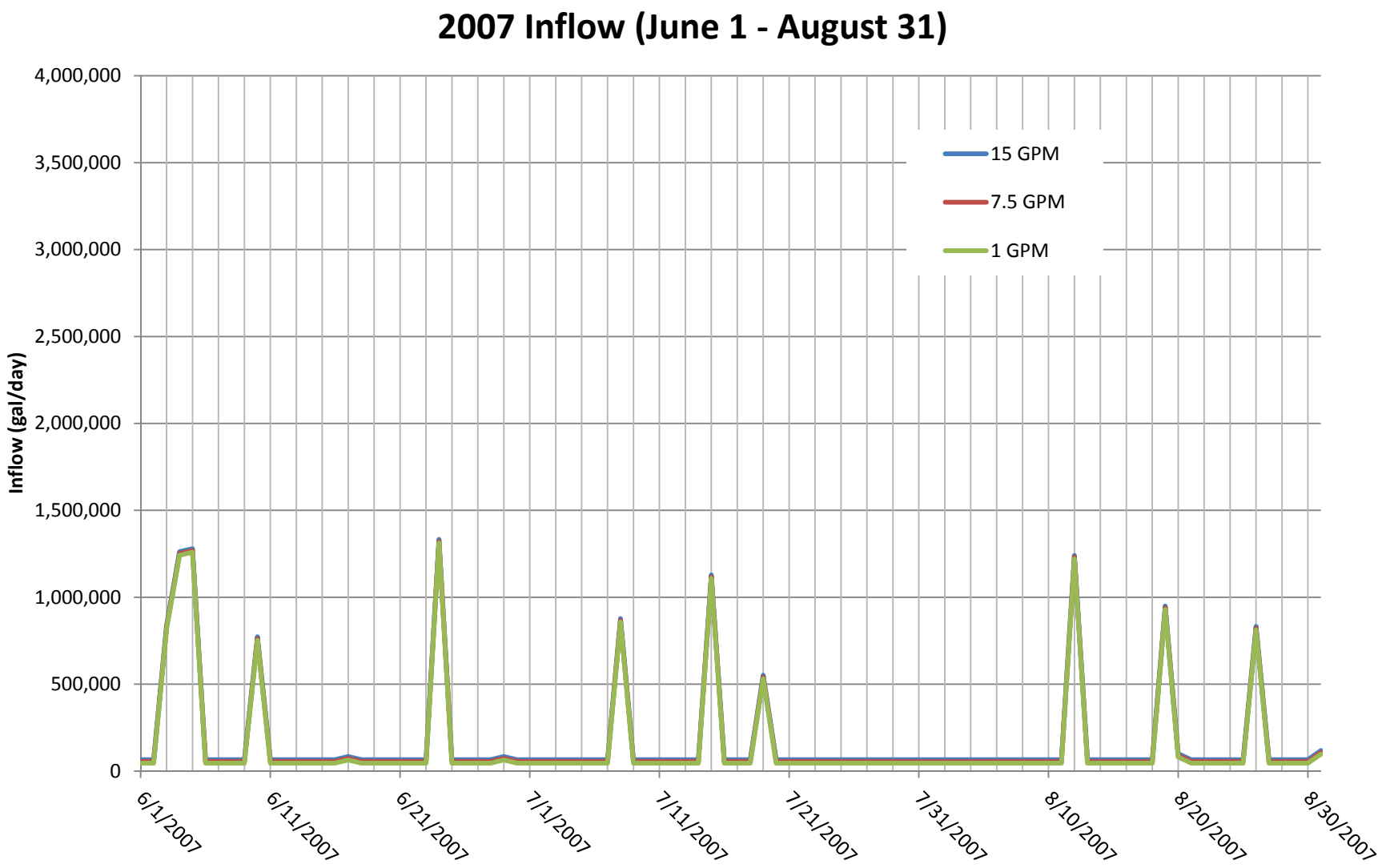
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2007 Operating Year

MWH

DATE
July 2014

FIGURE 11

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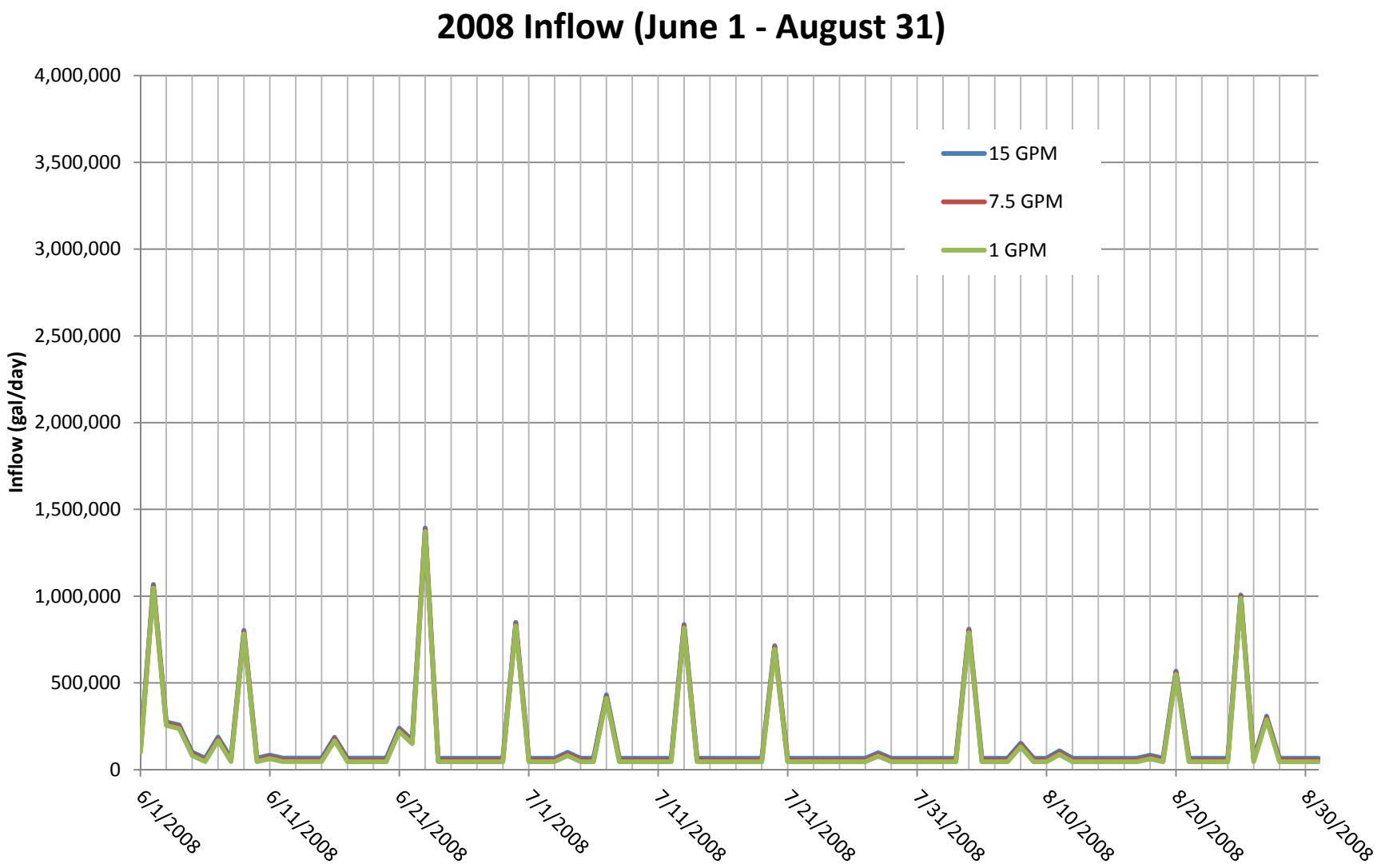
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2008 Operating Year

MWH

DATE
July 2014

FIGURE 12

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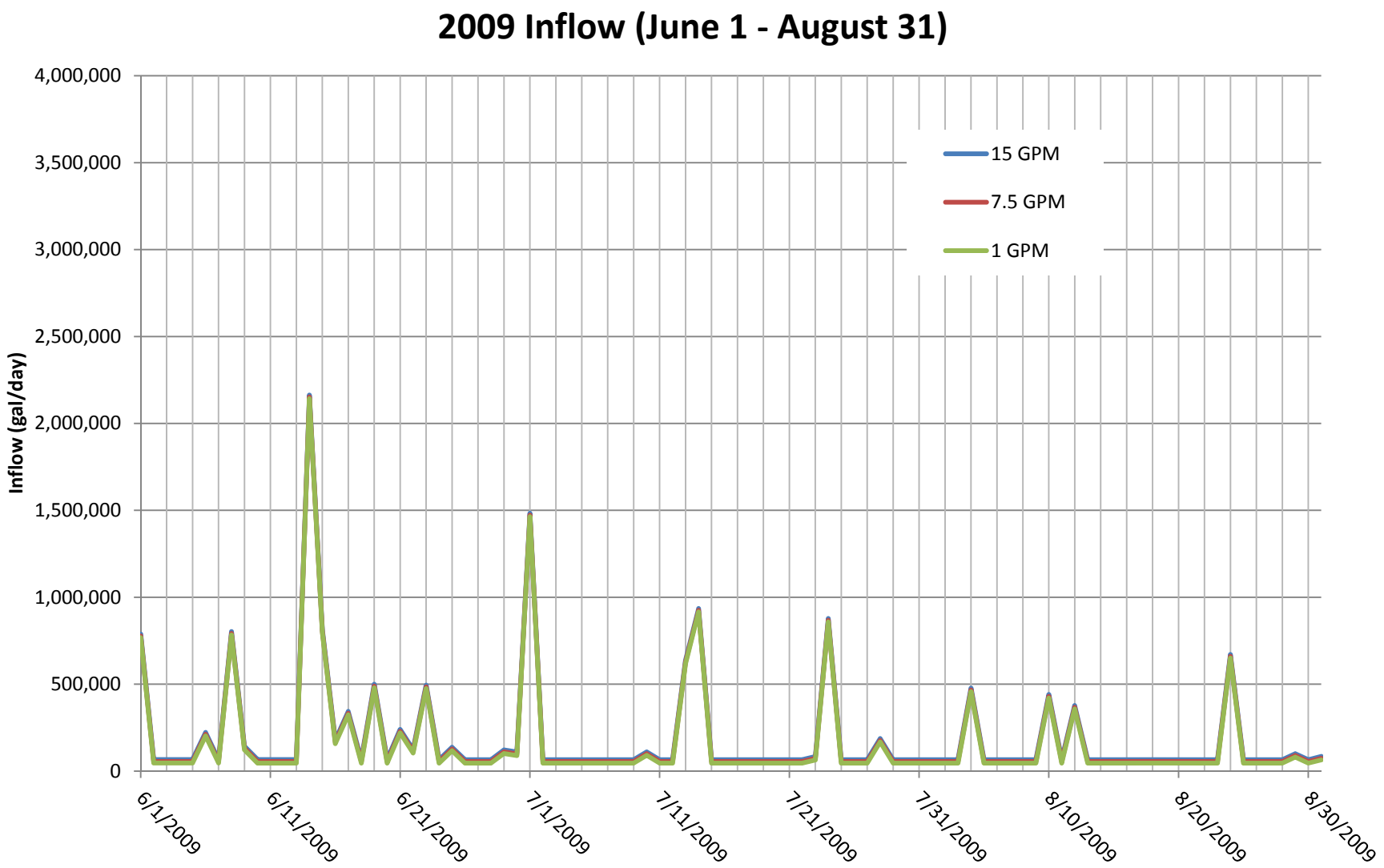
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

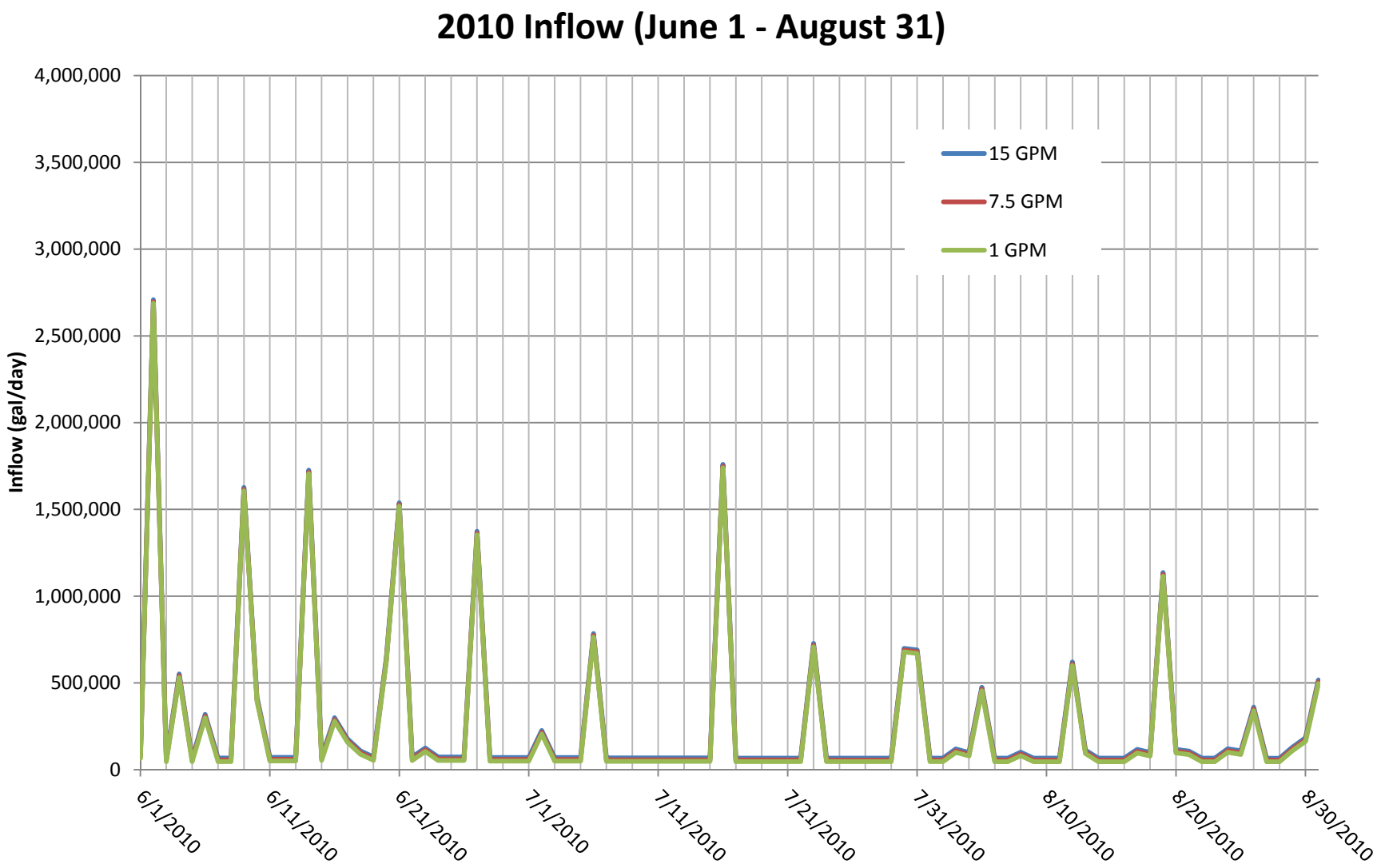
TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2009 Operating Year

MWH

DATE
July 2014

FIGURE 13

FILENAME
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

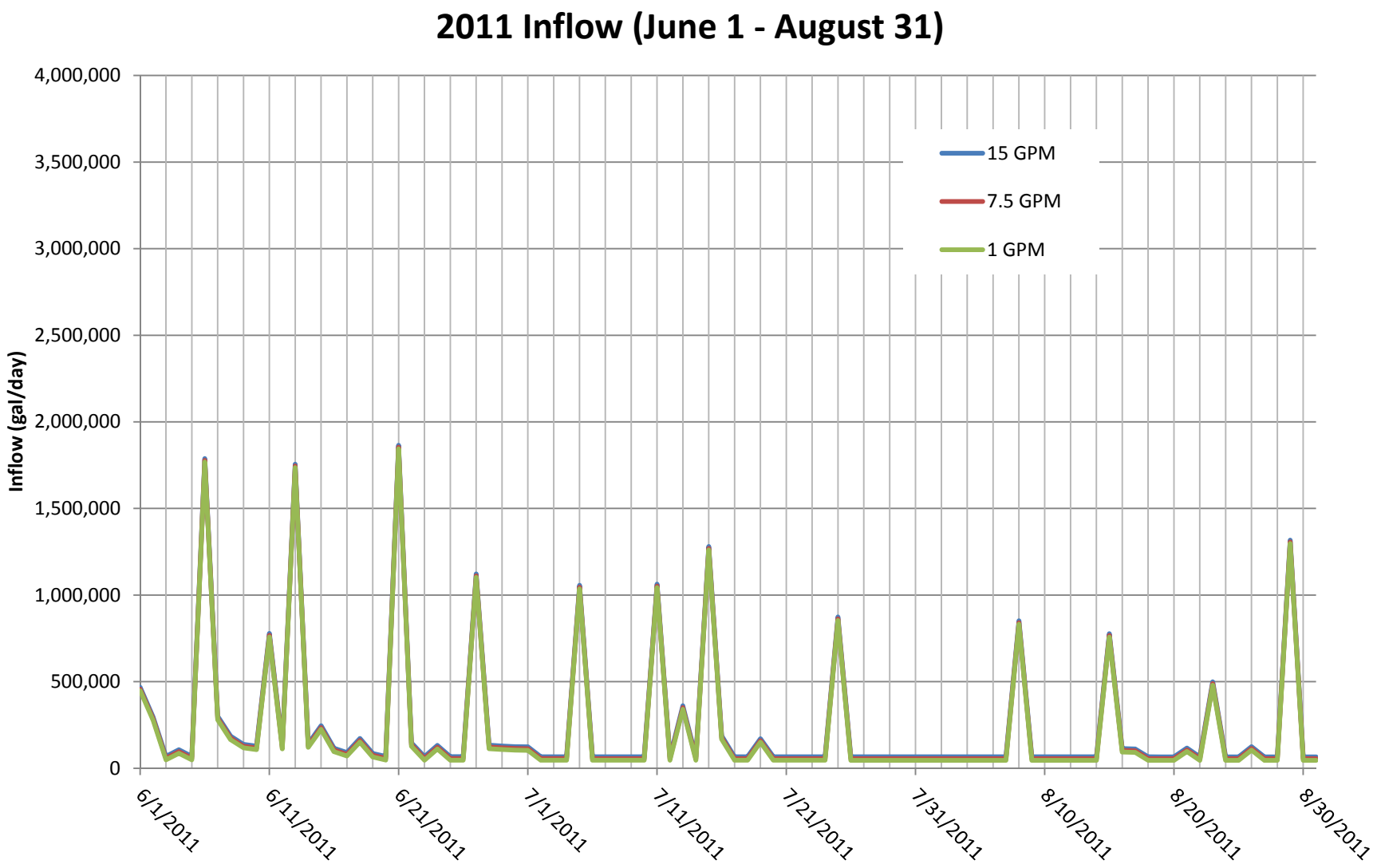
TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2010 Operating Year

MWH

DATE
July 2014

FIGURE 14

FILENAME
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

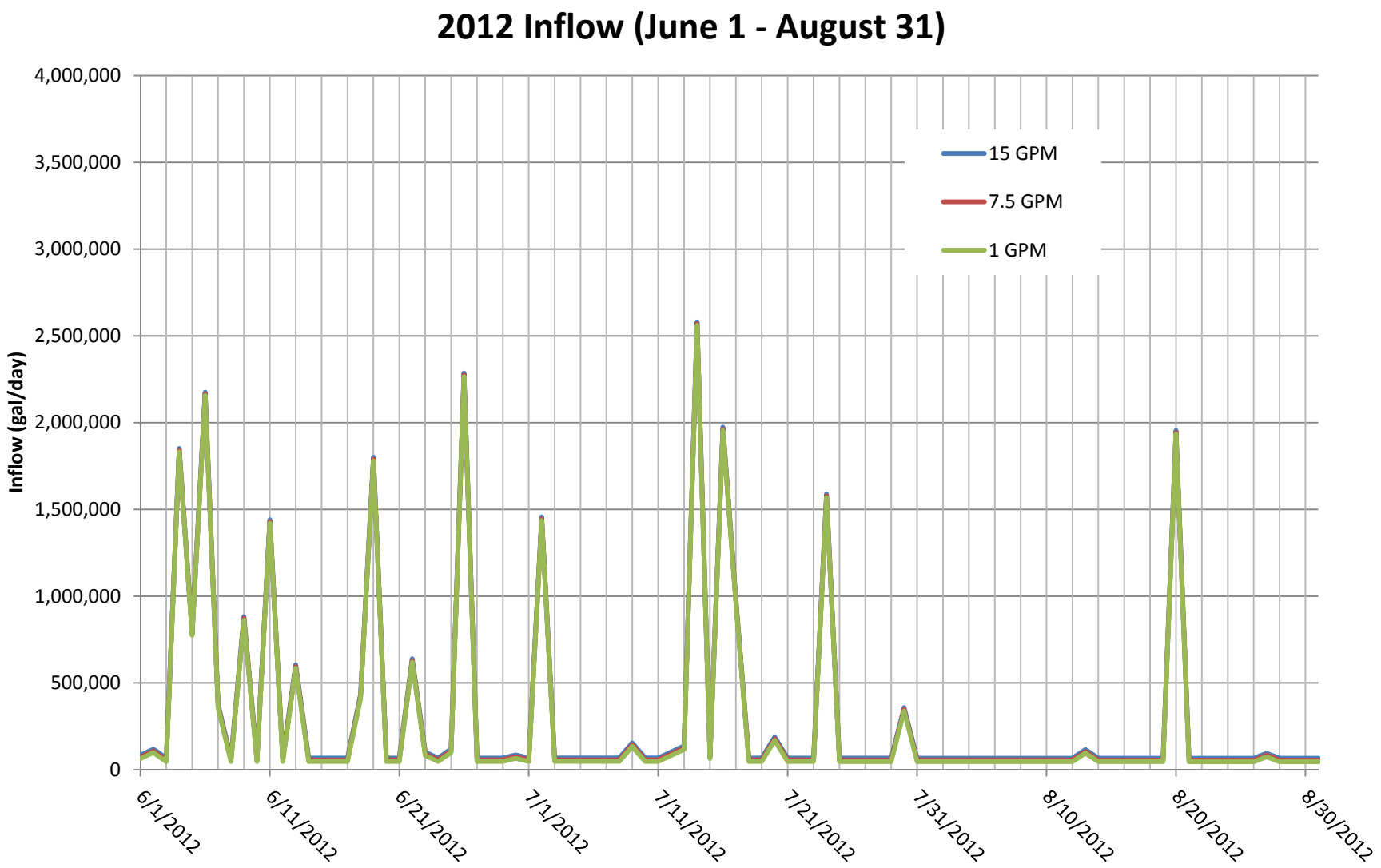
TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2011 Operating Year

MWH

DATE
July 2014

FIGURE 15

FILENAME
Supplement E-1-5_90% Design.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Water Balance Analysis - South Pond Inflows
(June 1 to August 31) - 2012 Operating Year

MWH

DATE
July 2014

FIGURE 16

FILENAME
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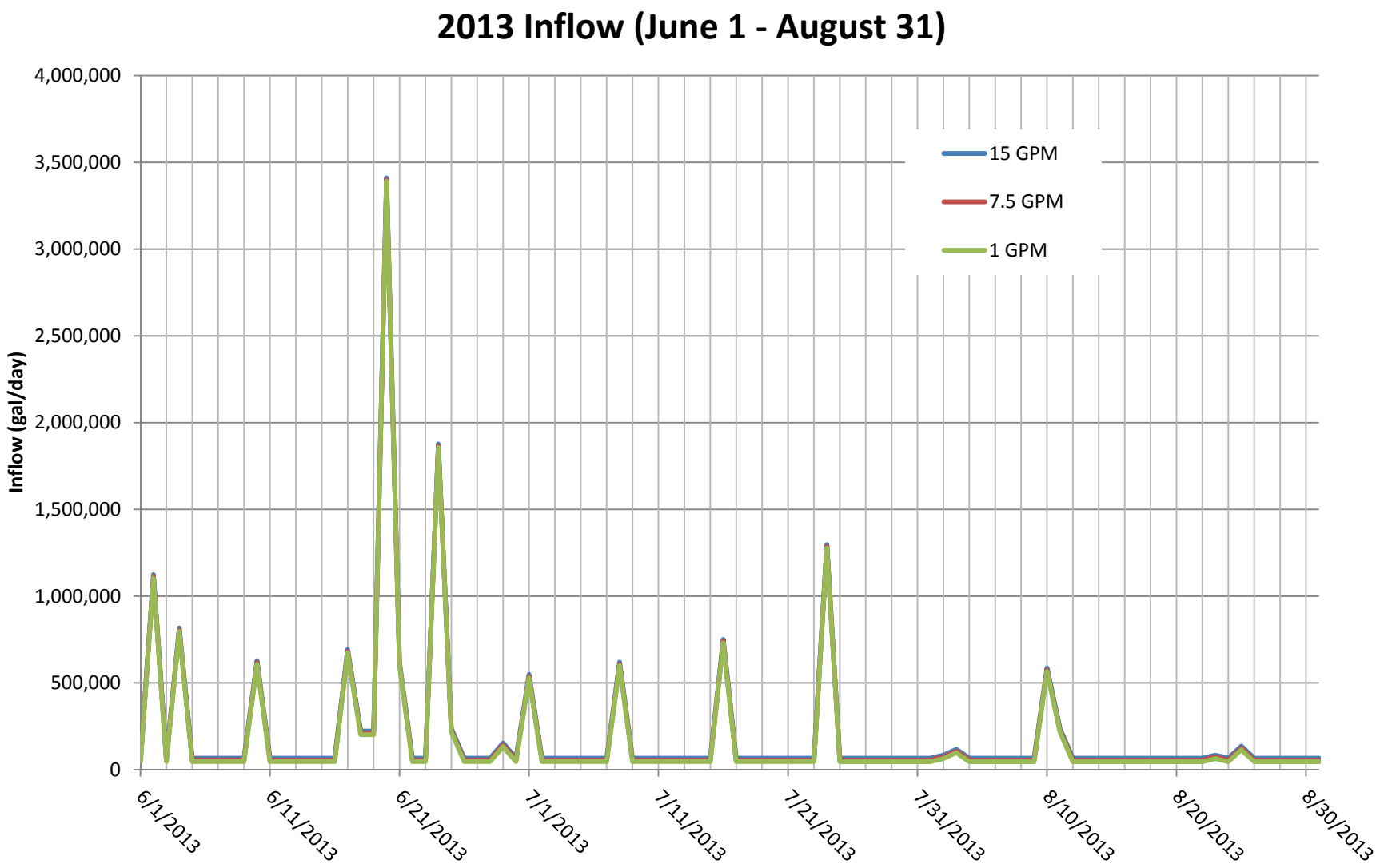

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MWH

DATE
July 2014

FIGURE 17

FILENAME
Supplement E-1-5_90% Design.pptx

Attachment E-2

South Pond Global Stability Analyses

ATTACHMENT E-2

MIDNITE MINE REMEDIAL DESIGN - SOUTH POND GLOBAL STABILITY ANALYSIS

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*07-Dec-12*	*30% Design*	*J.B. Varnier and S. McManus*	*Tom Kelley*	*07-Dec-12*	*Vance Drain*
1	*19-Nov-13*	*60% Design*	*J.B. Varnier and S. McManus*	*Melanie Davis*	*06-Dec-13*	*Tom Kelley*
2	*19-Jun-14*	*90% Design*	*J.B. Varnier and S. McManus*	*Melanie Davis*	*10-Jul-2014*	*Clint Strachan*
2	*14-May-15*	*100% Design – no changes*				

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E - Water Management Ponds\90% Submittal\Att E-2 South Pond Stability

The following calculations were generated using the following software:

Geo-Slope International, Ltd., 2012 (Slope/W)

AutoCAD Civil3D 2011 (Autodesk, 2010)

Supplements

Supplement E-2.1 - Midnite Mine Central Drainage Drill Logs Used for South Pond Slope Stability Analyses
Supplement E-2.2 – Midnite Mine Remedial Design South Pond Global Stability Analysis Supplement to Post-Earthquake Analyses

1.0 OBJECTIVE

The objective of these analyses was to evaluate the slope stability of the proposed South Pond on top of the South Waste Rock Pile (SWRP) at the Midnite Mine Superfund Site (the Site) for the 90% design. No specific performance standards for storage pond stability are defined in the scope of work (SOW) to the Remedial Design/Remedial Action (RD/RA) Consent Decree (CD; EPA, 2011) however, overall stability requirements are specified. In addition, the storage ponds will be designed in substantial compliance with Washington State dam safety criteria (Washington Department of Ecology, Dam Safety Section, 2005) to the extent these criteria are applicable to the South Pond.

2.0 BACKGROUND

The proposed South Pond will be a synthetically-lined water management pond constructed during RA construction at the Site. The South Pond will provide temporary storage for mine-impacted water during the RA. The pond will be constructed by excavating into waste rock in the SWRP and no additional fill will be placed in the South Pond area as part of the construction. This pond will be removed before completion of the RA. The proposed location for this pond is on top of the South Waste Rock Pile as depicted on Figures 1 and 5. The proposed grading for the South Pond has been slightly revised from the 60% to 90% design. The contours within the pond at the interior corners have been smoothed to eliminate sharp breaks. Figures 1 through 5 have been updated to reflect this revision. This revision does not impact the slope stability analysis; therefore the results presented in this attachment are consistent with the results presented in the 60% design (MWH, 2013).

The South Pond will meet the stability performance standards listed in the CD (EPA, 2011) and will be designed in substantial compliance with criteria from the Washington State Department of Ecology (WSDOE) Dam Safety Program. These WSDOE criteria will be applied to a synthetically-lined storage pond, with intermittent operation.

1) Regulations governing jurisdictional dams are provided at: http://www.ecy.wa.gov/programs/wr/dams/Regulations.html.
2) Engineering guidance for design and construction are outlined in guidance documents that are available for download at: http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs.html.

3.0 METHODS AND ASSUMPTIONS

3.1 METHODS

The geotechnical slope stability analysis was performed using the SLOPE/W computer software (Geo-Slope International, Ltd., 2012) to analyze slope stability sections (models) of the facility using limit-equilibrium methods. The stability sections of the facility were developed based on ground surface topography and subsurface stratigraphy in the vicinity of the South Waste Rock Pile, specifically in the Central Drainage. The methods of analysis for the computer models and how those models were developed are discussed in detail in the following subsections. This analysis resulted in factors of safety against shear failure for the deeper failure surfaces that could impact the South Pond. Shallow failure surfaces involving the outslope of the SWRP that would not involve loss of freeboard in the South Pond were not considered, as discussed below.

The calculated factors of safety from this analysis were compared to performance criteria set forth in the CD (EPA, 2011) as well as typical dam safety criteria. Although the safety factor criteria in the CD do not specifically apply to storage pond design, they were compared to the dam criteria and the more stringent of the two criteria were applied. In addition to the analyses specified in the CD, which consisted of analysis of static and pseudo-static earthquake conditions, analyses were performed of post-earthquake stability assuming cyclical softening and/or liquefaction will occur in saturated alluvial soils in the valley bottoms near the toe of the SWRP. The post-earthquake analyses are presented in Supplement E-2.2. Design criteria selected for the evaluation of the South Pond stability are summarized in Table 1.

Table 1. Design Criteria – Minimum Required Factors of Safety for Stability Analyses

Condition	Minimum Factor of Safety from Consent Decree	Minimum Factor of Safety based upon Dam Safety Guidelines	Minimum Factor of Safety Selected for Design
Static	1.3	1.5	1.5
Pseudo-static	1.0	1.0 to 1.1	1.1
Post-seismic Stability[a]	N/A	1.0 to 1.1	1.1

Notes: (a) Post-seismic analyses included as Supplement E-2.2

3.2 DEVELOPMENT OF THE STABILITY SECTIONS

Two sections were selected to represent the most critical conditions for the slope stability analysis (depicted on Figure 1). These sections are located such that they pass through the proposed South Pond where the waste rock fill is the highest and the foundation conditions are the least favorable for slope stability. The sections are oriented parallel to the existing fill slope of the South Waste Rock Pile and extend downslope of the toe of the fill. Per discussion at the Response to Comments on 30% Design Meeting in Salt Lake City, Utah on August 6th and 7th, 2013, analysis of an additional slope section (Section 3) has been included to satisfy EPA concerns regarding slope stability of the west-facing slope. Sections were developed using existing ground surface (Spatial Intel, 2010) and pre-mining ground surface (USBM, 1995) surveys in conjunction with the proposed South Pond grading surfaces. Information from subsurface investigations in the vicinity of the proposed South Pond and Central Drainage were used to develop the estimated subsurface stratigraphy. Drill logs from the subsurface investigations are attached to this calculation summary as Supplement E-2.1. The subsurface stratigraphy beneath the proposed South Pond footprint was modeled using information from boreholes drilled and logged in the vicinity of the pond. The following primary material designations are used in this effort:

1. Mine Waste
2. Colluvium
3. Bedrock

The definitions of these materials are as follows:

Mine Waste is the byproduct of mining activities at the site and is generally coarse-grained, free-draining material. According to the United Soil Classification System (USCS), it is generally classified as gravel or sand with clay and silt, and contains broken rock of cobble and boulder size.

Colluvium is used to describe transported soil of varying origins and characteristics. In this analysis it refers to all soils overlying the weathered and unweathered bedrock. The colluvium near the South Pond contains low-strength clays, clays consolidated due to mine waste overburden, and other depositional soils classified as silts or sands according to the USCS. Although there is evidence that soil stripping occurred in some portions of the SWRP footprint during mine development (Peters, 1999), which would have resulted in the removal of the colluvium layer in some areas, a review of historic aerial photographs indicates that soil stripping did not occur in the vicinity of the current toe.

Bedrock refers to weathered bedrock and unweathered bedrock, and residuum (highly weathered bedrock at the contact with the colluvium). The residuum is a soil-like product of in-place weathering of the underlying rock mass. This material has a lower void ratio than transported soils, exhibits very high blow counts during SPT testing, and typically exhibits highly dilatant behavior during shearing. This results in a material that has a shear strength similar to that of a very weak rock mass or heavily over-consolidated soil (i.e., a curved failure envelope with no cohesion, but a very high initial tangent friction angle) as opposed to a typical normally-consolidated soil.

Engineering properties and input parameters of these three materials are discussed below in the Material Properties section.

To develop the subsurface stratigraphy for the stability sections, a corridor of interest 250 feet wide, 2,000 feet long, and containing stability sections 1 and 2 was identified and visually assessed to delineate the native terrain into three categories: Ridges, Drainage Valley Bottoms, and Drainage Valley Walls (see Figure 2). An additional corridor of interest approximately 70 feet wide, 1,700 feet long, and enveloping stability section 3 was also developed. Each stability section then was divided into segments corresponding to one of the three terrain types and the depth to bedrock for each segment was estimated using information from nearby boreholes located in the same terrain type. The terrain type associated with each borehole is presented in Table 2. Table 3 presents the percentage of the corridor of interest's area corresponding to each terrain type.

For each terrain type, an estimate of the proportion of clay (low-strength clay and consolidated clay) in the colluvium was made. This estimate was based on materials encountered during subsurface investigations and is expressed as a percentage of the total colluvium in Table 3.

The stability sections developed for use in this analysis are presented in Figures 3 and 4.

Table 2. Terrain Type Associated with Boreholes

Borehole ID	Drainage Valley Bottom, Wall, or Ridge	Borehole ID	Drainage Valley Bottom, Wall, or Ridge
PBC-01	Bottom	B-07	Wall
PBC-02	Bottom	B-08	Ridge
PBC-03	Bottom	MWCD-01	Bottom
CD-B1	Ridge	MWCD-02a	Bottom
CD-B2	Bottom	MWCD-02b	Bottom
CD-B3	Wall	THSS-01	Ridge
CD-B4	Wall	THSS-02	Ridge
B-04	Wall	GW-42	Bottom
B-05	Bottom	GW-51	Bottom
B-06	Wall		

Table 3. Colluvium Characteristics

	Percentage of Area of Interest	Avg. Colluvium Thickness (ft)	Avg. Thickness of Clay (Consolidated and Low-Strength) (ft)	Percentage of Low-Strength Clay
Drainage Valley Bottom	23%	18.3	11.4	62%
Drainage Valley Wall	51%	4.2	2.5	58%
Ridge	26%	0.8	0.2	27%

3.3 GROUNDWATER CONDITIONS

The stability analyses for the South Pond assume that groundwater levels are at the waste rock/native soil contact, or at the ground surface in the toe area where waste rock does not overlie the ground surface. This assumption is considered conservative, especially since shallow (alluvial) groundwater typically only occurs in the very narrow bands (in plan view) in the bottoms of the buried alluvial channels under the waste rock.

Beyond using this assumption regarding the extent of groundwater at the native soil contact, no explicit accounting for pond leakage has been included in the South Pond Stability analyses. It should be kept in mind that the South Pond is designed as a double-lined pond with a leak detection layer between the two liners to detect leakage through the primary liner if it should occur. Since downgradient collection and control of impacted water is provided by the existing PCP at the toe of the SWRP, the primary purpose for the leak detection monitoring is provide an indication if leakage is occurring, and to provide a means to measure the rate of leakage. A low-height divider berm is included in the design of the South Pond so that if excessive leakage does develop, repairs can be made to the liner system while allowing for pond operation (at a restricted water level).

Given that the South Pond is underlain by high-permeability waste rock, it is highly unlikely that leakage from the double-lined impoundment would occur at a rate that would significantly elevate the groundwater levels at the waste rock/native soil contact, Any leakage that does occur would be concentrated within the narrow band in the bottoms of the two buried alluvial

channels and express themselves as increased flow in the Submerged Seep and the Pumphouse Seep.

3.4 SLOPE STABILITY MODELING

Slope stability analyses were performed using two-dimensional limit equilibrium methods with the aid of the program SLOPE/W (GEO-SLOPE, 2012). The Morgenstern-Price method (Morgenstern and Price, 1965) with a half-sine function for inter-slice forces was used for the analysis. This method evaluates both circular and non-circular slip surfaces, and satisfies both force and moment equilibrium in the factor of safety calculation (GEO-SLOPE, 2012).

The analyses were performed by calculating the factors of safety along circular and block specified wedge failure surfaces. The failure surfaces analyzed by the model were restricted to only those deeper failure surfaces which could potentially affect the South Pond. This was achieved by excluding from the analysis any failure surface daylighting on the uphill end at a distance farther than 10-20 feet from the South Pond crest.

The global slope stability analyses under seismic loading conditions were conducted using a pseudo-static approach, where a constant horizontal acceleration is applied to the numerical models. This horizontal acceleration simulates an inertial force due to a seismic event. The peak ground acceleration (PGA) for a probability of exceedance of 10 percent in 250 years at the Site for site Class B (rock) is 0.131g (MGC, 2010), where g is the acceleration of gravity. The PGA at the Site was adjusted to site Class C (very dense soil and soft rock) to represent waste rock for the slope stability analyses. The recommendations presented in USGS (2013) were used to calculate the adjusted PGA. The Class C PGA at the Site is 0.157g. The strategy of representing the seismic coefficient as a function of the PGA has been adopted in review of uranium facility design and documented by the U.S. Department of Energy (DOE, 1989). DOE (1989) recommends the use of a horizontal seismic coefficient of $^{2}/_{3g}$ of the PGA for pseudo-static stability analyses for post-reclamation conditions. The U.S. Nuclear Regulatory Commission (NRC, 2003) recommends the seismic coefficient be either 67 percent of the PGA or 0.1, whichever is greater. The horizontal seismic coefficient used for the pseudo-static stability analyses is 0.105.

Analyses presented in Attachment E-3 indicate that some of the colluvium may be susceptible to a shear strength reduction as a result of dynamic loading. Therefore, under post-earthquake conditions these materials may exhibit reduced shear strength. The reduction to shear strength under post-earthquake conditions is discussed in detail in Supplement E-2.2.

3.5 ASSUMPTIONS

Assumptions regarding interpretation of drilling logs are summarized in the following paragraphs, grouped by investigation. Borehole locations and general notes regarding interpretation of the drilling logs are presented on Figure 5. The following material classifications were used to interpret the drilling logs of the following investigations of the Site. These data were reclassified and combined into the three primary material designations identified below and described above:

1. Waste Rock (in logs) = Mine Waste (in this evaluation)
2. Low-Strength Clay =Colluvium
3. Consolidated Clay = Colluvium

4. Other Colluvium = Colluvium
5. Residuum/Weathered Bedrock = Bedrock
6. Competent Bedrock = Bedrock

3.6 INVESTIGATIONS AND BORINGS USED FOR DEVELOPMENT OF STRATIGRAPHY

Investigations used to develop the stratigraphy for slope stability modeling are listed chronologically in the following sections.

Hydrogeology of the Midnite Mine: Borings BOM-3 and BOM-4 (Riley, et al, 1991)
The drilling logs associated with these borings were not presented in a way that allowed detailed interpretation of the materials encountered during drilling. However, it was evident from the logs that mud and clay were encountered when BOM-89-4 was drilled. There was no mention of mud or clay in the drilling log for BOM-89-3; therefore it was assumed that the foundation material in this area does not include significant amounts of these materials.

Monitoring Well Installation: Borings GW-42, GW-43, GW-51 (SMI, 1999)
Materials described as “abundant clay/fines” and located under 75 feet of waste rock (or more) were assumed to be Consolidated Clays. Materials described as “porphyritic quartz-monzonite” or containing “coarse lag phyllite-schist, calc-silicate” were assumed to be Residuum. Materials described as predominately sandy with gravel, silt, and clay were assumed to be Other Colluvium. Materials described as “very competent” or lacking iron staining on the drill cuttings were assumed to be Bedrock.

Phase 1A RI/FS: Borings MWCD-01, MWCD-02a, and MWCD-03 (URS, 2005)
These holes were drilled using air rotary methods and samples were collected using a cyclone. No SPT, or other quantitative measurement of material density/consistency/strength, were performed. Lacking these estimates, it was conservatively assumed that all materials described as CL on the drill logs are Low-Strength Clays. Materials composed primarily of sand (SM, SC) were assumed to be Other Colluvium, as were non-plastic fine-grained materials (ML). Due to the finer-grained nature of the colluvium at this site, it is likely that materials with sand and gravel contents greater than 50 percent are products of the bedrock weathering process and were assumed to be Residuum (GM). Contact with the Bedrock was assumed to occur where indicated on the drill logs (either as “bedrock” or “quartz monzonite”).

Phase 2A/1B RI/FS: Borings THSS-01 and THSS-02 (URS, 2005)
In THSS-01, the material immediately under the waste was described as “clayey bedrock,” “weathered bedrock,” and “gravelly sandy clay.” Seven feet of this material was found clogged in the drilling barrel. This material was assumed to be Residuum. No Low-Strength Clay, Consolidated Clay, or Other Colluvium was identified in this borehole. No Bedrock contact was identified.

In THSS-02, a split spoon sample obtained at the base of the waste rock collected “stiff clay” above “decomposed rock.” The stiff clay was assumed to be Consolidated Clay and the decomposed rock was assumed to be Residuum. No Bedrock contact was identified.

Interim Mechanisms: Borings PBC-01 through PBC-03 (Tetra Tech, 2010)
Clay or silt materials with trace, or less, amounts of sand and gravel were assumed to be low-strength clays. Materials with more than trace amounts of sand and/or gravel were as assumed to be Other Colluvium, unless the material was described as “soft” in the drilling log, in which

case it was conservatively assumed to be Low-Strength Clay. Materials described as “low plasticity” were assumed to be Other Colluvium. Due to the finer-grained nature of the colluvium in this area of the Site, it is likely that materials described as “gravel/sand/clay” are products of the bedrock weathering process and were therefore assumed to be Residuum. Auger refusal (where noted in the drill logs) was assumed to correspond with very hard Bedrock (unrippable).

Interim Mechanisms: Boring MWCD-02b (Tetra Tech, 2010)
Material with medium or high plasticity and trace or no sand/gravel was assumed to be Low-Strength Clay. Materials with more than trace amounts of sand and/or gravel and low plasticity were assumed to be Other Colluvium. Due to the finer-grained nature of the colluvium at this site, it is likely that the gravelly materials identified in this borehole are products of the bedrock weathering process and were assumed to be Residuum. Material identified as “bedrock” but exhibiting a blow count significantly lower than 50 (N=29) was assumed to be Residuum. Bedrock was not encountered in this borehole.

Mine Waste Investigations: Borings B-04 Through B-08 (MGC, 2011)
Native materials are located under waste rock overburden. As such, all clay materials have been consolidated and do not exhibit the low SPT blow counts that are characteristic of the Low-Strength Clays located downstream of the waste rock pile. Due to the relatively fine-grained nature of the colluvium at this site, it is likely that materials with sand and gravel contents greater than 50 percent are products of the bedrock weathering process and were assumed to be Residuum. Descriptions of material consistency presented on the drill logs were not consistent with the SPT blow counts and were disregarded in favor of consistency correlations based on the SPT blow counts (Terzaghi and Peck, 1948).

Storage Ponds Investigation: Borings CD-B1 Through CD-B4 (MWH, 2012)
Clays with soft and very soft consistencies were assumed to be Low-Strength Clays. Consistencies were determined based on Standard Penetration Test (SPT) blow counts and the correlations presented in Sowers (1979). Also, material visually identified as “clayey sands” were conservatively assumed to be sandy clays and assumed to be Low-Strength Clays if the blow counts correlated to a soft or very soft consistency. If the SPT blow counts exceeded 5 blows for 12 inches of sampler progression, then the material consistency was firmer than “soft” or “very soft” and the material assumed to be Other Colluvium. Materials which had SPT blow counts greater than 50 were assumed to be Residuum. Auger refusal (where noted in the drill logs) was assumed to correspond with very hard Bedrock (unrippable).

4.0 MATERIAL PROPERTY ASSUMPTIONS IN MODEL

The stability sections were developed using the three primary material types: mine waste, colluvium, and bedrock. The material properties for each material are discussed below and summarized in Table 4.

4.1 MINE WASTE

The density and effective strength parameters of the mine waste used in the analyses were based on subsurface information provided in URS (2001) and material parameters used for stability analyses presented in URS (2002). Effective strength parameters were used to represent the mine strengths due to the relatively coarse, free-draining nature of the mine waste.

4.2 COLLUVIUM

The Colluvium is transported soil containing varying amounts of clay, silt, and sand the term as used in this calculation brief is inclusive of colluvial sediments in the valley bottom. The density of the colluvium was calculated from the measured in-place dry density and the natural water content for a sample representative of the colluvium in the area, sample CD-B4 at 6 to 7.5 feet, presented MWH (2012).

Under static conditions the Colluvium has no excess pore pressure and was therefore modeled using effective shear strength parameters. The effective friction angle used for the colluvium was estimated based on the average measured plasticity index (PI) of colluvium samples located above weathered bedrock or bedrock from MWH (2012) and using the relationship between PI and the effective angle of internal friction angle presented in Duncan and Wright (2005). The effective cohesion value was assumed to be zero. This estimated effective friction angle is very similar to that obtained from triaxial testing performed as part of the previous storage pond investigation (MWH, 2012). A consolidated-undrained triaxial test, with pore pressure measurements was performed on specimens of low-strength colluvium (colluvial clay) from Test Pit CDTP2 (7 to 14 foot depth), located adjacent to CD-B2. Although the triaxial tests were run on remoulded specimens compacted to 98 percent of the standard Proctor maximum dry density at 1 percent above the optimum moisture content, the post-peak results at large strain (15 percent) for the specimen tested at the highest effective consolidation pressure (8,640 psf) can reasonably be expected to represent the normally-consolidated, constant-volume shear strength of the low-strength colluvium. Analysis of the result from this test specimen indicates a constant-volume effective stress friction angle slightly higher (32.4 degrees) than the estimated value of 30.8 degrees. The lower estimated value of 30.8 degrees was used as a conservative estimate of effective stress friction angle. Under earthquake (pseudo-static), the colluvium shear strength was modeled using the total shear strength parameters to account for rapid loading conditions during the design seismic event. Undrained shear strengths recommended in Attachment E-3 were used in the analysis for colluvium. The undrained shear strengths are based upon the interpretations of piezocone (CPT) investigations along the toe of the SWRP and summarized in Attachment E-3 in the alluvial clays. The undrained shear strengths based upon estimated c/p' ratios recommended in Attachment E-3 are used for pseudo-static conditions. The normally-consolidated c/p' ratio are used, in conjunction with the SHANSEP parameters recommended in Attachment E-3, to calculate the shear strengths at various waste rock burial depths in the model.

It should be noted that the recommended normally-consolidated c/p' ratio (0.4) presented in Attachment E-3 is somewhat lower (i.e., more conservative) than indicated by the undrained triaxial test from material from CDTP2 discussed in the previous paragraph. Back calculation of the c/p' ratio from the large strain (15 percent) undrained shear strength of the highest stress specimen suggests a c/p' ratio of 0.47. This may be the result of the apparent overestimation of overconsolidation ratios in the CPT interpretation, as discussed in Attachment E-3. Regardless, the use of the normally consolidated c/p' ratio and SHANSEP parameters from the CPT interpretations, which were run on alluvial clays in the valley bottoms to represent all of the colluvium in the SWRP foundation, is considered very conservative.

The 30', 65', and 120' waste rock fill cases indicate that 30', 65' and 120' of waste rock fill is located above the colluvium at various locations in the stability section. The pond case indicates that the colluvium is located below the south pond. The numerical model was discretized based on these five cases: (e.g., the 30' field dam was assigned when between 15' and 47.5' of waste rock is located above the colluvium) and the undrained shear strength

estimated based upon calculated overconsolidation ratios using the free-field (no fill) case as for the initial stress state.

As shown in Table 4, the estimated c/p' ratio decreases with increasing waste rock overburden, and approaches the estimated normally-consolidated c/p' ratio once the colluvium is overlain by 120 feet of waste rock.

Analyses were also performed under post-earthquake conditions. These additional analyses are presented in Supplement E-2.2.

4.3 BEDROCK

The bedrock was modeled as an impenetrable surface and it is anticipated that the critical slip surfaces will not intercept this stronger material underlying a much weaker colluvium, but rather slide along the weaker colluvium at the bedrock contact.

Table 4. Material Properties Used in Stability Analysis

Material Type	Total Density (pcf)	Effective Friction Angle, ϕ' (deg)	Effective Cohesion, c' (psf)	Undrained shear strength ratio, s_u/σ_v'
Mine Waste	135	38.0	0	-
Colluvium	122	30.8[(a)]	0[(a)]	2.10 [(b)] (Free Field) 0.56 [(b)] (30' Dam Fill) 0.46 [(b)] (65' Dam Fill) 0.41 [(b)] (120' Dam Fill) 0.50 [(b)] (Pond)
Bedrock	Impenetrable			-

Notes: (a) Static conditions
(b) Pseudo-static conditions

5.0 RESULTS

The factors of safety against slope stability failure that were calculated in this analysis are provided in Table 5 and in Figures 6 to 20. The required minimum factors of safety are 1.5 under static conditions and 1.1 under pseudo-static conditions as discussed in Section 2.1.

The factors of safety under static and pseudo-static conditions for all cases exceed the minimum required factors of safety. The results of post-earthquake analyses are provided in Supplement E-2.2.

Table 5. Factors of Safety for Against Deep-Seated Slope Failures

Failure Surface	Factor of Safety (FOS)			
	Static 1.5 Minimum FOS		**Pseudo-Static** 1.1 Minimum FOS	
	Circular	Wedge	Circular	Wedge
Cross-Section 1	1.6	1.8	1.1	1.1
Cross-Section 2	1.5	1.8	1.2	1.4
Cross-Section 3	2.0	2.3	1.5	1.6

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Slope Stability Figures

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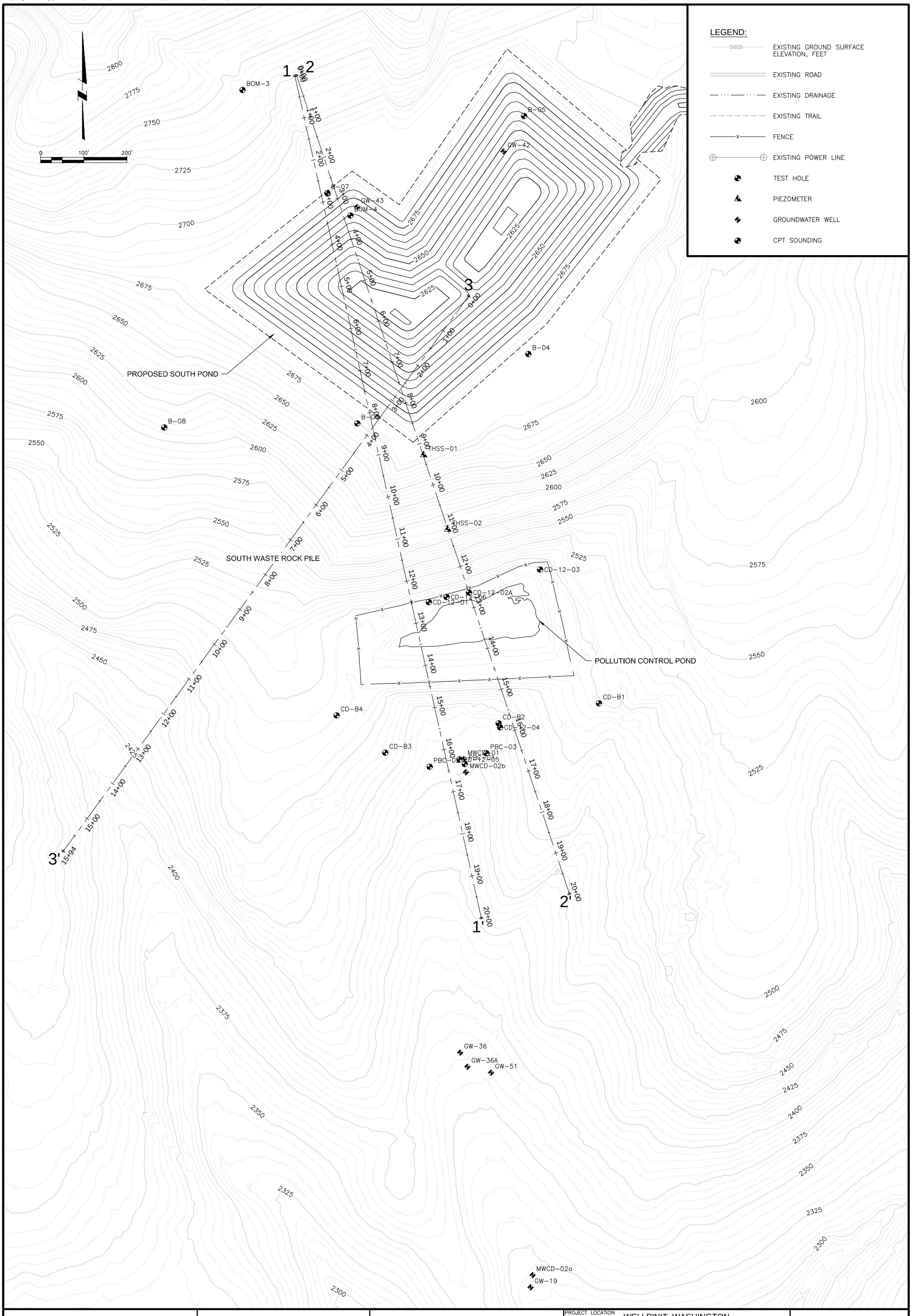

DRAWING REFERENCE(S):

- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.
- PREMINE TOPOGRAPHY AND PIT EXCAVATION TOPOGRAPHY BASED UPON INFORMATION PROVIDED BY U.S. BUREAU OF MINES (USBM), JULY, 1995. ORIGINAL COORDINATE SYSTEM USED IN USBM MAPPING (NAD27/NGVD29) HAS BEEN CONVERTED TO NAD83/NAVD88 BASED COORDINATES.
- TOPOGRAPHY PRESENTED HEREIN IS BASED ON THE PROPOSED CONDITIONS AT THE END OF PHASE 2 OF THE REMEDIAL ACTION.

0 100' 200'

CONTOUR INTERVAL = 5 FT

NEWMONT

PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 1 - SOUTH POND STABILITY SECTION LOCATIONS
FIGURE	1
REVISION	2
FILE NAME	F1_SECTIONS
DATE	JUNE 2014

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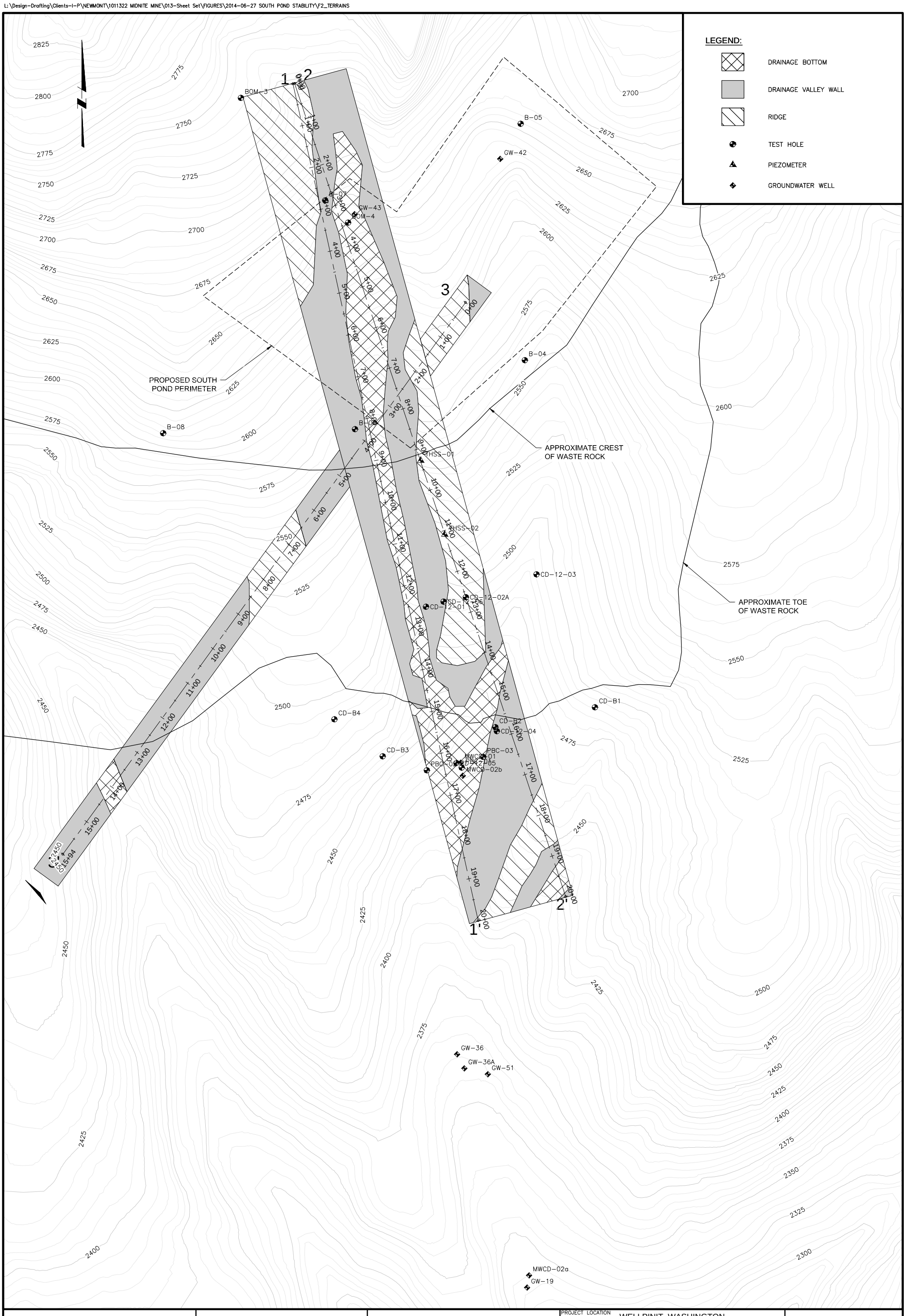

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- TOPOGRAPHY PRESENTED HEREIN IS BASED ON THE PROPOSED CONDITIONS AT THE END OF PHASE 2 OF THE REMEDIAL ACTION.

0 100' 200'

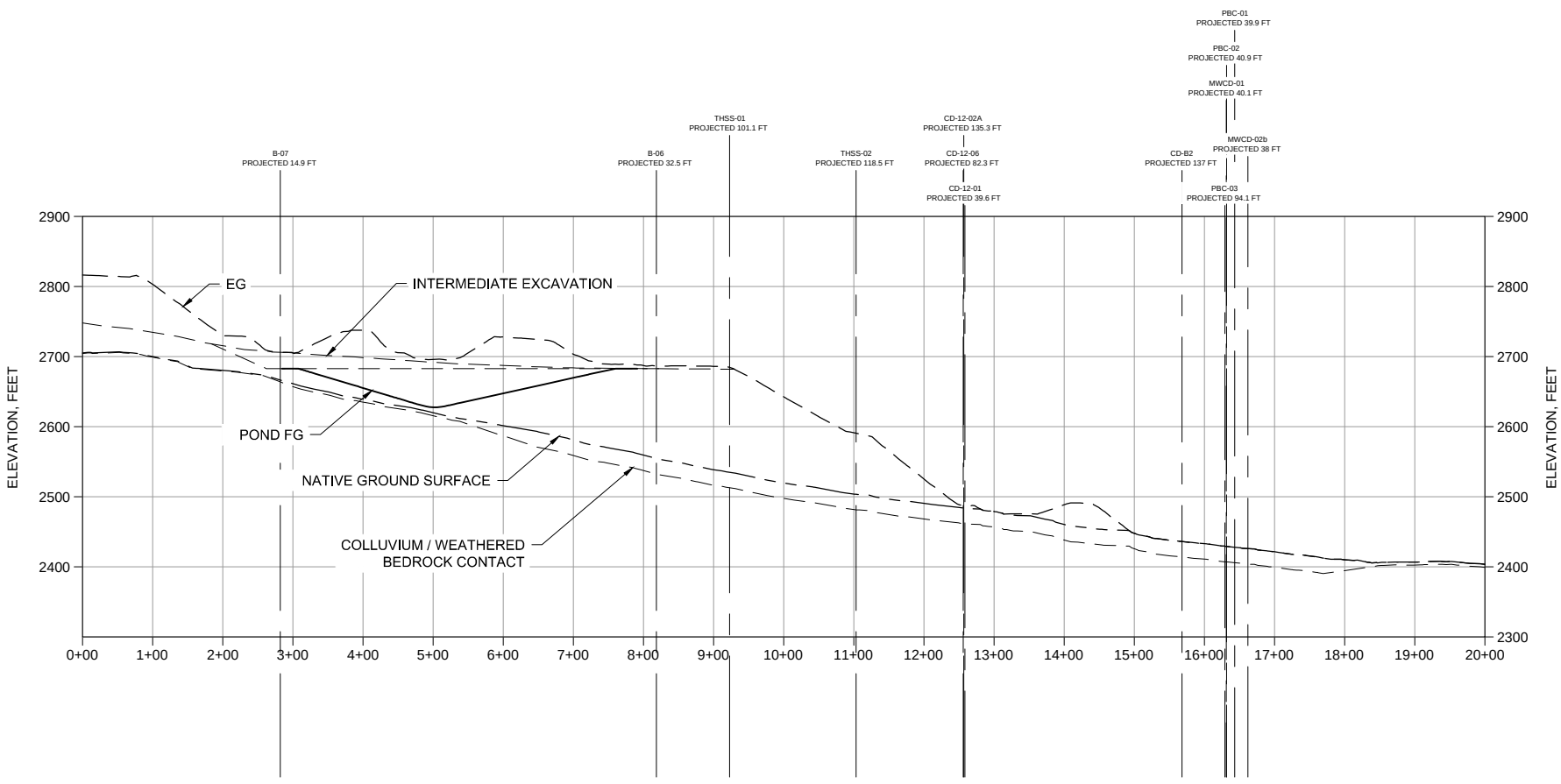
CONTOUR INTERVAL = 5 FT

NEWMONT

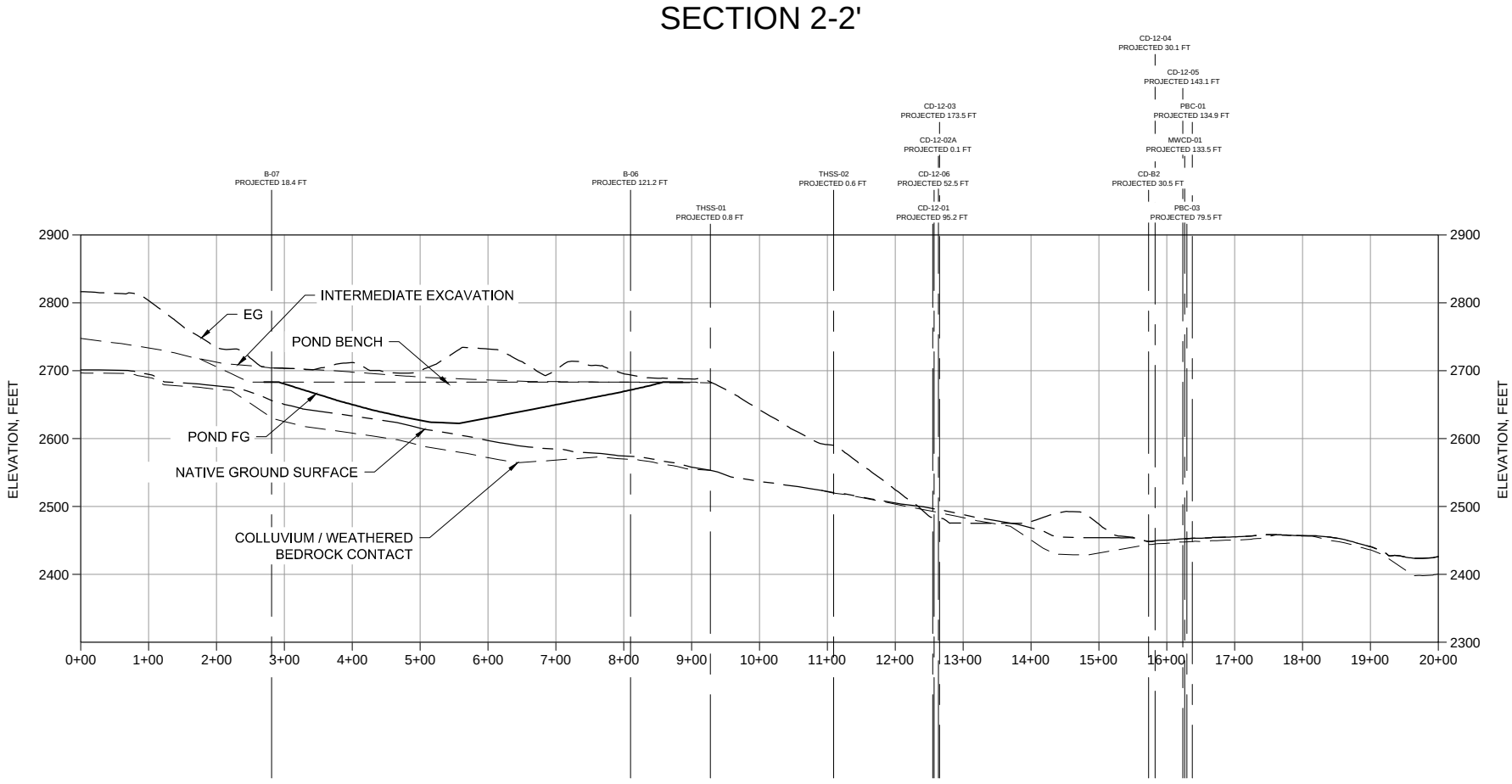
PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 2 - SOUTH POND STRATIGRAPHY TERRAIN TYPES
FIGURE	2
REVISION	2
FILE NAME	F2_TERRAINS
DATE	JUNE 2014

MWH

SECTION 1-1'



SECTION 2-2'



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- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.
- PREMINE TOPOGRAPHY AND PIT EXCAVATION TOPOGRAPHY BASED UPON INFORMATION PROVIDED BY U.S. BUREAU OF MINES (USBM), JULY, 1995. ORIGINAL COORDINATE SYSTEM USED IN USBM MAPPING (NAD27/NGVD29) HAS BEEN CONVERTED TO NAD83/NAVD88 BASED COORDINATES.
- TOPOGRAPHY PRESENTED HEREIN IS BASED ON THE PROPOSED CONDITIONS AT THE END OF PHASE 2 OF THE REMEDIAL ACTION.

0 120' 240'

NEWMONT

PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 3 - SOUTH POND STABILITY SECTIONS (1 OF 2)
FIGURE	3
REVISION	2
FILE NAME	F3_SECTIONS
DATE	JUNE 2014

MWH

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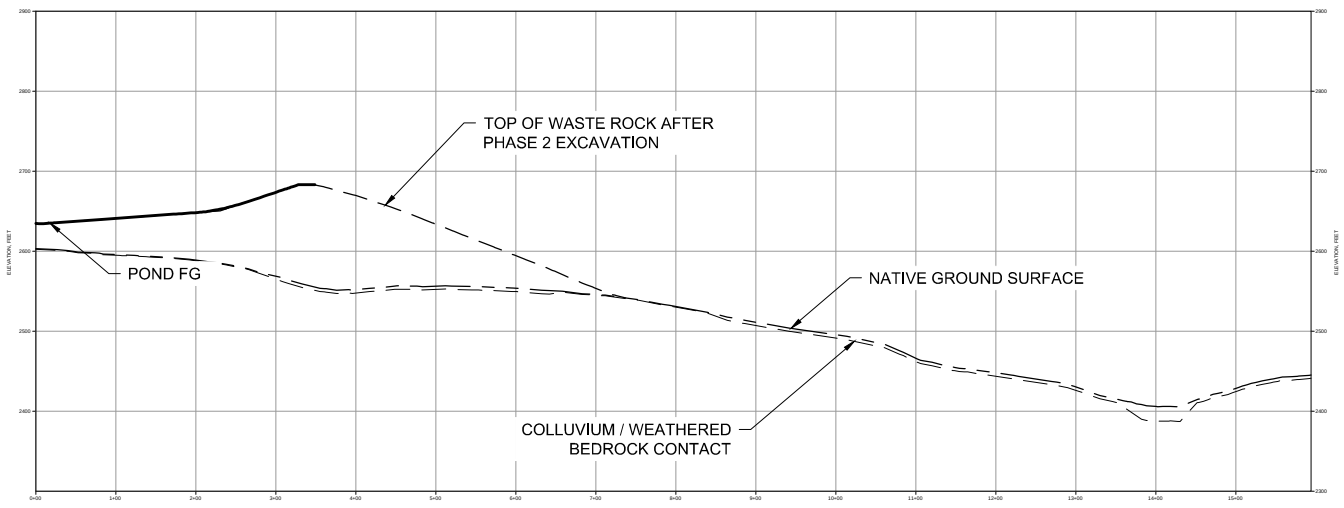
SECTION 3-3'



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- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.
- PREMINE TOPOGRAPHY AND PIT EXCAVATION TOPOGRAPHY BASED UPON INFORMATION PROVIDED BY U.S. BUREAU OF MINES (USBM), JULY, 1995. ORIGINAL COORDINATE SYSTEM USED IN USBM MAPPING (NAD27/NGVD29) HAS BEEN CONVERTED TO NAD83/NAVD88 BASED COORDINATES.
- TOPOGRAPHY PRESENTED HEREIN IS BASED ON THE PROPOSED CONDITIONS AT THE END OF PHASE 2 OF THE REMEDIAL ACTION.

0 120' 240'

NEWMONT

PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 4 - SOUTH POND STABILITY SECTIONS (2 OF 2)
FIGURE	4
REVISION	2
FILE NAME	F3_SECTIONS
DATE	JUNE 2014

MWH

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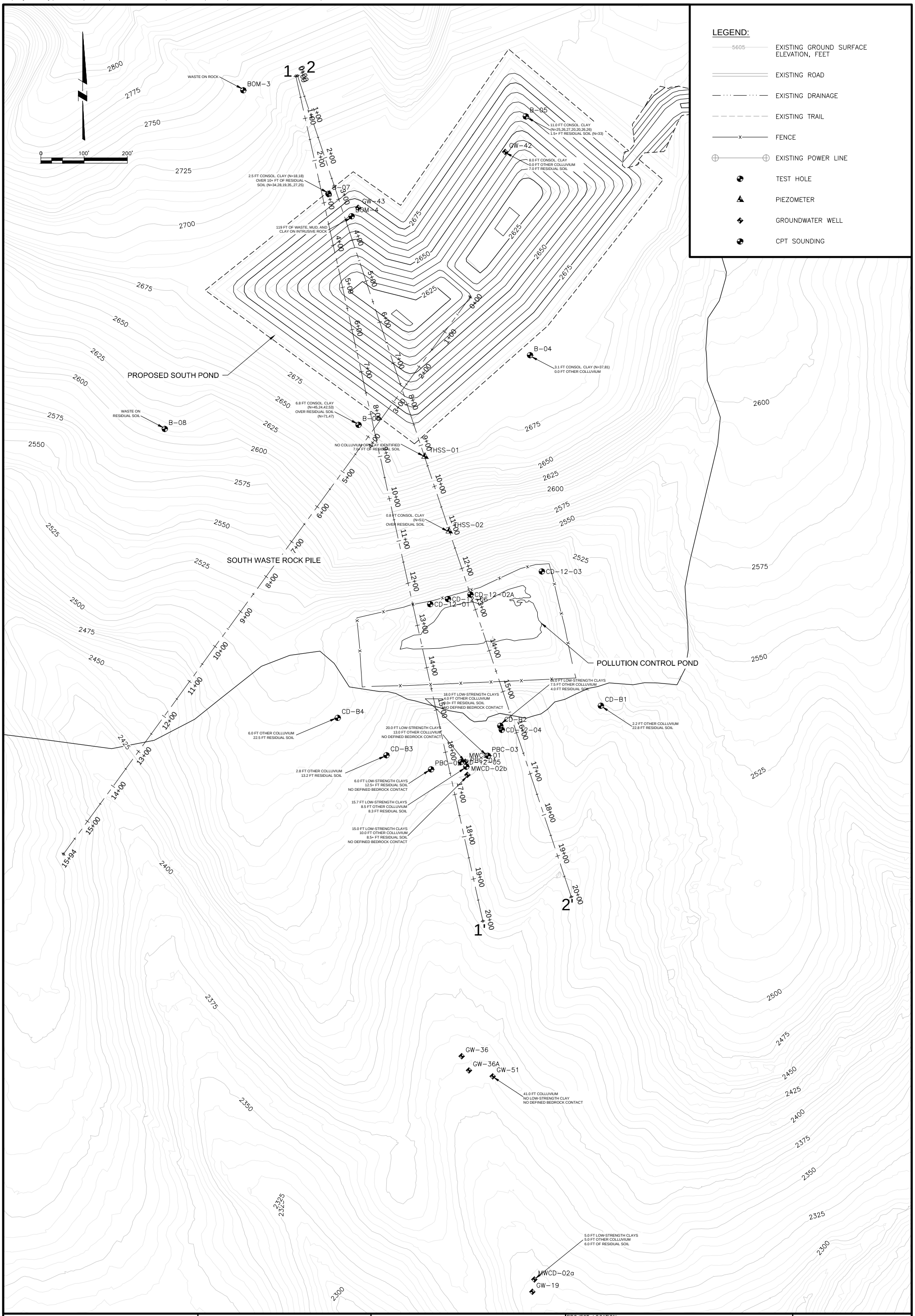

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- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.
- PREMINE TOPOGRAPHY AND PIT EXCAVATION TOPOGRAPHY BASED UPON INFORMATION PROVIDED BY U.S. BUREAU OF MINES (USBM), JULY, 1995. ORIGINAL COORDINATE SYSTEM USED IN USBM MAPPING (NAD27/NGVD29) HAS BEEN CONVERTED TO NAD83/NAVD88 BASED COORDINATES.
- TOPOGRAPHY PRESENTED HEREIN IS BASED ON THE PROPOSED CONDITIONS AT THE END OF PHASE 2 OF THE REMEDIAL ACTION.

0 100' 200'

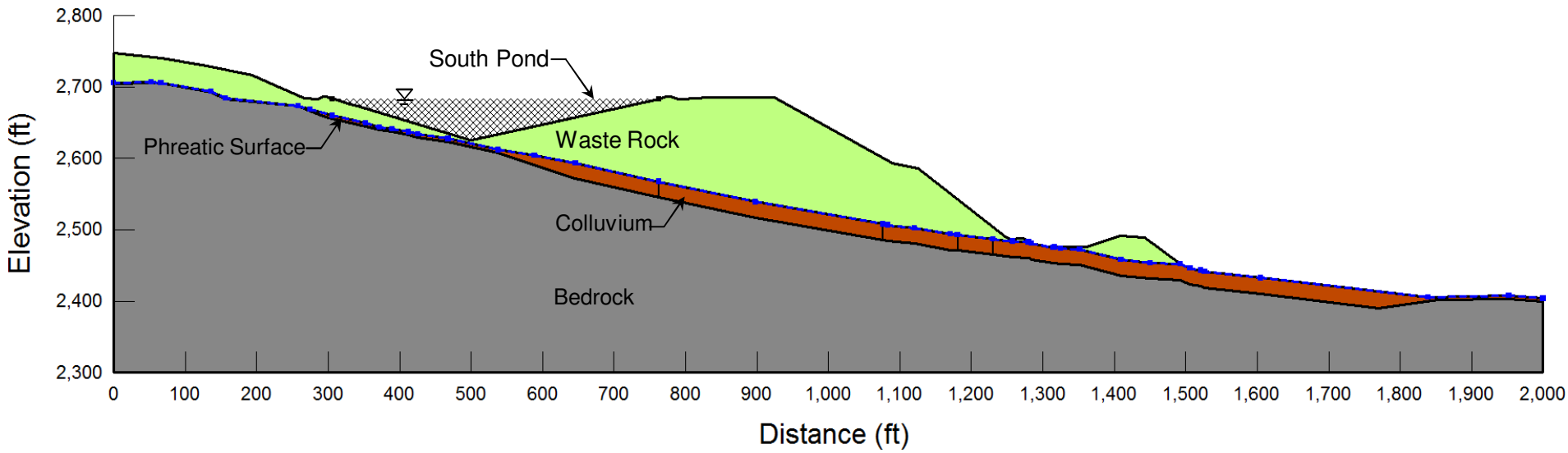
CONTOUR INTERVAL = 5 FT

NEWMONT

PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 5 - BOREHOLE NOTES FOR SOUTH POND STRATIGRAPHY
FIGURE	5
REVISION	2
FILE NAME	F5_BOREHOLES
DATE	JUNE 2014

MWH

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Geometry



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis - Geometry
South Pond - Cross-Section 1

MWH

DATE
NOV 2013

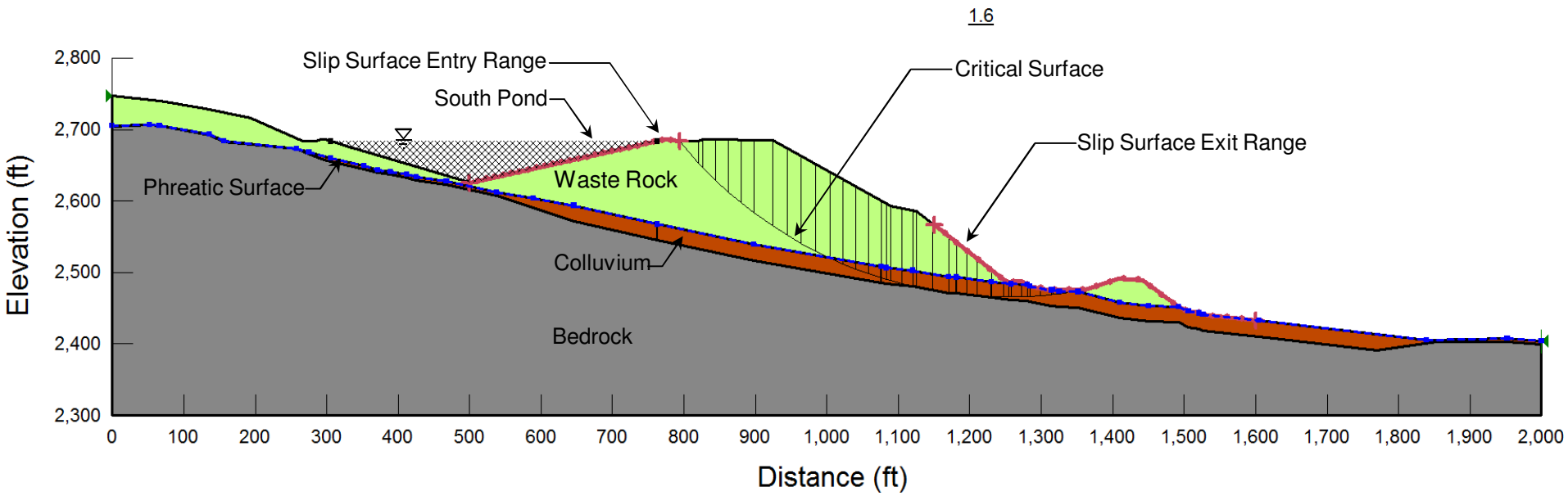
FIGURE 6

FILENAME
South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Static Conditions
Circular Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Waste Rock	135	38.0	0
Colluvium	122	30.8	0
Bedrock	Impenetrable		



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Static Conditions
South Pond - Cross-Section 1
Circular Failure Surface

MWH

DATE: NOV 2013

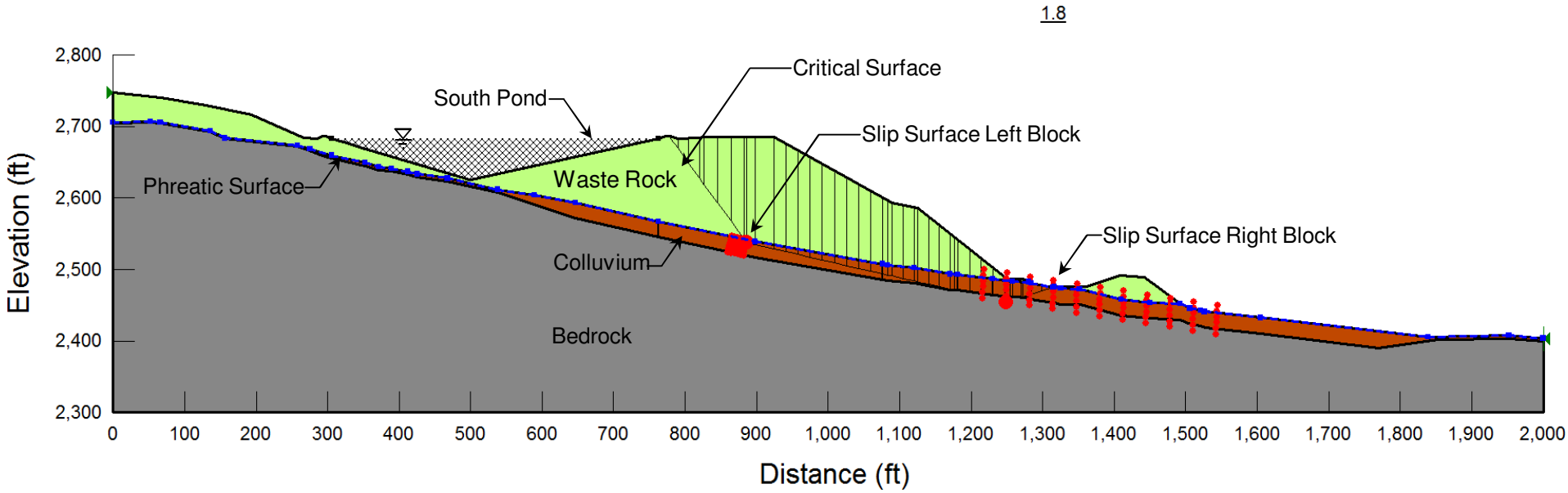
FIGURE 7

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Static Conditions
Block Specified Wedge Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Waste Rock	135	38.0	0
Colluvium	122	30.8	0
Bedrock	Impenetrable		



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Static Conditions
South Pond - Cross-Section 1
Block Specified Wedge Failure Surface

MWH

DATE: NOV 2013

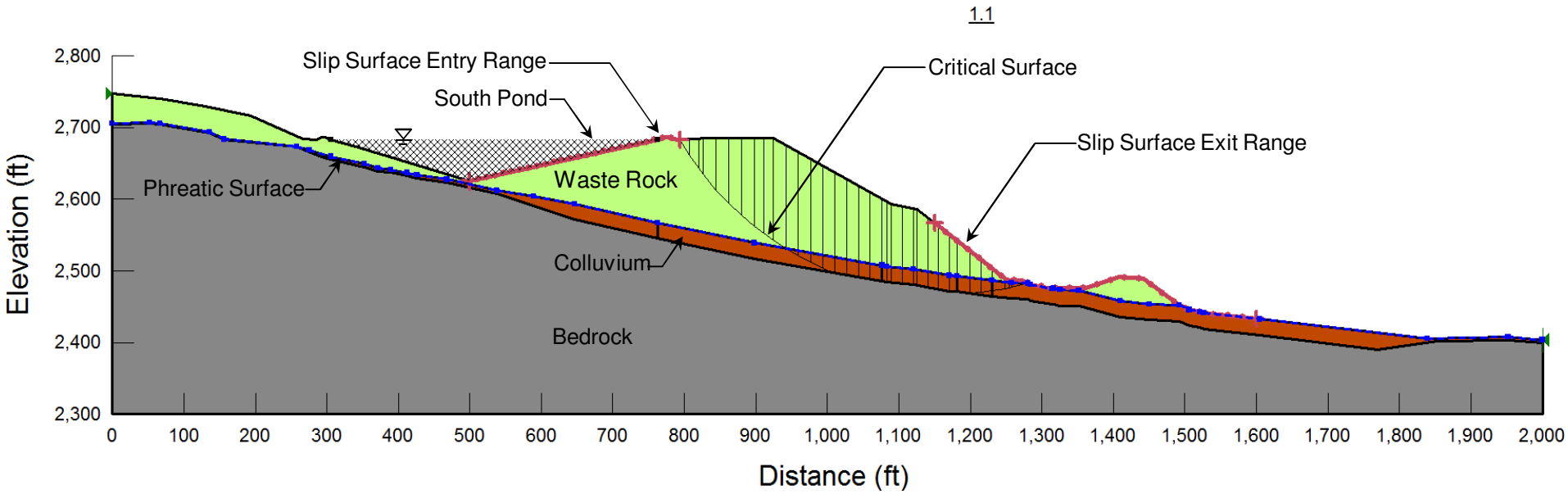
FIGURE 8

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Pseudo-Static Conditions (K_h=0.105)
Circular Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	2.10 (Free Field) 0.56 (30' Dam Fill) 0.46 (65' Dam Fill) 0.41 (120' Dam Fill) 0.50 (Pond)
Bedrock	Impenetrable			-



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Pseudo-Static Conditions
South Pond - Cross-Section 1
Circular Failure Surface

MWH

DATE: NOV 2013

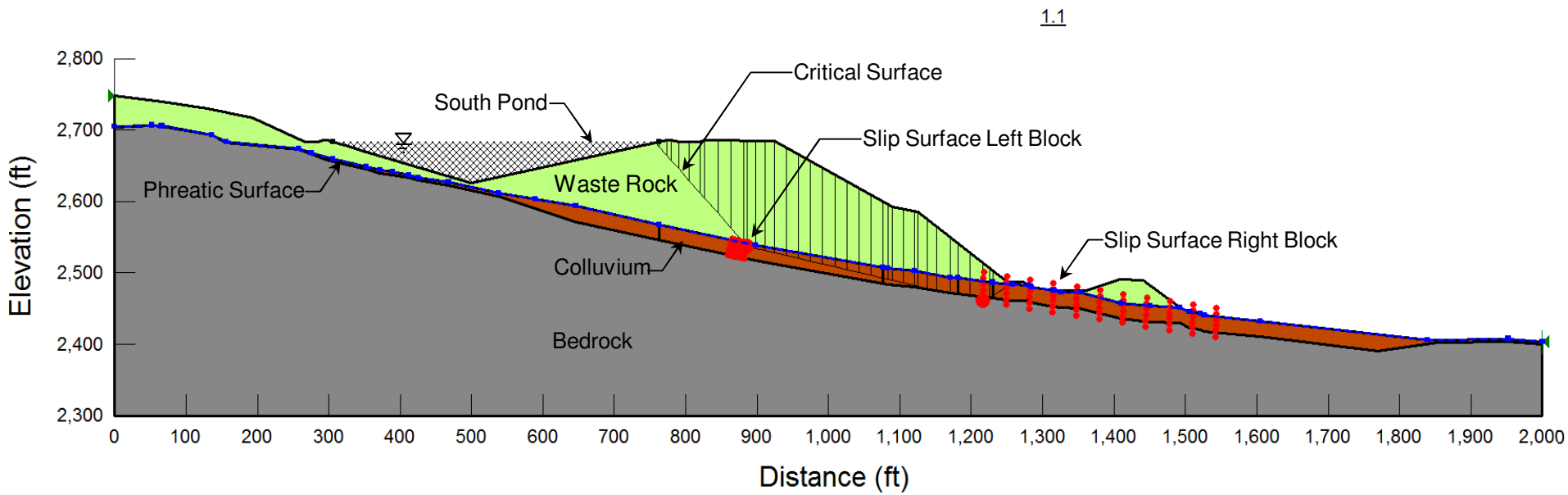
FIGURE 9

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Pseudo-Static Conditions (K_h=0.105)
Block Specified Wedge Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	2.10 (Free Field) 0.56 (30' Dam Fill) 0.46 (65' Dam Fill) 0.41 (120' Dam Fill) 0.50 (Pond)
Bedrock	Impenetrable			-



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Pseudo-Static Conditions
South Pond - Cross-Section 1
Block Specified Wedge Failure Surface

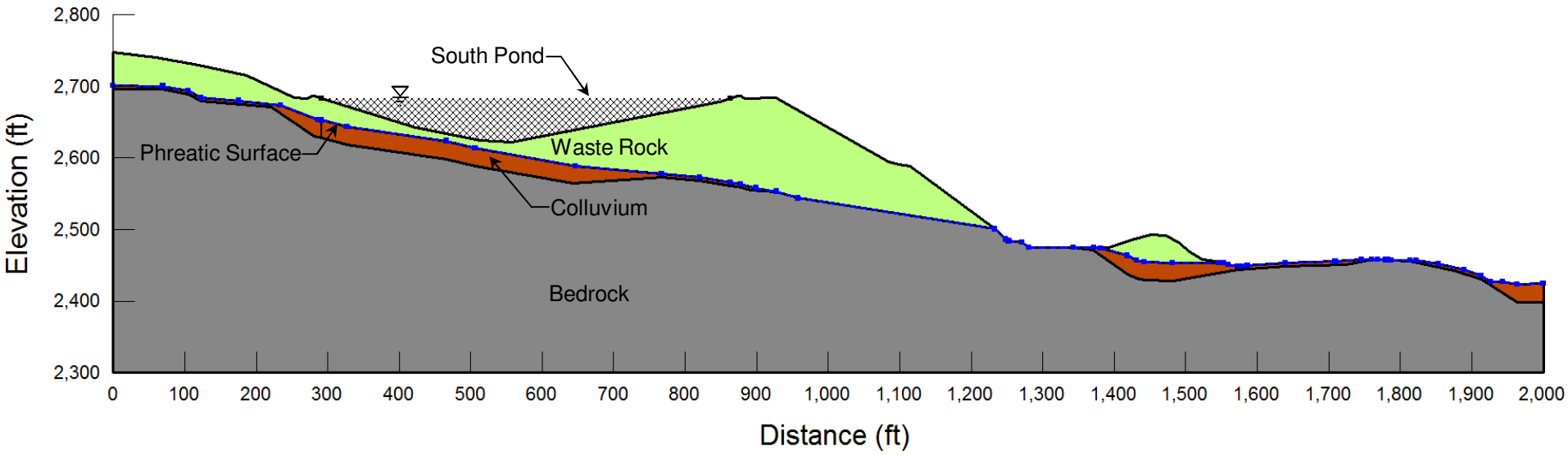
MWH

DATE: NOV 2013

FIGURE 10

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 2
Geometry



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Geometry
South Pond - Cross-Section 2

MWH

DATE: NOV 2013

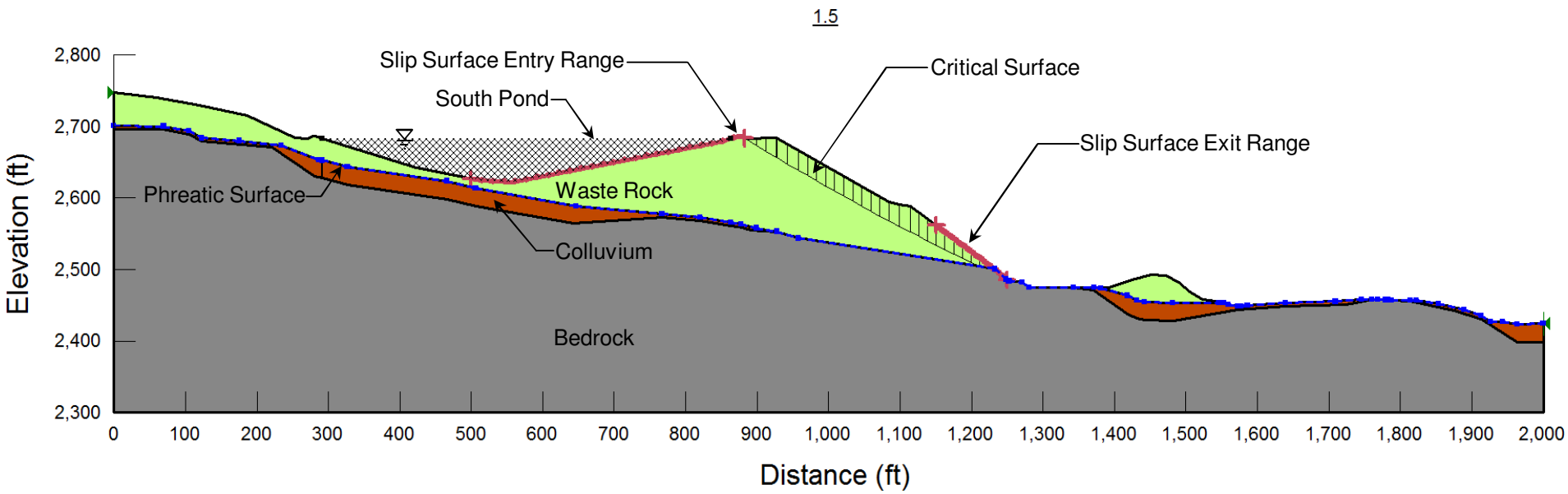
FIGURE 11

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 2
Static Conditions
Circular Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Waste Rock	135	38.0	0
Colluvium	122	30.8	0
Bedrock	Impenetrable		



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Static Conditions
South Pond - Cross-Section 2
Circular Failure Surface

MWH

DATE: NOV 2013

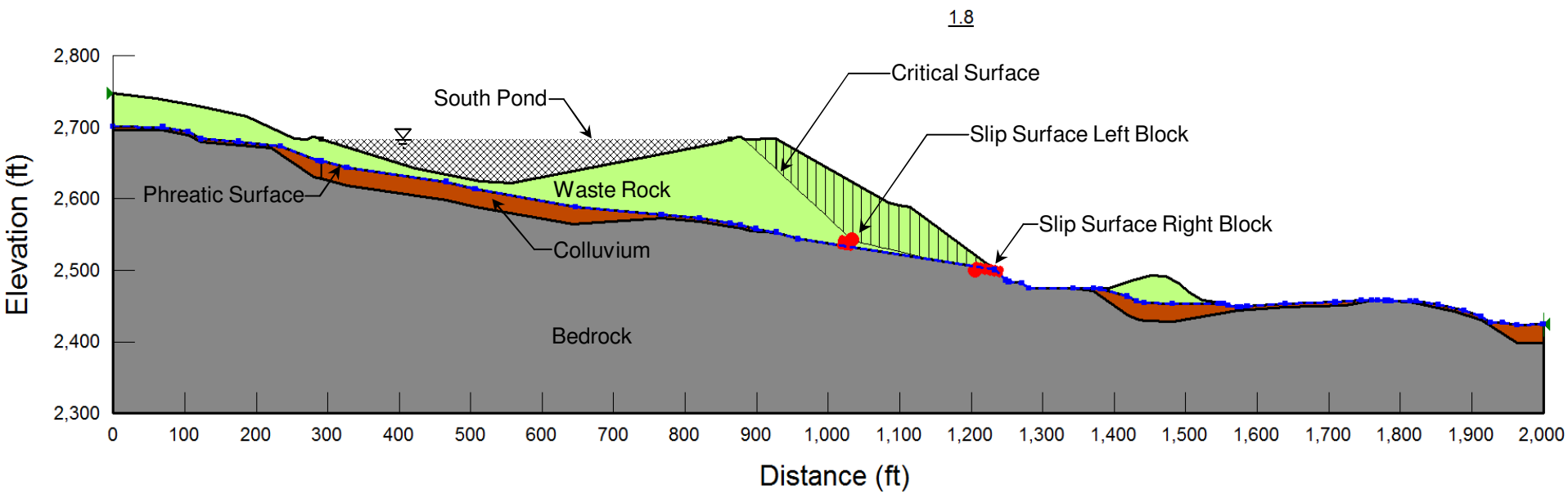
FIGURE 12

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 2
Static Conditions
Block Specified Wedge Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Waste Rock	135	38.0	0
Colluvium	122	30.8	0
Bedrock	Impenetrable		



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Static Conditions
South Pond - Cross-Section 2
Block Specified Wedge Failure Surface

MWH

DATE: NOV 2013

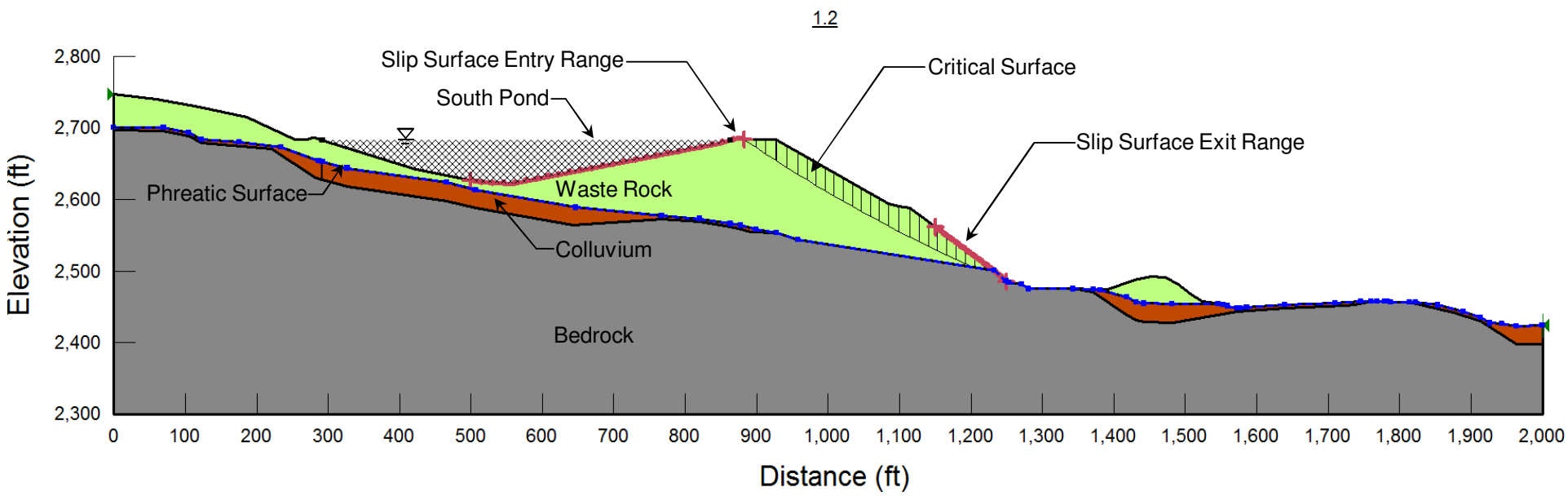
FIGURE 13

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 2
Pseudo-Static Conditions (K_h=0.105)
Circular Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	2.10 (Free Field) 0.56 (30' Dam Fill) 0.46 (65' Dam Fill) 0.41 (120' Dam Fill) 0.50 (Pond)
Bedrock	Impenetrable			-



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Pseudo-Static Conditions
South Pond - Cross-Section 2
Circular Failure Surface

MWH

DATE: NOV 2013

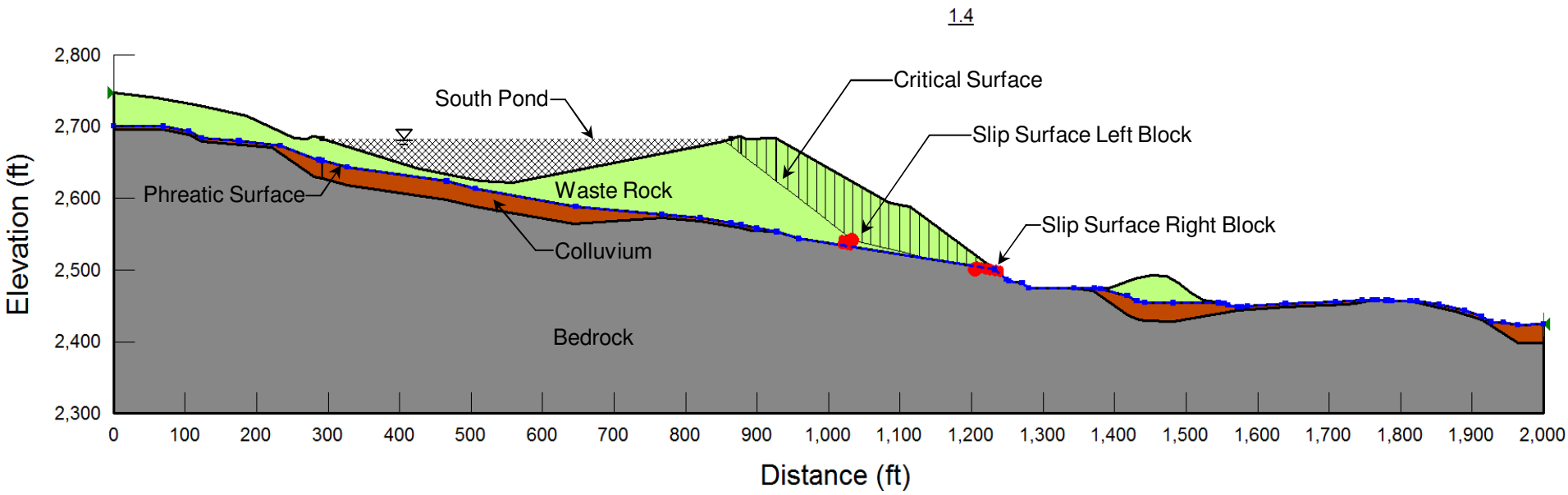
FIGURE 14

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 2
Pseudo-Static Conditions (K_h=0.105)
Block Specified Wedge Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	2.10 (Free Field) 0.56 (30' Dam Fill) 0.46 (65' Dam Fill) 0.41 (120' Dam Fill) 0.50 (Pond)
Bedrock	Impenetrable			-



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Pseudo-Static Conditions
South Pond - Cross-Section 2
Block Specified Wedge Failure Surface

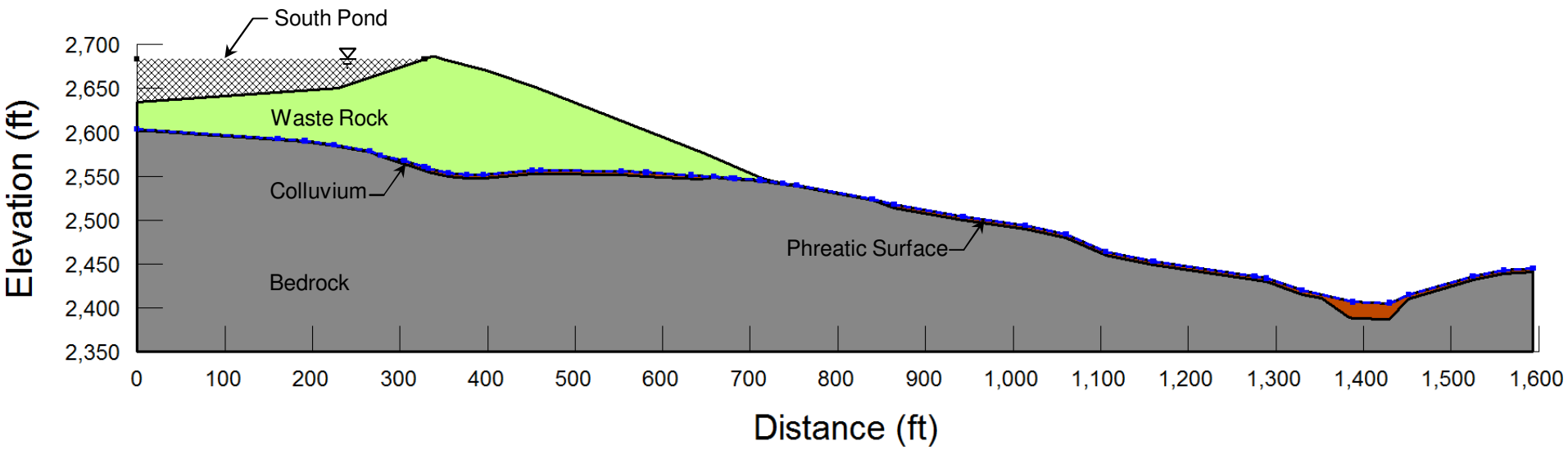
MWH

DATE: NOV 2013

FIGURE 15

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 3
Geometry



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis - Geometry
South Pond - Cross-Section 3

MWH

DATE
NOV 2013

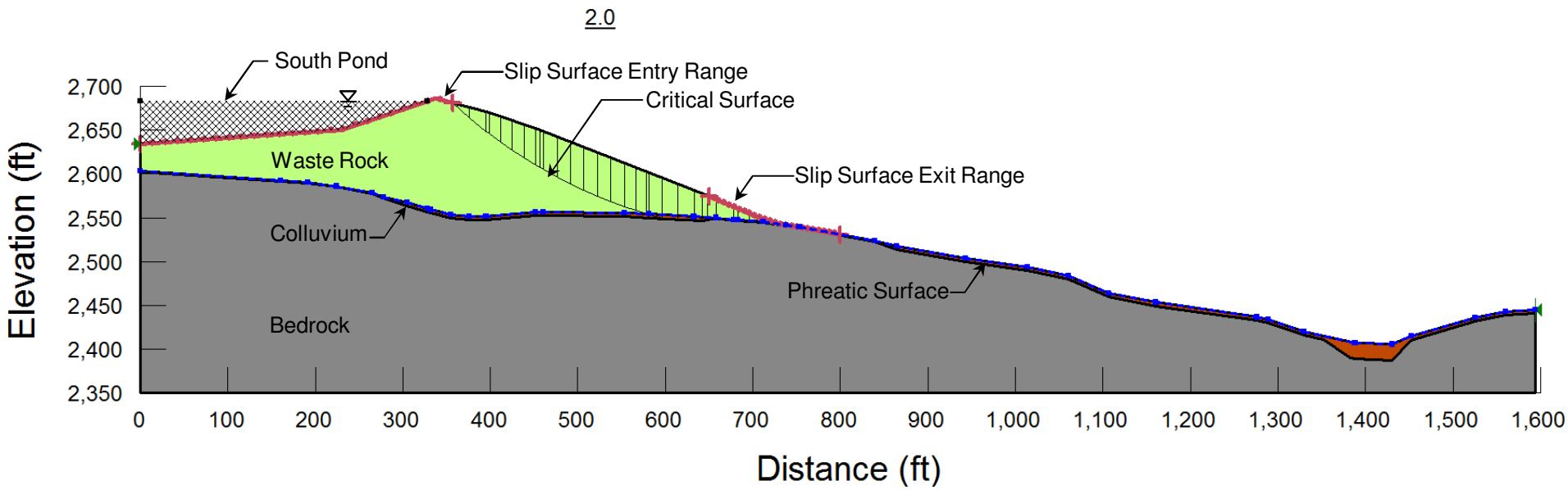
FIGURE 16

FILENAME
South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 3
Static Conditions
Circular Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Waste Rock	135	38.0	0
Colluvium	122	30.8	0
Bedrock	Impenetrable		



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Static Conditions
South Pond - Cross-Section 3
Circular Failure Surface

MWH

DATE: NOV 2013

FIGURE 17

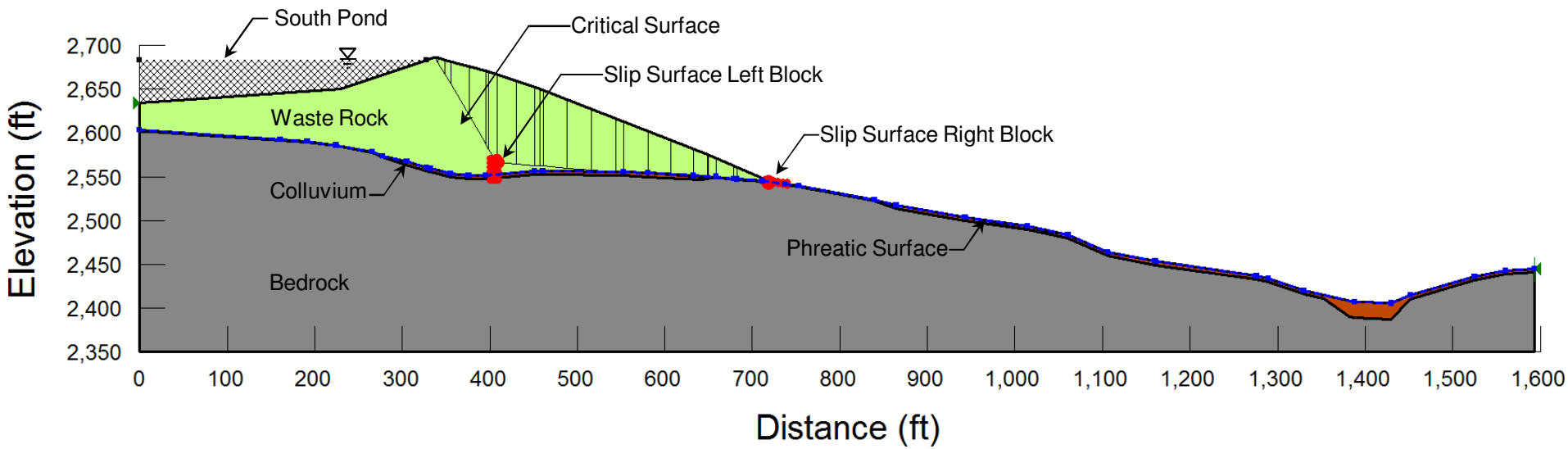
FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 3
Static Conditions
Block Specified Wedge Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Waste Rock	135	38.0	0
Colluvium	122	30.8	0
Bedrock	Impenetrable		

2.3



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Static Conditions
South Pond - Cross-Section 3
Block Specified Wedge Failure Surface

MWH

DATE: NOV 2013

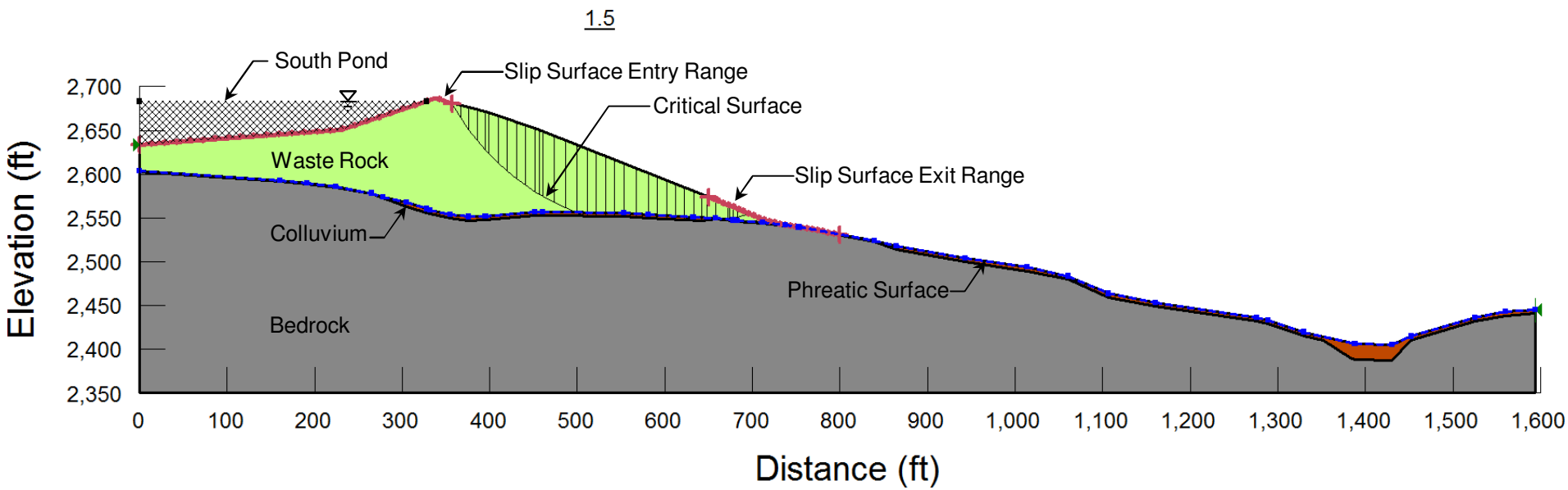
FIGURE 18

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 3
Pseudo-Static Conditions (K_h=0.105)
Circular Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	2.10 (Free Field) 0.56 (30' Dam Fill) 0.46 (65' Dam Fill) 0.41 (120' Dam Fill) 0.50 (Pond)
Bedrock	Impenetrable			-



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Pseudo-Static Conditions
South Pond - Cross-Section 3
Circular Failure Surface

MWH

DATE: NOV 2013

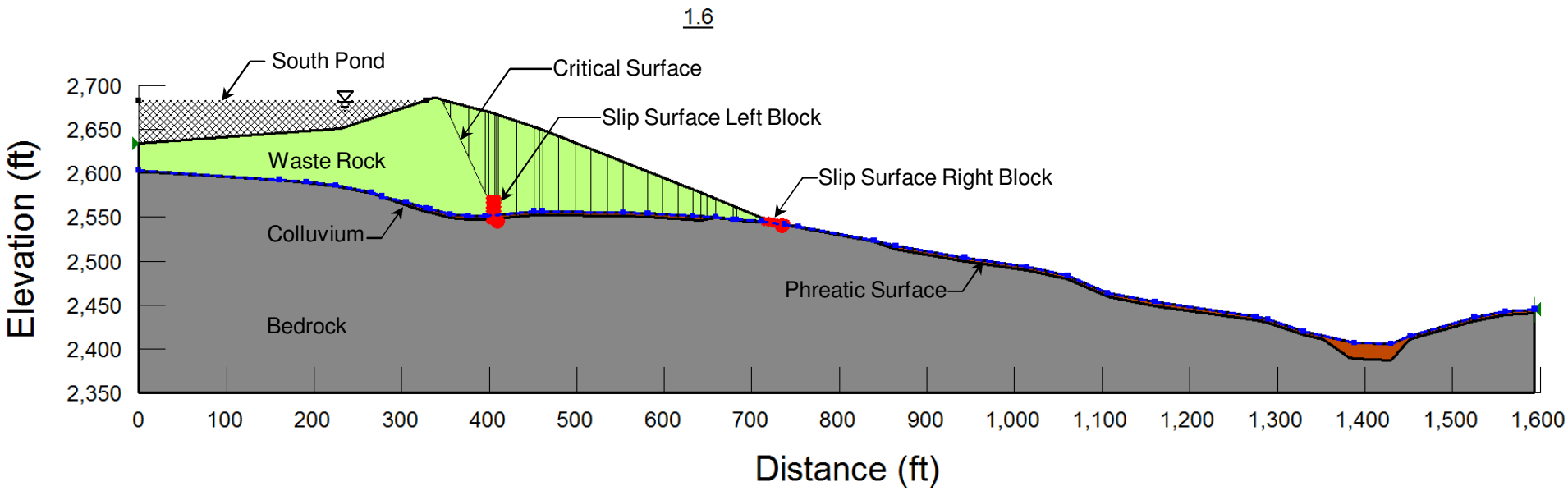
FIGURE 19

FILENAME: South Pond - Figures.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 3
Pseudo-Static Conditions (K_h=0.105)
Block Specified Wedge Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	2.10 (Free Field) 0.56 (30' Dam Fill) 0.46 (65' Dam Fill) 0.41 (120' Dam Fill) 0.50 (Pond)
Bedrock	Impenetrable			-



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Pseudo-Static Conditions
South Pond - Cross-Section 3
Block Specified Wedge Failure Surface

MWH

DATE: NOV 2013

FIGURE 20

FILENAME: South Pond - Figures.pptx

Supplement E-2.1

Midnite Mine Central Drainage Drill Logs Used for South Pond Slope Stability Analyses

BOREHOLE ID: PBC-01

TETRA TECH Tetra Tech

CLIENT Dawn Mining Company
PROJECT NAME Midnite Mine
PROJECT NUMBER 114-181850.2010
PROJECT LOCATION Central and Western Drainage

DATE(S) OF DRILLING: 07/12/2010 - 07/13/2010
GROUND ELEVATION: 2,428.2 ft
METHOD: 8 1/4" ID x 12 1/8" OD
CONSULTANT: Tetra Tech
NORTHING: 352,269 ft
LOGGED BY: Joe Reed
DRILLING CONTRACTOR: Ruen Drilling
EASTING: 511,850 ft
DRILLED BY: Jim Erdman
DRILL RIG: BK-66
HAMMER TYPE: N/A
LOCATION: Midnite Mine

DEPTH (ft)	SAMPLE TYPE	RECOVERY %	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
0					
1.5					**TOPSOIL** Sandy Clayey Silt, dark brown, slightly moist, soft, fine to coarse grained sand, trace gravel, slightly cohesive, frequent roots
8.5					**SANDY CLAY, CL** Dark yellowish brown (10YR 3/4), moist to wet, medium stiff, fine to coarse grained sand, trace gravel, wet at 4 feet, low plasticity, angular to sub-rounded
10.5					**SANDY CLAY, CL** Dark yellowish brown (10YR 3/4), moist to wet, medium stiff to stiff, trace fine grained sand, medium plasticity
16.0					**SANDY CLAY, CL** Dark gray (10YR 4/1), moist to wet, stiff, trace fine grained sand, medium to high plasticity, less sand than above
19.5	SS 1	90			**SILTY CLAY, CL** Very dark gray (10YR 3/1), moist to wet, stiff, trace fine grained sand, silt, sandy layer with roots from 16.5 to 16.7 feet, medium plasticity, more silt less and plastic than above
24.2	SS 2	76			No Recovery from 19 to 19.5 feet **CLAYEY SILT, ML** Dark gray (10YR 4/1), moist to wet, very fine grained sand, micaceous, cohesive, organic layers (stems, twigs)
24.5					**SANDY GRAVELLY CLAYEY SILT, ML**

BOREHOLE/TP/WELL - VECTOR MIDNIGHT MINE, C&WD, GINT.GPJ ROCK SPRINGS DATA TEMPLATE.GDT 11/15/10

(Continued Next Page)

BOREHOLE ID: PBC-01

TETRA TECH Tetra Tech

CLIENT Dawn Mining Company **PROJECT NAME** Midnite Mine

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** Central and Western Drainage

DEPTH (ft)	SAMPLE TYPE	RECOVERY %	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
25					
26	SS 3	50			Brown (10YR 5/3), moist to wet, medium dense, gravel and sand in clayey silt matrix, fe (iron) stained, micaceous GRAVELLY SAND/SANDY GRAVEL, SC/GC
27				27.0	Yellowish brown (10YR 5/4), wet, dense, fine to coarse grained sand and gravel, cohesive, clay *(continued)* Drilling change at 27 feet
28					WEATHERED BEDROCK Yellowish brown (10YR 5/6)
29					
30					
31					Hard Drilling at 31 feet
32					
33	SS 4	80	50/6"	33.0	Very hard auger refusal at 32.5 feet

Bottom of hole at 33.0 feet.

BOREHOLE ID: PBC-02

TETRA TECH Tetra Tech

CLIENT Dawn Mining Company **PROJECT NAME** Midnite Mine

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** Central and Western Drainage

DATE(S) OF DRILLING: 07/14/2010 - 07/14/2010 **GROUND ELEVATION:** 2,430.4 ft **METHOD:** 8 1/4" ID x 12 1/8" OD

CONSULTANT: Tetra Tech **NORTHING:** 352,262 ft **LOGGED BY:** Joe Reed

DRILLING CONTRACTOR: Ruen Drilling **EASTING:** 511,769 ft **DRILLED BY:** Jim Erdman

DRILL RIG: BK-66 **HAMMER TYPE:** N/A **LOCATION:** Midnite Mine

DEPTH (ft)	SAMPLE TYPE	RECOVERY %	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
0					
1.5					**SANDY CLAYEY SILT, ML** Dark yellowish brown (10YR 4/6), dry, soft, fine grained sand, trace gravel, frequent roots
3.0					**SANDY SILTY CLAY, CL** Dark yellowish brown (10YR 3/4), dry to slightly moist, soft, fine to coarse grained sand, trace fine gravel, trace roots
6.0					**SILTY CLAY, CL** Dark yellowish brown (10YR 3/4), dry, soft to medium stiff, trace fine to coarse grained sand and gravel, medium plastic to plastic, 5 feet to moist
11.0					**SANDY GRAVELLY CLAY, CL** Dark gray (10YR 3/1), moist, to wet at 7 feet, medium stiff, fine to coarse grained sand, fine gravel, medium plastic to plastic Increase in sand and gravel - harder from 9 to 11 feet
14	SS 1	67	18-18-30		**WEATHERED BEDROCK** Yellowish brown (10YR 5/6), fe (iron) stained
18.5					Bottom of hole at 18.5 feet.

BOREHOLE/TP/WELL - VECTOR MIDNIGHT MINE, C&WD, GINT.GPJ ROCK SPRINGS DATA TEMPLATE.GDT 11/15/10

BOREHOLE ID: PBC-03

TETRA TECH Tetra Tech

CLIENT Dawn Mining Company
PROJECT NAME Midnite Mine
PROJECT NUMBER 114-181850.2010
PROJECT LOCATION Central and Western Drainage

DATE(S) OF DRILLING: 07/15/2010 - 07/22/2010
GROUND ELEVATION: 2,428.1 ft
METHOD: 8 1/4" ID x 12 1/8" OD HSA
CONSULTANT: Tetra Tech
NORTHING: 352,294 ft
LOGGED BY: Joe Reed
DRILLING CONTRACTOR: Ruen Drilling
EASTING: 511,900 ft
DRILLED BY: Jim Erdman
DRILL RIG: BK-66
HAMMER TYPE: N/A
LOCATION: Midnite Mine

DEPTH (ft)	SAMPLE TYPE	RECOVERY %	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
0					
0.5					**TOPSOIL, CL** Sandy Silty Clay
1–4					**SANDY SILTY CLAY, CL** Dark yellowish brown (10YR 3/4), moist to wet at 2 feet, medium to stiff, fine to coarse grained sand, trace fine gravel, medium to high plasticity, roots to 3.5 feet
4.0					**CLAY, CL** Dark yellowish brown (10YR 3/4), moist to wet, stiff, trace fine grained sand, high plasticity
6.5					**SANDY CLAY, CL** Dark gray (10YR 3/1), moist to wet, stiff, trace fine to coarse grained sand, high plasticity, trace fine gravel
8.5					**SANDY CLAY, CL** Greenish gray (GLEY2 5/1), wet, stiff, trace fine to coarse grained sand, high plasticity
22.0					**WEATHERED BEDROCK**
25	SS 1	67	7-11-19		Weathered Bedrock, yellowish brown (10YR 5/6) at 24 to 25.5 feet

(Continued Next Page)

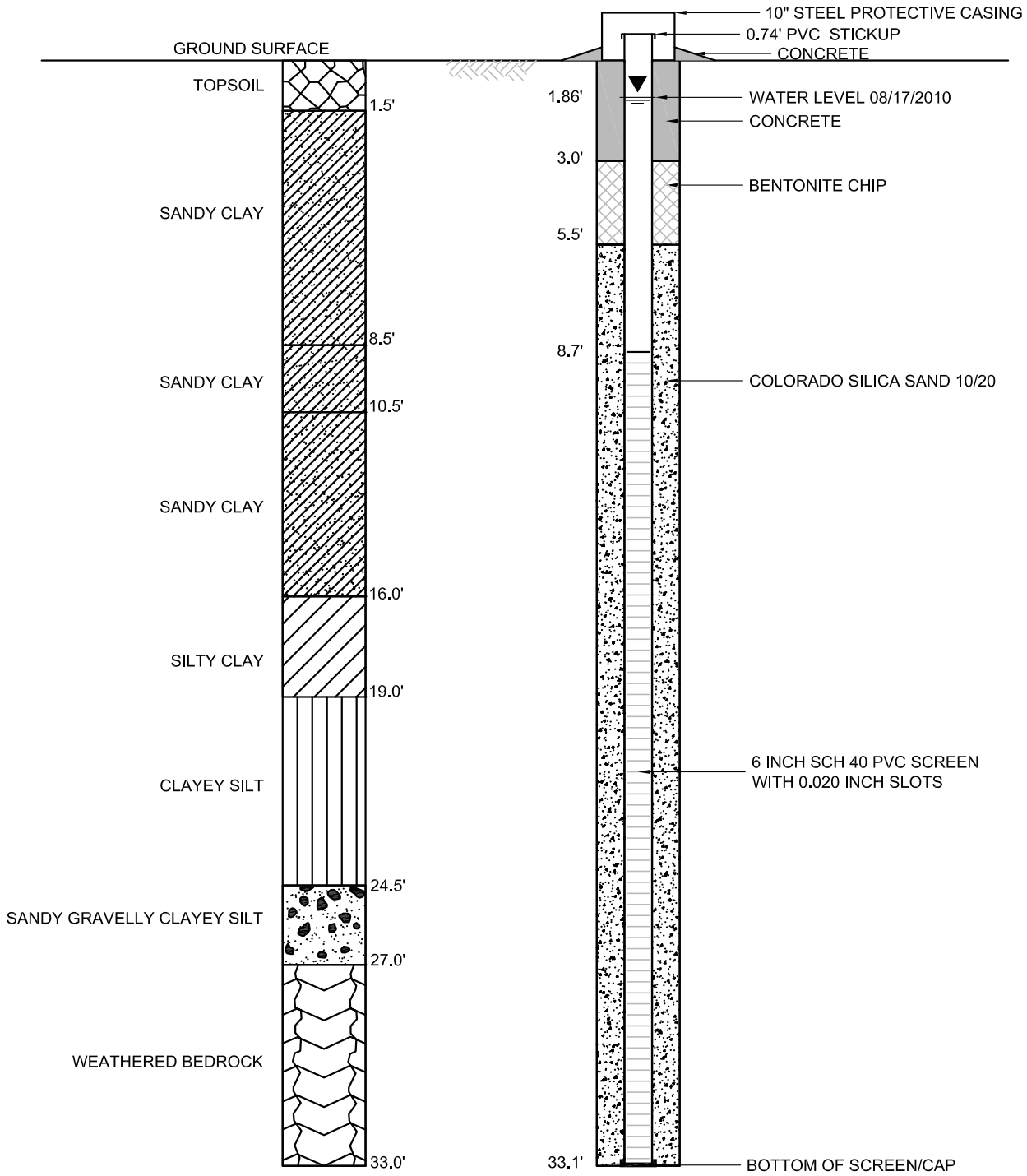
BOREHOLE ID: PBC-03

TETRA TECH Tetra Tech

CLIENT Dawn Mining Company **PROJECT NAME** Midnite Mine

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** Central and Western Drainage

DEPTH (ft)	SAMPLE TYPE	RECOVERY %	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
25					
					WEATHERED BEDROCK *(continued)*
26					
27					
28					
29					
30					
31					31.0
					Bottom of hole at 31.0 feet.



ALL DEPTHS BELOW GROUND SURFACE.

NOT TO SCALE

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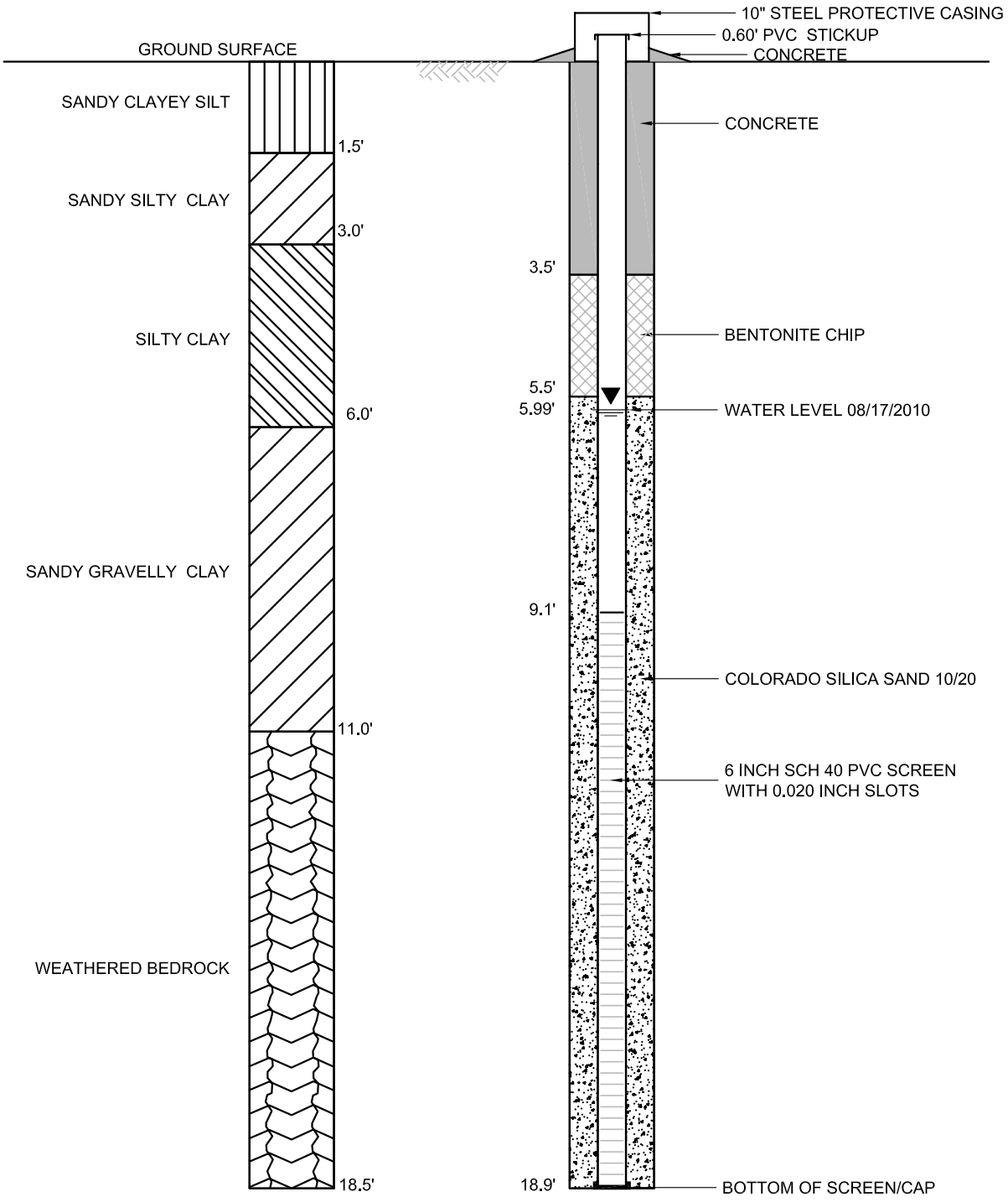
Project No. 181850

November 2010

Figure 1
Well Completion Diagram PBC-01



ALL DEPTHS BELOW GROUND SURFACE.

NOT TO SCALE

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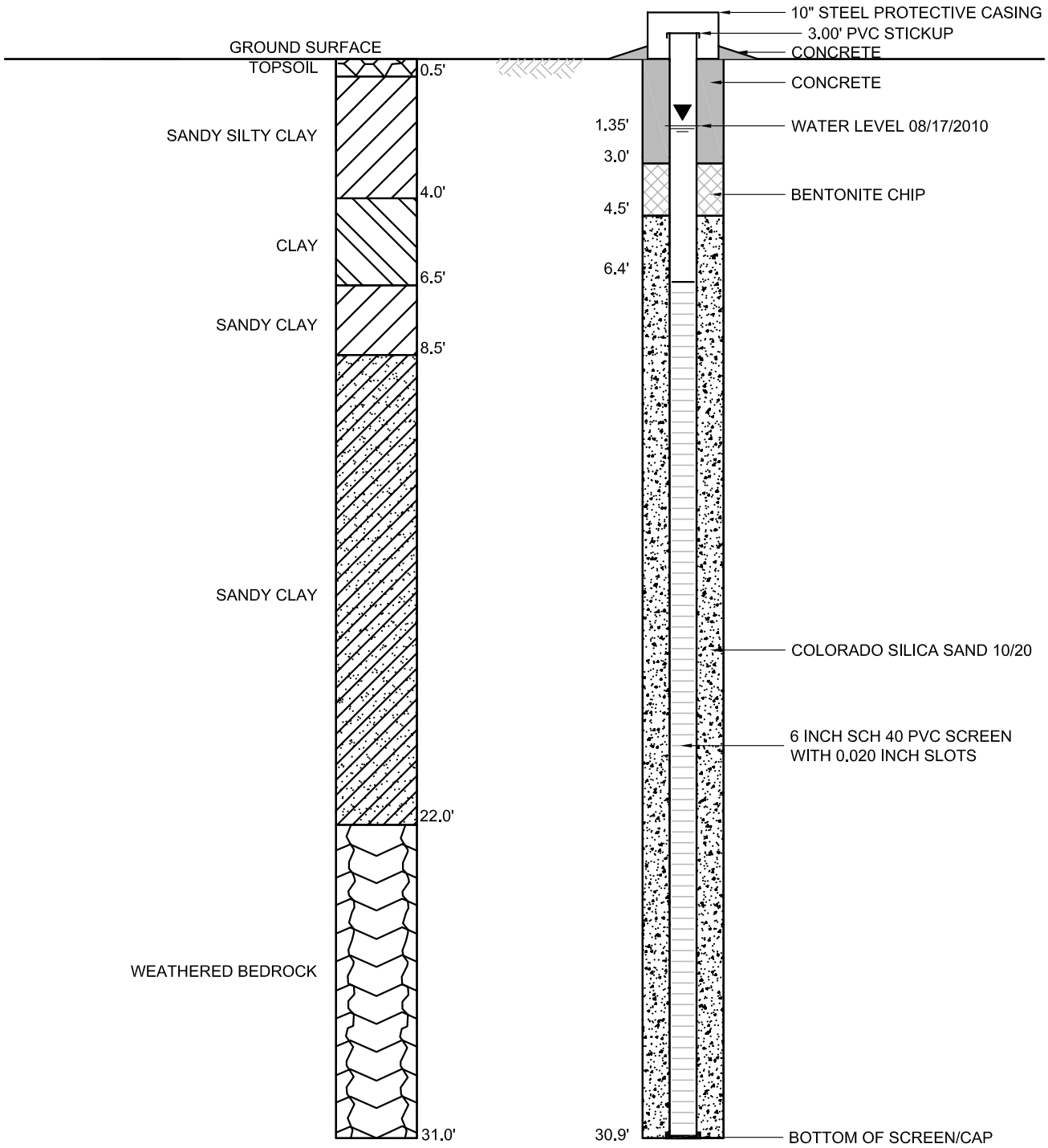
Project No. 181850

November 2010

Figure 2
Well Completion Diagram PBC-02



ALL DEPTHS BELOW GROUND SURFACE.

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Project No. 181850

November 2010

Figure 3
Well Completion Diagram PBC-03

BOREHOLE ID: MWCD-02

TETRA TECH Tetra Tech

CLIENT Dawn Mining Company
PROJECT NAME Midnite Mine
PROJECT NUMBER 114-181850.2010
PROJECT LOCATION Central and Western Drainage

DATE(S) OF DRILLING: 07/23/2010 - 07/23/2010
GROUND ELEVATION: 2,425.7 ft
METHOD: 8 1/4" ID x 12 1/8" OD HSA
CONSULTANT: Tetra Tech
NORTHING: 352,250 ft
LOGGED BY: Joe Reed
DRILLING CONTRACTOR: Ruen Drilling
EASTING: 511,853 ft
DRILLED BY: Jim Erdman
DRILL RIG: BK-66
HAMMER TYPE: N/A
LOCATION: Midnite Mine

DEPTH (ft)	SAMPLE TYPE	RECOVERY %	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
0					
1.5					**TOPSOIL, ML** Sandy Clayey Silt, dark brown, slightly moist, soft, fine to coarse grained sand, trace gravel, slightly cohesive, frequent roots
10.0					**SANDY CLAY, CL** Dark yellowish brown (10YR 3/4), moist to wet, medium stiff, fine to coarse grained sand, trace fine gravel, wet at approx. 5 feet, low plasticity, decreasing sand with depth
25.0					**CLAY, CL** Dark gray (10YR 4/1), moist to wet, stiff, trace fine grained sand, medium to high plasticity Very little return on auger flights from 12.5 to 17.5 feet Dark gray (10YR 3/1), wet at 18 feet

BOREHOLE/TP/WELL - VECTOR MIDNIGHT MINE, C&WD, GINT.GPJ ROCK SPRINGS DATA TEMPLATE.GDT 11/15/10

(Continued Next Page)

BOREHOLE ID: MWCD-02

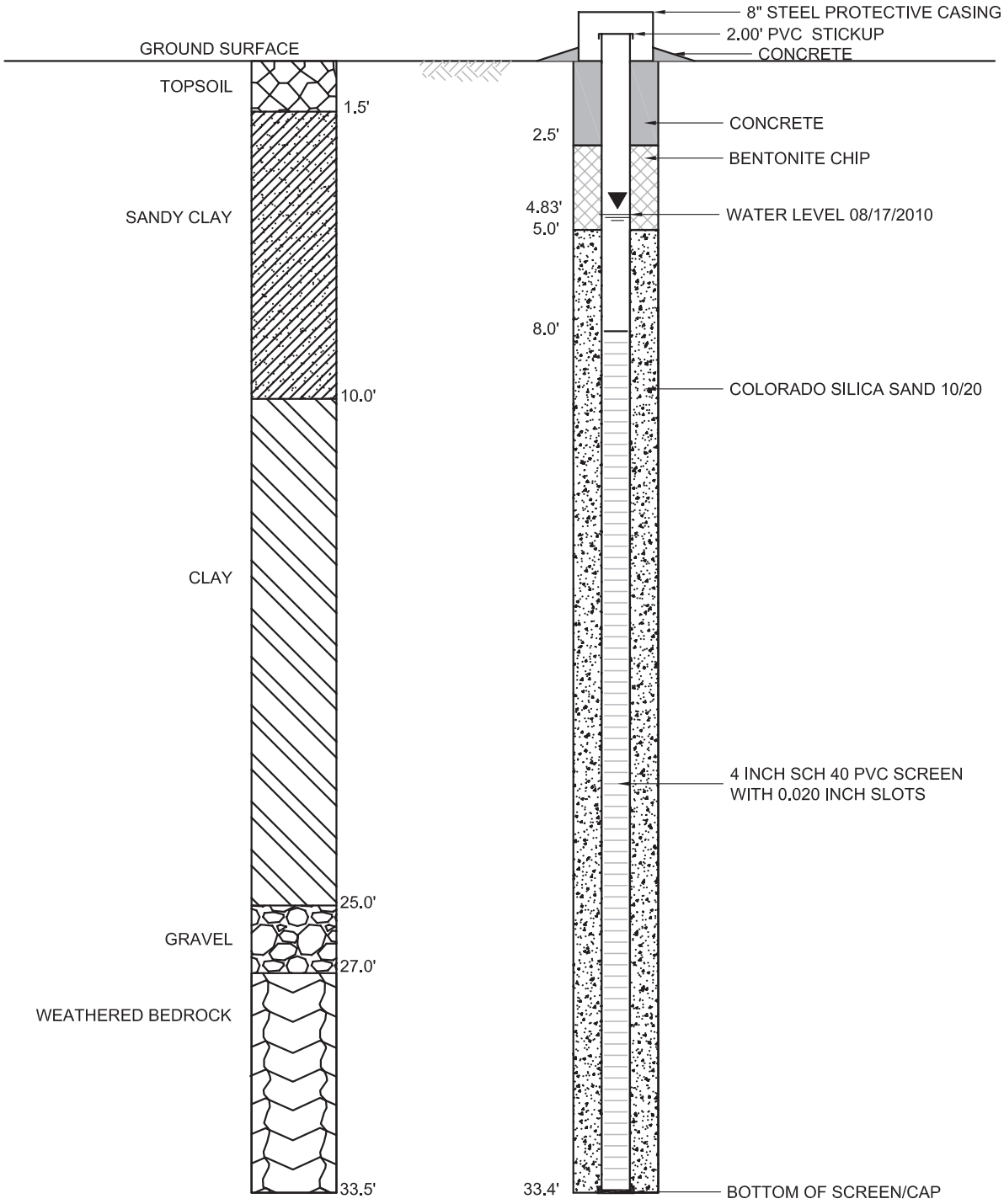
TETRA TECH Tetra Tech

CLIENT Dawn Mining Company **PROJECT NAME** Midnite Mine

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** Central and Western Drainage

DEPTH (ft)	SAMPLE TYPE	RECOVERY %	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
25					Gravel starts (drilling change) at 25 feet
26					GRAVEL
27					27.0
28	SS 1	60	10-11-18		BEDROCK Yellowish brown (10YR 5/6), moist
29					
30					
31					
32					
33					33.5
					Bottom of hole at 33.5 feet.

BOREHOLE/TP/WELL - VECTOR MIDNIGHT MINE, C&WD, GINT.GPJ ROCK SPRINGS DATA TEMPLATE.GDT 11/15/10



ALL DEPTHS BELOW GROUND SURFACE.

NOT TO SCALE

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Project No. 181850

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Figure 4
Well Completion Diagram MWCD-02

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Salt Lake City, Utah 84121
Telephone: (801) 617-3200
Fax: (801) 617-4200

CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011
DRILLING DATE 9/13/2011 **COMPLETION DATE** 9/14/2011 **LOGGED BY** Bill Bragdon
DRILL METHOD HSA / Core **BOREHOLE DIAMETER** HSA 8 inch, 0 to 25 feet; Core 2.5 inch, 25 feet to EOB **DRILLING COMPANY** Ruen Drilling

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
0.0							Silty sand to about 2.2 feet.		
	SS	16 25 18	100	NA	NA	NA	Silty fine to medium-grained sand (SP/SM), yellowish brown (10YR 5/4), medium dense, at 1.0 feet bgs grades to low plasticity, very stiff, dry (fill possible).		
2.5							Weathered quartz monzonite from about 2.2 to 31 feet bgs.		
	SS	14 24 42	100	NA	9	NA	Fine to coarse-grained sand (SP) of decomposed (W9) quartz monzonite, pale brown (10YR 6/3), hard, dry, does not break with finger pressure. Feldspars are soft and discolored, trace FeOx.		
5.0									
	SS	15 30 35	100	NA	9	NA	Fine to medium-grained sand (SP) of decomposed (W9) quartz monzonite, breaks easily under finger pressure, dry. Feldspar are decomposed to clay, grades to pale yellowish (5Y 8/4), slightly plastic, very stiff to hard.		
7.5									
	CA	32 49 65	100	NA	9	NA	As above at 5 feet bgs, collected brass liner "B" from 8 to 8.5 feet.		
10.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
10.0									
	SS	24 44 46	100	NA	9	NA	Fine to medium-grained sand (SP) of decomposed (W9) quartz monzonite, pale yellow (5Y 8/4) to (5Y 8/2), trace FeOx,crumbles under finger pressure, slightly to low plasticity, very stiff to hard, dry.		
12.5									
	SS	10 12 25	100	NA	9	NA	As above, grading to medium plasticity, stiff to very stiff, slighly moist. Water at 12.5 to 13.		
15.0									
	SS	36 46 50	100	NA	9	NA	Clayey fine-grained sand (SC) of decomposed (W9) quartz monzonite, pale yellow (5Y 8/3), low plasticity, hard, dry to slightly moist, crumbles under finger pressure, trace FeOx at 15 to 15.5.		
17.5									
	SS	12 20 25	100	NA	9	NA	Clayey fine-grained sand (SC) of decomposed (W9) quartz monzonite, crumbles easily under finger pressure, strong FeOx and manganese at 17.5 to 18.0 feet bgs, stiff to very stiff, slightly moist to moist, pale yellow (5Y 8/2), medium plasticity, medium stiff to very stiff, moist.		
20.0									

(Continued Next Page)

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
20.0									
	SS	6 12 21	100	NA	9	NA	Clayey fine-grained sand (SC) of decomposed (W9) quartz monzonite as above at 17.5 feet bgs.		
22.5									
	SS	83 180	100	NA	7 to 8	NA	Clayey fine-grained sand (SC) of intensely weathered (W7) to very intensely weathered (W8) quartz monzonite, pale olive (5Y 6/4), fine to medium grained, wet, FeOx and trace manganese locally. Retained brass liner 22.5 to 23 feet and 5 gallon bucket.		Water encountered at 23 feet bgs during drilling.
25.0									
	SS	50	50	NA	7	NA	50 blows for 2 inches. Practical HSA refusal, 1 inch slough recovery at 25 feet. Switched to HQ core at 25 feet.		
27.5	HQ Core								No Recovery (material likely removed during drilling by circulation water.)
			30	16	6	4	Fine-to very coarse-grained quartz monzonite, feldspars up to 1 inch, generally <1 inch, intensely to moderately weathered (W6), moderately hard (H4), light yellowish brown (10YR 6/4) and light reddish brown (2.5YR 7/3), trace FeOx locally.		Drilling induced rubble of fine to coarse sand and fine gravel. 70° 20° weak FeOx. 40° rubble.
30.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
30.0									
	HQ Core								No Recovery (material likely removed during drilling by circulation water.)
							Quartz monzonite from about 31 feet to EOB.		20°
32.5			80	62	6	5	Fine to very coarse-grained quartz monzonite, very pale brown (10YR 7/4), intensely to moderately weathered (W6), moderately soft (H5) grading to moderately hard (H4), moderate argillic and FeOx, some manganese.		10°
									20° 20° weak FeOx
									0° 1.0 inch of argillic.
									20° 20°
35.0									10° strong FeOx and manganese.
									30° with strong FeOx
									40° with FeOx
									20°
									10° 50° healed with FeOx
			100	81	5	3	As above, grading to moderately weathered (W5), hard (H3) to moderately hard (H4), trace argillic at 37.8 feet, some FeOx.		0° microfractures with trace FeOx, healed.
37.5									70°
									15° rubble with argillic.
									10°
									15° with moderate FeOx
			100	72	4	3	As above with healed microfractures with trace to some FeOx, grades to moderately to slightly weathered (W4) and hard (H3).		20° 20° with very weak FeOx
40.0									60°

(Continued Next Page)

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
40.0									
42.5	HQ Core		100	70	4	3	Fine-to coarse-grained quartz monzonite as above with fractured rock at 40.6 feet and 41.2. Overall low to moderate FeOx, trace argillic at 41.6 to 41.9 feet.		60° BXA. 10° 70° healed. 70° some FeOx. 10° 10° healed microfractures. 5°
45.0			100	84	4	3	Fine-to very coarse-grained quartz monzonite as above with manganese locally.		60° with trace to some manganese. 40° trace FeOx. 0° argillic FeOx and manganese. 40° 75° with some FeOx. 0° weak manganese.
47.5									
50.0			95	74	4	3	As above with increase in manganese, very pale brown (10YR 7/3) and pale yellow (2.5Y 8/4), feldspars up to 1.5 inch.		0° 0° 60° fine sand. 80° 50° with FeOx.

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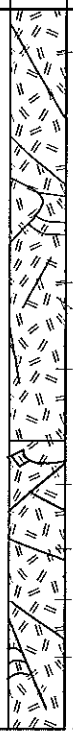
CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
50.0									
	HQ Core		100	90	3	3	Grades to slightly weathered (W3), very hard to hard (H3), decrease in FeOx and manganese.		70° 60° with FeOx. 0° healed with weak FeOx, trace manganese. 80°
52.5									
				NA	3	2	Fine-to very fine-grained quartz monzonite with feldspars to 1.25 inch generally 1/2 to 1 inch, strong manganese in matrix and along fractures at 54 to 55 feet, light brown (7.5YR 6/3) and pale yellow (2.5Y 7/2) slightly weathered (W3) to very hard (H2) to hard (H3).		40° 20° 30° 70° strong manganese.
55.0									



End of borehole at 55.0 feet.

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Salt Lake City, Utah 84121
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Fax: (801) 617-4200

CD-B2

CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DRILLING DATE 8/30/2011 **COMPLETION DATE** 8/30/2011 **LOGGED BY** Bill Bragdon

DRILL METHOD HSA / Core **BOREHOLE DIAMETER** HSA 8 inch, 0 to 25.5 feet; Core 2.5 inch, 25.5 feet to EOB **DRILLING COMPANY** Ruen Drilling

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
0.0							Sandy and silty clay to approximately 10 feet.		
	SS	2 1 1	87	NA	NA	NA	Silty clay (CL) with trace medium-grained sand, brown (7.5YR 5/3), low to medium plasticity, very soft, dry grading to slightly moist at 1.3 feet, tree roots at 1.1 to 1.2 feet, some roots and organics.		
2.5									
	SS	3 5 5	87	NA	NA	NA	Silty clay (CL) with trace to some medium- to coarse-grained sand, very dark grayish brown (10YR 3/2), medium plasticity, medium stiff, dry, few roots and organics.		
5.0	SS	2 3 4	100	NA	NA	NA	Fine-grained sandy clay (CL) dark brown (7.5YR 3/2), medium plasticity, soft, slightly moist to moist at 6.3 feet bgs, trace roots, fine-grained mica.		
7.5	SS	0 0 0	66	NA	NA	NA	Fine-grained sandy clay (CL) as above, grading to very dark brown (10YR 2/2), very soft, moist. Weight of sampler pushed into clay.		
10.0									Water encountered at 10 feet bgs during drilling.

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
10.0							Clayey sand from about 10 feet to 22.5 feet.		
	SS	1 2 3	100	NA	NA	NA	Clayey fine- to medium-grained sand at 10.2 feet, grading to clayey fine-grained sand (SC), dark greenish gray (10Y 4/1), medium plasticity, very soft, wet.		
12.5									
	SS	1 1 1	100	NA	NA	NA	Clayey fine-grained sand (SC), greenish gray (10GY 5/1) grading to (10Y 5/1) greenish gray, medium plasticity, very soft, moist to wet.		
15.0									
	SS	1 1 1	100	NA	NA	NA	Clayey fine- to medium-grained sand (SC), grayish brown (2.5Y 5/2) grading to light olive brown (2.5Y 5/4), medium plasticity, very soft, wet, trace FeOx.		
17.5									
	SS	0 0 0	87	NA	NA	NA	Clayey fine- to medium-grained sand (SC) with trace silt, yellowish brown (10YR 5/4), medium plasticity, very soft, wet, trace FeOx. Medium sand is subangular.		
20.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
20.0									
	SS	1 1 5	100	NA	NA	NA	As above at 17.5 feet, very soft to soft, trace coarse gravel at 21.2 feet, angular, grades to brown (7.5YR 4/4) at 21 feet.		
22.5									
							Weathered quartz monzonite from about 22.5 to 29 feet bgs.		
	SS	3 29 50	100	NA	9	NA	Fine- to coarse-grained sand (SP) with few fine gravel of decomposed (W9) quartz monzonite, grayish brown (10YR 5/2) grades to reddish brown (5Y 4/4), non plastic, wet, angular fragments of feldspar, dense to very dense.		
25.0									
	SS	18 29 27	100	NA	9	NA	Fine- to coarse-grained sand (SP) size with few fine gravel of decomposed (W9) quartz monzonite, angular to subangular, light olive gray (2.5Y 5/4), wet, trace argillic at 26.3 to 26.5 feet, trace FeOx and manganese.		
							Very hard HSA drilling, practical HSA refusal. Switched to HQ core.		
27.5									
	HQ Core		25	0	9	4	Fine- to coarse-grained quartz monzonite, only 1.3 feet of recovery of fine to coarse gravel size material, trace argillic and some FeOx, generally greenish gray (5GY 6/1), decomposed (W9) and moderately hard (H4).		No Recovery (material likely removed during drilling by circulation water.)
							Quartz monzonite from about 29 feet to EOB.		
30.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
30.0									
32.5	HQ Core		80	62	8	5	Fine- to very coarse-grained quartz monzonite with feldspars to 1.5 inch, moderately soft (H5) to soft (H6), very intensely weathered (W8), generally light greenish gray (10Y 7/1) and light reddish brown (2.5YR 7/3).		No Recovery (material likely removed during drilling by circulation water.) 0° 5° 70° healed. 50° healed. 70° healed. 50° healed with trace of FeOx. 50° healed fractures. 0° fine to medium sand with a few quartz monzonite coarse gravel. 0° 75° with FeOx.
35.0									
37.5			60	56	9	5	Fine- to very coarse-grained decomposed (W9) quartz monzonite, soft (H5).		No Recovery (material likely removed during drilling by circulation water.) Drilling induced rubble with strong argillic alteration. 0° rounded off by drilling. 0° 0° microfractures, healed. 0° 5° 80° trace argillic alteration.
							Grades to intensely to moderately (W6) weathered, moderately hard (H4).		
40.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
40.0									
42.5	HQ Core		85	71	6	4	Fine- to very coarse-grained quartz monzonite, greenish gray (10Y 7/1) and light reddish brown (2.5YR 7/3), intensely to moderate weathered (W6) and moderately hard (H4), fine to coarse decomposed quartz monzonite at 43 to 43.5 feet and fine to medium sand at 44.5 to 44.7 feet.		No Recovery (material likely removed during drilling by circulation water.) 0° rubble of coarse sand size rock. 60° 70° healed with FeOx (wk). 20° 20° with weak FeOx. 20° 20° 0.1 inch with argillic. 30° fine to coarse sand, trace argillic. 60° 70° 0° fine to medium sand and argillic. 60° with argillic.
45.0									
47.5			100	83	6	4	Fine- to very coarse-grained quartz monzonite with feldspars up to 1 inch, moderately hard (H4), intensely to moderate weathered (W6).		30° 30° 30° 70° 60° 30° 30° 20° 30° fine to coarse sand with strong argillic.
							Pale green (5G 7/2) along fractures.		60° argillic fine to coarse sand. 60° argillic.
50.0					3	3	Grades to medium- to coarse-grained, generally pale green (5G 7/2) and some light reddish brown (2.5Y 7/3), some light green gray (10YR 7/1), slightly weathered (W3) and hard (H3).		

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION
50.0							
52.5	HQ Core		100	100	2	3	Fine- to very coarse-grained quartz monzonite with feldspars up to 1.5 inch, generally 0.5 to 1 inch, greenish gray (5G 5/2) and light reddish brown (2.5Y 7/3), slightly weathered and fresh (W2), hard (H3), grading to very hard.
55.0					2	2	Grades to very hard (H2).
57.5			100	93	3	2	Fine- to very coarse-grained quartz monzonite with feldspars to 1.5 inch, greenish gray (5G 5/2) and light reddish brown (2.5Y 7/3), slightly weathered (W2) and very hard (H3).
60.0							

GRAPHIC LOG

Fracture

60°
60° no FeOx, argillic or manganese along fractures.
80°
20° 0.1 to 1.3 inch gap.
50°
40°
40°
30°
60°
50°
60°
40°
70°
50°
30°
30°
60°
10°
80°
Broken to fine gravel grading to fine sand, weak argillic.
40°
40° healed.
80° healed.
70°

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
60.0									
62.5	HQ Core		100	100	2	2	As above at 55 feet.		70° 30° 20° 20° 5° 85°
65.0									

End of borehole at 65.0 feet.

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CD-B3

CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DRILLING DATE 9/7/2011 **COMPLETION DATE** 9/7/2011 **LOGGED BY** Bill Bragdon

DRILL METHOD HSA / Core **BOREHOLE DIAMETER** HSA 8 inch, 0 to 45 feet; Core 2.5 inch, 45 feet to EOB **DRILLING COMPANY** Ruen Drilling

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
0.0							Clayey silt to about 2.8 feet.		
	SS	3 6 8	93	NA	NA	NA	Clayey silt (ML/CL) with some fine- to medium-grained sand, yellowish brown (10YR 5/4), low plasticity, medium stiff, very compacted, hard to break with fingers with trace organic and roots.		
2.5							Weathered quartz monzonite from about 2.8 to 45 feet bgs.		
	SS	7 21 33	100	NA	9	NA	Fine- to coarse-grained sand (SP) with trace silt of decomposed (W9) quartz monzonite, generally very pale brown (10 YR 7/3) to light yellowish brown (10YR 6/4), subangular, non plastic, medium dense.		
5.0									
	CA	31 42 52	100	NA	9	NA	As above at 2.8 feet, at 6 feet collected "A" bottom and "B" middle brass liners.		
7.5									
	SS	21 49 62	100	NA	9	NA	Fine- to coarse-grained sand with trace silt (SP) of decomposed (W9) quartz monzonite, generally very pale brown (10YR 7/4), angular to subangular, non plastic, dense, dry.		
10.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
10.0									
	SS	38 50	100	NA	9	NA	Decomposed (W9) quartz monzonite as above at 7.5 feet, grading to very dense. 50 blows for 4 inches.		
	SS								
12.5									
	SS	50	100	NA	NA	NA	As above at 7.5 feet, very dense. 50 blows for 4 inches.		
	SS								
15.0									
	SS	48 50	100	NA	NA	NA	Decomposed (W9) quartz monzonite as above at 7.5 feet. 50 blows for 4 inches. Switched to HQ core. Practical HSA refusal.		
17.5									
	HQ Core	0	0	9	7		15 to 20 feet no recovery in core barrel, fine- to medium-grained sand size quartz monzonite in circulation water, decomposed (W9), very soft (H7).		No Recovery (material likely removed during drilling by circulation water.)
20.0									

(Continued Next Page)

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
20.0									
	HQ Core		0	0	9	7	No recovery, likely decomposed (W9) quartz monzonite, very soft (H7).		No Recovery (material likely removed during drilling by circulation water.)
22.5									
			20	0	9	7	6 inches of decomposed quartz monzonite with feldspars up to 1/2 inch, light yellowish brown (2.5Y 6/4) and light olive brown (2.5Y 5/6), decomposed (W9) and very soft (H7), argillic alteration.		
25.0									Drilling induced rubble.
27.5			20	0	9	7	1 foot of decomposed (W9) quartz monzonite, very soft (H7), light olive brown (2.5Y 6/4).		No Recovery (material likely removed during drilling by circulation water.)
30.0									Drilling induced rubble.

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
30.0									
	HQ Core						Some lost circulation with water at 30 to 30.5 feet bgs.		No Recovery (material likely removed during drilling by circulation water.)
32.5									
			26	0	9	4	1.3 feet of coarse-grained sand/fine gravel, angular fragments of fine-grained decomposed (W9) quartz monzonite with trace FeOx, some fine- to medium-grained sand and coarse-grained sand, light yellowish brown (2.5Y 6/3), moderately hard (H4).		
						3	Grades to hard (H3).		Drilling induced rubble.
35.0									
									No Recovery (material likely removed during drilling by circulation water.)
37.5									Drilling induced rubble.
			50	40	9	6	Fine- to coarse-grained quartz monzonite, decomposed (W9) with feldspars to 1/2 inch, light yellowish brown (2.5Y 6/3), soft (H6), argillic alteration throughout, some manganese at 37.5 feet.		
40.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
40.0									
42.5	HQ Core		60	45	9	6 to 7	Fine to coarse-grained quartz monzonite, decomposed (W9), feldspars argillically altered, soft (H6) to very soft (H7), generally pale yellow (2.5Y 7/5), strong argillic alteration throughout.		No Recovery (material likely removed during drilling by circulation water.) Rubble of hard (H3) fine grained quartz monzonite
45.0							Quartz monzonite from about 45 feet to EOB.		20° manganese. 20° 30° healed. 10° 20° with manganese. 10° with manganese. 20° with trace manganese.
47.5			100	95	6	4	Fine to coarse-grained quartz monzonite, feldspars to 1/2 inch, moderately hard (H4), intensely to moderately weathered (W6), manganese along fractures grading to FeOx at 49.6 feet, generally light greenish gray (10Y 7/1) and reddish brown (2.5YR 7/3).		0.2 gap with mangane 40° with trace FeOx 20°
50.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
50.0									
52.5	HQ Core		100	80	4	3 to 4	Fine- to very coarse-grained quartz monzonite with feldspars up to 1 inch, hard (H3) to moderately hard (H4). Moderately to slightly weathered (W4), FeOx and argillic alterations along fractures, pale yellow (2.5Y 7/5).		FeOx 90° healed. 70° with FeOx 10° with FeOx (0.1 inch) and trace argillic. 80° with FeOx (0.1 inch). 60° 10° highly fractured to BX4, strong FeOx 60° 10° 10° 20° with FeOx
55.0									
57.5			100	93	3	3	Fine- to very coarse-grained quartz monzonite with feldspars up to 1 inch, light greenish gray (10Y 7/1) and reddish brown (2.5YR 7/3) with some pale yellow (2.5Y 7/5), slightly weathered (W3) and hard (H3).		70° fractured to BX4, strong FeOx 10° 60° FeOx (0.1 inch). 80° trace FeOx (0.1 inch). 20° trace FeOx 10° FeOx (0.1 inch). 10° 50° with medium sand (0.2 inch). 40° 10° fresh. 80° healed.
60.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
60.0									
62.5	HQ Core		100	90	3	3	Fine- to very coarse-grained quartz monzonite, feldspars to 1.5 inch, slightly weathered (W3) to intensely weathered (W7) at 62 feet, generally hard (H3) grading to soft (H6) where argillic alteration in feldspar. Generally light gray (10Y 7/1) and reddish brown (2.5YR 7/3).		80° 70° with trace FeOx. 60° with trace fine sand. 50° with FeOx. 50° with strong argillic and manganese. microfractured with weak FeOx. 30° 50° with FeOx (0.1 inch). 0° with trace manganese.
65.0									
67.5			95	68	3	3	Fine- to very coarse-grained quartz monzonite, feldspars to +1.5 inch, generally slightly weathered (W3) with intensely to moderately weathered (W6) locally where argillic. Generally hard (H3) grading to very soft (H7) where argillic. FeOx and argillic along fractures, greenish gray (10Y 7/1) and reddish brown (2.5YR 7/3).		10° 50° 10° 2 inches of fine to medium sand with argillic alteration. weak FeOx. 20° 1.5 inches of argillic alteration with FeOx. 0° healed FeOx. 60° 30° fractures with wea FeOx, weak argillic. 70°
70.0					6	7			grades to fresh argillic with FeOx at 69.5 feet alteration.

End of borehole at 70.0 feet.

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CD-B4

CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DRILLING DATE 9/13/2011 **COMPLETION DATE** 9/13/2011 **LOGGED BY** Bill Bragdon

DRILL METHOD HSA / Core **BOREHOLE DIAMETER** HSA 8 inch, 0 to 29 feet; Core 2.5 inch, 29 feet to EOB **DRILLING COMPANY** Ruen Drilling

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
0.0							Silty and sandy clay to about 22.3 feet.		
	SS	3 4 5	87	NA	NA	NA	Silty clay (CL), pale brown (10YR 6/3), low to medium plasticity, soft to medium stiff, dry, few roots and organics.		
2.5									
	SS	5 4 3	67	NA	NA	NA	Silty clay (CL) as above, increase in roots, grades to yellowish brown (10YR 5/6), clumpy clay, breaks under finger pressure.		
5.0	SS	1 1 5	87	NA	NA	NA	Silty clay (CL), reddish brown (7.5 YR 7/6), very soft grading to medium stiff, dry, trace fine- to medium-grained sand at about 5 feet, grades to very stiff to hard, cannot break with fingers.		
7.5	CA	20 30 50	100	NA	NA	NA	Silty clay (CL), as above at 4.0 feet.		
	SS	18 40 49	100	NA	NA	NA	Silty clay (CL), light yellowish brown (10YR 6/4), low plasticity, very stiff to hard, dry, crumbles under hard finger pressure.		
10.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
10.0									
12.5	SS	14 28 42	100	NA	NA	NA	Silty clay (CL) as above at 7.5 feet with medium plasticity, crumbles easily under finger pressure.		
15.0	SS	14 26 45	100	NA	NA	NA	Clay with trace silt (CL), pale yellow (2.5Y 7/3), medium plasticity, very stiff to hard, dry, crumbles under finger pressure, trace manganese spots locally.		
17.5	SS	13 27 43	100	NA	NA	NA	As above at 14 feet, crumbles under slight to strong finger pressure.		
20.0	SS	11 20	100	NA	NA	NA	Fine to sandy clay (CL), yellowish brown (10YR 5/4), medium plasticity, very stiff, dry to slightly moist on sampler, crumbles under strong finger pressure, trace FeOx and manganese spots.		

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
20.0		25							
22.5	SS	41 39 43	100	NA	9	NA	Weathered quartz monzonite from 22.3 feet to about 30 feet bgs. Fine- to coarse-grained sand fragment of weathered quartz monzonite (W9), generally brown (7/5YR 5/3) with trace of FeOx and manganese locally, few fine-grained coarse angular gravel of gray (N5), dry to slightly moist feldspar altered to clay.		
	SS	50	100	NA	9	NA	Decomposed (W9) quartz monzonite as above at 22 feet, breaks under finger pressure. 50 blows for 5 inches. Retained a 5-gallon bucket from cutting at 23 to 29 feet bgs.		
25.0									
27.5									
	SS	50	100	NA	9	NA	Decomposed (W9) quartz monzonite, brown (7/5YR 5/3), 50 blows for 3 inches.		
							Practical HSA refusal. Switched to HQ core.		
30.0	HQ Core		100	88	9	7	Decomposed (W9) fine- to medium- grained quartz monzonite feldspars argillically altered, some FeOx, very soft (H7), generally reddish yellow (7.5YR 6/6).		

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
30.0							Quartz monzonite from about 30 feet to EOB.		
32.5	HQ Core		100	88	9	7	Fine- to medium-grained quartz monzonite feldspars argillically altered, some FeOx, decomposed (W9), very soft (H7), generally reddish yellow (7.5YR 6/6).		Broken to rubble.
					8		Feldspar to 0.5 inch, grades to soft (H6).		Strong FeOX alteration.
35.0							Grades to intensely weathered (W8) at 35 feet with feldspars to 1.5 inch, generally 1.5 to 1 inch.		Vugs of strong FeOx, 0.2 feet deep.
							Grades to pale yellow (5Y 8/4).		10°
37.5			72	72	8	6	Fine- to medium-grained quartz monzonite, feldspars argillically altered, some FeOx, intensely weathered (W8), soft (H6).		10°
40.0									No Recovery (material likely removed during drilling by circulation water.)

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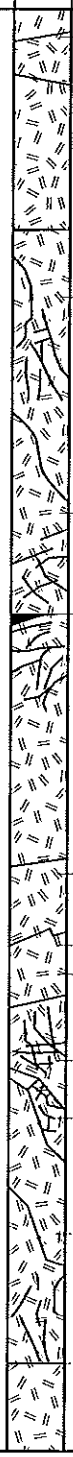
CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
40.0									
42.5	HQ Core		100	100	8 to 9	6 to 7	Fine- to very coarse-grained quartz monzonite, strong argillic alteration throughout, soft (H6) to very soft (H7), decomposed (W9) to very weathered (W8) locally. Feldspar to 1.5, light greenish gray (5GY 8/1) and pale yellowish (5Y 8/4) with FeOx and manganese.		10° 10° very soft. 90° 80° microfractures. 0°
45.0									8° 20° 20° strong manganese.
47.5			96	84	4	4	Fine- to very coarse-grained quartz monzonite, feldspar to 1.5 inch, weak argillic, strong manganese and moderate FeOx. Generally light greenish gray (5GY 8/1) and pale yellowish (5Y 8/4), moderately to slightly weathered (W4), moderately hard (H4).		Microfractures (healed). 70° microfractures with manganese in feldspar to 1.5 inches. 70° with weak FeOx. 0° with FeOx.
50.0									



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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
50.0									
52.5	HQ Core			100	3	3	Fine- to very coarse-grained quartz monzonite with feldspar up to 2 inches, generally 0.5 to 1 inch, trace FeOx at 50 to 50.5 feet, light greenish gray (5G 7/1) to pale green (5G 8/2) and pale red (10R 7/3), hard (H3), slightly weathered (W3) to slightly weathered to fresh (W2).		40° 50° with trace FeOx. 10° 50° 70° 0° 5° 80° 80° 0° 80°
55.0			100	96	2	3	Quartz monzonite as above at 50 to 54.5 feet, increase in argillic alteration in fillings along fractures, slightly weathered to fresh (W2), hard (H3).		70° 50° 90° with trace of fine sand and argillic alteration. 70° 50° 50° 50° 80° 90° very fractured with trace argillic filling. 80° 8° argillic filling. 5° pale green clay (0.8 inches) strong argillic alteration. 60°
57.5									

End of borehole at 59.5 feet.

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BOREHOLE ID: B-04

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DATE(S) OF DRILLING: *10/11/2010 - 10/13/2010* **GROUND ELEVATION:** *2,684.8 ft* **HOLE SIZE:** *4.5" 0'-4.5', 3.8" 4.5'-142'*

LOGGED BY: *Phil Leonhardt, Joe Reed* **NORTHING:** *353,220 ft* **SAMPLE:** *Split Spoon SPT, HQ3*

DRILLING CONTRACTOR: *Ruen Drilling, Inc* **EASTING:** *311,998 ft* **GROUNDWATER:** *Unknown - Drilling With Water*

DRILL RIG: *BK-66* **LOCATION:** *South WR Pile* **DEPTH TO SOIL/BEDROCK:** *133.9/137 ft*

METHOD: *HWT Casing Advance* **TOTAL DEPTH:** *142 ft* **NOTES:** *None Recorded*

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
0						
					0.0 HWT CASING ADVANCE IN WASTE ROCK	2684.8
2						
4					4.5	2680.3
					HQ3 CORE **WASTE ROCK**	
6						
8						
10	RC	2.5				
12						
14						
16						
18						
20	RC	2.2				
22						
24						
26	RC	1.5				
28						
30						

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BOREHOLE ID: B-04

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
30					HQ3 CORE *(continued)*
32	RC	2.1			
34					
36	RC	1.2			
38	RC	0.5			
40					
42					
44	RC	1.8			
46					
48					
50	RC	1.2			
52					
54					
56	RC	1			
58					
60					
62	RC	1.5			
64					

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BOREHOLE ID: B-04

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
66	RC	1			HQ3 CORE *(continued)*
68	RC	1.2			
70, 72, 74, 76	RC	4			
78, 80	RC	2.5			
82, 84, 86	RC	1.2			
88, 90	RC	2			
92	RC	1			
94, 96	RC	0.6			
98	RC	1.5			

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BOREHOLE ID: B-04

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
					HQ3 CORE *(continued)*
100					
102					
104	RC	1.1			
106					
108					
110	RC				
112					
114	RC				
116					
118	RC	1.7			
120					
122					**WASTE ROCK (120.0 - 125.0)** Rock and rock pieces with some clay
124	RC	1.6			
					125.0 2559.8
126	SPT		17-1/0"		**WASTE ROCK (125.0 - 130.0)** Mostly gravelly clay
128	RC	2.8			
130					130.0 2554.8
	SPT	0.1	27/4"		
132	RC	3			

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BOREHOLE ID: B-04

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
134					HQ3 CORE *(continued)*	
					133.9 **WASTE ROCK (130.5 - 133.9)**	2550.9
	SPT	1.5	13-16-21		Rock with 0.1 foot Foundation Soil in shoe	
					FOUNDATION SOIL (133.9 - 137.0)	
136	SPT	1.2	12-28-53		Clay, dark gray (10YR 4/1), moist, very stiff, trace coarse sand, trace gravel, high plasticity, trace roots	
					137.0	2547.8
138	SPT	0.8	22-42-35/2"		**WEATHERED BEDROCK (137.0 - 142.0)** light brownish gray (10YR 6/2), granitic	
140	RC	0				
142	RC	0.3				
					142.0	2542.8

Bottom of hole at 142.0 feet.

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BOREHOLE ID: B-05

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DATE(S) OF DRILLING: *09/30/2010 - 10/05/2010* **GROUND ELEVATION:** *2,699.6 ft* **HOLE SIZE:** *4.5" 0-70, 3" 70-72, 2.5" 72-73.5, 2" 73.5-75*

LOGGED BY: *Ed Muller/Joe Reed* **NORTHING:** *353,771 ft* **SAMPLE:** *Split Spoon (SPT, 2.5", and 2"ID)*

DRILLING CONTRACTOR: *Ruen Drilling, Inc* **EASTING:** *311,988 ft* **GROUNDWATER:** *Unknown - Drilling With Water*

DRILL RIG: *BK-66* **LOCATION:** *South WR Pile* **DEPTH TO SOIL/BEDROCK:** *62.5/NA ft*

METHOD: *HWT Casing Advance* **TOTAL DEPTH:** *75 ft* **NOTES:** *None Recorded*

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
0					0.0 HWT CASING ADVANCE IN WASTE ROCK	2699.6
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						
22						
24						
26						
28						
30						

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BOREHOLE ID: B-05

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
					HWT CASING ADVANCE IN WASTE ROCK *(continued)*
32					
34					
36	SS 2.5"	0.7	10-11-11-7		
38	SS 2.0"	0.1	7-6-12		
40	SPT	0.6	9-7-8		
42	SS 2.5"	1.1	17-19-18-15		
44	SS 2.0"	1	9-13-15		
46	SPT	1.3	7-8-7		
48	SS 2.5"	1.3	7-12-28-19		
50	SS 2.5"	0.6	8-8-7		
52	SPT	0.4	5-9-11		
54	SS 2.5"	0.7	12-15-21-15		
56	SS 2.0"	1	10-13-14		**WASTE ROCK (52.0 - 53.5)** Gravelly sandy silty clay, CL, yellowish red (5YR 4/6), slightly moist, stiff, 10% small gravel, 30% fine to coarse sand, 60% fines, cohesive (53.5 – 2646.1)
58	SPT	1.3	6-12-15		**WASTE ROCK (53.5 - 55.0)** Gravelly sandy silty clay, ML-CL, reddish brown (5YR 4/4), moist, medium stiff, 20% small gravel, 30% fine to coarse sand, 50% fines, medium cohesive (55.0 – 2644.6)
60	SS 2.5"	1.8	11-16-21-26		**WASTE ROCK (55.0 - 62.0)**
62	SS 2.0"		11-17-28		
64	SPT		7-11-12		
	SS 2.5"	1.2	11-18-29		(62.0 – 2637.6)
					(62.5 – 2637.1) Rock at 62 feet, refusal with split spoon (2.0"), HWT past rock
	SS 2.5"	1.5	5-9-16		**FOUNDATION SOIL (62.5 - 64.0)** Sandy silty clay, greenish black (10Y 2.5/1), moist, very stiff, 30% very fine quartz and mica sand, 70% fines, high plasticity, cohesive, slight organic odor, abundant roots at top decreasing with depth (64.0 – 2635.6)
	SS 2.0"	1.9	8-12-14		

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BOREHOLE ID: B-05

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
66	SS 2.5"	1.5	10-11-16		65.5 HWT CASING ADVANCE IN WASTE ROCK *(continued)*	2634.1
					FOUNDATION SOIL (64.0 - 65.5) Sandy silty clay, dark greenish gray (Gley 1 4/6), moist, very stiff, 30% very fine quartz and mica sand, 70% fines, high plasticity, cohesive, slight organic odor, few roots *(continued)*	2632.6
68	SS 2.0"	1.5	7-9-11		67.0 **FOUNDATION SOIL (65.5 - 67.0)** Sandy silty clay, dark yellowish brown (10YR 4/6), moist, stiff, 40% very fine quartz sand, 60% fines, medium plasticity, cohesive	2631.1
70	SPT	1.5	6-8-12		68.5 **FOUNDATION SOIL (67.0 - 68.5)** Sandy silty clay, mottled brownish yellow (10YR 6/6) and brown (10YR 4/3), moist, soft, 30% very fine sand, 70% fines, medium-high plasticity, slightly cohesive	2629.6
72	SS 2.5"	2	9-11-15		70.0 **FOUNDATION SOIL (68.5 - 70.0)** Sandy silty clay, dark grayish brown (2.5Y 4/2), moist, soft, 30% very fine sand, 70% fines, medium-high plasticity, cohesive, borehole measured 70.5 feet at end of drive	
74	SS 2.0"	2	8-11-15		73.5 **FOUNDATION SOIL (70.0 - 73.5)** Sandy silty clay, mottled brownish yellow (10YR 6/6) and brow (10YR 4/3), moist, soft, 30% very fine sand, 70% fines, medium plasticity, cohesive	2626.1
	SPT	1	10-13-20		75.0 **FOUNDATION SOIL (73.5 - 75.0)** Clayey silty sand, brownish yellow (10YR 4/6), wet, loose, 60% very fine to fine sand, 40% fines, trace gravel up to 10mm, slighty cohesive	2624.6

Bottom of hole at 75.0 feet.

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BOREHOLE ID: B-06

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DATE(S) OF DRILLING: *09/26/2010 - 09/29/2010* **GROUND ELEVATION:** *2,686.5 ft* **HOLE SIZE:** *4.5" 0'-31', 3.8" 31'-144.5', 2" 144.5'-146.0'*

LOGGED BY: *Joe Reed* **NORTHING:** *353,058 ft* **SAMPLE:** *Split Spoon SPT, HQ3*

DRILLING CONTRACTOR: *Ruen Drilling, Inc* **EASTING:** *311,602 ft* **GROUNDWATER:** *Unknown - Drilling With Water*

DRILL RIG: *BK-66* **LOCATION:** *South WR Pile* **DEPTH TO SOIL/BEDROCK:** *136.2/143 ft*

METHOD: *HWT Casing Advance, HQ3 Core* **TOTAL DEPTH:** *146 ft* **NOTES:** *None Recorded*

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
0					0.0 HWT CASING ADVANCE IN WASTE ROCK	2686.5
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						
22						
24						
26						
28						
30						

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BOREHOLE ID: B-06

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
30					HWT CASING ADVANCE IN WASTE ROCK *(continued)*
					31.0 — 2655.5
32					HQ3 CORE
					WASTE ROCK
34	RC	2			
36					NEW BIT AT 36 FEET
38	RC	2			
40					
42					
44	RC	0.3			
46					
48	RC	0			
50	RC	0			
52					
54	RC	1			
56					
58	RC	4.4			
60					
62					
64	RC	0.7			

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BOREHOLE ID: B-06

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
					HQ3 CORE *(continued)*
66	RC	1.2			
68	RC	1.7			
70					
72	RC	1.6			
74					
76					
78	RC	2			
80					
82					
84					
86					
88	RC	0.7			
90	RC	1.7			
92					
94					
96	RC	2			
98					

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CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
					HQ3 CORE *(continued)*
100					
102	RC	1.5			
104	RC	0.5			
106					
108	RC	1.3			
110					
112	RC	0.8			
114					
116					
118	RC	4.5			
120					
122					
124	RC	1.4			
126	SPT	0.4	16-11-16-6/4"		**WASTE ROCK (125.0 - 127.0)** Rock and Gravel
					127.0 — 2559.5
	RC				**WASTE ROCK**
128	SPT	0.8	6-10-11-22		
130					
132	RC	1			

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BOREHOLE ID: B-06

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
134	SPT	0.5	10-18-24		HQ3 CORE *(continued)*	
	SPT	0.1	22-1/0"			
	RC	1.8				
136	SPT	1.3	14-15-14		136.2	2550.3
					FOUNDATION SOIL (136.2 - 138.5) Clay, OH/CH, black (10YR 2/1) and dark yellowish brown (10YR 4/4) and dark reddish brown (5YR 3/4), slightly moist to moist, very stiff, trace fine to medium sand, trace fine gravel, high plasticity, trace mica, HCl none, trace roots, organic, possibly disturbed	
138	SPT	1.5	14-22-23		138.5	2548.0
					FOUNDATION SOIL (138.5 - 143.0) Clay, black (10YR 2/1), slightly moist to moist, stiff, trace fine to coarse sand, trace fine gravel, organic, very plastic, trace roots, density increases with depth to very stiff then hard	
140	SPT	1.2	8-11-13			
	SPT	1.5	17-20-22			
142	SPT	1.2	11-22-31		143.0	2543.5
					WEATHERED BEDROCK (143.0 - 146.0)	
144	SPT	1	32-41-30			
146	SPT	0.8	12-17-30		146.0	2540.5

Bottom of hole at 146.0 feet.

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BOREHOLE ID: B-07

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DATE(S) OF DRILLING: *10/01/2010 - 10/07/2010* **GROUND ELEVATION:** *2,705.3 ft* **HOLE SIZE:** *4.5" 0'-55', 3" 55-57, 2.5" 57-58.5, 2" 58.5-60*

LOGGED BY: *Ed Muller* **NORTHING:** *353,593 ft* **SAMPLE:** *Split Spoon (SPT, 2.5", and 2"ID)*

DRILLING CONTRACTOR: *Ruen Drilling, Inc* **EASTING:** *311,532 ft* **GROUNDWATER:** *Unknown - Drilling With Water*

DRILL RIG: *BK-66* **LOCATION:** *South WR Pile* **DEPTH TO SOIL/BEDROCK:** *47.5/NA ft*

METHOD: *HWT Casing Advance* **TOTAL DEPTH:** *60 ft* **NOTES:** *None Recorded*

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
0						
					0.0 HWT CASING ADVANCE IN WASTE ROCK	2705.3
2						
4						
6						
8						
					9.0	2696.3
10	SS 2.5"	1.5	3-2-2-2		TELESCOPE IN WITH SAMPLERS 5 FEET THEN ADVANCING HWT CASING 5 FEET	
12	SS 2.5"	0.8	23-22			
	SS 2.0"	0.8	2-2-3			
14	SPT	0	3-4-5			
16	SS 2.5"	0.6	4-12-13-10			
18	SS 2.0"	0.6	8-11-11			
20	SPT	0	6-6-5			
22	SS 2.5"	1	7-6-9-6			
	SS 2.0"	0.5	5-4-6			
24	SPT	0.5	3-4-5			
26	SS 2.5"	1.3	3-4-4-6			
28	SS 2.0"	1	5-4-5			
30	SPT	0.7	4-5-10			

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BOREHOLE ID: B-07

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
30					
32	SS 2.5"	1	14-15-14-11		TELESCOPE IN WITH SAMPLERS 5 FEET THEN ADVANCING HWT CASING 5 FEET *(continued)*
34	SS 2.0"	0.5	7-7-7		**WASTE ROCK (32.0 - 33.5)** Gravelly Sandy Clay, dark gray (2.5 Y 4/1), moist, soft, non cohesive, gravel up to 3 mm, granite altered to primary clays with quartz crystals (33.5, 2671.8)
	SPT	0.5	3-3-8		**WASTE ROCK (33.5 - 47.5)**
36	SS 2.5"	1.3	46-44-22-16		
38	SS 2.0"	1.3	9-10-39		
40	SPT	0.6	12-15-14		
42	SS 2.5"	1.3	5-7-12-16		
44	SS 2.0"	0.1	7-8-12		
	SPT	0	6-11-11		
46	SS 2.5"	1	9-46-37-27		
48	SS 2.0"	1.2	6-6-12		(47.5, 2657.8) **FOUNDATION SOIL (47.5 - 48.0)** Organic Silty Clay, black (10YR 2/1), moist, soft, cohesive, low plasticity, mud (48.0, 2657.3)
50	SPT	0.4	3-7-11		**FOUNDATION SOIL (48.0 - 50.0)** Silty Clay, brown (10YR 4/3), moist, soft, cohesive, medium plasticity, trace small gravel, abundant roots (50.0, 2655.3)
52	SS 2.5"	2	6-11-15-19		**FOUNDATION SOIL (50.0 - 53.0)** Gravelly Sandy Clay, brown (7.5YR 4/4), moist, stiff, 70% fine sand, 20% very fine sand, 10% gravel, cohesive, medium plasticity, some roots (53.0, 2652.3)
54	SS 2.0"	2	6-13-15		**FOUNDATION SOIL (53.0 - 53.5)** Clayey Sandy Gravel, dark grayish brown (2.5Y 3/2), moist, loose, 40% fines, 20% fine to coarse sand, 40% gravel to less than 40 mm, cohesive (53.5, 2651.8)
	SPT	0	2-7-12		NO RECOVERY (55.0, 2650.3)
56	SS 2.5"	1.7	10-16-16-19		**FOUNDATION SOIL (55.0 - 57.0)** Gravelly Clay, dark yellowish brown (10YR 4/4), moist, stiff, with 35% small to large (less than 30 mm) gravel, medium plasticity (57.0, 2648.3)
58	SS 2.0"	2	7-11-16		**FOUNDATION SOIL (57.0 - 58.5)** Gravelly silty clay, dark gray (10YR 4/1), moist, medium stiff, with 20% small gravel, moderately cohesive, low to medium plasticity, some roots (58.5, 2646.8)
60	SPT		5-9-16		**FOUNDATION SOIL (58.5 - 60.0)** Gravelly silty clay, brown (10YR 4/3), moist, stiff, with 10% small gravel, cohesive, low plasticity (60.0, 2645.3)

Bottom of hole at 60.0 feet.

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BOREHOLE ID: B-08

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DATE(S) OF DRILLING: *07/10/2010 - 08/21/2010* **GROUND ELEVATION:** *2,697.0 ft* **HOLE SIZE:** *5.5" 0'-12', 4.5" 12'-86', 3.8" 86'-108.5'*

LOGGED BY: *Joe Reed* **NORTHING:** *353,049 ft* **SAMPLE:** *Split Spoon (SPT, 2.5", and 2"ID), HQ3*

DRILLING CONTRACTOR: *Ruen Drilling, Inc* **EASTING:** *311,154 ft* **GROUNDWATER:** *Unknown - Drilling With Water*

DRILL RIG: *BK-66* **LOCATION:** *South WR Pile* **DEPTH TO SOIL/BEDROCK:** *95.5/99 ft*

METHOD: *PW and HWT Casing Advance* **TOTAL DEPTH:** *108.5 ft* **NOTES:** *None Recorded*

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
0						
					0.0 PW CASING ADVANCE	2697.0
2						
4						
6						
8						
10						
12					11.5	2685.5
					HWT CASING ADVANCE	
14						
16						
18						
20						
22						
24						
26						
28						
30						
32						
34						
36						
38						
40						

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BORE HOLE ID: B-08

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
40					HWT CASING ADVANCE *(continued)*
42					
44					
46					
48					
50					
52					
54					
56					
58					
60	SS 2.5"	1.3	11-7-38-18		**WASTE ROCK (58.0 - 61.0)** Gravelly Sand, dark yellowish brown (10YR 4/4), wet, dense to very dense, fine to coarse sand and gravel, angular to very angular, slightly cohesive, trace clay, trace silt
61.0					AT 61 FEET START TELESCOPING IN WITH SAMPLERS 5 FEET THEN ADVANCING HWT CASING 5 FEET 2636.0
62	SS 2.5"	1.4	13-12-11-15		**WASTE ROCK (61.0 - 86.0)** Sandy Gravel, dark yellowish brown (10YR 4/4), wet, medium dense, fine to coarse sand and gravel, angular, slightly cohesive, trace clay, trace silt, as above but larger grained
64	SS 2.0"	1.25	10-10-12		
66	SPT	0.9	11-11-10		
68	SS 2.5"	0.6	95-57-23-14		
70	SS 2.0"	0.5	7-6-11		
72	SPT	0.5	5-6-12		
74	SS 2.5"	0.8	12-12-23-24		
76	SS 2.0"	0.75	6-12-25		
78	SPT	0.45	8-11-17		
80	SS 2.5"	0.7	52-27-18-20		
82	SS 2.0"	0.7	7-20-30		
84	SPT	1	10-15-20		
	SS 2.5"	0.2	31-39-22-18		
	SS 2.0"	0.3	5-14-21		
	SPT	0	3-1-50/4"		

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BOREHOLE ID: B-08

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
86					86.0 HQ3 Core 2611.0
88	RC	2.4			**WASTE ROCK (86.0 - 95.5)** Rock core, very hard, HCl weak to none, some angled bedding
90					
92					
94	RC	3.1			
96					95.5 2601.5 **FOUNDATION SOIL (95.5 - 98.5)** Gravelly Sandy Clay, CL, dark brown (10YR 3/3), slightly moist, very hard and dense, fine to coarse sand and gravel in clay matrix, trace roots, medium plasticity, angular to subrounded
98	RC	3.6			98.5 2598.5 **WEATHERED BEDROCK (98.5 - 108.5)** Clayey Sandy Gravel/Clayey Gravelly Sand, yellowish red (5YR 5/6), Slightly moist to dry, dense, fine to coarse sand and gravel, very angular to subrounded, trace silt, trace roots, HCl none, non plastic, well graded, weathering decreases with depth, grain size increases with depth
100					
102	RC	5.5			
104					
106					
108	RC	3.7			108.5 2588.5

Bottom of hole at 108.5 feet.

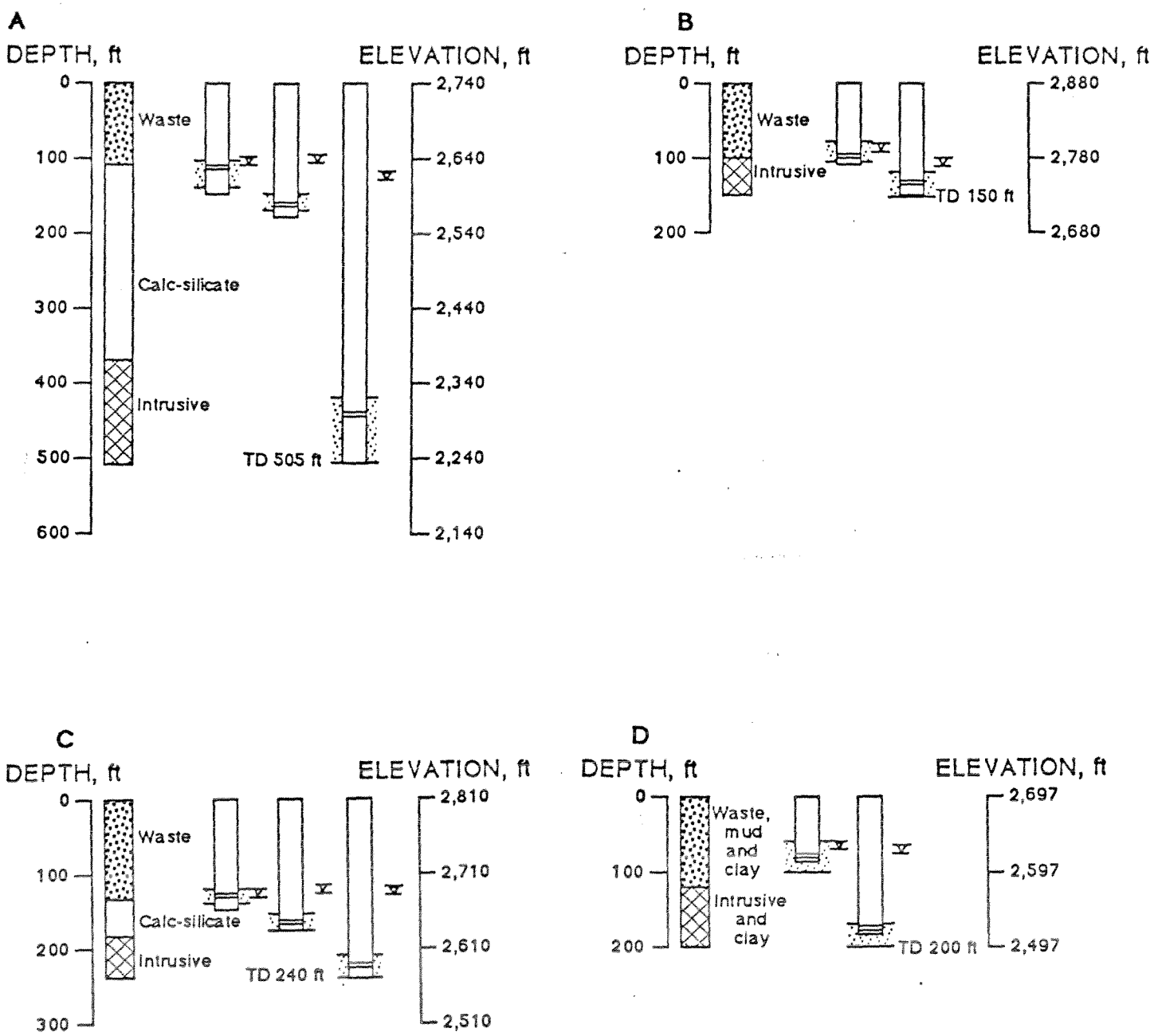
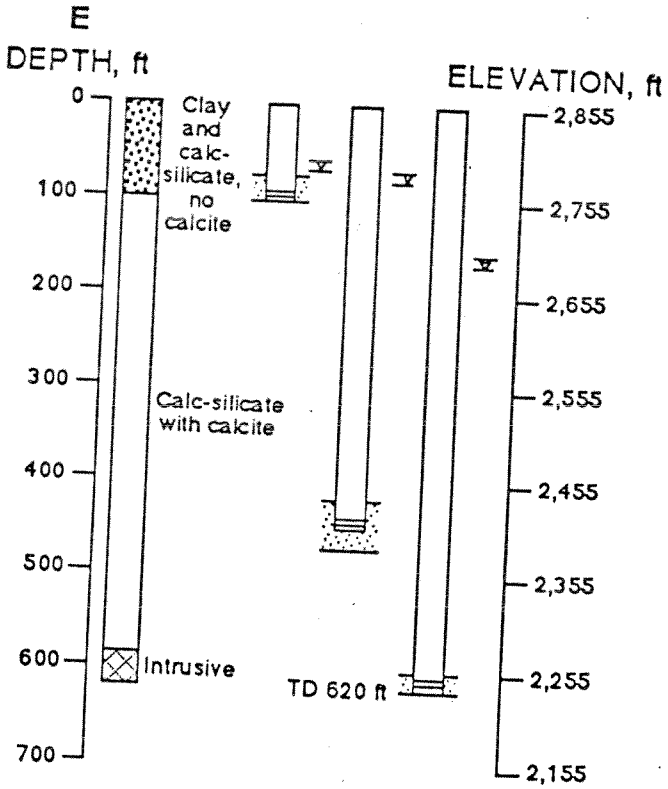
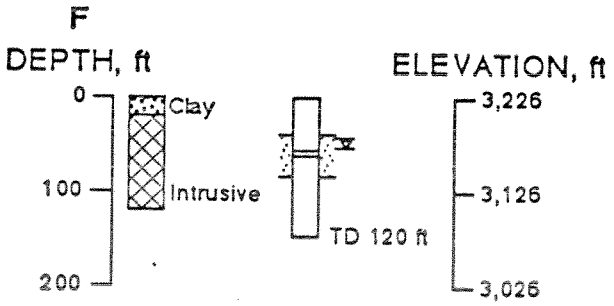


Figure 3. Monitor well completion details:
A, Well 89-1
B, Well 89-2
C, Well 89-3
D, Well 89-4
E, Well 89-5
F, Well 89-6
G, Well 89-7





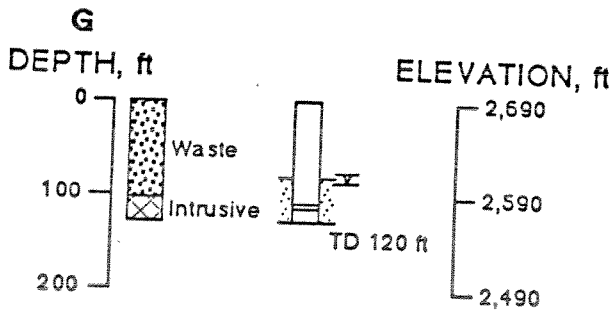


Figure 3. Monitor well completion details: Continued--
A, Well 89-1
B, Well 89-2
C, Well 89-3
D, Well 89-4
E, Well 89-5
F, Well 89-6
G, Well 89-7

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring MWCD-01
	Project Location: Midnite Mine	1 OF 2
	Project Number: 53F4001800.03	

Date(s) Drilled	10/7/99-8/99	Logged By	ROBERT MARTIN	Total Depth of Borehole (ft)	117.5
Drilling Method	AIR ROTARY 8" NOM	Diameter of Borehole (in)	8"	Ground Surface Elevation (ft-msl)	2429.69
Drill Rig Type	STAR 30K	Drilling Company	CASCADE	Groundwater Elevation (ft-msl)	107' BGS
Driller's Name	TODD	Sampler Type	cyclone	Checked By	DK Nicholson	Measuring Point Elevation (ft-msl)	GROUND SURFACE
Locations / Comments	Central Drainage					Northing / Easting	352337 / 2671713

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer Saturation	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	1609		160			SC		CLAYEY SAND - MOIST, DARK BROWN, FINE SAND	
8	1618 1626		155			SC		CLAYEY SAND - DARK BROWN, FINE SAND.	8' - ADDING WATER ADD RODS AT 8' FOR DRILLING.
13	1630 1637		50			CL		CLAY WITH SAND - GRAY, FINE SAND.	
18	1641 1657		50			CL		CLAY WITH SAND - GRAY CLAY W/ LIGHT BROWN LUMPS OF CLAYEY SAND	
23	1700		60			CL		CLAY WITH SAND - GRAY W/ COARSE SAND	
28	1703 1740		65			CL		CLAY WITH SAND - SAME AS ABOVE	28 - @ BOTTOM SOME YELLOW-BROWN SAND POSSIBLE BEDROCK.
33	1752 1755		40					QUART MONZONITE, MEDIUM TO COARSE GRAINED	30 - HOLE MAKING 1-2 GPM 31 - IN BEDROCK, HARDER DRILLING.
38	1803 1857		35						10/8/99 - WATER IN HOLE AT START
43	800		53						
48	805 810		45						48 - CUTTINGS DRY
53	814		45						54 - A LITTLE HARDER NO WATER AT START
58	819 823		50						
63	831		50						62 - HAVING TROUBLE W/ CUTTINGS COMING OUT OF HOLE.
68	840 846		55						66' - ADDING MORE WATER TO CLEAR CUTTINGS.
73	854		45						

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring MWCD-01 2 OF 2
	Project Location: Midnite Mine	
	Project Number: 53F4001800.03	

Date(s) Drilled 10/7/99	Logged By ROBERT MARTIN	Total Depth of Borehole (ft) 117.5
Drilling Method AIR ROTARY 8" NOM	Diameter of Borehole (in) 8'	Ground Surface Elevation (ft-msl)
Drill Rig Type STAR 30K	Drilling Company CASCADE	Groundwater Elevation (ft-msl) 107' BGS
Driller's Name TODD / Sampler Type	Checked By DK Nicholson	Measuring Point Elevation (ft-msl) GROUND SURFACE
Locations / Comments		Northing / Easting

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	RQD (%)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
78	90 / 91		50						78 - WET AT START BUT INJECTING WATER POSSIBLE H_2O AT 78-79 (AS PER TODD). 80' - STOPPED INJECTING H_2O, LOOKS WET. 83' - NOT INJECTED H_2O CUTTINGS WET IN CLUMPS 89' - INJECTING H_2O
83	91 / 6		40						
88	92 / 93		45						
93	93 / 9		40						
98	94 / 95		45						98-98 DRILLER SAYS HARD 99 - SOFTER DRILLING
103	100		30						107 - LARGE 1-2" ~~CHUNK~~ CHIPS OF ROCK IN CUTTINGS - FRESH NOT INJECTING H_2O WET AT 108'
108	100 / 101		50						
113	102 / 4		40						111' - HOLE PRODUCING A LITTLE WATER. < 1 GPM 114' - STARTED INJECTING WATER - TOO DRY TO GET CUTTING OUT.
118	103 / 5		30						
123								TOTAL DEPTH 117.5'	
12									
14									

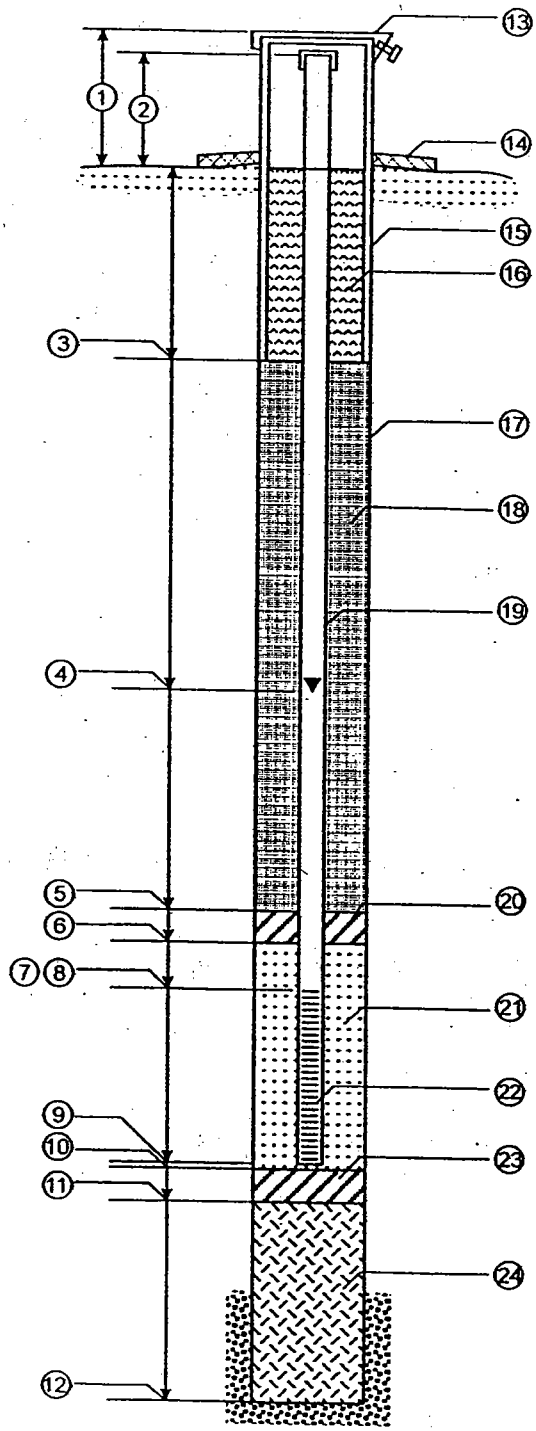
URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Project Number	Project Name	Date/Time Started
53F4001800.03	MIONITE MINE	~~10/8/99~~ 10/7/99 16:00
Well/Borehole Number	**Well/Borehole Location**	**Date/Time Completed**
MWCD-01	Central Drainage	10/8/99 16:30

Installation Team	Type of Drilling	Ground Surface Elev.	Top of Well Casing Elev.
TEAM #3	AIR ROTARY	2429.69 ft.msl	2431.29 ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: ~~2.45~~ 2.8 ft.
2. Stick-Up Well Casing Above Ground: 1.6' ~~2.7~~ ~~2.45~~ ft. DKN 10-12-99
3. Depth to Bottom of Upper Seal/Protective Casing: _____ ft.
4. Depth to Initial Ground Water Surface Elevation: _____ ft.
5. Depth to Top of Top Seal: 0 ft.
6. Depth to Bottom of Top Seal: 80 ft.
7. Depth to Top of Well Point or Screen: 95 ft.
8. Total Length of Blank Casing: 95 ft.
9. Bottom Depth of Well Screen: 115 ft.
10. Depth to Top of Bottom Seal (If Installed): N/A ft.
11. Depth to Bottom of Bottom Seal (If Installed): N/A ft.
12. Depth of Borehole: 117 ft.
13. Protective Casing: ☒ Yes ☐ No Locking Cap: ☒ Yes ☐ No
14. Sanitary Seal: ☒ Yes ☐ No
15. Type of Protective Casing: STEEL Diameter: 8 in.
16. Type of Upper Seal: ~~Portland~~ Concrete DKN
17. Borehole Diameter: 8 in.
18. Type of Upper Backfill: cement/bentonite grout
19. Type of Well Casing: PVC SCH 80 Diameter: 4 in.
20. Type of Top Seal (IF Installed): PURE GOLD BENTONITE CHIPS
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: 10x20 Diameter: 8 in.
22. Type of Screen Material: PVC SCH 80 Slot Size: 0.030 in.
23. Type of Bottom Seal (If Installed): N/A
24. Type of Lower Backfill: N/A

Recorded By	Date	Checked By	Date
[signature]	10/7/99	DK Nicholson	4/26/00

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS Project Location: Midnite Mine Project Number: 53F4001800.03	Log of Boring CD-02 PAGE 1 OF 4

Date(s) Drilled 9/23/99 - 9/24/99	Logged By GARRETT BROWN/CH2M HILL	Total Depth of Borehole (ft) 116.8' bgs	
Drilling Method AIR ROTARY WITH CASING DRIVER	Diameter of Borehole (in) 7 7/8" HAMMER BIT	Ground Surface Elevation (ft-msl) ~~TBD~~ 2319.14	
Drill Rig Type INGERSOLL-RAND T3W	Drilling Company CASCADE, SEATTLE	Groundwater Elevation (ft-msl) TBD	
Driller's Name ROB LEININGER	Sampler Type CYCLONE GRAB SAMPLE	Checked By DK Nicholson	Measuring Point Elevation (ft-msl) ~~TBD~~ 2321.29
Locations / Comments 9 3/4" OD (8 1/2" ID) THREADED STEEL CASING			Northing ~~TBD~~ 351136 Easting 2671877

Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS CD-02, is located 80' north of well GW-19
					10YR-3/2	ML		Surface material is sandy silt, dry, non-cohesive, very dark grayish brown (10YR/3-2)	9/23/99 - Began drilling/driving casing at 1355
5	GRAB				10YR-5/4	CL		Clay - very moist, yellowish brown, stiff, cohesive.	1359; RAD=50uR/h SWL ≅ 6' bgs
10	GRAB				10YR-5/4	GM		Sandy to silty gravel - wet, yellowish brown, fine to coarse sand w/ 20% silt and angular to sub-rounded gravel up to 2cm in diameter. Color change to brown (10YR/4-3) at 15-16' bgs.	1415; RAD=38uR/h
15	GRAB GRAB			16'	10YR-5/6	BEDROCK		Porphyritic quartz monzonite - saturated producing 2-3gpm, yellowish brown (unweathered), very weathered and stained, moderately soft. Predom. K feldspar, quartz, plagioclase, and <5% biotite. Coarse grained crystals, especially the K feldspar.	1440; RAD=59uR/h ↳ sample for 16-25' description; collection at 20'
20	GRAB								
25	GRAB				10YR-5/3			As above, only color change to brown (unweathered) and slightly harder and less weathered; producing 2 gpm.	1447; RAD=67uR/h Steel casing set at 28' bgs and began drilling open hole.
30									

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring CD-02
	Project Location: Midnite Mine	PAGE 2 OF 4
	Project Number: 53F4001800.03	

Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
30	GRAB				10YR-5/3	BEDROCK		Porphyritic qtz. monzonite - as above only no more water production. Still wet cuttings	1457; RAD=63uR/h
35	GRAB				10YR-5/6			Porphyritic qtz. monzonite - wet but no H_2O production, yellowish brown (unweathered), mod. hard, slightly weathered pink K feldspar, translucent qtz, greenish white plagioclase, and traced black biotite	1518; RAD=44uR/h
40	GRAB				2.5Y-6/4			As above, only less moist. Begin H_2O injection at 43' to assist in lifting cuttings (< 1 gpm) Harder, slower drilling	1527; RAD=45uR/h
45	GRAB				2.5Y-6/1			Porphyritic qtz monzonite - wet from H_2O injection (<1gpm), hard, competent, gray (unweathered), clean other than slightly weathered and stained K feldspar.	1554; RAD=49uR/h Stopped H_2O injection
50	GRAB				2.5Y-6/1			Porphy. qtz. monzonite - saturated producing 2-3gpm, clean, competent, hard, no weathered surfaces, gray (unweathered),	1618; RAD=56uR/h Slow hard drilling
55	GRAB				2.5Y-6/1			Porphy. qtz. monzonite - as above, hard, gray, competent. Saturated but no water production.	1627; RAD=62uR/h
60	GRAB				2.5Y 7/1			As above, only color change to light gray; producing < 1gpm.	1645; RAD=46uR/h
65									

Woodward Clyde

Project Name: Phase IA RI/FS
Project Location: Midnite Mine
Project Number: 53F4001800.03

Log of Boring CD-02

Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
65	GRAB				2.5Y-7/1	BEDROCK		Porphyritic qtz. monzonite - saturated, producing < 1 gpm, light gray, hard, competent, no weathered surfaces, coarse grained crystals of K feldspar, (pink), greenish plagioclase and hunty qtz.	1700 - RAD=51uR/h
70	GRAB				2.5Y-7/1			Porphyritic qtz. monzonite - as above Producing 2 gpm	1715; RAD=45uR/h
75	GRAB				2.5Y-7/1			Porphy. qtz. monzonite - as above Producing 2 gpm	1740; RAD=61uR/h
80	GRAB				2.5Y 7/1			Porphyritic qtz monzonite - as above Producing 1 gpm	1755; RAD=53uR/h Tripped hole to change out hammer bit. E.O.D. at 1830.
									9-24-99 - Tripped back into hole w/ new bit, Began drilling at 1025 from 81'.
85	GRAB				2.5Y 7/1			Porphy. qtz. monzonite - larger cuttings and less pulverization because of new bit (2-3 gpm), hard, competent, very coarse grains, pink K feldspar, hunty qtz, greenish white plagioclase, 5-10% biotite and trace of pyrite.	1036 - 85' sample RAD=78uR/h Faster drill speed because of new bit.
90	GRAB				2.5Y 7/1			Porphy. qtz. monzonite - as above Producing 2-3 gpm.	1045; RAD=56uR/h
95	GRAB				2.5Y-7/1			Porphy. qtz. monzonite - as above Producing < 1 gpm	1056; RAD=51uR/h
100									

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring CD-02
	Project Location: Midnite Mine	PAGE 4 OF 4
	Project Number: 53F4001800.03	

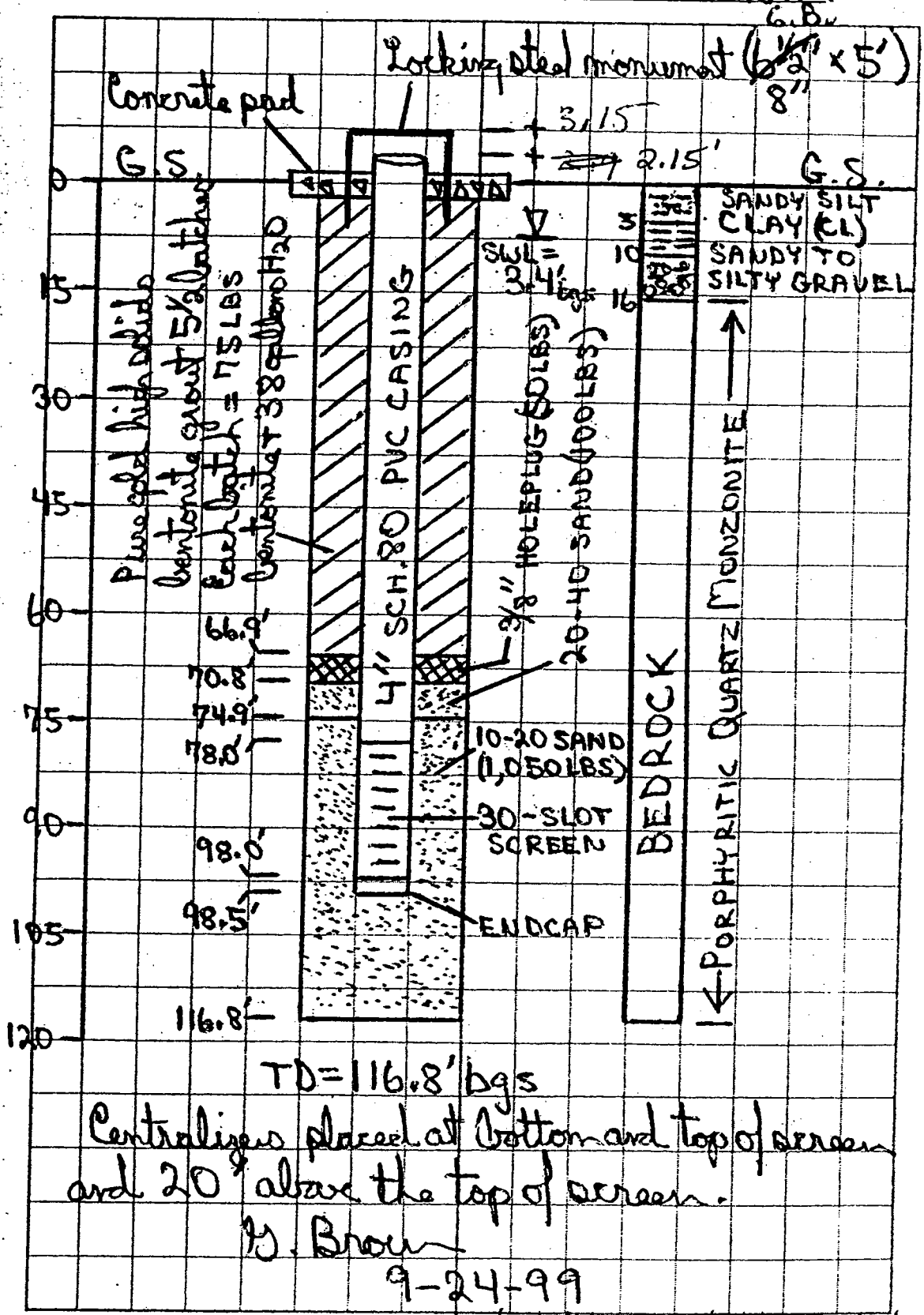
Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
100'	GRAB				2.5Y-7/1	BEDROCK		Porphyritic qtz. monzonite - as above Producing <1 gpm	1104 - RAD=46 uR/h
105'	GRAB				2.5Y-7/1			Porphy. qtz. monzonite - as above Producing <1 gpm	1112 - RAD=59 uR/h
110'	GRAB				2.5Y-7/1			Porphy. qtz. monzonite - as above Producing 1-2 gpm	1120 - RAD=48 uR/h
115'	GRAB				2.5Y-7-1			Porphy. qtz. monzonite - as above Producing <1 gpm	1134; RAD=57 uR/h
								T.D.=116.8' bgs	1137 - Circulated hole w/ 5-10 gpm for 10 minutes until return is clear.
120'									1147-1205 → Stripped hole of drill rods.
125'									1210-1410 - Completed geophysical logging w/ WL (not static) at 65' and rising.
130'									1410-1830 - Completed well and pulled steel casing.
135'									

Notes: Ran caliper, temp, natural gamma, and S.P. geophysical logs after removing drill rods. The temp, gamma, and S.P. logs do not show much. The caliper log shows slight widening of the borehole between 78-80' bgs and 91-92' bgs. Decided to set screen interval (Sch 80; 30-slot) between 78'-98' bgs. Sand pack is placed from bottom of borehole at 116.8' bgs to 70.8' bgs.

Location MWCD-02 Date 9-24-99

Project / Client T28N-R37E-SEC.13-NE¼NW¼

WELL CD-02 COMPLETION DIAGRAM



TD=116.8' bgs

Centralizers placed at bottom and top of screen and 20' above the top of screen.

D. Brown
9-24-99

checked by DK Nicholson 4/26/00

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring MWCD-03
	Project Location: Midnite Mine	
	Project Number: 53F4001800.03	

Date(s) Drilled	10/9/99	Logged By	ROBERT MARTIN	Total Depth of Borehole (ft)	56
Drilling Method	AIR ROTARY 8" NOM	Diameter of Borehole (in)	8"	Ground Surface Elevation (ft-msl)	2495.66
Drill Rig Type	STAR 30K	Drilling Company	CASCADE	Groundwater Elevation (ft-msl)	47' BGS
Driller's Name	TODD	Sampler Type	Cyclone	Checked By	DK Nicholson	Measuring Point Elevation (ft-msl)	GROUND SURFACE
Locations / Comments	Central Drainage					Northing	351788
						Easting	2672362

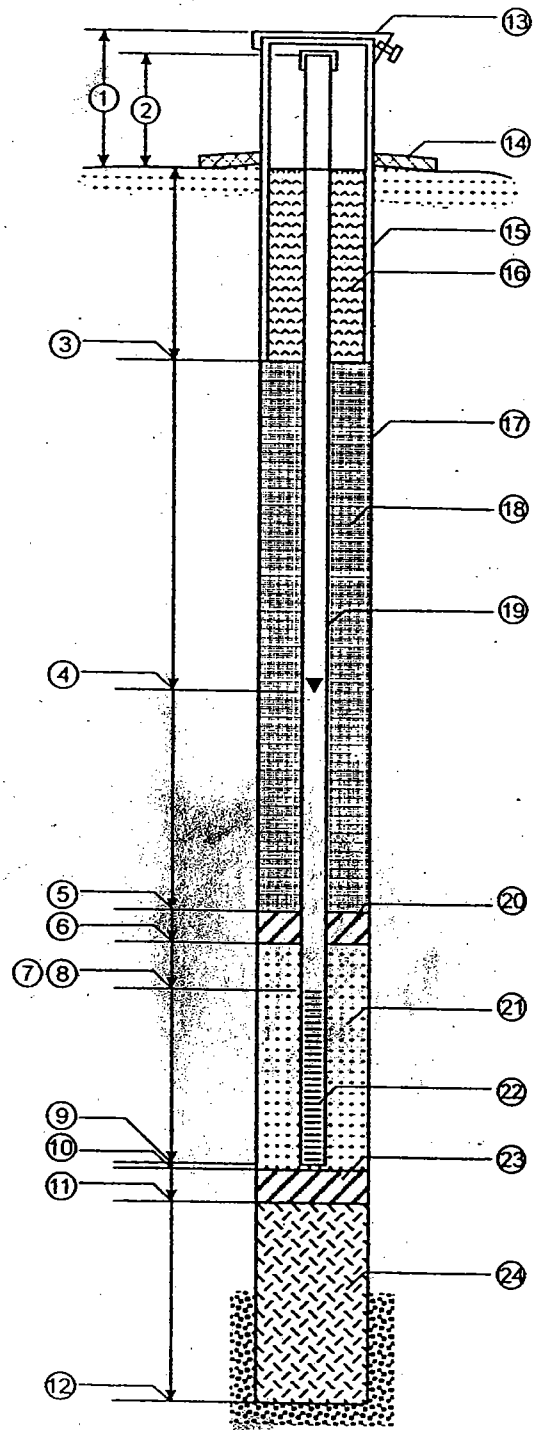
Depth (ft-bgs)	SAMPLES: Blows/Foot	SAMPLES: Recovery (ft)	SAMPLES: PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	950					SM		SILTY SAND, DRY, LIGHT BROWN	1- ROCK, CALC-SILICATES
5	959		35					CALC-SILICATE - DRY - COARSE CUTTINGS, LT. TAN W/ BANDS OF GREEN AND RED BROWN STAINING NO FIZZ W/ HCL	RELATIVELY SOFT DRILLING.
7	1005 1011		20						
12	1021 1044		10					CALC-SILICATE - DRY, NO FIZZ W/ HCL	12' STOPPING TO TUNE BIT. 15' DUST DROPPED, MORE CUTTINGS MUCH FINER
17	1048 1057		15					CALC-SILICATE - MOIST, CUTTINGS FINE, W/ A FEW LARGER CHIPS, SOFTER, COLOR LT. TAN	20' COLOR CHANGE FROM TAN TO GRAY BROWN
22	1103 1108		10					CALC-SILICATE - MOIST, CUTTINGS COARSE, APPARENT LITHOLOGY CHANGE FROM 15-20'	24' DUSTY, INJECTING H2O
27	1136 1144		10					CALC-SILICATE, DRY, CUTTINGS GRAVEL SIZE, TAN-GREEN W/ BANDS	27' BAND OF FINER, SOFTER QTZITE
32	1148 1157		5					CALC-SILICATE - AS ABOVE	
37	1201 1232		20					CALC-SILICATE - SOFT, LT TAN, FINE CUTTINGS W/ SOME COARSER GRAY-GREEN SILICATES	37' BACK INTO SOFT TAN MATERIAL
42									40' LITHOLOGY CHANGE TO GRAY QTZITE 41' - OPEN HOLE DRILLING
46	1254 1259		15					~~CALC-SILICATE~~ APALITE DIKE - HARD, DK GRAY K-SPAR RICH.	47' WATER IN CUTTINGS
52	1305		20					APALITE DIKE - AS ABOVE @ 51.5' BACK INTO CALC-SILICATE SOFT, LT TAN COLOR.	51' INTO SOFTER 2" TAN, FINER GRAINED CALC-SILICATE
56	1314		45					56' CALC-SILICATE, MOIST-WET LT TAN-GREEN CHIPS OF QTZITE	
62									
67								EXTENDED HOLE TO 64' TO COMPLETE WELL	

URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Project Number: 53F4001800.03	Project Name: MIDWITE MINE	Date/Time Started: 10/9/99 09:30
Well/Borehole Number: MWCD-03	Well/Borehole Location: Central Drainage	Date/Time Completed: 10/9/99 17:20
Installation Team: TEAM#3	Type of Drilling: AIR ROTARY	Ground Surface Elev.: 2495.66 ft.msl
		Top of Well Casing Elev.: 2497.44 ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: 2.7 ft.
2. Stick-Up Well Casing Above Ground: ~~2.3 27"~~ 1.8' ft. DKN
3. Depth to Bottom of Upper Seal/Protective Casing: ____ ft.
4. Depth to Initial Ground Water Surface Elevation: ____ ft.
5. Depth to Top of Top Seal: 2 ft.
6. Depth to Bottom of Top Seal: 35 ft.
7. Depth to Top of Well Point or Screen: 40 ft.
8. Total Length of Blank Casing: 40 ft.
9. Bottom Depth of Well Screen: 60 ft.
10. Depth to Top of Bottom Seal (If Installed): N/A ft.
11. Depth to Bottom of Bottom Seal (If Installed): N/A ft.
12. Depth of Borehole: 64 ft.
13. Protective Casing: [X] Yes [ ] No Locking Cap: [X] Yes [ ] No
14. Sanitary Seal: [X] Yes [ ] No
15. Type of Protective Casing: STEEL Diameter: 8 in.
16. Type of Upper Seal: ~~PORTLAND~~ DKN Concrete
17. Borehole Diameter: 8 in.
18. Type of Upper Backfill: cement/bentonite grout
19. Type of Well Casing: PVC SCH 80 Diameter: 4 in.
20. Type of Top Seal (IF Installed): PURE GOLD BENTONITE CHIPS
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: 10X20 Diameter: 8 in.
22. Type of Screen Material: PVC SCH 80 Slot Size: 0.030 in.
23. Type of Bottom Seal (If Installed): N/A
24. Type of Lower Backfill: N/A

Recorded By	Date	Checked By	Date
[signature]	10/9/99	DK Nicholson	4/26/00

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring THSS-01 10/4/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Date(s) Drilled	10/4/00 - 10/6/00	Logged By	CHRIS WILLIAMS	Total Depth of Borehole (ft)	146 FEET
Drilling Method	BECKER HAMMER	Diameter of Borehole (in)	6 INCH	Ground Surface Elevation (ft-msl)	
Drill Rig Type	AP1000 DRILL SYSTEMS	Drilling Company	GREAT WEST DRLG	Groundwater Elevation (ft-msl)	NONE
Driller's Name	JIM BENSON	Sampler Type	CYCLONE TO BECKER	Checked By	CHUCK HART	Measuring Point Elevation (ft-msl)	
Locations / Comments					Northing / Easting	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	27	B			10YR 6/2	GM		LOOSE TO MED DENSE, MOIST YELLOW ORANGE TO LT GRAY, FINE TO MED SANDY GRAVEL, SOME SILT, MINOR CLAY	
2	39								
	38								
4	25								
	42	B			10YR 6/2	GM		LOOSE, MOIST, YELLOWISH ORANGE, FINE SANDY GRAVEL SOME SILT, MINOR CLAY	
6	22								
	15								
8	18								
	14	S 1.3			5YR 4/4	GC		LOOSE, LT BROWN, MOIST, FINE SANDY GRAVEL, SOME SILT AND CLAY	SPT 8/9/15
10	11	B							
	26								
12	16								
	19								
14	23	B							
	25								

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring TH55-01

10/4/00

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
					10YR 5/4	GC		LOOSE TO MED DENSE, LT BROWN, MOIST, GRAVELY SAND, SOME SILT, SOME CLAY	POOR RETURN
16	33								
	33								
18	35								
	20	S 1.0							SPT 7/2/14 - clayey, weathered wasterock
20	30	B			5Y 5/6	GC		LOOSE TO MED DENSE, LT BROWN MOIST, CLAYEY GRAVEL AND SAND, SOME CLAY BALLS	POOR RETURN
	30								
22	27								
	29								
24	35	B							
	27				5Y 5/2	GM		LOOSE TO MED DENSE, GREENISH GRAY, MOIST, SANDY GRAVEL SOME SILT, MINOR CLAY	POOR RETURN
26	18								
	19								% ROCK AND SIZE NOT DISTINGUISHABLE BY BLOW COUNT THUS FAR
28	46								
	78	S 0.0							SPT-26 FOR 3" ON ROCK
30	92	B			5Y 4/4	GC		LOOSE TO MED DENSE, YELLOWISH ORANGE, SANDY GRAVEL, SOME SILT AND CLAY >1" ~ 10% >3" ~ 5% RELATIVELY FRESH UNWEATHERED ROCK IN SAMPLE	
	44								
32	33								
	27								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH55-01 10/4/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
34	33								
	42	B			54 4/4	GC		AS BEFORE, WELL GRADED, MORE WEATHERING	COMPOSITE? WITH 30-35 FOR FULL BUCKET
36	35								
	40								
38	39								
	37								SPT 7/ROCK SMALL SAMPLE
		S 0.7							
40	35	B			54 5/6	GC		AS BEFORE	POOR RETURN
	35								
42	57								
	35								
44	29								
	10	B			54 4/4	GC		LOOSE TO MED DENSE, OLIVE GRAY, MOIST, GRAVELY SAND, SOME SILT AND CLAY	POOR RETURN
46	19								
	25								
48	46								
	65								SPT 14/52/31
		S 1.5							
50	76	B			54 44	GC		AS BEFORE BUT MED DENSE TO DENSE (ROCKS)	
	92								

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring TH55-01 10/4/00

Depth (ft-bgs)	Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
52	45								
	29								
54	29								
	30	B			5Y 6/4	GM		MED DENSE, MOIST, YELLOW GRAY SILTY GRAVEL, SOME SAND MINOR CLAY	
56	34								
	33								
58	39								
	37	5 1,3							SPT 16/16/13
60	25	B			5Y 6/4	GM		LOOSE TO MED DENSE, YELLOWISH GRAY, SILTY FINE SAND, SOME GRAVEL, MINOR CLAY	POOR RETURN
	23								
62	27								
	45								
64	70								
	34	B			5Y 6/4	GM		AS BEFORE, BUT GRAVELY SAND	
66	26								
	38								
68	47								
	47								

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring TH55-01 10/4/00

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		0.7							SPT 8/21/32
70	39	B			5Y 6/4	GM		AS BEFORE, BUT LESS GRAVEL	POOR RETURN
	55								
72	46								
	49								
74	40	B							
	40				10YR 6/2	GM		LOOSE TO MED DENSE, MOIST, LT GRAY, FINE SANDY GRAVEL, SOME SILT	
76	25								
	39								
78	40								
	58	B							SPT 5/2/7 No SAMPLE ROCK PROB. BLOCKED 55
80	69				5Y 5/2	GM		MED DENSE, LT GRAY, MOIST GRAVELY FINE SAND, SOME SILT, MINOR CLAY	
	52								
82	42								
	37								
84	40	B			5YR 6/1	GM		LOOSE, MOIST, LT GRAY, FINE SANDY TO SILTY GRAVEL, MINOR CLAY >3" ~ 15% >1" ~ 35%	
	30								
86	33								
	38								

URS	Project Name: Phase 2A/1B RI/FS	Log of Boring TP55-01
	Project Location: Midnite Mine	10/5/00
	Project Number: 53F4001800.03	

Depth (ft-bgs)	Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
88	69	S 0.0							HIGH COUNT-ROCKS, POOR RETURN
	130	B			5YR 6/1	GM		MED DENSE, MOIST, LT GRAY SILTY GRAVELLY SAND (VERY SILTY)	SPT 4/5/30
90	36								
	49								
92	59								
	50								
94	35	B			10YR 6/2	GM		MED DENSE, MOIST, LT BROWN GRAVELY SAND, SOME SILT MINOR CLAY	
	50								
96	51							73"~10%, 71"~15%	
	110								
98	55								
	69	S 1.3			10YR 5/4	GM		SOFT TO MED DENSE, MOIST YELLOWISH ORANGE AND GRAY SANDY GRAVEL, SOME SILT, MINOR CLAY	SPT 12/27/29
100	30	B							
	40							73"~10%, 7"~20%	
102	37								
	36								
104	56	B			10YR 6/2	GM		MED DENSE, MOIST, LT GRAY + GRAY, SANDY GRAVEL, SOME SILT, TRACE CLAY	
	60								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring THSS-01 10/5/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
106	60								
	61								
108	38								
	43	S 1.4			10YR 6/2	GM		MED DENSE, MOIST, LT TO OLIVE GRAY, GRAVELY MED-FINE SAND, WELL GRADED, SOME SILT, MINOR CLAY >1" = 0	SPT 19/42/41
110	65	B							
	45								
112	52								
	63								
114	55	B			5YR 6/1	GM		MED. DENSE, MOIST, LT GRAY, SILTY FINE SANDY GRAVEL >1" < 5%	
	60								
116	67								
	120								
118	68								
	140	B			10YR 5/4	GM		MED DENSE, MOIST, YELLOWISH ORANGE, GRAVELLY M-F SAND >1" < 5%, minor CLAY	SPT - 31/-/- REFUSAL AFTER 6", HIT ROCK
120	70								
	60								
122	50								
	30								

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring THSS-01
10/5/00

Depth (ft-bgs)	Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
~~16~~ 124	20	B			10YR 8/2	SM		LOOSE, MOIST, LT GRAY, SILTY FINE SAND	POOR RETURN
125	25								
~~18~~ 126	27								
127	25								
~~20~~ 128	28								
129	45								NO SPT - SKIP
~~22~~ 130	70	B			10YR 6/2	SM		MED DENSE, MOIST, LT GRAY SILTY FINE SAND, SOME SML GRAVEL (130'-140') (PROB LOOSE BUT BLOW COUNTS HIGH DUE TO CLOGGED CASING)	POOR SAMPLE RETURN, CASING LIKELY CLOGGED
131	70								
~~24~~ 132	52								
133	39								
~~26~~ 134	33								
135	38								NO BUCKET @ 135 - POOR RETURN, ROCK MAY BE BLOCKING CASING
~~28~~ 136	41								
137	27								
~~30~~ 138	63								
139	89	5 1.5							STOP TO DO STP TO UNCLOG CASING, STP NO COUNT
~~32~~ 140	250	B			5YR 4/4	CH		NOTE - SUDDEN INCREASE IN BLOW COUNT, PROBABLE TOP OF WEATHERED CLAYEY BEDROCK	
141	180				SEE NEXT PAGE				

8 9

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring THSS-01 10/6/00

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
141		S 1.5			5YR 4/4	CH		VERY STIFF, MOIST, LT BROWN GRAVELLY SANDY CLAY (SAMPLE FROM SPLIT SPOON IN CLOGGED CASING)	•WEATHERED BEDROCK •POOR RETURN CASING CLOGGED •FOUND 7 FEET OF CLAY IN PIPE (POUND OUT W/ SPLIT SPOON OVER 5 HOUR PERIOD) •LIKELY 8-10 FEET OF WEATHERED BEDROCK
~~34~~ 142	3/10								
143	4/10								
~~36~~ 144	9/9								
145	100								
~~38~~ 146		S 1.5			5YR 4/4	CH		VERY STIFF, MOIST, LT BROWN, SANDY CLAY (weathered bedrock)	SPT 15/31/51 -SPT IN BOTTOM OF HOLE
147									
~~40~~ 148									
149									
~~42~~ 150									
151									
~~44~~ 152									
153									
~~46~~ 154									
155									
~~48~~ 156									
157									
~~50~~ 158									
159									

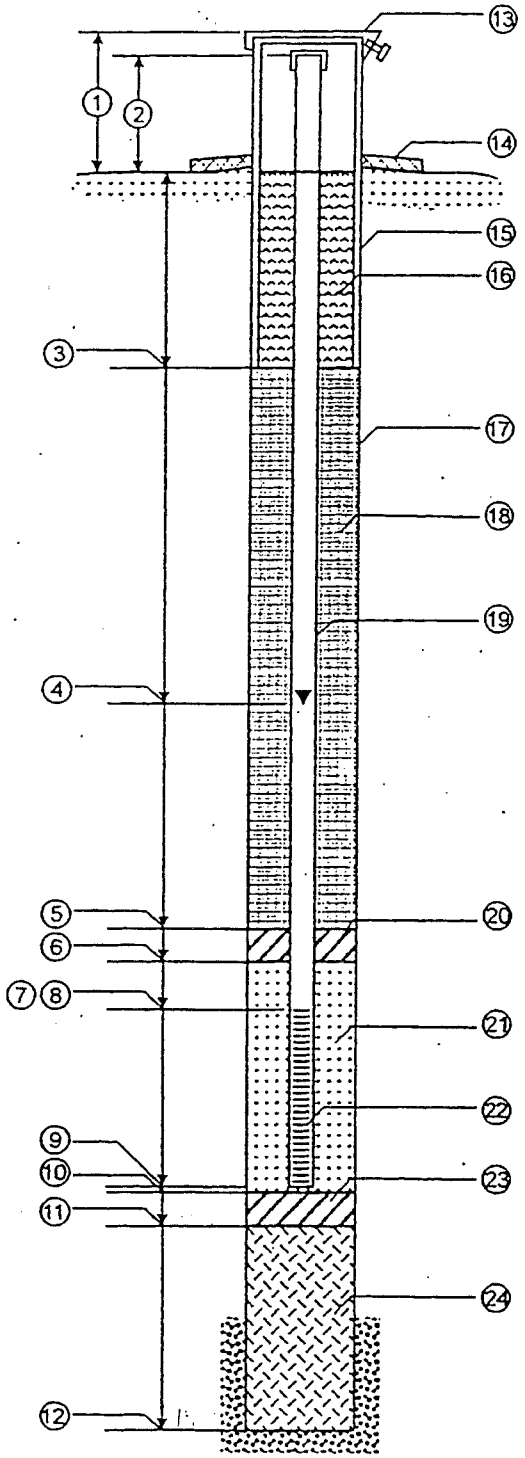
URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Project Number	Project Name	Date/Time Started
53F400 1800	MIDNITE MINE	10/4/00 - 1030
Well/Borehole Number	**Well/Borehole Location**	**Date/Time Completed**
TH 55-01	SOUTH DUMP	10/5/00 - 1400

Installation Team	Type of Drilling	Ground Surface Elev.	Top of Well Casing Elev.
GREAT WEST DRILL & URS	BECKER HAMMER	ft.msl	ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: ~3 ft.
2. Stick-Up Well Casing Above Ground: ~2.5 ft.
3. Depth to Bottom of Upper Seal/Protective Casing: ~2 ft.
4. Depth to Initial Ground Water Surface Elevation: NONE ft.
5. Depth to Top of Top Seal: ~3 ft.
6. Depth to Bottom of Top Seal: 118 ft.
7. Depth to Top of Well Point or Screen: 121 ft.
8. Total Length of Blank Casing: 123.5 ft.
9. Bottom Depth of Well Screen: 141 ft.
10. Depth to Top of Bottom Seal (If Installed): 141 ft.
11. Depth to Bottom of Bottom Seal (If Installed): 147.5 ft.
12. Depth of Borehole: 147.5 ft.
13. Protective Casing: ☐ Yes ☒ No Locking Cap: ☒ Yes ☐ No
14. Sanitary Seal: ☒ Yes ☐ No
15. Type of Protective Casing: STEEL Diameter: 5 in.
16. Type of Upper Seal: PORTLAND CEMENT TYPE II/III
17. Borehole Diameter: 6 in.
18. Type of Upper Backfill: PURE GOLD MED BENTONITE CHIPS
19. Type of Well Casing: PVC SCHED 80 Diameter: 1 in.
20. Type of Top Seal (IF Installed): PURE GOLD MED BENTONITE CHIPS
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: CSS 10-20 Diameter: 6 in.
22. Type of Screen Material: PVC SCHED 80 Slot Size: 0.01 in.
23. Type of Bottom Seal (If Installed): PURE GOLD MED BENTONITE CHIPS
24. Type of Lower Backfill: PURE GOLD MED BENTONITE CHIPS

Recorded By	Date	Checked By	Date
CHRIS WILLIAMS	10/5/00	Mark Hart	3/15/01

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring THSS-02
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Date(s) Drilled 10/25/00 - 10/26/00	Logged By CHRIS WILLIAMS		Total Depth of Borehole (ft) 90.5
Drilling Method BECKER HAMMER	Diameter of Borehole (in)		Ground Surface Elevation (ft-msl)
Drill Rig Type DRILL SYSTEMS AP1000	Drilling Company GREAT WEST DRLG		Groundwater Elevation (ft-msl) NONE
Driller's Name JIM BENSON	Sampler Type CYCLONE TO BUCKET	Checked By CHUCK HART	Measuring Point Elevation (ft-msl)
Locations / Comments SOUTH SPOILS - LOWER BENCH ABOVE SEEPAGE POND			Northing Easting

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	22	B 1/4			5YR 4/1	GM		LOOSE, BROWNISH GRAY AND LT GRAY (ROCKS), MOIST SANDY GRAVEL, MINOR SILT, TRACE CLAY	
2	57								
	78								
4	35								
	29	B 1/5			10YR 4/2	GC		AS BEFORE, BUT MORE CLAY (CLAY BALLS) AND VERY LOOSE TO LOOSE	
6	23								
	10								
8	6								
	7	S 0.4							SPT 6/5/6 - ROCK AND CLAY - POOR REPRESENT
10	8	B 1/4			10YR 4/2	GC		VERY LOOSE TO MED DENSE (ROCKS) YELLOWISH BROWN, MOIST, SANDY GRAVEL, SOME CLAY (SOME CLAY BALLS)	
	3								
12	2								
	22								
14	204								
	98								

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring

THSS-02
10/25/00

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		B 1/2			5YR 4/4	GM		LOOSE TO MED DENSE, LT OLIVE GRAY, GRAVELY SAND OR SAND GRAVEL, SOME SILT, TRACE CLAY	
16	49								
	68								
18	49								
	55	S 1.5							SPT 18/13/10
20	22	B 1/5			5YR 4/4	GM		AS BEFORE, BUT BROWNISH GRAY	- GC, clayey to sandy, GRAVEL - HIGHLY DECOMPOSED WASTE ROCK
	54								
22	82								
	77								
24	58								
	54	B 1/3			5YR 4/4	GM		AS BEFORE, BUT MINOR CLAY (MORE WEATHERING EVIDENT	
26	66								
	133								
28	160								
	94								SPT 20/24/20
30	42	B 1/4			5YR 4/4	GC		MED DENSE, YELLOWISH BROWN, MOIST, SANDY GRAVEL, SOME CLAY, SOME SILT	
	48								
32	80								
	84								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring THSS-02 10/25/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
34	49								
	57	B 1/3			5YR 4/4	GC		AS BEFORE	
36	73								
	70								
38	60								
	50	5 0.9							SPT 10/14/33
40	19	B 1/10			5YR 4/1	GM		MED DENSE TO DENSE, GRAY, SLIGHTLY MOIST, SANDY GRAVEL, MINOR SILT	- GC-GM, MOD TO HIGHLY DECOMPOSED ROCK - SOME CLAY ITS TO 4" - NO PHOTO VERY POOR RECOVERY
	45								
42	118								
	103								
44	120								
	138	B TR			5YR 4/1	GM		AS BEFORE	
46	74								
	57								
48	63								
	92								SPT 17/26/2
50	122					GC		MED DENSE TO DENSE, BROWN, MOIST, CLAYEY GRAVEL, SOME SAND (LARGE SANDY CLAY BALLS)	- GM - SANDY GRAV. - MOD + HIGH DECOMPOSED ROCK
	111								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring THSS-02 10/25/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
52	102								
	131								
54	128								
	112	B 1/3			5YR 4/1	GM		MEDDENSE TO DENSE, LT GRAY, FINE SANDY GRAVEL, SOME SILT, MINOR CLAY (MOSTLY CALC SILICATE)	
56	134								
	178								
58	274								
	255	S 1.0							SPT 15/32/37 GM SANDY GRAVEL - MOSTLY MOD DECOMPOSED ROCK - SOME HIGH DECOMP - SOME FRESH - A FEW CLAY BALLS
60	232	B 1/2			5YR 4/1	GM		AS BEFORE	
	179								
62	92								
	167								
64	245								
	228	B 1/5			5YR 4/1	GM		AS BEFORE	
66	224								
	126								
68	156								
	112								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring 7HSS-02 10/25/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		S 0.5							SPT 10/13/18 ROCK
70	36					GM		AS BEFORE	
	150								
72	226								
	262								
74	180								
	245					GC		MED DENSE TO DENSE, OLIVE GRAY AND LT GRAY, MOIST SANDY GRAVEL, SOME PLAY (ABUNDANT CLAY BALLS), MINOR SILT	
76	158								
	174								
78	162								
	121	S 0.8							SPT 15/22/28 ROCK AND MOIST SOFT CLAY
80	31					GC		AS BEFORE, BUT MORE SAND SANDY GRAVEL, SOME CLAY	
	195								
82	210								
	123								
84	334								
	322					GC		MED DENSE TO DENSE, GRAY MOIST, SANDY GRAVEL, SOME CLAY, SOME SILT	
86	577								
	474								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH55-02 10/25/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

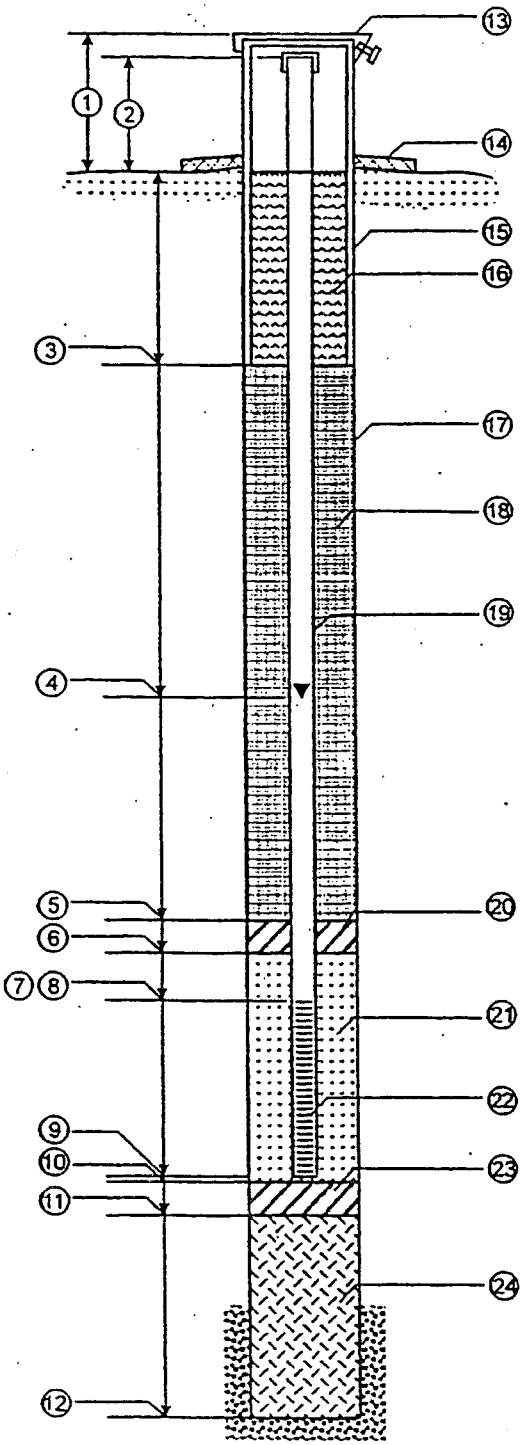
Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
88		152							
	S 1.3	99							SPT 15/23/28
90						CL			- 0.8 STIFF CLAY - 0.3 DEC ROCK CERANITE
								- TD Bottom of Split Spoon @ 90.5'	
92									
94									
96									
98									
100									
102									
104									

URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Number: 53F4001800.03	Project Name: Midnite Mine	Date/Time Started: 10/25/00 0800
Well/Borehole Number: TMSS-02	Well/Borehole Location: South Spoils - above PCP	Date/Time Completed: 10/27/00
Installation Team: Great West Drilling	Type of Drilling: Becker Hammer	Ground Surface Elev. ft.msl / Top of Well Casing Elev. ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: 0.5 ft.
2. Stick-Up Well Casing Above Ground: ____ ft.
3. Depth to Bottom of Upper Seal/Protective Casing: ____ ft.
4. Depth to Initial Ground Water Surface Elevation: 4.0 ft.
5. Depth to Top of Top Seal: 4.0 ft.
6. Depth to Bottom of Top Seal: 60 ft.
7. Depth to Top of Well Point or Screen: 64 ft.
8. Total Length of Blank Casing: ____ ft.
9. Bottom Depth of Well Screen: 84 ft.
10. Depth to Top of Bottom Seal (If Installed): 88 ft.
11. Depth to Bottom of Bottom Seal (If Installed): 92 ft.
12. Depth of Borehole: 92 ft.
13. Protective Casing: ☒ Yes ☐ No Locking Cap: ☐ Yes ☒ No
14. Sanitary Seal: ☒ Yes ☐ No
15. Type of Protective Casing: steel Diameter: 4 in.
16. Type of Upper Seal: Pure Gold Med Bentonite Chips
17. Borehole Diameter: 6 in.
18. Type of Upper Backfill: —
19. Type of Well Casing: PVC Schd 40 Diameter: 1 in.
20. Type of Top Seal (IF Installed): —
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: Washed Pea Gravel Diameter: 3/8 in.
22. Type of Screen Material: PVC Scd 40 Slot Size: 0.01 in.
23. Type of Bottom Seal (If Installed): Pure Gold Med Bentonite Chips
24. Type of Lower Backfill: Pure Gold Med Bentonite Chips

Recorded By	Date	Checked By	Date
DK Nicholson	10/27/00	David K Nicholson	11/13/01

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-42

PROJECT: MIDNITE MINE PAGE: 1 of 3
PROJECT NO.: 01-252 DATE: 10 OCTOBER 1998
NORTHING: 353741.0 EASTING: 2671809.1 GROUND ELEVATION: 2695.81
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CLINT BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
0	1023	DRY			0'-5': PHYLLITE/SCHIST, MEDIUM DARK GRAY (N4), MOSTLY COMPACT AND MASSIVE, TRACE OF RELICT BEDDING, MEGASCOPIC PYRITE (5-10%).
5	1036	DRY			5'-10': SAME AS 0'-5' WITH TRACE IRON STAINING, DARK YELLOWISH ORANGE (10YR 6/6).
10	1128	DRY			10'-15': SAME AS 5'-10'.
15	1136	DRY			15'-20': SAME AS 10'-15'.
20	1144	DRY			20'-25': SAME AS 15'-20'.
25	1150	DRY			25'-30': PHYLLITE/SCHIST, MEDIUM DARK GRAY (N4), MOSTLY COMPACT AND MASSIVE, MEGASCOPIC PYRITE (1-5%), ABUNDANT IRON STAINING, DARK YELLOWISH ORANGE (10YR 6/6).
30	1315	DRY			

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-42

PROJECT: MIDNITE MINE PAGE: 2 of 3
PROJECT NO.: 01-252 DATE: 10 OCTOBER 1998
NORTHING: 353741.0 EASTING: 2671809.1 GROUND ELEVATION: 2695.81
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CLINT BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
30	1315	DRY			30'-35': PHYLLITE/SCHIST, MEDIUM DARK GRAY (N4), COMPACT, MASSIVE, MEGASCOPIC PYRITE (1-3%), SOME IRON STAINING, DARK YELLOWISH ORANGE (10YR 6/6), TRACE FINES/CLAY.
35	1324	DRY			35'-40': SAME AS 30'-35'.
40	1335	DRY			40'-45': SAME AS 35'-40' WITH TRACE OF DACITE.
45	1343	DRY			45'-50': SAME AS 35'-40' WITH SOME MEDIUM STIFF CLAY, DARK GREENSIH GRAY (5G 4/1) (POSSIBLY MONTMORILLONITE)
50	1429	DRY			50'-55': PHYLLITE/SCHIST, MEDIUM DARK GRAY (N4), COMPACT, MASSIVE, TRACE OF RELICT BEDDING, SOME IRON/HEMATITE STAINING, DARK YELLOWISH ORANGE (10YR 6/6) TO MODERATE REDDISH BROWN (10R 4/6).
55	1435	DRY			55'-60': SAME AS 50'-55'.
60	1442	DRY			60'-65': PHYLLITE/SCHIST, MEDIUM DARK GRAY (N4), COMPACT, MASSIVE, SOME IRON/HEMATITE STAINING, DARK YELLOWISH ORANGE (10YR 6/6). TRACE FINES/CLAY.

BORING LOG

SHEPHERD MILLER
INCORPORATED

BORING NO.
GW-42

PROJECT: MIDNITE MINE PAGE: 3 of 3
PROJECT NO.: 01-252 DATE: 10-11 OCTOBER 1998
NORTHING: 353741.0 EASTING: 2671809.1 GROUND ELEVATION: 2695.81
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CLINT BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
65	1450	DRY			65'-70': SAME AS 60'-65'.
70	1601	H_2O INJECT			70'-75': PHYLLITE/SCHIST, MEDIUM DARK GRAY (N4), COMPACT, MASSIVE, SOME IRON/HEMATITE STAINING, DARK YELLOWISH ORANGE (10YR 6/6). TRACE FINES/CLAY. ABUNDANT PORPHYRITIC QUARTZ MONZONITE, SALT & PEPPER COLOR, COARSELY CRYSTALLINE, POTASSIUM FELDSPAR, SMOKEY QUARTZ, BIOTITE.
75	1617	H_2O INJECT			75'-77': SAME AS 70'-75'.
					77'-80': ABUNDANT CLAY/FINES, GRAYISH BLACK (N2), STIFF-MEDIUM STIFF, WOODY MATERIAL PRESENT (ROOTS, ETC.).
80	1627	H_2O INJECT			80'-85': ABUNDANT CLAY/FINES, MODERATE YELLOWISH BROWN (10YR 5/4), STIFF-MEDIUM STIFF.
85	1641	H_2O INJECT			85'-92': SAME AS 80'-85' WITH COARSE LAG FROM 90'-92'; PHYLLITE/SCHIST, CALC-SILICATE.
	10/10/98 - - - - - 10/11/98				
90	1205	H_2O INJECT			
					92'-95': PORPHYRITIC QUARTZ MONZONITE, DARK YELLOWISH ORANGE (10YR 6/6), COARSELY CRYSTALLINE, POTASSIUM FELDSPAR, SMOKEY QUARTZ, BIOTITE, VERY COMPETENT.
95	1220	H_2O INJECT			T.D.

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-43

PROJECT: MIDNITE MINE PAGE: 1 of 3
PROJECT NO.: 01-252 DATE: 8-9 OCTOBER 1998
NORTHING: 353612.1 EASTING: 2671469.7 GROUND ELEVATION: 2697.75
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CLINT BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
0	1416	-			0'-5': PHYLLITE/SCHIST (~95%), GREENISH BLACK (5G 2/1), SOME IRON STAINING, YELLOW (10YR 7/8), PORPHYRITIC QUARTZ MONZONITE AND QUARTZ PEGMATITE (~5%).
5	1430	0			5'-10': META CALC-SILICATE (~75%), GREENISH GRAY (5G 6/1). PHYLLITE/SCHIST (~25%), GREENISH BLACK (5G 2/1), IRON STAINING AND HEMATITE STAINING, REACTION WITH 10% HCl.
10	1515	0			10'-15': SAME AS 5'-10'.
15	1523	0			15'-20': META CALC-SILICATE (~80%), GRAYISH YELLOW GREEN (5GY 7/2), SLIGHT TO STRONG REACTION WITH 10% HCl, TRACE OF IRON STAINING. QUARTZ MONZONITE (~10-15%). TRACE PHYLLITE/SCHIST AND QUARTZ PEGMATITE.
20	1530	0			20'-25': SAME AS 15'-20'.
25	1635	0			25'-30': META CALC-SILICATE (~95%), GRAYISH YELLOW GREEN (5GY 7/2), VERY SLIGHT TO STRONG REACTION WITH 10% HCl. TRACE OF QUARTZ PEGMATITE AND PHYLLITE/SCHIST.
	10/8/98				
	10/9/98				
30	0745	0			

BORING LOG

SHEPHERD MILLER
INCORPORATED

BORING NO.
GW-43

PROJECT: MIDNITE MINE PAGE: 2 of 3
PROJECT NO.: 01-252 DATE: 9 OCTOBER 1998
NORTHING: 353612.1 EASTING: 2671469.7 GROUND ELEVATION: 2697.75
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CLINT BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
30	0745	0			30'-35': PHYLLITE SCHIST (~60%), DARK GRAY (N4), META CALC-SILICATE (~30%), GRAYISH YELLOW GREEN (5GY 7/2), VERY SLIGHT TO STRONG REACTION WITH 10% HCl. TRACE QUARTZ MONZONITE. ABUNDANT CLAY/FINES, MODERATE YELLOWISH BROWN (10YR 5/4).
35	0754	0			35'-40': META CALC-SILICATE, PALE GREENISH YELLOW (10Y 8/2), VERY WEAK REACTION WITH HCl. ABUNDANT CLAY/FINES, MODERATE YELLOWISH BROWN (10YR 5/4), TRACE PHYLLITE/SCHIST, DARK GRAY (N4).
40	0810	0			40'-45': SAME AS 35'-40'.
45	0820	0			45'-50': PHYLLITE/SCHIST (60-80%), DARK GRAY (N4), TRACE IRON AND HEMATITE STAINING. META CALC-SILICATE, PALE GREENISH YELLOW (10Y 8/2) TO YELLOWISH GRAY (5Y 7/2). ABUNDANT CLAY/FINES, MODERATE YELLOWISH BROWN (10YR 5/4).
50	0914	0			50'-55': SAME AS 45'-50'.
55	0921	0			55'-60': PHYLLITE/SCHIST, PORPHYRITIC QUARTZ MONZONITE, AND META CALC-SILICATE MIXTURE, TRACE OF CLAY/FINES.
60	1000	START WATER INJECT.			60'-65': PHYLLITE/SCHIST, DARK GRAY (N4), IRON AND HEMATITE STAINING. ABUNDANT CLAY/FINES, MODERATE YELLOWISH BROWN (10YR 5/4), TRACE META CALC-SILICATE AND PEGMATITE.

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-43

PROJECT: MIDNITE MINE PAGE: 3 of 3
PROJECT NO.: 01-252 DATE: 9 OCTOBER 1998
NORTHING: 353612.1 EASTING: 2671469.7 GROUND ELEVATION: 2697.75
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CLINT BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
65	1015	0			65'-70': SAME AS 60'-65'.
70	1142	0			70'-75': PHYLLITE/SCHIST, DARK GRAY (N4), IRON AND HEMATITE STAINING, VISIBLE PYRITE (1-2%). META CALC-SILICATE, SLIGHT REACTION WITH 10% HCl, GRAYISH YELLOW GREEN (5GY 7/2), THIN LAMINATE VISIBLE, CALCITE XTALS, TRACE QUARTZ PEGMATITE, NO CLAY/FINES.
75	1155	0			75'-80': PORPHYRITIC QUARTZ MONZONITE (~60%), ABUNDANT SMOKEY QUARTZ, POTASSIUM FELDSPAR, TRACE AMPHIBOLE. PHYLLITE/SCHIST (~20%), DARK GRAY (N4), IRON STAINING, TRACE FINES/CLAY.
80	1200	0.1			80'-85': PORPHYRITIC QUARTZ MONZONITE (~90%), DARK YELLOW ORANGE (10YR 6/6), ABUNDANT SMOKEY QUARTZ, WITH POTASSIUM FELDSPAR AND TRACE AMPHIBOLE. TRACE PHYLLITE/SCHIST AND META CALC-SILICATE.
85	1213	0.1			85'-90': PORPHYRITIC QUARTZ MONZONITE (~95%), DARK YELLOW ORANGE (10YR 6/6), ABUNDANT SMOKEY QUARTZ, WITH POTASSIUM FELDSPAR, TRACE AMPHIBOLE, TRACE PHYLLITE/SCHIST AND META CALC-SILICATE.
90	1457	0.1			90'-95': PORPHYRITIC QUARTZ MONZONITE, DARK YELLOW ORANGE (10YR 6/6), ABUNDANT SMOKEY QUARTZ, WITH POTASSIUM FELDSPAR, TRACE AMPHIBOLE.
95	1510	0.1			T.D.

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-51

PROJECT: MIDNITE MINE PAGE: 1 of 3
PROJECT NO.: 01-252 DATE: 8 NOVEMBER 1998
NORTHING: 351605.2 EASTING: 2671784.0 GROUND ELEVATION: 2355.76
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON LOGGED BY: TIM RUNNELLS

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
0	0812	MOIST			0'-4': NO SAMPLE.
	0906				4'-5': CLAYEY SILTY SANDY GRAVEL, PALE YELLOWISH BROWN (10YR 6/2) UNWASHED, DARK YELLOWISH ORANGE (10YR 6/6) WASHED, ROOTS PRESENT, VERY COARSE TO VERY FINE SAND, GRAVEL TO 10 mm, POORLY SORTED, ANGULAR TO SUB-ROUNDED, CHIPS ARE 90-95% QUARTZ, 5-10% HORNBLENDE AND BIOTITE, IRON STAINING ON 60-70% OF CHIPS, DARK YELLOWISH ORANGE (10YR 6/6), <20% OF ANY CHIP STAINED, <5% CLAY, 10-20% SILT, 30-40% SAND, 35-55% GRAVEL.
5	0912	MOIST			5'-10': SILTY GRAVELLY CLAYEY SAND, DUSKY YELLOWISH BROWN (10YR 2/2) UNWASHED, DARK YELLOWISH ORANGE (10YR 6/6) WASHED, VERY COARSE TO VERY FINE SAND, GRAVEL TO 10 mm, POORLY SORTED, ANGULAR TO SUB-ROUNDED, CHIPS ARE 90-95% QUARTZ, 5-10% HORNBLENDE AND BIOTITE, IRON STAINING ON 60-70% OF CHIPS, DARK YELLOWISH ORANGE (10YR 6/6), <20% OF ANY CHIP STAINED, 10-20% SILT, 10-20% GRAVEL, 20-30% CLAY, 30-40% SAND.
10	0919	MOIST			10'-15': SILTY CLAYEY SAND, MODERATE YELLOWISH BROWN (10YR 5/4) UNWASHED, DARK YELLOWISH ORANGE (10YR 6/6) WASHED, VERY COARSE TO VERY FINE SAND, GRAVEL TO 10 mm, POORLY SORTED, ANGULAR TO SUB-ROUNDED, CHIPS ARE 90-95% QUARTZ, 5-10% HORNBLENDE AND BIOTITE, IRON STAINING ON 60-70% OF CHIPS, DARK YELLOWISH ORANGE (10YR 6/6), <20% OF ANY CHIP STAINED, 10-20% SILT, 10-20% GRAVEL, 20-30% CLAY, 30-40% SAND.
		SATURATED			
15	0940	SATURATED			15'-20': SAME AS 10'-15'.
20	1051	SATURATED MOIST			20'-21': SAME AS 15'-20'.
					21'-25': SILTY GRAVELLY SAND, MODERATE YELLOWISH BROWN (10YR 5/4) UNWASHED, DARK YELLOWISH ORANGE (10YR 6/6) WASHED, VERY COARSE TO VERY FINE SAND, POORLY SORTED, ANGULAR TO SUB-ROUNDED, CHIPS ARE MOSTLY QUARTZ WITH SOME ORTHOCLASE AND BIOTITE (<10%), IRON STAINING ON 70-80% OF CHIPS, DARK YELLOWISH ORANGE (10YR 6/6), <20% OF ANY CHIP STAINED, <5% CLAY, 10-15% SILT, 25-40% GRAVEL, 50-60% SAND.
25	1105	MOIST			25'-30': SAME AS 21'-25'.
30	1240	MOIST			

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-51

PROJECT: MIDNITE MINE PAGE: 2 of 3
PROJECT NO.: 01-252 DATE: 8 NOVEMBER 1998
NORTHING: 351605.2 EASTING: 2671784.0 GROUND ELEVATION: 2355.76
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON LOGGED BY: TIM RUNNELLS

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
30	1240	MOIST			30'-35': SAME AS 25'-30'.
35	1250	MOIST			35'-40': SILTY GRAVELLY SAND, GRAYISH ORANGE (10YR 7/4) UNWASHED, DARK YELLOWISH ORANGE (10YR 6/6) WASHED, VERY COARSE TO VERY FINE SAND, POORLY SORTED, ANGULAR TO SUB-ROUNDED, CHIPS ARE MOSTLY QUARTZ WITH SOME ORTHOCLASE AND BIOTITE (<10%), IRON STAINING ON 70-80% OF CHIPS, DARK YELLOWISH ORANGE (10YR 6/6), <20% OF ANY CHIP STAINED, <5% CLAY, 10-15% SILT, 25-40% GRAVEL, 50-60% SAND.
		DRY			
40	1324	DRY			40'-41': SAME AS 35'-40'.
					41'-45': PORPHYRITIC QUARTZ MONZONITE, DARK YELLOWISH ORANGE (10YR 6/6) WASHED, CHIPS ARE MOSTLY QUARTZ WITH SOME ORTHOCLASE AND BIOTITE (<10%), IRON STAINING ON 70-80% OF CHIPS, DARK YELLOWISH ORANGE (10YR 6/6), <20% OF ANY CHIP STAINED.
45	1359	S. MOIST			45'-46': SAME AS 41'-45'.
					46'-50': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN BROWNISH GRAY (5YR 4/1) AND DARK GREENISH GRAY (5GY 4/1), MOSTLY QUARTZ (SMOKY AND ROSE), OLIGIOCLASE, ORTHOCLASE, BIOTITE, AND GREEN MINERAL, <10% OF CHIPS HAVE STAINING (STAINED CHIPS MAY BE FROM FURTHER UPHOLE), NONE OF THE GRAYISH/GREENISH CHIPS HAVE STAINING (>90% OF CHIPS), A FEW CHIPS HAVE A MINOR HCL REACTION.
50	1453	DRY			50'-55': SAME AS 46'-50', NO STAINING.
55	1439	S. MOIST			55'-60': SAME AS 50'-55'.
60	1445	S. MOIST			
		MOIST			

BORING LOG

SHEPHERD MILLER
INCORPORATED

BORING NO.
GW-51

PROJECT: MIDNITE MINE PAGE: 3 of 3
PROJECT NO.: 01-252 DATE: 8 NOVEMBER 1998
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DRILLER: CASEY BURTON LOGGED BY: TIM RUNNELLS

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
60	1445	S. MOIST			60'-65': SAME AS 55'-60'.
		MOIST			
		DRY			
65	1452	DRY			65'-70': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN BROWNISH GRAY (5YR 4/1) AND DARK GREENISH GRAY (5GY 4/1), MOSTLY QUARTZ, OLIGIOCLASE, ORTHOCLASE (MORE PROMINENT THAN ABOVE), BIOTITE, AND GREEN MINERAL, 20-30% OF CHIPS HAVE STAINING, A FEW CHIPS HAVE A MINOR HCL REACTION.
		MOIST			
		FREE WATER			
70	1510	SATUR-ATED			70'-75': SAME AS 65'-70'.
75	1515	SATUR-ATED			75'-78': SAME AS 70'-75'.
78					T.D.

Supplement E-2.2

Midnite Mine Remedial Design South Pond Global Stability Analysis Supplement to Post-Earthquake Analyses

Client:	*Newmont USA Ltd*	**Sheet:** *1*	**of** *10*
Project:	*Midnite Mine*	**Date:**	*April 16, 2013*
Description:	Supplemental Slope Stability Analysis for South Pond	**Job No:**	*1011322*
		By: *J.B. Varnier*	**Chkd By:** *T. Kelley*

MIDNITE MINE REMEDIAL DESIGN SOUTH POND GLOBAL STABILITY ANALYSIS SUPPLEMENT TO POST-EARTHQUAKE CONDITION ANALYSES

Revisioning

Rev.	Date	Description	By	Checked	Reviewed
A	*April 19, 2013*	*Initial Review*	*J.B. Varnier*	*T. Kelley*	*T. Kelley*
B					
C					
D					

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usftc2s01\Projects\Newmont\Midnite Mine_2011\6.0 Studies & Reports\6.2 Technical\Remedial Action Cover Design\Global Stability

The following calculations were generated using the following software:

Microsoft Excel

Geo-Slope International, Ltd., 2012 (Slope/W)

AutoCAD Civil3D 2011 (Autodesk, 2010)

Objective

This calculation brief summarizes the results of supplemental stability analyses for the proposed South Pond at the Midnite Mine (Site) near Wellpinit, WA. During the March 2013 technical meeting held in Spokane, WA the U.S. Environmental Protection Agency (EPA) and CH2M Hill (the EPA's technical consultant for the project) provided verbal comments on the South Pond stability analyses that were included as Appendix E (Attachment 3) of the 30% Basis of Design Report (30% BODR)(MWH, 2012b). The analyses presented in this calculation brief are intended to supplement the slope stability analyses presented 30% BODR in order to address those comments.

Background

The proposed South Pond will be a synthetically-lined water management pond constructed during remedial action (RA) construction at the Site and will provide temporary storage for mine-impacted water during the RA. The pond will be constructed by excavating into waste rock in the South Waste Rock Pile (SWRP) and no additional fill will be placed in the South Pond area as part of the construction. The South Pond will be removed prior to completion of the RA. The proposed location for this pond is on top of the SWRP as depicted in Figure 1. The South Pond will be designed to meet stability performance standards listed in the CD as well as in substantive compliance with Washington State Department of Ecology (WSDE) Dam Safety Program criteria. These WSDE criteria will be applied to a synthetically-lined storage pond, with intermittent operation.

Stability analyses for the South Pond were presented in the 30% BODR. In addition to evaluating stability under static and pseudostatic earthquake loadings, these analyses also included an evaluation of the potential for liquefaction or seismic softening of foundation materials underlying the SWRP (as Attachment 2 of Appendix E) during earthquake events. The evaluation of the potential for liquefaction/seismic softening in the 30% BODR was based upon previous drilling, sampling, and laboratory testing in SWRP and toe area as well as Cone Penetration testing(CPT) along the toe of the SWRP. The evaluation in the 30% BODR found that much of the foundation area of the SWRP is underlain by either a very thin (or non-existent) layer of unsaturated colluvium over residual soil that is the product of in-place weathering of bedrock and would not be susceptible to significant strength loss during seismic shaking. However portions of the SWRP are underlain by alluvial channels containing thicker layers of alluvial soils that may be susceptible to strength loss during seismic shaking. The location of these alluvial channels are shown on Figure 2.

The evaluation of liquefaction/seismic softening potential performed for the 30% BODR found that CPT-based soil behavior index (Ic) parameters calculated from generalized empirical correlations indicated the alluvial materials consisted predominantly of sands and silty sands, which are prone to liquefaction during large earthquakes. However side-by-side comparison of CPT soundings with boreholes and laboratory testing at two of the CPT locations indicated that although CPT-based Ic results indicated sands and silty sands, the actual samples retrieved from the boreholes consisted predominantly of clays and sandy clays. Further evaluation indicated that, based upon the plasticity and moisture content of sampled materials, ten samples classified as being "not susceptible", and two samples classified as "moderately susceptible" to liquefaction. No samples tested were classified as being "susceptible" to liquefaction. Thus, during the analyses for the 30% BODR the alluvial materials were evaluated assuming they behaved as clay materials which could be subject to cyclical softening and reduced strengths, as opposed to behaving as a sand material, which could experience true liquefaction and an almost complete strength loss, during seismic events.

Verbal comments from EPA based upon their initial review of the BODR expressed some concern over the potential that liquefaction-susceptible materials (materials that exhibit sand behavior) could exist within the

alluvium in the SWRP foundation. EPA suggested that a drilling and sampling program with a more continuous sampling interval could be used to evaluate this potential. Alternately, it was suggested that stability analyses be performed assuming sand behavior in order to evaluate the potential effects of liquefaction on the South Pond if potentially liquefiable materials do exist within the SWRP foundation. The supplemental stability analyses presented in this calculation brief were performed to specifically evaluate the potential effects of liquefaction in alluvial SWRP soils on South Pond stability.

Methodology & Assumptions

Methodology and assumptions used to estimate subsurface stratigraphy and groundwater levels were discussed in 30% BODR and have not changed. Two sections were selected for the 30% BODR analyses to represent the most critical conditions for the slope stability analysis (depicted in Figures 1 through 3). Of the two sections, the waste rock in Cross-section 1 is almost continuously underlain by alluvium and was selected for reevaluation of post-earthquake conditions assuming sand-like behavior. Cross-section 2 is less critical under post-earthquake conditions due to the minor amounts of saturated alluvium that could be susceptible to liquefaction at this section location. As a result, Cross-section 2 was not reevaluated under post-earthquake conditions.

As discussed in the 30% BODR, four CPT soundings were performed along the toe of the SWRP at locations shown on Figure 1, and alluvium was encountered at two of the four locations. Liquefaction triggering analyses were performed for the CPT soundings at the two locations where alluvium was encountered during CPT soundings, and the potential for liquefaction was identified at only one of these locations (CPT-12-03). The results of the liquefaction triggering analyses at CPT-12-03 were conservatively used to represent post- seismic conditions of all alluvium during subsequent slope stability analyses. The triggering analyses assumed that all alluvium contained 20 percent fines and would exhibit sand-like behavior during seismic shaking. The results of the seismic triggering analyses for varying thickness of overlying waste rock are shown on Figures 4 through 8. The results indicated that although significant thicknesses (greater than 1 foot thick) of potentially liquefiable material (indicated by a factor of safety against liquefaction less than one) were encountered under free field-conditions (i.e. no overlying waste rock). The thickness of liquefiable layers becomes insignificant once 10 feet of waste rock overlies the alluvial layer and no liquefiable layers were seen at waste rock burial depths greater than 30 feet. Thus, for the purposes of the updated stability analyses, it was assumed that liquefaction would occur in alluvium that was covered by less than 15 feet of waste rock, and would not liquefy in areas of greater amounts of waste rock cover.

Slope stability analyses were performed using the Slope/W (GeoSlope, 2012) two-dimensional, limit-equilibrium slope stability analysis software. The use of two-dimensional slope stability analyses are considered to be very conservative in this particular application as they do not account for the limited width of weaker alluvium/colluvium in the waste rock foundation, and the reinforcing effects of the adjacent stronger materials.

Material Properties

The stability sections were developed using the three primary material types: mine waste, colluvium, and bedrock. The material properties for each material are discussed below and summarized in Table 1.

Mine Waste

The density and effective strength parameters of the mine waste used in the analyses have not changed from the analyses in the 30% BODR. These parameters were based on subsurface information provided in the Geotechnical Investigations for Midnite Mine RI/FS Technical Memorandum (URS, 2001) and material parameters

used for stability analyses presented in the Midnite Mine Geotechnical Investigations and Existing Waste Rock Piles and Open Pit Highwalls Stability Evaluations Technical Memorandum (URS, 2002). Effective strength parameters were used to represent the waste rock strengths due to the relatively coarse, free-draining nature of the mine waste.

Alluvium/Colluvium

The alluvium/colluvium is transported soil containing varying amounts of clay, silt, and sand. The density of the alluvium/colluvium has not changed from the 30% BODR. The density was calculated from the measured in-place dry density and the natural water content for a sample representative of the colluvium in the Central Drainage, sample CD-B4 at 6 to 7.5 feet, presented in the Storage Ponds Investigation Report (MWH, 2012a).

Under post-earthquake conditions, the alluvium/colluvium was modeled in these supplemental stability analyses assuming (1) clay behavior (the case analyzed in the 30% BODR analyses), (2) sand behavior and (3) a conservative combination of sand-clay behavior. The three behaviors used in these supplemental stability analyses are described in the following subsections.

1 - Clay Behavior

The analyses of post-earthquake stability assuming clay behavior was made as part of the stability analyses presented on the 30% BODR. For the clay behavior analysis under post-earthquake conditions, the alluvium/colluvium shear strength was modeled assuming the residual shear strength parameters described in Attachment 2 to Appendix E of the 30% BODR. The residual shear strengths were calculated from two CPT soundings (CD-12-02A and CD-12-03) for five overburden stress levels: free field, 30' waste rock fill, 65' waste rock fill, 120' waste rock will and for the pond area. The residual shear strength values used in the analysis are an average of the shear strength estimated from the two CPT tests for the five cases. The free field case indicates that no overburden pressure is applied to the colluvium. The 30', 60' and 120' waste rock fill cases indicate that the 30', 60' and 120' of waste rock fill is located above the colluvium. The pond case indicates that the colluvium is located below the south pond. The numerical model was discretized based on these five cases (e.g., the 30' field dam was assigned when between 15' and 47.5' of waste rock is located above the colluvium).

2 - Sand Behavior

In the supplemental sand behavior stability analysis under post-earthquake conditions, the colluvium was assumed to liquefy when less than 15' of the waste rock fill overlies the alluvium/colluvium. The liquefied residual strength used in the analyses was based upon the average liquefied strength in the liquefiable zones under free-field stress conditions, as calculated from CPT sounding results at CPT-12-03. The strength of the un-liquefied alluvium/colluvium assumed a Mohr-Coulomb (internal friction angle only) failure envelop when more than 15' of rock fill exists above the colluvium. The angle of internal friction used to represent the un-liquefied colluvium (28 degrees) was selected as a conservative representation of internal friction angle calculated from CPT sounding results at CPT-12-03 (ranging from 30 to 44 degrees with an average of 34.4 degrees) to accounts for potential cyclic softening of un-liquefied alluvial/colluvial materials. It should be noted that the assumption of sand behavior results in lower post-earthquake strengths in areas of low stress (i.e. free field areas with less than 15 feet of overlying waste rock), and results higher post-earthquake shear strengths in more highly confined areas with more 15 feet of overlying waste rock relatively to the clay behavior case.

3 – Sand-Clay Behavior

The sand-slay behavior analysis under post-earthquake conditions is a hybrid model that assumes sand behavior (i.e. liquefied residual strengths) when less than 15' of the waste rock fill is located above the alluvium/colluvium and clay behavior (i.e. residual clay strengths) when more than 15 feet of waste rock overlies the alluvium/colluvium. This assumed behavior is assumed to be very conservative, but could be representative of a condition where interbedded sand and clay layers exist, and parallel the underlying weathered bedrock contact, thus allowing slippage along the weakest parallel layers within the alluvium/colluvium at varying overburden stress

levels.

Bedrock
The bedrock was modeled as an impenetrable surface where the slip surfaces being analyzed were not allowed to cut into this stronger material. Instead, slip surfaces were truncated at the bedrock contact and assumed to slide within the overlying a weaker alluvium/colluvium.

Table 1. Material Properties Used in Stability Analysis under Post-Earthquake Conditions

Material Type	Total Density (pcf)	Effective Friction Angle, ϕ' (deg)	Effective Cohesion, c' (psf)	Undrained shear strength ratio, s_u/σ_v'
Mine Waste	135	38.0	0	- -
Colluvium, Clay behavior	122	-	-	1.55 (Free Field) 0.42 (30' Dam Fill) 0.34 (65' Dam Fill) 0.31 (120' Dam Fill) 0.35 (Pond)
Colluvium, Sand behavior	122	- 28 (Unliquefied areas containing more than 15 feet of water rock fill)	- 0	0.08 (Free Field – 0 to 15 feet of overlying waste rock fill) -
Colluvium, Sand-Clay behavior	122	-	-	0.08 (Free Field) 0.42 (30' Dam Fill) 0.34 (65' Dam Fill) 0.31 (120' Dam Fill) 0.35 (Pond)
Bedrock	Impenetrable			- -

Results

The factors of safety against slope stability failure calculated in this analysis are summarized in Table 2 and shown on Figures 9 to 14.

Table 2. Factors of Safety for Global Stability under Post-Earthquake Conditions

Colluvium Behaviour	Factor of Safety	
	Truncated Circular	Wedge
Clay Behavior	1.2	1.2
Sand Behavior	1.3	1.6
Sand-Clay Behavior	1.1	1.1

Conclusions

As discussed in the 30% BODR, a minimum required factor of safety of 1.0 is being used as the slope stability design criterion for post-earthquake conditions. The minimum calculated factors of safety for all three assumed post-earthquake conditions, shown on Figures 9 through 14 and summarized in Table 2, indicate that this criterion is met for all three assumed post-earthquake behavior conditions. The results indicate that, even for the conservative conditions assumed in these analyses, that the South Pond will remain stable under reduced-strength, post-earthquake conditions for the design earthquake.

The assumption of sand behavior in the alluvium/colluvium layer resulted in the highest minimum calculated factors of safety of the three cases analyzed. This is due to liquefaction potential occurring only in the toe area where less than 15-feet of waste rock fill overlies this layer. In their unliquefied state, sand-like alluvial/colluvial materials will exhibit post-earthquake strengths exceeding those of clay-like materials. The conservative assumption of hybrid sand-clay behavior, where fully-liquefied strengths were assumed for alluvium/colluvium located in the toe area (areas with less than 15 feet of waste rock cover), and cyclically softened clay-like strengths were assumed in other higher-stress areas, resulted in the lowest factors of safety. This hybrid sand-clay behavior assumption is considered conservative in that assigns the weakest potential material-behavior-type to the entire extent (depth-wise and horizontal extent) of the alluvium/colluvium layer at each level of overburden stress. Even under the conservative assumption of hybrid sand-clay behavior, the minimum calculated factors of safety (1.1) exceeded the post-earthquake design criterion of 1.0.

The analyses presented in this calculation brief are based upon two-dimensional, limit-equilibrium analyses, where the weak alluvium/colluvium is assumed to be infinitely wide in the cross-slope direction. The assumption of two-dimensional conditions in these slope stability analyses are considered to be very conservative for the subsurface geometry at the South Pond it does not account for the limited width of weaker alluvium/colluvium in the waste rock foundation, and the reinforcing effects of the adjacent stronger materials.

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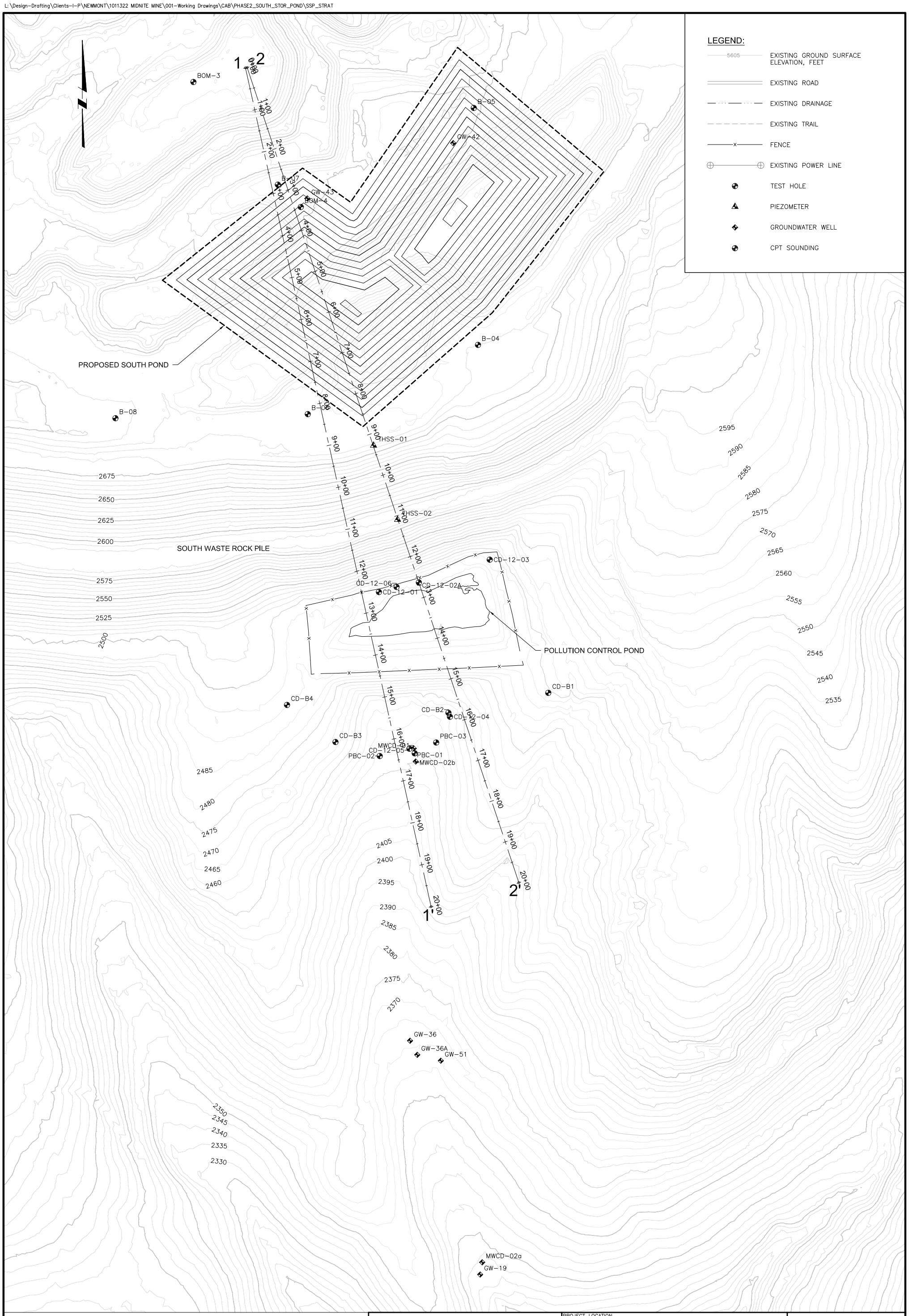
FIGURES

L:\Design-Drafting\Clients-I-P\NEWMONT\1011322 MIDNITE MINE\001-Working Drawings\CAB\PHASE2_SOUTH_STOR_POND\SSP_STRAT



DRAWING REFERENCE(S):
- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.

0 100' 200'

CONTOUR INTERVAL = 5 FT

NEWMONT

PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 1 - SOUTH POND SLOPE STABILITY SECTION LOCATIONS
FIGURE	1
REVISION	0
FILE NAME	SSP_STRAT
DATE	APR 2013

MWH

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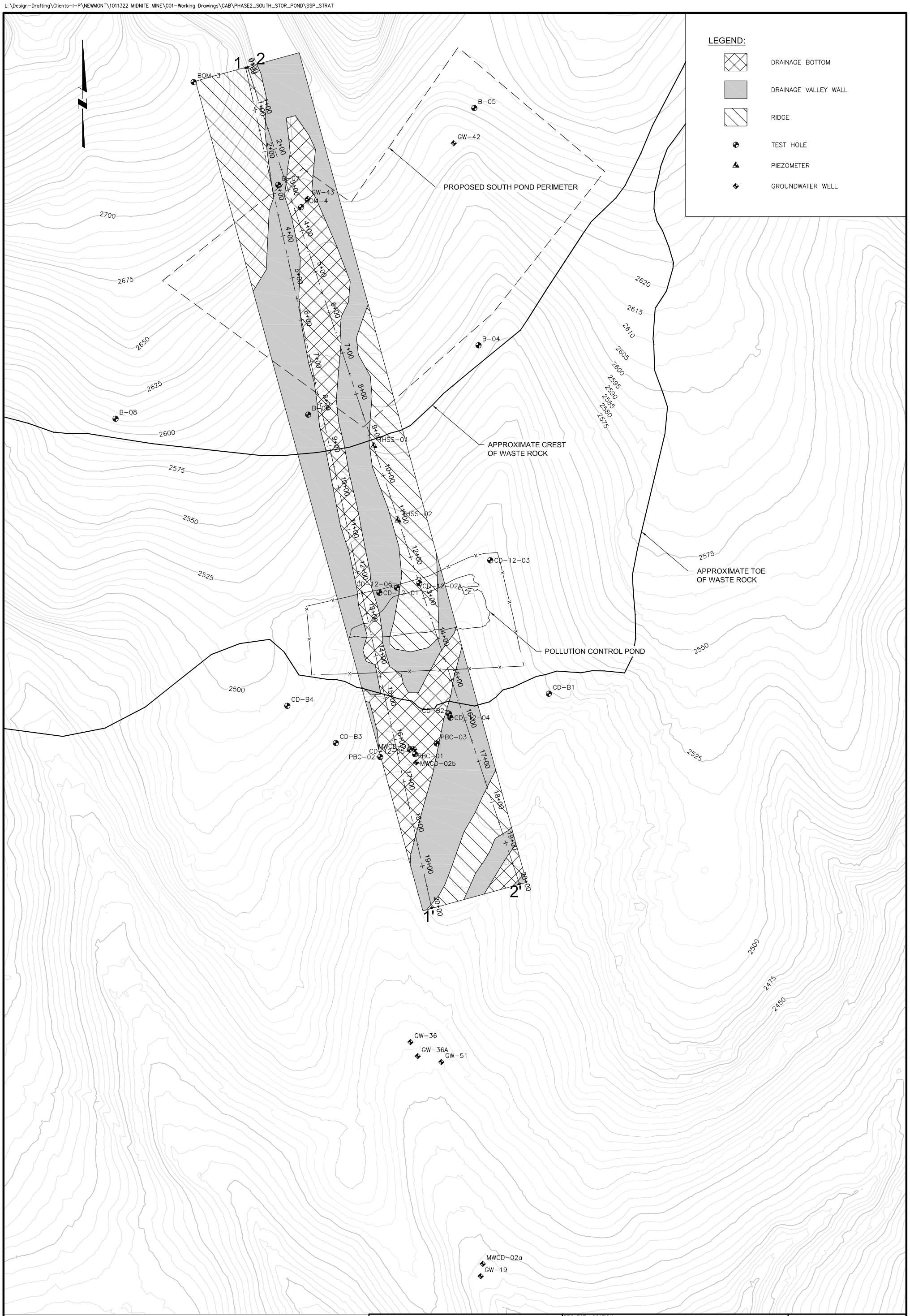

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- PREMINE TOPOGRAPHY AND PIT EXCAVATION TOPOGRAPHY BASED UPON INFORMATION PROVIDED BY U.S. BUREAU OF MINES (USBM), JULY, 1995. ORIGINAL COORDINATE SYSTEM USED IN USBM MAPPING (NAD27/NGVD29) HAS BEEN CONVERTED TO NAD83/NAVD88 BASED COORDINATES.

0 100' 200'

CONTOUR INTERVAL = 5 FT

NEWMONT

PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 2 - SOUTH POND CORRIDOR OF INTEREST
FIGURE	2
REVISION	0
FILE NAME	SSP_STRAT
DATE	APR 2013

MWH

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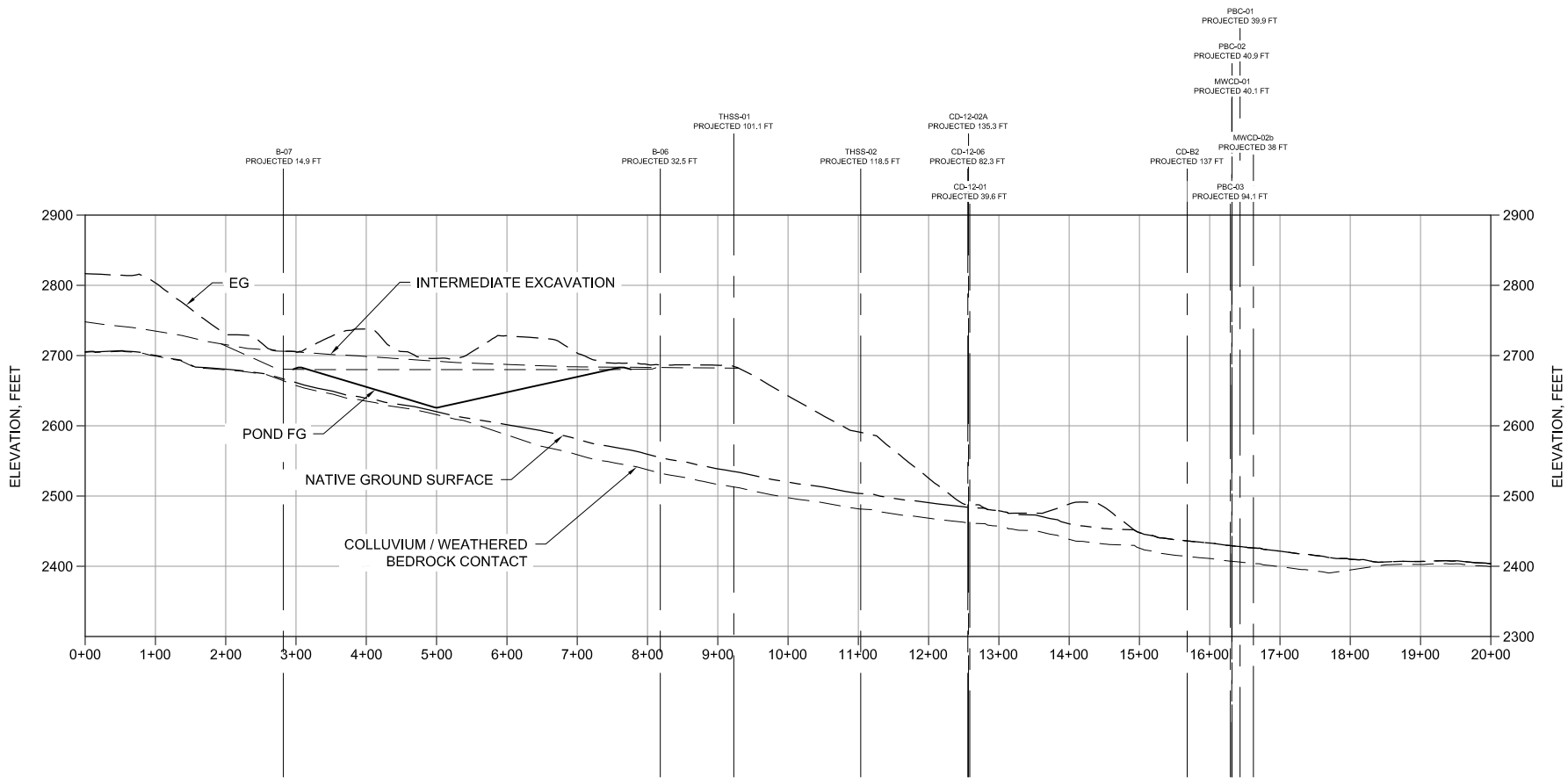
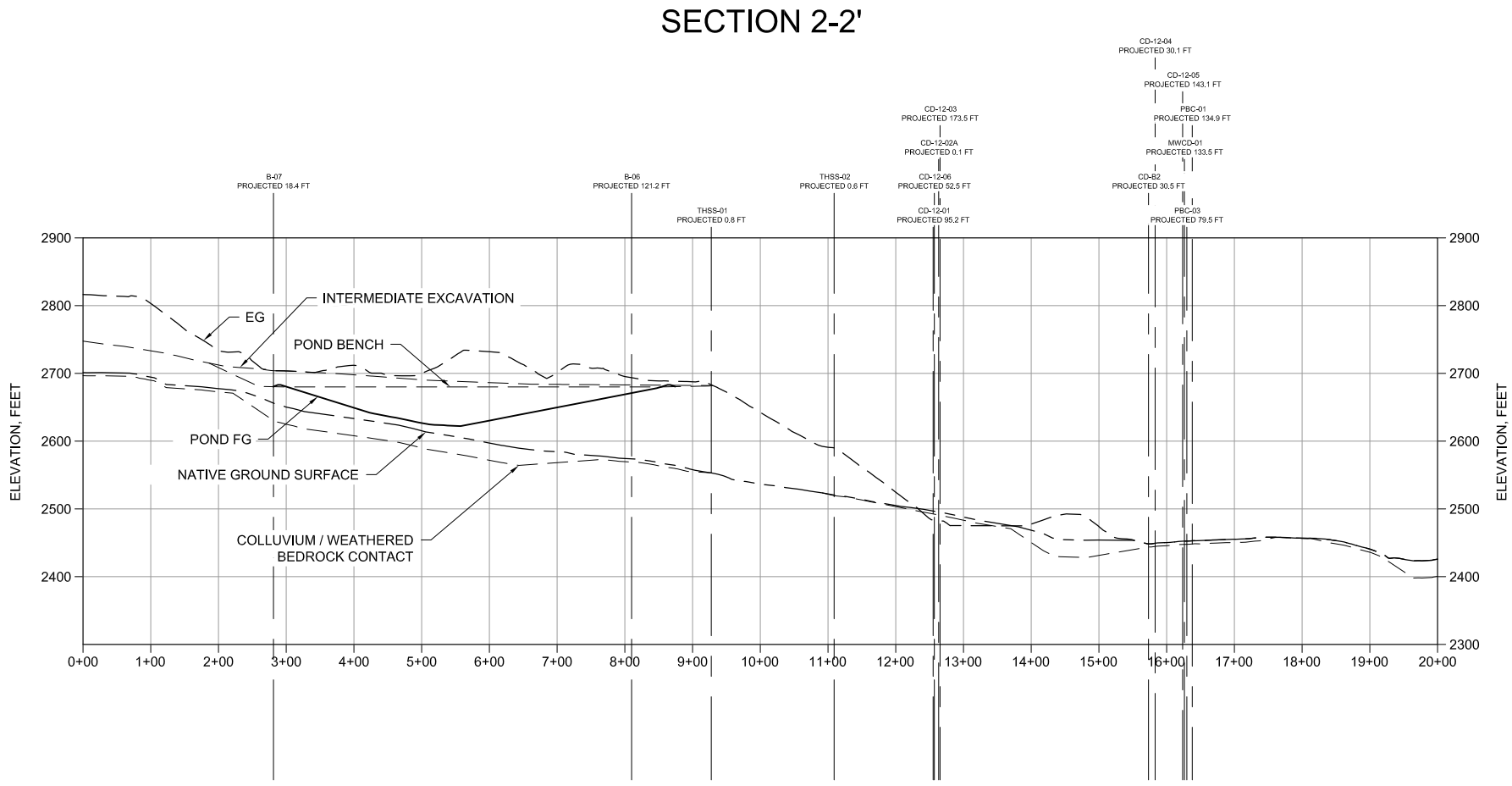
SECTION 1-1'



SECTION 2-2'



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- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.
- PREMINE TOPOGRAPHY AND PIT EXCAVATION TOPOGRAPHY BASED UPON INFORMATION PROVIDED BY U.S. BUREAU OF MINES (USBM), JULY, 1995. ORIGINAL COORDINATE SYSTEM USED IN USBM MAPPING (NAD27/NGVD29) HAS BEEN CONVERTED TO NAD83/NAVD88 BASED COORDINATES.

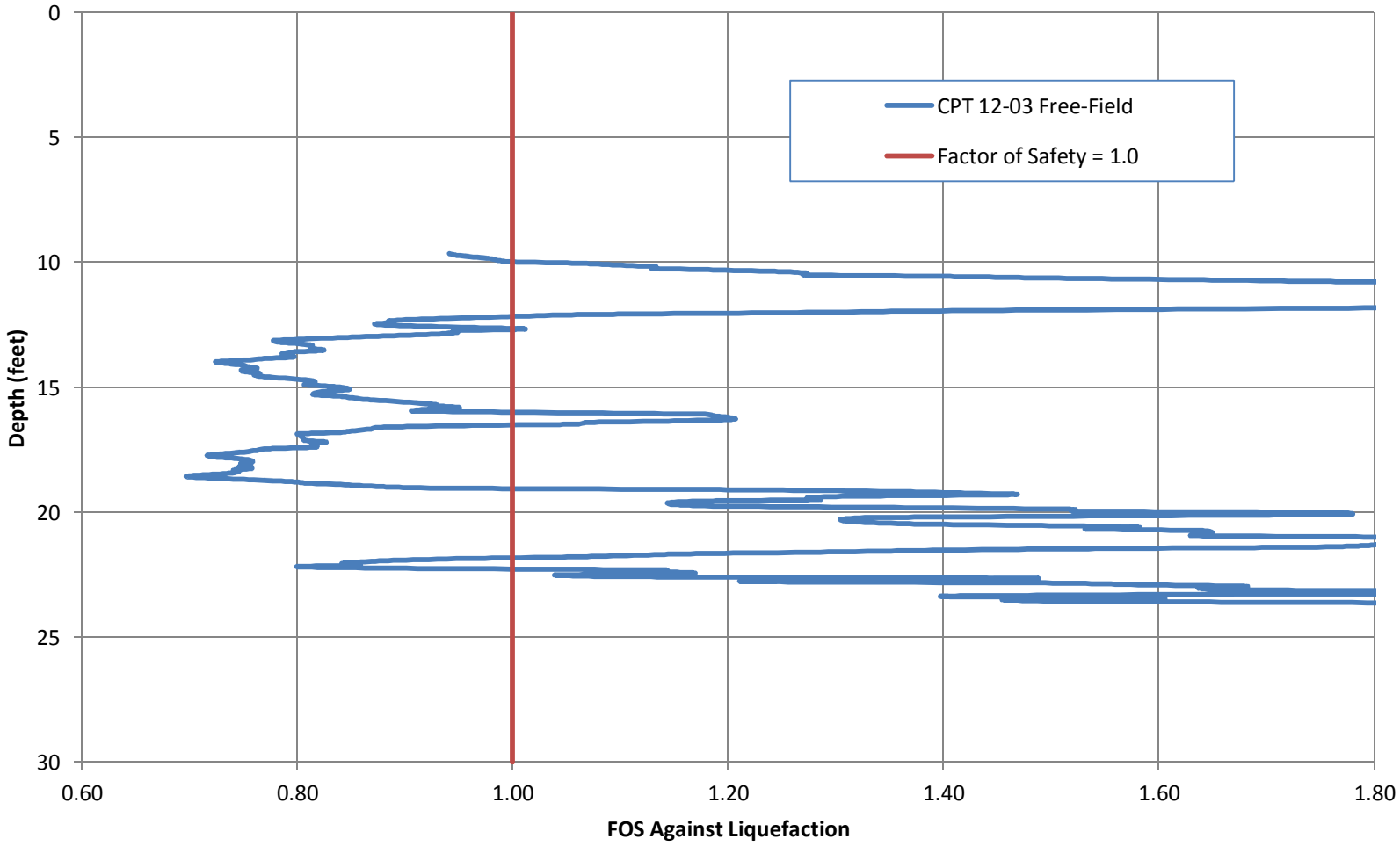
0 120' 240'

NEWMONT

PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 3 - SOUTH POND SLOPE STABILITY SECTIONS
FIGURE	3
REVISION	0
FILE NAME	SSP_STRAT
DATE	APR 2013

MWH

CPT 12-03 Free-field



NEWMONT

PROJECT
MIDNITE MINE

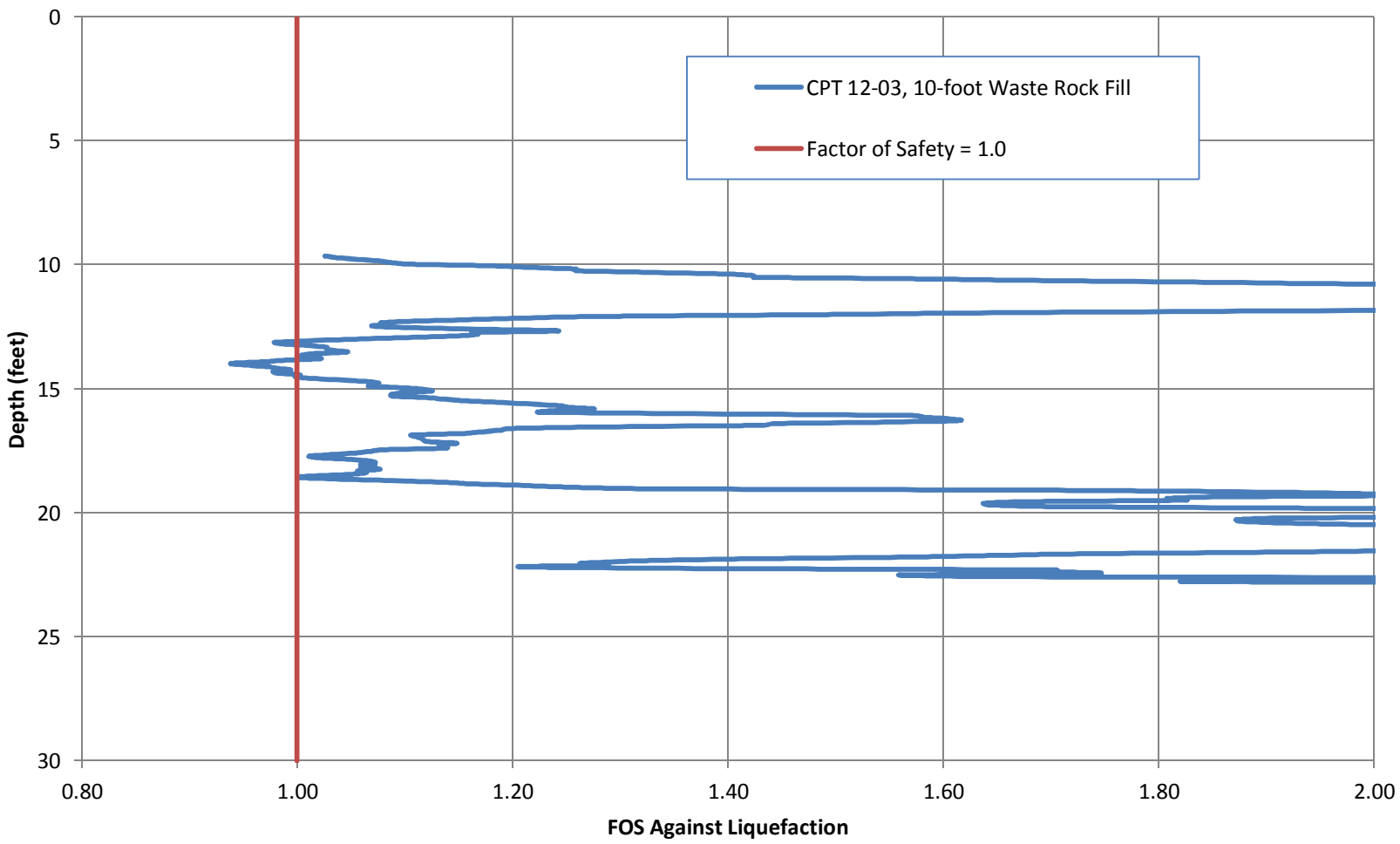
TITLE
Factor of Safety Against Liquefaction vs. Depth – Free Field

MWH

DATE
April 2013

FIGURE 4

FILENAME
South Pond Slope Stability Clac Brief – April 2013.pptx



NEWMONT

PROJECT
MIDNITE MINE

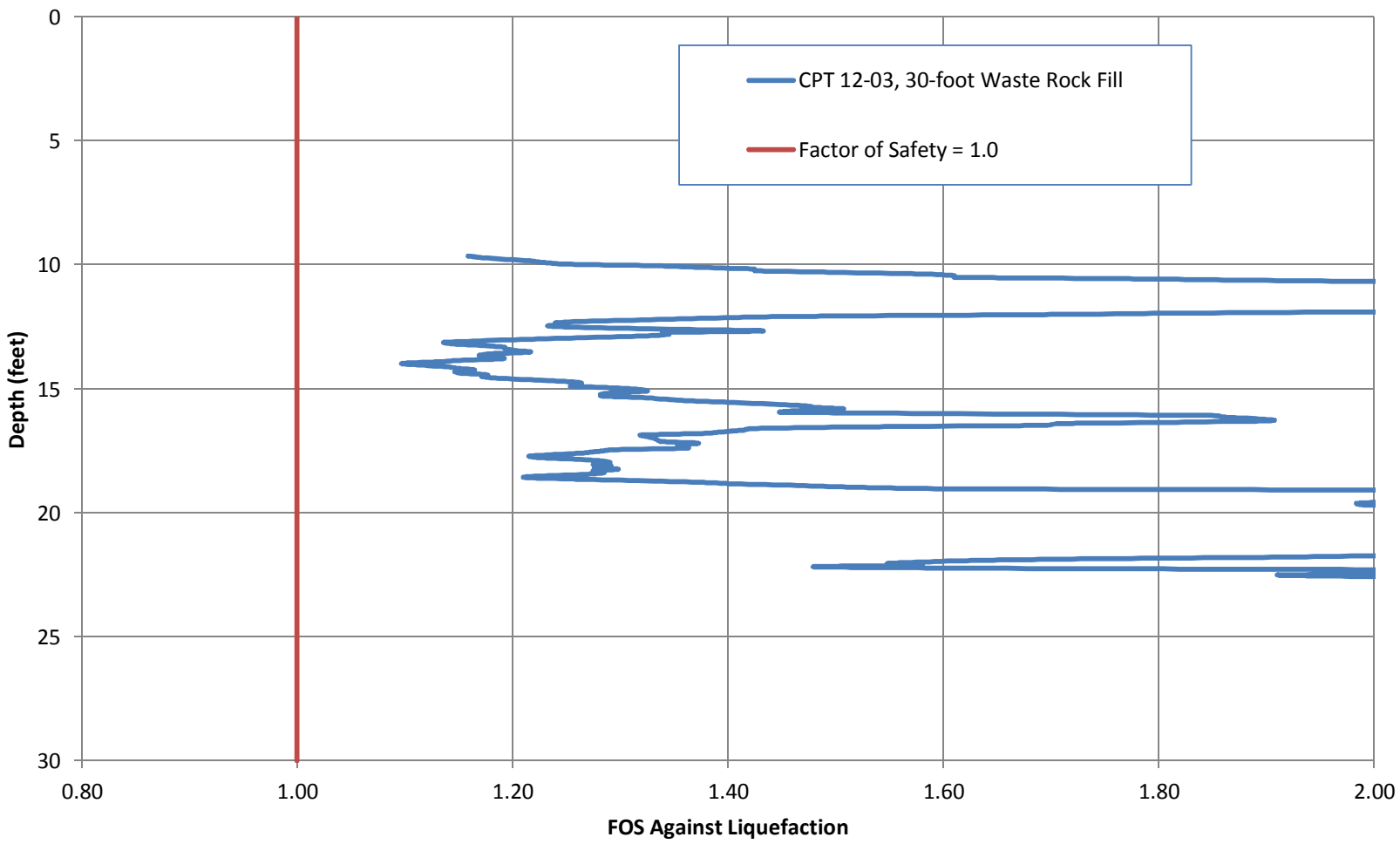
TITLE
Factor of Safety Against Liquefaction vs. Depth – 10-ft Waste Rock

MWH

DATE
April 2013

FIGURE 5

FILENAME
South Pond Slope Stability Clac Brief – April 2013.pptx



NEWMONT

PROJECT
MIDNITE MINE

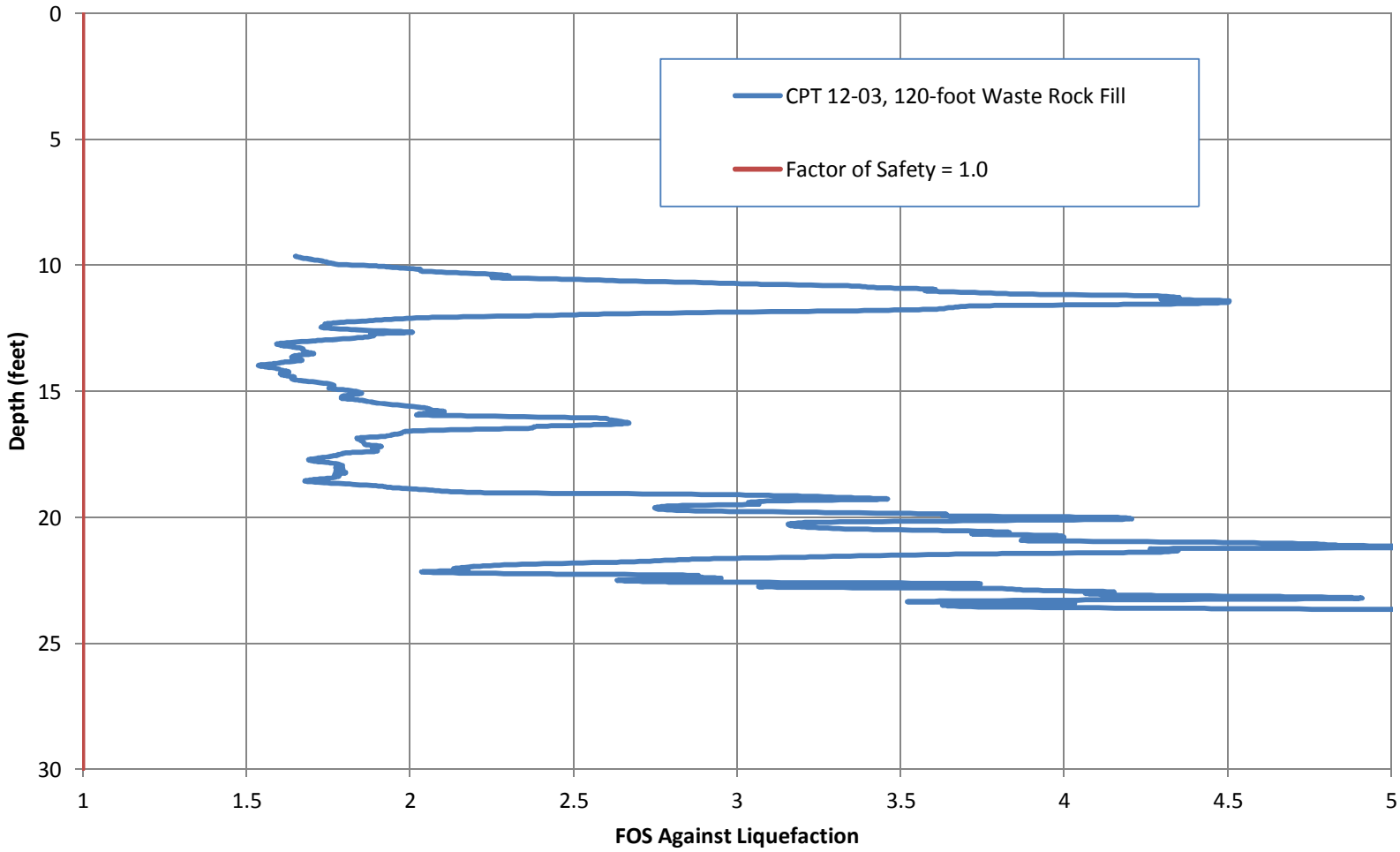
TITLE
Factor of Safety Against Liquefaction vs. Depth – 30-ft Waste Rock

MWH

DATE
April 2013

FIGURE 6

FILENAME
South Pond Slope Stability Clac Brief – April 2013.pptx



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Factor of Safety Against Liquefaction vs. Depth – 120-ft Waste Rock

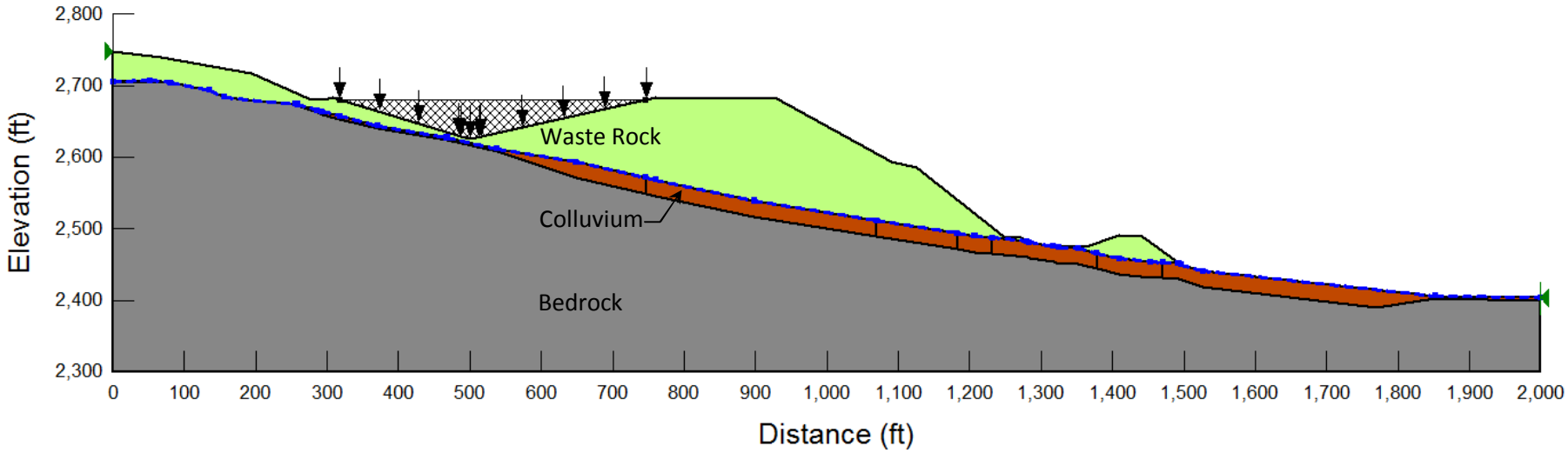
MWH

DATE
April 2013

FIGURE 7

FILENAME
South Pond Slope Stability Clac Brief – April 2013.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Geometry



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis - Post-Earthquake Conditions
South Pond - Cross-Section 1

MWH

DATE
April 2013

FIGURE 8

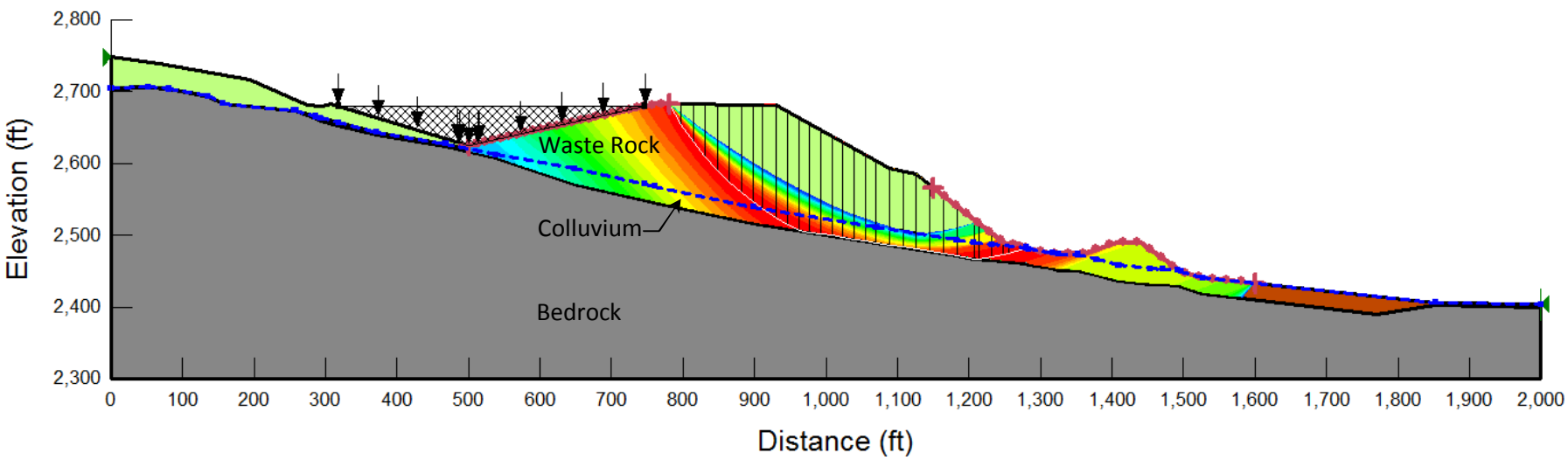
FILENAME
South Pond Slope Stability Clac Brief – April 2013.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Post-Earthquake Conditions
Circular Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	1.55 (Free Field) 0.42 (30' Dam Fill) 0.34 (65' Dam Fill) 0.31 (120' Dam Fill) 0.35 (Pond)
Bedrock	Impenetrable			-

1.2



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Post-Earthquake Conditions
Clay Behavior
South Pond - Cross-Section 1 - Circular Failure Surface

MWH

DATE: April 2013

FIGURE 9

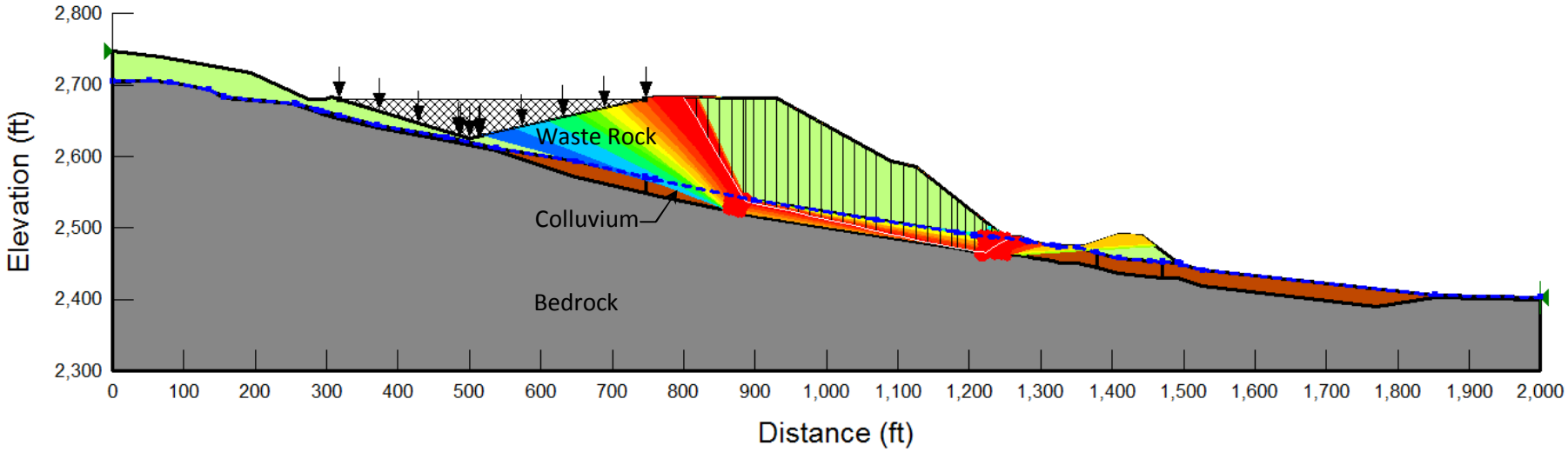
FILENAME: South Pond Slope Stability Clac Brief – April 2013.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Post-Earthquake Conditions
Block Specified Wedge Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	1.55 (Free Field) 0.42 (30' Dam Fill) 0.34 (65' Dam Fill) 0.31 (120' Dam Fill) 0.35 (Pond)
Bedrock	Impenetrable			-

1.2



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis - Post-Earthquake Conditions
Cay Behavior
South Pond - Cross-Section 1 - Wedge Failure Surface

MWH

DATE
April 2013

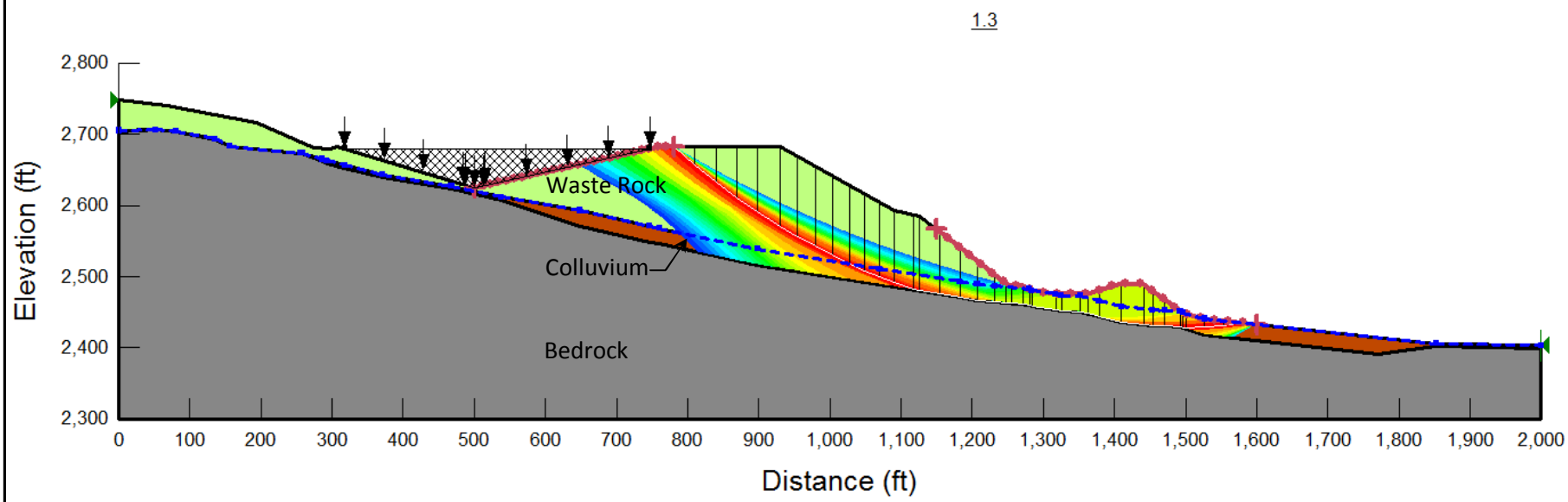
FIGURE 10

FILENAME
South Pond Slope Stability Clac Brief – April 2013.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Post-Earthquake Conditions
Circular Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	- 28	- 0	0.08 (Free Field) -
Bedrock	Impenetrable			-



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PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Post-Earthquake Conditions
Sand Behavior
South Pond - Cross-Section 1 - Circular Failure Surface

MWH

DATE: April 2013

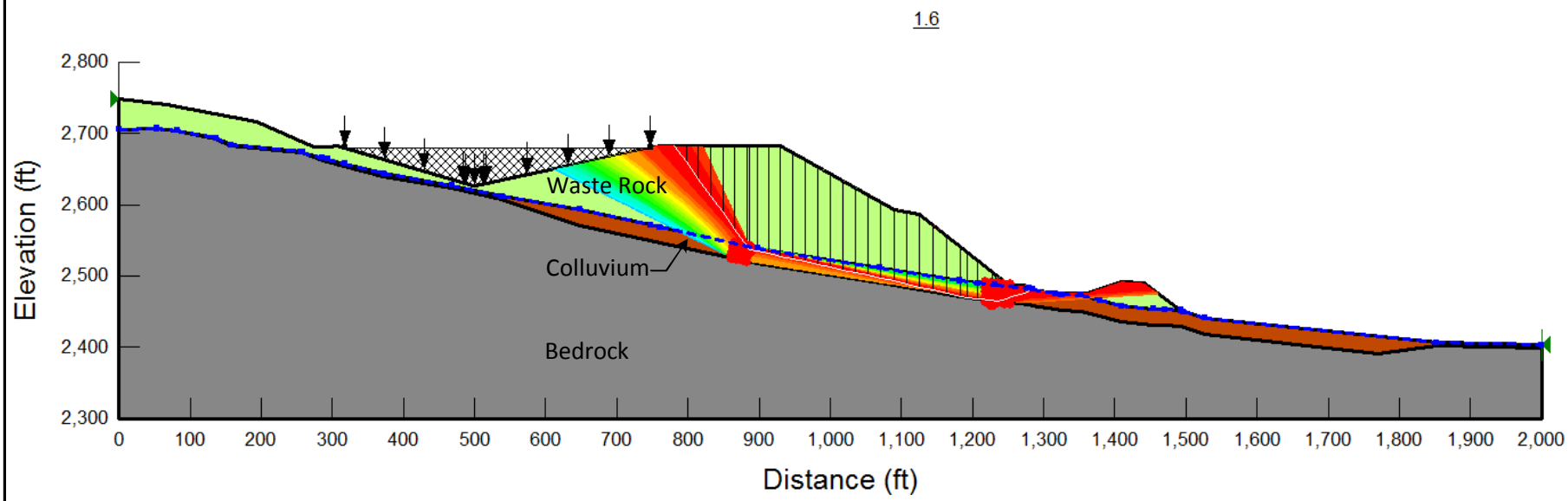
FIGURE 11

FILENAME: South Pond Slope Stability Clac Brief – April 2013.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Post-Earthquake Conditions
Block Specified Wedge Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	- 28	- 0	0.08 (Free Field) -
Bedrock	Impenetrable			-



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PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Post-Earthquake Conditions
Sand Behavior
South Pond - Cross-Section 1 - Wedge Failure Surface

MWH

DATE: April 2013

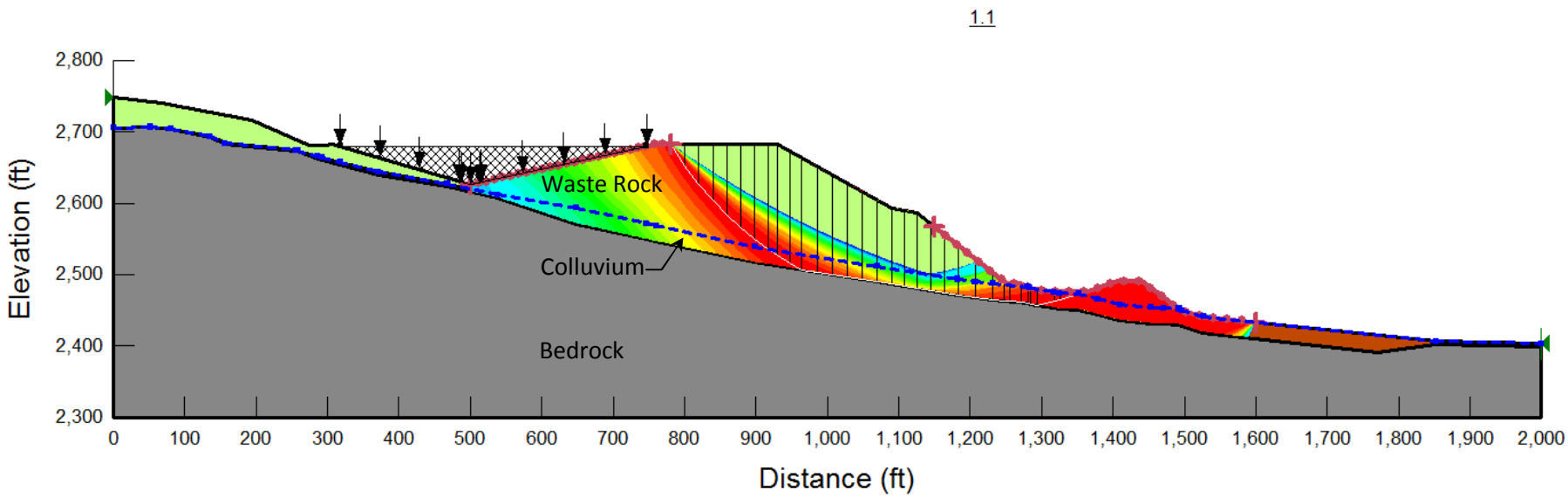
FIGURE 12

FILENAME: South Pond Slope Stability Clac Brief – April 2013.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Post-Earthquake Conditions
Circular Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	0.08 (Free Field) 0.42 (30' Dam Fill) 0.34 (65' Dam Fill) 0.31 (120' Dam Fill) 0.35 (Pond)
Bedrock	Impenetrable			-



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Post-Earthquake Conditions
Sand-Clay Behavior
South Pond - Cross-Section 1 - Circular Failure Surface

MWH

DATE: April 2013

FIGURE 13

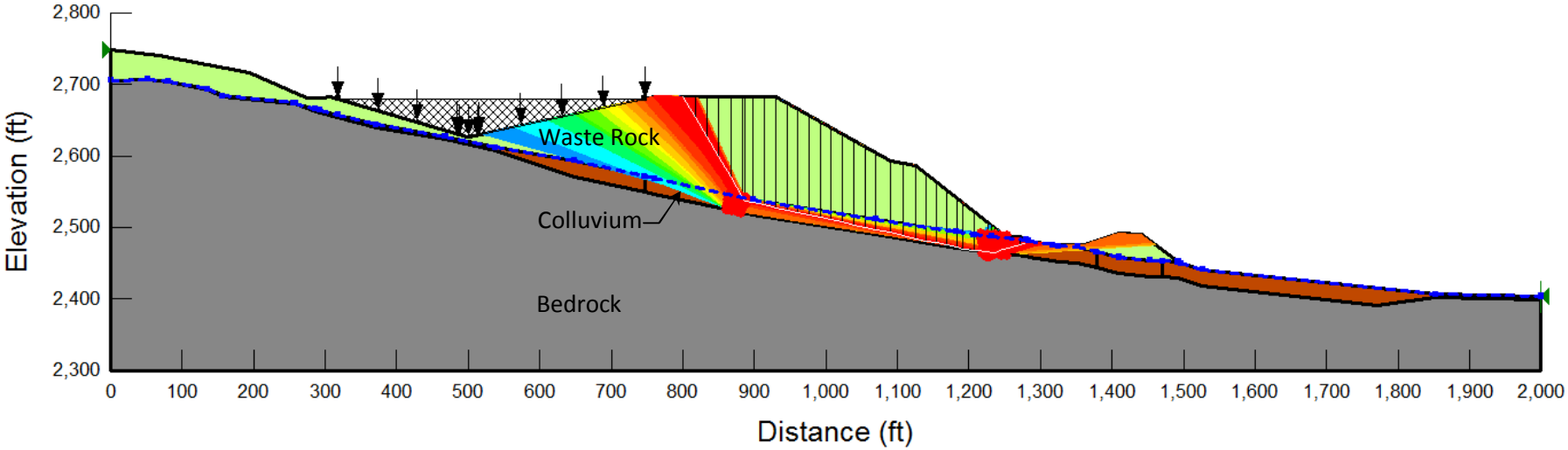
FILENAME: South Pond Slope Stability Clac Brief – April 2013.pptx

Midnite Mine
Slope Stability Analysis
South Pond - Cross-Section 1
Post-Earthquake Conditions
Block Specified Wedge Failure Surface

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)	s_u/σ_v'
Waste Rock	135	38.0	0	-
Colluvium	122	-	-	0.08 (Free Field) 0.42 (30' Dam Fill) 0.34 (65' Dam Fill) 0.31 (120' Dam Fill) 0.35 (Pond)
Bedrock	Impenetrable			-

1.1



NEWMONT

PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis - Post-Earthquake Conditions
Sand-Clay Behavior
South Pond - Cross-Section 1 - Wedge Failure Surface

MWH

DATE: April 2013

FIGURE 14

FILENAME: South Pond Slope Stability Clac Brief – April 2013.pptx

Attachment E-3

South Storage Pond Liquefaction/Cyclic Softening Analysis

ATTACHMENT E-3

MIDNIGHT MINE
SOUTH STORAGE POND
LIQUEFACTION/CYCLIC SOFTENING ANALYSIS

Revisioning					
Rev.	**Date**	**Description**	**By**	**Checked**	**Reviewed**
0	*12/03/2012*	*First Issue*	*Wonnie Kim*	*John Worthen*	*Tom Kelley*
0	*5/14/2015*	*No changes – 60%, 90% or 100% Design stages*			

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\USFTC2S01\Projects\Newmont\Midnite Mine_2011\6.0 Studies & Reports\6.2 Technical\South Dump Pond\Liquefaction
The following calculations were generated using the following software:

Excel

Supplements

Supplement E3.1 – CPTu Results

Supplement E3.2 – Liquefaction & Cyclic Softening Evaluation Calculations

1.0 OBJECTIVE

The potential for liquefaction and cyclic softening in the saturated foundation layers for the South Storage Pond (South Pond) was evaluated based upon previous investigations performed as part of the *Storage Ponds Investigation Report* (MWH, 2012) and recent piezocone (CPTu) soundings along the toe of the South Waste Rock Pile (SWRP). The proposed South pond will be excavated in the top surface of the SWRP at a setback distance of approximately 100 feet from the crest. The purpose of this analysis was to evaluate whether liquefaction or cyclic softening within the foundation soils may occur due to the design seismic event, and what impacts this might have on the undrained strengths of the foundation soils, and ultimately to the pond stability after the seismic event.

The foundation soils were screened for liquefaction susceptibility based on laboratory and field data obtained during the previous Storage Pond Investigation downstream of the current toe of the SWRP (MWW, 2012), and is summarized in this calculation. Both liquefaction triggering and cyclic softening evaluations were performed on the soils that were identified to be susceptible to liquefaction. Two simplified liquefaction triggering methods (Idriss and Boulanger, 2008; Youd et al., 2001) were used to evaluate low-plasticity soils and one simplified cyclic softening method (Idriss and Boulanger, 2008) was used to evaluate higher-plasticity fine-grained soils. Lastly, the post-earthquake strengths were estimated for zones that could be susceptible to liquefaction or cyclical softening during the design seismic event.

2.0 BACKGROUND

The proposed South Storage Pond will be constructed within the existing waste rock pile as shown on Figure 1. During investigations for the *Storage Ponds Design Investigation Report* (MWH 2012), drilling, SPT testing, sampling and laboratory testing was performed below the toe of the SWRP. The original proposed storage pond locations being considered during that investigation were located downstream of the toe of the SWRP, and the test hole locations were located approximately 300 feet downstream from the SWRP toe. Soft, fine-grained alluvial sediments were encountered in some borings located along the valley bottoms in the Central and Western Drainages during that investigation. Although very low SPT blow counts were obtained in some of these materials, there was concern that the drilling method (i.e. Hollow-stem auger drilling below the water table) may have resulted in borehole heave and influenced these initial geotechnical results.

The stratigraphy at the site generally consists of colluvium and/or alluvium over extremely weathered quartz-monzonite bedrock, which gradually transitions to less weathered bedrock. The extremely weathered bedrock typically has a soil-like texture (residuum), and would typically classify as a clayey sand to silty sand and gravel. Although it typically has a soil-like texture, the residuum is typically very dense to extremely dense with high SPT blow counts being measured. Above the valley floor, the thickness of colluvium has a typical thickness of three to five feet. In the valley bottoms, saturated alluvium, typically consisting of medium plasticity sandy clays and clayey sands are encountered, with occasional lower plasticity layers. A preliminary evaluation of results presented in the *Storage Ponds Design Investigation Report* from the four borings where soft alluvial sediments were encountered indicate the presence of a low-strength, low-plasticity clay that had moderate liquefaction potential. The potential for liquefaction for these clays was evaluated using criteria from Bray and Sancio, 2006, which is shown in Figure 3. The laboratory test results indicate that the majority of the samples were not susceptible to liquefaction, but two samples were moderately susceptible to liquefaction. The majority of the alluvial material is anticipated to be susceptible to cyclic softening (partial strength loss during seismic shaking), which is typical for materials with fines contents higher

than 50 percent and PI greater than 10-20 rather than liquefaction (where almost all strength may be lost due to shaking). However it is possible that some of the lower plasticity and lower fine content layers within the alluvium may be liquefiable. Thus, as a conservative approach, the liquefaction triggering evaluation was performed on the clay layer within the foundation. This evaluation resulted in factors of safety less than 1 in one boring (CD-B2).

Due to the distance of the previous data from the toe of the SWRP, and the concern over the potential effect of drilling methods on previous test results, CPTu soundings were proposed along the toe of the SWRP to measure the extent and in-situ undrained strength properties of the soft alluvial sediments in the valley bottom. Figure 1 shows the project area, boring locations, and CPTu sounding locations. , A typical section is included as Figure 2.
The additional CPTs were performed closer to the waste rock embankment to evaluate this clay layer. Two CPTs boring (i.e., CD-12-04 and CD-12-05) were pushed near previous borings from earlier investigations. CPT CD-12-04 was located next to borehole CD-B2, which was drilled as part of the previous storage pond investigation and where SPT results indicated factors of safety against liquefaction of less than one. These CPTu soundings were performed to evaluate and correlate the CPT results with the existing borehole data. Four CPTs were performed in the Central Drainage valley bottom along the toe of the SWRP at locations where soft alluvial sediments might be encountered: CD-12-01, CD-12-02A, CD-12-03, and CD-12-06. All CPTu sounding along the toe of the SWRP were predrilled through waste rock fill that had been placed to create a road between the toe of the SWRP and the Pollution Control Pond (PCP). Two of these CPTu sounding hit refusal in very dense clayey sand (extremely weathered bedrock) and could not be advanced into the foundation (CD-12-01, CD-12-06). These soundings indicated that low-strength, low-plasticity alluvial clays do not exist in the soils underlying these locations. These CPTu soundings were used to update the initial SPT-based evaluations of liquefaction potential, evaluate the potential for cyclical softening, and estimate the undrained strengths of the foundations in areas where soft, alluvial soil occur. For these more recent CPTu-based analyses, groundwater was generally assumed to be near contact of the waste rock roadway fill with the foundation soils.

3.0 ASSUMPTIONS AND LIMITATIONS

Site-specific correlations to provide estimates of soil classification using CPTu data are often used to provide rough interpretations of soil types although they are often unreliable and require correlation with site-specific borehole and laboratory test data in critical applications. In the case of the Midnite Mine alluvial soils the generalized correlations for CPT material type appeared to be highly inaccurate. As a result estimates of material type used in subsequent analyses were based upon a conservative interpretation borehole and laboratory testing data from previous investigations.

4.0 SEISMIC DESIGN CRITERIA

The design PGA was 0.131 g and the design magnitude was M6.5. The design criteria for liquefaction evaluation provided in the Technical Memorandum "*Midnite Mine – Site Seismicity Analysis*" (MGC, 2010) was used. The design PGA was the 10 percent exceedance in 250 years from the USGS hazard maps. Site specific seismicity analyses yielded lower PGAs, however, the site seismicity analysis report recommended to use the USGS values for random earthquakes. The magnitude used for analysis was a M6.5, which was the largest random earthquake considered in site seismicity analysis.

5.0 LIQUEFACTION AND CYCLIC SOFTENING ANALYSIS METHODOLOGY

5.1 GENERAL METHODOLOGY

The foundation low-strength, low-plasticity clays are anticipated to be susceptible to cyclic softening rather than be susceptible to the mechanisms of liquefaction; however, the potential that portions of the layer may be liquefiable cannot be eliminated. Thus, both liquefaction and cyclic softening potential and effects were evaluated. A four part evaluation was performed to evaluate the liquefaction and cyclic softening potential.

- **Step 1:** Validate/correlate the CPTs with the existing boring data. The CPTs CD-12-04 and CD-12-05 were performed in the area of the previous borings (CD-B1 through CD-B4) and were compared, with an emphasis on CD-12-04 which was located next to CD-B2 which was the boring which showed factors of safety against liquefaction of less than 1.
- **Step 2:** Evaluate liquefaction potential using two liquefaction triggering evaluations (Idriss and Boulanger, 2008; Youd et al, 2001) using the CPT data.
- **Step 3:** Evaluate cyclic softening potential using Idriss and Boulanger, 2008.
- **Step 4:** Estimate post-earthquake strengths based on the effects of these two mechanisms: liquefaction and cyclic softening.

Multiple points beneath the waste rock pile were evaluated, which are described below and illustrated on Figure 2.

- **Free Field:** The free field condition represents the conditions at the time the CPT was performed. The effect of the waste rock on the foundation soil through which the CPT was advanced through were ignored.
- **30' of Fill:** The point at which the waste rock fill is 30' thick above the low-strength, low plasticity clay.
- **65' of Fill:** The point at which the waste rock fill is 65' thick above the low-strength, low plasticity clay.
- **Pond with 40' of Fill, 80' Removed:** A point at the South Storage Pond in which the waste rock fill is 40' high above the low-strength, low plasticity clay and 80' of the waste rock pile has been removed to construct the pond. It was assumed that there is 30' of water above the bottom of the pond in this column. This was assumed to be a typical high water level for the pond.

5.2 LIQUEFACTION TRIGGERING EVALUATION – IDRISS AND BOULANGER (2008)

The Idriss and Boulanger (2008) liquefaction triggering method estimates the cyclic stress ratio (CSR) based on the seismic design criteria and estimates the cyclic resistance ratio (CRR) based on the CPT readings and site conditions. CSR is calculated using a simplified procedure to estimate earthquake induced stresses, calculated using the following relationship:

$$CSR_{M=7.5,\sigma'_{vc}=1} = 0.65\frac{a_{max}}{g}\frac{\sigma_{vc}}{\sigma'_{vc}}\frac{1}{MSF}\frac{1}{K_\sigma}\frac{1}{K_\alpha}$$

Where:

Amax: maximum horizontal ground surface acceleration

σ_{vc}': effective vertical confining stress
σ_{vc}: total vertical confining stress
r_d: shear stress reduction coefficient
MSF: earthquake magnitude scaling factor
K_σ: overburden correction factor
K_α: static shear stress correction factor

The equations for the correction factors applied to the CSR for this evaluation are the following:

$$r_d = \exp(\alpha(z) + \beta(z)M)$$

$$\alpha(z) = -1.012 - 1.126 \sin\left(\frac{z}{11.73} + 5.133\right)$$

$$\beta(z) = 0.106 + 0.118 \sin\left(\frac{z}{11.28} + 5.142\right)$$

$$\mathrm{MSF} = 6.9 \exp\left(\frac{-M}{4}\right) - 0.058 \quad \leq 1.8$$

$$K_\sigma = 1 - C_\sigma \ln\left(\frac{\sigma'_{vc}}{P_a}\right) \leq 1.1$$

$$C_\sigma = \frac{1}{37.3 - 8.27(q_{c1N})^{0.264}} \leq 0.3$$

Where:

q_{c1N}: tip resistance normalized to atmospheric pressure and overburden pressure

The foundation has a slope of approximately 5H:1V; however, since the waste rock pile confines the foundation soils further, the effects of the sloping surface were ignored. A static shear stress correction factor of $K_\alpha=1$ was used for all calculations.

The relationship for CRR is based on liquefaction case histories and is expressed as:

$$\mathrm{CRR}_{M=7.5,\sigma'_{vc}=1} = \exp\left(\frac{q_{c1Ncs}}{540} + \left(\frac{q_{c1Ncs}}{67}\right)^2 - \left(\frac{q_{c1Ncs}}{80}\right)^3 + \left(\frac{q_{c1Ncs}}{114}\right)^4 - 3\right)$$

Where:

q_{c1Ncs}: equivalent clean-sand corrected normalized tip resistance

$$q_{c1Ncs} = q_{c1N} + \Delta q_{c1N}$$

$$\Delta q_{c1N} = \left(5.4 + \frac{q_{c1N}}{16}\right) \cdot \exp\left(1.63 + \frac{9.7}{\mathrm{FC} + 0.01} - \left(\frac{15.7}{\mathrm{FC} + 0.01}\right)^2\right)$$

FC = Fines Content in %

The factor of safety against liquefaction was computed as:

$$FS_{liq} = \frac{\mathrm{CRR}_{M=7.5,\sigma'_{vc}=1}}{\mathrm{CSR}_{M=7.5,\sigma'_{vc}=1}}$$

The correlation between CSR, CRR, and q_{c1N} is shown in Figure 4.

5.3 LIQUEFACTION TRIGGERING EVALUATION – YOUD ET AL. (2001)

The Youd et al. (2001) liquefaction triggering method estimates the CSR based on the seismic design criteria and estimates the CRR based on the CPT readings and site conditions. CSR is calculated using a simplified procedure to estimate earthquake induced stresses, calculated using the following relationship:

$$CSR_{M=7.5,\sigma'_{vc}=1} = 0.65\frac{a_{max}}{g}\frac{\sigma_{vc}}{\sigma'_{vc}}\frac{1}{MSF}\frac{1}{K_\sigma}\frac{1}{K_\alpha}$$

Where:

Amax: maximum horizontal ground surface acceleration
σ_{vc}': effective vertical confining stress
σ_{vc}: total vertical confining stress
r_d: shear stress reduction coefficient
MSF: earthquake magnitude scaling factor
K_σ: overburden correction factor
K_α: static shear stress correction factor

The equations for the correction factors applied to the CSR for this evaluation are the following:

$$r_d = 1.0 - 0.00765z \quad \text{for } z \leq 9.15 \text{ m}$$

$$r_d = 1.174 - 0.0267z \quad \text{for } 9.15 \text{ m} < z \leq 23 \text{ m}$$

Revised Idriss Scaling Factor: $\mathrm{MSF} = 10^{2.24}/M_w^{2.56}$

Andrus & Stokoe (1997) Scaling Factor: $\mathrm{MSF} = (M_w/7.5)^{-2.56}$

$$K_\sigma = (\sigma'_{vo}/P_a)^{(f-1)}$$

Where:

Pa: Atmospheric Pressure
σ_{vc}': effective vertical overburden pressure
f=0.7 to 0.8 for 40% ≤ relative density, D_r ≤ 60%
0.6 to 0.7 for 60% < relative density, D_r ≤ 80%

$$D_r = \sqrt{\frac{q_{c1n}}{300}}$$

The foundation clays were evaluated assuming essentially flat ground, and ignored the effects of the slope at the toe of the SWRP. Thus, a static shear stress correction factor of $K_\alpha=1$ was used for all calculations.

The relationship for CRR is based on liquefaction case histories and is expressed as:

$$\text{If } (q_{c1N})_{cs} < 50 \quad \text{CRR}_{7.5} = 0.833[(q_{c1N})_{cs}/1{,}000] + 0.05$$
$$\text{If } 50 \le (q_{c1N})_{cs} < 160 \quad \text{CRR}_{7.5} = 93[(q_{c1N})_{cs}/1{,}000]^3 + 0.08$$

Where:

$q_{c1Ncs} = K_c * q_{c1N}$

for $I_c \le 1.64 \quad K_c = 1.0$

for $I_c > 1.64 \quad K_c = -0.403I_c^4 + 5.581I_c^3 - 21.63I_c^2 + 33.75I_c - 17.88$

The factor of safety against liquefaction was computed as:

$$FS_{liq} = \frac{\text{CRR}_{M=7.5,\sigma'_{vc}=1}}{\text{CSR}_{M=7.5,\sigma'_{vc}=1}}$$

The correlation between CSR, CRR, and q_{c1N} is shown in Figure 5.

5.4 LIQUEFACTION TRIGGERING EVALUATION – CALCULATIONS

The average factor of safety against liquefaction (FS_{liq}) between the two methods used to evaluate liquefaction potential in the foundation was calculated. In this analysis, when this average value for the FS_{liq} was less than one, the material was assumed to be liquefiable.

5.5 CYCLIC SOFTENING EVALUATION – IDRISS AND BOULANGER (2008)

The Idriss and Boulanger (2008) liquefaction triggering method estimates the cyclic stress ratio (CSR) based on the seismic design criteria and estimates the cyclic resistance ratio (CRR) based on the CPT readings and site conditions. The CSR is calculated for liquefaction triggering, as described above, was also used for the cyclic softening evaluation.

$$\text{CSR}_M = 0.65\frac{\tau_{peak}}{\sigma'_{vc}}$$

The relationship for CRR is based on liquefaction case histories and is expressed as:

$$\text{CRR}_M = 0.80\frac{s_u}{\sigma'_{vc}}\text{MSF} \cdot K_\alpha$$

A static shear stress correction factor of $K_\alpha=1$ was used for all calculations, as described previously.

An MSF applicable to clays was used (rather than the MSF used for the liquefaction triggering evaluation which is more applicable to sands).

$$\mathrm{MSF} = 1.12 \exp\left(\frac{-M}{4}\right) + 0.828$$

The factor of safety against cyclic softening was computed as:

$$FS_{\gamma=3\%} = \frac{\mathrm{CRR}_M}{\mathrm{CSR}_M}$$

5.6 POST-EARTHQUAKE STRENGTH ESTIMATES

Post-earthquake strengths were estimated using both liquefied strength estimates and residual strength estimates anticipated after cyclic softening.

Liquefied strengths were estimated using three methods (Robertson, 2010b; Idriss & Boulanger, 2008; Olson & Stark, 2003), which are expressed as shown below:

$$s_{u(\mathrm{liq})}/\sigma'_{vo} = [0.02199 - 0.0003124 Q_{tn,cs}]/ [1 - 0.02676 Q_{tn,cs} + 0.0001783 (Q_{tn,cs})^2] \quad \text{where } 0.03 \leq s_{u(\mathrm{liq})}/\sigma'_{vo} \leq \tan\varphi'.$$ (Robertson, 2010b)

$$\frac{S_r}{\sigma'_{vo}} = \exp\left(\frac{q_{c1Ncs-Sr}}{24.5} - \left(\frac{q_{c1Ncs-Sr}}{61.7}\right)^2 + \left(\frac{q_{c1Ncs-Sr}}{106}\right)^3 - 4.42\right) \leq \tan\phi'$$ (Idriss & Boulanger, 2008)

$$\frac{s_u(\mathrm{LIQ})}{\sigma'_{v0}} = 0.03 + 0.0143(q_{c1}) \pm 0.03 \quad \text{for } q_{c1} \leq 6.5 \text{ MPa}$$ (Olson & Stark, 2003)

Cyclic softening strengths were estimated using remolded strength estimates (Robertson, 2010a), which is expressed as:

$$s_{u\mathrm{Remolded}}/\sigma'_{vo} = f_s/\sigma'_{vo} = (F \cdot Q_t)/100$$

These strength estimates were used to estimate a SHANSEP model for peak strengths and residual, post-earthquake strengths (s_u/σ_v' and s_r/σ_v'). OCR was estimated based on the CPT interpretation using the relationships shown below. The SHANSEP models were used to predict strengths at the different points evaluated.

$$\mathrm{OCR} = 0.25\,(Q_t)^{1.25}$$ (Robertson, 2009)

$$\mathrm{OCR} = k\left(\frac{q_t - \sigma_{vo}}{\sigma'_{vo}}\right) = k\,Q_t$$ (Kulhawy and Mayne, 1990)

Where k typically ranges from 0.2 to 0.5. In order to achieve reasonable levels for OCR, a value of 0.15 was used for this analysis. The selection of this value is described further in the results section.

6.0 RESULTS

6.1 VALIDATE/CORRELATE CPTS WITH BORINGS

Interpretations of CPT CD-12-04 and CD-12-05 were evaluated and compared against the existing test hole data, particularly three CPT interpretations: soil behavior type, fines content, and factors of safety against liquefaction. These three items were compared to evaluate the accuracy of the CPTu interpretations.

Estimates of soil behavior types based upon generalized published interpretations of CPTu results for CD-12-04 and CD-12-05 generally ranged from cleans sands/silty sands/sandy silts to clayey silts/silty clays. Borings in this area indicated this material largely consisted of silty clays with some to no sand (CL to SC). CPTu sounding CD-12-05 showed a majority of soil behavior types of clayey silts/silty clays, which indicates reasonable agreement with the borings. However CPTu sounding CD-12-04 showed a significant portion of clean sands/silty sands/sandy silts. This indicates poor agreement with the borings, particularly since CD-12-04 was located in close proximity to CD-B2, which indicated silty clays (SC and CL) at the same intervals that clean sands to silty sands were interpreted. Thus, it appears that CPTu interpretations of soil behavior types based upon generalized empirical correlations of CPTu soundings are not reliable for these site soils. . As a result estimates of material type used in subsequent analyses were based upon conservative interpretations of borehole and laboratory testing data from previous investigations. Specifically, the susceptibility of the clays to liquefaction were based index properties including Atterberg limits, and water contents from available borehole and laboratory test results, in conjunction with conservative estimates of fines content from CPTu test results based upon site-specific correlations..

Fines content correlations typically relate friction ratio, sometimes in combination with tip resistance, with fines content. Site specific correlations are generally required for reliable estimation of fine content. However, there is no discernible trend with fines content and normalized friction ratio, as shown in Figure 6. Fines content in borings CD-B1 to CD-B4 range from 20 to 98 within the clay layer. As an estimate of fines content is needed for some of the analyses, a fines content of 20 percent was conservatively selected for the sandier materials and 50 percent for the finer (silty/clayey) materials based on normalized tip resistances (qc1n>20 FC=20 percent, qc1n<20 FC=50 percent) as shown on Figure 7.

The factors of safety against liquefaction were evaluated for CD-12-04, and was compared with the factors of safety against liquefaction estimated from SPT results from CD-B2, which are summarized in Table 1. The factors of safety in the top 6 ft. are similar. Tip resistances and sleeve friction in the top 6 ft. of CD-12-04 are higher than the rest of the CPT, and blow counts in the top 6 ft. of CD-B2 are also higher than the rest of the boring. The depth interval 6-18 ft. shows significantly lower factors of safety in the CPT CD-12-04 than in the boring CD-B2. The sleeve friction measurements in this interval are low, generally ranging from 0.1 to 0.2 tsf.

Table 1 – Comparison of FS_{liq} Between CD-B2 and CD-12-04

Interval - Depth (ft.)	Boring/CPT	Factors of Safety		
		Min	Max	Average
0-6 ft.	Boring CD-B2	0.8	1.3	1.1
	CPT CD-12-04	0.8	2.4	1.1
6-18 ft.	Boring CD-B2	0.8	1.2	0.9
	CPT CD-12-04	0.5	1.1	0.6

6.2 LIQUEFACTION POTENTIAL EVALUATION

FS_{liq} less than 1 was calculated CD-12-03; FS_{liq} was calculated to be greater than 1 in CD-12-02A. Assuming similar conditions under the toe of the SWRP, factors of safety will increase with increasing waste rock fill due to the effects of confinement. All calculated FS_{liq} were greater than 1 except in the free field condition (no overlying waste rock) of CD-12-03. A summary of the factors of safety is provided in Table 2.

Table 2 – Summary of FSliq

CPT	Case	FS_{liq}		Liquefaction in Layers > 0.5 ft.		
		Min	Average	Start Depth (ft.)	End Depth (ft.)	Thickness (ft.)
CD-12-02A	Free Field	1.35	2.94	No layers with FS_{liq} < 1		
	30' Waste rock	1.30	2.78	No layers with FS_{liq} < 1		
	65' Waste Rock	1.79	3.82	No layers with FS_{liq} < 1		
	120' Waste Rock	1.94	4.01	No layers with FS_{liq} < 1		
	Pond	1.78	3.92	No layers with FS_{liq} < 1		
CD-12-03	Free Field	0.70	3.38	12.27	15.94	3.67
				16.54	19.03	2.49
	30' Waste Rock	1.10	6.82	No layers with FS_{liq} < 1		
	65' Waste Rock	1.52	8.77	No layers with FS_{liq} < 1		
	120' Waste Rock	1.49	8.13	No layers with FS_{liq} < 1		
	Pond	1.54	9.00	No layers with FS_{liq} < 1		

As discussed above, the CPTu-based interpretations of soil type indicate that the materials are coarser and sandier than the actual material sampled in the borings from previous investigation. Sandier materials would be more prone to liquefaction. Thus, the calculated FS_{liq} are considered to be conservative in that they are lower than would be calculated for the actual conditions.

6.3 CYCLIC SOFTENING POTENTIAL EVALUATION

A factor of safety against cyclic softening ,FS_{cs}, less than 1 was calculated in both CPTs. A summary of the factors of safety is provided in Table 3.

The undrained strength for the dam fill cases was estimated based on a SHANSEP model estimated from CD-12-02A, which is described further in the strength estimation results. OCRs were calculated and were used to estimate stress conditions for the different cases, and also to develop the SHANSEP model to predict strengths for the different stress states than those measured at the location of the CPT soundings (i.e. to correct for varying amounts of overburden). The correlations for OCR used resulted in OCR generally ranging from 3 to 50. A large majority of the soil was calculated to be highly overconsolidated (OCR >10, despite borings, particularly CD-B2, which indicated the presence of low strength clays and dynamic

pore pressure measurements which indicated the presence of normally to slightly overconsolidated clays at many locations. Since the calculated OCRs calculated from the general (not site specific) CPT correlations appear unreasonably high based upon other field measurements and observations, the OCRs were adjusted by selecting the Kulhawy Mayne relationship with a slightly lower k of 0.15 (OCR=0.15*Qt). This resulted in OCRs ranging from 1 to 15 with an average of 5.4 in CD-12-02A and OCRs ranging from 2.2 to 27 with an average of 6.6 in CD-12-03, which although still considered high, appear to be reasonably conservative in the context that they are being used to back-calculated normally-consolidated strength parameters. Using the estimated OCRs from the CPT tests in the free-field condition as the initial condition for clays underlying the waste rock, the calculated OCRs approach the normally consolidated condition in areas with greater waste rock thickness (i.e. the current state of stress due to burial approaches the estimated preconsolidation pressure), as shown in Table 3. The average undrained strength ratio (s_u/σ_v') reduces with increasing fill, as the material becomes approaches a normally consolidated.

Since CRR_M is a linearly related to (s_u/σ_v') and the soils approach a normally consolidated under waste rock burial (s_u/σ_v' is nearly constant), CRR_M is nearly constant for the entire column as shown below:

$$\mathrm{CRR}_M = 0.80\frac{s_u}{\sigma'_{vc}}\mathrm{MSF}\cdot K_\alpha$$

$$CRR_M = 0.80 * \sim 0.40 * MSF * K_\alpha$$

$$CRR_M \approx \text{constant}$$

CSR is also relatively constant for the entire column, and thus the FS_{cs} is relatively constant for the entire column for the dam fill cases. This results in all cases of waste rock burial indicating the potential for cyclic softening if initial conditions (prior to burial) are assumed to be similar to those measured at CD-12-03. If initial conditions are assumed to be similar to those measured at CD-12-02A, a relatively thin layer (approximately 3 feet thick) would exhibit potential for cyclic softening.

Table 3 – Summary of FScs

CPT	Case	FS_{cs}		Cyclic Softening in Layers > 0.5 ft		
		Min	Average	Start Depth (ft)	End Depth (ft)	Thickness (ft)
CD-12-02A	Free Field	0.36	2.49	11.09	13.06	1.97
				14.76	15.81	1.05
	30' Dam Fill	0.36	0.63	11.09	14.63	3.54
				15.22	18.18	2.96
	65' Dam Fill	0.82	0.99	11.09	14.44	3.35
	120' Dam Fill	0.94	1.14	11.09	14.44	3.35
	Pond	0.66	0.80	11.15	14.50	3.35
CD-12-03	Free Field	0.87	1.51	No layers with FS_{liq} < 1 thicker than 0.5 ft		
	30' Dam Fill	0.58	0.69	9.65	23.56	13.91
	65' Dam Fill	0.81	0.88	9.65	23.56	13.91
	120' Dam Fill	0.84	0.88	9.65	23.69	14.04
	Pond	0.81	0.90	9.65	23.49	13.85

6.4 POST-EARTHQUAKE STRENGTHS

Peak strengths were estimated based on the CPT results. A SHANSEP model was developed based on CD-12-02A interpretations. This SHANSEP model is described below and shown in Figure 8:

$$\left(\frac{s_u}{\sigma_{v'}}\right)_{OC} = \left(\frac{s_u}{\sigma_{v'}}\right)_{NC} * OCR^m$$
$$\left(\frac{s_u}{\sigma_{v'}}\right)_{OC} = 0.40 * OCR^{1.0}$$

This SHANSEP model was used to predict the undrained strengths underneath the waste rock footprint for the various waste rock fill cases evaluated.

Since CD-12-02A did not have $FS_{liq} < 1$, at any point in the profile, it was assumed that any strength loss would be a result of cyclic softening. The potential for cyclic softening in CD-12-02A are limited to two zones, both approximately three feet in thickness. for the results from CD-12-03 indicate the potential for both liquefaction and cyclic softening, however the potential for liquefaction was seen only for the free field case downstream of the SWRP toe. The potential for cyclic softening in the free-field case at CD-12-03 was limited to layers less than 0.5 feet in thickness. Thus, post-earthquake strength estimates were based on cyclic softening strength estimates, rather than liquefied strength estimates.

The residual cyclic softening strengths were estimated based on a SHANSEP model developed on CD-12-02A. This SHANSEP model is described below and shown in Figure 9.

$$\left(\frac{s_u}{\sigma_{v'}}\right)_{OC} = \left(\frac{s_u}{\sigma_{v'}}\right)_{NC} * OCR^m$$
$$\left(\frac{s_u}{\sigma_{v'}}\right)_{OC} = 0.27 * OCR^{0.9}$$

A summary of the post-earthquake strength estimates is shown in Table 4. It should be noted that the results summarized in Table 4 are based upon back-calculation of the normally consolidated shear strengths using OCR ratios estimated from the CPT soundings. The CPT-based OCR ratios appear to be high when considering other field behavior, and the overestimation of OCR will result in an underestimation of the normally consolidated s_u/σ_v' ratio. Thus, all subsequently calculated values for s_u/σ_v' ratios under various thicknesses of waste rock fill can be considered conservative. Typical strength loss due to cyclic softening is estimated to be 20%. There does not appear to be potential for strength loss due to liquefaction with the possible exception of the toe area in the vicinity of CD-12-03.

Table 4 – Summary of Undrained Strength Estimates

CPT	Case	Average OCR	s_u/σ_v'		s_r/σ_v'		$s_{u,liq}/\sigma_{v'}$	
			Entire Layer Average	NC Soils	Entire Layer Average	NC Soils	Entire Layer Average	Liquefied Soils Only
CD-12-02A	Free Field	5.4	2.10	0.40	2.06	0.27	N/A	N/A
	30' Dam Fill	1.6	0.65		0.48		N/A	N/A
	65' Dam Fill	1.2	0.48		0.39		N/A	N/A
	120' Dam Fill	1.0	0.40		0.34		N/A	N/A
	Pond	1.4	0.55		0.42		N/A	N/A
CD-12-03	Free Field	6.6	2.10	0.40	1.04	0.27	1.12	0.08
	30' Dam Fill	1.2	0.47		0.35		N/A	N/A
	65' Dam Fill	1.1	0.43		0.28		N/A	N/A
	120' Dam Fill	1.0	0.41		0.27		N/A	N/A
	Pond	1.1	0.44		0.28		N/A	N/A

Calculations for each CPT are provided in Supplement E3.2.

7.0 CONCLUSIONS

Based on the results of the liquefaction and cyclic softening analysis for the conditions evaluated, cyclic softening is anticipated within portions of the foundation clays. Liquefaction is possible; however it is anticipated to be limited to thin layers within the clay layer at the dam toe. Based on the liquefaction and cyclic softening triggering analyses, it is recommended that stability analyses be performed to evaluate the effect of the post-earthquake strengths on the stability of the SWRP in areas of saturated alluvial clays using the average estimated strengths from CD-12-02A and CD-12-03 shown in Table 4. For the reasons discussed above, the estimates for normally consolidated undrained strength and undrained strength under the various waste rock loading conditions are considered conservative due to difficulties applying the general OCR correlations to the site.

8.0 REFERENCES

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Figures

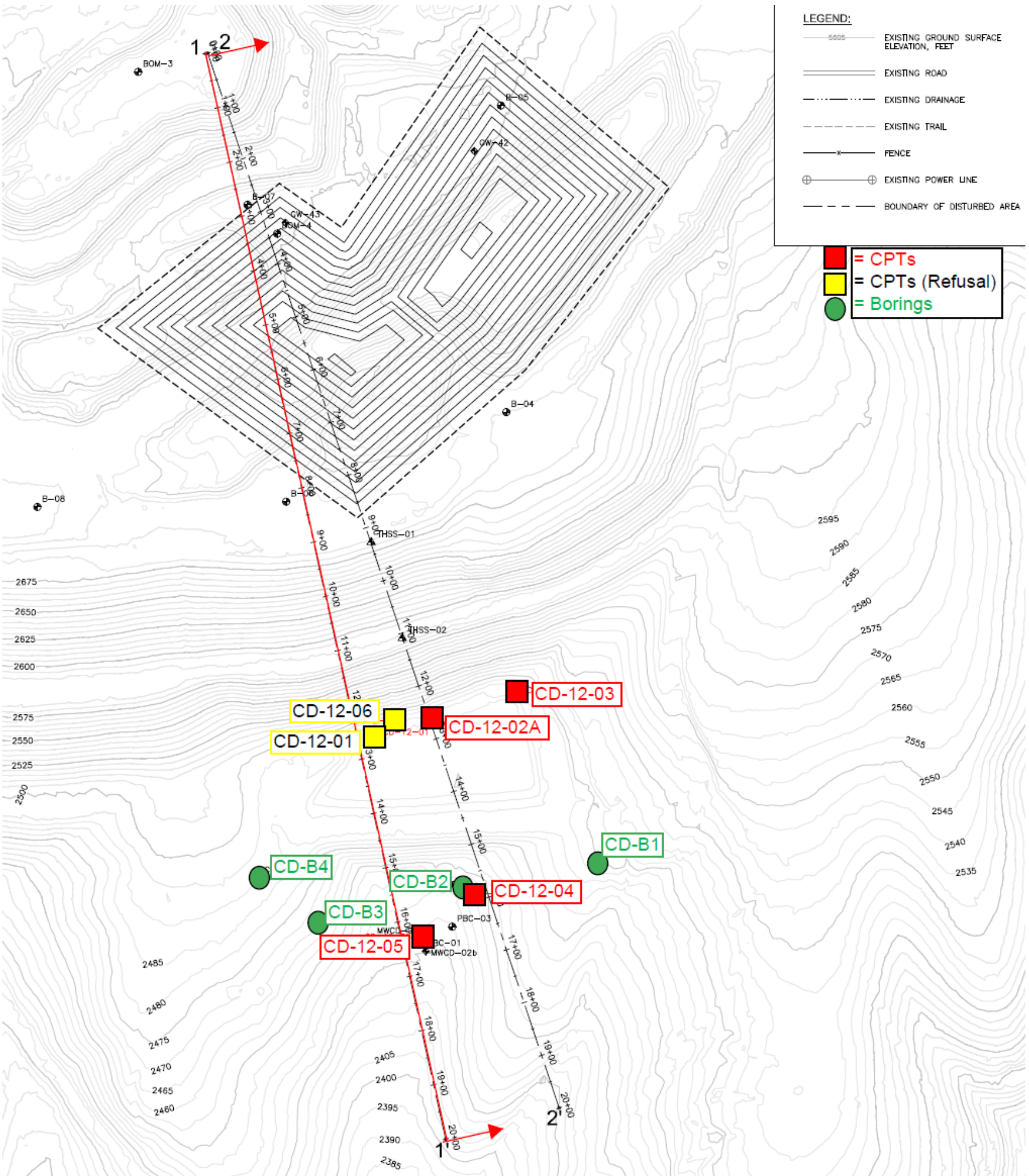

Figure 1 – Plan View of Project Area

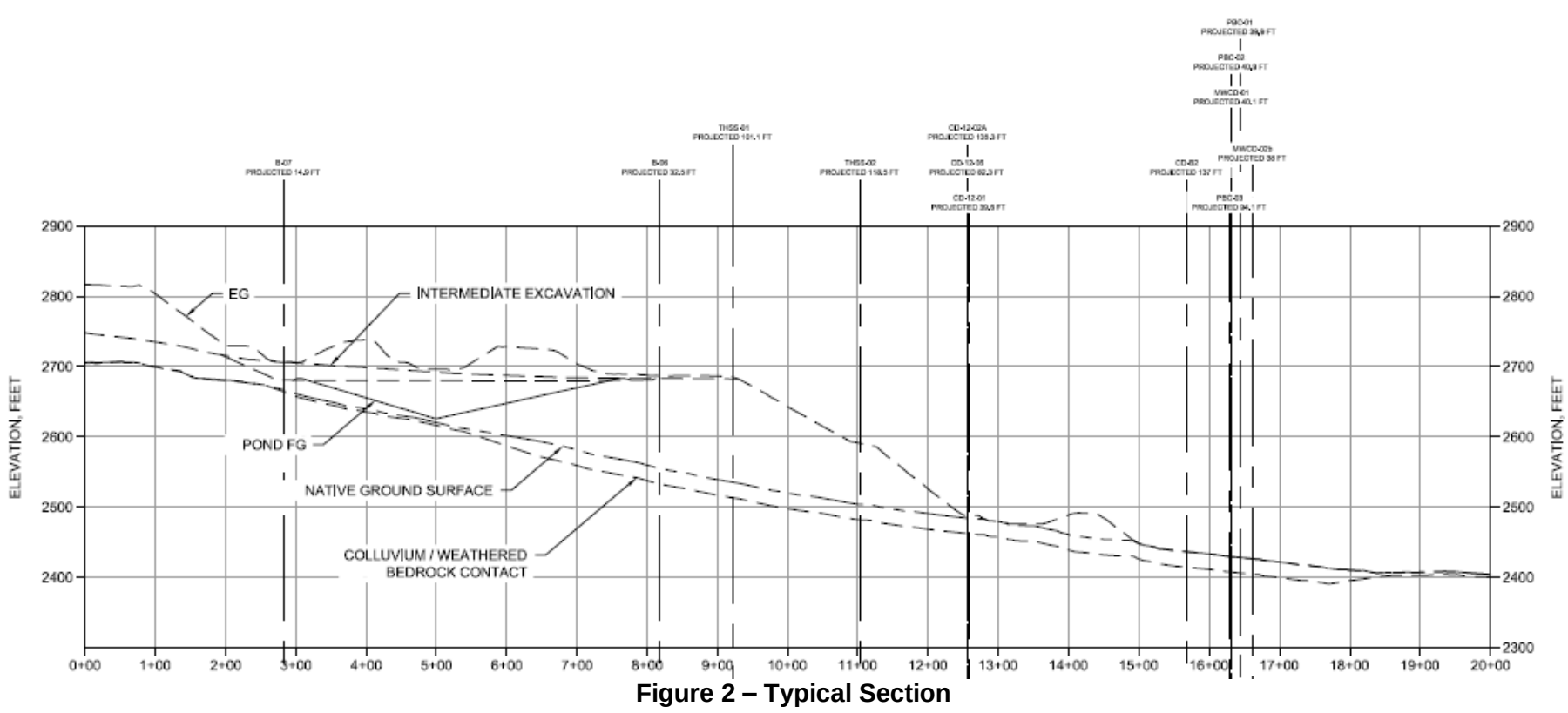

Figure 2 – Typical Section

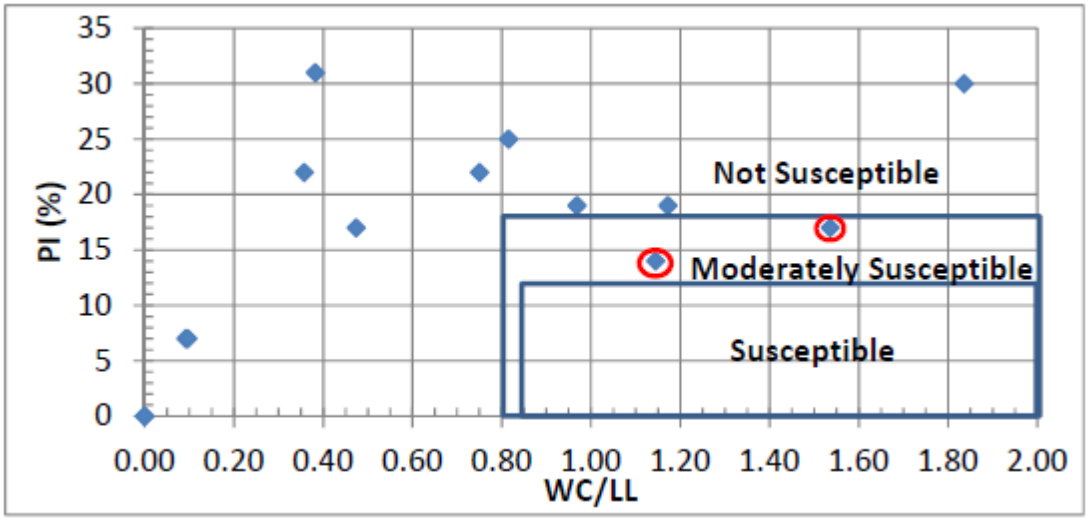

Figure 3 – Liquefaction Screening using Bray and Sancio, 2006

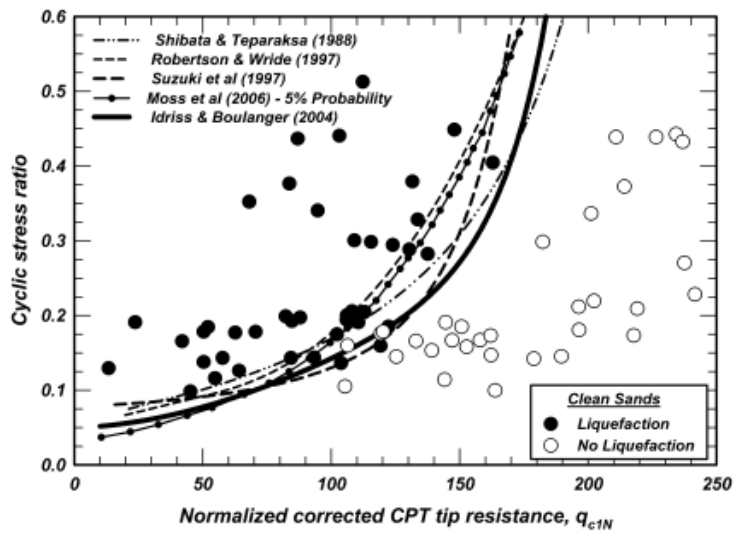

Figure 4 – Correlation between q_{c1n} and CRR (Idriss and Boulanger 2008)

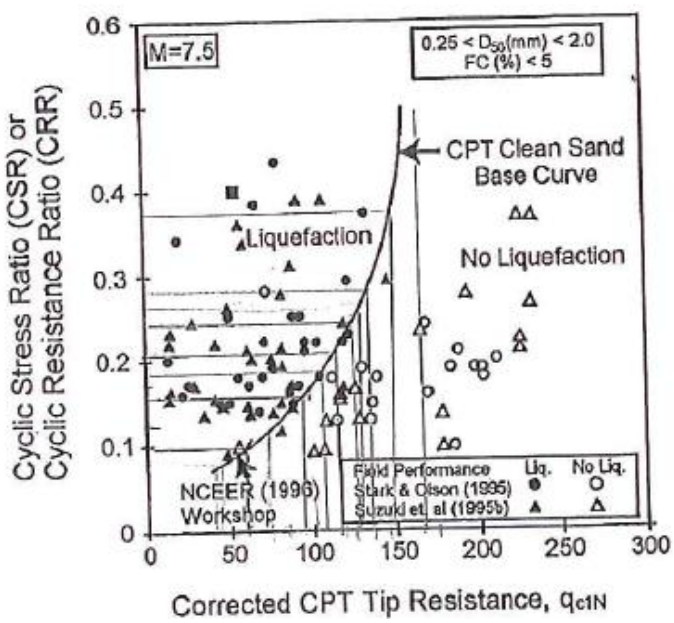

Figure 5 – Correlation between q_{c1n} and CRR (Youd et al 2001)

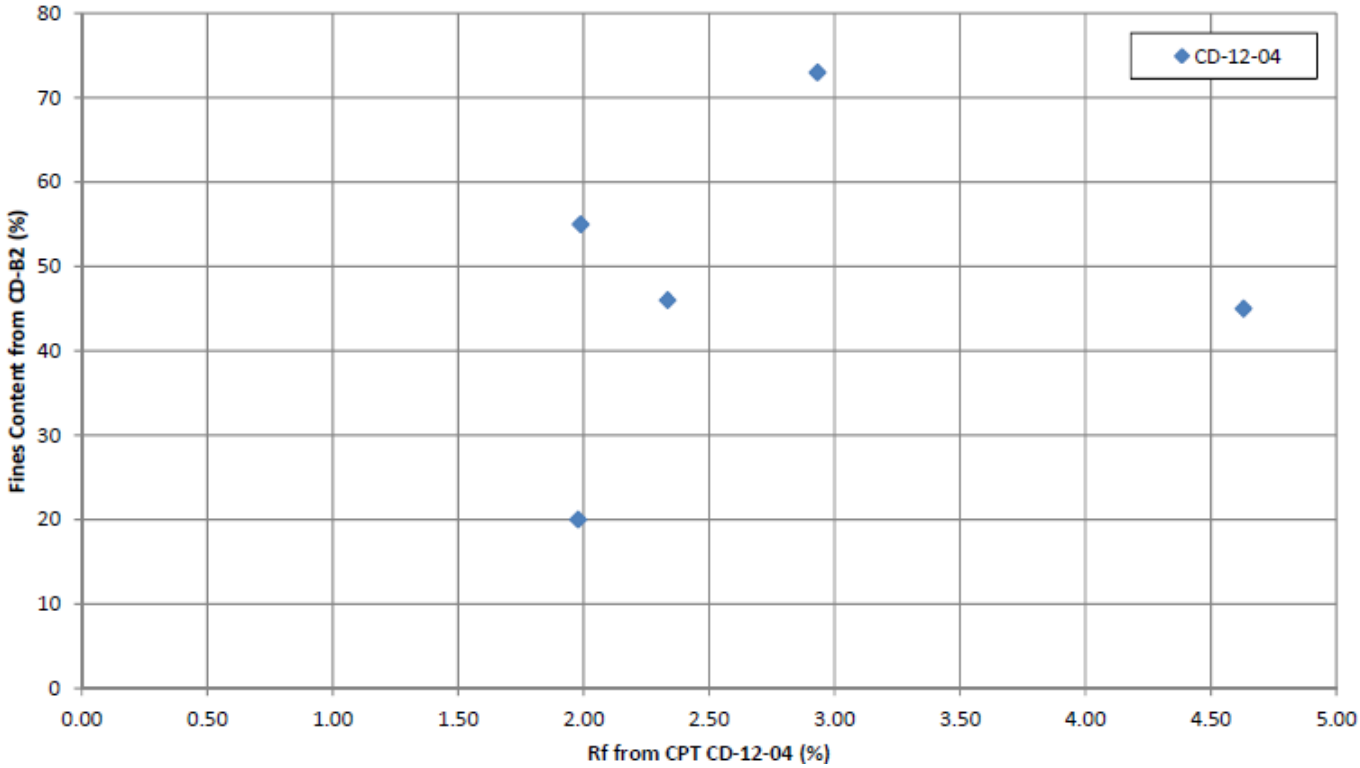

Figure 6 – Fines Content Comparison – Friction Ratio

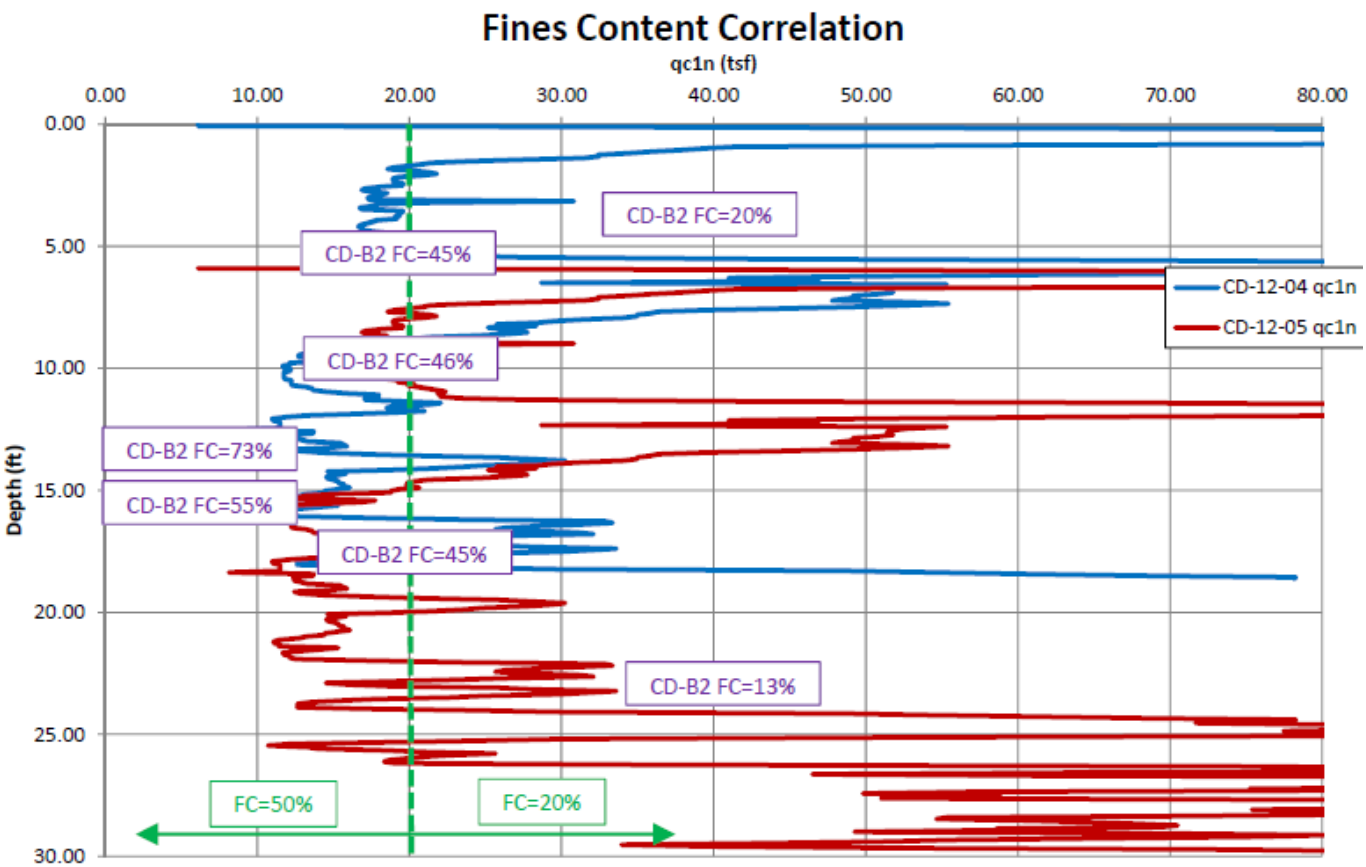

Figure 7 – Selected Fines Content Correlation – Tip Resistance

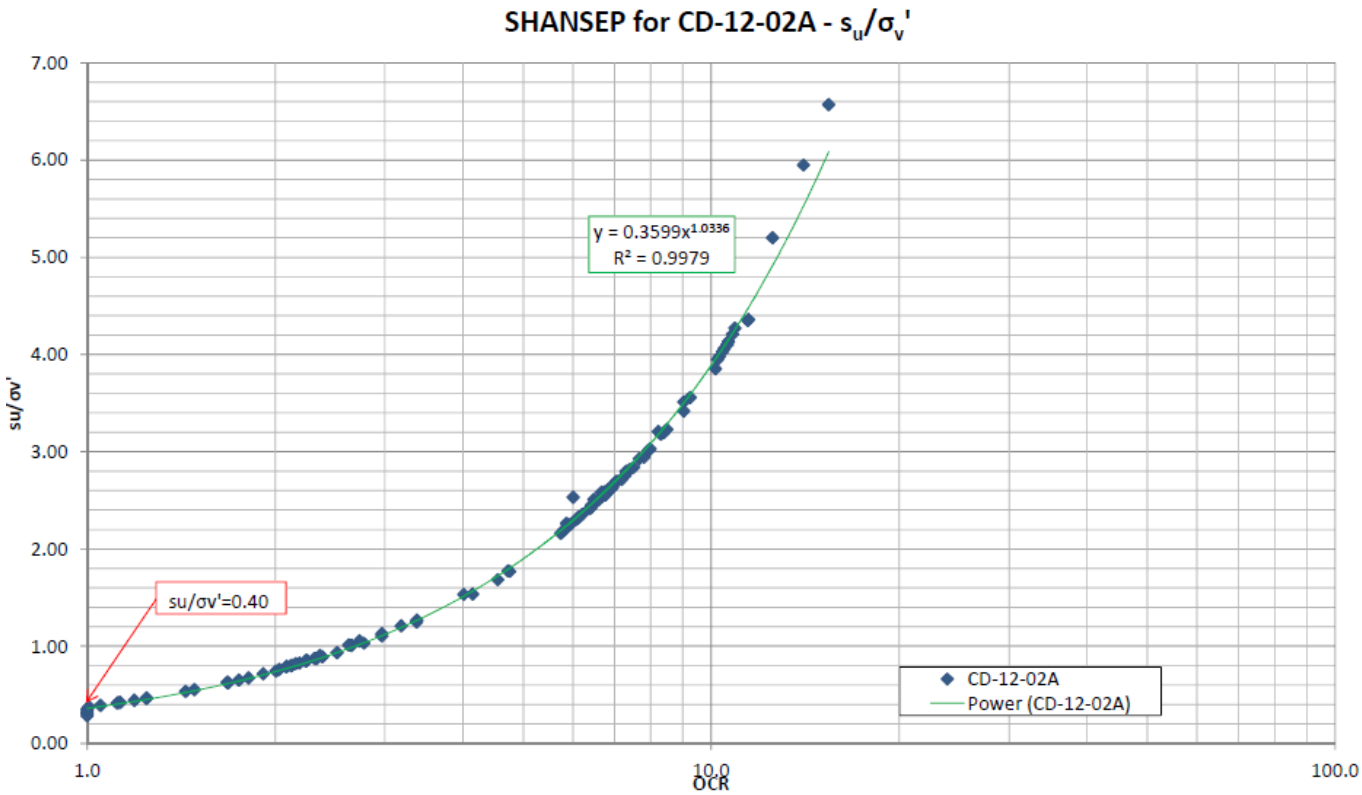

Figure 8 – SHANSEP Model - s_u/σ_v'

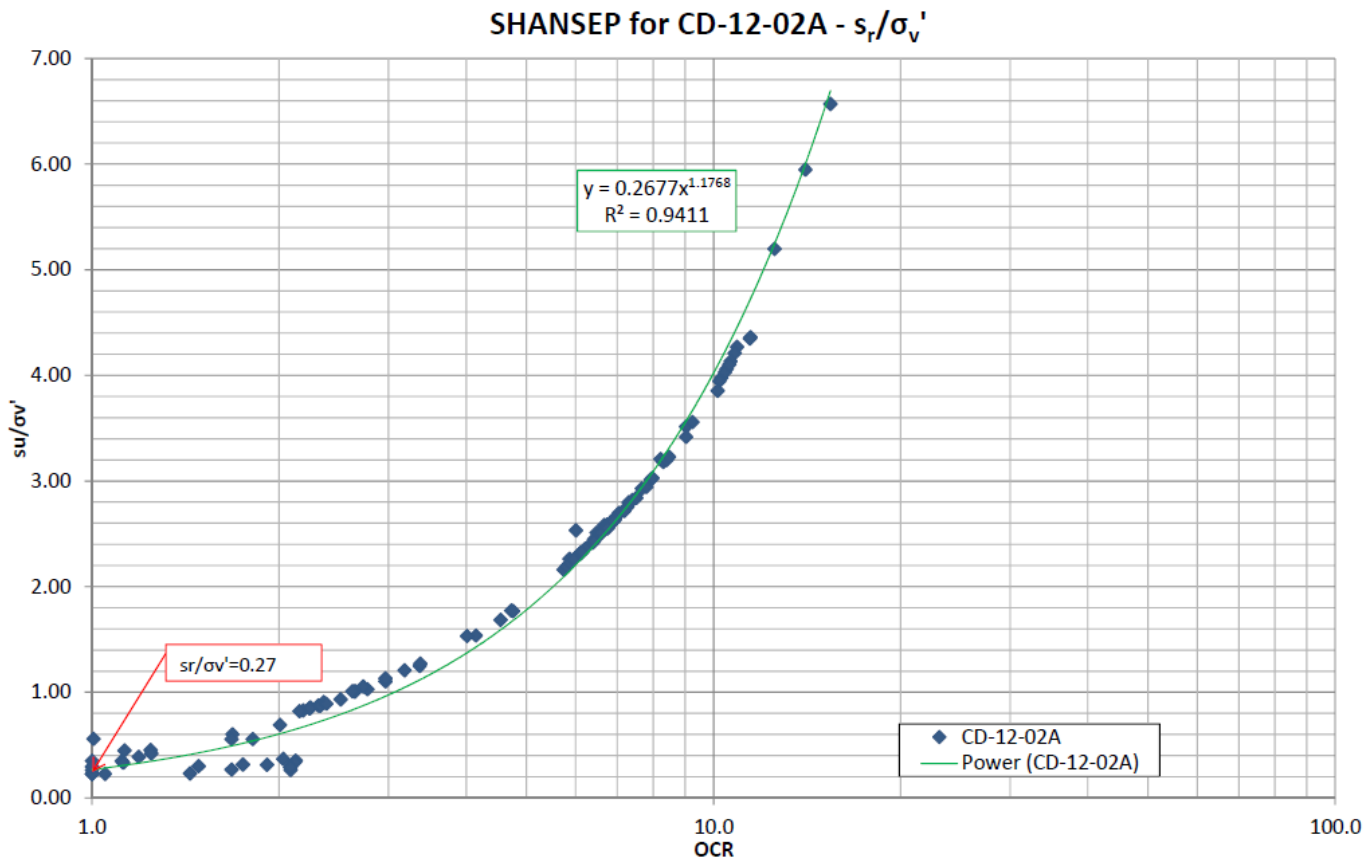

Figure 9 – SHANSEP Model – s_r/σ_v'

Supplement E3.1

CPTu Results

Results of Cone Penetration Test
CPT CD-12-02

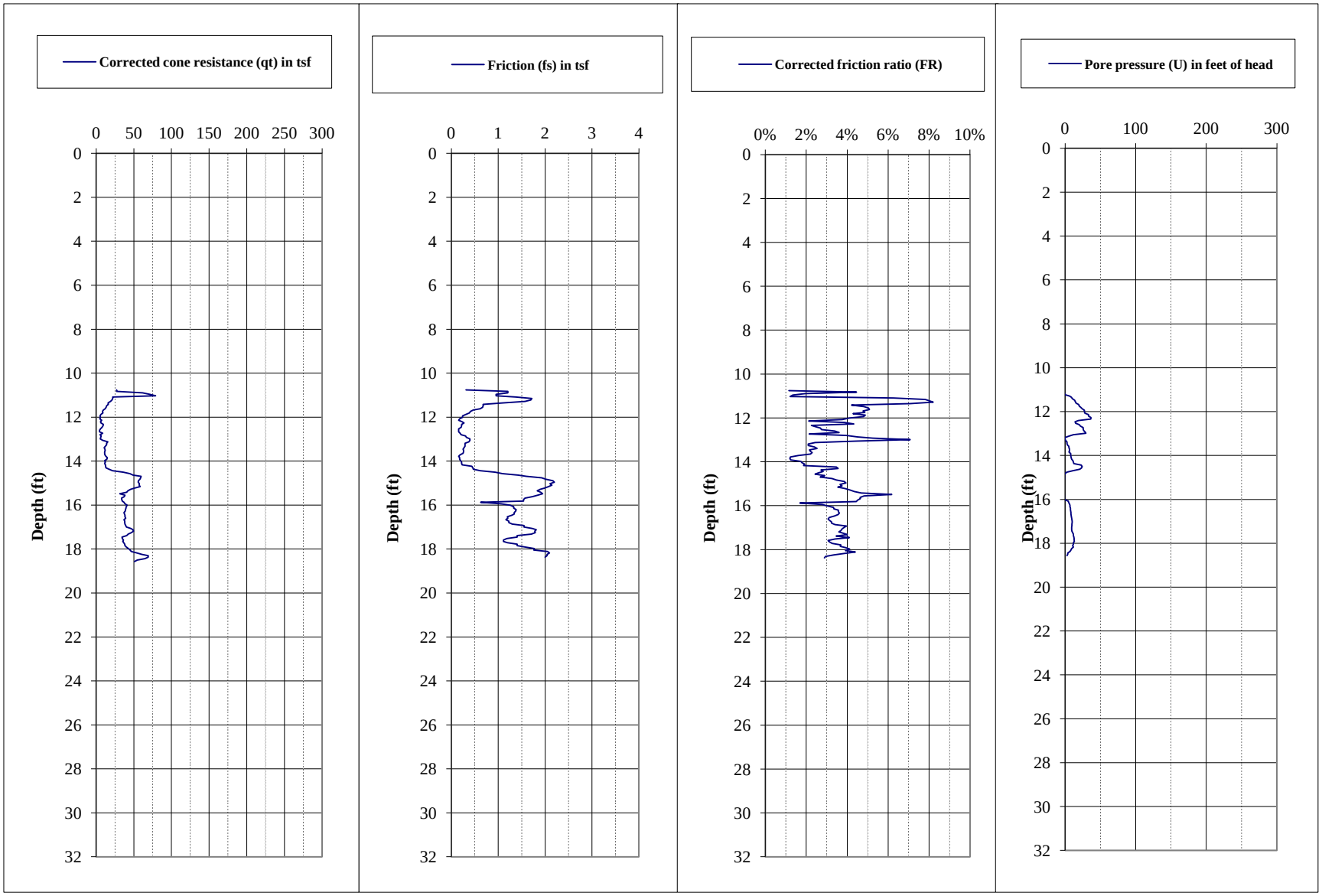

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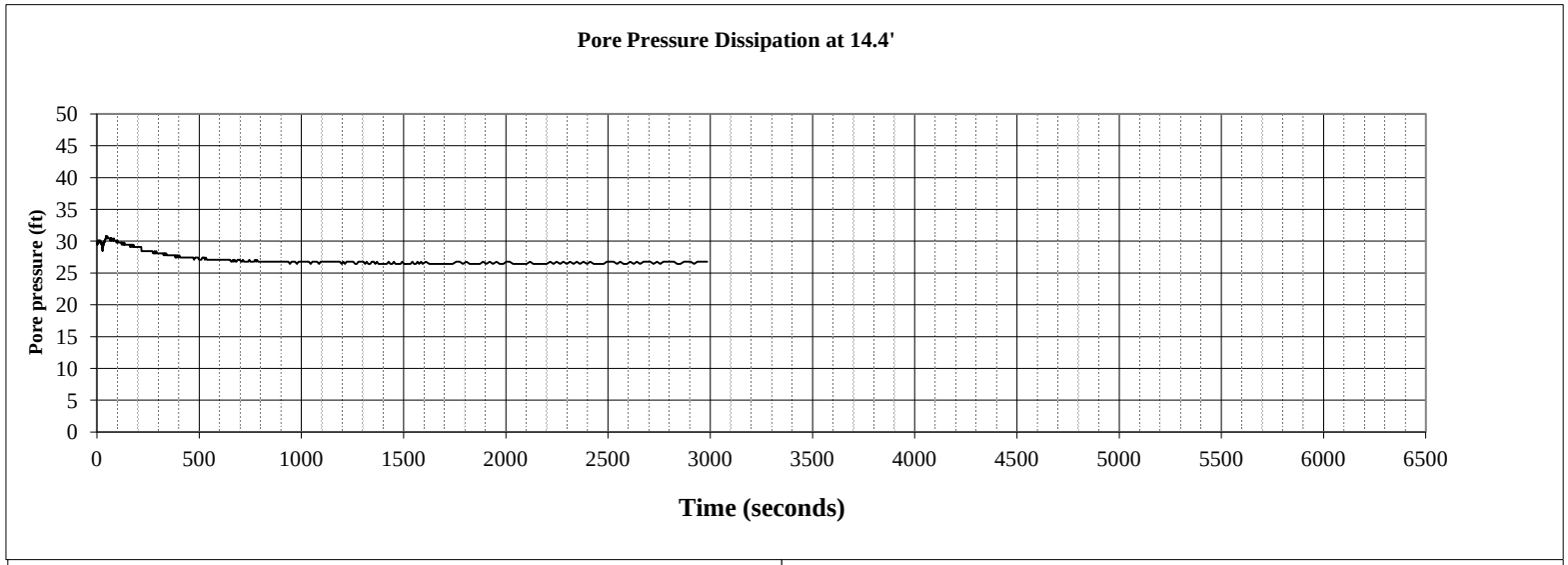
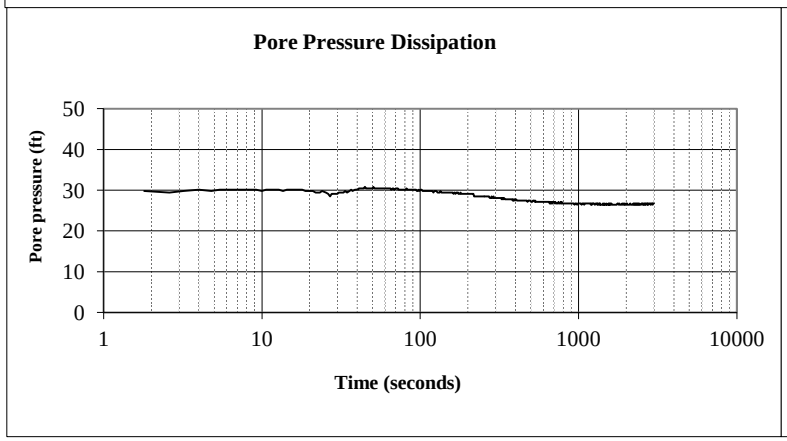
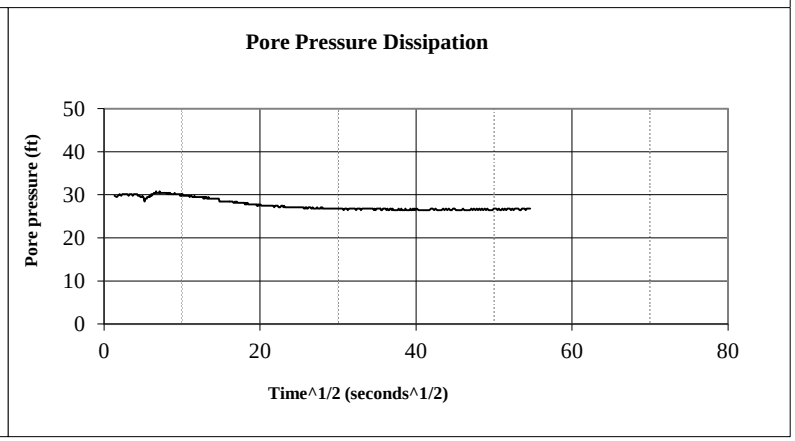
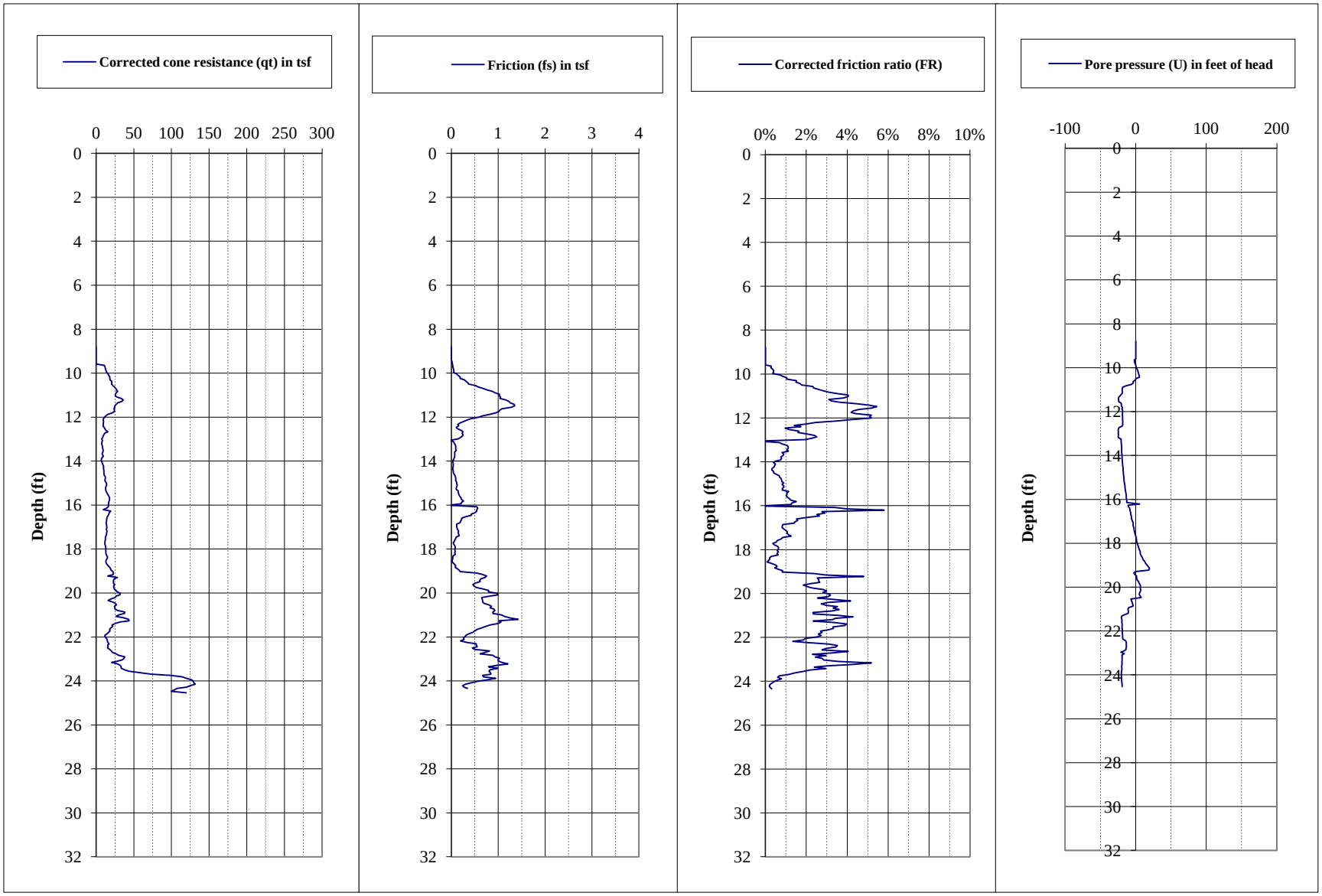
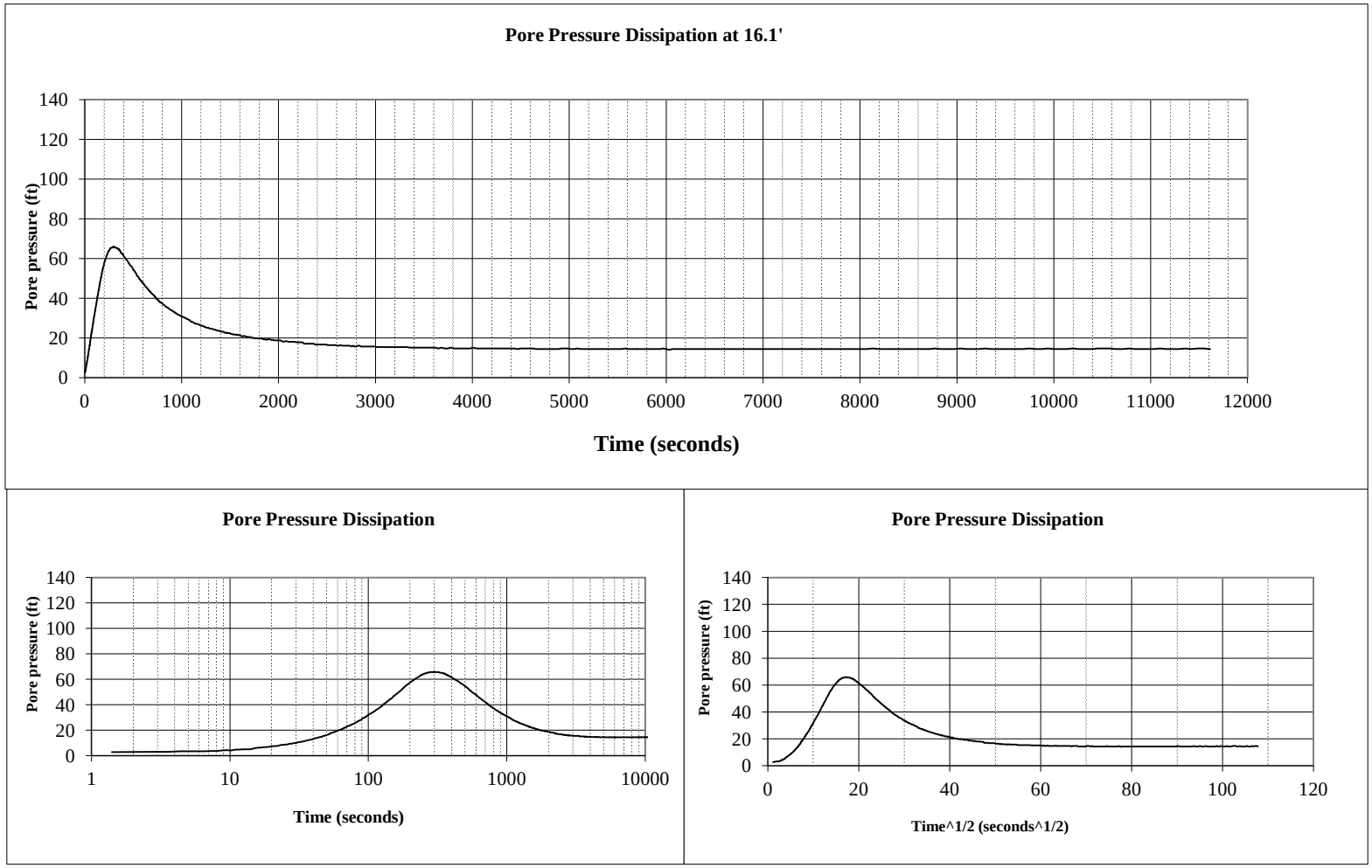
FIGURE 1-1


Pore Pressure Dissipation at 14.4'
Pore pressure (ft)
50
45
40
35
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
Time (seconds)


Pore Pressure Dissipation
Pore pressure (ft)
50
40
30
20
10
0
1
10
100
1000
10000
Time (seconds)


Pore Pressure Dissipation
Pore pressure (ft)
50
40
30
20
10
0
0
20
40
60
80
Time^1/2 (seconds^1/2)


Corrected cone resistance (qt) in tsf
0 50 100 150 200 250 300
Depth (ft)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Friction (fs) in tsf
0 1 2 3 4
Depth (ft)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Corrected friction ratio (FR)
0% 2% 4% 6% 8% 10%
Depth (ft)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Pore pressure (U) in feet of head
-100 0 100 200
Depth (ft)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32


Pore Pressure Dissipation at 16.1'
Pore pressure (ft)
140
120
100
80
60
40
20
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
Time (seconds)
Pore Pressure Dissipation
Pore pressure (ft)
140
120
100
80
60
40
20
0
1
10
100
1000
10000
Time (seconds)
Pore Pressure Dissipation
Pore pressure (ft)
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
Time^1/2 (seconds^1/2)

Pollution Control Pond
Midnight Mine

Results of Cone Penetration Test
CPT CD-12-04

Project No. D12421
Date: 11/5/2012

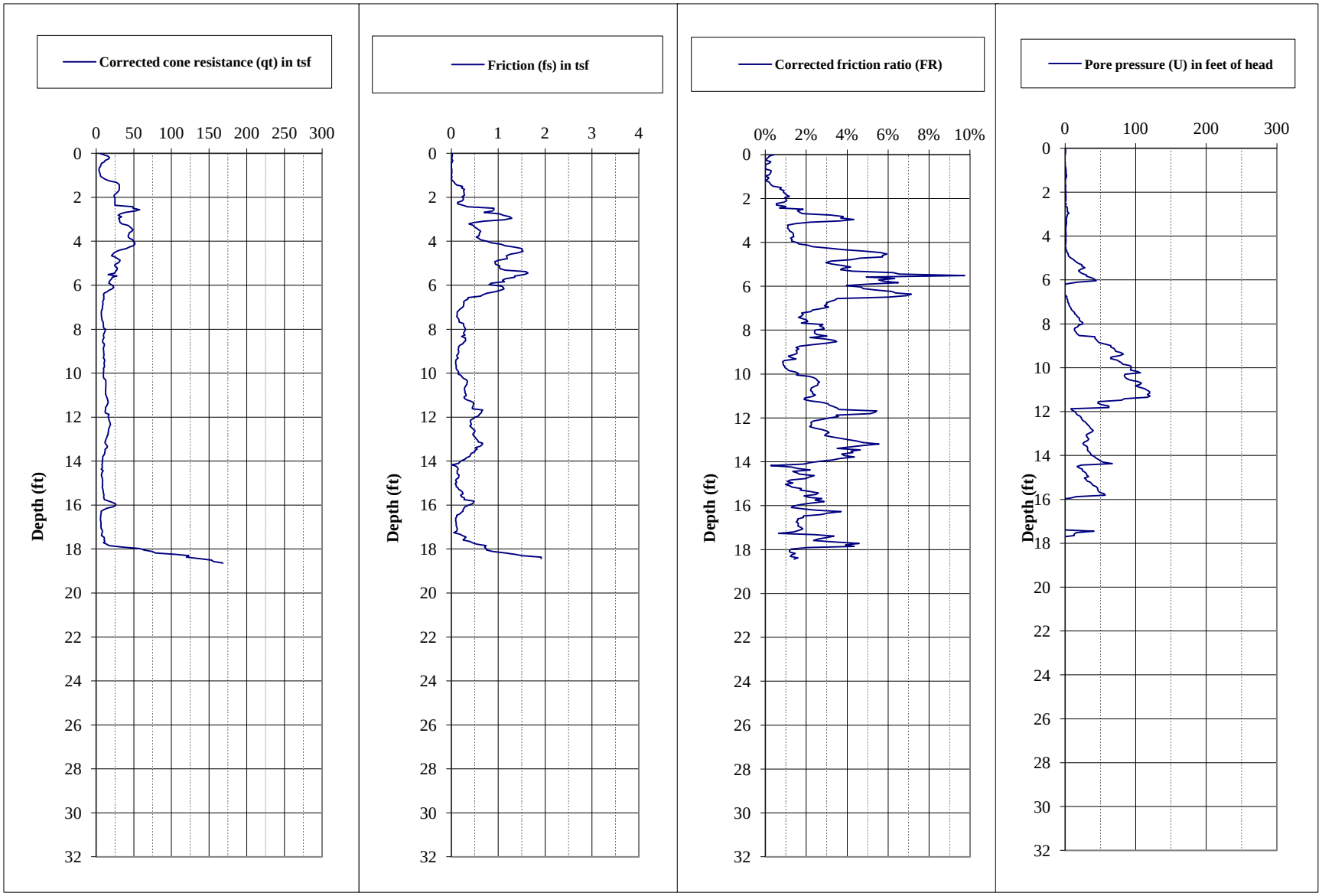


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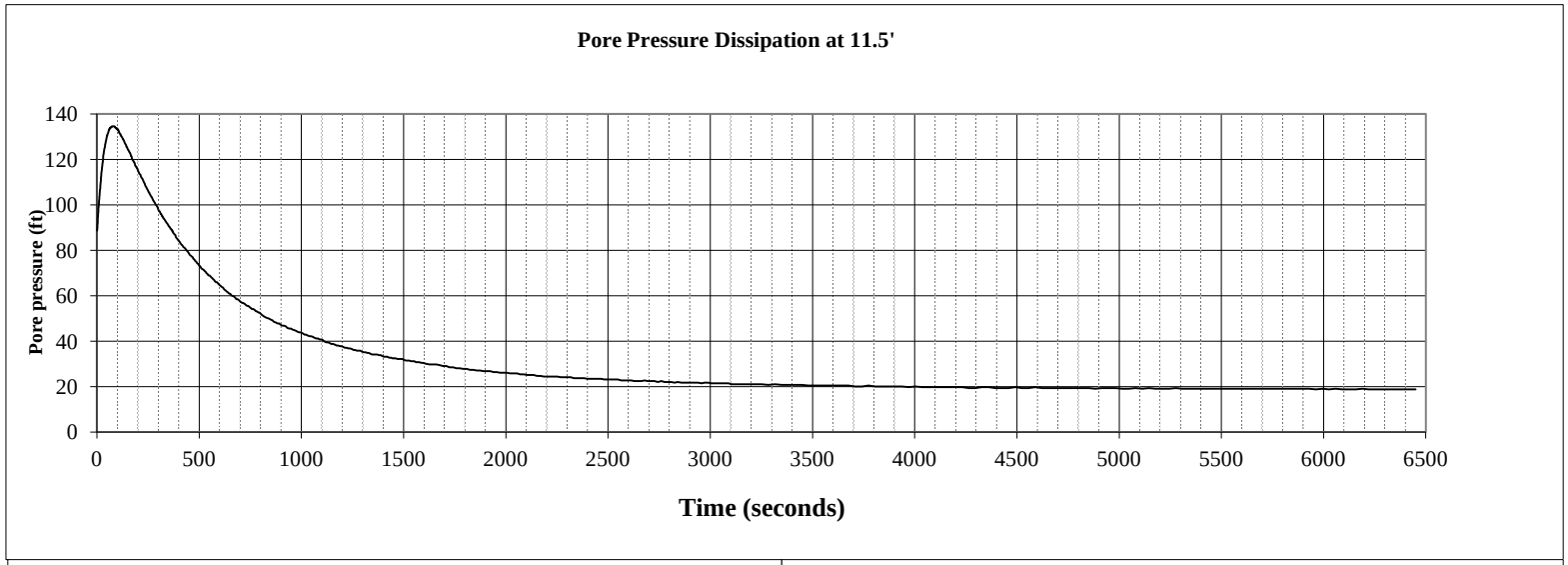
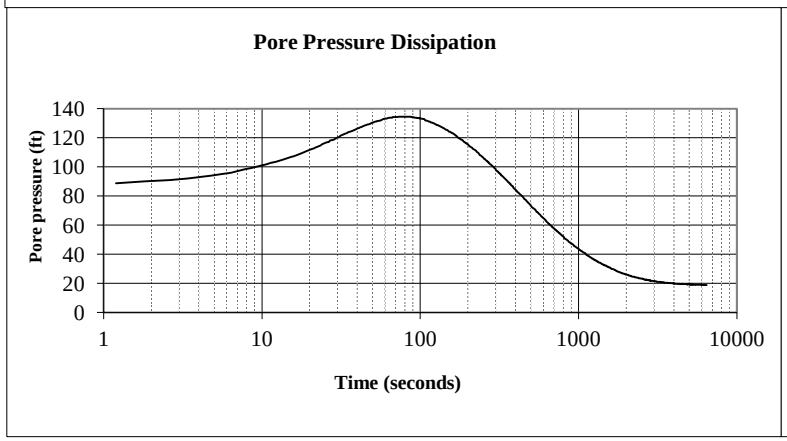
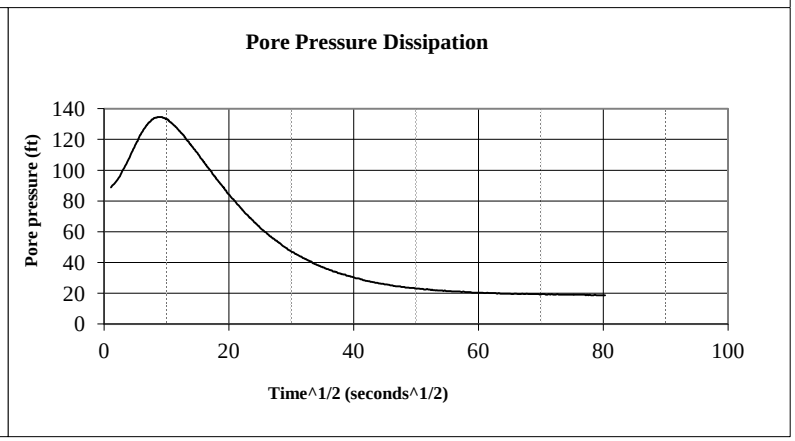
FIGURE 1-1


Pore Pressure Dissipation at 11.5'
Pore pressure (ft)
140
120
100
80
60
40
20
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
Time (seconds)


Pore Pressure Dissipation
Pore pressure (ft)
140
120
100
80
60
40
20
0
1
10
100
1000
10000
Time (seconds)


Pore Pressure Dissipation
Pore pressure (ft)
140
120
100
80
60
40
20
0
0
20
40
60
80
100
Time^1/2 (seconds^1/2)

Pollution Control Pond
Midnight Mine

Results of Cone Penetration Test
CPT CD-12-05

Project No. D12421
Date: 11/5/2012

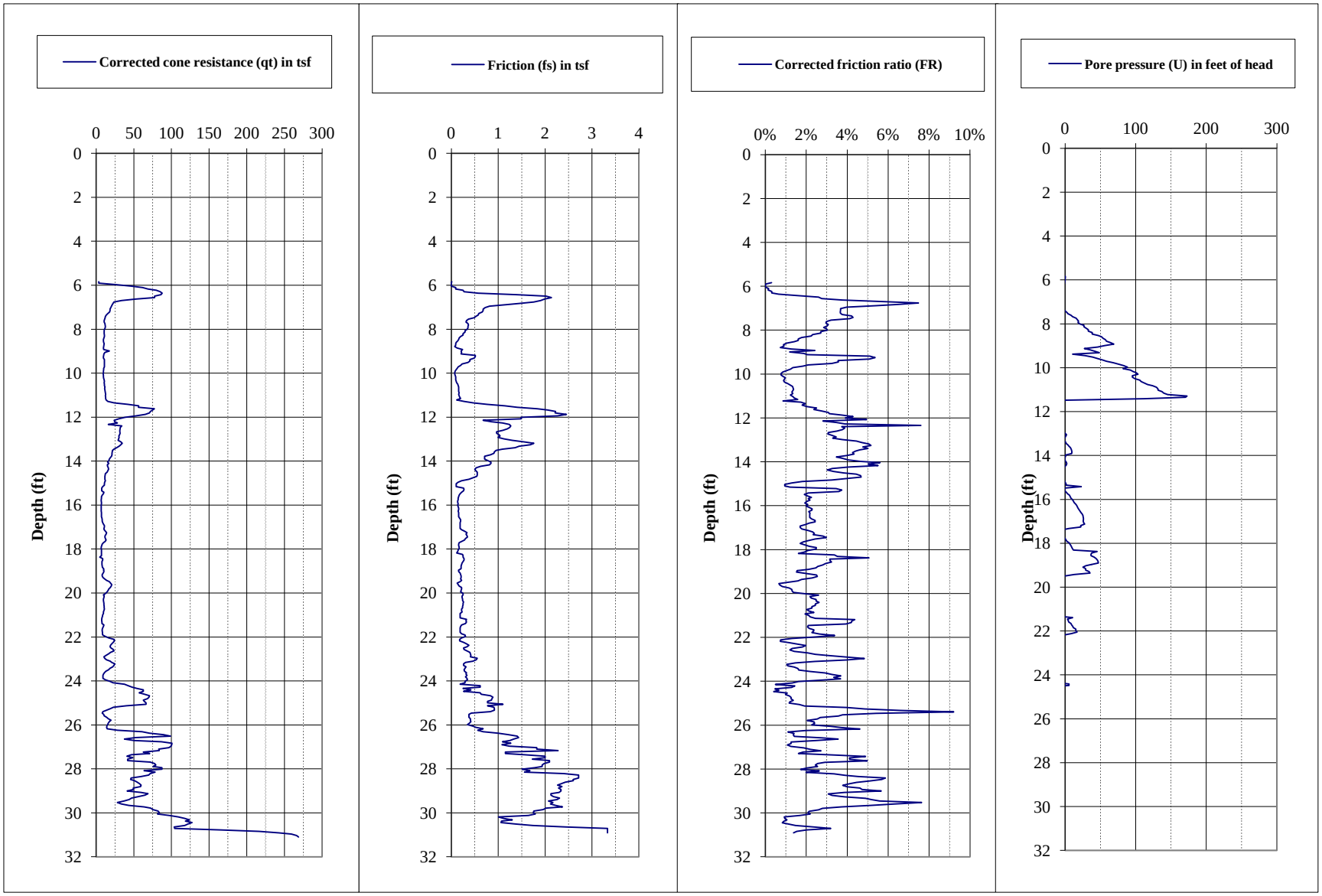


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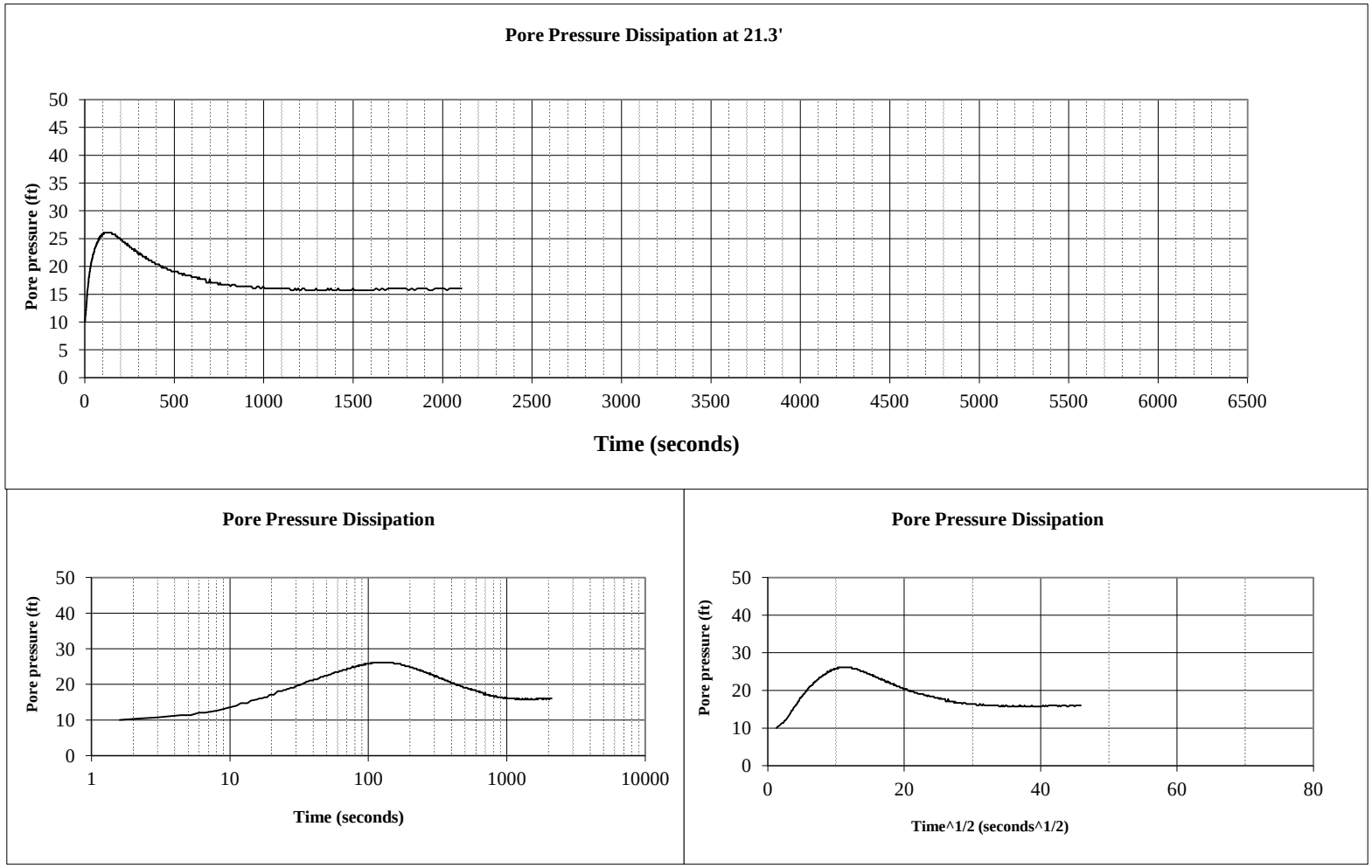
FIGURE 1-1


Pore Pressure Dissipation at 21.3'
Pore pressure (ft)
Time (seconds)
Pore Pressure Dissipation
Pore pressure (ft)
Time (seconds)
Pore Pressure Dissipation
Pore pressure (ft)
Time^1/2 (seconds^1/2)

Supplement E3.2

Liquefaction and Cyclic Softening Calculations

CD-12-02A LIQUEFACTION POTENTIAL & SHEAR STRENGTH CALCULATION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Location: **Midnight Mine South Storage Pond**

FoS<1 / FoS≥1 (legend, shown for Idriss & Boulanger (2008), Youd et al. (2001) and Cyclic Softening)

Constants		
Pa	0.97	tsf
Nkt	18	

Idriss & Boulanger (2008)	
Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Youd et al. (2001)		
Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

Cyclic Softening (Clays)	
Max. Horiz. Acceleration, Amax/g:	0.13
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.05

2011 CPT Data from ConeTec					CPT Data Interpretations																Liquefaction Triggering (Sands): Idriss & Boulanger (2008) – Cyclic Stress Ratio					Cyclic Resistance Ratio				Youd et al. (2001) – Cyclic Stress Ratio						Cyclic Resistance Ratio								Cyclic Softening (Clays): Idriss & Boulanger (2008) – Cyclic Resistance Ratio			
Depth (ft)	qt (tsf)	fs (tsf)	Pw (u2) (ft)	fs/qt (%)	Unit Weight (tcf)	Total Stress (tsf)	Equil Pore Pressure, u0 (tsf)	Effective Stress (tsf)	CN	qc1 TSF	qc1N	FC %	Qt1	Fr %	Bq	Ic	n	Qtn	SBTn	Soil Type (Using Qtn for calculating Ic (iterations))	r_d	C_s	K_σ	K_α	CSR M=7.5, s'v=1atm	Δqc_{1n}	qc_{1n-cs}	CRR M=7.5, s'v=1atm	FoS	r_d	D_r	f	K_σ	K_α	CSR M=7.5, s'v=1atm	Ic	Kc	qc_{1n-cs}	CRR M=7.5, s'v=1atm	FoS	Avg FoS	Liquefiable? 1=Yes 2=No	K_α	CSRM	CRRM	FoS
10.76	27.12	0.31	-3.35	1.143	0.0600	0.582	0.000	0.582	#####	#NUM!	#NUM!	20.0	45.57	1.17	0.00	2.27	0.7	40.04	5	Sand mixtures - silty sand to sandy silt	0.96	####	####	1.0	#NUM!	#####	#NUM!	#NUM!	#####	0.97	#####	#####	#####	1.0	#NUM!	2.268	1.85	#NUM!	#NUM!	#####	#####	#NUM!	1	0.626	2.124	3.40
10.83	27.12	1.21	-3.35	4.462	0.0600	0.650	0.000	0.650	1.32	35.69	36.94	50.0	40.74	4.57	0.00	2.66	0.9	39.09	4	Silt mixtures - clayey silt to silty clay	0.96	0.06	1.03	1.0	0.065	43.3	80.23	0.113	1.75	0.97	0.35	0.80	1.08	1.0	0.053	2.657	3.70	136.54	0.317	5.96	3.85	0	1	0.625	1.898	3.04
10.89	61.8	1.21	-3.35	1.958	0.0600	0.653	0.000	0.653	1.24	76.57	79.27	50.0	93.58	1.98	0.00	2.17	0.7	83.53	5	Sand mixtures - silty sand to sandy silt	0.96	0.09	1.04	1.0	0.065	58.1	137.40	0.224	3.44	0.97	0.51	0.74	1.11	1.0	0.052	2.167	1.59	126.02	0.266	5.11	4.27	0	1	0.625	4.361	6.98
10.96	71.06	0.96	-2.34	1.351	0.0549	0.658	0.000	0.658	1.22	86.84	89.90	20.0	107.06	1.36	0.00	2.02	0.7	93.71	6	Sands - clean sand to silty sand	0.96	0.10	1.04	1.0	0.065	49.3	139.23	0.230	3.52	0.97	0.55	0.73	1.11	1.0	0.052	2.020	1.33	119.28	0.238	4.59	4.06	0	1	0.625	4.989	7.98
11.02	78.85	0.96	-4.02	1.218	0.0549	0.661	0.000	0.661	1.21	95.34	98.70	20.0	118.25	1.23	0.00	1.96	0.6	102.81	6	Sands - clean sand to silty sand	0.96	0.11	1.04	1.0	0.065	51.8	150.50	0.274	4.18	0.97	0.57	0.71	1.11	1.0	0.052	1.959	1.25	123.42	0.255	4.94	4.56	0	1	0.625	5.511	8.82
11.09	21.91	1.37	-4.02	6.253	0.0563	0.665	0.000	0.665	1.31	28.74	29.75	50.0	31.93	6.45	-0.01	2.83	I	31.48	4	Silt mixtures - clayey silt to silty clay	0.96	0.06	1.02	1.0	0.064	40.8	70.52	0.100	1.56	0.97	0.31	0.80	1.08	1.0	0.053	2.830	5.04	150.03	0.394	7.38	4.47	0	1	0.624	1.488	2.38
11.15	21.96	1.72	-0.67	7.832	0.0572	0.669	0.000	0.669	1.31	28.70	29.71	50.0	31.83	8.08	0.00	2.90	I	31.70	4	Silt mixtures - clayey silt to silty clay	0.96	0.06	1.02	1.0	0.064	40.7	70.45	0.100	1.56	0.97	0.31	0.80	1.08	1.0	0.053	2.899	5.69	168.91	0.528	9.88	5.72	0	1	0.624	1.483	2.38
11.22	21.09	1.7	-0.67	8.061	0.0571	0.673	0.000	0.673	1.30	27.50	28.47	50.0	30.33	8.33	0.00	2.92	I	30.31	4	Silt mixtures - clayey silt to silty clay	0.96	0.06	1.02	1.0	0.064	40.3	68.78	0.098	1.53	0.97	0.31	0.80	1.07	1.0	0.054	2.922	5.91	168.34	0.524	9.79	5.66	0	1	0.624	1.413	2.26
11.29	19.15	1.57	6.02	8.198	0.0568	0.677	0.009	0.668	1.32	25.23	26.12	50.0	27.64	8.50	0.01	2.96	I	27.64	3	Clays - silty clay to clay	0.96	0.06	1.02	1.0	0.065	39.5	65.61	0.094	1.45	0.97	0.30	0.80	1.08	1.0	0.054	2.955	6.26	163.54	0.487	8.99	5.22	0	1	0.632	1.289	2.04
11.35	15.73	1.11	9.03	7.057	0.0555	0.681	0.011	0.670	1.33	20.90	21.64	50.0	22.46	7.38	0.02	2.97	I	22.46	3	Clays - silty clay to clay	0.96	0.05	1.02	1.0	0.065	37.9	59.55	0.087	1.34	0.97	0.27	0.80	1.08	1.0	0.054	2.974	6.46	139.88	0.335	6.16	3.75	0	1	0.634	1.047	1.65
11.42	16.03	0.68	10.37	4.242	0.0536	0.685	0.013	0.672	1.32	21.23	21.98	50.0	22.83	4.43	0.02	2.82	I	22.50	4	Silt mixtures - clayey silt to silty clay	0.96	0.05	1.02	1.0	0.065	38.0	60.02	0.088	1.35	0.97	0.27	0.80	1.08	1.0	0.055	2.823	4.98	109.52	0.202	3.71	2.53	0	1	0.636	1.065	1.68
11.48	14.05	0.68	13.38	4.840	0.0536	0.689	0.015	0.674	1.33	18.70	19.36	50.0	19.83	5.09	0.03	2.90	I	19.77	4	Silt mixtures - clayey silt to silty clay	0.96	0.05	1.02	1.0	0.065	37.1	56.47	0.084	1.29	0.97	0.25	0.80	1.07	1.0	0.055	2.905	5.75	111.23	0.208	3.80	2.55	0	1	0.637	0.925	1.45
11.55	13.2	0.67	14.39	5.076	0.0535	0.693	0.017	0.676	1.33	17.58	18.20	50.0	18.51	5.36	0.03	2.94	I	18.51	4	Silt mixtures - clayey silt to silty clay	0.96	0.05	1.02	1.0	0.066	36.7	54.91	0.082	1.26	0.97	0.25	0.80	1.07	1.0	0.055	2.941	6.11	111.24	0.208	3.79	2.52	0	1	0.639	0.864	1.35
11.61	12.05	0.61	15.39	5.062	0.0531	0.697	0.019	0.678	1.34	16.09	16.65	50.0	16.76	5.37	0.04	2.97	I	16.76	3	Clays - silty clay to clay	0.96	0.05	1.02	1.0	0.066	36.2	52.82	0.080	1.22	0.97	0.24	0.80	1.07	1.0	0.055	2.974	6.46	107.64	0.196	3.56	2.39	0	1	0.640	0.782	1.22
11.68	9.79	0.47	19.41	4.801	0.0521	0.701	0.021	0.680	1.34	13.16	13.63	50.0	13.37	5.17	0.06	3.04	I	13.37	3	Clays - silty clay to clay	0.96	0.05	1.02	1.0	0.066	35.1	48.73	0.076	1.16	0.97	0.21	0.80	1.07	1.0	0.055	3.038	7.18	97.85	0.167	3.03	2.09	0	1	0.642	0.625	0.97
11.75	8.35	0.41	20.08	4.910	0.0516	0.705	0.023	0.682	1.35	11.28	11.67	50.0	11.22	5.36	0.08	3.11	I	11.22	3	Clays - silty clay to clay	0.96	0.05	1.02	1.0	0.066	34.4	46.09	0.074	1.12	0.97	0.20	0.80	1.07	1.0	0.055	3.108	8.02	93.65	0.156	2.82	1.97	0	1	0.644	0.524	0.81
11.81	8.97	0.38	22.42	4.236	0.0513	0.709	0.025	0.683	1.34	12.05	12.48	50.0	12.09	4.60	0.08	3.04	I	12.09	3	Clays - silty clay to clay	0.96	0.05	1.02	1.0	0.066	34.7	47.17	0.075	1.13	0.97	0.20	0.80	1.07	1.0	0.056	3.041	7.21	89.92	0.148	2.66	1.89	0	1	0.645	0.565	0.88
11.88	6.39	0.31	24.09	4.851	0.0505	0.713	0.027	0.685	1.36	8.68	8.99	50.0	8.28	5.46	0.13	3.22	I	8.28	3	Clays - silty clay to clay	0.96	0.04	1.02	1.0	0.066	33.5	42.46	0.071	1.07	0.97	0.17	0.80	1.07	1.0	0.056	3.216	9.47	85.16	0.137	2.46	1.77	0	1	0.647	0.388	0.60
11.94	4.98	0.24	27.10	4.819	0.0495	0.716	0.029	0.687	1.37	6.82	7.06	50.0	6.21	5.63	0.19	3.32	I	6.21	3	Clays - silty clay to clay	0.96	0.04	1.01	1.0	0.066	32.8	39.85	0.068	1.03	0.97	0.15	0.80	1.07	1.0	0.056	3.324	11.09	78.26	0.125	2.23	1.63	0	1	0.648	0.291	0.45
12.01	5.85	0.24	27.44	4.103	0.0495	0.721	0.032	0.689	1.36	7.94	8.22	50.0	7.44	4.68	0.16	3.21	I	7.44	3	Clays - silty clay to clay	0.96	0.04	1.01	1.0	0.066	33.2	41.42	0.070	1.05	0.97	0.17	0.80	1.07	1.0	0.056	3.213	9.43	77.51	0.123	2.20	1.62	0	1	0.650	0.349	0.54
12.07	4.71	0.18	28.11	3.822	0.0483	0.724	0.033	0.691	1.36	6.43	6.65	50.0	5.77	4.52	0.21	3.29	I	5.77	3	Clays - silty clay to clay	0.96	0.04	1.01	1.0	0.067	32.7	39.31	0.068	1.02	0.97	0.15	0.80	1.07	1.0	0.056	3.294	10.63	70.72	0.113	2.01	1.51	0	1	0.651	0.271	0.42
12.14	7.37	0.16	33.13	2.171	0.0479	0.728	0.036	0.693	1.34	9.87	10.22	50.0	9.59	2.41	0.15	2.96	I	9.59	3	Clays - silty clay to clay	0.96	0.05	1.02	1.0	0.067	33.9	44.12	0.072	1.08	0.97	0.18	0.80	1.07	1.0	0.056	2.959	6.30	64.38	0.105	1.86	1.47	0	1	0.653	0.449	0.69
12.2	5.93	0.23	33.13	3.879	0.0493	0.732	0.037	0.695	1.35	7.99	8.27	50.0	7.48	4.42	0.19	3.20	I	7.48	3	Clays - silty clay to clay	0.96	0.04	1.01	1.0	0.067	33.2	41.49	0.070	1.04	0.97	0.17	0.80	1.07	1.0	0.057	3.197	9.21	76.13	0.121	2.14	1.59	0	1	0.654	0.351	0.54
12.27	6.26	0.27	36.47	4.313	0.0499	0.736	0.040	0.697	1.34	8.39	8.69	50.0	7.93	4.89	0.20	3.20	I	7.93	3	Clays - silty clay to clay	0.95	0.04	1.01	1.0	0.067	33.4	42.06	0.070	1.05	0.97	0.17	0.80	1.07	1.0	0.057	3.202	9.28	80.63	0.129	2.27	1.66	0	1	0.656	0.372	0.57
12.34	9.72	0.22	36.14	2.263	0.0491	0.740	0.042	0.699	1.32	12.78	13.23	50.0	12.85	2.45	0.12	2.86	I	12.75	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.02	1.0	0.067	35.0	48.20	0.076	1.13	0.97	0.21	0.80	1.07	1.0	0.057	2.860	5.32	70.37	0.112	1.97	1.55	0	1	0.657	0.602	0.92
12.4	8.92	0.22	19.07	2.466	0.0491	0.744	0.044	0.700	1.32	11.75	12.16	50.0	11.67	2.69	0.07	2.92	I	11.66	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.02	1.0	0.067	34.6	46.75	0.074	1.11	0.97	0.20	0.80	1.07	1.0	0.057	2.915	5.85	71.11	0.113	1.99	1.55	0	1	0.659	0.547	0.83
12.47	7.7	0.21	14.05	2.727	0.0489	0.748	0.046	0.702	1.32	10.17	10.53	50.0	9.90	3.02	0.06	3.00	I	9.90	3	Clays - silty clay to clay	0.95	0.05	1.01	1.0	0.067	34.0	44.55	0.072	1.07	0.97	0.19	0.80	1.07	1.0	0.057	3.002	6.77	71.30	0.114	1.98	1.53	0	1	0.660	0.464	0.70
12.53	5.68	0.16	14.72	2.817	0.0479	0.752	0.048	0.704	1.33	7.57	7.84	50.0	7.00	3.25	0.08	3.14	I	7.00	3	Clays - silty clay to clay	0.95	0.04	1.01	1.0	0.068	33.1	40.91	0.069	1.03	0.97	0.16	0.80	1.07	1.0	0.057	3.145	8.50	66.62	0.107	1.87	1.45	0	1	0.662	0.329	0.50
12.6	4.6	0.16	20.08	3.478	0.0479	0.756	0.050	0.706	1.34	6.16	6.38	50.0	5.44	4.16	0.15	3.30	I	5.44	3	Clays - silty clay to clay	0.95	0.04	1.01	1.0	0.068	32.6	38.94	0.068	1.00	0.97	0.15	0.80	1.06	1.0	0.058	3.295	10.64	67.87	0.109	1.89	1.45	0	1	0.663	0.257	0.39
12.66	4.33	0.16	21.75	3.695	0.0479	0.760	0.052	0.708	1.34	5.80	6.00	50.0	5.04	4.48	0.18	3.34	I	5.04	3	Clays - silty clay to clay	0.95	0.04	1.01	1.0	0.068	32.4	38.43	0.067	0.99	0.97	0.14	0.80	1.06	1.0	0.058	3.341	11.35	68.13	0.109	1.89	1.44	0	1	0.665	0.238	0.36
12.73	8.72	0.19	25.43	2.179	0.0486	0.764	0.054	0.710	1.30	11.37	11.77	50.0	11.21	2.39	0.09	2.90	I	11.18	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.068	34.4	46.22	0.074	1.09	0.97	0.20	0.80	1.06	1.0	0.058	2.901	5.71	67.21	0.108	1.87	1.48	0	1	0.666	0.526	0.79
12.8	5.24	0.21	25.43	4.008	0.0489	0.768	0.056	0.712	1.32	6.94	7.18	50.0	6.28	4.70	0.16	3.27	I	6.28	3	Clays - silty clay to clay	0.95	0.04	1.01	1.0	0.068	32.8	40.02	0.069	1.01	0.97	0.15	0.80	1.06	1.0	0.058	3.274	10.32	74.09	0.118	2.03	1.52	0	1	0.668	0.296	0.44
12.86	6.7	0.3	26.10	4.478	0.0503	0.772	0.058	0.714	1.31	8.78	9.09	50.0	8.31	5.06	0.13	3.19	I	8.31	3	Clays - silty clay to clay	0.95	0.04	1.01	1.0	0.068	33.5	42.60	0.071	1.04	0.97	0.17	0.80	1.06	1.0	0.058	3.195	9.18	83.41	0.134	2.30	1.67	0	1	0.669	0.391	0.58
12.93	6.16	0.32	28.44	5.195	0.0506	0.776	0.060	0.716	1.31	8.07	8.36	50.0	7.52	5.94	0.15	3.27	I	7.52	3	Clays - silty clay to clay	0.95	0.04	1.01	1.0	0.068	33.3	41.61	0.070	1.02	0.97	0.17	0.80	1.06	1.0	0.058	3.271	10.28	85.95	0.139	2.38	1.70	0	1	0.670	0.355	0.53
12.99	5.59	0.4	29.45	7.156	0.0515	0.779	0.062	0.717	1.31	7.34	7.59	50.0	6.71	8.31	0.18	3.40	I	6.71	3	Clays - silty clay to clay	0.95	0.04	1.01	1.0	0.069	33.0	40.58	0.069	1.01	0.97	0.16	0.80	1.06	1.0	0.059	3.401	12.35	93.75	0.157	2.67	1.84	0	1	0.672	0.317	0.47
13.06	8.83	0.4	11.71	4.530	0.0515	0.784	0.064	0.719	1.29	11.38	11.78	50.0	11.19	4.97	0.04	3.09	I	11.19	3	Clays - silty clay to clay	0.95	0.05	1.01	1.0	0.069	34.5	46.23	0.074	1.08	0.97	0.20	0.80	1.06	1.0	0.059	3.088	7.78	91.62	0.152	2.58	1.83	0	1	0.673	0.525	0.78
13.12	15.38	0.37	5.02	2.406	0.0512	0.787	0.066	0.721	1.26	19.37	20.05	50.0	20.24	2.54	0.01	2.71	0.9	19.78	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.02	1.0	0.069	37.4	57.41	0.085	1.23	0.97	0.26	0.80	1.06	1.0	0.059	2.714	4.10	82.12	0.131	2.23	1.73	0	1	0.674	0.947	1.41
13.19	13.87	0.29	-0.33	2.091	0.0502	0.791	0.068	0.723	1.26	17.50	18.12	50.0	18.09	2.22	-0.01	2.72	0.9	17.69	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.069	36.7	54.80	0.082	1.19	0.97	0.25	0.80	1.06	1.0	0.059	2.719	4.13	74.88	0.119	2.01	1.60	0	1	0.676	0.847	1.25
13.25	13.87	0.29	-0.33	2.091	0.0502	0.795	0.070	0.725	1.26	17.47	18.08	50.0	18.04	2.22	-0.01	2.72	0.9	17.65	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.069	36.7	54.75	0.082	1.19	0.97	0.25	0.80	1.06	1.0	0.059	2.719	4.14	74.87	0.119	2.01	1.60	0	1	0.677	0.845	1.25
13.32	12.15	0.29	1.00	2.387	0.0502	0.799	0.072	0.727	1.26	15.35	15.89	50.0	15.62	2.55	0.00	2.80	I	15.42	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.069	35.9	51.78	0.079	1.14	0.97	0.23	0.80	1.06	1.0	0.059	2.803	4.81	76.38	0.121	2.04	1.59	0	1	0.678	0.732	1.08
13.39	10.73	0.27	2.68	2.516	0.0499	0.803	0.075	0.729	1.27	13.59	14.06	50.0	13.62	2.72	0.00	2.86	I	13.54	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.069	35.3	49.32	0.077	1.11	0.97	0.22	0.80	1.06	1.0	0.060	2.865	5.36	75.37	0.120	2.01	1.56	0	1	0.680	0.639	0.94
13.45	11.6	0.25	2.68	2.155	0.0496	0.807	0.076	0.731	1.26	14.62	15.13	50.0	14.77	2.32	0.00	2.80	I	14.58	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.070	35.6	50.76	0.078	1.13	0.97	0.22	0.80	1.06	1.0	0.060	2.798	4.77	72.16	0.115	1.92	1.52	0	1	0.681	0.693	1.02
13.52	11.89	0.26	3.35	2.187	0.0498	0.811	0.079	0.733	1.26	14.94	15.46	50.0	15.12	2.35	0.00	2.79	I	14.92	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.070	35.7	51.21	0.079	1.13	0.97	0.23	0.80	1.06	1.0	0.060	2.793	4.73	73.09	0.116	1.94	1.54	0	1	0.682	0.710	1.04
13.58	11.34	0.26	5.02	2.293	0.0498	0.815	0.080	0.734	1.26	14.24	14.75	50.0	14.33	2.47	0.01	2.82	I	14.19	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.070	35.5	50.24	0.078	1.11	0.97	0.22	0.80	1.06	1.0	0.060	2.824	4.99	73.58	0.117	1.95	1.53	0	1	0.684	0.673	0.98
13.65	11.34	0.25	5.35	2.205	0.0496	0.819	0.083	0.736	1.25	14.21	14.71	50.0	14.29	2.38	0.01	2.82	I	14.14	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.070	35.5	50.20	0.078	1.11	0.97	0.22	0.80	1.06	1.0	0.060	2.816	4.92	72.36	0.115	1.91	1.51	0	1	0.685	0.671	0.98
13.71	11.64	0.19	6.02	1.632	0.0486	0.823	0.085	0.738	1.25	14.55	15.06	50.0	14.66	1.76	0.01	2.74	0.9	14.39	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.070	35.6	50.66	0.078	1.12	0.97	0.22	0.80	1.06	1.0	0.060	2.737	4.27	64.35	0.105	1.74	1.43	0	1	0.686	0.688	1.00
13.78	12.8	0.16	6.02	1.250	0.0479	0.827	0.087	0.740	1.24	15.91	16.47	20.0	16.18	1.34	0.01	2.64	0.9	15.73	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.070	28.8	45.26	0.073	1.04	0.97	0.23	0.80	1.05	1.0	0.061	2.642	3.59	59.17	0.099	1.64	1.34	0	1	0.687	0.759	1.10
13.85	14.81	0.18	5.35	1.215	0.0483	0.831	0.089	0.742	1.23	18.27	18.92	20.0	18.84	1.29	0.01	2.58	0.9	18.21	5	Sand mixtures - silty sand to sandy silt	0.95	0.05	1.01	1.0	0.070	29.5	48.39	0.076	1.08	0.97	0.25	0.80	1.05	1.0	0.061	2.579	3.20	60.55	0.101	1.66	1.37	0	1	0.689	0.883	1.28
13.91	14.27	0.18	7.70	1.261	0.0483	0.835	0.091	0.744	1.23	17.60	18.22	20.0	18.06	1.34	0.01	2.60	0.9	17.51	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.070	29.3	47.50	0.075	1.07	0.97	0.25	0.80	1.05	1.0	0.061	2.603	3.34	60.89	0.101	1.66	1.36	0	1	0.690	0.847	1.23
13.98	11.37	0.2	7.70	1.759	0.0488	0.839	0.093	0.746	1.24	14.10	14.60	50.0	14.12	1.90	0.01	2.77	0.9	13.91	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.071	35.4	50.04	0.078	1.10	0.97	0.22	0.80	1.05	1.0	0.061	2.767	4.51	65.90	0.107	1.75	1.42	0	1	0.691	0.664	0.96
14.04	12.24	0.22	8.03	1.797	0.0491	0.842	0.095	0.748	1.23	15.12	15.65	50.0	15.25	1.93	0.01	2.74	0.9	14.99	4	Silt mixtures - clayey silt to silty clay	0.95	0.05	1.01	1.0	0.071	35.8	51.46	0.079	1.12	0.97	0.23	0.80	1.05	1.0	0.061	2.744	4.33	67.73	0.109	1.78	1.45	0	1	0.692	0.716	1.03
14.11	11.39	0.22	8.70	1.932	0.0491	0.847	0.097	0.750	1.24	14.07	14.57	50.0	14.07	2.09	0.02	2.79	I	13.90	4	Silt mixtures - clayey silt to silty clay	0.94	0.05	1.01	1.0	0.071	35.4	50.00	0.077	1.10	0.97	0.22	0.80	1.05	1.0	0.061	2.790	4.70	68.48	0.110	1.79	1.44	0	1	0.694	0.662	0.95
14.17	12.26	0.23	9.37	1.876	0.0493	0.850	0.099	0.751	1.23	15.08	15.61	50.0	15.19	2.02	0.02	2.76	0.9	14.95	4	Silt mixtures - clayey silt to silty clay	0.94	0.05	1.01	1.0	0.071	35.8	51.41	0.079	1.11	0.97	0.23	0.80	1.05	1.0	0.061	2.755	4.42	68.96	0.110	1.80	1.46	0	1	0.695	0.714	1.03
14.24	12.57	0.44	11.04	3.500	0.0518	0.854	0.101	0.753	1.23	15.42	15.96	50.0	15.55	3.76	0.02	2.90	I	15.53	4	Silt mixtures - clayey silt to silty clay	0.94	0.05	1.01	1.0	0.071	35.9	51.88	0.079	1.12	0.97	0.23	0.80	1.05	1.0	0.062	2.901	5.71	91.04	0.150	2.44	1.78	0	1	0.696	0.731	1.05
14.3	12.87	0.46	11.71	3.574	0.0520	0.858	0.103	0.755	1.22	15.74	16.30	50.0	15.91	3.83	0.02	2.90	I	15.88	4	Silt mixtures - clayey silt to silty clay	0.94	0.05	1.01	1.0	0.071	36.0	52.34	0.080	1.12	0.97	0.23	0.80	1.05	1.0	0.062	2.898	5.68	92.59	0.154	2.49	1.81	0	1	0.697	0.748	1.07

CD-12-02A LIQUEFACTION POTENTIAL & SHEAR STRENGTH CALCULATION

FREE FIELD CONDITION

Data File: CD-12-02 (Input Data)
Location: Midnight Mine South Storage Pond

FoS<1 | FoS≥1

Constants		
Pa	0.97	tsf
Nkt	18	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

Max. Horiz. Acceleration, Amax/g:	0.13
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.05

2011 CPT Data from ConeTec					CPT Data Interpretations															
Depth (ft)	qt (tsf)	fs (tsf)	Pw (u2) (ft)	fs/qt (%)	Unit Weight (tcf)	Total Stress (tsf)	Equil Pore Pressure, u0 (tsf)	Effective Stress (tsf)	CN	qc1 TSF	qc1N	FC %	Qt1	Fr %	Bq	Ic	n	Qtn	SBTn	Soil Type
													Using Qtn for calculating Ic (iterations)							
14.37	17.22	0.47	12.38	2.729	0.0521	0.862	0.105	0.757	1.21	20.82	21.55	50.0	21.61	2.87	0.02	2.72	0.9	21.22	4	Silt mixtures - clayey silt to silty clay
14.44	21.68	0.61	22.75	2.814	0.0531	0.866	0.107	0.759	1.20	25.94	26.85	50.0	27.42	2.93	0.03	2.65	0.9	26.76	4	Silt mixtures - clayey silt to silty clay
14.5	36.15	0.94	24.09	2.600	0.0548	0.870	0.109	0.761	1.17	42.35	43.84	50.0	46.37	2.66	0.02	2.46	0.8	44.47	5	Sand mixtures - silty sand to sandy silt
14.57	44.81	1.09	23.09	2.432	0.0554	0.874	0.111	0.763	1.16	51.94	53.77	50.0	57.60	2.48	0.01	2.37	0.8	54.83	5	Sand mixtures - silty sand to sandy silt
14.63	49.12	1.42	20.75	2.891	0.0564	0.878	0.113	0.765	1.15	56.63	58.63	50.0	63.10	2.94	0.01	2.39	0.8	60.21	5	Sand mixtures - silty sand to sandy silt
14.7	59.68	1.6	11.04	2.681	0.0569	0.882	0.115	0.767	1.14	68.12	70.52	50.0	76.70	2.72	0.00	2.31	0.8	72.71	5	Sand mixtures - silty sand to sandy silt
14.76	58.99	1.92	2.34	3.255	0.0576	0.886	0.117	0.768	1.14	67.29	69.65	50.0	75.63	3.30	0.00	2.37	0.8	72.13	5	Sand mixtures - silty sand to sandy silt
14.83	58.09	2.02	0.00	3.477	0.0578	0.890	0.119	0.770	1.14	66.21	68.54	50.0	74.26	3.53	0.00	2.40	0.8	71.02	5	Sand mixtures - silty sand to sandy silt
14.9	56.05	2.16	-1.00	3.854	0.0581	0.894	0.122	0.772	1.14	63.89	66.14	50.0	71.42	3.92	0.00	2.44	0.8	68.59	5	Sand mixtures - silty sand to sandy silt
14.96	55.77	2.19	-1.00	3.927	0.0581	0.898	0.124	0.774	1.14	63.50	65.74	50.0	70.89	3.99	0.00	2.45	0.8	68.16	5	Sand mixtures - silty sand to sandy silt
15.03	57.5	2.1	-0.67	3.652	0.0580	0.902	0.126	0.776	1.14	65.29	67.59	50.0	72.93	3.71	0.00	2.42	0.8	69.98	5	Sand mixtures - silty sand to sandy silt
15.09	57.21	2.14	-1.34	3.741	0.0580	0.905	0.128	0.778	1.13	64.90	67.18	50.0	72.39	3.80	0.00	2.43	0.8	69.54	5	Sand mixtures - silty sand to sandy silt
15.16	58.36	2.07	-2.01	3.547	0.0579	0.910	0.130	0.780	1.13	66.05	68.38	50.0	73.67	3.60	0.00	2.40	0.8	70.68	5	Sand mixtures - silty sand to sandy silt
15.22	50.84	1.99	-2.34	3.914	0.0578	0.913	0.132	0.782	1.14	57.79	59.82	50.0	63.88	3.99	0.00	2.48	0.8	61.68	5	Sand mixtures - silty sand to sandy silt
15.29	45.64	1.89	-2.34	4.141	0.0576	0.917	0.134	0.784	1.14	52.02	53.85	50.0	57.08	4.23	0.00	2.53	0.9	55.35	5	Sand mixtures - silty sand to sandy silt
15.35	42.16	1.83	-2.68	4.341	0.0574	0.921	0.136	0.785	1.14	48.13	49.82	50.0	52.52	4.44	-0.01	2.57	0.9	51.11	5	Sand mixtures - silty sand to sandy silt
15.42	40.71	1.9	-2.68	4.667	0.0576	0.925	0.138	0.787	1.14	46.46	48.09	50.0	50.53	4.78	-0.01	2.60	0.9	49.32	4	Silt mixtures - clayey silt to silty clay
15.49	31.47	1.94	-2.34	6.165	0.0577	0.929	0.140	0.789	1.15	36.18	37.45	50.0	38.69	6.35	-0.01	2.77	0.9	38.26	4	Silt mixtures - clayey silt to silty clay
15.55	38.12	1.84	-2.01	4.827	0.0575	0.933	0.142	0.791	1.14	43.47	45.00	50.0	47.01	4.95	-0.01	2.63	0.9	46.02	4	Silt mixtures - clayey silt to silty clay
15.62	37.26	1.73	-2.01	4.643	0.0572	0.937	0.144	0.793	1.14	42.46	43.95	50.0	45.80	4.76	-0.01	2.63	0.9	44.84	4	Silt mixtures - clayey silt to silty clay
15.68	33.79	1.57	-1.67	4.646	0.0568	0.941	0.146	0.795	1.14	38.58	39.93	50.0	41.33	4.78	-0.01	2.66	0.9	40.57	4	Silt mixtures - clayey silt to silty clay
15.75	34.08	1.54	-1.67	4.519	0.0568	0.945	0.148	0.797	1.14	38.83	40.20	50.0	41.59	4.65	-0.01	2.65	0.9	40.80	4	Silt mixtures - clayey silt to silty clay
15.81	34.67	1.54	-1.34	4.442	0.0568	0.949	0.150	0.799	1.14	39.43	40.81	50.0	42.23	4.57	-0.01	2.64	0.9	41.41	4	Silt mixtures - clayey silt to silty clay
15.88	36.98	0.62	-1.00	1.677	0.0532	0.953	0.152	0.801	1.13	41.90	43.37	50.0	45.00	1.72	-0.01	2.34	0.8	43.21	5	Sand mixtures - silty sand to sandy silt
15.94	38.13	1.06	-1.00	2.780	0.0553	0.956	0.154	0.802	1.13	43.10	44.61	50.0	46.34	2.85	0.00	2.47	0.8	44.92	5	Sand mixtures - silty sand to sandy silt
16.01	41.32	1.26	-1.00	3.049	0.0560	0.961	0.156	0.804	1.13	46.51	48.14	50.0	50.18	3.12	0.00	2.47	0.8	48.68	5	Sand mixtures - silty sand to sandy silt
16.08	39.94	1.33	4.35	3.330	0.0562	0.965	0.158	0.806	1.13	44.93	46.51	50.0	48.34	3.41	0.00	2.51	0.8	47.03	5	Sand mixtures - silty sand to sandy silt
16.14	39.66	1.33	5.02	3.354	0.0562	0.968	0.160	0.808	1.12	44.57	46.14	50.0	47.88	3.44	0.00	2.52	0.9	46.62	5	Sand mixtures - silty sand to sandy silt
16.21	38.81	1.38	6.02	3.556	0.0563	0.973	0.163	0.810	1.12	43.57	45.11	50.0	46.71	3.65	0.00	2.54	0.9	45.57	5	Sand mixtures - silty sand to sandy silt
16.27	38.53	1.37	6.69	3.556	0.0563	0.976	0.164	0.812	1.12	43.21	44.73	50.0	46.26	3.65	0.00	2.54	0.9	45.16	5	Sand mixtures - silty sand to sandy silt
16.34	37.08	1.34	6.69	3.614	0.0562	0.980	0.167	0.814	1.12	41.56	43.03	50.0	44.36	3.71	0.00	2.56	0.9	43.37	5	Sand mixtures - silty sand to sandy silt
16.4	37.67	1.34	7.36	3.557	0.0562	0.984	0.168	0.816	1.12	42.15	43.63	50.0	44.98	3.65	0.00	2.55	0.9	43.97	5	Sand mixtures - silty sand to sandy silt
16.47	38.24	1.29	7.36	3.373	0.0561	0.988	0.171	0.818	1.12	42.70	44.20	50.0	45.57	3.46	0.00	2.53	0.9	44.49	5	Sand mixtures - silty sand to sandy silt
16.54	38.25	1.2	7.70	3.137	0.0558	0.992	0.173	0.820	1.11	42.64	44.14	50.0	45.46	3.22	0.00	2.51	0.8	44.35	5	Sand mixtures - silty sand to sandy silt
16.6	39.41	1.21	8.03	3.070	0.0558	0.996	0.175	0.821	1.11	43.84	45.38	50.0	46.77	3.15	0.00	2.50	0.8	45.60	5	Sand mixtures - silty sand to sandy silt
16.67	37.1	1.16	8.37	3.127	0.0556	1.000	0.177	0.823	1.11	41.27	42.73	50.0	43.85	3.21	0.00	2.52	0.9	42.83	5	Sand mixtures - silty sand to sandy silt
16.73	37.98	1.23	8.70	3.239	0.0559	1.004	0.179	0.825	1.11	42.17	43.65	50.0	44.82	3.33	0.00	2.53	0.9	43.80	5	Sand mixtures - silty sand to sandy silt
16.8	37.98	1.23	9.03	3.239	0.0559	1.008	0.181	0.827	1.11	42.10	43.58	50.0	44.70	3.33	0.00	2.53	0.9	43.71	5	Sand mixtures - silty sand to sandy silt
16.86	38.27	1.3	9.37	3.397	0.0561	1.012	0.183	0.829	1.11	42.36	43.85	50.0	44.96	3.49	0.00	2.54	0.9	44.00	5	Sand mixtures - silty sand to sandy silt
16.93	39.15	1.55	9.70	3.959	0.0568	1.016	0.185	0.831	1.10	43.24	44.76	50.0	45.90	4.06	0.00	2.58	0.9	45.05	5	Sand mixtures - silty sand to sandy silt
16.99	40.31	1.55	10.04	3.845	0.0568	1.019	0.187	0.833	1.10	44.43	45.99	50.0	47.20	3.94	0.00	2.56	0.9	46.28	5	Sand mixtures - silty sand to sandy silt
17.06	46.09	1.73	10.04	3.754	0.0572	1.024	0.189	0.835	1.10	50.54	52.32	50.0	54.00	3.84	0.00	2.51	0.9	52.83	5	Sand mixtures - silty sand to sandy silt
17.13	48.98	1.81	9.70	3.695	0.0574	1.028	0.191	0.837	1.09	53.54	55.43	50.0	57.32	3.77	0.00	2.49	0.8	56.03	5	Sand mixtures - silty sand to sandy silt
17.19	49.55	1.78	9.70	3.592	0.0573	1.031	0.193	0.838	1.09	54.08	55.99	50.0	57.88	3.67	0.00	2.48	0.8	56.56	5	Sand mixtures - silty sand to sandy silt
17.26	46.65	1.79	9.37	3.837	0.0573	1.036	0.195	0.840	1.09	50.92	52.72	50.0	54.28	3.92	0.00	2.52	0.9	53.18	5	Sand mixtures - silty sand to sandy silt
17.32	42.61	1.71	9.37	4.013	0.0572	1.039	0.197	0.842	1.09	46.56	48.20	50.0	49.37	4.11	0.00	2.56	0.9	48.49	5	Sand mixtures - silty sand to sandy silt
17.39	40.59	1.4	9.37	3.449	0.0564	1.043	0.199	0.844	1.09	44.34	45.90	50.0	46.85	3.54	0.00	2.53	0.9	45.96	5	Sand mixtures - silty sand to sandy silt
17.45	34.23	1.4	9.70	4.090	0.0564	1.047	0.201	0.846	1.10	37.49	38.81	50.0	39.23	4.22	0.00	2.64	0.9	38.71	4	Silt mixtures - clayey silt to silty clay
17.52	34.82	1.19	10.71	3.418	0.0557	1.051	0.203	0.848	1.09	38.06	39.40	50.0	39.83	3.52	0.00	2.58	0.9	39.19	5	Sand mixtures - silty sand to sandy silt
17.59	36.28	1.11	11.71	3.060	0.0555	1.055	0.206	0.850	1.09	39.56	40.95	50.0	41.45	3.15	0.00	2.53	0.9	40.71	5	Sand mixtures - silty sand to sandy silt
17.65	35.41	1.11	11.71	3.135	0.0555	1.059	0.207	0.852	1.09	38.58	39.93	50.0	40.34	3.23	0.00	2.55	0.9	39.66	5	Sand mixtures - silty sand to sandy silt
17.72	36.58	1.2	12.38	3.280	0.0558	1.063	0.210	0.854	1.09	39.76	41.16	50.0	41.61	3.38	0.00	2.55	0.9	40.93	5	Sand mixtures - silty sand to sandy silt
17.78	38.03	1.4	12.72	3.681	0.0564	1.067	0.212	0.855	1.08	41.25	42.70	50.0	43.22	3.79	0.01	2.57	0.9	42.56	5	Sand mixtures - silty sand to sandy silt
17.85	38.31	1.4	12.72	3.654	0.0564	1.071	0.214	0.857	1.08	41.48	42.94	50.0	43.44	3.76	0.00	2.57	0.9	42.79	5	Sand mixtures - silty sand to sandy silt

	Liquefaction Triggering (Sands)																						Cyclic Softening (Clays)			
	Idriss & Boulanger (2008)									Youd et al. (2001)													Idriss & Boulanger (2008)			
	Cyclic Stress Ratio					Cyclic Resistance Ratio				Cyclic Stress Ratio						Cyclic Resistance Ratio							Cyclic Resistance Ratio			
Depth (ft)	r_d	C_s	K_σ	K_α	CSR M=7.5, s'v=1atm	Δqc_{1n}	$qc_{1n\text{-}cs}$	CRR M=7.5, s'v=1atm	FoS	r_d	D_r	f	K_σ	K_α	CSR M=7.5, s'v=1atm	Ic	Kc	$qc_{1n\text{-}cs}$	CRR M=7.5, s'v=1atm	FoS	Avg FoS	Lique-fiable? 1=Yes 2=No	K_a	CSR_M	CRR_M	FoS
14.37	0.94	0.05	1.01	1.0	0.071	37.9	59.43	0.087	1.22	0.97	0.27	0.80	1.05	1.0	0.062	2.722	4.16	89.65	0.147	2.37	1.80	0	1	0.698	1.013	1.45
14.44	0.94	0.06	1.01	1.0	0.071	39.7	66.60	0.095	1.34	0.97	0.30	0.80	1.05	1.0	0.062	2.649	3.64	97.78	0.167	2.69	2.01	0	1	0.700	1.284	1.84
14.5	0.94	0.07	1.02	1.0	0.072	45.7	89.54	0.126	1.76	0.97	0.38	0.80	1.05	1.0	0.062	2.455	2.55	111.85	0.210	3.38	2.57	0	1	0.701	2.168	3.09
14.57	0.94	0.07	1.02	1.0	0.072	49.2	102.95	0.147	2.05	0.97	0.42	0.79	1.05	1.0	0.062	2.367	2.18	117.38	0.230	3.70	2.88	0	1	0.702	2.691	3.83
14.63	0.94	0.08	1.02	1.0	0.072	50.9	109.52	0.159	2.21	0.97	0.44	0.78	1.05	1.0	0.062	2.389	2.27	133.07	0.299	4.81	3.51	0	1	0.703	2.947	4.19
14.7	0.94	0.08	1.02	1.0	0.072	55.1	125.59	0.192	2.66	0.97	0.48	0.76	1.06	1.0	0.062	2.308	1.97	139.17	0.331	5.33	3.99	0	1	0.704	3.582	5.09
14.76	0.94	0.08	1.02	1.0	0.072	54.8	124.42	0.189	2.62	0.97	0.48	0.76	1.06	1.0	0.062	2.371	2.20	153.15	0.414	6.66	4.64	0	1	0.705	3.532	5.01
14.83	0.94	0.08	1.02	1.0	0.072	54.4	122.91	0.186	2.56	0.97	0.48	0.76	1.06	1.0	0.062	2.397	2.30	157.65	0.444	7.12	4.84	0	1	0.707	3.468	4.91
14.9	0.94	0.08	1.02	1.0	0.073	53.5	119.67	0.179	2.46	0.97	0.47	0.77	1.05	1.0	0.063	2.440	2.48	164.34	0.493	7.87	5.17	0	1	0.708	3.335	4.71
14.96	0.94	0.08	1.02	1.0	0.073	53.4	119.13	0.178	2.45	0.97	0.47	0.77	1.05	1.0	0.063	2.448	2.52	165.70	0.503	8.02	5.23	0	1	0.709	3.311	4.67
15.03	0.94	0.08	1.02	1.0	0.073	54.0	121.63	0.183	2.52	0.96	0.47	0.76	1.05	1.0	0.063	2.417	2.38	161.13	0.469	7.46	4.99	0	1	0.710	3.406	4.80
15.09	0.94	0.08	1.02	1.0	0.073	53.9	121.08	0.182	2.50	0.96	0.47	0.76	1.05	1.0	0.063	2.427	2.42	162.91	0.482	7.65	5.07	0	1	0.711	3.381	4.76
15.16	0.94	0.08	1.02	1.0	0.073	54.3	122.69	0.185	2.54	0.96	0.48	0.76	1.05	1.0	0.063	2.405	2.33	159.47	0.457	7.24	4.89	0	1	0.712	3.441	4.83
15.22	0.94	0.08	1.02	1.0	0.073	51.3	111.14	0.162	2.22	0.96	0.45	0.78	1.05	1.0	0.063	2.477	2.66	158.86	0.453	7.13	4.68	0	1	0.713	2.985	4.19
15.29	0.94	0.07	1.02	1.0	0.073	49.2	103.06	0.148	2.02	0.96	0.42	0.79	1.05	1.0	0.064	2.528	2.91	156.84	0.439	6.88	4.45	0	1	0.714	2.668	3.74
15.35	0.94	0.07	1.01	1.0	0.073	47.8	97.63	0.139	1.90	0.96	0.41	0.80	1.04	1.0	0.064	2.567	3.13	155.96	0.433	6.76	4.33	0	1	0.715	2.455	3.43
15.42	0.94	0.07	1.01	1.0	0.073	47.2	95.29	0.135	1.84	0.96	0.40	0.80	1.04	1.0	0.064	2.601	3.33	160.21	0.462	7.20	4.52	0	1	0.716	2.363	3.30
15.49	0.94	0.06	1.01	1.0	0.073	43.5	80.91	0.114	1.56	0.96	0.35	0.80	1.04	1.0	0.064	2.767	4.51	168.78	0.527	8.19	4.87	0	1	0.717	1.811	2.52
15.55	0.94	0.07	1.01	1.0	0.073	46.1	91.12	0.129	1.75	0.96	0.39	0.80	1.04	1.0	0.064	2.633	3.53	158.96	0.454	7.03	4.39	0	1	0.718	2.199	3.06
15.62	0.94	0.07	1.01	1.0	0.073	45.7	89.70	0.126	1.72	0.96	0.38	0.80	1.04	1.0	0.065	2.628	3.50	154.05	0.420	6.50	4.11	0	1	0.720	2.143	2.98
15.68	0.94	0.06	1.01	1.0	0.073	44.3	84.27	0.119	1.61	0.96	0.36	0.80	1.04	1.0	0.065	2.660	3.71	148.25	0.383	5.91	3.76	0	1	0.720	1.935	2.69
15.75	0.94	0.07	1.01	1.0	0.074	44.4	84.62	0.119	1.62	0.96	0.37	0.80	1.04	1.0	0.065	2.649	3.64	146.42	0.372	5.73	3.67	0	1	0.722	1.947	2.70
15.81	0.94	0.07	1.01	1.0	0.074	44.6	85.46	0.120	1.63	0.96	0.37	0.80	1.04	1.0	0.065	2.639	3.58	145.97	0.369	5.68	3.65	0	1	0.722	1.977	2.74
15.88	0.94	0.07	1.01	1.0	0.074	45.5	88.91	0.125	1.70	0.96	0.38	0.80	1.04	1.0	0.065	2.342	2.09	90.66	0.149	2.29	1.99	0	1	0.724	2.106	2.91
15.94	0.93	0.07	1.01	1.0	0.074	46.0	90.59	0.128	1.73	0.96	0.39	0.80	1.04	1.0	0.065	2.472	2.63	117.31	0.230	3.52	2.63	0	1	0.724	2.168	2.99
16.01	0.93	0.07	1.01	1.0	0.074	47.2	95.36	0.135	1.83	0.96	0.40	0.80	1.04	1.0	0.065	2.473	2.64	126.96	0.270	4.13	2.98	0	1	0.725	2.348	3.24
16.08	0.93	0.07	1.01	1.0	0.074	46.6	93.16	0.132	1.78	0.96	0.39	0.80	1.04	1.0	0.066	2.511	2.82	131.36	0.291	4.43	3.11	0	1	0.727	2.262	3.11
16.14	0.93	0.07	1.01	1.0	0.074	46.5	92.65	0.131	1.77	0.96	0.39	0.80	1.04	1.0	0.066	2.516	2.85	131.48	0.291	4.43	3.10	0	1	0.727	2.241	3.08
16.21	0.93	0.07	1.01	1.0	0.074	46.1	91.25	0.129	1.73	0.96	0.39	0.80	1.04	1.0	0.066	2.541	2.98	134.59	0.307	4.66	3.20	0	1	0.728	2.186	3.00
16.27	0.93	0.07	1.01	1.0	0.074	46.0	90.75	0.128	1.72	0.96	0.39	0.80	1.04	1.0	0.066	2.544	3.00	134.18	0.305	4.62	3.17	0	1	0.729	2.165	2.97
16.34	0.93	0.07	1.01	1.0	0.074	45.4	88.45	0.125	1.67	0.96	0.38	0.80	1.03	1.0	0.066	2.562	3.10	133.38	0.301	4.55	3.11	0	1	0.730	2.077	2.84
16.4	0.93	0.07	1.01	1.0	0.074	45.6	89.26	0.126	1.69	0.96	0.38	0.80	1.03	1.0	0.066	2.552	3.05	132.99	0.299	4.51	3.10	0	1	0.731	2.106	2.88
16.47	0.93	0.07	1.01	1.0	0.075	45.8	90.03	0.127	1.70	0.96	0.38	0.80	1.03	1.0	0.066	2.533	2.94	129.91	0.284	4.28	2.99	0	1	0.732	2.133	2.91
16.54	0.93	0.07	1.01	1.0	0.075	45.8	89.95	0.127	1.70	0.96	0.38	0.80	1.03	1.0	0.067	2.512	2.83	124.89	0.261	3.93	2.81	0	1	0.733	2.128	2.90
16.6	0.93	0.07	1.01	1.0	0.075	46.2	91.63	0.129	1.73	0.96	0.39	0.80	1.03	1.0	0.067	2.496	2.75	124.83	0.261	3.91	2.82	0	1	0.734	2.190	2.98
16.67	0.93	0.07	1.01	1.0	0.075	45.3	88.04	0.124	1.66	0.96	0.38	0.80	1.03	1.0	0.067	2.522	2.88	123.19	0.254	3.80	2.73	0	1	0.735	2.053	2.79
16.73	0.93	0.07	1.01	1.0	0.075	45.6	89.29	0.126	1.68	0.96	0.38	0.80	1.03	1.0	0.067	2.525	2.90	126.61	0.269	4.02	2.85	0	1	0.736	2.099	2.85
16.8	0.93	0.07	1.01	1.0	0.075	45.6	89.20	0.126	1.68	0.96	0.38	0.80	1.03	1.0	0.067	2.526	2.90	126.58	0.269	4.01	2.84	0	1	0.737	2.093	2.84
16.86	0.93	0.07	1.01	1.0	0.075	45.7	89.56	0.126	1.68	0.96	0.38	0.80	1.03	1.0	0.067	2.538	2.97	130.24	0.285	4.25	2.97	0	1	0.738	2.105	2.85
16.93	0.93	0.07	1.01	1.0	0.075	46.0	90.79	0.128	1.70	0.96	0.39	0.80	1.03	1.0	0.067	2.578	3.19	142.91	0.351	5.22	3.46	0	1	0.739	2.149	2.91
16.99	0.93	0.07	1.01	1.0	0.075	46.5	92.45	0.131	1.74	0.96	0.39	0.80	1.03	1.0	0.067	2.560	3.09	142.19	0.347	5.15	3.44	0	1	0.739	2.210	2.99
17.06	0.93	0.07	1.01	1.0	0.075	48.7	101.00	0.144	1.91	0.96	0.42	0.79	1.03	1.0	0.067	2.511	2.83	147.92	0.381	5.65	3.78	0	1	0.740	2.527	3.41
17.13	0.93	0.07	1.01	1.0	0.075	49.8	105.20	0.151	2.01	0.96	0.43	0.79	1.03	1.0	0.068	2.488	2.71	150.27	0.396	5.86	3.93	0	1	0.741	2.682	3.62
17.19	0.93	0.07	1.01	1.0	0.076	50.0	105.96	0.153	2.02	0.96	0.43	0.78	1.03	1.0	0.068	2.477	2.65	148.57	0.385	5.69	3.86	0	1	0.742	2.708	3.65
17.26	0.93	0.07	1.01	1.0	0.076	48.8	101.54	0.145	1.92	0.96	0.42	0.79	1.03	1.0	0.068	2.516	2.85	150.38	0.396	5.84	3.88	0	1	0.743	2.541	3.42
17.32	0.93	0.07	1.01	1.0	0.076	47.2	95.43	0.135	1.79	0.96	0.40	0.80	1.03	1.0	0.068	2.559	3.08	148.68	0.386	5.67	3.73	0	1	0.744	2.312	3.11
17.39	0.93	0.07	1.01	1.0	0.076	46.4	92.32	0.130	1.72	0.96	0.39	0.80	1.03	1.0	0.068	2.529	2.92	134.05	0.304	4.46	3.09	0	1	0.745	2.195	2.95
17.45	0.93	0.06	1.01	1.0	0.076	43.9	82.75	0.116	1.54	0.96	0.36	0.80	1.03	1.0	0.068	2.636	3.55	137.89	0.324	4.74	3.14	0	1	0.745	1.839	2.47
17.52	0.93	0.06	1.01	1.0	0.076	44.1	83.54	0.118	1.55	0.96	0.36	0.80	1.03	1.0	0.068	2.578	3.19	125.80	0.265	3.88	2.71	0	1	0.746	1.867	2.50
17.59	0.93	0.07	1.01	1.0	0.076	44.7	85.64	0.121	1.59	0.96	0.37	0.80	1.03	1.0	0.069	2.533	2.94	120.33	0.242	3.53	2.56	0	1	0.747	1.943	2.60
17.65	0.93	0.06	1.01	1.0	0.076	44.3	84.27	0.119	1.56	0.96	0.36	0.80	1.03	1.0	0.069	2.548	3.02	120.79	0.244	3.55	2.56	0	1	0.748	1.891	2.53
17.72	0.92	0.07	1.01	1.0	0.076	44.8	85.92	0.121	1.59	0.96	0.37	0.80	1.03	1.0	0.069	2.552	3.04	125.24	0.263	3.82	2.70	0	1	0.749	1.951	2.61
17.78	0.92	0.07	1.01	1.0	0.076	45.3	88.00	0.124	1.63	0.96	0.38	0.80	1.02	1.0	0.069	2.574	3.17	135.30	0.310	4.50	3.07	0	1	0.750	2.026	2.70
17.85	0.92	0.07	1.01	1.0	0.076	45.4	88.33	0.124	1.63	0.96	0.38	0.80	1.02	1.0	0.069	2.570	3.15	135.10	0.309	4.48	3.06	0	1	0.750	2.036	2.71

CD-12-02A LIQUEFACTION POTENTIAL & SHEAR STRENGTH CALCULATION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Location: **Midnight Mine South Storage Pond**

FoS<1 FoS≥1 | FoS<1 FoS≥1 | FoS<1 FoS≥1

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

Max. Horiz. Acceleration, Amax/g:	0.13
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.05

2011 CPT Data from ConeTec / CPT Data Interpretations

Depth (ft)	qt (tsf)	fs (tsf)	Pw (u2) (ft)	fs/qt (%)	Unit Weight (tcf)	Total Stress (tsf)	Equil Pore Pressure, u0 (tsf)	Effective Stress (tsf)	CN	qc1 TSF	qc1N	FC %
17.91	40.35	1.58	13.05	3.916	0.0569	1.075	0.216	0.859	1.08	43.59	45.12	50.0
17.98	42.93	1.77	11.71	4.123	0.0573	1.079	0.218	0.861	1.08	46.25	47.87	50.0
18.04	44.96	1.76	11.71	3.915	0.0573	1.082	0.220	0.863	1.07	48.32	50.03	50.0
18.11	46.67	2.05	10.71	4.393	0.0579	1.087	0.222	0.865	1.07	50.05	51.81	50.0
18.18	54.2	2.09	11.71	3.856	0.0580	1.091	0.224	0.867	1.07	57.87	59.91	50.0
18.24	61.11	2.04	9.37	3.338	0.0579	1.094	0.226	0.869	1.06	65.01	67.30	50.0
18.31	69.19	2.04	8.37	2.948	0.0579	1.099	0.228	0.871	1.06	73.32	75.90	50.0
18.37	69.16	2	6.69	2.892	0.0578	1.102	0.230	0.872	1.06	73.21	75.79	50.0
18.44	65.08		3.68	0.000		1.106	0.232	0.874	1.06	68.89	71.31	20.0
18.5	54.67		3.68	0.000		1.110	0.234	0.876	1.06	58.00	60.04	20.0
18.57	50.9		2.68	0.000		1.114	0.236	0.878	1.06	53.99	55.89	20.0
Averages:					0.0541							

CPT Data Interpretations (continued) — Using Qtn for calculating Ic (iterations)

Depth (ft)	Qt1	Fr %	Bq	Ic	n	Qtn	SBTn	Soil Type
17.91	45.72	4.02	0.00	2.57	0.9	45.06	5	Sand mixtures - silty sand to sandy silt
17.98	48.61	4.23	0.00	2.57	0.9	47.91	5	Sand mixtures - silty sand to sandy silt
18.04	50.86	4.01	0.00	2.54	0.9	50.08	5	Sand mixtures - silty sand to sandy silt
18.11	52.71	4.50	0.00	2.57	0.9	51.97	5	Sand mixtures - silty sand to sandy silt
18.18	61.27	3.94	0.00	2.48	0.8	60.22	5	Sand mixtures - silty sand to sandy silt
18.24	69.10	3.40	0.00	2.40	0.8	67.71	5	Sand mixtures - silty sand to sandy silt
18.31	78.22	3.00	0.00	2.32	0.8	76.45	5	Sand mixtures - silty sand to sandy silt
18.37	78.03	2.94	0.00	2.32	0.8	76.28	5	Sand mixtures - silty sand to sandy silt
18.44	73.17	0.00	0.00	#####	###	#NUM!	####	#NUM!
18.5	61.14	0.00	0.00	#####	###	#NUM!	####	#NUM!
18.57	56.70	0.00	0.00	#####	###	#NUM!	####	#NUM!

Liquefaction Triggering (Sands) — Idriss & Boulanger (2008)

Depth (ft)	Cyclic Stress Ratio r_d	C_s	K_σ	K_α	CSR M=7.5, s'v=1atm	Cyclic Resistance Ratio Δqc_{1n}	qc_{1n-cs}	CRR M=7.5, s'v=1atm	FoS
17.91	0.92	0.07	1.01	1.0	0.076	46.2	91.27	0.129	1.69
17.98	0.92	0.07	1.01	1.0	0.076	47.1	94.99	0.135	1.76
18.04	0.92	0.07	1.01	1.0	0.076	47.9	97.90	0.139	1.82
18.11	0.92	0.07	1.01	1.0	0.076	48.5	100.32	0.143	1.87
18.18	0.92	0.08	1.01	1.0	0.077	51.3	111.25	0.162	2.12
18.24	0.92	0.08	1.01	1.0	0.077	53.9	121.23	0.182	2.38
18.31	0.92	0.09	1.01	1.0	0.077	57.0	132.86	0.211	2.74
18.37	0.92	0.09	1.01	1.0	0.077	56.9	132.70	0.210	2.73
18.44	0.92	0.08	1.01	1.0	0.077	44.1	115.45	0.170	2.21
18.5	0.92	0.08	1.01	1.0	0.077	41.0	101.02	0.144	1.87
18.57	0.92	0.07	1.01	1.0	0.077	39.8	95.72	0.136	1.76

Liquefaction Triggering (Sands) — Youd et al. (2001); **Cyclic Softening (Clays)** — Idriss & Boulanger (2008)

Depth (ft)	Cyclic Stress Ratio r_d	D_r	f	K_σ	K_α	CSR M=7.5, s'v=1atm	Cyclic Resistance Ratio Ic	Kc	qc_{1n-cs}	CRR M=7.5, s'v=1atm	FoS	Avg FoS	Lique-fiable? 1=Yes 2=No	Cyclic Resistance Ratio K_a	CSRM	CRRM	FoS
17.91	0.96	0.39	0.80	1.02	1.0	0.069	2.574	3.17	143.20	0.353	5.11	3.40	0	1	0.751	2.142	2.85
17.98	0.96	0.40	0.80	1.02	1.0	0.069	2.571	3.16	151.05	0.401	5.78	3.77	0	1	0.752	2.277	3.03
18.04	0.96	0.41	0.80	1.02	1.0	0.069	2.541	2.99	149.40	0.390	5.63	3.72	0	1	0.753	2.382	3.16
18.11	0.96	0.42	0.79	1.02	1.0	0.069	2.566	3.13	161.96	0.475	6.84	4.36	0	1	0.753	2.468	3.28
18.18	0.96	0.45	0.78	1.02	1.0	0.069	2.480	2.67	159.96	0.461	6.63	4.37	0	1	0.754	2.867	3.80
18.24	0.96	0.47	0.76	1.03	1.0	0.069	2.399	2.31	155.32	0.428	6.17	4.27	0	1	0.755	3.232	4.28
18.31	0.96	0.50	0.75	1.03	1.0	0.070	2.323	2.02	153.64	0.417	6.00	4.37	0	1	0.756	3.657	4.84
18.37	0.96	0.50	0.75	1.03	1.0	0.070	2.317	2.01	152.01	0.407	5.84	4.29	0	1	0.756	3.648	4.82
18.44	0.96	0.49	0.76	1.02	1.0	0.070	#NUM!	####	#NUM!	#NUM!	#####	#####	#NUM!	1	0.757	3.422	4.52
18.5	0.96	0.45	0.78	1.02	1.0	0.070	#NUM!	####	#NUM!	#NUM!	#####	#####	#NUM!	1	0.758	2.862	3.78
18.57	0.96	0.43	0.78	1.02	1.0	0.070	#NUM!	####	#NUM!	#NUM!	#####	#####	#NUM!	1	0.759	2.655	3.50

CD-12-02A LIQUEFACTION POTENTIAL & SHEAR STRENGTH CALCULATION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)
Location: **Midnight Mine South Storage Pond**

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

s_u/s_r < 1 (Strength Loss)

2011 CPT Data from ConeTec					CPT Data Interpretations																Free Field Strength Estimates								
																					Robertson (2010a)								
																					Peak Strengths							Cyclic Softening Strengths	
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	OCR Robertson (2009)	OCR Kulhawy Mayne (1990)	Average OCR	$\sigma_{p'}$	s_u	$s_u/\sigma_{v'}$	$(s_u/\sigma_{v'})_{OC}/(s_u/\sigma_{v'})_{NC}$	$s_r/\sigma_{v'}$ FrQtn/100	s_r/s_u
(ft)	(tsf)	(tsf)	(ft)	(%)	(tcf)	(tsf)	(tsf)	(tsf)		TSF		%		%										(tsf)	(psf)				
10.76	27.12	0.31	-3.35	1.143	0.0600	0.582	0.000	0.582	#####	#NUM!	#NUM!	20.0	45.57	1.17	0.00	2.27	0.7	40.04	5	Sand mixtures - silty sand to sandy silt	25.2	10.0	17.6	10.2	2949	2.53	4.22	0.47	0.18
10.83	27.12	1.21	-3.35	4.462	0.0600	0.650	0.000	0.650	1.32	35.69	36.94	50.0	40.74	4.57	0.00	2.66	0.9	39.09	4	Silt mixtures - clayey silt to silty clay	24.4	9.8	17.1	11.1	2941	2.26	3.77	1.79	0.79
10.89	61.8	1.21	-3.35	1.958	0.0600	0.653	0.000	0.653	1.24	76.57	79.27	50.0	93.58	1.98	0.00	2.17	0.7	83.53	5	Sand mixtures - silty sand to sandy silt	63.1	20.9	42.0	27.4	6794	5.20	8.67	1.65	0.32
10.96	71.06	0.96	-2.34	1.351	0.0549	0.658	0.000	0.658	1.22	86.84	89.90	20.0	107.06	1.36	0.00	2.02	0.7	93.71	6	Sands - clean sand to silty sand	72.9	23.4	48.2	31.7	7822	5.95	9.91	1.28	0.21
11.02	78.85	0.96	-4.02	1.218	0.0549	0.661	0.000	0.661	1.21	95.34	98.70	20.0	118.25	1.23	0.00	1.96	0.6	102.81	6	Sands - clean sand to silty sand	81.8	25.7	53.8	35.6	8688	6.57	10.95	1.26	0.19
11.09	21.91	1.37	-4.02	6.253	0.0563	0.665	0.000	0.665	1.31	28.74	29.75	50.0	31.93	6.45	-0.01	2.83	1	31.48	4	Silt mixtures - clayey silt to silty clay	18.6	7.9	13.3	8.8	2361	1.77	2.96	2.03	1.14
11.15	21.96	1.72	-0.67	7.832	0.0572	0.669	0.000	0.669	1.31	28.70	29.71	50.0	31.83	8.08	0.00	2.90	1	31.70	4	Silt mixtures - clayey silt to silty clay	18.8	7.9	13.4	8.9	2366	1.77	2.95	2.56	1.45
11.22	21.09	1.7	-0.67	8.061	0.0571	0.673	0.000	0.673	1.30	27.50	28.47	50.0	30.33	8.33	0.00	2.92	1	30.31	4	Silt mixtures - clayey silt to silty clay	17.8	7.6	12.7	8.5	2269	1.68	2.81	2.52	1.50
11.29	19.15	1.57	6.02	8.198	0.0568	0.677	0.009	0.668	1.32	25.23	26.12	50.0	27.64	8.50	0.01	2.96	1	27.64	3	Clays - silty clay to clay	15.8	6.9	11.4	7.6	2054	1.54	2.56	2.35	1.53
11.35	15.73	1.11	9.03	7.057	0.0555	0.681	0.011	0.670	1.33	20.90	21.64	50.0	22.46	7.38	0.02	2.97	1	22.46	3	Clays - silty clay to clay	12.2	5.6	8.9	6.0	1673	1.25	2.08	1.66	1.33
11.42	16.03	0.68	10.37	4.242	0.0536	0.685	0.013	0.672	1.32	21.23	21.98	50.0	22.83	4.43	0.02	2.82	1	22.50	4	Silt mixtures - clayey silt to silty clay	12.3	5.6	8.9	6.0	1706	1.27	2.12	1.00	0.79
11.48	14.05	0.68	13.38	4.840	0.0536	0.689	0.015	0.674	1.33	18.70	19.36	50.0	19.83	5.09	0.03	2.90	1	19.77	4	Silt mixtures - clayey silt to silty clay	10.4	4.9	7.7	5.2	1486	1.10	1.84	1.01	0.91
11.55	13.2	0.67	14.39	5.076	0.0535	0.693	0.017	0.676	1.33	17.58	18.20	50.0	18.51	5.36	0.03	2.94	1	18.51	4	Silt mixtures - clayey silt to silty clay	9.6	4.6	7.1	4.8	1392	1.03	1.72	0.99	0.96
11.61	12.05	0.61	15.39	5.062	0.0531	0.697	0.019	0.678	1.34	16.09	16.65	50.0	16.76	5.37	0.04	2.97	1	16.76	3	Clays - silty clay to clay	8.5	4.2	6.3	4.3	1264	0.93	1.55	0.90	0.97
11.68	9.79	0.47	19.41	4.801	0.0521	0.701	0.021	0.680	1.34	13.16	13.63	50.0	13.37	5.17	0.06	3.04	1	13.37	3	Clays - silty clay to clay	6.4	3.3	4.9	3.3	1012	0.74	1.24	0.69	0.93
11.75	8.35	0.41	20.08	4.910	0.0516	0.705	0.023	0.682	1.35	11.28	11.67	50.0	11.22	5.36	0.08	3.11	1	11.22	3	Clays - silty clay to clay	5.1	2.8	4.0	2.7	852	0.63	1.04	0.60	0.96
11.81	8.97	0.38	22.42	4.236	0.0513	0.709	0.025	0.683	1.34	12.05	12.48	50.0	12.09	4.60	0.08	3.04	1	12.09	3	Clays - silty clay to clay	5.6	3.0	4.3	3.0	921	0.67	1.12	0.56	0.83
11.88	6.39	0.31	24.09	4.851	0.0505	0.713	0.027	0.685	1.36	8.68	8.99	50.0	8.28	5.46	0.13	3.22	1	8.28	3	Clays - silty clay to clay	3.5	2.1	2.8	1.9	634	0.46	0.77	0.45	0.98
11.94	4.98	0.24	27.10	4.819	0.0495	0.716	0.029	0.687	1.37	6.82	7.06	50.0	6.21	5.63	0.19	3.32	1	6.21	3	Clays - silty clay to clay	2.4	1.6	2.0	1.4	477	0.35	0.58	0.35	1.01
12.01	5.85	0.24	27.44	4.103	0.0495	0.721	0.032	0.689	1.36	7.94	8.22	50.0	7.44	4.68	0.16	3.21	1	7.44	3	Clays - silty clay to clay	3.1	1.9	2.5	1.7	573	0.42	0.69	0.35	0.84
12.07	4.71	0.18	28.11	3.822	0.0483	0.724	0.033	0.691	1.36	6.43	6.65	50.0	5.77	4.52	0.21	3.29	1	5.77	3	Clays - silty clay to clay	2.2	1.4	1.8	1.3	447	0.32	0.54	0.26	0.81
12.14	7.37	0.16	33.13	2.171	0.0479	0.728	0.036	0.693	1.34	9.87	10.22	50.0	9.59	2.41	0.15	2.96	1	9.59	3	Clays - silty clay to clay	4.2	2.4	3.3	2.3	742	0.54	0.89	0.23	0.43
12.2	5.93	0.23	33.13	3.879	0.0493	0.732	0.037	0.695	1.35	7.99	8.27	50.0	7.48	4.42	0.19	3.20	1	7.48	3	Clays - silty clay to clay	3.1	1.9	2.5	1.7	582	0.42	0.70	0.33	0.79
12.27	6.26	0.27	36.47	4.313	0.0499	0.736	0.040	0.697	1.34	8.39	8.69	50.0	7.93	4.89	0.20	3.20	1	7.93	3	Clays - silty clay to clay	3.3	2.0	2.7	1.8	618	0.44	0.74	0.39	0.87
12.34	9.72	0.22	36.14	2.263	0.0491	0.740	0.042	0.699	1.32	12.78	13.23	50.0	12.85	2.45	0.12	2.86	1	12.75	4	Silt mixtures - clayey silt to silty clay	6.0	3.2	4.6	3.2	1002	0.72	1.20	0.31	0.44
12.4	8.92	0.22	19.07	2.466	0.0491	0.744	0.044	0.700	1.32	11.75	12.16	50.0	11.67	2.69	0.07	2.92	1	11.66	4	Silt mixtures - clayey silt to silty clay	5.4	2.9	4.2	2.9	913	0.65	1.09	0.31	0.48
12.47	7.7	0.21	14.05	2.727	0.0489	0.748	0.046	0.702	1.32	10.17	10.53	50.0	9.90	3.02	0.06	3.00	1	9.90	3	Clays - silty clay to clay	4.4	2.5	3.4	2.4	778	0.55	0.92	0.30	0.54
12.53	5.68	0.16	14.72	2.817	0.0479	0.752	0.048	0.704	1.33	7.57	7.84	50.0	7.00	3.25	0.08	3.14	1	7.00	3	Clays - silty clay to clay	2.8	1.7	2.3	1.6	553	0.39	0.65	0.23	0.58
12.6	4.6	0.16	20.08	3.478	0.0479	0.756	0.050	0.706	1.34	6.16	6.38	50.0	5.44	4.16	0.15	3.30	1	5.44	3	Clays - silty clay to clay	2.1	1.4	1.7	1.2	433	0.31	0.51	0.23	0.74
12.66	4.33	0.16	21.75	3.695	0.0479	0.760	0.052	0.708	1.34	5.80	6.00	50.0	5.04	4.48	0.18	3.34	1	5.04	3	Clays - silty clay to clay	1.9	1.3	1.6	1.1	402	0.28	0.47	0.23	0.80
12.73	8.72	0.19	25.43	2.179	0.0486	0.764	0.054	0.710	1.30	11.37	11.77	50.0	11.21	2.39	0.09	2.90	1	11.18	4	Silt mixtures - clayey silt to silty clay	5.1	2.8	4.0	2.8	890	0.63	1.04	0.27	0.43
12.8	5.24	0.21	25.43	4.008	0.0489	0.768	0.056	0.712	1.32	6.94	7.18	50.0	6.28	4.70	0.16	3.27	1	6.28	3	Clays - silty clay to clay	2.5	1.6	2.0	1.4	503	0.35	0.59	0.30	0.83
12.86	6.7	0.3	26.10	4.478	0.0503	0.772	0.058	0.714	1.31	8.78	9.09	50.0	8.31	5.06	0.13	3.19	1	8.31	3	Clays - silty clay to clay	3.5	2.1	2.8	2.0	665	0.47	0.78	0.42	0.90
12.93	6.16	0.32	28.44	5.195	0.0506	0.776	0.060	0.716	1.31	8.07	8.36	50.0	7.52	5.94	0.15	3.27	1	7.52	3	Clays - silty clay to clay	3.1	1.9	2.5	1.8	605	0.42	0.70	0.45	1.06
12.99	5.59	0.4	29.45	7.156	0.0515	0.779	0.062	0.717	1.31	7.34	7.59	50.0	6.71	8.31	0.18	3.40	1	6.71	3	Clays - silty clay to clay	2.7	1.7	2.2	1.6	541	0.38	0.63	0.56	1.48
13.06	8.83	0.4	11.71	4.530	0.0515	0.784	0.064	0.719	1.29	11.38	11.78	50.0	11.19	4.97	0.04	3.09	1	11.19	3	Clays - silty clay to clay	5.1	2.8	4.0	2.8	901	0.63	1.04	0.56	0.89
13.12	15.38	0.37	5.02	2.406	0.0512	0.787	0.066	0.721	1.26	19.37	20.05	50.0	20.24	2.54	0.01	2.71	0.9	19.78	4	Silt mixtures - clayey silt to silty clay	10.4	4.9	7.7	5.5	1629	1.13	1.88	0.50	0.44
13.19	13.87	0.29	-0.33	2.091	0.0502	0.791	0.068	0.723	1.26	17.50	18.12	50.0	18.09	2.22	-0.01	2.72	0.9	17.69	4	Silt mixtures - clayey silt to silty clay	9.1	4.4	6.7	4.9	1461	1.01	1.68	0.39	0.39
13.25	13.87	0.29	-0.33	2.091	0.0502	0.795	0.070	0.725	1.26	17.47	18.08	50.0	18.04	2.22	-0.01	2.72	0.9	17.65	4	Silt mixtures - clayey silt to silty clay	9.0	4.4	6.7	4.9	1461	1.01	1.68	0.39	0.39
13.32	12.15	0.29	1.00	2.387	0.0502	0.799	0.072	0.727	1.26	15.35	15.89	50.0	15.62	2.55	0.00	2.80	1	15.42	4	Silt mixtures - clayey silt to silty clay	7.6	3.9	5.7	4.2	1269	0.87	1.46	0.39	0.45
13.39	10.73	0.27	2.68	2.516	0.0499	0.803	0.075	0.729	1.27	13.59	14.06	50.0	13.62	2.72	0.00	2.86	1	13.54	4	Silt mixtures - clayey silt to silty clay	6.5	3.4	4.9	3.6	1111	0.76	1.27	0.37	0.48
13.45	11.6	0.25	2.68	2.155	0.0496	0.807	0.076	0.731	1.26	14.62	15.13	50.0	14.77	2.32	0.00	2.80	1	14.58	4	Silt mixtures - clayey silt to silty clay	7.1	3.6	5.4	3.9	1208	0.83	1.38	0.34	0.41
13.52	11.89	0.26	3.35	2.187	0.0498	0.811	0.079	0.733	1.26	14.94	15.46	50.0	15.12	2.35	0.00	2.79	1	14.92	4	Silt mixtures - clayey silt to silty clay	7.3	3.7	5.5	4.1	1240	0.85	1.41	0.35	0.41
13.58	11.34	0.26	5.02	2.293	0.0498	0.815	0.080	0.734	1.26	14.24	14.75	50.0	14.33	2.47	0.01	2.82	1	14.19	4	Silt mixtures - clayey silt to silty clay	6.9	3.5	5.2	3.8	1178	0.80	1.34	0.35	0.44
13.65	11.34	0.25	5.35	2.205	0.0496	0.819	0.083	0.736	1.25	14.21	14.71	50.0	14.29	2.38	0.01	2.82	1	14.14	4	Silt mixtures - clayey silt to silty clay	6.9	3.5	5.2	3.8	1178	0.80	1.33	0.34	0.42
13.71	11.64	0.19	6.02	1.632	0.0486	0.823	0.085	0.738	1.25	14.55	15.06	50.0	14.66	1.76	0.01	2.74	0.9	14.39	4	Silt mixtures - clayey silt to silty clay	7.0	3.6	5.3	3.9	1211	0.82	1.37	0.25	0.31
13.78	12.8	0.16	6.02	1.250	0.0479	0.827	0.087	0.740	1.24	15.91	16.47	20.0	16.18	1.34	0.01	2.64	0.9	15.73	4	Silt mixtures - clayey silt to silty clay	7.8	3.9	5.9	4.4	1340	0.91	1.51	0.21	0.23
13.85	14.81	0.18	5.35	1.215	0.0483	0.831	0.089	0.742	1.23	18.27	18.92	20.0	18.84	1.29	0.01	2.58	0.9	18.21	5	Sand mixtures - silty sand to sandy silt	9.4	4.6	7.0	5.2	1563	1.05	1.76	0.23	0.22
13.91	14.27	0.18	7.70	1.261	0.0483	0.835	0.091	0.744	1.23	17.60	18.22	20.0	18.06	1.34	0.01	2.60	0.9	17.51	4	Silt mixtures - clayey silt to silty clay	9.0	4.4	6.7	5.0	1503	1.01	1.68	0.23	0.23
13.98	11.37	0.2	7.70	1.759	0.0488	0.839	0.093	0.746	1.24	14.10	14.60	50.0	14.12	1.90	0.01	2.77	0.9	13.91	4	Silt mixtures - clayey silt to silty clay	6.7	3.5	5.1	3.8	1180	0.79	1.32	0.26	0.33
14.04	12.24	0.22	8.03	1.797	0.0491	0.842	0.095	0.748	1.23	15.12	15.65	50.0	15.25	1.93	0.01	2.74	0.9	14.99	4	Silt mixtures - clayey silt to silty clay	7.4	3.7	5.6	4.2	1277	0.85	1.42	0.29	0.34
14.11	11.39	0.22	8.70	1.932	0.0491	0.847	0.097	0.750	1.24	14.07	14.57	50.0	14.07	2.09	0.02	2.79	1	13.90	4	Silt mixtures - clayey silt to silty clay	6.7	3.5	5.1	3.8	1182	0.79	1.31	0.29	0.37
14.17	12.26	0.23	9.37	1.876	0.0493	0.850	0.099	0.751	1.23	15.08	15.61	50.0	15.19	2.02	0.02	2.76	0.9	14.95	4	Silt mixtures - clayey silt to silty clay	7.4	3.7	5.5	4.2	1279	0.85	1.42	0.30	0.35
14.24	12.57	0.44	11.04	3.500	0.0518	0.854	0.101	0.753	1.23	15.42	15.96	50.0	15.55	3.76	0.02	2.90	1	15.53	4	Silt mixtures - clayey silt to silty clay	7.7	3.9	5.8	4.4	1313	0.87	1.45	0.58	0.67
14.3	12.87	0.46	11.71	3.574	0.0520	0.858	0.103	0.755	1.22	15.74	16.30	50.0	15.91	3.83	0.02	2.90	1	15.88	4	Silt mixtures - clayey silt to silty clay	7.9	4.0	5.9	4.5	1346	0.89	1.49	0.61	0.68

CD-12-02A LIQUEFACTION POTENTIAL & SHEAR STRENGTH CALCULATION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)
Location: **Midnight Mine South Storage Pond**

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

s_u/s_r < 1 (Strength Loss)

2011 CPT Data from ConeTec					CPT Data Interpretations																	Free Field Strength Estimates								
																						Robertson (2010a)								
																						Peak Strengths							Cyclic Softening Strengths	
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Using Qtn for calculating Ic (iterations) Soil Type	OCR Robertson (2009)	OCR Kulhawy Mayne (1990)	Average OCR	$\sigma_{p'}$	s_u	$s_u/\sigma_{v'}$	$(s_u/\sigma_{v'})_{OC}/(s_u/\sigma_{v'})_{NC}$	$s_r/\sigma_{v'}$ FrQtn/100	s_r/s_u
(ft)	(tsf)	(tsf)	(ft)	(%)	(tcf)	(tsf)	(tsf)	(tsf)		TSF		%		%										(tsf)	(psf)				
14.37	17.22	0.47	12.38	2.729	0.0521	0.862	0.105	0.757	1.21	20.82	21.55	50.0	21.61	2.87	0.02	2.72	0.9	21.22	4	Silt mixtures - clayey silt to silty clay	11.4	5.3	8.3	6.3	1829	1.21	2.01	0.61	0.50
14.44	21.68	0.61	22.75	2.814	0.0531	0.866	0.107	0.759	1.20	25.94	26.85	50.0	27.42	2.93	0.03	2.65	0.9	26.76	4	Silt mixtures - clayey silt to silty clay	15.2	6.7	11.0	8.3	2325	1.53	2.55	0.78	0.51
14.5	36.15	0.94	24.09	2.600	0.0548	0.870	0.109	0.761	1.17	42.35	43.84	50.0	46.37	2.66	0.02	2.46	0.8	44.47	5	Sand mixtures - silty sand to sandy silt	28.7	11.1	19.9	15.2	3932	2.58	4.31	1.18	0.46
14.57	44.81	1.09	23.09	2.432	0.0554	0.874	0.111	0.763	1.16	51.94	53.77	50.0	57.60	2.48	0.01	2.37	0.8	54.83	5	Sand mixtures - silty sand to sandy silt	37.3	13.7	25.5	19.5	4894	3.21	5.35	1.36	0.42
14.63	49.12	1.42	20.75	2.891	0.0564	0.878	0.113	0.765	1.15	56.63	58.63	50.0	63.10	2.94	0.01	2.39	0.8	60.21	5	Sand mixtures - silty sand to sandy silt	41.9	15.1	28.5	21.8	5373	3.51	5.86	1.77	0.50
14.7	59.68	1.6	11.04	2.681	0.0569	0.882	0.115	0.767	1.14	68.12	70.52	50.0	76.70	2.72	0.00	2.31	0.8	72.71	5	Sand mixtures - silty sand to sandy silt	53.1	18.2	35.6	27.3	6546	4.27	7.12	1.98	0.46
14.76	58.99	1.92	2.34	3.255	0.0576	0.886	0.117	0.768	1.14	67.29	69.65	50.0	75.63	3.30	0.00	2.37	0.8	72.13	5	Sand mixtures - silty sand to sandy silt	52.6	18.0	35.3	27.1	6469	4.21	7.02	2.38	0.57
14.83	58.09	2.02	0.00	3.477	0.0578	0.890	0.119	0.770	1.14	66.21	68.54	50.0	74.26	3.53	0.00	2.40	0.8	71.02	5	Sand mixtures - silty sand to sandy silt	51.5	17.8	34.6	26.7	6369	4.13	6.89	2.51	0.61
14.9	56.05	2.16	-1.00	3.854	0.0581	0.894	0.122	0.772	1.14	63.89	66.14	50.0	71.42	3.92	0.00	2.44	0.8	68.59	5	Sand mixtures - silty sand to sandy silt	49.4	17.1	33.2	25.7	6142	3.98	6.63	2.69	0.68
14.96	55.77	2.19	-1.00	3.927	0.0581	0.898	0.124	0.774	1.14	63.50	65.74	50.0	70.89	3.99	0.00	2.45	0.8	68.16	5	Sand mixtures - silty sand to sandy silt	49.0	17.0	33.0	25.5	6111	3.95	6.58	2.72	0.69
15.03	57.5	2.1	-0.67	3.652	0.0580	0.902	0.126	0.776	1.14	65.29	67.59	50.0	72.93	3.71	0.00	2.42	0.8	69.98	5	Sand mixtures - silty sand to sandy silt	50.6	17.5	34.0	26.4	6303	4.06	6.77	2.60	0.64
15.09	57.21	2.14	-1.34	3.741	0.0580	0.905	0.128	0.778	1.13	64.90	67.18	50.0	72.39	3.80	0.00	2.43	0.8	69.54	5	Sand mixtures - silty sand to sandy silt	50.2	17.4	33.8	26.3	6270	4.03	6.72	2.64	0.66
15.16	58.36	2.07	-2.01	3.547	0.0579	0.910	0.130	0.780	1.13	66.05	68.38	50.0	73.67	3.60	0.00	2.40	0.8	70.68	5	Sand mixtures - silty sand to sandy silt	51.2	17.7	34.5	26.9	6398	4.10	6.84	2.55	0.62
15.22	50.84	1.99	-2.34	3.914	0.0578	0.913	0.132	0.782	1.14	57.79	59.82	50.0	63.88	3.99	0.00	2.48	0.8	61.68	5	Sand mixtures - silty sand to sandy silt	43.2	15.4	29.3	22.9	5562	3.56	5.93	2.46	0.69
15.29	45.64	1.89	-2.34	4.141	0.0576	0.917	0.134	0.784	1.14	52.02	53.85	50.0	57.08	4.23	0.00	2.53	0.9	55.35	5	Sand mixtures - silty sand to sandy silt	37.7	13.8	25.8	20.2	4984	3.18	5.30	2.34	0.74
15.35	42.16	1.83	-2.68	4.341	0.0574	0.921	0.136	0.785	1.14	48.13	49.82	50.0	52.52	4.44	-0.01	2.57	0.9	51.11	5	Sand mixtures - silty sand to sandy silt	34.2	12.8	23.5	18.4	4597	2.93	4.88	2.27	0.77
15.42	40.71	1.9	-2.68	4.667	0.0576	0.925	0.138	0.787	1.14	46.46	48.09	50.0	50.53	4.78	-0.01	2.60	0.9	49.32	4	Silt mixtures - clayey silt to silty clay	32.7	12.3	22.5	17.7	4436	2.82	4.70	2.36	0.84
15.49	31.47	1.94	-2.34	6.165	0.0577	0.929	0.140	0.789	1.15	36.18	37.45	50.0	38.69	6.35	-0.01	2.77	0.9	38.26	4	Silt mixtures - clayey silt to silty clay	23.8	9.6	16.7	13.2	3409	2.16	3.60	2.43	1.13
15.55	38.12	1.84	-2.01	4.827	0.0575	0.933	0.142	0.791	1.14	43.47	45.00	50.0	47.01	4.95	-0.01	2.63	0.9	46.02	4	Silt mixtures - clayey silt to silty clay	30.0	11.5	20.7	16.4	4148	2.62	4.37	2.28	0.87
15.62	37.26	1.73	-2.01	4.643	0.0572	0.937	0.144	0.793	1.14	42.46	43.95	50.0	45.80	4.76	-0.01	2.63	0.9	44.84	4	Silt mixtures - clayey silt to silty clay	29.0	11.2	20.1	15.9	4052	2.55	4.26	2.14	0.84
15.68	33.79	1.57	-1.67	4.646	0.0568	0.941	0.146	0.795	1.14	38.58	39.93	50.0	41.33	4.78	-0.01	2.66	0.9	40.57	4	Silt mixtures - clayey silt to silty clay	25.6	10.1	17.9	14.2	3666	2.31	3.84	1.94	0.84
15.75	34.08	1.54	-1.67	4.519	0.0568	0.945	0.148	0.797	1.14	38.83	40.20	50.0	41.59	4.65	-0.01	2.65	0.9	40.80	4	Silt mixtures - clayey silt to silty clay	25.8	10.2	18.0	14.3	3698	2.32	3.87	1.90	0.82
15.81	34.67	1.54	-1.34	4.442	0.0568	0.949	0.150	0.799	1.14	39.43	40.81	50.0	42.23	4.57	-0.01	2.64	0.9	41.41	4	Silt mixtures - clayey silt to silty clay	26.3	10.4	18.3	14.6	3763	2.36	3.93	1.89	0.80
15.88	36.98	0.62	-1.00	1.677	0.0532	0.953	0.152	0.801	1.13	41.90	43.37	50.0	45.00	1.72	-0.01	2.34	0.8	43.21	5	Sand mixtures - silty sand to sandy silt	27.7	10.8	19.2	15.4	4020	2.51	4.18	0.74	0.30
15.94	38.13	1.06	-1.00	2.780	0.0553	0.956	0.154	0.802	1.13	43.10	44.61	50.0	46.34	2.85	0.00	2.47	0.8	44.92	5	Sand mixtures - silty sand to sandy silt	29.1	11.2	20.2	16.2	4148	2.58	4.31	1.28	0.50
16.01	41.32	1.26	-1.00	3.049	0.0560	0.961	0.156	0.804	1.13	46.51	48.14	50.0	50.18	3.12	0.00	2.47	0.8	48.68	5	Sand mixtures - silty sand to sandy silt	32.1	12.2	22.2	17.8	4502	2.80	4.66	1.52	0.54
16.08	39.94	1.33	4.35	3.330	0.0562	0.965	0.158	0.806	1.13	44.93	46.51	50.0	48.34	3.41	0.00	2.51	0.8	47.03	5	Sand mixtures - silty sand to sandy silt	30.8	11.8	21.3	17.2	4348	2.70	4.49	1.60	0.60
16.14	39.66	1.33	5.02	3.354	0.0562	0.968	0.160	0.808	1.12	44.57	46.14	50.0	47.88	3.44	0.00	2.52	0.9	46.62	5	Sand mixtures - silty sand to sandy silt	30.5	11.7	21.1	17.0	4317	2.67	4.45	1.60	0.60
16.21	38.81	1.38	6.02	3.556	0.0563	0.973	0.163	0.810	1.12	43.57	45.11	50.0	46.71	3.65	0.00	2.54	0.9	45.57	5	Sand mixtures - silty sand to sandy silt	29.6	11.4	20.5	16.6	4222	2.61	4.34	1.66	0.64
16.27	38.53	1.37	6.69	3.556	0.0563	0.976	0.164	0.812	1.12	43.21	44.73	50.0	46.26	3.65	0.00	2.54	0.9	45.16	5	Sand mixtures - silty sand to sandy silt	29.3	11.3	20.3	16.5	4191	2.58	4.30	1.65	0.64
16.34	37.08	1.34	6.69	3.614	0.0562	0.980	0.167	0.814	1.12	41.56	43.03	50.0	44.36	3.71	0.00	2.56	0.9	43.37	5	Sand mixtures - silty sand to sandy silt	27.8	10.8	19.3	15.7	4030	2.48	4.13	1.61	0.65
16.4	37.67	1.34	7.36	3.557	0.0562	0.984	0.168	0.816	1.12	42.15	43.63	50.0	44.98	3.65	0.00	2.55	0.9	43.97	5	Sand mixtures - silty sand to sandy silt	28.3	11.0	19.6	16.0	4095	2.51	4.18	1.61	0.64
16.47	38.24	1.29	7.36	3.373	0.0561	0.988	0.171	0.818	1.12	42.70	44.20	50.0	45.57	3.46	0.00	2.53	0.9	44.49	5	Sand mixtures - silty sand to sandy silt	28.7	11.1	19.9	16.3	4158	2.54	4.24	1.54	0.61
16.54	38.25	1.2	7.70	3.137	0.0558	0.992	0.173	0.820	1.11	42.64	44.14	50.0	45.46	3.22	0.00	2.51	0.8	44.35	5	Sand mixtures - silty sand to sandy silt	28.6	11.1	19.8	16.3	4159	2.54	4.23	1.43	0.56
16.6	39.41	1.21	8.03	3.070	0.0558	0.996	0.175	0.821	1.11	43.84	45.38	50.0	46.77	3.15	0.00	2.50	0.8	45.60	5	Sand mixtures - silty sand to sandy silt	29.6	11.4	20.5	16.8	4288	2.61	4.35	1.44	0.55
16.67	37.1	1.16	8.37	3.127	0.0556	1.000	0.177	0.823	1.11	41.27	42.73	50.0	43.85	3.21	0.00	2.52	0.9	42.83	5	Sand mixtures - silty sand to sandy silt	27.4	10.7	19.1	15.7	4031	2.45	4.08	1.38	0.56
16.73	37.98	1.23	8.70	3.239	0.0559	1.004	0.179	0.825	1.11	42.17	43.65	50.0	44.82	3.33	0.00	2.53	0.9	43.80	5	Sand mixtures - silty sand to sandy silt	28.2	11.0	19.6	16.1	4128	2.50	4.17	1.46	0.58
16.8	37.98	1.23	9.03	3.239	0.0559	1.008	0.181	0.827	1.11	42.10	43.58	50.0	44.70	3.33	0.00	2.53	0.9	43.71	5	Sand mixtures - silty sand to sandy silt	28.1	10.9	19.5	16.1	4128	2.50	4.16	1.45	0.58
16.86	38.27	1.3	9.37	3.397	0.0561	1.012	0.183	0.829	1.11	42.36	43.85	50.0	44.96	3.49	0.00	2.54	0.9	44.00	5	Sand mixtures - silty sand to sandy silt	28.3	11.0	19.7	16.3	4160	2.51	4.18	1.54	0.61
16.93	39.15	1.55	9.70	3.959	0.0568	1.016	0.185	0.831	1.10	43.24	44.76	50.0	45.90	4.06	0.00	2.58	0.9	45.05	5	Sand mixtures - silty sand to sandy silt	29.2	11.3	20.2	16.8	4258	2.56	4.27	1.83	0.71
16.99	40.31	1.55	10.04	3.845	0.0568	1.019	0.187	0.833	1.10	44.43	45.99	50.0	47.20	3.94	0.00	2.56	0.9	46.28	5	Sand mixtures - silty sand to sandy silt	30.2	11.6	20.9	17.4	4386	2.63	4.39	1.83	0.69
17.06	46.09	1.73	10.04	3.754	0.0572	1.024	0.189	0.835	1.10	50.54	52.32	50.0	54.00	3.84	0.00	2.51	0.9	52.83	5	Sand mixtures - silty sand to sandy silt	35.6	13.2	24.4	20.4	5028	3.01	5.02	2.03	0.67
17.13	48.98	1.81	9.70	3.695	0.0574	1.028	0.191	0.837	1.09	53.54	55.43	50.0	57.32	3.77	0.00	2.49	0.8	56.03	5	Sand mixtures - silty sand to sandy silt	38.3	14.0	26.2	21.9	5349	3.20	5.33	2.11	0.66
17.19	49.55	1.78	9.70	3.592	0.0573	1.031	0.193	0.838	1.09	54.08	55.99	50.0	57.88	3.67	0.00	2.48	0.8	56.56	5	Sand mixtures - silty sand to sandy silt	38.8	14.1	26.5	22.2	5412	3.23	5.38	2.07	0.64
17.26	46.65	1.79	9.37	3.837	0.0573	1.036	0.195	0.840	1.09	50.92	52.72	50.0	54.28	3.92	0.00	2.52	0.9	53.18	5	Sand mixtures - silty sand to sandy silt	35.9	13.3	24.6	20.7	5090	3.03	5.05	2.09	0.69
17.32	42.61	1.71	9.37	4.013	0.0572	1.039	0.197	0.842	1.09	46.56	48.20	50.0	49.37	4.11	0.00	2.56	0.9	48.49	5	Sand mixtures - silty sand to sandy silt	32.0	12.1	22.1	18.6	4641	2.76	4.59	1.99	0.72
17.39	40.59	1.4	9.37	3.449	0.0564	1.043	0.199	0.844	1.09	44.34	45.90	50.0	46.85	3.54	0.00	2.53	0.9	45.96	5	Sand mixtures - silty sand to sandy silt	29.9	11.5	20.7	17.5	4416	2.62	4.36	1.63	0.62
17.45	34.23	1.4	9.70	4.090	0.0564	1.047	0.201	0.846	1.10	37.49	38.81	50.0	39.23	4.22	0.00	2.64	0.9	38.71	4	Silt mixtures - clayey silt to silty clay	24.1	9.7	16.9	14.3	3709	2.19	3.65	1.63	0.74
17.52	34.82	1.19	10.71	3.418	0.0557	1.051	0.203	0.848	1.09	38.06	39.40	50.0	39.83	3.52	0.00	2.58	0.9	39.19	5	Sand mixtures - silty sand to sandy silt	24.5	9.8	17.2	14.5	3775	2.23	3.71	1.38	0.62
17.59	36.28	1.11	11.71	3.060	0.0555	1.055	0.206	0.850	1.09	39.56	40.95	50.0	41.45	3.15	0.00	2.53	0.9	40.71	5	Sand mixtures - silty sand to sandy silt	25.7	10.2	17.9	15.2	3937	2.32	3.86	1.28	0.55
17.65	35.41	1.11	11.71	3.135	0.0555	1.059	0.207	0.852	1.09	38.58	39.93	50.0	40.34	3.23	0.00	2.55	0.9	39.66	5	Sand mixtures - silty sand to sandy silt	24.9	9.9	17.4	14.8	3840	2.25	3.76	1.28	0.57
17.72	36.58	1.2	12.38	3.280	0.0558	1.063	0.210	0.854	1.09	39.76	41.16	50.0	41.61	3.38	0.00	2.55	0.9	40.93	5	Sand mixtures - silty sand to sandy silt	25.9	10.2	18.1	15.4	3970	2.33	3.88	1.38	0.59
17.78	38.03	1.4	12.72	3.681	0.0564	1.067	0.212	0.855	1.08	41.25	42.70	50.0	43.22	3.79	0.01	2.57	0.9	42.56	5	Sand mixtures - silty sand to sandy silt	27.2	10.6	18.9	16.2	4131	2.41	4.02	1.61	0.67
17.85	38.31	1.4	12.72	3.654	0.0564	1.071	0.214	0.857	1.08	41.48	42.94	50.0	43.44	3.76	0.00	2.57	0.9	42.79	5	Sand mixtures - silty sand to sandy silt	27.4	10.7	19.0	16.3	4161	2.43	4.05	1.61	0.66

CD-12-02A LIQUEFACTION POTENTIAL & SHEAR STRENGTH CALCULATION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Location: **Midnight Mine South Storage Pond**

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

s_u/s_r < 1 (Strength Loss)

2011 CPT Data from ConeTec					CPT Data Interpretations																	Free Field Strength Estimates								
																						Robertson (2010a)								
																						Peak Strengths							Cyclic Softening Strengths	
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	OCR Robertson (2009)	OCR Kulhawy Mayne (1990)	Average OCR	$\sigma_{p'}$	s_u	$s_u/\sigma_{v'}$	$(s_u/\sigma_{v'})_{OC}/(s_u/\sigma_{v'})_{NC}$	$s_r/\sigma_{v'}$ FrQtn/100	s_r/s_u
(ft)	(tsf)	(tsf)	(ft)	(%)	(tcf)	(tsf)	(tsf)	(tsf)		TSF		%		%										(tsf)	(psf)					
17.91	40.35	1.58	13.05	3.916	0.0569	1.075	0.216	0.859	1.08	43.59	45.12	50.0	45.72	4.02	0.00	2.57	0.9	45.06	5	Sand mixtures - silty sand to sandy silt	29.2	11.3	20.2	17.4	4388	2.55	4.26	1.81	0.71
17.98	42.93	1.77	11.71	4.123	0.0573	1.079	0.218	0.861	1.08	46.25	47.87	50.0	48.61	4.23	0.00	2.57	0.9	47.91	5	Sand mixtures - silty sand to sandy silt	31.5	12.0	21.7	18.7	4674	2.71	4.52	2.03	0.75
18.04	44.96	1.76	11.71	3.915	0.0573	1.082	0.220	0.863	1.07	48.32	50.03	50.0	50.86	4.01	0.00	2.54	0.9	50.08	5	Sand mixtures - silty sand to sandy silt	33.3	12.5	22.9	19.8	4900	2.84	4.73	2.01	0.71
18.11	46.67	2.05	10.71	4.393	0.0579	1.087	0.222	0.865	1.07	50.05	51.81	50.0	52.71	4.50	0.00	2.57	0.9	51.97	5	Sand mixtures - silty sand to sandy silt	34.9	13.0	23.9	20.7	5089	2.94	4.90	2.34	0.79
18.18	54.2	2.09	11.71	3.856	0.0580	1.091	0.224	0.867	1.07	57.87	59.91	50.0	61.27	3.94	0.00	2.48	0.8	60.22	5	Sand mixtures - silty sand to sandy silt	41.9	15.1	28.5	24.7	5926	3.42	5.70	2.37	0.69
18.24	61.11	2.04	9.37	3.338	0.0579	1.094	0.226	0.869	1.06	65.01	67.30	50.0	69.10	3.40	0.00	2.40	0.8	67.71	5	Sand mixtures - silty sand to sandy silt	48.6	16.9	32.7	28.4	6693	3.85	6.42	2.30	0.60
18.31	69.19	2.04	8.37	2.948	0.0579	1.099	0.228	0.871	1.06	73.32	75.90	50.0	78.22	3.00	0.00	2.32	0.8	76.45	5	Sand mixtures - silty sand to sandy silt	56.5	19.1	37.8	32.9	7591	4.36	7.27	2.29	0.53
18.37	69.16	2	6.69	2.892	0.0578	1.102	0.230	0.872	1.06	73.21	75.79	50.0	78.03	2.94	0.00	2.32	0.8	76.28	5	Sand mixtures - silty sand to sandy silt	56.4	19.1	37.7	32.9	7588	4.35	7.25	2.24	0.52
18.44	65.08		3.68	0.000		1.106	0.232	0.874	1.06	68.89	71.31	20.0	73.17	0.00	0.00	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#####	7134	4.08	6.80	#NUM!	#NUM!
18.5	54.67		3.68	0.000		1.110	0.234	0.876	1.06	58.00	60.04	20.0	61.14	0.00	0.00	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#####	5977	3.41	5.69	#NUM!	#NUM!
18.57	50.9		2.68	0.000		1.114	0.236	0.878	1.06	53.99	55.89	20.0	56.70	0.00	0.00	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#####	5558	3.17	5.28	#NUM!	#NUM!
Averages:					0.0541																					0.45	0.75	1.29	0.66

CD-12-02A LIQUEFACTION POTENTIAL & SHEAR STRENGTH CALCULATION

FREE FIELD CONDITION

Data File: CD-12-02 (Input Data)

Location: Midnight Mine South Storage Pond

Constants		
Pa	0.97	tsf
Nkt	18	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

0.20

SHANSEP			
s_u		s_r	
s_u/σ_v'	0.60	s_r/σ_v'	0.50
m	0.65	m	0.65

2011 CPT Data from ConeTec					CPT Data Interpretations																Strength Estimates under Dam																					
																					10' Fill					30' Fill					65' Fill					Pond - 40' Fill with 80' Removed				
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Using Qtn for calculating Ic (iterations) Qtn	SBTn	Soil Type	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r
(ft)	(tsf)	(tsf)	(ft)	(%)	(tcf)	(tsf)	(tsf)	(tsf)		TSF		%		%							(tsf)			(tsf)	(tsf)	(tsf)			(tsf)	(tsf)	(tsf)			(tsf)	(tsf)	(tsf)			(tsf)	(tsf)
10.76	27.12	0.31	-3.35	1.143	0.0600	0.582	0.000	0.582	#####	#NUM!	#NUM!	20.0	45.57	1.17	0.00	2.27	0.7	40.04	5	Sand mixtures - silty sand to sandy silt	1.80	10.25	5.68	3.35	2.79	2.81	10.25	3.65	3.91	3.26	4.48	10.25	2.28	4.60	3.84	4.28	10.25	2.40	4.53	3.77
10.83	27.12	1.21	-3.35	4.462	0.0600	0.650	0.000	0.650	1.32	35.69	36.94	50.0	40.74	4.57	0.00	2.66	0.9	39.09	4	Silt mixtures - clayey silt to silty clay	1.81	11.11	6.16	3.53	2.94	2.81	11.11	3.95	4.12	3.43	4.49	11.11	2.48	4.85	4.05	4.28	11.11	2.60	4.77	3.98
10.89	61.8	1.21	-3.35	1.958	0.0600	0.653	0.000	0.653	1.24	76.57	79.27	50.0	93.58	1.98	0.00	2.17	0.7	83.53	5	Sand mixtures - silty sand to sandy silt	1.81	27.45	15.19	6.35	5.30	2.81	27.45	9.76	7.42	6.18	4.49	27.45	6.12	8.74	7.28	4.28	27.45	6.41	8.59	7.16
10.96	71.06	0.96	-2.34	1.351	0.0549	0.658	0.000	0.658	1.22	86.84	89.90	20.0	107.06	1.36	0.00	2.02	0.7	93.71	6	Sands - clean sand to silty sand	1.81	31.67	17.51	6.98	5.81	2.81	31.67	11.25	8.14	6.79	4.49	31.67	7.05	9.59	7.99	4.28	31.67	7.40	9.43	7.86
11.02	78.85	0.96	-4.02	1.218	0.0549	0.661	0.000	0.661	1.21	95.34	98.70	20.0	118.25	1.23	0.00	1.96	0.6	102.81	6	Sands - clean sand to silty sand	1.81	35.55	19.64	7.52	6.27	2.82	35.55	12.62	8.78	7.32	4.49	35.55	7.91	10.34	8.62	4.28	35.55	8.30	10.17	8.48
11.09	21.91	1.37	-4.02	6.253	0.0563	0.665	0.000	0.665	1.31	28.74	29.75	50.0	31.93	6.45	-0.01	2.83	1	31.48	4	Silt mixtures - clayey silt to silty clay	1.81	8.82	4.87	3.04	#N/A	2.82	8.82	3.13	3.55	#N/A	4.49	8.82	1.96	4.18	#N/A	4.29	8.82	2.06	4.11	#N/A
11.15	21.96	1.72	-0.67	7.832	0.0572	0.669	0.000	0.669	1.31	28.70	29.71	50.0	31.83	8.08	0.00	2.90	1	31.70	4	Silt mixtures - clayey silt to silty clay	1.81	8.94	4.93	3.07	#N/A	2.82	8.94	3.17	3.58	#N/A	4.50	8.94	1.99	4.22	#N/A	4.29	8.94	2.09	4.15	#N/A
11.22	21.09	1.7	-0.67	8.061	0.0571	0.673	0.000	0.673	1.30	27.50	28.47	50.0	30.33	8.33	0.00	2.92	1	30.31	4	Silt mixtures - clayey silt to silty clay	1.82	8.53	4.70	2.98	#N/A	2.82	8.53	3.02	3.48	#N/A	4.50	8.53	1.90	4.09	#N/A	4.29	8.53	1.99	4.02	#N/A
11.29	19.15	1.57	6.02	8.198	0.0568	0.677	0.009	0.668	1.32	25.23	26.12	50.0	27.64	8.50	0.01	2.96	1	27.64	3	Clays - silty clay to clay	1.82	7.60	4.18	2.76	#N/A	2.82	7.60	2.69	3.23	#N/A	4.50	7.60	1.69	3.80	#N/A	4.29	7.60	1.77	3.73	#N/A
11.35	15.73	1.11	9.03	7.057	0.0555	0.681	0.011	0.670	1.33	20.90	21.64	50.0	22.46	7.38	0.02	2.97	1	22.46	3	Clays - silty clay to clay	1.82	5.98	3.29	2.36	#N/A	2.83	5.98	2.11	2.76	#N/A	4.50	5.98	1.33	3.25	#N/A	4.29	5.98	1.39	3.19	#N/A
11.42	16.03	0.68	10.37	4.242	0.0536	0.685	0.013	0.672	1.32	21.23	21.98	50.0	22.83	4.43	0.02	2.82	1	22.50	4	Silt mixtures - clayey silt to silty clay	1.82	6.01	3.30	2.37	1.98	2.83	6.01	2.12	2.77	2.31	4.50	6.01	1.33	3.26	2.72	4.29	6.01	1.40	3.21	2.67
11.48	14.05	0.68	13.38	4.840	0.0536	0.689	0.015	0.674	1.33	18.70	19.36	50.0	19.83	5.09	0.03	2.90	1	19.77	4	Silt mixtures - clayey silt to silty clay	1.82	5.18	2.84	2.16	1.80	2.83	5.18	1.83	2.51	2.10	4.51	5.18	1.15	2.96	2.47	4.30	5.18	1.20	2.91	2.42
11.55	13.2	0.67	14.39	5.076	0.0535	0.693	0.017	0.676	1.33	17.58	18.20	50.0	18.51	5.36	0.03	2.94	1	18.51	4	Silt mixtures - clayey silt to silty clay	1.82	4.81	2.63	2.05	1.71	2.83	4.81	1.70	2.40	2.00	4.51	4.81	1.07	2.82	2.35	4.30	4.81	1.12	2.77	2.31
11.61	12.05	0.61	15.39	5.062	0.0531	0.697	0.019	0.678	1.34	16.09	16.65	50.0	16.76	5.37	0.04	2.97	1	16.76	3	Clays - silty clay to clay	1.83	4.29	2.35	1.91	1.59	2.83	4.29	1.51	2.23	1.86	4.51	4.51	1.00	2.71	2.25	4.30	4.30	1.00	2.58	2.15
11.68	9.79	0.47	19.41	4.801	0.0521	0.701	0.021	0.680	1.34	13.16	13.63	50.0	13.37	5.17	0.06	3.04	1	13.37	3	Clays - silty clay to clay	1.83	3.31	1.81	1.61	1.34	2.84	3.31	1.17	1.88	1.57	4.51	4.51	1.00	2.71	2.26	4.30	4.30	1.00	2.58	2.15
11.75	8.35	0.41	20.08	4.910	0.0516	0.705	0.023	0.682	1.35	11.28	11.67	50.0	11.22	5.36	0.08	3.11	1	11.22	3	Clays - silty clay to clay	1.83	2.70	1.48	1.42	1.18	2.84	2.84	1.00	1.70	1.42	4.51	4.51	1.00	2.71	2.26	4.30	4.30	1.00	2.58	2.15
11.81	8.97	0.38	22.42	4.236	0.0513	0.709	0.025	0.683	1.34	12.05	12.48	50.0	12.09	4.60	0.08	3.04	1	12.09	3	Clays - silty clay to clay	1.83	2.96	1.62	1.50	1.25	2.84	2.96	1.04	1.75	1.46	4.52	4.52	1.00	2.71	2.26	4.31	4.31	1.00	2.58	2.15
11.88	6.39	0.31	24.09	4.851	0.0505	0.713	0.027	0.685	1.36	8.68	8.99	50.0	8.28	5.46	0.13	3.22	1	8.28	3	Clays - silty clay to clay	1.83	1.91	1.04	1.13	0.94	2.84	2.84	1.00	1.70	1.42	4.52	4.52	1.00	2.71	2.26	4.31	4.31	1.00	2.58	2.15
11.94	4.98	0.24	27.10	4.819	0.0495	0.716	0.029	0.687	1.37	6.82	7.06	50.0	6.21	5.63	0.19	3.32	1	6.21	3	Clays - silty clay to clay	1.84	1.84	1.00	1.10	#N/A	2.84	2.84	1.00	1.71	#N/A	4.52	4.52	1.00	2.71	#N/A	4.31	4.31	1.00	2.59	#N/A
12.01	5.85	0.24	27.44	4.103	0.0495	0.721	0.032	0.689	1.36	7.94	8.22	50.0	7.44	4.68	0.16	3.21	1	7.44	3	Clays - silty clay to clay	1.84	1.84	1.00	1.10	0.92	2.85	2.85	1.00	1.71	1.42	4.52	4.52	1.00	2.71	2.26	4.31	4.31	1.00	2.59	2.16
12.07	4.71	0.18	28.11	3.822	0.0483	0.724	0.033	0.691	1.36	6.43	6.65	50.0	5.77	4.52	0.21	3.29	1	5.77	3	Clays - silty clay to clay	1.84	1.84	1.00	1.10	0.92	2.85	2.85	1.00	1.71	1.42	4.52	4.52	1.00	2.71	2.26	4.31	4.31	1.00	2.59	2.16
12.14	7.37	0.16	33.13	2.171	0.0479	0.728	0.036	0.693	1.34	9.87	10.22	50.0	9.59	2.41	0.15	2.96	1	9.59	3	Clays - silty clay to clay	1.84	2.29	1.24	1.27	1.06	2.85	2.85	1.00	1.71	1.42	4.53	4.53	1.00	2.72	2.26	4.31	4.31	1.00	2.59	2.16
12.2	5.93	0.23	33.13	3.879	0.0493	0.732	0.037	0.695	1.35	7.99	8.27	50.0	7.48	4.42	0.19	3.20	1	7.48	3	Clays - silty clay to clay	1.84	1.84	1.00	1.11	0.92	2.85	2.85	1.00	1.71	1.43	4.53	4.53	1.00	2.72	2.26	4.32	4.32	1.00	2.59	2.16
12.27	6.26	0.27	36.47	4.313	0.0499	0.736	0.040	0.697	1.34	8.39	8.69	50.0	7.93	4.89	0.20	3.20	1	7.93	3	Clays - silty clay to clay	1.84	1.85	1.00	1.11	0.92	2.85	2.85	1.00	1.71	1.43	4.53	4.53	1.00	2.72	2.26	4.32	4.32	1.00	2.59	2.16
12.34	9.72	0.22	36.14	2.263	0.0491	0.740	0.042	0.699	1.32	12.78	13.23	50.0	12.85	2.45	0.12	2.86	1	12.75	4	Silt mixtures - clayey silt to silty clay	1.85	3.22	1.74	1.59	1.32	2.85	3.22	1.13	1.85	1.54	4.53	4.53	1.00	2.72	2.27	4.32	4.32	1.00	2.59	2.16
12.4	8.92	0.22	19.07	2.466	0.0491	0.744	0.044	0.700	1.32	11.75	12.16	50.0	11.67	2.69	0.07	2.92	1	11.66	4	Silt mixtures - clayey silt to silty clay	1.85	2.91	1.57	1.49	1.24	2.86	2.91	1.02	1.73	1.44	4.53	4.53	1.00	2.72	2.27	4.32	4.32	1.00	2.59	2.16
12.47	7.7	0.21	14.05	2.727	0.0489	0.748	0.046	0.702	1.32	10.17	10.53	50.0	9.90	3.02	0.06	3.00	1	9.90	3	Clays - silty clay to clay	1.85	2.41	1.30	1.32	1.10	2.86	2.86	1.00	1.72	1.43	4.54	4.54	1.00	2.72	2.27	4.32	4.32	1.00	2.59	2.16
12.53	5.68	0.16	14.72	2.817	0.0479	0.752	0.048	0.704	1.33	7.57	7.84	50.0	7.00	3.25	0.08	3.14	1	7.00	3	Clays - silty clay to clay	1.85	1.85	1.00	1.11	0.93	2.86	2.86	1.00	1.72	1.43	4.54	4.54	1.00	2.72	2.27	4.32	4.32	1.00	2.59	2.16
12.6	4.6	0.16	20.08	3.478	0.0479	0.756	0.050	0.706	1.34	6.16	6.38	50.0	5.44	4.16	0.15	3.30	1	5.44	3	Clays - silty clay to clay	1.85	1.85	1.00	1.11	0.93	2.86	2.86	1.00	1.72	1.43	4.54	4.54	1.00	2.72	2.27	4.33	4.33	1.00	2.60	2.16
12.66	4.33	0.16	21.75	3.695	0.0479	0.760	0.052	0.708	1.34	5.80	6.00	50.0	5.04	4.48	0.18	3.34	1	5.04	3	Clays - silty clay to clay	1.85	1.85	1.00	1.11	0.93	2.86	2.86	1.00	1.72	1.43	4.54	4.54	1.00	2.72	2.27	4.33	4.33	1.00	2.60	2.16
12.73	8.72	0.19	25.43	2.179	0.0486	0.764	0.054	0.710	1.30	11.37	11.77	50.0	11.21	2.39	0.09	2.90	1	11.18	4	Silt mixtures - clayey silt to silty clay	1.86	2.81	1.51	1.46	1.21	2.87	2.87	1.00	1.72	1.43	4.54	4.54	1.00	2.73	2.27	4.33	4.33	1.00	2.60	2.17
12.8	5.24	0.21	25.43	4.008	0.0489	0.768	0.056	0.712	1.32	6.94	7.18	50.0	6.28	4.70	0.16	3.27	1	6.28	3	Clays - silty clay to clay	1.86	1.86	1.00	1.12	0.93	2.87	2.87	1.00	1.72	1.43	4.55	4.55	1.00	2.73	2.27	4.33	4.33	1.00	2.60	2.17
12.86	6.7	0.3	26.10	4.478	0.0503	0.772	0.058	0.714	1.31	8.78	9.09	50.0	8.31	5.06	0.13	3.19	1	8.31	3	Clays - silty clay to clay	1.86	2.00	1.07	1.17	0.97	2.87	2.87	1.00	1.72	1.43	4.55	4.55	1.00	2.73	2.27	4.33	4.33	1.00	2.60	2.17
12.93	6.16	0.32	28.44	5.195	0.0506	0.776	0.060	0.716	1.31	8.07	8.36	50.0	7.52	5.94	0.15	3.27	1	7.52	3	Clays - silty clay to clay	1.86	1.86	1.00	1.12	#N/A	2.87	2.87	1.00	1.72	#N/A	4.55	4.55	1.00	2.73	#N/A	4.34	4.34	1.00	2.60	#N/A
12.99	5.59	0.4	29.45	7.156	0.0515	0.779	0.062	0.717	1.31	7.34	7.59	50.0	6.71	8.31	0.18	3.40	1	6.71	3	Clays - silty clay to clay	1.86	1.86	1.00	1.12	#N/A	2.87	2.87	1.00	1.72	#N/A	4.55	4.55	1.00	2.73	#N/A	4.34	4.34	1.00	2.60	#N/A
13.06	8.83	0.4	11.71	4.530	0.0515	0.784	0.064	0.719	1.29	11.38	11.78	50.0	11.19	4.97	0.04	3.09	1	11.19	3	Clays - silty clay to clay	1.87	2.85	1.53	1.47	1.23	2.88	2.88	1.00	1.73	1.44	4.55	4.55	1.00	2.73	2.28	4.34	4.34	1.00	2.60	2.17
13.12	15.38	0.37	5.02	2.406	0.0512	0.787	0.066	0.721	1.26	19.37	20.05	50.0	20.24	2.54	0.01	2.71	0.9	19.78	4	Silt mixtures - clayey silt to silty clay	1.87	5.54	2.97	2.27	1.89	2.88	5.54	1.93	2.64	2.20	4.56	5.54	1.22	3.10	2.59	4.34	5.54	1.28	3.05	2.54
13.19	13.87	0.29	-0.33	2.091	0.0502	0.791	0.068	0.723	1.26	17.50	18.12	50.0	18.09	2.22	-0.01	2.72	0.9	17.69	4	Silt mixtures - clayey silt to silty clay	1.87	4.88	2.61	2.09	1.74	2.88	4.88	1.69	2.43	2.03	4.56	4.88	1.07	2.86	2.38	4.34	4.88	1.12	2.81	2.34
13.25	13.87	0.29	-0.33	2.091	0.0502	0.795	0.070	0.725	1.26	17.47	18.08	50.0	18.04	2.22	-0.01	2.72	0.9	17.65	4	Silt mixtures - clayey silt to silty clay	1.87	4.88	2.61	2.09	1.74	2.88	4.88	1.69	2.43	2.03	4.56	4.88	1.07	2.86	2.38	4.34	4.88	1.12	2.81	2.34
13.32	12.15	0.29	1.00	2.387	0.0502	0.799	0.072	0.727	1.26	15.35	15.89	50.0	15.62	2.55	0.00	2.80	1	15.42	4	Silt mixtures - clayey silt to silty clay	1.87	4.18	2.23	1.89	1.58	2.88	4.18	1.45	2.20	1.83	4.56	4.56	1.00	2.74	2.28	4.35	4.35	1.00	2.61	2.17
13.39	10.73	0.27	2.68	2.516	0.0499	0.803	0.075	0.729	1.27	13.59	14.06	50.0	13.62	2.72	0.00	2.86	1	13.54	4	Silt mixtures - clayey silt to silty clay	1.87	3.60	1.92	1.72	1.43	2.89	3.60	1.25	2.00	1.67	4.56	4.56	1.00	2.74	2.28	4.35	4.35	1.00	2.61	2.17
13.45	11.6	0.25	2.68	2.155	0.0496	0.807	0.076	0.731	1.26	14.62	15.13	50.0	14.77	2.32	0.00	2.80	1	14.58	4	Silt mixtures - clayey silt to silty clay	1.88	3.93	2.10	1.82	1.52	2.89	3.93	1.36	2.12	1.77	4.57	4.57	1.00	2.74	2.28	4.35	4.35	1.00	2.61	2.17
13.52	11.89	0.26	3.35	2.187	0.0498	0.811	0.079	0.733	1.26	14.94	15.46	50.0	15.12	2.35	0.00	2.79	1	14.92	4	Silt mixtures - clayey silt to silty clay	1.88	4.05	2.16	1.86	1.55	2.89	4.05	1.40	2.16	1.80	4.57	4.57	1.00	2.74	2.28	4.35	4.35	1.00	2.61	2.18
13.58	11.34	0.26	5.02	2.293	0.0498	0.815	0.080	0.734	1.26	14.24	14.75	50.0	14.33	2.47	0.01	2.82	1	14.19	4	Silt mixtures - clayey silt to silty clay	1.88	3.83	2.04	1.79	1.49	2.89	3.83	1.33	2.08	1.74	4.57	4.57	1.00	2.74	2.28	4.35	4.35	1.00	2.61	2.18
13.65	11.34	0.25	5.35	2.205	0.0496	0.819	0.083	0.736	1.25	14.21	14.71	50.0	14.29	2.38	0.01	2.82	1	14.14	4	Silt mixtures - clayey silt to silty clay	1.88	3.82	2.03	1.79	1.49	2.89	3.82	1.32	2.08	1.73	4.57	4.57	1.00	2.74	2.29	4.36	4.36	1.00	2.61	2.18
13.71	11.64	0.19	6.02	1.632	0.0486	0.823	0.085	0.738	1.25	14.55	15.06	50.0	14.66	1.76	0.01	2.74	0.9	14.39	4	Silt mixtures - clayey silt to silty clay	1.88	3.91	2.08	1.82	1.51	2.89	3.91	1.35	2.11	1.76	4.57	4.57	1.00	2.74	2.29	4.36	4.36	1.00	2.61	2.18
13.78	12.8	0.16	6.02	1.250	0.0479	0.827	0.087	0.740	1.24	15.91	16.47	20.0	16.18	1.34	0.01	2.64	0.9	15.73	4	Silt mixtures - clayey silt to silty clay	1.89	4.35	2.31	1.95	1.62	2.90	4.35	1.50	2.26	1.89	4.58	4.58	1.00	2.75	2.29	4.36	4.36	1.00	2.62	2.18
13.85	14.81	0.18	5.35	1.215	0.0483	0.831	0.089	0.742	1.23	18.27	18.92	20.0	18.84	1.29	0.01	2.58	0.9	18.21	5	Sand mixtures - silty sand to sandy silt	1.89	5.18	2.74	2.18	1.82	2.90	5.18	1.79	2.54	2.11	4.58	5.18	1.13	2.98	2.48	4.36	5.18	1.19	2.93	2.44
13.91	14.27	0.18	7.70	1.261	0.0483	0.835	0.091	0.744	1.23	17.60	18.22	20.0	18.06	1.34	0.01	2.60	0.9	17.51	4	Silt mixtures - clayey silt to silty clay	1.89	4.96	2.62	2.12	1.77	2.90	4.96	1.71	2.47	2.05	4.58	4.96	1.08	2.89	2.41	4.36	4.96	1.14	2.84	2.37
13.98	11.37	0.2	7.70	1.759	0.0488	0.839	0.093	0.746	1.24	14.10	14.60	50.0	14.12	1.90	0.01	2.77	0.9	13.91	4	Silt mixtures - clayey silt to silty clay	1.89	3.80	2.01	1.79	1.49	2.90	3.80	1.31	2.08	1.73	4.58	4.58	1.00	2.75	2.29	4.36	4.36	1.00	2.62	2.18
14.04	12.24	0.22	8.03	1.797	0.0491	0.842	0.095	0.748	1.23	15.12	15.65	50.0	15.25	1.93	0.01	2.74	0.9	14.99	4	Silt mixtures - clayey silt to silty clay	1.89	4.16	2.20	1.89	1.58	2.90	4.16	1.43	2.20	1.83	4.58	4.58	1.00	2.75	2.29	4.37	4.37	1.00	2.62	2.18
14.11	11.39	0.22	8.70	1.932	0.0491	0.847	0.097	0.750	1.24	14.07	14.57	50.0	14.07	2.09	0.02	2.79	1	13.90	4	Silt mixtures - clayey silt to silty clay	1.89	3.82	2.01	1.79	1.49	2.91	3.82	1.31	2.08	1.73	4.59	4.59	1.00	2.75	2.29	4.37	4.37	1.00	2.62	2.18
14.17	12.26	0.23	9.37	1.876	0.0493	0.850	0.099	0.751	1.23	15.08	15.61	50.0	15.19	2.02	0.02	2.76	0.9	14.95	4	Silt mixtures - clayey silt to silty clay	1.90	4.17	2.20	1.90	1.58	2.91	4.17	1.43	2.20	1.84	4.59	4.59	1.00	2.75	2.29	4.37	4.37	1.00	2.62	2.18
14.24	12.57	0.44	11.04	3.500	0.0518	0.854	0.101	0.753	1.23	15.42	15.96	50.0	15.55	3.76	0.02	2.90	1	15.53	4	Silt mixtures - clayey silt to silty clay	1.90	4.37	2.30	1.96	1.63	2.91	4.37	1.50	2.27	1.89	4.59	4.59	1.00	2.75	2.29	4.37	4.37	1.00	2.62	2.19
14.3	12.87	0.46	11.71	3.574	0.0520	0.858	0.103	0.755	1.22	15.74	16.30	50.0	15.91	3.83	0.02	2.90	1	15.88	4	Silt mixtures - clayey silt to silty clay	1.90	4.49	2.36	1.99	1.66	2.91	4.49	1.54	2.32	1.93	4.59	4.59	1.00	2.75	2.30	4.37	4.49	1.03	2.67	2.22

CD-12-02A LIQUEFACTION POTENTIAL & SHEAR STRENGTH CALCULATION

FREE FIELD CONDITION

Data File: CD-12-02 (Input Data)

Location: Midnight Mine South Storage Pond

Constants		
Pa	0.97	tsf
Nkt	18	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

0.20

SHANSEP			
s_u		s_r	
s_u/σ_v'	0.60	s_r/σ_v'	0.50
m	0.65	m	0.65

2011 CPT Data from ConeTec					CPT Data Interpretations																	Strength Estimates under Dam																				
												FC										10' Fill					30' Fill					65' Fill					Pond - 40' Fill with 80' Removed				
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N		Qt1	Fr	Bq	Ic	n	Using Qtn for calculating Ic (iterations) Qtn	SBTn	Soil Type	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r
(ft)	(tsf)	(tsf)	(ft)	(%)	(tcf)	(tsf)	(tsf)	(tsf)		TSF		%		%							(tsf)			(tsf)	(tsf)	(tsf)			(tsf)	(tsf)	(tsf)			(tsf)	(tsf)	(tsf)			(tsf)	(tsf)
14.37	17.22	0.47	12.38	2.729	0.0521	0.862	0.105	0.757	1.21	20.82	21.55	50.0	21.61	2.87	0.02	2.72	0.9	21.22	4	Silt mixtures - clayey silt to silty clay	1.90	6.32	3.32	2.49	2.08	2.91	6.32	2.17	2.89	2.41	4.59	6.32	1.38	3.39	2.83	4.38	6.32	1.44	3.33	2.78
14.44	21.68	0.61	22.75	2.814	0.0531	0.866	0.107	0.759	1.20	25.94	26.85	50.0	27.42	2.93	0.03	2.65	0.9	26.76	4	Silt mixtures - clayey silt to silty clay	1.90	8.31	4.37	2.98	2.48	2.92	8.31	2.85	3.46	2.88	4.59	8.31	1.81	4.05	3.38	4.38	8.31	1.90	3.98	3.32
14.5	36.15	0.94	24.09	2.600	0.0548	0.870	0.109	0.761	1.17	42.35	43.84	50.0	46.37	2.66	0.02	2.46	0.8	44.47	5	Sand mixtures - silty sand to sandy silt	1.91	15.15	7.95	4.40	3.67	2.92	15.15	5.19	5.11	4.26	4.60	15.15	3.30	5.99	4.99	4.38	15.15	3.46	5.89	4.91
14.57	44.81	1.09	23.09	2.432	0.0554	0.874	0.111	0.763	1.16	51.94	53.77	50.0	57.60	2.48	0.01	2.37	0.8	54.83	5	Sand mixtures - silty sand to sandy silt	1.91	19.45	10.20	5.18	4.31	2.92	19.45	6.66	6.01	5.01	4.60	19.45	4.23	7.05	5.87	4.38	19.45	4.44	6.93	5.77
14.63	49.12	1.42	20.75	2.891	0.0564	0.878	0.113	0.765	1.15	56.63	58.63	50.0	63.10	2.94	0.01	2.39	0.8	60.21	5	Sand mixtures - silty sand to sandy silt	1.91	21.78	11.41	5.57	4.65	2.92	21.78	7.46	6.47	5.39	4.60	21.78	4.74	7.58	6.32	4.38	21.78	4.97	7.46	6.21
14.7	59.68	1.6	11.04	2.681	0.0569	0.882	0.115	0.767	1.14	68.12	70.52	50.0	76.70	2.72	0.00	2.31	0.8	72.71	5	Sand mixtures - silty sand to sandy silt	1.91	27.31	14.29	6.46	5.38	2.92	27.31	9.34	7.50	6.25	4.60	27.31	5.93	8.79	7.32	4.38	27.31	6.23	8.64	7.20
14.76	58.99	1.92	2.34	3.255	0.0576	0.886	0.117	0.768	1.14	67.29	69.65	50.0	75.63	3.30	0.00	2.37	0.8	72.13	5	Sand mixtures - silty sand to sandy silt	1.91	27.11	14.18	6.43	5.36	2.92	27.11	9.27	7.46	6.22	4.60	27.11	5.89	8.75	7.29	4.39	27.11	6.18	8.60	7.17
14.83	58.09	2.02	0.00	3.477	0.0578	0.890	0.119	0.770	1.14	66.21	68.54	50.0	74.26	3.53	0.00	2.40	0.8	71.02	5	Sand mixtures - silty sand to sandy silt	1.91	26.69	13.94	6.37	5.31	2.93	26.69	9.12	7.39	6.16	4.61	26.69	5.79	8.66	7.22	4.39	26.69	6.08	8.51	7.09
14.9	56.05	2.16	-1.00	3.854	0.0581	0.894	0.122	0.772	1.14	63.89	66.14	50.0	71.42	3.92	0.00	2.44	0.8	68.59	5	Sand mixtures - silty sand to sandy silt	1.92	25.68	13.40	6.21	5.18	2.93	25.68	8.77	7.21	6.01	4.61	25.68	5.57	8.45	7.04	4.39	25.68	5.85	8.30	6.92
14.96	55.77	2.19	-1.00	3.927	0.0581	0.898	0.124	0.774	1.14	63.50	65.74	50.0	70.89	3.99	0.00	2.45	0.8	68.16	5	Sand mixtures - silty sand to sandy silt	1.92	25.55	13.32	6.19	5.16	2.93	25.55	8.72	7.18	5.99	4.61	25.55	5.54	8.42	7.02	4.39	25.55	5.82	8.28	6.90
15.03	57.5	2.1	-0.67	3.652	0.0580	0.902	0.126	0.776	1.14	65.29	67.59	50.0	72.93	3.71	0.00	2.42	0.8	69.98	5	Sand mixtures - silty sand to sandy silt	1.92	26.42	13.76	6.33	5.28	2.93	26.42	9.01	7.34	6.12	4.61	26.42	5.73	8.61	7.17	4.39	26.42	6.01	8.46	7.05
15.09	57.21	2.14	-1.34	3.741	0.0580	0.905	0.128	0.778	1.13	64.90	67.18	50.0	72.39	3.80	0.00	2.43	0.8	69.54	5	Sand mixtures - silty sand to sandy silt	1.92	26.29	13.68	6.31	5.26	2.93	26.29	8.96	7.32	6.10	4.61	26.29	5.70	8.58	7.15	4.39	26.29	5.98	8.43	7.03
15.16	58.36	2.07	-2.01	3.547	0.0579	0.910	0.130	0.780	1.13	66.05	68.38	50.0	73.67	3.60	0.00	2.40	0.8	70.68	5	Sand mixtures - silty sand to sandy silt	1.92	26.87	13.97	6.41	5.34	2.94	26.87	9.15	7.43	6.19	4.62	26.87	5.82	8.70	7.25	4.40	26.87	6.11	8.56	7.13
15.22	50.84	1.99	-2.34	3.914	0.0578	0.913	0.132	0.782	1.14	57.79	59.82	50.0	63.88	3.99	0.00	2.48	0.8	61.68	5	Sand mixtures - silty sand to sandy silt	1.93	22.91	11.90	5.78	4.81	2.94	22.91	7.80	6.70	5.58	4.62	22.91	4.96	7.85	6.54	4.40	22.91	5.21	7.72	6.43
15.29	45.64	1.89	-2.34	4.141	0.0576	0.917	0.134	0.784	1.14	52.02	53.85	50.0	57.08	4.23	0.00	2.53	0.9	55.35	5	Sand mixtures - silty sand to sandy silt	1.93	20.21	10.49	5.33	4.44	2.94	20.21	6.87	6.18	5.15	4.62	20.21	4.37	7.23	6.03	4.40	20.21	4.59	7.11	5.93
15.35	42.16	1.83	-2.68	4.341	0.0574	0.921	0.136	0.785	1.14	48.13	49.82	50.0	52.52	4.44	-0.01	2.57	0.9	51.11	5	Sand mixtures - silty sand to sandy silt	1.93	18.43	9.56	5.02	4.18	2.94	18.43	6.26	5.82	4.85	4.62	18.43	3.99	6.81	5.68	4.40	18.43	4.19	6.70	5.58
15.42	40.71	1.9	-2.68	4.667	0.0576	0.925	0.138	0.787	1.14	46.46	48.09	50.0	50.53	4.78	-0.01	2.60	0.9	49.32	4	Silt mixtures - clayey silt to silty clay	1.93	17.72	9.18	4.89	4.08	2.94	17.72	6.02	5.67	4.73	4.62	17.72	3.83	6.64	5.54	4.40	17.72	4.02	6.53	5.44
15.49	31.47	1.94	-2.34	6.165	0.0577	0.929	0.140	0.789	1.15	36.18	37.45	50.0	38.69	6.35	-0.01	2.77	0.9	38.26	4	Silt mixtures - clayey silt to silty clay	1.93	13.17	6.81	4.04	#N/A	2.95	13.17	4.47	4.68	#N/A	4.63	13.17	2.85	5.48	#N/A	4.41	13.17	2.99	5.39	#N/A
15.55	38.12	1.84	-2.01	4.827	0.0575	0.933	0.142	0.791	1.14	43.47	45.00	50.0	47.01	4.95	-0.01	2.63	0.9	46.02	4	Silt mixtures - clayey silt to silty clay	1.93	16.40	8.48	4.66	3.88	2.95	16.40	5.57	5.40	4.50	4.63	16.40	3.54	6.32	5.27	4.41	16.40	3.72	6.21	5.18
15.62	37.26	1.73	-2.01	4.643	0.0572	0.937	0.144	0.793	1.14	42.46	43.95	50.0	45.80	4.76	-0.01	2.63	0.9	44.84	4	Silt mixtures - clayey silt to silty clay	1.94	15.95	8.24	4.57	3.81	2.95	15.95	5.41	5.30	4.42	4.63	15.95	3.44	6.21	5.17	4.41	15.95	3.62	6.10	5.08
15.68	33.79	1.57	-1.67	4.646	0.0568	0.941	0.146	0.795	1.14	38.58	39.93	50.0	41.33	4.78	-0.01	2.66	0.9	40.57	4	Silt mixtures - clayey silt to silty clay	1.94	14.20	7.33	4.24	3.54	2.95	14.20	4.81	4.92	4.10	4.63	14.20	3.07	5.76	4.80	4.41	14.20	3.22	5.66	4.72
15.75	34.08	1.54	-1.67	4.519	0.0568	0.945	0.148	0.797	1.14	38.83	40.20	50.0	41.59	4.65	-0.01	2.65	0.9	40.80	4	Silt mixtures - clayey silt to silty clay	1.94	14.33	7.39	4.27	3.56	2.95	14.33	4.85	4.95	4.12	4.63	14.33	3.09	5.79	4.83	4.41	14.33	3.25	5.69	4.75
15.81	34.67	1.54	-1.34	4.442	0.0568	0.949	0.150	0.799	1.14	39.43	40.81	50.0	42.23	4.57	-0.01	2.64	0.9	41.41	4	Silt mixtures - clayey silt to silty clay	1.94	14.62	7.53	4.33	3.61	2.95	14.62	4.95	5.01	4.18	4.64	14.62	3.15	5.87	4.89	4.41	14.62	3.31	5.77	4.81
15.88	36.98	0.62	-1.00	1.677	0.0532	0.953	0.152	0.801	1.13	41.90	43.37	50.0	45.00	1.72	-0.01	2.34	0.8	43.21	5	Sand mixtures - silty sand to sandy silt	1.94	15.41	7.93	4.48	3.73	2.96	15.41	5.21	5.19	4.32	4.64	15.41	3.32	6.07	5.06	4.42	15.41	3.49	5.97	4.98
15.94	38.13	1.06	-1.00	2.780	0.0553	0.956	0.154	0.802	1.13	43.10	44.61	50.0	46.34	2.85	0.00	2.47	0.8	44.92	5	Sand mixtures - silty sand to sandy silt	1.94	16.17	8.31	4.62	3.85	2.96	16.17	5.46	5.35	4.46	4.64	16.17	3.48	6.27	5.22	4.42	16.17	3.66	6.16	5.13
16.01	41.32	1.26	-1.00	3.049	0.0560	0.961	0.156	0.804	1.13	46.51	48.14	50.0	50.18	3.12	0.00	2.47	0.8	48.68	5	Sand mixtures - silty sand to sandy silt	1.95	17.82	9.15	4.93	4.11	2.96	17.82	6.02	5.70	4.75	4.64	17.82	3.84	6.68	5.56	4.42	17.82	4.03	6.56	5.47
16.08	39.94	1.33	4.35	3.330	0.0562	0.965	0.158	0.806	1.13	44.93	46.51	50.0	48.34	3.41	0.00	2.51	0.8	47.03	5	Sand mixtures - silty sand to sandy silt	1.95	17.15	8.80	4.81	4.01	2.96	17.15	5.79	5.57	4.64	4.64	17.15	3.69	6.51	5.43	4.42	17.15	3.88	6.40	5.34
16.14	39.66	1.33	5.02	3.354	0.0562	0.968	0.160	0.808	1.12	44.57	46.14	50.0	47.88	3.44	0.00	2.52	0.9	46.62	5	Sand mixtures - silty sand to sandy silt	1.95	17.01	8.72	4.78	3.99	2.96	17.01	5.74	5.54	4.61	4.65	17.01	3.66	6.48	5.40	4.42	17.01	3.85	6.37	5.31
16.21	38.81	1.38	6.02	3.556	0.0563	0.973	0.163	0.810	1.12	43.57	45.11	50.0	46.71	3.65	0.00	2.54	0.9	45.57	5	Sand mixtures - silty sand to sandy silt	1.95	16.60	8.50	4.71	3.92	2.97	16.60	5.60	5.45	4.54	4.65	16.60	3.57	6.38	5.32	4.43	16.60	3.75	6.27	5.23
16.27	38.53	1.37	6.69	3.556	0.0563	0.976	0.164	0.812	1.12	43.21	44.73	50.0	46.26	3.65	0.00	2.54	0.9	45.16	5	Sand mixtures - silty sand to sandy silt	1.95	16.46	8.42	4.68	3.90	2.97	16.46	5.55	5.42	4.52	4.65	16.46	3.54	6.34	5.29	4.43	16.46	3.72	6.24	5.20
16.34	37.08	1.34	6.69	3.614	0.0562	0.980	0.167	0.814	1.12	41.56	43.03	50.0	44.36	3.71	0.00	2.56	0.9	43.37	5	Sand mixtures - silty sand to sandy silt	1.96	15.73	8.04	4.55	3.79	2.97	15.73	5.30	5.27	4.39	4.65	15.73	3.38	6.16	5.13	4.43	15.73	3.55	6.06	5.05
16.4	37.67	1.34	7.36	3.557	0.0562	0.984	0.168	0.816	1.12	42.15	43.63	50.0	44.98	3.65	0.00	2.55	0.9	43.97	5	Sand mixtures - silty sand to sandy silt	1.96	16.02	8.18	4.61	3.84	2.97	16.02	5.39	5.33	4.44	4.65	16.02	3.44	6.24	5.20	4.43	16.02	3.62	6.13	5.11
16.47	38.24	1.29	7.36	3.373	0.0561	0.988	0.171	0.818	1.12	42.70	44.20	50.0	45.57	3.46	0.00	2.53	0.9	44.49	5	Sand mixtures - silty sand to sandy silt	1.96	16.29	8.31	4.66	3.88	2.97	16.29	5.48	5.39	4.49	4.66	16.29	3.50	6.30	5.25	4.43	16.29	3.67	6.20	5.16
16.54	38.25	1.2	7.70	3.137	0.0558	0.992	0.173	0.820	1.11	42.64	44.14	50.0	45.46	3.22	0.00	2.51	0.8	44.35	5	Sand mixtures - silty sand to sandy silt	1.96	16.27	8.29	4.66	3.88	2.98	16.27	5.47	5.39	4.49	4.66	16.27	3.49	6.30	5.25	4.43	16.27	3.67	6.19	5.16
16.6	39.41	1.21	8.03	3.070	0.0558	0.996	0.175	0.821	1.11	43.84	45.38	50.0	46.77	3.15	0.00	2.50	0.8	45.60	5	Sand mixtures - silty sand to sandy silt	1.96	16.85	8.58	4.76	3.97	2.98	16.85	5.66	5.51	4.59	4.66	16.85	3.62	6.45	5.37	4.44	16.85	3.80	6.34	5.28
16.67	37.1	1.16	8.37	3.127	0.0556	1.000	0.177	0.823	1.11	41.27	42.73	50.0	43.85	3.21	0.00	2.52	0.9	42.83	5	Sand mixtures - silty sand to sandy silt	1.97	15.69	7.98	4.55	3.79	2.98	15.69	5.26	5.26	4.39	4.66	15.69	3.37	6.15	5.13	4.44	15.69	3.53	6.05	5.04
16.73	37.98	1.23	8.70	3.239	0.0559	1.004	0.179	0.825	1.11	42.17	43.65	50.0	44.82	3.33	0.00	2.53	0.9	43.80	5	Sand mixtures - silty sand to sandy silt	1.97	16.14	8.20	4.64	3.86	2.98	16.14	5.41	5.36	4.47	4.66	16.14	3.46	6.27	5.23	4.44	16.14	3.63	6.16	5.14
16.8	37.98	1.23	9.03	3.239	0.0559	1.008	0.181	0.827	1.11	42.10	43.58	50.0	44.70	3.33	0.00	2.53	0.9	43.71	5	Sand mixtures - silty sand to sandy silt	1.97	16.14	8.20	4.64	3.86	2.98	16.14	5.41	5.36	4.47	4.66	16.14	3.46	6.27	5.23	4.44	16.14	3.63	6.16	5.14
16.86	38.27	1.3	9.37	3.397	0.0561	1.012	0.183	0.829	1.11	42.36	43.85	50.0	44.96	3.49	0.00	2.54	0.9	44.00	5	Sand mixtures - silty sand to sandy silt	1.97	16.30	8.27	4.67	3.89	2.99	16.30	5.46	5.40	4.50	4.67	16.30	3.49	6.31	5.26	4.44	16.30	3.67	6.21	5.17
16.93	39.15	1.55	9.70	3.959	0.0568	1.016	0.185	0.831	1.10	43.24	44.76	50.0	45.90	4.06	0.00	2.58	0.9	45.05	5	Sand mixtures - silty sand to sandy silt	1.97	16.80	8.52	4.76	3.97	2.99	16.80	5.62	5.51	4.59	4.67	16.80	3.60	6.44	5.37	4.45	16.80	3.78	6.33	5.27
16.99	40.31	1.55	10.04	3.845	0.0568	1.019	0.187	0.833	1.10	44.43	45.99	50.0	47.20	3.94	0.00	2.56	0.9	46.28	5	Sand mixtures - silty sand to sandy silt	1.97	17.38	8.80	4.87	4.06	2.99	17.38	5.81	5.63	4.69	4.67	17.38	3.72	6.58	5.49	4.45	17.38	3.91	6.47	5.39
17.06	46.09	1.73	10.04	3.754	0.0572	1.024	0.189	0.835	1.10	50.54	52.32	50.0	54.00	3.84	0.00	2.51	0.9	52.83	5	Sand mixtures - silty sand to sandy silt	1.98	20.37	10.31	5.40	4.50	2.99	20.37	6.81	6.24	5.20	4.67	20.37	4.36	7.30	6.08	4.45	20.37	4.58	7.18	5.98
17.13	48.98	1.81	9.70	3.695	0.0574	1.028	0.191	0.837	1.09	53.54	55.43	50.0	57.32	3.77	0.00	2.49	0.8	56.03	5	Sand mixtures - silty sand to sandy silt	1.98	21.89	11.06	5.66	4.72	2.99	21.89	7.31	6.55	5.45	4.67	21.89	4.68	7.65	6.38	4.45	21.89	4.92	7.52	6.27
17.19	49.55	1.78	9.70	3.592	0.0573	1.031	0.193	0.838	1.09	54.08	55.99	50.0	57.88	3.67	0.00	2.48	0.8	56.56	5	Sand mixtures - silty sand to sandy silt	1.98	22.18	11.20	5.71	4.76	2.99	22.18	7.41	6.60	5.50	4.68	22.18	4.74	7.72	6.43	4.45	22.18	4.98	7.59	6.32
17.26	46.65	1.79	9.37	3.837	0.0573	1.036	0.195	0.840	1.09	50.92	52.72	50.0	54.28	3.92	0.00	2.52	0.9	53.18	5	Sand mixtures - silty sand to sandy silt	1.98	20.67	10.43	5.46	4.55	3.00	20.67	6.90	6.31	5.26	4.68	20.67	4.42	7.37	6.14	4.45	20.67	4.64	7.25	6.04
17.32	42.61	1.71	9.37	4.013	0.0572	1.039	0.197	0.842	1.09	46.56	48.20	50.0	49.37	4.11	0.00	2.56	0.9	48.49	5	Sand mixtures - silty sand to sandy silt	1.98	18.57	9.36	5.09	4.24	3.00	18.57	6.19	5.89	4.90	4.68	18.57	3.97	6.88	5.73	4.46	18.57	4.17	6.76	5.63
17.39	40.59	1.4	9.37	3.449	0.0564	1.043	0.199	0.844	1.09	44.34	45.90	50.0	46.85	3.54	0.00	2.53	0.9	45.96	5	Sand mixtures - silty sand to sandy silt	1.99	17.47	8.80	4.90	4.08	3.00	17.47	5.82	5.66	4.72	4.68	17.47	3.73	6.61	5.51	4.46	17.47	3.92	6.50	5.42
17.45	34.23	1.4	9.70	4.090	0.0564	1.047	0.201	0.846	1.10	37.49	38.81	50.0	39.23	4.22	0.00	2.64	0.9	38.71	4	Silt mixtures - clayey silt to silty clay	1.99	14.30	7.20	4.30	3.58	3.00	14.30	4.76	4.97	4.14	4.68	14.30	3.05	5.81	4.84	4.46	14.30	3.21	5.71	4.76
17.52	34.82	1.19	10.71	3.418	0.0557	1.051	0.203	0.848	1.09	38.06	39.40	50.0	39.83	3.52	0.00	2.58	0.9	39.19	5	Sand mixtures - silty sand to sandy silt	1.99	14.55	7.31	4.35	3.62	3.00	14.55	4.84	5.02	4.19	4.69	14.55	3.10	5.87	4.89	4.46	14.55	3.26	5.77	4.81
17.59	36.28	1.11	11.71	3.060	0.0555	1.055	0.206	0.850	1.09	39.56	40.95	50.0	41.45	3.15	0.00	2.53	0.9	40.71	5	Sand mixtures - silty sand to sandy silt	1.99	15.25	7.66	4.49	3.74	3.01	15.25	5.07	5.18	4.32	4.69	15.25	3.25	6.05	5.05	4.46	15.25	3.42	5.95	4.96
17.65	35.41	1.11	11.71	3.135	0.0555	1.059	0.207	0.852	1.09	38.58	39.93	50.0	40.34	3.23	0.00	2.55	0.9	39.66	5	Sand mixtures - silty sand to sandy silt	1.99	14.81	7.43	4.40	3.67	3.01	14.81	4.93	5.09	4.24	4.69	14.81	3.16	5.94	4.95	4.47	14.81	3.32	5.84	4.87
17.72	36.58	1.2	12.38	3.280	0.0558	1.063	0.210	0.854	1.09	39.76	41.16	50.0	41.61	3.38	0.00	2.55	0.9	40.93	5	Sand mixtures - silty sand to sandy silt	1.99	15.41	7.73	4.52	3.77	3.01	15.41	5.12	5.22	4.35	4.69	15.41	3.28	6.10	5.08	4.47	15.41	3.45	5.99	5.00
17.78	38.03	1.4	12.72	3.681	0.0564	1.067	0.212	0.855	1.08	41.25	42.70	50.0	43.22	3.79	0.01	2.57	0.9	42.56	5	Sand mixtures - silty sand to sandy silt	2.00	16.17	8.10	4.67	3.89	3.01	16.17	5.37	5.39	4.49	4.69	16.17	3.45	6.29	5.24	4.47	16.17	3.62	6.19	5.16
17.85	38.31	1.4	12.72	3.654	0.0564	1.071	0.214	0.857	1.08	41.48	42.94	50.0	43.44	3.76	0.00	2.57	0.9	42.79	5	Sand mixtures - silty sand to sandy silt	2.00	16.31	8.16	4.69	3.91	3.01	16.31	5.41	5.42	4.52	4.70	16.31	3.47	6.33	5.27	4.47	16.31	3.65	6.22	5.18

CD-12-02A LIQUEFACTION POTENTIAL & SHEAR STRENGTH CALCULATION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Location: **Midnight Mine South Storage Pond**

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

0.20

SHANSEP			
s_u		s_r	
s_u/σ_v'	**0.60**	s_r/σ_v'	**0.50**
m	**0.65**	**m**	**0.65**

2011 CPT Data from ConeTec					CPT Data Interpretations																	Strength Estimates under Dam																				
																						10' Fill					30' Fill					65' Fill					Pond - 40' Fill with 80' Removed				
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Using Qtn for calculating Ic (iterations) Qtn	SBTn	Soil Type	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r
(ft)	(tsf)	(tsf)	(ft)	(%)	(tcf)	(tsf)	(tsf)	(tsf)		TSF		%		%							(tsf)			(tsf)	(tsf)	(tsf)			(tsf)	(tsf)	(tsf)			(tsf)	(tsf)	(tsf)			(tsf)	(tsf)
17.91	40.35	1.58	13.05	3.916	0.0569	1.075	0.216	0.859	1.08	43.59	45.12	50.0	45.72	4.02	0.00	2.57	0.9	45.06	5	Sand mixtures - silty sand to sandy silt	2.00	17.37	8.69	4.89	4.08	3.02	17.37	5.76	5.65	4.71	4.70	17.37	3.70	6.60	5.50	4.47	17.37	3.88	6.48	5.40
17.98	42.93	1.77	11.71	4.123	0.0573	1.079	0.218	0.861	1.08	46.25	47.87	50.0	48.61	4.23	0.00	2.57	0.9	47.91	5	Sand mixtures - silty sand to sandy silt	2.00	18.72	9.35	5.14	4.28	3.02	18.72	6.20	5.93	4.94	4.70	18.72	3.98	6.92	5.77	4.47	18.72	4.18	6.81	5.67
18.04	44.96	1.76	11.71	3.915	0.0573	1.082	0.220	0.863	1.07	48.32	50.03	50.0	50.86	4.01	0.00	2.54	0.9	50.08	5	Sand mixtures - silty sand to sandy silt	2.00	19.77	9.86	5.32	4.44	3.02	19.77	6.55	6.14	5.12	4.70	19.77	4.20	7.17	5.98	4.48	19.77	4.42	7.05	5.88
18.11	46.67	2.05	10.71	4.393	0.0579	1.087	0.222	0.865	1.07	50.05	51.81	50.0	52.71	4.50	0.00	2.57	0.9	51.97	5	Sand mixtures - silty sand to sandy silt	2.01	20.70	10.32	5.49	4.57	3.02	20.70	6.85	6.33	5.28	4.70	20.70	4.40	7.39	6.16	4.48	20.70	4.62	7.27	6.06
18.18	54.2	2.09	11.71	3.856	0.0580	1.091	0.224	0.867	1.07	57.87	59.91	50.0	61.27	3.94	0.00	2.48	0.8	60.22	5	Sand mixtures - silty sand to sandy silt	2.01	24.70	12.30	6.16	5.13	3.02	24.70	8.17	7.10	5.92	4.71	24.70	5.25	8.29	6.91	4.48	24.70	5.51	8.15	6.79
18.24	61.11	2.04	9.37	3.338	0.0579	1.094	0.226	0.869	1.06	65.01	67.30	50.0	69.10	3.40	0.00	2.40	0.8	67.71	5	Sand mixtures - silty sand to sandy silt	2.01	28.44	14.15	6.75	5.62	3.02	28.44	9.40	7.79	6.49	4.71	28.44	6.04	9.09	7.58	4.48	28.44	6.35	8.94	7.45
18.31	69.19	2.04	8.37	2.948	0.0579	1.099	0.228	0.871	1.06	73.32	75.90	50.0	78.22	3.00	0.00	2.32	0.8	76.45	5	Sand mixtures - silty sand to sandy silt	2.01	32.92	16.37	7.42	6.19	3.03	32.92	10.87	8.57	7.14	4.71	32.92	6.99	10.00	8.33	4.48	32.92	7.34	9.83	8.19
18.37	69.16	2	6.69	2.892	0.0578	1.102	0.230	0.872	1.06	73.21	75.79	50.0	78.03	2.94	0.00	2.32	0.8	76.28	5	Sand mixtures - silty sand to sandy silt	2.01	32.89	16.34	7.42	6.19	3.03	32.89	10.86	8.56	7.14	4.71	32.89	6.98	10.00	8.33	4.49	32.89	7.33	9.83	8.19
18.44	65.08		3.68	0.000		1.106	0.232	0.874	1.06	68.89	71.31	20.0	73.17	0.00	0.00	#####	###	#NUM!	####	#NUM!	2.01	#NUM!	#NUM!	#NUM!	#NUM!	3.03	#NUM!	#NUM!	#NUM!	#NUM!	4.71	#NUM!	#NUM!	#NUM!	#NUM!	4.49	#NUM!	#NUM!	#NUM!	#NUM!
18.5	54.67		3.68	0.000		1.110	0.234	0.876	1.06	58.00	60.04	20.0	61.14	0.00	0.00	#####	###	#NUM!	####	#NUM!	2.02	#NUM!	#NUM!	#NUM!	#NUM!	3.03	#NUM!	#NUM!	#NUM!	#NUM!	4.71	#NUM!	#NUM!	#NUM!	#NUM!	4.49	#NUM!	#NUM!	#NUM!	#NUM!
18.57	50.9		2.68	0.000		1.114	0.236	0.878	1.06	53.99	55.89	20.0	56.70	0.00	0.00	#####	###	#NUM!	####	#NUM!	2.02	#NUM!	#NUM!	#NUM!	#NUM!	3.03	#NUM!	#NUM!	#NUM!	#NUM!	4.72	#NUM!	#NUM!	#NUM!	#NUM!	4.49	#NUM!	#NUM!	#NUM!	#NUM!
Averages:					0.0541																			#N/A					#N/A					#N/A					#N/A	

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION
FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)
Locatiomight Mine South Storage Pond

FoS<1
FoS≥1

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

Max. Horiz. Acceleration, Amax/g:	0.13
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.05

2011 CPT Data from ConeTec / CPT Data Interpretations

Depth (ft)	qt (tsf)	fs (tsf)	Pw (u2) (ft)	fs/qt (%)	Unit Weight (tcf)	Total Stress (tsf)	Equil Pore Pressure, u0 (tsf)	Effective Stress (tsf)	CN	qc1 TSF	qc1N	FC %	Qt1	Fr %	Bq	Ic	n	Qtn	SBTn	Soil Type
8.7927	0.0	0.00	0.00	######	0.0450	0.396	0.118	0.277	1.70	0.00	0.00	####	45.57	1.17	0.30	#####	1	-1.43	####	#NUM!
8.8583	0.0	0.00	0.00	######	0.0450	0.399	0.120	0.278	1.70	0.00	0.00	####	-1.43	0.00	0.30	#####	###	#NUM!	####	#NUM!
8.9239	0.0	0.00	0.00	######	0.0450	0.402	0.122	0.279	1.70	0.00	0.00	####	-1.44	0.00	0.30	#####	###	#NUM!	####	#NUM!
8.9895	0.0	0.00	0.00	######	0.0450	0.405	0.124	0.280	1.70	0.00	0.00	####	-1.44	0.00	0.31	#####	###	#NUM!	####	#NUM!
9.0551	0.0	0.00	0.00	######	0.0450	0.407	0.127	0.281	1.70	0.00	0.00	####	-1.45	0.00	0.31	#####	###	#NUM!	####	#NUM!
9.1207	0.0	0.00	0.00	######	0.0450	0.410	0.129	0.282	1.70	0.00	0.00	####	-1.46	0.00	0.31	#####	###	#NUM!	####	#NUM!
9.1864	0.0	0.00	0.00	######	0.0450	0.413	0.131	0.283	1.70	0.00	0.00	####	-1.46	0.00	0.32	#####	###	#NUM!	####	#NUM!
9.252	0.0	0.00	0.00	######	0.0450	0.416	0.133	0.284	1.70	0.00	0.00	####	-1.47	0.00	0.32	#####	###	#NUM!	####	#NUM!
9.3176	0.0	0.00	0.00	######	0.0450	0.419	0.135	0.285	1.70	0.00	0.00	####	-1.47	0.00	0.32	#####	###	#NUM!	####	#NUM!
9.3832	0.0	0.00	0.00	######	0.0450	0.422	0.137	0.285	1.70	0.00	0.00	####	-1.48	0.00	0.32	#####	###	#NUM!	####	#NUM!
9.4488	0.0	0.01	0.00	######	0.0450	0.425	0.139	0.286	1.70	0.00	0.00	####	-1.48	-2.45	0.33	#####	###	#NUM!	####	#NUM!
9.5144	0.0	0.02	0.00	######	0.0450	0.428	0.141	0.287	1.70	0.00	0.00	####	-1.49	-4.86	0.33	#####	###	#NUM!	####	#NUM!
9.5801	0.0	0.02	0.00	######	0.0450	0.431	0.143	0.288	1.70	0.00	0.00	####	-1.50	-4.82	0.33	#####	###	#NUM!	####	#NUM!
9.6457	11.0	0.03	-2.01	0.285	0.0450	0.434	0.145	0.289	1.70	18.63	19.28	20.0	36.39	0.30	-0.02	2.18	0.7	25.22	5	Sand mixtures - silty sand to sandy silt
9.7113	11.5	0.03	-1.67	0.270	0.0450	0.437	0.147	0.290	1.70	19.62	20.31	20.0	38.29	0.28	-0.02	2.16	0.7	26.27	5	Sand mixtures - silty sand to sandy silt
9.7769	12.1	0.04	-1.67	0.343	0.0450	0.440	0.149	0.291	1.70	20.60	21.32	20.0	40.13	0.36	-0.02	2.17	0.7	27.71	5	Sand mixtures - silty sand to sandy silt
9.8425	12.7	0.05	-0.33	0.409	0.0450	0.443	0.151	0.292	1.70	21.62	22.38	20.0	42.05	0.42	-0.01	2.18	0.7	29.17	5	Sand mixtures - silty sand to sandy silt
9.9081	13.3	0.05	0.00	0.391	0.0450	0.446	0.153	0.293	1.70	22.60	23.39	20.0	43.88	0.40	-0.01	2.16	0.7	30.18	5	Sand mixtures - silty sand to sandy silt
9.9738	14.2	0.05	0.67	0.367	0.0450	0.449	0.155	0.294	1.70	24.10	24.94	20.0	46.74	0.38	-0.01	2.12	0.7	31.72	5	Sand mixtures - silty sand to sandy silt
10.039	15.9	0.11	1.67	0.719	0.0450	0.452	0.157	0.295	1.70	27.05	28.00	20.0	52.49	0.74	-0.01	2.19	0.7	36.80	5	Sand mixtures - silty sand to sandy silt
10.105	16.8	0.15	2.68	0.867	0.0450	0.455	0.159	0.295	1.70	28.56	29.57	20.0	55.32	0.89	0.00	2.21	0.7	39.15	5	Sand mixtures - silty sand to sandy silt
10.171	18.0	0.19	3.35	1.042	0.0450	0.458	0.161	0.296	1.70	30.54	31.61	20.0	59.07	1.07	0.00	2.23	0.7	42.15	5	Sand mixtures - silty sand to sandy silt
10.236	18.0	0.19	3.68	1.042	0.0450	0.461	0.163	0.297	1.70	30.54	31.62	20.0	58.89	1.07	0.00	2.23	0.7	42.07	5	Sand mixtures - silty sand to sandy silt
10.302	18.6	0.28	4.35	1.513	0.0450	0.464	0.165	0.298	1.70	31.55	32.66	50.0	60.69	1.55	0.00	2.30	0.7	44.83	5	Sand mixtures - silty sand to sandy silt
10.367	20.9	0.31	5.02	1.495	0.0450	0.467	0.167	0.299	1.70	35.49	36.74	20.0	68.24	1.53	0.00	2.26	0.7	49.59	5	Sand mixtures - silty sand to sandy silt
10.433	20.9	0.35	5.35	1.693	0.0450	0.469	0.170	0.300	1.70	35.50	36.75	50.0	68.04	1.73	0.00	2.29	0.7	50.16	5	Sand mixtures - silty sand to sandy silt
10.499	20.5	0.36	0.00	1.774	0.0450	0.472	0.172	0.301	1.70	34.88	36.11	50.0	66.63	1.82	-0.01	2.31	0.7	49.54	5	Sand mixtures - silty sand to sandy silt
10.564	22.0	0.51	-0.67	2.321	0.0450	0.475	0.174	0.302	1.70	37.33	38.64	50.0	71.18	2.37	-0.01	2.36	0.8	54.09	5	Sand mixtures - silty sand to sandy silt
10.63	24.2	0.57	-3.68	2.361	0.0450	0.478	0.176	0.303	1.70	41.18	42.63	50.0	78.45	2.41	-0.01	2.33	0.8	59.05	5	Sand mixtures - silty sand to sandy silt
10.696	26.0	0.68	-3.35	2.603	0.0450	0.481	0.178	0.304	1.70	44.14	45.70	50.0	83.94	2.65	-0.01	2.34	0.8	63.43	5	Sand mixtures - silty sand to sandy silt
10.761	27.1	0.76	-6.36	2.803	0.0450	0.484	0.180	0.305	1.70	46.04	47.66	50.0	87.35	2.85	-0.01	2.35	0.8	66.31	5	Sand mixtures - silty sand to sandy silt
10.827	28.4	0.87	-13.38	3.072	0.0450	0.487	0.182	0.305	1.70	48.34	50.04	50.0	91.51	3.13	-0.02	2.36	0.8	69.90	5	Sand mixtures - silty sand to sandy silt
10.892	26.6	0.94	-18.74	3.514	0.0450	0.490	0.184	0.306	1.70	45.29	46.88	50.0	85.36	3.58	-0.03	2.42	0.8	66.88	5	Sand mixtures - silty sand to sandy silt
10.958	25.5	1.03	-19.07	4.043	0.0450	0.493	0.186	0.307	1.70	43.30	44.82	50.0	81.30	4.12	-0.03	2.47	0.8	65.21	5	Sand mixtures - silty sand to sandy silt
11.024	25.2	1.02	-19.41	4.047	0.0450	0.496	0.188	0.308	1.70	42.81	44.32	50.0	80.12	4.13	-0.03	2.48	0.8	64.43	5	Sand mixtures - silty sand to sandy silt
11.089	27.5	1.05	-19.07	3.820	0.0450	0.499	0.190	0.309	1.70	46.75	48.39	50.0	87.36	3.89	-0.03	2.44	0.8	69.10	5	Sand mixtures - silty sand to sandy silt
11.155	33.6	1.04	-19.07	3.099	0.0450	0.502	0.192	0.310	1.70	57.05	59.06	50.0	106.66	3.15	-0.02	2.32	0.8	80.40	5	Sand mixtures - silty sand to sandy silt
11.22	36.1	1.16	-20.75	3.222	0.0450	0.505	0.194	0.311	1.70	61.45	63.62	50.0	114.67	3.27	-0.02	2.32	0.7	86.20	5	Sand mixtures - silty sand to sandy silt
11.286	34.1	1.23	-22.42	3.599	0.0450	0.508	0.196	0.312	1.70	57.97	60.01	50.0	107.75	3.65	-0.03	2.36	0.8	82.76	5	Sand mixtures - silty sand to sandy silt
11.352	28.6	1.26	-24.09	4.402	0.0450	0.511	0.198	0.313	1.70	48.60	50.31	50.0	89.80	4.48	-0.03	2.47	0.8	72.23	5	Sand mixtures - silty sand to sandy silt
11.417	26.6	1.34	-24.43	5.050	0.0450	0.514	0.200	0.314	1.70	45.16	46.75	50.0	83.08	5.15	-0.04	2.53	0.8	68.62	5	Sand mixtures - silty sand to sandy silt
11.483	24.8	1.35	-24.09	5.445	0.0450	0.517	0.202	0.314	1.70	42.21	43.70	50.0	77.32	5.56	-0.04	2.57	0.8	65.02	5	Sand mixtures - silty sand to sandy silt
11.549	24.5	1.28	-24.09	5.213	0.0450	0.520	0.204	0.315	1.70	41.72	43.19	50.0	76.17	5.33	-0.04	2.56	0.8	63.83	5	Sand mixtures - silty sand to sandy silt
11.614	23.7	1.08	-20.75	4.560	0.0450	0.523	0.206	0.316	1.70	40.33	41.74	50.0	73.35	4.66	-0.04	2.53	0.8	60.74	5	Sand mixtures - silty sand to sandy silt
11.68	24.3	1.04	-20.41	4.280	0.0450	0.526	0.208	0.317	1.70	41.31	42.76	50.0	74.95	4.37	-0.04	2.51	0.8	61.47	5	Sand mixtures - silty sand to sandy silt
11.745	24.3	1.02	-20.41	4.195	0.0450	0.529	0.210	0.318	1.70	41.31	42.76	50.0	74.72	4.29	-0.04	2.50	0.8	61.19	5	Sand mixtures - silty sand to sandy silt
11.811	21.4	0.95	-18.74	4.417	0.0450	0.531	0.213	0.319	1.70	36.43	37.71	50.0	65.51	4.53	-0.04	2.55	0.8	54.81	5	Sand mixtures - silty sand to sandy silt
11.877	15.6	0.81	-19.74	5.189	0.0450	0.534	0.215	0.320	1.70	26.58	27.51	50.0	47.20	5.37	-0.06	2.69	0.9	41.81	4	Silt mixtures - clayey silt to silty clay
11.942	13.0	0.67	-18.74	5.102	0.0450	0.537	0.217	0.321	1.70	22.18	22.96	50.0	38.99	5.32	-0.06	2.74	0.9	35.26	4	Silt mixtures - clayey silt to silty clay
12.008	11.0	0.57	-18.74	5.187	0.0450	0.540	0.219	0.322	1.70	18.75	19.41	50.0	32.60	5.45	-0.08	2.79	0.9	30.19	4	Silt mixtures - clayey silt to silty clay
12.073	9.6	0.41	-18.74	4.233	0.0450	0.543	0.221	0.323	1.70	16.29	16.86	50.0	28.02	4.49	-0.09	2.78	0.9	25.85	4	Silt mixtures - clayey silt to silty clay
12.139	9.3	0.32	-19.07	3.472	0.0450	0.546	0.223	0.324	1.70	15.79	16.34	50.0	27.02	3.69	-0.09	2.74	0.9	24.53	4	Silt mixtures - clayey silt to silty clay
12.205	10.2	0.25	-18.74	2.458	0.0450	0.549	0.225	0.324	1.70	17.26	17.87	50.0	29.61	2.60	-0.08	2.63	0.9	25.66	4	Silt mixtures - clayey silt to silty clay
12.27	9.3	0.19	-18.74	2.015	0.0450	0.552	0.227	0.325	1.70	15.80	16.35	50.0	26.86	2.14	-0.09	2.62	0.9	23.15	4	Silt mixtures - clayey silt to silty clay
12.336	9.6	0.14	-18.74	1.411	0.0450	0.555	0.229	0.326	1.70	16.29	16.86	20.0	27.67	1.50	-0.09	2.53	0.8	23.01	5	Sand mixtures - silty sand to sandy silt

Liquefaction Triggering (Sands) / Cyclic Softening (Clays)

Depth (ft)	Idriss & Boulanger (2008) Cyclic Stress Ratio r_d	C_s	K_σ	K_α	CSR M=7.5, s'v=1atm	Idriss & Boulanger (2008) Cyclic Resistance Ratio Δqc_{1n}	qc_{1n-cs}	CRR M=7.5, s'v=1atm	FoS	Youd et al. (2001) Cyclic Stress Ratio r_d	D_r	f	K_σ	K_α	CSR M=7.5, s'v=1atm	Youd et al. (2001) Cyclic Resistance Ratio Ic	Kc	qc_{1n-cs}	CRR M=7.5, s'v=1atm	FoS	Avg FoS	Liquefiable? 1=Yes 2=No	Cyclic Softening (Clays) Idriss & Boulanger (2008) Cyclic Resistance Ratio K_a	CSRM	CRRM	FoS
8.7927	0.97	0.03	1.03	1.0	0.088	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.20	1.0	0.069	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.901	#####	#####
8.8583	0.97	0.03	1.03	1.0	0.088	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.19	1.0	0.069	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.905	#####	#####
8.9239	0.97	0.03	1.03	1.0	0.089	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.19	1.0	0.070	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.908	#####	#####
8.9895	0.97	0.03	1.03	1.0	0.089	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.19	1.0	0.070	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.912	#####	#####
9.0551	0.97	0.03	1.03	1.0	0.089	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.19	1.0	0.071	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.915	#####	#####
9.1207	0.97	0.03	1.03	1.0	0.090	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.19	1.0	0.071	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.918	#####	#####
9.1864	0.97	0.03	1.03	1.0	0.090	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.19	1.0	0.071	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.922	#####	#####
9.252	0.97	0.03	1.03	1.0	0.090	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.18	1.0	0.072	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.925	#####	#####
9.3176	0.97	0.03	1.03	1.0	0.091	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.18	1.0	0.072	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.928	#####	#####
9.3832	0.97	0.03	1.03	1.0	0.091	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.18	1.0	0.072	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.932	#####	#####
9.4488	0.97	0.03	1.03	1.0	0.091	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.18	1.0	0.073	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.935	#####	#####
9.5144	0.97	0.03	1.03	1.0	0.092	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.18	1.0	0.073	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.938	#####	#####
9.5801	0.97	0.03	1.03	1.0	0.092	#####	#DIV/0!	#DIV/0!	#####	0.98	0.00	0.80	1.18	1.0	0.073	#NUM!	#NUM!	#NUM!	#NUM!	#####	#DIV/0!	#NUM!	1	0.941	#####	#####
9.6457	0.97	0.05	1.06	1.0	0.090	29.6	48.86	0.076	0.85	0.98	0.25	0.80	1.17	1.0	0.074	2.181	1.62	31.26	0.076	1.03	0.94	1	1	0.944	1.509	1.60
9.7113	0.97	0.05	1.06	1.0	0.090	29.9	50.18	0.078	0.87	0.98	0.26	0.80	1.17	1.0	0.074	2.157	1.57	31.84	0.077	1.03	0.95	1	1	0.948	1.517	1.60
9.7769	0.97	0.05	1.06	1.0	0.090	30.1	51.47	0.079	0.88	0.98	0.27	0.80	1.17	1.0	0.075	2.169	1.59	34.00	0.078	1.05	0.96	1	1	0.951	1.511	1.59
9.8425	0.97	0.05	1.06	1.0	0.090	30.4	52.82	0.080	0.89	0.98	0.27	0.80	1.17	1.0	0.075	2.177	1.61	36.06	0.080	1.07	0.98	1	1	0.954	1.506	1.58
9.9081	0.97	0.05	1.07	1.0	0.090	30.7	54.12	0.082	0.90	0.98	0.28	0.80	1.17	1.0	0.075	2.155	1.56	36.59	0.080	1.07	0.99	1	1	0.957	1.515	1.58
9.9738	0.97	0.06	1.07	1.0	0.091	31.2	56.10	0.084	0.92	0.98	0.29	0.80	1.17	1.0	0.076	2.124	1.50	37.43	0.081	1.07	1.00	1	1	0.960	1.525	1.59
10.039	0.97	0.06	1.07	1.0	0.091	32.0	60.02	0.088	0.97	0.98	0.31	0.80	1.16	1.0	0.076	2.194	1.65	46.24	0.089	1.17	1.07	0	1	0.963	1.475	1.53
10.105	0.97	0.06	1.07	1.0	0.091	32.5	62.02	0.090	0.99	0.98	0.31	0.80	1.16	1.0	0.076	2.212	1.70	50.16	0.092	1.20	1.10	0	1	0.966	1.457	1.51
10.171	0.97	0.06	1.07	1.0	0.091	33.0	64.64	0.093	1.02	0.98	0.32	0.80	1.16	1.0	0.077	2.228	1.74	54.97	0.095	1.24	1.13	0	1	0.969	1.435	1.48
10.236	0.96	0.06	1.07	1.0	0.091	33.0	64.65	0.093	1.02	0.98	0.32	0.80	1.16	1.0	0.077	2.229	1.74	55.04	0.096	1.24	1.13	0	1	0.972	1.441	1.48
10.302	0.96	0.06	1.07	1.0	0.092	41.8	74.44	0.105	1.15	0.98	0.33	0.80	1.16	1.0	0.077	2.302	1.95	63.81	0.104	1.35	1.25	0	1	0.975	1.374	1.41
10.367	0.96	0.06	1.07	1.0	0.092	34.5	71.20	0.101	1.10	0.98	0.35	0.80	1.16	1.0	0.078	2.263	1.84	67.44	0.109	1.40	1.25	0	1	0.978	1.383	1.41
10.433	0.96	0.06	1.07	1.0	0.092	43.2	79.96	0.113	1.22	0.98	0.35	0.80	1.16	1.0	0.078	2.293	1.93	70.83	0.113	1.45	1.34	0	1	0.981	1.358	1.38
10.499	0.96	0.06	1.07	1.0	0.092	43.0	79.10	0.111	1.21	0.98	0.35	0.80	1.15	1.0	0.078	2.311	1.98	71.61	0.114	1.46	1.33	0	1	0.984	1.351	1.37
10.564	0.96	0.06	1.07	1.0	0.092	43.9	82.52	0.116	1.26	0.98	0.36	0.80	1.15	1.0	0.079	2.358	2.15	83.07	0.133	1.69	1.47	0	1	0.986	1.273	1.29
10.63	0.96	0.07	1.08	1.0	0.092	45.3	87.91	0.124	1.34	0.98	0.38	0.80	1.15	1.0	0.079	2.335	2.07	88.06	0.144	1.81	1.58	0	1	0.989	1.273	1.29
10.696	0.96	0.07	1.08	1.0	0.093	46.4	92.05	0.130	1.40	0.98	0.39	0.80	1.15	1.0	0.079	2.342	2.09	95.48	0.161	2.03	1.72	0	1	0.992	1.242	1.25
10.761	0.96	0.07	1.08	1.0	0.093	47.0	94.70	0.134	1.45	0.97	0.40	0.80	1.15	1.0	0.080	2.350	2.12	101.10	0.176	2.21	1.83	0	1	0.995	1.218	1.22
10.827	0.96	0.07	1.08	1.0	0.093	47.9	97.92	0.139	1.50	0.97	0.41	0.80	1.15	1.0	0.080	2.363	2.17	108.45	0.199	2.49	1.99	0	1	0.998	1.183	1.19
10.892	0.96	0.07	1.08	1.0	0.093	46.8	93.65	0.132	1.42	0.97	0.40	0.80	1.15	1.0	0.080	2.419	2.39	112.12	0.211	2.62	2.02	0	1	1.000	1.123	1.12
10.958	0.96	0.07	1.08	1.0	0.094	46.0	90.87	0.128	1.37	0.97	0.39	0.80	1.14	1.0	0.081	2.472	2.63	117.84	0.232	2.88	2.12	0	1	1.003	1.049	1.05
11.024	0.96	0.07	1.08	1.0	0.094	45.9	90.19	0.127	1.35	0.97	0.38	0.80	1.14	1.0	0.081	2.476	2.65	117.37	0.230	2.84	2.10	0	1	1.006	1.055	1.05
11.089	0.96	0.07	1.08	1.0	0.094	47.3	95.69	0.136	1.44	0.97	0.40	0.80	1.14	1.0	0.081	2.436	2.47	119.33	0.238	2.93	2.18	0	1	1.008	1.096	1.09
11.155	0.96	0.08	1.09	1.0	0.094	51.0	110.11	0.160	1.71	0.97	0.44	0.78	1.16	1.0	0.081	2.324	2.03	119.70	0.240	2.97	2.34	0	1	1.011	1.211	1.20
11.22	0.96	0.08	1.09	1.0	0.094	52.6	116.26	0.172	1.84	0.97	0.46	0.77	1.16	1.0	0.080	2.316	2.00	127.23	0.272	3.38	2.61	0	1	1.014	1.199	1.18
11.286	0.96	0.08	1.09	1.0	0.094	51.4	111.39	0.162	1.73	0.97	0.45	0.78	1.15	1.0	0.081	2.364	2.17	130.24	0.285	3.52	2.62	0	1	1.016	1.149	1.13
11.352	0.96	0.07	1.08	1.0	0.095	48.0	98.28	0.140	1.47	0.97	0.41	0.80	1.14	1.0	0.082	2.470	2.62	131.76	0.293	3.55	2.51	0	1	1.019	1.036	1.02
11.417	0.96	0.07	1.08	1.0	0.095	46.7	93.47	0.132	1.38	0.97	0.39	0.80	1.13	1.0	0.083	2.530	2.92	136.70	0.318	3.83	2.61	0	1	1.021	0.946	0.93
11.483	0.96	0.07	1.08	1.0	0.096	45.7	89.35	0.126	1.31	0.97	0.38	0.80	1.13	1.0	0.083	2.570	3.15	137.67	0.323	3.87	2.59	0	1	1.024	0.895	0.87
11.549	0.96	0.07	1.07	1.0	0.096	45.5	88.66	0.125	1.30	0.97	0.38	0.80	1.13	1.0	0.084	2.561	3.10	133.80	0.303	3.62	2.46	0	1	1.027	0.936	0.91
11.614	0.96	0.07	1.07	1.0	0.097	45.0	86.71	0.122	1.26	0.97	0.37	0.80	1.13	1.0	0.084	2.532	2.94	122.55	0.251	2.99	2.13	0	1	1.029	1.039	1.01
11.68	0.96	0.07	1.07	1.0	0.097	45.3	88.08	0.124	1.28	0.97	0.38	0.80	1.13	1.0	0.084	2.508	2.81	120.12	0.241	2.86	2.07	0	1	1.032	1.087	1.05
11.745	0.96	0.07	1.07	1.0	0.097	45.3	88.08	0.124	1.28	0.97	0.38	0.80	1.13	1.0	0.085	2.503	2.78	119.00	0.237	2.80	2.04	0	1	1.034	1.106	1.07
11.811	0.96	0.06	1.07	1.0	0.098	43.6	81.26	0.114	1.17	0.97	0.35	0.80	1.13	1.0	0.085	2.553	3.05	114.99	0.221	2.61	1.89	0	1	1.036	1.080	1.04
11.877	0.96	0.06	1.06	1.0	0.098	40.0	67.48	0.097	0.98	0.97	0.30	0.80	1.13	1.0	0.085	2.687	3.90	107.40	0.195	2.29	1.64	0	1	1.039	0.974	0.94
11.942	0.96	0.05	1.06	1.0	0.099	38.4	61.33	0.089	0.90	0.97	0.28	0.80	1.12	1.0	0.086	2.736	4.26	97.87	0.167	1.95	1.43	0	1	1.041	0.994	0.95
12.008	0.96	0.05	1.06	1.0	0.099	37.1	56.54	0.084	0.85	0.97	0.25	0.80	1.12	1.0	0.086	2.791	4.71	91.37	0.151	1.76	1.30	0	1	1.044	0.988	0.95
12.073	0.96	0.05	1.06	1.0	0.100	36.2	53.10	0.081	0.81	0.97	0.24	0.80	1.12	1.0	0.086	2.782	4.63	78.09	0.124	1.44	1.12	0	1	1.046	1.133	1.08
12.139	0.96	0.05	1.05	1.0	0.100	36.1	52.40	0.080	0.80	0.97	0.23	0.80	1.12	1.0	0.086	2.742	4.32	70.53	0.113	1.30	1.05	0	1	1.049	1.249	1.19
12.205	0.96	0.05	1.06	1.0	0.100	36.6	54.46	0.082	0.82	0.97	0.24	0.80	1.12	1.0	0.087	2.630	3.52	62.87	0.103	1.19	1.00	0	1	1.051	1.400	1.33
12.27	0.95	0.05	1.05	1.0	0.101	36.1	52.41	0.080	0.79	0.97	0.23	0.80	1.12	1.0	0.087	2.615	3.42	55.92	0.096	1.11	0.95	1	1	1.053	1.469	1.39
12.336	0.95	0.05	1.05	1.0	0.101	28.9	45.76	0.074	0.73	0.97	0.24	0.80	1.12	1.0	0.087	2.528	2.91	49.15	0.091	1.04	0.89	1	1	1.056	1.561	1.48

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: CD-12-02 (Input Data)

Locatiomight Mine South Storage Pond

FoS<1 FoS≥1 | FoS<1 FoS≥1 | FoS<1 FoS≥1

Constants		
Pa	0.97	tsf
Nkt	18	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

Max. Horiz. Acceleration, Amax/g:	0.13
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.05

2011 CPT Data from ConeTec / CPT Data Interpretations

Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type
													Using Qtn for calculating Ic (iterations)							
12.402	9.0	0.16	-18.74	1.733	0.0450	0.558	0.231	0.327	1.70	15.30	15.84	50.0	25.81	1.85	-0.10	2.59	0.9	22.07	5	Sand mixtures - silty sand to sandy silt
12.467	10.7	0.10	-18.40	0.968	0.0450	0.561	0.233	0.328	1.70	18.26	18.90	20.0	31.03	1.02	-0.08	2.41	0.8	24.65	5	Sand mixtures - silty sand to sandy silt
12.533	11.6	0.14	-18.74	1.166	0.0450	0.564	0.235	0.329	1.70	19.72	20.41	20.0	33.55	1.23	-0.07	2.43	0.8	26.79	5	Sand mixtures - silty sand to sandy silt
12.598	12.8	0.21	-18.40	1.629	0.0450	0.567	0.237	0.330	1.70	21.71	22.47	50.0	36.99	1.70	-0.07	2.47	0.8	30.04	5	Sand mixtures - silty sand to sandy silt
12.664	15.6	0.25	-19.41	1.596	0.0450	0.570	0.239	0.331	1.70	26.58	27.52	50.0	45.55	1.66	-0.06	2.39	0.8	35.97	5	Sand mixtures - silty sand to sandy silt
12.73	11.3	0.23	-23.76	2.033	0.0450	0.573	0.241	0.332	1.70	19.13	19.80	50.0	32.20	2.14	-0.09	2.56	0.8	27.20	5	Sand mixtures - silty sand to sandy silt
12.795	10.4	0.25	-24.43	2.407	0.0450	0.576	0.243	0.333	1.70	17.63	18.25	50.0	29.45	2.55	-0.10	2.63	0.9	25.58	4	Silt mixtures - clayey silt to silty clay
12.861	9.5	0.24	-24.76	2.517	0.0450	0.579	0.245	0.333	1.70	16.16	16.72	50.0	26.76	2.68	-0.11	2.67	0.9	23.64	4	Silt mixtures - clayey silt to silty clay
12.927	8.6	0.20	-24.43	2.286	0.0450	0.582	0.247	0.334	1.70	14.70	15.21	50.0	24.11	2.45	-0.13	2.68	0.9	21.40	4	Silt mixtures - clayey silt to silty clay
12.992	7.5	0.15	-24.76	1.948	0.0450	0.585	0.249	0.335	1.70	12.71	13.16	50.0	20.55	2.11	-0.15	2.69	0.9	18.36	4	Silt mixtures - clayey silt to silty clay
13.058	8.4	-0.03	-24.43	-0.373	0.0450	0.588	0.251	0.336	1.70	14.20	14.70	20.0	23.10	-0.40	-0.13	#####	###	#NUM!	####	#NUM!
13.123	7.8	0.05	-24.76	0.670	0.0450	0.591	0.253	0.337	1.70	13.20	13.67	20.0	21.29	0.72	-0.14	2.48	0.8	17.45	5	Sand mixtures - silty sand to sandy silt
13.189	7.5	0.06	-24.43	0.834	0.0450	0.594	0.255	0.338	1.70	12.72	13.16	20.0	20.37	0.91	-0.15	2.53	0.8	17.06	5	Sand mixtures - silty sand to sandy silt
13.255	7.8	0.08	-20.75	1.064	0.0450	0.596	0.258	0.339	1.70	13.29	13.76	20.0	21.31	1.15	-0.13	2.56	0.8	18.06	5	Sand mixtures - silty sand to sandy silt
13.32	8.4	0.09	-20.75	1.114	0.0450	0.599	0.260	0.340	1.70	14.28	14.79	20.0	22.96	1.20	-0.12	2.54	0.8	19.34	5	Sand mixtures - silty sand to sandy silt
13.386	8.4	0.09	-20.75	1.114	0.0450	0.602	0.262	0.341	1.70	14.28	14.79	20.0	22.89	1.20	-0.12	2.54	0.8	19.30	5	Sand mixtures - silty sand to sandy silt
13.451	9.0	0.09	-20.41	1.043	0.0450	0.605	0.264	0.342	1.70	15.26	15.80	20.0	24.51	1.12	-0.11	2.51	0.8	20.38	5	Sand mixtures - silty sand to sandy silt
13.517	9.3	0.10	-20.41	1.122	0.0450	0.608	0.266	0.343	1.70	15.76	16.31	20.0	25.29	1.20	-0.10	2.51	0.8	21.06	5	Sand mixtures - silty sand to sandy silt
13.583	9.0	0.07	-20.08	0.810	0.0450	0.611	0.268	0.343	1.70	15.27	15.81	20.0	24.37	0.87	-0.11	2.46	0.8	19.93	5	Sand mixtures - silty sand to sandy silt
13.648	8.1	0.07	-20.08	0.897	0.0450	0.614	0.270	0.344	1.70	13.80	14.29	20.0	21.80	0.97	-0.12	2.52	0.8	18.23	5	Sand mixtures - silty sand to sandy silt
13.714	8.4	0.07	-20.08	0.866	0.0450	0.617	0.272	0.345	1.70	14.30	14.80	20.0	22.57	0.93	-0.12	2.50	0.8	18.75	5	Sand mixtures - silty sand to sandy silt
13.78	9.6	0.07	-20.08	0.761	0.0450	0.620	0.274	0.346	1.70	16.26	16.83	20.0	25.84	0.81	-0.10	2.43	0.8	20.90	5	Sand mixtures - silty sand to sandy silt
13.845	7.8	0.06	-20.08	0.797	0.0450	0.623	0.276	0.347	1.70	13.31	13.78	20.0	20.76	0.87	-0.13	2.51	0.8	17.36	5	Sand mixtures - silty sand to sandy silt
13.911	7.0	0.05	-19.74	0.746	0.0450	0.626	0.278	0.348	1.70	11.85	12.26	20.0	18.23	0.82	-0.14	2.55	0.8	15.46	5	Sand mixtures - silty sand to sandy silt
13.976	6.7	0.03	-19.74	0.467	0.0450	0.629	0.280	0.349	1.70	11.35	11.75	20.0	17.34	0.52	-0.15	2.49	0.8	14.40	5	Sand mixtures - silty sand to sandy silt
14.042	7.8	0.03	-19.41	0.398	0.0450	0.632	0.282	0.350	1.70	13.32	13.79	20.0	20.60	0.43	-0.12	2.41	0.8	16.57	5	Sand mixtures - silty sand to sandy silt
14.108	8.4	0.04	-19.41	0.494	0.0450	0.635	0.284	0.351	1.70	14.31	14.82	20.0	22.20	0.53	-0.11	2.41	0.8	17.89	5	Sand mixtures - silty sand to sandy silt
14.173	9.0	0.04	-19.41	0.463	0.0450	0.638	0.286	0.352	1.70	15.29	15.82	20.0	23.76	0.50	-0.11	2.38	0.8	18.91	5	Sand mixtures - silty sand to sandy silt
14.239	9.9	0.04	-19.07	0.422	0.0450	0.641	0.288	0.352	1.70	16.78	17.37	20.0	26.18	0.45	-0.10	2.33	0.8	20.46	5	Sand mixtures - silty sand to sandy silt
14.304	9.6	0.03	-19.07	0.326	0.0450	0.644	0.290	0.353	1.70	16.28	16.86	20.0	25.28	0.35	-0.10	2.31	0.7	19.61	5	Sand mixtures - silty sand to sandy silt
14.37	9.9	0.03	-18.74	0.316	0.0450	0.647	0.292	0.354	1.70	16.79	17.38	20.0	26.04	0.34	-0.10	2.29	0.7	20.10	5	Sand mixtures - silty sand to sandy silt
14.436	10.4	0.04	-18.74	0.398	0.0450	0.650	0.294	0.355	1.70	17.76	18.38	20.0	27.58	0.42	-0.09	2.30	0.7	21.38	5	Sand mixtures - silty sand to sandy silt
14.501	10.2	0.04	-18.40	0.409	0.0450	0.653	0.296	0.356	1.70	17.27	17.88	20.0	26.69	0.44	-0.09	2.32	0.8	20.83	5	Sand mixtures - silty sand to sandy silt
14.567	10.2	0.05	-18.07	0.512	0.0450	0.656	0.298	0.357	1.70	17.28	17.89	20.0	26.63	0.55	-0.09	2.35	0.8	21.06	5	Sand mixtures - silty sand to sandy silt
14.633	10.7	0.07	-18.07	0.677	0.0450	0.658	0.301	0.358	1.70	18.27	18.91	20.0	28.18	0.72	-0.09	2.38	0.8	22.52	5	Sand mixtures - silty sand to sandy silt
14.698	11.9	0.08	-18.07	0.699	0.0450	0.661	0.303	0.359	1.70	20.23	20.94	20.0	31.32	0.74	-0.08	2.34	0.8	24.74	5	Sand mixtures - silty sand to sandy silt
14.764	12.2	0.09	-17.73	0.767	0.0450	0.664	0.305	0.360	1.70	20.73	21.46	20.0	32.05	0.81	-0.07	2.35	0.8	25.42	5	Sand mixtures - silty sand to sandy silt
14.829	11.9	0.09	-17.73	0.786	0.0450	0.667	0.307	0.361	1.70	20.24	20.95	20.0	31.16	0.83	-0.08	2.37	0.8	24.86	5	Sand mixtures - silty sand to sandy silt
14.895	11.6	0.09	-17.07	0.805	0.0450	0.670	0.309	0.362	1.70	19.76	20.45	20.0	30.29	0.85	-0.08	2.38	0.8	24.31	5	Sand mixtures - silty sand to sandy silt
14.961	12.8	0.11	-16.73	0.894	0.0450	0.673	0.311	0.362	1.70	21.74	22.51	20.0	33.43	0.94	-0.07	2.37	0.8	26.70	5	Sand mixtures - silty sand to sandy silt
15.026	13.9	0.11	-16.73	0.820	0.0450	0.676	0.313	0.363	1.70	23.71	24.54	20.0	36.52	0.86	-0.06	2.32	0.8	28.68	5	Sand mixtures - silty sand to sandy silt
15.092	13.9	0.12	-16.40	0.895	0.0450	0.679	0.315	0.364	1.70	23.71	24.55	20.0	36.43	0.94	-0.06	2.34	0.8	28.82	5	Sand mixtures - silty sand to sandy silt
15.157	12.8	0.11	-16.40	0.894	0.0450	0.682	0.317	0.365	1.70	21.75	22.52	20.0	33.17	0.94	-0.07	2.37	0.8	26.56	5	Sand mixtures - silty sand to sandy silt
15.223	12.5	0.10	-16.06	0.831	0.0450	0.685	0.319	0.366	1.70	21.26	22.01	20.0	32.30	0.88	-0.07	2.36	0.8	25.83	5	Sand mixtures - silty sand to sandy silt
15.289	12.5	0.10	-15.73	0.831	0.0450	0.688	0.321	0.367	1.70	21.27	22.02	20.0	32.22	0.88	-0.07	2.36	0.8	25.79	5	Sand mixtures - silty sand to sandy silt
15.354	12.8	0.15	-15.39	1.137	0.0450	0.691	0.323	0.368	1.70	21.77	22.54	20.0	32.94	1.20	-0.07	2.42	0.8	26.91	5	Sand mixtures - silty sand to sandy silt
15.42	14.0	0.15	-15.06	1.042	0.0450	0.694	0.325	0.369	1.70	23.74	24.58	20.0	35.99	1.10	-0.06	2.37	0.8	28.91	5	Sand mixtures - silty sand to sandy silt
15.486	14.8	0.16	-15.06	1.052	0.0450	0.697	0.327	0.370	1.70	25.21	26.10	20.0	38.23	1.10	-0.06	2.35	0.8	30.52	5	Sand mixtures - silty sand to sandy silt
15.551	16.3	0.17	-14.72	1.022	0.0450	0.700	0.329	0.371	1.70	27.68	28.65	20.0	42.04	1.07	-0.05	2.32	0.8	33.13	5	Sand mixtures - silty sand to sandy silt
15.617	17.1	0.19	-14.39	1.092	0.0450	0.703	0.331	0.372	1.70	29.15	30.18	20.0	44.27	1.14	-0.05	2.31	0.8	34.86	5	Sand mixtures - silty sand to sandy silt
15.682	17.7	0.21	-14.05	1.173	0.0450	0.706	0.333	0.372	1.70	30.15	31.21	20.0	45.73	1.22	-0.05	2.32	0.8	36.09	5	Sand mixtures - silty sand to sandy silt
15.748	17.7	0.22	-13.72	1.231	0.0450	0.709	0.335	0.373	1.70	30.16	31.22	20.0	45.62	1.28	-0.04	2.33	0.8	36.18	5	Sand mixtures - silty sand to sandy silt
15.814	17.2	0.26	-13.38	1.515	0.0450	0.712	0.337	0.374	1.70	29.17	30.20	50.0	43.96	1.58	-0.05	2.39	0.8	35.63	5	Sand mixtures - silty sand to sandy silt
15.879	16.9	0.22	-13.38	1.294	0.0450	0.715	0.339	0.375	1.70	28.70	29.71	20.0	43.09	1.35	-0.05	2.36	0.8	34.58	5	Sand mixtures - silty sand to sandy silt
15.945	16.6	0.21	-13.38	1.254	0.0450	0.718	0.341	0.376	1.70	28.20	29.19	20.0	42.21	1.31	-0.05	2.36	0.8	33.89	5	Sand mixtures - silty sand to sandy silt
16.01	16.3	-0.05	-12.72	-0.319	0.0450	0.720	0.344	0.377	1.70	27.72	28.70	20.0	41.35	-0.33	-0.05	#####	###	#NUM!	####	#NUM!
16.076	16.0	0.54	-12.72	3.377	0.0450	0.723	0.346	0.378	1.70	27.23	28.19	50.0	40.47	3.54	-0.05	2.61	0.9	35.61	4	Silt mixtures - clayey silt to silty clay

Liquefaction Triggering (Sands)

Depth	Idriss & Boulanger (2008) Cyclic Stress Ratio r_d	C_s	K_σ	K_α	CSR	Cyclic Resistance Ratio Δq_{c1N}	q_{c1Ncs}	CRR	FoS	Youd et al. (2001) Cyclic Stress Ratio r_d	D_r	f	K_σ	K_α	CSR	Cyclic Resistance Ratio Ic	Kc	q_{c1Ncs}	CRR	FoS	Avg	Lique-fiable? 1=Yes
12.402	0.95	0.05	1.05	1.0	0.101	35.9	51.72	0.079	0.78	0.97	0.23	0.80	1.12	1.0	0.088	2.594	3.29	52.16	0.093	1.06	0.92	1
12.467	0.95	0.05	1.06	1.0	0.101	29.5	48.37	0.076	0.75	0.97	0.25	0.80	1.11	1.0	0.088	2.414	2.37	44.85	0.087	0.99	0.87	1
12.533	0.95	0.05	1.06	1.0	0.101	29.9	50.31	0.078	0.77	0.97	0.26	0.80	1.11	1.0	0.088	2.425	2.42	49.36	0.091	1.03	0.90	1
12.598	0.95	0.05	1.06	1.0	0.101	38.2	60.68	0.089	0.87	0.97	0.27	0.80	1.11	1.0	0.089	2.465	2.60	58.38	0.099	1.11	0.99	1
12.664	0.95	0.06	1.06	1.0	0.101	40.0	67.50	0.097	0.95	0.97	0.30	0.80	1.11	1.0	0.089	2.395	2.29	63.05	0.103	1.16	1.06	0
12.73	0.95	0.05	1.06	1.0	0.102	37.3	57.07	0.085	0.83	0.97	0.26	0.80	1.11	1.0	0.089	2.559	3.08	61.08	0.101	1.14	0.98	1
12.795	0.95	0.05	1.05	1.0	0.102	36.7	54.98	0.082	0.81	0.97	0.25	0.80	1.11	1.0	0.089	2.626	3.49	63.71	0.104	1.16	0.98	1
12.861	0.95	0.05	1.05	1.0	0.103	36.2	52.91	0.080	0.78	0.97	0.24	0.80	1.11	1.0	0.090	2.667	3.76	62.89	0.103	1.15	0.97	1
12.927	0.95	0.05	1.05	1.0	0.103	35.7	50.87	0.078	0.76	0.97	0.23	0.80	1.11	1.0	0.090	2.677	3.83	58.33	0.098	1.09	0.93	1
12.992	0.95	0.05	1.05	1.0	0.103	34.9	48.09	0.076	0.73	0.97	0.21	0.80	1.11	1.0	0.090	2.693	3.95	51.93	0.093	1.03	0.88	1
13.058	0.95	0.05	1.05	1.0	0.103	28.3	43.00	0.071	0.69	0.97	0.22	0.80	1.10	1.0	0.091	#NUM!	#NUM!	#NUM!	#NUM!	#####	#NUM!	#NUM!
13.123	0.95	0.05	1.05	1.0	0.104	28.0	41.67	0.070	0.67	0.97	0.21	0.80	1.10	1.0	0.091	2.476	2.65	36.24	0.080	0.88	0.78	1
13.189	0.95	0.05	1.05	1.0	0.104	27.9	41.03	0.069	0.67	0.97	0.21	0.80	1.10	1.0	0.091	2.529	2.92	38.41	0.082	0.90	0.78	1
13.255	0.95	0.05	1.05	1.0	0.104	28.0	41.79	0.070	0.67	0.97	0.21	0.80	1.10	1.0	0.091	2.557	3.08	42.33	0.085	0.93	0.80	1
13.32	0.95	0.05	1.05	1.0	0.104	28.3	43.10	0.071	0.68	0.97	0.22	0.80	1.10	1.0	0.092	2.541	2.98	44.11	0.087	0.95	0.81	1
13.386	0.95	0.05	1.05	1.0	0.104	28.3	43.10	0.071	0.68	0.97	0.22	0.80	1.10	1.0	0.092	2.542	2.99	44.18	0.087	0.94	0.81	1
13.451	0.95	0.05	1.05	1.0	0.105	28.6	44.40	0.072	0.69	0.97	0.23	0.80	1.10	1.0	0.092	2.506	2.80	44.20	0.087	0.94	0.82	1
13.517	0.95	0.05	1.05	1.0	0.105	28.7	45.06	0.073	0.70	0.97	0.23	0.80	1.10	1.0	0.093	2.509	2.82	45.93	0.088	0.95	0.82	1
13.583	0.95	0.05	1.05	1.0	0.105	28.6	44.41	0.072	0.69	0.97	0.23	0.80	1.10	1.0	0.093	2.461	2.58	40.75	0.084	0.90	0.80	1
13.648	0.95	0.05	1.05	1.0	0.105	28.2	42.47	0.071	0.67	0.97	0.22	0.80	1.09	1.0	0.093	2.517	2.86	40.83	0.084	0.90	0.79	1
13.714	0.95	0.05	1.05	1.0	0.106	28.3	43.12	0.071	0.67	0.97	0.22	0.80	1.09	1.0	0.093	2.499	2.76	40.88	0.084	0.90	0.79	1
13.78	0.95	0.05	1.05	1.0	0.106	28.9	45.72	0.074	0.70	0.97	0.24	0.80	1.09	1.0	0.094	2.429	2.43	40.98	0.084	0.90	0.80	1
13.845	0.95	0.05	1.05	1.0	0.106	28.0	41.81	0.070	0.66	0.97	0.21	0.80	1.09	1.0	0.094	2.513	2.83	39.05	0.083	0.88	0.77	1
13.911	0.95	0.05	1.05	1.0	0.106	27.6	39.88	0.069	0.64	0.97	0.20	0.80	1.09	1.0	0.094	2.547	3.02	37.01	0.081	0.86	0.75	1
13.976	0.95	0.05	1.05	1.0	0.107	27.5	39.22	0.068	0.64	0.97	0.20	0.80	1.09	1.0	0.095	2.493	2.73	32.10	0.077	0.81	0.72	1
14.042	0.95	0.05	1.05	1.0	0.107	28.0	41.83	0.070	0.66	0.97	0.21	0.80	1.09	1.0	0.095	2.408	2.35	32.36	0.077	0.81	0.73	1
14.108	0.94	0.05	1.05	1.0	0.107	28.3	43.14	0.071	0.67	0.97	0.22	0.80	1.09	1.0	0.095	2.412	2.36	34.97	0.079	0.83	0.75	1
14.173	0.94	0.05	1.05	1.0	0.107	28.6	44.43	0.072	0.68	0.97	0.23	0.80	1.09	1.0	0.095	2.377	2.22	35.17	0.079	0.83	0.75	1
14.239	0.94	0.05	1.05	1.0	0.107	29.0	46.41	0.074	0.69	0.97	0.24	0.80	1.09	1.0	0.096	2.329	2.05	35.53	0.080	0.83	0.76	1
14.304	0.94	0.05	1.05	1.0	0.107	28.9	45.75	0.074	0.69	0.97	0.24	0.80	1.08	1.0	0.096	2.307	1.97	33.25	0.078	0.81	0.75	1
14.37	0.94	0.05	1.05	1.0	0.107	29.0	46.42	0.074	0.69	0.97	0.24	0.80	1.08	1.0	0.096	2.293	1.93	33.45	0.078	0.81	0.75	1
14.436	0.94	0.05	1.05	1.0	0.107	29.3	47.71	0.075	0.70	0.97	0.25	0.80	1.08	1.0	0.096	2.302	1.96	35.94	0.080	0.83	0.77	1
14.501	0.94	0.05	1.05	1.0	0.108	29.2	47.06	0.075	0.69	0.97	0.24	0.80	1.08	1.0	0.097	2.317	2.01	35.85	0.080	0.83	0.76	1
14.567	0.94	0.05	1.05	1.0	0.108	29.2	47.07	0.075	0.69	0.97	0.24	0.80	1.08	1.0	0.097	2.351	2.12	37.95	0.082	0.84	0.77	1
14.633	0.94	0.05	1.05	1.0	0.108	29.5	48.38	0.076	0.70	0.97	0.25	0.80	1.08	1.0	0.097	2.376	2.22	41.95	0.085	0.87	0.79	1
14.698	0.94	0.05	1.05	1.0	0.108	30.0	50.98	0.078	0.73	0.97	0.26	0.80	1.08	1.0	0.097	2.345	2.10	44.01	0.087	0.89	0.81	1
14.764	0.94	0.05	1.05	1.0	0.108	30.2	51.65	0.079	0.73	0.97	0.27	0.80	1.08	1.0	0.098	2.353	2.13	45.77	0.088	0.90	0.82	1
14.829	0.94	0.05	1.05	1.0	0.108	30.0	50.99	0.078	0.72	0.97	0.26	0.80	1.08	1.0	0.098	2.367	2.18	45.76	0.088	0.90	0.81	1
14.895	0.94	0.05	1.05	1.0	0.109	29.9	50.36	0.078	0.72	0.97	0.26	0.80	1.08	1.0	0.098	2.381	2.24	45.77	0.088	0.90	0.81	1
14.961	0.94	0.05	1.05	1.0	0.109	30.5	52.99	0.080	0.74	0.97	0.27	0.80	1.07	1.0	0.098	2.367	2.18	49.15	0.091	0.92	0.83	1
15.026	0.94	0.06	1.05	1.0	0.109	31.0	55.59	0.083	0.77	0.96	0.29	0.80	1.07	1.0	0.099	2.321	2.02	49.49	0.091	0.92	0.84	1
15.092	0.94	0.06	1.05	1.0	0.109	31.1	55.60	0.083	0.76	0.96	0.29	0.80	1.07	1.0	0.099	2.338	2.08	50.97	0.092	0.93	0.85	1
15.157	0.94	0.05	1.05	1.0	0.109	30.5	53.00	0.080	0.74	0.96	0.27	0.80	1.07	1.0	0.099	2.369	2.19	49.34	0.091	0.92	0.83	1
15.223	0.94	0.05	1.05	1.0	0.109	30.3	52.35	0.080	0.73	0.96	0.27	0.80	1.07	1.0	0.100	2.364	2.17	47.83	0.090	0.90	0.82	1
15.289	0.94	0.05	1.05	1.0	0.109	30.3	52.36	0.080	0.73	0.96	0.27	0.80	1.07	1.0	0.100	2.365	2.17	47.89	0.090	0.90	0.82	1
15.354	0.94	0.05	1.05	1.0	0.110	30.5	53.03	0.080	0.73	0.96	0.27	0.80	1.07	1.0	0.100	2.419	2.39	53.90	0.095	0.95	0.84	1
15.42	0.94	0.06	1.05	1.0	0.110	31.1	55.64	0.083	0.76	0.96	0.29	0.80	1.07	1.0	0.100	2.371	2.20	54.06	0.095	0.94	0.85	1
15.486	0.94	0.06	1.05	1.0	0.110	31.5	57.58	0.085	0.78	0.96	0.29	0.80	1.07	1.0	0.101	2.353	2.13	55.60	0.096	0.96	0.87	1
15.551	0.94	0.06	1.06	1.0	0.110	32.2	60.85	0.089	0.81	0.96	0.31	0.80	1.07	1.0	0.101	2.315	2.00	57.27	0.097	0.97	0.89	1
15.617	0.94	0.06	1.06	1.0	0.110	32.6	62.80	0.091	0.83	0.96	0.32	0.80	1.07	1.0	0.101	2.312	1.99	59.98	0.100	0.99	0.91	1
15.682	0.94	0.06	1.06	1.0	0.110	32.9	64.13	0.093	0.84	0.96	0.32	0.80	1.06	1.0	0.101	2.316	2.00	62.50	0.103	1.01	0.93	1
15.748	0.94	0.06	1.06	1.0	0.110	32.9	64.14	0.093	0.84	0.96	0.32	0.80	1.06	1.0	0.101	2.328	2.04	63.70	0.104	1.03	0.93	1
15.814	0.94	0.06	1.06	1.0	0.110	40.9	71.12	0.101	0.92	0.96	0.32	0.80	1.06	1.0	0.102	2.386	2.26	68.13	0.109	1.08	1.00	1
15.879	0.94	0.06	1.06	1.0	0.110	32.5	62.20	0.090	0.82	0.96	0.31	0.80	1.06	1.0	0.102	2.357	2.14	63.69	0.104	1.02	0.92	1
15.945	0.93	0.06	1.06	1.0	0.111	32.4	61.55	0.090	0.81	0.96	0.31	0.80	1.06	1.0	0.102	2.356	2.14	62.56	0.103	1.01	0.91	1
16.01	0.93	0.06	1.05	1.0	0.111	32.2	60.91	0.089	0.80	0.96	0.31	0.80	1.06	1.0	0.102	#NUM!	#NUM!	#NUM!	#NUM!	#####	#NUM!	#NUM!
16.076	0.93	0.06	1.05	1.0	0.111	40.2	68.40	0.098	0.88	0.96	0.31	0.80	1.06	1.0	0.103	2.609	3.38	95.37	0.161	1.56	1.22	0

Cyclic Softening (Clays)

Depth	Idriss & Boulanger (2008) Cyclic Resistance Ratio K_σ	CSR_M	CRR_M	
12.402	1	1.058	1.520	1.44
12.467	1	1.060	1.634	1.54
12.533	1	1.062	1.610	1.52
12.598	1	1.065	1.550	1.46
12.664	1	1.067	1.559	1.46
12.73	1	1.069	1.503	1.41
12.795	1	1.071	1.456	1.36
12.861	1	1.073	1.446	1.35
12.927	1	1.076	1.483	1.38
12.992	1	1.078	1.535	1.42
13.058	1	1.080	1.862	1.72
13.123	1	1.082	1.722	1.59
13.189	1	1.084	1.703	1.57
13.255	1	1.086	1.676	1.54
13.32	1	1.088	1.674	1.54
13.386	1	1.090	1.678	1.54
13.451	1	1.092	1.693	1.55
13.517	1	1.094	1.686	1.54
13.583	1	1.096	1.733	1.58
13.648	1	1.098	1.726	1.57
13.714	1	1.100	1.734	1.58
13.78	1	1.102	1.753	1.59
13.845	1	1.104	1.752	1.59
13.911	1	1.106	1.763	1.59
13.976	1	1.108	1.805	1.63
14.042	1	1.110	1.818	1.64
14.108	1	1.112	1.809	1.63
14.173	1	1.114	1.817	1.63
14.239	1	1.116	1.827	1.64
14.304	1	1.118	1.843	1.65
14.37	1	1.119	1.849	1.65
14.436	1	1.121	1.842	1.64
14.501	1	1.123	1.844	1.64
14.567	1	1.125	1.835	1.63
14.633	1	1.127	1.817	1.61
14.698	1	1.128	1.818	1.61
14.764	1	1.130	1.813	1.60
14.829	1	1.132	1.815	1.60
14.895	1	1.134	1.816	1.60
14.961	1	1.135	1.809	1.59
15.026	1	1.137	1.822	1.60
15.092	1	1.139	1.816	1.60
15.157	1	1.140	1.820	1.60
15.223	1	1.142	1.832	1.60
15.289	1	1.144	1.836	1.61
15.354	1	1.145	1.801	1.57
15.42	1	1.147	1.817	1.58
15.486	1	1.149	1.819	1.58
15.551	1	1.150	1.827	1.59
15.617	1	1.152	1.822	1.58
15.682	1	1.153	1.816	1.57
15.748	1	1.155	1.812	1.57
15.814	1	1.156	1.781	1.54
15.879	1	1.158	1.812	1.56
15.945	1	1.159	1.821	1.57
16.01	1	1.161	2.019	1.74
16.076	1	1.163	1.566	1.35

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

FoS<1 FoS≥1 FoS<1 FoS≥1 FoS<1 FoS≥1

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

Max. Horiz. Acceleration, Amax/g:	0.13
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.05

2011 CPT Data from ConeTec					CPT Data Interpretations																Liquefaction Triggering (Sands)																							Cyclic Softening (Clays)			
																					Idriss & Boulanger (2008)									Youd et al. (2001)											Avg	Liquefiable? 1=Yes		Idriss & Boulanger (2008)			
													Using Qtn for calculating Ic (iterations)								Cyclic Stress Ratio					Cyclic Resistance Ratio				Cyclic Stress Ratio						Cyclic Resistance Ratio								Cyclic Resistance Ratio			
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	r_d	C_s	K_σ	K_α	CSR	Δqc_{1N}	$qc_{1N,cs}$	CRR	FoS	r_d	D_r	f	K_σ	K_α	CSR	Ic	Kc	$qc_{1N,cs}$	CRR	FoS				K_α	CSRM	CRRM	
16.142	14.0	0.56	-12.72	4.012	0.0450	0.726	0.348	0.379	1.70	23.80	24.63	50.0	35.04	4.23	-0.06	2.70	0.9	31.83	4	Silt mixtures - clayey silt to silty clay	0.93	0.06	1.05	1.0	0.111	39.0	63.60	0.092	0.82	0.96	0.29	0.80	1.06	1.0	0.103	2.698	3.98	98.08	0.168	1.63	1.23	0		1	1.164	1.492	1.28
16.207	9.3	0.54	5.35	5.805	0.0450	0.729	0.350	0.380	#####	#NUM!	#NUM!	50.0	22.62	6.30	-0.02	2.93	1	22.31	4	Silt mixtures - clayey silt to silty clay	0.93	####	####	1.0	#NUM!	#####	#NUM!	#NUM!	#####	0.96	####	####	####	1.0	#NUM!	2.929	5.99	#NUM!	#NUM!	#####	#NUM!	#NUM!		1	1.165	1.277	1.10
16.273	19.5	0.54	-11.04	2.772	0.0450	0.732	0.352	0.381	1.70	33.17	34.34	50.0	49.34	2.88	-0.04	2.50	0.8	41.78	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.06	1.0	0.111	42.4	76.71	0.108	0.97	0.96	0.34	0.80	1.06	1.0	0.103	2.498	2.76	94.68	0.159	1.54	1.26	0		1	1.167	1.653	1.42
16.339	17.5	0.51	-10.37	2.913	0.0450	0.735	0.354	0.381	1.70	29.74	30.78	50.0	43.93	3.04	-0.04	2.55	0.8	37.85	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.06	1.0	0.112	41.1	71.91	0.102	0.91	0.96	0.32	0.80	1.06	1.0	0.104	2.546	3.01	92.65	0.154	1.49	1.20	0		1	1.168	1.640	1.40
16.404	16.9	0.43	-8.70	2.517	0.0450	0.738	0.356	0.382	1.70	28.80	29.82	50.0	42.38	2.63	-0.04	2.52	0.8	36.18	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.112	40.8	70.60	0.100	0.90	0.96	0.32	0.80	1.06	1.0	0.104	2.519	2.87	85.42	0.138	1.33	1.11	0		1	1.170	1.693	1.45
16.47	16.1	0.43	-8.03	2.652	0.0450	0.741	0.358	0.383	1.70	27.33	28.29	50.0	40.01	2.78	-0.04	2.55	0.8	34.55	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.112	40.2	68.54	0.098	0.87	0.96	0.31	0.80	1.05	1.0	0.104	2.550	3.03	85.77	0.139	1.33	1.10	0		1	1.171	1.680	1.43
16.535	14.9	0.30	-7.70	2.020	0.0450	0.744	0.360	0.384	1.70	25.38	26.27	50.0	36.92	2.13	-0.04	2.51	0.8	31.42	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.112	39.5	65.81	0.095	0.84	0.96	0.30	0.80	1.05	1.0	0.104	2.507	2.81	73.72	0.117	1.12	0.98	1		1	1.173	1.761	1.50
16.601	14.4	0.22	-7.03	1.520	0.0450	0.747	0.362	0.385	1.70	24.42	25.28	50.0	35.36	1.60	-0.04	2.46	0.8	29.56	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.112	39.2	64.47	0.093	0.83	0.96	0.29	0.80	1.05	1.0	0.105	2.455	2.55	64.51	0.105	1.00	0.91	1		1	1.174	1.825	1.55
16.67	13.8	0.22	-7.0	1.585	0.0450	0.750	0.364	0.386	1.70	23.43	24.25	50.0	33.76	1.68	-0.04	2.48	0.8	28.48	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.113	38.8	63.08	0.091	0.81	0.96	0.28	0.80	1.05	1.0	0.105	2.479	2.67	64.68	0.105	1.00	0.91	1		1	1.176	1.821	1.55
16.73	13.8	0.20	-6.4	1.433	0.0450	0.753	0.366	0.387	1.70	23.44	24.27	20.0	33.70	1.52	-0.04	2.46	0.8	28.22	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.113	31.0	55.24	0.083	0.73	0.96	0.28	0.80	1.05	1.0	0.105	2.458	2.56	62.20	0.102	0.97	0.85	1		1	1.177	1.843	1.57
16.80	13.2	0.19	-6.0	1.417	0.0450	0.756	0.368	0.388	1.70	22.46	23.25	20.0	32.12	1.50	-0.04	2.47	0.8	27.04	5	Sand mixtures - silty sand to sandy silt	0.93	0.05	1.05	1.0	0.113	30.7	53.94	0.081	0.72	0.96	0.28	0.80	1.05	1.0	0.105	2.471	2.62	61.03	0.101	0.96	0.84	1		1	1.178	1.848	1.57
16.86	13.5	0.11	-6.0	0.847	0.0450	0.759	0.370	0.389	1.70	22.96	23.76	20.0	32.79	0.90	-0.04	2.36	0.8	26.56	5	Sand mixtures - silty sand to sandy silt	0.93	0.05	1.05	1.0	0.113	30.8	54.60	0.082	0.73	0.96	0.28	0.80	1.05	1.0	0.106	2.358	2.15	51.09	0.092	0.88	0.80	1		1	1.180	1.920	1.63
16.93	13.8	0.11	-5.4	0.829	0.0450	0.762	0.372	0.390	1.70	23.47	24.29	20.0	33.47	0.88	-0.04	2.35	0.8	27.02	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.113	31.0	55.27	0.083	0.73	0.96	0.28	0.80	1.05	1.0	0.106	2.347	2.11	51.21	0.092	0.87	0.80	1		1	1.181	1.926	1.63
16.99	14.1	0.11	-4.7	0.811	0.0450	0.765	0.374	0.391	1.70	23.98	24.82	20.0	34.16	0.86	-0.04	2.34	0.8	27.48	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.113	31.1	55.95	0.083	0.74	0.96	0.29	0.80	1.05	1.0	0.106	2.336	2.07	51.33	0.093	0.87	0.80	1		1	1.182	1.931	1.63
17.06	13.8	0.12	-3.7	0.903	0.0450	0.768	0.376	0.391	1.70	23.50	24.33	20.0	33.36	0.96	-0.04	2.36	0.8	27.12	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.114	31.0	55.32	0.083	0.73	0.96	0.28	0.80	1.05	1.0	0.106	2.364	2.17	52.84	0.094	0.88	0.81	1		1	1.184	1.924	1.62
17.13	13.5	0.14	-3.7	0.999	0.0450	0.771	0.378	0.392	1.70	23.01	23.82	20.0	32.53	1.06	-0.04	2.39	0.8	26.73	5	Sand mixtures - silty sand to sandy silt	0.93	0.05	1.05	1.0	0.114	30.8	54.66	0.082	0.72	0.96	0.28	0.80	1.05	1.0	0.106	2.393	2.28	54.35	0.095	0.89	0.81	1		1	1.185	1.916	1.62
17.19	14.4	0.16	-3.7	1.083	0.0450	0.774	0.380	0.393	1.70	24.49	25.36	20.0	34.67	1.14	-0.04	2.39	0.8	28.45	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.114	31.3	56.63	0.084	0.74	0.96	0.29	0.80	1.05	1.0	0.107	2.387	2.26	57.32	0.098	0.91	0.83	1		1	1.186	1.909	1.61
17.26	13.8	0.15	-3.0	1.052	0.0450	0.777	0.382	0.394	1.70	23.52	24.35	20.0	33.13	1.12	-0.04	2.40	0.8	27.28	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.114	31.0	55.34	0.083	0.73	0.96	0.28	0.80	1.04	1.0	0.107	2.397	2.30	55.96	0.096	0.90	0.81	1		1	1.188	1.916	1.61
17.32	13.8	0.16	-2.3	1.127	0.0450	0.780	0.384	0.395	1.70	23.53	24.36	20.0	33.07	1.19	-0.04	2.41	0.8	27.38	5	Sand mixtures - silty sand to sandy silt	0.93	0.06	1.05	1.0	0.114	31.0	55.36	0.083	0.73	0.96	0.28	0.80	1.04	1.0	0.107	2.411	2.36	57.45	0.098	0.91	0.82	1		1	1.189	1.911	1.61
17.39	13.3	0.17	-2.3	1.255	0.0450	0.782	0.387	0.396	1.70	22.54	23.34	20.0	31.51	1.33	-0.04	2.45	0.8	26.46	5	Sand mixtures - silty sand to sandy silt	0.93	0.05	1.05	1.0	0.114	30.7	54.05	0.082	0.71	0.96	0.28	0.80	1.04	1.0	0.107	2.450	2.53	58.97	0.099	0.92	0.82	1		1	1.190	1.899	1.60
17.45	12.4	0.10	-2.0	0.839	0.0450	0.785	0.389	0.397	1.70	21.08	21.82	20.0	29.27	0.90	-0.04	2.39	0.8	24.12	5	Sand mixtures - silty sand to sandy silt	0.93	0.05	1.05	1.0	0.115	30.3	52.11	0.080	0.69	0.96	0.27	0.80	1.04	1.0	0.108	2.394	2.29	49.94	0.092	0.85	0.77	1		1	1.192	1.951	1.64
17.52	12.1	0.09	-1.3	0.772	0.0450	0.788	0.391	0.398	1.70	20.60	21.33	20.0	28.49	0.83	-0.04	2.39	0.8	23.44	5	Sand mixtures - silty sand to sandy silt	0.93	0.05	1.05	1.0	0.115	30.1	51.48	0.079	0.69	0.96	0.27	0.80	1.04	1.0	0.108	2.388	2.26	48.29	0.090	0.84	0.76	1		1	1.193	1.962	1.64
17.59	12.4	0.07	-1.0	0.586	0.0450	0.791	0.393	0.399	1.70	21.11	21.85	20.0	29.16	0.63	-0.04	2.33	0.8	23.55	5	Sand mixtures - silty sand to sandy silt	0.93	0.05	1.05	1.0	0.115	30.3	52.14	0.080	0.69	0.96	0.27	0.80	1.04	1.0	0.108	2.331	2.05	44.86	0.087	0.81	0.75	1		1	1.194	1.987	1.66
17.65	11.6	0.06	-0.3	0.540	0.0450	0.794	0.395	0.400	1.70	19.65	20.34	20.0	26.94	0.58	-0.04	2.35	0.8	21.88	5	Sand mixtures - silty sand to sandy silt	0.93	0.05	1.05	1.0	0.115	29.9	50.22	0.078	0.68	0.96	0.26	0.80	1.04	1.0	0.108	2.346	2.10	42.81	0.086	0.79	0.73	1		1	1.195	1.996	1.67
17.72	11.6	0.04	0.3	0.360	0.0450	0.797	0.397	0.400	1.70	19.67	20.36	20.0	26.90	0.39	-0.04	2.29	0.7	21.43	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.115	29.9	50.24	0.078	0.67	0.96	0.26	0.80	1.04	1.0	0.108	2.286	1.91	38.79	0.082	0.76	0.72	1		1	1.197	2.020	1.69
17.78	11.6	0.05	0.7	0.449	0.0450	0.800	0.399	0.401	1.70	19.68	20.37	20.0	26.84	0.48	-0.04	2.32	0.8	21.63	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.115	29.9	50.25	0.078	0.67	0.96	0.26	0.80	1.04	1.0	0.109	2.318	2.01	40.92	0.084	0.77	0.72	1		1	1.198	2.012	1.68
17.85	12.2	0.07	1.3	0.599	0.0450	0.803	0.401	0.402	1.70	20.66	21.39	20.0	28.22	0.64	-0.03	2.35	0.8	22.96	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.115	30.2	51.56	0.079	0.68	0.96	0.27	0.80	1.04	1.0	0.109	2.346	2.10	45.02	0.088	0.80	0.74	1		1	1.199	1.998	1.67
17.91	12.7	0.08	1.3	0.653	FALSE	0.806	0.403	0.403	1.70	21.65	22.41	20.0	29.59	0.70	-0.03	2.34	0.8	24.07	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.115	30.5	52.87	0.080	0.70	0.96	0.27	0.80	1.04	1.0	0.109	2.344	2.10	47.00	0.089	0.82	0.76	1		1	1.200	1.995	1.66
17.98	13.0	0.08	2.0	0.638	FALSE	0.809	0.405	0.404	1.70	22.16	22.94	20.0	30.26	0.68	-0.03	2.33	0.8	24.53	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.116	30.6	53.54	0.081	0.70	0.96	0.28	0.80	1.04	1.0	0.109	2.332	2.05	47.12	0.089	0.82	0.76	1		1	1.202	2.000	1.66
18.04	12.8	0.07	2.7	0.571	0.0450	0.812	0.407	0.405	1.70	21.68	22.45	20.0	29.49	0.61	-0.03	2.32	0.8	23.84	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.116	30.5	52.91	0.080	0.69	0.96	0.27	0.80	1.04	1.0	0.110	2.322	2.02	45.33	0.088	0.80	0.75	1		1	1.203	2.011	1.67
18.11	13.1	0.08	3.3	0.637	FALSE	0.815	0.409	0.406	1.70	22.19	22.97	20.0	30.15	0.68	-0.02	2.33	0.8	24.48	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.116	30.6	53.58	0.081	0.70	0.96	0.28	0.80	1.03	1.0	0.110	2.332	2.06	47.24	0.089	0.81	0.76	1		1	1.204	2.006	1.67
18.18	12.8	0.07	4.0	0.570	0.0450	0.818	0.411	0.407	1.70	21.71	22.48	20.0	29.38	0.61	-0.02	2.32	0.8	23.79	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.116	30.5	52.95	0.080	0.69	0.96	0.27	0.80	1.03	1.0	0.110	2.322	2.02	45.45	0.088	0.80	0.75	1		1	1.205	2.017	1.67
18.24	13.4	0.08	4.7	0.623	FALSE	0.821	0.413	0.408	1.70	22.70	23.50	20.0	30.74	0.66	-0.02	2.32	0.8	24.89	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.116	30.8	54.26	0.082	0.70	0.96	0.28	0.80	1.03	1.0	0.110	2.321	2.02	47.42	0.090	0.81	0.76	1		1	1.206	2.014	1.67
18.31	14.2	0.04	5.4	0.292	0.0450	0.824	0.415	0.409	1.70	24.20	25.05	20.0	32.82	0.31	-0.02	2.18	0.7	25.42	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.116	31.2	56.24	0.084	0.72	0.96	0.29	0.80	1.03	1.0	0.110	2.184	1.63	40.79	0.084	0.76	0.74	1		1	1.207	2.054	1.70
18.37	15.1	0.03	6.4	0.206	0.0450	0.827	0.417	0.410	1.70	25.69	26.59	20.0	34.88	0.22	-0.02	2.12	0.7	26.50	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.116	31.6	58.22	0.086	0.74	0.96	0.30	0.80	1.03	1.0	0.111	2.122	1.50	39.78	0.083	0.75	0.75	1		1	1.209	2.067	1.71
18.44	14.5	0.03	6.4	0.215	0.0450	0.830	0.419	0.410	1.70	24.72	25.59	20.0	33.40	0.23	-0.02	2.14	0.7	25.56	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.116	31.3	56.93	0.085	0.73	0.96	0.29	0.80	1.03	1.0	0.111	2.142	1.54	39.29	0.083	0.75	0.74	1		1	1.210	2.069	1.71
18.50	13.4	0.02	6.7	0.155	0.0450	0.833	0.421	0.411	1.70	22.74	23.54	20.0	30.50	0.17	-0.02	2.15	0.7	23.39	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.117	30.8	54.31	0.082	0.70	0.96	0.28	0.80	1.03	1.0	0.111	2.146	1.55	36.38	0.080	0.72	0.71	1		1	1.211	2.079	1.72
18.57	12.8	0.01	7.7	0.081	0.0450	0.836	0.423	0.412	1.70	21.79	22.56	20.0	29.07	0.09	-0.02	2.13	0.7	22.19	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.117	30.5	53.06	0.081	0.69	0.96	0.27	0.80	1.03	1.0	0.111	2.130	1.51	34.10	0.078	0.70	0.70	1		1	1.212	2.090	1.72
18.64	13.1	0.04	9.0	0.317	0.0450	0.839	0.425	0.413	1.70	22.32	23.10	20.0	29.75	0.34	-0.01	2.23	0.7	23.47	5	Sand mixtures - silty sand to sandy silt	0.92	0.05	1.05	1.0	0.117	30.6	53.75	0.081	0.70	0.96	0.28	0.80	1.03	1.0	0.111	2.229	1.74	40.24	0.084	0.75	0.72	1		1	1.213	2.066	1.70
18.70	14.6	0.07	9.7	0.499	0.0450	0.842	0.427	0.414	1.70	24.79	25.66	20.0	33.19	0.53	-0.01	2.26	0.7	26.42	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.117	31.4	57.03	0.085	0.72	0.96	0.29	0.80	1.03	1.0	0.112	2.255	1.81	46.53	0.089	0.79	0.76	1		1	1.214	2.049	1.69
18.77	16.3	0.09	11.0	0.573	0.0450	0.844	0.430	0.415	1.70	27.76	28.73	20.0	37.31	0.60	-0.01	2.24	0.7	29.54	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.117	32.2	60.95	0.089	0.76	0.96	0.31	0.80	1.03	1.0	0.112	2.236	1.76	50.59	0.092	0.82	0.79	1		1	1.215	2.043	1.68
18.83	18.1	0.08	13.1	0.460	0.0450	0.847	0.432	0.416	1.70	30.75	31.84	20.0	41.46	0.48	0.00	2.16	0.7	32.07	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.117	33.1	64.93	0.093	0.80	0.96	0.33	0.80	1.03	1.0	0.112	2.162	1.58	50.24	0.092	0.82	0.81	1		1	1.216	2.059	1.69
18.90	19.3	0.12	13.7	0.648	0.0450	0.850	0.434	0.417	1.70	32.73	33.88	20.0	44.15	0.68	0.00	2.20	0.7	34.58	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.117	33.7	67.55	0.097	0.83	0.96	0.34	0.80	1.03	1.0	0.112	2.199	1.66	56.37	0.097	0.86	0.84	1		1	1.217	2.041	1.68
18.96	19.9	0.17	15.4	0.838	0.0450	0.853	0.436	0.418	1.70	33.76	34.95	20.0	45.50	0.88	0.00	2.24	0.7	36.11	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.117	34.0	68.91	0.098	0.84	0.96	0.34	0.80	1.03	1.0	0.112	2.238	1.76	61.67	0.102	0.91	0.87	1		1	1.218	2.022	1.66
19.03	22.5	0.19	16.7	0.833	0.0450	0.856	0.438	0.419	1.70	38.21	39.55	20.0	51.65	0.87	0.00	2.19	0.7	40.44	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.117	35.3	74.80	0.106	0.91	0.96	0.36	0.80	1.02	1.0	0.113	2.193	1.65	65.30	0.106	0.94	0.92	1		1	1.220	2.026	1.66
19.09	22.8	0.54	18.4	2.373	0.0450	0.859	0.440	0.420	1.70	38.74	40.10	50.0	52.27	2.47	0.01	2.43	0.8	44.22	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.117	44.4	84.50	0.119	1.02	0.96	0.37	0.80	1.02	1.0	0.113	2.435	2.46	98.62	0.169	1.50	1.26	0		1	1.221	1.858	1.52
19.16	22.5	0.67	19.4	2.957	0.0450	0.862	0.442	0.420	1.70	38.27	39.61	50.0	51.49	3.07	0.01	2.50	0.8	44.45	5	Sand mixtures - silty sand to sandy silt	0.92	0.06	1.05	1.0	0.117	44.2	83.84	0.118	1.01	0.96	0.36	0.80	1.02	1.0	0.113	2.497	2.75	109.14	0.201	1.78	1.39	0		1	1.222	1.796	1.47
19.23	15.6	0.75	18.4	4.812	0.0450	0.865	0.444	0.421	1.70	26.45	27.38	50.0	34.88	5.10	0.01	2.75	0.9	32.59	4	Silt mixtures - clayey silt to silty clay	0.92	0.06	1.05	1.0	0.118	39.9	67.31	0.096	0.82	0.96	0.30	0.80	1.02	1.0	0.113	2.747	4.35	119.06	0.237	2.09	1.46	0		1	1.223	1.594	1.30
19.29	28.3	0.72	-0.7	2.535	0.0450	0.868	0.446	0.422	1.70	48.06	49.75	50.0	65.00	2.61	-0.02	2.39	0.8	54.22	5	Sand mixtures - silty sand to sandy silt	0.92	0.07	1.06	1.0	0.116	47.8	97.53	0.139	1.19	0.96	0.41	0.80	1.02	1.0	0.113	2.386	2.26	112.31	0.212	1.87	1.53	0		1	1.224	1.849	1.51
19.36	24.0	0.62	-2.7	2.605	0.0450	0.871	0.448	0.423	1.70	40.73	42.16	50.0	54.56	2.70	-0.02	2.45	0.8	46.40	5	Sand mixtures - silty sand to sandy silt	0.92	0.07	1.05	1.0	0.117	45.1	87.28	0.123	1.05	0.95	0.37	0.80	1.02	1.0	0.114	2.446	2.51	105.76	0.190	1.67	1.36	0		1	1.225	1.845	1.51
19.42	23.1	0.60	-1.3	2.611	0.0450	0.874	0.450	0.424	1.70	39.27	40.66	50.0	52.42	2.71	-0.02	2.46	0.8	44.77	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.117	44.6	85.24	0.120	1.02	0.95	0.37	0.80	1.02	1.0	0.114	2.458	2.57	104.32	0.186	1.63	1.33	0		1	1.226	1.848	1.51
19.49	23.1	0.61	1.0	2.653	0.0450	0.877	0.452	0.425	1.70	39.33	40.71	50.0	52.37	2.76	-0.02	2.46	0.8	44.82	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.117	44.6	85.31	0.120	1.02	0.95	0.37	0.80	1.02	1.0	0.114	2.463	2.59	105.29	0.189	1.65	1.34	0		1	1.227	1.846	1.51
19.55	22.8	0.51	1.3	2.231	0.0450	0.880	0.454	0.426	1.70	38.84	40.20	50.0	51.58	2.32	-0.02	2.42	0.8	43.60	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.117	44.4	84.63	0.119	1.01	0.95	0.37	0.80	1.02	1.0	0.114	2.422	2.40	96.62	0.164	1.43	1.22	0		1	1.228	1.896	1.54
19.62	24.6	0.46	1.7	1.861	0.0450	0.883	0.456	0.427	1.70	41.80	43.27	50.0	55.55	1.93	-0.02	2.35	0.8	45.97	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.117	45.5	88.77	0.125	1.07	0.95	0.38	0.80	1.02	1.0	0.115	2.352	2.13	92.11	0.153	1.33	1.20	0		1	1.229	1.939	1.58
19.69	23.4	0.48	2.3	2.041	0.0450	0.886	0.458	0.428	1.70	39.85	41.25	50.0	52.74	2.12	-0.02	2.39	0.8	44.21	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.118	44.8	86.05	0.121	1.03	0.95	0.37	0.80	1.02	1.0	0.115	2.392	2.28	94.02	0.157	1.37	1.20	0		1	1.230	1.923	1.56
19.75	23.2	0.53	4.0	2.289	0.0450	0.889	0.460	0.429	1.70	39.39	40.78	50.0	52.00	2.38	-0.02	2.43	0.8	44.06	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.118	44.6	85.41	0.120	1.02	0.95	0.37	0.80	1.02	1.0	0.115	2.426	2.42	98.67	0.169	1.47	1.25	0		1	1.231	1.899	1.54
19.82	24.1	0.68	4.7	2.810	0.0450	0.892	0.462	0.429	1.70	40.89	42.33	50.0	53.93	2.92	-0.01	2.47	0.8	46.34	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.118	45.2	87.51	0.123	1.05	0.95	0.38	0.80	1.02	1.0	0.115	2.469	2.62	110.70	0.206	1.79	1.42	0		1	1.232	1.845	1.50

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION
FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)
Locatiomight Mine South Storage Pond

FoS<1
FoS≥1

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

Max. Horiz. Acceleration, Amax/g:	0.13
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.05

2011 CPT Data from ConeTec					CPT Data Interpretations																Liquefaction Triggering (Sands)																							Cyclic Softening (Clays)			
													Using Qtn for calculating Ic (iterations)								Idriss & Boulanger (2008)									Youd et al. (2001)													Idriss & Boulanger (2008)			
																					Cyclic Stress Ratio					Cyclic Resistance Ratio				Cyclic Stress Ratio						Cyclic Resistance Ratio							Cyclic Resistance Ratio			
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	r_d	C_s	K_σ	K_α	CSR	Δqc_{1n}	$qc_{1n,cs}$	CRR	FoS	r_d	D_r	f	K_σ	K_α	CSR	Ic	Kc	$qc_{1n,cs}$	CRR	FoS	Avg	Lique-fiable? 1=Yes	K	CSRM	CRRM	
19.88	26.4	0.79	6.0	2.996	0.0450	0.895	0.464	0.430	1.70	44.72	46.29	50.0	59.22	3.10	-0.01	2.46	0.8	50.74	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.06	1.0	0.118	46.6	92.85	0.131	1.12	0.95	0.39	0.80	1.02	1.0	0.115	2.458	2.57	118.80	0.236	2.05	1.58	0	1	1.233	1.828	1.48
19.95	28.1	0.79	6.7	2.810	0.0450	0.898	0.466	0.431	1.68	47.23	48.89	50.0	63.13	2.90	-0.01	2.42	0.8	53.51	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.06	1.0	0.118	47.5	96.37	0.137	1.16	0.95	0.40	0.80	1.01	1.0	0.115	2.422	2.40	117.50	0.231	2.00	1.58	0	1	1.233	1.852	1.50
20.01	32.2	0.99	6.4	3.071	0.0450	0.901	0.468	0.432	1.65	53.02	54.88	50.0	72.35	3.16	-0.01	2.41	0.8	61.07	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.06	1.0	0.117	49.6	104.46	0.150	1.28	0.95	0.43	0.79	1.02	1.0	0.116	2.407	2.34	128.48	0.277	2.40	1.84	0	1	1.234	1.827	1.48
20.08	31.3	1.00	6.7	3.190	0.0450	0.904	0.470	0.433	1.65	51.71	53.53	50.0	70.18	3.28	-0.01	2.43	0.8	59.63	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.06	1.0	0.118	49.1	102.64	0.147	1.25	0.95	0.42	0.79	1.01	1.0	0.116	2.426	2.42	129.70	0.283	2.44	1.85	0	1	1.235	1.817	1.47
20.14	26.7	0.82	7.0	3.079	0.0450	0.906	0.473	0.434	1.68	44.95	46.53	50.0	59.40	3.19	-0.01	2.46	0.8	51.08	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.06	1.0	0.118	46.6	93.18	0.132	1.12	0.95	0.39	0.80	1.01	1.0	0.116	2.465	2.60	120.77	0.244	2.10	1.61	0	1	1.236	1.832	1.48
20.21	25.2	0.64	6.4	2.556	0.0450	0.909	0.475	0.435	1.69	42.75	44.26	50.0	55.92	2.65	-0.01	2.43	0.8	47.63	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.118	45.9	90.11	0.127	1.07	0.95	0.38	0.80	1.01	1.0	0.116	2.432	2.45	108.24	0.198	1.70	1.39	0	1	1.237	1.892	1.53
20.28	19.4	0.66	5.4	3.371	0.0450	0.912	0.477	0.436	1.70	33.04	34.20	50.0	42.50	3.54	-0.02	2.59	0.9	37.99	5	Sand mixtures - silty sand to sandy silt	0.91	0.06	1.05	1.0	0.119	42.3	76.52	0.108	0.91	0.95	0.34	0.80	1.01	1.0	0.116	2.589	3.26	111.45	0.209	1.79	1.35	0	1	1.238	1.808	1.46
20.34	16.0	0.67	5.0	4.171	0.0450	0.915	0.479	0.437	1.70	27.13	28.08	50.0	34.44	4.43	-0.02	2.71	0.9	31.95	4	Silt mixtures - clayey silt to silty clay	0.91	0.06	1.05	1.0	0.119	40.2	68.26	0.097	0.82	0.95	0.31	0.80	1.01	1.0	0.117	2.710	4.07	114.32	0.219	1.88	1.35	0	1	1.239	1.726	1.39
20.41	21.8	0.67	6.4	3.059	0.0450	0.918	0.481	0.438	1.70	36.99	38.29	50.0	47.62	3.19	-0.01	2.53	0.8	41.81	5	Sand mixtures - silty sand to sandy silt	0.91	0.06	1.05	1.0	0.119	43.8	82.04	0.115	0.97	0.95	0.36	0.80	1.01	1.0	0.117	2.528	2.91	111.58	0.209	1.79	1.38	0	1	1.240	1.847	1.49
20.47	25.5	0.70	7.7	2.728	0.0450	0.921	0.483	0.439	1.68	43.00	44.52	50.0	56.14	2.83	-0.01	2.45	0.8	48.13	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.119	45.9	90.46	0.128	1.08	0.95	0.39	0.80	1.01	1.0	0.117	2.448	2.52	112.05	0.211	1.80	1.44	0	1	1.241	1.886	1.52
20.54	26.8	0.80	-6.7	2.988	0.0450	0.924	0.485	0.439	1.67	44.80	46.37	50.0	58.88	3.10	-0.03	2.46	0.8	50.67	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.119	46.6	92.97	0.131	1.11	0.95	0.39	0.80	1.01	1.0	0.117	2.458	2.57	118.99	0.237	2.02	1.56	0	1	1.242	1.861	1.50
20.60	24.2	0.85	-6.0	3.525	0.0450	0.927	0.487	0.440	1.69	40.91	42.35	50.0	52.84	3.67	-0.03	2.54	0.8	46.56	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.119	45.2	87.53	0.123	1.04	0.95	0.38	0.80	1.01	1.0	0.117	2.536	2.96	125.19	0.262	2.24	1.64	0	1	1.242	1.808	1.45
20.67	24.8	0.82	-5.4	3.315	0.0450	0.930	0.489	0.441	1.68	41.74	43.21	50.0	54.07	3.44	-0.03	2.51	0.8	47.32	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.119	45.5	88.69	0.125	1.05	0.95	0.38	0.80	1.01	1.0	0.118	2.512	2.83	122.23	0.250	2.12	1.59	0	1	1.243	1.833	1.47
20.73	25.1	0.90	-4.7	3.607	0.0450	0.933	0.491	0.442	1.68	42.13	43.61	50.0	54.63	3.75	-0.03	2.53	0.8	48.12	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.119	45.6	89.24	0.126	1.06	0.95	0.38	0.80	1.01	1.0	0.118	2.532	2.94	128.11	0.276	2.34	1.70	0	1	1.244	1.805	1.45
20.80	28.6	0.93	-4.0	3.241	0.0450	0.936	0.493	0.443	1.65	47.14	48.80	50.0	62.34	3.35	-0.02	2.46	0.8	53.83	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.119	47.4	96.25	0.136	1.15	0.95	0.40	0.80	1.01	1.0	0.118	2.464	2.59	126.47	0.268	2.27	1.71	0	1	1.245	1.847	1.48
20.87	38.1	0.88	-3.7	2.320	0.0450	0.939	0.495	0.444	1.59	60.54	62.67	50.0	83.70	2.38	-0.02	2.28	0.7	68.56	5	Sand mixtures - silty sand to sandy silt	0.91	0.08	1.06	1.0	0.118	52.3	114.98	0.169	1.43	0.95	0.46	0.77	1.01	1.0	0.118	2.284	1.90	119.03	0.237	2.01	1.72	0	1	1.246	1.947	1.56
20.93	37.7	0.88	-10.0	2.343	0.0450	0.942	0.497	0.445	1.59	59.97	62.08	50.0	82.71	2.40	-0.02	2.29	0.7	67.90	5	Sand mixtures - silty sand to sandy silt	0.91	0.08	1.06	1.0	0.118	52.1	114.19	0.168	1.42	0.95	0.45	0.77	1.01	1.0	0.118	2.290	1.92	119.08	0.237	2.00	1.71	0	1	1.247	1.947	1.56
21.00	29.9	1.07	-11.0	3.581	0.0450	0.945	0.499	0.446	1.64	48.92	50.65	50.0	64.98	3.70	-0.03	2.48	0.8	56.45	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.06	1.0	0.119	48.1	98.74	0.140	1.18	0.95	0.41	0.79	1.00	1.0	0.119	2.480	2.67	135.16	0.310	2.61	1.90	0	1	1.248	1.821	1.46
21.06	26.5	1.13	-10.7	4.285	0.0450	0.948	0.501	0.447	1.66	43.88	45.42	50.0	57.10	4.44	-0.03	2.57	0.9	50.93	5	Sand mixtures - silty sand to sandy silt	0.91	0.07	1.05	1.0	0.119	46.3	91.68	0.129	1.08	0.95	0.39	0.80	1.00	1.0	0.119	2.568	3.14	142.59	0.350	2.95	2.01	0	1	1.248	1.750	1.40
21.13	36.6	1.25	-10.4	3.413	0.0450	0.951	0.503	0.448	1.59	58.17	60.22	50.0	79.57	3.50	-0.02	2.41	0.8	67.74	5	Sand mixtures - silty sand to sandy silt	0.90	0.08	1.06	1.0	0.119	51.5	111.67	0.163	1.37	0.95	0.45	0.78	1.00	1.0	0.119	2.408	2.35	141.33	0.343	2.88	2.13	0	1	1.249	1.845	1.48
21.19	43.2	1.42	-11.0	3.297	0.0450	0.954	0.505	0.448	1.55	67.18	69.54	50.0	94.23	3.37	-0.02	2.35	0.8	78.93	5	Sand mixtures - silty sand to sandy silt	0.90	0.08	1.06	1.0	0.118	54.7	124.26	0.189	1.60	0.95	0.48	0.76	1.00	1.0	0.119	2.351	2.12	147.73	0.380	3.19	2.39	0	1	1.250	1.860	1.49
21.26	43.7	1.02	-15.7	2.331	0.0450	0.957	0.507	0.449	1.55	67.79	70.18	50.0	95.17	2.38	-0.02	2.25	0.7	77.38	5	Sand mixtures - silty sand to sandy silt	0.90	0.08	1.06	1.0	0.118	54.9	125.13	0.191	1.61	0.95	0.48	0.76	1.00	1.0	0.119	2.248	1.79	125.73	0.265	2.22	1.92	0	1	1.251	1.963	1.57
21.33	31.5	1.06	-20.1	3.364	0.0450	0.960	0.509	0.450	1.62	50.95	52.74	50.0	67.89	3.47	-0.04	2.45	0.8	58.56	5	Sand mixtures - silty sand to sandy silt	0.90	0.07	1.06	1.0	0.119	48.8	101.57	0.145	1.22	0.95	0.42	0.79	1.00	1.0	0.119	2.449	2.52	133.07	0.299	2.50	1.86	0	1	1.252	1.859	1.49
21.39	25.2	1.00	-20.4	3.966	0.0450	0.963	0.511	0.451	1.66	41.76	43.23	50.0	53.65	4.12	-0.05	2.56	0.9	47.87	5	Sand mixtures - silty sand to sandy silt	0.90	0.07	1.05	1.0	0.120	45.5	88.72	0.125	1.04	0.95	0.38	0.80	1.00	1.0	0.120	2.564	3.11	134.50	0.306	2.56	1.80	0	1	1.252	1.800	1.44
21.46	21.1	0.82	-19.7	3.889	0.0450	0.966	0.513	0.452	1.69	35.73	36.98	50.0	44.59	4.08	-0.06	2.61	0.9	40.36	4	Silt mixtures - clayey silt to silty clay	0.90	0.06	1.05	1.0	0.120	43.3	80.28	0.113	0.94	0.95	0.35	0.80	1.00	1.0	0.120	2.612	3.40	125.87	0.265	2.22	1.58	0	1	1.253	1.811	1.45
21.52	22.0	0.73	-19.7	3.309	0.0450	0.969	0.515	0.453	1.68	36.99	38.29	50.0	46.42	3.46	-0.05	2.56	0.8	41.35	5	Sand mixtures - silty sand to sandy silt	0.90	0.06	1.05	1.0	0.120	43.8	82.04	0.115	0.96	0.95	0.36	0.80	1.00	1.0	0.120	2.556	3.07	117.37	0.230	1.92	1.44	0	1	1.254	1.874	1.49
21.59	19.4	0.64	-19.7	3.324	0.0450	0.971	0.518	0.454	1.70	32.98	34.14	50.0	40.59	3.50	-0.06	2.60	0.9	36.61	5	Sand mixtures - silty sand to sandy silt	0.90	0.06	1.05	1.0	0.121	42.3	76.44	0.108	0.89	0.95	0.34	0.80	1.00	1.0	0.120	2.597	3.31	113.01	0.214	1.78	1.34	0	1	1.255	1.875	1.49
21.65	18.0	0.55	-19.4	3.070	0.0450	0.974	0.520	0.455	1.70	30.53	31.60	50.0	37.34	3.25	-0.07	2.60	0.9	33.72	4	Silt mixtures - clayey silt to silty clay	0.90	0.06	1.05	1.0	0.121	41.4	73.01	0.103	0.85	0.95	0.32	0.80	1.00	1.0	0.120	2.602	3.34	105.47	0.189	1.57	1.21	0	1	1.255	1.904	1.52
21.72	18.5	0.50	-19.4	2.694	0.0450	0.977	0.522	0.456	1.70	31.50	32.61	50.0	38.51	2.84	-0.06	2.56	0.8	34.36	5	Sand mixtures - silty sand to sandy silt	0.90	0.06	1.05	1.0	0.121	41.8	74.37	0.105	0.87	0.95	0.33	0.80	1.00	1.0	0.121	2.558	3.08	100.37	0.174	1.44	1.16	0	1	1.256	1.945	1.55
21.78	16.5	0.46	-19.4	2.772	0.0450	0.980	0.524	0.457	1.70	28.07	29.06	50.0	34.01	2.95	-0.07	2.60	0.9	30.76	4	Silt mixtures - clayey silt to silty clay	0.90	0.06	1.04	1.0	0.121	40.5	69.57	0.099	0.82	0.95	0.31	0.80	1.00	1.0	0.121	2.604	3.35	97.42	0.166	1.38	1.10	0	1	1.257	1.940	1.54
21.85	14.5	0.37	-19.4	2.585	0.0450	0.983	0.526	0.458	1.70	24.62	25.49	50.0	29.50	2.77	-0.08	2.63	0.9	26.90	4	Silt mixtures - clayey silt to silty clay	0.90	0.06	1.04	1.0	0.122	39.3	64.75	0.093	0.77	0.95	0.29	0.80	1.00	1.0	0.121	2.632	3.53	89.95	0.148	1.22	0.99	1	1	1.258	1.962	1.56
21.92	11.9	0.32	-19.4	2.713	0.0450	0.986	0.528	0.458	1.70	20.20	20.91	50.0	23.77	2.96	-0.10	2.71	0.9	22.19	4	Silt mixtures - clayey silt to silty clay	0.90	0.05	1.04	1.0	0.122	37.7	58.57	0.086	0.71	0.95	0.26	0.80	1.00	1.0	0.121	2.715	4.11	85.84	0.139	1.15	0.93	1	1	1.258	1.952	1.55
21.98	11.6	0.29	-19.1	2.511	0.0450	0.989	0.530	0.459	1.70	19.71	20.41	50.0	23.09	2.75	-0.11	2.71	0.9	21.51	4	Silt mixtures - clayey silt to silty clay	0.90	0.05	1.04	1.0	0.122	37.5	57.89	0.086	0.70	0.95	0.26	0.80	1.00	1.0	0.121	2.705	4.04	82.36	0.132	1.09	0.89	1	1	1.259	1.975	1.57
22.05	13.3	0.26	-19.1	1.950	0.0450	0.992	0.532	0.460	1.70	22.67	23.46	50.0	26.81	2.11	-0.09	2.59	0.9	24.21	5	Sand mixtures - silty sand to sandy silt	0.90	0.05	1.04	1.0	0.122	38.6	62.02	0.090	0.74	0.95	0.28	0.80	0.99	1.0	0.121	2.595	3.30	77.34	0.123	1.01	0.88	1	1	1.260	2.035	1.62
22.11	14.5	0.27	-19.1	1.867	0.0450	0.995	0.534	0.461	1.70	24.63	25.49	50.0	29.26	2.00	-0.08	2.56	0.8	26.14	5	Sand mixtures - silty sand to sandy silt	0.90	0.06	1.04	1.0	0.122	39.3	64.76	0.093	0.77	0.95	0.29	0.80	0.99	1.0	0.122	2.555	3.06	78.13	0.124	1.02	0.89	1	1	1.260	2.046	1.62
22.18	14.8	0.20	-18.7	1.337	0.0450	0.998	0.536	0.462	1.70	25.13	26.01	20.0	29.83	1.43	-0.08	2.47	0.8	26.05	5	Sand mixtures - silty sand to sandy silt	0.90	0.06	1.04	1.0	0.122	31.5	57.48	0.085	0.70	0.95	0.29	0.80	0.99	1.0	0.122	2.473	2.63	68.53	0.110	0.90	0.80	1	1	1.261	2.102	1.67
22.24	15.6	0.32	-18.7	2.061	0.0450	1.001	0.538	0.463	1.70	26.60	27.53	50.0	31.63	2.20	-0.08	2.55	0.8	28.26	5	Sand mixtures - silty sand to sandy silt	0.90	0.06	1.04	1.0	0.122	40.0	67.52	0.097	0.79	0.95	0.30	0.80	0.99	1.0	0.122	2.553	3.05	84.01	0.135	1.11	0.95	1	1	1.262	2.032	1.61
22.31	17.1	0.53	-18.7	3.103	0.0450	1.004	0.540	0.464	1.70	29.06	30.08	50.0	34.68	3.30	-0.07	2.63	0.9	31.64	4	Silt mixtures - clayey silt to silty clay	0.90	0.06	1.04	1.0	0.122	40.9	70.95	0.101	0.83	0.95	0.32	0.80	0.99	1.0	0.122	2.627	3.50	105.15	0.188	1.54	1.18	0	1	1.263	1.930	1.53
22.38	15.1	0.53	-18.4	3.518	0.0450	1.007	0.542	0.465	1.70	25.63	26.53	50.0	30.27	3.77	-0.08	2.70	0.9	28.22	4	Silt mixtures - clayey silt to silty clay	0.90	0.06	1.04	1.0	0.122	39.6	66.17	0.095	0.78	0.95	0.30	0.80	0.99	1.0	0.122	2.703	4.02	106.57	0.193	1.57	1.18	0	1	1.263	1.891	1.50
22.44	16.0	0.55	-14.4	3.446	0.0450	1.010	0.544	0.466	1.70	27.19	28.15	50.0	32.18	3.68	-0.07	2.68	0.9	29.79	4	Silt mixtures - clayey silt to silty clay	0.90	0.06	1.04	1.0	0.122	40.2	68.34	0.098	0.80	0.95	0.31	0.80	0.99	1.0	0.122	2.678	3.84	108.07	0.197	1.61	1.21	0	1	1.264	1.901	1.50
22.51	15.1	0.45	-13.4	2.953	0.0450	1.013	0.546	0.467	1.70	25.74	26.65	50.0	30.29	3.16	-0.07	2.66	0.9	27.88	4	Silt mixtures - clayey silt to silty clay	0.90	0.06	1.04	1.0	0.122	39.7	66.32	0.095	0.78	0.95	0.30	0.80	0.99	1.0	0.123	2.657	3.69	98.42	0.169	1.38	1.08	0	1	1.265	1.953	1.54
22.57	18.0	0.50	-13.4	2.768	0.0450	1.016	0.548	0.467	1.69	30.39	31.46	50.0	36.41	2.93	-0.06	2.58	0.9	32.83	5	Sand mixtures - silty sand to sandy silt	0.90	0.06	1.04	1.0	0.122	41.4	72.82	0.103	0.84	0.95	0.32	0.80	0.99	1.0	0.123	2.581	3.22	101.16	0.176	1.44	1.14	0	1	1.265	1.974	1.56
22.64	20.1	0.81	-13.4	4.045	0.0450	1.019	0.550	0.468	1.66	33.37	34.55	50.0	40.64	4.26	-0.05	2.65	0.9	37.36	4	Silt mixtures - clayey silt to silty clay	0.90	0.06	1.04	1.0	0.122	42.4	76.99	0.109	0.89	0.95	0.34	0.80	0.99	1.0	0.123	2.650	3.65	125.96	0.266	2.16	1.53	0	1	1.266	1.850	1.46
22.70	21.8	0.72	-13.1	3.293	0.0450	1.022	0.552	0.469	1.65	35.90	37.16	50.0	44.26	3.45	-0.05	2.57	0.8	39.79	5	Sand mixtures - silty sand to sandy silt	0.90	0.06	1.05	1.0	0.122	43.4	80.52	0.113	0.93	0.95	0.35	0.80	0.99	1.0	0.123	2.567	3.13	116.35	0.226	1.84	1.38	0	1	1.267	1.927	1.52
22.77	26.7	0.61	-13.7	2.298	0.0450	1.025	0.554	0.470	1.61	42.95	44.46	50.0	54.61	2.39	-0.04	2.41	0.8	46.98	5	Sand mixtures - silty sand to sandy silt	0.89	0.07	1.05	1.0	0.122	45.9	90.38	0.127	1.05	0.95	0.38	0.80	0.99	1.0	0.123	2.406	2.34	103.86	0.184	1.49	1.27	0	1	1.267	2.029	1.60
22.83	29.9	0.88	-13.7	2.959	0.0450	1.028	0.556	0.471	1.59	47.38	49.05	50.0	61.23	3.06	-0.03	2.44	0.8	53.20	5	Sand mixtures - silty sand to sandy silt	0.89	0.07	1.05	1.0	0.122	47.5	96.58	0.137	1.13	0.95	0.40	0.80	0.99	1.0	0.123	2.440	2.48	121.78	0.248	2.01	1.57	0	1	1.268	1.966	1.55
22.90	37.9	0.93	-15.7	2.440	0.0450	1.031	0.558	0.472	1.54	58.42	60.47	50.0	78.20	2.51	-0.03	2.31	0.8	65.66	5	Sand mixtures - silty sand to sandy silt	0.89	0.08	1.06	1.0	0.121	51.5	112.01	0.164	1.35	0.95	0.45	0.78	0.99	1.0	0.124	2.314	1.99	120.56	0.243	1.96	1.66	0	1	1.268	2.020	1.59
22.97	37.0	1.03	-21.1	2.782	0.0450	1.033	0.561	0.473	1.54	57.09	59.10	50.0	76.07	2.86	-0.03	2.36	0.8	64.69	5	Sand mixtures - silty sand to sandy silt	0.89	0.08	1.05	1.0	0.121	51.1	110.16	0.160	1.32	0.95	0.44	0.78	0.99	1.0	0.124	2.359	2.15	127.19	0.271	2.19	1.76	0	1	1.269	1.989	1.57
23.03	35.0	1.00	-16.1	2.849	0.0450	1.036	0.563	0.474	1.55	54.37	56.28	50.0	71.77	2.94	-0.03	2.38	0.8	61.46	5	Sand mixtures - silty sand to sandy silt	0.89	0.07	1.05	1.0	0.121	50.1	106.35	0.153	1.26	0.95	0.43	0.78	0.98	1.0	0.124	2.382	2.24	126.16	0.267	2.15	1.71	0	1	1.270	1.985	1.56
23.10	28.4	1.01	-19.7	3.558	0.0450	1.039	0.565	0.475	1.59	45.04	46.62	50.0	57.53	3.69	-0.04	2.51	0.8	51.02	5	Sand mixtures - silty sand to sandy silt	0.89	0.07	1.05	1.0	0.122	46.7	93.30	0.132	1.08	0.95	0.39	0.80	0.99	1.0	0.124	2.510	2.82	131.47	0.291	2.35	1.71	0	1	1.270	1.918	1.51
23.16	20.8	1.08	-19.4	5.188	0.0450	1.042	0.567	0.476	1.64	34.22	35.42	50.0	41.64	5.46	-0.06	2.71	0.9	39.02	4	Silt mixtures - clayey silt to silty clay	0.89	0.06	1.04	1.0	0.123	42.8	78.17	0.110	0.90	0.95	0.34	0.80	0.98	1.0	0.124	2.713	4.09	144.95	0.363	2.92	1.91	0	1	1.271	1.761	1.39
23.23	28.1	1.21	-19.4	4.299	0.0450	1.045	0.569	0.477	1.59	44.53	46.10	50.0	56.70	4.46	-0.04	2.57	0.9	51.12	5	Sand mixtures - silty sand to sandy silt	0.89	0.07	1.05	1.0	0.122	46.5	92.60	0.131	1.07	0.95	0.39	0.80	0.98	1.0	0.124	2.569	3.14	144.81	0.362	2.91	1.99	0	1	1.271	1.851	1.46
23.29	32.1	0.98	-19.4	3.044	0.0450	1.048	0.571	0.477	1.56	50.13	51.90	50.0	65.08	3.15	-0.04	2.43	0.8	56.53	5	Sand mixtures - silty sand to sandy silt	0.89	0.07	1.05	1.0	0.122	48.5	100.43	0.143	1.17	0.95	0.42	0.79	0.98	1.0	0.125	2.429	2.44	126.40	0.268	2.15	1.66	0	1	1.272	1.977	1.55
23.36	33.0	0.79	-19.4	2.396	0.0450	1.051	0.573	0.478	1.55	51.27	53.07	50.0	66.75	2.48	-0.04	2.35	0.8	56.87	5	Sand mixtures - silty sand to sandy silt	0.89	0.07	1.05	1.0	0.122	48.9	102.01	0.146	1.20	0.95	0.42	0.79	0.98	1.0	0.125	2.355	2.14	113.43	0.216	1.73	1.46	0	1	1.273	2.042	1.60
23.43	33.6	0.99	-19.7	2.945	0.0450	1.054	0.575	0.479	1.55	51.99	53.82	50.0	67.81	3.04	-0.04	2.41	0.8	58.61	5	Sand mixtures - silty sand to sandy silt	0.89	0.07	1.05	1.0	0.122	49.2	103.03	0.148	1.21	0.95	0.42	0.79	0.98	1.0	0.125	2.408	2.34	126.14	0.267	2.13	1.67	0	1	1.273	1.991	1.56
23.49	37.6	0.82	-19.4	2.184	0.0450	1.057	0.577	0.480	1.53	57.44	59.47	50.0	76.13	2.25	-0.03	2.29	0.7	63.80	5	Sand mixtures - silty sand to sandy silt	0.89	0.08	1.05	1.0	0.122	51.2	110.65	0.161	1.32	0.95	0.45	0.78	0.98	1.0	0.125	2.290	1.92	113.96	0.218	1.74	1.53	0	1	1.274	2.068	1.62
23.56	43.7	0.80	-19.7	1.834	0.0450	1.060	0.579	0.481	1.50	65.44	67.75	50.0	88.57	1.88	-0.03	2.20	0.7	72.45	5	Sand mixtures - silty sand to sandy silt	0.89	0.08	1.06	1.0	0.121	54.1	121.84	0.184	1.51	0.95	0.48	0.76	0.98	1.0	0.126	2.196	1.66	112.32	0.212	1.68	1.60	0	1	1.274	2.104	1.65

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION
FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)
Locatiomight Mine South Storage Pond

FoS<1 FoS≥1 | FoS<1 FoS≥1 | FoS<1 FoS≥1

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

Max. Horiz. Acceleration, Amax/g:	0.13
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.05

2011 CPT Data from ConeTec					CPT Data Interpretations								Using Qtn for calculating Ic (iterations)							
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type
23.62	58.4	0.83	-20.1	1.425	0.0450	1.063	0.581	0.482	1.44	84.30	87.26	20.0	118.97	1.45	-0.02	2.04	0.7	93.39	6	Sands - clean sand to silty sand
23.69	73.4	0.84	-19.7	1.147	0.0450	1.066	0.583	0.483	1.40	102.76	106.38	20.0	149.89	1.16	-0.02	1.91	0.6	113.83	6	Sands - clean sand to silty sand
23.75	99.2	0.67	-19.7	0.671	0.0450	1.069	0.585	0.484	1.34	132.97	137.65	20.0	202.76	0.68	-0.01	1.68	0.5	144.96	6	Sands - clean sand to silty sand
23.82	114.8	0.69	-20.1	0.598	0.0450	1.072	0.587	0.485	1.31	150.58	155.88	20.0	234.58	0.60	-0.01	1.60	0.5	164.59	6	Sands - clean sand to silty sand
23.88	120.0	0.95	-20.4	0.789	0.0450	1.075	0.589	0.486	1.30	156.27	161.77	20.0	244.83	0.80	-0.01	1.66	0.5	174.62	6	Sands - clean sand to silty sand
23.95	126.6	0.77	-20.4	0.608	0.0450	1.078	0.591	0.487	1.29	163.52	169.28	20.0	258.03	0.61	-0.01	1.58	0.5	180.17	6	Sands - clean sand to silty sand
24.02	129.2	0.56	-20.4	0.435	0.0450	1.081	0.593	0.487	1.29	166.28	172.13	20.0	262.88	0.44	-0.01	1.49	0.4	179.59	6	Sands - clean sand to silty sand
24.08	129.5	0.43	-20.4	0.329	0.0450	1.084	0.595	0.488	1.29	166.50	172.36	20.0	262.98	0.33	-0.01	1.43	0.4	177.02	6	Sands - clean sand to silty sand
24.15	131.5	0.30	-20.1	0.229	0.0450	1.087	0.597	0.489	1.28	168.61	174.55	20.0	266.62	0.23	-0.01	1.36	0.4	176.29	6	Sands - clean sand to silty sand
24.21	124.9	0.24	-20.1	0.192	0.0450	1.090	0.599	0.490	1.29	161.23	166.90	20.0	252.56	0.19	-0.01	1.35	0.4	166.79	6	Sands - clean sand to silty sand
24.28	120.3	0.27	-20.1	0.225	0.0450	1.093	0.601	0.491	1.30	156.03	161.52	20.0	242.69	0.23	-0.01	1.39	0.4	162.07	6	Sands - clean sand to silty sand
24.34	107.5	0.34	-19.7	0.319	0.0450	1.095	0.604	0.492	1.32	141.71	146.69	20.0	216.39	0.32	-0.01	1.49	0.4	148.55	6	Sands - clean sand to silty sand
24.41	103.8	#N/A	-19.4	#N/A	0.0450	1.098	0.606	0.493	1.32	137.36	142.20	#N/A	208.38	#N/A	-0.01	#N/A	###	#N/A	#N/A	#N/A
24.48	99.7	#N/A	-19.4	#N/A	0.0450	1.101	0.608	0.494	1.33	132.65	137.32	#N/A	199.78	#N/A	-0.01	#N/A	###	#N/A	#N/A	#N/A
24.54	119.7	#N/A	-19.4	#N/A	0.0450	1.104	0.610	0.495	1.30	155.02	160.48	#N/A	239.73	#N/A	-0.01	#N/A	###	#N/A	#N/A	#N/A
Averages:					0.0450															

	Liquefaction Triggering (Sands)																							Cyclic Softening (Clays)			
	Idriss & Boulanger (2008)									Youd et al. (2001)														Idriss & Boulanger (2008)			
	Cyclic Stress Ratio					Cyclic Resistance Ratio				Cyclic Stress Ratio						Cyclic Resistance Ratio								Cyclic Resistance Ratio			
Depth	r_d	C_s	K_σ	K_α	CSR	Δqc_{1n}	$qc_{1n,cs}$	CRR	FoS	r_d	D_r	f	K_σ	K_α	CSR	Ic	Kc	$qc_{1n,cs}$	CRR M=7.5	FoS	Avg	Lique-fiable? 1=Yes	K_σ	CSRM	CRRM	
23.62	0.89	0.10	1.07	1.0	0.120	48.6	135.87	0.219	1.82	0.94	0.54	0.73	0.97	1.0	0.126	2.039	1.35	118.21	0.234	1.85	1.84	0	1	1.275	2.146	1.68
23.69	0.89	0.11	1.08	1.0	0.119	54.0	160.33	0.328	2.75	0.94	0.60	0.70	0.97	1.0	0.127	1.911	1.20	127.59	0.273	2.15	2.45	0	1	1.276	2.175	1.71
23.75	0.89	0.14	1.10	1.0	0.117	62.7	200.36	1.157	9.90	0.94	0.68	0.66	0.97	1.0	0.128	1.679	1.02	140.89	0.340	2.67	6.28	0	1	1.276	2.223	1.74
23.82	0.89	0.17	1.10	1.0	0.117	67.8	223.68	4.588	39.25	0.94	0.72	0.64	0.96	1.0	0.128	1.604	1.00	155.88	0.432	3.38	21.31	0	1	1.277	2.233	1.75
23.88	0.89	0.18	1.10	1.0	0.117	69.5	231.23	8.316	71.12	0.94	0.73	0.63	0.96	1.0	0.128	1.663	1.01	163.75	0.488	3.80	37.46	0	1	1.277	2.216	1.74
23.95	0.89	0.19	1.10	1.0	0.117	71.6	240.83	20.131	#####	0.94	0.75	0.62	0.96	1.0	0.129	1.578	1.00	169.28	0.531	4.13	88.11	0	1	1.278	2.236	1.75
24.02	0.89	0.20	1.10	1.0	0.117	72.4	244.48	29.361	#####	0.94	0.76	0.62	0.96	1.0	0.129	1.490	1.00	172.13	0.554	4.30	127.59	0	1	1.278	2.255	1.76
24.08	0.89	0.20	1.10	1.0	0.117	72.4	244.78	30.299	#####	0.94	0.76	0.62	0.96	1.0	0.129	1.429	1.00	172.36	0.556	4.31	131.55	0	1	1.279	2.267	1.77
24.15	0.89	0.20	1.10	1.0	0.117	73.0	247.58	41.200	#####	0.94	0.76	0.62	0.96	1.0	0.129	1.356	1.00	174.55	0.575	4.44	178.09	0	1	1.279	2.278	1.78
24.21	0.89	0.19	1.10	1.0	0.117	70.9	237.80	14.974	#####	0.94	0.75	0.63	0.96	1.0	0.130	1.347	1.00	166.90	0.512	3.96	65.87	0	1	1.280	2.284	1.78
24.28	0.89	0.18	1.10	1.0	0.117	69.4	230.91	8.094	69.05	0.94	0.73	0.63	0.96	1.0	0.130	1.386	1.00	161.52	0.472	3.64	36.34	0	1	1.280	2.283	1.78
24.34	0.88	0.16	1.10	1.0	0.117	65.2	211.93	2.118	18.06	0.94	0.70	0.65	0.96	1.0	0.130	1.489	1.00	146.69	0.374	2.88	10.47	0	1	1.281	2.276	1.78
24.41	0.88	0.15	1.10	1.0	0.117	#N/A	#N/A	#N/A	#N/A	0.94	0.69	0.66	0.96	1.0	0.130	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1	1.281	#N/A	#N/A
24.48	0.88	0.14	1.10	1.0	0.118	#N/A	#N/A	#N/A	#N/A	0.94	0.68	0.66	0.96	1.0	0.130	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1	1.282	#N/A	#N/A
24.54	0.88	0.18	1.10	1.0	0.117	#N/A	#N/A	#N/A	#N/A	0.94	0.73	0.63	0.95	1.0	0.131	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1	1.282	#N/A	#N/A

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

s_u/s_r < 1 (Strength Loss)

FC%	Δqc1n-Sr
0	10.00
10	10.00
25	25.00
50	45.00
75	55.00
100	55.00

2011 CPT Data from ConeTec					CPT Data Interpretations																Robertson (2010a)								Robertson (2010b)		Idriss & Boulanger (2008)				Olson & Stark (2003)		
																		Using Qtn for calculating Ic (iterations)			Peak Strengths						Cyclic Softening Strengths		Liquefied Strengths								
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	OCR Robertson (2009)	OCR Kulhawy Mayne (1990)	Selected OCR	$\sigma_{p'}$	s_u	$s_u/\sigma_{v'}$	$s_r/\sigma_{v'}$ FrQtn/100	s_r/s_u	$Q_{tn\text{-}cs}$	$s_{u,LIQ}/\sigma_{v'}$	Fines Adjust $\Delta q_{c1n\text{-}Sr}$	$q_{c1n,cs\text{-}Sr}$	$s_{u,LIQ}/\sigma_v'$ Sig Void Redist	$s_{u,LIQ}/\sigma_v'$ Insig Void Redist	qc1	qc1	$s_{u,LIQ}/\sigma_v'$
(ft)	(tsf)	(tsf)	(ft)	(%)	(tcf)	(tsf)	(tsf)	(tsf)		TSF		%		%										(tsf)	(psf)										(tsf)	(MPa)	
8.7927	0.0	0.00	0.00	######	0.0450	0.396	0.118	0.277	1.70	0.00	0.00	####	45.57	1.17	0.30	#####	1	-1.43	####	#NUM!	#NUM!	-0.4	#NUM!	#NUM!	#DIV/0!	#DIV/0!	-0.02	#DIV/0!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
8.8583	0.0	0.00	0.00	######	0.0450	0.399	0.120	0.278	1.70	0.00	0.00	####	-1.43	0.00	0.30	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
8.9239	0.0	0.00	0.00	######	0.0450	0.402	0.122	0.279	1.70	0.00	0.00	####	-1.44	0.00	0.30	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
8.9895	0.0	0.00	0.00	######	0.0450	0.405	0.124	0.280	1.70	0.00	0.00	####	-1.44	0.00	0.31	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.0551	0.0	0.00	0.00	######	0.0450	0.407	0.127	0.281	1.70	0.00	0.00	####	-1.45	0.00	0.31	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.1207	0.0	0.00	0.00	######	0.0450	0.410	0.129	0.282	1.70	0.00	0.00	####	-1.46	0.00	0.31	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.1864	0.0	0.00	0.00	######	0.0450	0.413	0.131	0.283	1.70	0.00	0.00	####	-1.46	0.00	0.32	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.252	0.0	0.00	0.00	######	0.0450	0.416	0.133	0.284	1.70	0.00	0.00	####	-1.47	0.00	0.32	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.3176	0.0	0.00	0.00	######	0.0450	0.419	0.135	0.285	1.70	0.00	0.00	####	-1.47	0.00	0.32	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.3832	0.0	0.00	0.00	######	0.0450	0.422	0.137	0.285	1.70	0.00	0.00	####	-1.48	0.00	0.32	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.4488	0.0	0.01	0.00	######	0.0450	0.425	0.139	0.286	1.70	0.00	0.00	####	-1.48	-2.45	0.33	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.5144	0.0	0.02	0.00	######	0.0450	0.428	0.141	0.287	1.70	0.00	0.00	####	-1.49	-4.86	0.33	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.5801	0.0	0.02	0.00	######	0.0450	0.431	0.143	0.288	1.70	0.00	0.00	####	-1.50	-4.82	0.33	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#NUM!	#NUM!	#NUM!	#NUM!	#VALUE!	#VALUE!	#NUM!	#NUM!	0.00	0.00	#NUM!
9.6457	11.0	0.03	-2.01	0.285	0.0450	0.434	0.145	0.289	1.70	18.63	19.28	20.0	36.39	0.30	-0.02	2.18	0.7	25.22	5	Sand mixtures - silty sand to sandy silt	14.1	6.3	1.0	0.29	1040	1.80	0.07	0.04	40.89	0.05	19.5	38.78	0.04	0.04	17.94	1.72	0.05
9.7113	11.5	0.03	-1.67	0.270	0.0450	0.437	0.147	0.290	1.70	19.62	20.31	20.0	38.29	0.28	-0.02	2.16	0.7	26.27	5	Sand mixtures - silty sand to sandy silt	14.9	6.6	1.0	0.29	1049	1.81	0.07	0.04	41.17	0.05	19.5	39.81	0.04	0.04	18.88	1.81	0.06
9.7769	12.1	0.04	-1.67	0.343	0.0450	0.440	0.149	0.291	1.70	20.60	21.32	20.0	40.13	0.36	-0.02	2.17	0.7	27.71	5	Sand mixtures - silty sand to sandy silt	15.9	6.9	1.0	0.29	1048	1.80	0.10	0.05	44.20	0.05	19.5	40.82	0.04	0.04	19.80	1.90	0.06
9.8425	12.7	0.05	-0.33	0.409	0.0450	0.443	0.151	0.292	1.70	21.62	22.38	20.0	42.05	0.42	-0.01	2.18	0.7	29.17	5	Sand mixtures - silty sand to sandy silt	16.9	7.3	1.0	0.29	1048	1.80	0.12	0.07	47.01	0.05	19.5	41.88	0.04	0.04	20.77	1.99	0.06
9.9081	13.3	0.05	0.00	0.391	0.0450	0.446	0.153	0.293	1.70	22.60	23.39	20.0	43.88	0.40	-0.01	2.16	0.7	30.18	5	Sand mixtures - silty sand to sandy silt	17.7	7.5	1.0	0.29	1057	1.81	0.12	0.07	47.20	0.05	19.5	42.89	0.05	0.05	21.69	2.08	0.06
9.9738	14.2	0.05	0.67	0.367	0.0450	0.449	0.155	0.294	1.70	24.10	24.94	20.0	46.74	0.38	-0.01	2.12	0.7	31.72	5	Sand mixtures - silty sand to sandy silt	18.8	7.9	1.0	0.29	1067	1.82	0.12	0.07	47.61	0.05	19.5	44.44	0.05	0.05	23.11	2.21	0.06
10.039	15.9	0.11	1.67	0.719	0.0450	0.452	0.157	0.295	1.70	27.05	28.00	20.0	52.49	0.74	-0.01	2.19	0.7	36.80	5	Sand mixtures - silty sand to sandy silt	22.7	9.2	1.0	0.29	1036	1.76	0.27	0.15	60.77	#N/A	19.5	47.50	#N/A	#N/A	25.92	2.48	#N/A
10.105	16.8	0.15	2.68	0.867	0.0450	0.455	0.159	0.295	1.70	28.56	29.57	20.0	55.32	0.89	0.00	2.21	0.7	39.15	5	Sand mixtures - silty sand to sandy silt	24.5	9.8	1.0	0.30	1026	1.74	0.35	0.20	66.41	#N/A	19.5	49.07	#N/A	#N/A	27.35	2.62	#N/A
10.171	18.0	0.19	3.35	1.042	0.0450	0.458	0.161	0.296	1.70	30.54	31.61	20.0	59.07	1.07	0.00	2.23	0.7	42.15	5	Sand mixtures - silty sand to sandy silt	26.8	10.5	1.0	0.30	1014	1.71	0.45	0.26	73.29	#N/A	19.5	51.11	#N/A	#N/A	29.21	2.80	#N/A
10.236	18.0	0.19	3.68	1.042	0.0450	0.461	0.163	0.297	1.70	30.54	31.62	20.0	58.89	1.07	0.00	2.23	0.7	42.07	5	Sand mixtures - silty sand to sandy silt	26.8	10.5	1.0	0.30	1022	1.72	0.45	0.26	73.23	#N/A	19.5	51.12	#N/A	#N/A	29.20	2.80	#N/A
10.302	18.6	0.28	4.35	1.513	0.0450	0.464	0.165	0.298	1.70	31.55	32.66	50.0	60.69	1.55	0.00	2.30	0.7	44.83	5	Sand mixtures - silty sand to sandy silt	29.0	11.2	1.0	0.30	977	1.64	0.70	0.42	87.58	#N/A	45	77.66	#N/A	#N/A	30.13	2.89	#N/A
10.367	20.9	0.31	5.02	1.495	0.0450	0.467	0.167	0.299	1.70	35.49	36.74	20.0	68.24	1.53	0.00	2.26	0.7	49.59	5	Sand mixtures - silty sand to sandy silt	32.9	12.4	1.0	0.30	986	1.65	0.76	0.46	91.03	#N/A	19.5	56.24	#N/A	#N/A	33.87	3.24	#N/A
10.433	20.9	0.35	5.35	1.693	0.0450	0.469	0.170	0.300	1.70	35.50	36.75	50.0	68.04	1.73	0.00	2.29	0.7	50.16	5	Sand mixtures - silty sand to sandy silt	33.4	12.5	1.0	0.30	971	1.62	0.87	0.54	96.68	#N/A	45	81.75	#N/A	#N/A	33.84	3.24	#N/A
10.499	20.5	0.36	0.00	1.774	0.0450	0.472	0.172	0.301	1.70	34.88	36.11	50.0	66.63	1.82	-0.01	2.31	0.7	49.54	5	Sand mixtures - silty sand to sandy silt	32.9	12.4	1.0	0.30	969	1.61	0.90	0.56	98.23	#N/A	45	81.11	#N/A	#N/A	33.23	3.18	#N/A
10.564	22.0	0.51	-0.67	2.321	0.0450	0.475	0.174	0.302	1.70	37.33	38.64	50.0	71.18	2.37	-0.01	2.36	0.8	54.09	5	Sand mixtures - silty sand to sandy silt	36.7	13.5	1.0	0.30	916	1.52	1.28	0.85	116.29	#N/A	45	83.64	#N/A	#N/A	35.53	3.40	#N/A
10.63	24.2	0.57	-3.68	2.361	0.0450	0.478	0.176	0.303	1.70	41.18	42.63	50.0	78.45	2.41	-0.01	2.33	0.8	59.05	5	Sand mixtures - silty sand to sandy silt	40.9	14.8	1.0	0.30	919	1.52	1.42	0.94	121.98	#N/A	45	87.63	#N/A	#N/A	39.17	3.75	#N/A
10.696	26.0	0.68	-3.35	2.603	0.0450	0.481	0.178	0.304	1.70	44.14	45.70	50.0	83.94	2.65	-0.01	2.34	0.8	63.43	5	Sand mixtures - silty sand to sandy silt	44.7	15.9	1.0	0.30	899	1.48	1.68	1.14	132.52	#N/A	45	90.70	#N/A	#N/A	41.95	4.02	#N/A
10.761	27.1	0.76	-6.36	2.803	0.0450	0.484	0.180	0.305	1.70	46.04	47.66	50.0	87.35	2.85	-0.01	2.35	0.8	66.31	5	Sand mixtures - silty sand to sandy silt	47.3	16.6	1.0	0.30	884	1.45	1.89	1.30	140.66	#N/A	45	92.66	#N/A	#N/A	43.71	4.19	#N/A
10.827	28.4	0.87	-13.38	3.072	0.0450	0.487	0.182	0.305	1.70	48.34	50.04	50.0	91.51	3.13	-0.02	2.36	0.8	69.90	5	Sand mixtures - silty sand to sandy silt	50.5	17.5	1.0	0.31	862	1.41	2.18	1.55	151.50	#N/A	45	95.04	#N/A	#N/A	45.86	4.39	#N/A
10.892	26.6	0.94	-18.74	3.514	0.0450	0.490	0.184	0.306	1.70	45.29	46.88	50.0	85.36	3.58	-0.03	2.42	0.8	66.88	5	Sand mixtures - silty sand to sandy silt	47.8	16.7	1.0	0.31	820	1.34	2.39	1.79	159.95	#N/A	45	91.88	#N/A	#N/A	42.92	4.11	#N/A
10.958	25.5	1.03	-19.07	4.043	0.0450	0.493	0.186	0.307	1.70	43.30	44.82	50.0	81.30	4.12	-0.03	2.47	0.8	65.21	5	Sand mixtures - silty sand to sandy silt	46.3	16.3	1.0	0.31	768	1.25	2.69	2.15	171.45	#N/A	45	89.82	#N/A	#N/A	41.00	3.93	#N/A
11.024	25.2	1.02	-19.41	4.047	0.0450	0.496	0.188	0.308	1.70	42.81	44.32	50.0	80.12	4.13	-0.03	2.48	0.8	64.43	5	Sand mixtures - silty sand to sandy silt	45.6	16.1	1.0	0.31	775	1.26	2.66	2.11	170.62	#N/A	45	89.32	#N/A	#N/A	40.51	3.88	#N/A
11.089	27.5	1.05	-19.07	3.820	0.0450	0.499	0.190	0.309	1.70	46.75	48.39	50.0	87.36	3.89	-0.03	2.44	0.8	69.10	5	Sand mixtures - silty sand to sandy silt	49.8	17.3	1.0	0.31	808	1.31	2.69	2.06	170.39	#N/A	45	93.39	#N/A	#N/A	44.20	4.23	#N/A
11.155	33.6	1.04	-19.07	3.099	0.0450	0.502	0.192	0.310	1.70	57.05	59.06	50.0	106.66	3.15	-0.02	2.32	0.8	80.40	5	Sand mixtures - silty sand to sandy silt	60.2	20.1	1.0	0.31	895	1.44	2.53	1.75	162.95	#N/A	45	104.06	#N/A	#N/A	53.90	5.16	#N/A
11.22	36.1	1.16	-20.75	3.222	0.0450	0.505	0.194	0.311	1.70	61.45	63.62	50.0	114.67	3.27	-0.02	2.32	0.7	86.20	5	Sand mixtures - silty sand to sandy silt	65.7	21.6	1.0	0.31	889	1.43	2.82	1.97	172.41	#N/A	45	108.62	#N/A	#N/A	58.00	5.56	#N/A
11.286	34.1	1.23	-22.42	3.599	0.0450	0.508	0.196	0.312	1.70	57.97	60.01	50.0	107.75	3.65	-0.03	2.36	0.8	82.76	5	Sand mixtures - silty sand to sandy silt	62.4	20.7	1.0	0.31	854	1.37	3.02	2.21	179.62	#N/A	45	105.01	#N/A	#N/A	54.67	5.24	#N/A
11.352	28.6	1.26	-24.09	4.402	0.0450	0.511	0.198	0.313	1.70	48.60	50.31	50.0	89.80	4.48	-0.03	2.47	0.8	72.23	5	Sand mixtures - silty sand to sandy silt	52.6	18.1	1.0	0.31	772	1.23	3.24	2.62	189.19	#N/A	45	95.31	#N/A	#N/A	45.79	4.39	#N/A
11.417	26.6	1.34	-24.43	5.050	0.0450	0.514	0.200	0.314	1.70	45.16	46.75	50.0	83.08	5.15	-0.04	2.53	0.8	68.62	5	Sand mixtures - silty sand to sandy silt	49.4	17.2	1.0	0.31	707	1.13	3.53	3.13	200.67	#N/A	45	91.75	#N/A	#N/A	42.52	4.07	#N/A
11.483	24.8	1.35	-24.09	5.445	0.0450	0.517	0.202	0.314	1.70	42.21	43.70	50.0	77.32	5.56	-0.04	2.57	0.8	65.02	5	Sand mixtures - silty sand to sandy silt	46.2	16.3	1.0	0.31	671	1.07	3.62	3.39	204.84	#N/A	45	88.70	#N/A	#N/A	39.71	3.80	#N/A
11.549	24.5	1.28	-24.09	5.213	0.0450	0.520	0.204	0.315	1.70	41.72	43.19	50.0	76.17	5.33	-0.04	2.56	0.8	63.83	5	Sand mixtures - silty sand to sandy silt	45.1	16.0	1.0	0.32	704	1.12	3.40	3.05	197.76	#N/A	45	88.19	#N/A	#N/A	39.21	3.76	#N/A
11.614	23.7	1.08	-20.75	4.560	0.0450	0.523	0.206	0.316	1.70	40.33	41.74	50.0	73.35	4.66	-0.04	2.53	0.8	60.74	5	Sand mixtures - silty sand to sandy silt	42.4	15.2	1.0	0.32	784	1.24	2.83	2.29	178.32	#N/A	45	86.74	#N/A	#N/A	37.87	3.63	#N/A
11.68	24.3	1.04	-20.41	4.280	0.0450	0.526	0.208	0.317	1.70	41.31	42.76	50.0	74.95	4.37	-0.04	2.51	0.8	61.47	5	Sand mixtures - silty sand to sandy silt	43.0	15.4	1.0	0.32	822	1.30	2.69	2.07	172.68	#N/A	45	87.76	#N/A	#N/A	38.76	3.71	#N/A
11.745	24.3	1.02	-20.41	4.195	0.0450	0.529	0.210	0.318	1.70	41.31	42.76	50.0	74.72	4.29	-0.04	2.50	0.8	61.19	5	Sand mixtures - silty sand to sandy silt	42.8	15.3	1.0	0.32	839	1.32	2.62	1.99	170.29	#N/A	45	87.76	#N/A	#N/A	38.73	3.71	#N/A
11.811	21.4	0.95	-18.74	4.417	0.0450	0.531	0.213	0.319	1.70	36.43	37.71	50.0	65.51	4.53	-0.04	2.55	0.8	54.81	5	Sand mixtures - silty sand to sandy silt	37.3	13.7	1.0	0.32	822	1.29	2.48	1.93	167.13	#N/A	45	82.71	#N/A	#N/A	34.13	3.27	#N/A
11.877	15.6	0.81	-19.74	5.189	0.0450	0.534	0.215	0.320	1.70	26.58	27.51	50.0	47.20	5.37	-0.06	2.69	0.9	41.81	4	Silt mixtures - clayey silt to silty clay	26.6	10.5	1.0	0.32	743	1.16	2.25	1.93	163.23	#N/A	45	72.51	#N/A	#N/A	24.88	2.38	#N/A
11.942	13.0	0.67	-18.74	5.102	0.0450	0.537	0.217	0.321	1.70	22.18	22.96	50.0	38.99	5.32	-0.06	2.74	0.9	35.26	4	Silt mixtures - clayey silt to silty clay	21.5	8.8	1.0	0.32	760	1.18	1.88	1.58	150.32	#N/A	45	67.96	#N/A	#N/A	20.74	1.99	#N/A
12.008	11.0	0.57	-18.74	5.187	0.0450	0.540	0.219	0.322	1.70	18.75	19.41	50.0	32.60	5.45	-0.08	2.79	0.9	30.19	4	Silt mixtures - clayey silt to silty clay	17.7	7.5	1.0	0.32	758	1.18	1.65	1.40	142.12	#N/A	45	64.41	#N/A	#N/A	17.52	1.68	#N/A
12.073	9.6	0.41	-18.74	4.233	0.0450	0.543	0.221	0.323	1.70	16.29	16.86	50.0	28.02	4.49	-0.09	2.78	0.9	25.85	4	Silt mixtures - clayey silt to silty clay	14.6	6.5	1.0	0.32	871	1.35	1.16	0.86	119.70	#N/A	45	61.86	#N/A	#N/A	15.21	1.46	#N/A
12.139	9.3	0.32	-19.07	3.472	0.0450	0.546	0.223	0.324	1.70	15.79	16.34	50.0	27.02	3.69	-0.09	2.74	0.9	24.53	4	Silt mixtures - clayey silt to silty clay	13.6	6.1	1.0	0.32	963	1.49	0.90	0.61	105.84	#N/A	45	61.34	#N/A	#N/A	14.73	1.41	#N/A
12.205	10.2	0.25	-18.74	2.458	0.0450	0.549	0.225	0.324	1.70	17.26	17.87	50.0	29.61	2.60	-0.08	2.63	0.9	25.66	4	Silt mixtures - clayey silt to silty clay	14.4	6.4	1.0	0.32	1083	1.67	0.67	0.40	90.28	#N/A	45	62.87	#N/A	#N/A	16.09	1.54	#N/A
12.27	9.3	0.19	-18.74	2.015	0.0450	0.552	0.227	0.325	1.70	15.80	16.35	50.0	26.86	2.14	-0.09	2.62	0.9	23.15	4	Silt mixtures - clayey silt to silty clay	12.7	5.8	1.0	0.33	1140	1.75	0.50	0.28	79.16	#N/A	45	61.35	0.07	0.07	14.71	1.41	0.05
12.336	9.6	0.14	-18.74	1.411	0.0450	0.555	0.229	0.326	1.70	16.29	16.86	20.0	27.67	1.50	-0.09	2.53	0.8	23.01	5	Sand mixtures - silty sand to sandy silt	12.6	5.8	1.0	0.33	1214	1.86	0.34	0.19	67.06	0.14	19.5	36.36	0.04	0.04	15.16	1.45	0.05

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

s_u/s_r < 1 (Strength Loss)

FC%	Δqc1n-Sr
0	10.00
10	10.00
25	25.00
50	45.00
75	55.00
100	55.00

2011 CPT Data from ConeTec					CPT Data Interpretations															Free Field Strength Estimates																		
																				Robertson (2010a)								Robertson (2010b)		Idriss & Boulanger (2008)				Olson & Stark (2003)		
																Using Qtn for calculating Ic (iterations)								Peak Strengths						Cyclic Softening Strengths		Liquefied Strengths						
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	OCR	OCR	Selected	$\sigma_{v'}$	s_r	$s_r/\sigma_{v'}$	s_r/s_u	$s_{r,LIQ}$	$s_{r,LIQ}/\sigma_{v'}$	s_r/s_u	Fines	$\Delta qc1n_{cs,Sr}$	$s_{u,LIQ}/\sigma_v'$	$s_{u,LIQ}/\sigma_v'$	qc1	qc1	$s_{u,LIQ}/\sigma_v'$
12.402	9.0	0.16	-18.74	1.733	0.0450	0.558	0.231	0.327	1.70	15.30	15.84	50.0	25.81	1.85	-0.10	2.59	0.9	22.07	5	Sand mixtures - silty sand to sandy silt	12.0	5.5	1.0	0.33	1185	1.81	0.41	0.23	72.66	0.60	45	60.84	0.07	0.07	14.23	1.36	0.05
12.467	10.7	0.10	-18.40	0.968	0.0450	0.561	0.233	0.328	1.70	18.26	18.90	20.0	31.03	1.02	-0.08	2.41	0.8	24.65	5	Sand mixtures - silty sand to sandy silt	13.7	6.2	1.0	0.33	1278	1.95	0.25	0.13	58.49	0.08	19.5	38.40	0.04	0.04	16.97	1.63	0.05
12.533	11.6	0.14	-18.74	1.166	0.0450	0.564	0.235	0.329	1.70	19.72	20.41	20.0	33.55	1.23	-0.07	2.43	0.8	26.79	5	Sand mixtures - silty sand to sandy silt	15.2	6.7	1.0	0.33	1263	1.92	0.33	0.17	64.77	0.12	19.5	39.91	0.04	0.04	18.31	1.75	0.06
12.598	12.8	0.21	-18.40	1.629	0.0450	0.567	0.237	0.330	1.70	21.71	22.47	50.0	36.99	1.70	-0.07	2.47	0.8	30.04	5	Sand mixtures - silty sand to sandy silt	17.6	7.5	1.0	0.33	1219	1.85	0.51	0.28	78.04	0.64	45	67.47	0.07	0.08	20.14	1.93	0.06
12.664	15.6	0.25	-19.41	1.596	0.0450	0.570	0.239	0.331	1.70	26.58	27.52	50.0	45.55	1.66	-0.06	2.39	0.8	35.97	5	Sand mixtures - silty sand to sandy silt	22.0	9.0	1.0	0.33	1230	1.86	0.60	0.32	82.41	#N/A	45	72.52	#N/A	#N/A	24.64	2.36	#N/A
12.73	11.3	0.23	-23.76	2.033	0.0450	0.573	0.241	0.332	1.70	19.13	19.80	50.0	32.20	2.14	-0.09	2.56	0.8	27.20	5	Sand mixtures - silty sand to sandy silt	15.5	6.8	1.0	0.33	1189	1.79	0.58	0.33	83.90	0.62	45	64.80	0.07	0.07	17.72	1.70	0.05
12.795	10.4	0.25	-24.43	2.407	0.0450	0.576	0.243	0.333	1.70	17.63	18.25	50.0	29.45	2.55	-0.10	2.63	0.9	25.58	4	Silt mixtures - clayey silt to silty clay	14.4	6.4	1.0	0.33	1154	1.74	0.65	0.38	89.30	#N/A	45	63.25	0.07	0.07	16.31	1.56	0.05
12.861	9.5	0.24	-24.76	2.517	0.0450	0.579	0.245	0.333	1.70	16.16	16.72	50.0	26.76	2.68	-0.11	2.67	0.9	23.64	4	Silt mixtures - clayey silt to silty clay	13.0	5.9	1.0	0.33	1149	1.72	0.63	0.37	88.89	#N/A	45	61.72	0.07	0.07	14.94	1.43	0.05
12.927	8.6	0.20	-24.43	2.286	0.0450	0.582	0.247	0.334	1.70	14.70	15.21	50.0	24.11	2.45	-0.13	2.68	0.9	21.40	4	Silt mixtures - clayey silt to silty clay	11.5	5.3	1.0	0.33	1182	1.77	0.52	0.30	82.03	#N/A	45	60.21	0.07	0.07	13.58	1.30	0.05
12.992	7.5	0.15	-24.76	1.948	0.0450	0.585	0.249	0.335	1.70	12.71	13.16	50.0	20.55	2.11	-0.15	2.69	0.9	18.36	4	Silt mixtures - clayey silt to silty clay	9.5	4.6	1.0	0.34	1227	1.83	0.39	0.21	72.47	#N/A	45	58.16	0.06	0.06	11.73	1.12	0.05
13.058	8.4	-0.03	-24.43	-0.373	0.0450	0.588	0.251	0.336	1.70	14.20	14.70	20.0	23.10	-0.40	-0.13	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	1.0	0.34	1492	2.22	#NUM!	#NUM!	#NUM!	#NUM!	19.5	34.20	#NUM!	#NUM!	13.10	1.25	#NUM!
13.123	7.8	0.05	-24.76	0.670	0.0450	0.591	0.253	0.337	1.70	13.20	13.67	20.0	21.29	0.72	-0.14	2.48	0.8	17.45	5	Sand mixtures - silty sand to sandy silt	8.9	4.4	1.0	0.34	1384	2.05	0.13	0.06	46.26	0.05	19.5	33.17	0.04	0.04	12.17	1.17	0.05
13.189	7.5	0.06	-24.43	0.834	0.0450	0.594	0.255	0.338	1.70	12.72	13.16	20.0	20.37	0.91	-0.15	2.53	0.8	17.06	5	Sand mixtures - silty sand to sandy silt	8.7	4.3	1.0	0.34	1373	2.03	0.15	0.08	49.78	0.06	19.5	32.66	0.04	0.04	11.71	1.12	0.05
13.255	7.8	0.08	-20.75	1.064	0.0450	0.596	0.258	0.339	1.70	13.29	13.76	20.0	21.31	1.15	-0.13	2.56	0.8	18.06	5	Sand mixtures - silty sand to sandy silt	9.3	4.5	1.0	0.34	1355	2.00	0.21	0.10	55.56	0.07	19.5	33.26	0.04	0.04	12.23	1.17	0.05
13.32	8.4	0.09	-20.75	1.114	0.0450	0.599	0.260	0.340	1.70	14.28	14.79	20.0	22.96	1.20	-0.12	2.54	0.8	19.34	5	Sand mixtures - silty sand to sandy silt	10.1	4.8	1.0	0.34	1356	2.00	0.23	0.12	57.69	0.08	19.5	34.29	0.04	0.04	13.13	1.26	0.05
13.386	8.4	0.09	-20.75	1.114	0.0450	0.602	0.262	0.341	1.70	14.28	14.79	20.0	22.89	1.20	-0.12	2.54	0.8	19.30	5	Sand mixtures - silty sand to sandy silt	10.1	4.8	1.0	0.34	1364	2.00	0.23	0.12	57.66	0.08	19.5	34.29	0.04	0.04	13.12	1.26	0.05
13.451	9.0	0.09	-20.41	1.043	0.0450	0.605	0.264	0.342	1.70	15.26	15.80	20.0	24.51	1.12	-0.11	2.51	0.8	20.38	5	Sand mixtures - silty sand to sandy silt	10.8	5.1	1.0	0.34	1379	2.02	0.23	0.11	56.99	0.08	19.5	35.30	0.04	0.04	14.01	1.34	0.05
13.517	9.3	0.10	-20.41	1.122	0.0450	0.608	0.266	0.343	1.70	15.76	16.31	20.0	25.29	1.20	-0.10	2.51	0.8	21.06	5	Sand mixtures - silty sand to sandy silt	11.3	5.3	1.0	0.34	1377	2.01	0.25	0.13	59.30	0.09	19.5	35.81	0.04	0.04	14.45	1.38	0.05
13.583	9.0	0.07	-20.08	0.810	0.0450	0.611	0.268	0.343	1.70	15.27	15.81	20.0	24.37	0.87	-0.11	2.46	0.8	19.93	5	Sand mixtures - silty sand to sandy silt	10.5	5.0	1.0	0.34	1419	2.07	0.17	0.08	51.37	0.06	19.5	35.31	0.04	0.04	13.99	1.34	0.05
13.648	8.1	0.07	-20.08	0.897	0.0450	0.614	0.270	0.344	1.70	13.80	14.29	20.0	21.80	0.97	-0.12	2.52	0.8	18.23	5	Sand mixtures - silty sand to sandy silt	9.4	4.6	1.0	0.34	1417	2.06	0.18	0.09	52.09	0.06	19.5	33.79	0.04	0.04	12.64	1.21	0.05
13.714	8.4	0.07	-20.08	0.866	0.0450	0.617	0.272	0.345	1.70	14.30	14.80	20.0	22.57	0.93	-0.12	2.50	0.8	18.75	5	Sand mixtures - silty sand to sandy silt	9.8	4.7	1.0	0.35	1428	2.07	0.18	0.08	51.80	0.06	19.5	34.30	0.04	0.04	13.08	1.25	0.05
13.78	9.6	0.07	-20.08	0.761	0.0450	0.620	0.274	0.346	1.70	16.26	16.83	20.0	25.84	0.81	-0.10	2.43	0.8	20.90	5	Sand mixtures - silty sand to sandy silt	11.2	5.2	1.0	0.35	1446	2.09	0.17	0.08	50.89	0.06	19.5	36.33	0.04	0.04	14.86	1.42	0.05
13.845	7.8	0.06	-20.08	0.797	0.0450	0.623	0.276	0.347	1.70	13.31	13.78	20.0	20.76	0.87	-0.13	2.51	0.8	17.36	5	Sand mixtures - silty sand to sandy silt	8.9	4.3	1.0	0.35	1450	2.09	0.15	0.07	49.21	0.06	19.5	33.28	0.04	0.04	12.15	1.16	0.05
13.911	7.0	0.05	-19.74	0.746	0.0450	0.626	0.278	0.348	1.70	11.85	12.26	20.0	18.23	0.82	-0.14	2.55	0.8	15.46	5	Sand mixtures - silty sand to sandy silt	7.7	3.9	1.0	0.35	1463	2.10	0.13	0.06	46.65	0.05	19.5	31.76	0.03	0.03	10.81	1.04	0.04
13.976	6.7	0.03	-19.74	0.467	0.0450	0.629	0.280	0.349	1.70	11.35	11.75	20.0	17.34	0.52	-0.15	2.49	0.8	14.40	5	Sand mixtures - silty sand to sandy silt	7.0	3.6	1.0	0.35	1501	2.15	0.07	0.03	39.33	0.04	19.5	31.25	0.03	0.03	10.35	0.99	0.04
14.042	7.8	0.03	-19.41	0.398	0.0450	0.632	0.282	0.350	1.70	13.32	13.79	20.0	20.60	0.43	-0.12	2.41	0.8	16.57	5	Sand mixtures - silty sand to sandy silt	8.4	4.1	1.0	0.35	1516	2.17	0.07	0.03	38.87	0.04	19.5	33.29	0.04	0.04	12.14	1.16	0.05
14.108	8.4	0.04	-19.41	0.494	0.0450	0.635	0.284	0.351	1.70	14.31	14.82	20.0	22.20	0.53	-0.11	2.41	0.8	17.89	5	Sand mixtures - silty sand to sandy silt	9.2	4.5	1.0	0.35	1513	2.16	0.10	0.04	42.22	0.05	19.5	34.32	0.04	0.04	13.03	1.25	0.05
14.173	9.0	0.04	-19.41	0.463	0.0450	0.638	0.286	0.352	1.70	15.29	15.82	20.0	23.76	0.50	-0.11	2.38	0.8	18.91	5	Sand mixtures - silty sand to sandy silt	9.9	4.7	1.0	0.35	1523	2.17	0.09	0.04	42.02	0.05	19.5	35.32	0.04	0.04	13.90	1.33	0.05
14.239	9.9	0.04	-19.07	0.422	0.0450	0.641	0.288	0.352	1.70	16.78	17.37	20.0	26.18	0.45	-0.10	2.33	0.8	20.46	5	Sand mixtures - silty sand to sandy silt	10.9	5.1	1.0	0.35	1535	2.18	0.09	0.04	41.87	0.05	19.5	36.87	0.04	0.04	15.25	1.46	0.05
14.304	9.6	0.03	-19.07	0.326	0.0450	0.644	0.290	0.353	1.70	16.28	16.86	20.0	25.28	0.35	-0.10	2.31	0.7	19.61	5	Sand mixtures - silty sand to sandy silt	10.3	4.9	1.0	0.35	1553	2.20	0.07	0.03	38.68	0.04	19.5	36.36	0.04	0.04	14.79	1.42	0.05
14.37	9.9	0.03	-18.74	0.316	0.0450	0.647	0.292	0.354	1.70	16.79	17.38	20.0	26.04	0.34	-0.10	2.29	0.7	20.10	5	Sand mixtures - silty sand to sandy silt	10.6	5.0	1.0	0.35	1562	2.20	0.07	0.03	38.70	0.04	19.5	36.88	0.04	0.04	15.23	1.46	0.05
14.436	10.4	0.04	-18.74	0.398	0.0450	0.650	0.294	0.355	1.70	17.76	18.38	20.0	27.58	0.42	-0.09	2.30	0.7	21.38	5	Sand mixtures - silty sand to sandy silt	11.5	5.3	1.0	0.36	1560	2.20	0.09	0.04	41.79	0.05	19.5	37.88	0.04	0.04	16.10	1.54	0.05
14.501	10.2	0.04	-18.40	0.409	0.0450	0.653	0.296	0.356	1.70	17.27	17.88	20.0	26.69	0.44	-0.09	2.32	0.8	20.83	5	Sand mixtures - silty sand to sandy silt	11.1	5.2	1.0	0.36	1566	2.20	0.09	0.04	41.77	0.05	19.5	37.38	0.04	0.04	15.65	1.50	0.05
14.567	10.2	0.05	-18.07	0.512	0.0450	0.656	0.298	0.357	1.70	17.28	17.89	20.0	26.63	0.55	-0.09	2.35	0.8	21.06	5	Sand mixtures - silty sand to sandy silt	11.3	5.3	1.0	0.36	1562	2.19	0.12	0.05	44.68	0.05	19.5	37.39	0.04	0.04	15.64	1.50	0.05
14.633	10.7	0.07	-18.07	0.677	0.0450	0.658	0.301	0.358	1.70	18.27	18.91	20.0	28.18	0.72	-0.09	2.38	0.8	22.52	5	Sand mixtures - silty sand to sandy silt	12.3	5.6	1.0	0.36	1551	2.17	0.16	0.08	49.94	0.06	19.5	38.41	0.04	0.04	16.52	1.58	0.05
14.698	11.9	0.08	-18.07	0.699	0.0450	0.661	0.303	0.359	1.70	20.23	20.94	20.0	31.32	0.74	-0.08	2.34	0.8	24.74	5	Sand mixtures - silty sand to sandy silt	13.8	6.2	1.0	0.36	1555	2.17	0.18	0.08	52.00	0.06	19.5	40.44	0.04	0.04	18.28	1.75	0.06
14.764	12.2	0.09	-17.73	0.767	0.0450	0.664	0.305	0.360	1.70	20.73	21.46	20.0	32.05	0.81	-0.07	2.35	0.8	25.42	5	Sand mixtures - silty sand to sandy silt	14.3	6.4	1.0	0.36	1555	2.16	0.21	0.10	54.21	0.07	19.5	40.96	0.04	0.04	18.72	1.79	0.06
14.829	11.9	0.09	-17.73	0.786	0.0450	0.667	0.307	0.361	1.70	20.24	20.95	20.0	31.16	0.83	-0.08	2.37	0.8	24.86	5	Sand mixtures - silty sand to sandy silt	13.9	6.2	1.0	0.36	1560	2.16	0.21	0.10	54.30	0.07	19.5	40.45	0.04	0.04	18.26	1.75	0.06
14.895	11.6	0.09	-17.07	0.805	0.0450	0.670	0.309	0.362	1.70	19.76	20.45	20.0	30.29	0.85	-0.08	2.38	0.8	24.31	5	Sand mixtures - silty sand to sandy silt	13.5	6.1	1.0	0.36	1566	2.16	0.21	0.10	54.39	0.07	19.5	39.95	0.04	0.04	17.81	1.71	0.05
14.961	12.8	0.11	-16.73	0.894	0.0450	0.673	0.311	0.362	1.70	21.74	22.51	20.0	33.43	0.94	-0.07	2.37	0.8	26.70	5	Sand mixtures - silty sand to sandy silt	15.2	6.7	1.0	0.36	1563	2.16	0.25	0.12	58.30	0.08	19.5	42.01	0.04	0.04	19.59	1.88	0.06
15.026	13.9	0.11	-16.73	0.820	0.0450	0.676	0.313	0.363	1.70	23.71	24.54	20.0	36.52	0.86	-0.06	2.32	0.8	28.68	5	Sand mixtures - silty sand to sandy silt	16.6	7.2	1.0	0.36	1578	2.17	0.25	0.11	57.84	0.08	19.5	44.04	0.05	0.05	21.34	2.04	0.06
15.092	13.9	0.12	-16.40	0.895	0.0450	0.679	0.315	0.364	1.70	23.71	24.55	20.0	36.43	0.94	-0.06	2.34	0.8	28.82	5	Sand mixtures - silty sand to sandy silt	16.7	7.2	1.0	0.36	1577	2.17	0.27	0.13	59.83	0.09	19.5	44.05	0.05	0.05	21.33	2.04	0.06
15.157	12.8	0.11	-16.40	0.894	0.0450	0.682	0.317	0.365	1.70	21.75	22.52	20.0	33.17	0.94	-0.07	2.37	0.8	26.56	5	Sand mixtures - silty sand to sandy silt	15.1	6.6	1.0	0.37	1585	2.17	0.25	0.12	58.21	0.08	19.5	42.02	0.04	0.04	19.55	1.87	0.06
15.223	12.5	0.10	-16.06	0.831	0.0450	0.685	0.319	0.366	1.70	21.26	22.01	20.0	32.30	0.88	-0.07	2.36	0.8	25.83	5	Sand mixtures - silty sand to sandy silt	14.6	6.5	1.0	0.37	1599	2.18	0.23	0.10	56.13	0.07	19.5	41.51	0.04	0.04	19.10	1.83	0.06
15.289	12.5	0.10	-15.73	0.831	0.0450	0.688	0.321	0.367	1.70	21.27	22.02	20.0	32.22	0.88	-0.07	2.36	0.8	25.79	5	Sand mixtures - silty sand to sandy silt	14.5	6.4	1.0	0.37	1606	2.19	0.23	0.10	56.09	0.07	19.5	41.52	0.04	0.04	19.09	1.83	0.06
15.354	12.8	0.15	-15.39	1.137	0.0450	0.691	0.323	0.368	1.70	21.77	22.54	20.0	32.94	1.20	-0.07	2.42	0.8	26.91	5	Sand mixtures - silty sand to sandy silt	15.3	6.7	1.0	0.37	1580	2.15	0.32	0.15	64.35	0.12	19.5	42.04	0.04	0.04	19.52	1.87	0.06
15.42	14.0	0.15	-15.06	1.042	0.0450	0.694	0.325	0.369	1.70	23.74	24.58	20.0	35.99	1.10	-0.06	2.37	0.8	28.91	5	Sand mixtures - silty sand to sandy silt	16.8	7.2	1.0	0.37	1598	2.17	0.32	0.15	63.60	0.11	19.5	44.08	0.05	0.05	21.27	2.04	0.06
15.486	14.8	0.16	-15.06	1.052	0.0450	0.697	0.327	0.370	1.70	25.21	26.10	20.0	38.23	1.10	-0.06	2.35	0.8	30.52	5	Sand mixtures - silty sand to sandy silt	17.9	7.6	1.0	0.37	1604	2.17	0.34	0.16	65.03	0.12	19.5	45.60	0.05	0.05	22.57	2.16	0.06
15.551	16.3	0.17	-14.72	1.022	0.0450	0.700	0.329	0.371	1.70	27.68	28.65	20.0	42.04	1.07	-0.05	2.32	0.8	33.13	5	Sand mixtures - silty sand to sandy silt	19.9	8.3	1.0	0.37	1614	2.18	0.35	0.16	66.22	0.13	19.5	48.15	0.05	0.05	24.76	2.37	0.06
15.617	17.1	0.19	-14.39	1.092	0.0450	0.703	0.331	0.372	1.70	29.15	30.18	20.0	44.27	1.14	-0.05	2.31	0.8	34.86	5	Sand mixtures - silty sand to sandy silt	21.2	8.7	1.0	0.37	1614	2.17	0.40	0.18	69.28	0.19	19.5	49.68	0.05	0.05	26.06	2.50	0.07
15.682	17.7	0.21	-14.05	1.173	0.0450	0.706	0.333	0.372	1.70	30.15	31.21	20.0	45.73	1.22	-0.05	2.32	0.8	36.09	5	Sand mixtures - silty sand to sandy silt	22.1	9.0	1.0	0.37	1612	2.16	0.44	0.20	72.28	0.67	19.5	50.71	0.05	0.05	26.93	2.58	0.07
15.748	17.7	0.22	-13.72	1.231	0.0450	0.709	0.335	0.373	1.70	30.16	31.22	20.0	45.62	1.28	-0.04	2.33	0.8	36.18	5	Sand mixtures - silty sand to sandy silt	22.2	9.0	1.0	0.37	1613	2.16	0.46	0.21	73.82	0.67	19.5	50.72	0.05	0.05	26.91	2.58	0.07
15.814	17.2	0.26	-13.38	1.515	0.0450	0.712	0.337	0.374	1.70	29.17	30.20	50.0	43.96	1.58	-0.05	2.39	0.8	35.63	5	Sand mixtures - silty sand to sandy silt	21.8	8.9	1.0	0.37	1589	2.12	0.56	0.27	80.37	0.67	45	75.20	0.08	0.09	26.02	2.49	0.07
15.879	16.9	0.22	-13.38	1.294	0.0450	0.715	0.339	0.375	1.70	28.70	29.71	20.0	43.09	1.35	-0.05	2.36	0.8	34.58	5	Sand mixtures - silty sand to sandy silt	21.0	8.6	1.0	0.38	1621	2.16	0.47	0.22	74.14	0.67	19.5	49.21	0.05	0.05	25.57	2.45	0.07
15.945	16.6	0.21	-13.38	1.254	0.0450	0.718	0.341	0.376	1.70	28.20	29.19	20.0	42.21	1.31	-0.05	2.36	0.8	33.89	5	Sand mixtures - silty sand to sandy silt	20.4	8.5	1.0	0.38	1632	2.17	0.44	0.20	72.61	0.66	19.5	48.69	0.05	0.05	25.11	2.41	0.06
16.01	16.3	-0.05	-12.72	-0.319	0.0450	0.720	0.344	0.377	1.70	27.72	28.70	20.0	41.35	-0.33	-0.05	#####	###	#NUM!	####	#NUM!	#NUM!	#NUM!	1.0	0.38	1814	2.41	#NUM!	#NUM!	#NUM!	#NUM!	19.5	48.20	#NUM!	#NUM!	24.66	2.36	#NUM!
16.076	16.0	0.54	-12.72	3.377	0.0450	0.723	0.346	0.378	1.70	27.23	28.19	50.0	40.47	3.54	-0.05	2.61	0.9	35.61	4	Silt mixtures - clayey silt to silty clay	21.7	8.9	1.0	0.38	1411	1.87	1.26	0.67	120.50	#N/A	45	73.19	#N/A	#N/A	24.20	2.32	#N/A

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

s_u/s_r < 1 (Strength Loss)

FC%	Δqc1n-Sr
0	10.00
10	10.00
25	25.00
50	45.00
75	55.00
100	55.00

2011 CPT Data from ConeTec					CPT Data Interpretations																	Free Field Strength Estimates																	
																						Robertson (2010a)									Robertson (2010b)		Idriss & Boulanger (2008)				Olson & Stark (2003)		
																						Peak Strengths						Cyclic Softening Strengths			Liquefied Strengths								
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Using Qtn for calculating Ic (iterations) Qtn	SBTn	Soil Type	OCR	OCR	Selected	σ_{vc}'	s_u	s_u/σ_{vc}'	s_r/σ_v'	s_r/s_u	$Q_{tn,cs}$	$s_{u,LIQ}/\sigma_{vc}'$	Fines	$\Delta qc1n_{cs,Sr}$	$s_{u,LIQ}/\sigma_v'$	$s_{u,LIQ}/\sigma_v'$	qc1	qc1	$s_{u,LIQ}/\sigma_{vc}'$
16.142	14.0	0.56	-12.72	4.012	0.0450	0.726	0.348	0.379	1.70	23.80	24.63	50.0	35.04	4.23	-0.06	2.70	0.9	31.83	4	Silt mixtures - clayey silt to silty clay	18.9	8.0	1.0	0.38	1348	1.78	1.35	0.76	126.74	#N/A	45	69.63	#N/A	#N/A	21.14	2.02	#N/A
16.207	9.3	0.54	5.35	5.805	0.0450	0.729	0.350	0.380	#####	#NUM!	#NUM!	50.0	22.62	6.30	-0.02	2.93	1	22.31	4	Silt mixtures - clayey silt to silty clay	12.1	5.6	1.0	0.38	1156	1.52	1.41	0.92	133.55	#NUM!	45	#NUM!	#NUM!	#NUM!	14.06	1.35	#NUM!
16.273	19.5	0.54	-11.04	2.772	0.0450	0.732	0.352	0.381	1.70	33.17	34.34	50.0	49.34	2.88	-0.04	2.50	0.8	41.78	5	Sand mixtures - silty sand to sandy silt	26.6	10.4	1.0	0.38	1500	1.97	1.20	0.61	115.21	#N/A	45	79.34	#N/A	#N/A	29.41	2.82	#N/A
16.339	17.5	0.51	-10.37	2.913	0.0450	0.735	0.354	0.381	1.70	29.74	30.78	50.0	43.93	3.04	-0.04	2.55	0.8	37.85	5	Sand mixtures - silty sand to sandy silt	23.5	9.5	1.0	0.38	1492	1.96	1.15	0.59	113.90	#N/A	45	75.78	#N/A	#N/A	26.35	2.52	#N/A
16.404	16.9	0.43	-8.70	2.517	0.0450	0.738	0.356	0.382	1.70	28.80	29.82	50.0	42.38	2.63	-0.04	2.52	0.8	36.18	5	Sand mixtures - silty sand to sandy silt	22.2	9.0	1.0	0.38	1543	2.02	0.95	0.47	103.66	#N/A	45	74.82	#N/A	#N/A	25.50	2.44	#N/A
16.47	16.1	0.43	-8.03	2.652	0.0450	0.741	0.358	0.383	1.70	27.33	28.29	50.0	40.01	2.78	-0.04	2.55	0.8	34.55	5	Sand mixtures - silty sand to sandy silt	20.9	8.6	1.0	0.38	1535	2.00	0.96	0.48	104.74	#N/A	45	73.29	#N/A	#N/A	24.18	2.32	#N/A
16.535	14.9	0.30	-7.70	2.020	0.0450	0.744	0.360	0.384	1.70	25.38	26.27	50.0	36.92	2.13	-0.04	2.51	0.8	31.42	5	Sand mixtures - silty sand to sandy silt	18.6	7.9	1.0	0.38	1613	2.10	0.67	0.32	88.17	0.65	45	71.27	0.08	0.08	22.43	2.15	0.06
16.601	14.4	0.22	-7.03	1.520	0.0450	0.747	0.362	0.385	1.70	24.42	25.28	50.0	35.36	1.60	-0.04	2.46	0.8	29.56	5	Sand mixtures - silty sand to sandy silt	17.2	7.4	1.0	0.39	1676	2.18	0.47	0.22	75.45	0.64	45	70.28	0.08	0.08	21.57	2.07	0.06
16.67	13.8	0.22	-7.0	1.585	0.0450	0.750	0.364	0.386	1.70	23.43	24.25	50.0	33.76	1.68	-0.04	2.48	0.8	28.48	5	Sand mixtures - silty sand to sandy silt	16.4	7.1	1.0	0.39	1676	2.17	0.48	0.22	75.96	0.64	45	69.25	0.08	0.08	20.68	1.98	0.06
16.73	13.8	0.20	-6.4	1.433	0.0450	0.753	0.366	0.387	1.70	23.44	24.27	20.0	33.70	1.52	-0.04	2.46	0.8	28.22	5	Sand mixtures - silty sand to sandy silt	16.3	7.1	1.0	0.39	1700	2.20	0.43	0.19	72.34	0.64	19.5	43.77	0.05	0.05	20.68	1.98	0.06
16.80	13.2	0.19	-6.0	1.417	0.0450	0.756	0.368	0.388	1.70	22.46	23.25	20.0	32.12	1.50	-0.04	2.47	0.8	27.04	5	Sand mixtures - silty sand to sandy silt	15.4	6.8	1.0	0.39	1709	2.20	0.41	0.18	70.98	0.63	19.5	42.75	0.05	0.05	19.79	1.90	0.06
16.86	13.5	0.11	-6.0	0.847	0.0450	0.759	0.370	0.389	1.70	22.96	23.76	20.0	32.79	0.90	-0.04	2.36	0.8	26.56	5	Sand mixtures - silty sand to sandy silt	15.1	6.6	1.0	0.39	1780	2.29	0.24	0.10	57.10	0.08	19.5	43.26	0.05	0.05	20.21	1.94	0.06
16.93	13.8	0.11	-5.4	0.829	0.0450	0.762	0.372	0.390	1.70	23.47	24.29	20.0	33.47	0.88	-0.04	2.35	0.8	27.02	5	Sand mixtures - silty sand to sandy silt	15.4	6.8	1.0	0.39	1789	2.30	0.24	0.10	56.96	0.08	19.5	43.79	0.05	0.05	20.65	1.98	0.06
16.99	14.1	0.11	-4.7	0.811	0.0450	0.765	0.374	0.391	1.70	23.98	24.82	20.0	34.16	0.86	-0.04	2.34	0.8	27.48	5	Sand mixtures - silty sand to sandy silt	15.7	6.9	1.0	0.39	1798	2.30	0.24	0.10	56.84	0.08	19.5	44.32	0.05	0.05	21.08	2.02	0.06
17.06	13.8	0.12	-3.7	0.903	0.0450	0.768	0.376	0.391	1.70	23.50	24.33	20.0	33.36	0.96	-0.04	2.36	0.8	27.12	5	Sand mixtures - silty sand to sandy silt	15.5	6.8	1.0	0.39	1795	2.29	0.26	0.11	58.90	0.08	19.5	43.83	0.05	0.05	20.65	1.98	0.06
17.13	13.5	0.14	-3.7	0.999	0.0450	0.771	0.378	0.392	1.70	23.01	23.82	20.0	32.53	1.06	-0.04	2.39	0.8	26.73	5	Sand mixtures - silty sand to sandy silt	15.2	6.7	1.0	0.39	1792	2.28	0.28	0.12	60.99	0.09	19.5	43.32	0.05	0.05	20.20	1.93	0.06
17.19	14.4	0.16	-3.7	1.083	0.0450	0.774	0.380	0.393	1.70	24.49	25.36	20.0	34.67	1.14	-0.04	2.39	0.8	28.45	5	Sand mixtures - silty sand to sandy silt	16.4	7.1	1.0	0.39	1790	2.28	0.33	0.14	64.31	0.12	19.5	44.86	0.05	0.05	21.48	2.06	0.06
17.26	13.8	0.15	-3.0	1.052	0.0450	0.777	0.382	0.394	1.70	23.52	24.35	20.0	33.13	1.12	-0.04	2.40	0.8	27.28	5	Sand mixtures - silty sand to sandy silt	15.6	6.8	1.0	0.39	1801	2.28	0.30	0.13	62.71	0.10	19.5	43.85	0.05	0.05	20.61	1.97	0.06
17.32	13.8	0.16	-2.3	1.127	0.0450	0.780	0.384	0.395	1.70	23.53	24.36	20.0	33.07	1.19	-0.04	2.41	0.8	27.38	5	Sand mixtures - silty sand to sandy silt	15.7	6.8	1.0	0.40	1800	2.28	0.33	0.14	64.58	0.12	19.5	43.86	0.05	0.05	20.61	1.97	0.06
17.39	13.3	0.17	-2.3	1.255	0.0450	0.782	0.387	0.396	1.70	22.54	23.34	20.0	31.51	1.33	-0.04	2.45	0.8	26.46	5	Sand mixtures - silty sand to sandy silt	15.0	6.6	1.0	0.40	1793	2.26	0.35	0.16	66.85	0.14	19.5	42.84	0.05	0.05	19.73	1.89	0.06
17.45	12.4	0.10	-2.0	0.839	0.0450	0.785	0.389	0.397	1.70	21.08	21.82	20.0	29.27	0.90	-0.04	2.39	0.8	24.12	5	Sand mixtures - silty sand to sandy silt	13.4	6.0	1.0	0.40	1846	2.33	0.22	0.09	55.20	0.07	19.5	41.32	0.04	0.04	18.44	1.77	0.06
17.52	12.1	0.09	-1.3	0.772	0.0450	0.788	0.391	0.398	1.70	20.60	21.33	20.0	28.49	0.83	-0.04	2.39	0.8	23.44	5	Sand mixtures - silty sand to sandy silt	12.9	5.9	1.0	0.40	1861	2.34	0.19	0.08	53.08	0.07	19.5	40.83	0.04	0.04	18.00	1.72	0.05
17.59	12.4	0.07	-1.0	0.586	0.0450	0.791	0.393	0.399	1.70	21.11	21.85	20.0	29.16	0.63	-0.04	2.33	0.8	23.55	5	Sand mixtures - silty sand to sandy silt	13.0	5.9	1.0	0.40	1889	2.37	0.15	0.06	48.37	0.06	19.5	41.35	0.04	0.04	18.43	1.77	0.06
17.65	11.6	0.06	-0.3	0.540	0.0450	0.794	0.395	0.400	1.70	19.65	20.34	20.0	26.94	0.58	-0.04	2.35	0.8	21.88	5	Sand mixtures - silty sand to sandy silt	11.8	5.5	1.0	0.40	1901	2.38	0.13	0.05	46.06	0.05	19.5	39.84	0.04	0.04	17.15	1.64	0.05
17.72	11.6	0.04	0.3	0.360	0.0450	0.797	0.397	0.400	1.70	19.67	20.36	20.0	26.90	0.39	-0.04	2.29	0.7	21.43	5	Sand mixtures - silty sand to sandy silt	11.5	5.4	1.0	0.40	1929	2.41	0.08	0.03	40.82	0.05	19.5	39.86	0.04	0.04	17.15	1.64	0.05
17.78	11.6	0.05	0.7	0.449	0.0450	0.800	0.399	0.401	1.70	19.68	20.37	20.0	26.84	0.48	-0.04	2.32	0.8	21.63	5	Sand mixtures - silty sand to sandy silt	11.7	5.4	1.0	0.40	1926	2.40	0.10	0.04	43.45	0.05	19.5	39.87	0.04	0.04	17.14	1.64	0.05
17.85	12.2	0.07	1.3	0.599	0.0450	0.803	0.401	0.402	1.70	20.66	21.39	20.0	28.22	0.64	-0.03	2.35	0.8	22.96	5	Sand mixtures - silty sand to sandy silt	12.6	5.7	1.0	0.40	1917	2.38	0.15	0.06	48.32	0.06	19.5	40.89	0.04	0.04	17.98	1.72	0.05
17.91	12.7	0.08	1.3	0.653	FALSE	0.806	0.403	0.403	1.70	21.65	22.41	20.0	29.59	0.70	-0.03	2.34	0.8	24.07	5	Sand mixtures - silty sand to sandy silt	13.3	6.0	1.0	0.40	1918	2.38	0.17	0.07	50.47	0.06	19.5	41.91	0.04	0.04	18.83	1.80	0.06
17.98	13.0	0.08	2.0	0.638	FALSE	0.809	0.405	0.404	1.70	22.16	22.94	20.0	30.26	0.68	-0.03	2.33	0.8	24.53	5	Sand mixtures - silty sand to sandy silt	13.6	6.1	1.0	0.40	1927	2.38	0.17	0.07	50.39	0.06	19.5	42.44	0.05	0.05	19.26	1.85	0.06
18.04	12.8	0.07	2.7	0.571	0.0450	0.812	0.407	0.405	1.70	21.68	22.45	20.0	29.49	0.61	-0.03	2.32	0.8	23.84	5	Sand mixtures - silty sand to sandy silt	13.2	6.0	1.0	0.41	1942	2.40	0.15	0.06	48.15	0.06	19.5	41.95	0.04	0.04	18.83	1.80	0.06
18.11	13.1	0.08	3.3	0.637	FALSE	0.815	0.409	0.406	1.70	22.19	22.97	20.0	30.15	0.68	-0.02	2.33	0.8	24.48	5	Sand mixtures - silty sand to sandy silt	13.6	6.1	1.0	0.41	1941	2.39	0.17	0.07	50.33	0.06	19.5	42.47	0.05	0.05	19.26	1.84	0.06
18.18	12.8	0.07	4.0	0.570	0.0450	0.818	0.411	0.407	1.70	21.71	22.48	20.0	29.38	0.61	-0.02	2.32	0.8	23.79	5	Sand mixtures - silty sand to sandy silt	13.1	5.9	1.0	0.41	1956	2.40	0.14	0.06	48.10	0.06	19.5	41.98	0.04	0.04	18.83	1.80	0.06
18.24	13.4	0.08	4.7	0.623	FALSE	0.821	0.413	0.408	1.70	22.70	23.50	20.0	30.74	0.66	-0.02	2.32	0.8	24.89	5	Sand mixtures - silty sand to sandy silt	13.9	6.2	1.0	0.41	1958	2.40	0.17	0.07	50.23	0.06	19.5	43.00	0.05	0.05	19.67	1.88	0.06
18.31	14.2	0.04	5.4	0.292	0.0450	0.824	0.415	0.409	1.70	24.20	25.05	20.0	32.82	0.31	-0.02	2.18	0.7	25.42	5	Sand mixtures - silty sand to sandy silt	14.3	6.4	1.0	0.41	2002	2.45	0.08	0.03	41.40	0.05	19.5	44.55	0.05	0.05	20.95	2.01	0.06
18.37	15.1	0.03	6.4	0.206	0.0450	0.827	0.417	0.410	1.70	25.69	26.59	20.0	34.88	0.22	-0.02	2.12	0.7	26.50	5	Sand mixtures - silty sand to sandy silt	15.0	6.6	1.0	0.41	2018	2.46	0.06	0.02	39.63	0.04	19.5	46.09	0.05	0.05	22.22	2.13	0.06
18.44	14.5	0.03	6.4	0.215	0.0450	0.830	0.419	0.410	1.70	24.72	25.59	20.0	33.40	0.23	-0.02	2.14	0.7	25.56	5	Sand mixtures - silty sand to sandy silt	14.4	6.4	1.0	0.41	2025	2.47	0.06	0.02	39.24	0.04	19.5	45.09	0.05	0.05	21.37	2.05	0.06
18.50	13.4	0.02	6.7	0.155	0.0450	0.833	0.421	0.411	1.70	22.74	23.54	20.0	30.50	0.17	-0.02	2.15	0.7	23.39	5	Sand mixtures - silty sand to sandy silt	12.9	5.8	1.0	0.41	2039	2.48	0.04	0.02	36.15	0.04	19.5	43.04	0.05	0.05	19.65	1.88	0.06
18.57	12.8	0.01	7.7	0.081	0.0450	0.836	0.423	0.412	1.70	21.79	22.56	20.0	29.07	0.09	-0.02	2.13	0.7	22.19	5	Sand mixtures - silty sand to sandy silt	12.0	5.5	1.0	0.41	2054	2.49	0.02	0.01	33.53	0.04	19.5	42.06	0.04	0.04	18.81	1.80	0.06
18.64	13.1	0.04	9.0	0.317	0.0450	0.839	0.425	0.413	1.70	22.32	23.10	20.0	29.75	0.34	-0.01	2.23	0.7	23.47	5	Sand mixtures - silty sand to sandy silt	12.9	5.9	1.0	0.41	2035	2.46	0.08	0.03	40.87	0.05	19.5	42.60	0.05	0.05	19.25	1.84	0.06
18.70	14.6	0.07	9.7	0.499	0.0450	0.842	0.427	0.414	1.70	24.79	25.66	20.0	33.19	0.53	-0.01	2.26	0.7	26.42	5	Sand mixtures - silty sand to sandy silt	15.0	6.6	1.0	0.41	2022	2.44	0.14	0.06	47.90	0.06	19.5	45.16	0.05	0.05	21.36	2.05	0.06
18.77	16.3	0.09	11.0	0.573	0.0450	0.844	0.430	0.415	1.70	27.76	28.73	20.0	37.31	0.60	-0.01	2.24	0.7	29.54	5	Sand mixtures - silty sand to sandy silt	17.2	7.4	1.0	0.41	2021	2.44	0.18	0.07	52.00	0.06	19.5	48.23	0.05	0.05	23.90	2.29	0.06
18.83	18.1	0.08	13.1	0.460	0.0450	0.847	0.432	0.416	1.70	30.75	31.84	20.0	41.46	0.48	0.00	2.16	0.7	32.07	5	Sand mixtures - silty sand to sandy silt	19.1	8.0	1.0	0.42	2041	2.45	0.15	0.06	50.61	0.06	19.5	51.34	0.05	0.06	26.46	2.54	0.07
18.90	19.3	0.12	13.7	0.648	0.0450	0.850	0.434	0.417	1.70	32.73	33.88	20.0	44.15	0.68	0.00	2.20	0.7	34.58	5	Sand mixtures - silty sand to sandy silt	21.0	8.6	1.0	0.42	2028	2.43	0.23	0.10	57.54	0.08	19.5	53.38	0.06	0.06	28.14	2.70	0.07
18.96	19.9	0.17	15.4	0.838	0.0450	0.853	0.436	0.418	1.70	33.76	34.95	20.0	45.50	0.88	0.00	2.24	0.7	36.11	5	Sand mixtures - silty sand to sandy silt	22.1	9.0	1.0	0.42	2014	2.41	0.32	0.13	63.72	0.11	19.5	54.45	0.06	0.06	29.00	2.78	0.07
19.03	22.5	0.19	16.7	0.833	0.0450	0.856	0.438	0.419	1.70	38.21	39.55	20.0	51.65	0.87	0.00	2.19	0.7	40.44	5	Sand mixtures - silty sand to sandy silt	25.5	10.1	1.0	0.42	2022	2.41	0.35	0.14	66.76	0.14	19.5	59.05	0.06	0.06	32.80	3.14	0.07
19.09	22.8	0.54	18.4	2.373	0.0450	0.859	0.440	0.420	1.70	38.74	40.10	50.0	52.27	2.47	0.01	2.43	0.8	44.22	5	Sand mixtures - silty sand to sandy silt	28.5	11.1	1.0	0.42	1858	2.21	1.09	0.49	108.73	#N/A	45	85.10	#N/A	#N/A	33.23	3.18	#N/A
19.16	22.5	0.67	19.4	2.957	0.0450	0.862	0.442	0.420	1.70	38.27	39.61	50.0	51.49	3.07	0.01	2.50	0.8	44.45	5	Sand mixtures - silty sand to sandy silt	28.7	11.1	1.0	0.42	1800	2.14	1.37	0.64	122.46	#N/A	45	84.61	#N/A	#N/A	32.80	3.14	#N/A
19.23	15.6	0.75	18.4	4.812	0.0450	0.865	0.444	0.421	1.70	26.45	27.38	50.0	34.88	5.10	0.01	2.75	0.9	32.59	4	Silt mixtures - clayey silt to silty clay	19.5	8.1	1.0	0.42	1601	1.90	1.66	0.87	141.70	#N/A	45	72.38	#N/A	#N/A	22.66	2.17	#N/A
19.29	28.3	0.72	-0.7	2.535	0.0450	0.868	0.446	0.422	1.70	48.06	49.75	50.0	65.00	2.61	-0.02	2.39	0.8	54.22	5	Sand mixtures - silty sand to sandy silt	36.8	13.6	1.0	0.42	1862	2.20	1.42	0.64	122.39	#N/A	45	94.75	#N/A	#N/A	41.19	3.95	#N/A
19.36	24.0	0.62	-2.7	2.605	0.0450	0.871	0.448	0.423	1.70	40.73	42.16	50.0	54.56	2.70	-0.02	2.45	0.8	46.40	5	Sand mixtures - silty sand to sandy silt	30.3	11.6	1.0	0.42	1861	2.20	1.25	0.57	116.39	#N/A	45	87.16	#N/A	#N/A	34.83	3.34	#N/A
19.42	23.1	0.60	-1.3	2.611	0.0450	0.874	0.450	0.424	1.70	39.27	40.66	50.0	52.42	2.71	-0.02	2.46	0.8	44.77	5	Sand mixtures - silty sand to sandy silt	29.0	11.2	1.0	0.42	1868	2.20	1.22	0.55	114.90	#N/A	45	85.66	#N/A	#N/A	33.56	3.22	#N/A
19.49	23.1	0.61	1.0	2.653	0.0450	0.877	0.452	0.425	1.70	39.33	40.71	50.0	52.37	2.76	-0.02	2.46	0.8	44.82	5	Sand mixtures - silty sand to sandy silt	29.0	11.2	1.0	0.42	1871	2.20	1.24	0.56	115.91	#N/A	45	85.71	#N/A	#N/A	33.58	3.22	#N/A
19.55	22.8	0.51	1.3	2.231	0.0450	0.880	0.454	0.426	1.70	38.84	40.20	50.0	51.58	2.32	-0.02	2.42	0.8	43.60	5	Sand mixtures - silty sand to sandy silt	28.0	10.9	1.0	0.43	1925	2.26	1.01	0.45	104.77	#N/A	45	85.20	#N/A	#N/A	33.14	3.17	#N/A
19.62	24.6	0.46	1.7	1.861	0.0450	0.883	0.456	0.427	1.70	41.80	43.27	50.0	55.55	1.93	-0.02	2.35	0.8	45.97	5	Sand mixtures - silty sand to sandy silt	29.9	11.5	1.0	0.43	1973	2.31	0.89	0.38	97.86	#N/A	45	88.27	#N/A	#N/A	35.64	3.41	#N/A
19.69	23.4	0.48	2.3	2.041	0.0450	0.886	0.458	0.428	1.70	39.85	41.25	50.0	52.74	2.12	-0.02	2.39	0.8	44.21	5	Sand mixtures - silty sand to sandy silt	28.5	11.1	1.0	0.43	1960	2.29	0.94	0.41	100.76	#N/A	45	86.25	#N/A	#N/A	33.95	3.25	#N/A
19.75	23.2	0.53	4.0	2.289	0.0450	0.889	0.460	0.429	1.70	39.39	40.78	50.0	52.00	2.38	-0.02	2.43	0.8	44.06	5	Sand mixtures - silty sand to sandy silt	28.4	11.0	1.0	0.43	1940	2.26	1.05	0.46	106.62	#N/A	45	85.78	#N/A	#N/A	33.54	3.21	#N/A
19.82	24.1	0.68	4.7	2.810	0.0450	0.892	0.462	0.429	1.70	40.89	42.33	50.0	53.93	2.92	-0.01	2.47	0.8	46.34	5	Sand mixtures - silty sand to sandy silt	30.2	11.6	1.0	0.43	1890	2.20	1.35	0.61	121.18	#N/A	45	87.33	#N/A	#N/A	34.79	3.33	#N/A

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

s_u/s_r < 1 (Strength Loss)

FC%	Δqc1n-Sr
0	10.00
10	10.00
25	25.00
50	45.00
75	55.00
100	55.00

2011 CPT Data from ConeTec					CPT Data Interpretations																	Free Field Strength Estimates																
																						Robertson (2010a)									Robertson (2010b)		Idriss & Boulanger (2008)			Olson & Stark (2003)		
																Using Qtn for calculating Ic (iterations)						Peak Strengths						Cyclic Softening Strengths			Liquefied Strengths						
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	OCR	OCR	Selected	$\sigma_{v'}$	s_u	$s_u/\sigma_{v'}$	$s_r/\sigma_{v'}$	s_r/s_u	$Q_{tn,cs}$	$s_{u,LIQ}/\sigma_{v'}$	Fines	$qc1n_{cs,Sr}$	$s_{u,LIQ}/\sigma_{v'}$	$s_{u,LIQ}/\sigma_{v'}$	qc1	qc1	$s_{u,LIQ}/\sigma_{v'}$
19.88	26.4	0.79	6.0	2.996	0.0450	0.895	0.464	0.430	1.70	44.72	46.29	50.0	59.22	3.10	-0.01	2.46	0.8	50.74	5	Sand mixtures - silty sand to sandy silt	33.9	12.7	1.0	0.43	1876	2.18	1.57	0.72	130.23	#N/A	45	91.29	#N/A	#N/A	38.12	3.65	#N/A
19.95	28.1	0.79	6.7	2.810	0.0450	0.898	0.466	0.431	1.68	47.23	48.89	50.0	63.13	2.90	-0.01	2.42	0.8	53.51	5	Sand mixtures - silty sand to sandy silt	36.2	13.4	1.0	0.43	1904	2.21	1.55	0.70	128.61	#N/A	45	93.89	#N/A	#N/A	40.62	3.89	#N/A
20.01	32.2	0.99	6.4	3.071	0.0450	0.901	0.468	0.432	1.65	53.02	54.88	50.0	72.35	3.16	-0.01	2.41	0.8	61.07	5	Sand mixtures - silty sand to sandy silt	42.7	15.3	1.0	0.43	1882	2.18	1.93	0.89	142.98	#N/A	45	99.88	#N/A	#N/A	46.42	4.45	#N/A
20.08	31.3	1.00	6.7	3.190	0.0450	0.904	0.470	0.433	1.65	51.71	53.53	50.0	70.18	3.28	-0.01	2.43	0.8	59.63	5	Sand mixtures - silty sand to sandy silt	41.4	14.9	1.0	0.43	1877	2.17	1.96	0.90	144.48	#N/A	45	98.53	#N/A	#N/A	45.13	4.32	#N/A
20.14	26.7	0.82	7.0	3.079	0.0450	0.906	0.473	0.434	1.68	44.95	46.53	50.0	59.40	3.19	-0.01	2.46	0.8	51.08	5	Sand mixtures - silty sand to sandy silt	34.1	12.8	1.0	0.43	1896	2.18	1.63	0.75	132.58	#N/A	45	91.53	#N/A	#N/A	38.45	3.68	#N/A
20.21	25.2	0.64	6.4	2.556	0.0450	0.909	0.475	0.435	1.69	42.75	44.26	50.0	55.92	2.65	-0.01	2.43	0.8	47.63	5	Sand mixtures - silty sand to sandy silt	31.3	11.9	1.0	0.43	1962	2.26	1.26	0.56	116.50	#N/A	45	89.26	#N/A	#N/A	36.33	3.48	#N/A
20.28	19.4	0.66	5.4	3.371	0.0450	0.912	0.477	0.436	1.70	33.04	34.20	50.0	42.50	3.54	-0.02	2.59	0.9	37.99	5	Sand mixtures - silty sand to sandy silt	23.6	9.5	1.0	0.44	1878	2.15	1.34	0.62	123.78	#N/A	45	79.20	#N/A	#N/A	27.96	2.68	#N/A
20.34	16.0	0.67	5.0	4.171	0.0450	0.915	0.479	0.437	1.70	27.13	28.08	50.0	34.44	4.43	-0.02	2.71	0.9	31.95	4	Silt mixtures - clayey silt to silty clay	19.0	8.0	1.0	0.44	1797	2.06	1.41	0.69	130.05	#N/A	45	73.08	#N/A	#N/A	22.94	2.20	#N/A
20.41	21.8	0.67	6.4	3.059	0.0450	0.918	0.481	0.438	1.70	36.99	38.29	50.0	47.62	3.19	-0.01	2.53	0.8	41.81	5	Sand mixtures - silty sand to sandy silt	26.6	10.5	1.0	0.44	1928	2.20	1.34	0.61	121.86	#N/A	45	83.29	#N/A	#N/A	31.25	2.99	#N/A
20.47	25.5	0.70	7.7	2.728	0.0450	0.921	0.483	0.439	1.68	43.00	44.52	50.0	56.14	2.83	-0.01	2.45	0.8	48.13	5	Sand mixtures - silty sand to sandy silt	31.7	12.0	1.0	0.44	1972	2.25	1.36	0.61	121.15	#N/A	45	89.52	#N/A	#N/A	36.66	3.51	#N/A
20.54	26.8	0.80	-6.7	2.988	0.0450	0.924	0.485	0.439	1.67	44.80	46.37	50.0	58.88	3.10	-0.03	2.46	0.8	50.67	5	Sand mixtures - silty sand to sandy silt	33.8	12.7	1.0	0.44	1950	2.22	1.57	0.71	130.00	#N/A	45	91.37	#N/A	#N/A	38.44	3.68	#N/A
20.60	24.2	0.85	-6.0	3.525	0.0450	0.927	0.487	0.440	1.69	40.91	42.35	50.0	52.84	3.67	-0.03	2.54	0.8	46.56	5	Sand mixtures - silty sand to sandy silt	30.4	11.6	1.0	0.44	1898	2.15	1.71	0.79	137.63	#N/A	45	87.35	#N/A	#N/A	34.68	3.32	#N/A
20.67	24.8	0.82	-5.4	3.315	0.0450	0.930	0.489	0.441	1.68	41.74	43.21	50.0	54.07	3.44	-0.03	2.51	0.8	47.32	5	Sand mixtures - silty sand to sandy silt	31.0	11.8	1.0	0.44	1928	2.19	1.63	0.75	133.86	#N/A	45	88.21	#N/A	#N/A	35.50	3.40	#N/A
20.73	25.1	0.90	-4.7	3.607	0.0450	0.933	0.491	0.442	1.68	42.13	43.61	50.0	54.63	3.75	-0.03	2.53	0.8	48.12	5	Sand mixtures - silty sand to sandy silt	31.7	12.0	1.0	0.44	1903	2.15	1.80	0.84	141.34	#N/A	45	88.61	#N/A	#N/A	35.90	3.44	#N/A
20.80	28.6	0.93	-4.0	3.241	0.0450	0.936	0.493	0.443	1.65	47.14	48.80	50.0	62.34	3.35	-0.02	2.46	0.8	53.83	5	Sand mixtures - silty sand to sandy silt	36.5	13.5	1.0	0.44	1951	2.20	1.80	0.82	139.50	#N/A	45	93.80	#N/A	#N/A	40.84	3.91	#N/A
20.87	38.1	0.88	-3.7	2.320	0.0450	0.939	0.495	0.444	1.59	60.54	62.67	50.0	83.70	2.38	-0.02	2.28	0.7	68.56	5	Sand mixtures - silty sand to sandy silt	49.3	17.1	1.0	0.44	2061	2.32	1.63	0.70	130.22	#N/A	45	107.67	#N/A	#N/A	54.45	5.22	#N/A
20.93	37.7	0.88	-10.0	2.343	0.0450	0.942	0.497	0.445	1.59	59.97	62.08	50.0	82.71	2.40	-0.02	2.29	0.7	67.90	5	Sand mixtures - silty sand to sandy silt	48.7	17.0	1.0	0.44	2065	2.32	1.63	0.70	130.24	#N/A	45	107.08	#N/A	#N/A	53.88	5.16	#N/A
21.00	29.9	1.07	-11.0	3.581	0.0450	0.945	0.499	0.446	1.64	48.92	50.65	50.0	64.98	3.70	-0.03	2.48	0.8	56.45	5	Sand mixtures - silty sand to sandy silt	38.7	14.1	1.0	0.45	1935	2.17	2.09	0.96	150.63	#N/A	45	95.65	#N/A	#N/A	42.68	4.09	#N/A
21.06	26.5	1.13	-10.7	4.285	0.0450	0.948	0.501	0.447	1.66	43.88	45.42	50.0	57.10	4.44	-0.03	2.57	0.9	50.93	5	Sand mixtures - silty sand to sandy silt	34.0	12.7	1.0	0.45	1864	2.09	2.26	1.08	159.88	#N/A	45	90.42	#N/A	#N/A	37.72	3.61	#N/A
21.13	36.6	1.25	-10.4	3.413	0.0450	0.951	0.503	0.448	1.59	58.17	60.22	50.0	79.57	3.50	-0.02	2.41	0.8	67.74	5	Sand mixtures - silty sand to sandy silt	48.6	16.9	1.0	0.45	1968	2.20	2.37	1.08	159.00	#N/A	45	105.22	#N/A	#N/A	52.10	4.99	#N/A
21.19	43.2	1.42	-11.0	3.297	0.0450	0.954	0.505	0.448	1.55	67.18	69.54	50.0	94.23	3.37	-0.02	2.35	0.8	78.93	5	Sand mixtures - silty sand to sandy silt	58.8	19.7	1.0	0.45	1989	2.22	2.66	1.20	167.67	#N/A	45	114.54	#N/A	#N/A	61.52	5.89	#N/A
21.26	43.7	1.02	-15.7	2.331	0.0450	0.957	0.507	0.449	1.55	67.79	70.18	50.0	95.17	2.38	-0.02	2.25	0.7	77.38	5	Sand mixtures - silty sand to sandy silt	57.4	19.3	1.0	0.45	2103	2.34	1.84	0.79	138.62	#N/A	45	115.18	#N/A	#N/A	62.21	5.96	#N/A
21.33	31.5	1.06	-20.1	3.364	0.0450	0.960	0.509	0.450	1.62	50.95	52.74	50.0	67.89	3.47	-0.04	2.45	0.8	58.56	5	Sand mixtures - silty sand to sandy silt	40.5	14.6	1.0	0.45	1996	2.22	2.03	0.92	147.75	#N/A	45	97.74	#N/A	#N/A	44.82	4.29	#N/A
21.39	25.2	1.00	-20.4	3.966	0.0450	0.963	0.511	0.451	1.66	41.76	43.23	50.0	53.65	4.12	-0.05	2.56	0.9	47.87	5	Sand mixtures - silty sand to sandy silt	31.5	12.0	1.0	0.45	1936	2.15	1.97	0.92	148.94	#N/A	45	88.23	#N/A	#N/A	35.76	3.43	#N/A
21.46	21.1	0.82	-19.7	3.889	0.0450	0.966	0.513	0.452	1.69	35.73	36.98	50.0	44.59	4.08	-0.06	2.61	0.9	40.36	4	Silt mixtures - clayey silt to silty clay	25.4	10.1	1.0	0.45	1952	2.16	1.64	0.76	137.35	#N/A	45	81.98	#N/A	#N/A	29.99	2.87	#N/A
21.52	22.0	0.73	-19.7	3.309	0.0450	0.969	0.515	0.453	1.68	36.99	38.29	50.0	46.42	3.46	-0.05	2.56	0.8	41.35	5	Sand mixtures - silty sand to sandy silt	26.2	10.3	1.0	0.45	2024	2.23	1.43	0.64	126.74	#N/A	45	83.29	#N/A	#N/A	31.20	2.99	#N/A
21.59	19.4	0.64	-19.7	3.324	0.0450	0.971	0.518	0.454	1.70	32.98	34.14	50.0	40.59	3.50	-0.06	2.60	0.9	36.61	5	Sand mixtures - silty sand to sandy silt	22.5	9.2	1.0	0.45	2029	2.24	1.28	0.57	121.18	#N/A	45	79.14	#N/A	#N/A	27.49	2.63	#N/A
21.65	18.0	0.55	-19.4	3.070	0.0450	0.974	0.520	0.455	1.70	30.53	31.60	50.0	37.34	3.25	-0.07	2.60	0.9	33.72	4	Silt mixtures - clayey silt to silty clay	20.3	8.4	1.0	0.45	2065	2.27	1.09	0.48	112.55	#N/A	45	76.60	#N/A	#N/A	25.43	2.44	#N/A
21.72	18.5	0.50	-19.4	2.694	0.0450	0.977	0.522	0.456	1.70	31.50	32.61	50.0	38.51	2.84	-0.06	2.56	0.8	34.36	5	Sand mixtures - silty sand to sandy silt	20.8	8.6	1.0	0.46	2114	2.32	0.98	0.42	105.76	#N/A	45	77.61	#N/A	#N/A	26.22	2.51	#N/A
21.78	16.5	0.46	-19.4	2.772	0.0450	0.980	0.524	0.457	1.70	28.07	29.06	50.0	34.01	2.95	-0.07	2.60	0.9	30.76	4	Silt mixtures - clayey silt to silty clay	18.1	7.7	1.0	0.46	2113	2.31	0.91	0.39	103.13	#N/A	45	74.06	#N/A	#N/A	23.35	2.24	#N/A
21.85	14.5	0.37	-19.4	2.585	0.0450	0.983	0.526	0.458	1.70	24.62	25.49	50.0	29.50	2.77	-0.08	2.63	0.9	26.90	4	Silt mixtures - clayey silt to silty clay	15.3	6.7	1.0	0.46	2141	2.34	0.75	0.32	94.95	#N/A	45	70.49	0.08	0.08	20.47	1.96	0.06
21.92	11.9	0.32	-19.4	2.713	0.0450	0.986	0.528	0.458	1.70	20.20	20.91	50.0	23.77	2.96	-0.10	2.71	0.9	22.19	4	Silt mixtures - clayey silt to silty clay	12.0	5.5	1.0	0.46	2134	2.33	0.66	0.28	91.11	#N/A	45	65.91	0.07	0.07	16.78	1.61	0.05
21.98	11.6	0.29	-19.1	2.511	0.0450	0.989	0.530	0.459	1.70	19.71	20.41	50.0	23.09	2.75	-0.11	2.71	0.9	21.51	4	Silt mixtures - clayey silt to silty clay	11.6	5.4	1.0	0.46	2163	2.35	0.59	0.25	86.81	#N/A	45	65.41	0.07	0.07	16.36	1.57	0.05
22.05	13.3	0.26	-19.1	1.950	0.0450	0.992	0.532	0.460	1.70	22.67	23.46	50.0	26.81	2.11	-0.09	2.59	0.9	24.21	5	Sand mixtures - silty sand to sandy silt	13.4	6.1	1.0	0.46	2233	2.43	0.51	0.21	79.81	0.63	45	68.46	0.08	0.08	18.80	1.80	0.06
22.11	14.5	0.27	-19.1	1.867	0.0450	0.995	0.534	0.461	1.70	24.63	25.49	50.0	29.26	2.00	-0.08	2.56	0.8	26.14	5	Sand mixtures - silty sand to sandy silt	14.8	6.5	1.0	0.46	2250	2.44	0.52	0.21	80.10	0.63	45	70.49	0.08	0.08	20.41	1.96	0.06
22.18	14.8	0.20	-18.7	1.337	0.0450	0.998	0.536	0.462	1.70	25.13	26.01	20.0	29.83	1.43	-0.08	2.47	0.8	26.05	5	Sand mixtures - silty sand to sandy silt	14.7	6.5	1.0	0.46	2316	2.51	0.37	0.15	68.62	0.17	19.5	45.51	0.05	0.05	20.82	1.99	0.06
22.24	15.6	0.32	-18.7	2.061	0.0450	1.001	0.538	0.463	1.70	26.60	27.53	50.0	31.63	2.20	-0.08	2.55	0.8	28.26	5	Sand mixtures - silty sand to sandy silt	16.3	7.1	1.0	0.46	2243	2.42	0.62	0.26	86.22	0.64	45	72.53	0.08	0.08	22.01	2.11	0.06
22.31	17.1	0.53	-18.7	3.103	0.0450	1.004	0.540	0.464	1.70	29.06	30.08	50.0	34.68	3.30	-0.07	2.63	0.9	31.64	4	Silt mixtures - clayey silt to silty clay	18.8	7.9	1.0	0.46	2134	2.30	1.04	0.45	110.61	#N/A	45	75.08	#N/A	#N/A	24.03	2.30	#N/A
22.38	15.1	0.53	-18.4	3.518	0.0450	1.007	0.542	0.465	1.70	25.63	26.53	50.0	30.27	3.77	-0.08	2.70	0.9	28.22	4	Silt mixtures - clayey silt to silty clay	16.3	7.1	1.0	0.46	2095	2.25	1.06	0.47	113.33	#N/A	45	71.53	#N/A	#N/A	21.18	2.03	#N/A
22.44	16.0	0.55	-14.4	3.446	0.0450	1.010	0.544	0.466	1.70	27.19	28.15	50.0	32.18	3.68	-0.07	2.68	0.9	29.79	4	Silt mixtures - clayey silt to silty clay	17.4	7.4	1.0	0.47	2111	2.27	1.10	0.48	114.39	#N/A	45	73.15	#N/A	#N/A	22.45	2.15	#N/A
22.51	15.1	0.45	-13.4	2.953	0.0450	1.013	0.546	0.467	1.70	25.74	26.65	50.0	30.29	3.16	-0.07	2.66	0.9	27.88	4	Silt mixtures - clayey silt to silty clay	16.0	7.0	1.0	0.47	2173	2.33	0.88	0.38	102.97	#N/A	45	71.65	#N/A	#N/A	21.25	2.04	#N/A
22.57	18.0	0.50	-13.4	2.768	0.0450	1.016	0.548	0.467	1.69	30.39	31.46	50.0	36.41	2.93	-0.06	2.58	0.9	32.83	5	Sand mixtures - silty sand to sandy silt	19.6	8.2	1.0	0.47	2200	2.35	0.96	0.41	105.56	#N/A	45	76.46	#N/A	#N/A	25.28	2.42	#N/A
22.64	20.1	0.81	-13.4	4.045	0.0450	1.019	0.550	0.468	1.66	33.37	34.55	50.0	40.64	4.26	-0.05	2.65	0.9	37.36	4	Silt mixtures - clayey silt to silty clay	23.1	9.3	1.0	0.47	2066	2.21	1.59	0.72	136.22	#N/A	45	79.55	#N/A	#N/A	28.09	2.69	#N/A
22.70	21.8	0.72	-13.1	3.293	0.0450	1.022	0.552	0.469	1.65	35.90	37.16	50.0	44.26	3.45	-0.05	2.57	0.9	39.79	5	Sand mixtures - silty sand to sandy silt	25.0	9.9	1.0	0.47	2157	2.30	1.37	0.60	124.57	#N/A	45	82.16	#N/A	#N/A	30.51	2.92	#N/A
22.77	26.7	0.61	-13.7	2.298	0.0450	1.025	0.554	0.470	1.61	42.95	44.46	50.0	54.61	2.39	-0.04	2.41	0.8	46.98	5	Sand mixtures - silty sand to sandy silt	30.7	11.7	1.0	0.47	2275	2.42	1.12	0.46	109.75	#N/A	45	89.46	#N/A	#N/A	37.36	3.58	#N/A
22.83	29.9	0.88	-13.7	2.959	0.0450	1.028	0.556	0.471	1.59	47.38	49.05	50.0	61.23	3.06	-0.03	2.44	0.8	53.20	5	Sand mixtures - silty sand to sandy silt	35.9	13.3	1.0	0.47	2208	2.34	1.63	0.70	132.09	#N/A	45	94.05	#N/A	#N/A	41.76	4.00	#N/A
22.90	37.9	0.93	-15.7	2.440	0.0450	1.031	0.558	0.472	1.54	58.42	60.47	50.0	78.20	2.51	-0.03	2.31	0.8	65.66	5	Sand mixtures - silty sand to sandy silt	46.7	16.4	1.0	0.47	2273	2.41	1.65	0.68	130.90	#N/A	45	105.47	#N/A	#N/A	53.00	5.08	#N/A
22.97	37.0	1.03	-21.1	2.782	0.0450	1.033	0.561	0.473	1.54	57.09	59.10	50.0	76.07	2.86	-0.03	2.36	0.8	64.69	5	Sand mixtures - silty sand to sandy silt	45.9	16.2	1.0	0.47	2243	2.37	1.85	0.78	139.22	#N/A	45	104.10	#N/A	#N/A	51.66	4.95	#N/A
23.03	35.0	1.00	-16.1	2.849	0.0450	1.036	0.563	0.474	1.55	54.37	56.28	50.0	71.77	2.94	-0.03	2.38	0.8	61.46	5	Sand mixtures - silty sand to sandy silt	43.0	15.4	1.0	0.47	2243	2.37	1.80	0.76	137.77	#N/A	45	101.28	#N/A	#N/A	48.88	4.68	#N/A
23.10	28.4	1.01	-19.7	3.558	0.0450	1.039	0.565	0.475	1.59	45.04	46.62	50.0	57.53	3.69	-0.04	2.51	0.8	51.02	5	Sand mixtures - silty sand to sandy silt	34.1	12.8	1.0	0.47	2171	2.29	1.88	0.82	143.87	#N/A	45	91.62	#N/A	#N/A	39.52	3.79	#N/A
23.16	20.8	1.08	-19.4	5.188	0.0450	1.042	0.567	0.476	1.64	34.22	35.42	50.0	41.64	5.46	-0.06	2.71	0.9	39.02	4	Silt mixtures - clayey silt to silty clay	24.4	9.8	1.0	0.48	1997	2.10	2.13	1.01	159.66	#N/A	45	80.42	#N/A	#N/A	29.04	2.78	#N/A
23.23	28.1	1.21	-19.4	4.299	0.0450	1.045	0.569	0.477	1.59	44.53	46.10	50.0	56.70	4.46	-0.04	2.57	0.9	51.12	5	Sand mixtures - silty sand to sandy silt	34.2	12.8	1.0	0.48	2103	2.21	2.28	1.03	160.57	#N/A	45	91.10	#N/A	#N/A	39.06	3.74	#N/A
23.29	32.1	0.98	-19.4	3.044	0.0450	1.048	0.571	0.477	1.56	50.13	51.90	50.0	65.08	3.15	-0.04	2.43	0.8	56.53	5	Sand mixtures - silty sand to sandy silt	38.8	14.1	1.0	0.48	2250	2.36	1.78	0.75	137.70	#N/A	45	96.90	#N/A	#N/A	44.67	4.28	#N/A
23.36	33.0	0.79	-19.4	2.396	0.0450	1.051	0.573	0.478	1.55	51.27	53.07	50.0	66.75	2.48	-0.04	2.35	0.8	56.87	5	Sand mixtures - silty sand to sandy silt	39.0	14.2	1.0	0.48	2329	2.43	1.41	0.58	121.55	#N/A	45	98.07	#N/A	#N/A	45.84	4.39	#N/A
23.43	33.6	0.99	-19.7	2.945	0.0450	1.054	0.575	0.479	1.55	51.99	53.82	50.0	67.81	3.04	-0.04	2.41	0.8	58.61	5	Sand mixtures - silty sand to sandy silt	40.5	14.7	1.0	0.48	2276	2.37	1.78	0.75	137.38	#N/A	45	98.82	#N/A	#N/A	46.59	4.46	#N/A
23.49	37.6	0.82	-19.4	2.184	0.0450	1.057	0.577	0.480	1.53	57.44	59.47	50.0	76.13	2.25	-0.03	2.29	0.7	63.80	5	Sand mixtures - silty sand to sandy silt	45.1	16.0	1.0	0.48	2367	2.47	1.43	0.58	122.26	#N/A	45	104.47	#N/A	#N/A	52.20	5.00	#N/A
23.56	43.7	0.80	-19.7	1.834	0.0450	1.060	0.579	0.481	1.50	65.44	67.75	50.0	88.57	1.88	-0.03	2.20	0.7	72.45	5	Sand mixtures - silty sand to sandy silt	52.8	18.1	1.0	0.48	2414	2.51	1.36	0.54	120.11	#N/A	45	112.75	#N/A	#N/A	60.56	5.80	#N/A

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

s_u/s_r < 1 (Strength Loss)

FC%	Δqc1n-Sr
0	10.00
10	10.00
25	25.00
50	45.00
75	55.00
100	55.00

2011 CPT Data from ConeTec					CPT Data Interpretations															Free Field Strength Estimates																	
																				Robertson (2010a)												Robertson (2010b)		Idriss & Boulanger (2008)				Olson & Stark (2003)		
																				Peak Strengths						Cyclic Softening Strengths		Liquefied Strengths										
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	OCR	OCR	Selected	σ_{vc}'	s_u	s_u/σ_{vc}'	s_r/σ_v'	s_r/s_u	$Q_{tn,cs}$	$s_{u,liq}/\sigma_{vc}'$	Fines	$qc1n_{cs,Sr}$	$s_{u,liq}/\sigma_v'$	$s_{u,liq}/\sigma_v'$	qc1	qc1	$s_{u,liq}/\sigma_v'$
23.62	58.4	0.83	-20.1	1.425	0.0450	1.063	0.581	0.482	1.44	84.30	87.26	20.0	118.97	1.45	-0.02	2.04	0.7	93.39	6	Sands - clean sand to silty sand	72.6	23.3	1.0	0.48	2466	2.56	1.36	0.53	126.51	#N/A	19.5	106.76	#N/A	#N/A	80.93	7.75	#N/A
23.69	73.4	0.84	-19.7	1.147	0.0450	1.066	0.583	0.483	1.40	102.76	106.38	20.0	149.89	1.16	-0.02	1.91	0.6	113.83	6	Sands - clean sand to silty sand	93.0	28.5	1.0	0.48	2505	2.59	1.32	0.51	136.53	#N/A	19.5	125.88	#N/A	#N/A	101.70	9.74	#N/A
23.75	99.2	0.67	-19.7	0.671	0.0450	1.069	0.585	0.484	1.34	132.97	137.65	20.0	202.76	0.68	-0.01	1.68	0.5	144.96	6	Sands - clean sand to silty sand	125.7	36.2	1.0	0.48	2565	2.65	0.98	0.37	148.36	#N/A	19.5	157.15	#N/A	#N/A	137.22	13.15	#N/A
23.82	114.8	0.69	-20.1	0.598	0.0450	1.072	0.587	0.485	1.31	150.58	155.88	20.0	234.58	0.60	-0.01	1.60	0.5	164.59	6	Sands - clean sand to silty sand	147.4	41.1	1.0	0.48	2580	2.66	0.99	0.37	164.59	#N/A	19.5	175.38	#N/A	#N/A	158.70	15.20	#N/A
23.88	120.0	0.95	-20.4	0.789	0.0450	1.075	0.589	0.486	1.30	156.27	161.77	20.0	244.83	0.80	-0.01	1.66	0.5	174.62	6	Sands - clean sand to silty sand	158.7	43.7	1.0	0.49	2566	2.64	1.39	0.53	176.75	#N/A	19.5	181.27	#N/A	#N/A	165.76	15.88	#N/A
23.95	126.6	0.77	-20.4	0.608	0.0450	1.078	0.591	0.487	1.29	163.52	169.28	20.0	258.03	0.61	-0.01	1.58	0.5	180.17	6	Sands - clean sand to silty sand	165.0	45.0	1.0	0.49	2594	2.67	1.10	0.41	180.17	#N/A	19.5	188.78	#N/A	#N/A	174.82	16.75	#N/A
24.02	129.2	0.56	-20.4	0.435	0.0450	1.081	0.593	0.487	1.29	166.28	172.13	20.0	262.88	0.44	-0.01	1.49	0.4	179.59	6	Sands - clean sand to silty sand	164.4	44.9	1.0	0.49	2620	2.69	0.79	0.29	179.59	#N/A	19.5	191.63	#N/A	#N/A	178.28	17.08	#N/A
24.08	129.5	0.43	-20.4	0.329	0.0450	1.084	0.595	0.488	1.29	166.50	172.36	20.0	262.98	0.33	-0.01	1.43	0.4	177.02	6	Sands - clean sand to silty sand	161.4	44.3	1.0	0.49	2639	2.70	0.59	0.22	177.02	#N/A	19.5	191.86	#N/A	#N/A	178.56	17.11	#N/A
24.15	131.5	0.30	-20.1	0.229	0.0450	1.087	0.597	0.489	1.28	168.61	174.55	20.0	266.62	0.23	-0.01	1.36	0.4	176.29	6	Sands - clean sand to silty sand	160.6	44.1	1.0	0.49	2658	2.72	0.41	0.15	176.29	#N/A	19.5	194.05	#N/A	#N/A	181.21	17.36	#N/A
24.21	124.9	0.24	-20.1	0.192	0.0450	1.090	0.599	0.490	1.29	161.23	166.90	20.0	252.56	0.19	-0.01	1.35	0.4	166.79	6	Sands - clean sand to silty sand	149.8	41.7	1.0	0.49	2669	2.72	0.32	0.12	166.79	#N/A	19.5	186.40	#N/A	#N/A	171.93	16.47	#N/A
24.28	120.3	0.27	-20.1	0.225	0.0450	1.093	0.601	0.491	1.30	156.03	161.52	20.0	242.69	0.23	-0.01	1.39	0.4	162.07	6	Sands - clean sand to silty sand	144.6	40.5	1.0	0.49	2673	2.72	0.37	0.14	162.07	#N/A	19.5	181.02	#N/A	#N/A	165.46	15.85	#N/A
24.34	107.5	0.34	-19.7	0.319	0.0450	1.095	0.604	0.492	1.32	141.71	146.69	20.0	216.39	0.32	-0.01	1.49	0.4	148.55	6	Sands - clean sand to silty sand	129.7	37.1	1.0	0.49	2669	2.71	0.48	0.18	148.55	#N/A	19.5	166.19	#N/A	#N/A	147.86	14.16	#N/A
24.41	103.8	#N/A	-19.4	#N/A	0.0450	1.098	0.606	0.493	1.32	137.36	142.20	#N/A	208.38	#N/A	-0.01	#N/A	###	#N/A	#N/A	#N/A	#N/A	#N/A	1.0	0.49	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#VALUE!	#VALUE!	#N/A	#N/A	142.60	13.66	#N/A
24.48	99.7	#N/A	-19.4	#N/A	0.0450	1.101	0.608	0.494	1.33	132.65	137.32	#N/A	199.78	#N/A	-0.01	#N/A	###	#N/A	#N/A	#N/A	#N/A	#N/A	1.0	0.49	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#VALUE!	#VALUE!	#N/A	#N/A	136.93	13.12	#N/A
24.54	119.7	#N/A	-19.4	#N/A	0.0450	1.104	0.610	0.495	1.30	155.02	160.48	#N/A	239.73	#N/A	-0.01	#N/A	###	#N/A	#N/A	#N/A	#N/A	#N/A	1.0	0.49	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#VALUE!	#VALUE!	#N/A	#N/A	164.20	15.73	#N/A
Averages:					0.0450																																

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

SHANSEP			
s_u		s_r	
s_u/σ_v'	**0.60**	s_r/σ_v'	**0.50**
m	**0.65**	**m**	**0.65**

| 2011 CPT Data from ConeTec | | | | | CPT Data Interpretations | | | | |

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

SHANSEP			
s_u		s_r	
$s_u/\sigma_{v'}$	**0.60**	$s_r/\sigma_{v'}$	**0.50**
m	**0.65**	**m**	**0.65**

2011 CPT Data from ConeTec					CPT Data Interpretations																																								
														Using Qtn for calculating Ic (iterations)								Strength Estimates under Dam																						
																						10' Fill					30' Fill					65' Fill					Pond - 40' Fill with 80' Removed				
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r
12.402	9.0	0.16	-18.74	1.733	0.0450	0.558	0.231	0.327	1.70	15.30	15.84	50.0	25.81	1.85	-0.10	2.59	0.9	22.07	5	Sand mixtures - silty sand to sandy silt	1.85	1.85	1.00	1.11	0.92	2.86	2.86	1.00	1.71	1.43	4.53	4.53	1.00	2.72	2.27	3.44	3.44	1.00	2.06	1.72
12.467	10.7	0.10	-18.40	0.968	0.0450	0.561	0.233	0.328	1.70	18.26	18.90	20.0	31.03	1.02	-0.08	2.41	0.8	24.65	5	Sand mixtures - silty sand to sandy silt	1.85	1.85	1.00	1.11	0.92	2.86	2.86	1.00	1.71	1.43	4.54	4.54	1.00	2.72	2.27	3.44	3.44	1.00	2.06	1.72
12.533	11.6	0.14	-18.74	1.166	0.0450	0.564	0.235	0.329	1.70	19.72	20.41	20.0	33.55	1.23	-0.07	2.43	0.8	26.79	5	Sand mixtures - silty sand to sandy silt	1.85	1.85	1.00	1.11	0.93	2.86	2.86	1.00	1.72	1.43	4.54	4.54	1.00	2.72	2.27	3.44	3.44	1.00	2.07	1.72
12.598	12.8	0.21	-18.40	1.629	0.0450	0.567	0.237	0.330	1.70	21.71	22.47	50.0	36.99	1.70	-0.07	2.47	0.8	30.04	5	Sand mixtures - silty sand to sandy silt	1.85	1.85	1.00	1.11	0.93	2.86	2.86	1.00	1.72	1.43	4.54	4.54	1.00	2.72	2.27	3.44	3.44	1.00	2.07	1.72
12.664	15.6	0.25	-19.41	1.596	0.0450	0.570	0.239	0.331	1.70	26.58	27.52	50.0	45.55	1.66	-0.06	2.39	0.8	35.97	5	Sand mixtures - silty sand to sandy silt	1.85	1.85	1.00	1.11	#N/A	2.86	2.86	1.00	1.72	1.43	4.54	4.54	1.00	2.73	2.27	3.45	3.45	1.00	2.07	1.72
12.73	11.3	0.23	-23.76	2.033	0.0450	0.573	0.241	0.332	1.70	19.13	19.80	50.0	32.20	2.14	-0.09	2.56	0.8	27.20	5	Sand mixtures - silty sand to sandy silt	1.86	1.86	1.00	1.11	0.93	2.87	2.87	1.00	1.72	1.43	4.54	4.54	1.00	2.73	2.27	3.45	3.45	1.00	2.07	1.72
12.795	10.4	0.25	-24.43	2.407	0.0450	0.576	0.243	0.333	1.70	17.63	18.25	50.0	29.45	2.55	-0.10	2.63	0.9	25.58	4	Silt mixtures - clayey silt to silty clay	1.86	1.86	1.00	1.12	#N/A	2.87	2.87	1.00	1.72	1.43	4.55	4.55	1.00	2.73	2.27	3.45	3.45	1.00	2.07	1.72
12.861	9.5	0.24	-24.76	2.517	0.0450	0.579	0.245	0.333	1.70	16.16	16.72	50.0	26.76	2.68	-0.11	2.67	0.9	23.64	4	Silt mixtures - clayey silt to silty clay	1.86	1.86	1.00	1.12	#N/A	2.87	2.87	1.00	1.72	1.43	4.55	4.55	1.00	2.73	2.27	3.45	3.45	1.00	2.07	1.73
12.927	8.6	0.20	-24.43	2.286	0.0450	0.582	0.247	0.334	1.70	14.70	15.21	50.0	24.11	2.45	-0.13	2.68	0.9	21.40	4	Silt mixtures - clayey silt to silty clay	1.86	1.86	1.00	1.12	#N/A	2.87	2.87	1.00	1.72	1.44	4.55	4.55	1.00	2.73	2.27	3.45	3.45	1.00	2.07	1.73
12.992	7.5	0.15	-24.76	1.948	0.0450	0.585	0.249	0.335	1.70	12.71	13.16	50.0	20.55	2.11	-0.15	2.69	0.9	18.36	4	Silt mixtures - clayey silt to silty clay	1.86	1.86	1.00	1.12	#N/A	2.87	2.87	1.00	1.72	1.44	4.55	4.55	1.00	2.73	2.28	3.46	3.46	1.00	2.07	1.73
13.058	8.4	-0.03	-24.43	-0.373	0.0450	0.588	0.251	0.336	1.70	14.20	14.70	20.0	23.10	-0.40	-0.13	#####	###	#NUM!	####	#NUM!	1.87	1.87	1.00	1.12	#NUM!	2.88	2.88	1.00	1.73	#NUM!	4.55	4.55	1.00	2.73	#NUM!	3.46	3.46	1.00	2.07	#NUM!
13.123	7.8	0.05	-24.76	0.670	0.0450	0.591	0.253	0.337	1.70	13.20	13.67	20.0	21.29	0.72	-0.14	2.48	0.8	17.45	5	Sand mixtures - silty sand to sandy silt	1.87	1.87	1.00	1.12	0.93	2.88	2.88	1.00	1.73	1.44	4.56	4.56	1.00	2.73	2.28	3.46	3.46	1.00	2.08	1.73
13.189	7.5	0.06	-24.43	0.834	0.0450	0.594	0.255	0.338	1.70	12.72	13.16	20.0	20.37	0.91	-0.15	2.53	0.8	17.06	5	Sand mixtures - silty sand to sandy silt	1.87	1.87	1.00	1.12	0.93	2.88	2.88	1.00	1.73	1.44	4.56	4.56	1.00	2.73	2.28	3.46	3.46	1.00	2.08	1.73
13.255	7.8	0.08	-20.75	1.064	0.0450	0.596	0.258	0.339	1.70	13.29	13.76	20.0	21.31	1.15	-0.13	2.56	0.8	18.06	5	Sand mixtures - silty sand to sandy silt	1.87	1.87	1.00	1.12	0.94	2.88	2.88	1.00	1.73	1.44	4.56	4.56	1.00	2.74	2.28	3.46	3.46	1.00	2.08	1.73
13.32	8.4	0.09	-20.75	1.114	0.0450	0.599	0.260	0.340	1.70	14.28	14.79	20.0	22.96	1.20	-0.12	2.54	0.8	19.34	5	Sand mixtures - silty sand to sandy silt	1.87	1.87	1.00	1.12	0.94	2.88	2.88	1.00	1.73	1.44	4.56	4.56	1.00	2.74	2.28	3.46	3.46	1.00	2.08	1.73
13.386	8.4	0.09	-20.75	1.114	0.0450	0.602	0.262	0.341	1.70	14.28	14.79	20.0	22.89	1.20	-0.12	2.54	0.8	19.30	5	Sand mixtures - silty sand to sandy silt	1.87	1.87	1.00	1.12	0.94	2.88	2.88	1.00	1.73	1.44	4.56	4.56	1.00	2.74	2.28	3.47	3.47	1.00	2.08	1.73
13.451	9.0	0.09	-20.41	1.043	0.0450	0.605	0.264	0.342	1.70	15.26	15.80	20.0	24.51	1.12	-0.11	2.51	0.8	20.38	5	Sand mixtures - silty sand to sandy silt	1.88	1.88	1.00	1.13	0.94	2.89	2.89	1.00	1.73	1.44	4.57	4.57	1.00	2.74	2.28	3.47	3.47	1.00	2.08	1.73
13.517	9.3	0.10	-20.41	1.122	0.0450	0.608	0.266	0.343	1.70	15.76	16.31	20.0	25.29	1.20	-0.10	2.51	0.8	21.06	5	Sand mixtures - silty sand to sandy silt	1.88	1.88	1.00	1.13	0.94	2.89	2.89	1.00	1.73	1.44	4.57	4.57	1.00	2.74	2.28	3.47	3.47	1.00	2.08	1.73
13.583	9.0	0.07	-20.08	0.810	0.0450	0.611	0.268	0.343	1.70	15.27	15.81	20.0	24.37	0.87	-0.11	2.46	0.8	19.93	5	Sand mixtures - silty sand to sandy silt	1.88	1.88	1.00	1.13	0.94	2.89	2.89	1.00	1.73	1.45	4.57	4.57	1.00	2.74	2.28	3.47	3.47	1.00	2.08	1.74
13.648	8.1	0.07	-20.08	0.897	0.0450	0.614	0.270	0.344	1.70	13.80	14.29	20.0	21.80	0.97	-0.12	2.52	0.8	18.23	5	Sand mixtures - silty sand to sandy silt	1.88	1.88	1.00	1.13	0.94	2.89	2.89	1.00	1.74	1.45	4.57	4.57	1.00	2.74	2.29	3.47	3.47	1.00	2.08	1.74
13.714	8.4	0.07	-20.08	0.866	0.0450	0.617	0.272	0.345	1.70	14.30	14.80	20.0	22.57	0.93	-0.12	2.50	0.8	18.75	5	Sand mixtures - silty sand to sandy silt	1.88	1.88	1.00	1.13	0.94	2.89	2.89	1.00	1.74	1.45	4.57	4.57	1.00	2.74	2.29	3.48	3.48	1.00	2.09	1.74
13.78	9.6	0.07	-20.08	0.761	0.0450	0.620	0.274	0.346	1.70	16.26	16.83	20.0	25.84	0.81	-0.10	2.43	0.8	20.90	5	Sand mixtures - silty sand to sandy silt	1.89	1.89	1.00	1.13	0.94	2.90	2.90	1.00	1.74	1.45	4.58	4.58	1.00	2.75	2.29	3.48	3.48	1.00	2.09	1.74
13.845	7.8	0.06	-20.08	0.797	0.0450	0.623	0.276	0.347	1.70	13.31	13.78	20.0	20.76	0.87	-0.13	2.51	0.8	17.36	5	Sand mixtures - silty sand to sandy silt	1.89	1.89	1.00	1.13	0.94	2.90	2.90	1.00	1.74	1.45	4.58	4.58	1.00	2.75	2.29	3.48	3.48	1.00	2.09	1.74
13.911	7.0	0.05	-19.74	0.746	0.0450	0.626	0.278	0.348	1.70	11.85	12.26	20.0	18.23	0.82	-0.14	2.55	0.8	15.46	5	Sand mixtures - silty sand to sandy silt	1.89	1.89	1.00	1.13	0.94	2.90	2.90	1.00	1.74	1.45	4.58	4.58	1.00	2.75	2.29	3.48	3.48	1.00	2.09	1.74
13.976	6.7	0.03	-19.74	0.467	0.0450	0.629	0.280	0.349	1.70	11.35	11.75	20.0	17.34	0.52	-0.15	2.49	0.8	14.40	5	Sand mixtures - silty sand to sandy silt	1.89	1.89	1.00	1.13	0.95	2.90	2.90	1.00	1.74	1.45	4.58	4.58	1.00	2.75	2.29	3.48	3.48	1.00	2.09	1.74
14.042	7.8	0.03	-19.41	0.398	0.0450	0.632	0.282	0.350	1.70	13.32	13.79	20.0	20.60	0.43	-0.12	2.41	0.8	16.57	5	Sand mixtures - silty sand to sandy silt	1.89	1.89	1.00	1.14	0.95	2.90	2.90	1.00	1.74	1.45	4.58	4.58	1.00	2.75	2.29	3.48	3.48	1.00	2.09	1.74
14.108	8.4	0.04	-19.41	0.494	0.0450	0.635	0.284	0.351	1.70	14.31	14.82	20.0	22.20	0.53	-0.11	2.41	0.8	17.89	5	Sand mixtures - silty sand to sandy silt	1.89	1.89	1.00	1.14	0.95	2.91	2.91	1.00	1.74	1.45	4.58	4.58	1.00	2.75	2.29	3.49	3.49	1.00	2.09	1.74
14.173	9.0	0.04	-19.41	0.463	0.0450	0.638	0.286	0.352	1.70	15.29	15.82	20.0	23.76	0.50	-0.11	2.38	0.8	18.91	5	Sand mixtures - silty sand to sandy silt	1.90	1.90	1.00	1.14	0.95	2.91	2.91	1.00	1.74	1.45	4.59	4.59	1.00	2.75	2.29	3.49	3.49	1.00	2.09	1.74
14.239	9.9	0.04	-19.07	0.422	0.0450	0.641	0.288	0.352	1.70	16.78	17.37	20.0	26.18	0.45	-0.10	2.33	0.8	20.46	5	Sand mixtures - silty sand to sandy silt	1.90	1.90	1.00	1.14	0.95	2.91	2.91	1.00	1.75	1.45	4.59	4.59	1.00	2.75	2.29	3.49	3.49	1.00	2.09	1.74
14.304	9.6	0.03	-19.07	0.326	0.0450	0.644	0.290	0.353	1.70	16.28	16.86	20.0	25.28	0.35	-0.10	2.31	0.7	19.61	5	Sand mixtures - silty sand to sandy silt	1.90	1.90	1.00	1.14	0.95	2.91	2.91	1.00	1.75	1.46	4.59	4.59	1.00	2.75	2.30	3.49	3.49	1.00	2.09	1.75
14.37	9.9	0.03	-18.74	0.316	0.0450	0.647	0.292	0.354	1.70	16.79	17.38	20.0	26.04	0.34	-0.10	2.29	0.7	20.10	5	Sand mixtures - silty sand to sandy silt	1.90	1.90	1.00	1.14	0.95	2.91	2.91	1.00	1.75	1.46	4.59	4.59	1.00	2.76	2.30	3.49	3.49	1.00	2.10	1.75
14.436	10.4	0.04	-18.74	0.398	0.0450	0.650	0.294	0.355	1.70	17.76	18.38	20.0	27.58	0.42	-0.09	2.30	0.7	21.38	5	Sand mixtures - silty sand to sandy silt	1.90	1.90	1.00	1.14	0.95	2.92	2.92	1.00	1.75	1.46	4.59	4.59	1.00	2.76	2.30	3.49	3.49	1.00	2.10	1.75
14.501	10.2	0.04	-18.40	0.409	0.0450	0.653	0.296	0.356	1.70	17.27	17.88	20.0	26.69	0.44	-0.09	2.32	0.8	20.83	5	Sand mixtures - silty sand to sandy silt	1.91	1.91	1.00	1.14	0.95	2.92	2.92	1.00	1.75	1.46	4.60	4.60	1.00	2.76	2.30	3.50	3.50	1.00	2.10	1.75
14.567	10.2	0.05	-18.07	0.512	0.0450	0.656	0.298	0.357	1.70	17.28	17.89	20.0	26.63	0.55	-0.09	2.35	0.8	21.06	5	Sand mixtures - silty sand to sandy silt	1.91	1.91	1.00	1.14	0.95	2.92	2.92	1.00	1.75	1.46	4.60	4.60	1.00	2.76	2.30	3.50	3.50	1.00	2.10	1.75
14.633	10.7	0.07	-18.07	0.677	0.0450	0.658	0.301	0.358	1.70	18.27	18.91	20.0	28.18	0.72	-0.09	2.38	0.8	22.52	5	Sand mixtures - silty sand to sandy silt	1.91	1.91	1.00	1.15	0.95	2.92	2.92	1.00	1.75	1.46	4.60	4.60	1.00	2.76	2.30	3.50	3.50	1.00	2.10	1.75
14.698	11.9	0.08	-18.07	0.699	0.0450	0.661	0.303	0.359	1.70	20.23	20.94	20.0	31.32	0.74	-0.08	2.34	0.8	24.74	5	Sand mixtures - silty sand to sandy silt	1.91	1.91	1.00	1.15	0.96	2.92	2.92	1.00	1.75	1.46	4.60	4.60	1.00	2.76	2.30	3.50	3.50	1.00	2.10	1.75
14.764	12.2	0.09	-17.73	0.767	0.0450	0.664	0.305	0.360	1.70	20.73	21.46	20.0	32.05	0.81	-0.07	2.35	0.8	25.42	5	Sand mixtures - silty sand to sandy silt	1.91	1.91	1.00	1.15	0.96	2.92	2.92	1.00	1.75	1.46	4.60	4.60	1.00	2.76	2.30	3.50	3.50	1.00	2.10	1.75
14.829	11.9	0.09	-17.73	0.786	0.0450	0.667	0.307	0.361	1.70	20.24	20.95	20.0	31.16	0.83	-0.08	2.37	0.8	24.86	5	Sand mixtures - silty sand to sandy silt	1.91	1.91	1.00	1.15	0.96	2.93	2.93	1.00	1.76	1.46	4.61	4.61	1.00	2.76	2.30	3.51	3.51	1.00	2.10	1.75
14.895	11.6	0.09	-17.07	0.805	0.0450	0.670	0.309	0.362	1.70	19.76	20.45	20.0	30.29	0.85	-0.08	2.38	0.8	24.31	5	Sand mixtures - silty sand to sandy silt	1.92	1.92	1.00	1.15	0.96	2.93	2.93	1.00	1.76	1.46	4.61	4.61	1.00	2.77	2.30	3.51	3.51	1.00	2.10	1.75
14.961	12.8	0.11	-16.73	0.894	0.0450	0.673	0.311	0.362	1.70	21.74	22.51	20.0	33.43	0.94	-0.07	2.37	0.8	26.70	5	Sand mixtures - silty sand to sandy silt	1.92	1.92	1.00	1.15	0.96	2.93	2.93	1.00	1.76	1.47	4.61	4.61	1.00	2.77	2.31	3.51	3.51	1.00	2.11	1.75
15.026	13.9	0.11	-16.73	0.820	0.0450	0.676	0.313	0.363	1.70	23.71	24.54	20.0	36.52	0.86	-0.06	2.32	0.8	28.68	5	Sand mixtures - silty sand to sandy silt	1.92	1.92	1.00	1.15	0.96	2.93	2.93	1.00	1.76	1.47	4.61	4.61	1.00	2.77	2.31	3.51	3.51	1.00	2.11	1.76
15.092	13.9	0.12	-16.40	0.895	0.0450	0.679	0.315	0.364	1.70	23.71	24.55	20.0	36.43	0.94	-0.06	2.34	0.8	28.82	5	Sand mixtures - silty sand to sandy silt	1.92	1.92	1.00	1.15	0.96	2.93	2.93	1.00	1.76	1.47	4.61	4.61	1.00	2.77	2.31	3.51	3.51	1.00	2.11	1.76
15.157	12.8	0.11	-16.40	0.894	0.0450	0.682	0.317	0.365	1.70	21.75	22.52	20.0	33.17	0.94	-0.07	2.37	0.8	26.56	5	Sand mixtures - silty sand to sandy silt	1.92	1.92	1.00	1.15	0.96	2.94	2.94	1.00	1.76	1.47	4.62	4.62	1.00	2.77	2.31	3.51	3.51	1.00	2.11	1.76
15.223	12.5	0.10	-16.06	0.831	0.0450	0.685	0.319	0.366	1.70	21.26	22.01	20.0	32.30	0.88	-0.07	2.36	0.8	25.83	5	Sand mixtures - silty sand to sandy silt	1.93	1.93	1.00	1.16	0.96	2.94	2.94	1.00	1.76	1.47	4.62	4.62	1.00	2.77	2.31	3.52	3.52	1.00	2.11	1.76
15.289	12.5	0.10	-15.73	0.831	0.0450	0.688	0.321	0.367	1.70	21.27	22.02	20.0	32.22	0.88	-0.07	2.36	0.8	25.79	5	Sand mixtures - silty sand to sandy silt	1.93	1.93	1.00	1.16	0.96	2.94	2.94	1.00	1.76	1.47	4.62	4.62	1.00	2.77	2.31	3.52	3.52	1.00	2.11	1.76
15.354	12.8	0.15	-15.39	1.137	0.0450	0.691	0.323	0.368	1.70	21.77	22.54	20.0	32.94	1.20	-0.07	2.42	0.8	26.91	5	Sand mixtures - silty sand to sandy silt	1.93	1.93	1.00	1.16	0.96	2.94	2.94	1.00	1.77	1.47	4.62	4.62	1.00	2.77	2.31	3.52	3.52	1.00	2.11	1.76
15.42	14.0	0.15	-15.06	1.042	0.0450	0.694	0.325	0.369	1.70	23.74	24.58	20.0	35.99	1.10	-0.06	2.37	0.8	28.91	5	Sand mixtures - silty sand to sandy silt	1.93	1.93	1.00	1.16	0.97	2.94	2.94	1.00	1.77	1.47	4.62	4.62	1.00	2.77	2.31	3.52	3.52	1.00	2.11	1.76
15.486	14.8	0.16	-15.06	1.052	0.0450	0.697	0.327	0.370	1.70	25.21	26.10	20.0	38.23	1.10	-0.06	2.35	0.8	30.52	5	Sand mixtures - silty sand to sandy silt	1.93	1.93	1.00	1.16	0.97	2.95	2.95	1.00	1.77	1.47	4.63	4.63	1.00	2.78	2.31	3.52	3.52	1.00	2.11	1.76
15.551	16.3	0.17	-14.72	1.022	0.0450	0.700	0.329	0.371	1.70	27.68	28.65	20.0	42.04	1.07	-0.05	2.32	0.8	33.13	5	Sand mixtures - silty sand to sandy silt	1.93	1.93	1.00	1.16	0.97	2.95	2.95	1.00	1.77	1.47	4.63	4.63	1.00	2.78	2.31	3.53	3.53	1.00	2.12	1.76
15.617	17.1	0.19	-14.39	1.092	0.0450	0.703	0.331	0.372	1.70	29.15	30.18	20.0	44.27	1.14	-0.05	2.31	0.8	34.86	5	Sand mixtures - silty sand to sandy silt	1.94	1.94	1.00	1.16	0.97	2.95	2.95	1.00	1.77	1.47	4.63	4.63	1.00	2.78	2.31	3.53	3.53	1.00	2.12	1.76
15.682	17.7	0.21	-14.05	1.173	0.0450	0.706	0.333	0.372	1.70	30.15	31.21	20.0	45.73	1.22	-0.05	2.32	0.8	36.09	5	Sand mixtures - silty sand to sandy silt	1.94	1.94	1.00	1.16	0.97	2.95	2.95	1.00	1.77	1.48	4.63	4.63	1.00	2.78	2.32	3.53	3.53	1.00	2.12	1.76
15.748	17.7	0.22	-13.72	1.231	0.0450	0.709	0.335	0.373	1.70	30.16	31.22	20.0	45.62	1.28	-0.04	2.33	0.8	36.18	5	Sand mixtures - silty sand to sandy silt	1.94	1.94	1.00	1.16	0.97	2.95	2.95	1.00	1.77	1.48	4.63	4.63	1.00	2.78	2.32	3.53	3.53	1.00	2.12	1.77
15.814	17.2	0.26	-13.38	1.515	0.0450	0.712	0.337	0.374	1.70	29.17	30.20	50.0	43.96	1.58	-0.05	2.39	0.8	35.63	5	Sand mixtures - silty sand to sandy silt	1.94	1.94	1.00	1.16	0.97	2.96	2.96	1.00	1.77	1.48	4.64	4.64	1.00	2.78	2.32	3.53	3.53	1.00	2.12	1.77
15.879	16.9	0.22	-13.38	1.294	0.0450	0.715	0.339	0.375	1.70	28.70	29.71	20.0	43.09	1.35	-0.05	2.36	0.8	34.58	5	Sand mixtures - silty sand to sandy silt	1.94	1.94	1.00	1.17	0.97	2.96	2.96	1.00	1.77	1.48	4.64	4.64	1.00	2.78	2.32	3.53	3.53	1.00	2.12	1.77
15.945	16.6	0.21	-13.38	1.254	0.0450	0.718	0.341	0.376	1.70	28.20	29.19	20.0	42.21	1.31	-0.05	2.36	0.8	33.89	5	Sand mixtures - silty sand to sandy silt	1.95	1.95	1.00	1.17	0.97	2.96	2.96	1.00	1.78	1.48	4.64	4.64	1.00	2.78	2.32	3.54	3.54	1.00	2.12	1.77
16.01	16.3	-0.05	-12.72	-0.319	0.0450	0.720	0.344	0.377	1.70	27.72	28.70	20.0	41.35	-0.33	-0.05	#####	###	#NUM!	####	#NUM!	1.95	1.95	1.00	1.17	#NUM!	2.96	2.96	1.00	1.78	#NUM!	4.64	4.64	1.00	2.78	#NUM!	3.54	3.54	1.00	2.12	#NUM!
16.076	16.0	0.54	-12.72	3.377	0.0450	0.723	0.346	0.378	1.70	27.23	28.19	50.0	40.47	3.54	-0.05	2.61	0.9	35.61	4	Silt mixtures - clayey silt to silty clay	1.95	1.95	1.00	1.17	#N/A	2.96	2.96	1.00	1.78	1.48	4.64	4.64	1.00	2.79	2.32	3.54	3.54	1.00	2.12	1.77

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

Constants		
Pa	0.97	tsf
Nkt	18	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

SHANSEP			
s_u		s_r	
$s_u/\sigma_{v'}$	0.60	$s_r/\sigma_{v'}$	0.50
m	0.65	m	0.65

2011 CPT Data from ConeTec					CPT Data Interpretations																Strength Estimates under Dam																			
																					10' Fill					30' Fill					65' Fill					Pond - 40' Fill with 80' Removed				
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Using Qtn for calculating Ic (iterations) Soil Type	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r
16.142	14.0	0.56	-12.72	4.012	0.0450	0.726	0.348	0.379	1.70	23.80	24.63	50.0	35.04	4.23	-0.06	2.70	0.9	31.83	4	Silt mixtures - clayey silt to silty clay	1.95	1.95	1.00	1.17	#N/A	2.96	2.96	1.00	1.78	1.48	4.65	4.65	1.00	2.79	2.32	3.54	3.54	1.00	2.13	1.77
16.207	9.3	0.54	5.35	5.805	0.0450	0.729	0.350	0.380	#####	#NUM!	#NUM!	50.0	22.62	6.30	-0.02	2.93	1	22.31	4	Silt mixtures - clayey silt to silty clay	1.95	1.95	1.00	1.17	#NUM!	2.97	2.97	1.00	1.78	1.48	4.65	4.65	1.00	2.79	2.32	3.54	3.54	1.00	2.13	1.77
16.273	19.5	0.54	-11.04	2.772	0.0450	0.732	0.352	0.381	1.70	33.17	34.34	50.0	49.34	2.88	-0.04	2.50	0.8	41.78	5	Sand mixtures - silty sand to sandy silt	1.95	1.95	1.00	1.17	#N/A	2.97	2.97	1.00	1.78	1.48	4.65	4.65	1.00	2.79	2.32	3.55	3.55	1.00	2.13	1.77
16.339	17.5	0.51	-10.37	2.913	0.0450	0.735	0.354	0.381	1.70	29.74	30.78	50.0	43.93	3.04	-0.04	2.55	0.8	37.85	5	Sand mixtures - silty sand to sandy silt	1.96	1.96	1.00	1.17	#N/A	2.97	2.97	1.00	1.78	1.49	4.65	4.65	1.00	2.79	2.33	3.55	3.55	1.00	2.13	1.77
16.404	16.9	0.43	-8.70	2.517	0.0450	0.738	0.356	0.382	1.70	28.80	29.82	50.0	42.38	2.63	-0.04	2.52	0.8	36.18	5	Sand mixtures - silty sand to sandy silt	1.96	1.96	1.00	1.17	#N/A	2.97	2.97	1.00	1.78	1.49	4.65	4.65	1.00	2.79	2.33	3.55	3.55	1.00	2.13	1.77
16.47	16.1	0.43	-8.03	2.652	0.0450	0.741	0.358	0.383	1.70	27.33	28.29	50.0	40.01	2.78	-0.04	2.55	0.8	34.55	5	Sand mixtures - silty sand to sandy silt	1.96	1.96	1.00	1.18	#N/A	2.97	2.97	1.00	1.78	1.49	4.66	4.66	1.00	2.79	2.33	3.55	3.55	1.00	2.13	1.78
16.535	14.9	0.30	-7.70	2.020	0.0450	0.744	0.360	0.384	1.70	25.38	26.27	50.0	36.92	2.13	-0.04	2.51	0.8	31.42	5	Sand mixtures - silty sand to sandy silt	1.96	1.96	1.00	1.18	0.98	2.98	2.98	1.00	1.79	1.49	4.66	4.66	1.00	2.79	2.33	3.55	3.55	1.00	2.13	1.78
16.601	14.4	0.22	-7.03	1.520	0.0450	0.747	0.362	0.385	1.70	24.42	25.28	50.0	35.36	1.60	-0.04	2.46	0.8	29.56	5	Sand mixtures - silty sand to sandy silt	1.96	1.96	1.00	1.18	0.98	2.98	2.98	1.00	1.79	1.49	4.66	4.66	1.00	2.80	2.33	3.55	3.55	1.00	2.13	1.78
16.67	13.8	0.22	-7.0	1.585	0.0450	0.750	0.364	0.386	1.70	23.43	24.25	50.0	33.76	1.68	-0.04	2.48	0.8	28.48	5	Sand mixtures - silty sand to sandy silt	1.97	1.97	1.00	1.18	0.98	2.98	2.98	1.00	1.79	1.49	4.66	4.66	1.00	2.80	2.33	-4.55	0.39	-0.08	#NUM!	#NUM!
16.73	13.8	0.20	-6.4	1.433	0.0450	0.753	0.366	0.387	1.70	23.44	24.27	20.0	33.70	1.52	-0.04	2.46	0.8	28.22	5	Sand mixtures - silty sand to sandy silt	1.97	1.97	1.00	1.18	0.98	2.98	2.98	1.00	1.79	1.49	4.66	4.66	1.00	2.80	2.33	-4.55	0.39	-0.09	#NUM!	#NUM!
16.80	13.2	0.19	-6.0	1.417	0.0450	0.756	0.368	0.388	1.70	22.46	23.25	20.0	32.12	1.50	-0.04	2.47	0.8	27.04	5	Sand mixtures - silty sand to sandy silt	1.97	1.97	1.00	1.18	0.98	2.98	2.98	1.00	1.79	1.49	4.66	4.66	1.00	2.80	2.33	-4.55	0.39	-0.09	#NUM!	#NUM!
16.86	13.5	0.11	-6.0	0.847	0.0450	0.759	0.370	0.389	1.70	22.96	23.76	20.0	32.79	0.90	-0.04	2.36	0.8	26.56	5	Sand mixtures - silty sand to sandy silt	1.97	1.97	1.00	1.18	0.99	2.99	2.99	1.00	1.79	1.49	4.67	4.67	1.00	2.80	2.33	-4.55	0.39	-0.09	#NUM!	#NUM!
16.93	13.8	0.11	-5.4	0.829	0.0450	0.762	0.372	0.390	1.70	23.47	24.29	20.0	33.47	0.88	-0.04	2.35	0.8	27.02	5	Sand mixtures - silty sand to sandy silt	1.97	1.97	1.00	1.18	0.99	2.99	2.99	1.00	1.79	1.49	4.67	4.67	1.00	2.80	2.33	-4.55	0.39	-0.09	#NUM!	#NUM!
16.99	14.1	0.11	-4.7	0.811	0.0450	0.765	0.374	0.391	1.70	23.98	24.82	20.0	34.16	0.86	-0.04	2.34	0.8	27.48	5	Sand mixtures - silty sand to sandy silt	1.97	1.97	1.00	1.18	0.99	2.99	2.99	1.00	1.79	1.49	4.67	4.67	1.00	2.80	2.34	-4.55	0.39	-0.09	#NUM!	#NUM!
17.06	13.8	0.12	-3.7	0.903	0.0450	0.768	0.376	0.391	1.70	23.50	24.33	20.0	33.36	0.96	-0.04	2.36	0.8	27.12	5	Sand mixtures - silty sand to sandy silt	1.98	1.98	1.00	1.19	0.99	2.99	2.99	1.00	1.79	1.50	4.67	4.67	1.00	2.80	2.34	-4.55	0.39	-0.09	#NUM!	#NUM!
17.13	13.5	0.14	-3.7	0.999	0.0450	0.771	0.378	0.392	1.70	23.01	23.82	20.0	32.53	1.06	-0.04	2.39	0.8	26.73	5	Sand mixtures - silty sand to sandy silt	1.98	1.98	1.00	1.19	0.99	2.99	2.99	1.00	1.80	1.50	4.67	4.67	1.00	2.80	2.34	-4.55	0.39	-0.09	#NUM!	#NUM!
17.19	14.4	0.16	-3.7	1.083	0.0450	0.774	0.380	0.393	1.70	24.49	25.36	20.0	34.67	1.14	-0.04	2.39	0.8	28.45	5	Sand mixtures - silty sand to sandy silt	1.98	1.98	1.00	1.19	0.99	2.99	2.99	1.00	1.80	1.50	4.68	4.68	1.00	2.81	2.34	-4.55	0.39	-0.09	#NUM!	#NUM!
17.26	13.8	0.15	-3.0	1.052	0.0450	0.777	0.382	0.394	1.70	23.52	24.35	20.0	33.13	1.12	-0.04	2.40	0.8	27.28	5	Sand mixtures - silty sand to sandy silt	1.98	1.98	1.00	1.19	0.99	3.00	3.00	1.00	1.80	1.50	4.68	4.68	1.00	2.81	2.34	-4.55	0.39	-0.09	#NUM!	#NUM!
17.32	13.8	0.16	-2.3	1.127	0.0450	0.780	0.384	0.395	1.70	23.53	24.36	20.0	33.07	1.19	-0.04	2.41	0.8	27.38	5	Sand mixtures - silty sand to sandy silt	1.98	1.98	1.00	1.19	0.99	3.00	3.00	1.00	1.80	1.50	4.68	4.68	1.00	2.81	2.34	-4.55	0.40	-0.09	#NUM!	#NUM!
17.39	13.3	0.17	-2.3	1.255	0.0450	0.782	0.387	0.396	1.70	22.54	23.34	20.0	31.51	1.33	-0.04	2.45	0.8	26.46	5	Sand mixtures - silty sand to sandy silt	1.99	1.99	1.00	1.19	0.99	3.00	3.00	1.00	1.80	1.50	4.68	4.68	1.00	2.81	2.34	-4.55	0.40	-0.09	#NUM!	#NUM!
17.45	12.4	0.10	-2.0	0.839	0.0450	0.785	0.389	0.397	1.70	21.08	21.82	20.0	29.27	0.90	-0.04	2.39	0.8	24.12	5	Sand mixtures - silty sand to sandy silt	1.99	1.99	1.00	1.19	0.99	3.00	3.00	1.00	1.80	1.50	4.68	4.68	1.00	2.81	2.34	-4.55	0.40	-0.09	#NUM!	#NUM!
17.52	12.1	0.09	-1.3	0.772	0.0450	0.788	0.391	0.398	1.70	20.60	21.33	20.0	28.49	0.83	-0.04	2.39	0.8	23.44	5	Sand mixtures - silty sand to sandy silt	1.99	1.99	1.00	1.19	0.99	3.00	3.00	1.00	1.80	1.50	4.69	4.69	1.00	2.81	2.34	-4.55	0.40	-0.09	#NUM!	#NUM!
17.59	12.4	0.07	-1.0	0.586	0.0450	0.791	0.393	0.399	1.70	21.11	21.85	20.0	29.16	0.63	-0.04	2.33	0.8	23.55	5	Sand mixtures - silty sand to sandy silt	1.99	1.99	1.00	1.19	1.00	3.01	3.01	1.00	1.80	1.50	4.69	4.69	1.00	2.81	2.34	-4.55	0.40	-0.09	#NUM!	#NUM!
17.65	11.6	0.06	-0.3	0.540	0.0450	0.794	0.395	0.400	1.70	19.65	20.34	20.0	26.94	0.58	-0.04	2.35	0.8	21.88	5	Sand mixtures - silty sand to sandy silt	1.99	1.99	1.00	1.20	1.00	3.01	3.01	1.00	1.80	1.50	4.69	4.69	1.00	2.81	2.34	-4.55	0.40	-0.09	#NUM!	#NUM!
17.72	11.6	0.04	0.3	0.360	0.0450	0.797	0.397	0.400	1.70	19.67	20.36	20.0	26.90	0.39	-0.04	2.29	0.7	21.43	5	Sand mixtures - silty sand to sandy silt	1.99	1.99	1.00	1.20	1.00	3.01	3.01	1.00	1.81	1.50	4.69	4.69	1.00	2.82	2.35	-4.55	0.40	-0.09	#NUM!	#NUM!
17.78	11.6	0.05	0.7	0.449	0.0450	0.800	0.399	0.401	1.70	19.68	20.37	20.0	26.84	0.48	-0.04	2.32	0.8	21.63	5	Sand mixtures - silty sand to sandy silt	2.00	2.00	1.00	1.20	1.00	3.01	3.01	1.00	1.81	1.51	4.69	4.69	1.00	2.82	2.35	-4.55	0.40	-0.09	#NUM!	#NUM!
17.85	12.2	0.07	1.3	0.599	0.0450	0.803	0.401	0.402	1.70	20.66	21.39	20.0	28.22	0.64	-0.03	2.35	0.8	22.96	5	Sand mixtures - silty sand to sandy silt	2.00	2.00	1.00	1.20	1.00	3.01	3.01	1.00	1.81	1.51	4.70	4.70	1.00	2.82	2.35	-4.55	0.40	-0.09	#NUM!	#NUM!
17.91	12.7	0.08	1.3	0.653	FALSE	0.806	0.403	0.403	1.70	21.65	22.41	20.0	29.59	0.70	-0.03	2.34	0.8	24.07	5	Sand mixtures - silty sand to sandy silt	2.00	2.00	1.00	1.20	1.00	3.02	3.02	1.00	1.81	1.51	4.70	4.70	1.00	2.82	2.35	-4.55	0.40	-0.09	#NUM!	#NUM!
17.98	13.0	0.08	2.0	0.638	FALSE	0.809	0.405	0.404	1.70	22.16	22.94	20.0	30.26	0.68	-0.03	2.33	0.8	24.53	5	Sand mixtures - silty sand to sandy silt	2.00	2.00	1.00	1.20	1.00	3.02	3.02	1.00	1.81	1.51	4.70	4.70	1.00	2.82	2.35	-4.55	0.40	-0.09	#NUM!	#NUM!
18.04	12.8	0.07	2.7	0.571	0.0450	0.812	0.407	0.405	1.70	21.68	22.45	20.0	29.49	0.61	-0.03	2.32	0.8	23.84	5	Sand mixtures - silty sand to sandy silt	2.00	2.00	1.00	1.20	1.00	3.02	3.02	1.00	1.81	1.51	4.70	4.70	1.00	2.82	2.35	-4.55	0.41	-0.09	#NUM!	#NUM!
18.11	13.1	0.08	3.3	0.637	FALSE	0.815	0.409	0.406	1.70	22.19	22.97	20.0	30.15	0.68	-0.02	2.33	0.8	24.48	5	Sand mixtures - silty sand to sandy silt	2.01	2.01	1.00	1.20	1.00	3.02	3.02	1.00	1.81	1.51	4.70	4.70	1.00	2.82	2.35	-4.55	0.41	-0.09	#NUM!	#NUM!
18.18	12.8	0.07	4.0	0.570	0.0450	0.818	0.411	0.407	1.70	21.71	22.48	20.0	29.38	0.61	-0.02	2.32	0.8	23.79	5	Sand mixtures - silty sand to sandy silt	2.01	2.01	1.00	1.20	1.00	3.02	3.02	1.00	1.81	1.51	4.71	4.71	1.00	2.82	2.35	-4.55	0.41	-0.09	#NUM!	#NUM!
18.24	13.4	0.08	4.7	0.623	FALSE	0.821	0.413	0.408	1.70	22.70	23.50	20.0	30.74	0.66	-0.02	2.32	0.8	24.89	5	Sand mixtures - silty sand to sandy silt	2.01	2.01	1.00	1.21	1.00	3.02	3.02	1.00	1.81	1.51	4.71	4.71	1.00	2.82	2.35	-4.55	0.41	-0.09	#NUM!	#NUM!
18.31	14.2	0.04	5.4	0.292	0.0450	0.824	0.415	0.409	1.70	24.20	25.05	20.0	32.82	0.31	-0.02	2.18	0.7	25.42	5	Sand mixtures - silty sand to sandy silt	2.01	2.01	1.00	1.21	1.01	3.03	3.03	1.00	1.82	1.51	4.71	4.71	1.00	2.83	2.35	-4.55	0.41	-0.09	#NUM!	#NUM!
18.37	15.1	0.03	6.4	0.206	0.0450	0.827	0.417	0.410	1.70	25.69	26.59	20.0	34.88	0.22	-0.02	2.12	0.7	26.50	5	Sand mixtures - silty sand to sandy silt	2.01	2.01	1.00	1.21	1.01	3.03	3.03	1.00	1.82	1.51	4.71	4.71	1.00	2.83	2.36	-4.55	0.41	-0.09	#NUM!	#NUM!
18.44	14.5	0.03	6.4	0.215	0.0450	0.830	0.419	0.410	1.70	24.72	25.59	20.0	33.40	0.23	-0.02	2.14	0.7	25.56	5	Sand mixtures - silty sand to sandy silt	2.01	2.01	1.00	1.21	1.01	3.03	3.03	1.00	1.82	1.52	4.71	4.71	1.00	2.83	2.36	-4.55	0.41	-0.09	#NUM!	#NUM!
18.50	13.4	0.02	6.7	0.155	0.0450	0.833	0.421	0.411	1.70	22.74	23.54	20.0	30.50	0.17	-0.02	2.15	0.7	23.39	5	Sand mixtures - silty sand to sandy silt	2.02	2.02	1.00	1.21	1.01	3.03	3.03	1.00	1.82	1.52	4.72	4.72	1.00	2.83	2.36	-4.55	0.41	-0.09	#NUM!	#NUM!
18.57	12.8	0.01	7.7	0.081	0.0450	0.836	0.423	0.412	1.70	21.79	22.56	20.0	29.07	0.09	-0.02	2.13	0.7	22.19	5	Sand mixtures - silty sand to sandy silt	2.02	2.02	1.00	1.21	1.01	3.03	3.03	1.00	1.82	1.52	4.72	4.72	1.00	2.83	2.36	-4.55	0.41	-0.09	#NUM!	#NUM!
18.64	13.1	0.04	9.0	0.317	0.0450	0.839	0.425	0.413	1.70	22.32	23.10	20.0	29.75	0.34	-0.01	2.23	0.7	23.47	5	Sand mixtures - silty sand to sandy silt	2.02	2.02	1.00	1.21	1.01	3.04	3.04	1.00	1.82	1.52	4.72	4.72	1.00	2.83	2.36	-4.55	0.41	-0.09	#NUM!	#NUM!
18.70	14.6	0.07	9.7	0.499	0.0450	0.842	0.427	0.414	1.70	24.79	25.66	20.0	33.19	0.53	-0.01	2.26	0.7	26.42	5	Sand mixtures - silty sand to sandy silt	2.02	2.02	1.00	1.21	1.01	3.04	3.04	1.00	1.82	1.52	4.72	4.72	1.00	2.83	2.36	-4.55	0.41	-0.09	#NUM!	#NUM!
18.77	16.3	0.09	11.0	0.573	0.0450	0.844	0.430	0.415	1.70	27.76	28.73	20.0	37.31	0.60	-0.01	2.24	0.7	29.54	5	Sand mixtures - silty sand to sandy silt	2.02	2.02	1.00	1.21	1.01	3.04	3.04	1.00	1.82	1.52	4.72	4.72	1.00	2.83	2.36	-4.55	0.41	-0.09	#NUM!	#NUM!
18.83	18.1	0.08	13.1	0.460	0.0450	0.847	0.432	0.416	1.70	30.75	31.84	20.0	41.46	0.48	0.00	2.16	0.7	32.07	5	Sand mixtures - silty sand to sandy silt	2.03	2.03	1.00	1.22	1.01	3.04	3.04	1.00	1.83	1.52	4.72	4.72	1.00	2.83	2.36	-4.55	0.42	-0.09	#NUM!	#NUM!
18.90	19.3	0.12	13.7	0.648	0.0450	0.850	0.434	0.417	1.70	32.73	33.88	20.0	44.15	0.68	0.00	2.20	0.7	34.58	5	Sand mixtures - silty sand to sandy silt	2.03	2.03	1.00	1.22	1.01	3.04	3.04	1.00	1.83	1.52	4.73	4.73	1.00	2.84	2.36	-4.55	0.42	-0.09	#NUM!	#NUM!
18.96	19.9	0.17	15.4	0.838	0.0450	0.853	0.436	0.418	1.70	33.76	34.95	20.0	45.50	0.88	0.00	2.24	0.7	36.11	5	Sand mixtures - silty sand to sandy silt	2.03	2.03	1.00	1.22	1.01	3.05	3.05	1.00	1.83	1.52	4.73	4.73	1.00	2.84	2.36	-4.55	0.42	-0.09	#NUM!	#NUM!
19.03	22.5	0.19	16.7	0.833	0.0450	0.856	0.438	0.419	1.70	38.21	39.55	20.0	51.65	0.87	0.00	2.19	0.7	40.44	5	Sand mixtures - silty sand to sandy silt	2.03	2.03	1.00	1.22	1.02	3.05	3.05	1.00	1.83	1.52	4.73	4.73	1.00	2.84	2.37	-4.55	0.42	-0.09	#NUM!	#NUM!
19.09	22.8	0.54	18.4	2.373	0.0450	0.859	0.440	0.420	1.70	38.74	40.10	50.0	52.27	2.47	0.01	2.43	0.8	44.22	5	Sand mixtures - silty sand to sandy silt	2.03	2.03	1.00	1.22	#N/A	3.05	3.05	1.00	1.83	1.52	4.73	4.73	1.00	2.84	2.37	-4.55	0.42	-0.09	#NUM!	#NUM!
19.16	22.5	0.67	19.4	2.957	0.0450	0.862	0.442	0.420	1.70	38.27	39.61	50.0	51.49	3.07	0.01	2.50	0.8	44.45	5	Sand mixtures - silty sand to sandy silt	2.04	2.04	1.00	1.22	#N/A	3.05	3.05	1.00	1.83	1.53	4.73	4.73	1.00	2.84	2.37	-4.55	0.42	-0.09	#NUM!	#NUM!
19.23	15.6	0.75	18.4	4.812	0.0450	0.865	0.444	0.421	1.70	26.45	27.38	50.0	34.88	5.10	0.01	2.75	0.9	32.59	4	Silt mixtures - clayey silt to silty clay	2.04	2.04	1.00	1.22	#N/A	3.05	3.05	1.00	1.83	1.53	4.74	4.74	1.00	2.84	2.37	-4.55	0.42	-0.09	#NUM!	#NUM!
19.29	28.3	0.72	-0.7	2.535	0.0450	0.868	0.446	0.422	1.70	48.06	49.75	50.0	65.00	2.61	-0.02	2.39	0.8	54.22	5	Sand mixtures - silty sand to sandy silt	2.04	2.04	1.00	1.22	#N/A	3.06	3.06	1.00	1.83	1.53	4.74	4.74	1.00	2.84	2.37	-4.55	0.42	-0.09	#NUM!	#NUM!
19.36	24.0	0.62	-2.7	2.605	0.0450	0.871	0.448	0.423	1.70	40.73	42.16	50.0	54.56	2.70	-0.02	2.45	0.8	46.40	5	Sand mixtures - silty sand to sandy silt	2.04	2.04	1.00	1.22	#N/A	3.06	3.06	1.00	1.83	1.53	4.74	4.74	1.00	2.84	2.37	-4.55	0.42	-0.09	#NUM!	#NUM!
19.42	23.1	0.60	-1.3	2.611	0.0450	0.874	0.450	0.424	1.70	39.27	40.66	50.0	52.42	2.71	-0.02	2.46	0.8	44.77	5	Sand mixtures - silty sand to sandy silt	2.04	2.04	1.00	1.23	#N/A	3.06	3.06	1.00	1.84	1.53	4.74	4.74	1.00	2.85	2.37	-4.55	0.42	-0.09	#NUM!	#NUM!
19.49	23.1	0.61	1.0	2.653	0.0450	0.877	0.452	0.425	1.70	39.33	40.71	50.0	52.37	2.76	-0.02	2.46	0.8	44.82	5	Sand mixtures - silty sand to sandy silt	2.04	2.04	1.00	1.23	#N/A	3.06	3.06	1.00	1.84	1.53	4.74	4.74	1.00	2.85	2.37	-4.55	0.42	-0.09	#NUM!	#NUM!
19.55	22.8	0.51	1.3	2.231	0.0450	0.880	0.454	0.426	1.70	38.84	40.20	50.0	51.58	2.32	-0.02	2.42	0.8	43.60	5	Sand mixtures - silty sand to sandy silt	2.05	2.05	1.00	1.23	#N/A	3.06	3.06	1.00	1.84	1.53	4.75	4.75	1.00	2.85	2.37	-4.55	0.43	-0.09	#NUM!	#NUM!
19.62	24.6	0.46	1.7	1.861	0.0450	0.883	0.456	0.427	1.70	41.80	43.27	50.0	55.55	1.93	-0.02	2.35	0.8	45.97	5	Sand mixtures - silty sand to sandy silt	2.05	2.05	1.00	1.23	#N/A	3.06	3.06	1.00	1.84	1.53	4.75	4.75	1.00	2.85	2.37	-4.55	0.43	-0.09	#NUM!	#NUM!
19.69	23.4	0.48	2.3	2.041	0.0450	0.886	0.458	0.428	1.70	39.85	41.25	50.0	52.74	2.12	-0.02	2.39	0.8	44.21	5	Sand mixtures - silty sand to sandy silt	2.05	2.05	1.00	1.23	#N/A	3.07	3.07	1.00	1.84	1.53	4.75	4.75	1.00	2.85	2.37	-4.55	0.43	-0.09	#NUM!	#NUM!
19.75	23.2	0.53	4.0	2.289	0.0450	0.889	0.460	0.429	1.70	39.39	40.78	50.0	52.00	2.38	-0.02	2.43	0.8	44.06	5	Sand mixtures - silty sand to sandy silt	2.05	2.05	1.00	1.23	#N/A	3.07	3.07	1.00	1.84	1.53	4.75	4.75	1.00	2.85	2.38	-4.55	0.43	-0.09	#NUM!	#NUM!
19.82	24.1	0.68	4.7	2.810	0.0450	0.892	0.462	0.429	1.70	40.89	42.33	50.0	53.93	2.92	-0.01	2.47	0.8	46.34	5	Sand mixtures - silty sand to sandy silt	2.05	2.05	1.00	1.23	#N/A	3.07	3.07	1.00	1.84	1.54	4.75	4.75	1.00	2.85	2.38	-4.55	0.43	-0.09	#NUM!	#NUM!

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION
FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)
Locatiomight Mine South Storage Pond

Constants		
Pa	0.97	tsf
Nkt	18	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

SHANSEP			
s_u		s_r	
$s_u/\sigma_{v'}$	0.60	$s_r/\sigma_{v'}$	0.50
m	0.65	m	0.65

2011 CPT Data from ConeTec					CPT Data Interpretations																Strength Estimates under Dam																			
													Using Qtn for calculating Ic (iterations)								10' Fill					30' Fill					65' Fill					Pond - 40' Fill with 80' Removed				
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r
19.88	26.4	0.79	6.0	2.996	0.0450	0.895	0.464	0.430	1.70	44.72	46.29	50.0	59.22	3.10	-0.01	2.46	0.8	50.74	5	Sand mixtures - silty sand to sandy silt	2.06	2.06	1.00	1.23	#N/A	3.07	3.07	1.00	1.84	1.54	4.76	4.76	1.00	2.85	2.38	-4.55	0.43	-0.09	#NUM!	#NUM!
19.95	28.1	0.79	6.7	2.810	0.0450	0.898	0.466	0.431	1.68	47.23	48.89	50.0	63.13	2.90	-0.01	2.42	0.8	53.51	5	Sand mixtures - silty sand to sandy silt	2.06	2.06	1.00	1.23	#N/A	3.07	3.07	1.00	1.84	1.54	4.76	4.76	1.00	2.85	2.38	-4.55	0.43	-0.09	#NUM!	#NUM!
20.01	32.2	0.99	6.4	3.071	0.0450	0.901	0.468	0.432	1.65	53.02	54.88	50.0	72.35	3.16	-0.01	2.41	0.8	61.07	5	Sand mixtures - silty sand to sandy silt	2.06	2.06	1.00	1.24	#N/A	3.08	3.08	1.00	1.85	1.54	4.76	4.76	1.00	2.86	2.38	-4.55	0.43	-0.09	#NUM!	#NUM!
20.08	31.3	1.00	6.7	3.190	0.0450	0.904	0.470	0.433	1.65	51.71	53.53	50.0	70.18	3.28	-0.01	2.43	0.8	59.63	5	Sand mixtures - silty sand to sandy silt	2.06	2.06	1.00	1.24	#N/A	3.08	3.08	1.00	1.85	1.54	4.76	4.76	1.00	2.86	2.38	-4.55	0.43	-0.10	#NUM!	#NUM!
20.14	26.7	0.82	7.0	3.079	0.0450	0.906	0.473	0.434	1.68	44.95	46.53	50.0	59.40	3.19	-0.01	2.46	0.8	51.08	5	Sand mixtures - silty sand to sandy silt	2.06	2.06	1.00	1.24	#N/A	3.08	3.08	1.00	1.85	1.54	4.76	4.76	1.00	2.86	2.38	-4.55	0.43	-0.10	#NUM!	#NUM!
20.21	25.2	0.64	6.4	2.556	0.0450	0.909	0.475	0.435	1.69	42.75	44.26	50.0	55.92	2.65	-0.01	2.43	0.8	47.63	5	Sand mixtures - silty sand to sandy silt	2.07	2.07	1.00	1.24	#N/A	3.08	3.08	1.00	1.85	1.54	4.76	4.76	1.00	2.86	2.38	-4.55	0.43	-0.10	#NUM!	#NUM!
20.28	19.4	0.66	5.4	3.371	0.0450	0.912	0.477	0.436	1.70	33.04	34.20	50.0	42.50	3.54	-0.02	2.59	0.9	37.99	5	Sand mixtures - silty sand to sandy silt	2.07	2.07	1.00	1.24	#N/A	3.08	3.08	1.00	1.85	1.54	4.77	4.77	1.00	2.86	2.38	-4.55	0.44	-0.10	#NUM!	#NUM!
20.34	16.0	0.67	5.0	4.171	0.0450	0.915	0.479	0.437	1.70	27.13	28.08	50.0	34.44	4.43	-0.02	2.71	0.9	31.95	4	Silt mixtures - clayey silt to silty clay	2.07	2.07	1.00	1.24	#N/A	3.09	3.09	1.00	1.85	1.54	4.77	4.77	1.00	2.86	2.38	-4.55	0.44	-0.10	#NUM!	#NUM!
20.41	21.8	0.67	6.4	3.059	0.0450	0.918	0.481	0.438	1.70	36.99	38.29	50.0	47.62	3.19	-0.01	2.53	0.8	41.81	5	Sand mixtures - silty sand to sandy silt	2.07	2.07	1.00	1.24	#N/A	3.09	3.09	1.00	1.85	1.54	4.77	4.77	1.00	2.86	2.39	-4.55	0.44	-0.10	#NUM!	#NUM!
20.47	25.5	0.70	7.7	2.728	0.0450	0.921	0.483	0.439	1.68	43.00	44.52	50.0	56.14	2.83	-0.01	2.45	0.8	48.13	5	Sand mixtures - silty sand to sandy silt	2.07	2.07	1.00	1.24	#N/A	3.09	3.09	1.00	1.85	1.54	4.77	4.77	1.00	2.86	2.39	-4.55	0.44	-0.10	#NUM!	#NUM!
20.54	26.8	0.80	-6.7	2.988	0.0450	0.924	0.485	0.439	1.67	44.80	46.37	50.0	58.88	3.10	-0.03	2.46	0.8	50.67	5	Sand mixtures - silty sand to sandy silt	2.07	2.07	1.00	1.24	#N/A	3.09	3.09	1.00	1.85	1.55	4.77	4.77	1.00	2.86	2.39	-4.55	0.44	-0.10	#NUM!	#NUM!
20.60	24.2	0.85	-6.0	3.525	0.0450	0.927	0.487	0.440	1.69	40.91	42.35	50.0	52.84	3.67	-0.03	2.54	0.8	46.56	5	Sand mixtures - silty sand to sandy silt	2.08	2.08	1.00	1.25	#N/A	3.09	3.09	1.00	1.86	1.55	4.78	4.78	1.00	2.87	2.39	-4.55	0.44	-0.10	#NUM!	#NUM!
20.67	24.8	0.82	-5.4	3.315	0.0450	0.930	0.489	0.441	1.68	41.74	43.21	50.0	54.07	3.44	-0.03	2.51	0.8	47.32	5	Sand mixtures - silty sand to sandy silt	2.08	2.08	1.00	1.25	#N/A	3.09	3.09	1.00	1.86	1.55	4.78	4.78	1.00	2.87	2.39	-4.55	0.44	-0.10	#NUM!	#NUM!
20.73	25.1	0.90	-4.7	3.607	0.0450	0.933	0.491	0.442	1.68	42.13	43.61	50.0	54.63	3.75	-0.03	2.53	0.8	48.12	5	Sand mixtures - silty sand to sandy silt	2.08	2.08	1.00	1.25	#N/A	3.10	3.10	1.00	1.86	1.55	4.78	4.78	1.00	2.87	2.39	-4.55	0.44	-0.10	#NUM!	#NUM!
20.80	28.6	0.93	-4.0	3.241	0.0450	0.936	0.493	0.443	1.65	47.14	48.80	50.0	62.34	3.35	-0.02	2.46	0.8	53.83	5	Sand mixtures - silty sand to sandy silt	2.08	2.08	1.00	1.25	#N/A	3.10	3.10	1.00	1.86	1.55	4.78	4.78	1.00	2.87	2.39	-4.55	0.44	-0.10	#NUM!	#NUM!
20.87	38.1	0.88	-3.7	2.320	0.0450	0.939	0.495	0.444	1.59	60.54	62.67	50.0	83.70	2.38	-0.02	2.28	0.7	68.56	5	Sand mixtures - silty sand to sandy silt	2.08	2.08	1.00	1.25	#N/A	3.10	3.10	1.00	1.86	1.55	4.78	4.78	1.00	2.87	2.39	-4.55	0.44	-0.10	#NUM!	#NUM!
20.93	37.7	0.88	-10.0	2.343	0.0450	0.942	0.497	0.445	1.59	59.97	62.08	50.0	82.71	2.40	-0.02	2.29	0.7	67.90	5	Sand mixtures - silty sand to sandy silt	2.09	2.09	1.00	1.25	#N/A	3.10	3.10	1.00	1.86	1.55	4.79	4.79	1.00	2.87	2.39	-4.55	0.44	-0.10	#NUM!	#NUM!
21.00	29.9	1.07	-11.0	3.581	0.0450	0.945	0.499	0.446	1.64	48.92	50.65	50.0	64.98	3.70	-0.03	2.48	0.8	56.45	5	Sand mixtures - silty sand to sandy silt	2.09	2.09	1.00	1.25	#N/A	3.10	3.10	1.00	1.86	1.55	4.79	4.79	1.00	2.87	2.39	-4.55	0.45	-0.10	#NUM!	#NUM!
21.06	26.5	1.13	-10.7	4.285	0.0450	0.948	0.501	0.447	1.66	43.88	45.42	50.0	57.10	4.44	-0.03	2.57	0.9	50.93	5	Sand mixtures - silty sand to sandy silt	2.09	2.09	1.00	1.25	#N/A	3.11	3.11	1.00	1.86	#N/A	4.79	4.79	1.00	2.87	#N/A	-4.55	0.45	-0.10	#NUM!	#N/A
21.13	36.6	1.25	-10.4	3.413	0.0450	0.951	0.503	0.448	1.59	58.17	60.22	50.0	79.57	3.50	-0.02	2.41	0.8	67.74	5	Sand mixtures - silty sand to sandy silt	2.09	2.09	1.00	1.25	#N/A	3.11	3.11	1.00	1.86	#N/A	4.79	4.79	1.00	2.87	#N/A	-4.55	0.45	-0.10	#NUM!	#N/A
21.19	43.2	1.42	-11.0	3.297	0.0450	0.954	0.505	0.448	1.55	67.18	69.54	50.0	94.23	3.37	-0.02	2.35	0.8	78.93	5	Sand mixtures - silty sand to sandy silt	2.09	2.09	1.00	1.26	#N/A	3.11	3.11	1.00	1.87	#N/A	4.79	4.79	1.00	2.88	#N/A	-4.55	0.45	-0.10	#NUM!	#N/A
21.26	43.7	1.02	-15.7	2.331	0.0450	0.957	0.507	0.449	1.55	67.79	70.18	50.0	95.17	2.38	-0.02	2.25	0.7	77.38	5	Sand mixtures - silty sand to sandy silt	2.10	2.10	1.00	1.26	#N/A	3.11	3.11	1.00	1.87	1.56	4.80	4.80	1.00	2.88	2.40	-4.55	0.45	-0.10	#NUM!	#NUM!
21.33	31.5	1.06	-20.1	3.364	0.0450	0.960	0.509	0.450	1.62	50.95	52.74	50.0	67.89	3.47	-0.04	2.45	0.8	58.56	5	Sand mixtures - silty sand to sandy silt	2.10	2.10	1.00	1.26	#N/A	3.11	3.11	1.00	1.87	1.56	4.80	4.80	1.00	2.88	2.40	-4.55	0.45	-0.10	#NUM!	#NUM!
21.39	25.2	1.00	-20.4	3.966	0.0450	0.963	0.511	0.451	1.66	41.76	43.23	50.0	53.65	4.12	-0.05	2.56	0.9	47.87	5	Sand mixtures - silty sand to sandy silt	2.10	2.10	1.00	1.26	#N/A	3.12	3.12	1.00	1.87	1.56	4.80	4.80	1.00	2.88	2.40	-4.55	0.45	-0.10	#NUM!	#NUM!
21.46	21.1	0.82	-19.7	3.889	0.0450	0.966	0.513	0.452	1.69	35.73	36.98	50.0	44.59	4.08	-0.06	2.61	0.9	40.36	4	Silt mixtures - clayey silt to silty clay	2.10	2.10	1.00	1.26	#N/A	3.12	3.12	1.00	1.87	1.56	4.80	4.80	1.00	2.88	2.40	-4.55	0.45	-0.10	#NUM!	#NUM!
21.52	22.0	0.73	-19.7	3.309	0.0450	0.969	0.515	0.453	1.68	36.99	38.29	50.0	46.42	3.46	-0.05	2.56	0.8	41.35	5	Sand mixtures - silty sand to sandy silt	2.10	2.10	1.00	1.26	#N/A	3.12	3.12	1.00	1.87	1.56	4.80	4.80	1.00	2.88	2.40	-4.55	0.45	-0.10	#NUM!	#NUM!
21.59	19.4	0.64	-19.7	3.324	0.0450	0.971	0.518	0.454	1.70	32.98	34.14	50.0	40.59	3.50	-0.06	2.60	0.9	36.61	5	Sand mixtures - silty sand to sandy silt	2.10	2.10	1.00	1.26	#N/A	3.12	3.12	1.00	1.87	1.56	4.80	4.80	1.00	2.88	2.40	-4.55	0.45	-0.10	#NUM!	#NUM!
21.65	18.0	0.55	-19.4	3.070	0.0450	0.974	0.520	0.455	1.70	30.53	31.60	50.0	37.34	3.25	-0.07	2.60	0.9	33.72	4	Silt mixtures - clayey silt to silty clay	2.11	2.11	1.00	1.26	#N/A	3.12	3.12	1.00	1.87	1.56	4.81	4.81	1.00	2.88	2.40	-4.55	0.45	-0.10	#NUM!	#NUM!
21.72	18.5	0.50	-19.4	2.694	0.0450	0.977	0.522	0.456	1.70	31.50	32.61	50.0	38.51	2.84	-0.06	2.56	0.8	34.36	5	Sand mixtures - silty sand to sandy silt	2.11	2.11	1.00	1.26	#N/A	3.12	3.12	1.00	1.87	1.56	4.81	4.81	1.00	2.89	2.40	-4.55	0.46	-0.10	#NUM!	#NUM!
21.78	16.5	0.46	-19.4	2.772	0.0450	0.980	0.524	0.457	1.70	28.07	29.06	50.0	34.01	2.95	-0.07	2.60	0.9	30.76	4	Silt mixtures - clayey silt to silty clay	2.11	2.11	1.00	1.27	#N/A	3.13	3.13	1.00	1.88	1.56	4.81	4.81	1.00	2.89	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
21.85	14.5	0.37	-19.4	2.585	0.0450	0.983	0.526	0.458	1.70	24.62	25.49	50.0	29.50	2.77	-0.08	2.63	0.9	26.90	4	Silt mixtures - clayey silt to silty clay	2.11	2.11	1.00	1.27	#N/A	3.13	3.13	1.00	1.88	1.56	4.81	4.81	1.00	2.89	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
21.92	11.9	0.32	-19.4	2.713	0.0450	0.986	0.528	0.458	1.70	20.20	20.91	50.0	23.77	2.96	-0.10	2.71	0.9	22.19	4	Silt mixtures - clayey silt to silty clay	2.11	2.11	1.00	1.27	#N/A	3.13	3.13	1.00	1.88	1.57	4.81	4.81	1.00	2.89	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
21.98	11.6	0.29	-19.1	2.511	0.0450	0.989	0.530	0.459	1.70	19.71	20.41	50.0	23.09	2.75	-0.11	2.71	0.9	21.51	4	Silt mixtures - clayey silt to silty clay	2.12	2.12	1.00	1.27	#N/A	3.13	3.13	1.00	1.88	1.57	4.82	4.82	1.00	2.89	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
22.05	13.3	0.26	-19.1	1.950	0.0450	0.992	0.532	0.460	1.70	22.67	23.46	50.0	26.81	2.11	-0.09	2.59	0.9	24.21	5	Sand mixtures - silty sand to sandy silt	2.12	2.12	1.00	1.27	1.06	3.13	3.13	1.00	1.88	1.57	4.82	4.82	1.00	2.89	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
22.11	14.5	0.27	-19.1	1.867	0.0450	0.995	0.534	0.461	1.70	24.63	25.49	50.0	29.26	2.00	-0.08	2.56	0.8	26.14	5	Sand mixtures - silty sand to sandy silt	2.12	2.12	1.00	1.27	1.06	3.14	3.14	1.00	1.88	1.57	4.82	4.82	1.00	2.89	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
22.18	14.8	0.20	-18.7	1.337	0.0450	0.998	0.536	0.462	1.70	25.13	26.01	20.0	29.83	1.43	-0.08	2.47	0.8	26.05	5	Sand mixtures - silty sand to sandy silt	2.12	2.12	1.00	1.27	1.06	3.14	3.14	1.00	1.88	1.57	4.82	4.82	1.00	2.89	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
22.24	15.6	0.32	-18.7	2.061	0.0450	1.001	0.538	0.463	1.70	26.60	27.53	50.0	31.63	2.20	-0.08	2.55	0.8	28.26	5	Sand mixtures - silty sand to sandy silt	2.12	2.12	1.00	1.27	1.06	3.14	3.14	1.00	1.88	1.57	4.82	4.82	1.00	2.89	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
22.31	17.1	0.53	-18.7	3.103	0.0450	1.004	0.540	0.464	1.70	29.06	30.08	50.0	34.68	3.30	-0.07	2.63	0.9	31.64	4	Silt mixtures - clayey silt to silty clay	2.13	2.13	1.00	1.28	#N/A	3.14	3.14	1.00	1.88	1.57	4.83	4.83	1.00	2.90	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
22.38	15.1	0.53	-18.4	3.518	0.0450	1.007	0.542	0.465	1.70	25.63	26.53	50.0	30.27	3.77	-0.08	2.70	0.9	28.22	4	Silt mixtures - clayey silt to silty clay	2.13	2.13	1.00	1.28	#N/A	3.14	3.14	1.00	1.89	1.57	4.83	4.83	1.00	2.90	2.41	-4.55	0.46	-0.10	#NUM!	#NUM!
22.44	16.0	0.55	-14.4	3.446	0.0450	1.010	0.544	0.466	1.70	27.19	28.15	50.0	32.18	3.68	-0.07	2.68	0.9	29.79	4	Silt mixtures - clayey silt to silty clay	2.13	2.13	1.00	1.28	#N/A	3.15	3.15	1.00	1.89	1.57	4.83	4.83	1.00	2.90	2.41	-4.55	0.47	-0.10	#NUM!	#NUM!
22.51	15.1	0.45	-13.4	2.953	0.0450	1.013	0.546	0.467	1.70	25.74	26.65	50.0	30.29	3.16	-0.07	2.66	0.9	27.88	4	Silt mixtures - clayey silt to silty clay	2.13	2.13	1.00	1.28	#N/A	3.15	3.15	1.00	1.89	1.57	4.83	4.83	1.00	2.90	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
22.57	18.0	0.50	-13.4	2.768	0.0450	1.016	0.548	0.467	1.69	30.39	31.46	50.0	36.41	2.93	-0.06	2.58	0.9	32.83	5	Sand mixtures - silty sand to sandy silt	2.13	2.13	1.00	1.28	#N/A	3.15	3.15	1.00	1.89	1.57	4.83	4.83	1.00	2.90	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
22.64	20.1	0.81	-13.4	4.045	0.0450	1.019	0.550	0.468	1.66	33.37	34.55	50.0	40.64	4.26	-0.05	2.65	0.9	37.36	4	Silt mixtures - clayey silt to silty clay	2.13	2.13	1.00	1.28	#N/A	3.15	3.15	1.00	1.89	1.58	4.83	4.83	1.00	2.90	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
22.70	21.8	0.72	-13.1	3.293	0.0450	1.022	0.552	0.469	1.65	35.90	37.16	50.0	44.26	3.45	-0.05	2.57	0.9	39.79	5	Sand mixtures - silty sand to sandy silt	2.14	2.14	1.00	1.28	#N/A	3.15	3.15	1.00	1.89	1.58	4.84	4.84	1.00	2.90	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
22.77	26.7	0.61	-13.7	2.298	0.0450	1.025	0.554	0.470	1.61	42.95	44.46	50.0	54.61	2.39	-0.04	2.41	0.8	46.98	5	Sand mixtures - silty sand to sandy silt	2.14	2.14	1.00	1.28	#N/A	3.15	3.15	1.00	1.89	1.58	4.84	4.84	1.00	2.90	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
22.83	29.9	0.88	-13.7	2.959	0.0450	1.028	0.556	0.471	1.59	47.38	49.05	50.0	61.23	3.06	-0.03	2.44	0.8	53.20	5	Sand mixtures - silty sand to sandy silt	2.14	2.14	1.00	1.28	#N/A	3.16	3.16	1.00	1.89	1.58	4.84	4.84	1.00	2.90	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
22.90	37.9	0.93	-15.7	2.440	0.0450	1.031	0.558	0.472	1.54	58.42	60.47	50.0	78.20	2.51	-0.03	2.31	0.8	65.66	5	Sand mixtures - silty sand to sandy silt	2.14	2.14	1.00	1.29	#N/A	3.16	3.16	1.00	1.90	1.58	4.84	4.84	1.00	2.91	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
22.97	37.0	1.03	-21.1	2.782	0.0450	1.033	0.561	0.473	1.54	57.09	59.10	50.0	76.07	2.86	-0.03	2.36	0.8	64.69	5	Sand mixtures - silty sand to sandy silt	2.14	2.14	1.00	1.29	#N/A	3.16	3.16	1.00	1.90	1.58	4.84	4.84	1.00	2.91	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
23.03	35.0	1.00	-16.1	2.849	0.0450	1.036	0.563	0.474	1.55	54.37	56.28	50.0	71.77	2.94	-0.03	2.38	0.8	61.46	5	Sand mixtures - silty sand to sandy silt	2.15	2.15	1.00	1.29	#N/A	3.16	3.16	1.00	1.90	1.58	4.85	4.85	1.00	2.91	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
23.10	28.4	1.01	-19.7	3.558	0.0450	1.039	0.565	0.475	1.59	45.04	46.62	50.0	57.53	3.69	-0.04	2.51	0.8	51.02	5	Sand mixtures - silty sand to sandy silt	2.15	2.15	1.00	1.29	#N/A	3.16	3.16	1.00	1.90	1.58	4.85	4.85	1.00	2.91	2.42	-4.55	0.47	-0.10	#NUM!	#NUM!
23.16	20.8	1.08	-19.4	5.188	0.0450	1.042	0.567	0.476	1.64	34.22	35.42	50.0	41.64	5.46	-0.06	2.71	0.9	39.02	4	Silt mixtures - clayey silt to silty clay	2.15	2.15	1.00	1.29	#N/A	3.17	3.17	1.00	1.90	#N/A	4.85	4.85	1.00	2.91	#N/A	-4.55	0.48	-0.10	#NUM!	#N/A
23.23	28.1	1.21	-19.4	4.299	0.0450	1.045	0.569	0.477	1.59	44.53	46.10	50.0	56.70	4.46	-0.04	2.57	0.9	51.12	5	Sand mixtures - silty sand to sandy silt	2.15	2.15	1.00	1.29	#N/A	3.17	3.17	1.00	1.90	#N/A	4.85	4.85	1.00	2.91	#N/A	-4.55	0.48	-0.10	#NUM!	#N/A
23.29	32.1	0.98	-19.4	3.044	0.0450	1.048	0.571	0.477	1.56	50.13	51.90	50.0	65.08	3.15	-0.04	2.43	0.8	56.53	5	Sand mixtures - silty sand to sandy silt	2.15	2.15	1.00	1.29	#N/A	3.17	3.17	1.00	1.90	1.58	4.85	4.85	1.00	2.91	2.43	-4.55	0.48	-0.10	#NUM!	#NUM!
23.36	33.0	0.79	-19.4	2.396	0.0450	1.051	0.573	0.478	1.55	51.27	53.07	50.0	66.75	2.48	-0.04	2.35	0.8	56.87	5	Sand mixtures - silty sand to sandy silt	2.16	2.16	1.00	1.29	#N/A	3.17	3.17	1.00	1.90	1.59	4.86	4.86	1.00	2.91	2.43	-4.55	0.48	-0.11	#NUM!	#NUM!
23.43	33.6	0.99	-19.7	2.945	0.0450	1.054	0.575	0.479	1.55	51.99	53.82	50.0	67.81	3.04	-0.04	2.41	0.8	58.61	5	Sand mixtures - silty sand to sandy silt	2.16	2.16	1.00	1.29	#N/A	3.17	3.17	1.00	1.90	1.59	4.86	4.86	1.00	2.91	2.43	-4.55	0.48	-0.11	#NUM!	#NUM!
23.49	37.6	0.82	-19.4	2.184	0.0450	1.057	0.577	0.480	1.53	57.44	59.47	50.0	76.13	2.25	-0.03	2.29	0.7	63.80	5	Sand mixtures - silty sand to sandy silt	2.16	2.16	1.00	1.30	#N/A	3.18	3.18	1.00	1.91	1.59	4.86	4.86	1.00	2.92	2.43	-4.55	0.48	-0.11	#NUM!	#NUM!
23.56	43.7	0.80	-19.7	1.834	0.0450	1.060	0.579	0.481	1.50	65.44	67.75	50.0	88.57	1.88	-0.03	2.20	0.7	72.45	5	Sand mixtures - silty sand to sandy silt	2.16	2.16	1.00	1.30	#N/A	3.18	3.18	1.00	1.91	1.59	4.86	4.86	1.00	2.92	2.43	-4.55	0.48	-0.11	#NUM!	#NUM!

CD-12-03 LIQUEFACTION POTENTIAL CALCULATION SPREADSHEET FREE FIELD CONDITION

FREE FIELD CONDITION

Data File: **CD-12-02** (Input Data)

Locatiomight Mine South Storage Pond

Constants		
Pa	**0.97**	**tsf**
Nkt	**18**	

Max. Horiz. Acceleration, Amax/g:	0.131
Earthquake Moment Magnitude, M:	6.5
Magnitude Scaling Factor, MSF:	1.30

Max. Horiz. Acceleration, Amax/g:	0.131	
Earthquake Moment Magnitude, M:	6.5	
Magnitude Scaling Factor, MSF:	1.44	1.44

SHANSEP			
s_u		s_r	
$s_u/\sigma_{v'}$	**0.60**	$s_r/\sigma_{v'}$	**0.50**
m	**0.65**	**m**	**0.65**

2011 CPT Data from ConeTec					CPT Data Interpretations																					Strength Estimates under Dam																	
														Using Qtn for calculating Ic (iterations)								10' Fill					30' Fill					65' Fill					Pond - 40' Fill with 80' Removed				
Depth	qt	fs	Pw (u2)	fs/qt	Unit Weight	Total Stress	Equil Pore Pressure, u0	Effective Stress	CN	qc1	qc1N	FC	Qt1	Fr	Bq	Ic	n	Qtn	SBTn	Soil Type	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r	σ_v'	σ_p'	OCR	s_u	s_r
23.62	58.4	0.83	-20.1	1.425	0.0450	1.063	0.581	0.482	1.44	84.30	87.26	20.0	118.97	1.45	-0.02	2.04	0.7	93.39	6	Sands - clean sand to silty sand	2.16	2.16	1.00	1.30	#N/A	3.18	3.18	1.00	1.91	1.59	4.86	4.86	1.00	2.92	2.43	-4.55	0.48	-0.11	#NUM!	#NUM!
23.69	73.4	0.84	-19.7	1.147	0.0450	1.066	0.583	0.483	1.40	102.76	106.38	20.0	149.89	1.16	-0.02	1.91	0.6	113.83	6	Sands - clean sand to silty sand	2.17	2.17	1.00	1.30	#N/A	3.18	3.18	1.00	1.91	1.59	4.87	4.87	1.00	2.92	2.43	-4.55	0.48	-0.11	#NUM!	#NUM!
23.75	99.2	0.67	-19.7	0.671	0.0450	1.069	0.585	0.484	1.34	132.97	137.65	20.0	202.76	0.68	-0.01	1.68	0.5	144.96	6	Sands - clean sand to silty sand	2.17	2.17	1.00	1.30	#N/A	3.18	3.18	1.00	1.91	1.59	4.87	4.87	1.00	2.92	2.43	-4.55	0.48	-0.11	#NUM!	#NUM!
23.82	114.8	0.69	-20.1	0.598	0.0450	1.072	0.587	0.485	1.31	150.58	155.88	20.0	234.58	0.60	-0.01	1.60	0.5	164.59	6	Sands - clean sand to silty sand	2.17	2.17	1.00	1.30	#N/A	3.18	3.18	1.00	1.91	1.59	4.87	4.87	1.00	2.92	2.43	-4.55	0.48	-0.11	#NUM!	#NUM!
23.88	120.0	0.95	-20.4	0.789	0.0450	1.075	0.589	0.486	1.30	156.27	161.77	20.0	244.83	0.80	-0.01	1.66	0.5	174.62	6	Sands - clean sand to silty sand	2.17	2.17	1.00	1.30	#N/A	3.19	3.19	1.00	1.91	1.59	4.87	4.87	1.00	2.92	2.44	-4.55	0.49	-0.11	#NUM!	#NUM!
23.95	126.6	0.77	-20.4	0.608	0.0450	1.078	0.591	0.487	1.29	163.52	169.28	20.0	258.03	0.61	-0.01	1.58	0.5	180.17	6	Sands - clean sand to silty sand	2.17	2.17	1.00	1.30	#N/A	3.19	3.19	1.00	1.91	1.59	4.87	4.87	1.00	2.92	2.44	-4.55	0.49	-0.11	#NUM!	#NUM!
24.02	129.2	0.56	-20.4	0.435	0.0450	1.081	0.593	0.487	1.29	166.28	172.13	20.0	262.88	0.44	-0.01	1.49	0.4	179.59	6	Sands - clean sand to silty sand	2.17	2.17	1.00	1.30	#N/A	3.19	3.19	1.00	1.91	1.60	4.87	4.87	1.00	2.92	2.44	-4.55	0.49	-0.11	#NUM!	#NUM!
24.08	129.5	0.43	-20.4	0.329	0.0450	1.084	0.595	0.488	1.29	166.50	172.36	20.0	262.98	0.33	-0.01	1.43	0.4	177.02	6	Sands - clean sand to silty sand	2.18	2.18	1.00	1.31	#N/A	3.19	3.19	1.00	1.92	1.60	4.88	4.88	1.00	2.93	2.44	-4.55	0.49	-0.11	#NUM!	#NUM!
24.15	131.5	0.30	-20.1	0.229	0.0450	1.087	0.597	0.489	1.28	168.61	174.55	20.0	266.62	0.23	-0.01	1.36	0.4	176.29	6	Sands - clean sand to silty sand	2.18	2.18	1.00	1.31	#N/A	3.19	3.19	1.00	1.92	1.60	4.88	4.88	1.00	2.93	2.44	-4.55	0.49	-0.11	#NUM!	#NUM!
24.21	124.9	0.24	-20.1	0.192	0.0450	1.090	0.599	0.490	1.29	161.23	166.90	20.0	252.56	0.19	-0.01	1.35	0.4	166.79	6	Sands - clean sand to silty sand	2.18	2.18	1.00	1.31	#N/A	3.20	3.20	1.00	1.92	1.60	4.88	4.88	1.00	2.93	2.44	-4.55	0.49	-0.11	#NUM!	#NUM!
24.28	120.3	0.27	-20.1	0.225	0.0450	1.093	0.601	0.491	1.30	156.03	161.52	20.0	242.69	0.23	-0.01	1.39	0.4	162.07	6	Sands - clean sand to silty sand	2.18	2.18	1.00	1.31	#N/A	3.20	3.20	1.00	1.92	1.60	4.88	4.88	1.00	2.93	2.44	-4.55	0.49	-0.11	#NUM!	#NUM!
24.34	107.5	0.34	-19.7	0.319	0.0450	1.095	0.604	0.492	1.32	141.71	146.69	20.0	216.39	0.32	-0.01	1.49	0.4	148.55	6	Sands - clean sand to silty sand	2.18	2.18	1.00	1.31	#N/A	3.20	3.20	1.00	1.92	1.60	4.88	4.88	1.00	2.93	2.44	-4.55	0.49	-0.11	#NUM!	#NUM!
24.41	103.8	#N/A	-19.4	#N/A	0.0450	1.098	0.606	0.493	1.32	137.36	142.20	#N/A	208.38	#N/A	-0.01	#N/A	###	#N/A	#N/A	#N/A	2.19	2.19	1.00	1.31	#N/A	3.20	3.20	1.00	1.92	#N/A	4.89	4.89	1.00	2.93	#N/A	-4.55	0.49	-0.11	#NUM!	#N/A
24.48	99.7	#N/A	-19.4	#N/A	0.0450	1.101	0.608	0.494	1.33	132.65	137.32	#N/A	199.78	#N/A	-0.01	#N/A	###	#N/A	#N/A	#N/A	2.19	2.19	1.00	1.31	#N/A	3.20	3.20	1.00	1.92	#N/A	4.89	4.89	1.00	2.93	#N/A	-4.55	0.49	-0.11	#NUM!	#N/A
24.54	119.7	#N/A	-19.4	#N/A	0.0450	1.104	0.610	0.495	1.30	155.02	160.48	#N/A	239.73	#N/A	-0.01	#N/A	###	#N/A	#N/A	#N/A	2.19	2.19	1.00	1.31	#N/A	3.21	3.21	1.00	1.92	#N/A	4.89	4.89	1.00	2.93	#N/A	-4.55	0.49	-0.11	#NUM!	#N/A
Averages:					0.0450																																						

Attachment E-4

West Pond Global Stability Analysis

ATTACHMENT E-4

MIDNITE MINE REMEDIAL DESIGN - WEST POND GLOBAL STABILITY ANALYSIS

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*29-Nov-13*	*60% Design*	*S. McManus and J.B. Varnier*	*Melanie Davis*	*06-Dec-13*	*Tom Kelley*
1	*2-Jun-14*	*90% Design*	*S. McManus and J.B. Varnier*	*Melanie Davis*	*10-Jul-14*	*Clint Strachan*
1	*14-May-15*	*100% Design – no changes*				

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E - Water Management Ponds\90% Submittal\Att E-4 West Pond Stability

The following calculations were generated using the following software:

Geo-Slope International, Ltd., 2012 (Slope/W)

AutoCAD Civil3D 2011 (Autodesk, 2010)

Supplements

Supplement E-4.1 - Midnite Mine Drill Logs Used for West Pond Slope Stability Analyses

1.0 OBJECTIVE

The objective of these analyses was to evaluate the slope stability of the proposed West Pond for the 90% design. The West Pond is located in the Western Drainage at the Midnite Mine Superfund Site (the Site). No specific performance standards for storage pond stability are defined in the scope of work (SOW) to the Remedial Design/Remedial Action (RD/RA) Consent Decree (CD; EPA, 2011) however, overall stability requirements are specified. In addition, the storage ponds will be designed in substantial compliance with Washington State dam safety criteria (Washington Department of Ecology, Dam Safety Section, 2005) to the extent these criteria are applicable to the West Pond.

2.0 BACKGROUND

The proposed West Pond will be a synthetically-lined water management pond with double containment and a leak detection system between the two synthetic geomembrane liners. The West Pond will be constructed during Phase 3 of the RA construction at the Site. The West Pond will provide temporary storage for mine-impacted water during the RA. The location of the West Pond is shown on Figure 1. The pond will be constructed by excavating soils from the West Pond embankment footprint and the impoundment area immediately upstream of the embankment, and using the excavated soils for construction of the embankment across the Western Drainage. This pond will be removed after completion of the RA when flows of impacted water at the Site have reduced to the point where the storage capacity it provides is no longer necessary. The proposed location for this pond is within the Western Drainage at the Site currently covered by waste rock from the South Waste Rock Pile (SWRP). The waste rock in this area will be removed during Phase 2 of the RA. The West Pond will meet the stability performance standards listed in the CD (EPA, 2011) and will be designed in substantial compliance with criteria from the Washington State Department of Ecology (WDOE) Dam Safety Program. These WSDE criteria will be applied to a synthetically-lined storage pond, with intermittent operation.

1) Regulations governing jurisdictional dams are provided at: http://www.ecy.wa.gov/programs/wr/dams/Regulations.html.
2) Engineering guidance for design and construction are outlined in guidance documents that are available for download at: http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs.html.

3.0 SITE CONDITIONS AND SLOPE STABLITY SECTIONS

3.1 SUBSURFACE CONDITIONS

The discussions of subsurface conditions and estimated material properties in this section are based on field exploration and laboratory investigations (Moore et al., 1996; SMI, 1999; URS, 2002; URS, 2005; Tetra Tech, 2010; MGC, 2011; MWH, 2012; and MWH, 2013), a review of past mining and waste rock pile construction activities (Peters, 1999), and anecdotal site knowledge. The locations of test holes and monitoring wells that have been drilled in the vicinity of the West Pond are shown on Figure 1.

Of the test holes and monitoring wells drilled in the West Pond area, boring logs for test holes B-10 (MGC, 2011) and THSS-05 (URS, 2002) provided the most detailed information on sub-waste stratigraphy and geotechnical properties since disturbed but representative samples and

standard penetration test (SPT) blow counts (N-values) were performed during drilling. In addition, Becker-drill blow counts (BDN-values) were obtained continuously during advancement of THSS-05 (URS, 2002) and can be used to estimate SPT N-values. A comparison of blow counts indicated although there was considerable variability in blow counts, as would be expected in coarse-grained materials with a significant percentage of oversized material, the SPT N-Values were on average 84 percent of the corresponding BDN-values at a similar depth interval. Thus, if the BDN-values are reduced by multiplying by a factor of 0.84, they can be used to estimate equivalent N-values for intervals at depth intervals where SPT tests were not performed in THSS-05 (URS, 2002).

Although drilling logs for wells GW-44 (URS, 2002), and BOM-11 and BOM-16 (Moore et al., 1996) do not contain detailed geotechnical information that can be used for material property estimates, they do provide information regarding sub-waste stratigraphy in the West Pond area. Test holes THSS-06 (URS, 2002) and B-09 (MGC, 2011) were abandoned before fully penetrating the overlying waste rock due to drilling difficulties and as a result, do not provide any information regarding sub-waste stratigraphy or material properties. Likewise drilling logs were not available for Wells 94-01, 94-02, 94-03, and 94-04 (Moore et al., 1996) and thus no information regarding sub-waste stratigraphy or material properties were obtained from these holes.

3.2 SITE GEOLOGY

The West Pond will be located within the Western Drainage at the Site in an area that is currently covered with mine waste materials. This mine waste in the West Pond area will be removed prior to construction of the West Pond during Phase 1 of RA construction activities. The underlying geology in the West Pond area consists of bedrock overlain by unconsolidated surficial soils that have been deposited by fluvial processes and glacial activity. Bedrock in the western portion of the Site, including the area that will be occupied by the West Pond, consists of variably-weathered quartz monzonite, with the uppermost bedrock typically being extremely weathered with soil-like properties (residuum). The degree of bedrock weathering typically decreases gradually with increasing depth.

3.3 SITE STRATIGRAPHY

The stratigraphy within the West Pond area generally consists of shallow bedrock overlain by native overburden materials (colluvium, alluvium, and residual soils). Drilling in the western portion of the site has generally shown overburden soils to be thickest in the valley bottoms and thinnest on the ridge tops, with valley wall overburden thicknesses generally between those of the ridge tops and valley bottoms.

The colluvium in the western portion of the Site is the product of weathering and subsequent transport of the site bedrock material. This material generally consists of silty clay or silty or clayey sand with traces of gravel originating from the quartz monzonite bedrock. The colluvium typically has a lower density and finer gradation than the underlying extremely-weathered bedrock because it has been transported and more extensively weathered. The extremely-weathered bedrock is material resulting from the nearly complete in-place weathering of the parent (quartz monzonite) bedrock. This material retains the structure of the parent bedrock and is more coarse-grained than the colluvium, but has weathered and weakened to the point where it can be sampled using a split-spoon SPT sampler and can be drilled using hollow-stem augers (HSA). Because this material has not been transported or sheared, it typically has a similar, but slightly higher density and higher SPT blow counts than the overlying transported

soils. Although it is difficult to distinguish between extremely-weathered bedrock and overlying transported colluvial soils in the logs from previous drilling in the West Pond area, it is assumed that both of these materials will be removed from the foundation area prior to West Pond embankment construction. As a result, these two soil-like stratigraphic layers were lumped together when developing the stratigraphy for embankment stability analyses.

For the purpose of slope stability analyses, a distinction was made between extremely-weathered and highly-weathered bedrock. This distinction was made based upon SPT blow counts, with highly-weathered bedrock being defined as residual soils having SPT blow counts of at least 50 blows per foot (bpf). Although both extremely-weathered and highly-weathered bedrock are both residual soils resulting from extensive weathering of the parent bedrock and have similar gradation and compositional characteristics, the density and strength of highly-weathered bedrock is higher than the extremely-weathered bedrock, as indicated by higher SPT blow counts. Excavation of highly weathered bedrock using a medium-weight hydraulic excavator (e.g. Caterpillar 320 excavator) is expected to be difficult or impossible without ripping or using other methods to first loosen this material. For the purposes of defining stratigraphy for slope stability analyses, competent bedrock was defined as quartz monzonite material that resulted in SPT-refusal (N-values and equivalent N-values greater than 100 bpf).

Test hole B-10 (MGC, 2011) was located near the Western Drainage valley bottom near the upstream end of the proposed West Pond. The detailed drilling log for B-10 (MGC, 2011) indicated that approximately 8 feet of colluvium/extremely-weathered bedrock overlie highly weathered bedrock at this location. Test hole B-10 (MGC, 2011) penetrated approximately 3 feet of additional material beneath the colluvium/extremely weathered bedrock with N-values in excess of 50 bpf (interpreted to be highly-weathered bedrock) prior to termination of the hole. BOM-16 (Moore et al., 1996) and GW-44 (SMI, 1999) were drilled in the valley wall, near the drainage bottom, and found quartz monzonite bedrock directly underlying the waste rock, with no colluvium/extremely-weathered bedrock being encountered at these locations. BOM-11 (Moore et al., 1996) was drilled in the east valley wall of the Western Drainage near the upstream end of the proposed West Pond and encountered approximately 4 feet of soil-like material (interpreted to be colluvium/extremely-weathered bedrock) overlying intrusive bedrock. THSS-05 (URS, 2002) was also drilled in the east valley wall of the Western Drainage at a location downstream (south) of the proposed West Pond embankment. Although detailed stratigraphic descriptions were lacking in the drilling log for THSS-05 (URS, 2002), it appears based upon interpretation of blow counts that approximately 10 feet of colluvium/extremely-weathered bedrock (N-values and equivalent N-values of 30 to 42 bpf) overlies approximately 4 feet of highly-weathered bedrock (N-values and equivalent N-values of approximately 50 to 72), overlying competent bedrock (equivalent N-values greater than 100).

A review of historic aerial photos taken at various stages of mine development indicate that stripping of at least some of the overburden soils (colluvium, alluvium, and possibly extremely-weathered bedrock) occurred in the valley bottom and eastern valley wall in West Pond area prior to waste rock placement (Peters, 1999). This could account for the variation seen in the thickness of colluvium/extremely-weathered bedrock and explain why the soil-like material layer appears to be thinner, or nonexistent, in the vicinity of the West Pond than in some other areas in the Western Drainage.

3.4 GROUNDWATER

Groundwater was assumed to be at the highly-weathered bedrock surface in the slope-stability analyses.

3.5 DEVELOPMENT OF STABILITY SECTIONS

Two stability sections were selected for the embankment to represent the most critical conditions for the slope stability analysis. The section locations, shown on Figure 1, pass through the point of the embankments with the maximum fill section, and are parallel to the embankment slopes. The sections were developed using the existing ground surface (Spatial Intel, 2010) and the pre-mining ground surface (USBM, 1995) surveys in conjunction with the proposed West Pond grading surface for the 90% design. Section 1-1' continues parallel to the embankment slope, even after passing beyond the embankment toe. Section 2-2' was developed to assess a theoretical worst-case condition (after passing beyond the toe of the embankment, Section 2-2' follows the bottom of the drainage). This results in a section containing thicker layers of Highly-Weathered Bedrock and colluvium/extremely-weathered bedrock than would be observed in a planar two-dimensional stability section.

To develop the stability sections, a corridor of interest approximately 800 feet wide, 3,000 feet long, and containing the two stability sections was identified and visually assessed to delineate the native terrain into three categories: Ridges, Drainage Valley Bottoms, and Drainage Valley Walls (see Figure 2). Each stability section then was divided into segments corresponding to one of the three terrain types. The thickness of the stratigraphic units for each terrain type were developed based upon information obtained from the test hole logs discussed above, in the *Site Stratigraphy* section. As discussed previously, it is assumed that the colluvium/extremely-weathered bedrock will be excavated and replaced with suitable compacted fill in the entire embankment footprint.

The terrain type associated with each borehole is presented in Table 1. Table 2 presents the thickness of each stratigraphic unit corresponding to each terrain type.

The stability sections developed for use in this analysis are presented in Figure 3.

Table 1. Terrain Type Associated with Boreholes

Borehole ID	Drainage Valley Bottom, Wall, or Ridge
THSS-03	Ridge
THSS-04	Ridge
THSS-05	Wall
THSS-06	Bottom
BOM-7	Wall
BOM-94-01	Wall
BOM-94-02	Wall
BOM-94-03	Wall
B-08	Ridge
B-09	Wall
B-10	Bottom
GW-35A	Bottom
GW-44	Wall

Borehole ID	Drainage Valley Bottom, Wall, or Ridge
GW-50	Bottom
WD-B1	Wall
WD-B2	Wall
WD-B3	Ridge
WD-B5	Bottom
MWWD-01	Bottom
MWWD-02a	Ridge
MWWD-02b	Bottom
MWWD-03	Ridge
MW-01	Bottom
PBW-01	Bottom
PBW-02	Bottom

Table 2. Stratigraphy by Terrain Type

Terrain Type	Avg. Thickness of Colluvium/Extremely-Weathered Bedrock (ft)	Avg. Thickness of Highly-Weathered Bedrock (ft)
Drainage Valley Bottom	11.9	6.8
Drainage Valley Wall	10.8	6.5
Ridge	3.0	6.0

4.0 METHODOLOGY AND ASSUMPTIONS

4.1 METHODOLOGY

The geotechnical slope stability analysis was performed using the SLOPE/W computer software (Geo-Slope International, Ltd., 2012) to analyze slope stability sections (models) of the facility using limit-equilibrium methods. The stability sections of the facility were developed based on ground surface topography and subsurface stratigraphy in the vicinity of the proposed West Pond. The methods of analysis for the computer models and how those models were developed are discussed in detail in the following subsections. This analysis resulted in factors of safety against shear failure for the deeper failure surfaces that could impact the West Pond. Shallow failure surfaces involving the outslope of the West Pond that would not involve loss of freeboard in the West Pond were not considered, as discussed below.

The calculated factors of safety from this analysis were compared to performance criteria set forth in the CD (EPA, 2011) as well as typical dam safety criteria. Although the safety factor criteria in the CD do not specifically apply to storage pond design, they were compared to the dam criteria and the more stringent of the two criteria were applied. Design criteria selected for the evaluation of the South Pond stability are summarized in Table 3.

Table 3. Design Criteria – Minimum Required Factors of Safety for Stability Analyses

Condition	Minimum Factor of Safety - Consent Decree	Minimum Factor of Safety based upon Dam Safety Guidelines	Minimum Factor of Safety Selected for Design
Static	1.3	1.5	1.5
Pseudo-static	1.0	1.0 to 1.1	1.1

4.2 SLOPE STABILITY MODELING

Slope stability analyses were performed using two-dimensional limit equilibrium methods with the aid of the program SLOPE/W (GEO-SLOPE, 2012). The Morgenstern-Price method (Morgenstern and Price, 1965) with a half-sine function for inter-slice forces was used for the analysis. This method evaluates both circular and non-circular slip surfaces, and satisfies both force and moment equilibrium in the factor of safety calculation (GEO-SLOPE, 2012).

The analyses were performed by calculating factors of safety along circular failure surfaces under static and pseudo-static analyses. As mentioned previously, the colluvium and highly-weathered bedrock will be excavated from the pond foundation. The static and pseudo-static models were performed assuming (1) both highly-weathered and bedrock and (2) bedrock at the

embankment foundation. Due to the circular geometry of the failure surface, the first case does not allow the failure surface to occur along the compacted fill and highly-weathered bedrock interface. Failure surfaces are only allowed to truncate at the bedrock contact. The second case was analyzed to allow the failure surface to occur along the actual compacted fill and highly-weathered bedrock interface by replacing the highly-weathered bedrock by bedrock in the model. The failure surfaces analyzed by the model were restricted to only those deeper failure surfaces which could potentially affect the West Pond. This was achieved by excluding any failure surface daylighting on the uphill end at a distance farther than 20 feet from the West Pond crest from the analysis.

The phreatic surface in the model is assumed to be at the highly-weathered bedrock surface in the slope-stability analyses. It is assumed that the West Pond embankment will not develop a saturated zone since interceptor ditches above the West Pond will intercept any surface or subsurface flow from the contributing drainage area above the pond, and the double-liner system will minimize leakage from the pond.

4.3 SITE SEISMICITY

The slope stability analyses under seismic loading conditions were conducted using a pseudo-static approach, where a constant horizontal acceleration is applied to the numerical models. This horizontal acceleration simulates an inertial force due to a seismic event. The peak ground acceleration (PGA) for a probability of exceedance of 10 percent in 250 years at the Site for site Class B (rock) is 0.131g (MGC, 2010), where g is the acceleration of gravity. The PGA at the Site was adjusted to site Class C (very dense soil and soft rock) to conservatively represent site conditions for the slope stability analyses. The recommendations presented in USGS (2013) were used to calculate the adjusted PGA. The Class C PGA at the Site is 0.157g. The strategy of representing the seismic coefficient as a function of the PGA has been adopted in review of uranium facility design and documented by the U.S. Department of Energy (DOE, 1989). DOE (1989) recommends the use of a horizontal seismic coefficient of $^{2}/_{3g}$ of the PGA for pseudo-static stability analyses for post-reclamation conditions. The U.S. Nuclear Regulatory Commission (NRC, 2003) recommends the seismic coefficient be either 67 percent of the PGA or 0.1, whichever is greater. The horizontal seismic coefficient used for the pseudo-static stability analyses is 0.105.

4.4 LIQUEFACTION POTENTIAL

Earthquakes can commonly induce liquefaction within saturated granular materials of low relative density. Liquefaction is most common in poorly-graded sand and silty sand deposits, though it has been known to occur in other types of materials. Conditions susceptible to liquefaction generally occur in areas where the accumulated material is composed of low-density granular material and the groundwater level is high. Although less common, sites without high groundwater levels or substantial thickness of saturated soils can also sustain earthquake-induced damages; including ground-rupture, flow slides and settlement. The materials encountered at this site that could potentially be liquefiable or experience cyclical softening due to seismic shaking are the saturated colluvium and possibly the upper extremely-weathered bedrock layers. Since these materials will be removed from the West Pond embankment footprint and replaced with suitable compacted material, liquefaction and cyclical softening were not considered in the stability analyses.

5.0 MATERIAL PROPERTIES

The material properties used in the slope stability analysis are discussed in the following sections and are listed in Table 4.

Table 4. Material Properties for Stability Analyses

Material	Total Unit Weight, γ (pcf)	Effective Shear Strength, ϕ' (degrees)	Effective Cohesion, c' (psf)
Compacted fill	132	34.5	0
Colluvium/ Extremely-Weathered Bedrock	128	32	0
Highly-Weathered Bedrock	135/N/A	38/Impenetrable	0/Impenetrable
Bedrock	N/A	Impenetrable	Impenetrable

5.1 COLLUVIUM/EXTREMELY-WEATHERED BEDROCK

The colluvium/extremely-weathered bedrock in the Western Drainage is derived from quartz monzonite bedrock that has undergone the weathering process to the point that it has soil-like properties as discussed previously in the Site Stratigraphy section. In general, this material is sandy with varying amounts of gravel and clay (MWH, 2012). It is anticipated that any colluvium/extremely-weathered bedrock in the embankment footprint will be excavated and replaced with suitable compacted fill and thus, will have a very limited, if any, effect on embankment stability.

The in-place unit weight of the colluvium/extremely-weathered bedrock was estimated through analysis of drive samples collected from boreholes CD-B1 and CD-B4 in the lower Central Drainage south of the toe of the South Waste Rock Pile (MWH, 2012) and the Shelby tube samples collected from borings. TH-12-6 and TH-12-11 at the new water treatment plant site located southwest of the proposed West Pond along the ridge at the top of the western flank of the western drainage (MWH, 2013). Under static and pseudo-static conditions the colluvium/extremely-weathered bedrock is expected to generally be in a partially-saturated state and the strength envelope is therefore represented by effective shear strength parameters.

The effective friction angle used for the colluvium/extremely-weathered bedrock was estimated by considering the results of triaxial compression testing on remolded samples of colluvium from the Western and Central Drainages performed as part of the storage pond investigations (MWH, 2012), as well as testing of remolded triaxial tests performed as part of the WTP Investigation (MWH, 2013). Specifically, the effective-stress friction angles obtained from triaxial compression tests on materials from test pits WDTP-1 (37.8 degrees), CDTP-2 (32.4 degrees), and CDTP-4 (31.7 degrees) from the storage pond investigation (MWH, 2012), and the composite colluvium sample from the WTP investigation (35.7 degrees) were used to evaluate the effective shear strength of the colluvium. Based upon the evaluation of these results, a friction angle of 32.0 degrees, representing the average of the two lower-strength colluvium samples was selected for use in stability analyses.

5.2 COMPACTED FILL

Compacted fill will be constructed from compacted colluvium and extremely-weathered quartz monzonite bedrock excavated from the embankment footprint and pond area. Compacted fill will be moisture conditioned as necessary, placed in horizontal lifts, and compacted. As the West Pond impoundment will be lined with a synthetic geomembrane, it is reasonable to assume the embankment fill will be in a partially-saturated state during and after construction, and therefore the strength was represented by effective stress strength parameters.

The unit weight of the compacted fill was estimated from the results of previous compaction testing of colluvium and extremely-weathered bedrock samples from the previous storage pond investigation (MWH, 2012). Specifically, unit weights were estimated from the results of compaction testing on samples from test pits CDTP-4 and CDTP-6 (MWH, 2012). The unit weight for the fill in the slope stability analyses was calculated to assuming the fill will be placed at 98 percent of the average maximum total moist density identified during these laboratory tests. The strength results for tests on the extremely-weathered bedrock samples were generally higher than those for samples classified as colluvium. Although the West Pond embankment will be constructed from both colluvium and highly-weathered bedrock materials, the strength of the compacted embankment fill was conservatively estimated as the average shear strength results of only the colluvium samples. Specifically, test results on samples from the test pits WDTP-1 (37.8 degrees), CDTP-2 (32.4 degrees), and CDTP-4 (31.7 degrees) from the storage pond investigation (MWH, 2012) and the composite colluvium sample from the WTP investigation (35.7 degrees) were used to provide a conservative estimate of the embankment fill strength. Based upon these results, an average friction angle of 34.5 degrees was selected to represent the compacted embankment fill in the stability analyses.

5.3 HIGHLY-WEATHERED BEDROCK

Highly weathered quartz monzonite refers to weathered bedrock that has weathered in-place to a very dense soil-like material. As discussed previously, although this material may have a similar textural composition to the extremely-weathered bedrock included in the colluvium/extremely weathered bedrock layer, the highly-weathered bedrock is distinguished from the extremely-weathered bedrock by measurement of very high N-values (greater than 50 bpf) during SPT testing. This material can be expected to have a shear strength similar to that of a very weak rock mass or heavily over-consolidated soil (i.e., a curved failure envelope with no cohesion, but a very high initial tangential friction angle) as opposed to a typical normally-consolidated soil. The highly weathered quartz monzonite was modeled as a high-strength soil like material with an estimated effective friction angle of 38 degrees based upon a minimum N-value of 50 bpf and a conservatively interpretation of published correlations (Bowles, 1982) between SPT-N-values and shear strengths. In order to evaluate the potential for critical shear surfaces sliding along the highly weathered bedrock surface, rather than penetrating it, “truncated” circular failure surfaces were also evaluated by representing the highly weathered bedrock as an impenetrable material in Slope/W. For cases where the highly-weathered bedrock was modeled as an impenetrable surface, no unit weight or strength were specified.

5.4 BEDROCK

Bedrock refers to quartz monzonite bedrock that would generally result in SPT refusal (N-values greater than 100 bpf) during geotechnical field investigations. The bedrock was modeled as an impenetrable surface where the slip surfaces being analyzed were not allowed to cut into this

stronger material. Instead, slip surfaces were truncated at the bedrock contact and sliding was assumed to occur along the interface in the weaker overlying material.

6.0 RESULTS

The factors of safety against slope stability failure that were calculated in this analysis are provided in Table 5 and in Figures 4 to 15. The required minimum factors of safety are 1.5 under static conditions and 1.1 under pseudo-static conditions as discussed in Section 4.1.

The factors of safety under static and pseudo-static conditions for all cases exceed the minimum required factors of safety.

Table 5. Factors of Safety for Against Deep-Seated Slope Failures

Model Case	Loading Condition	Cross-Section 1	Cross-Section 2
Highly-Weathered Bedrock Modeled as High Strength Material	**Static** 1.5 Minimum FOS	1.8	1.8
	Pseudo-Static 1.1 Minimum FOS	1.4	1.4
Highly-Weathered Bedrock Modeled as Impenetrable	**Static** 1.5 Minimum FOS	1.8	1.8
	Pseudo-Static 1.1 Minimum FOS	1.4	1.4

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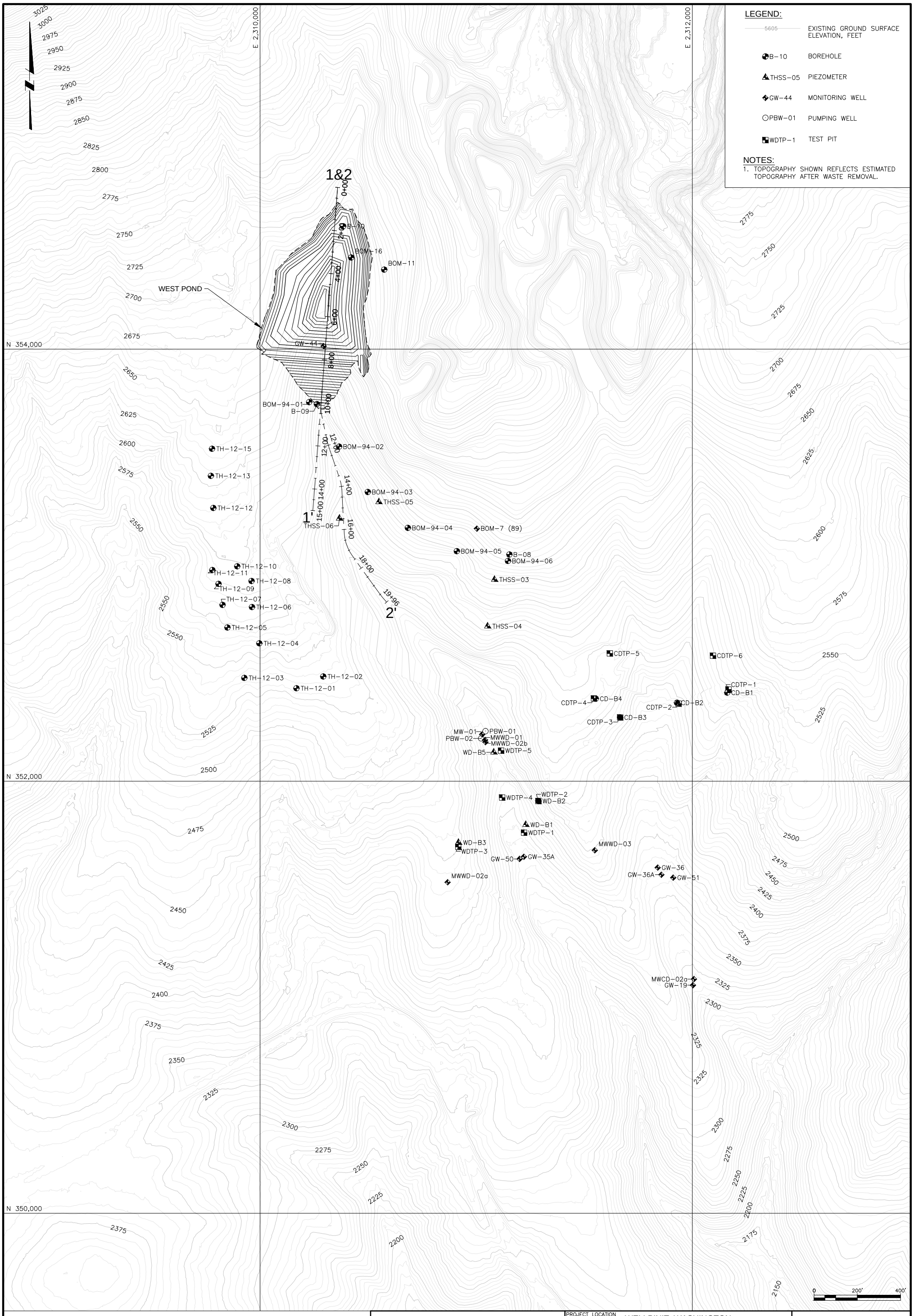
FIGURES

L:\Design-Drafting\Clients-I-P\NEWMONT\1011322 MIDNITE MINE\013-Sheet Set\FIGURES\2013-11-16 WEST POND STABILITY\F1_PLAN



DRAWING REFERENCE(S):

- EXISTING TOPOGRAPHY BASED UPON LIDAR MAPPING BY SPATIAL INTEL, 2010. WASHINGTON STATE PLANE-NORTH, NAD 83/NAVD 88.
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NEWMONT

PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 1 - WEST POND LOCATION AND FIELD EXPLORATIONS
FIGURE	1
REVISION	0
FILE NAME	F1_PLAN
DATE	JUNE 2014

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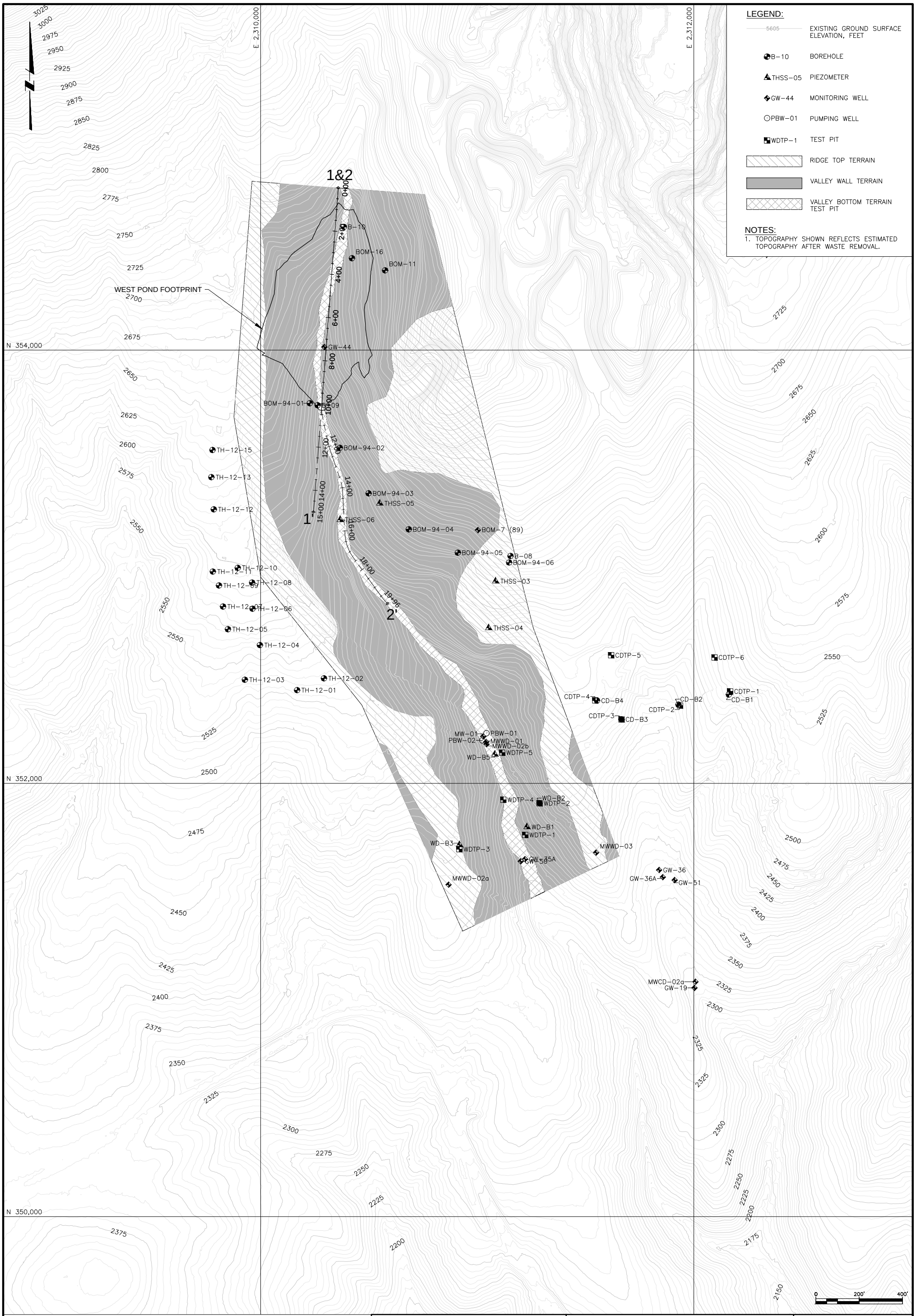
L:\Design-Drafting\Clients-I-P\NEWMONT\1011322 MIDNITE MINE\013-Sheet Set\FIGURES\2013-11-16 WEST POND STABILITY\F2_GEO_DELIN



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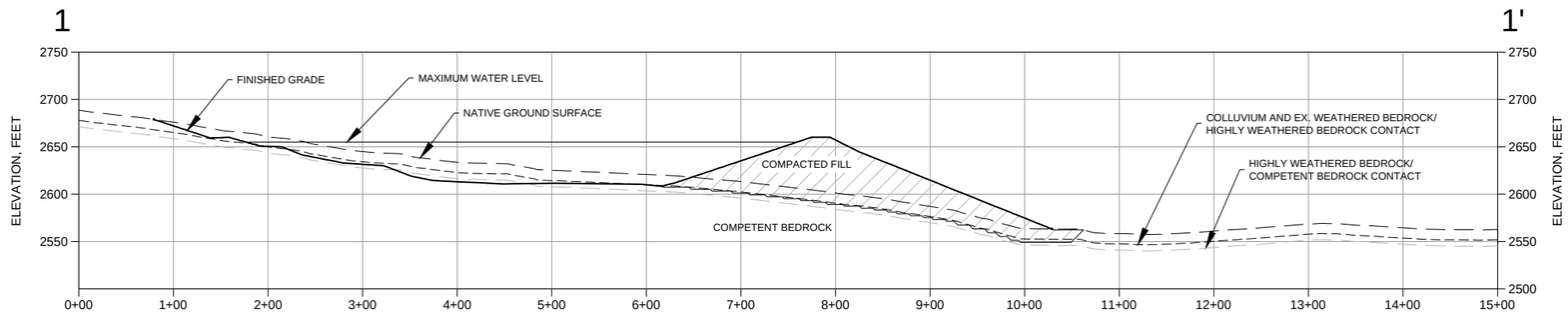
- PREMINE TOPOGRAPHY AND PIT EXCAVATION TOPOGRAPHY BASED UPON INFORMATION PROVIDED BY U.S. BUREAU OF MINES (USBM), JULY, 1995. ORIGINAL COORDINATE SYSTEM USED IN USBM MAPPING (NAD27/NGVD29) HAS BEEN CONVERTED TO NAD83/NAVD88 BASED COORDINATES.

NEWMONT

PROJECT LOCATION	WELLPINIT, WASHINGTON
PROJECT	MIDNITE MINE
TITLE	FIGURE 2 - WESTERN DRAINAGE TERRAIN DELINEATION
FIGURE	2
REVISION	0
FILE NAME	F2_GEO_DELIN
DATE	JUNE 2014

MWH



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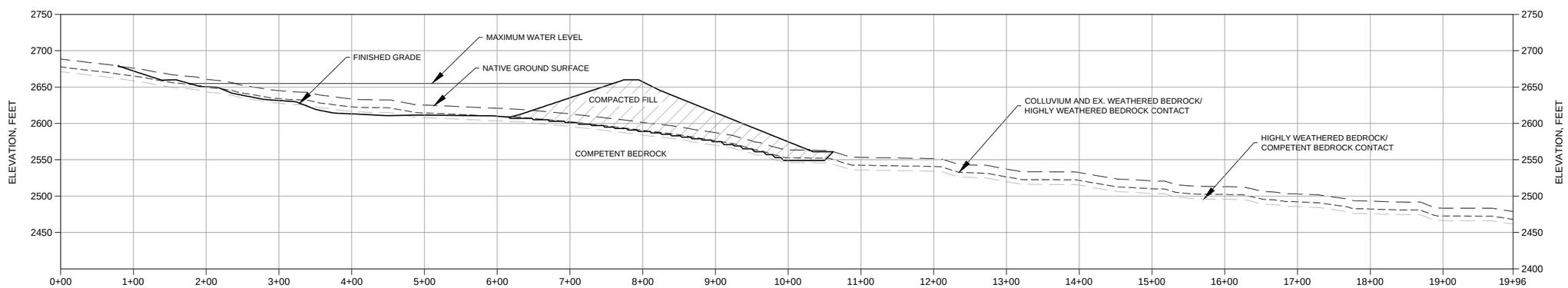

SECTION 2-2'

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NEWMONT

PROJECT LOCATION: WELLPINIT, WASHINGTON

PROJECT: MIDNITE MINE

TITLE: FIGURE 3 - WEST POND SLOPE STABILITY SECTIONS

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FIGURE	REVISION
3	0
FILE NAME: F3_SECTIONS	DATE: JUNE 2014

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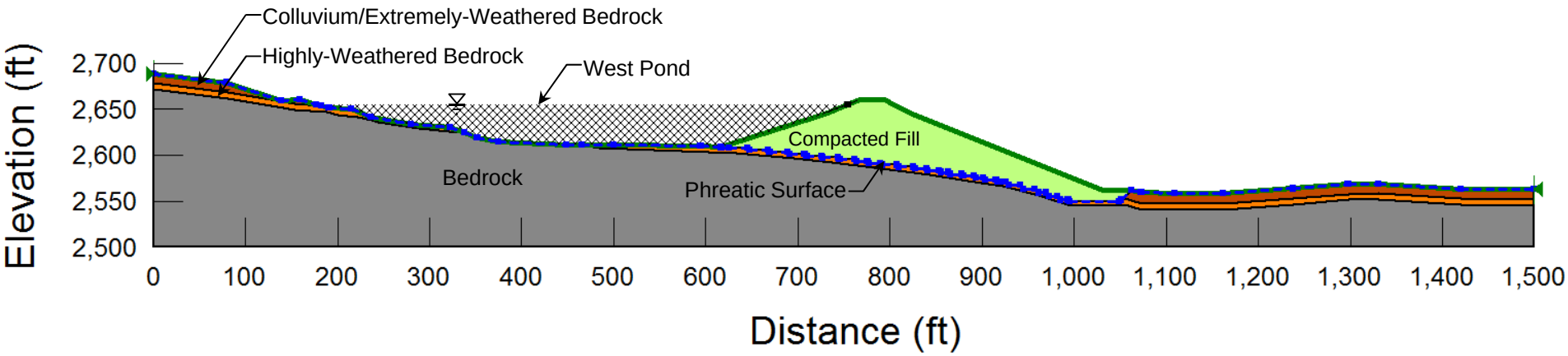
Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 1
With Highly-Weathered Bedrock
Geometry



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PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis – Geometry
West Pond - Cross-Section 1
With Highly-Weathered Bedrock

MWH

DATE: JUN 2014

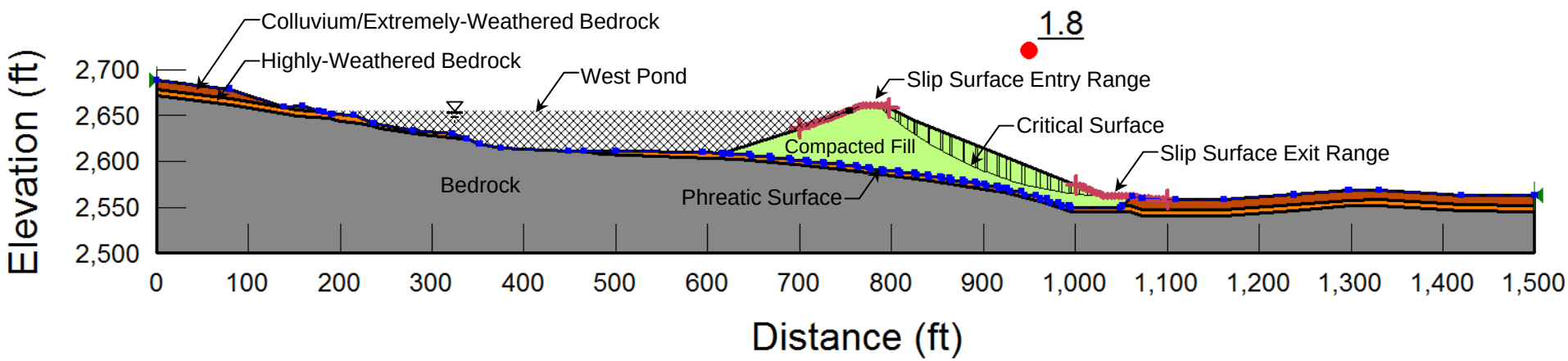
FIGURE 4

FILENAME: West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 1
With Highly-Weathered Bedrock
Static Conditions

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Compacted Fill	132	34.5	0
Colluvium/Extremely-Weathered Bedrock	128	32.0	0
Highly-Wethered Bedrock	135	38	0
Bedrock	Impenetrable		



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis – Static Conditions
West Pond - Cross-Section 1
With Extremely-Weathered Bedrock

MWH

DATE
JUN 2014

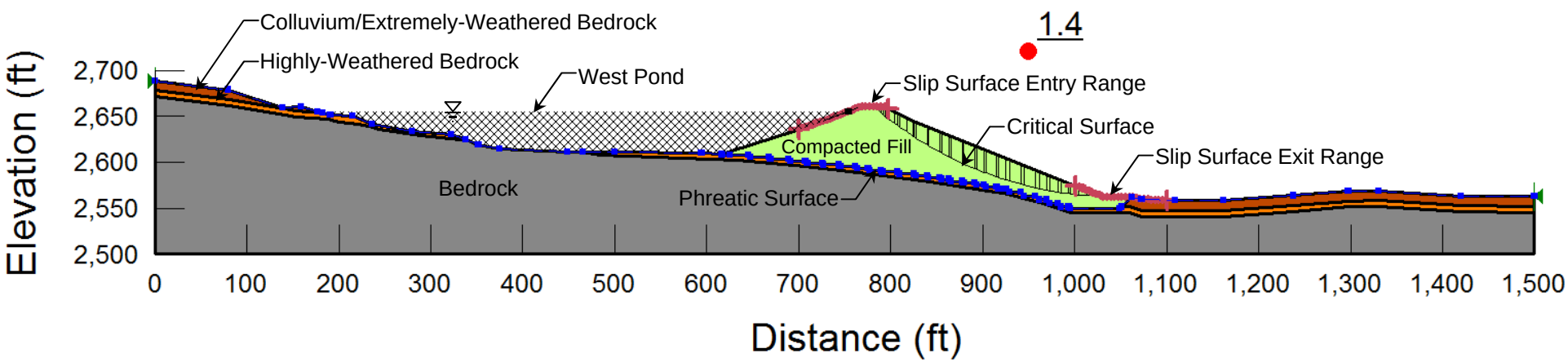
FIGURE 5

FILENAME
West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 1
With Highly-Weathered Bedrock
Pseudo-Static Conditions (K_h=0.105)

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Compacted Fill	132	34.5	0
Colluvium/Extremely-Weathered Bedrock	128	32.0	0
Highly-Wethered Bedrock	135	38	0
Bedrock	Impenetrable		



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis – Pseudo-Static Conditions
West Pond - Cross-Section 1
With Extremely-Weathered Bedrock

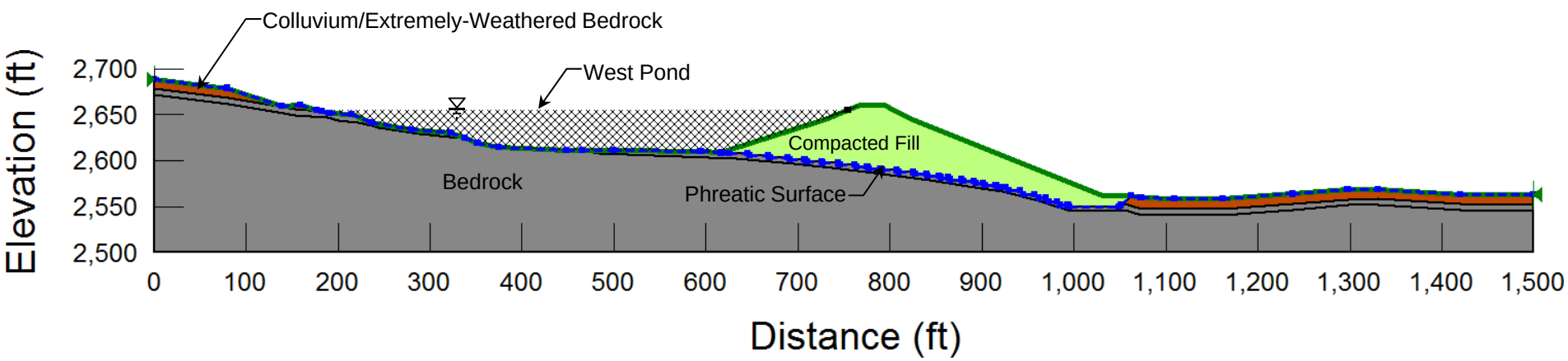
MWH

DATE
JUN 2014

FIGURE 6

FILENAME
West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 1
Without Highly-Weathered Bedrock
Geometry



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis – Geometry
West Pond - Cross-Section 1
Without Extremely-Weathered Bedrock

MWH

DATE
JUN 2014

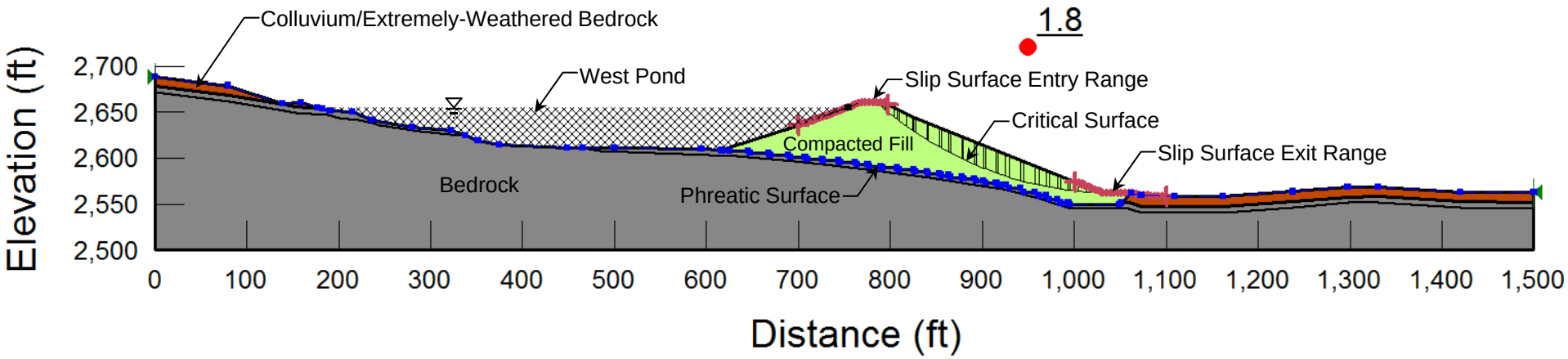
FIGURE 7

FILENAME
West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 1
Without Highly-Weathered Bedrock
Static Conditions

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Compacted Fill	132	34.5	0
Colluvium/Extremely-Weathered Bedrock	128	32.0	0
Bedrock	Impenetrable		



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PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis – Static Conditions
West Pond - Cross-Section 1
Without Highly-Weathered Bedrock

MWH

DATE
JUN 2014

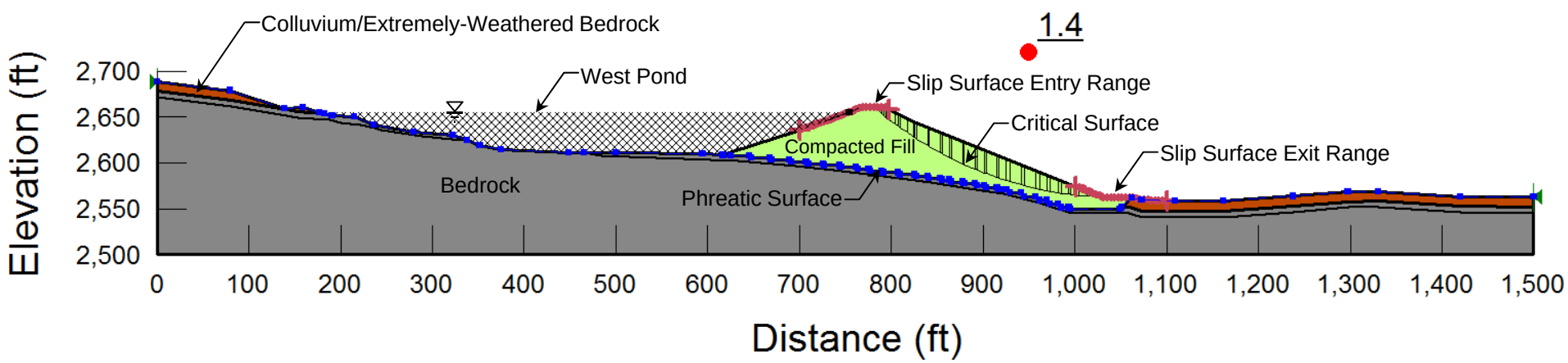
FIGURE 8

FILENAME
West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 1
Without Highly-Weathered Bedrock
Pseudo-Static Conditions (K_h=0.105)

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Compacted Fill	132	34.5	0
Colluvium/Extremely-Weathered Bedrock	128	32.0	0
Bedrock	Impenetrable		



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PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis – Pseudo-Static Conditions
West Pond - Cross-Section 1
Without Highly-Weathered Bedrock

MWH

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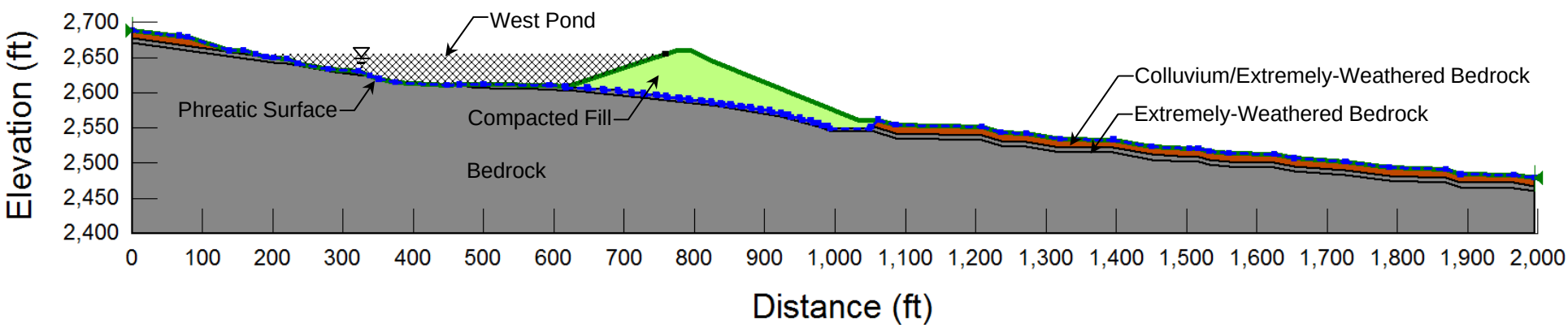
JUN 2014

FIGURE 9

FILENAME
West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 2
With Highly-Weathered Bedrock
Geometry



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PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis – Geometry
West Pond - Cross-Section 2
With Highly-Weathered Bedrock

MWH

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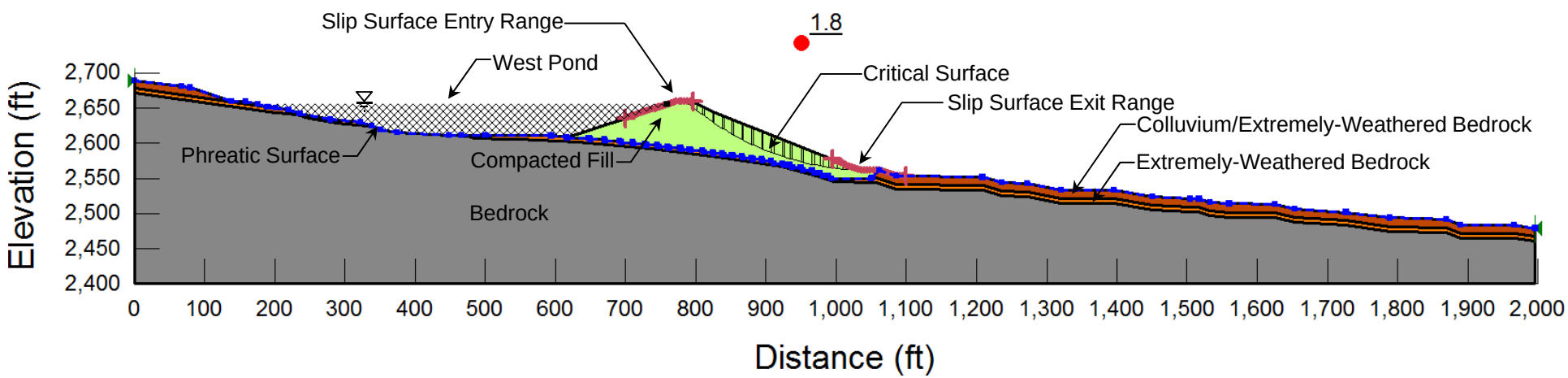
FIGURE 10

FILENAME
West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 2
With Highly-Weathered Bedrock
Static Conditions

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Compacted Fill	132	34.5	0
Colluvium/Extremely-Weathered Bedrock	128	32.0	0
Highly-Wethered Bedrock	135	38	0
Bedrock	Impenetrable		



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PROJECT: MIDNITE MINE

TITLE: Slope Stability Analysis – Static Conditions
West Pond - Cross-Section 2
With Highly-Weathered Bedrock

MWH

DATE: JUN 2014

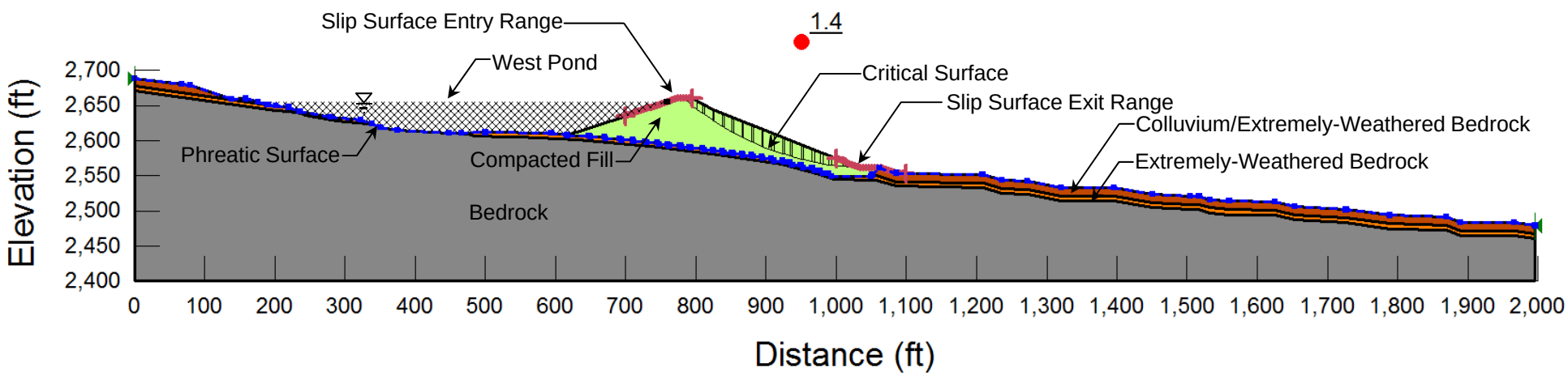
FIGURE 11

FILENAME: West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 2
With Highly-Weathered Bedrock
Pseudo-Static Conditions (K_h=0.105)

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Compacted Fill	132	34.5	0
Colluvium/Extremely-Weathered Bedrock	128	32.0	0
Highly-Wethered Bedrock	135	38	0
Bedrock	Impenetrable		



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PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis – Pseudo-Static Conditions
West Pond - Cross-Section 2
With Highly-Weathered Bedrock

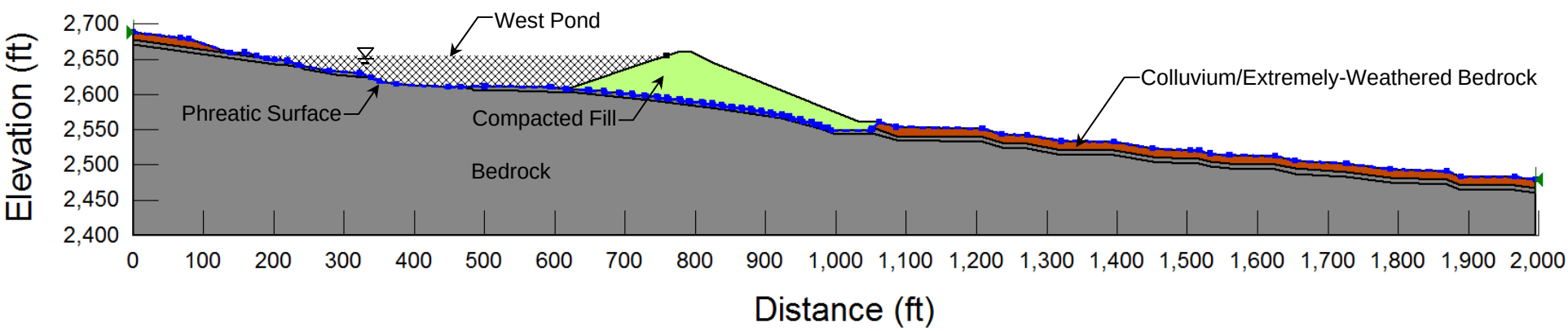
MWH

DATE
JUN 2014

FIGURE 12

FILENAME
West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 2
Without Highly-Weathered Bedrock
Geometry

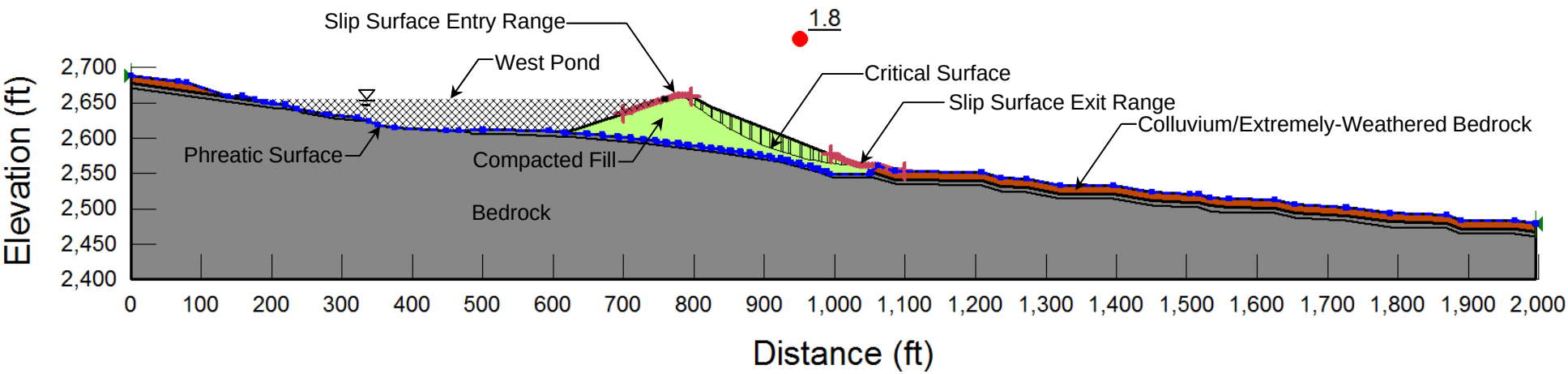


NEWMONT	PROJECT: MIDNITE MINE	MWH
	TITLE: Slope Stability Analysis – Geometry West Pond - Cross-Section 2 Without Highly-Weathered Bedrock	DATE: JUN 2014 — FIGURE 13
		FILENAME: West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 2
Without Highly-Weathered Bedrock
Static Conditions

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Compacted Fill	132	34.5	0
Colluvium/Extremely-Weathered Bedrock	128	32.0	0
Bedrock	Impenetrable		



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PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis – Static Conditions
West Pond - Cross-Section 2
Without Highly-Weathered Bedrock

MWH

DATE
JUN 2014

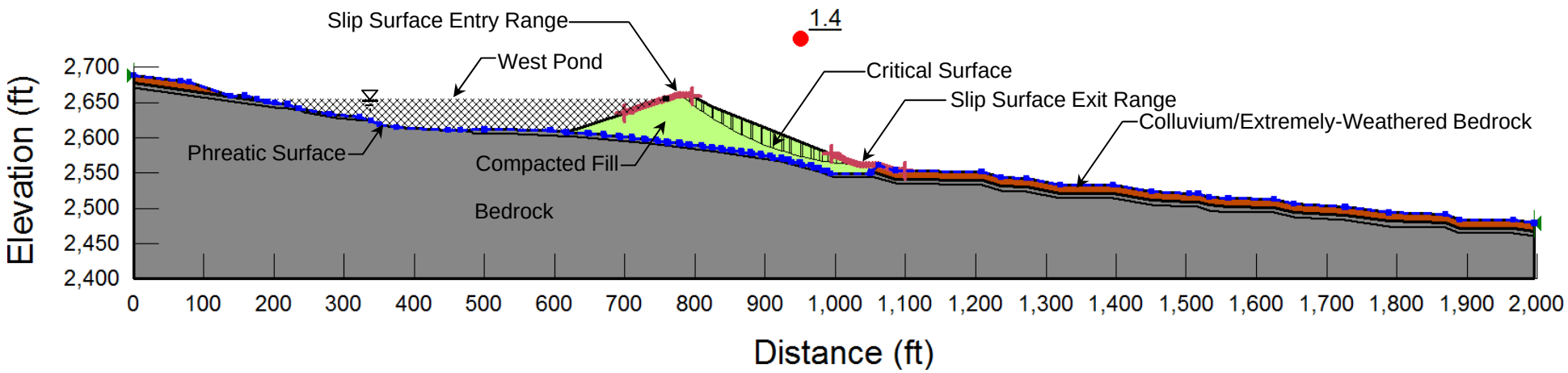
FIGURE 14

FILENAME
West Pond - Figures 4 to 15.pptx

Midnite Mine
Slope Stability Analysis
West Pond - Cross-Section 2
Without Highly-Weathered Bedrock
Pseudo-Static Conditions (K_h=0.105)

Material Parameters Used in Stability Analyses

Material Type	Total Unit Weight (pcf)	Friction Angle, ϕ' (deg)	Cohesion, c' (psf)
Compacted Fill	132	34.5	0
Colluvium/Extremely-Weathered Bedrock	128	32.0	0
Bedrock	Impenetrable		



NEWMONT

PROJECT
MIDNITE MINE

TITLE
Slope Stability Analysis – Pseudo-Static Conditions
West Pond - Cross-Section 2
Without Highly-Weathered Bedrock

MWH

DATE
JUN 2014

FIGURE 15

FILENAME
West Pond - Figures 4 to 15.pptx

Supplement E-4.1

Midnite Mine Drill Logs Used for West Pond Slope Stability Analyses

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BOREHOLE ID: B-08

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DATE(S) OF DRILLING: *07/10/2010 - 08/21/2010* **GROUND ELEVATION:** *2,697.0 ft* **HOLE SIZE:** *5.5" 0'-12', 4.5" 12'-86', 3.8" 86'-108.5'*

LOGGED BY: *Joe Reed* **NORTHING:** *353,049 ft* **SAMPLE:** *Split Spoon (SPT, 2.5", and 2"ID), HQ3*

DRILLING CONTRACTOR: *Ruen Drilling, Inc* **EASTING:** *311,154 ft* **GROUNDWATER:** *Unknown - Drilling With Water*

DRILL RIG: *BK-66* **LOCATION:** *South WR Pile* **DEPTH TO SOIL/BEDROCK:** *95.5/99 ft*

METHOD: *PW and HWT Casing Advance* **TOTAL DEPTH:** *108.5 ft* **NOTES:** *None Recorded*

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
0						
2					0.0 PW CASING ADVANCE	2697.0
4						
6						
8						
10						
12					11.5 HWT CASING ADVANCE	2685.5
14						
16						
18						
20						
22						
24						
26						
28						
30						
32						
34						
36						
38						
40						

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BORE HOLE ID: B-08

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
40					HWT CASING ADVANCE *(continued)*
42					
44					
46					
48					
50					
52					
54					
56					
58					
60	SS 2.5"	1.3	11-7-38-18		**WASTE ROCK (58.0 - 61.0)** Gravelly Sand, dark yellowish brown (10YR 4/4), wet, dense to very dense, fine to coarse sand and gravel, angular to very angular, slightly cohesive, trace clay, trace silt
61.0					AT 61 FEET START TELESCOPING IN WITH SAMPLERS 5 FEET THEN ADVANCING HWT CASING 5 FEET 2636.0
62	SS 2.5"	1.4	13-12-11-15		**WASTE ROCK (61.0 - 86.0)** Sandy Gravel, dark yellowish brown (10YR 4/4), wet, medium dense, fine to coarse sand and gravel, angular, slightly cohesive, trace clay, trace silt, as above but larger grained
64	SS 2.0"	1.25	10-10-12		
66	SPT	0.9	11-11-10		
68	SS 2.5"	0.6	95-57-23-14		
70	SS 2.0"	0.5	7-6-11		
72	SPT	0.5	5-6-12		
74	SS 2.5"	0.8	12-12-23-24		
76	SS 2.0"	0.75	6-12-25		
78	SPT	0.45	8-11-17		
80	SS 2.5"	0.7	52-27-18-20		
82	SS 2.0"	0.7	7-20-30		
84	SPT	1	10-15-20		
	SS 2.5"	0.2	31-39-22-18		
	SS 2.0"	0.3	5-14-21		
	SPT	0	3-1-50/4"		

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BOREHOLE ID: B-08

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
86					86.0 HQ3 Core 2611.0
88	RC	2.4			**WASTE ROCK (86.0 - 95.5)** Rock core, very hard, HCl weak to none, some angled bedding
90					
92					
94	RC	3.1			
96					95.5 2601.5
98	RC	3.6			**FOUNDATION SOIL (95.5 - 98.5)** Gravelly Sandy Clay, CL, dark brown (10YR 3/3), slightly moist, very hard and dense, fine to coarse sand and gravel in clay matrix, trace roots, medium plasticity, angular to subrounded 98.5 2598.5
100					**WEATHERED BEDROCK (98.5 - 108.5)** Clayey Sandy Gravel/Clayey Gravelly Sand, yellowish red (5YR 5/6), Slightly moist to dry, dense, fine to coarse sand and gravel, very angular to subrounded, trace silt, trace roots, HCl none, non plastic, well graded, weathering decreases with depth, grain size increases with depth
102	RC	5.5			
104					
106	RC	3.7			
108					108.5 2588.5

Bottom of hole at 108.5 feet.

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BOREHOLE ID: B-09

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DATE(S) OF DRILLING: *09/21/2010 - 09/25/2010* **GROUND ELEVATION:** *2,764.0 ft* **HOLE SIZE:** *4.5" 0'-13.5', 3.8" 13.5'-146.25'*

LOGGED BY: *Joe Reed* **NORTHING:** *353,745 ft* **SAMPLE:** *HQ3 Core*

DRILLING CONTRACTOR: *Ruen Drilling, Inc* **EASTING:** *310,263 ft* **GROUNDWATER:** *Unknown - Drilling With Water*

DRILL RIG: *BK-66* **LOCATION:** *South WR Pile* **DEPTH TO SOIL/BEDROCK:** *NA/NA ft*

METHOD: *HWT Casing Advance, HQ3 Core* **TOTAL DEPTH:** *146.25 ft* **NOTES:** *Borehole Abandoned - Extream Bit wear*

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	
0					
				0.0 HWT CASING ADVANCE IN WASTE ROCK	2764.0
2					
4					
6					
8					
10					
12					
				13.5	2750.5
14				HQ3 CORE IN WASTE ROCK	
16	RC				
18	RC	1			
20					
22					
24	RC	2			
26					
28	RC	2.1			
30					

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BOREHOLE ID: B-09

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION
30				HQ3 CORE IN WASTE ROCK *(continued)*
32	RC	4.3		
34				
36				
38	RC	1.2		
40				
	RC	1		
42	RC	2.1		
44				
46				
48	RC	2		
50				
52	RC	1.8		
54				
56				
58	RC	1.2		
60				
62	RC	2.4		
64				

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BOREHOLE ID: B-09

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION
				HQ3 CORE IN WASTE ROCK *(continued)*
66				
68	RC	2.3		
70				
72	RC	2		
74				
76				
	RC	0		
78				77.5 FEET CHANGE TO NEW CORE BIT
80	RC	1.5		
82				81 FEET CHANGE TO NEW CORE BIT
84	RC	0		
86	RC	1.5		
88				
90	RC	1.9		
92				
94	RC	1.2		
96				
98				

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BOREHOLE ID: B-09

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION
100	RC	2		HQ3 CORE IN WASTE ROCK *(continued)*
102				
104	RC	2.9		
106				
108	RC	0.3		
110				
112				
114	RC	0		
116				
118	RC	0		
120				
122				
124	RC	0		
126				
128	RC	1		
130				
132				

(Continued Next Page)

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BOREHOLE ID: B-09

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION
134	RC	2.4		HQ3 CORE IN WASTE ROCK *(continued)*
136				
138	RC	1.3		
140	RC	1.3		
142				
144	RC	2.2		
146				
	RC	0		146.3 146 FEET CHANGE TO NEW CORE BIT DRILL 0.25 FEET CORE BARREL STUCK AND BAD CORE BIT ABANDON HOLE 2617.8

Bottom of hole at 146.3 feet.

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BOREHOLE ID: B-10

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DATE(S) OF DRILLING: *09/25/2010 - 09/26/2010* **GROUND ELEVATION:** *2,736.4 ft* **HOLE SIZE:** *4.5" 0'-4', 3.8" 4'-87', 2" 87'-88.5'*

LOGGED BY: *Joe Reed* **NORTHING:** *354,569 ft* **SAMPLE:** *Split Spoon SPT*

DRILLING CONTRACTOR: *Ruen Drilling, Inc* **EASTING:** *310,384 ft* **GROUNDWATER:** *Unknown - Drilling With Water*

DRILL RIG: *BK-66* **LOCATION:** *South WR Pile* **DEPTH TO SOIL/BEDROCK:** *77.5/88.5 ft*

METHOD: *HWT Casing Advance, HQ3 Core* **TOTAL DEPTH:** *88.5 ft* **NOTES:** *None Recorded*

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION	
0						
					0.0 HWT CASING ADVANCE IN WASTE ROCK	2736.4
2						
4					4.0	2732.4
					HQ3 CORE IN WASTE ROCK	
6						
8	RC	2.3				
10						
12						
14	RC	1.9				
16						
18	RC	1.1				
20	RC	1.4				
22						
24	RC	2.6				
26						
28						
30	RC	1.5				

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BOREHOLE ID: B-10

CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
30					HQ3 CORE IN WASTE ROCK *(continued)*
32	RC	0.6			
34					
36					
38	RC	1.3			
40					
42	RC	2.1			
44					
46	RC	1.2			
48	RC	0.9			
50					
52	RC	0.6			
54					
56					
58	RC	1			
60					
62	RC	1			
64					

(Continued Next Page)

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BOREHOLE ID: B-10

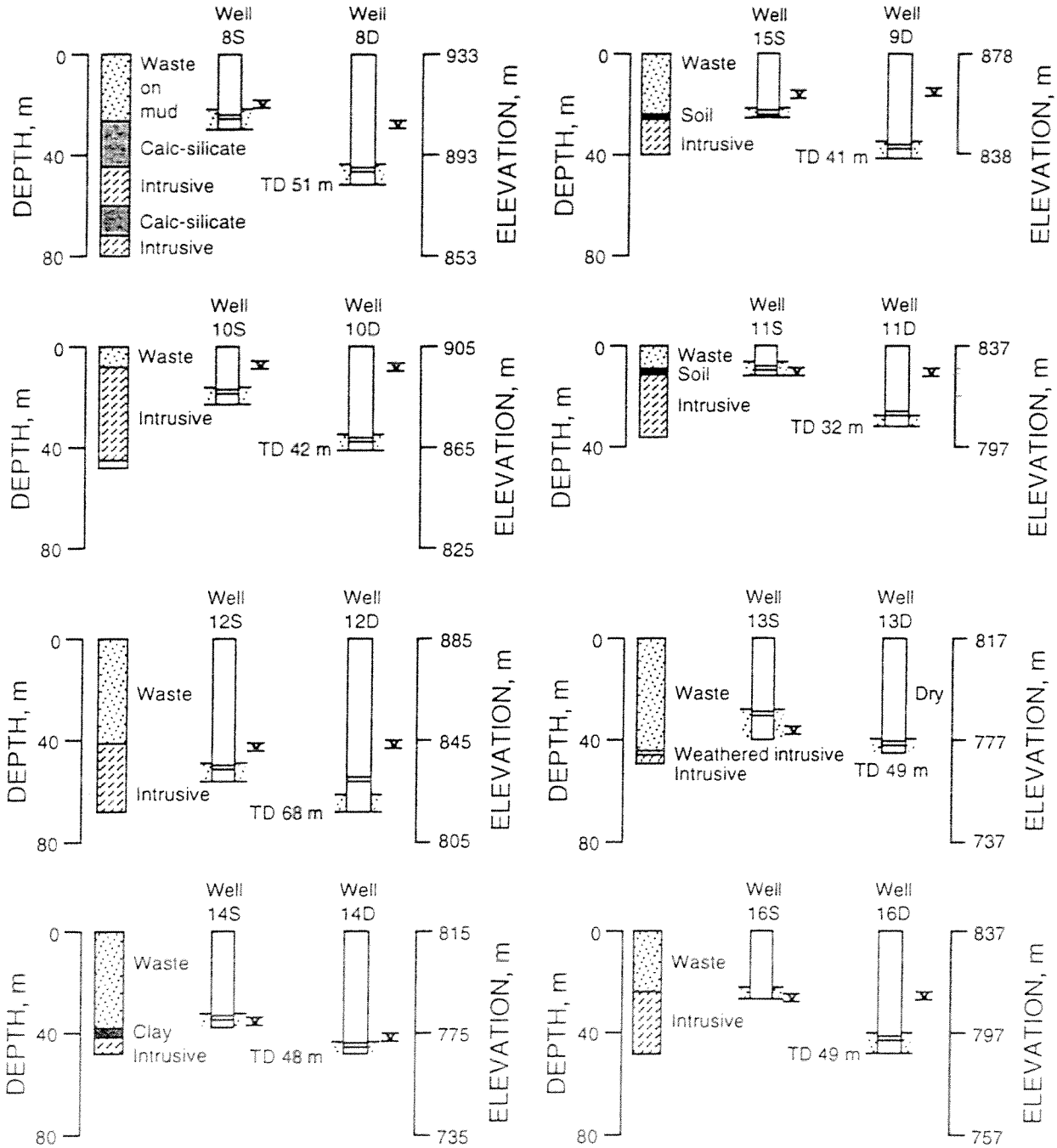
CLIENT DAWN MINING COMPANY **PROJECT NAME** MIDNITE MINE

PROJECT NUMBER 114-181850.2010 **PROJECT LOCATION** WELLPINIT, WA

DEPTH (ft)	SAMPLE TYPE	RECOVERY (ft)	BLOWCOUNT	GRAPHIC LOG	MATERIAL DESCRIPTION
66					HQ3 CORE IN WASTE ROCK *(continued)*
68	RC	2			
70					
72	RC	3			
74					
76	RC				AT 76 FEET ATTEMPTED SPT SAMPLE BUT REFUSAL, HQ3 TILL THROUGH ROCK AT 77.5 FEET
78	SPT	1.5	8-17-20-15		77.5 — 2658.9 **FOUNDATION SOIL (77.5 - 84.0)** Clayey Gravelly Sand, GC, very dark grayish brown (10YR 3/2) grades to dark yellowish brown (10YR 4/4), moist, medium dense to dense, fine to coarse sand, cohesive, low plasticity, trace iron staining, trace sandier layers, trace fine gravel
80	SPT	1.4	6-8-10		
82	SPT	1.5	8-10-11		
84	SPT	1.2	9-13-23		84.0 — 2652.4
	SPT	1.5	11-15-24		**FOUNDATION SOIL (84.0 - 85.5)** Clayey Silty Sand/Sandy Clayey Silt, SM/ML, light yellowish brown (10YR 6/4), moist, dense, fine sand, trace medium and coarse sand, roots at 84 feet
86	SPT	1.4	15-21-29		85.5 — 2650.9 **FOUNDATION SOIL (85.5 - 88.5)** Sandy Gravel, GC, dark yellowish brown (10YR 4/6), moist, dense, fine to coarse sand and gravel, slightly cohesive, trace clay, trace silt, root at 85.5, at 88.5 feet possible bedrock in shoe but not enough sample to identify with certainty
88	SPT	0.5	20-34-50/3"		88.5 — 2647.9

Bottom of hole at 88.5 feet.

Figure 4



Well construction details and lithologic logs of drilling locations.—Continued

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-44

PROJECT: MIDNITE MINE PAGE: 1 of 5
PROJECT NO.: 01-252 DATE: 24-25 OCTOBER 1998
NORTHING: 354066.1 EASTING: 2670163.2 GROUND ELEVATION: 2737.53
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON/ DUANE BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
0	0825	0			0'-5': PHYLLITE/SCHIST (~90%), DARK GRAY (N3) MOSTLY COMPACT AND MASSIVE, TRACE RELICT BEDDING, QUARTZ, MICA, PYRITE (1-5%), SOME IRON/HEMATITE STAINING, DARK YELLOWISH ORANGE (10YR 6/6). TRACE META CALC-SILICATE (~10%), GREENISH GRAY (5G 6/1), STRONG REACTION WITH 10% HCl.
5	0835	0			5'-10': SAME AS 0'-5'.
10	0937	0			10'-15': NO CUTTINGS/RETURNS
15	0951	0			15'-20': META CALC-SILICATE (>90%), WHITE (N9) TO MEDIUM GRAY (N5) WITH GREENISH GRAY (5G 6/1), MOSTLY MASSIVE, SOME RELICT BEDDING, QUARTZ, CALCITE, PYRITE (1-10%), STRONG REACTION WITH 10% HCl. TRACE PHYLLITE/SCHIST (<10%), DARK GRAY (N3), COMPACT, MASSIVE.
	10/24/98 - - - - 10/25/98				
20	1540	0			20'-25': SAME AS 15'-20' WITH TRACE QUARTZ MONZONITE (2-4%), MODERATE ORANGE PINK (10R 7/4), COARSE CRYSTALLINE, SMOKEY QUARTZ, POTASSIUM FELDSPAR.
25	1550	0			25'-30': SAME AS 20'-25'.
30	1633	0			

BORING LOG

SHEPHERD MILLER
INCORPORATED

BORING NO.
GW-44

PROJECT: MIDNITE MINE PAGE: 2 of 5
PROJECT NO.: 01-252 DATE: 25-26 OCTOBER 1998
NORTHING: 354066.1 EASTING: 2670163.2 GROUND ELEVATION: 2737.53
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON/ H.D. BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
30	1633	0			30'-35': PHYLLITE/SCHIST (~80%), DARK GRAY (N3) MOSTLY MASSIVE AND COMPACT, PYRITE (1-5%). SOME META CALC-SILICATE, WHITE (N9) TO MEDIUM GRAY (N5), CALCITE, QUARTZ, REACTION WITH 10% HCl. TRACE PORPHYRITIC QUARTZ MONZONITE, COARSE CRYSTALLINE, SMOKEY QUARTZ, POTASIUM FELDSPAR, SODIUM FELDSPAR.
35	1644	0			35'-40': SAME AS 30'-35' WITH SOME (20-30%) PORPHYRITIC QUARTZ MONZONITE.
40	1654	0			40'-45': PHYLLITE/SCHIST (~70%), DARK GRAY (N3) MOSTLY COMPACT AND MASSIVE, TRACE RELICT BEDDING, PYRITE (5-10%), NO STAINING. SOME META CALC-SILICATE (~15%), GREENISH GRAY (5G 6/1), MOSTLY MASSIVE, REACTION WITH 10% HCl. SOME PORPHYRITIC QUARTZ MONZONITE (15%), MODERATE ORANGE PINK (10R 7/4), COARSE CRYSTALLINE, POTASIUM FELDSPAR, SMOKEY QUARTZ.
45	1702	0			45'-50': META CALC-SILICATE (~90%), GREENISH GRAY (5G 6/1), MOSTLY MASSIVE, TRACE RELICT BEDDING, QUARTZ, CALCITE, EFFERVESLES IN 10% HCl. TRACE PHYLLITE/SCHIST, DARK GRAY (N3), COMPACT AND MASSIVE, TRACE RELICT BEDDING, TRACE IRON STAINING.
	10/25/98 - - - - - 10/26/98				
50	0801	0			50'-55': SAME AS 45'-50'.
55	1631	0			55'-60': SAME AS 50'-55' WITH SOME SILT/CLAY/FINES, DARK YELLOWISH ORANGE (10YR 6/6).
60	1643	0			

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-44

PROJECT: MIDNITE MINE PAGE: 3 of 5
PROJECT NO.: 01-252 DATE: 26-27 OCTOBER 1998
NORTHING: 354066.1 EASTING: 2670163.2 GROUND ELEVATION: 2737.53
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON/ H.D. BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
60	1643	0			60'-65': META CALC-SILICATE, DUSKY YELLOW (5Y 6/4) AND GREENISH GRAY (5G 6/1), MOSTLY MASSIVE, TRACE RELICT BEDDING, CALCITE, QUARTZ, EFFERVESLES IN 10% HCl. TRACE PHYLLITE/SCHIST (<5%), DARK GRAY (N3), COMPACT AND MASSIVE, PYRITE (1-3%).
	10/26/98 - - - - 10/27/98				
65	0707	MOIST			65'-70': META CALC-SILICATE (~40%), GRAYISH YELLOW (5Y 8/4) AND MEDIUM GRAY (N5), MOSTLY MASSIVE, TRACE RELICT BEDDING, CALCITE, QUARTZ, REACTION WITH 10% HCl. PHYLLITE/SCHIST, DARK GRAY (N3), COMPACT AND MASSIVE, PYRITE (3-5%), MICA, QUARTZ, NO IRON STAINING. FINES, CLAY & SILT COMMON (~20%).
70	0716	MOIST			70'-75': SAME AS 65'-70'.
75	0725	MOIST			75'-80': SAME AS 70'-75'.
80	0735	MOIST			80'-85': SAME AS 75'-80'.
85	0741	MOIST			85'-90': SAME AS 80'-85' WITH TRACE IRON STAINING ON PHYLLITE/SCHIST.
90	0837	MOIST			

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-44

PROJECT: MIDNITE MINE PAGE: 4 of 5
PROJECT NO.: 01-252 DATE: 27 OCTOBER 1998
NORTHING: 354066.1 EASTING: 2670163.2 GROUND ELEVATION: 2737.53
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON/ H.D. BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
90	0837	MOIST			90'-95': META CALC-SILICATE (~40%), GREENISH GRAY (5Y 8/4) TO GRAYISH GREEN (5G 6/1), MASSIVE WITH SOME RELICT BEDDING, CALCITE, QUARTZ, REACTION WITH 10% HCl. PHYLLITE/SCHIST (~40%), MOSTLY COMPACT AND MASSIVE, TRACE RELICT BEDDING, TRACE IRON/HEMATITE STAINING, DARK YELLOWISH ORANGE (10YR 6/6), PYRITE (1-3%), FINES (CLAY/SILT) COMMON, MODERATE YELLOWISH BROWN (10YR 5/4).
95	0845	MOIST			95'-100': SAME AS 90'-95'.
100	0853	MOIST			100-105': PHYLLITE/SCHIST (~70%), DARK GRAY (N3), MOSTLY COMPACT AND MASSIVE, TRACE RELICT BEDDING, MICA, PYRITE (1-3%), FINES (CLAY AND SILT) COMMON (20-25%), TRACE META CALC-SILICATE (<10%), GREENISH GRAY (5G 6/1) TO MEDIUM GRAY (N5), MOSTLY MASSIVE, CALCITE, QUARTZ, REACTION WITH 10% HCl.
105	0902	MOIST			105'-110': SAME AS 100'-105'.
110	0947	MOIST			110'-115': SAME AS 105'-110'.
115	0959	SLIGHT MOIST			115'-120': META CALC-SILICATE (~50%), GREENISH GRAY (5G 6/1) TO YELLOWISH GRAY (5Y 8/1), MOSTLY MASSIVE WITH SOME RELICT BEDDING, CALCITE, QUARTZ, REACTION WITH 10% HCl. PHYLLITE/SCHIST, DARK GRAY (N3), COMPACT AND MASSIVE WITH TRACE RELICT BEDDING, MICA, PYRITE (1-3%). TRACE FINES (CLAY & SILT) (<2%).
120	1006	DRY			

BORING LOG

SHEPHERD MILLER
INCORPORATED

BORING NO.
GW-44

PROJECT: MIDNITE MINE PAGE: 5 of 5
PROJECT NO.: 01-252 DATE: 27 OCTOBER 1998
NORTHING: 354066.1 EASTING: 2670163.2 GROUND ELEVATION: 2737.53
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON/ H.D. BRONSON LOGGED BY: ROB NOBLE

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
120	1006	DRY			120'-125': PHYLLITE/SCHIST, MEDIUM DARK GRAY (N4), MOSTLY COMPACT AND MASSIVE, TRACE RELICT BEDDING, TRACE IRON/HEMATITE STAINING, DARK YELLOWISH ORANGE (10YR 6/6), META CALC-SILICATE, WHITE (N9) TO MEDIUM GRAY (N5) WITH GREENISH GRAY (5G 6/1), MASSIVE WITH SOME RELICT BEDDING, REACTION WITH 10% HCl, SOME CLAY/FINES.
125	1015	DRY			125'-130': VERY FINE TO FINE SAND AND SILT SIZED CUTTINGS COMPOSED OF META CALC-SILICATE QUARTZ, CALCITE, QUARTZ MONZONITE, QUARTZ, POTASSIUM FELDSPAR, SODIUM FELDSPAR, AND PHYLLITE/SCHIST, QUARTZ, MICA, NO CLAY.
130	1055	DRY			130'-135': PORPHYRITIC QUARTZ MONZONITE, SALT & PEPPER WITH MODERATE ORANGE PINK (10R 7/4), COARSE CRYSTALLINE, SMOKEY QUARTZ, POTASSIUM FELDSPAR, SODIUM FELDSPAR, BIOTITE, TRACE FINES/CLAY.
135	1107	DRY & VERY DUSTY			135'-140': PORPHYRITIC QUARTZ MONZONITE, SALT & PEPPER WITH MODERATE ORANGE PINK (10R 7/4), COARSE CRYSTALLINE, SMOKEY QUARTZ, POTASSIUM FELDSPAR, SODIUM FELDSPAR, BIOTITE.
140	1123	DRY & VERY DUSTY			T.D.

BORING/WELL COMPLETION LOG

SHEPHERD MILLER
INCORPORATED

BORING/WELL NO.
GW-35A

PROJECT: MIDNITE MINE – ALLUVIAL AQUIFER INVESTIGATION PAGE: 1 OF 2
PROJECT NO.: 01-252-2 DATE: 10/25/96
CLIENT: DAWN MINING COMPANY
LOCATION: WESTERN DRAINAGE NEAR GW-35 N351703.55' E2671089.95'
DATE DRILLED: 10/1/96 DATE COMPLETED: 10/2/96 SURFACE ELEVATION: 2356.7'
BORING DEPTH (FT): 18.0 WELL DEPTH (FT): 12.5' BOREHOLE DIA. (FT): 0.83
WATER LEVEL (FT): INIT. 8.0 24-HOURS: NM COMPLETION: 5.48
CASING: DIA. (IN) 4 LENGTH (FT): 10.4 TYPE: SCHED. 40 PVC
SCREEN: DIA. (IN) 4 LENGTH (FT): 4.3 SLOT SIZE (IN): 0.020 DEPTH (FT): 11.7
DRILLING COMPANY: RUEN DRILLING CO. DRILLING METHOD: HSA -10" OD
DRILLER: JIM ERDMAN / DOUG SPEELMON DATUM:
LOGGED BY: R. SCHAUT CHECKED BY:

DEPTH (FT)	WELL GRAPHIC	% RECOVERY	BLOW COUNT	SAMPLE TYPE	SAMPLE NUMBER	LITHOLOGY GRAPHIC	SOIL DESCRIPTION
0		100			35A-1		0–1.5' SILTY SAND (SM), 10YR 4/2 dark grayish brown, very fine to fine silty sand, some organic material, angular to sub-rounded, low sphericity, slightly moist, a few very coarse sand to gravel-sized angular fragments of granitic parent rock, approx. 75% sand, 25% silt
1							
2		100	10 7 5		35A-2		1.5–3' SILTY SAND (SM), 10YR 5/4 yellowish brown, silty very fine to fine sand, angular to sub-angular quartz sand, low sphericity, moderately dense, slightly moist, approx. 60% sand 40% silt
3			4				3–5' SANDY SILT (ML), med. to dark brown, sandy silt with very fine to fine granitic sand grains (quartz and feldspar), angular to sub-angular sand grains, moderately stiff, slightly moist, slight plasticity, approx. 60% silt, 40% sand
4		17	2 3 3				
5		67	4 5 6		35A-3		5–6.7' SANDY SILT/SILTY SAND (ML/SM), med. to dark brown, fine to medium silty sand and sandy silt, angular to sub-angular sand, loose to moderately dense, moist to very moist, slight plasticity, approx. 40–60% sand, 40–60% silt
6							
7		100	9 8 7		35A-4		6.7–9.5' SANDY SILT (ML), 10YR 5/3 brown, sandy silt with very fine to medium sand grains, angular to sub-angular sand, stiff to very stiff, very moist to saturated, becomes saturated at about 8.0 ft.
8			7		35A-5		
9		78	6 11		35A-6		
10			12 17		35A-7		9.5–10' SILTY SAND (SM), 10YR 5/6 yellowish brown, fine to medium silty sand, angular to sub-angular, moderately dense, saturated, zones of orange staining, likely decomposed granitic material (quartz & mica seen) 10–10.6' SAND (SP), 10YR 5/6 yellowish brown, decomposed bedrock, medium to coarse sand with some gravel, poorly graded, angular sand and gravel, dense 10.6–10.8' SANDY SILT (ML), yellowish gray, sandy silt, very fine to fine sand, saturated
11		100	19 34		35A-8		10.8–12' SANDY GRAVEL with SILT (GM), 5YR 4/4 reddish brown, sandy gravel with silt, angular sand and gravel, very dense, likely decomposed granitic material, but some darker colored alluvial gravel seen
12		50	30 28		35A-9		12–15' SILTY SAND with GRAVEL (SM), 5YR 4/4 reddish brown, medium to coarse sand with silt and gravel, angular sand, moderately dense to very dense, moist
13			30 33				
14			7 12 23				

BORING/WELL COMPLETION LOG

BORING/WELL NO. GW-35A

PROJECT: MIDNITE MINE – ALLUVIAL AQUIFER INVESTIGATION PAGE: 2 OF 2

PROJECT NO.: 01-252-2 DATE: 10/25/96

DEPTH (FT)	WELL GRAPHIC	% RECOVERY	BLOW COUNT	SAMPLE TYPE	SAMPLE NUMBER	LITHOLOGY GRAPHIC	SOIL DESCRIPTION
15			100/4"			NO SAMPLING	15' 100 blows/4" (sampler refusal), 4" piece of angular granitic rock with red/orange staining, also some fragments of more heavily decomposed granitic material with quartz and mica, also some medium to coarse angular sand with gravel and silt (SM), saturated
16							
17							15–18' Auger advancement to more competent bedrock with no sampling
18							18' Auger refusal at 18'
19							
20							
21							Note: Lithologic logs from a boring approximately 5 feet south of GW-35A location.
22							Note: Color classification using Munsell soil color chart (Munsell Color, 1994).
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-50

PROJECT: MIDNITE MINE PAGE: 1 of 3
PROJECT NO.: 01-252 DATE: 9 NOVEMBER 1998
NORTHING: 351691.9 EASTING: 2671069.7 GROUND ELEVATION: 2354.13
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON LOGGED BY: TIM RUNNELLS

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
0	1310	MOIST			0'-5': CLAYEY SILTY GRAVELLY SAND, DARK YELLOWISH BROWN (10YR 4/2) UNWASHED, DARK YELLOWISH ORANGE (10YR 6/6) WASHED, VERY COARSE TO VERY FINE SAND, POORLY SORTED, SUB-ROUNDED TO ROUND, IRON STAINING ON MOST CHIPS, DARK YELLOWISH ORANGE (10YR 6/6), 10-15% CLAY, 10-15% SILT, 20-30% GRAVEL, 50-60% SAND.
5	1317	MOIST			5'-10': SILTY CLAYEY GRAVELLY SAND, DARK YELLOWISH BROWN (10YR 4/2) UNWASHED, DARK YELLOWISH ORANGE (10YR 6/6) WASHED, VERY COARSE TO VERY FINE SAND, POORLY SORTED, SUB-ROUNDED TO ROUND, IRON STAINING ON MOST CHIPS, DARK YELLOWISH ORANGE (10YR 6/6), 5-10% SILT, 15-20% SILT, 20-30% GRAVEL, 50-60% SAND.
10	1402	FREE WATER			10'-15': CLAYEY SILTY GRAVELLY SAND, DARK YELLOWISH BROWN (10YR 4/2) UNWASHED, DARK YELLOWISH ORANGE (10YR 6/6) WASHED, VERY COARSE TO VERY FINE SAND, GRAVEL SIZE INCREASES TO ½", POORLY SORTED, SUB-ROUNDED TO ROUND, IRON STAINING ON MOST CHIPS, DARK YELLOWISH ORANGE (10YR 6/6), 10-15% CLAY, 10-15% SILT, 30-40% GRAVEL, 40-50% SAND.
15	1422	MOIST			15'-16.5': SAME AS 10'-15'.
		DRY			16.5'-19.5': WEATHERED QUARTZ MONZONITE (FROM CHANGES IN COLOR OF CUTTINGS AND MOISTURE).
20	1458	DRY & DUSTY			19.5'-20': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT BROWNISH GRAY (5YR 6/1) AND GREENISH GRAY (5G 6/1), MOSTLY QUARTZ AND ORTHOCLASE AND GREEN MINERAL, SMALL PERCENTAGE OF HORNBLENDE AND BIOTITE, CHIPS FAIRLY UNIFORM AND <5 mm, NO STAINING.
					20'-25': SAME AS 19.5'-20'.
25	1504	DRY & DUSTY			25'-30': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT BROWNISH GRAY (5YR 6/1) AND GREENISH GRAY (5G 6/1), MOSTLY QUARTZ, ORTHOCLASE AND GREEN MINERAL, SMALL PERCENTAGE OF HORNBLENDE AND BIOTITE, CHIPS VARY BETWEEN 15 mm AND 2 mm, IRON STAINING ON <5% OF CHIPS.
30	1520	DRY & DUSTY			

BORING LOG

SHEPHERD MILLER INCORPORATED

BORING NO. GW-50

PROJECT: MIDNITE MINE PAGE: 2 of 3
PROJECT NO.: 01-252 DATE: 9 NOVEMBER 1998
NORTHING: 351691.9 EASTING: 2671069.7 GROUND ELEVATION: 2354.13
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON LOGGED BY: TIM RUNNELLS

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
30	1520	DRY & DUSTY			30'-35': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT GRAY (N7) AND YELLOWISH GRAY (5Y 8/1), MOSTLY QUARTZ, OLIGIOCLASE, CALCITE AND GREEN MINERAL, CHIPS <2 mm AND UNIFORM IN SIZE, IRON STAINING ON <1% OF CHIPS, MODERATE HCL REACTION ON SOME CHIPS.
		MOIST			32': CUTTINGS BROWNER.
					33.5': CUTTINGS GRAYER.
35	1524	DRY & DUSTY			35'-40': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT GRAY (N7) AND YELLOWISH GRAY (5Y 8/1), MOSTLY QUARTZ, OLIGIOCLASE, ORTHOCLASE, HORNBLENDE, BIOTITE, AND GREEN MINERAL, CHIPS VARY BETWEEN 15 mm AND 2 mm, IRON STAINING ON <10% OF CHIPS, A FEW VISIBLE GRAINS OF PYRITE, ONE CHIP HAS FRACTURE WITH PYRITE INFILLING.
					39': CHIP SIZE INCREASES.
40	1530	DRY & DUSTY			40'-45': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT GRAY (N7) AND YELLOWISH GRAY (5Y 8/1), MOSTLY QUARTZ, OLIGIOCLASE, ORTHOCLASE, HORNBLENDE, BIOTITE, AND GREEN MINERAL, CHIPS <5 mm.
					44.5': CHIP SIZE DECREASES.
45	1535	DRY & DUSTY			45'-50': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT GRAY (N7) AND YELLOWISH GRAY (5Y 8/1), MOSTLY QUARTZ, ORTHOCLASE, HORNBLENDE, BIOTITE, AND GREEN MINERAL, CHIPS VARY BETWEEN 15 mm AND 2 mm.
					49': CUTTINGS BROWNER.
50	1549	DRY			50'-55': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT GRAY (N7) AND YELLOWISH GRAY (5Y 8/1), MOSTLY QUARTZ, OLIGIOCLASE, ORTHOCLASE, HORNBLENDE, BIOTITE, AND GREEN MINERAL, CHIPS <5 mm, MINOR HCL REACTION.
		S. MOIST			
55	1553	S. MOIST			55'-60': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT GRAY (N7) AND YELLOWISH GRAY (5Y 8/1), MOSTLY QUARTZ, OLIGIOCLASE, ORTHOCLASE, HORNBLENDE, BIOTITE, AND GREEN MINERAL, CHIPS <5 mm, MODERATE HCL REACTION.
		DRY & DUSTY			
60	1615	DRY & DUSTY			

BORING LOG

SHEPHERD MILLER
INCORPORATED

BORING NO.
GW-50

PROJECT: MIDNITE MINE PAGE: 3 of 3
PROJECT NO.: 01-252 DATE: 9 NOVEMBER 1998
NORTHING: 351691.9 EASTING: 2671069.7 GROUND ELEVATION: 2354.13
DRILLING COMPANY: RUEN DRILLING METHOD: AIR ROTARY/CASING ADVANCE
DRILLER: CASEY BURTON LOGGED BY: TIM RUNNELLS

DEPTH (FT)	TIME	DISCHARGE (gpm)	LITHOLOGY	STRATIGRAPHY	DESCRIPTION/NOTES
60	1615	DRY & DUSTY			60'-65': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT GRAY (N7) AND YELLOWISH GRAY (5Y 8/1), MOSTLY QUARTZ, ORTHOCLASE, HORNBLENDE, BIOTITE, AND GREEN MINERAL, CHIPS VARY BETWEEN 15 mm AND 2 mm, IRON STAINING ON <10% OF CHIPS, A FEW VISIBLE GRAINS OF PYRITE, MODERATE HCL REACTION.
65	1621	DRY & DUSTY			65'-70': PORPHYRITIC QUARTZ MONZONITE, COLOR RANGES BETWEEN LIGHT GRAY (N7) AND YELLOWISH GRAY (5Y 8/1), MOSTLY QUARTZ, ORTHOCLASE, HORNBLENDE, BIOTITE, AND GREEN MINERAL, CHIPS VARY BETWEEN 15 mm AND 2 mm, IRON STAINING ON <10% OF CHIPS, A FEW VISIBLE GRAINS OF PYRITE, MINOR HCL REACTION.
70					T.D.

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring WD-01
	Project Location: Midnite Mine	PAGE 1 OF 4
	Project Number: 53F4001800.03	

Date(s) Drilled 9/14/99 - 9/15/99	Logged By GARRETT BROWN/CH2M HILL		Total Depth of Borehole (ft) 119.6' BGS
Drilling Method AIR ROTARY WITH CASING DRIVER	Diameter of Borehole (in) 7 7/8" HAMMER BIT		Ground Surface Elevation (ft-msl) ~~TBD~~ 2404.08
Drill Rig Type INGERSOLL-RAND T3W	Drilling Company CASCADE, SEATTLE		Groundwater Elevation (ft-msl) TBD
Driller's Name ROB LEININGER	Sampler Type CYCLONE GRAB SAMPLE	Checked By DK Nicholson	Measuring Point Elevation (ft-msl) ~~TBD~~ 2406.49
Locations / Comments 9 3/4" OD (8 1/2" ID) THREADED STEEL CASING			Northing 352242 Easting ~~TBD~~ 2670910

Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
								G.B. WD-01 IS LOCATED 30' SOUTH ~~N NW~~ OF WELL MW-1	
								Silt, gravel, and organic debris at ground surface.	9-14-99 Began drilling at 11:55.
5	GRAB				2.5Y-4/2	SM		Silty sand - dark grayish brown, slightly moist, non-cohesive, loose, fine to med-grained sand w/ 10-20% silt	11:59; RAD=45 uR/h 1203-1250 - Casing driver malfunctions Down for repairs. SWL=6 to 8' bgs.
10	GRAB				10YR-5/2	GW		Gravel - grayish brown, saturated, producing several gpm, clean, well graded (poorly sorted), angular to sub-rounded; up to 2cm; little fines	1305; RAD=48 uR/h
14					10YR-3/3	GM		Silty gravel	
15	GRAB				2.5Y-5/2	BEDROCK		Porphyritic qtz monzonite. Bedrock went dry. See description below.	1320 Set casing (temporary) in bedrock at 16'.
20	GRAB				2.5Y 5/2			Porphy. qtz. monzonite - dry, hard, slightly weathered and iron stained, predominantly pink K feldspar, and smoky qtz. Minor plagioclase and less than 5% biotite. Also unidentified greenish mineral. Perhaps altered K feldspar or plagioclase? Coarse-grained phenocrysts, especially K feldspar. No formation water.	1334; RAD=34 uR/h
25	GRAB								1346; RAD=49 uR/h Injecting water to control dust. Cuttings still dry. No formation water
30									

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring WD-01
	Project Location: Midnite Mine	PAGE 2 OF 4
	Project Number: 53F4001800.03	

Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
30	GRAB				2.54 6/1	BEDROCK		Porphyritic qtz. monzonite - gray, dry even though injecting water to control dust, clean, unweathered hard, competent.	1410 - RAD=53uR/h
35	GRAB				2.54-7/1			Porphy. qtz monzonite - as above only color change to light gray.	1430; RAD=56uR/h H_2O injection to control dust.
40	GRAB							As above. H_2O injection, yet cuttings dry.	1450; RAD=73uR/h
45	GRAB							As above, cuttings dry even w/ H_2O injection to control dust.	1507; RAD=49uR/h
50	GRAB							As above, cuttings dry	1537; RAD=32uR/h
55	GRAB							As above, cuttings dry	1550; RAD=42uR/h
60	GRAB							As above, cuttings dry.	1615; RAD=39uR/h
65									

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring WD-01
	Project Location: Midnite Mine	PAGE 3 OF 4
	Project Number: 53F4001800.03	

Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
65	GRAB				2.54 7/1	BEDROCK		Porphy. qtz. monzonite - as above, dry, even w/ injected water to control dust.	1628; RAD=64uR/h. 1645-1720 - Stripped hole to load 20' rods.
70	GRAB				2.54-7/1			As above, only wet from H_2O injection and slightly weathered surfaces.	1725; RAD=63uR/h
75	GRAB				2.54-6/1			Porphy. qtz. monzonite - moist from H_2O injection, med. hard, gray.	1740; RAD=54uR/h Faster drill speed.
80	GRAB				2.54 7/1			Porphy. qtz. monzonite - light gray, moist from H_2O injection, hard, competent, clean. no weathering	1805; RAD=48uR/h
85	GRAB							As above, only dry even though injecting water to control dust.	1827; RAD=71uR/h
90	GRAB							As above, very hard and dry.	1850; RAD=74uR/h
95	GRAB							As above.	1910; RAD=113uR/h
100									

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring WD-01
	Project Location: Midnite Mine	PAGE 4 OF 4
	Project Number: 53F4001800.03	

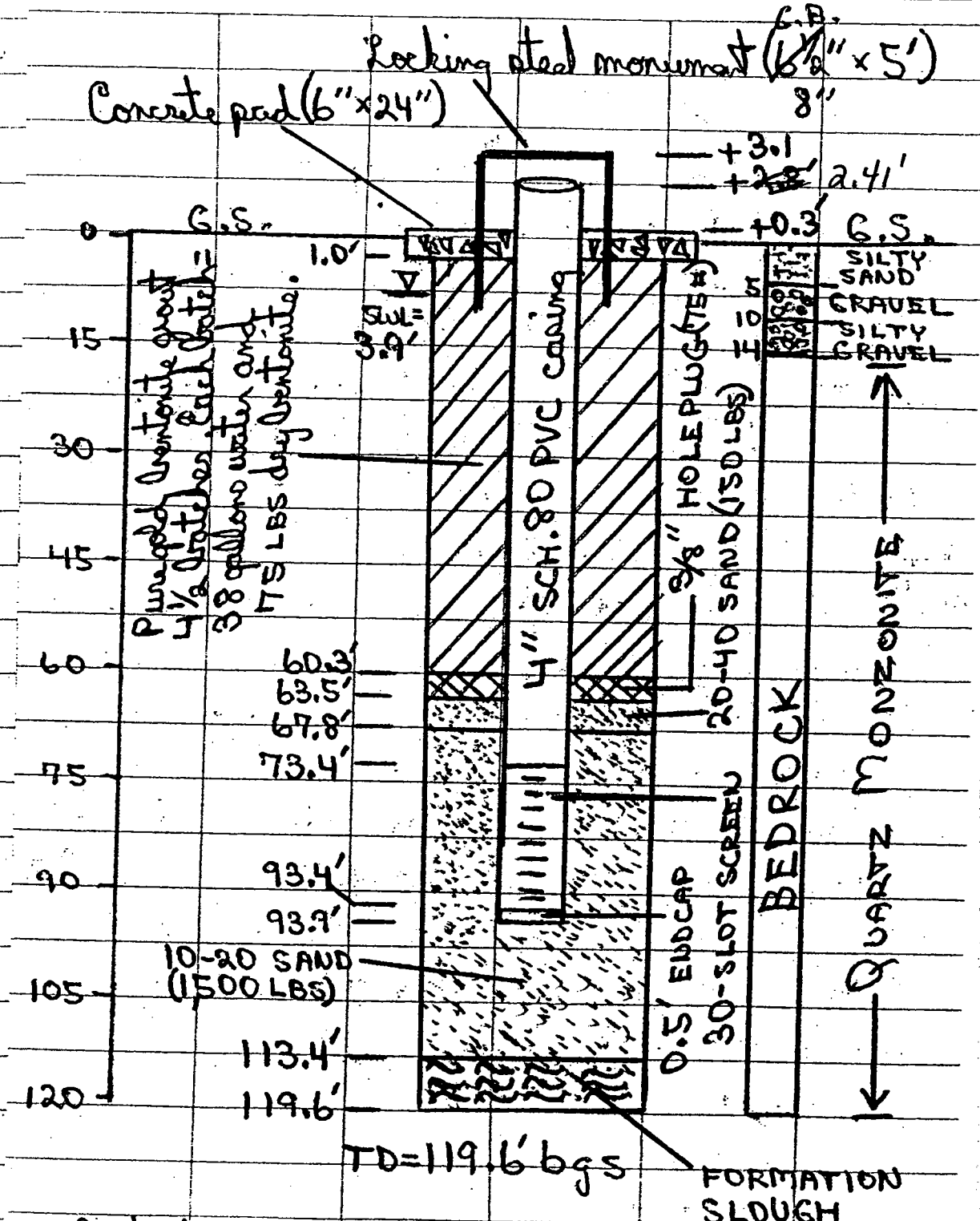
Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
100'					2.5Y-7-1	BEDROCK		Porphyritic qtz. monzonite – as above, dry.	
105	GRAB							As above, only cuttings muddy I injecting water to control dust.	1958; RAD=98uR/h
110'	GRAB							As above.	2018; RAD=108
115'									Flushed borehole for 10 minutes at 5-10 gpm to clean out. Tripped borehole of drill rods.
120'								TD=119.6' BGS	9-15-99 0800 - Tagged bottom at 113.4' Hole sloughed approx 6' overnight. SWL=3.9' BGS
125'									
130'									
135'									

Notes: After tripping out of borehole, the tagged depth at 119.6' BGS was 10 feet deeper than expected. Lost track of borehole depth between 70' and 119.6' bgs. It is all porphyritic qtz. monzonite, however. Geophysical caliper log indicates major fracture and borehole widening between 81' and 83' bgs. The rest of the borehole is very even. Set screen between 73.4 and 93.4' BGS. Sand pack from 63.5' to 113.4' BGS.

30 Location Weston Drainage MWWD-01 Date 9-15-99

Project / Client T28N-R37E-SEC13-NW¼NW¼

WELL WD-01 COMPLETION DIAGRAM



Centralizers at bottom and top of screen and 20' above top of screen.

checked by DK Nicholson 4/24/00

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	MWWD Ø2 Log of Boring
	Project Location: Midnite Mine	PAGE 1 of 4
	Project Number: 53F4001800.03	

Date(s) Drilled: 9/30/99 to	Logged By: M. Henry / CH2M HILL	Total Depth of Borehole (ft): 104.8	
Drilling Method: Air Rotary. Temp. casing to 10' bgs. Hammer bit	Diameter of Borehole (in): 8 inch nominal	Ground Surface Elevation (ft-msl): 2442.94	
Drill Rig Type: Failing Star 30K	Drilling Company: Cascade Drilling	Groundwater Elevation (ft-msl): —	
Driller's Name: T. Mechan	Sampler Type: Cuttings from cyclone	Checked By: DK Nicholson	Measuring Point Elevation (ft-msl): 2444.90
Locations / Comments: Top of ridge located between southwestern and western drainages			Northing: 351584 Easting: 2670737

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	~~Penetrometer~~ RAD ~~tsf~~ mR/hr	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS (RAD background 10-30 mR/hr)
0								Topsoil	16:50 9/30/99
								Weathered quartz monzonite	
5'				25-40	10YR 7/4	SP		Poorly graded sand, grayish orange, fine-grained quartz-rich sand, dry	Begin Injecting water at 6'
10'				25-40	10YR 7/4			Weathered qtz monzonite, grayish orange. Fine grained sand with rock frags up to 1". Abundant qtz (clear to gray), K feldspar (pink) and biotite, and white-buff plagioclase	Temp. casing to 10' bgs, open hole drilling below
15'				15-35	10YR 7/4	SP		Poorly graded sand, grayish orange, occasional rock frags to 1/4 inch.	08:15 10/1/99 Much harder after 15'
20'				20-40	10YR 7/4	SP		As above, larger % of rock fragments, porphyritic	
25'				15-40				As above, larger % of rock fragments, porphyritic	
30'									

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	MWWD02 Log of Boring
	Project Location: Midnite Mine	
	Project Number: 53F4001800.03	PAGE 2 OF 4

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
								Quartz Monzonite	
30				15-35	10YR 7/4			Qtz monzonite - large phenocrysts of quartz and K-feldspar, occasional biotite and plagioclase	0900 10/1/99
35				10-30	5YR 6/1			As above, color change to light brownish gray, similar lithology as above, but now have 5-10% greenish-gray plagioclase	
40				20-40	5YR 6/1			As above	
45				20-45	5YR 6/1			As above, similar lithology but up to 20% greenish plagioclase. Qtz is grayish, large phenocrysts of K-feldspar	Hard drilling
50				20-60	5YR 8/1			As above, Qtz: 50-60%, K feldspar 15%, green plag-5% minor biotite, pinkish gray in color	
55				15-45	5YR 8/1			As above, larger fragment size than above	53-57 softer than above
60				25-45	5YR 8/1			As above	
65									Stopped for 40 minutes, but no water

URS GREINER
Woodward Clyde

Project Name:	Phase 1A RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

MWWD02

Log of Boring

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
								Qtz Monzonite	
65				10-30	5YR 8/1			Qtz monzonite, qtz: 50-60%, pink K Feldspar 15%, green plagioclase 5%, minor biotite.	11:00 10/1/94 very hard drilling around 65'
70				10-30	5YR 8/1			As above	
75					5YR 8/1			As above	11:30 let stand with TD @ 74' bgs for 1 hr - hole not making water
80				15-30	5YR 8/1			As above	
85				15-35	N7			As above, qtz 40-50%; greenish plagioclase 20-30%, K Feldspar 20%, minor biotite, color change to light gray	generally very hard drilling
90				20-30	N7			As above	
95				15-35	N7			As above	
100					N7			As above	

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	MWWD#2 Log of Boring
	Project Location: Midnite Mine	PAGE 4 OF 4
	Project Number: 53F4001800.03	

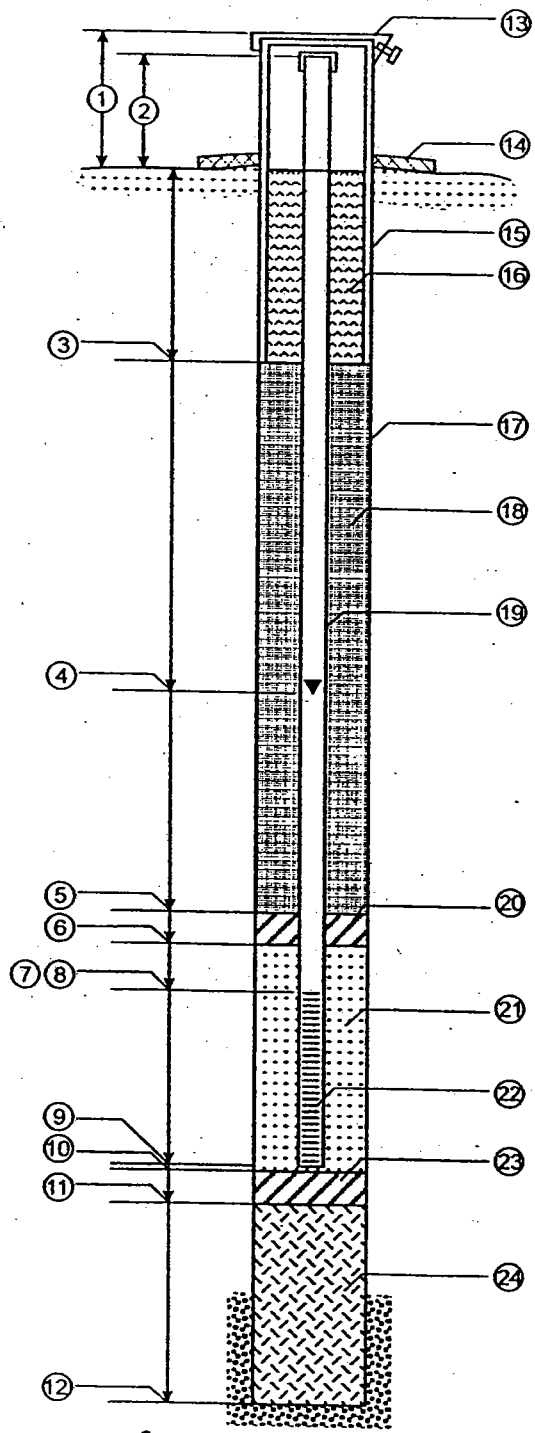
Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	~~Penetrometer~~ RQD	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
								Qtz Monzonite	
100'				20-40	N7			qtz 40-50%, grayish plagioclase 20-30%, K feldspar 20%, minor biotite.	14:00 10/1/99 softer from 102-103
105'									Stopped drilling for day @ 104.8' bgs. DTW = 102.8' bgs @ 1435
									TD = 104.8'
110'									
115'									
120'									
125'									
130'									
135'									

URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Project Number: 53F4001800.03	Project Name: MIDNITE MINE	Date/Time Started: ~~10/6/99~~ 10/1/99 14:00	
Well/Borehole Number: MWWD-02	Well/Borehole Location: Western Drainage	Date/Time Completed: 10/6/99 14:00	
Installation Team: TEAM #3	Type of Drilling: AIR ROTARY	Ground Surface Elev.: 2442.94 ft.msl	Top of Well Casing Elev.: 2444.90 ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: 2.85 ft.
2. Stick-Up Well Casing Above Ground: HTR 1.96' 10-12-99 DKN ~~3.11~~ ~~2.45~~ ft.
3. Depth to Bottom of Upper Seal/Protective Casing: ____ ft.
4. Depth to Initial Ground Water Surface Elevation: ____ ft.
5. Depth to Top of Top Seal: 0 ft.
6. Depth to Bottom of Top Seal: 41 ft.
7. Depth to Top of Well Point or Screen: 50 ft.
8. Total Length of Blank Casing: 50 ft.
9. Bottom Depth of Well Screen: 70 ft.
10. Depth to Top of Bottom Seal (If Installed): 71 ft.
11. Depth to Bottom of Bottom Seal (If Installed): 76 ft.
12. Depth of Borehole: 104 ft.
13. Protective Casing: ☒ Yes ☐ No Locking Cap: ☒ Yes ☐ No
14. Sanitary Seal: ☒ Yes ☐ No
15. Type of Protective Casing: STEEL Diameter: 8 in.
16. Type of Upper Seal: ~~Bentonite~~ Concrete DKN
17. Borehole Diameter: ~~8~~ 10 in.
18. Type of Upper Backfill: cement/bentonite grout
19. Type of Well Casing: PVC SCH 80 Diameter: 4 in.
20. Type of Top Seal (IF Installed): PURE GOLD BENTONITE CHIPS
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: 10X20 Diameter: 8 in.
22. Type of Screen Material: PVC SCH 80 Slot Size: 0.030 in.
23. Type of Bottom Seal (If Installed): bentonite chips
24. Type of Lower Backfill: 10/20 Silica sand

Recorded By	Date	Checked By	Date
[signature]	10/6/99	DK Nicholson	4/26/00

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring MWWD-03
	Project Location: Midnite Mine	1 OF 2
	Project Number: 53F4001800.03	

Date(s) Drilled 10/6-7/99	Logged By ROBERT MARTIN	Total Depth of Borehole (ft) 56	
Drilling Method AIR ROTARY 8"NOM	Diameter of Borehole (in) 8"	Ground Surface Elevation (ft-msl) 2423.33	
Drill Rig Type STAR 30K	Drilling Company CASCADE	Groundwater Elevation (ft-msl)	
Driller's Name TODD	Sampler Type cyclone	Checked By DK Nicholson	Measuring Point Elevation (ft-msl) 2425.26
Locations / Comments Western Drainage			Northing 351732 Easting 2671418

Depth (ft-bgs)	SAMPLES: Blows/Foot	Time	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	17 28			15					QUARTZ MONZONITE - COARSE GRAINED, HIGHLY WEATHERED	DRIVING CASING, THEN DRILLING OUT 1ST 5 FT INTERVAL.
5	17 48 / 8 12			20					QUARTZ MONZONITE - SAME AS ABOVE	6' DRILLED TO 6 FT 10/7/99 STOPPED FOR NIGHT.
10	8 22			25					QUARTZ MONZONITE AS ABOVE	
15	8 35			25					QUARTZ MONZONITE AS ABOVE	
20	8 39			25					QUARTZ MONZONITE - MED TO COARSE GRAINED, HIGHLY WEATHERED	21' - CUTTINGS CLEANER < CLAY, DRILLER SAYS SLIGHTLY HARDER DRILLING.
25	8 44 / 8 51			15					QUARTZ MONZONITE - COARSE GRAINED. MODERATELY WEATHERED.	
30	8 55			20					QUARTZ MONZONITE - FINE TO MEDIUM-GRAINED, MODERATELY WEATHERED	
35	9 00 / 9 05			20					QUARTZ MONZONITE - AS ABOVE	

URS GREINER Woodward Clyde	Project Name: Phase 1A RI/FS	Log of Boring MWWD-03
	Project Location: Midnite Mine	2 of 2
	Project Number: 53F4001800.03	

Date(s) Drilled 10/6-7/99	Logged By ROBERT WARTON		Total Depth of Borehole (ft) 56
Drilling Method AIR ROTARY 8" NOM HAMMER	Diameter of Borehole (in) 8"		Ground Surface Elevation (ft-msl)
Drill Rig Type STAR 30K	Drilling Company CASCADE		Groundwater Elevation (ft-msl)
Driller's Name GOOD	Sampler Type	Checked By DKNicholson	Measuring Point Elevation (ft-msl)
Locations / Comments			Northing / Easting

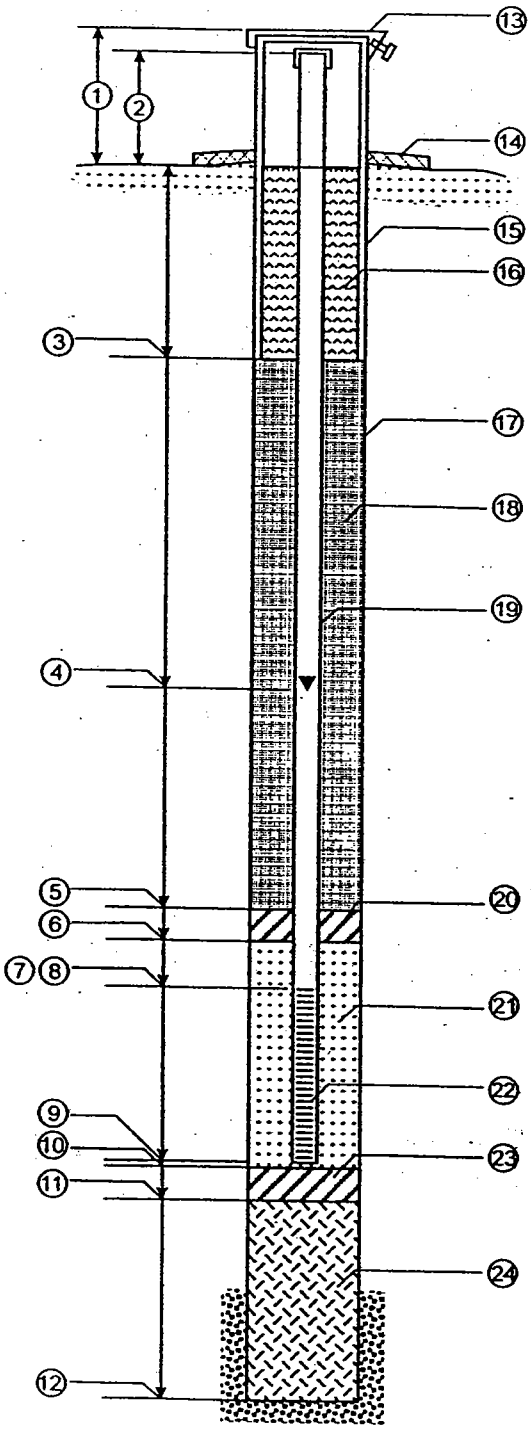
Depth (ft-bgs)	SAMPLES: Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
40	908		70					QUARTZ MONZONITE - MEDIUM TO COARSE GRAINED, MODERATELY WEATHERED	- MOIST, LESS DUST PRODUCTION
46	912 954		25					QUARTZ MONZONITE - FINE TO MEDIUM GRAINED, MODERATELY WEATHERED.	- DRY
50	958		20					QUARTZ MONZONITE - FINE GRAINED, CUTTINGS MORE YELLOW-ORANGE	
56	1002		30					QUARTZ MONZONITE - MEDIUM TO COARSE GRAINED, PLAG LT. GREEN COLOR	
								TOTAL DEPTH 56'	
60									
65									
70									

URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Project Number: 53F4001800.03	Project Name: MIDNITE MINE	Date/Time Started: ~~10/7/99~~ 10/6/99 17:1
Well/Borehole Number: MWWD-03	Well/Borehole Location: Western Drainage	Date/Time Completed: 10/7/99 13:30
Installation Team: TEAM #3	Type of Drilling: AIR ROTARY	Ground Surface Elev.: 2423.33 ft.msl
		Top of Well Casing Elev.: 2425.26 ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: 2.95 ft.
2. Stick-Up Well Casing Above Ground: HG 1.93' ~~30 H 2.83~~ ft.
   10-12-99 DKN
3. Depth to Bottom of Upper Seal/Protective Casing: ____ ft.
4. Depth to Initial Ground Water Surface Elevation: ____ ft.
5. Depth to Top of Top Seal: 2 ft.
6. Depth to Bottom of Top Seal: 31 ft.
7. Depth to Top of Well Point or Screen: ~~36~~ 35.5 ft.
8. Total Length of Blank Casing: 36 ft.
9. Bottom Depth of Well Screen: ~~56~~ 55.5 ft.
10. Depth to Top of Bottom Seal (If Installed): N/A ft.
11. Depth to Bottom of Bottom Seal (If Installed): N/A ft.
12. Depth of Borehole: 56 ft.
13. Protective Casing: ☒ Yes ☐ No Locking Cap: ☒ Yes ☐ No
14. Sanitary Seal: ☒ Yes ☐ No
15. Type of Protective Casing: STEEL Diameter: 8 in.
16. Type of Upper Seal: ~~PORTLAND~~ Concrete DKN
17. Borehole Diameter: 8 in.
18. Type of Upper Backfill: Cement / bentonite grout
19. Type of Well Casing: PVC SCH 80 Diameter: 4 in.
20. Type of Top Seal (IF Installed): PURE GOLD BENTONITE CHIPS
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: 10X20 Diameter: 8 in.
22. Type of Screen Material: PVC SCH 80 Slot Size: 0.030 in.
23. Type of Bottom Seal (If Installed): N/A
24. Type of Lower Backfill: N/A

Recorded By	Date	Checked By	Date
[signature]	10/7/99	DK Nicholson	4/26/00

BOREHOLE ID: MWWD-02

TETRA TECH Tetra Tech

CLIENT Dawn Mining Company
PROJECT NAME Midnite Mine
PROJECT NUMBER 114-181850.2010
PROJECT LOCATION Central and Western Drainage

DATE(S) OF DRILLING: 07/27/2010 - 07/27/2010
GROUND ELEVATION: 2,403.5 ft
METHOD: 8 1/4" ID x 12 1/8" OD
CONSULTANT: Tetra Tech
NORTHING: 352,180 ft
LOGGED BY: Joe Reed
DRILLING CONTRACTOR: Ruen Drilling
EASTING: 511,043 ft
DRILLED BY: Jim Erdman
DRILL RIG: BK-66
HAMMER TYPE: N/A
LOCATION: Midnite Mine

DEPTH (ft)	SAMPLE TYPE	GRAPHIC LOG	MATERIAL DESCRIPTION
0			
0.5			**GRAVEL** road gravel
1			**SANDY GRAVELLY CLAY, GC** Dark yellowish brown (10YR 3/4), moist to wet at 3.5 feet, soft to medium stiff, fine to coarse grained sand, fine gravel, roots
2			
3			
4			
4.5			**SANDY CLAYEY GRAVEL/GRAVELLY CLAYEY SAND, GC/SC** Dark yellowish brown (10YR 3/4), wet, medium dense, fine to coarse grained sand and gravel, low plasticity
5			
6			
7			
8			
9			
10			
11			
12			
12.0			**WEATHERED BEDROCK**
13			
14			Harder at 14 feet
15			
16			
16.5			Auger refusal at 16.5 feet

Bottom of hole at 16.5 feet.

BOREHOLE/TP/WELL - VECTOR MIDNIGHT MINE, C&WD, GINT.GPJ ROCK SPRINGS DATA TEMPLATE.GDT 11/15/10

BOREHOLE ID: PBW-01

TETRA TECH Tetra Tech

CLIENT Dawn Mining Company
PROJECT NAME Midnite Mine
PROJECT NUMBER 114-181850.2010
PROJECT LOCATION Central and Western Drainage

DATE(S) OF DRILLING: 07/24/2010 - 07/24/2010
GROUND ELEVATION: 2,406.3 ft
METHOD: 8 1/4" ID x 12 1/8" OD
CONSULTANT: Tetra Tech
NORTHING: 352,231 ft
LOGGED BY: Joe Reed
DRILLING CONTRACTOR: Ruen Drilling
EASTING: 511,043 ft
DRILLED BY: Jim Erdman
DRILL RIG: BK-66
HAMMER TYPE: N/A
LOCATION: Midnite Mine

DEPTH (ft)	SAMPLE TYPE	GRAPHIC LOG	MATERIAL DESCRIPTION
0			
1, 2			**SANDY GRAVELLY CLAY, CL** Dark yellowish brown (10YR 4/4), dry, soft, fine to coarse grained sand, fine gravel, frequent roots
2.0			
3, 4			**SANDY CLAY, CL** Dark yellowish brown (10YR 4/4), slightly moist, medium stiff, fine to coarse grained sand, trace fine gravel, medium plasticity, to moist at 3 feet
4.0			
5, 6, 7			**SANDY CLAYEY GRAVEL, GC** Dark yellowish brown (10YR 4/4), wet, dense, fine to coarse grained sand and gravel, cohesive, gravel size and amounts decrease with depth, trace silt
7.0			
8, 9, 10			**GRAVELLY CLAYEY SAND, SC** Dark yellowish brown (10YR 4/4), wet, dense, fine to coarse grained sand, fine gravel, cohesive, trace silt, layer of gravel above bedrock
10.0			
11, 12, 13, 14, 15			**WEATHERED BEDROCK**
15.0			
			Bottom of hole at 15.0 feet.

BOREHOLE/TP/WELL - VECTOR MIDNIGHT MINE, C&WD, GINT.GPJ ROCK SPRINGS DATA TEMPLATE.GDT 11/15/10

BOREHOLE ID: PBW-02

TETRA TECH Tetra Tech

CLIENT Dawn Mining Company
PROJECT NAME Midnite Mine
PROJECT NUMBER 114-181850.2010
PROJECT LOCATION Central and Western Drainage

DATE(S) OF DRILLING: 07/25/2010 - 07/25/2010
GROUND ELEVATION: 2,404.8 ft
METHOD: 8 1/4" ID x 12 1/8" OD
CONSULTANT: Tetra Tech
NORTHING: 352,198 ft
LOGGED BY: Joe Reed
DRILLING CONTRACTOR: Ruen Drilling
EASTING: 511,023 ft
DRILLED BY: Jim Erdman
DRILL RIG: BK-66
HAMMER TYPE: N/A
LOCATION: Midnite Mine

DEPTH (ft)	SAMPLE TYPE	GRAPHIC LOG	MATERIAL DESCRIPTION
0			
			SILTY CLAYEY SAND, SM/SC Yellowish brown (10YR 5/6), dry, loose, fine to coarse grained sand, trace gravel, frequent roots
2.0			**CLAYEY SAND/SANDY CLAY, SC/CL** Dark yellowish brown (10YR 3/4), moist to wet at 3 feet, soft/loose, fine to coarse grained sand, low plasticity
7.0			**GRAVELLY CLAYEY SAND/GRAVELLY SANDY CLAY, SC/CL** Dark yellowish brown (10YR 3/4), wet, medium dense, fine to coarse grained sand, fine gravel, low plasticity, trace cobbles
9.0			**WEATHERED BEDROCK** Yellowish brown Drilling requires more torque, possibly clayey from 9 to 11.5 feet Hard Bedrock from 11.5 to 12 feet Softer Bedrock layered with hard and soft intervals
18.5			Bottom of hole at 18.5 feet.

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TMSS-03 10/10/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Date(s) Drilled	10/10/00	Logged By	CHRIS WILLIAMS	Total Depth of Borehole (ft)	123
Drilling Method	BECKER HAMMER	Diameter of Borehole (in)	6	Ground Surface Elevation (ft-msl)	
Drill Rig Type	AP1000 DRILL SYSTEMS	Drilling Company	GREAT WEST DRILLING	Groundwater Elevation (ft-msl)	NONE
Driller's Name	JIM BENSEN	Sampler Type	CYCLONE TO BUCKET	Checked By	CHUCK HART	Measuring Point Elevation (ft-msl)	
Locations / Comments	UPPER BENCH (BELOW ROAD) MIDDLE OF SOUTH SPOILS					Northing / Easting	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	30	B 2/3			5Y 6/1	GM		LOOSE, LT GRAY, DRY, SILTY GRAVEL, SOME FINE SAND 7/" ~ 20%	
2	35								
	37								
4	40								
	30	B 1/3			5Y 6/1	GM		AS BEFORE	-POOR RETURN, 0-10 COMPOSITE
6	24								
	9								
8	16								
	22	S 0.8							SPT 17/21/18
10	38	B 1/10			5Y 3/2	GM		LOOSE, OLIVE GRAY, SLIGHTLY MOIST, FINE SANDY TO SILTY GRAVEL, SOME CLAY 7/" ~ 15%	-POOR RETURN, PROB LOOSING AIR TO FILL
	39								
12	36								
	49								
14	66								
	47								

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring THSS-03 10/10/00

Depth (ft-bgs)	Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		B TR						AS BEFORE	POOR RETURN NO SAMPLE
16	47								
	27								
18	33								
	28	S 0.6							SPT 10/7/8
20	22	B 1/10			5Y 3/2	GM		LOOSE TO MED DENSE, OLIVE GRAY, MOIST GRAVEL SOME FINE SAND & SILT, FRESH GRAY BROKEN ROCK	POOR RETURN - HAMMER PUSHING ROCK
	23								
22	49								
	40								
24	62								
	88	B TR			5Y 3/2	GM		AS BEFORE	POOR RETURN NO BUCKET
26	46								
	61								
28	25								
	34								SPT 5/14/17 NO SAMPLE BLOCKED BY ROCK
30	59	B 1/10			5Y 3/2	GM		AS BEFORE BUT LOOSE	POOR RETURN
	26								
32	20								
	24								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH55-03 10/10/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
34	23								BLOWS SHORTEN
	18	B 1/10						LOOSE, GRAY AND REDDISH ORANGE, MOIST, FINE SANDY GRAVEL, SOME SILT, SOME CLAY	POOR RETURN
36	23								
	26								
38	30								
	49	S 0.0							SPT 20/ROCK NO SAMPL
40	40	B 1/2			10YR 4/2	GM		LOOSE TO MED DENSE, LT BROWN AND GRAY, FINE TO MED SAND, SOME GRAVEL & SILT, TRACE CLAY, LG FRESH BROKEN ROCK FRAGS ABUNDANT	
	51								
42	66								
	70								
44	46								
	44	B 1/10			5Y 3/2	GC		LOOSE TO MED DENSE, MOIST, OLIVE GRAY AND GRAY, GRAVELY F-M SAND, SOME CLAY AND SILT, FRESH ROCK FRAGS ABUNDANT	POOR RETURN
46	60								
	45								
48	64								
	62	S 0.0							SPT 20/ROCK NO SAMPLE
50	30	B 1/4			5Y 3/2	GM		AS BEFORE, LESS CLAY, MORE SILT	
	41								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH55-03 10/10/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
					5Y 3/2	GM		SEE PAGE BEFORE	
52	50								
	82								
54	55								
	79	B 1/10			5Y 3/2	GM		AS BEFORE	POOR RETURN AIR CIRCULATION LOST TO FILL
56	42								
	45								
58	49								
	36	S 1.0							SPT 40/16/14
60	23	B 1/10			5Y 5/2	GC		LOOSE TO MED DENSE, LT GRAY MOIST, F. SANDY TO SILTY GRAVEL, ABUNDANT FRESH ROCK FRAGS, SOME CLAY	POOR RETURN
	48								
62	50								
	62								
64	59								
	51	B 1/10			5Y 5/2	GM		AS BEFORE, LESS CLAY SOME MED SAND, ROCK FRESHER LESS WEATHERED, NEAR DRY	POOR RETURN, AIR LOST TO FILL
66	54								
	52								
68	58								
	69								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring T/HSS-03 10/11/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
									SPT 12/ROCK NO SAMPLE - END PLUGGED
70	53	B TR			5Y 5/2	GM		AS BEFORE	
	54								
72	45								
	67								
74	58								
	62	B 1/10			5Y 5/2	GM		AS BEFORE	POOR RETURN, AIR LOST TO FILL
76	78								
	65								
78	47								
	25	S 0.3							SPT 12/38/16 POOR SAMPLE ~ 3" OF ROCK
80	58	B 1/10			5Y 5/2	GM		AS BEFORE, VERY FRESH ROCK, LITTLE WEATHERING	POOR BUCKET RETURN
	48								
82	63								
	58								
84	57								
	37	B 4/10			5Y 5/2	GM		AS BEFORE	POOR RETURN
86	49								
	46								

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring THSS-03 10/11/00

Depth (ft-bgs)	Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
88	51								
	54	S 6.0							SPT 56/ROCK for 3" NO SAMPLE VERY POOR BUCKET RETURN
90	40	B TR			5Y 5/2	GM		AS BEFORE	
	26								
92	28								
	27								
94	28								
	42	B TR			5Y 5/2	GM		LOOSE TO MED DENSE, LT GRAY, SLIGHTLY MOIST, FINE SANDY GRAVEL, SOME SILT, MINOR CLAY, ABUNDANT FRESH BROKEN ROCK FRAGS (PROBABLY LARGER ROCK FILL)	POOR RETURN
96	58								
	58								
98	83								
	47	S 10.4							SPT 25/25/6
100	22	B 1/16			5Y 5/2	GM		AS BEFORE BUT GRAVELY FINE SAND	POOR, RETURN
	54								
102	49								
	79								
104	64								
	45								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring	THSS-03 10/11/00
	Project Location:	Midnite Mine		
	Project Number:	53F4001800.03		

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		B 1/10			5Y 5/2	GM		LOOSE TO MED DENSE, SLIGHTLY MOIST, LT GRAY, f-to c. GRAVEL SOME FINE SAND + SILT, TRACE CLAY, FRESH BROKEN ROCK (ROCKY FILL)	POOR RETURN
106	64								
	45								
108	41								
	72	S 0.3							SPT 17/27/36 POOR RETURN-S ONLY ROCKS
110	72	B 1/4			5Y 5/2	GM		AS BEFORE, BUT PROB LG ROCK ENCOUNTERED, DRY	POOR RETURN
	74								
112	150								
	178								LARGE ROCK IN HOLE
114	103								
	53	B 1/5							← NO SIGN OF WATER
116	30							LOOSE TO MED DENSE, LT GRAY AND LT BROWN, MOIST FINE SANDY GRAVEL, SOME SILT AND CLAY, REDDISH CLAY BALLS IN SAMPLE INDICATING POSSIBLE BEDROCK	
	31								
118	68								← APPROX BEDROCK CONTACT, RED CLAY BALLS IN SAMPLE, APPARENT THIN CLAYEY SOIL OVER WEATHERED GRANITE
	84	S 0.0							
120	373				10YR 5/4			VERY DENSE, YELLOWISH ORANGE, DRY, FINE GRAVELY SAND, SOME SILT, TRACE CLAY (WEATHERED GRANITE OR QUARTZ MONZONITE BEDROCK)	SPT NO COUNT ON ROCK ← NO SIGN OF WATER
	226								
122	308	S 0.4							SPT ATTEMPT 5/ COUNT FOR 5" OF BEDROCK (REFUSAL)
	296								

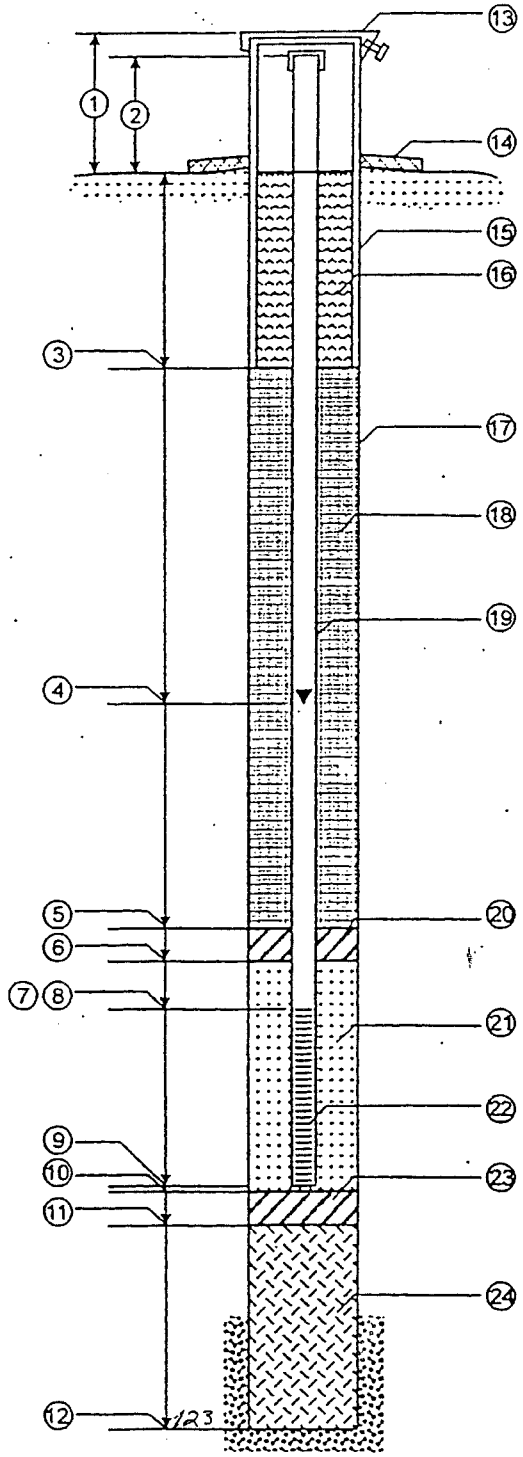
URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Project Number	Project Name	Date/Time Started
53F4001800.03	MIDNITE MINE - GEOTECH PROGRAM	10/10/00 - 1530
Well/Borehole Number	**Well/Borehole Location**	**Date/Time Completed**
TH55-03	SOUTH DUMP	10/12/00 - 0900

Installation Team	Type of Drilling	Ground Surface Elev.	Top of Well Casing Elev.
GREAT WEST DRLG & URS	BECKER HAMMER	ft.msl	ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: ~3.0 ft.
2. Stick-Up Well Casing Above Ground: ~2.5 ft.
3. Depth to Bottom of Upper Seal/Protective Casing: ~2.0 ft.
4. Depth to Initial Ground Water Surface Elevation: NA ft.
5. Depth to Top of Top Seal: 68 ft.
6. Depth to Bottom of Top Seal: 88 ft.
7. Depth to Top of Well Point or Screen: 91 ft.
8. Total Length of Blank Casing: ~93.5 ft.
9. Bottom Depth of Well Screen: 111 ft.
10. Depth to Top of Bottom Seal (If Installed): 111 ft.
11. Depth to Bottom of Bottom Seal (If Installed): 123 ft.
12. Depth of Borehole: 123 ft.
13. Protective Casing: ☒ Yes ☐ No Locking Cap: ☒ Yes ☐ No
14. Sanitary Seal: ☒ Yes ☐ No
15. Type of Protective Casing: STEEL Diameter: 5 in.
16. Type of Upper Seal: PURE GOLD MEDIUM BENTONITE CHIPS
17. Borehole Diameter: 6 in.
18. Type of Upper Backfill: PURE GOLD BENTONITE GROUT & MED CHIPS
19. Type of Well Casing: PVC SCHED 80 Diameter: 1 in.
20. Type of Top Seal (IF Installed): PURE GOLD BENTONITE MED CHIPS
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: 10-20 SILICA SAND Diameter: 1 in.
22. Type of Screen Material: PVC SCHED 80 Slot Size: 0.01 in.
23. Type of Bottom Seal (If Installed): PURE GOLD MED BENTONITE CHIPS
24. Type of Lower Backfill: PURE GOLD MEDIUM BENTONITE CHIPS 4.5 BAGS (LOST PART OF HOLE TO CAVING)

Recorded By	Date	Checked By	Date
CHRIS WILLIAMS	10/12/00	[illegible]	03/15/01

URS	Project Name: Phase 2A/1B RI/FS	Log of Boring THSS-04 10/23/00
	Project Location: Midnite Mine	
	Project Number: 53F4001800.03	

Date(s) Drilled	10/23/00 – 10/24/00	Logged By	CHRIS WILLIAMS	Total Depth of Borehole (ft)	90.5
Drilling Method	BECKER HAMMER	Diameter of Borehole (in)	6	Ground Surface Elevation (ft-msl)	
Drill Rig Type	DRILL SYSTEMS AP1000	Drilling Company	GREAT WEST DRILL	Groundwater Elevation (ft-msl)	NONE
Driller's Name	JIM BENSON	Sampler Type	CYCLONE TO BUCKET	Checked By	CHUCK HART	Measuring Point Elevation (ft-msl)
Locations / Comments	SOUTH SPOILS – LOWER BENCH MIDDLE				Northing / Easting

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		B 1			10YR 4/2	GC		LOOSE, OLIVE GRAY, SLIGHTLY MOIST, GRAVELY FINE TO MED SAND, SOME SILT SOME CLAY. 7/11" ~ 15%	
	69								
2	45								
	37								
4	23								
	24	B 1/2			5Y 4/2	GC		AS BEFORE, BUT MORE GRAVELY SANDY, GRAVEL 7/11" ~15-20%	
6	12								
	33								
8	31								
	26	5 0.2							SPT (3/11/09 – poor rock sample
10	12	B 0.0			5Y 4/2	GC		AS BEFORE	
	33								
12	31								
	31								
14	56								

6

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring

TH55-04
10/23/00

Depth (ft-bgs)	Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	42	B JR			5Y 4/2	GM		AS BEFORE, BUT LESS CLAY	
16	42								
	55								
18	44								
	35	5 0.0							SPT 4/4/7 - NO SAMPLE
20	8	B 0.0						NO SAMPLE	
	29						NO SAMPLE		
22	46								
	50								
24	43								
	69	B 1/2			5YR 4/4	GC		MED DENSE, LT OLIVE GRAY, SLIGHTLY MOIST, FINE SANDY GRAVEL, SOME SILT, SOME CLAY 71" ~ 20%	
26	43								
	58								
28	98								
	79								SPT 12/14/16 • POOR ROCK SAMPLE
30	73	B 2/3			10YR 6/6	GC		MED DENSE TO DENSE (ROCKS) YELLOWISH ORANGE AND GRAY, MOIST, SANDY GRAVEL, SOME CLAY, MINOR SILT 71" ~ 10-15%	
	155								
32	95								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring THS 5-04 10/23/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	75								
34	68								
	67	B 2/3			10YR 6/6	GC		AS BEFORE	
36	64								
	54								
38	94								SPT 10/36/17 - ROCKY SAMPLE
	95	S 0.5							
40	37	B 1/5			10YR 6/6	GC		AS BEFORE	POOR RETURN
	117								
42	48								
	56								PIEZO COMPLETION TOOK >20 BAGS CHIPS TO FILL 3 FEET ∴ BIG VOIDS
44	61								
	32	B 1/3			5Y 4/4	GM		MED DENSE, YELLOWISH BROWN AND GRAY, SLIGHTLY MOIST SANDY FINE TO COARSE GRAVEL, SOME SILT, MINOR CLAY 7½" ~15%	
46	58								
	83								
48	43								
	58	S 0.4							SPT 17/21/Rock - ROCK SAMPLE
50	112	B			5Y 4/4	GM		MED DENSE TO DENSE (ROCKY), LT GRAY, MOIST, SILTY TO FINE SAND GRAVEL (MOSTLY FINE)	(MOSTLY CALC-SILICATE ROCK)

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH55-04 10/23/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	371								LARGE ROCK, EASE THROUGH TO AVOID BENDING PIPES
52	389								
	138								
54	101								
	55	B 1/2			5Y 6/4	GM		AS ABOVE (MOSTLY CALC-SILICATE WASTE ROCK).	
56	119								
	107								
58	103								
	85	S 0.2							DEVIATION SURVEY SHOWS SIGNIFICANT PIPE BENDING, BOULDERS
60	293	B 1/3			5Y 6/4	GM		AS BEFORE 7" ~ 20%	SPT 15/ROCK - SMALL ROCK SAMPLE
	127								CONTINUE DRILLING W/ REDUCED PRESSURE
62	103								
	418								
64	76								
	246	B 1/2			5Y 6/4	GM		AS BEFORE, BUT MORE SILT (PULVERIZED CALCSILICATE)	
66	277								
	205								
68	162								
	150								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH55-04 10/23/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		S 0.6							SPT 43/21/25 - ROCK SAMPLE, CALC SILICATE
70	130	B 4/6			5Y 6/4	GM		AS BEFORE, BUT DRY, FINE SANDY FINE GRAVEL (POOR RETURN	VERY POOR RETURN
	199								
72	69								
	108								
74	140								
	140	B 1/2			5Y 4/4	GM		MED DENSE TO DENSE (ROCKY), LT LT OLIVE GRAY, MOIST, SANDY GRAVEL, SOME SILT, TRACE CLAY	
76	91								
	90								
78	131								ROCK STUCK IN BIT
	113	S 1.1							SPT 17/16/11
80	55	B 1/16			5Y 6/1	GM		MED DENSE TO DENSE (ROCKY) LT GRAY, DRY, FINE SANDY, FINE GRAVEL, SOME SILT (PULVERIZE WASTE ROCK)	• SANDY GRAVEL • CALC SILICATE 0.7' • WEATHERED MONZONITE 0.4 POOR RETURN
	92								
82	573								
	169								
84	115								
	94	B 1/2			5Y 4/1	GM		MED DENSE, GRAY, MOIST, SANDY GRAVEL, SOME SILT, MINOR CLAY	
86	64								
	56								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH53-04 10/24/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
88	78								SPT 9/14/19
	45	5 / 1.5							• STIFF, GRAVELY CLAY
90									• SOIL BEDROCK
									• GOOD SAMPLE
									– STOP DRILLING TO AVOID CLOGGING DRILL PIPE
92									
94									
96									
98									
100									
102									
104									

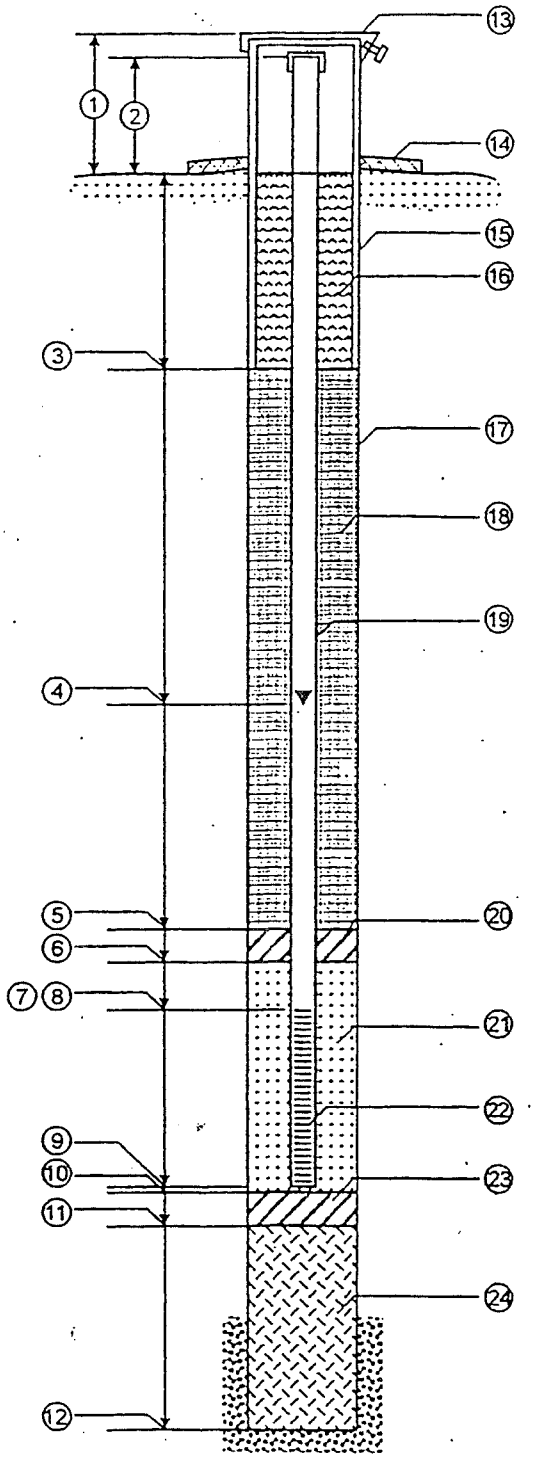
URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Project Number	Project Name	Date/Time Started
53F40.01800.03	Mionite Mine	10/23/00 - 1400
Well/Borehole Number	**Well/Borehole Location**	**Date/Time Completed**
THSS - 04	South Spoils - Lower Bench Middle	10/24/00 - 1700

Installation Team	Type of Drilling	Ground Surface Elev.	Top of Well Casing Elev.
Great West Drlg	Becker Hammer	ft.msl	ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: ~3 ft.
2. Stick-Up Well Casing Above Ground: ~2.5 ft.
3. Depth to Bottom of Upper Seal/Protective Casing: ~2 ft.
4. Depth to Initial Ground Water Surface Elevation: None ft.
5. Depth to Top of Top Seal: 5 ft.
6. Depth to Bottom of Top Seal: 67 ft.
7. Depth to Top of Well Point or Screen: 69 ft.
8. Total Length of Blank Casing: ~91.5 ft.
9. Bottom Depth of Well Screen: 89 ft.
10. Depth to Top of Bottom Seal (If Installed): 89 ft.
11. Depth to Bottom of Bottom Seal (If Installed): 101.5 ft.
12. Depth of Borehole: 101.5 ft.
13. Protective Casing: ☒ Yes ☐ No Locking Cap: ☒ Yes ☐ No
14. Sanitary Seal: ☒ Yes ☐ No
15. Type of Protective Casing: Steel Diameter: 5 in.
16. Type of Upper Seal: Portland Cement Type II/III
17. Borehole Diameter: 6 in.
18. Type of Upper Backfill: Pure Gold Med Bentonite Chips & Grout
19. Type of Well Casing: PVC Sched 40 Diameter: 1 in.
20. Type of Top Seal (IF Installed): Pure Gold Bentonite Med Chips
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: CSS 10-20 Diameter: 6 in.
22. Type of Screen Material: PVC Sched 80 Slot Size: 0.010 in.
23. Type of Bottom Seal (If Installed): Pure Gold Med Bentonite Chips
24. Type of Lower Backfill: Pure Gold Med Bentonite Chips

Recorded By	Date	Checked By	Date
Chris Williams	10/24/00	[illegible]	03/15/01

URS	Project Name: Phase 2A/1B RI/FS	Log of Boring THSS-05 10/9/00
	Project Location: Midnite Mine	
	Project Number: 53F4001800.03	

Date(s) Drilled	10/9/00 - 10/10/00	Logged By	CHRIS WILLIAMS	Total Depth of Borehole (ft)	134
Drilling Method	BECKER HAMMER	Diameter of Borehole (in)	6 INCH	Ground Surface Elevation (ft-msl)	
Drill Rig Type	AP1000 DRILL SYSTEMS	Drilling Company	GREAT WEST DRLG	Groundwater Elevation (ft-msl)	NONE
Driller's Name	TIM BENSEN	Sampler Type	CYCLONE TO BUCKET	Checked By	CHUCK HART	Measuring Point Elevation (ft-msl)	
Locations / Comments	SOUTH SPOILS - WEST SIDE OF TOP LIFT ON ROAD				Northing / Easting	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	38	B			5YR 5/2	GC		LOOSE TO MED DENSE LT GRAY MOIST, SILTY GRAVELY SAND SOME CLAY, WELL GRADED	
2	45								
	55								
4	45								HIT ROCK - MOVED OVER 8' TO MAKE HOLE STRAIGHT
	60	B			5YR 5/6	GC		LOOSE TO MED DENSE, LT GRAY MOIST GRAVELY FINE SAND SOME SILT, SOME CLAY, WELL GRADED	
6	47								
	43								
8	40								
	32	5 2.4							
10	20	B			10YR 5/4	GM		LOOSE TO MED DENSE, YELLOW ORANGE AND LT GRAY, MOIST SANDY f-m GRAVEL, SOME SILT, MINOR CLAY, WELL GRADED	SPT 20/15/Rock REFUSAL ON LAST 6" 4" ROCK IN SS
	24								
12	60								
	47								
14	30								
	64								

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring 7455-05 10/9/00

Depth (ft-bgs)	Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		B			5YR 5/2	GM		LOOSE TO MED DENSE, LT OLIVE, GRAY, MOIST, FINE GRAVELY SAND, SOME SILT	
16	73								
	49								
18	24								
	18	S 1.2							SPT 12/10/0
20	24	B			10YR 6/2	GM		LOOSE TO MED DENSE, GRAY, MOIST, SANDY FINE TO COARSE GRAVEL, SOME SILT, MINOR CLAY. >3" ~10%, >1" ~20%	SPT 12/10/10
	31								
22	79								
	84								
24	88								APPARENT ROCK IN HOLE ~ >2'd LARGE ROCK FRAGS IN BUCKET
	45	B			5YR 5/2	GM		LOOSE TO MED DENSE, LT GRAY, MOIST, GRAVELY FINE TO COARSE SAND, SOME SILT, LGER ROCKS PRESENT >3" ~10% >1" ~15	
26	48								
	64								
28	50								
	25	S 0.2							SPT 11/12/14 POOR SAMPLE - ROCK FRAGMENTS
30	22	B			5YR 6/4	GM		LOOSE, YELLOWISH ORANGE, MOIST SILTY & FINE SANDY FINE TO COARSE GRAVEL. >3" ~10% >1" ~20%	
	24								
32	20								
	19								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH55-05 10/9/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	19								
34	19								
		B							
	42				5Y 5/2	GC		LOOSE TO MED DENSE, OLIVE GRAY, MOIST, GRAVELY SAND SOME SILT + CLAY, WELL GRADED 7/" ~ 10%	
36	27								
	50								
38	45								
	47								
40	26	B			5Y 5/2	GC		AS BEFORE	SPT SKIPPED
	45								
42	47								
	40								
44	41								
	50	B			5Y 5/2	GC		MED DENSE, OLIVE GRAY, MOIST GRAVELY SAND, SOME SILT + CLAY, WELL GRADED 7/" ~ 5%	
46	58								
	55								
48	43								
	47	S							SPT 13/16/18
		2.6 B							INCREASE IN MOISTURE CONTENT AND GRAVEL
50	22				5Y 5/2	GC		AS BEFORE 7/" ~ 10%	
	25								

URS	Project Name: Phase 2A/1B RI/FS	Log of Boring THSS-05
	Project Location: Midnite Mine	10/9/00
	Project Number: 53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
52	47								
	43								
54	52								
	32	B			5Y 4/4	GC		LOOSE TO MED DENSE, LT BROWN MOIST, FINE GRAVELY SAND, SOME CLAY, SOME SILT WELL GRADED (MED PLASTIC CLAY BALLS IN SAMPLE)	
56	50								
	56								
58	69								
	55	S 1.3							SPT 12/27/15
60	25	B			5Y 4/4	GC		LOOSE, LT BROWN, MOIST FINE GRAVELY SAND, SOME CLAY + SILT, WELL GRADED; MED PLASTIC CLAY BALLS 5-10% (MOSTLY AS BEFORE)	
	31								
62	30								
	28								
64	33								
	41	B			5Y 4/4	GM		LOOSE TO MED DENSE, LT BROWN MOIST, FINE TO MED SAND, SOME FINE GRAVEL, SOME SILT, MINOR CLAY	
66	75								
	73								
68	63								
	77								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH55-05 10/9/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		S 1.3							SPT 20/29/24 4" OF ROCK 11" OF HIGHLY WEATHERED WHST ROCK
70	59	B			5Y 5/2	GC		MED DENSE, OLIVE GRAY, MOIST, GRAVELY SAND, SOME CLAY + SILT, WELL GRDD 7/" <5%	
	55								
72	47							HIGHLY WEATHERED COMPOSITE MATERIALS, ONLY SPARSE FRESH BROKEN ROCK FRAGS	
	63								
74	59								
	30	B			5Y 5/2	GC		AS BEFORE 7/" <5%	
76	57								
	53								
78	44								
	60								SPT SKIPPED
80	45	B			5Y 5/2	GC		MEDIUM DENSE, OLIVE GRAY, MOIST, GRAVELY FINE SAND, SOME CLAY + SILT (MOSTLY WELL GRADED) SOME MED PLASTC CLAY BALLS 7/" <5%	
	50								
82	43								
	48								
84	38								
	40	B						AS BEFORE 7/" ~ 5%	
86	53								
	58								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring	THSS-05 10/9/00
	Project Location:	Midnite Mine		
	Project Number:	53F4001800.03		

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
88	62								
	58	5 1.4							SPT 20/21/22 - highly weathered wastrock, clayey
90	25	B			5Y 5/2	GC		MEDIUM DENSE, OLIVE GRAY, MOIST, GRAVELY SAND SOME CLAY + SILT, WELL GRADED 7/1" ~5%	
	41								
92	65								
	42								
94	60								
	65				5Y 5/2	GC		MEDIUM DENSE, OLIVE GRAY AND GRAY, SANDY GRAVEL SOME SILT + CLAY 7/1" ~35% > 3" ~5%	
96	62								
	79								
98	105								PROBABLY ROCKS w/ HIGHER COUNT
	80								SPT Skipped
100	90	B			5Y 4/4	GC		MEDIUM DENSE, OLIVE GRAY, CLAYEY SAND, SOME GRAVEL, SOME SILT	
	31								
102	31								
	39								
104	34								
	70								

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring TH55-05

10/9/00

Depth (ft-bgs)	Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
106	42				10YR 5/4	GC		MEDIUM DENSE, YELLOWISH ORANGE MOIST, FINE TO COARSE SANDY, FINE TO COARSE GRAVEL, SOME CLAY CLAY BALLS PRESENT WITH WEATHERED WASTE ROCK ABUNDANT 7/11 ~5%	
	41								
108	60								
	115								SPT 8/9/18 - 1/2 REL FRESH WASTEROCK - 1/2 HIGHLY WEATHERED
110	169	B			10YR 5/4	SM		MEDIUM DENSE TO DENSE, YELLOWISH ORANGE, SLIGHTLY MOIST, SILTY FINE TO MEDIUM SAND, SOME GRAVEL 7/11 <5%	
	170								
112	419								
	129								
114	88								ROCKS OR POSSIBLE BEDROCK
	118				5YR 4/4	GM		MEDIUM DENSE TO DENSE, LIGHT GRAY AND YELLOWISH ORANGE, MOIST, GRAVELY FINE TO MED SAND, SOME SILT, MINOR CLAY 7/11 <5%	
116	110								
	115								
118	112								
	61								SPT 16/17/25 - 2/3 fresh rock - 1/3 weathered clayey material (maybe bedrock
120	54	B						SEE 125 - POOR RETURN	
	65								
122	70								
	72								

8

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring THSS-05 10/9/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
124 ~~52~~	35								
125	50				5YR 3/2	GM		MEDIUM DENSE, OLIVE GRAY SLIGHTLY MOIST, GRAVELY FINE SAND, SOME SILT, MINOR CLAY	RED CLAY BALLS, WITH BROWN FINES INDICATIVE OF BEDROCK, POOR RETURN W/ 10 FOOT SAMPLE TAKEN
126 ~~54~~	52								
127	45								
128 ~~56~~	50								
129	47		5						
			0.6						SPT 22/34/53
130 ~~58~~	55		13		5YR 3/2	GM		MED DENSE TO DENSE, OLIVE GRAY, MOIST, SANDY FINE GRAVEL (POOR RETURN)	- FRESH ROCK MAY BE PUSHING ROCK INTO SOIL
131	55								VERY POOR RETURN IN BUCKET
132 ~~60~~	85								
133	160								
134 ~~62~~	140							TD	ORGANICS IN RETURN (MAY BE FROM LAST SEVERAL FEET) POOR RETURN, REFUSAL OF BIT @ 133, PROBABLE BEDROCK NO SIGN OF WATER
135									
136 ~~64~~									
137									
138 ~~66~~									
139									
140 ~~68~~									
141									

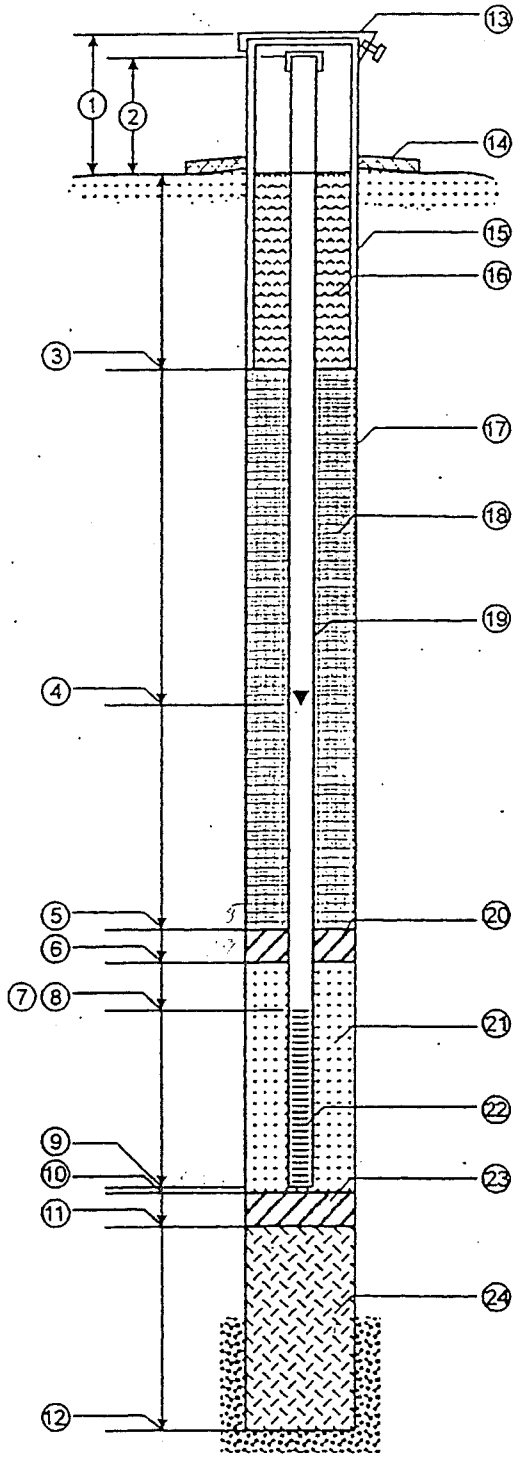
URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Project Number	Project Name	Date/Time Started
53F4001800.03	MIONITE MINE RI	10/9/00 0930
Well/Borehole Number	**Well/Borehole Location**	**Date/Time Completed**
THSS-05		10/10/00 01430

Installation Team	Type of Drilling	Ground Surface Elev.	Top of Well Casing Elev.
GREAT WEST DRILL & URS	BECKER HAMMER	ft.msl	ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: ~3 ft.
2. Stick-Up Well Casing Above Ground: ~2.5 ft.
3. Depth to Bottom of Upper Seal/Protective Casing: ~2 ft.
4. Depth to Initial Ground Water Surface Elevation: NONE ft.
5. Depth to Top of Top Seal: 85 ft.
6. Depth to Bottom of Top Seal: 99 ft.
7. Depth to Top of Well Point or Screen: 99 ft.
8. Total Length of Blank Casing: ~102 ft.
9. Bottom Depth of Well Screen: 123 ft.
10. Depth to Top of Bottom Seal (If Installed): 123 ft.
11. Depth to Bottom of Bottom Seal (If Installed): 144 ft.
12. Depth of Borehole: 144 ft.
13. Protective Casing: ☒ Yes ☐ No Locking Cap: ☒ Yes ☐ No
14. Sanitary Seal: ☒ Yes ☐ No
15. Type of Protective Casing: STEEL Diameter: 5 in.
16. Type of Upper Seal: PORTLAND CEMENT TYPE II/III
17. Borehole Diameter: 6 in.
18. Type of Upper Backfill: PURE GOLD BENTONITE GROUT & CHIPS
19. Type of Well Casing: PVC SCHED 40 Diameter: 1 in.
20. Type of Top Seal (IF Installed): PURE GOLD MED BENTONITE CHIPS
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: 10-20 SIL SAND Diameter: 1 in.
22. Type of Screen Material: SCHED 40 PVC Slot Size: .1 in.
23. Type of Bottom Seal (If Installed): PURE GOLD MED BENTONITE CHIPS
24. Type of Lower Backfill: PURE GOLD MEDIUM BENTONITE CHIPS

Recorded By	Date	Checked By	Date
CHRIS WILLIAMS	10/10/00	Hugh Hall	03/15/01

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring THSS-06

10/12/00

Date(s) Drilled	10/12/00 - 10/14/00	Logged By	CHRIS WILLIAMS	Total Depth of Borehole (ft)	77
Drilling Method	BECKER HAMMER	Diameter of Borehole (in)	6	Ground Surface Elevation (ft-msl)	
Drill Rig Type	DRILL SYSTEMS AP 1000	Drilling Company	GREAT WEST DRILLING	Groundwater Elevation (ft-msl)	NONE
Driller's Name	JIM BENSLH	Sampler Type	SPLIT SPOON & CYCLONE TO BUCKET	Checked By	CHUCK HART
Measuring Point Elevation (ft-msl)					
Locations / Comments	ORIGINAL BOREHOLE LOST WHEN DRILL PIPE BROKE - REDRILLED 25 FEET WEST TO ISTALL PIEZO AFTER 2 ADDITIONAL FAILED ATTEMPTS			Northing / Easting	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
	8	B 1/3			5Y 5/2	GM		LOOSE TO MED DENSE, LT GRAY, MOIST, GRAVELLY FINE SAND (OR SILT) SOME SILT	ROCKS MAY ACCOUNT FOR HIGHER COUNTS
	82								
2	81								
	51								
4	46								
	23	B 1/10			5Y 5/2	GM		AS BEFORE, BUT VERY LOOSE	POOR RETURN
6	24								
	19								
8	27								
	17	S 0.0							SPT 19/12/7
10	4	B 1/10						NO SAMPLE (NO RETURN)	POOR RETURN
	13								
12	10								
	12								
14	30								
	21	B 1/10							

6

URS

Project Name:	Phase 2A/1B RI/FS
Project Location:	Midnite Mine
Project Number:	53F4001800.03

Log of Boring THSS-06

10/12/00

Depth (ft-bgs)	Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
					5Y 5/2	GM		VERY LOOSE, TO LOOSE, LT GRAY, SLIGHTLY MOIST, F. SANDY TO SILTY GRAVEL, TRACE CLAY, ABUNDANT FRESH ROCK FRAGS	POOR RETURN
16	18								
	4								
18	0								DRILLSTEM DROPPED 134.1 FOOT
	13	S 0.9							SPT 20/37 ROCK REFUSAL @ 11.5"
20	85	B 1/2			10YR 5/4	GM		LOOSE TO MED DENSE, MOIST, LT BRWN SILTY FINE SAND, SOME GRAVEL, MINOR CLAY, WEATHERED ROCK CLASTS MIXED W/ FRESH	POOR RETURN
	61								
22	34								
	34								
24	28								
	41	B 1/3			10YR 5/4	GM		AS BEFORE	POOR RETURN
26	24								
	31								
28	35								
	29								SPT 5/9/9
30	17	B 1/10			5Y 4/4	GM		LOOSE TO MED DENSE OLIVE GRAY, SLIGHTLY MOIST, GRAVELY SAND, SOME SILT, MINOR TO TRACE CLAY, SOME WEATHERED MATERIAL, SOME FRESH	POOR RETURN
	33								
32	24								
	7								

6

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring	THBS-06 10/12/00
	Project Location:	Midnite Mine		
	Project Number:	53F4001800.03		

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
34	36								
	39	B 1/10			5YR 4/1	GM		LOOSE-TO MED DENSE, GRAY, FINE SANDY FINE TO COARSE GRAVEL, ABUNDANT FRESH ROCK, MINOR SILT	BEST RETURN YET, CALC SILICATE DOMINANT - POOR RETURN ON REDRILL 30-40
36	41								
	93								
38	58								
	36								SPT 18/29/15
40	80	B 1/10			5YR 4/1	GM		AS ABOVE	POOR RETURN, POOR RETURN ON REDRILL AS WELL 40-50
	66								
42	38								
	48								
44	42								
	82	B 1/2			10YR 5/4	GM		MED DENSE, LT BROWN, FINE SANDY COARSE GRAVEL, STILL FRESH MATERIAL, MINOR SILT + CLAY, SLIGHTLY MOIST TO DRY	CALC SILICATE MOSTLY, PROB MORE ROCK THAN RETURN THROUGH OUT
46	46								
	34								
48	51								
	48	S 0.3							
50	45	13 1/10			10YR 5/4	GM		AS BEFORE, BUT OLIVE GRAY, FINER GRAVEL	SPT 17/19/19 ONLY ROCK IN SS
	52								

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring THSS-06 10/13/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
		B			5YR 4/4	GM		AS BEFORE, BUT OLIVE GRAY, FINE GRAVEL	POOR RETURN - DRILLING OBVIOUSLY PULVARIZES ROCK TO MUCH FINER GRADE
52	30								
	12								
54	51								
	64	B 3/4			5Y 5/2	GM		MED DENSE, OLIVE GRAY, SLIGHTLY MOIST, SILTY TO FINE SANDY, COARSE GRAVEL, MINOR CLAY, FRESH UNWEATHERED CALC SILICATE ROCK FRAGS	- SAMPLE BOOSTED BY 50-60 REDRILL HOLE MATERIAL (VERY SIMILAR)
56	94								
58	65								
	34	S 0.0							SPT 26/Rock NO SAMPLE
60	81	B			5Y 5/2	GM		AS BEFORE	POOR RETURN
	81								
62	36								
	57								
64	57								
	41	B 1/2			5Y 5/2	GM		AS BEFORE, BUT FINE-MED SANDY GRAVEL	
66	35								
	47								
68	32								
	45								SPT 16/13/00

6

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring TH55-06 10/13/00
	Project Location:	Midnite Mine	
	Project Number:	53F4001800.03	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
70	47	B	B			GM		AS BEFORE,	-VERY POOR RETURN
	32								- DRILLING THROUGH BIG BLOCKY ROCKS, CIRC LOST TO VOIDS
72	45								- UPON REDRILL USED ~2 TONS OF SAND/GRAVEL TO FILL VOIDS IN PIEZO SCREEN SECTION (20 FT OF 6 INCH HOLE FROM 77-57)
	42								
74	35								
	136	B			5Y 5/2	GM		MED DENSE TO DENSE, LT OLIVE GRAY, GRAVELY FINE SAND, SOME SILT, MINOR CLAY, SLIGHTLY MOIST	POOR RETURN
76	43								
	44								
78	96								- HIGH BLOW COUNTS BIG ROCKS
	97	5 1.3 B							SPT 25/23/24 - highly weathered waste rock - clayey - good return
80	72				5Y 5/2	GM		AS BEFORE	- VERY POOR RETURN
	55								
82	43								
	58								- NO SIGN OF WATER
84	38								
	44	B			5Y 5/2	GM		MED DENSE TO DENSE, LT OLIVE GRAY, SLIGHTLY MOIST, FINE SANDY GRAVEL, SOME SILT (DERIVED FROM LARGE BLOCKS OF CALC SILICATE)	- VERY POOR RETURN
86	162								
	116								- HIGH BLOW COUNT ROCKS

URS	Project Name:	Phase 2A/1B RI/FS	Log of Boring	THSS-06 10/13/00
	Project Location:	Midnite Mine		
	Project Number:	53F4001800.03		

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	Penetrometer (tsf)	Munsell Color	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
88	70								- NO WATER DRY HOLE
	90	S 1.3							SPT 48/27/ROCK - highly weathered waste rock - good return - green, clayey
90								TD - END OF SPLITSPOON	CIRCULATION LOST PULLED RODS AND FOUND LAST ROD BROKEN OFF ALONG WITH BIT + HAVE TO REDRILL HOLE
92									
94									
96									
98									
100									
102									
104									

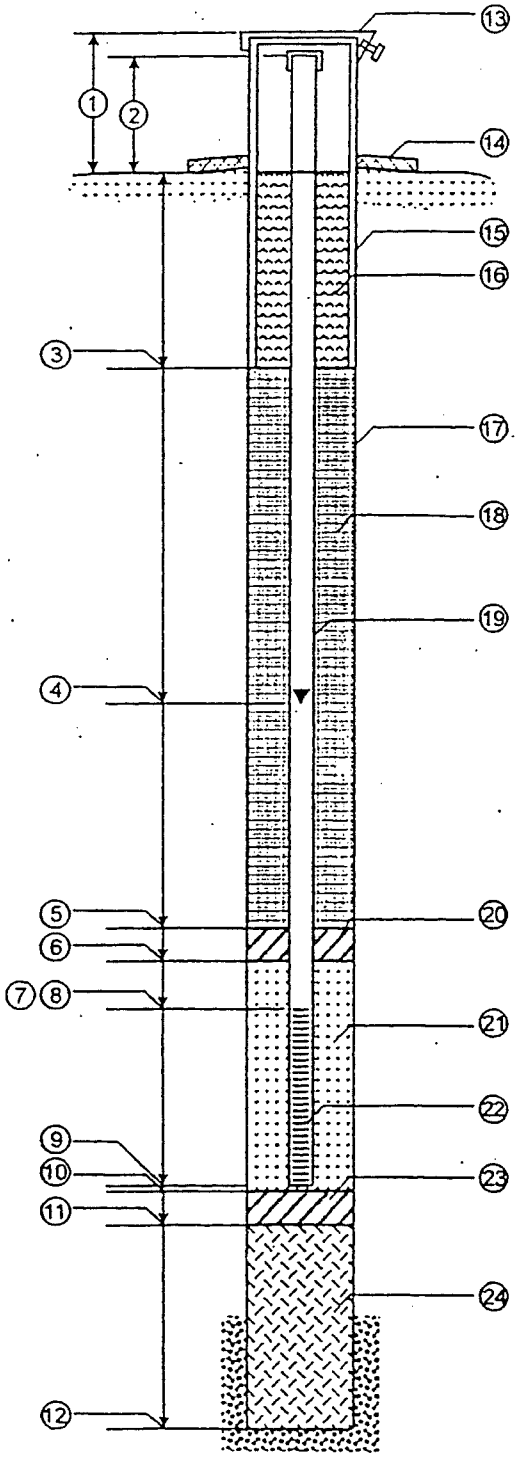
URS Greiner Woodward-Clyde

Monitoring Well Installation Log

Records Management Data

Project Number	Project Name	Date/Time Started
53F4001800.03	MIDNITE MINE	10/12/00 - 1230
Well/Borehole Number	**Well/Borehole Location**	**Date/Time Completed**
THSS-06	SOUTH DUMP - MIDDLE BENCH	10/14/00 - 1800

Installation Team	Type of Drilling	Ground Surface Elev.	Top of Well Casing Elev.
GREAT WEST DRILL - URS	BECKER HAMMER	ft.msl	ft.msl



1. Stick-Up of Protective Casing (If Any) Above Ground: ~3 ft.
2. Stick-Up Well Casing Above Ground: 2.8 ft.
3. Depth to Bottom of Upper Seal/Protective Casing: ~2 ft.
4. Depth to Initial Ground Water Surface Elevation: NONE ft.
5. Depth to Top of Top Seal: 3 ft.
6. Depth to Bottom of Top Seal: 3 ft.
7. Depth to Top of Well Point or Screen: 57 ft.
8. Total Length of Blank Casing: 59.8 ft.
9. Bottom Depth of Well Screen: 77 ft.
10. Depth to Top of Bottom Seal (If Installed): NA ft.
11. Depth to Bottom of Bottom Seal (If Installed): NA ft.
12. Depth of Borehole: 77 ft.
13. Protective Casing: ☒ Yes ☐ No Locking Cap: ☒ Yes ☐ No
14. Sanitary Seal: ☒ Yes ☐ No
15. Type of Protective Casing: STEEL Diameter: 5 in.
16. Type of Upper Seal: PORTLAND CEMENT TYPE II/III
17. Borehole Diameter: 6 in.
18. Type of Upper Backfill: PURE GOLD MEDIUM BENTONITE CHIPS AND PURE GOLD GROUT
19. Type of Well Casing: PVC SCHED 80 Diameter: 1 in.
20. Type of Top Seal (IF Installed): PURE GOLD MED BENTONITE CHIPS
21. Type/Size of Gravel/Sand Pack Around Well Point or Screen: 10-20 SILICA SAND Diameter: 6 in.
22. Type of Screen Material: PVC SCHED 40 Slot Size: 0.010 in.
23. Type of Bottom Seal (If Installed): NONE
24. Type of Lower Backfill: NONE

Recorded By	Date	Checked By	Date
CHRIS WILLIAMS	10/14/00	Mick Hart	03/15/01

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2890 East Cottonwood Parkway, Suite 300
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Fax: (801) 617-4200

WD-B1

CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DRILLING DATE 8/28/2011 **COMPLETION DATE** 8/28/2011 **LOGGED BY** Bill Bragdon

DRILL METHOD HSA / Core **BOREHOLE DIAMETER** HSA 8 inch, 0 to 20.25 feet; Core 2.5 inch, 20.25 to EOB **DRILLING COMPANY** Ruen Drilliing

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture	Piezometer Completion
0.0	SS	3 7 7	87	NA	NA	NA	Silty clay to about 3 feet. Silty clay, dark yellowish brown (10YR 4/4), grades to very pale brown (10YR 7/3) at 0.8 feet with some medium sand, subangular, low plasticity, soft to medium stiff, dry, abundant roots and organics, organic odor.			+2.5; Bentonite seal; 2 inch sch. 40 PVC
2.5	SS	7 7 8	87	NA	NA	NA	Weathered quartz monzonite from about 3 to 20.5 feet bgs. As above at 0.8 feet with some coarse gravel-size decomposed quartz monzonite, increase in fine to coarse sand, low to medium placticity, dry.			
5.0	SS	7 6 7	100	NA	NA	NA	Silty clayey fine- to coarse-grained sand, light yellowish brown (10YR 6/4), low to medium placticity, medium stiff, slightly moist, decomposed size quartz monzonite, trace FeOx.			
7.5	SS	3 4 4	93	NA	NA	NA	Clayey fine- to medium-grained sand, yellowish brown (10YR 5/8), medium plasticity, soft, slightly moist. Decomposed quartz monzonite with feldspar up + 1/2, some FeOx locally.			
10.0							.			

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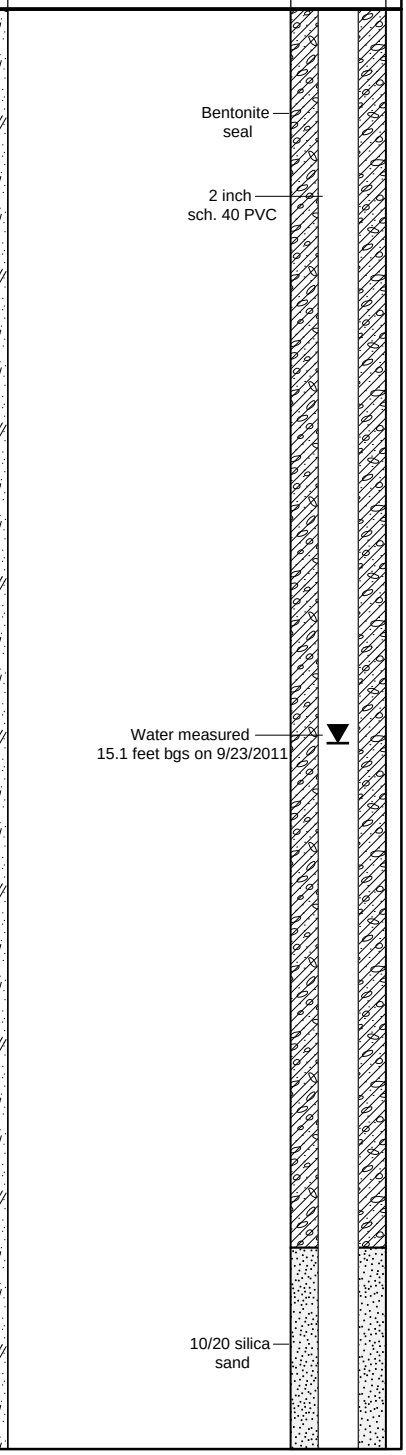
CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION
10.0	SS	5 6 6	100	NA	NA	NA	As above at 7.5 feet with feldspar crystals up to 1/2 inch, no FeOx, grades to medium stiff.
12.5	SS	5 5 5	100	NA	NA	NA	Clayey fine- to medium-grained sand, yellowish brown (10YR 5/8) grading to brown (7.5YR 5/4) at 13 feet, medium placticity, medium stiff, slightly moist ot moist, trace FeOx locally.
15.0	SS	28 50	100	NA	9	NA	Fine- to medium-grained decomposed (W9) quartz monzonite, brown (10YR 5/3), with FeOx of dark reddish brown (5YR 3/3), trace argillic alteration. Feldspar up to 1/2 inch, slightly moist to moist. 50 blows for 2 inches.
17.5	SS	50	100	NA	9	NA	As above at 15 feet, grading to wet. 50 blows for 4.5 inches.
20.0							

GRAPHIC LOG



Piezometer Completion

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture	Piezometer Completion
20.0	SS						Practical HSA refusal. Switched to HQ 2.5 inch core.			
	HQ Core						Quartz monzonite from about 20.5 feet to EOB.			
			17	0	9	5 to 6	0.5 feet of recovery of coarse gravel, rubble of fine to coarse quartz monzonite, few coarse gravels, greenish gray (10GY 6/1) and reddish yellow (7.5YR 6/8), strong argillic alteration, decomposed (W9), moderately soft to soft (H5 to H6).		No Recovery (material likely removed during drilling by circulation water.).	
22.5									0.5 feet drilling-induced rubble.	
			0	0	NA	NA	No recovery.		No Recovery (material likely removed during drilling by circulation water.).	
25.0										
					9	6	Coarse-grained sand to coarse gravel size fragments of decomposed (W9) quartz monzonite, feldspar and quartz crystals, trace argillic coating on fragments.		Argillic (clay) and strong FeOx.	
27.5			94	74	9	3	Fine- to coarse-grained quartz monzonite, very intensely weathered (W8) to decomposed (W9), generally moderately soft (H5), FeOx and argillic alteration, some FeOx in healed fractures; 29 to 30 feet, grades to slightly weathered to fresh (W2) and moderately hard (H4) feldspar to 1 inch.		0º 0º 5º 5º 90º 90º 90º 0º healed 30º healed microfractures weak FeOx. 80º 5º 5º fine to medium sand, soft rubble, weak FeOx, moderate argillic. 70º 80º	
					2	4				
30.0									50º	

10/20 silica sand
2 inch sch. 40 PVC
0.010 slot size
V-wire (installed at 24.5 feet (27 feet btoc) on 11/3/2011)

(Continued Next Page)

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

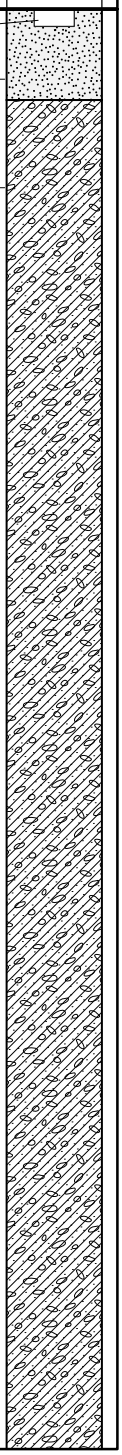
DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION
30.0							
	HQ Core		100	100	2	3	Grades to greenish gray (10GY 5/1) and light reddish brown (2.5YR 7/4), hard (H3) and slightly weathered (W2).
32.5							
			92	92	2	3	Grades to slightly weathered (W2) and hard (H3) with FeOx and trace argillic along fractures.
35.0							
37.5			100	100	2	3	Fine- to coarse-grained quartz monzonite with feldspar up to 1.5 inch, generally light reddish brown (2.5YR 7/4) and greenish gray (10GY 5/1), slightly weathered (W2) to fresh, hard (H3), no FeOx, trace thin argillic clay along fractures at 39.7 feet with trace of manganese.
40.0							

GRAPHIC LOG

Fracture

50º
80º with 0.1 to 0.2 inch argillic filling, trace manganese.
20º
80º
30º
60º
60º feldspar with healed fractures, weak FeOx, argillic.
40º
80º
85º sandy gravel.
10º
10º
30º
80º few healed fractures.
70º
10º trace argillic.
70º trace manganese.

Piezometer Completion



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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture	Piezometer Completion
40.0										
42.5	HQ Core		92	86	2	3	Quartz monzonite as above at 35 feet.		3/8-inch coated Bentonite pellets; 40º fractured to rubble, some manganese, no FeOx.; 40º; 80º healed fracture.; 50º; 0º; 0º; 80º; 80º	
45.0			96	96	2	2	Fine- to coarse-grained quartz monzonite, generally light reddish brown (2.5YR 7/4) and greenish gray (10GY 5/1) with feldspar up to 1 inch, trace argillic coating locally along fractures, slightly weathered to fresh (W2), very hard (H2).		20º; 40º; 80º; 30º argillic coating.	
47.5							Grades to hard (H3), horizontal fractures from about 47.5 to 50 feet.		20º; 90º; 80º; 80º; 90º; 90º; 30º with sandy filling 0.2. inch.	
50.0										

End of borehole at 50.0 feet.

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WD-B2

CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DRILLING DATE 8/26/2011 **COMPLETION DATE** 8/26/2011 **LOGGED BY** Bill Bragdon

DRILL METHOD HSA / Core **BOREHOLE DIAMETER** HSA 8 inch, 0 to 14 feet; Core 2.5 inch, 14 to EOB **DRILLING COMPANY** Ruen Drilliing

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
0.0	SS	11 16 17	93	NA	NA	NA	Silty and gravely sand to about 3.5 feet. Silty fine- to medium-grained sand (SM), light reddish gray (2.5YR 7/1), non plastic, medium dense, dry, grades to pinkish gray (7.5YR 7/2).		
2.5	SS	6 8 12	93	NA	NA	NA	Fine- to coarse-grained sand (SP) with some silt and coarse gravel, strong brown (7.5YR 5/6), non plastic, loose, dry to slightly moist, primarily decomposed quartz monzonite, subangular gravel with trace clay stringers.		
							Weathered quartz monzonite from about 3.5 to 19 feet bgs.		
5.0	SS	9 13 14	100	NA	9	7	Decomposed (W9) quartz monzonite with trace of FeOx along bedding and trace argillic alteration locally, very soft (H7), strong brown to brownish yellow (10YR 5/4) dry.		
7.5	SS	21 40 53	100	NA	9	7	Decomposed (W9) very soft (H7) fine- to coarse-grained quartz monzonite, brownish yellow (10YR 6/6) grading to gray (10YR 7/2) some feldspar xtals to 1/2 inch, dry.		
10.0	SS	21 30	100	NA	9	7	Decomposed (W9) very soft (H7) fine- to coarse-grained quartz monzonite as above with argillic alternation 10 to 10.5 feet, brownish yellow (10YR 6/6), dry.		

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DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
10.0		44							
	SS	50	100	NA	9	7	As above at 9 feet. 50 blows for 4 inches.		
12.5									
	SS	50	100	NA	9	7	As above at 9 feet. 50 blows for 2 inches. Practical HSA refusal. Switched to HQ core.		
15.0	HQ Core								No Recovery (material likely removed during drilling by circulation water).
			20	0	9	7	Fine- to coarse-grained quartz monzonite, reddish yellow (7.5YR 6/8) to very pale brown (10YR 7/3), heavy FeOx and argillic alteration, decomposed (W9), very soft (H7). At 19 feet with strong argillic alteration, pale yellow (2.5Y 8/3), wet, FeOx locally about 19.7 feet.		
17.5									Drilling induced rubble.
							Quartz monzonite from about 19 feet to EOB.		
20.0									

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WD-B2

CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
20.0									
22.5	HQ Core		78	62	7	4	Medium- to coarse-grained quartz monzonite, feldspar up to 1 inch, light reddish brown (10YR 7/3), quartz veining at 21.3 feet, rubble at 21.3 to 21.7 feet, moderately hard (H4), intensely weathered (W7). At 24.5 feet, fractures with strong FeOx.		0º 20º 20º 20º 20º Fine to coarse sand, rubble. 60º 90º 80º 60º
25.0									90º
27.5			100	87	6	6	Fine- to coarse-grained quartz monzonite, feldspar up to 1/2 inch, moderately soft to soft (H6) where weathered to argillic, moderately to intensely weathered (W6), decomposed locally, light reddish brown (5YR 6/3) and dark greenish gray (10GY 6/1). Pale yellow (2.5Y 8/6) where argillic.		20º 90º FeOx and argillic. 80º 80º 90º Void with FeOx decomposed argillic alteration. 60º 90º with FeOx and argillic. 80º 10º with argillic alteration. 80º 0º Healed fractures with trace FeOx and argillic. 60º FeOx with some argillic along fractures. 40º 30º 0º 90º
30.0									

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CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture
30.0									
32.5	HQ Core		72	97	7	4 to 5	Fine- to coarse-grained quartz monzonite, feldspar up to 1/2 inch, intensely weathered (W7), moderately hard (H4) to moderately soft (H5), light reddish brown (5YR 6/3) and dark greenish gray (10GY 6/1). At 34 feet FeOx along most fractures with no argillic alteration.		85º healed fracture. 50º with FeOx, 0.2 inch gap. 20º no FeOx. 60º rubble of fine to coarse sand, FeOx, argillic. 60º hard FeOx. 60º 60º 60º 80º 80º 80º 70º 75º 70º 60º
35.0									
37.5			37	77	5 to 9	3 to 5	Medium- to coarse-grained quartz monzonite with feldspars up to 1 inch, strong FeOx staining along fractures, some manganese, light reddish brown (5YR 6/3) and dark greenish gray (10GY 6/1), moderately hard (H5) to hard (H3), some strong argillic and FeOx locally, moderately weathered (W5) to decomposed (W9) at about 37 to 38.2 feet, some to strong argillic and FeOx locally.		70º Moderate FeOx. 70º 75º 70º 70º 70º 70º Drilling induced rubble. Very soft drilling, likely zone where decomposed matrix washed out. 80º Weak FeOx, strong argillic.
40.0									

End of borehole at 40.0 feet.

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WD-B5

CLIENT Newmont **PROJECT NAME** Storage Pond Investigation - 2011

DRILLING DATE 8/26/2011 **COMPLETION DATE** 8/26/2011 **LOGGED BY** Bill Bragdon

DRILL METHOD HSA / Core **BOREHOLE DIAMETER** HSA 8 inch, 0 to 12.5 feet; Core 2.5 inch, 12.5 to EOB **DRILLING COMPANY** Ruen Drilliing

DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture	Piezometer Completion
0.0	SS	10 8 5	80	NA	NA	NA	Silty gravel to about 2.5 feet. Silty fine gravel (GM) with some fine- to coarse-grained sand, pale yellowish (2.5Y 8/2), subangular to angular, non plastic, loose, dry, trace quartz crystals and mica.			+2.5 Bentonite seal 2 inch sch. 40 PVC
2.5							Clayey sand approximately 2.5 feet to approximately 6 feet.			
	SS	4 4 6	100	NA	NA	NA	Clayey fine- to medium-grained sand (SC), dark reddish brown (5Y3/2), subangular, low to medium plasticity, medium stiff, slightly moist, decrease in clay at 3.7 feet bgs, low plasticity.			
5.0										
	SS	4 2 2	100	NA	NA	NA	Clayey fine- to medium-grained sand (SC) with trace silt, few coarse gravels. Dark reddish brown (5Y 3/2), low to medium plasticity, medium stiff, slightly moist.			
							Silty clay approximately 6 feet to approximately 7.5 feet. Silty clay with trace to fine- to medium-grained sand (CL), very dark gray (5YR 3/1), medium plasticity, soft, moist to wet, few organic (roots), organic odor (weak). At 7.8 feet decomposed (W9) BR.			
7.5										
	CA	3 8	100	NA	NA	NA	Clayey sand approximately 7.5 feet to approximately 9 feet. Clayey fine- to coarse-grained sand (SC), very dark gray to black (5YR 2.5/1), medium plasticity, soft to medium stiff, wet, abundant roots, strong organic odor. Collected "A" and "B" brass liners.			Water measured 8.2 feet bgs on 9/23/2011 10/20 silica sand
	SS	2 1 1	100	NA	NA	NA	Sandy silt approximately 9 feet to approximately 10.5 feet. Fine- to medium-grained sandy silt (ML), brown (7.5YR 5/3), low plasticity, very soft, wet, organics (roots).			
10.0										

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DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture	Piezometer Completion
10.0	CA	5 5	100	NA	NA	NA	Silty sand, approximately 10.5 feet to approximately 12.5 feet. Grades to silty fine- to coarse-grained sand (SM), brown (7.5YR 5/3), cobble at contact between ML and SM, low plasticity, medium stiff, wet. Brass liners not collected.		10/20 silica sand	2 inch sch. 40 PVC; 0.010 slot size
12.5	SS	3 5 7	100				As above with intensely weathered bedrock fragments of quartz monzonite, light red (2.5YR 7/8) and greenish black (5GY 2.5/1).			
	HQ Core		53	0	9	4	Switched to HQ core, competent bedrock. Quartz monzonite approximately 12.5 feet to approximately 30 feet. Decomposed (W9) fine-grained quartz monzonite with biotite and quartz crystals, light greenish gray (5GY 8/1) and pale red (10 R 7/4), moderately hard (H4), FeOx.		No Recovery (material likely removed during drilling by circulation water). 40º; Drilling induced rubble. 50º	
15.0									No Recovery (material likely removed during drilling by circulation water).	
17.5			28	NA	9	NA	Gravel fine-grained quartz monzonite as above. Decomposed (W9), quartz monzonite being removed as cuttings in circulation water.		Drilling induced rubble.	V-wire (installed at 16.5 feet (19 feet btoc) on 11/3/2011)
			0	0	NA	NA	No recovery.		No Recovery (material likely removed during drilling by circulation water).	
			75	0	3	4	Fine-grained quartz monzonite rubble.		Drilling induced rubble.	
20.0			0	0	NA	NA	No recovery		No Recovery (as above).	

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DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	Fracture
20.0								
	HQ Core		66	0	9	4	Rubble recovery of 1.3 feet of decomposed (W9), moderately hard (H4), fine- to medium-grained quartz monzonite, brown (7.5YR 4/3).	No Recovery (material likely removed during drilling by circulation water). Drilling induced rubble.
			20	0	6	4	3 pieces of coarse gravel size quartz monzonite.	No Recovery (material likely removed during drilling by circulation water). Drilling induced rubble.
22.5								No Recovery (as above). Drilling induced rubble.
			100	60	6	4	Medium- to coarse-grained quartz monzonite, light reddish brown (5YR 6/3) and dark greenish gray (10GY 6/1), intensely to medium weathered (W6), moderate hard (H4).	80º; 50º; 40º highly fractured.
25.0								
			30	60	NA	NA	Quartz monzonite as above at 23 feet.	80º; 10º; 20º; 85º; 70º; 10º
27.5								
			100	37	4	4	Fine- to coarse-grained quartz monzonite as above at 23 feet.	0º with argillic alteration and trace FeOx.; 60º; 60º few vugs.; 5º; 0º; 10º
30.0								

GRAPHIC LOG

Piezometer Completion: 10/20 silica sand; 2 inch PVC cap; 3/8-inch coated Bentonite pellets

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DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture		Piezometer Completion
30.0											
	HQ Core		100	33	3	2	Fine- to medium-grained dacite (?) dike, bluish gray (10B 6/1) with abundant biotite and quartz crystals, very hard (H2), slightly weathered (W3).		0º contact. 30º rubble with weak FeOx on top. 80º 0º contact.		
							Quartz monzonite, approximately 32 feet to EOB.				
32.5									90º very fractured.		
			100	66	6	4	Medium- to coarse-grained quartz monzonite, light reddish brown (5YR 6/3) and dark greenish gray (10GY 6/1), intensely to medium weathered (W6), moderate hard (H4).		30º 40º 60º mechanical fractures. 30º	3/8-inch coated Bentonite pellets	
35.0											
			97	65	2	2	Fine- to medium-grained quartz monzonite, trace argillic clay along fractures, slightly weathered to fresh (W2), very hard (H2), fractures with no FeOx, light reddish brown (5YR 6/3) with dark greenish gray (10GY 6/1).		10º 10º 60º 0º trace argillic. 70º 5º 80º 80º 80º 80º 70º 5º No Recovery (material likely removed during drilling by circulation water).		
37.5											
40.0											

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DEPTH (ft)	Sample Method	Blow Counts	% Sample Recovery	% RQD	Weathering	Strength	MATERIAL DESCRIPTION	GRAPHIC LOG	Fracture		Piezometer Completion
40.0											
	HQ Core			NA	1	2	Medium- to coarse-grained quartz monzonite as above at 35 feet, fresh (W1), very hard (H2) to hard (H3).			3/8-inch coated Bentonite pellets	

End of borehole at 41.5 feet.

Attachment E-5

Liner System Anchor Trench Analysis

ATTACHMENT E-5

MIDNITE MINE REMEDIAL ACTION LINER SYSTEM ANCHOR TRENCH ANALYSIS

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*22-Nov-13*	*60% Design*	*Christin Kapatayes*	*Christine Weber*	*05-Dec13*	*Melanie Davis and Tom Kelley*
1	*21-Jul-14*	*90% Design*	*Christin Kapatayes*	*Christine Weber and Melanie Davis*	*21-Jul-14*	*Tom Kelley*
2	*19-Aug-15*	*100% Design*	*Christin Kapatayes*	*Christine Weber and Melanie Davis*	*19-Aug-15*	*Tom Kelley*

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usftc2s01\Projects\Newmont\Midnite Mine_2011\6.0 Studies & Reports\6.2 Technical\ Storage Ponds\Anchor Trench

The following calculations were generated using the following software:

Microsoft Office Professional Plus 2010 (Microsoft Excel)

Supplement

Supplement E-5.1 – Anchor Trench Analysis Calculations

1.0 BACKGROUND

An anchor trench analysis was performed for standard L-shaped anchor trenches required for the liner system to be installed in the South Pond, West Pond, and Water Treatment Plant (WTP) Ponds (Raw Mine Water Equalization Pond and Pretreated Mine Water Equalization Pond) as shown in Section 5 of the drawings. The analysis was performed for the steepest slopes that the liner system will be installed on at 2.5H:1V (horizontal:vertical) slope for the West Pond and WTP Ponds, and at 3H:1V slope for the South Pond. Each pond will have a similar liner system installed. The proposed liner system consists of a lower 60 mil HDPE (with a smooth lower and a textured upper surface) geomembrane overlain by a geonet overlain by an upper 60 mil HDPE (textured on both sides) geomembrane. The geonet will be placed in the same anchor trench as the lower geomembrane, but will be separated from the lower geomembrane by 0.5 ft of backfill. The upper geomembrane will be placed in a separate anchor trench than the lower geomembrane and the geonet. Anchor trench depths were estimated assuming the minimum anchor trench widths are 1.5 feet.

2.0 METHODOLOGY & ASSUMPTIONS

Anchor trench design calculations were performed using methodology presented in *Designing With Geosynthetics* by Robert M. Koerner (2005). The liner system components were evaluated for a balanced design where the anchor trench pullout resistance is equal to the allowable tensile strength at yield.

The calculations were performed using the following equations:

$$Anchor\ Trench\ Pullout\ Resistance = T_{allow}\cos(\beta) = P_{r_1} + P_{r_2} + P_{r_3}$$

$$P_{r_1} = \left(\sigma_{n_1}\tan(\delta) + a\right)L_{RO} + T_{allow}\sin(\beta)\tan(\delta)$$

$$P_{r_2} = \left(\sigma_{n_2}\tan(\delta) + a\right)L_{AT} = \left((\gamma_{CS}d_{CS} + \gamma_{TR}d_{AT})tan(\delta) + a\right)L_{AT}$$

$$P_{r_3} = P_P - P_a = \left(0.5\gamma_{TR}d_{AT} + \sigma_{CS}\right)K_p d_{AT} - \left(0.5\gamma_{TR}d_{AT} + \sigma_{CS}\right)K_a d_{AT}$$

where:

T_{allow} = Allowable Tensile Strength at Yield [lbs/(ft − width)]
β = Slope Angle [degrees]
P_{r_1} = Anchor Trench Runout Resistance [lbs/ft]
P_{r_2} = Anchor Trench Bottom Resistance [lbs/ft]
P_{r_3} = Anchor Trench Sidewall Resistance [lbs/ft]
$\sigma_{n_1} = \sigma_{CS}$ = Applied Normal Stress of Cover Soil [psf]
σ_{n_2} = Applied Normal Stress of Compacted Backfill [psf]
δ = Interface Friction Angle [degrees]
γ_{CS} = Cover Soil Density [pcf]
γ_{TR} = Anchor Trench Soil Density [pcf]
d_{AT} = Anchor Trench Depth [ft]
d_{CS} = Cover Soil Depth [ft]

K_a = Coefficient of Active Earth Pressure = $\tan^2(45 - \phi/2)$
K_p = Coefficient of Passive Earth Pressure = $\tan^2(45 + \phi/2)$
ϕ = Effective Shear Strength of Soil [degees]
L_{AT} = Anchor Trench Width [ft]
L_{RO} = Runout Length [ft]

The geometric parameters evaluated in this analysis are defined as shown on Figure 1 below.

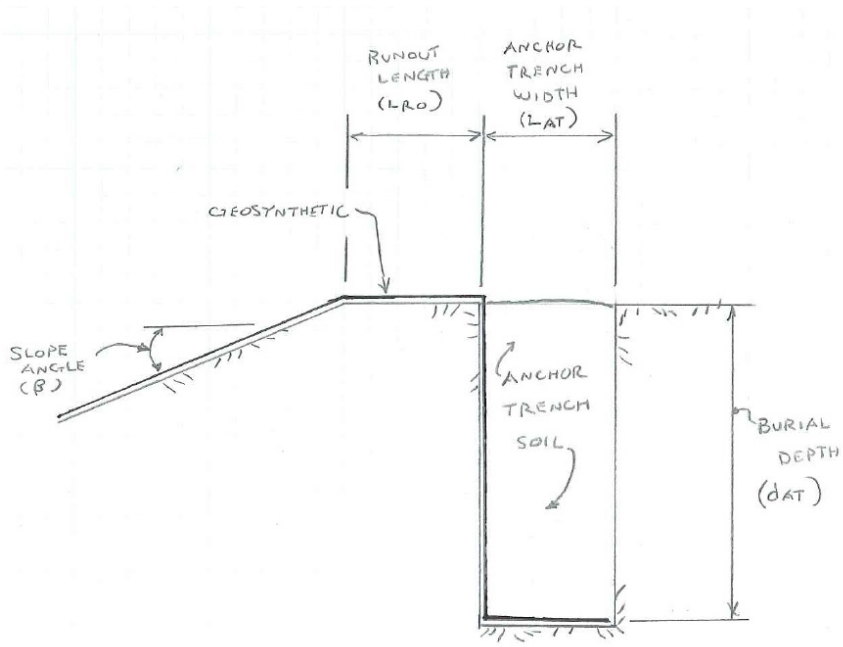

Figure 1 Anchor Trench Geometric Parameters.

The following describes the assumptions and values used to evaluate the anchor trench pullout resistance, depth, and width. Slope dimensions for each pond are presented in Table 1. Slope angles are necessary to calculate the full yield strength of the liner system.

Table 1. Slope Geometry

Pond	Slope	Slope Angle, β (deg)
South Pond	3H:1V	18.4
West Pond & WTP Ponds	2.5H:1V	21.8

Backfill soil properties were obtained from the *Geotechnical Evaluation Report IX Water Treatment Facility, Midnite Mine, Rev. 0* prepared by MWH (2013). A summary of the material properties assigned to the backfill material are presented in Table 2.

Table 2. Summary of Material Properties for Backfill Soil

Total Unit Weight (pcf)	Effective Shear Strength (deg)	Effective Cohesion (psf)
132	34.5	0

Interface friction angles used were estimated based on average peak values from *Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces* by G.R. Koerner and D. Narejo (2005). Table 3 presents a summary of the interface friction angles used for the analyses of upper and lower geomembrane liners. The anchor trenches for both liners were designed using a friction angle of 13° (representing the interface between a geonet and textured geomembrane).

Table 3. Summary of Interface Friction Angles

Liner	Critical Interface	Friction Angle (deg)
Upper geomembrane (primary)	60 mil HDPE Textured Geomembrane to underlying Geonet	13
Lower geomembrane (secondary)	Geonet to underlying 60 mil HDPE Textured (upper side) Geomembrane	13

Parameters for the liner system components were estimated from manufacturer's product data sheets from GSE Environmental (2012 and 2013) and are presented in Table 4**.**

Table 4. Tensile Strength at Yield for Liner System Components

Properties	60 mil Textured (single-sided and double-sided) Geomembrane	200 mil Geonet
Tensile Strength at Yield (lbs/ft)	1512	540

3.0 RESULTS

Calculations to estimate the dimensions for the anchor trench system were performed using the equations presented in Section 2.0. The anchor trench analysis for each pond is summarized in Table 5. The minimum anchor trench dimensions listed in Table 5 are applicable for geosynthetic materials with minimum tensile strengths at yield listed in Table 4. Detailed calculations are provided in Supplement E-5.1. The proposed design dimensions for the anchor trenches are provided in Table 6. The proposed dimensions shown in Section 5 of the design drawings meet or exceed the minimum required dimensions in all instances.

Table 5. Required Dimensions from Anchor Trench Analysis

Analysis	West Pond and WTP Ponds			South Pond		
	Upper 60 mil Textured (double-sided) Geomembrane	Geonet	Lower 60 mil Textured (single-sided) Geomembrane	Upper 60 mil Textured (double-sided) Geomembrane	Geonet	Lower 60 mil Textured (single-sided) Geomembrane
Full Yield Strength (lbs/ft)	1512	540	1512	1512	540	1512
Pull Out Resistance (lbs/ft)	1512	540	1512	1512	540	1512
Runout Length (ft)	3.5	1.0	1.0	3.5	1.0	1.0
Minimum Anchor Trench Width (ft)	1.5	1.5	1.5	1.5	1.5	1.5
Minimum Anchor Trench Depth (ft)	2.4	1.4	2.4	2.4	1.4	2.4

Table 6. Anchor Trench Design Dimensions

Anchor Trench Dimension	Upper 60 mil Textured (double-sided) Geomembrane	Geonet	Lower 60 mil Textured (single-sided) Geomembrane
Runout Length (ft)	3.5	1.0	1.0
Minimum Anchor Trench Width (ft)	1.5	1.5	1.5
Minimum Anchor Trench Depth (ft)	3.0	2.5	3.0

4.0 REFERENCES

GSE Environmental, 2012. GSE HD Textured Geomembrane Product Data Sheet.

GSE Environmental, 2013. GSE HyperNet Geonet 175-225 mil Product Data Sheet.

Koerner, R., 2005. Designing with Geosynthetics. 5th Edition. Pearson Prentice Hall, Upper Saddle River, NJ.

Koerner, G.R., and D. Narejo, (2005). Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces, GRI Report #30. Geosynthetic Research Institute.

MWH Americas, Inc. (MWH), 2013. Geotechnical Evaluation Report IX Water Treatment Facility, Midnite Mine, Revision 0. Prepared for Dawn Mining Company, LLC and Newmont USA Limited.

Supplement E-5.1

Anchor Trench Analysis Calculations

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	7/21/2014
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C. Kapatayes
Detail:	Anchor Trench Pullout Resistance Calculation	Checked By:	C.Weber/ M.Davis

OBJECTIVE: Estimate the anchor trench pull out resistance.
Upper Liner System - West & WTP Ponds

INPUT/ ASSUMPTIONS:

Cover soil	Assume no cover soil		
Tensile Strength at Yield:		1512	lbs/ft-width
Allowable Tensile Strength:		1512	lbs/ft-width
	H		V
Slope	2.5		1
Slope Angle:		21.8	
$T_{allow}\cos(\beta)$:		1404	
Minimum liner interface friction angle (δ) :		13	degrees
Minimum liner interface adhesion (a) :		0	kPa
	Compacted Fill		
Cover Soil Density (γ_{CS}) :		0	pcf
Anchor Trench Soil Density (γ_{TR}) :		132	pcf
Anchor Trench Width (L_{AT}) :		1.5	ft
Anchor Trench Depth (d_{AT}) :		2.40	ft
Cover Soil Depth (d_{CS}) :		0	ft
Runout to Trench Length (L_{RO}) :		3.5	ft
Anchor Trench Backfill Friction Angle (ϕ_{TR}) :		34.5	degrees

CALCULATION:

Anchor Trench Runout Resistance

$Pr_1 = (\sigma_{n1} \tan\delta + a)L_{RO} + T_{allow}\sin(\beta)\tan(\delta)$

$\sigma_{n1} = \gamma_{CS}\, d_{CS}$

Cover Soil σ_{n1} = 0 psf

Total Pr_1 = 129.6 lbs/ft

Anchor Trench Bottom Resistance

$Pr_2 = (\sigma_{n2} \tan\delta + a)L_{AT}$

$\sigma_{n2} = \gamma_{CS}\, d_{CS} + \gamma_{TR}\, d_{AT}$

Compacted Backfill σ_{n2} = 317.3394936 psf

Pr_2 = 109.9 lbs/ft

Anchor Trench Sidewall Resistance

$Pr_3 = P_P - P_A$

$\sigma_{nCS} = \sigma_{n1}$

σ_{nCS} = 0 psf

$k_a = \tan^2(45-\phi/2)$

$k_a = 0.277$

$P_A = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_a*d_{AT}$

$P_A = 105.59$

$k_p = \tan^2(45+\phi/2)$

$k_p = 3.61$

$P_P = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_p*d_{AT}$

$P_P = 1378.05$

Pr_3 = 1272.5 lbs/ft

Total Anchor Trench Pullout Resistance

$Tr = Pr_3+Pr_2+Pr_1$

Tr = 1512 lbs/ft

References:

GSE Environmental (2012). GSE HD Textured Geomembrane Product Data Sheet.
GSE Environmental (2013). GSE HyperNet Geonet 175-225 mil Product Data Sheet.
Koerner, R., 2005. Designing with Geosynthetics. 5th Edition. Pearson Prentice Hall, Upper Saddle River, NJ.
Koerner, G.R., and Narejo, D. (2005). Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces, GRI Report #30.
MWH (2013). Geotechnical Evaluation Report IX Water Treatment Facility, Midnite Mine, Rev.0. Prepared for Dawn Mining Company, LLC and Newmont USA Limited.

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	7/21/2014
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C. Kapatayes
Detail:	Anchor Trench Pullout Resistance Calculation	Checked By:	C.Weber/ M.Davis

OBJECTIVE: Estimate the anchor trench pull out resistance.
Upper Liner System - South Pond

INPUT/ ASSUMPTIONS:

Cover soil	Assume no cover soil	
Tensile Strength at Yield:	1512	lbs/ft-width
Allowable Tensile Strength:	1512	lbs/ft-width
	H	V
Slope	3.0	1
Slope Angle:	18.4	
Tallowcos(B):	1434	
Minimum liner interface friction angle(δ) :	13	degrees
Minimum liner interface adhesion (a) :	0	kPa
	Compacted Fill	
Cover Soil Density (γ_{CS}) :	0	pcf
Anchor Trench Soil Density (γ_{TR}) :	132	pcf
Anchor Trench Width (L_{AT}) :	1.5	ft
Anchor Trench Depth (d_{AT}) :	2.42	ft
Cover Soil Depth (d_{CS}) :	0	ft
Runout to Trench Length (L_{RO}) :	3.5	ft
Anchor Trench Backfill Friction Angle (ϕ_{TR}) :	34.5	degrees

CALCULATION:

Anchor Trench Runout Resistance

$Pr_1 = (\sigma_{n1} \tan\delta + a)L_{RO} + T_{allow}\sin(\beta)\tan(\delta)$

$\sigma_{n1} = \gamma_{CS}\, d_{CS}$

Cover Soil σ_{n1} = 0 psf

Total Pr_1 = 110.4 lbs/ft

Anchor Trench Bottom Resistance

$Pr_2 = (\sigma_{n2} \tan\delta + a)L_{AT}$

$\sigma_{n2} = \gamma_{CS}\, d_{CS} + \gamma_{TR}\, d_{AT}$

Compacted Backfill σ_{n2} = 319.6332651 psf

Pr_2 = 110.7 lbs/ft

Anchor Trench Sidewall Resistance

$Pr_3 = P_P - P_A$

$\sigma_{nCS} = \sigma_{n1}$

σ_{nCS} = 0 psf

$k_a = \tan^2(45-\phi/2)$

k_a = 0.277

$P_A = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_a*d_{AT}$

P_A = 107.12

$k_p = \tan^2(45+\phi/2)$

k_p = 3.61

$P_P = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_p*d_{AT}$

P_P = 1398.05

Pr_3 = 1290.9 lbs/ft

Total Anchor Trench Pullout Resistance

$Tr = Pr_3+Pr_2+Pr_1$

Tr = 1512 lbs/ft

References:

GSE Environmental (2012). GSE HD Textured Geomembrane Product Data Sheet.
GSE Environmental (2013). GSE HyperNet Geonet 175-225 mil Product Data Sheet.
Koerner, R., 2005. Designing with Geosynthetics 5th Edition. Pearson Prentice Hall, Upper Saddle River, NJ.
Koerner, G.R., and Narejo, D. (2005). Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces, GRI Report #30.
MWH (2013). Geotechnical Evaluation Report IX Water Treatment Facility, Midnite Mine, Rev.0. Prepared for Dawn Mining Company, LLC and Newmont USA Limited.

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	11/22/2013
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C. Kapatayes
Detail:	Anchor Trench Pullout Resistance Calculation	Checked By:	C.Weber

OBJECTIVE: Estimate the anchor trench pull out resistance.
Lower Liner System - West & WTP Ponds

INPUT/ ASSUMPTIONS:

Cover soil	Assume no cover soil	
Tensile Strength at Yield:	1512	lbs/ft-width
Allowable Tensile Strength:	1512	lbs/ft-width
	H	V
Slope	2.5	1
Slope Angle:	21.8	
Tallowcos(B):	1404	
Minimum liner interface friction angle(δ) :	13	degrees
Minimum liner interface adhesion (a) :	0	kPa
	Compacted Fill	
Cover Soil Density (γ_{CS}) :	0	pcf
Anchor Trench Soil Density (γ_{TR}) :	132	pcf
Anchor Trench Width (L_{AT}) :	1.5	ft
Anchor Trench Depth (d_{AT}) :	2.40	ft
Cover Soil Depth (d_{CS}) :	0	ft
Runout to Trench Length (L_{RO}) :	1	ft
Anchor Trench Backfill Friction Angle (ϕ_{TR}) :	34.5	degrees

CALCULATION:

Anchor Trench Runout Resistance

$Pr_1 = (\sigma_{n1} \tan\delta + a)L_{RO} + T_{allow}\sin(\beta)\tan(\delta)$

$\sigma_{n1} = \gamma_{CS}\, d_{CS}$

Cover Soil σ_{n1} = 0 psf

Total Pr_1 = 129.6 lbs/ft

Anchor Trench Bottom Resistance

$Pr_2 = (\sigma_{n2} \tan\delta + a)L_{AT}$

$\sigma_{n2} = \gamma_{CS}\, d_{CS} + \gamma_{TR}\, d_{AT}$

Compacted Backfill σ_{n2} = 317.3394937 psf

Pr_2 = 109.9 lbs/ft

Anchor Trench Sidewall Resistance

$Pr_3 = P_P - P_A$

$\sigma_{nCS} = \sigma_{n1}$

σ_{nCS} = 0 psf

$k_a = \tan^2(45-\phi/2)$

k_a = 0.277

$P_A = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_a*d_{AT}$

P_A = 105.59

$k_p = \tan^2(45+\phi/2)$

k_p = 3.61

$P_P = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_p*d_{AT}$

P_P = 1378.05

Pr_3 = 1272.5 lbs/ft

Total Anchor Trench Pullout Resistance

$Tr = Pr_3+Pr_2+Pr_1$

Tr = 1512 lbs/ft

References:

GSE Environmental (2012). GSE HD Textured Geomembrane Product Data Sheet.
GSE Environmental (2013). GSE HyperNet Geonet 175-225 mil Product Data Sheet.
Koerner, R., 2005. Designing with Geosynthetics 5th Edition. Pearson Prentice Hall, Upper Saddle River, NJ.
Koerner, G.R., and Narejo, D. (2005). Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces, GRI Report #30.
MWH (2013). Geotechnical Evaluation Report IX Water Treatment Facility, Midnite Mine, Rev.0. Prepared for Dawn Mining Company, LLC and Newmont USA Limited.

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	11/22/2013
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C. Kapatayes
Detail:	Anchor Trench Pullout Resistance Calculation	Checked By:	C.Weber

OBJECTIVE: Estimate the anchor trench pull out resistance.
Lower Liner System - South Pond

INPUT/ ASSUMPTIONS:

Cover soil	Assume no cover soil	
Tensile Strength at Yield:	1512	lbs/ft-width
Allowable Tensile Strength:	1512	lbs/ft-width
	H	V
Slope	3.0	1
Slope Angle:	18.4	
Tallowcos(B):	1434	
Minimum liner interface friction angle (δ) :	13	degrees
Minimum liner interface adhesion (a) :	0	kPa
	Compacted Fill	
Cover Soil Density (γ_{CS}) :	0	pcf
Anchor Trench Soil Density (γ_{TR}) :	132	pcf
Anchor Trench Width (L_{AT}) :	1.5	ft
Anchor Trench Depth (d_{AT}) :	2.42	ft
Cover Soil Depth (d_{CS}) :	0	ft
Runout to Trench Length (L_{RO}) :	1	ft
Anchor Trench Backfill Friction Angle (ϕ_{TR}) :	34.5	degrees

CALCULATION:

Anchor Trench Runout Resistance

$Pr_1 = (\sigma_{n1} \tan\delta + a)L_{RO} + T_{allow}\sin(\beta)\tan(\delta)$

$\sigma_{n1} = \gamma_{CS}\, d_{CS}$

Cover Soil σ_{n1} = 0 psf

Total Pr_1 = 110.4 lbs/ft

Anchor Trench Bottom Resistance

$Pr_2 = (\sigma_{n2} \tan\delta + a)L_{AT}$

$\sigma_{n2} = \gamma_{CS}\, d_{CS} + \gamma_{TR}\, d_{AT}$

Compacted Backfill σ_{n2} = 319.6332652 psf

Pr_2 = 110.7 lbs/ft

Anchor Trench Sidewall Resistance

$Pr_3 = P_P - P_A$

$\sigma_{nCS} = \sigma_{n1}$

σ_{nCS} = 0 psf

$k_a = \tan^2(45-\phi/2)$

k_a = 0.277

$P_A = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_a*d_{AT}$

P_A = 107.12

$k_p = \tan^2(45+\phi/2)$

k_p = 3.61

$P_P = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_p*d_{AT}$

P_P = 1398.05

Pr_3 = 1290.9 lbs/ft

Total Anchor Trench Pullout Resistance

$Tr = Pr_3+Pr_2+Pr_1$

Tr = 1512 lbs/ft

References:

GSE Environmental (2012). GSE HD Textured Geomembrane Product Data Sheet.
GSE Environmental (2013). GSE HyperNet Geonet 175-225 mil Product Data Sheet.
Koerner, R., 2005. Designing with Geosynthetics. 5th Edition. Pearson Prentice Hall, Upper Saddle River, NJ.
Koerner, G.R., and Narejo, D. (2005). Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces, GRI Report #30.
MWH (2013). Geotechnical Evaluation Report IX Water Treatment Facility, Midnite Mine, Rev.0. Prepared for Dawn Mining Company, LLC and Newmont USA Limited.

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	11/22/2013
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C. Kapatayes
Detail:	Anchor Trench Pullout Resistance Calculation	Checked By:	C.Weber

OBJECTIVE: Estimate the anchor trench pull out resistance.
Geonet - West & WTP Ponds

INPUT/ ASSUMPTIONS:

Cover soil	Assume no cover soil	
Tensile Strength at Yield:	540	lbs/ft-width
Allowable Tensile Strength:	540	lbs/ft-width
	H	V
Slope	2.5	1
Slope Angle:	21.8	
Tallowcos(B):	501	
Minimum liner interface friction angle(δ) :	13	degrees
Minimum liner interface adhesion (a) :	0	kPa
	Compacted Fill	
Cover Soil Density (γ_{CS}) :	0	pcf
Anchor Trench Soil Density (γ_{TR}) :	132	pcf
Anchor Trench Width (L_{AT}) :	1.5	ft
Anchor Trench Depth (d_{AT}) :	1.40	ft
Cover Soil Depth (d_{CS}) :	0	ft
Runout to Trench Length (L_{RO}) :	1	ft
Anchor Trench Backfill Friction Angle (ϕ_{TR}) :	34.5	degrees

CALCULATION:

Anchor Trench Runout Resistance

$Pr_1 = (\sigma_{n1} \tan\delta + a)L_{RO} + T_{allow}\sin(\beta)\tan(\delta)$

$\sigma_{n1} = \gamma_{CS}\, d_{CS}$

Cover Soil σ_{n1} = 0 psf

Total Pr_1 = 46.3 lbs/ft

Anchor Trench Bottom Resistance

$Pr_2 = (\sigma_{n2} \tan\delta + a)L_{AT}$

$\sigma_{n2} = \gamma_{CS}\, d_{CS} + \gamma_{TR}\, d_{AT}$

Compacted Backfill σ_{n2} = 184.4374253 psf

Pr_2 = 63.9 lbs/ft

Anchor Trench Sidewall Resistance

$Pr_3 = P_P - P_A$

$\sigma_{nCS} = \sigma_{n1}$

σ_{nCS} = 0 psf

$k_a = \tan^2(45-\phi/2)$

k_a = 0.277

$P_A = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_a*d_{AT}$

P_A = 35.67

$k_p = \tan^2(45+\phi/2)$

k_p = 3.61

$P_P = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_p*d_{AT}$

P_P = 465.50

Pr_3 = 429.8 lbs/ft

Total Anchor Trench Pullout Resistance

$Tr = Pr_3+Pr_2+Pr_1$

Tr = 540 lbs/ft

References:

GSE Environmental (2012). GSE HD Textured Geomembrane Product Data Sheet.
GSE Environmental (2013). GSE HyperNet Geonet 175-225 mil Product Data Sheet.
Koerner, R., 2005. Designing with Geosynthetics 5th Edition. Pearson Prentice Hall, Upper Saddle River, NJ.
Koerner, G.R., and Narejo, D. (2005). Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces, GRI Report #30.
MWH (2013). Geotechnical Evaluation Report IX Water Treatment Facility, Midnite Mine, Rev.0. Prepared for Dawn Mining Company, LLC and Newmont USA Limited.

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	11/22/2013
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C. Kapatayes
Detail:	Anchor Trench Pullout Resistance Calculation	Checked By:	C.Weber

Anchor Trench Pullout Resistance Calculation

OBJECTIVE: Estimate the anchor trench pull out resistance.
Geonet - South Pond

INPUT/ ASSUMPTIONS:

Cover soil	Assume no cover soil	
Tensile Strength at Yield:	540	lbs/ft-width
Allowable Tensile Strength:	540	lbs/ft-width
	H	V
Slope	3.0	1
Slope Angle:	18.4	
Tallowcos(B):	512	
Minimum liner interface friction angle(δ) :	13	degrees
Minimum liner interface adhesion (a) :	0	kPa
	Compacted Fill	
Cover Soil Density (γ_{CS}) :	0	pcf
Anchor Trench Soil Density (γ_{TR}) :	132	pcf
Anchor Trench Width (L_{AT}) :	1.5	ft
Anchor Trench Depth (d_{AT}) :	1.41	ft
Cover Soil Depth (d_{CS}) :	0	ft
Runout to Trench Length (L_{RO}) :	1	ft
Anchor Trench Backfill Friction Angle (ϕ_{TR}) :	34.5	degrees

CALCULATION:

Anchor Trench Runout Resistance

$Pr_1 = (\sigma_{n1} \tan\delta + a)L_{RO} + T_{allow}\sin(\beta)\tan(\delta)$

$\sigma_{n1} = \gamma_{CS}\, d_{CS}$

Cover Soil σ_{n1} = 0 psf

Total Pr_1 = 39.4 lbs/ft

Anchor Trench Bottom Resistance

$Pr_2 = (\sigma_{n2} \tan\delta + a)L_{AT}$

$\sigma_{n2} = \gamma_{CS}\, d_{CS} + \gamma_{TR}\, d_{AT}$

Compacted Backfill σ_{n2} = 185.8061207 psf

Pr_2 = 64.3 lbs/ft

Anchor Trench Sidewall Resistance

$Pr_3 = P_P - P_A$

$\sigma_{nCS} = \sigma_{n1}$

σ_{nCS} = 0 psf

$k_a = \tan^2(45-\phi/2)$

k_a = 0.277

$P_A = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_a*d_{AT}$

P_A = 36.20

$k_p = \tan^2(45+\phi/2)$

k_p = 3.61

$P_P = (0.5*\gamma_{TR}*d_{AT}+\sigma_{nCS})*k_p*d_{AT}$

P_P = 472.43

Pr_3 = 436.2 lbs/ft

Total Anchor Trench Pullout Resistance

$Tr = Pr_3+Pr_2+Pr_1$

Tr = 540 lbs/ft

References:

GSE Environmental (2012). GSE HD Textured Geomembrane Product Data Sheet.
GSE Environmental (2013). GSE HyperNet Geonet 175-225 mil Product Data Sheet.
Koerner, R., 2005. Designing with Geosynthetics 5th Edition. Pearson Prentice Hall, Upper Saddle River, NJ.
Koerner, G.R., and Narejo, D. (2005). Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces, GRI Report #30.
MWH (2013). Geotechnical Evaluation Report IX Water Treatment Facility, Midnite Mine, Rev.0. Prepared for Dawn Mining Company, LLC and Newmont USA Limited.

Attachment E-6

Liner System Wind Uplift Analysis

ATTACHMENT E-6

MIDNITE MINE REMEDIAL ACTION LINER SYSTEM WIND UPLIFT ANALYSIS

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*25-Nov-13*	*60% Design*	*Christine Weber*	*John Worthen*	*05-Dec-13*	*Melanie Davis and Tom Kelley*
1	*20-Jun-14*	*90% Design*	*Melanie Davis*	*Christine Weber*	*20-Jun-14*	*Tom Kelley*
2	*15-May-15*	*100% Design*	*Melanie Davis and Stephen Gooding*	*Christine Weber and Melanie Davis*	*13-Jun-15*	*Tom Kelley*

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usftc2s01\Projects\Newmont\Midnite Mine_2011\6.0 Studies & Reports\6.2 Technical\ Storage Ponds\Wind Uplift

The following calculations were generated using the following software:

Microsoft Office Professional Plus 2010 (Microsoft Excel)

Supplement

Supplement E-6.1 – Wind Uplift Analysis Calculations

1.0 BACKGROUND

A wind uplift analysis was performed for the geosynthetic liner system to be installed in the South Pond, West Pond, and Water Treatment Plant (WTP) Ponds (Raw Mine Water Equalization Pond and Pretreated Mine Water Equalization Pond). Each pond will have a similar liner system installed. The proposed liner system in all ponds will consist of a lower 60 mil HDPE (with a smooth lower surface and a textured upper surface) geomembrane overlain by a geonet overlain by an upper 60 mil HDPE (textured on both sides) geomembrane. The liner system will be installed on a maximum 2.5H:1V (horizontal:vertical) slope for the West Pond and WTP Ponds, and on a maximum 3H:1V slope for the South Pond.

The purpose of the wind uplift analysis was to estimate the uplift suction on the geosynthetic liner system and to estimate the internal tension and strain for the liner system due to thermal contraction, gravity, and wind uplift, assuming unballasted conditions. Also, the wind uplift calculations were used to evaluate the ability of the anchor trenches to resist the forces generated due to uplift of the liner system. The wind uplift of the liner system was evaluated for conditions during construction and during operations.

2.0 METHODS & ASSUMPTIONS

Wind uplift calculations were performed using methodology developed by Giroud et al. (1995) and Zornberg and Giroud (1997). The calculations were performed assuming the geosynthetic liner system acts as one material and is exposed to uplift forces due to wind. These calculations consider the very limited volume of gas (air) that could exist between the two geomembrane layers in the liner system. This limited gas volume will result in a reduction of air pressure (suction) between the two geomembrane layers if upward displacement (uplift) of the upper geomembrane occurs relative to the other geosynthetic layers in the liner system. As a result, the entire geosynthetic (upper geomembrane, internal drainage layer, and lower geomembrane) cover system is expected to act (mechanically) as one unit in the event of uplift forces. As a result, the uplift of the geosynthetic liner system was analyzed assuming it would act as one unit, and separation of the upper geomembrane from the lower layers was not considered realistic. Calculations were also performed to evaluate dimensions for proposed ballast.

The wind uplift calculations were performed using the following equations:

- To calculate the minimum (threshold) wind velocity required to uplift the geosynthetic liner system, V_{up}:

$$V_{up} = 3.895e^{(6.259x10^{-5})z}\sqrt{\mu_{GM}\ cos\beta/\lambda}$$

μ_{GM} = Mass per unit area of the geosynthetic liner system (kg/m^2)
λ = Suction factor (dimensionless; assumed to be 0.7 for these calculations as the entire side slope is considered)
z = Elevation above sea level (masl) (m)
β = Slope angle

The mass per unit area of the geosynthetic liner system was calculated as the sum of the mass per unit area of each of the three components of the liner system. The mass per unit area of the geomembrane layers was calculated by multiplying the thickness of

the geomembranes by the density of the geomembrane material. A typical mass per unit area value of 0.79 kg/m^2 for 200 mil HyperNet geonet (GSE Environmental, personal communication, September 2, 2014) was used for the geonet component of the liner system.

If the maximum wind velocity at the site (V) is greater than V_{up}, then uplift of the geosynthetic liner system will occur. Calculations are required to estimate uplift and to estimate strain and tension in the geosynthetic liner system developed due to wind uplift.

- To estimate the amount of strain and tension developed in the geosynthetic liner system due to temperature changes and gravity (initial condition prior to wind uplift):

$$\varepsilon_{temp} = \alpha \Delta \Gamma$$

ε_{temp} = Strain in geosynthetic liner system due to temperature change
α = Coefficient of thermal expansion
$\Delta\Gamma$ = Change in temperature (maximum daily temperature change estimated using difference of monthly average maximum daily temperature and monthly average minimum daily temperature)

$$T_{temp} = J\varepsilon_{temp}$$

T_{temp} = Tension in geosynthetic liner system due to temperature change
J = Geosynthetic liner system tensile stiffness

$$T_g = \mu_{GM}\ g\ L\ sin\beta$$

T_g = Tension in geosynthetic liner system due to gravity
g = Acceleration due to gravity (9.81 m/s^2)
L = Length of slope being considered
All other variables as previously defined

$$\varepsilon_g = T_g/J$$

ε_g = Strain in geosynthetic liner system due to gravity
All other variables as previously defined

$$\varepsilon_0 = \varepsilon_{temp} + \varepsilon_g$$

ε_0 = Initial strain in geosynthetic liner system due to temperature changes and gravity
All other variables as previously defined

$$T_0 = T_{temp} + T_g$$

T_0 = Initial tension in geosynthetic liner system due to temperature changes and gravity
All other variables as previously defined

- Calculate effective suction force acting on the geosynthetic liner system (effective suction is the uplift suction pressure minus the downward forces due to the weight of the geosynthetic liner system):

$$S_e = 0.6465\lambda V^2 e^{-(1.252x10^{-4})z} - 9.81\mu_{GM} cos\beta$$

S_e = Effective suction (Pa)
V = Maximum wind speed (m/s)
All other variables as previously defined

- Estimate strain and tension in geosynthetic liner system due to wind uplift. The following equation was solved for ε_w using the Solver add-in for Excel® to iterate until the two terms in the equation were equal (difference was equal to zero):

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right]$$

ε_w = Strain in geosynthetic liner system due to wind uplift
All other variables as previously defined

$$T_w = J\varepsilon_w$$

T_w = Tension in geosynthetic liner system due to wind uplift
All other variables as previously defined

- Calculate total strain and tension developed in the geosynthetic liner system due to temperature changes, gravity and wind uplift

$$\varepsilon_t = \varepsilon_w + \varepsilon_0$$

ε_t = Total tension in the geosynthetic liner system due to wind uplift, temperature changes, and gravity
All other variables as previously defined

$$T_t = T_w + T_0$$

T_t = Total tension in the geosynthetic liner system due to wind uplift, temperature changes, and gravity
All other variables as previously defined

- Calculate the uplift of the geosynthetic liner system (assuming no ballasting):

$$\frac{u}{L} = \frac{T_t}{S_e L} - \sqrt{\left(\frac{T_t}{S_e L}\right)^2 - \frac{1}{4}}$$

u = Uplift of the geosynthetic liner system
All other variables as previously defined

Multiply u/L term by the length of the slope (L) to calculate the amount of uplift (u) in the geosynthetic liner system

- Calculate the angle of the uplifted geosynthetic liner system:

$$\theta = 2tan^{-1}\left(\frac{2u}{L}\right)$$

θ = Angle of the uplifted geosynthetic liner system
All other variables as previously defined

- Evaluate anchor trench design for wind uplift:

$$W_{min,uplifting} = T_d sin(\theta_d - \beta_d) + T_u sin(\theta_u - \beta_u)$$

$W_{min,uplifting}$ = Minimum weight of anchor material per unit width (into the page) required to resist uplift forces acting on geosynthetic liner system
T_d = Tension in geosynthetic liner system on downslope side of anchor
θ_d = Angle of uplifted geosynthetic liner system with slope on downslope side of anchor
β_d = Slope angle on downslope side of anchor
T_u = Tension in geosynthetic liner system on upslope side of anchor
θ_u = Angle of uplifted geosynthetic liner system with slope on upslope side of anchor
β_u = Slope angle on upslope side of anchor

Since the anchor trench is at the crest of the slope, only the downslope direction is considered for this calculation (i.e. $T_u = \theta_u = \beta_u = 0$).

As recommended in Giroud et al. (1999), a factor of safety of 1.5 was applied to the minimum weight of the anchor material:

$$W_{factored} = W_{min,uplifting} * 1.5$$

The required cross-sectional area of the anchor trench was calculated as follows:

$$A_{req} = W_{factored}/\gamma$$

A_{req} = Required cross-sectional area of the anchor trench
$W_{factored}$ = Minimum weight of anchor material with 1.5 factor of safety
γ = Unit weight of anchor trench backfill material

The required cross-sectional area of the anchor trench (A_{req}) was compared to the design cross-sectional area of the anchor trench (A_{design}). The design dimensions of the anchor trenches were obtained from the *Midnite Mine Remedial Action – Liner System Anchor Trench Analysis Rev.2* prepared by MWH (2014).

Ballast is recommended in the corners of the South and West Ponds to provide additional support and reduce the potential for uplift that might result in reversal of curvature of the

geosynthetic liner system in these areas. The proposed ballast is 6-inch HDPE pipe filled with sand. Calculations were performed to determine minimum thickness, as defined by the Standard Dimension Ratio (SDR), and thus the tensile strength of the ballast pipe needed to handle tensions forces imparted by the gravity loading of the pipe and sand fill. The equation used to estimate the amount of tension developed in the pipe and sand ballast due to gravity conservatively neglects any frictional sliding resistance along the base of the pipe and is:

$$T_{pipe} = W_{pipe}\, L\, sin\beta / \mathrm{A}_{pipe}$$

T_{pipe} = Tension in HDPE pipe due to gravity
W_{pipe} = weight of sand and HDPE per foot
L = Length of slope being considered
β = Slope angle
A_{pipe} = Area of pipe annulus

3.0 ANALYSIS INPUTS

3.1 WIND UPLIFT ANALYSIS

Climate data used in the wind uplift analysis includes temperature and wind data. The data were obtained from the Western Regional Climate Center (WRCC; http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?waWMID and http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?waWWLP) for the Midnite Mine and Wellpinit climate stations, respectively. Wind data was obtained from the nearby Wellpinit climate station due to erroneous wind data available for the Midnite Mine climate station. The data used in the calculations are summarized in Table 1. The temperature data obtained for the Midnite Mine climate station is in degrees Fahrenheit. However, as the calculations require temperature input in degrees Celsius, the temperatures were converted to degrees Celsius prior to calculating maximum temperature change. The maximum daily temperature change was estimated using the difference of the monthly average maximum daily temperature and the monthly average minimum daily temperature for the period of record (April 1991 – May 2014). The month in which the maximum temperature change occurred was July 2012. The maximum wind speed used for the analysis is 39 mph, which represents the 90th percentile of the maximum monthly wind gust at the Wellpinit climate station for the period of record (June 2002 – May 2014). For the purposes of this analysis, these two occurrences were assumed to occur simultaneously.

Table 1. Climate Data Inputs

Pond	Value
Maximum Temperature Change	14.6 °C
Maximum Wind Speed	39 mph

Slope geometries used in the wind uplift calculations for each pond are presented in Table 2. The slope lengths were estimated for construction (no water) and operation (dead storage) conditions. Dead storage conditions were estimated using the minimum operating water levels for each pond.

Table 2. Slope Geometry for Wind Uplift Calculations

Pond	Elevation (ft masl)	Slope	Slope Angle, β (deg)	Slope Length, L
South Pond	2,683	3H:1V	18.4	206 ft – During Construction 155 ft – During Operation
West Pond	2,660	2.5H:1V	21.8	148 ft – During Construction 121 ft – During Operation
WTP Ponds	2,584	2.5H:1V	21.8	46 ft – During Construction 40 ft – During Operation

Parameters for the liner system components were estimated from manufacturer's product data sheets from GSE Environmental (2012, 2013) and from GSE Environmental personnel (GSE Environmental, personal communications, September 2, 2014 and September 10, 2014) and are presented in Table 3. The coefficient of thermal expansion for HDPE was obtained from Koerner (2005). The coefficient of thermal expansion reported in Koerner (2005) range from $11x10^{-5}$/°C to $13x10^{-5}$/°C. An average value of $12x10^{-5}$/°C was used in these calculations. The geomembrane tensile stiffness was estimated using Figure 12 in Giroud et al. (1995) – tension-strain curve for a 1.5 mm HDPE geomembrane. The tensile stiffness was calculated as the slope of the elastic portion of the tension-strain curve for a 60 mil HDPE geomembrane. In Figure 12 of Giroud et al. (1995), a tension of 15 N/mm corresponds to a strain of 2.8 percent, resulting in a tensile stiffness (J) of 536 N/mm (or 536 kN/m). The geonet tensile stiffness was estimated using a typical tension-strain curve (transverse direction) from GSE Environmental for a GSE HyperNet 200 mil geonet. The tensile stiffness was calculated as the slope of the elastic portion of the tension-strain. From the typical curve, a tension of 2 kN/m corresponds to a strain of 3.5 percent, resulting in a tensile stiffness of 57 kN/m.

Table 3. Geosynthetic Liner System Properties

Properties	60 mil HDPE Geomembrane	200 mil Geonet
Thickness	60 mil 1.5 mm	200 mil 5.1 mm
Density	0.94 g/cm^3	0.94 g/cm^3
Strain at Yield (%)	12	NA
Tensile Strength at 12% Strain	126 lb/in 22.1 kN/m	6 lb/in 1.1 kN/m
Coefficient of Thermal Expansion	$12x10^{-5}$/°C	$12x10^{-5}$/°C
Tensile Stiffness	536 kN/m	57 kN/m

The unit weight of the anchor trench backfill material used in these calculations was 132 pcf. Backfill soil properties were obtained from the *Geotechnical Evaluation Report IX Water Treatment Facility, Midnite Mine, Rev. 0* prepared by MWH (2013).

3.2 LINER BALLAST CALCULATIONS

Ballast is proposed for each corner in the South and West Ponds. For the purposes of these calculations, the South Pond corners were designated as North 1, North 2, East, South, and West. The North 1 corner is located to the west of the North 2 corner. For the West Pond, the corners were designated as North, East, and West. Slope dimensions used for the evaluation of the liner ballast for each pond are presented in Table 4.

Table 4. Slope Geometry for Liner Ballast Calculations

Pond	Corner Designation	Slope Angle	β (degrees)	Length (ft)
South Pond	North 1	3.8H:1V	14.7	195
	North 2	4.5H:1V	12.5	230
	East	4.2H:1V	13.4	215
	South	3.9H:1V	14.4	199
	West	4.9H:1V	11.5	253
West Pond	North	5.9H:1V	9.6	249
	East	4.4H:1V	12.8	187
	West	6.1H:1V	9.3	252

The properties used for the 6-inch HDPE pipe are from Polypipe (2005) and are listed in Table 5.

Table 5. 6-inch HDPE Pipe Properties

Properties	6-inch HDPE Pipe
SDR	17
Outer Diameter	6.625 in
Inner Diameter	5.8 in
Weight of HDPE pipe	3.338 lb/ft
Tensile Strength at Yield	3500 psi

The minimum allowable cold (field) bending radius for a 6-inch HDPE pipe with an SDR of 17 is 27 times the pipe outer diameter (Chevron Phillips, 2012) corresponding to 15 feet. The minimum design bending radius for the ballast pipes is greater than 20 feet. Thus the ballast pipes will have the ability to conform to the as-designed pond surfaces without special field fabrication or heat bending of pipes.

4.0 RESULTS

Calculations to evaluate the wind uplift, to estimate the tension and strain developed in the geosynthetic liner system due to wind uplift, and to verify the ability of the anchor trench design to resist wind uplift were performed using the equations presented in Section 2.0. The results of the analysis for each pond are summarized in Table 6. The maximum strain and tension values listed in Table 4 include the amount of strain and tension developed in the geosynthetic liner system due to temperature changes and gravity prior to wind uplift, as well as the strain and tension developed due to wind uplift. Detailed calculations are provided in Supplement E-6.1.

As discussed previously, these calculations are considered conservative, as the suction that could be developed on the bottom surface of the lower geomembrane during uplift is ignored.

Although the geomembrane liner system and anchor system as designed will resist wind uplift forces, it is recommended that ballast be provided at the corners of the South and West Ponds to provide additional support in these areas. The proposed ballast is 6-inch diameter HDPE pipe filled with sand from the crest to the elevation for dead storage. The recommended maximum SDR is 17. Calculations to confirm that the recommended SDR is sufficient to handle the tension forces on the pipe due to gravity loading are provided in Supplement E-6.1 and the results of summarized in Table 7. For all corners in the South and West Ponds, the maximum tension calculated for the HDPE geomembrane pipe is less than the allowable tension. Calculations for calculating the allowable cold bending radius for the ballast pipes are provided in Supplement E-6.1. The calculations indicated that the specified HDPE ballast pipe are sufficiently flexible to conform to the design pond slopes without needing to resort to special fabrication or heat bending of the pipes. Calculations to evaluate whether the support required for the ballast pipes are provided in Supplement E-6.1.

Table 6. Results for Wind Uplift Analysis

	West Pond		WTP Ponds		South Pond	
	Construction	Operation	Construction	Operation	Construction	Operation
Maximum Strain	0.9%	0.8%	0.5%	0.4%	1.1%	0.9%
Allowable Strain	6%	6%	6%	6%	6%	6%
Maximum Tension	10.3 kN/m	9.0 kN/m	5.1 kN/m	4.7 kN/m	12.5 kN/m	10.5 kN/m
Allowable Tensile Strength	45 kN/m	45 kN/m	45 kN/m	45 kN/m	45 kN/m	45 kN/m
Uplift Height	7.5 ft	5.7 ft	1.4 ft	1.2 ft	11.8 ft	8.0 ft
Anchor Trench Design	OK	OK	OK	OK	OK	OK

Table 7. Results for Evaluation of Liner Ballast

Pond	Corner Designation	Slope Angle	Length (ft)	Maximum Tension (psi)	Allowable Tension, (50% yield tension) (psi)
South Pond	North 1	3.8H:1V	195	305	1750
	North 2	4.5H:1V	230	306	
	East	4.2H:1V	215	306	
	South	3.9H:1V	199	303	
	West	4.9H:1V	253	311	
West Pond	North	5.9H:1V	249	255	1750
	East	4.4H:1V	187	254	
	West	6.1H:1V	252	250	

5.0 CONCLUSIONS & RECOMMENDATIONS

The tension and strain developed in the geosynthetic liner system due to wind uplift for the maximum wind speed do not exceed the allowable tensile strength and strain values of the components of the geomembrane liner system. The support provided by the anchor trench design presented in MWH (2014) is more than adequate to resist uplift forces generated by the design wind speed at the site. Although not accounted for in these analyses, atmospheric vents are recommended along the geomembrane at the top of the slopes to reduce pressures that may develop due to heating of gasses (air) trapped in the leak detection system between the two HDPE geomembranes. As noted in Giroud et al. (1995), there is not a method available to design such vents; however, a typical spacing that has been used is 15 meters. A minimum spacing of 15 meters (approximately 50 feet) is recommended for the vents. Ballast at the corners of the West and South Ponds is also recommended to reduce the potential of reversal of curvature in the geosynthetic liner system if uplift does occur, and is proposed to be 6-inch SDR 17 HDPE pipe filled with sand.

6.0 REFERENCES

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Supplement E-6.1

Wind Uplift Analysis Calculations

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	10/24/2014
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C.Weber(rev. 0)/M.Davis(rev. 1&2)
Detail:	Wind Uplift Calculation	Checked By:	J.Worthen(rev. 0)/C.Weber(rev. 1&2)

WEST POND - DURING CONSTRUCTION

Purpose:

Estimate the uplift suction on the geosynthetic liner system at Midnite Mine. Also, estimate the internal tension and strain for the liner system due to thermal contraction, gravity, and wind uplift, assuming unballasted conditions. Evaluate the anchor trenches for wind uplift.

Method:

Giroud, J.P., Pelte, T., and Bathurst, R.J., 1995, "Uplift of Geomembranes by Wind", *Geosynthetics International*, Vol. 2, No. 8, pp. 897 - 951.

Zornberg, J.G. and Giroud, J.P., 1997, "Uplift of Geomembranes by Wind - Extension of Equations", *Geosynthetics International*, Vol. 4, No. 2, pp. 187 - 207.

Giroud, J.P., Gleason, M.H., and Zornberg, J.G., 1999, "Design of Geomembrane Anchorage Against Wind Action", *Geosynthetics International*, Vol. 6, No. 6, pp. 481-507.

Assumptions:

1. The maximum allowable liner strain is the yield strain (with a factor of safety of 2 applied)
2. The soil is significantly permeable so that a negative pressure is not developed under the liner due to uplift
3. The tension/strain calculations analyze a section of a uniformly oriented liner system and the effects of the liner system movement (i.e. changes in geometry due to uplift) are not considered. As such, it is assumed that the liner system is fully anchored at the bottom and top of the slope.
4. The geosynthetic liner system consists of a lower 60 mil HDPE geomembrane (with a smooth lower and a textured upper surface) overlain by a 200 mil geonet overlain by an upper 60 HPE geomembrane (textured on both sides). The liner system is assumed to act as one material.

Objectives:

1. Estimate the suction uplift pressure for West Pond (2.5H:1V Side Slopes), WTP Ponds (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
2. Calculate the tension and strain for West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
3. Evaluate anchor trench design for wind uplift

Notes:

1. The Zornberg and Giroud (1997) equations account for the slope on the which the liner system is installed. West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes) are evaluated.

Summary of Results:

	West Pond (2.5H:1V Side Slopes) - During Construction			
1	The liner system placed on the side slopes will not exceed the yield strain due to the combined worst-case effects of thermal change, gravity, and wind uplift (assuming it is fully anchored at its top and bottom).			
	Max Strain:	0.9 %	Allowable Strain (FoS = 2):	6.0 %
	Max Tension:	10.3 kN/m	Allowable Tensile Strength:	45.2 kN/m
2	The uplift height assuming no ballasting:		2.3 m	
			7.5 ft	
3	Anchor Trench Design:	Area of Anchor Trench, $A_{design} > A_{req}$		

Calculate uplift and tension and strain of liner system for West Pond (2.5H:1V Side Slopes)

Limiting Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2 for strain

Side Slope Characteristics:

Slope Angle
β = 21.8 degrees

West Pond - Maximum Unsupported Length:
L = 148 ft
= 45.1 m

Elevation above mean sea level, z 2660 ft
811 m

Temperature and Wind Speed Data:

The maximum daily temperature change is:
From July 2012
ΔTemp = 14.6 °C

Data obtained from: http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?waWMID
- Data is in °F, converted to °C prior to calculating max temperature change
- Maximum daily temperature change estimated using difference of monthly average maximum daily temperature and monthly average minimum daily temperature

The maximum wind speed is:

V = 39 mph
17.4 m/s

Data obtained from: http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?waWWLP
- Maximum wind speed is 90th percentile of maximum monthly wind gust at the Wellpinit climate station for the period of record of 2002-2014

Geosynthetic Liner System Properties/Behavior

Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2

Geomembrane Density: 0.94 g/cm^3 — From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

GeomembraneThickness: 120 mil — Sum of thicknesses for the two geomembrane layers.
= 3.0 mm
= 0.30 cm

Mass per Unit Area (μ_{gm}):
Geomembranes 0.29 g/cm^2 — Calculated as the product of the thickness of the geomembrane layers and the geomembrane material density.
Geonet 0.162 lb/sf — Typical value from GSE for GSE 200 mil HyperNet geonet. For comparison, Koerner (2005) lists a typical range of 800 to 1600 g/m^2 for 5-mm thick , solid-rib extgruded biplanar geonet (Koerner, 2005)
791 g/m^2
0.0791 g/cm^2

Total Mass per Unit Area (μ_{gm}):
0.37 g/cm^2 — Sum of mass per unit areas for the three components of the liner system
= 3.66 kg/m^2

Coefficient of Thermal Expansion
α = 0.00012 C^-1 — Average value reported for HDPE in Koerner (2005)

Tensile strength:
Upper geomembrane 126 lb/in — From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet
Geonet 6 lb/in — Estimated from typical test results provided by GSE for 200 mil HyperNet geonet tested in the transverse direction. Value selected at 12% strain.
Lower geomembrane 126 lb/in — From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

Total strength at yield of: 258 lb/in — Sum of strengths for the three liner system materials.
45.2 kN/m

Strain at yield: 12 % — Elongation at yield for geomembrane

For a Factor of Safety of 2, maximum strain = 6 %

Using Figure 12 in Giroud et al. (1995) - Tension-strain curve for 1.5 mm (60 mil) HDPE geomembrane, estimate J - the geomembrane tensile stiffness:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =	15.0 kN/m		
Strain (elastic) =	2.8 %	=	0.028
So, J = Rise/Run =		=	536 kN/m

Use typical tension-strain curve (transverse direction) from GSE Environmental to estimate J for a GSE HyperNet 200 mil geonet:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =	2.0 kN/m		
Strain (elastic) =	3.5 %	=	0.035
So, J = Rise/Run =		=	57 kN/m

Total J=	**1129 kN/m**

Calculated as sum of tensile stiffness for the three liner system materials.

Calculate threshold uplift wind velocity

From Zornberg & Giroud (1997):

$$V \leq V_{up} = 3.895e^{(6.259 \times 10^{-5})z}\sqrt{\mu_{GM}\cos\beta/\lambda} \qquad \text{(A-25)}$$

with V_{up}(m/s), z(m) and μ_{GM}(kg/m^2)

V_{up} = Uplift wind velocity (threshold velocity required to uplift liner system)

μ_{gm} = 3.66 kg/m^2

λ = 0.7

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

z = 811 m (Elevation above sea level)

β = 21.8 degrees

V_{up} =	**9.02 m/s**
	20.2 mph

$V > V_{up}$ **Maximum Wind Velocity at the site exceeds the threshold wind velocity required for uplift**

Estimate Tension and Strain due to Thermal Effects and Gravity in the West Pond Side Slopes

Strain due to themal change:
Assume worst case scenario - maximum temperature change

ε_{temp} = Coefficient of Thermal Expansion * Change in Temperature
ε_{temp} = = 0.0018
= 0.18 %

Tension due to themal change:

T_{temp} = $J^*\varepsilon_{temp}$ Equation 5 in Zornberg & Giroud (1997)
= 1.98 kN/m
Maximum Uplift Strain will result from the initial state of a wrinked liner (positive strain) - Giroud pg 942

Tension due to gravity:

T_g = $=\mu_{gm}*g*L*\sin\beta$ Equation 6 in Zornberg & Giroud (1997)

μ_{gm} =	3.66	kg/m^2
g =	9.81	m/s^2
L =	45.1	m
β =	21.8	

T_g = 601 N/m
0.60 kN/m

Strain due to gravity:

ε_g = Tension due to gravity / Stiffness
ε_g = T_g/J Equation 7 in Zornberg & Giroud (1997)
= 0.0005
= 0.05 %

Total Initial Strain and Tension due to thermal change and gravity (prior to wind uplift):

ε_0 = strain due to gravity + strain due to thermal change
ε_0 = $\varepsilon_g + \varepsilon_{temp}$ Equation 2 in Zornberg & Giroud (1997)
ε_0 = 0.0023
ε_0 = 0.23 %

T_0 = Tension due to thermal change + tension due to gravity
T_0 = $T_{temp} + T_g$ Equation 3 in Zornberg & Giroud (1997)
T_0 = 2.58 kN/m

Calculate the Effective Suction Force upon the geosynthetic liner system placed on the West Pond Side Slopes

The effective suction is the uplift suction pressure minus the downward force due to the weight of the liner

Using Equation A-40 - in Appendix A-3 of Zornberg & Giroud (1997)

$$S_e = 0.6465\lambda V^2 e^{-(1.252 \times 10^{-4})z} - 9.81\mu_{GM}\cos\beta \qquad \text{(A-40)}$$

with S_e(Pa), V(m/s), z(m) and μ_{GM}(kg/m^2)

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

Where:

λ =	0.7		
V =	17.4	m/s	
z =	811	m	(Elevation above sea level)
μ_{gm} =	3.66	kg/m^2	
β =	21.8		

S_e = 91.0 Pa

1 Pa = 1 N/m^2

S_e = 91.0 N/m^2

Estimate Tension and Strain due to wind uplift for the West Pond geosynthetic liner system

S_e*L = 4103 N/m (per unit length running perpendicular to the perimeter of the pond)

S_e*L = 4.10 kN/m

Estimate Strain Due to Wind:

Using iterations, the following equation can be solved for ε_w (Sin in radians):

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right] \qquad \text{(A-57a)}$$

Using Solver to iterate ε_w until the two terms in Equation A-57a are equal (Difference is equal to zero):

ε_w = 0.0068

= **0.68** %

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = 0.2001 \qquad 0.2001 = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right]$$

Difference 0.0000

Tension Due to Wind:

T_w = J*ε_w Equation 8 in Zornberg & Giroud (1997)

= 7.67 kN/m

Estimate the total strain and tension due to wind, gravity, and thermal changes in geosynthetic liner system on the West Pond Side Slopes

Sum of the total strain due to wind, gravity, and thermal changes:

ε_t	=	$\varepsilon_w + \varepsilon_0$	Equation 9 in Zornberg & Giroud (1997)
	=	0.009	
ε_t	**=**	**0.91 %**	

Sum of the total tension due to wind, gravity, and thermal changes:

T_t	=	$T_0 + T_w$	Equation 10 in Zornberg & Giroud (1997)
T_t	**=**	**10.25 kN/m**	

The total strain is less than the allowable strain (with a FS of 2) of 6 %
The total tension is less than the allowable tensile strength of 45.2 kN/m

Estimate the uplift of the geosynthetic liner system on the West Pond Side Slopes (assuming no ballasting)

From Giroud et al. (1995):

$$\frac{u}{L} = \frac{T}{S_e L} - \sqrt{\left(\frac{T}{S_e L}\right)^2 - \frac{1}{4}} \qquad (53)$$

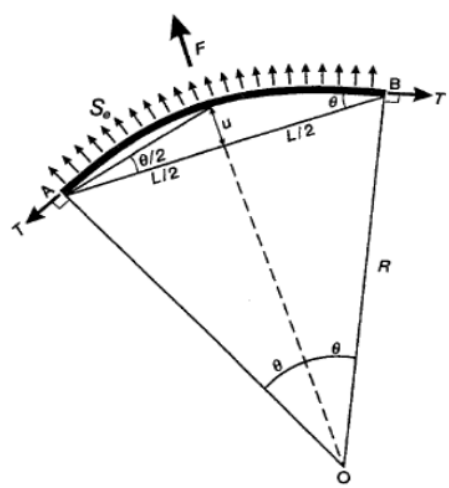
where:

u -	Uplift
L -	Slope length
T -	Total tension
S_eL -	Effective Suction

$T = T_t =$	10.25	kN/m
L =	45.1	m
S_eL =	4.10	kN/m

u/L =	0.051		
u =	**2.28 m**	7.48	ft

This assumes that the liner will have a uniform uplift shape with the uplift perpendicular to the slope at its maximum height



Evaluate the anchor trench design with respect to wind uplift for the West Pond Side Slopes

The anchor trenches were evaluated using Equation 9 (uplifting) from Giroud et al. (1999). This assumes that the anchor trench was designed to provide sufficient passive pressure against lateral sliding.

Anchor Failure by Uplifting

$$W_{min} = W_{min\,uplifting} = T_d \sin(\theta_d - \beta_d) + T_u \sin(\theta_u + \beta_u) \qquad (9)$$

where:

W_{min} =	minimum required weight of anchor material per unit width
T_d	Geosynthetic liner system tension on downslope side of anchor
θ_d	Angle of uplifted geosynthetic liner system with slope on downslope side of anchor
β_d	Slope angle on downslope side of anchor
T_u	Geosynthetic liner system tension on upslope side of anchor
θ_u	Angle of uplifted geosynthetic liner system with slope on upslope side of anchor
β_u	Slope angle on upslope side of anchor

Since the anchor trench is at the crest of the slope, only the downslope direction is considered for this calculation.
$T_u = \theta_u = \beta_u = 0$

Geosynthetic liner system tension on downslope side of anchor is equal to the total tension due to uplift
$T_d = T_t$ = 10.25 kN/m
$\beta_d = \beta$ = 21.8 degrees

To estimate the angle of uplifted geosynthetic liner system:

$$\theta = 2\tan^{-1}\left(\frac{2u}{L}\right)$$ Equation 55 from Giroud et al. (1995)

u = 2.28 m
L = 45.1 m

$\theta = \theta_d$ = 0.20 radians
11.5 degrees

$W_{min,\ uplifting}$ = 0.00 kN/m

Applying a factor of safety of 1.5 to the W_{min} value is suggested by Giroud et al. (1999)
$W_{factored}$ 0.0 kN/m

Required cross-sectional area of the anchor trench
A_{req} = $W_{factored} / \gamma$ Equation 19 from Giroud et al. (1999)

γ = Unit weight of anchor trench soil
γ = 132 pcf
20.8 kN/m^3

A_{req} 0.00 m^2
A_{req} 0.00 ft^2 0.0 ft square anchor trench

Compare to Anchor Trench Design:
Anchor Trench Width 1.5 ft
Anchor Trench Depth 3 ft

Anchor Trench Area, A_{Design} 4.5 ft^2

$A_{design} > A_{req}$

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	10/24/2014
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C.Weber(rev. 0)/M.Davis(rev. 1&2)
Detail:	Wind Uplift Calculation	Checked By:	J.Worthen(rev. 0)/C.Weber(rev. 1&2)

WEST POND - DURING OPERATION

Purpose:

Estimate the uplift suction on the geosynthetic liner system at Midnite Mine. Also, estimate the internal tension and strain for the liner system due to thermal contraction, gravity, and wind uplift, assuming unballasted conditions. Evaluate the anchor trenches for wind uplift.

Method:

Giroud, J.P., Pelte, T., and Bathurst, R.J., 1995, "Uplift of Geomembranes by Wind", *Geosynthetics International*, Vol. 2, No. 8, pp. 897 - 951.

Zornberg, J.G. and Giroud, J.P., 1997, "Uplift of Geomembranes by Wind - Extension of Equations", *Geosynthetics International*, Vol. 4, No. 2, pp. 187 - 207.

Giroud, J.P., Gleason, M.H., and Zornberg, J.G., 1999, "Design of Geomembrane Anchorage Against Wind Action", *Geosynthetics International*, Vol. 6, No. 6, pp. 481-507.

Assumptions:

1. The maximum allowable liner strain is the yield strain (with a factor of safety of 2 applied)
2. The soil is significantly permeable so that a negative pressure is not developed under the liner due to uplift
3. The tension/strain calculations analyze a section of a uniformly oriented liner system and the effects of the liner system movement (i.e. changes in geometry due to uplift) are not considered. As such, it is assumed that the liner system is fully anchored at the bottom and top of the slope.
4. The geosynthetic liner system consists of a lower 60 mil HDPE geomembrane (with a smooth lower and a textured upper surface) overlain by a 200 mil geonet overlain by an upper 60 HPE geomembrane (textured on both sides). The liner system is assumed to act as one material.

Objectives:

1. Estimate the suction uplift pressure for West Pond (2.5H:1V Side Slopes), WTP Ponds (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
2. Calculate the tension and strain for West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
3. Evaluate anchor trench design for wind uplift

Notes:

1. The Zornberg and Giroud (1997) equations account for the slope on the which the liner system is installed. West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes) are evaluated.

Summary of Results:

	West Pond (2.5H:1V Side Slopes) - During Operation			
1	The liner system placed on the side slopes will not exceed the yield strain due to the combined worst-case effects of thermal change, gravity, and wind uplift (assuming it is fully anchored at its top and bottom).			
	Max Strain:	0.8 %	Allowable Strain (FoS = 2):	6.0 %
	Max Tension:	9.0 kN/m	Allowable Tensile Strength:	45.2 kN/m
2	The uplift height assuming no ballasting:		1.7 m	
			5.7 ft	
3	Anchor Trench Design:	Area of Anchor Trench, $A_{design} > A_{req}$		

Calculate uplift and tension and strain of liner system for West Pond (2.5H:1V Side Slopes)

Limiting Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2 for strain

Side Slope Characteristics:

Slope Angle
β = 21.8 degrees

West Pond - Maximum Unsupported Length:
L = 121 ft *Considers dead storage volume in pond
= 36.9 m

Elevation above mean sea level, z 2660 ft
811 m

Temperature and Wind Speed Data:

The maximum daily temperature change is:
From July 2012
ΔTemp = 14.6 °C Data obtained from: http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?waWMID
- Data is in °F, converted to °C prior to calculating max temperature change
- Maximum daily temperature change estimated using difference of monthly average maximum daily temperature and monthly average minimum daily temperature

The maximum wind speed is:

V = 39 mph Data obtained from: http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?waWWLP
17.4 m/s - Maximum wind speed is 90th percentile of maximum monthly wind gust at the Wellpinit climate station for the period of record of 2002-2014

Geosynthetic Liner System Properties/Behavior

Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2

Geomembrane Density: 0.94 g/cm^3 From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

GeomembraneThickness: 120 mil Sum of thicknesses for the two geomembrane layers.
= 3.0 mm
= 0.30 cm

Mass per Unit Area (μ_{gm}):
Geomembranes 0.29 g/cm^2 Calculated as the product of the thickness of the geomembrane layers and the geomembrane material density.
Geonet 0.162 lb/sf Typical value from GSE for GSE 200 mil HyperNet geonet. For comparison, Koerner
791 g/m^2 (2005) lists a typical range of 800 to 1600 g/m^2 for 5-mm thick , solid-rib extgruded
0.0791 g/cm^2 biplanar geonet (Koerner, 2005)

Total Mass per Unit Area (μ_{gm}):
0.37 g/cm^2 Sum of mass per unit areas for the three components of the liner system
= 3.66 kg/m^2

Coefficient of Thermal Expansion
α = 0.00012 C^-1 Average value reported for HDPE in Koerner (2005)

Tensile strength:
Upper geomembrane 126 lb/in From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet
Geonet 6 lb/in Estimated from typical test results provided by GSE for 200 mil HyperNet geonet tested in the transverse direction. Value selected at 12% strain.
Lower geomembrane 126 lb/in From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

Total strength at yield of: 258 lb/in Sum of strengths for the three liner system materials.
45.2 kN/m

Strain at yield: 12 % Elongation at yield for geomembrane

For a Factor of Safety of 2, maximum strain = 6 %

Using Figure 12 in Giroud et al. (1995) - Tension-strain curve for 1.5 mm (60 mil) HDPE geomembrane, estimate J - the geomembrane tensile stiffness:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =	15.0 kN/m		
Strain (elastic) =	2.8 %	=	0.028
So, J = Rise/Run =		=	536 kN/m

Use typical tension-strain curve (transverse direction) from GSE Environmental to estimate J for a GSE HyperNet 200 mil geonet:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =	2.0 kN/m		
Strain (elastic) =	3.5 %	=	0.035
So, J = Rise/Run =		=	57 kN/m

Total J= 1129 kN/m Calculated as sum of tensile stiffness for the three liner system materials.

Calculate threshold uplift wind velocity

From Zornberg & Giroud (1997):

$$V \leq V_{up} = 3.895e^{(6.259 \times 10^{-5})\, z} \sqrt{\mu_{GM} \cos\beta/\lambda} \qquad \text{(A-25)}$$

with V_{up}(m/s), z(m) and μ_{GM}(kg/m^2)

V_{up} = Uplift wind velocity (threshold velocity required to uplift liner system)

μ_{gm} = 3.66 kg/m^2

λ = 0.7

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

z = 811 m (Elevation above sea level)

β = 21.8 degrees

V_{up} = 9.02 m/s

20.2 mph

$V > V_{up}$ Maximum Wind Velocity at the site exceeds the threshold wind velocity required for uplift

Estimate Tension and Strain due to Thermal Effects and Gravity in the West Pond Side Slopes

Strain due to themal change:
Assume worst case scenario - maximum temperature change

ε_{temp} = Coefficient of Thermal Expansion * Change in Temperature
ε_{temp} = = 0.0018
= 0.18 %

Tension due to themal change:

T_{temp} = $J^*\varepsilon_{temp}$ Equation 5 in Zornberg & Giroud (1997)
= 1.98 kN/m
Maximum Uplift Strain will result from the initial state of a wrinked liner (positive strain) - Giroud pg 942

Tension due to gravity:

T_g = $=\mu_{gm}^*g^*L^*\sin\beta$ Equation 6 in Zornberg & Giroud (1997)

μ_{gm} =	3.66	kg/m^2
g =	9.81	m/s^2
L =	36.9	m
β =	21.8	

T_g = 491 N/m
0.49 kN/m

Strain due to gravity:

ε_g = Tension due to gravity / Stiffness
ε_g = T_g/J Equation 7 in Zornberg & Giroud (1997)
= 0.0004
= 0.04 %

Total Initial Strain and Tension due to thermal change and gravity (prior to wind uplift):

ε_0 = strain due to gravity + strain due to thermal change
ε_0 = $\varepsilon_g + \varepsilon_{temp}$ Equation 2 in Zornberg & Giroud (1997)
ε_0 = 0.0022
ε_0 = 0.22 %

T_0 = Tension due to thermal change + tension due to gravity
T_0 = $T_{temp} + T_g$ Equation 3 in Zornberg & Giroud (1997)
T_0 = 2.47 kN/m

Calculate the Effective Suction Force upon the geosynthetic liner system placed on the West Pond Side Slopes

The effective suction is the uplift suction pressure minus the downward force due to the weight of the liner

Using Equation A-40 - in Appendix A-3 of Zornberg & Giroud (1997)

$$S_e = 0.6465\lambda V^2 e^{-(1.252 \times 10^{-4})z} - 9.81\mu_{GM}\cos\beta \qquad \text{(A-40)}$$

with S_e(Pa), V(m/s), z(m) and μ_{GM}(kg/m^2)

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

Where:

λ =	0.7		
V =	17.4	m/s	
z =	811	m	(Elevation above sea level)
μ_{gm} =	3.66	kg/m^2	
β =	21.8		

S_e = 91.0 Pa

1 Pa = 1 N/m^2

S_e = 91.0 N/m^2

Estimate Tension and Strain due to wind uplift for the West Pond geosynthetic liner system

S_e*L = 3355 N/m (per unit length running perpendicular to the perimeter of the pond)

S_e*L = 3.35 kN/m

Estimate Strain Due to Wind:

Using iterations, the following equation can be solved for ε_w (Sin in radians):

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right] \qquad \text{(A-57a)}$$

Using Solver to iterate ε_w until the two terms in Equation A-57a are equal (Difference is equal to zero):

ε_w = 0.0058

= **0.58** %

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = 0.1855 \qquad 0.1855 = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right]$$

Difference 0.0000

Tension Due to Wind:

T_w = J*ε_w Equation 8 in Zornberg & Giroud (1997)

= 6.57 kN/m

Estimate the total strain and tension due to wind, gravity, and thermal changes in geosynthetic liner system on the West Pond Side Slopes

Sum of the total strain due to wind, gravity, and thermal changes:

ε_t	=	$\varepsilon_w + \varepsilon_0$	Equation 9 in Zornberg & Giroud (1997)
	=	0.008	
ε_t	**=**	**0.80 %**	

Sum of the total tension due to wind, gravity, and thermal changes:

T_t	=	$T_0 + T_w$	Equation 10 in Zornberg & Giroud (1997)
T_t	**=**	**9.04 kN/m**	

The total strain is less than the allowable strain (with a FS of 2) of 6 %
The total tension is less than the allowable tensile strength of 45.2 kN/m

Estimate the uplift of the geosynthetic liner system on the West Pond Side Slopes (assuming no ballasting)

From Giroud et al. (1995):

$$\frac{u}{L} = \frac{T}{S_e L} - \sqrt{\left(\frac{T}{S_e L}\right)^2 - \frac{1}{4}} \qquad (53)$$

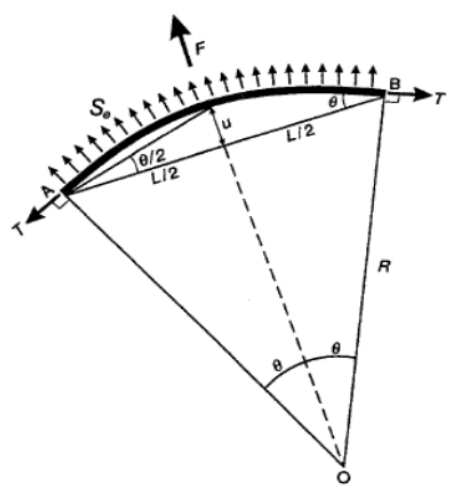
where:

u -	Uplift
L -	Slope length
T -	Total tension
S_eL -	Effective Suction

$T = T_t =$	9.04	kN/m
L =	36.9	m
S_eL =	3.35	kN/m

u/L =	0.047		
u =	**1.72 m**	5.66	ft

This assumes that the liner will have a uniform uplift shape with the uplift perpendicular to the slope at its maximum height



Evaluate the anchor trench design with respect to wind uplift for the West Pond Side Slopes

The anchor trenches were evaluated using Equation 9 (uplifting) from Giroud et al. (1999). This assumes that the anchor trench was designed to provide sufficient passive pressure against lateral sliding.

Anchor Failure by Uplifting

$$W_{min} = W_{min\,uplifting} = T_d \sin(\theta_d - \beta_d) + T_u \sin(\theta_u + \beta_u) \qquad (9)$$

where:

W_{min} =	minimum required weight of anchor material per unit width
T_d	Geosynthetic liner system tension on downslope side of anchor
θ_d	Angle of uplifted geosynthetic liner system with slope on downslope side of anchor
β_d	Slope angle on downslope side of anchor
T_u	Geosynthetic liner system tension on upslope side of anchor
θ_u	Angle of uplifted geosynthetic system with slope on upslope side of anchor
β_u	Slope angle on upslope side of anchor

Since the anchor trench is at the crest of the slope, only the downslope direction is considered for this calculation.
$T_u = \theta_u = \beta_u = 0$

Geosynthetic liner system tension on downslope side of anchor is equal to the total tension due to uplift
$T_d = T_t$ = 9.04 kN/m
$\beta_d = \beta$ = 21.8 degrees

To estimate the angle of uplifted geosynthetic liner system:

$$\theta = 2\tan^{-1}\left(\frac{2u}{L}\right)$$ Equation 55 from Giroud et al. (1995)

u = 1.72 m
L = 36.9 m

$\theta = \theta_d$ = 0.19 radians
10.7 degrees

$W_{min,\ uplifting}$ = 0.00 kN/m

Applying a factor of safety of 1.5 to the W_{min} value is suggested by Giroud et al. (1999)
$W_{factored}$ 0.0 kN/m

Required cross-sectional area of the anchor trench
A_{req} = $W_{factored} / \gamma$ Equation 19 from Giroud et al. (1999)

γ = Unit weight of anchor trench soil
γ = 132 pcf
20.8 kN/m^3

A_{req} 0.00 m^2
A_{req} 0.00 ft^2 0.0 ft square anchor trench

Compare to Anchor Trench Design:
Anchor Trench Width 1.5 ft
Anchor Trench Depth 3 ft

Anchor Trench Area, A_{Design} 4.5 ft^2

$A_{design} > A_{req}$

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	10/24/2014
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C.Weber(rev. 0)/M.Davis(rev. 1&2)
Detail:	Wind Uplift Calculation	Checked By:	J.Worthen(rev. 0)/C.Weber(rev. 1&2)

WTP PONDS - DURING CONSTRUCTION

Purpose:

Estimate the uplift suction on the geosynthetic liner system at Midnite Mine. Also, estimate the internal tension and strain for the liner system due to thermal contraction, gravity, and wind uplift, assuming unballasted conditions. Evaluate the anchor trenches for wind uplift.

Method:

Giroud, J.P., Pelte, T., and Bathurst, R.J., 1995, "Uplift of Geomembranes by Wind", *Geosynthetics International*, Vol. 2, No. 8, pp. 897 - 951.

Zornberg, J.G. and Giroud, J.P., 1997, "Uplift of Geomembranes by Wind - Extension of Equations", *Geosynthetics International*, Vol. 4, No. 2, pp. 187 - 207.

Giroud, J.P., Gleason, M.H., and Zornberg, J.G., 1999, "Design of Geomembrane Anchorage Against Wind Action", *Geosynthetics International*, Vol. 6, No. 6, pp. 481-507.

Assumptions:

1. The maximum allowable liner strain is the yield strain (with a factor of safety of 2 applied)
2. The soil is significantly permeable so that a negative pressure is not developed under the liner due to uplift
3. The tension/strain calculations analyze a section of a uniformly oriented liner system and the effects of the liner system movement (i.e. changes in geometry due to uplift) are not considered. As such, it is assumed that the liner system is fully anchored at the bottom and top of the slope.
4. The geosynthetic liner system consists of a lower 60 mil HDPE geomembrane (with a smooth lower and a textured upper surface) overlain by a 200 mil geonet overlain by an upper 60 HPE geomembrane (textured on both sides). The liner system is assumed to act as one material.

Objectives:

1. Estimate the suction uplift pressure for West Pond (2.5H:1V Side Slopes), WTP Ponds (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
2. Calculate the tension and strain for West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
3. Evaluate anchor trench design for wind uplift

Notes:

1. The Zornberg and Giroud (1997) equations account for the slope on the which the liner system is installed. West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes) are evaluated.

Summary of Results:

	WTP Ponds (2.5H:1V Side Slopes) - During Construction			
1	The liner system placed on the side slopes will not exceed the yield strain due to the combined worst-case effects of thermal change, gravity, and wind uplift (assuming it is fully anchored at its top and bottom).			
	Max Strain:	0.5 %	Allowable Strain (FoS = 2):	6.0 %
	Max Tension:	5.1 kN/m	Allowable Tensile Strength:	45.2 kN/m
2	The uplift height assuming no ballasting:		0.4 m	
			1.4 ft	
3	Anchor Trench Design:	Area of Anchor Trench, $A_{design} > A_{req}$		

Calculate uplift and tension and strain of liner system for WTP Ponds (2.5H:1V Side Slopes)

Limiting Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2 for strain

Side Slope Characteristics:

Slope Angle
β = 21.8 degrees

WTP Ponds - Maximum Unsupported Length:
L = 46 ft
= 14.0 m

Elevation above mean sea level, z 2584 ft
788 m

Temperature and Wind Speed Data:

The maximum daily temperature change is:
From July 2012
ΔTemp = 14.6 °C

Data obtained from: http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?waWMID
- Data is in °F, converted to °C prior to calculating max temperature change
- Maximum daily temperature change estimated using difference of monthly average maximum daily temperature and monthly average minimum daily temperature

The maximum wind speed is:

V = 39 mph
17.4 m/s

Data obtained from: http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?waWWLP
- Maximum wind speed is 90th percentile of maximum monthly wind gust at the Wellpinit climate station for the period of record of 2002-2014

Geosynthetic Liner System Properties/Behavior

Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2

Geomembrane Density: 0.94 g/cm^3 — From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

GeomembraneThickness: 120 mil — Sum of thicknesses for the two geomembrane layers.
= 3.0 mm
= 0.30 cm

Mass per Unit Area (μ_{gm}):
Geomembranes 0.29 g/cm^2 — Calculated as the product of the thickness of the geomembrane layers and the geomembrane material density.
Geonet 0.162 lb/sf — Typical value from GSE for GSE 200 mil HyperNet geonet. For comparison, Koerner (2005) lists a typical range of 800 to 1600 g/m^2 for 5-mm thick , solid-rib extgruded biplanar geonet (Koerner, 2005)
791 g/m^2
0.0791 g/cm^2

Total Mass per Unit Area (μ_{gm}):
0.37 g/cm^2 — Sum of mass per unit areas for the three components of the liner system
= 3.66 kg/m^2

Coefficient of Thermal Expansion
α = 0.00012 C^-1 — Average value reported for HDPE in Koerner (2005)

Tensile strength:
Upper geomembrane 126 lb/in — From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet
Geonet 6 lb/in — Estimated from typical test results provided by GSE for 200 mil HyperNet geonet tested in the transverse direction. Value selected at 12% strain.
Lower geomembrane 126 lb/in — From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

Total strength at yield of: 258 lb/in — Sum of strengths for the three liner system materials.
45.2 kN/m

Strain at yield: 12 % — Elongation at yield for geomembrane

For a Factor of Safety of 2, maximum strain = 6 %

Using Figure 12 in Giroud et al. (1995) - Tension-strain curve for 1.5 mm (60 mil) HDPE geomembrane, estimate J - the geomembrane tensile stiffness:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =		15.0 kN/m		
Strain (elastic) =		2.8 %	=	0.028
So, J =	Rise/Run =		=	536 kN/m

Use typical tension-strain curve (transverse direction) from GSE Environmental to estimate J for a GSE HyperNet 200 mil geonet:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =		2.0 kN/m		
Strain (elastic) =		3.5 %	=	0.035
So, J =	Rise/Run =		=	57 kN/m

Total J=	**1129 kN/m**

Calculated as sum of tensile stiffness for the three liner system materials.

Calculate threshold uplift wind velocity

From Zornberg & Giroud (1997):

$$V \leq V_{up} = 3.895e^{(6.259 \times 10^{-5})\, z} \sqrt{\mu_{GM} \cos\beta / \lambda} \qquad \text{(A-25)}$$

with V_{up}(m/s), z(m) and μ_{GM}(kg/m^2)

V_{up} = Uplift wind velocity (threshold velocity required to uplift liner system)

μ_{gm} =	3.66	kg/m^2
λ =	0.7	

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

z =	788	m	(Elevation above sea level)
β =	21.8	degrees	

V_{up} =	**9.01 m/s**
	20.2 mph

$V > V_{up}$ **Maximum Wind Velocity at the site exceeds the threshold wind velocity required for uplift**

Estimate Tension and Strain due to Thermal Effects and Gravity in the WTP Ponds Side Slopes

Strain due to themal change:
Assume worst case scenario - maximum temperature change

ε_{temp} = Coefficient of Thermal Expansion * Change in Temperature
ε_{temp} = = 0.0018
= 0.18 %

Tension due to themal change:

T_{temp} = $J^*\varepsilon_{temp}$ Equation 5 in Zornberg & Giroud (1997)
= 1.98 kN/m
Maximum Uplift Strain will result from the initial state of a wrinked liner (positive strain) - Giroud pg 942

Tension due to gravity:

T_g = $=\mu_{gm}*g*L*\sin\beta$ Equation 6 in Zornberg & Giroud (1997)

μ_{gm} = 3.66 kg/m^2
g = 9.81 m/s^2
L = 14.0 m
β = 21.8

T_g = 187 N/m
0.19 kN/m

Strain due to gravity:

ε_g = Tension due to gravity / Stiffness
ε_g = T_g/J Equation 7 in Zornberg & Giroud (1997)
= 0.0002
= 0.02 %

Total Initial Strain and Tension due to thermal change and gravity (prior to wind uplift):

ε_0 = strain due to gravity + strain due to thermal change
ε_0 = $\varepsilon_g + \varepsilon_{temp}$ Equation 2 in Zornberg & Giroud (1997)
ε_0 = 0.0019
ε_0 = 0.19 %

T_0 = Tension due to thermal change + tension due to gravity
T_0 = $T_{temp} + T_g$ Equation 3 in Zornberg & Giroud (1997)
T_0 = 2.17 kN/m

Calculate the Effective Suction Force upon the geosynthetic liner system placed on the WTP Ponds Side Slopes

The effective suction is the uplift suction pressure minus the downward force due to the weight of the liner

Using Equation A-40 - in Appendix A-3 of Zornberg & Giroud (1997)

$$S_e = 0.6465\lambda V^2 e^{-(1.252 \times 10^{-4})z} - 9.81\mu_{GM}\cos\beta \qquad \text{(A-40)}$$

with S_e(Pa), V(m/s), z(m) and μ_{GM}(kg/m^2)

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

Where:

λ =	0.7		
V =	17.4	m/s	
z =	788	m	(Elevation above sea level)
μ_{gm} =	3.66	kg/m^2	
β =	21.8		

S_e = 91.3 Pa

1 Pa = 1 N/m^2

S_e = 91.3 N/m^2

Estimate Tension and Strain due to wind uplift for the WTP Ponds geosynthetic liner system

S_e*L = 1280 N/m (per unit length running perpendicular to the perimeter of the pond)

S_e*L = 1.28 kN/m

Estimate Strain Due to Wind:

Using iterations, the following equation can be solved for ε_w (Sin in radians):

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right] \qquad \text{(A-57a)}$$

Using Solver to iterate ε_w until the two terms in Equation A-57a are equal (Difference is equal to zero):

ε_w = 0.0026

= **0.26** %

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = 0.1249 \qquad 0.1249 = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right]$$

Difference 0.0000

Tension Due to Wind:

T_w = J*ε_w Equation 8 in Zornberg & Giroud (1997)

= 2.96 kN/m

Estimate the total strain and tension due to wind, gravity, and thermal changes in geosynthetic liner system on the WTP Ponds Side Slopes

Sum of the total strain due to wind, gravity, and thermal changes:

ε_t	=	$\varepsilon_w + \varepsilon_0$	Equation 9 in Zornberg & Giroud (1997)
	=	0.005	
ε_t	**=**	**0.45 %**	

Sum of the total tension due to wind, gravity, and thermal changes:

T_t	=	$T_0 + T_w$	Equation 10 in Zornberg & Giroud (1997)
T_t	**=**	**5.12 kN/m**	

The total strain is less than the allowable strain (with a FS of 2) of 6 %
The total tension is less than the allowable tensile strength of 45.2 kN/m

Estimate the uplift of the geosynthetic liner system on the WTP Ponds Side Slopes (assuming no ballasting)

From Giroud et al. (1995):

$$\frac{u}{L} = \frac{T}{S_e L} - \sqrt{\left(\frac{T}{S_e L}\right)^2 - \frac{1}{4}} \qquad (53)$$

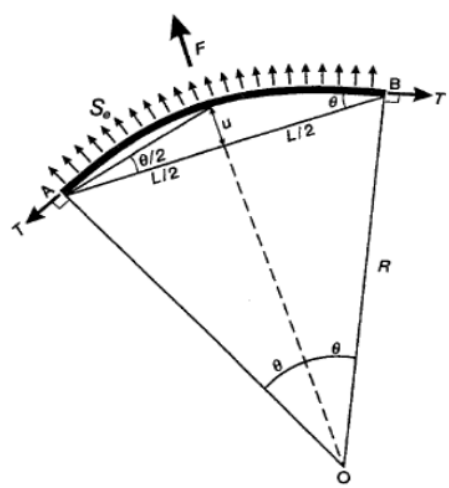
where:

u -	Uplift
L -	Slope length
T -	Total tension
S_eL -	Effective Suction

$T = T_t$ =	5.12 kN/m
L =	14.0 m
S_eL =	1.28 kN/m

u/L =	0.031	
u =	**0.44 m**	1.44 ft

This assumes that the liner will have a uniform uplift shape with the uplift perpendicular to the slope at its maximum height



Evaluate the anchor trench design with respect to wind uplift for the WTP Ponds Side Slopes

The anchor trenches were evaluated using Equation 9 (uplifting) from Giroud et al. (1999). This assumes that the anchor trench was designed to provide sufficient passive pressure against lateral sliding.

Anchor Failure by Uplifting

$$W_{min} = W_{min\,uplifting} = T_d \sin(\theta_d - \beta_d) + T_u \sin(\theta_u + \beta_u) \qquad (9)$$

where:

W_{min} =	minimum required weight of anchor material per unit width
T_d	Geosynthetic liner system tension on downslope side of anchor
θ_d	Angle of uplifted geosynthetic liner system with slope on downslope side of anchor
β_d	Slope angle on downslope side of anchor
T_u	Geosynthetic liner system tension on upslope side of anchor
θ_u	Angle of uplifted geosynthetic system with slope on upslope side of anchor
β_u	Slope angle on upslope side of anchor

Since the anchor trench is at the crest of the slope, only the downslope direction is considered for this calculation.
$T_u = \theta_u = \beta_u = 0$

Geosynthetic liner system tension on downslope side of anchor is equal to the total tension due to uplift
$T_d = T_t$ = 5.12 kN/m
$\beta_d = \beta$ = 21.8 degrees

To estimate the angle of uplifted geosynthetic liner system:

$$\theta = 2\tan^{-1}\left(\frac{2u}{L}\right)$$ Equation 55 from Giroud et al. (1995)

u = 0.44 m
L = 14.0 m

$\theta = \theta_d$ = 0.13 radians
7.2 degrees

$W_{min,\ uplifting}$ = 0.00 kN/m

Applying a factor of safety of 1.5 to the W_{min} value is suggested by Giroud et al. (1999)
$W_{factored}$ 0.0 kN/m

Required cross-sectional area of the anchor trench
A_{req} = $W_{factored} / \gamma$ Equation 19 from Giroud et al. (1999)

γ = Unit weight of anchor trench soil
γ = 132 pcf
20.8 kN/m^3

A_{req} 0.00 m^2
A_{req} 0.00 ft^2 0.0 ft square anchor trench

Compare to Anchor Trench Design:
Anchor Trench Width 1.5 ft
Anchor Trench Depth 3 ft

Anchor Trench Area, A_{Design} 4.5 ft^2

$A_{design} > A_{req}$

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	10/24/2014
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C.Weber(rev. 0)/M.Davis(rev. 1&2)
Detail:	Wind Uplift Calculation	Checked By:	J.Worthen(rev. 0)/C.Weber(rev. 1&2)

WTP PONDS - DURING OPERATION

Purpose:

Estimate the uplift suction on the geosynthetic liner system at Midnite Mine. Also, estimate the internal tension and strain for the liner system due to thermal contraction, gravity, and wind uplift, assuming unballasted conditions. Evaluate the anchor trenches for wind uplift.

Method:

Giroud, J.P., Pelte, T., and Bathurst, R.J., 1995, "Uplift of Geomembranes by Wind", *Geosynthetics International*, Vol. 2, No. 8, pp. 897 - 951.

Zornberg, J.G. and Giroud, J.P., 1997, "Uplift of Geomembranes by Wind - Extension of Equations", *Geosynthetics International*, Vol. 4, No. 2, pp. 187 - 207.

Giroud, J.P., Gleason, M.H., and Zornberg, J.G., 1999, "Design of Geomembrane Anchorage Against Wind Action", *Geosynthetics International*, Vol. 6, No. 6, pp. 481-507.

Assumptions:

1. The maximum allowable liner strain is the yield strain (with a factor of safety of 2 applied)
2. The soil is significantly permeable so that a negative pressure is not developed under the liner due to uplift
3. The tension/strain calculations analyze a section of a uniformly oriented liner system and the effects of the liner system movement (i.e. changes in geometry due to uplift) are not considered. As such, it is assumed that the liner system is fully anchored at the bottom and top of the slope.
4. The geosynthetic liner system consists of a lower 60 mil HDPE geomembrane (with a smooth lower and a textured upper surface) overlain by a 200 mil geonet overlain by an upper 60 HPE geomembrane (textured on both sides). The liner system is assumed to act as one material.

Objectives:

1. Estimate the suction uplift pressure for West Pond (2.5H:1V Side Slopes), WTP Ponds (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
2. Calculate the tension and strain for West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
3. Evaluate anchor trench design for wind uplift

Notes:

1. The Zornberg and Giroud (1997) equations account for the slope on the which the liner system is installed. West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes) are evaluated.

Summary of Results:

	WTP Ponds (2.5H:1V Side Slopes) - During Operation			
1	The liner system placed on the side slopes will not exceed the yield strain due to the combined worst-case effects of thermal change, gravity, and wind uplift (assuming it is fully anchored at its top and bottom).			
	Max Strain:	0.4 %	Allowable Strain (FoS = 2):	6.0 %
	Max Tension:	4.7 kN/m	Allowable Tensile Strength:	45.2 kN/m
2	The uplift height assuming no ballasting:		0.4 m	
			1.2 ft	
3	Anchor Trench Design:	Area of Anchor Trench, $A_{design} > A_{req}$		

Calculate uplift and tension and strain of liner system for WTP Ponds (2.5H:1V Side Slopes)

Limiting Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2 for strain

Side Slope Characteristics:

Slope Angle
β = 21.8 degrees

WTP Ponds - Maximum Unsupported Length:
L = 40 ft *Considers dead storage volume in pond
= 12.2 m

Elevation above mean sea level, z 2584 ft
788 m

Temperature and Wind Speed Data:

The maximum daily temperature change is:
From July 2012
ΔTemp = 14.6 °C Data obtained from: http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?waWMID
- Data is in °F, converted to °C prior to calculating max temperature change
- Maximum daily temperature change estimated using difference of monthly average maximum daily temperature and monthly average minimum daily temperature

The maximum wind speed is:

V = 39 mph Data obtained from: http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?waWWLP
17.4 m/s - Maximum wind speed is 90th percentile of maximum monthly wind gust at the Wellpinit climate station for the period of record of 2002-2014

Geosynthetic Liner System Properties/Behavior

Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2

Geomembrane Density: 0.94 g/cm^3 From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

GeomembraneThickness: 120 mil Sum of thicknesses for the two geomembrane layers.
= 3.0 mm
= 0.30 cm

Mass per Unit Area (μ_{gm}):
Geomembranes 0.29 g/cm^2 Calculated as the product of the thickness of the geomembrane layers and the geomembrane material density.
Geonet 0.162 lb/sf Typical value from GSE for GSE 200 mil HyperNet geonet. For comparison, Koerner
791 g/m^2 (2005) lists a typical range of 800 to 1600 g/m^2 for 5-mm thick , solid-rib extgruded
0.0791 g/cm^2 biplanar geonet (Koerner, 2005)

Total Mass per Unit Area (μ_{gm}):
0.37 g/cm^2 Sum of mass per unit areas for the three components of the liner system
= 3.66 kg/m^2

Coefficient of Thermal Expansion
α = 0.00012 C^-1 Average value reported for HDPE in Koerner (2005)

Tensile strength:
Upper geomembrane 126 lb/in From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet
Geonet 6 lb/in Estimated from typical test results provided by GSE for 200 mil HyperNet geonet tested in the transverse direction. Value selected at 12% strain.
Lower geomembrane 126 lb/in From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

Total strength at yield of: 258 lb/in Sum of strengths for the three liner system materials.
45.2 kN/m

Strain at yield: 12 % Elongation at yield for geomembrane

For a Factor of Safety of 2, maximum strain = 6 %

Using Figure 12 in Giroud et al. (1995) - Tension-strain curve for 1.5 mm (60 mil) HDPE geomembrane, estimate J - the geomembrane tensile stiffness:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =		15.0 kN/m		
Strain (elastic) =		2.8 %	=	0.028
So, J =	Rise/Run =		=	536 kN/m

Use typical tension-strain curve (transverse direction) from GSE Environmental to estimate J for a GSE HyperNet 200 mil geonet:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =		2.0 kN/m		
Strain (elastic) =		3.5 %	=	0.035
So, J =	Rise/Run =		=	57 kN/m

Total J=	**1129 kN/m**

Calculated as sum of tensile stiffness for the three liner system materials.

Calculate threshold uplift wind velocity

From Zornberg & Giroud (1997):

$$V \leq V_{up} = 3.895e^{(6.259 \times 10^{-5})\, z} \sqrt{\mu_{GM} \cos\beta / \lambda} \qquad \text{(A-25)}$$

with V_{up}(m/s), z(m) and μ_{GM}(kg/m^2)

V_{up} = Uplift wind velocity (threshold velocity required to uplift liner system)

μ_{gm} =	3.66	kg/m^2
λ =	0.7	

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

z =	788	m	(Elevation above sea level)
β =	21.8	degrees	

V_{up} =	**9.01 m/s**
	20.2 mph

$V > V_{up}$ **Maximum Wind Velocity at the site exceeds the threshold wind velocity required for uplift**

Estimate Tension and Strain due to Thermal Effects and Gravity in the WTP Ponds Side Slopes

Strain due to themal change:
Assume worst case scenario - maximum temperature change

ε_{temp} = Coefficient of Thermal Expansion * Change in Temperature
ε_{temp} = = 0.0018
= 0.18 %

Tension due to themal change:

T_{temp} = $J^*\varepsilon_{temp}$ Equation 5 in Zornberg & Giroud (1997)
= 1.98 kN/m
Maximum Uplift Strain will result from the initial state of a wrinked liner (positive strain) - Giroud pg 942

Tension due to gravity:

T_g = $=\mu_{gm}*g*L*\sin\beta$ Equation 6 in Zornberg & Giroud (1997)

μ_{gm} = 3.66 kg/m^2
g = 9.81 m/s^2
L = 12.2 m
β = 21.8

T_g = 162 N/m
0.16 kN/m

Strain due to gravity:

ε_g = Tension due to gravity / Stiffness
ε_g = T_g/J Equation 7 in Zornberg & Giroud (1997)
= 0.0001
= 0.01 %

Total Initial Strain and Tension due to thermal change and gravity (prior to wind uplift):

ε_0 = strain due to gravity + strain due to thermal change
ε_0 = $\varepsilon_g + \varepsilon_{temp}$ Equation 2 in Zornberg & Giroud (1997)
ε_0 = 0.0019
ε_0 = 0.19 %

T_0 = Tension due to thermal change + tension due to gravity
T_0 = $T_{temp} + T_g$ Equation 3 in Zornberg & Giroud (1997)
T_0 = 2.14 kN/m

Calculate the Effective Suction Force upon the geosynthetic liner system placed on the WTP Ponds Side Slopes

The effective suction is the uplift suction pressure minus the downward force due to the weight of the liner

Using Equation A-40 - in Appendix A-3 of Zornberg & Giroud (1997)

$$S_e = 0.6465\lambda V^2 e^{-(1.252 \times 10^{-4})z} - 9.81\mu_{GM}\cos\beta \qquad \text{(A-40)}$$

with S_e(Pa), V(m/s), z(m) and μ_{GM}(kg/m^2)

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

Where:

λ =	0.7		
V =	17.4	m/s	
z =	788	m	(Elevation above sea level)
μ_{gm} =	3.66	kg/m^2	
β =	21.8		

S_e = 91.3 Pa

1 Pa = 1 N/m^2

S_e = 91.3 N/m^2

Estimate Tension and Strain due to wind uplift for the WTP Ponds geosynthetic liner system

S_e*L = 1113 N/m (per unit length running perpendicular to the perimeter of the pond)

S_e*L = 1.11 kN/m

Estimate Strain Due to Wind:

Using iterations, the following equation can be solved for ε_w (Sin in radians):

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right] \qquad \text{(A-57a)}$$

Using Solver to iterate ε_w until the two terms in Equation A-57a are equal (Difference is equal to zero):

ε_w = 0.0023

= **0.23** %

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = 0.1173 \qquad 0.1173 = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right]$$

Difference 0.0000

Tension Due to Wind:

T_w = J*ε_w Equation 8 in Zornberg & Giroud (1997)

= 2.60 kN/m

Estimate the total strain and tension due to wind, gravity, and thermal changes in geosynthetic liner system on the WTP Ponds Side Slopes

Sum of the total strain due to wind, gravity, and thermal changes:

ε_t	=	$\varepsilon_w + \varepsilon_0$	Equation 9 in Zornberg & Giroud (1997)
	=	0.004	
ε_t	**=**	**0.42 %**	

Sum of the total tension due to wind, gravity, and thermal changes:

T_t	=	$T_0 + T_w$	Equation 10 in Zornberg & Giroud (1997)
T_t	**=**	**4.75 kN/m**	

The total strain is less than the allowable strain (with a FS of 2) of 6 %
The total tension is less than the allowable tensile strength of 45.2 kN/m

Estimate the uplift of the geosynthetic liner system on the WTP Ponds Side Slopes (assuming no ballasting)

From Giroud et al. (1995):

$$\frac{u}{L} = \frac{T}{S_e L} - \sqrt{\left(\frac{T}{S_e L}\right)^2 - \frac{1}{4}} \qquad (53)$$

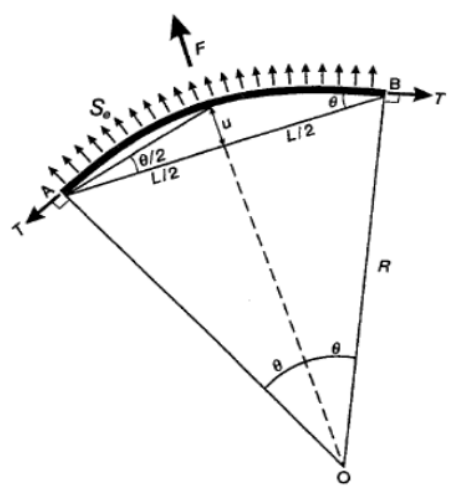
where:

u -	Uplift
L -	Slope length
T -	Total tension
S_eL -	Effective Suction

$T = T_t =$	4.75	kN/m
L =	12.2	m
$S_eL =$	1.11	kN/m

u/L =	0.029		
u =	**0.36 m**	1.18	ft

This assumes that the liner will have a uniform uplift shape with the uplift perpendicular to the slope at its maximum height



Evaluate the anchor trench design with respect to wind uplift for the WTP Ponds Side Slopes

The anchor trenches were evaluated using Equation 9 (uplifting) from Giroud et al. (1999). This assumes that the anchor trench was designed to provide sufficient passive pressure against lateral sliding.

Anchor Failure by Uplifting

$$W_{min} = W_{min\,uplifting} = T_d \sin(\theta_d - \beta_d) + T_u \sin(\theta_u + \beta_u) \qquad (9)$$

where:

W_{min} =	minimum required weight of anchor material per unit width
T_d	Geosynthetic liner system tension on downslope side of anchor
θ_d	Angle of uplifted geosynthetic liner system with slope on downslope side of anchor
β_d	Slope angle on downslope side of anchor
T_u	Geosynthetic liner system tension on upslope side of anchor
θ_u	Angle of uplifted geosynthetic system with slope on upslope side of anchor
β_u	Slope angle on upslope side of anchor

Since the anchor trench is at the crest of the slope, only the downslope direction is considered for this calculation.
$T_u = \theta_u = \beta_u = 0$

Geosynthetic liner system tension on downslope side of anchor is equal to the total tension due to uplift
$T_d = T_t$ = 4.75 kN/m
$\beta_d = \beta$ = 21.8 degrees

To estimate the angle of uplifted geosynthetic liner system:

$$\theta = 2\tan^{-1}\left(\frac{2u}{L}\right)$$ Equation 55 from Giroud et al. (1995)

u = 0.36 m
L = 12.2 m

$\theta = \theta_d$ = 0.12 radians
6.7 degrees

$W_{min,\ uplifting}$ = 0.00 kN/m

Applying a factor of safety of 1.5 to the W_{min} value is suggested by Giroud et al. (1999)
$W_{factored}$ 0.0 kN/m

Required cross-sectional area of the anchor trench
A_{req} = $W_{factored} / \gamma$ Equation 19 from Giroud et al. (1999)

γ = Unit weight of anchor trench soil
γ = 132 pcf
20.8 kN/m^3

A_{req} 0.00 m^2
A_{req} 0.00 ft^2 0.0 ft square anchor trench

Compare to Anchor Trench Design:
Anchor Trench Width 1.5 ft
Anchor Trench Depth 3 ft

Anchor Trench Area, A_{Design} 4.5 ft^2

$A_{design} > A_{req}$

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	10/24/2014
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C.Weber(rev. 0)/M.Davis(rev. 1&2)
Detail:	Wind Uplift Calculation	Checked By:	J.Worthen(rev. 0)/C.Weber(rev. 1&2)

SOUTH POND - DURING CONSTRUCTION

Purpose:

Estimate the uplift suction on the geosynthetic liner system at Midnite Mine. Also, estimate the internal tension and strain for the liner system due to thermal contraction, gravity, and wind uplift, assuming unballasted conditions. Evaluate the anchor trenches for wind uplift.

Method:

Giroud, J.P., Pelte, T., and Bathurst, R.J., 1995, "Uplift of Geomembranes by Wind", *Geosynthetics International*, Vol. 2, No. 8, pp. 897 - 951.

Zornberg, J.G. and Giroud, J.P., 1997, "Uplift of Geomembranes by Wind - Extension of Equations", *Geosynthetics International*, Vol. 4, No. 2, pp. 187 - 207.

Giroud, J.P., Gleason, M.H., and Zornberg, J.G., 1999, "Design of Geomembrane Anchorage Against Wind Action", *Geosynthetics International*, Vol. 6, No. 6, pp. 481-507.

Assumptions:

1. The maximum allowable liner strain is the yield strain (with a factor of safety of 2 applied)
2. The soil is significantly permeable so that a negative pressure is not developed under the liner due to uplift
3. The tension/strain calculations analyze a section of a uniformly oriented liner system and the effects of the liner system movement (i.e. changes in geometry due to uplift) are not considered. As such, it is assumed that the liner system is fully anchored at the bottom and top of the slope.
4. The geosynthetic liner system consists of a lower 60 mil HDPE geomembrane (with a smooth lower and a textured upper surface) overlain by a 200 mil geonet overlain by an upper 60 HPE geomembrane (textured on both sides). The liner system is assumed to act as one material.

Objectives:

1. Estimate the suction uplift pressure for West Pond (2.5H:1V Side Slopes), WTP Ponds (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
2. Calculate the tension and strain for West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
3. Evaluate anchor trench design for wind uplift

Notes:

1. The Zornberg and Giroud (1997) equations account for the slope on the which the liner system is installed. West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes) are evaluated.

Summary of Results:

	South Pond (3H:1V Side Slopes) - During Construction			
1	The liner system placed on the side slopes will not exceed the yield strain due to the combined worst-case effects of thermal change, gravity, and wind uplift (assuming it is fully anchored at its top and bottom).			
	Max Strain:	1.1 %	Allowable Strain (FoS = 2):	6.0 %
	Max Tension:	12.5 kN/m	Allowable Tensile Strength:	45.2 kN/m
2	The uplift height assuming no ballasting:		3.6 m	
			11.8 ft	
3	Anchor Trench Design:	Area of Anchor Trench, $A_{design} > A_{req}$		

Calculate uplift and tension and strain of liner system for South Pond (3H:1V Side Slopes)

Limiting Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2 for strain

Side Slope Characteristics:

Slope Angle
β = 18.4 degrees

South Pond - Maximum Unsupported Length:
L = 206 ft
= 62.8 m

Elevation above mean sea level, z 2683 ft
818 m

Temperature and Wind Speed Data:

The maximum daily temperature change is:
From July 2012
ΔTemp = 14.6 °C

Data obtained from: http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?waWMID
- Data is in °F, converted to °C prior to calculating max temperature change
- Maximum daily temperature change estimated using difference of monthly average maximum daily temperature and monthly average minimum daily temperature

The maximum wind speed is:

V = 39 mph
17.4 m/s

Data obtained from: http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?waWWLP
- Maximum wind speed is 90th percentile of maximum monthly wind gust at the Wellpinit climate station for the period of record of 2002-2014

Geosynthetic Liner System Properties/Behavior

Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2

Geomembrane Density: 0.94 g/cm^3 — From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

GeomembraneThickness: 120 mil — Sum of thicknesses for the two geomembrane layers.
= 3.0 mm
= 0.30 cm

Mass per Unit Area (μ_{gm}):

Geomembranes	0.29	g/cm^2	Calculated as the product of the thickness of the geomembrane layers and the geomembrane material density.
Geonet	0.162	lb/sf	Typical value from GSE for GSE 200 mil HyperNet geonet. For comparison, Koerner (2005) lists a typical range of 800 to 1600 g/m^2 for 5-mm thick , solid-rib extgruded biplanar geonet (Koerner, 2005)
	791	g/m^2	
	0.0791	g/cm^2	

Total Mass per Unit Area (μ_{gm}):
0.37 g/cm^2 — Sum of mass per unit areas for the three components of the liner system
= 3.66 kg/m^2

Coefficient of Thermal Expansion
α = 0.00012 C^-1 — Average value reported for HDPE in Koerner (2005)

Tensile strength:

Upper geomembrane	126	lb/in	From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet
Geonet	6	lb/in	Estimated from typical test results provided by GSE for 200 mil HyperNet geonet tested in the transverse direction. Value selected at 12% strain.
Lower geomembrane	126	lb/in	From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

Total strength at yield of: 258 lb/in — Sum of strengths for the three liner system materials.
45.2 kN/m

Strain at yield: 12 % — Elongation at yield for geomembrane

For a Factor of Safety of 2, maximum strain = 6 %

Using Figure 12 in Giroud et al. (1995) - Tension-strain curve for 1.5 mm (60 mil) HDPE geomembrane, estimate J - the geomembrane tensile stiffness:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =	15.0 kN/m		
Strain (elastic) =	2.8 %	=	0.028
So, J = Rise/Run =		=	536 kN/m

Use typical tension-strain curve (transverse direction) from GSE Environmental to estimate J for a GSE HyperNet 200 mil geonet:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =	2.0 kN/m		
Strain (elastic) =	3.5 %	=	0.035
So, J = Rise/Run =		=	57 kN/m

Total J= 1129 kN/m Calculated as sum of tensile stiffness for the three liner system materials.

Calculate threshold uplift wind velocity

From Zornberg & Giroud (1997):

$$V \leq V_{up} = 3.895e^{(6.259 \times 10^{-5})\, z} \sqrt{\mu_{GM} \cos\beta/\lambda} \qquad \text{(A-25)}$$

with V_{up}(m/s), z(m) and μ_{GM}(kg/m^2)

V_{up} = Uplift wind velocity (threshold velocity required to uplift liner system)

μ_{gm} = 3.66 kg/m^2

λ = 0.7

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

z = 818 m (Elevation above sea level)

β = 18.4 degrees

V_{up} = 9.13 m/s

20.4 mph

V > V_{up} Maximum Wind Velocity at the site exceeds the threshold wind velocity required for uplift

Estimate Tension and Strain due to Thermal Effects and Gravity in the SouthPond Side Slopes

Strain due to themal change:
Assume worst case scenario - maximum temperature change

ε_{temp} = Coefficient of Thermal Expansion * Change in Temperature
ε_{temp} = = 0.0018
= 0.18 %

Tension due to themal change:

T_{temp} = $J^*\varepsilon_{temp}$ Equation 5 in Zornberg & Giroud (1997)
= 1.98 kN/m
Maximum Uplift Strain will result from the initial state of a wrinked liner (positive strain) - Giroud pg 942

Tension due to gravity:

T_g = $=\mu_{gm}*g*L*\sin\beta$ Equation 6 in Zornberg & Giroud (1997)

μ_{gm} = 3.66 kg/m^2
g = 9.81 m/s^2
L = 62.8 m
β = 18.4

T_g = 712 N/m
0.71 kN/m

Strain due to gravity:

ε_g = Tension due to gravity / Stiffness
ε_g = T_g/J Equation 7 in Zornberg & Giroud (1997)
= 0.0006
= 0.06 %

Total Initial Strain and Tension due to thermal change and gravity (prior to wind uplift):

ε_0 = strain due to gravity + strain due to thermal change
ε_0 = $\varepsilon_g + \varepsilon_{temp}$ Equation 2 in Zornberg & Giroud (1997)
ε_0 = 0.0024
ε_0 = 0.24 %

T_0 = Tension due to thermal change + tension due to gravity
T_0 = $T_{temp} + T_g$ Equation 3 in Zornberg & Giroud (1997)
T_0 = 2.69 kN/m

Calculate the Effective Suction Force upon the geosynthetic liner system placed on the South Pond Side Slopes

The effective suction is the uplift suction pressure minus the downward force due to the weight of the liner

Using Equation A-40 - in Appendix A-3 of Zornberg & Giroud (1997)

$$S_e = 0.6465\lambda V^2 e^{-(1.252 \times 10^{-4})z} - 9.81\mu_{GM}\cos\beta \qquad \text{(A-40)}$$

with S_e(Pa), V(m/s), z(m) and μ_{GM}(kg/m^2)

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

Where:

λ =	0.7		
V =	17.4	m/s	
z =	818	m	(Elevation above sea level)
μ_{gm} =	3.66	kg/m^2	
β =	18.4		

S_e = 90.1 Pa

1 Pa = 1 N/m^2

S_e = 90.1 N/m^2

Estimate Tension and Strain due to wind uplift for the South Pond geosynthetic liner system

S_e*L = 5659 N/m (per unit length running perpendicular to the perimeter of the pond)

S_e*L = 5.66 kN/m

Estimate Strain Due to Wind:

Using iterations, the following equation can be solved for ε_w (Sin in radians):

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right] \qquad \text{(A-57a)}$$

Using Solver to iterate ε_w until the two terms in Equation A-57a are equal (Difference is equal to zero):

ε_w = 0.0087

= **0.87** %

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = 0.2259 \qquad 0.2259 = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right]$$

Difference 0.0000

Tension Due to Wind:

T_w = J*ε_w Equation 8 in Zornberg & Giroud (1997)

= 9.83 kN/m

Estimate the total strain and tension due to wind, gravity, and thermal changes in geosynthetic liner system on the Sputh Pond Side Slopes

Sum of the total strain due to wind, gravity, and thermal changes:

ε_t	=	$\varepsilon_w + \varepsilon_0$	Equation 9 in Zornberg & Giroud (1997)
	=	0.011	
ε_t	**=**	**1.11 %**	

Sum of the total tension due to wind, gravity, and thermal changes:

T_t	=	$T_0 + T_w$	Equation 10 in Zornberg & Giroud (1997)
T_t	**=**	**12.52 kN/m**	

The total strain is less than the allowable strain (with a FS of 2) of 6 %
The total tension is less than the allowable tensile strength of 45.2 kN/m

Estimate the uplift of the geosynthetic liner system on the South Pond Side Slopes (assuming no ballasting)

From Giroud et al. (1995):

$$\frac{u}{L} = \frac{T}{S_e L} - \sqrt{\left(\frac{T}{S_e L}\right)^2 - \frac{1}{4}} \qquad (53)$$

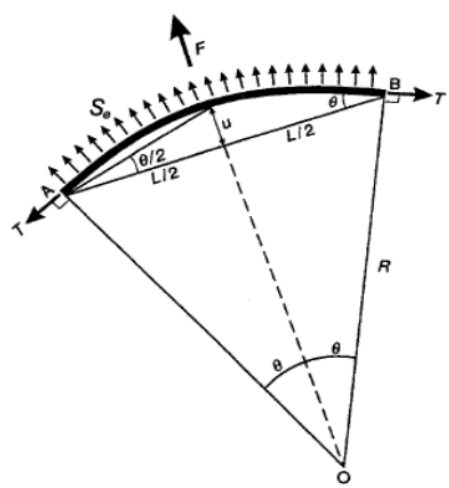
where:

u -	Uplift
L -	Slope length
T -	Total tension
S_eL -	Effective Suction

$T = T_t =$	12.52	kN/m
L =	62.8	m
S_eL =	5.66	kN/m

u/L =	0.057		
u =	**3.59 m**	11.79	ft

This assumes that the liner will have a uniform uplift shape with the uplift perpendicular to the slope at its maximum height



Evaluate the anchor trench design with respect to wind uplift for the South Pond Side Slopes

The anchor trenches were evaluated using Equation 9 (uplifting) from Giroud et al. (1999). This assumes that the anchor trench was designed to provide sufficient passive pressure against lateral sliding.

Anchor Failure by Uplifting

$$W_{min} = W_{min\,uplifting} = T_d \sin(\theta_d - \beta_d) + T_u \sin(\theta_u + \beta_u) \qquad (9)$$

where:

W_{min} =	minimum required weight of anchor material per unit width
T_d	Geosynthetic liner system tension on downslope side of anchor
θ_d	Angle of uplifted geosynthetic liner system with slope on downslope side of anchor
β_d	Slope angle on downslope side of anchor
T_u	Geosynthetic liner system tension on upslope side of anchor
θ_u	Angle of uplifted geosynthetic system with slope on upslope side of anchor
β_u	Slope angle on upslope side of anchor

Since the anchor trench is at the crest of the slope, only the downslope direction is considered for this calculation.
$T_u = \theta_u = \beta_u = 0$

Geosynthetic liner system tension on downslope side of anchor is equal to the total tension due to uplift
$T_d = T_t$ = 12.52 kN/m
$\beta_d = \beta$ = 18.4 degrees

To estimate the angle of uplifted geosynthetic liner system:

$$\theta = 2\tan^{-1}\left(\frac{2u}{L}\right)$$ Equation 55 from Giroud et al. (1995)

u = 3.59 m
L = 62.8 m

$\theta = \theta_d$ = 0.23 radians
13.1 degrees

$W_{min,\ uplifting}$ = 0.00 kN/m

Applying a factor of safety of 1.5 to the W_{min} value is suggested by Giroud et al. (1999)
$W_{factored}$ 0.0 kN/m

Required cross-sectional area of the anchor trench
A_{req} = $W_{factored} / \gamma$ Equation 19 from Giroud et al. (1999)

γ = Unit weight of anchor trench soil
γ = 132 pcf
20.8 kN/m^3

A_{req} 0.00 m^2
A_{req} 0.00 ft^2 0.0 ft square anchor trench

Compare to Anchor Trench Design:
Anchor Trench Width 1.5 ft
Anchor Trench Depth 3 ft

Anchor Trench Area, A_{Design} 4.5 ft^2

$A_{design} > A_{req}$

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	10/24/2014
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	C.Weber(rev. 0)/M.Davis(rev. 1&2)
Detail:	Wind Uplift Calculation	Checked By:	J.Worthen(rev. 0)/C.Weber(rev. 1&2)

SOUTH POND - DURING OPERATION

Purpose:

Estimate the uplift suction on the geosynthetic liner system at Midnite Mine. Also, estimate the internal tension and strain for the liner system due to thermal contraction, gravity, and wind uplift, assuming unballasted conditions. Evaluate the anchor trenches for wind uplift.

Method:

Giroud, J.P., Pelte, T., and Bathurst, R.J., 1995, "Uplift of Geomembranes by Wind", *Geosynthetics International*, Vol. 2, No. 8, pp. 897 - 951.

Zornberg, J.G. and Giroud, J.P., 1997, "Uplift of Geomembranes by Wind - Extension of Equations", *Geosynthetics International*, Vol. 4, No. 2, pp. 187 - 207.

Giroud, J.P., Gleason, M.H., and Zornberg, J.G., 1999, "Design of Geomembrane Anchorage Against Wind Action", *Geosynthetics International*, Vol. 6, No. 6, pp. 481-507.

Assumptions:

1. The maximum allowable liner strain is the yield strain (with a factor of safety of 2 applied)
2. The soil is significantly permeable so that a negative pressure is not developed under the liner due to uplift
3. The tension/strain calculations analyze a section of a uniformly oriented liner system and the effects of the liner system movement (i.e. changes in geometry due to uplift) are not considered. As such, it is assumed that the liner system is fully anchored at the bottom and top of the slope.
4. The geosynthetic liner system consists of a lower 60 mil HDPE geomembrane (with a smooth lower and a textured upper surface) overlain by a 200 mil geonet overlain by an upper 60 HPE geomembrane (textured on both sides). The liner system is assumed to act as one material.

Objectives:

1. Estimate the suction uplift pressure for West Pond (2.5H:1V Side Slopes), WTP Ponds (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
2. Calculate the tension and strain for West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes)
3. Evaluate anchor trench design for wind uplift

Notes:

1. The Zornberg and Giroud (1997) equations account for the slope on the which the liner system is installed. West Pond (2.5H:1V Side Slopes), WTP Pond (2.5H:1V Side Slopes) and South Pond (3H:1V Side Slopes) are evaluated.

Summary of Results:

	South Pond (3H:1V Side Slopes) - During Operation			
1	The liner system placed on the side slopes will not exceed the yield strain due to the combined worst-case effects of thermal change, gravity, and wind uplift (assuming it is fully anchored at its top and bottom).			
	Max Strain:	0.9 %	Allowable Strain (FoS = 2):	6.0 %
	Max Tension:	10.5 kN/m	Allowable Tensile Strength:	45.2 kN/m
2	The uplift height assuming no ballasting:		2.4 m	
			8.0 ft	
3	Anchor Trench Design:	Area of Anchor Trench, $A_{design} > A_{req}$		

Calculate uplift and tension and strain of liner system for South Pond (3H:1V Side Slopes)

Limiting Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2 for strain

Side Slope Characteristics:

Slope Angle
β = 18.4 degrees

South Pond - Maximum Unsupported Length:
L = 155 ft *Considers dead storage volume in pond
= 47.2 m

Elevation above mean sea level, z 2683 ft
818 m

Temperature and Wind Speed Data:

The maximum daily temperature change is:
From July 2012
ΔTemp = 14.6 °C Data obtained from: http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?waWMID
- Data is in °F, converted to °C prior to calculating max temperature change
- Maximum daily temperature change estimated using difference of monthly average maximum daily temperature and monthly average minimum daily temperature

The maximum wind speed is:

V = 39 mph Data obtained from: http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?waWWLP
17.4 m/s - Maximum wind speed is 90th percentile of maximum monthly wind gust at the Wellpinit climate station for the period of record of 2002-2014

Geosynthetic Liner System Properties/Behavior

Assumptions:
Maximum allowable strain is yield strain - due to excessive deflections and resulting membrane thinning
Use a factor of safety of 2

Geomembrane Density: 0.94 g/cm^3 From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

GeomembraneThickness: 120 mil Sum of thicknesses for the two geomembrane layers.
= 3.0 mm
= 0.30 cm

Mass per Unit Area (μ_{gm}):
Geomembranes 0.29 g/cm^2 Calculated as the product of the thickness of the geomembrane layers and the geomembrane material density.
Geonet 0.162 lb/sf Typical value from GSE for GSE 200 mil HyperNet geonet. For comparison, Koerner
791 g/m^2 (2005) lists a typical range of 800 to 1600 g/m^2 for 5-mm thick , solid-rib extgruded
0.0791 g/cm^2 biplanar geonet (Koerner, 2005)

Total Mass per Unit Area (μ_{gm}):
0.37 g/cm^2 Sum of mass per unit areas for the three components of the liner system
= 3.66 kg/m^2

Coefficient of Thermal Expansion
α = 0.00012 C^-1 Average value reported for HDPE in Koerner (2005)

Tensile strength:
Upper geomembrane 126 lb/in From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet
Geonet 6 lb/in Estimated from typical test results provided by GSE for 200 mil HyperNet geonet tested in the transverse direction. Value selected at 12% strain.
Lower geomembrane 126 lb/in From GSE Environmental "GSE HD Textured Geomembrane" Product Data Sheet

Total strength at yield of: 258 lb/in Sum of strengths for the three liner system materials.
45.2 kN/m

Strain at yield: 12 % Elongation at yield for geomembrane

For a Factor of Safety of 2, maximum strain = 6 %

Using Figure 12 in Giroud et al. (1995) - Tension-strain curve for 1.5 mm (60 mil) HDPE geomembrane, estimate J - the geomembrane tensile stiffness:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =	15.0 kN/m		
Strain (elastic) =	2.8 %	=	0.028
So, J = Rise/Run =		=	536 kN/m

Use typical tension-strain curve (transverse direction) from GSE Environmental to estimate J for a GSE HyperNet 200 mil geonet:

Looking at the linear (elastic) portion of the curve:

Tension (elastic) =	2.0 kN/m		
Strain (elastic) =	3.5 %	=	0.035
So, J = Rise/Run =		=	57 kN/m

Total J= 1129 kN/m Calculated as sum of tensile stiffness for the three liner system materials.

Calculate threshold uplift wind velocity

From Zornberg & Giroud (1997):

$$V \leq V_{up} = 3.895e^{(6.259 \times 10^{-5})\, z} \sqrt{\mu_{GM} \cos\beta/\lambda} \qquad \text{(A-25)}$$

with V_{up}(m/s), z(m) and μ_{GM}(kg/m^2)

V_{up} = Uplift wind velocity (threshold velocity required to uplift liner system)

μ_{gm} = 3.66 kg/m^2

λ = 0.7

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

z = 818 m (Elevation above sea level)

β = 18.4 degrees

V_{up} = 9.13 m/s

20.4 mph

$V > V_{up}$ Maximum Wind Velocity at the site exceeds the threshold wind velocity required for uplift

Estimate Tension and Strain due to Thermal Effects and Gravity in the SouthPond Side Slopes

Strain due to themal change:
Assume worst case scenario - maximum temperature change

ε_{temp} = Coefficient of Thermal Expansion * Change in Temperature
ε_{temp} = = 0.0018
= 0.18 %

Tension due to themal change:

T_{temp} = $J^*\varepsilon_{temp}$ Equation 5 in Zornberg & Giroud (1997)
= 1.98 kN/m
Maximum Uplift Strain will result from the initial state of a wrinked liner (positive strain) - Giroud pg 942

Tension due to gravity:

T_g = $=\mu_{gm}*g*L*\sin\beta$ Equation 6 in Zornberg & Giroud (1997)

μ_{gm} = 3.66 kg/m^2
g = 9.81 m/s^2
L = 47.2 m
β = 18.4

T_g = 536 N/m
0.54 kN/m

Strain due to gravity:

ε_g = Tension due to gravity / Stiffness
ε_g = T_g/J Equation 7 in Zornberg & Giroud (1997)
= 0.0005
= 0.05 %

Total Initial Strain and Tension due to thermal change and gravity (prior to wind uplift):

ε_0 = strain due to gravity + strain due to thermal change
ε_0 = $\varepsilon_g + \varepsilon_{temp}$ Equation 2 in Zornberg & Giroud (1997)
ε_0 = 0.0022
ε_0 = 0.22 %

T_0 = Tension due to thermal change + tension due to gravity
T_0 = $T_{temp} + T_g$ Equation 3 in Zornberg & Giroud (1997)
T_0 = 2.52 kN/m

Calculate the Effective Suction Force upon the geosynthetic liner system placed on the South Pond Side Slopes

The effective suction is the uplift suction pressure minus the downward force due to the weight of the liner

Using Equation A-40 - in Appendix A-3 of Zornberg & Giroud (1997)

$$S_e = 0.6465\lambda V^2 e^{-(1.252 \times 10^{-4})z} - 9.81\mu_{GM}\cos\beta \qquad \text{(A-40)}$$

with S_e(Pa), V(m/s), z(m) and μ_{GM}(kg/m^2)

Pg 905 of Giroud et al. (1995): Assume the critical leeward slope experiences suction over the entire length (λ = 0.7)

Where:

λ =	0.7		
V =	17.4	m/s	
z =	818	m	(Elevation above sea level)
μ_{gm} =	3.66	kg/m^2	
β =	18.4		

S_e = 90.1 Pa

1 Pa = 1 N/m^2

S_e = 90.1 N/m^2

Estimate Tension and Strain due to wind uplift for the South Pond geosynthetic liner system

S_e*L = 4258 N/m (per unit length running perpendicular to the perimeter of the pond)

S_e*L = 4.26 kN/m

Estimate Strain Due to Wind:

Using iterations, the following equation can be solved for ε_w (Sin in radians):

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right] \qquad \text{(A-57a)}$$

Using Solver to iterate ε_w until the two terms in Equation A-57a are equal (Difference is equal to zero):

ε_w = 0.0070

= **0.70** %

$$\frac{S_e L}{2(T_0 + J\varepsilon_w)} = 0.2036 \qquad 0.2036 = \sin\left[\frac{S_e L}{2(T_0 + J\varepsilon_w)}(1 + \varepsilon_w)\right]$$

Difference 0.0000

Tension Due to Wind:

$T_w = J^*\varepsilon_w$ Equation 8 in Zornberg & Giroud (1997)

= 7.94 kN/m

Estimate the total strain and tension due to wind, gravity, and thermal changes in geosynthetic liner system on the Sputh Pond Side Slopes

Sum of the total strain due to wind, gravity, and thermal changes:

ε_t	=	$\varepsilon_w + \varepsilon_0$	Equation 9 in Zornberg & Giroud (1997)
	=	0.009	
ε_t	**=**	**0.93 %**	

Sum of the total tension due to wind, gravity, and thermal changes:

T_t	=	$T_0 + T_w$	Equation 10 in Zornberg & Giroud (1997)
T_t	**=**	**10.46 kN/m**	

The total strain is less than the allowable strain (with a FS of 2) of 6 %
The total tension is less than the allowable tensile strength of 45.2 kN/m

Estimate the uplift of the geosynthetic liner system on the South Pond Side Slopes (assuming no ballasting)

From Giroud et al. (1995):

$$\frac{u}{L} = \frac{T}{S_e L} - \sqrt{\left(\frac{T}{S_e L}\right)^2 - \frac{1}{4}} \qquad (53)$$

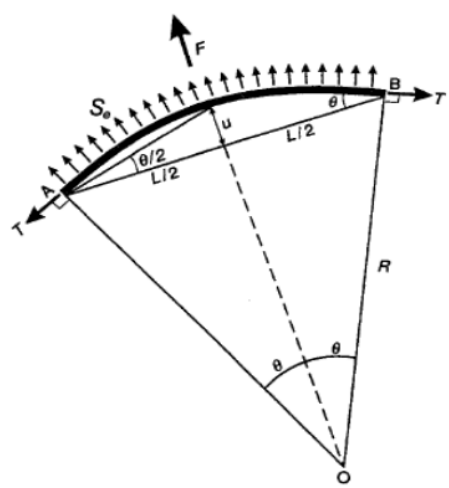
where:

u -	Uplift
L -	Slope length
T -	Total tension
S_eL -	Effective Suction

$T = T_t$ =	10.46 kN/m
L =	47.2 m
S_eL =	4.26 kN/m

u/L =	0.051	
u =	**2.43 m**	7.97 ft

This assumes that the liner will have a uniform uplift shape with the uplift perpendicular to the slope at its maximum height



Evaluate the anchor trench design with respect to wind uplift for the South Pond Side Slopes

The anchor trenches were evaluated using Equation 9 (uplifting) from Giroud et al. (1999). This assumes that the anchor trench was designed to provide sufficient passive pressure against lateral sliding.

Anchor Failure by Uplifting

$$W_{min} = W_{min\,uplifting} = T_d \sin(\theta_d - \beta_d) + T_u \sin(\theta_u + \beta_u) \qquad (9)$$

where:

W_{min} =	minimum required weight of anchor material per unit width
T_d	Geosynthetic liner system tension on downslope side of anchor
θ_d	Angle of uplifted geosynthetic liner system with slope on downslope side of anchor
β_d	Slope angle on downslope side of anchor
T_u	Geosynthetic liner system tension on upslope side of anchor
θ_u	Angle of uplifted geosynthetic system with slope on upslope side of anchor
β_u	Slope angle on upslope side of anchor

Since the anchor trench is at the crest of the slope, only the downslope direction is considered for this calculation.
$T_u = \theta_u = \beta_u = 0$

Geosynthetic liner system tension on downslope side of anchor is equal to the total tension due to uplift
$T_d = T_t$ = 10.46 kN/m
$\beta_d = \beta$ = 18.4 degrees

To estimate the angle of uplifted geosynthetic liner system:

$$\theta = 2\tan^{-1}\left(\frac{2u}{L}\right)$$ Equation 55 from Giroud et al. (1995)

u = 2.43 m
L = 47.2 m

$\theta = \theta_d$ = 0.20 radians
11.7 degrees

$W_{min,\ uplifting}$ = 0.00 kN/m

Applying a factor of safety of 1.5 to the W_{min} value is suggested by Giroud et al. (1999)
$W_{factored}$ 0.0 kN/m

Required cross-sectional area of the anchor trench
A_{req} = $W_{factored} / \gamma$ Equation 19 from Giroud et al. (1999)

γ = Unit weight of anchor trench soil
γ = 132 pcf
20.8 kN/m^3

A_{req} 0.00 m^2
A_{req} 0.00 ft^2 0.0 ft square anchor trench

Compare to Anchor Trench Design:
Anchor Trench Width 1.5 ft
Anchor Trench Depth 3 ft

Anchor Trench Area, A_{Design} 4.5 ft^2

$A_{design} > A_{req}$

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	5/5/2015
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	S. Goodwin
Detail:	South Pond - Evaluate Recommended SDR for HDPE Pipe Ballast	Checked By:	M. Davis

SOUTH POND

Purpose: Evaluate Standard Dimension Ratio (SDR) 17 recommended for ballast piping (6-inch HDPE pipe filled with sand) for the corners of the South Pond.

References: PolyPipe, 2005. Design and Engineering Guide for Polyethylene Piping. December.

Assumption: Unit weight of sand within the pipe is estimated as 120 pcf.

Objective: Calculate the tension for the ballast pipe and compare to the allowable tension to determine if estimated SDR is sufficient.

Note:

All corner locations were evaluated for these calculations for conditions during operations. For the purpose of these calculations, the corners were labeled as North 1, North 2, East, South, and West. The North 1 corner is to the west of the North 2 corner.

Summary of Results:

	South Pond - During Operation			
1	A 6-inch HDPE pipe with a SDR of 17 will not exceed the 50% yield tension due to gravity.			
	Max Tension:	159 psi	Allowable Tensile Strength (50% of yield):	1750 psi
2	SDR	17.0		

Side Slope Characteristics (North 1 Corner

Corner	Slope Angle	β (degrees)	Length (ft)
North 1	3.8H:1V	14.7	195
North 2	4.5H:1V	12.5	230
East	4.2H:1V	13.4	215
South	3.9H:1V	14.4	199
West	4.9H:1V	11.5	253

Note: Length is equal to the length along the corner slope from the top of the embankment(2683') to the dead storage elevation (2633')

HDPE Pipe Properties/Behavior

Pipe is 6-inch HDPE pipe. Properties from PolyPipe (2005) for PE3408

SDR		17	Maximum SDR available
Outer Diameter:		6.625 in	
Inner Diameter:		5.8 in	
Inner Area of Pipe:		26.42 in^2	
	=	0.18 sf	
Area of Pipe (HDPE only):		8.05 in^2	
Weight of HDPE Pipe:		3.338 lb/ft	

Tensile strength at yield: 3500 psi

Estimate Tension due to Gravity

Tension due to gravity:

T_{pipe} = $=W_{pipe}*L*\sin\beta/A_{pipe}$

W_{HDPE}=	3.34 lb/ft	from HDPE Pipe Properties/Behavior (above)
W_{sand}=	22.02 lb/ft	calculated as the unit weight of sand (120 pcf) multiplied by the inner area of the pipe
W_{pipe}=	25.36 lb/ft	calculated as the sum of W_{HDPE} and W_{sand}
A_{pipe}=	8.05 in^2	from HDPE Pipe Properties/Behavior (above)

Corner	Slope Angle	β (degrees)	Length (ft)	T_{pipe} (psi)
North 1	3.8H:1V	14.7	195	156
North 2	4.5H:1V	12.5	230	157
East	4.2H:1V	13.4	215	157
South	3.9H:1V	14.4	199	156
West	4.9H:1V	11.5	253	159

Maximum T_{pipe} 159 psi

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	5/5/2015
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	S. Goodwin
Detail:	West Pond - Evaluate Recommended SDR for HDPE Pipe Ballast	Checked By:	M. Davis

WEST POND

Purpose: Evaluate Standard Dimension Ratio (SDR) 17 recommended for ballast piping (6-inch HDPE pipe filled with sand) for the corners of the West Pond.

References: PolyPipe, 2005. Design and Engineering Guide for Polyethylene Piping. December.

Assumption: Unit weight of sand within the pipe is estimated as 120 pcf.

Objective: Calculate the tension for the ballast pipe and compare to the allowable tension to determine if recommended SDR is sufficient.

Note:

All corner locations were evaluated for these calculations for conditions during operations. For the purpose of these calculations, the corners were labeled as North, East, and West

Summary of Results:

	West Pond - During Operation			
1	A 6-inch HDPE pipe with a SDR of 17 will not exceed the 50% yield tension due to gravity.			
	Max Tension:	131 psi	Allowable Tensile Strength (50% of yield):	1750 psi
2	SDR	17.0		

Side Slope Characteristics (North 1 Corner

Corner	Slope Angle	β (degrees)	Length (ft)
North	5.9H:1V	9.6	249
East	4.4H:1V	12.8	187
West	6.1H:1V	9.3	252

Note: Length is equal to the length along the corner slope from the top of the embankment(2660') to the dead storage elevation (2619')

HDPE Pipe Properties/Behavior

Pipe is 6-inch HDPE pipe. Properties from PolyPipe (2005) for PE3408

SDR		17	Recommended SDR
Outer Diameter:		6.625 in	
Inner Diameter:		5.8 in	
Inner Area of Pipe:		26.42 in^2	
	=	0.18 sf	
Area of Pipe (HDPE only):		8.05 in^2	
Weight of HDPE Pipe:		3.338 lb/ft	
Tensile strength at yield:		3500 psi	

Estimate Tension due to Gravity

Tension due to gravity:

T_{pipe} = $=W_{pipe}*L*\sin\beta/A_{pipe}$

W_{HDPE}=	3.34 lb/ft	from HDPE Pipe Properties/Behavior (above)
W_{sand}=	22.02 lb/ft	calculated as the unit weight of sand (120 pcf) multiplied by the inner area of the pipe
W_{pipe}=	25.36 lb/ft	calculated as the sum of W_{HDPE} and W_{sand}
A_{pipe}=	8.05 in^2	from HDPE Pipe Properties/Behavior (above)

Corner	Slope Angle	β (degrees)	Length (ft)	T_{pipe} (psi)
North	5.9H:1V	9.6	249	131
East	4.4H:1V	12.8	187	131
West	6.1H:1V	9.3	252	128

Maximum T_{pipe} 131 psi

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	5/5/2015
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	S. Goodwin
Detail:	Minimum Allowable Bend Radius for Cold (Field) Bending of Ballast Tubes	Checked By:	M. Davis

Cold (Field) Bending

Purpose: Estimate the minimum allowable bend radius for the recommended ballast for the South and West Ponds (6 in. pipe with a SDR of 17) that is cold bent in the field and ensure the minimum allowable bend radius is less than the minimum design radius.

References: Chevron Pillips Chemical Company LP, Performance Pipe Field Handbook, June 2012.

Assumption: The minimum cold (field) bending radius (long-term) from Table 26 (pp) in the Performance Pipe Field Handbook (June 2012) can be applied. The table is shown below:

Pipe DR	Minimum Cold Bending Radius
9	20 times pipe OD
>9 - 13.5	25 times pipe OD
>13.5 - 21	27 times pipe OD
26	34 times pipe OD
32.5	42 times pipe OD
41	52 times pipe OD
Fitting or flange present in bend	100 times pipe OD

Objective: Calculate the minimum allowable bend radius for a 6 in. pipe with a SDR of 17 that is cold bent in the field.

Summary of Results:

Minimum Design Bending Radius	
20 ft.	from Design Drawings

Pipe SDR	
17 in.	
Minimum Cold Bending Radius	
27 times pipe OD	from the table above
Pipe OD	
6.625 in.	

Minimum Cold Bending Radius
179 in
15 ft.

The miminum cold bending radius for a 6 in. pipe with a SDR 17 is 15 ft which is less than the 20 ft. minimum design bending radius.

Client:	Newmont Mining USA	Job No.:	1011322
Project:	Midnite Mine	Date:	5/20/2015
Description:	Remedial Action Liner Design for Storage Ponds	Computed By:	S. Goodwin
Detail:	Evaluate Adequacy of Support for the Ballast Tubes	Checked By:	M. Davis

Purpose: Evaluate the load on the support holding the ballast tubes within the South Pond and West Pond

Objective: Determine the force on the support holding the ballast tubes and confirm support is sufficient for load.

Summary of Results:

The support for the ballast tubes shown on Drawing 5-14 are sufficient to handle the loads due to the ballast weight.

Estimate the loads of the ballast tubes

Weight per Foot		
HDPE Weight	3.338 lb/ft	from ballast SDR calc sheets
Sand Weight	22.02 lb/ft	from ballast SDR calc sheets

Slope angles are from the Drawings.

Length			Total Weight	Slope Angle (degrees)	Total Force	
West Pond	North Corner	249 ft	6,314 lb	9.62	North Corner	1,055.15 lb
West Pond	East Corner	187 ft	4,742 lb	12.80	East Corner	1,050.92 lb
West Pond	West Corner	252 ft	6,390 lb	9.31	West Corner	1,033.78 lb
South Pond	North 1 Corner	195 ft	4,945 lb	14.74	North 1 Corner	1,258.42 lb
South Pond	North 2 Corner	230 ft	5,832 lb	12.53	North 2 Corner	1,265.21 lb
South Pond	East Corner	215 ft	5,452 lb	13.39	East Corner	1,262.79 lb
South Pond	South Corner	199 ft	5,046 lb	14.38	South Corner	1,253.36 lb
South Pond	West Corner	253 ft	6,416 lb	11.53	West Corner	1,282.86 lb

Determine the maximum allowable load for the ballast support

	Tensile Strength (psi)				Maximum Load Before Tensile Failure (lb)		Maximum Load Before Yielding (lb)	
	Minimum	Maximum	Yield Strength (psi)	Area (in^2)	Minimum	Maximum		Source
1" x 3 1/2" SS Bolt with Washers and Nut	85,000	140,000	45,000	0.6057	51,485	84,798	27,257	http://www.fastenal.com/content/documents/FastenalTechnicalR

	Rated Capacity (lbs)	Source
1" Dia. SS Lifting Eye Nut (0 deg)	9,000	http://www.ewdaniel.com/catalog/images/EWD_Catalog.pdf
1" Dia. SS Lifting Eye Nut (45 deg)	2,250	http://www.ewdaniel.com/catalog/images/EWD_Catalog.pdf

	Nominal Strength (lbs)	Source
7/16" SS Wire Rope 6x19 & 6x37 XIP Grade IWRC	20,400	http://www.wiscolift.com/pages/Wire-Rope-and-Cable.html
7/16" SS Wire Rope 6x19 & 6x37 XIP Grade Fiber Core	18,200	http://www.wiscolift.com/pages/Wire-Rope-and-Cable.html
7/16" SS Wire Rope 6x19 & 6x37 XXIP Grade	22,400	http://www.wiscolift.com/pages/Wire-Rope-and-Cable.html

	Min. Breaking Strength (lbs)	Safe Load (lbs)	Source
7/16" SS Wire Rope	16,540	3,310	http://www.engineeringtoolbox.com/wire-rope-strength-d_1518.html

Attachment E-7

South and West Pond Dead Storage Evaporation Loss Analysis

ATTACHMENT E-7

MIDNITE MINE REMEDIAL ACTION SOUTH AND WEST POND DEAD STORAGE EVAPORATION LOSS ANALYSIS

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*28-Apr-2014*	*Interim Submittal to EPA*	*Christin Kapatayes*	*Melanie Davis*	*28-Apr-2014*	*Tom Kelley*
1	*1-Jul-2014*	*90% Design (minor text changes)*	*Christin Kapatayes*	*Melanie Davis*	*1-Jul-2014*	*Tom Kelley*
1	*14-May-2015*	*100% Design – no changes*				

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usftc2s01\Projects\Newmont\Midnite Mine_2011\6.0 Studies & Reports\6.1 Reports\MWH Reports\90% Basis of Design Report\Interim Submittals\ Pond Evap Loss Analysis

The following calculations were generated using the following software:

Microsoft Office Professional Plus 2010 (Microsoft Excel)

Supplement

Supplement E-7.1 – South and West Ponds Stage-Storage Curves
Supplement E-7.2 – Selected Schematic Water Management System Flow Diagrams - Appendix E, 60% BODR

1.0 INTRODUCTION

Temporary Water Management Ponds will be needed as part of the system for collection, storage, and conveyance of impacted water to the Water Treatment Plant during the Remedial Action (RA) at the Midnite Mine Superfund Site (Site). As now designed, minimum water levels are required in the synthetically-lined Water Management Ponds to provide ballast for wind uplift resistance as described in Appendix E of the 60% Basis of Design Report (BODR).

This memorandum was prepared at the request of EPA's technical reviewers to provide clarification as to whether the anticipated inflows to the Water Management Ponds will be sufficient to maintain the required liner ballast during dry periods. The technical reviewers have expressed concern that if storage pond inflows are not sufficient to offset evaporation losses during dry periods, then additional makeup water will be needed to ensure the necessary amount of ballast is maintained in the Ponds. This memorandum was provided as an interim submittal between the 60% and 90% design stages and was intended to provide additional information for the technical reviewers to aid their evaluation of Water Management Pond designs.

2.0 BACKGROUND

Currently, impacted water is stored in Pit 3 and Pit 4 at the Site prior to treatment at the existing Water Treatment Plant. During the course of the RA, these pits will sequentially be backfilled, and ultimately will no longer be available for water storage once backfilling commences. Two temporary storage ponds (the South Pond and the West Pond) will be used for temporary storage impacted-water during various phases of construction as described in Appendix E of the 60% Basis Of Design Report (MWH, 2013).

During Phase 1, Pit 4 will be dewatered, prepared to receive mine wastes from the Site, and then backfilled. During Phase 1 of the RA, storage of impacted water at the site will occur in Pit 3. At the end of Phase 1, Pit 4 backfilling will be completed and mine waste in the Pit 4 area covered to reduce infiltration of meteoric water. Backfilling will begin in Pit 3 in Phase 2 of the RA. At commencement of Phase 2 construction, the South Pond will be required as Pit 3 will no longer available for water storage.

The South Pond will be constructed as a synthetically-lined pond with double containment provided by two synthetic geomembranes separated by a leak detection layer and used for water storage during the Phase 2 of the RA at the Site. The South Pond will have an effective storage capacity of approximately 64 million gallons (Mgal) after accounting for the approximately 3.2 Mgal of dead storage (which corresponds to a pond elevation of 2,633 ft) that will be maintained in the pond bottom to provide ballast for the liner system. At the minimum dead storage pool elevation of 2,633 ft, the South Pond water surface area will be 61,952 square feet (s.f.). The stage storage curve for the South Pond is included in Supplement E-7.1.

The West Pond will replace the South Pond beginning in Phase 3 of the RA, which includes removal of mine waste beneath and surrounding the South Pond and the completion of backfilling and capping of the Pit 3 Waste Containment Area. The West Pond will remain operational until post-RA water management flows subside to the point where the equalization ponds adjacent to the WTP provide sufficient storage volume for the overall water management system. Similar to the South Pond, the West Pond will include dual-synthetic liner with leak detection as discussed above. The West Pond will have an effective storage capacity of

approximately 24 Mgal after accounting for approximately 1.4 Mgal of dead storage (which corresponds to a pond elevation of 2,619 ft) that will be maintained in the impoundment bottom to provide ballast for the liner system. At the minimum dead storage pool elevation of 2,619 ft, the West Pond water surface area will be 24,927 s.f. The stage storage curve for the West Pond is also included in Supplement E-7.1.

Evaporation losses at the dead storage pool elevations in the South Pond and the West Pond were estimated from historic climate data recorded at the Midnite Mine climate station (NWS Station No. 452913) located near Pit 3 at the Site. This station is a Remote Automated Weather Station (RAWS) that was installed by the U.S. Department of Interior, Bureau of Land Management in approximately 1990. The period of record for the Midnite Mine climate station extends from 1991 through the present (23 years). Specifically, the climate data used in these analyses were the daily calculated evapotranspiration (ET) records obtained from the Western Regional Climate Center website (WRCC, 2013). The calculated evapotranspiration results reported by the WRCC use the Penman-Montieth equation (Allen et al., 1998) to estimate ET from measured daily climate data from the Midnite Mine Station. Climate data used in the calculations include the minimum and maximum temperature, average wind speed, solar radiation, and relative humidity.

3.0 METHOD

3.1 DRY-PERIOD POND INFLOW RATES

Sources of impacted water that will be collected by the Site water management system and contribute to storage pond inflows, both under current conditions and anticipated conditions at key points during construction are discussed in Appendix E of the BODR. It should be noted that some estimates for individual flow components used in water balance calculations presented in Appendix E were based upon assumptions that were conservative (representing the high end of potential flow rates) when used for calculating required pond capacities during wet periods. However, these individual inflow components would not be considered conservative if they were used to estimate the water that may be available for maintaining pond ballast during dry periods.

In cases where potential flow components were identified as inputs for water balance calculations in Appendix E, but may be unreliable as water sources during dry periods, or may be uncertain (e.g., precipitation inputs, inflows from as-yet unidentified residual seeps) these flows were conservatively (from the water-supply perspective) neglected for the purposes of the analyses presented in this memorandum. As a result, the estimated flows at various stages of construction presented in this memorandum are much lower than the estimated flows presented in Appendix E of the 60% BODR.

Based upon the results of water balance analyses of current (historic) conditions using a combination of measured flow records and estimated inflows as shown on Figure E-1 in Appendix E of the 60% BODR, 28-day-averaged inflows into Pit 3 have historically varied from 30 gallons per minute (gpm) to almost 1,000 gpm. It should be noted that the lowest inflow measurements occurred during dry periods in late summer or early autumn when the Water Treatment Plant had stopped operating for the year. For the lowest flow measurements, totalizing flow meters were being read very sporadically, and certain inflow components may not have been correctly accounted for during those periods. A more reliable estimate of current low-inflow rates to Pit 3 during dry times of the year under current (historic) conditions is probably on the order of 50 to 60 gpm. The estimated 28-day-averaged inflows into Pit 4 under

current conditions range from 13 gallons per minute (gpm) to 80 gpm. Based upon the data and calculations used in the water balance analyses of historic conditions, the total 28-day-averaged inflow to Pits 3 and 4 under current conditions can be expected to vary from 63 gpm to approximately 1,000 gpm, with higher flows occurring during the spring snow melt season.

Flow components during the initial Phase 2 South Pond operations are shown on Figure E-3 of Appendix E. The flow components for the water management system will be relatively unchanged from the current system and it is anticipated that pond inflows will be similar to those currently reporting to Pit 3 and Pit 4 (i.e. flows may range from approximately 60 gpm to 1,000 gpm). At the end of South Pond operations (the end of Phase 2), flow components in the water management system will be similar to those shown for the beginning of Phase 3 operations depicted on Figure E-4 of Appendix E.

The end of Phase 2 will be the most critical for South Pond operations from the standpoint of available water supply for maintaining ballast during dry periods. At this point, it is expected that flow from the Western Drainage and East Drainage Area Seeps will be greatly diminished as mine waste in these drainages will have been removed, and only water from residual seeps that may be encountered during the RA will be collected and conveyed to the South Pond. Since the extents and flow rates associated with residual seeps that may persist in the Western and Eastern Drainages after completion of mine waste removal are uncertain, they were conservatively neglected in estimating dry season water availability for these analyses. Likewise, precipitation and surface water inputs, and potential flows from the alluvial groundwater collection system were conservatively neglected in estimating dry season water availability.

For the purposes of providing a conservative, lower bound estimate of water availability to maintain liner ballast at the end of South Pond operations, it is assumed that groundwater inflows to Pit 3, Pit 4, and the BPA are the only reliable pond inflow water sources during extreme dry periods. Using a similar reasoning, it is assumed that groundwater inflows to Pit 3, Pit 4, and the BPA will be the only inflow sources to the West Pond during extreme dry periods. The estimated groundwater inflow rates for Pit 3 (17.5 gpm) and Pit 4 (13.2 gpm) used in water balance modelling summarized in Attachment E-1 to Appendix E were based upon an average of measured and estimated inflow rates from previous investigations (MGC, 2011 and URS, 2002) and were used to provide estimates of dry season inflow rates for the South Pond and West Pond for the evaluation presented in this memorandum.

The BPA consists of the Boyd Pit, Pit 2, Pit 2 West, and Adit Pit that were backfilled (or in the case of the Adit Pit, partially backfilled) during mining operations. The two largest BPA pits, the Boyd Pit and Pit 2 intercept groundwater flow, which will be pumped to the Water Management Ponds during and after the RA. The groundwater inflow rates into the BPA were estimated based upon data obtained during previous BPA dewatering investigations that were submitted to the Bureau of Land Management by Dawn Mining Company in the form of Data Transmittals and a summarized in a memorandum to the EPA titled “Phase I Hydrologic Modeling for Midnite Mine RI/FS” (URS, 2002). The previous BPA dewatering investigation measured groundwater inflow rates into the Boyd Pit (the larger of the two backfilled pits) ranging from 5 to 7 gpm. This is in reasonable agreement with results of the quasi-steady state dewatering that is currently ongoing at a rate of approximately 5 gpm from Boyd Pit and at 4 to 5 gpm from Pit 2 in the BPA. Since a slight water-level drawdown is still occurring in both pits, it is assumed that the long-term pumping rate will be somewhat lower than is currently being realized and a groundwater inflow contribution of 5 to 7 gpm inflow is considered a reasonably conservative estimate for the combined pond inflow from the two BPA pits.

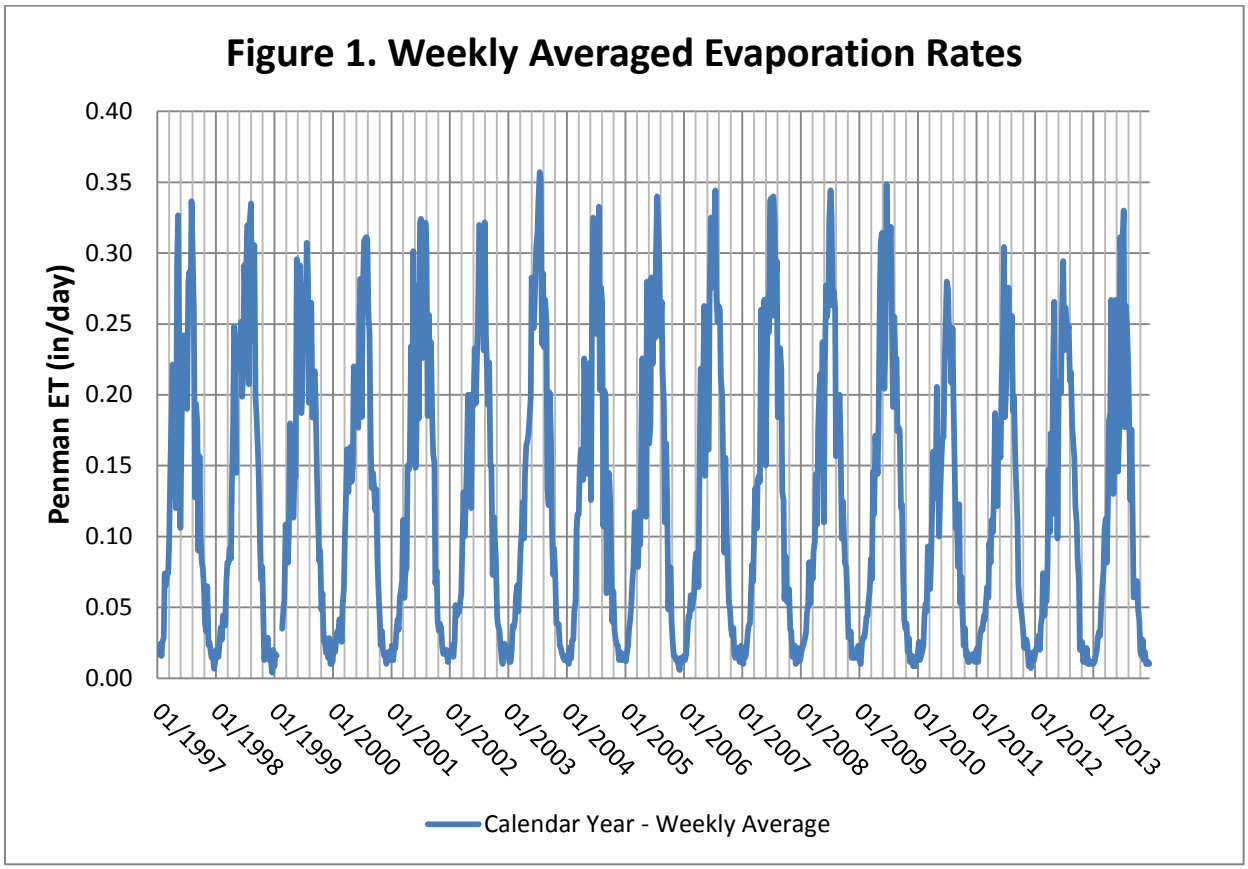
Estimated dry-period pond inflow rates are summarized in Table 1.

Table 1. Estimated Dry-Period Pond Inflow Rates

Stage	Dry-Period Inflow Rate (gpm)
Initial South Pond Inflows – Similar to Current (Historic) Dry-Period Inflow Rates	60 gpm
South Pond - End of Phase 2	35.7 gpm to 37.7 gpm
West Pond – Long Term	35.7 gpm to 37.7 gpm

3.2 EVAPORATIVE LOSSES

Estimates for evaporation losses were used to evaluate if flows from the water management system to the ponds will be sufficient to maintain dead storage volumes in the South and West Ponds. Average weekly evaporation rates were calculated using historical RAWS data from the period from 1997 to 2013. Weekly average evaporation rates (reported in units of inches per day) are shown in Figure 1.



Evaporation losses from the Water Management Ponds were computed using the weekly average evaporation rates and the water surface areas at the dead storage pool elevations for the South and West Ponds as shown in Table 2. An evaporation pan coefficient of 1.0 was

conservatively used for the analysis for estimating evaporation from the storage ponds. Evaporation losses were calculated as follows:

$$Evaporation\ Loss\ = (1.0)(Evaporation\ Rate)(Water\ Surface\ Area)$$

Table 2. South and West Ponds - Dead Storage

Pond	Elevation (ft)	Area (s.f.)	Volume (Mgal)
South Pond	2633	61,952	3.2
West Pond	2619	24,927	1.4

4.0 RESULTS

The results of the pond evaporation loss calculations are summarized in Table 3 below. The results indicate a maximum evaporation loss, based upon historical evaporation rates, of 3.9 gpm for the West Pond at the dead storage pool elevation, with a calculated average evaporation loss of 1.3 gpm. Evaporation losses for the South Pond at the dead-storage pool level are estimated to be a maximum of 9.6 gpm, and 3.3 gpm on average.

Table 3. South Pond and West Pond Dead Storage - Evaporation Losses Summary

	South Pond - Evaporation Losses Weekly Average		West Pond - Evaporation Losses Weekly Average	
	gal/day	gpm	gal/day	gpm
Maximum	13792	9.58	5549	3.85
Average	4759	3.31	1915	1.33
Minimum	154	0.11	62	0.04

5.0 CONCLUSIONS

The following conclusions are based upon results of pond evaporation loss calculations and estimates of dry-period pond inflow rates that conservatively include only pit groundwater inflow components as a water source:

- The South Pond dead storage evaporation losses are expected be less than 9.6 gpm at the dead-storage pool level and on average evaporation losses at this pool level are expected to be about 3.3 gpm.

- The West Pond dead storage evaporation losses are expected to be less than 3.9 gpm at the dead-storage pool level and on average are expected to be approximately 1.3 gpm at this pool level.

- Minimum dry-period inflows to the water management ponds are conservatively estimated to be at least 35 gpm for the South and West Ponds.

- The estimated minimum dry period inflow rates exceed the estimated maximum evaporation losses in both the South Pond and the West Pond by a factor of more than three. Thus, it is concluded that pond inflows will be sufficient to maintain sufficient ballast without the need for adding supplemental water during dry periods.

6.0 REFERENCES

Allen, G; L. Pereira, and D. Raes, 1998. Crop Evaporation – Guidelines for Computing Crop Water Requirements – FAO Irrigation and Drainage Paper 56. ISBN 92-5-104219-5

Miller Geotechnical Consultants (MGC), 2011. Midnite Mine Design Investigation Report – Groundwater Investigations, Revision 2. Prepared on behalf of Newmont USA Limited and Dawn Mining Company for U.S. Environmental Protection Agency, Region 10. June 9.

MWH, 2013. Midnite Mine Superfund Site Preliminary 60 Percent - Basis of Design Report, prepared for Dawn Mining Company and Newmont USA Ltd., December 16.

URS, 2002. Phase I Hydrologic Modeling for Midnite Mine RI/FS, prepared for EPA Region 10, August 15.

Western Regional Climate Center (WRCC), 2013. Monthly and Daily Climate Data for Midnite Mine Climate Station NWS No. 452913. Data accessed via http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?waWMID

Supplement E-7.1 – South and West Ponds Stage-Storage Curves

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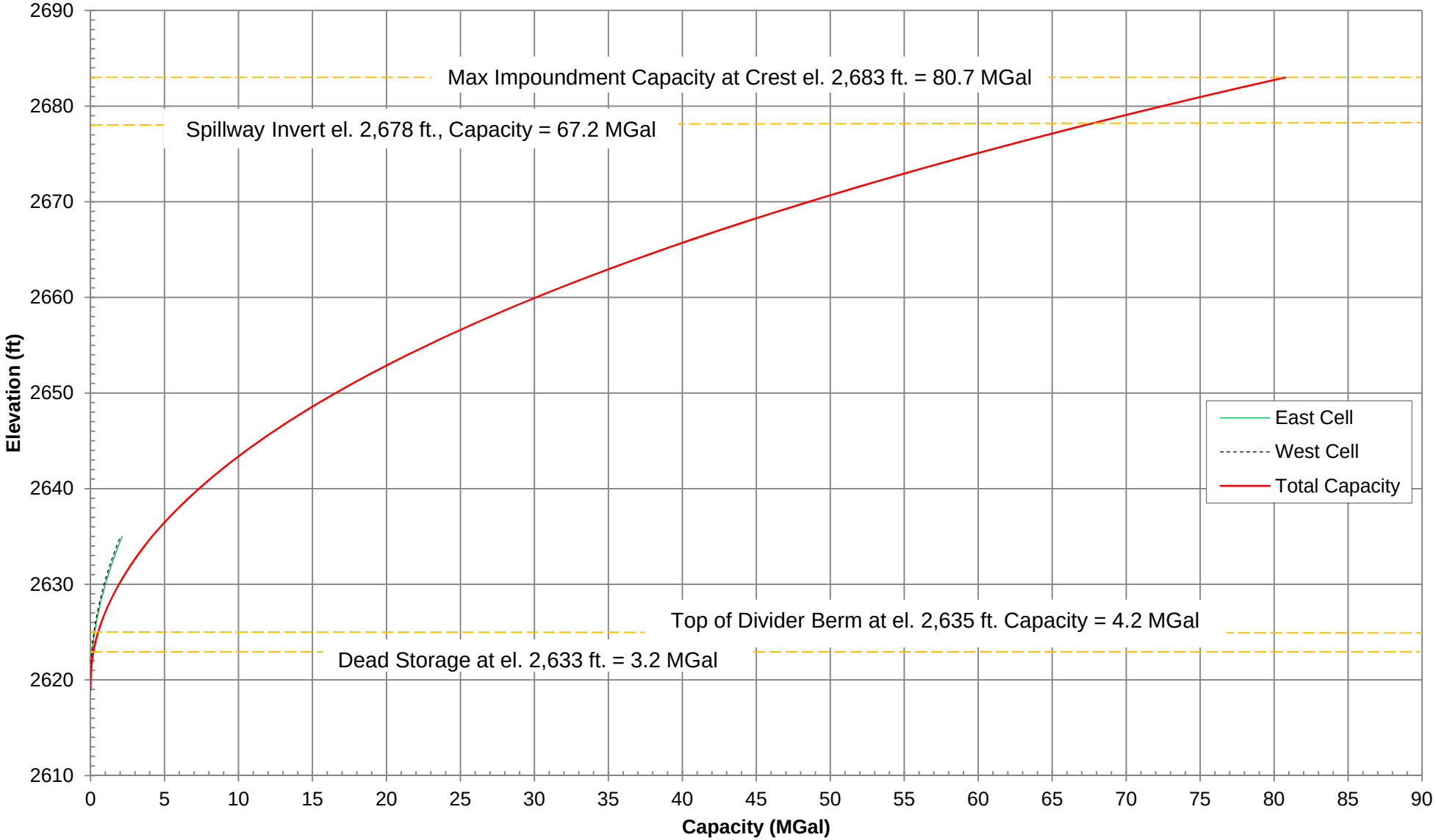
South Pond Stage-Storage



NEWMONT

PROJECT: MIDNITE MINE

TITLE: South Pond Stage-Storage Curve

MWH

DATE: APR 2014

FIGURE S1

FILENAME: Supplement 1.pptx

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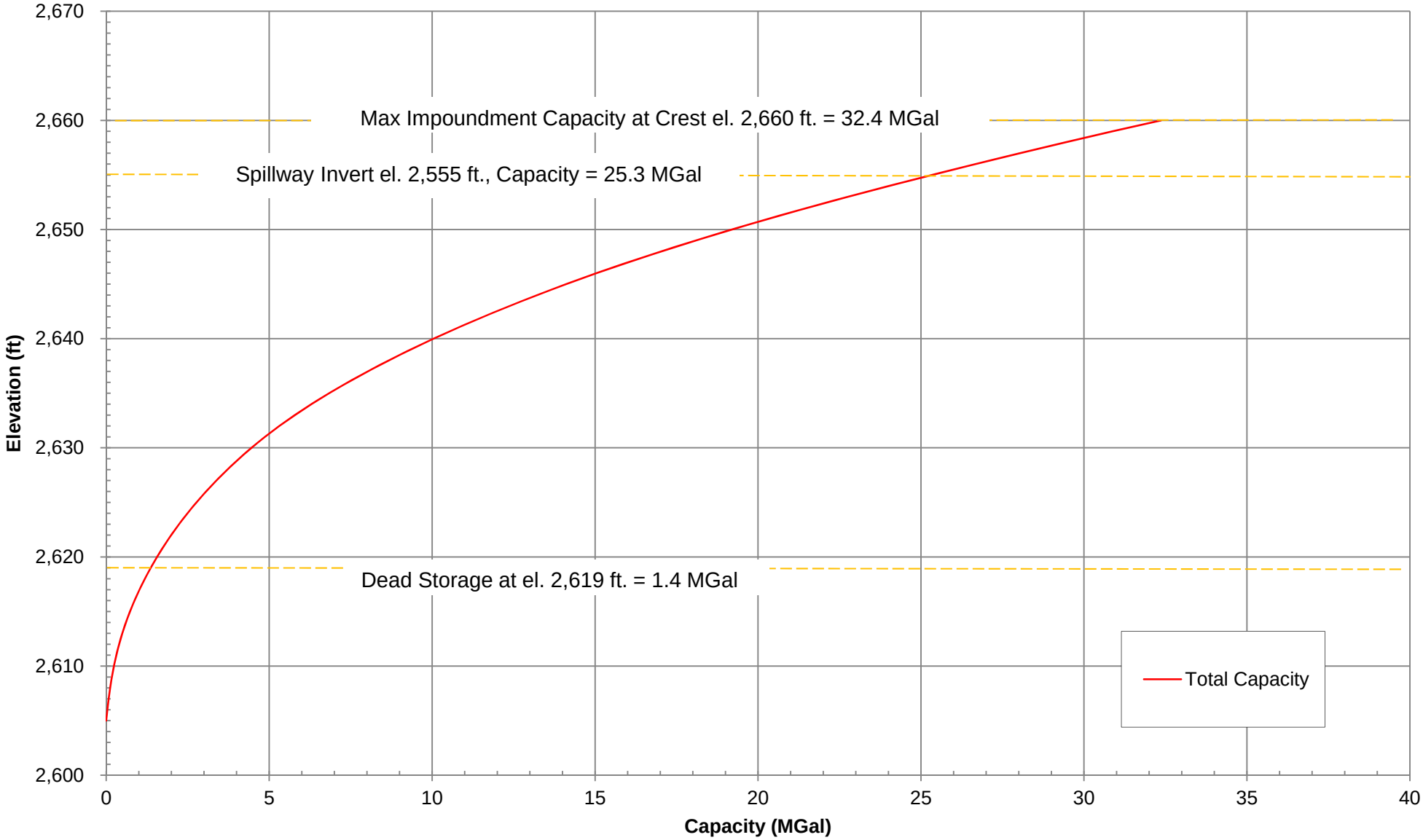
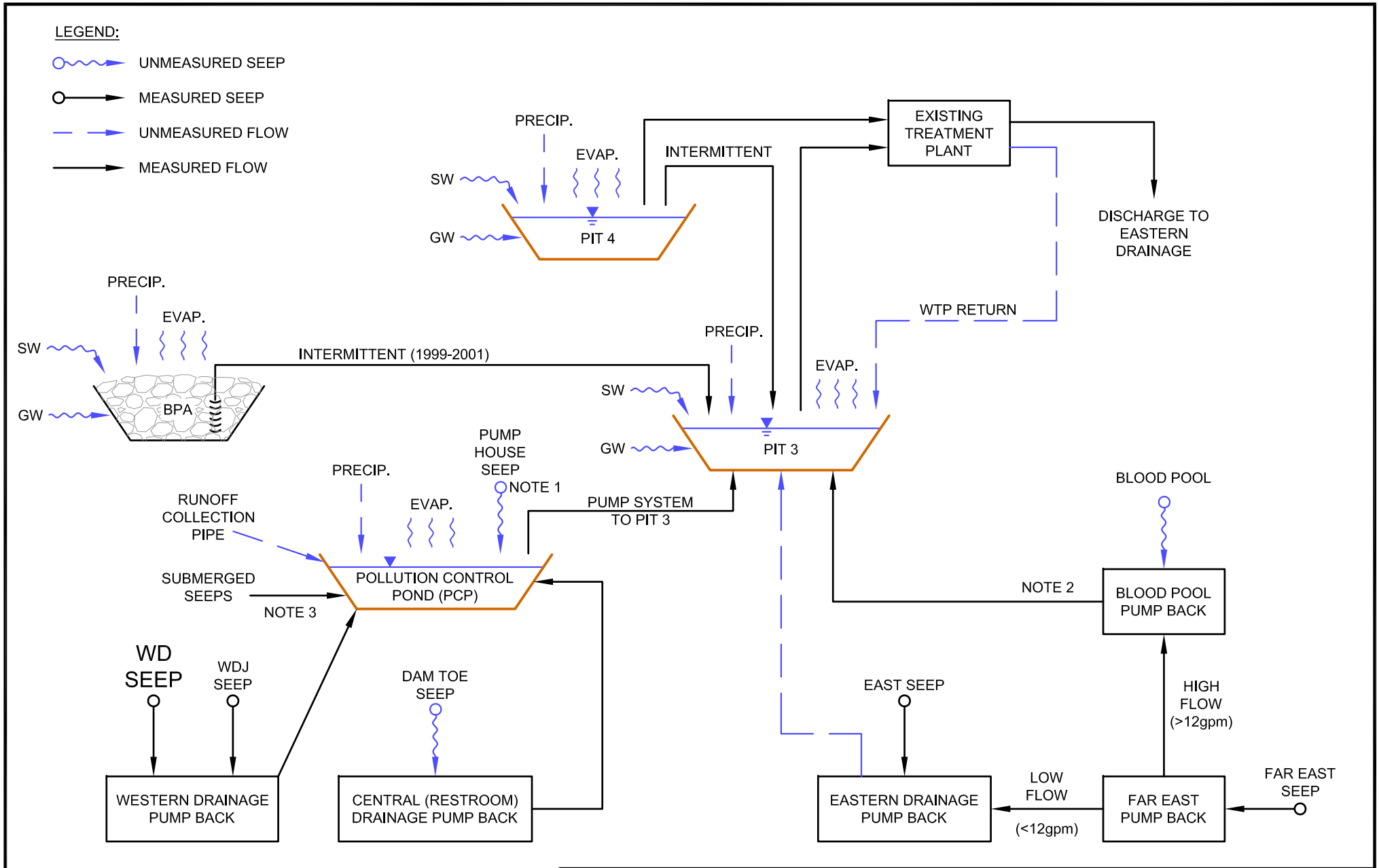
West Pond Stage-Storage



NEWMONT	PROJECT: MIDNITE MINE	MWH
	TITLE: West Pond Stage-Storage Curve	DATE: APR 2014 — FIGURE S2
		FILENAME: Supplement 1.pptx

Supplement E-7.2 – Selected Schematic Water Management System Flow Diagrams - Appendix E, 60% BODR

J:\NRII\Clients_I-P\Newmont\1011322 Midnite Mine\Midnite Mine Water Balance\MidniteMine_60%Design\Schematics\MM_Schematics60%_AppE



NOTES:

1. NOT MEASURED AFTER 2004.
2. NOT MEASURED PRIOR TO 2010.
3. NOT MEASURED PRIOR TO JULY, 2011.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR CURRENT CONDITIONS

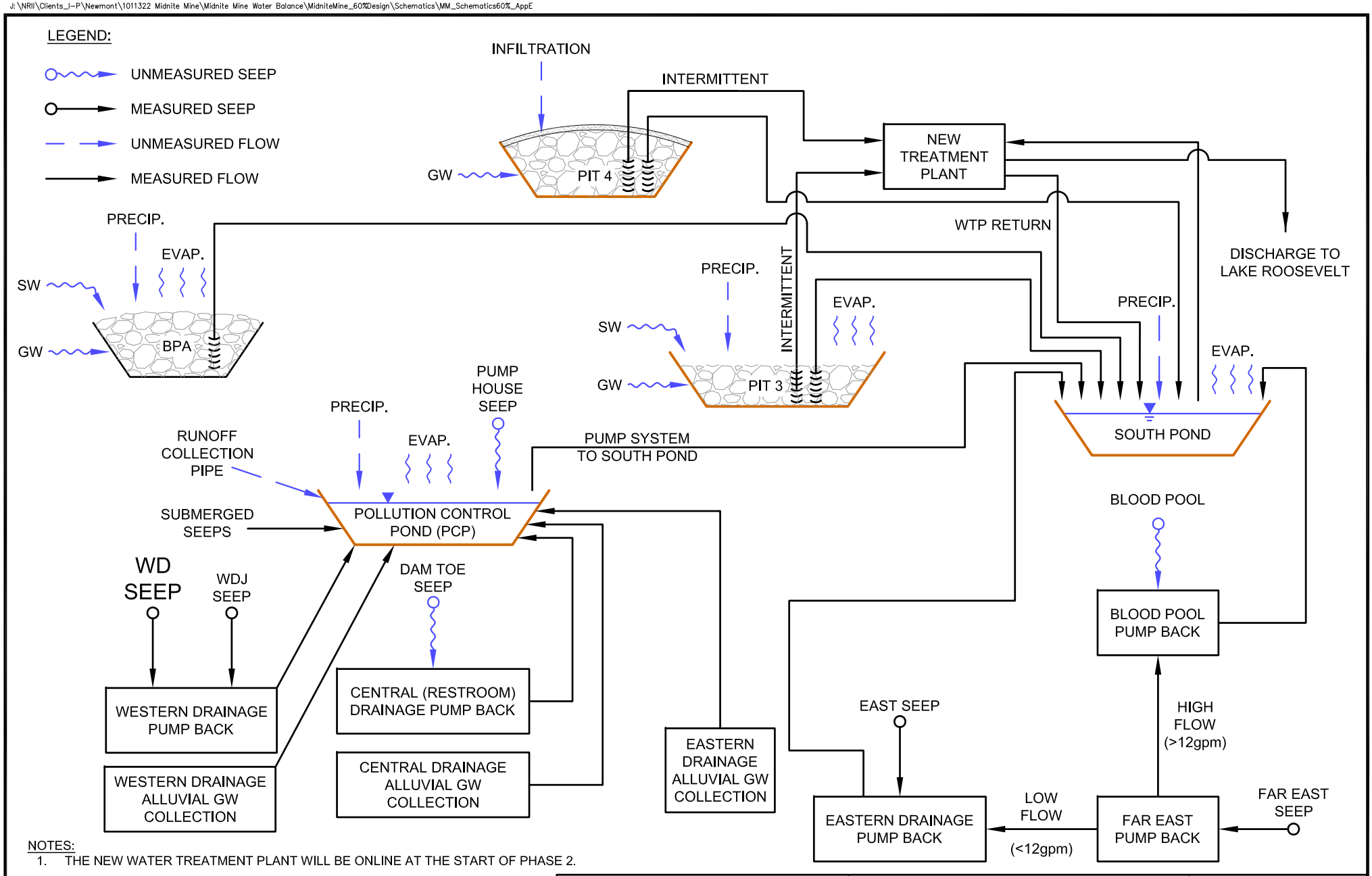
MWH

DATE: DEC 2013

FIGURE E-1

FILE NAME: MM_Schematics60%_AppE

J:\NRII\Clients_I-P\Newmont\1011322 Midnite Mine\Midnite Mine Water Balance\MidniteMine_60%Design\Schematics\MM_Schematics60%_AppE



NOTES:

1. THE NEW WATER TREATMENT PLANT WILL BE ONLINE AT THE START OF PHASE 2.
2. PIT 4 WILL BE COVERED AT START OF PHASE 2.
3. SOUTH POND WILL BE IN OPERATION AT THE START OF PHASE 2.
4. PIT 3 WILL BE DEWATERED, AND BACKFILLED WITH MINE WASTE IN PHASE 2.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR PHASE 2

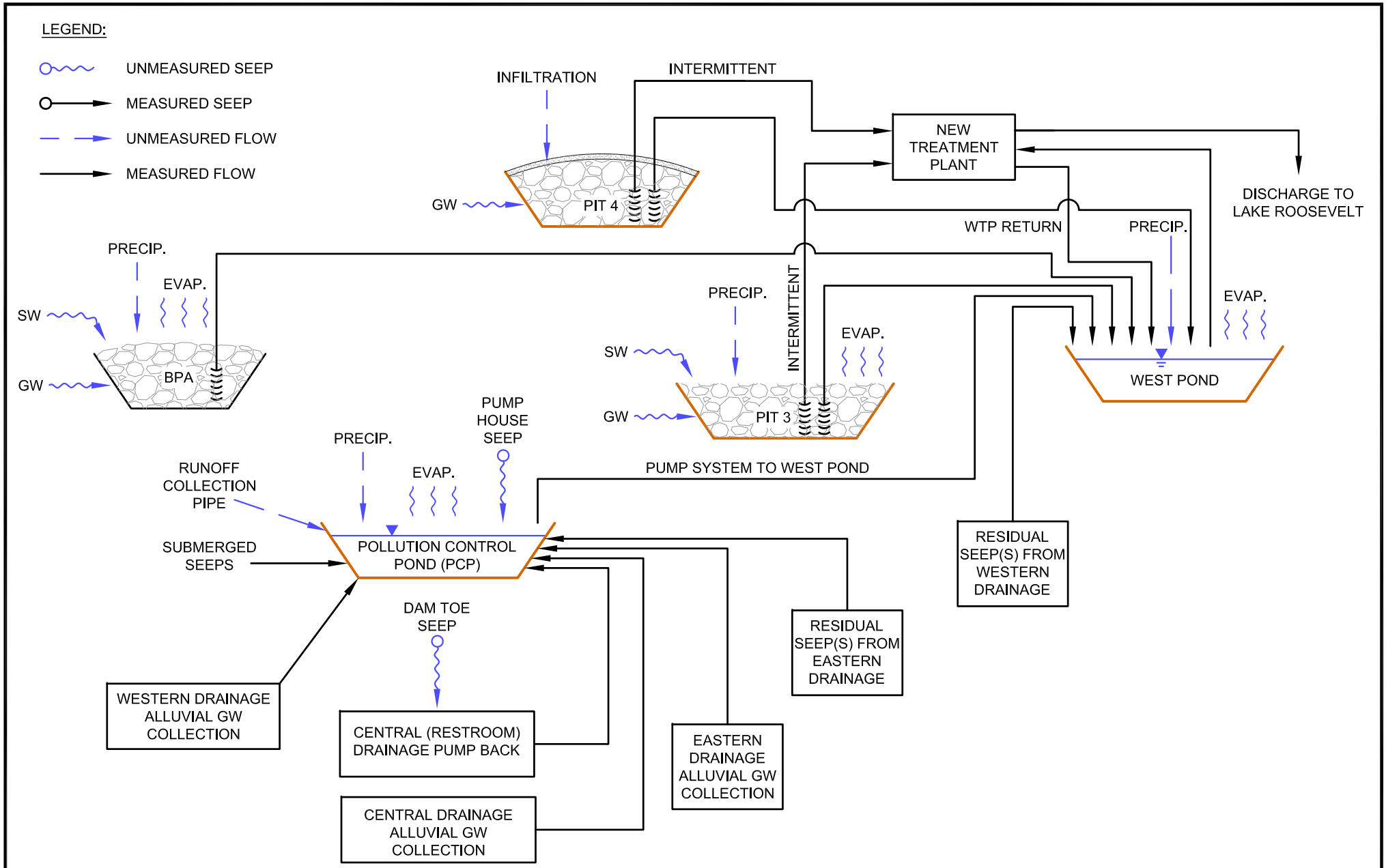
MWH

DATE: DEC 2013

FIGURE E-3

FILE NAME: MM_Schematics60%_AppE

J:\NRII\Clients_I-P\Newmont\1011322 Midnite Mine\Midnite Mine Water Balance\MidniteMine_60%Design\Schematics\MM_Schematics60%_AppE



NOTES:

1. SOUTH POND WILL BE DECOMMISSIONED AT START OF PHASE 3.
2. WEST POND WILL BE IN OPERATION AT START OF PHASE 3.
3. PIT 3 WILL CONTINUE TO BE BACKFILLED WITH MINE WASTE IN PHASE 3.

NEWMONT

PROJECT: MIDNITE MINE

TITLE: WATER BALANCE SCHEMATIC FLOW DIAGRAM FOR PHASE 3

MWH

DATE: DEC 2013

FIGURE E-4

FILE NAME: MM_Schematics60%_AppE

Attachment E-8

Design Step Summary for the Midnite Water Management Ponds

ATTACHMENT E-8

MIDNITE MINE REMEDIAL ACTION DESIGN STEP SUMMARY FOR THE MIDNITE WATER MANAGEMENT PONDS

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*27-Nov-13*	*Draft*	*Luis Calderon*	*Zach Elliott*	*05-Dec-13*	*Carmen Bernedo*
1	*12-Jun-14*	*90% Design*	*Chris Gifford-Miears*	*Zach Elliott*	*23-Jun-14*	*Carmen Bernedo*
1	*15-May-15*	*100% Design – no changes*				

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E - Water Management Ponds\90% Submittal\Att E-8 Design Step Summary

The following calculations were generated using the following software:

Microsoft Office Professional Plus 2010 (Microsoft Excel)

Supplements

Supplement E-8.1 – Design Step Format Worksheet
Supplement E-8.2 – Dam Break Calculation

1.0 INTRODUCTION

This Technical Memorandum presents the assessment of the preliminary design storm or annual exceedance probability (AEP) to be used for emergency overflow spillway design for Water Management Ponds that are part of the remedial activities (RA) at the Midnite Mine Superfund Site (Site). The Site is located in Stevens County on the Spokane Indian Reservation in eastern Washington State, see Figure 1. The Design storms were generated using Washington State Department of Ecology (WSDOE) Dam Safety guidelines, which were selected as the basis for substantive compliance of the storage pond design with applicable regulations.

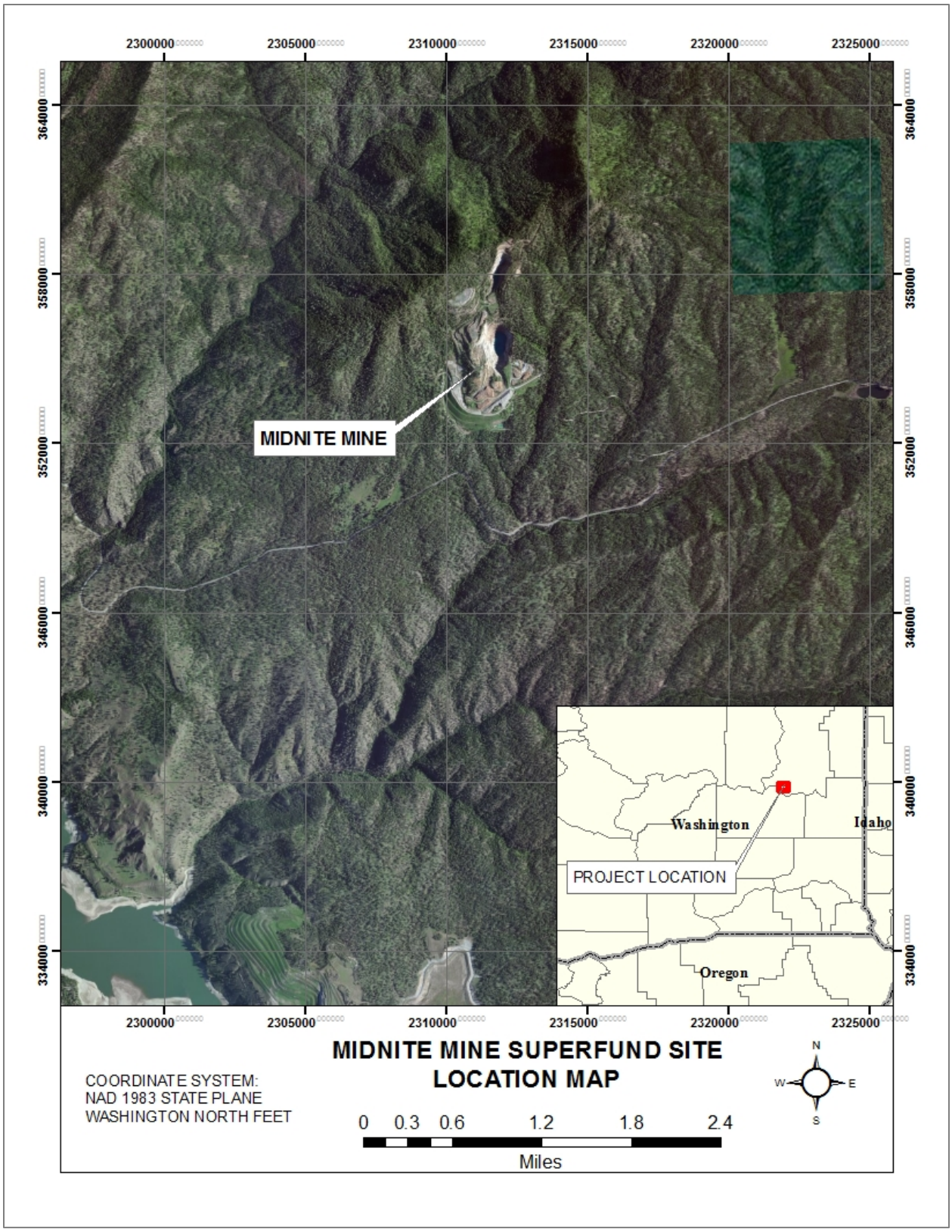


Figure 1. Midnite Mine Project Location

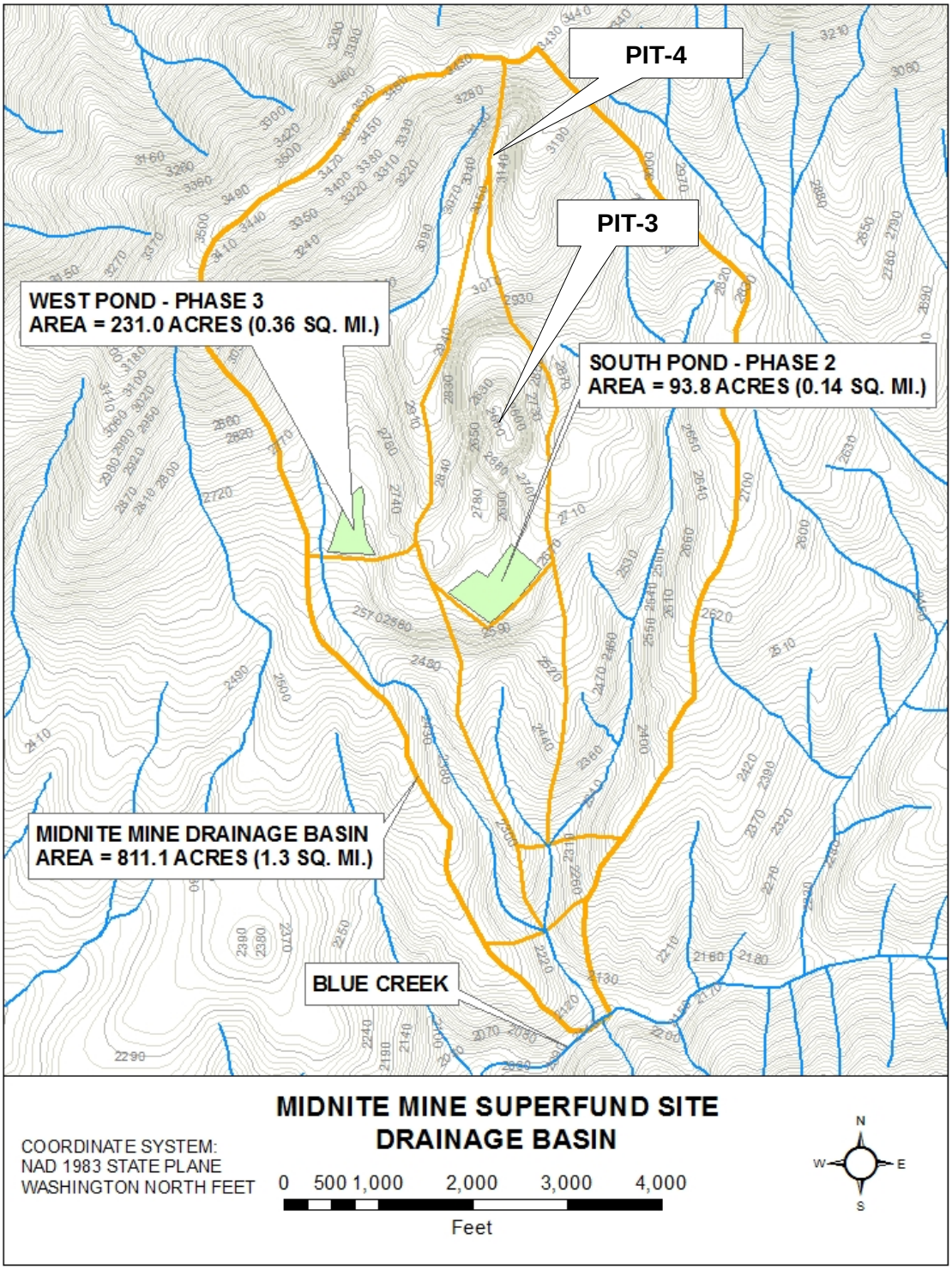


Figure 2. Midnite Mine Storage Pond Location

2.0 STORAGE POND DESCRIPTION

The RA requires consolidation of the mine wastes into Pit 3 and Pit 4 and isolation of the wastes from groundwater and surface water infiltration. Under the current water management system (WMS), Pits 3 and 4 are used to store mine-impacted surface and groundwater prior to water treatment and discharge from the site. Temporary water management ponds (aka, storage ponds) will be needed during RA construction to store the impacted water once pit backfilling commences and the pits are no longer available for water storage.

The South Pond will be constructed during Phase 1 for water storage during Phase 2 and the West Pond will be constructed during Phase 2 for water storage during Phase 3. The South Pond will be decommissioned during Phase 3 after approximately 5 years of operation and the West Pond will be decommissioned after the combined inflow to the WMS has decreased to less than 50 gallons per minute (gpm). It is estimated that the West Pond will be in operation for approximately 15 years. The locations of the proposed storage ponds are shown in Figure 2. Figures 3 and 4 show cross sections for the South and West Ponds, respectively. Further details of the preliminary designs of the storage ponds can be found in Appendix E of the Midnite Mine Superfund Site Preliminary (60 Percent) Design Report (MWH, 2013).

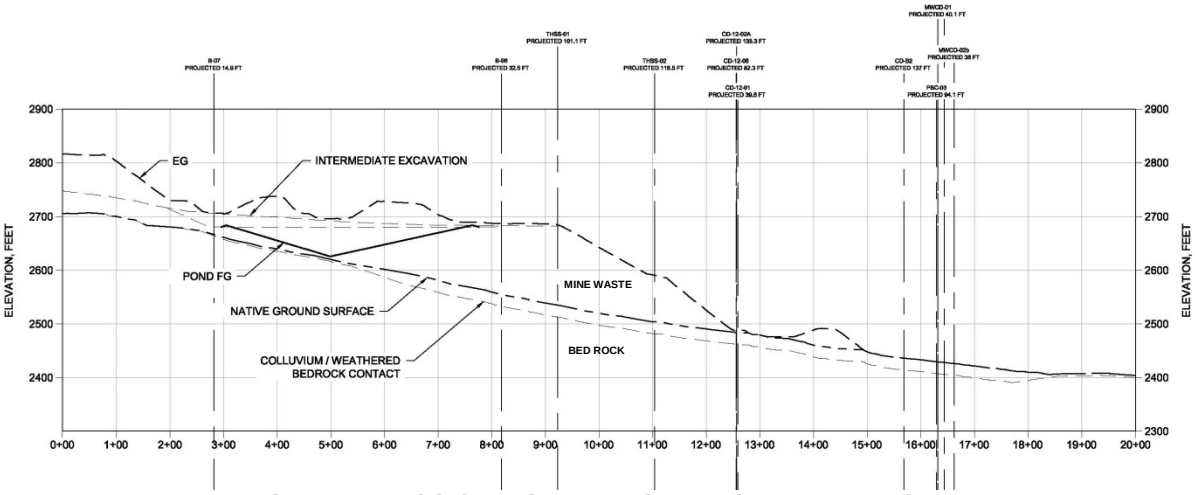


Figure 3. Midnite Mine South Pond Cross Section

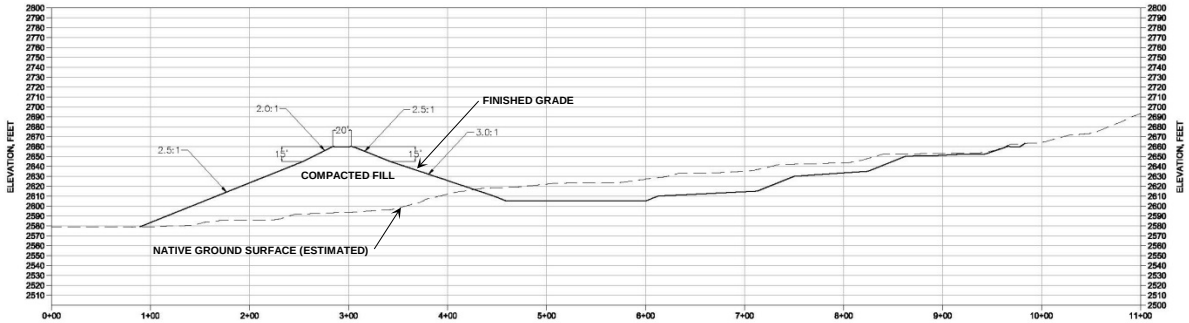


Figure 4. Midnite Mine West Pond Cross Section

3.0 DESIGN STORM

The storage capacities for the South and West Ponds were based on the volume needed to contain flows during the six-week, 100-year wet period assuming that the WTP is inoperable for entire six-week duration. The Design Storm Determinations for the South and West Ponds were performed according to the Design Step Format outlined in *Technical Note 2: Selection of Design/Performance Goals for Critical Project Elements* of the Washington State Department of Ecology Dam Safety Guidelines (WSDOE, 1992b). The design step format incorporates Consequence Dependent Design Levels and Balanced Protection concepts and consists of an eight step increasingly stringent scale of design/performance goals. The eight steps range from an annual exceedance probability (AEP) of 1 in 500 at step 1, to 1 in 1,000,000 at step 8. Step 8 roughly corresponds to theoretical maximum events (i.e. the probable maximum precipitation or PMP) for critical project elements.

The eight design steps and associated AEP are illustrated in Figure 5.

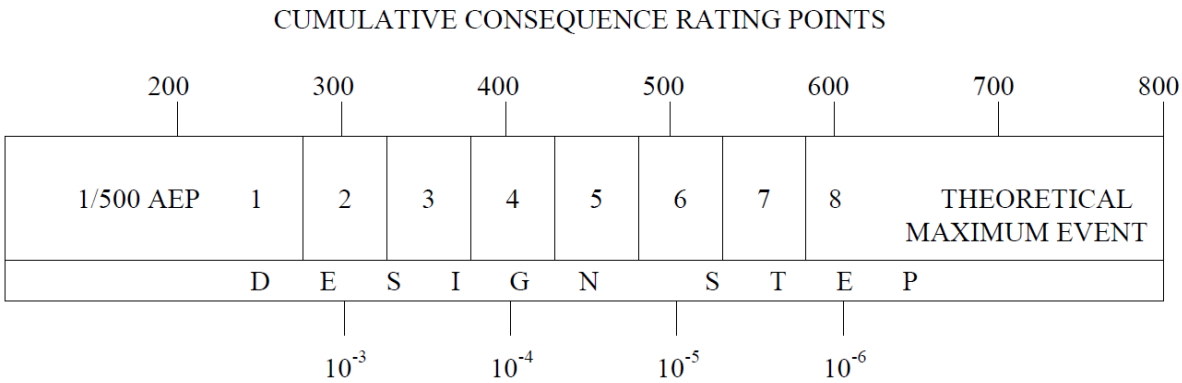


Figure 5. Design Step Format (WSDOE, 1992b)

4.0 DESIGN STEP METHOD

The selection of the design step for critical project elements is based upon cumulative consequence rating points, which are divided into three general categories:

1. Capital value of project
2. Potential for loss of life
3. Potential for property damage

The worksheets used for establishing the design step for the South and West Ponds are included in Supplement E-8.1. Design step ratings were performed by three independent evaluators. The median of the three ratings was used to determine the design step. The following sections document the selection of the final parameters used for selecting the design step for Midnite Mine.

4.1 CAPITAL VALUE OF THE PROJECT

According to WSDOE the capital value consequence rating points can be determined based on the dam height and estimated project benefits. Dam height is indicative of the capital value of the dam. The dam heights for the South Pond and West Pond are shown in Table 1. The dam

height at the upstream toe was used to estimate the capital value index for the South Pond and the dam height at the dam crest centerline was used for the West Pond. Figure 3 of Technical Note 2 was used to estimate the consequence rating points based on dam height as shown in Figure 6. Table 2 shows the capital value consequence rating points for each pond.

Table 1. Dam Heights

Pond	Dam Height at Upstream Toe (ft)	Dam Height at Downstream Toe (ft)	Dam Height Beneath Dam crest (ft)
South Pond	64	180	130
West Pond	55	97	70

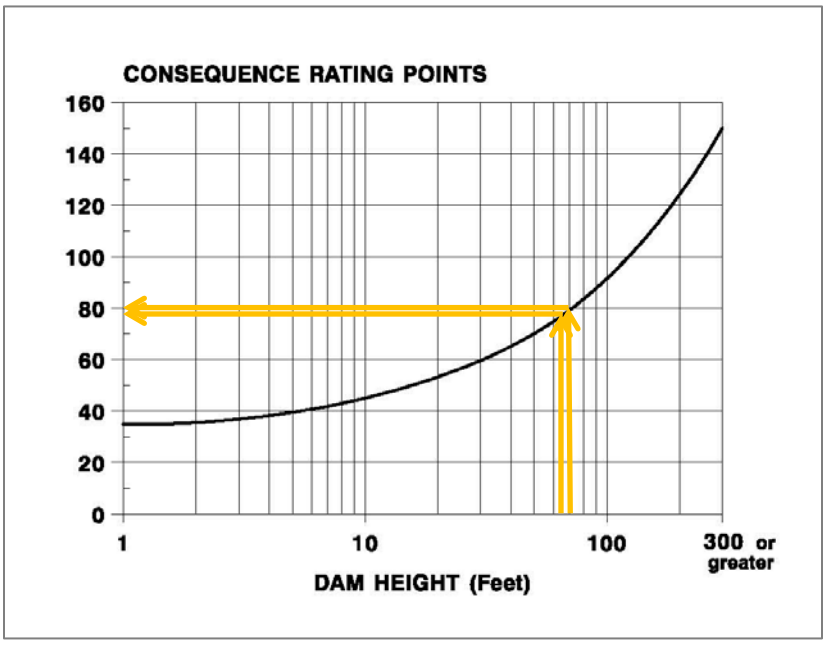


Figure 6. Capital Value Consequence Rating Points

Table 2. Capital Value Consequence Rating Points

Pond	Dam Height (ft)	Consequence Rating Points
South Pond	64	80
West Pond	70	80

The South Pond will be constructed by excavating into the waste rock of the South Waste Rock Pile, rather than by placing and compacting embankment fill to form an impoundment. As such, embankment height at the dam centerline is not a reasonable indicator of the capital value of the pond. The overall capital value of the South Pond is expected to be similar to, or less than that of the West Pond, which will require placement of embankment fill. Correspondence with WSDOE engineer Marty Walther supports using dam height at the upstream toe, or pond excavation depth, for capital value assessment of the South Pond. His opinion is that for the Design Step calculation, the dam height should not exceed the depth of water impounded (personal communication, May 21, 2014). Using the excavated height as an indicator of capital value for the South Pond yields a conservative estimate of the design step.

Project benefit consequence rating points are assigned based on benefits for the general public (mandatory) and benefits for the owner and private enterprise (discretionary) per Table 2 of Technical Note 2. Table 3 lists the project benefit assumptions for Midnite Mine. There are no mandatory considerations for the South and West Ponds. The water contained in the South Pond and West Pond will be impacted site waters that will be treated at the water treatment plant and released, via the Blue Creek pipeline through a diffuser into the Spokane Arm of Lake Roosevelt. As such, the water contained in these ponds has no tangible economic value.

Table 3. Project Benefits

Benefit	Midnite Mine Assumption
Public Water Supply	Not applicable
Irrigation/Industrial Water Supply	Not applicable
Hydropower	Not applicable
Process Water	Not applicable
Recreation / Habitat	Not applicable
Other	Not applicable

4.2 POTENTIAL FOR LOSS OF LIFE

The potential loss of life consequence rating points for each critical project element are determined by three factors:

- Catastrophic potential index
- Population at risk index
- Adequacy of warning

The catastrophic potential index is the ratio of the dam breach peak potential discharge to the 100-year flood peak discharge. The consequence rating points based catastrophic potential index are estimated based on Figure 4 of Technical Note 2. Since both dams are greater than 50 feet, the “Large” dam index was used (WSDOE 1992b).

The dam breach peak discharge for the proposed impoundments was estimated using the simplified methods presented in *Technical Note 1: Dam Break Inundation Analysis and Downstream Hazard Classification* of the Washington State Department of Ecology Dam Safety Guidelines (WSDOE 1992a). Dam breach peak flow estimates using the simplified methods are usually conservative and can be considered very conservative for the South Pond, where the waste rock fill in the embankment will consist of coarse rock fill with boulders up to 3 feet in size. Detailed calculations are included in Supplement E-8.2. Table 4 shows the estimated dam break peak flows for the storage ponds.

Table 4. Dam Break Peak Flows

Pond	Dam Break Peak Flows (cfs)
South Pond	9,946
West Pond	5,663

The 100-year flow peak discharge estimate was taken from a rainfall-runoff model developed for surface water and sediment control design at the Midnite Mine site (MWH, 2013). The design step format requires the 100-year peak flow to be determined at a point where the first residence would be affected by flooding from a dam failure. If there are no permanent dwellings it should be evaluated at a point 1 mile downstream from the dam. Since there are no dwellings downstream, the peak flow was evaluated at the confluence of the Midnite site drainage with Blue Creek. This point is approximately 1.24 miles and 0.96 miles (average 1.1 miles) downstream of the West and South ponds, respectively. Table 5 shows the estimated 100-year peak flows at 1.1 miles downstream of the storage ponds. The consequence rating points were determined based on the ratio of dam breach peak flow and 100-year peak flow as shown in Figure 7 and Table 6.

Table 5. 100-Year 24-hour Peak Flow

Midnite Drainage Area (mi^2)	100-Year 24-hour Precipitation (in)	100-Year 24-hour Peak Flow (cfs)
1.3	2.6	8.5

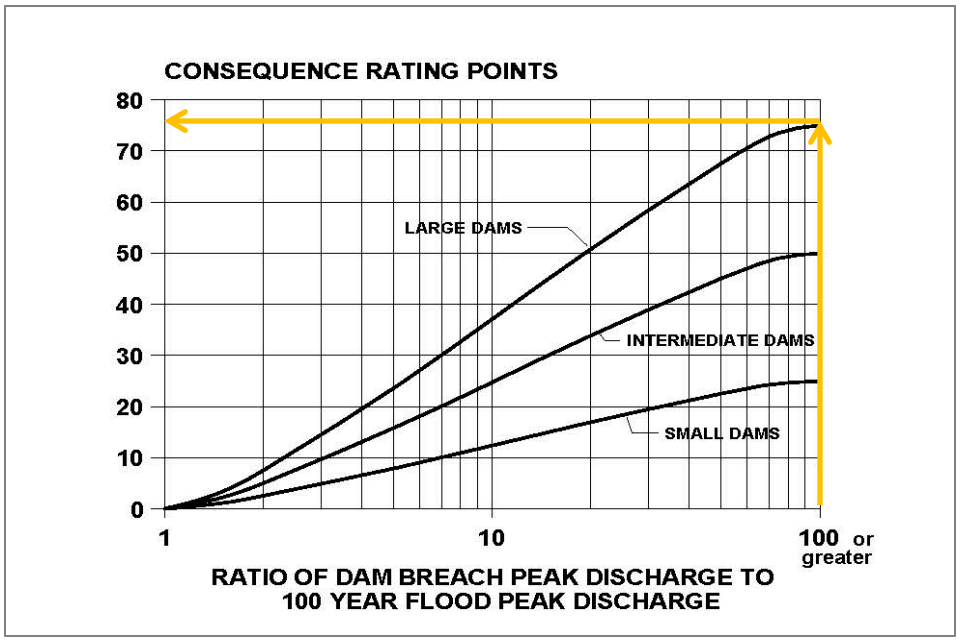


Figure 7. Catastrophic Potential Index Consequence Rating Points

Table 6. Catastrophic Potential Index Consequence Rating Points

Pond	Dam Breach Peak Discharge (cfs)	100-Year Peak Discharge (cfs)	Ratio	Consequence Rating Points Based on Large Dams
South Pond	9,946	8.5	1170	75
West Pond	5,663	8.5	666	75

The population at risk (PAR) was assessed using the methods in *Technical Note 1: Dam Break Inundation Analysis and Downstream Hazard Classification* of the Washington State Department of Ecology Dam Safety Guidelines (WSDOE, 1992a). There are no dwellings or structures downstream of the Midnite Mine drainage. There are three roads downstream as shown in Figure 8. The West End road is a paved road located immediately downstream of the Midnite Mine drainage. Elijah road is unpaved and is located immediately downstream of the Midnite Mine drainage. Blue Creek road is unpaved and parallels Blue Creek to the confluence with the Spokane River. Technically, the upper end of the Blue Creek Road is labeled on maps as Elijah Road, thus, there are two crossings of Elijah Road in close proximity to each other, but no crossings of Blue Creek Road. Only West End road and Elijah road will be considered in the population and property at risk estimates.

WSDOE does not provide specific guidance regarding the PAR for roads. State of Montana dam safety guidelines (MT DNRC, 2010) provide the following guidance in absence of site specific information, shown in Table 7.

Table 7. Population at Risk Estimates for Structures of Human Habitation (Montana DNRC, 2010)

Structure	Estimated PAR
Residence	3
Farm shop building	2
Commercial building	10
Hospital	100
School	100
Municipal park	10
Campground	30
Golf course	30
Airport	30
Paved road	2
Railroad	2

Due to the remoteness of the Midnite Mine location a PAR of 2 persons was assigned for each of the roads downstream of the mine. The consequence rating points based on PAR are estimated based on Figure 5 of Technical Note 2, as shown in Figure 9 and Table 8.

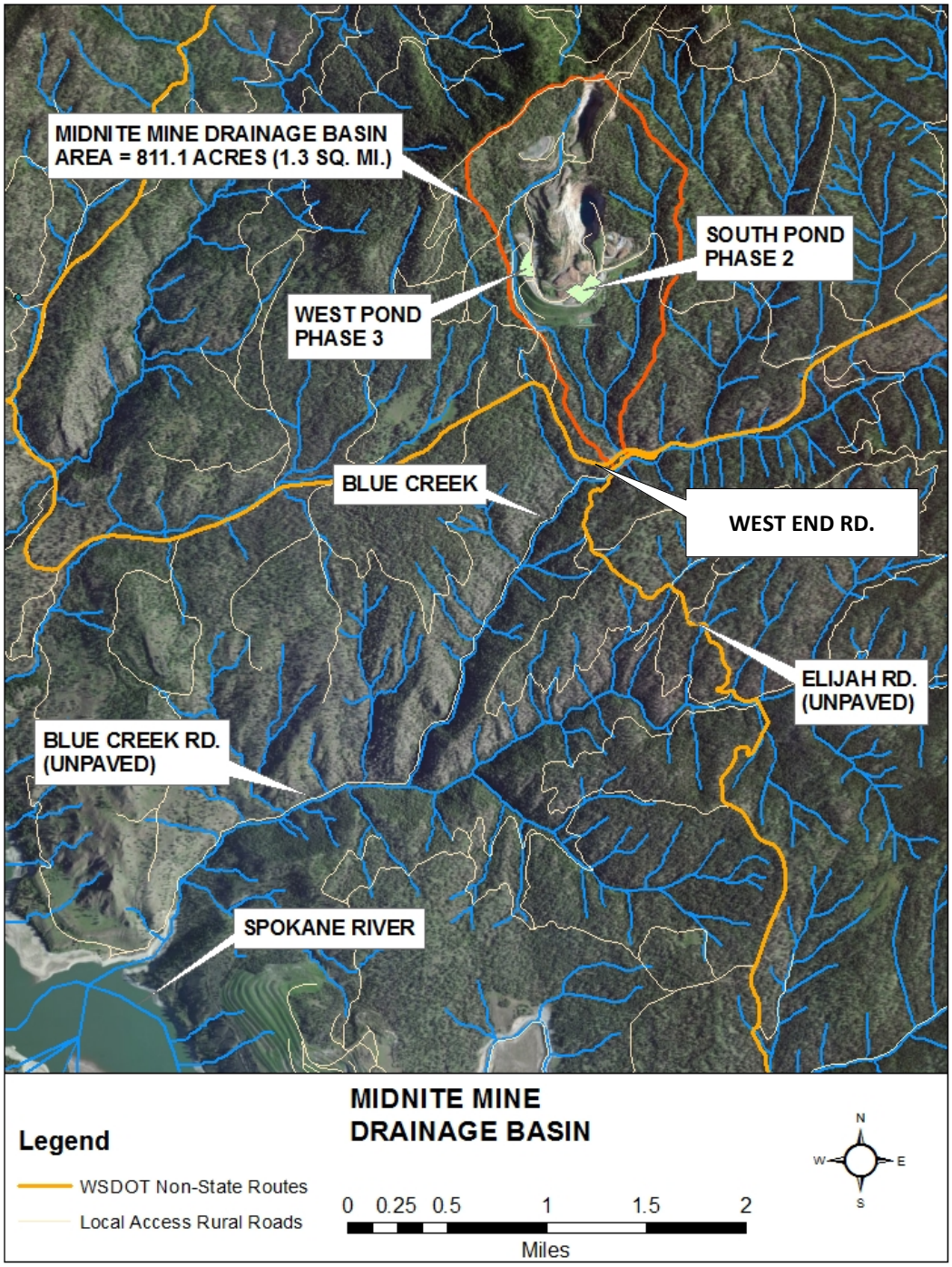


Figure 8. Roads Downstream of Midnite Mine

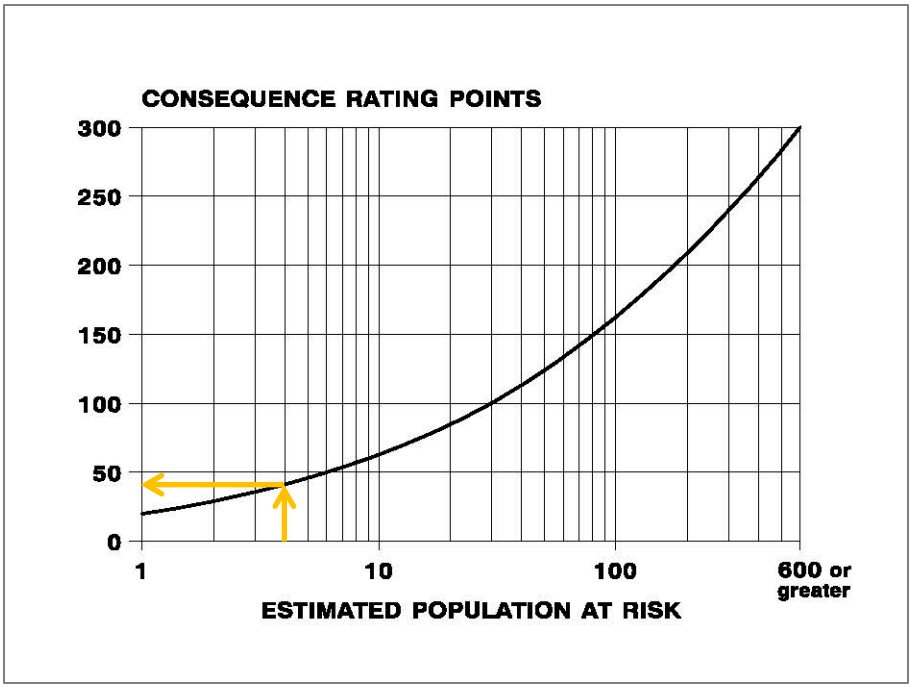


Figure 9. Population at Risk Consequence Rating Points

Table 8. Population at Risk Consequence Rating Points

Pond	Estimated PAR (Number of persons)	Consequence Rating Points
South Pond	4	40
West Pond	4	40

The advanced warning time or time for evacuation after notification or self-recognition of a dangerous situation was classified as adequate or more than 30 minutes. Personnel will be on site during the remediation activities and Water Treatment Plant Operations, therefore the likelihood of a dangerous situation being observed is high. Based on the remoteness of the area and the limited roadway system a marginal rating was assigned to downstream valley setting considerations. Overall, the adequacy of warning is considered adequate. The consequence rating points based on advanced warning time, valley setting and likelihood of notification was estimated based on Table 4 and Figure 6 of Technical Note 2 as shown in Figure 10 and Table 9.

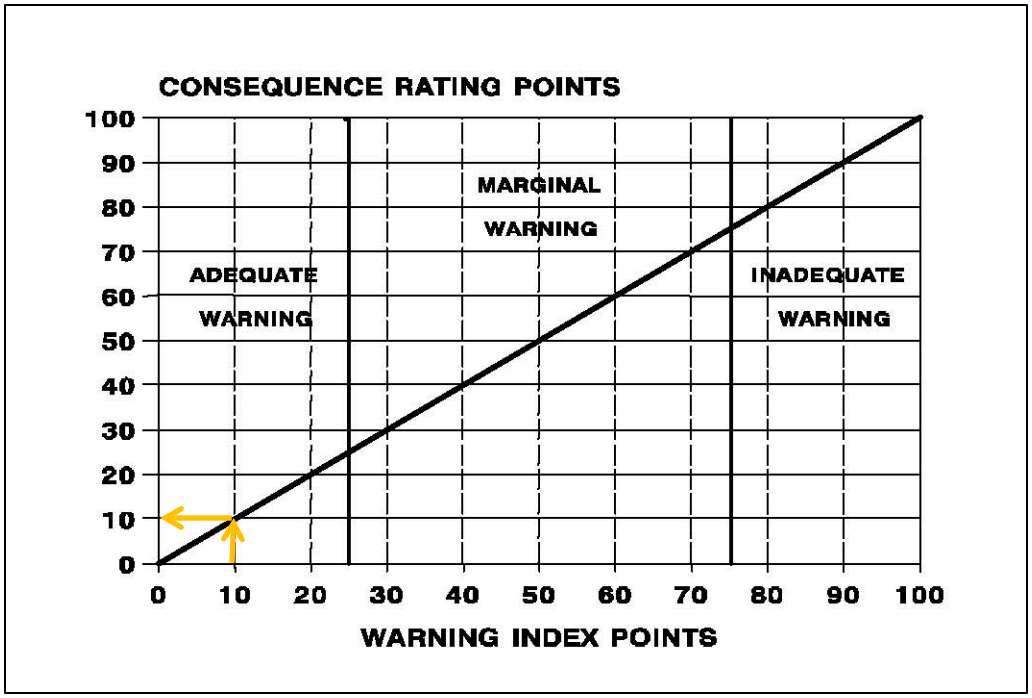


Figure 10. Advanced Warning Consequence Rating Points

Table 9. Advanced Warning Consequence Rating Points

Pond	Advanced Warning Time	Advanced Warning Time	Ease of Evacuation	Overall	Consequence Rating Points
South Pond	Adequate	Adequate	Marginal	Adequate	10
West Pond	Adequate	Adequate	Marginal	Adequate	10

4.3 DOWNSTREAM PROPERTY AT RISK

The potential property damage consequence rating points is determined by four factors:

- Residential units
- Lifeline facilities
- Other important facilities
- Environmental degradation

There are no residential units downstream of the storage ponds or the Midnite Mine drainage. The lifeline facilities downstream are West End road and Elijah road. These are classified as “other public roads” per WSDOE. Property damage consequence rating points were estimated using Figure 7 and Table 5 of Technical Note 2.

Since the storage ponds will be used to store impacted water the contents of the reservoirs are considered deleterious. Release of the reservoir contents would result in release of deleterious material stored on-site and potentially result in long-term environmental degradation. Table 5 and Appendix B of Technical Note 2 were used to establish the rating points for the proposed ponds at Midnite Mine. Table 10 shows the downstream property risk factors considered for

Midnite Mine. The consequence rating points for lifeline facilities and environmental degradation are shown in Tables 11 and 12, respectively.

Table 10. Downstream Property at Risk Factors

Factor	Assumption for Midnite Mine
Residential units:	No residential units downstream
Lifeline facilities:	
- Major highways/ rail lines	Not applicable
- State highways	Not applicable
- Other roads / rail lines	2 roads downstream, 1 paved
Water supply:	
- Storage reservoirs	Not applicable
- Treatment facilities	Not applicable
- Delivery systems	Not applicable
Waste treatment:	Not applicable
Electric power:	Not applicable
Emergency facilities:	Not applicable
Other facilities:	Not applicable
Environmental degradation:	Long term environmental degradation

Table 11. Lifeline Facilities Consequence Rating Points

Pond	Item	Points per item	Consequence Rating Points
South Pond	2 roads	3	6
West Pond	2 roads	3	6

Table 12. Environmental Degradation Consequence Rating Points

Pond	Environmental Degradation	Consequence Rating Points
South Pond	Long term environmental damage	50
West Pond	Long term environmental damage	50

5.0 DESIGN STEP ESTIMATE AND AEP SELECTION

The design step and AEP for the Midnite Mine project elements was determined by adding the consequence rating points obtained from the three categories discussed above and Figure 5. Although different failure modes can produce different design steps, the South and West Ponds

were evaluated for dam failure by overtopping as this generally produces the more severe consequences. Table 13 shows the summary of consequence rating points for the South and West Pond, respectively.

Table 13. Summary of Consequence Rating Points

Category	South Pond	West Pond
Capital Value of Project	80	80
Population at Risk	125	125
Downstream Property at Risk	56	56
Base Points	150	150
Cumulative Consequence Rating Points	**411**	**411**
Design Step	**4**	**4**

Based on Figure 5 both the South and West Ponds falls under a Design Step of 4.The annual exceedance probability (AEP) to be used in spillway design for this design step is 10^{-4} or a return period of approximately 10,000 years.

The Washington State Department of Ecology (WSDOE) Dam Safety Guidelines, *Technical Note 3, Design Storm Construction* (WSDOE, 2009) provides methods for determining precipitation depths and design storm temporal patterns for developing inflow design floods (IDF) in Washington. The procedures used in Technical Note 3 (TN 3) to provide site-specific precipitation magnitude-frequency estimates are based on regional analysis procedures contained in *Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-hour and 2-hour durations in Western and Eastern Washington* (Schaefer et al 2006).

Gridded precipitation datasets were developed as part of the regional precipitation-frequency analysis that allow the user to determine precipitation depths for a selected location, storm durations of 2-hour, 6-hour, and 24-hour, and 10-year, 25-year, 100-year and Design Steps 1 to 8.

For the selection of the design storm dimensionless hyetographs TN 3 divides the state of Washington in regions with similar climatic and topographic characteristics that result in storms having similar characteristics. The climatic regions are shown in Figure 11.

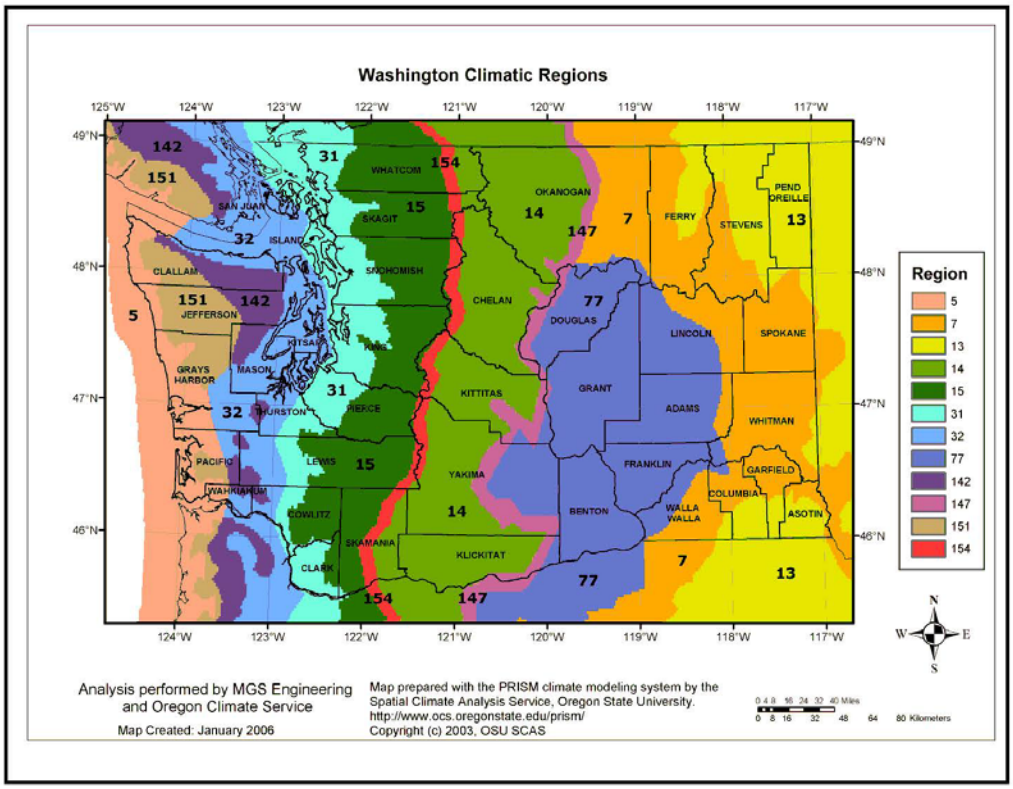


Figure 11. Climatic Regions for Washington State (source: WDOE, 2009)

The Midnite Mine drainage basin is located entirely within Region 7 – Okanogan, Spokane, and Palouse of Eastern Washington.

The following steps are used to determine the storm depths and candidate design storms for a particular location:

1. Determine the Design Step and project design/performance goal as shown on *Technical Note 2* (WSDOE, 1992b).
2. Compute precipitation scaling depth for selected design step for duration used for scaling candidate design storm.
3. Select dimensionless design hyetograph for chosen storm duration for project location.
4. Scale dimensionless design hyetograph by precipitation scaling depth to produce candidate design storm.

WSDOE provides a spreadsheet and gridded precipitation datasets that allow the user to compute the precipitation depths for various durations and design steps. Table 14 shows the results for the 2-hour, 6-hour and 24-hour storms.

Table 14. Storm Depths for Midnite Mine Drainage Basin, Region 7, Washington

Design Step	Storm depth for indicated duration (inches)		
	2-hour	6-hour	24-hour
Design Step 1	1.86	2.10	3.23
Design Step 2	2.15	2.33	3.54
Design Step 3	2.76	2.75	4.09
Design Step 4	**3.51**	**3.22**	**4.68**
Design Step 5	4.46	3.76	5.33
Design Step 6	5.65	4.37	6.03
Design Step 7	7.16	5.07	6.80
Design Step 8	9.05	5.86	7.63

TN 3 recommends that the precipitation depths obtained from the gridded datasets are increased by 15 percent for use in engineering design applications to incorporate some conservatism, account for uncertainty and provide protection from under-design. The scaling depths after applying a 1.15 factor are shown in Table 15. The total storm depths used to generate the WSDOE short, intermediate, and long duration design storms are shown in Table 16.

Table 15. Storm Depths for Midnite Mine Drainage Basin, Region 7, Washington (Increased by 1.15)

Design Step	Storm depth for indicated duration (inches)		
	2-hour	6-hour	24-hour
Design Step 1	2.13	2.42	3.71
Design Step 2	2.48	2.68	4.07
Design Step 3	3.17	3.16	4.70
Design Step 4	**4.03**	**3.70**	**5.38**
Design Step 5	5.13	4.32	6.13
Design Step 6	6.50	5.03	6.93
Design Step 7	8.23	5.83	7.82
Design Step 8	10.41	6.74	8.77

Table 16. Total Storm Depths for Midnite Mine Drainage Basin, Region 7, Washington

Design Step	Storm depth for indicated duration (inches)		
	Short duration	Intermediate duration	Long duration
	4-hour	18-hour	72-hour
Design Step 1	2.21	3.74	4.66
Design Step 2	2.56	4.15	5.11
Design Step 3	3.28	4.90	5.89
Design Step 4	**4.18**	**5.74**	**6.75**
Design Step 5	5.31	6.70	7.68
Design Step 6	6.73	7.80	8.70
Design Step 7	8.52	9.04	9.81
Design Step 8	10.77	10.45	11.01

6.0 REFERENCES

Montana Department of Natural Resources (DNRC), 2010. *Dam Safety Program, Technical Note 2, Loss of Life Determination for Spillway Capacity analysis*.

MWH Americas, Inc. (MWH), 2013. *Midnite Mine Superfund Site Preliminary (60 Percent) Design Report*.

Washington State Department of Ecology (WSDOE), 1992a. *Dam Safety Guidelines, Technical Note 1: Dam Break Inundation Analysis and Downstream Hazard Classification*. Revised, October 2007.

Washington State Department of Ecology (WSDOE), 1992b. *Dam Safety Guidelines, Technical Note 2: Selection of Design/Performance Goals for Critical Project Elements*. July.

Washington State Department of Ecology (WSDOE), 2009. *Dam Safety Guidelines, Technical Note 3, Design Storm Construction.* October.

Supplement E-8.1

Design Step Format Worksheet

Midnite Mine - South Pond

Worksheet for Downstream Hazard Classification and
Selection of Design/Performance Goals for Critical Project Elements
Reference: Technical Note 2, Table 7 on page 23 and worksheet from pages 37 to 47
C. Gifford-Miears

Decision-making framework for Downstream Hazard Classification :

Resources at risk			Hazard	
Population	Economic	Environmental	Class	
0	Minimal	Minimal	**3**	Low
0	Appreciable	Short-term	**2E**	Significant
1 to 6	Appreciable	Short-term	**2D**	Significant
7 to 30	Major	Severe / long-term	**1C**	High
31 to 300	Extreme	Severe / long-term	**1B**	High
> 300	Extreme	Severe / long-term	**1A**	High

Decision-making framework for Design Step:

Consequence Rating Points :	< 270	275 - 320	325 - 370	375 - 420	425 - 470	475 - 520	525 - 570	> 575
Design Step:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Summary for this project :

Hazard Class :		Resources at risk	Hazard Class for that resource	
Population	=	4	2D	<= 2D or higher requires
Economic	=	Minimal	3	Step 3 or higher
Environmental	=	Severe / long-term	1C	

Highest hazard class governs : **1C**

Design Step summary :	Consequence rating points
Capital value of project	80
Population at risk	125
Property at risk	56
Base points	150
Cumulative points	411
Design step	**4**

Midnite Mine - South Pond

Worksheet for Downstream Hazard Classification and
Selection of Design/Performance Goals for Critical Project Elements
Reference: Technical Note 2, Table 7 on page 23 and worksheet from pages 37 to 47
C. Gifford-Miears

					Consequence rating points
I. Capital Value of Project					
A. Dam Height Index	height =	64	feet		80
	(see Tech Note 2, pg. 38)				
B. Value of Reservoir Contents / Project Benefits		Typical points per item	No. of items	Points per item	
Public Water Supply		25 - 75			0
Irrig/Indust Water Supply		10 - 75			0
Hydropower		10 - 75			0
Process Water		10 - 75			0
Recreation / Habitat		10 - 25			0
Other:					0
		Capital Value of Project subtotal =			80

II. Population at Risk

A. Catastrophic Potential Index

Dam breach peak discharge =	9946	cfs	(at dam)	
100-yr flood peak discharge =	8.5	cfs	(at 1st residence downstream or 1 mile downstream)	
Dam size: Small / Intermediate / Large		Large		
Ratio dam breach/100-yr flood	1170.118			75
(see Tech Note 2, pg. 40)				

B. Population at Risk Index

Current population at risk =	4		
Increase due to development =	0	(estimated or projected)	
Future population at risk =	4		40
(see Tech Note 2, pg. 41)			

C. Adequacy of Warning (see Tech Note 2, pp. 42 - 43)

item	index points	Typical points (see pg. 42) Adequate	Marginal	Inadequate
Advanced Warning Time	0	0	25	50
Likelihood of Notification	0	0	15	30
Ease of Evacuation	10	0	10	20

Warning Index Points =	10	(see pg. 43)	10
Warning rated as :	Adequate / Marginal / Inadequate / not applicable		
Population at Risk subtotal =			125

Midnite Mine - South Pond

Worksheet for Downstream Hazard Classification and
Selection of Design/Performance Goals for Critical Project Elements
Reference: Technical Note 2, Table 7 on page 23 and worksheet from pages 37 to 47
C. Gifford-Miears

III. Downstream Property at Risk				Consequence rating points
A. Residential Units				
Number of homes or ERU's =	0			0
(see Tech Note 2, pg. 44)				
B. Lifeline Facilities	Typical points per item	No. of items	Points per item	
Transportation				
Major highways / rail lines	25			0
State highways	10			0
Other roads / rail lines	2 - 5	2	3	6
Water supply				
Storage reservoirs	10 - 75			0
Treatment facilities	10 - 25			0
Delivery systems	5 - 25			0
Waste treatment	5 - 25			0
Electric power	5 - 75			0
Emergency facilities	10 - 75			0
			Lifeline subtotal =	6
C. Other Important Facilities				
Public buildings	10 - 75			0
Fish hatcheries	5 - 25			0
Comm/Indust/Agric	5 - 75			0
Other facilities				0
			Facilities subtotal =	0
D. Environmental Degradation from hazardous releases				
Deleterious contents of reservoir				
Long term environmental damage	10 - 75	1	50	50
Temporary, minor impacts	5 - 20			0
Damage to & releases from other facilities				
Long term environmental damage	10 - 75			0
Temporary, minor impacts	5 - 20			0
			Environment subtotal =	50
			Downstream Property at Risk subtotal =	56

Midnite Mine - West Pond

Worksheet for Downstream Hazard Classification and
Selection of Design/Performance Goals for Critical Project Elements
Reference: Technical Note 2, Table 7 on page 23 and worksheet from pages 37 to 47
C. Gifford-Miears

Decision-making framework for Downstream Hazard Classification :

Resources at risk			Hazard	
Population	Economic	Environmental	Class	
0	Minimal	Minimal	**3**	Low
0	Appreciable	Short-term	**2E**	Significant
1 to 6	Appreciable	Short-term	**2D**	Significant
7 to 30	Major	Severe / long-term	**1C**	High
31 to 300	Extreme	Severe / long-term	**1B**	High
> 300	Extreme	Severe / long-term	**1A**	High

Decision-making framework for Design Step:

Consequence Rating Points :	< 270	275 - 320	325 - 370	375 - 420	425 - 470	475 - 520	525 - 570	> 575
Design Step:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Summary for this project :

Hazard Class :		Resources at risk	Hazard Class for that resource	
Population	=	4	2D	<= 2D or higher requires
Economic	=	Minimal	3	Step 3 or higher
Environmental	=	Severe / long-term	1C	

Highest hazard class governs : **1C**

Design Step summary :	Consequence rating points
Capital value of project	80
Population at risk	125
Property at risk	56
Base points	150
Cumulative points	411
Design step	**4**

Midnite Mine - West Pond

Worksheet for Downstream Hazard Classification and
Selection of Design/Performance Goals for Critical Project Elements
Reference: Technical Note 2, Table 7 on page 23 and worksheet from pages 37 to 47
C. Gifford-Miears

					Consequence rating points
I. Capital Value of Project					
A. Dam Height Index	height =	70	feet		80
	(see Tech Note 2, pg. 38)				
B. Value of Reservoir Contents / Project Benefits		Typical points per item	No. of items	Points per item	
Public Water Supply		25 - 75			0
Irrig/Indust Water Supply		10 - 75			0
Hydropower		10 - 75			0
Process Water		10 - 75			0
Recreation / Habitat		10 - 25			0
Other:					0
		Capital Value of Project subtotal =			80

II. Population at Risk

A. Catastrophic Potential Index

Dam breach peak discharge =	5663	cfs	(at dam)
100-yr flood peak discharge =	8.5	cfs	(at 1st residence downstream or 1 mile downstream)
Dam size: Small / Intermediate / Large		Large	
Ratio dam breach/100-yr flood	666.2353		75
(see Tech Note 2, pg. 40)			

B. Population at Risk Index

Current population at risk =	4		
Increase due to development =	0	(estimated or projected)	
Future population at risk =	4		40
(see Tech Note 2, pg. 41)			

C. Adequacy of Warning (see Tech Note 2, pp. 42 - 43)

item	index points	Typical points (see pg. 42) Adequate	Marginal	Inadequate
Advanced Warning Time	0	0	25	50
Likelihood of Notification	0	0	15	30
Ease of Evacuation	10	0	10	20

Warning Index Points =	10	(see pg. 43)	10
Warning rated as :	Adequate / Marginal / Inadequate / not applicable		
Population at Risk subtotal =			125

Midnite Mine - West Pond

Worksheet for Downstream Hazard Classification and
Selection of Design/Performance Goals for Critical Project Elements
Reference: Technical Note 2, Table 7 on page 23 and worksheet from pages 37 to 47
C. Gifford-Miears

III. Downstream Property at Risk				Consequence rating points
A. Residential Units				
Number of homes or ERU's =	0			0
(see Tech Note 2, pg. 44)				
B. Lifeline Facilities	Typical points per item	No. of items	Points per item	
Transportation				
Major highways / rail lines	25			0
State highways	10			0
Other roads / rail lines	2 - 5	2	3	6
Water supply				
Storage reservoirs	10 - 75			0
Treatment facilities	10 - 25			0
Delivery systems	5 - 25			0
Waste treatment	5 - 25			0
Electric power	5 - 75			0
Emergency facilities	10 - 75			0
			Lifeline subtotal =	6
C. Other Important Facilities				
Public buildings	10 - 75			0
Fish hatcheries	5 - 25			0
Comm/Indust/Agric	5 - 75			0
Other facilities				0
			Facilities subtotal =	0
D. Environmental Degradation from hazardous releases				
Deleterious contents of reservoir				
Long term environmental damage	10 - 75	1	50	50
Temporary, minor impacts	5 - 20			0
Damage to & releases from other facilities				
Long term environmental damage	10 - 75			0
Temporary, minor impacts	5 - 20			0
			Environment subtotal =	50
			Downstream Property at Risk subtotal =	56

Supplement E-8.2

Dam Break Calculation

SUPPLEMENT E-8.2

MIDNITE MINE REMEDIAL ACTION DAM BREAK CALCULATIONS FOR WATER MANAGEMENT PONDS

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*10-Nov-13*	*First Issue*	*Zach Elliott*	*Luis Calderon*	*21-Nov-12*	*Carmen Bernedo*
1	*23-May-14*	*West Pond 90% Updates*	*Zach Elliott*	*Chris Gifford-Miears*	*23-Jun-14*	*Carmen Bernedo*
1	*15-May-15*	*100% Design – no changes*				

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E - Water Management Ponds\90% Submittal\Att E-8 Design Step Summary

The following calculations were generated using the following software:

Microsoft Office Professional Plus 2010 (Microsoft Excel)

1.0 OBJECTIVE

The objective of these calculations is to estimate the characteristics of flooding that could occur downstream of the Midnite Mine West and South Water Management Ponds in the event of a dam failure. Characteristic estimated include the time to failure, peak outflow rate, and downstream flooding characteristics. The simplified method presented by the Washington State Department of Ecology (WSDOE) were used in making these estimates. The results of these simplified analyses are only to be used for the purposes of establishing the design step and annual exceedance probability (AEP) for design of emergency overflow spillways for the West Pond (Phase 3) and South Pond (Phase 2) according to WSDOE design step format for critical project elements (WSDOE, 1992b).

2.0 ASSUMPTIONS

- The maximum water surface elevation is the dam crest elevation
- The West Pond will be constructed by excavating soils from the impoundment area immediately upstream of the West Pond and using them for construction of a pond embankment across the Western Drainage
- The South Pond will be excavated in the South Waste Rock Pile
- The dam breach geometry is trapezoidal
- The downstream limit of the dam break study is the Spokane Arm of Lake Roosevelt
- The flow is steady and one-dimensional

3.0 METHODS AND ANALYSIS

The potential for breaching of a dam or embankment and the resulting impact of the release of stored water downstream is often evaluated during the design of a dam. A simplified dam breach and routing computation given by the Washington State Department of Ecology (WSDOE) was used to estimate the characteristics of flooding that could occur downstream of the Midnite Mine West and South Water Management Ponds in the event of a dam failure. The first step in the simplified calculation was to estimate the breach configuration, geometry, and temporal characteristics for each of the ponds. The peak outflows, flood wave attenuation, and flood wave depths and velocities in the downstream channel were then estimated for the downstream reaches to the Spokane Arm of Lake Roosevelt (Spokane Arm). Figure 1 shows the Midnite Mine project area drainage basin and surrounding roads and creeks to the Spokane Arm. The green lines represent the dam breach flow paths and stations along the flow paths from the West and South Ponds to the Spokane Arm are considered in this analysis.

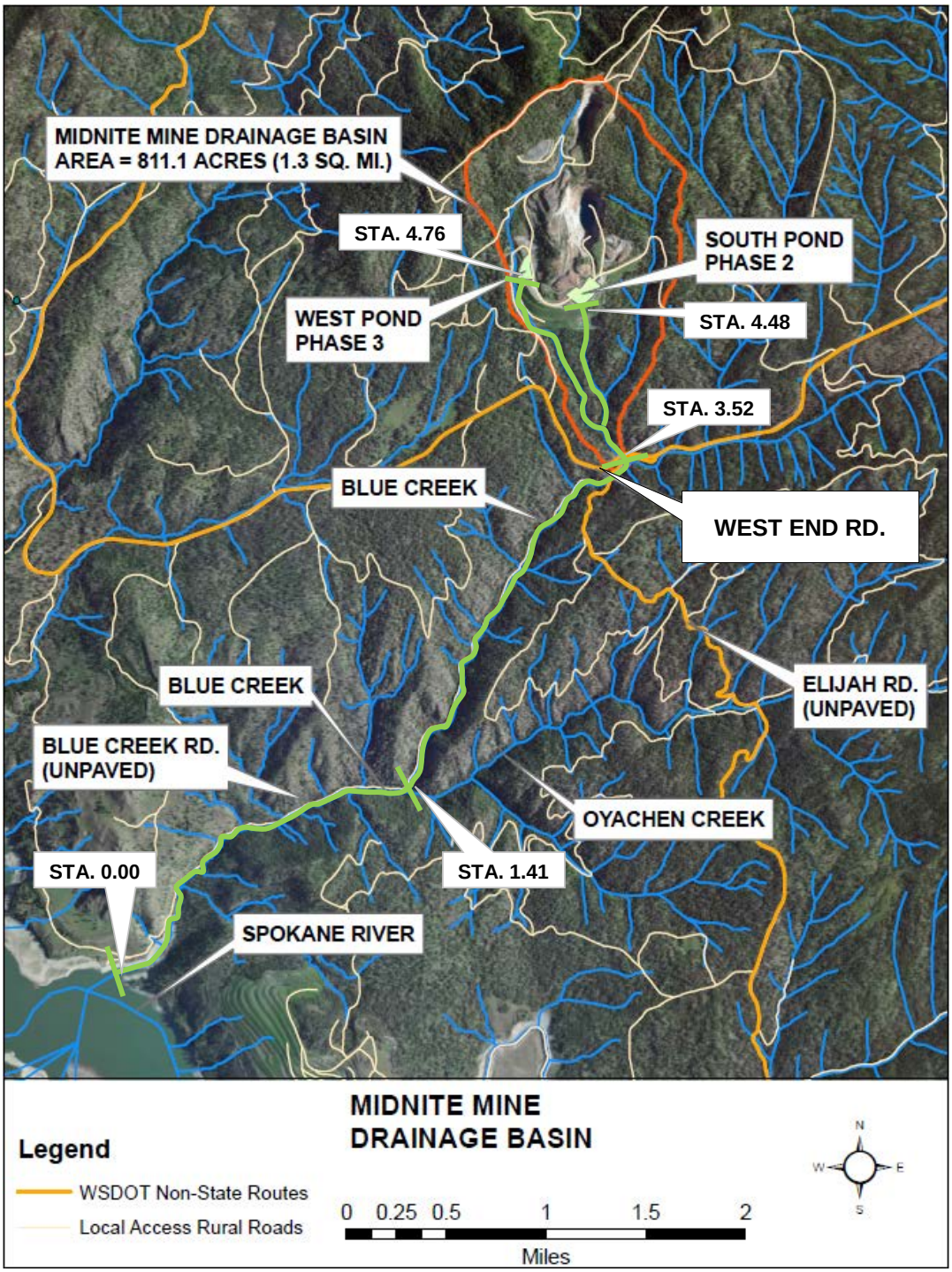


Figure 1. Midnite Mine Project Area

For the purpose of this preliminary assessment, the Spokane Arm (between 4 and 5 miles downstream of West and South Ponds) was assumed to be the downstream limit of the dam break study. The Midnite Mine drainage basin downstream of the West and South Ponds drains to Blue

Creek, approximately 1.1 miles downstream. Blue Creek then flows approximately 3.5 miles downstream to the Spokane Arm. There are no dwellings that were identified in the downstream reach to the Spokane River. However, there are three locations that were identified where the flow path crosses roads. The Midnite Mine drainage crosses the paved West End Road and the unpaved Elijah Road just upstream of its confluence with Blue Creek. Once the Midnite Mine drainage joins Blue Creek, the flow path also crosses Elijah Road again approximately 500 feet downstream of the confluence. Blue Creek then follows the non-paved Blue Creek Road to its outlet at the Spokane Arm. There are also several confluences with tributary creeks along the downstream reach. The Oyachen Creek joins Blue Creek approximately 1.4 miles upstream of the Spokane Arm. These points of interest are identified by the stations shown in Figure 1 where preliminary flooding characteristics were considered.

The geometry, dimensions, and stage-storage data for the West and South Ponds were obtained from the 90% design drawings and the spreadsheet *South_and_West_Pond_Curves_20140428.xlsx* (MWH, 2014). A summary of the input parameters for the WSDOE simplified dam break inundation analysis for the Midnite Mine West and South Ponds is provided in Table 1.

Table 1. Summary of Input Parameters for Simplified Dam Break Inundation Analysis

Input Parameter	West Pond	South Pond
Dam crest elevation (ft)	2,660	2,683
Breach base elevation (ft)	2,605	2,619
Hydraulic height of breach[(1)] (ft)	55	64
Dam crest width (ft)	20	50
Reservoir volume (acre-ft)	99.85	247.78
Reservoir surface area (acres)	4.67	8.79
Slope of upstream face of dam (Z_1:1)	3.0	3.0
Slope of downstream face of dam (Z_2:1)	2.5	2.0

Notes:
[(1)]Maximum water surface elevation assumed to be dam crest elevation

The temporal and geometric parameters of the breach, including the average final breach width and time of breach formation (failure), can be estimated in a number of different ways. A method for estimating these two dam breach parameters can be found in the Washington State Department of Ecology (WSDOE) Dam Safety Guidelines documentation (WSDOE 1992a). An initial guide to estimating limits of these parameters for earthfill dams is given in Table 2 (WSDOE 1992a).

Table 2. Summary of WSDOE Breach Parameters for Earthfill Dams (WSDOE, 1992a)

Dam Type	Average Breach Width (Dam Heights)	Side Slope of Breach Z_b (Z_b H:1 V)	Failure Time (Hours)
Earthfill Dam	Min: 0.4 Max: 13 Mean: 4	Min: 0 Max: 6 Mean: 1	Min: 0.1 Max: 12 Mean: 2

Further estimations of these parameters can be obtained by using empirical equations presented in the WSDOE Dam Safety Guidelines documentation (WSDOE 1992a). Because the dam breach size is expressed as a function of the volume of material eroded (V_m) in the WSDOE documentation, a parameter known as the dam factor or breach formation factor (BFF), which is related toV_m, can be formed as a product of the height and volume of water behind the dam:

$$BFF = V_w(H_w)$$

Where:

BFF = breach formation factor

V_w = volume of water stored in the reservoir at the water surface elevation under consideration (acre-ft)

H_w = height of water over the base elevation of the breach (ft)

The volume of material eroded away in earthen dams composed of cohesionless embankment materials can be estimated from:

$$V_m = 3.75(BFF)^{0.77}$$

Where:

V_m = volume of material in breach that is eroded (yd^3)

The volume of material eroded away in earthen dams composed of erosion-resistant embankment materials can be estimated from:

$$V_m = 2.50(BFF)^{0.77}$$

These equations are shown graphically in Figure 2 below (WSDOE, 1992a).

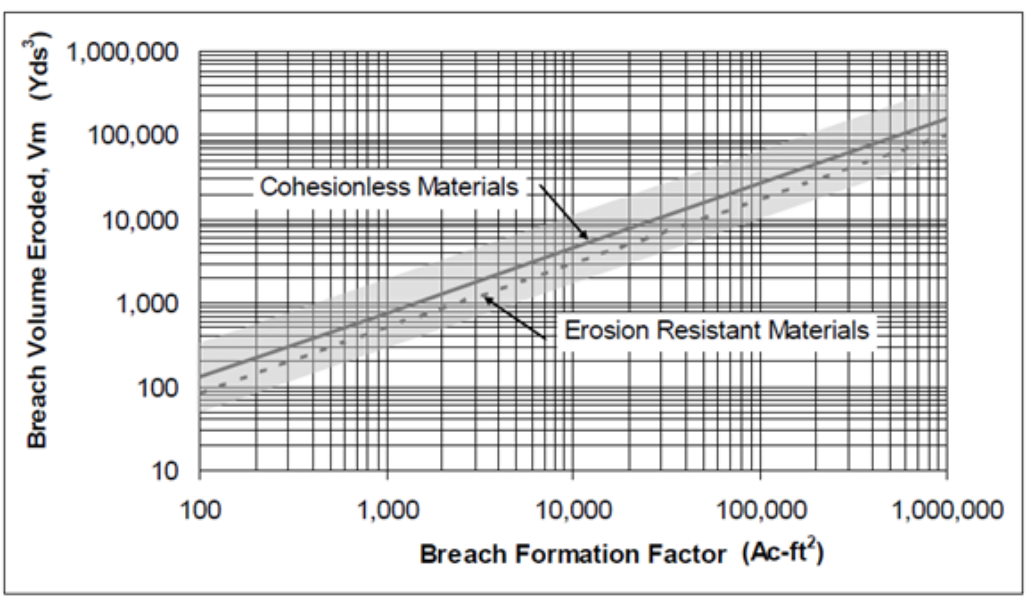


Figure 2. Estimated Eroded Volume of Breach (WSDOE, 1992a)

Breaches in earthen dams are generally trapezoidal in shape as shown in Figure 3 (WSDOE, 1992a). The base elevation of the breach usually is approximated as the elevation of the streambed downstream unless some site-specific condition restricts erosion to some other elevation (WSDOE, 1992a).

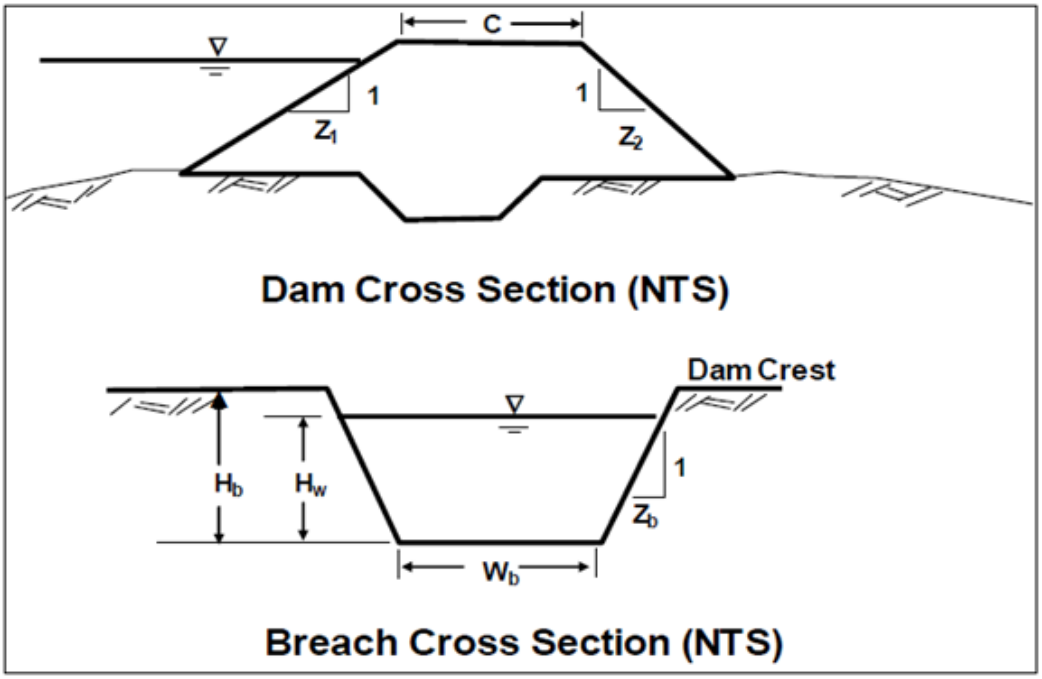


Figure 3. Dam and Breach Geometry (WSDOE, 1992a)

The base width of the breach can be estimated as a function of the eroded volume of material as:

$$W_b = \frac{27V_m - H_b^2(CZ_b + H_bZ_bZ_3/3)}{H_b(C + H_bZ_3/2)}$$

Where:

W_b = width of breach at base elevation of breach (ft)
V_m = volume of material in breach that is eroded (yd^3)
H_b = depth of breach from dam crest to base elevation of breach (ft)
C = crest width of dam (ft)
Z_b = side slope of trapezoidal breach (Z_b:1)
Z_3 = $Z_1 + Z_2$
Z_1 = slope of upstream face of dam Z_1:1)
Z_2 = slope of downstream face of dam Z_2:1)

For a rectangular breach, Z_b = 0, the equation above reduces to:

$$W_b = \frac{27V_m}{H_b(C + H_bZ_3/2)}$$

If the equations given above for W_b yield values less than zero, W_b = 0 ft. should be used for the purpose of obtaining dam breach and peak outflow results for this analysis.

An equation for predicting the time for the breach to develop is given as a function of the volume of material that is eroded away during a breach. For dams composed of cohesionless embankment materials, the breach formation time is given by:

$$\tau = 0.020 V_m^{0.36}$$

Where:

τ = breach formation time (hours)
V_m = volume of material in breach that is eroded (yd^3)

The breach formation time for dams composed of erosion-resistant embankment materials is given by:

$$\tau = 0.036 V_m^{0.36}$$

These equations are shown graphically in Figure 4 below (WSDOE, 1992a).

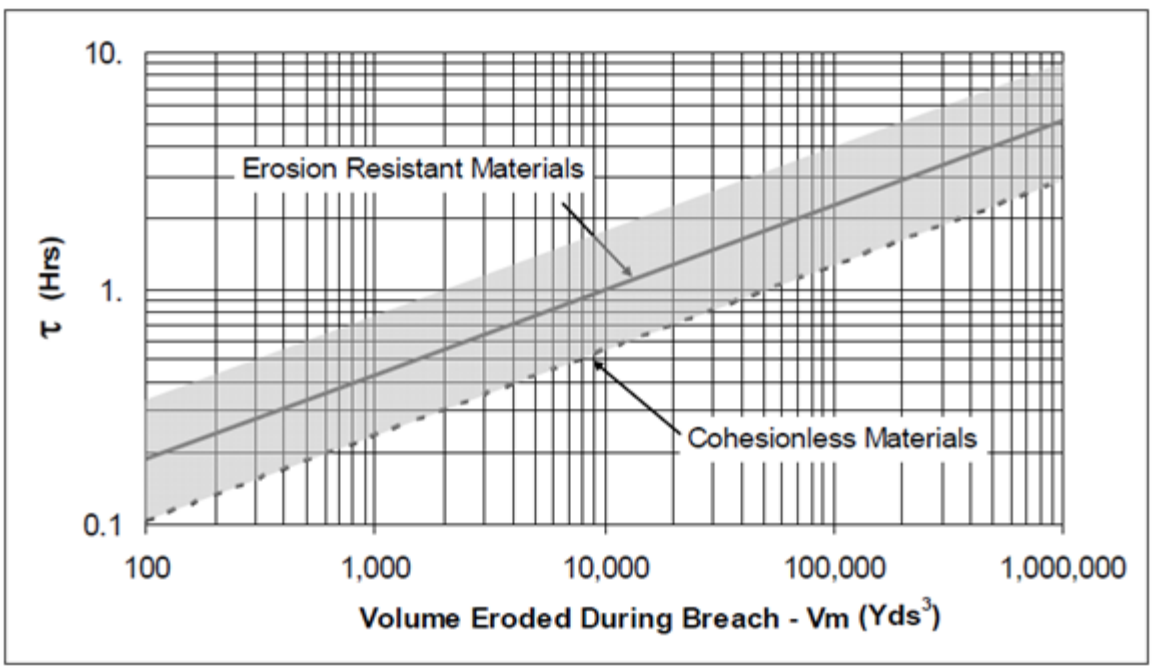


Figure 4. Elapsed time in breach development (WSDOE, 1992a)

The peak outflow rate resulting from a dam breach is an important parameter for predicting dam failure scenarios. Peak outflows can be used to model and route a resulting flood wave and assess attenuation and flow depths and velocities in the area downstream of the dam. There are numerous empirical equations available in literature for predicting peak outflows for dam breaches. One approach suitable for many planning purposes given by WSDOE (1992a) is the empirical equation developed by Fread based on numerous simulations with the DAMBRK model and used in the

National Weather Service (NWS) Simplified Dam Break (SMPDBK) Model. Estimation of the peak discharge from a dam breach is computed as:

$$Q_p = 3.1 W H_w^{1.5} \left[\frac{A}{A + \tau\sqrt{H_w}} \right]^3$$

Where:

Q_p = dam breach peak discharge (cfs)
W = average breach width (ft) = $W_b + Z_b H_w$
H_w = initial height of water over the base elevation of the breach (ft)
A = $23.4 S_a / W$
S_a = surface area of reservoir at reservoir level corresponding to depth H_w (acres)
τ = elapsed time for breach development (hours)

WSDOE (1992a) presents a simplified procedure suitable for planning purposes for estimating the flood wave attenuation and flood depths and velocities downstream based on generalized flood attenuation curves. The curves were developed using the HEC-HMS and HEC-RAS models with hypothetical channels developed using geometric characteristics (width and slope) of actual stream channels. The curves should be used conservatively, as they utilize generalized solutions to approximate the reduction of flood peak discharge with distance downstream of the dam. The generalized flood attenuation curves are shown in Figure 5 and Figure 6 below (WSDOE, 1992a).

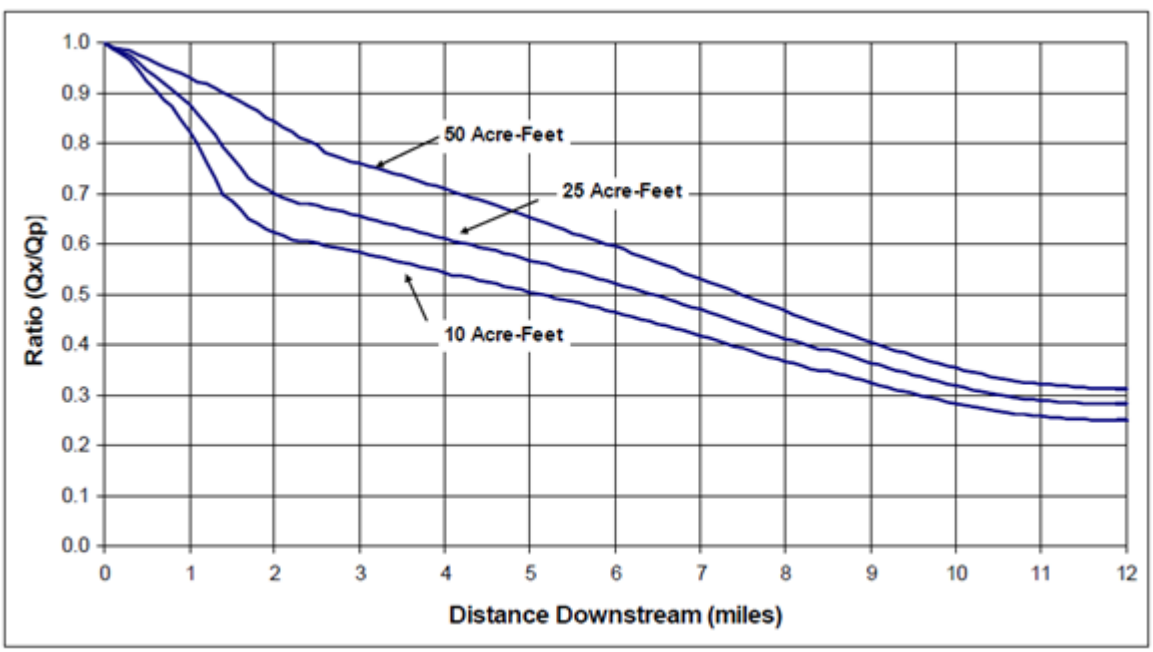


Figure 5. Generalized Flood Attenuation Curves (for reservoirs < 100 acre-ft) (WSDOE, 1992a)

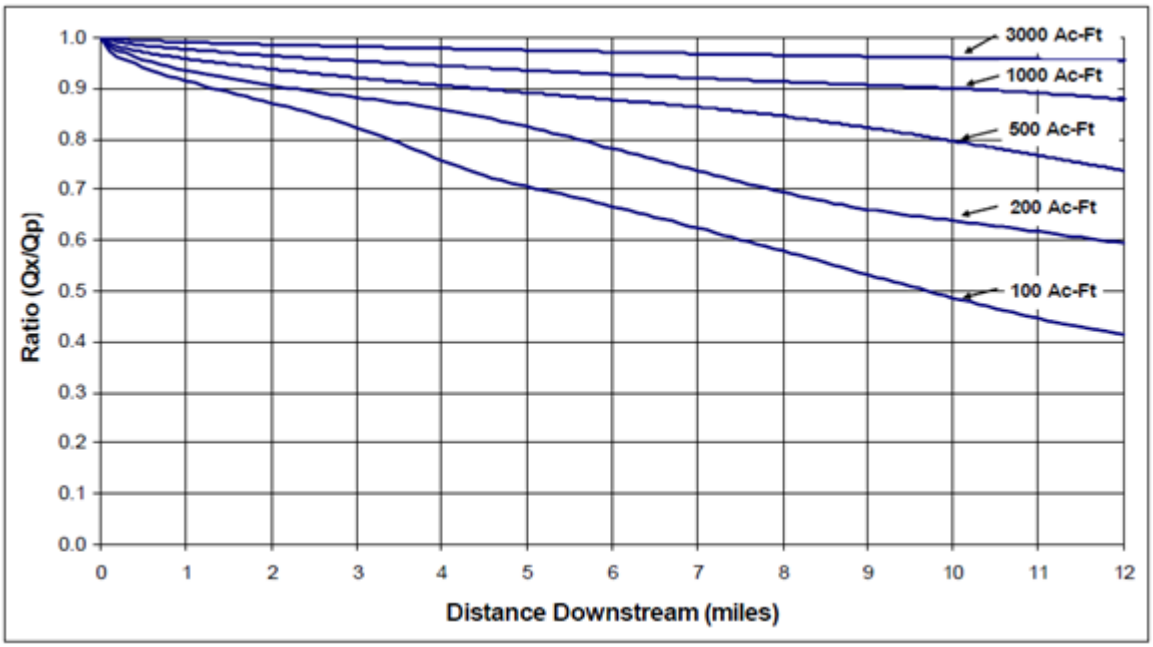


Figure 6. Generalized Flood Attenuation Curves (for reservoirs > 100 acre-ft) (WSDOE, 1992a)

Representative flow velocities based on the bedslope of the downstream channel reach and type of channel and overbanks are given in the WSDOE guidelines. Figure 7 shows the table of representative velocities for use in estimating inundation from dam break floods (WSDOE, 1992a). A reasonable approximation of the inundation at a given location can be made based on the velocity and site-specific cross-section data. However, for the purpose of this analysis, inundation limits were not estimated. A detailed inundation study will be prepared as part of development of an operations and emergency management plan for the Water Management Ponds

TYPE 1 MAIN CHANNEL - GRAVEL OVERBANKS - GRASS, PASTURE		TYPE 2 MAIN CHANNEL - GRAVEL, COBBLES OVERBANKS - IRREGULAR, BRUSH, SCATTERED SHRUBS		TYPE 3 MAIN CHANNEL GRAVEL COBBLES, BOULDERS OVERBANKS WOODED	
BEDSLOPE (ft/mi)	VELOCITY (ft/sec)	BEDSLOPE (ft/mi)	VELOCITY (ft/sec)	BEDSLOPE (ft/ml)	VELOCITY (ft/sec)
5	2.4	5	1.7	5	1.4
10	3.4	10	2.4	10	1.9
15	4.1	15	3.0	15	2.4
20	4.8	20	3.5	20	2.7
30	5.8	30	4.2	30	3.3
40	6.7	40	4.9	40	3.8
60	8.2	60	6.0	60	4.7
80	9.5	80	6.9	80	5.4
100	10.6	100	7.7	100	6.1
200	12.0	200	10.9	200	8.6
300	12.0	300	12.0	300	10.5
400 or greater	12.0	400 or greater	12.0	400 or greater	12.0

Figure 7. Representative Velocities for Use in Estimating Inundation from Dam Break Floods (WSDOE, 1992a)

A Type 3 channel and overbanks described in Figure 7 was selected to be representative of the flow paths downstream of the West and South Ponds based on Google Earth aerial imagery shown in Figure 1. Channel bedslopes along the flow paths shown by the green line in Figure 1 were calculated from 10-ft. USGS contours (MWH, 2012). Figure 8 and Figure 9 show the profiles of the flow paths to the Spokane Arm from the West and South Ponds, respectively.

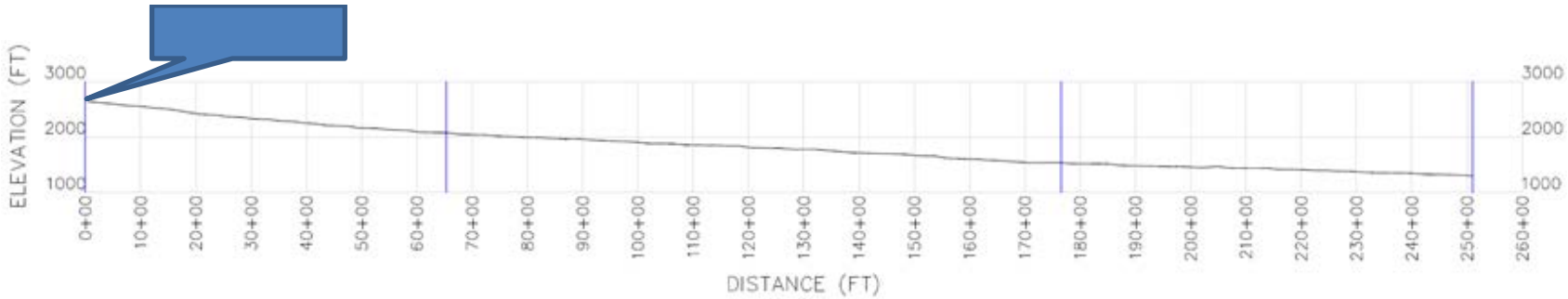


Figure 8. Profile of flow path from West Pond to Spokane Arm

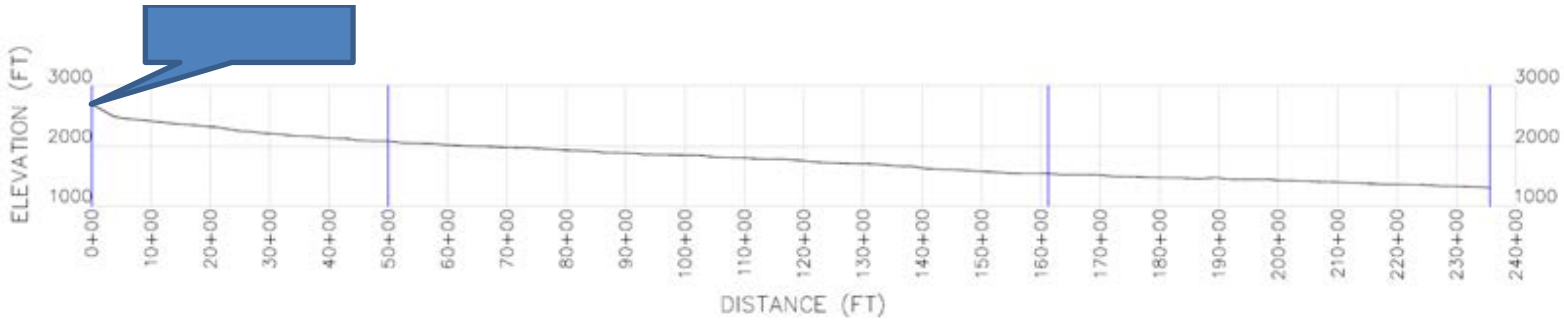


Figure 9. Profile of flow path from South Pond to Spokane Arm

4.0 RESULTS

The input parameters for the Midnite Mine West and South Water Management Ponds presented in Table 1 were used with the WSDOE simplified dam break inundation analysis methods and equations described above to estimate the characteristics of flooding that could occur downstream in the event of a dam failure. Dam breach peak flow estimates using the simplified methods are usually conservative and can be considered very conservative for the South Pond, where the waste rock fill in the embankment will consist of coarse rock fill with boulders up to 3 feet in size, which may result in considerable erosional resistance in the event of overtopping. Further peak flow conservatism is introduced by assuming the South and West Pond embankments are composed of cohesionless materials. The dam breach and peak outflow results estimated for the West and South Ponds are summarized in Table 3.

Table 3. Summary of Dam Breach and Peak Outflow Results

Dam Breach Result	West Pond	South Pond
Breach formation factor (BFF)	5,492	15,858
Volume of breach material eroded[(1)] (yd^3)	2,842	6,430
Breach side slope (Z_b:1)	1	1
Breach width at base of breach[(2)] (ft)	0	0
Average final breach width (ft)	55.0	64.0
Breach top width (ft)	110.0	128.0
Breach formation time[(1)] (hours)	0.35	0.47
Dam breach peak discharge (cfs)	5,663	9,946

Notes:
[(1)]Dam embankments were assumed to be made of cohesionless materials
[(2)]If WSDOE equation for W_b gives value less than zero, W_b = 0 ft. was used

Cross-sections showing the breach geometry for the West Pond and South Pond are shown in Figure 10 and Figure 11, respectively.

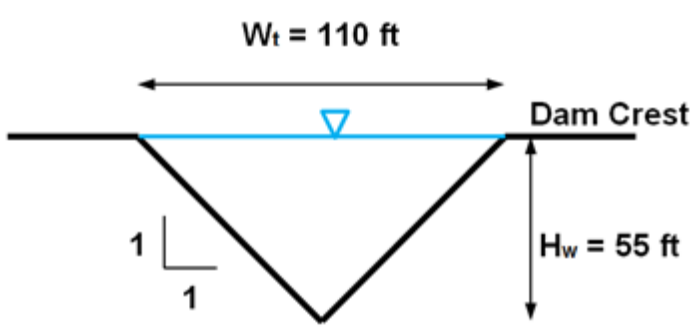


Figure 10. Dam Breach Cross-sectional Geometry from West Pond

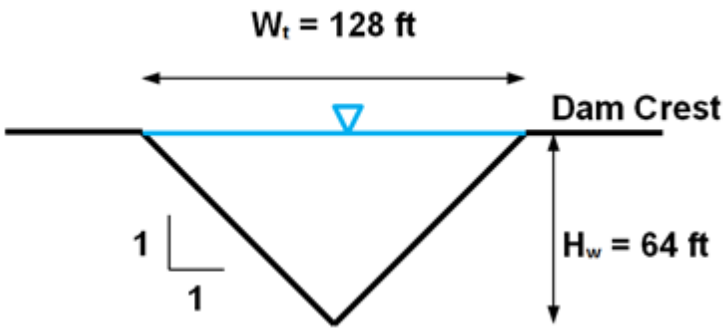


Figure 11. Dam Breach Cross-sectional Geometry for South Pond

The approximate flood peak discharge reduction at each of the critical points shown in Figure 1 downstream of the dam was estimated using the generalized flood attenuation curves in Figure 5 (WSDOE, 1992a). The ratios of Q_x to Q_p at each of the critical points downstream were estimated graphically for the West and South Ponds and are shown in Figure 12 and Figure 13, respectively.

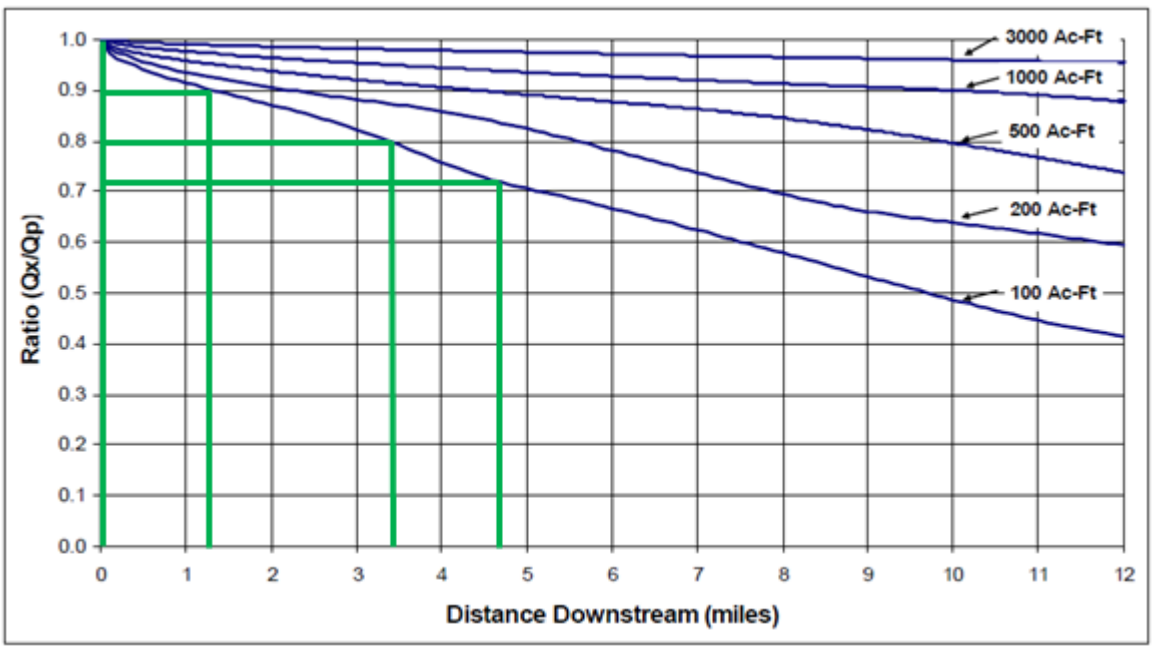


Figure 12. Flood Peak Discharge Reduction for West Pond Downstream Reach

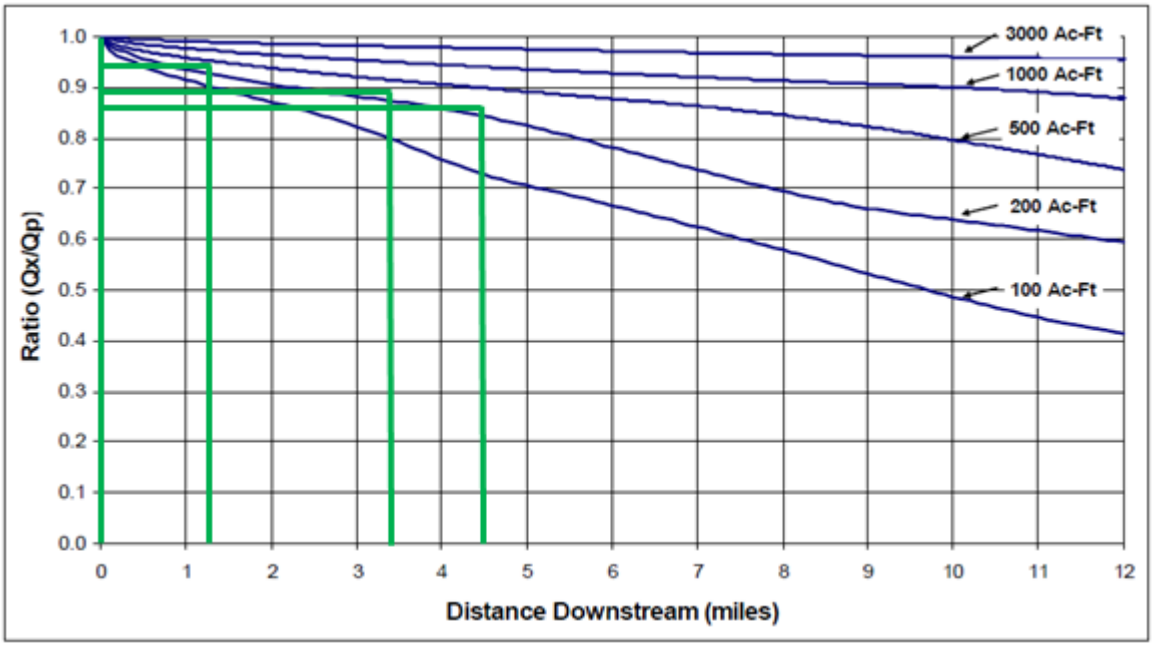


Figure 13. Flood Peak Discharge Reduction for South Pond Downstream Reach

The downstream flooding characteristics estimated for the West and South Ponds are summarized in Table 4 and Table 5, respectively.

Table 4. Summary of Downstream Flooding Characteristics Results for West Pond

Location	Station (mi)	Downstream Distance (mi)	Ratio (Q_x/Q_p)	Q_x (cfs)	Bedslope (ft/mi)	Velocity (ft/sec)
West Pond	4.76	0.00	1.00	5,663	-	-
West-End Road	3.52	1.24	0.90	5,096	462	12.0
Oyachen Creek	1.41	3.35	0.80	4,530	256	9.7
Spokane River	0.00	4.76	0.72	4077	170	7.9

Table 5. Summary of Downstream Flooding Characteristics Results for South Pond

Location	Station (mi)	Downstream Distance (mi)	Ratio (Q_x/Q_p)	Q_x (cfs)	Bedslope (ft/mi)	Velocity (ft/sec)
South Pond	4.48	0.00	1.00	9,946	-	-
West-End Road	3.52	0.96	0.95	9,449	633	12.0
Oyachen Creek	1.41	3.07	0.90	8,951	256	9.7
Spokane River	0.00	4.48	0.87	8,653	170	7.9

5.0 CONCLUSIONS

The conclusions of the Midnite Mine Water Management Ponds preliminary dam break calculations are summarized as follows:

1. The characteristics of flooding that could occur downstream of the Midnite Mine West and South Water Management Ponds in the event of a dam failure, including time to failure, peak outflow rate, and downstream flooding characteristics using the simplified method presented by the Washington State Department of Ecology (WSDOE) were estimated in this analysis.
2. The scope of this preliminary analysis intended provide information needed to establish the design step and annual exceedance probability (AEP) for design of the West Pond (Phase 3) and South Pond (Phase 2) according to WSDOE design step format for critical project elements (WSDOE, 1992b). The analysis are not intended to, and do not provide detailed dam break and inundation analyses that may be needed for Emergency Management Planning purposes.
3. Based on the dam geometry, dimensions, and breach parameters estimated for the West and South Ponds, the dam breach peak discharges at the embankments were estimated to be 5,663 cfs and 9,946 cfs, respectively. The downstream characteristics of flooding including flood peak discharge attenuation and representative flow velocities were also estimated according to the WSDOE simplified dam break inundation analysis.

6.0 REFERENCES

MWH Americas, Inc. (MWH), 2012. 10-ft. USGS contours from *1011322_CONTS_10FT_USGS.dwg*. Modified October 23.

MWH Americas, Inc. (MWH), 2014. West and South Water Management Ponds stage-storage data from *South_and_West_Pond_Curves_20140428.xlsx*. Received April 28.

Washington State Department of Ecology (WSDOE), 1992a. *Dam Safety Guidelines – Technical Note 1: Dam Break Inundation Analysis and Downstream Hazard Classification*. Revised, October 2007.

Washington State Department of Ecology (WSDOE), 1992b. *Dam Safety Guidelines – Technical Note 2: Selection of Design/Performance Goals for Critical Project Elements*. July.

Attachment E-9

Design Flow Estimates for Spillway Design

ATTACHMENT E-9

MIDNITE MINE REMEDIAL ACTION DESIGN FLOW ESTIMATES FOR SPILLWAY DESIGN

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*07-Jul-14*	*90% Design*	*Chris Gifford-Miears*	*Zach Elliott*	*14-Jul-14*	*Carmen Bernedo*
1	*13-May-15*	*100% Design*	*Chris Gifford-Miears*	*Zach Elliott*	*15-May-15*	*Carmen Bernedo*

Location and Format

Electronic copies of these calculations are located in the project files system at:

[\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E - Water Management Ponds\100% Submittal\Att E-9 Flow Estimates]

The following calculations were generated using the following software:

Microsoft Office Professional Plus 2010 (Microsoft Excel)

Hydrologic Modeling System (HEC-HMS), Version 3.5

ArcGIS 10.1

1.0 INTRODUCTION

1.1 OBJECTIVE

The main objective of this document is to report the estimated design flows for South and West Pond spillways at the Midnite Mine Superfund Site (Site). The Site is located in Stevens County on the Spokane Indian Reservation in eastern Washington State, see Figure 1. Flow estimates were made using Washington State Department of Ecology (WSDOE) Dam Safety guidelines, which were selected as the basis for substantive compliance of the storage pond design with applicable regulations. Spillway design flows have been updated from the 90% Design estimates using the most up-to-date soil cover and land use information. Also, 90% snowmelt runoff estimates were updated, producing more realistic results.

1.2 ASSUMPTIONS

- Snowmelt and rainfall peaks coincide for rain-on-snow events
- Uniform snow depth distribution over Midnite Mine drainage basin
- Wind speed adopted for rain on snow estimates at the Midnite Mine is 33 miles per hour (mph) based on the range of values reported on HMR 57 for a Probable Maximum Precipitation (PMP) storm event in North Eastern Washington during the month of February (NWS 1994)
- Initial Abstraction for rainfall runoff, I_a, is equal to zero, to simulate saturated soil and basin conditions
- Spillway bottom widths are 10 feet, channel side slopes are 2H:1V, and control section are 15 feet long

1.3 AVAILABLE INFORMATION/REFERENCES

The following sources of information and references were also used in this analysis:

- Hydrometeorological Report No. 57 (HMR 57), National Weather Service (NWS), 1994
- Engineering and Design – Runoff from Snowmelt, U.S. Army Corps of Engineers, 1998
- Wellpinit, WA GHCN climate station (station USC0045098), Period of record 1923-2007
- Dam Safety Guidelines Technical Notes 2 through 3, Washington State Department of Ecology (WSDOE), 1992-2009
- U.S. Bureau of Mines (USBM), 1995. Premine and Pit Excavation Topography.

2.0 PROJECT SETTING

The Midnite Mine drainage basin is located on the Spokane Indian Reservation in Stevens County, Washington, at approximately longitude 118°5’39” W, latitude 47°56’20” N. The elevations range from 2,080 feet to 3,550 feet. The mean basin elevation is approximately 2,785 feet. The drainage areas are approximately 0.31 and 0.19 square miles for the West and South Ponds, respectively. Figure 1 shows the Midnite Mine site location map.

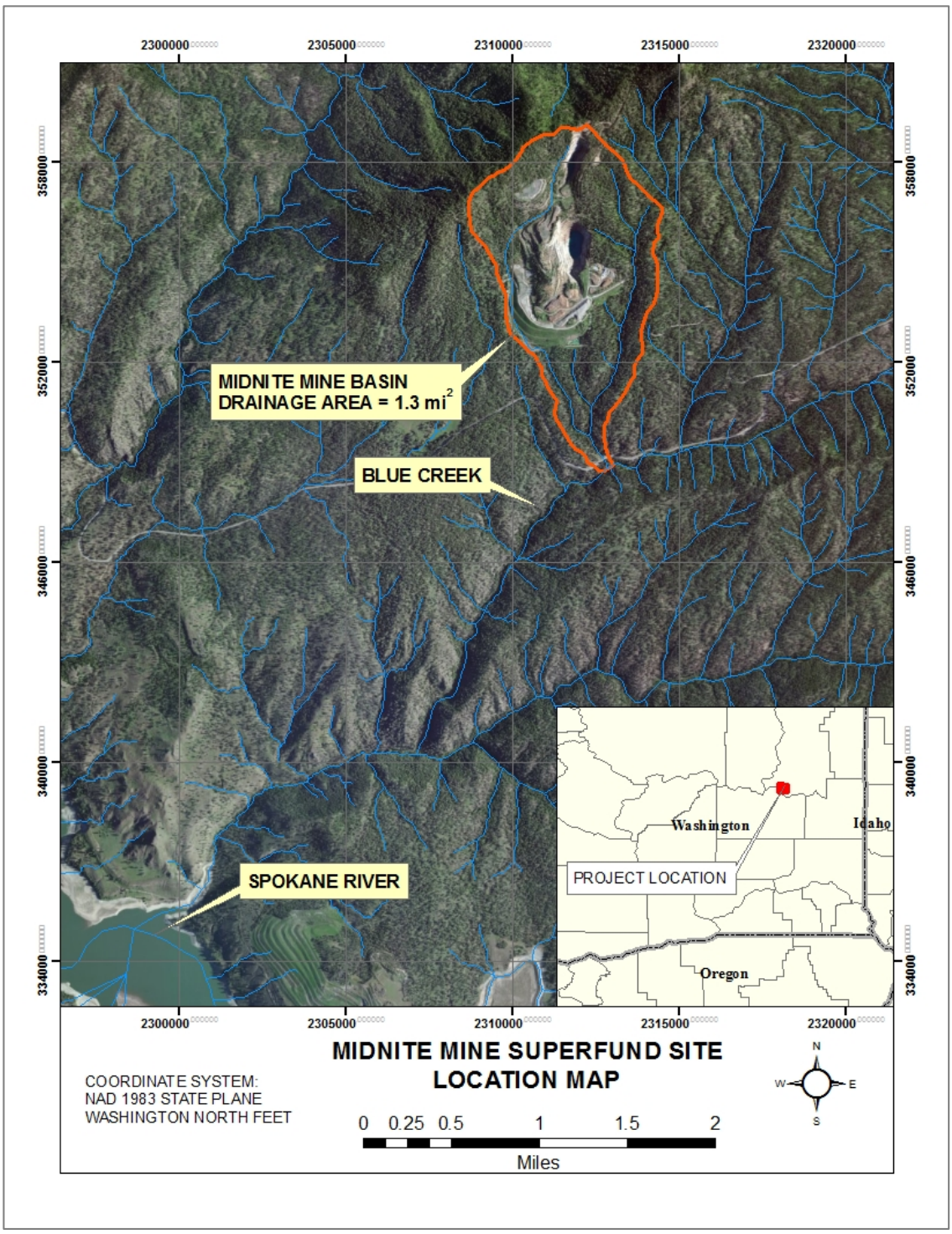


Figure 1. Midnite Mine Drainage Basin Location Map

3.0 PRECIPITATION ANALYSIS

WSDOE Dam Safety Office Guidelines, *Technical Note 3, Design Storm Construction* (WSDOE 2009) provide methods for determining precipitation depths and design storm temporal patterns for developing inflow design floods (IDF). The procedures used in Technical Note 3 (TN 3) to provide site-specific precipitation magnitude-frequency estimates are based on regional analysis procedures contained in *Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-hour and 2-hour durations in Western Washington* (Schaefer et al. 2002) and *Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-hour and 2-hour durations in Eastern Washington* (Schaefer et al. 2006).

Gridded precipitation datasets were developed as part of the regional precipitation-frequency analysis that allows the user to determine precipitation depths for a selected location, storm durations of 2-hour, 6-hour, and 24-hour, and 10-year, 25-year, 100-year and Design Steps 1 to 8. Design Steps 1 to 8 are described in *Technical Note 2* (WSDOE 1992b). Design Step 1 corresponds to an event with a 1/500 annual exceedance probability (AEP) and Design Step 8 corresponds to a theoretical maximum event.

For the selection of the design storm dimensionless hyetographs, TN 3 divides the state of Washington in regions with similar climatic and topographic characteristics that result in storms having similar characteristics. The climatic regions are shown on Figure 2.

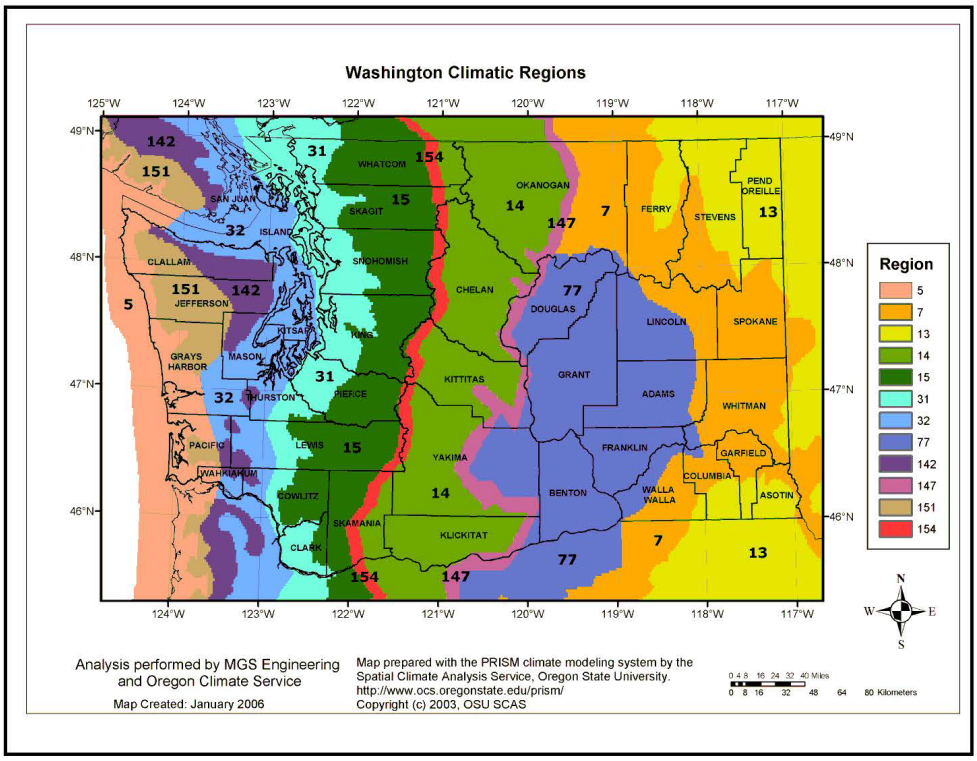


Figure 2. Climatic Regions for Washington State (Source: WSDOE 2009)

The Midnite Mine drainage basin is located entirely within Region 7 – Okanogan, Spokane, Palouse of Eastern Washington. TN 3 describes this region as:

*"**Region 7 – Okanogan, Spokane, Palouse** - This region is comprised of a mixture of lowland areas of low to moderate relief and extensive valley areas between mountain barriers. This includes areas near Spokane, the Palouse, and areas along the Okanogan River. The region is bounded to the northwest by Region 14. It is bounded to the south and west by Region 77, which generally conforms to the contour line of 12 inches mean annual precipitation at the eastern edge of the Central Basin. It is bounded to the northeast by the Kettle River Range and Selkirk Mountains at approximately the contour line of 22 inches mean annual precipitation. It is bounded to the southeast by the Blue Mountains also at the contour line of 22 inches mean annual precipitation."*

3.1 DESIGN STORM DEPTH

The following steps are used to determine the storm depths and candidate design storms for a particular location:

1. Determine the Design Step and project design/performance goal as shown in *Technical Note 2* (WSDOE 1992b).
2. Compute precipitation scaling depth for selected design step and duration used for scaling candidate design storm.
3. Select dimensionless design hyetograph for chosen storm duration for project location.
4. Scale dimensionless design hyetograph by precipitation scaling depth to produce candidate design storm.

WSDOE provides a spreadsheet and gridded precipitation datasets that allow the user to compute the precipitation depths for various durations and design steps. Figure 3 shows the input screen and resulting precipitation depths for the 24-hour duration precipitation magnitude-frequency for the Midnite Mine drainage basin. Table 1 shows the results for the 2-hour, 6-hour and 24-hour storms.

Precipitation Magnitude-Frequency Gridded Data Set Lookup Calculator

This Work Book contains a Visual Basic for Applications macro that interpolates precipitation magnitude from gridded data set files. The user inputs the latitude and longitude of the location of interest, the precipitation duration (2-hours, 6-hours, or 24-hours), and the interpolation method. Clicking the ***Calculate*** button runs the macro and outputs the Climatic Region Number, L-Moment Statistics, and Precipitation Magnitude-Frequency Statistics below.

User Inputs		
Latitude (Decimal Degrees)	47.940556	
Longitude (Decimal Degrees)	-118.094167	
Duration (hours)	24	(Enter 2, 6, or 24)
Grid Cell Interpolation Method	1	(Enter 0 for Center of Grid-Cell or 1 for Inverse Distance Weighting)

Project Name	Midnite Mine Superfund Site

Calculate

Program Output	
Climatic Region Number	7
Mean Annual Precipitation (inches)	19.7
At-Site Mean (inches)	1.258
L-Cv	0.1639
L-Skew	0.2104
Hondo	-0.050

Precipitation Magnitude Frequency Output, 24-Hour Duration	
Precipitation Frequency	
10-Year	1.75
25-Year	2.07
100-Year	2.58
Step 1	3.23
Step 2	3.54
Step 3	4.09
Step 4	4.68
Step 5	5.33
Step 6	6.03
Step 7	6.80
Step 8	7.63
Program Status Message	*Successful*

Figure 3. Technical Note 3 Companion Spreadsheet Input Screen (WSDOE 2009)

Table 1. Storm Depths for Midnite Mine Drainage Basin, Region 7, Washington

Precipitation Frequency	Storm depth for indicated duration (inches)		
	2-hour	6-hour	24-hour
10 year	0.75	1.08	1.75
25 year	0.94	1.29	2.07
100 year	1.30	1.63	2.58
Design Step 1	1.86	2.10	3.23
Design Step 2	2.15	2.33	3.54
Design Step 3	2.76	2.75	4.09
Design Step 4	3.51	3.22	4.68
Design Step 5	4.46	3.76	5.33
Design Step 6	5.65	4.37	6.03
Design Step 7	7.16	5.07	6.80
Design Step 8	9.05	5.86	7.63

TN 3 recommends that the precipitation depths obtained from the gridded datasets are increased by 15 percent for use in engineering design applications to incorporate some conservatism, account for uncertainty, and provide protection from under-design. The scaling depths after applying a 1.15 factor are shown in Table 2. In order to scale the precipitation depths for each WSDOE storm hyetograph (i.e., short, intermediate, and long duration), a

region specific multiplier is applied to the scaling depths to obtain total storm depths. Total storm depths to be distributed using the WSDOE design storm hyetographs are shown in Table 3.

Table 2. Scaling Depths for Midnite Mine Drainage Basin, Region 7, Washington

Precipitation Frequency	Storm depth for indicated duration (inches)		
	2-hour	6-hour	24-hour
10 year	0.87	1.24	2.01
25 year	1.09	1.48	2.38
100 year	1.50	1.87	2.97
Design Step 1	2.13	2.42	3.71
Design Step 2	2.48	2.68	4.07
Design Step 3	3.17	3.16	4.70
Design Step 4	4.03	3.70	5.38
Design Step 5	5.13	4.32	6.13
Design Step 6	6.50	5.03	6.93
Design Step 7	8.23	5.83	7.82
Design Step 8	10.41	6.74	8.77

Table 3. Total Storm Depths for Midnite Mine Drainage Basin, Region 7, Washington

Design Step	Storm depth for indicated duration (inches)		
	Short duration	Intermediate duration	Long duration
	4-hour	18-hour	72-hour
Design Step 1	2.21	3.74	4.66
Design Step 2	2.56	4.15	5.11
Design Step 3	3.28	4.90	5.89
Design Step 4	**4.18**	**5.74**	**6.75**
Design Step 5	5.31	6.70	7.68
Design Step 6	6.73	7.80	8.70
Design Step 7	8.52	9.04	9.81
Design Step 8	10.77	10.45	11.01

Based on the Design Step assessment included as Attachment E-8 of the 100% BODR, it was determined that the Design Step rating for both the South and West Ponds is Design Step 4. Therefore, design storm depths for WSDOE and distributed storms to be used for design flow estimations are presented in Table 4.

Table 4. Summary of Design Step 4 Precipitation Depths and Distributions

Distribution	Storm Name	Duration (hours)	Total Storm Depth (inches)
WSDOE:	Short	4	4.18
	Intermediate	18	5.74
	Long	72	6.75
SCS Type 1A:	24-hour	24	5.38

3.2 RAINFALL DISTRIBUTION

In addition to climatic regions, storms in Washington are classified according to duration. The durations are defined by WSDOE as follows:

1. Short duration - A precipitation event lasting from 30 minutes to 6 hours. When used in the context of a design storm, this term commonly refers to thunderstorm events characterized by short bursts of very high rainfall intensities, often with limited total volume occurring over isolated areas. For short duration storms, the 2-hour scaling depth is increased by the regional multiplier, and is then used to scale the dimensionless hyetograph ordinates.

2. Intermediate duration - A precipitation event where the duration of precipitation typically persists from 6 to 18 hours. When used in the context of a design storm, this term refers to 18-hour events which are characterized by moderate to high rainfall intensities, contain a large total precipitation volume. For intermediate duration storms, the 6-hour scaling depth is increased by the regional multiplier, and is then used to scale the dimensionless hyetograph ordinates.

3. Long duration - A precipitation event that typically persists from 24 to 72 hours. When used in the context of a design storm, this term refers to 72-hour events characterized by relatively moderate and uniform intensities, containing a very large total volume. For long duration storms, the 6-hour scaling depth is increased by the regional multiplier, and is then used to scale the dimensionless hyetograph ordinates.

3.2.1 Short Storm Hyetographs

The recommended short duration dimensionless storm hyetograph for Region 7 in Washington is shown on Figure 4.

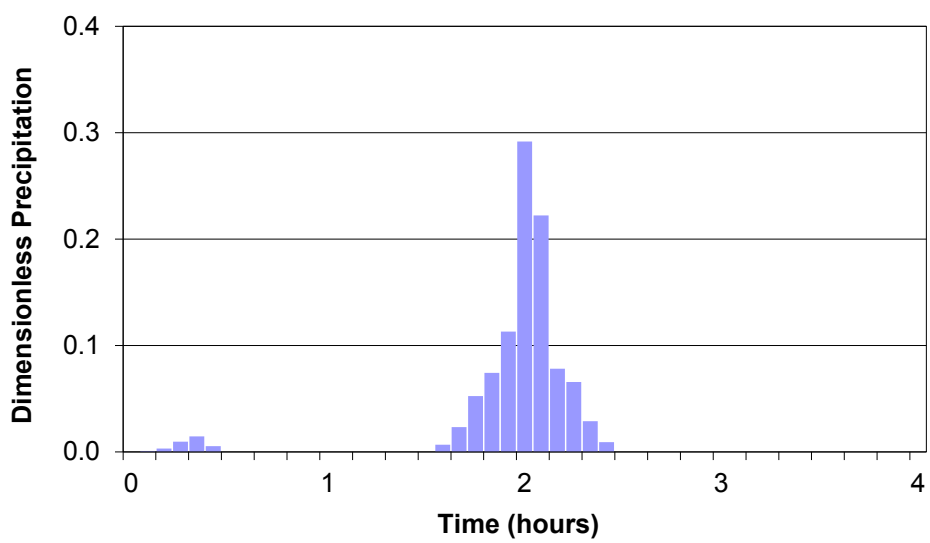


Figure 4. Short Storm Dimensionless Hyetograph – Washington Climatic Region 7 (WSDOE 2009)

Multiplying the 2-hour, total storm scaling depths from Table 3 by the dimensionless ordinates yields the design storm hyetographs shown on Figure 5, for Design Step 4.

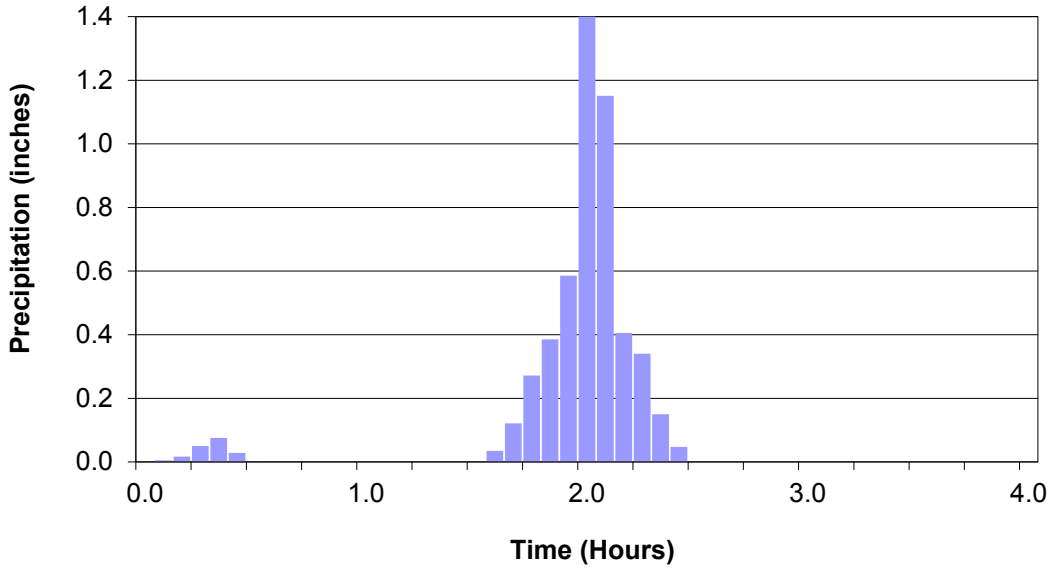


Figure 5. Design Step 4 Short Duration Storm Hyetograph – Washington Climatic Region 7

3.2.2 Intermediate Storm Hyetographs

The recommended long duration dimensionless storm hyetograph for Region 7 in Washington is shown on Figure 6.

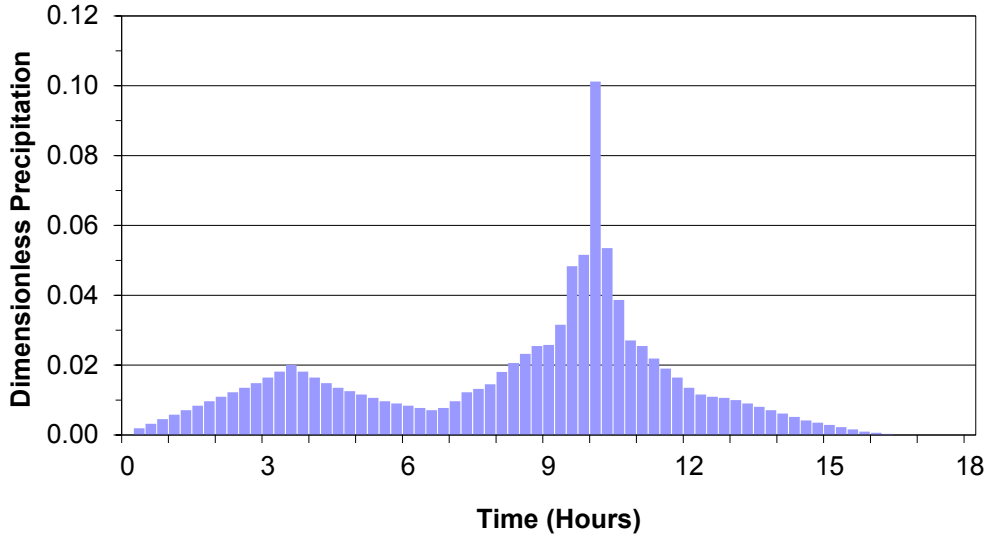


Figure 6. Intermediate Duration Storm Dimensionless Hyetograph – Washington Climatic Region 7 (WSDOE 2009)

Multiplying the 6-hour, total storm scaling depths from Table 3 by the dimensionless ordinates yields the design storm hyetographs shown on Figure 7 for Design Step 4.

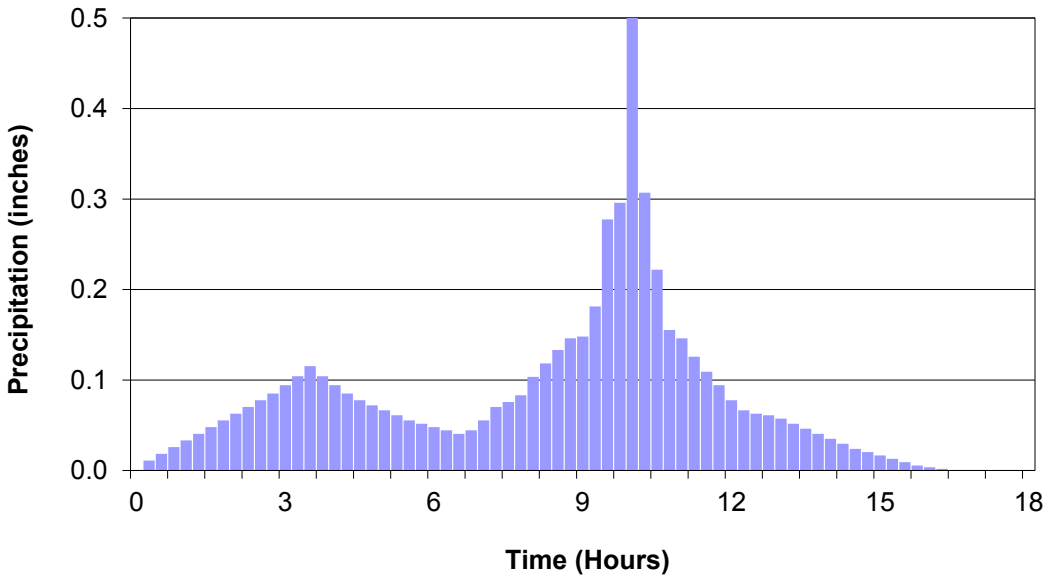


Figure 7. Design Step 4 Intermediate Duration Storm Hyetograph – Washington Climatic Region 7

3.2.3 Long Storm Hyetographs

The recommended long duration dimensionless storm hyetograph for Region 7 in Washington is shown on Figure 8.

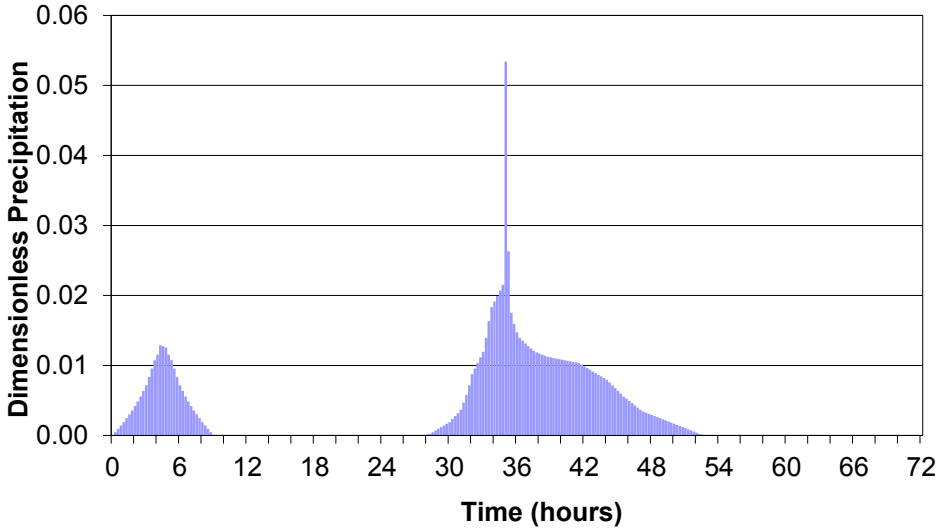


Figure 8. Long Duration Storm Dimensionless Hyetograph – Washington Climatic Region 7 (WSDOE 2009)

Multiplying the 24-hour, total storm scaling depths from Table 3 by the dimensionless ordinates yields the design storm hyetographs shown on Figure 9, for Design Step 4.

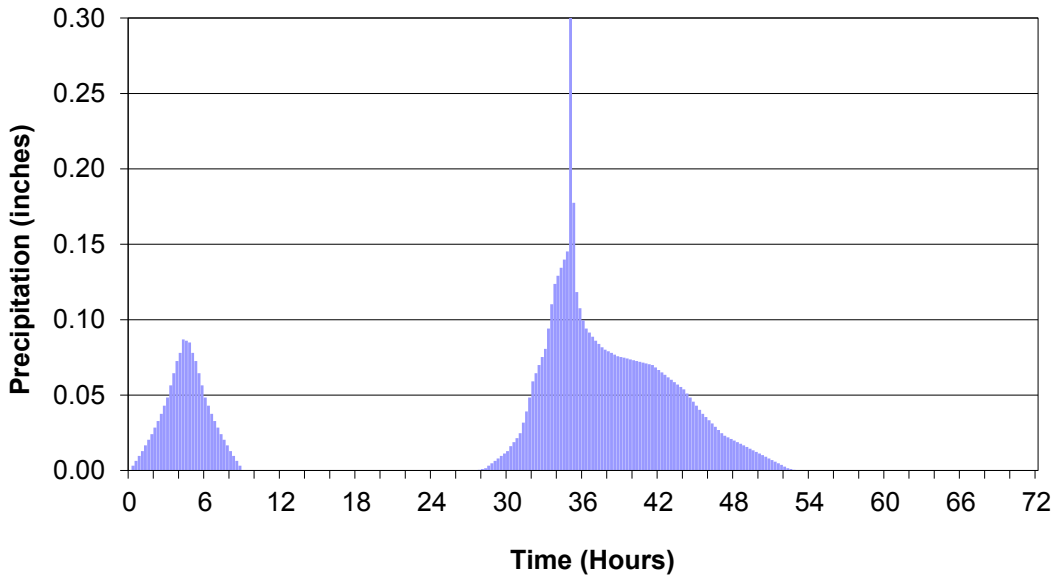


Figure 9. Design Step 4 Long Duration Storm Hyetograph – Washington Climatic Region 7

3.3 SNOWMELT

The Midnite Mine project is located in Stevens County, Washington State. The highest monthly snowfall and snow accumulation typically occurs between December and February. It is during these months that rain-on-snow events may occur; they do so most frequently in the transient-snow zone, where average air temperatures fluctuate around freezing and precipitation alternates between rain and snow (USGS 1996). Spring snowmelt generally occurs during the months of March and April. Climate data from the Wellpinit WA climate station was obtained and selected as the representative station for the site.

Rain-on-snow events that affect Stevens County occur when significant snow pack exists in the upper reaches of the drainage, situated in lower to intermediate elevations (Stevens County, 2006). Based on stream gage records at the Midnite Mine site (USGS gauge # 12433556), peak discharge generally occurs when early-spring rains fall on the snowpack (USGS 2007). Discharge of flood events from October 1983 to May 2006 report that early-spring rains on snowpack have occurred during January to April (USGS 2007). The all-season probable maximum precipitation (PMP) percentages from HMR 57 and average snow data from the Wellpinit GHCN climate station (GHCN USC0045098) are shown on Figure 10. Daily snow depth and precipitation values for the Wellpinit WA station are shown on Figure 11. Significant snow depths and early-spring rains have been reported to occur in February for the Midnite Mine site, therefore, rain-on-snow events were estimated using February climate data.

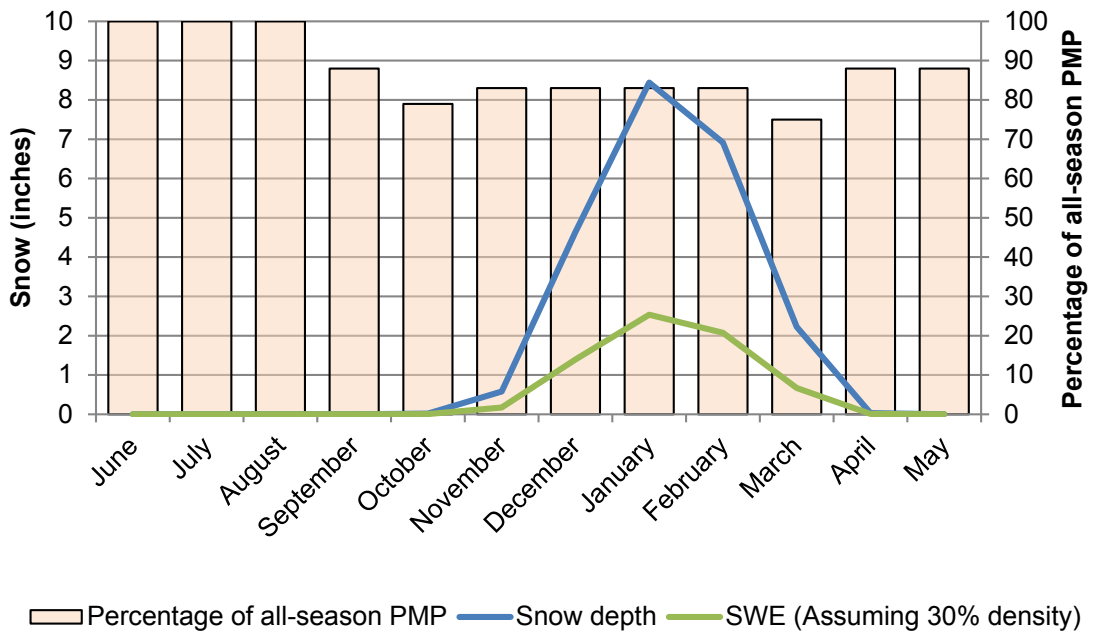


Figure 10. All-Season PMP Percentages and Snow Depth

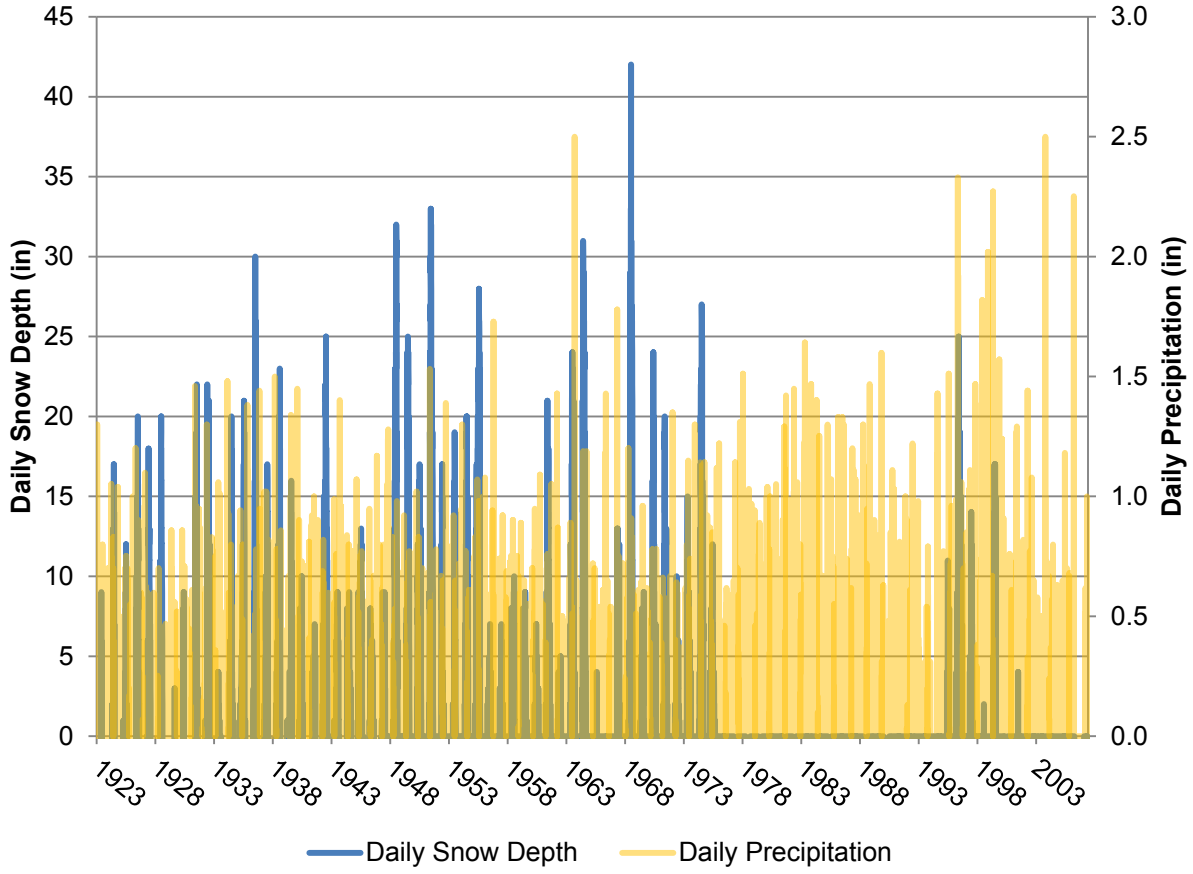


Figure 11. Wellpinit WA Station – Daily Snow Depth and Daily Precipitation Data

The contribution of snowmelt to the design storm event can be estimated from the U.S. Army Corps of Engineers (USACE) energy equation. The equation takes various forms depending on surface cover and rain periods. For a rain-on-snow event on an open to partly forested basin (10-80 percent cover) the energy equation takes the following form (USACE 1998):

$$M = (0.029 + 0.0084 * k * v + 0.007 * Pr)(Ta - 32) + 0.09$$

Where:
M = snowmelt runoff (inches/day)
k = basin convection-condensation melt factor
v = wind speed (mph)
Pr = precipitation (inches/day)
Ta = air temperature (°F)

The partly forested equation includes a basin convection-condensation parameter (wind coefficient), *k*; and the wind speed, *v*. The wind coefficient, *k*, varies from 0.3 for heavily forested areas to 1.0 for un-forested plains (USACE 1998). Seasonal wind speed during a PMP storm event is assumed as the wind speed for the project site (NWS 1994). The recurrence interval for Design step 4 is 10,000 years, therefore using HMR 57 as a reference for wind speed during a large design storm was considered suitable. Based on site characteristics and land use of the Midnite Mine basin, the Energy Method using the partially forested equation, an average wind speed of 33 mph, based on HMR 57, and a wind coefficient of 0.65 is assumed.

3.3.1 Snowmelt Distribution

Snowmelt runoff depth was estimated using the partially forested Energy Equation and the distribution of snowmelt was estimated using a diurnal temperature variation. The diurnal temperature variation can be simulated by using the following sine function (NRCS 2004):

$$T = Ta + A\{\sin[15(t + C)]\}$$

Where:
T = temperature at time t, ºF.
Ta = mean temperature, ºF.
A = amplitude, (Tmax - Tmin)/2
t = hour of the day
C = time shift, hours (calculated as 30 – maximum hour).

The average temperature during the maximum melt period, February, at the Wellpinit WA station is 31.2 ºF, the maximum temperature is 64.0 ºF, and the minimum temperature is assumed to be 32.0 ºF. It is assumed that the Wellpinit WA station peak temperature generally occurs at approximately 14:00 hours (2 pm). For peak flow estimates the most critical condition of coincident maximum temperature and rainfall was modeled. Using the above parameters, the temperature variation is developed as shown on Figure 12. The 10,000-year (Design Step 4) design total storm depths and temperature described above are used as inputs to compute the hourly snowmelt increments using the Energy Equation. The hourly increments are summed to develop the cumulative snowmelt distribution as shown on Figure 13. Snowmelt depths resulting from the considered 10,000-year precipitation events are summarized in Table 5. The

distribution of the 24-hour, SCS Type 1A storm and cumulative snowmelt distribution is shown on Figure 14.

Table 5. Design Step 4 Snowmelt Depths

Distribution	Storm Name	Duration (hours)	Total Snowmelt Depth (inches)
WSDOE:	Intermediate	18	1.44
	Long	72	1.80*
SCS Type 1A:	24-hour	24	1.32

*Total snowmelt depth limited to max available snow water equivalent assuming a snow density of 30%

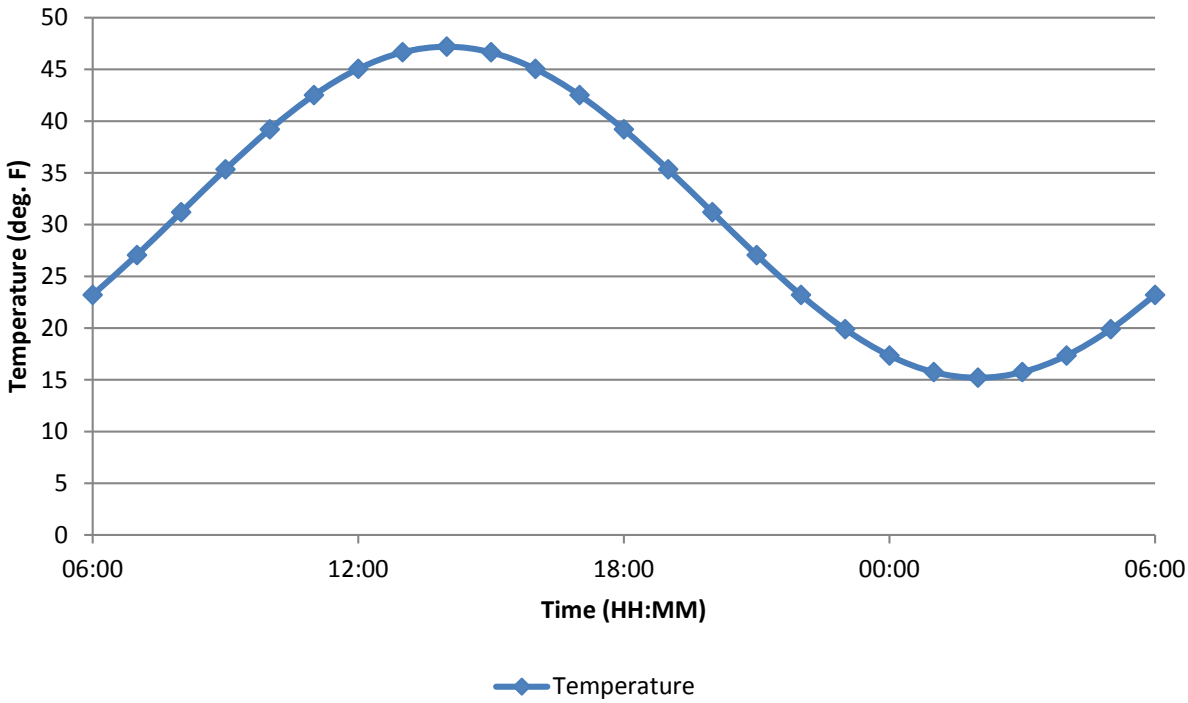


Figure 12. Diurnal Temperature Variation

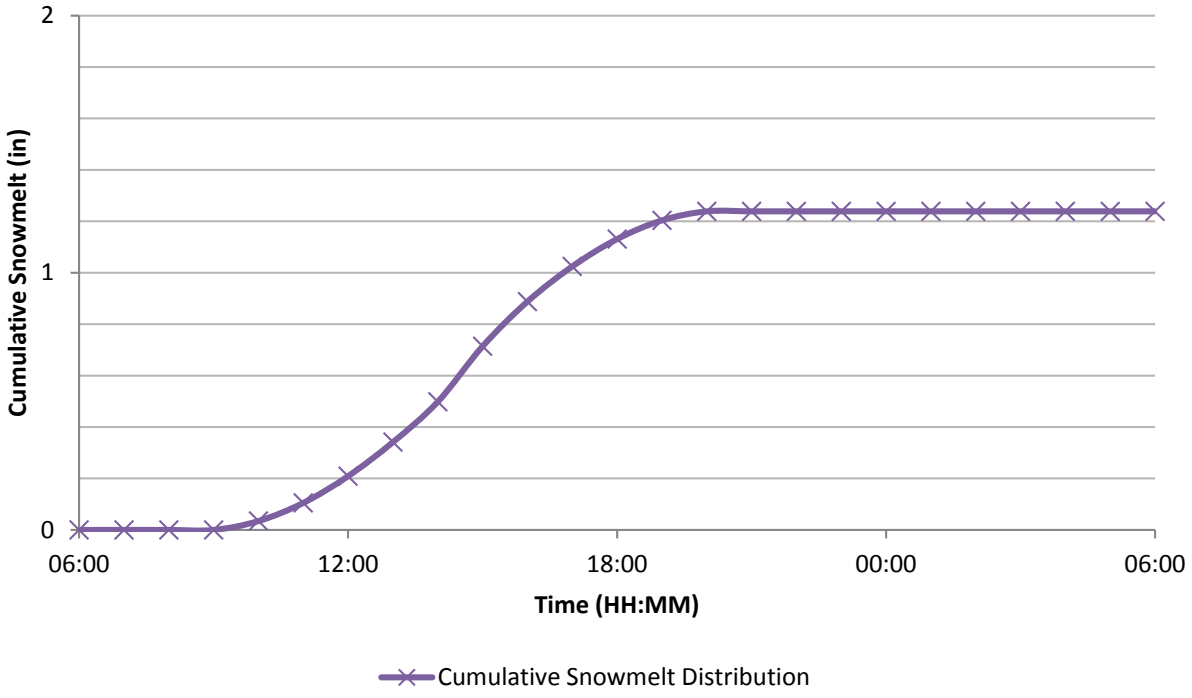


Figure 13. Cumulative Snowmelt Distribution

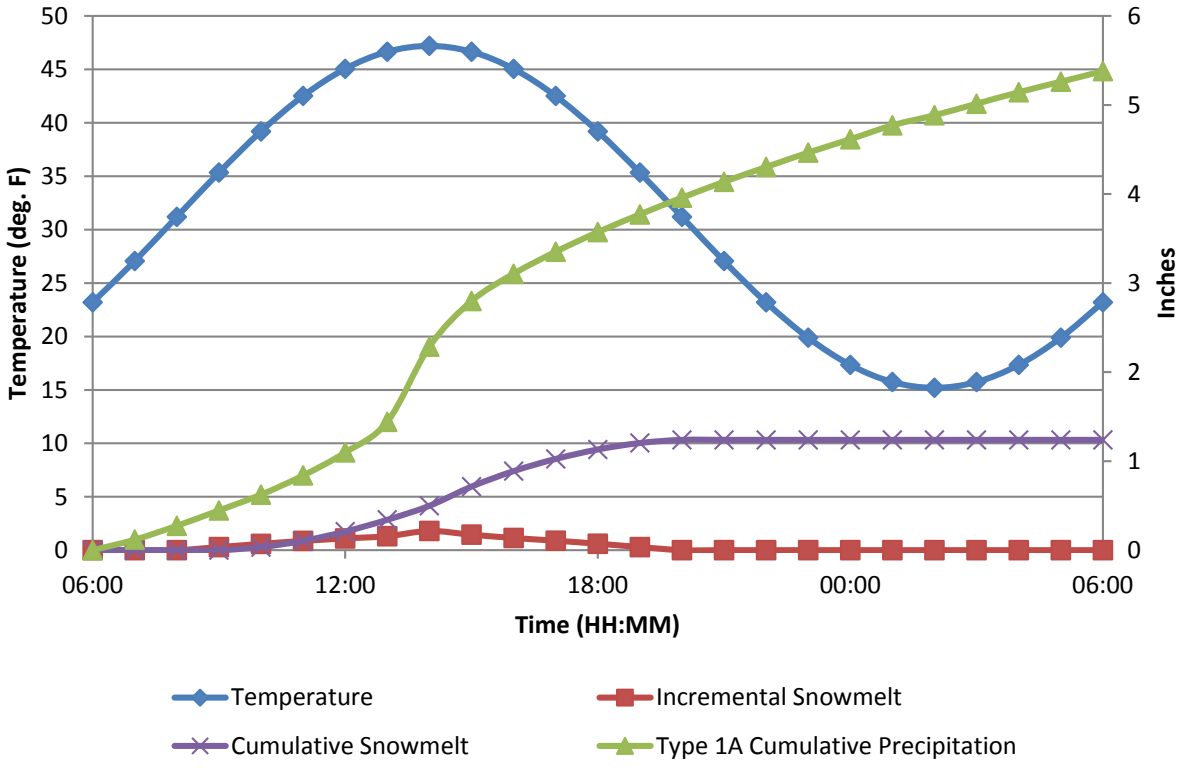


Figure 14. 24-hour Duration Storm and Snowmelt Cumulative Depth Distribution

4.0 PRECIPITATION-RUNOFF ANALYSIS

Runoff for the subbasins was estimated using the Natural Resources Conservation Service (NRCS) Curve Number method within HEC-HMS 3.5 (USACE, 2010). The NRCS Curve Number method estimates rainfall excess as a function of cumulative rainfall, soil cover, land use and antecedent moisture condition. The watershed characteristics are related the Curve Number (CN) parameter based on tables developed by NRCS.

The NRCS runoff equation is:

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

Where:
Q = runoff (in)
P = rainfall (in)
S = potential retention after runoff begins (in)

The initial abstraction is assumed to be:

$$Ia = 0$$

Potential soil water retention is related to the curve number by the following equation:

$$S = 1000/CN - 10$$

Where:
S = potential retention in watershed (in)
CN = SCS curve number for the drainage area

The direct runoff from the subbasins was estimated using the NRCS Unit Hydrograph method. This method uses the watershed time lag to estimate the time to peak and peak discharge of the unit hydrograph. The watershed time lag estimated with the NRCS Lag Time Equation:

$$T_{LAG} = L^{0.8} \frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

Where:
T_{LAG} = lag time (hr)
L = hydraulic length of watershed (ft)
Y = average watershed slope (%)
S = potential retention in watershed (in)

4.1 SUBBASIN DELINEATION

The drainage areas and flow paths for each subbasin were delineated using LiDAR topography that was collected for the site, national hydrography dataset (NHD) flow lines, 90% Design

construction phase topography (MWH 2014), and ArcGIS 10.1 software. The peak flows for each subbasin were calculated using HEC-HMS 3.5. The NRCS Curve Number method was used to compute the runoff from the subbasins and the Unit Hydrograph method was selected as the transform method. The lag time was calculated using the SCS Lag Time Equation which uses basin length, basin slope and curve number as parameters. The basin delineation and subbasin naming convention for each pond is shown on Figures 15 and 16.

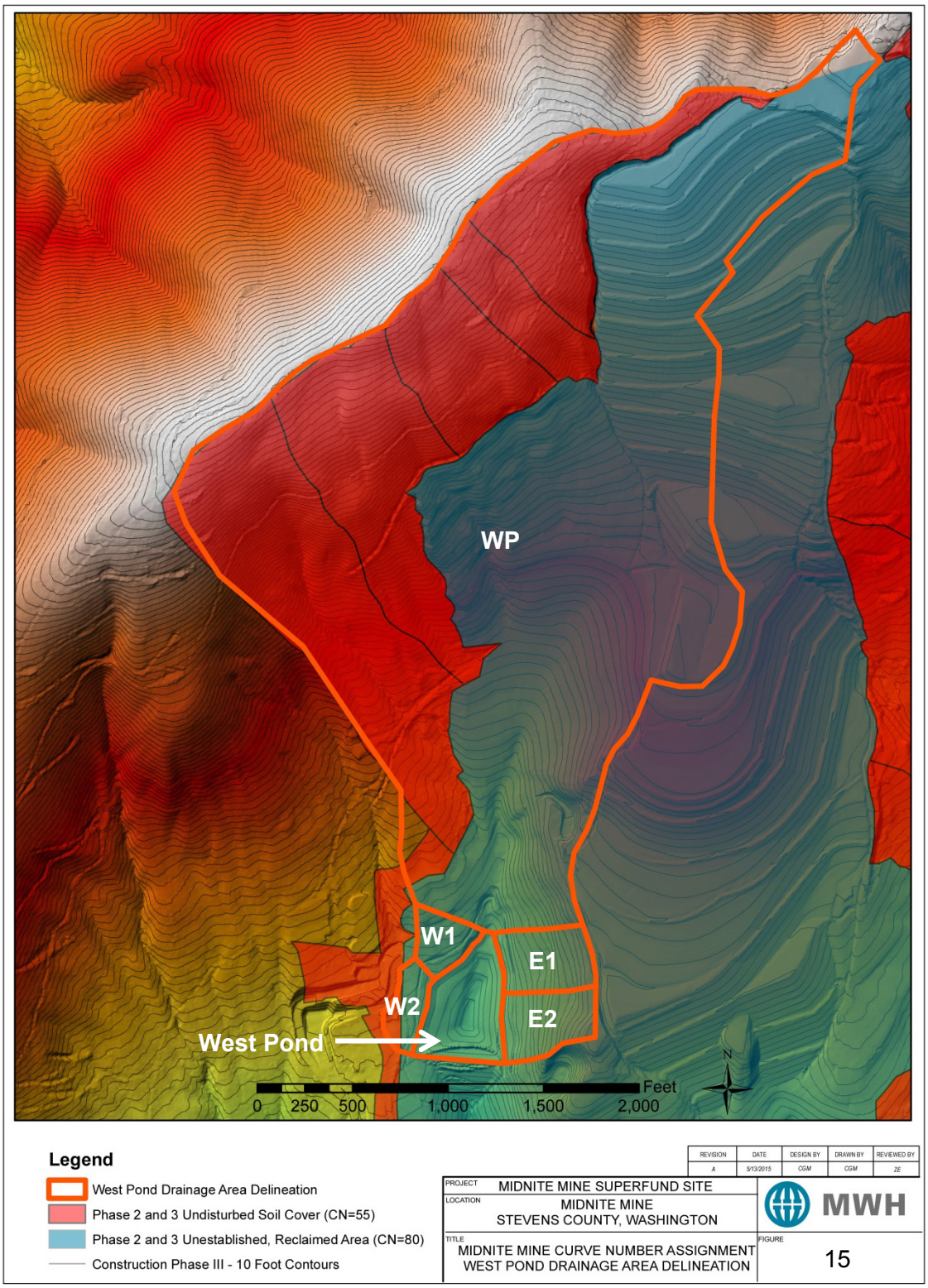


Figure 15. West Pond Subbasin Delineation

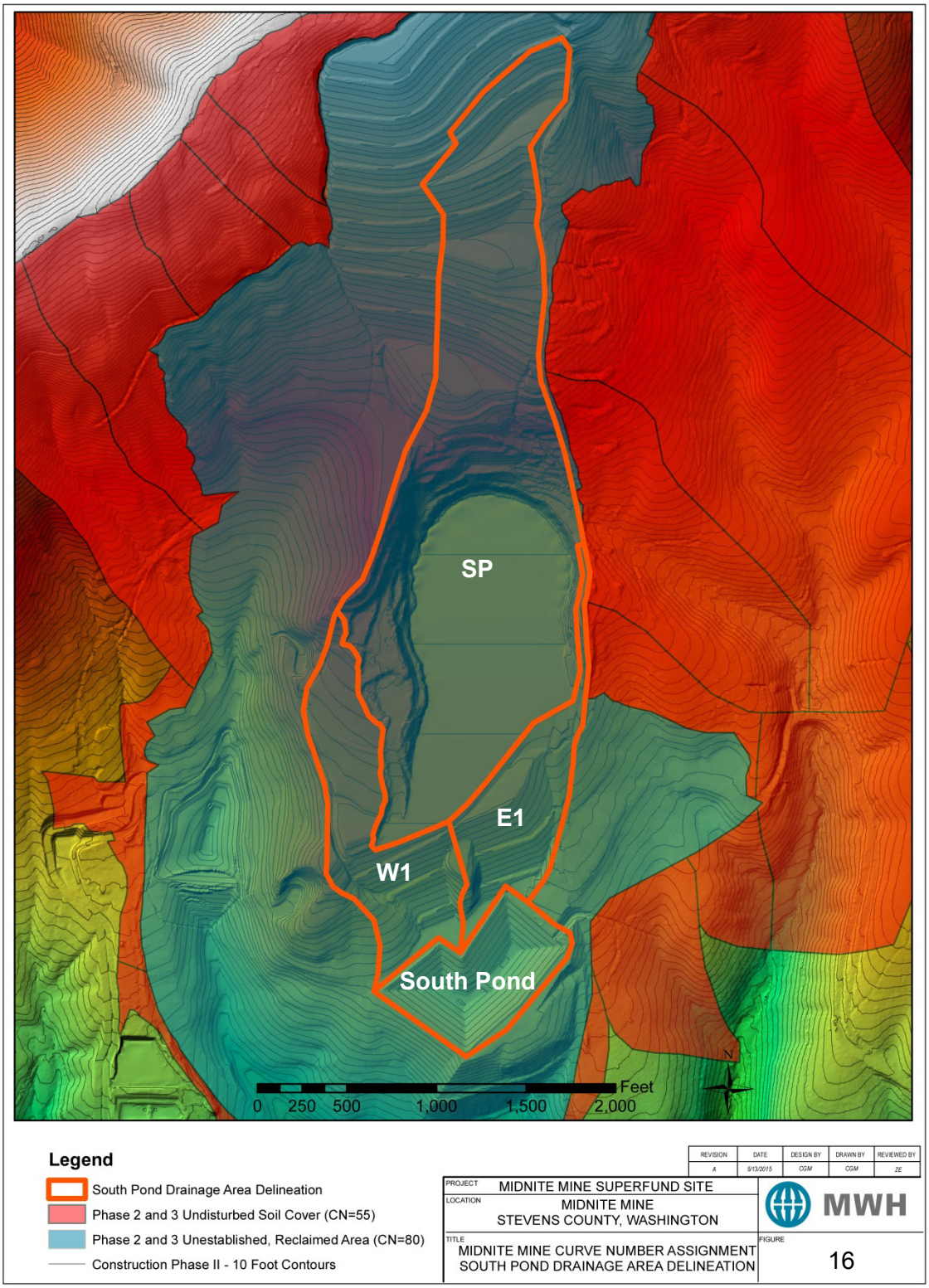


Figure 16. South Pond Subbasin Delineation

4.2 CURVE NUMBER SELECTION

Undisturbed areas outside of the mine affected area are best classified as “woods” in “good” condition (Tetra Tech 2011). A curve number of 55 was selected for all undisturbed areas based on Table 9-1 in the National Engineering Handbook (NRCS 2004) and Table 4.5.2 in the Stormwater Management Manual for Eastern Washington (WSDOE 2004) for hydrologic soil group B (Tetra Tech 2011). For purposes of the design flow and volume estimates, a curve number of 80, associated with “sagebrush with grass understory” in “poor (<30 percent ground cover)” condition (WSDOE 2004), was selected for the unestablished reclaimed areas of the site (MWH 2014). The curve numbers for each basin for the West and South ponds are shown in Tables 6 and 7, respectively. These curve number values are applicable under normal antecedent moisture conditions (AMC II) and are the basis of design in eastern Washington (WSDOE 2004).

Table 6. Midnite West Pond Basin Curve Numbers

Basin	Area (acres)	Land Use	CN	CN x A	%	Weighted CN
WP	78.59	UNESTABLISHED RECLAIMED AREA	80	4,322.5	34.9	
WP	100.75	UNDISTURBED	55	8,060.3		
Total	179.35			12,382.9		69
W1	1.90	UNESTABLISHED RECLAIMED AREA	80	152.3	100.0	
Total	1.90			152.3		80
W2	1.28	UNESTABLISHED RECLAIMED AREA	80	65.1	49.4	
W2	0.50	UNDISTURBED	55	27.7		
Total	1.78			130.2		73
E1	3.62	UNESTABLISHED RECLAIMED AREA	80	289.5	100.0	
Total	3.62			289.5		80
E2	3.51	UNESTABLISHED RECLAIMED AREA	80	281.2	100.0	
Total	3.51			281.2		80
Pond	5.19	POND	100	519.1	100.0	
Total	5.19			519.1		100

Table 7. Midnite South Pond Basin Curve Numbers

Basin	Area (acres)	Land Use	CN	CN x A	%	Weighted CN
SP	77.79	UNESTABLISHED RECLAIMED AREA	80	6,223.2	100.0	
Total	77.79			6,223.2		80
E1	12.57	UNESTABLISHED RECLAIMED AREA	80	1,005.6	100.0	
Total	12.57			1,005.6		80
W1	17.49	UNESTABLISHED RECLAIMED AREA	80	1,399.2	100.0	
Total	17.49			1,399.2		80
Pond	11.74	POND	100	1,174.0	100.0	
Total	11.74			1,174.0		100

An initial abstraction of zero was assumed for the runoff modeling in this analysis. The Loss Method was assumed to be the SCS Curve Number and the Transform Method was the SCS Unit Hydrograph. A time step of 5 minutes was selected for short duration storms, and a time step of 15 minutes was selected for long duration storms.

Curve numbers for snowmelt were set equal to 100 for producing snowmelt hydrographs (NRCS 2004). This provides a method for modeling the hourly snowmelt runoff, produced by diurnal temperature variation, into the hydrologic model. Setting the curve number equal to 100 is equivalent to specifying an impervious surface. During construction phases 2 and 3, stormwater management and operations channels will be constructed throughout the Midnite Mine site. As a conservative estimate of the spillway design inflow, drainage basin delineation for the West and South Ponds does not consider the runoff that would be diverted by the channels.

4.3 POND CHARACTERISTICS

The spillway geometry and stage-storage data for the West and South Ponds were obtained from the 90% Design drawings (MWH, 2014) and their configuration is shown on Figure 17. These configurations have not changed significantly for the 100% Design. The stage-storage data for the South and West Ponds are shown in Tables 8 and 9, respectively. The West Pond facility will be constructed during Construction Phase III after significant clean-up of waste rock and contaminated soils. The West Pond configuration is currently based on pre-mine topography (i.e., USBM (1995)) which is likely to change and require updated analyses based on as-built conditions once prior waste rock removal and soil cleanup have been completed in this area. An updated design, based on the as-built topography and updated analyses will be required for the West Pond embankment, impoundment, and spillway prior to construction. Therefore, West Pond design flows and spillway calculations presented in this document are considered preliminary. For the purposes of the design flow estimations the spillway shape is assumed to be trapezoidal with the dimensions shown on the 100% Design Drawings and summarized in Table 10. Standard trapezoidal broad-crested weir discharge can be estimated as (Bos 1989):

$$Q = C_d\{b_c y_c + z_c y_c^2\}\{2g(H_1 - y_c)\}^{0.5}$$

Where

$Q =$ discharge (cfs)

b_c = bottom width (ft)
y_c = critical depth in spillway (ft)
z_c = side slope of traditional trapezoidal geometry (H:V)
H_1 = reservoir head (ft)
$C_d = 0.93 + 0.1 * \frac{H_1}{l}$
l = control section length (ft)

Rating curves were developed using the trapezoidal broad-crested weir equation and were used to model the conceptual spillway discharge.

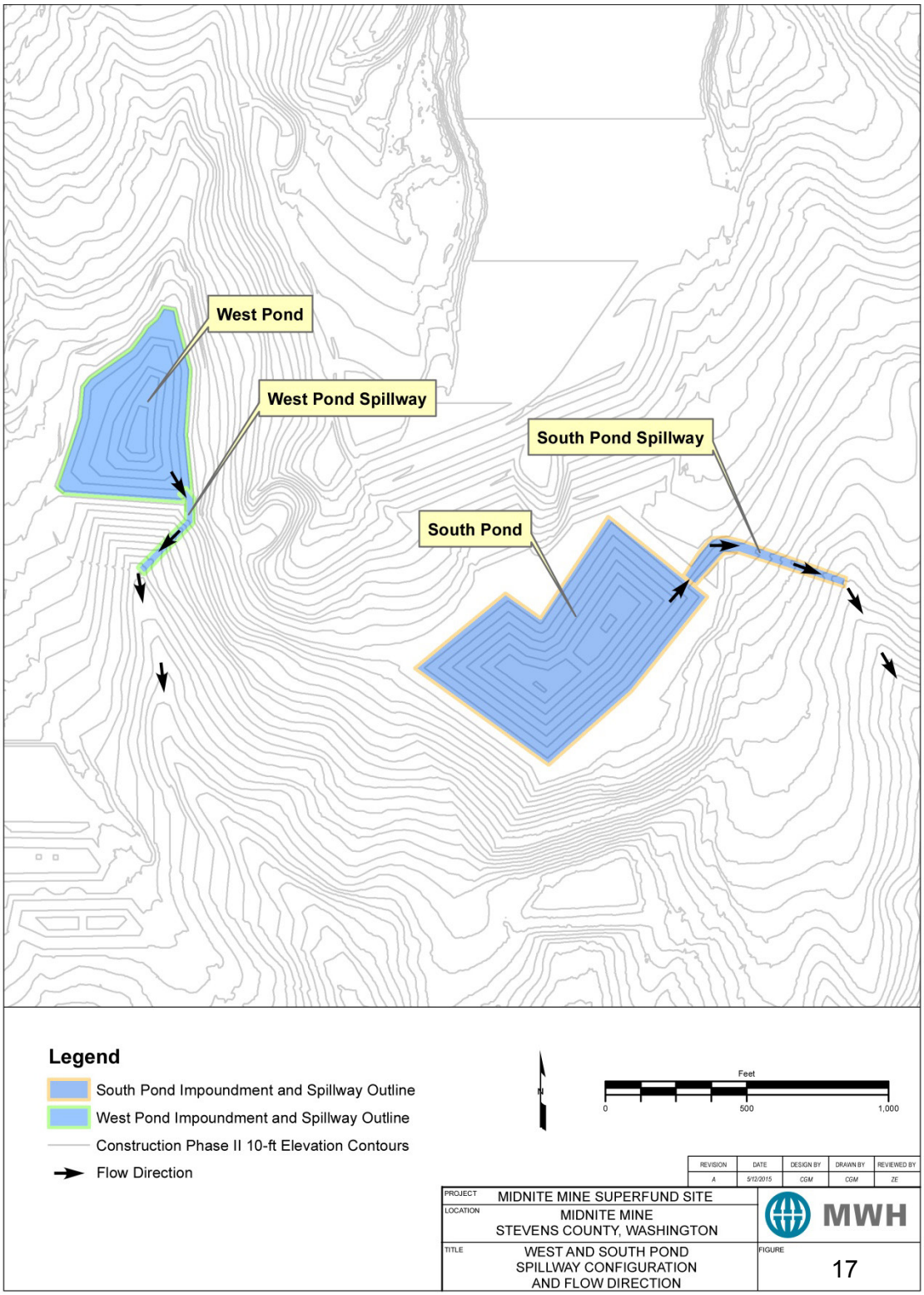


Figure 17. West and South Pond Schematic Spillway Configuration

Table 8. South Pond Stage-Storage Data

Elevation	Acre-ft	Elevation	Acre-ft	Elevation	Acre-ft
2,619	0.00	2,641	24.78	2,663	107.72
2,620	0.02	2,642	27.19	2,664	113.13
2,621	0.12	2,643	29.71	2,665	118.70
2,622	0.31	2,644	32.35	2,666	124.43
2,623	0.60	2,645	35.11	2,667	130.32
2,624	1.02	2,646	38.00	2,668	136.37
2,625	1.55	2,647	41.01	2,669	142.59
2,626	2.22	2,648	44.15	2,670	148.97
2,627	3.00	2,649	47.42	2,671	155.52
2,628	3.87	2,650	50.82	2,672	162.24
2,629	4.84	2,651	54.35	2,673	169.12
2,630	5.90	2,652	58.02	2,674	176.18
2,631	7.06	2,653	61.82	2,675	183.42
2,632	8.33	2,654	65.77	2,676	190.83
2,633	9.69	2,655	69.85	2,677	198.42
2,634	11.17	2,656	74.07	2,678[1]	206.19
2,635	12.76	2,657	78.43	2,679	214.14
2,636	14.49	2,658	82.94	2,680	222.27
2,637	16.32	2,659	87.60	2,681	230.59
2,638	18.27	2,660	92.40	2,682	239.09
2,639	20.33	2,661	97.35	2,683[2]	247.78
2,640	22.50	2,662	102.46	-	-

Notes: [1] South Pond spillway invert elevation (2,678 ft)
[2] South Pond embankment crest elevation (2,683 ft)

Table 9. West Pond Stage-Storage Data

Elevation	Acre-ft	Elevation	Acre-ft	Elevation	Acre-ft
2,605	0.00	2,624	7.65	2,643	37.98
2,606	0.10	2,625	8.49	2,644	40.59
2,607	0.22	2,626	9.40	2,645	43.32
2,608	0.37	2,627	10.37	2,646	46.17
2,609	0.53	2,628	11.40	2,647	49.16
2,610	0.72	2,629	12.51	2,648	52.28
2,611	0.95	2,630	13.68	2,649	55.55
2,612	1.21	2,631	14.94	2,650	58.95
2,613	1.51	2,632	16.30	2,651	62.50
2,614	1.85	2,633	17.76	2,652	66.19
2,615	2.23	2,634	19.32	2,653	70.01
2,616	2.66	2,635	20.98	2,654	73.93
2,617	3.13	2,636	22.75	2,655(1)	77.97
2,618	3.64	2,637	24.62	2,656	82.12
2,619	4.19	2,638	26.59	2,657	86.38
2,620	4.78	2,639	28.66	2,658	90.75
2,621	5.42	2,640	30.83	2,659	95.24
2,622	6.11	2,641	33.10	2,660(2)	99.85
2,623	6.85	2,642	35.49	-	-

Notes: (1) West Pond spillway invert elevation (2,655 ft)
(2) West Pond embankment crest elevation (2,660 ft)

Table 10. West and South Pond Spillway Dimensions

	West Pond	South Pond
Bottom Width (ft)	10	10
Side Slopes	2H:1V	2H:1V
Cross-section Shape	Trapezoid	Trapezoid
Spillway Invert Elev. (ft)	2655	2678
Dam Crest Elev. (ft)	2660	2683
Control Section Length (ft)	15	15

4.4 SCENARIOS MODELED

The following seven scenarios for estimating the Design Step 4, 10,000-year event, peak flows due to rainfall and snowmelt were evaluated:

Scenario 1: Design Step 4 storm depth of 4.18" from the WSDOE Dam Safety Guidelines, distributed using the 4-hour duration short-storm hyetograph. Scenario 1 assumes that no contribution of snowmelt occurs.

Scenario 2: Design Step 4 storm depth of 5.74" from the WSDOE Dam Safety Guidelines, distributed using the 18-hour duration intermediate-storm hyetograph. Scenario 2 assumes that no contribution of snowmelt occurs.

Scenario 3: Design Step 4 storm depth of 6.75" from the WSDOE Dam Safety Guidelines, distributed using the 72-hour duration long-storm hyetograph. Scenario 3 assumes that no contribution of snowmelt occurs.

Scenario 4: Design Step 4, 24-hour storm depth of 5.38" from the WSDOE Dam Safety Guidelines, distributed using an SCS Type 1A distribution. Scenario 4 assumes that no contribution of snowmelt occurs.

Scenario 5: Design Step 4, 18-hour storm depth of 5.74" from the WSDOE Dam Safety Guideline and snowmelt distributed using daily temperature variation and the Energy Budget method.

Scenario 6: Design Step 4, 24-hour storm depth of 5.38" distributed using a SCS Type 1A distribution and snowmelt distributed using daily temperature variation and the Energy Budget method.

Scenario 7: Design Step 4, 72-storm depth of 6.75" from the WSDOE Dam Safety Guideline and snowmelt distributed using daily temperature variation and the Energy Budget method.

5.0 RESULTS

A summary of the subbasin parameters used for the precipitation-runoff analyses is shown in Tables 11 and 12.

Table 11. Midnite West Pond Basin Parameters[(1)]

Subbasin	Area (mi^2)	CN	Length (ft)	Average Slope (%)	Lag Time (min)
WP	0.2802	69	5,268	31.2	18
W1	0.0030	80	144	28.3	1
W2	0.0028	73	384	32.8	2
E1	0.0057	80	473	38.0	2
E2	0.0055	80	491	29.4	2
Pond	0.0081	100	0	31.3	0

Notes: [(1)] West Pond results are preliminary due to potential configuration revisions during Construction Phase III

Table 12. Midnite South Pond Basin Parameters

Subbasin	Area (mi^2)	CN	Length (ft)	Average Slope (%)	Lag Time (min)
SP	0.1216	80	5,086	23.8	14
E1	0.0196	80	2,052	23.8	7
W1	0.0273	80	1,369	20.5	5
Pond	0.0183	100	0	28.4	0

Using the above parameters and time steps of 5 minutes for short and intermediate storm durations (4- to 24-hour) and 15 minutes for long storm durations (72-hour), the simulations

were carried out in HEC-HMS 3.5. A summary of the peak discharge results for Design Step 4 for the West and South Ponds are shown in Tables 13 and 14, respectively.

Table 13. Midnite Mine West Pond Peak Flow Results – Design Step 4[1]

West Pond		Design Step 4			
		Scenario 1 4-hr storm	Scenario 2 18-hr storm	Scenario 3 72-hr storm	Scenario 4 24-hr storm[2]
Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Peak Discharge (CFS)	Peak Discharge (CFS)	Peak Discharge (CFS)
WP	0.2802	632.4	215.0	124.3	105.2
Pond	0.0081	64.1	12.1	6.7	6.7
E1	0.0057	31.5	7.1	3.7	3.3
E2	0.0055	31.930.6	6.9	3.6	3.2
W1	0.0030	16.6	3.7	1.9	1.7
W2	0.0028	13.4	3.1	1.6	1.4
Inflow	0.3053	662.8	232.5	138.4	114.7
West Pond	0.3053	384.1	176.8	102.4	74.5
Outflow	**0.3053**	**384.1**	**176.8**	**102.4**	**74.5**

Notes: [1] West Pond results are preliminary due to potential and configuration revisions during Construction Phase III
[2] SCS Type 1A Rainfall Distribution

Table 14. Midnite Mine South Pond Peak Flow Results – Design Step 4

South Pond		Design Step 4			
		Scenario 1 4-hr storm	Scenario 2 18-hr storm	Scenario 3 72-hr storm	Scenario 4 24-hr storm[1]
Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Peak Discharge (CFS)	Peak Discharge (CFS)	Peak Discharge (CFS)
SP	0.122	406.6	119.8	68.6	63.8
W1	0.027	136.8	33.0	17.9	15.7
E1	0.020	85.4	22.4	12.8	11.1
Pond	0.018	144.9	27.3	15.2	15.2
Inflow	0.187	619.0	187.8	106.4	102.9
South Pond	0.187	161.3	94.9	55.1	41.3
Outflow	**0.187**	**161.3**	**94.9**	**55.1**	**41.3**

Notes: [1] SCS Type 1A Rainfall Distribution

West and South Pond precipitation runoff volume results are shown below in Tables 15 and 16, respectively.

Table 15. Midnite Mine West Pond Runoff Volume Results – Design Step 4[1]

West Pond		Design Step 4			
		Scenario 1 4-hr storm	Scenario 2 18-hr storm	Scenario 3 72-hr storm	Scenario 4 24-hr storm[2]
Hydrologic Element	Drainage Area (mi^2)	Volume (Acre-Feet)	Volume (Acre-Feet)	Volume (Acre-Feet)	Volume (Acre-Feet)
WP	0.2802	30.1	48.1	60.6	43.8
Pond	0.0081	1.8	2.5	2.9	2.3
E1	0.0057	0.8	1.2	1.5	1.1
E2	0.0055	0.8	1.2	1.4	1.1
W1	0.0030	0.4	0.6	0.8	0.6
W2	0.0028	0.3	0.5	0.6	0.5
Inflow	0.3053	34.2	54.1		
West Pond	0.3053	34.2	54.1	67.8	49.4
Outflow	**0.3053**	**34.2**	**54.1**		**49.4**

Notes: [1] West Pond results are preliminary due to potential configuration revisions during Construction Phase III
[2] SCS Type 1A Rainfall Distribution

Table 16. Midnite Mine South Pond Runoff Volume Results – Design Step 4

South Pond		Design Step 4			
		Scenario 1 4-hr storm	Scenario 2 18-hr storm	Scenario 3 72-hr storm	Scenario 4 24-hr storm[1]
Hydrologic Element	Drainage Area (mi^2)	Volume (Acre-Feet)	Volume (Acre-Feet)	Volume (Acre-Feet)	Volume (Acre-Feet)
SP	0.122	17.0	25.9		23.8
W1	0.027	3.8	5.8	7.2	5.4
E1	0.020	2.7	4.2	5.2	3.8
Pond	0.018	4.1	5.6	6.6	5.3
Inflow	0.187	27.6	41.6	50.9	38.3
South Pond	0.187	27.6	41.6	50.9	38.3
Outflow	**0.187**	**27.6**	**41.6**	**50.9**	**38.3**

Notes: [1] SCS Type 1A Rainfall Distribution

Rain-on-snow peak flow results for West and South Ponds are summarized in Tables 17 and 18, respectively.

Table 17. Midnite Mine West Pond Rain-On-Snow Peak Flow Results – Design Step 4[(1)]

West Pond	Design Step 4 - Rain-on-snow		
	Scenario 5 WDOE 18-hr storm	Scenario 6 SCS Type 1A 24-hr storm	Scenario 7 WDOE 72-hr storm
Hydrologic Element	**Peak Discharge (CFS)**	**Peak Discharge (CFS)**	**Peak Discharge (CFS)**
Rain-on-Snow Inflow	266.2	157.1	138.4
West Pond	221.7	120.6	104.8
Outflow	221.7	120.6	104.8

Notes: [(1)] West Pond results are preliminary due to potential soil cover and configuration revisions during Construction Phase III

Table 18. Midnite Mine South Pond Rain-On-Snow Peak Flow Results – Design Step 4

South Pond	Design Step 4 - Rain-on-snow		
	Scenario 5 WDOE 18-hr storm	Scenario 6 SCS Type 1A 24-hr storm	Scenario 7 WDOE 72-hr storm
Hydrologic Element	**Peak Discharge (CFS)**	**Peak Discharge (CFS)**	**Peak Discharge (CFS)**
Rain-on-Snow Inflow	214.3	123.4	106.4
South Pond	125.9	65.9	64.1
Outflow	125.9	65.9	64.1

Rain-on-snow runoff volume results for West and South Ponds are summarized in Tables 19 and 20, respectively.

Table 19. Midnite Mine West Pond Rain-On-Snow Runoff Volume Results–Design Step 4[(1)]

West Pond	Design Step 4 - Rain-on-snow		
	Scenario 5 WDOE 18-hr storm	Scenario 6 SCS Type 1A 24-hr storm	Scenario 7 WDOE 72-hr storm
Hydrologic Element	**Volume (Acre-Feet)**	**Volume (Acre-Feet)**	**Volume (Acre-Feet)**
Rain-on-Snow Inflow	77.8	71.1	102.597.4
West Pond	77.8	71.1	97.4
Outflow	77.8	71.1	97.4

Notes: [(1)] West Pond results are preliminary due to potential soil cover and configuration revisions during Construction Phase III

Table 20. Midnite Mine South Pond Rain-On-Snow Runoff Volume Results–Design Step 4

South Pond	Design Step 4 - Rain-on-snow		
	Scenario 5 WDOE 18-hr storm	Scenario 6 SCS Type 1A 24-hr storm	Scenario 7 WDOE 72-hr storm
Hydrologic Element	**Volume (Acre-Feet)**	**Volume (Acre-Feet)**	**Volume (Acre-Feet)**
Rain-on-Snow Inflow	67.855.9	51.4	68.8
South Pond	67.855.9	51.4	68.8
Outflow	55.9	51.4	68.8

Subbasins contributing inflows to the West and South Ponds are represented as hydrologic junction element "**Inflow**" for each respective pond. Rainfall falling directly onto pond water surfaces is treated as direct inflow to each reservoir. Rain-on-snow runoff events are estimated by combining rainfall and corresponding snowmelt runoff as a single inflow hydrograph to each pond. Table 21 summarizes the inflow and outflow characteristics of the West and South pond and the corresponding increase in water rise during each storm scenario. Based on peak water rise results, the controlling scenario for both West and South Ponds is Scenario 1, the short duration WSDOE storm. Maximum runoff volumes resulted from Scenario 7, the combined long duration precipitation event and snowmelt runoff. For the purposes of estimating maximum outflows for spillway design, the storage ponds were assumed to be full at the start of the design runoff event. This is considered to be a very conservative assumption since under normal operating conditions, the ponds will be nearly empty.

Table 21. West and South Pond Inflow (Q_{in}) and Outflow (Q_{out}) Summary

	West Pond[1]			South Pond			DT
	Q_{in} (cfs)	Q_{out} (cfs)	Peak Water Rise (ft)	Q_{in} (cfs)	Q_{out} (cfs)	Peak Water Rise (ft)	(min)
Scenario 1[2]	662.8	384.1	4.1	619.0	161.3	2.6	5
Scenario 2	232.5	176.8	2.7	187.8	94.9	1.9	5
Scenario 3	138.4	102.4	2.0	106.4	55.1	1.4	15
Scenario 4	114.7	74.5	1.6	102.9	41.3	1.1	5
Scenario 5	266.2	221.7	3.0	214.3	125.9	2.2	5
Scenario 6	157.1	120.6	2.2	123.4	65.9	1.5	5
Scenario 7	138.4	104.8	2.0	106.4	64.1	1.5	15

Notes: [1] West Pond results are preliminary due to potential soil cover and configuration revisions during Construction Phase III

[2] Scenario 1 is the critical scenario; therefore a sensitivity analysis was performed. A water rise of 3.8 ft was obtained when using a time step of 15 min. A water rise of 3.2 ft was obtained when the initial abstraction was determined as a function of the CN.

Inflow and outflow hydrographs are presented for West Pond rainfall and snowmelt scenarios on Figures 18 to 24.

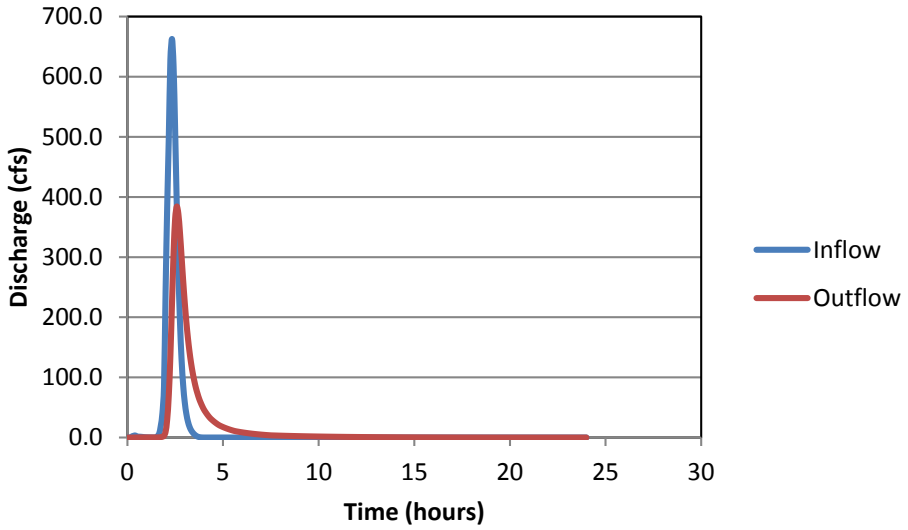


Figure 18. West Pond WSDOE Short Duration Storm Inflow and Outflow Hydrographs

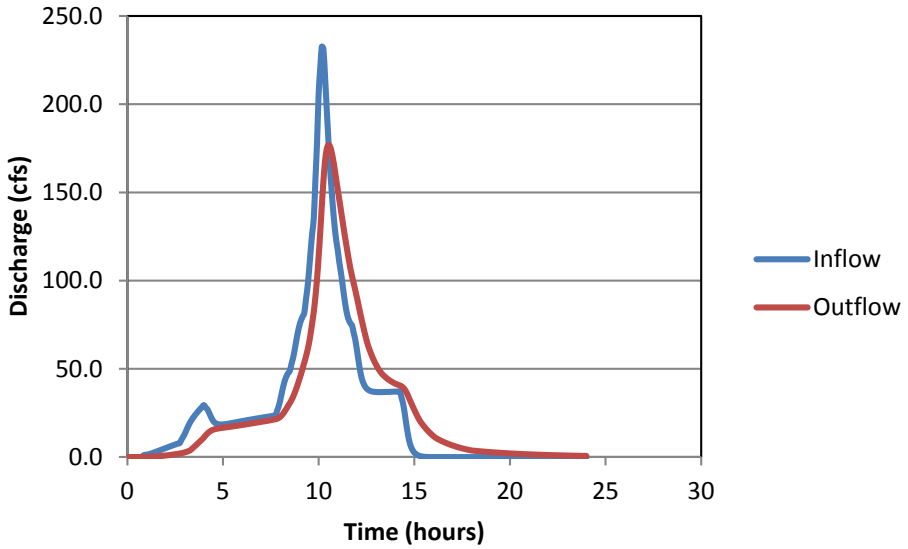


Figure 19. West Pond WSDOE Intermediate Duration Storm Inflow and Outflow Hydrographs

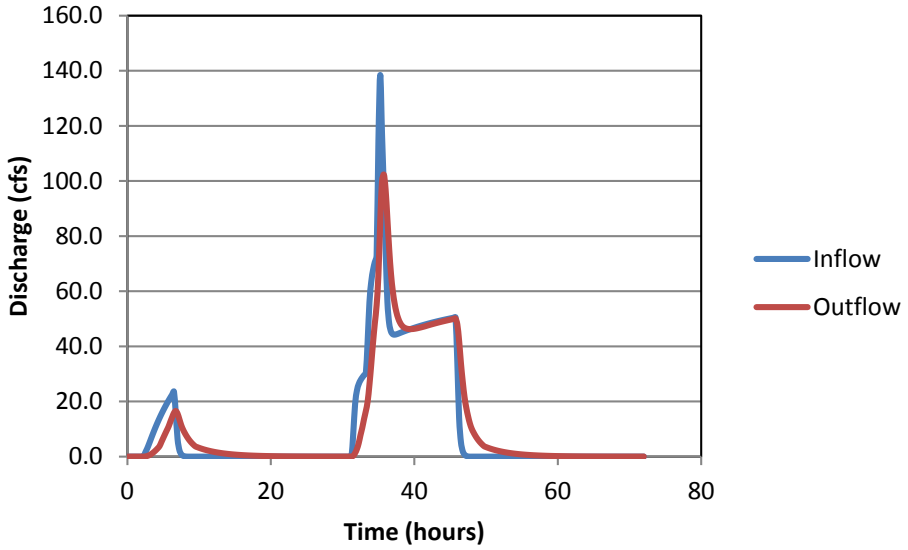


Figure 20. West Pond WSDOE Long Duration Storm Inflow and Outflow Hydrographs

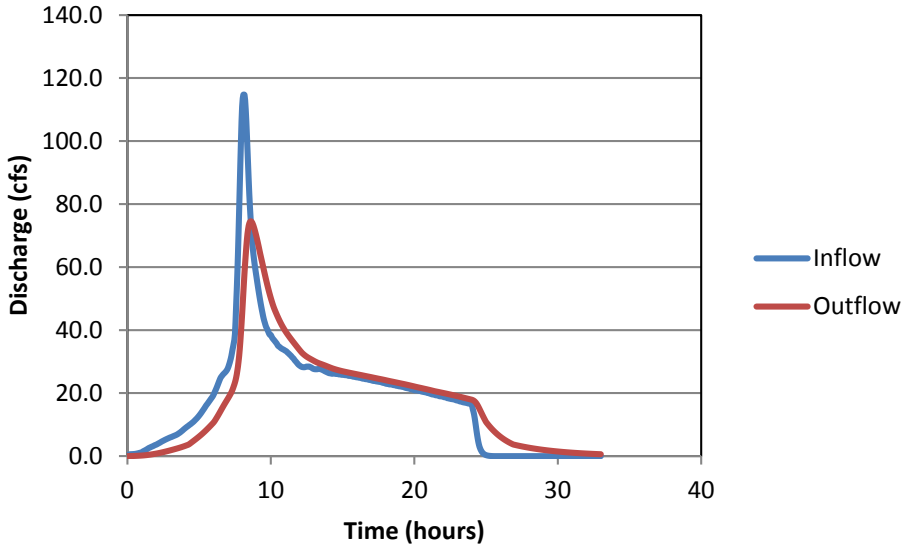


Figure 21. West Pond SCS Type 1A 24-hour Duration Storm Inflow and Outflow Hydrographs

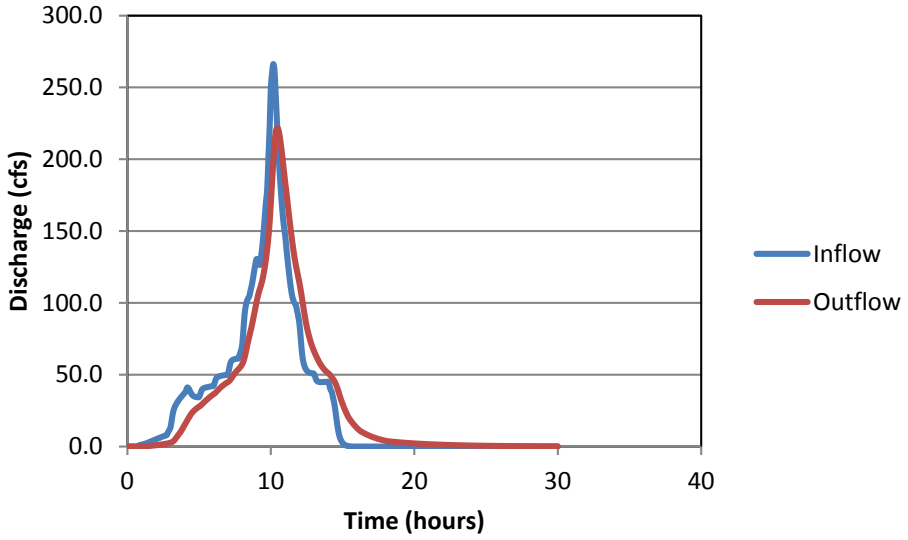


Figure 22. West Pond WSDOE 18-hour Rain-on-Snow Inflow and Outflow Hydrographs

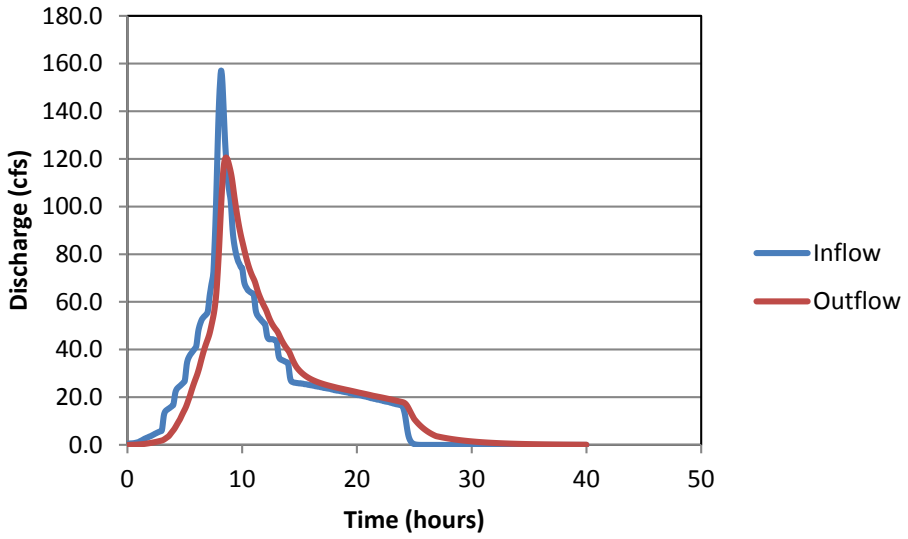


Figure 23. Figure 22. West Pond SCS Type 1A 24-hour Rain-on-Snow Inflow and Outflow Hydrographs

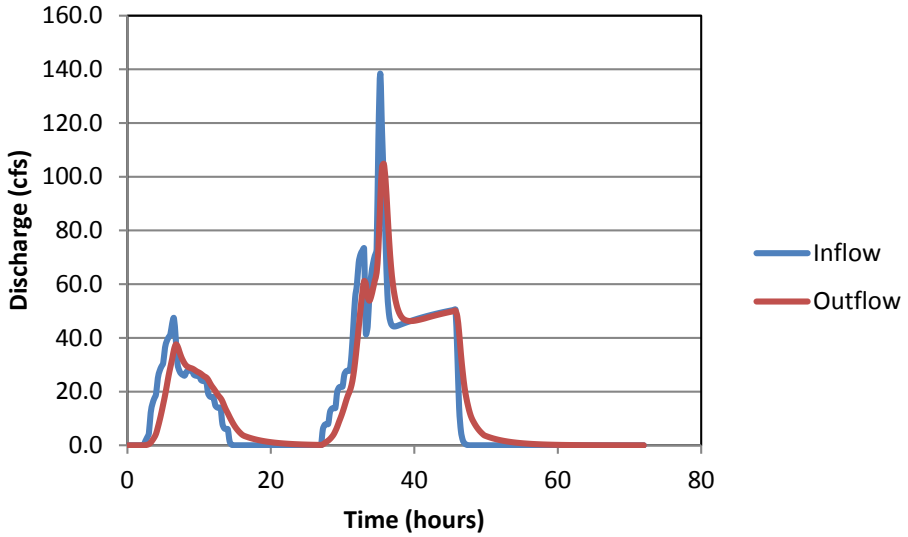


Figure 24. West Pond WSDOE 72-hour Rain-on-Snow Inflow and Outflow Hydrographs

Inflow and outflow hydrographs are presented for South Pond rainfall and snowmelt scenarios on Figures 25 to 31.

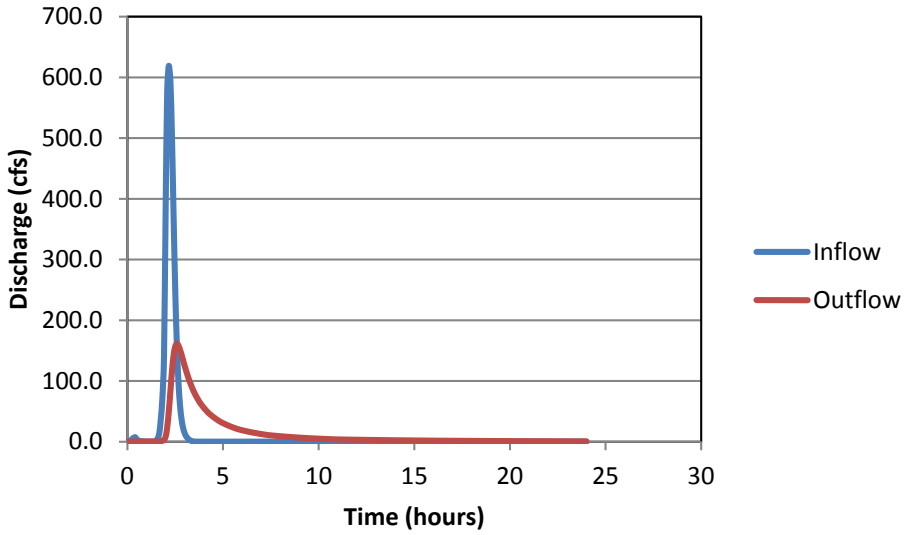


Figure 25. South Pond WSDOE Short Duration Storm Inflow and Outflow Hydrographs

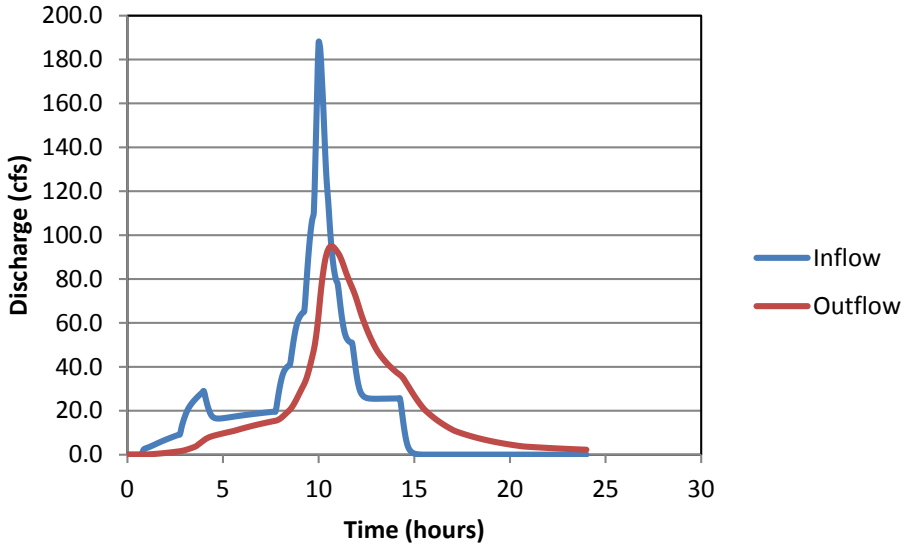


Figure 26. South Pond WSDOE Intermediate Duration Storm Inflow and Outflow Hydrographs

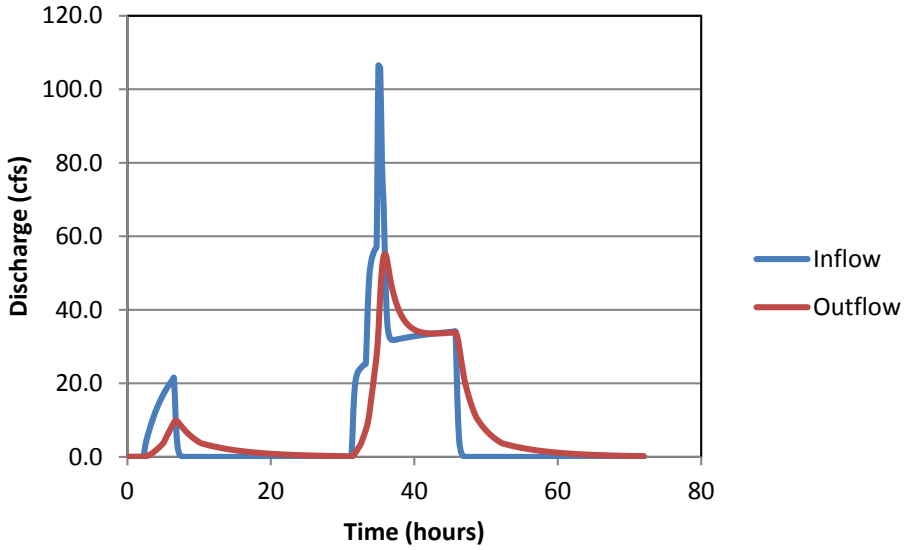


Figure 27. South Pond WSDOE Long Duration Storm Inflow and Outflow Hydrographs

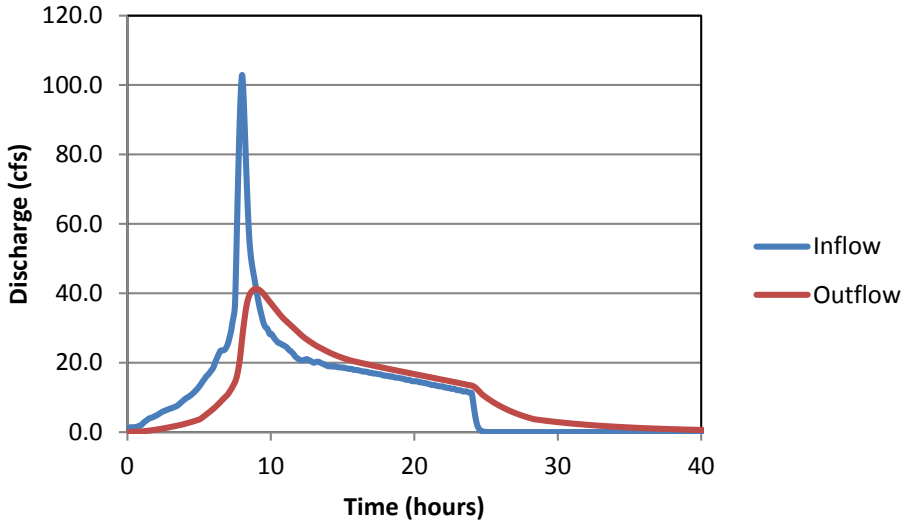


Figure 28. South Pond SCS Type 1A 24-hour Duration Storm Inflow and Outflow Hydrographs

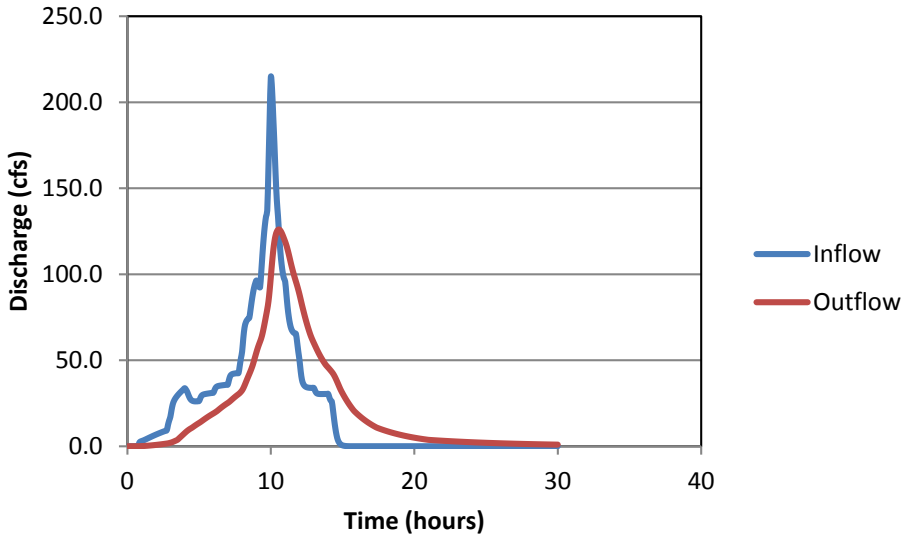


Figure 29. South Pond WSDOE 18-hour Rain-on-Snow Inflow and Outflow Hydrographs

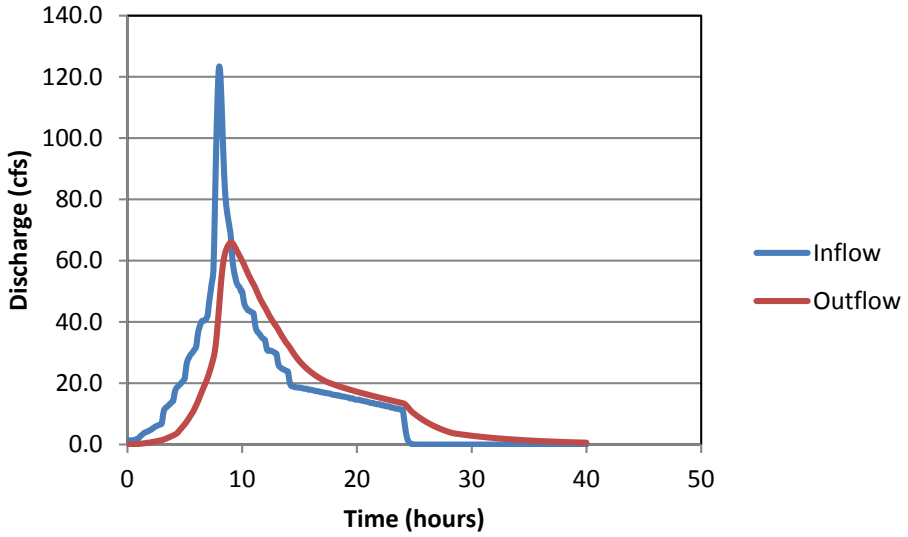


Figure 30. South Pond SCS Type 1A 24-hour Rain-on-Snow Inflow and Outflow Hydrographs

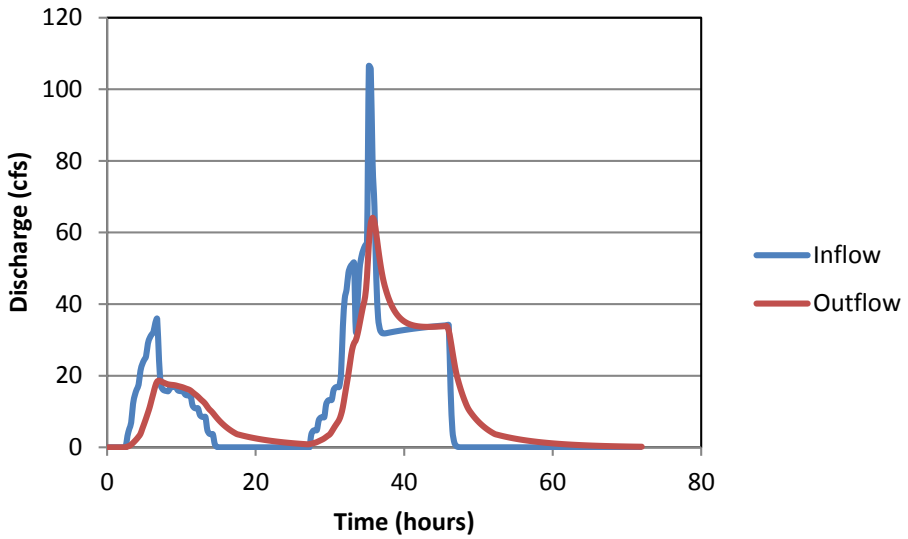


Figure 31. Figure 30. South Pond WSDOE 72-hour Rain-on-Snow Inflow and Outflow Hydrographs

6.0 SUMMARY AND CONCLUSIONS

Precipitation frequency analysis and storm distributions used for estimating runoff volumes and design flows were estimated using the WSDOE Dam Safety Guidelines. Design storm depths for 4-hour, 18-hour, 24-hour, and 72-hour events and corresponding temporal distributions were produced following the procedures outlined in *Technical Note 3* (WSDOE 2009). Based on the Midnite Mine hydrology and site characteristics, design inflows and runoff volumes were estimated for an event magnitude of Design Step 4. A Design Step 4 event corresponds to an Annual Exceedance Probability of 1/10,000, or a 10,000-year return interval as shown in the design step summary for the Midnite Mine water management ponds. Total storm depths utilized in this analysis are summarized in Table 22.

Table 22. Summary of Design Step 4 Precipitation Depths and Distributions

Distribution	Storm Name	Duration (hours)	Total Storm Depth (inches)
WSDOE:	Short	4	4.18
	Intermediate	18	5.74
	Long	72	6.75
SCS Type 1A:	24-hour	24	5.38

Rain-on-snow events were considered using the Energy Budget Partly Forested equation developed by USACE. A wind speed of 33 mph was assumed and a wind coefficient of 0.65 was selected as being representative of the site conditions. A sine function was used to simulate the diurnal temperature variation and develop the cumulative snowmelt distribution. Using this method, a snowmelt depth of 1.32 inches occurs from the 24-hour, Design Step 4 precipitation event of 5.38 inches. Table 23 presents Design Step 4 snowmelt depths used to produce peak flow and runoff volume estimates for the Midnite Mine site.

Table 23. Design Step 4 Snowmelt Depths

Distribution	Storm Name	Duration (hours)	Total Snowmelt Depth (inches)
WSDOE:	Intermediate	18	1.44
	Long	72	1.80
SCS Type 1A:	24-hour	24	1.32

Runoff and peak flow estimates were determined using HEC-HMS utilizing the design rainfall and snowmelt distribution established for the site. The NRCS CN method was used to estimate runoff from rainfall and snowmelt. CN selection was based on soil cover and conditions expected during Construction Phases II and III under normal antecedent moisture conditions (AMC II). A CN value of 100 was used to estimate snowmelt runoff (NRCS 2004). The SCS Unit Hydrograph was selected as the transform method. The peak discharge for the West and South Pond resulted from the WSDOE short duration storm. Peak runoff volumes resulted from the rain-on-snow event combining the WSDOE 72-hour duration precipitation event and the corresponding snowmelt runoff. The resulting peak flows to be used in the design of the West and South Pond Spillways are presented in Table 24. When the West Pond is constructed (i.e., end of Construction Phase II), the configuration may vary from that shown which is based on pre-mine USGS topography from the early 1950s. The intent is that the actual topography after cleaning up the waste rock and contaminated soils in this basin be resurveyed, and necessary

geotechnical and other investigations be performed at that time. The design for the West Pond, including the spillway will then be finalized.

Table 24. Design Step 4 Inflow and Runoff Volumes

Pond	Inflow (CFS)	Outflow (CFS)	Peak Runoff Volume (Acre-feet)	Peak Water Rise (ft)
West[1]	662.8	384.1	97.4	4.1
South	619.0	161.3	68.8	2.6

Notes: [1] West Pond results are preliminary due to potential soil cover and configuration revisions during Construction Phase III

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Attachment E-10

Spillway Designs

ATTACHMENT E-10

MIDNITE MINE REMEDIAL ACTION SPILLWAYS DESIGN

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
0	*10-July-14*	*90% Design*	*Chris Michalos*	*Carmen Bernedo*	*14-July-14*	*Tom Kelley*
1	*26-May-15*	*100% Design*	*Chris Gifford-Miears*	*Wade Moore*	*29-May-15*	*Clint Strachan*

Location and Format

Electronic copies of these calculations are located in the project files system at:

\\usslc1s01\IFO\Industrial Projects\MIDNITE MINE\Deliverables_Working Documents\Basis of Design Rpt\Appendix E - Water Management Ponds\100% Submittal\Att E-10 Spillway Design

The following calculations were generated using the following software:

Microsoft Office Professional Plus 2010 (Microsoft Excel)

River Analysis System (HEC-RAS), Version 4.1

1.0 PURPOSE

This calculation brief presents the results of the emergency overflow spillway sizing for both the South and West Ponds that will be part of the Remedial Action (RA) at the Midnite Mine Superfund Site (Site). The Site is located in Stevens County on the Spokane Indian Reservation in eastern Washington State. An emergency overflow spillway is required to conform to the Washington State Department of Ecology (WSDOE) Dam Safety guidelines, which were selected as the basis for substantive compliance of the storage pond design with applicable regulations.

The downdrain portion of the West Pond emergency overflow spillway will also receive flow from the West Pond Bypass Channel which will convey non-impacted surface water from upstream sources around the West Pond for storm flows up to the 500-year event. Storm flows associated with events larger than the 500-year storm will exceed the design capacity of the West Pond diversion channel and are assumed to report directly to the West Pond. As such, the West Pond Bypass Channel is neglected in the spillway analyses, which are designed for significantly larger storm events (up to the 10,000-year storm) in order conform to WSDOE Dam Safety Guidelines, and all upland flow associated with the spillway design event is assumed to be routed through the spillway.

Spillway design flows presented in Attachment E-9 have been updated from 90% Design to 100% Design based on expected soil cover delineations after completion of Construction Phase II and Phase III. This calculation brief presents 100% Design updates for the South Pond emergency spillway incorporating the updated spillway design flows. West Pond emergency spillway design has not been changed from 90% Design since the topographic information after Construction Phase II waste rock excavation will need to be confirmed and the design for the West Pond, including the spillway, will then need to be updated.

Final South Pond spillway hydraulics were estimated using the one-dimensional hydraulics model HEC-RAS (USACE, 2010). Initial screening of potential channel linings was performed assuming uniform flow conditions and hydraulic characteristics were estimated using Manning's equation.

2.0 DESIGN FLOWS

As identified in Attachment E-9, the 4-hour, short duration storm event (Scenario 1) produced the largest peak runoff and was selected as the design storm event for the sizing and design of the West and South Pond emergency overflow spillways and associated hydraulic structures. The estimated peak discharge inflow and outflow from the South and West Ponds are provided below (Table 1). The difference between the inflow and outflow is a result of the attenuation of the design storm through the pond. In addition, Attachment E-9 showed that the West and South ponds experience approximately a 4.1 ft and 2.6 ft water rise respectively above the spillway invert during the design peak discharge, which is less than the proposed design freeboard of 5 feet at the dam crest. These estimated attenuated outflow values and heights of water level rise are considered to be conservative, since they are based on assumed full pond conditions, with pond water levels at the spillway invert elevation at the onset of the design storm. During normal operations, the water level in both ponds will in reality be kept very low.

Table 1. Design Peak Discharges[1]

Pond	Inflow (ft^3/s)	Outflow (ft^3/s)	Peak Water Rise (ft)
West	662.8	384.1	4.1
South	619.0	161.3	2.6

Notes: [1] Attachment E-9: Design Flow Estimates for Spillways Design

The West Pond Bypass Channel has the capacity to convey 22 cubic feet per second (cfs) (from the 500-yr storm event) of non-impacted surface water from the site around the West Pond and discharge to the West Pond Emergency Spillway Channel.

3.0 ANALYSES

The analysis of both the South and West Pond overflow spillways included sizing the spillway channel to convey the design peak discharge and evaluated overflow spillway channel lining and downstream channel erosion protection options. Spillway channel linings considered included:

- Concrete
- Grouted riprap
- Articulated Concrete Block (ACB)
- Riprap
- Natural or cut bedrock

Manning's equation was used to calculate flow depths, average flow velocities, and channel dimensions assuming steady uniform flow in the channel for screening different channel linings. The one-dimensional hydraulics model HEC-RAS was used to estimate final hydraulic characteristics for South Pond spillway channels. The spillway channels were analyzed based upon assumed trapezoidal geometries with 2H:1V (2 horizontal to 1 vertical) side slopes, using the peak flows listed under the pond outflow condition. The freeboard accounts for wave action, uncertainty in the estimation of the design flow and channel roughness, and super elevation in channel bends. Manning's equation is presented as:

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

Where:

Q = discharge (cubic feet per second [cfs])
n = Manning's roughness coefficient
A = cross-sectional flow area (square feet [ft^2])
P = wetted perimeter (feet [ft])
R = hydraulic radius = A/P (ft)
S = bed slope (ft/ft)

The alignment of both the proposed West Pond and South Pond Emergency overflow spillways are shown in Figures 1 and 3 respectively. The average spillway channel slopes were estimated from the existing site topography data to be approximately 36.7 percent and 37.9 percent for the

West and South Pond Overflow Spillways, respectively. Both spillways discharge to existing natural drainages with slopes of approximately 9.5 percent for the South Pond Spillway Channel and 2.0 percent for the West Pond Spillway Channel. Since both of the natural drainage channels provide steep slopes, the overflow spillway channels will be designed to convey supercritical flow to the natural channels at the outfall of the spillways which reduces the need to provide energy dissipation at the spillway channel outfall. The spillway channel slope at the channel outfall will be adjusted to match the natural drainage slope to decrease the velocity and provide a smooth transition from the spillway channel to the natural drainage channel while maintaining supercritical flow. In addition, the natural drainage channel downstream of the spillway channel will be lined with loose riprap to mitigate against potential scour and erosion due to the spillway channel discharge, see Figures 2 and 4.

Typical Manning's n values for the selected channel linings are provided in Table 2.

Table 2. Typical Manning's n Values

Channel Lining	Manning's n
Concrete	0.013
Grouted riprap	0.035
Articulated Concrete Block (ACB)	0.015
Riprap	0.040
Natural or excavated bedrock	0.040

Utilizing the typical Manning's n values, channel flow parameters including flow depth, velocity and Froude number were computed for both the South Pond and West Pond spillway channels assuming trapezoidal cross sections with a 10 ft bottom width, 2:1 side slopes, and bed slopes of 25 and 35 percent which is approximately the average bed slope of the spillway chute for the South and West Ponds, respectively. The results were used to evaluate and screen potential channel lining alternatives and are summarized in Table 3. The analysis was performed using both the inflow and outflow peak discharges shown in Table 1. The spillways channel inflow design discharge was used to assess that the channel could convey the inflow without any freeboard, assuming little to no attenuation.

Table 3. Spillway Channel Flow Parameters

Channel Lining	South Pond Spillway (Outflow) / (Inflow)			West Pond Spillway (Outflow) / (Inflow)		
	Flow depth (ft)	Velocity (ft/s)	Froude No.	Flow depth (ft)	Velocity (ft/s)	Froude No.
Concrete	0.5 / (1.0)	32.0 / (50.9)	8.7 / (9.6)	0.7 / (1.0)	48.5 / (58.3)	10.9 / (11.3)
Grouted riprap	0.8 / (1.8)	16.8 / (25.8)	3.5 / (3.8)	1.2 / (1.7)	25.0 / (29.7)	4.4 / (4.5)
ACB	0.5 / (1.1)	29.2 / (46.2)	7.6 / (8.5)	0.8 / (1.0)	44.1 / (53.0)	9.5 / (9.9)
Riprap	0.9 / (1.9)	15.4 / (23.5)	3.1 / (3.4)	1.3 / (1.8)	22.8 / (27.0)	3.8 / (4.0)
Natural or cut bedrock	0.9 / (1.9)	15.4 / (23.5)	3.1 / (3.4)	1.3 / (1.8)	22.8 / (27.0)	3.8 / (4.0)

As shown in Table 3, concrete and ACB linings produce very high velocities. Therefore, concrete and ACB linings were not considered further.

Utilizing the calculated velocity for riprap channel lining, the median rock size for riprap can be calculated using the Isbash Equation (Lagasse et. al, 2006):

$$d_{50} = \frac{0.692(KV)^2}{2g\left(\frac{\gamma_s - \gamma_w}{\gamma_w}\right)}$$

Where:

d_{50} = median riprap diameter (ft)
K = coefficient (generally taken as K = 1)
V = flow velocity (feet per second [ft/sec])
g = gravitational acceleration (32.2 feet per second squared [ft/sec^2])
γ_s = specific weight of the stone (172 pounds per cubic foot [lb/ft^3])
γ_w = specific weight of water (62.4 lb/ft^3)

The above riprap sizing equation does not provide for a safety factor; therefore, a safety factor of 1.25 was applied to account for uncertainty with the potential flow characteristics and site conditions.

Utilizing the Isbash equation, riprap sizing for the West and South Pond Emergency Spillway channel provides a d_{50} = 48 inches for the West Pond channel and d_{50}=24" for the South Pond Channel. Typically the d_{100} of the gradation is 2 times d_{50} which provides d_{100} = 96" for the West Pond spillway channel and a d_{100}= 48" for the South Pond Spillway channel. Although riprap is a viable channel lining option, due to the calculated large d_{50} for both spillway channels, the application of loose riprap for a channel lining was determined to be unfeasible and was not considered further.

Both grouted riprap and excavated bedrock provide suitable channel linings and could be considered for the final design. Bedrock lining can be utilized if competent bedrock is encountered during spillway excavation. If competent bedrock is not encountered during spillway excavation, then grouted riprap should be used. Based upon the current foundation bedrock information, it is assumed that 1) grouted riprap spillway channels for the West Pond and 2) excavated bedrock channels for the South Pond will be provided for the final designs. Therefore, the final spillway channel sizing was performed utilizing a grouted riprap lining for the West Pond and a combination of grouted riprap and excavated bedrock for the South Pond.

As indicated in Attachment E-9, the water level rise in the ponds due to the design storm event is approximately 4.1 ft and 2.6 ft for the West and South ponds, respectively. These levels, and the estimated pond outflows, assume that the water level would be at the spillway invert elevation when the design storm event occurs. This assumption is considered to be conservative since, during normal operations both the West Pond and South Pond will be nearly empty. The pond outlet channels were sized with a trapezoidal cross section, 5 ft channel depth, and 2:1 side slopes (See Figure 5). If the South Pond channel is excavated into competent bedrock then a channel cross-section with a wider base and steeper side slopes, such as a bottom width of 21 ft and side slopes of 1:5 or steeper, could be used to reduce excavation for the South Pond outlet channel (see Figure 6). The 5-ft channel depth was utilized through the entire spillway to maintain consistent channel depths. The spillway channels will be provided with a concrete lining from the pond to a point 15 ft downstream, where the channel lining changes from concrete to grouted riprap. Concrete was selected for the first reach of the spillway channel to provide a constant, level, and smooth spillway crest elevation and provide a smooth flow distribution leaving the pond. The South Pond grouted riprap lining transitions to natural cut bedrock channel approximately 55 ft beyond the concrete lining as shown on Figure

3. Although competent rock is expected for the South Pond channel lining, the grouted riprap section will provide additional protection against erosion that could potentially affect structural integrity of the pond embankment.

Providing a 5-ft channel depth for both spillways provides sufficient freeboard for all channel reaches. The recommended freeboard for channels conveying supercritical flow is twice the flow depth to account for wave action and uncertainty in the hydraulic calculations. A 5-ft channel depth for all channel reaches provides freeboard that is more than twice the flow depth along the spillway chute and less than twice the flow depth for the upper and lower spillway channel reaches. Providing smaller freeboard at the upper and lower reaches is acceptable because of the lower Froude numbers in these locations. The channel along the lower end of the spillway chutes could be reduced to a depth of 3.5 ft, which would reduce the volume of riprap to be installed, but would not significantly change the volume of excavation since the planned spillway alignment follows the existing grade.

Spillway Outlet Riprap Apron

Since the existing drainage channels at the spillway outlet are steep slopes with supercritical flow, a stilling basin will not be provided at the channel outlet in order to maintain supercritical flow through the drainage system. As previously mentioned, the spillway channel slope will be adjusted to match the existing natural channel slope at the terminal points. A loose riprap apron will be provided at the outfall of the spillway to transition from the spillway channel to the natural drainage channel. Using the Isbash Equation, the d_{50} of the riprap apron was determined to require a d_{50} = 18 inches for the West Pond spillway channel apron and a d_{50} = 24 inches for the South Pond spillway channel apron. Although a d_{50} of 18 inches can be provided for the West Pond Spillway Channel outfall apron, it is recommended to use a d_{50} of 24 inches for this location, which will keep the riprap gradation consistent for the entire spillway.

West Pond Diversion Channel

The West Pond Diversion Channel conveys 22 cfs through a triangular grass-lined channel with 1.5:1 side slopes and 3 ft channel depth. The bypass channel connects to the West Pond Emergency Spillway at the upstream end of the spillway chute, which results in drainage directly to the spillway chute, minimizing potential backwater affects along the spillway crest. The diversion channel slope increases to approximately a 1:1 slope as is approaches the spillway channel. Due to the very steep slope, the diversion channel will be provided with a grouted riprap lining which matches the proposed spillway lining. The grass lined channel will transition to grouted riprap approximately 15 ft upstream of the break in slope and continue as a grouted riprap lined channel to the confluence with the spillway channel. The invert of the grouted riprap diversion channel will intersect with the top of the spillway channel side slope. The diversion channel connection to the West Pond Spillway is shown in Figure 1.

Grouted Riprap

It was assumed that quality riprap will be available for RA construction. Although there are no guidelines for sizing the median rock size/diameter (d_{50}) for grouted riprap, based on past experience, the minimum recommended riprap size (d_{50}) for grouted riprap is between 18 – 24 inches in size with a minimum layer thickness of 48 inches. The recommended d_{50} provides a large enough void ratio to allow sufficient grout penetration to join all riprap. The smaller riprap,

compared to the ungrouted or loose riprap size, is also generally easier to obtain, transport, and place, especially on relatively steep slopes. The riprap is placed on a granular filter drain zone approximately 10 inches thick to relieve pore pressures and minimize erosion that can develop under the riprap lining.

Riprap Gradations

The following equations were used to calculate the maximum and minimum particle sizes for the d_{10}, d_{15}, d_{50}, d_{60}, d_{85} and d_{100} (Lagasse et. al, 2006).

$d_{10min} = 0.58*d_{50}$ $\quad$ $d_{10max} = 0.84*d_{50}$

$d_{15min} = 0.61*d_{50}$ $\quad$ $d_{15max} = 0.87*d_{50}$

$d_{50min} = 0.95*d_{50}$ $\quad$ $d_{50max} = 1.15*d_{50}$

$d_{60min} = 1.05*d_{50}$ $\quad$ $d_{60max} = 1.25*d_{50}$

$d_{85min} = 1.30*d_{50}$ $\quad$ $d_{85max} = 1.54*d_{50}$

$d_{100max} = 2.0*d_{50}$

The proposed riprap gradation for a riprap with a d_{50} =24 inches is shown in Table 4.

Table 4. Riprap Gradation

d_{50} (inches)	d_{15} (inches)		d_{50} (inches)		d_{60} (inches)		d_{85} (inches)		d_{100} (inches)
	Min	Max	Min	Max	Min	Max	Min	Max	
24	12.8	18.3	20.0	24.25	22.1	26.3	27.3	32.3	42

Riprap Granular Filter Method

A granular filter will be placed in between the riprap and the base soil. The granular filter prevents the migration of the base soil particles through the voids of the riprap, distributes the weight of the armor units to provide more uniform settlement, and permits relief of hydrostatic pressures within the base soil. The granular filter was sized based upon the procedure outlined in River Mechanics (Julien 2002), which is provided in numerous texts and must satisfy the relationships below.

$$\frac{d_{15\,upper}}{d_{85\,lower}} < 5 \qquad 5 < \frac{d_{15\,upper}}{d_{15\,lower}} < 40 \qquad \frac{d_{50\,upper}}{d_{50\,lower}} < 40$$

In the above relationships “upper” refers to the overlying material and “lower” refers to the underlying material. The relationships above must hold between both the filter blanket and the base material and between riprap and filter blanket. The following granular filter gradation can be applied to both the grouted and loose riprap gradations.

Table 5. Granular Filter Gradation

	Size (in)
d_{100}	6
d_{85}	3
d_{50}	2
d_{15}	0.5
Thickness	10

4.0 SUMMARY AND RECOMMENDATIONS

It is recommended that the West Pond Emergency Spillway Channel be lined with grouted riprap unless excavated in competent bedrock. The grouted riprap should have a median size (d_{50}) of 24 inches to allow for sufficient grout penetration and the grouted rip rap erosion protection layer should be 48 inches thick (i.e. the riprap erosion protection layer thickness should be twice the d_{50} of the riprap material). A granular filter should be provided under the grouted riprap to allow for pore pressure relief under the grouted riprap. It is expected that the West Pond Emergency Spillway channel slopes, alignment, and grading will need to be updated after completion of cleanup of waste rock and contaminated soils to account for as-built conditions in the West Pond area.

It is recommended that the South Pond Emergency Spillway Channel be lined with grouted riprap for a 55 foot section immediately downstream of the concrete-lined inlet (see Figure 3). As with the West Pond, the grouted riprap portion of the South Pond Emergency should include a 48-inch-thick grouted riprap erosion protection layer constructed from riprap with a mean particle size of 24 inches, and the grouted riprap layer should be underlain by a granular filter to allow for pore pressure relief under the grouted riprap.

Spillway channels were sized to convey the pond outflow discharge provided in Table 1. A 5-ft channel depth provides a consistent depth for both spillways and sufficient freeboard for all channel reaches. The recommended freeboard for channels conveying supercritical flow is twice the flow depth to account for wave action, uncertainty in the hydraulic calculations, and provide super elevation in channel bends. A 5-ft channel depth for all spillway channel reaches provides freeboard that is more than twice the flow depth along the spillway chute and less than twice the flow depth for the upper and lower spillway channel reaches. Providing smaller freeboard at the upper and lower reaches is acceptable because of the lower Froude numbers in these locations. The channel along the spillway chutes could be reduced to a depth of 3.5 ft which would reduce the volume of riprap to be installed but would not significantly change the volume of excavation since the planned spillway alignment follows the existing grade.

The selected channel sizing was also checked to ensure that the pond Inflow Design Discharge could be conveyed by the spillway channel with no freeboard in the event that a larger storm event occurred when the pond was full.

A summary of the channel flow parameters are provided in Table 6 and typical channel plans, sections, and details are provided in Figures 1 through 5. From Table 6, a channel bottom width of 10 ft and 5 ft channel depth provide adequate capacity for the pond outflow design peak flows (Table 1) with adequate freeboard as well as sufficient capacity for the pond inflow design peak flows with no freeboard. If the South Pond channel is excavated into competent bedrock then a channel cross-section with a wider base and steeper side slopes, such as a bottom width of 21 ft and side slopes of 1:5 or steeper, could be used to reduce excavation for the South Pond outlet channel (see Figure 6).

Since the existing site drainage channels at the spillway outlets are steep slopes with supercritical flow, the spillway slope will be adjusted to match the slope of the existing channel

at the spillway outlet in order to maintain supercritical flow through the drainage system. A loose riprap apron will be provided at the outlet of the spillway to transition from the spillway channel to the natural drainage channel. Using the Isbash Equation, the d_{50} of the riprap apron was determined to require a d_{50} = 18 inches for the West Pond spillway channel apron and a d_{50} = 24 inches for the South Pond spillway channel apron. Although a d_{50} of 18 inches can be provided for the West Pond spillway channel outfall apron, it is recommended to use a d_{50} of 24 inches for this location, which will keep the riprap gradation consistent for the entire spillway.

When the West Pond is constructed (i.e., end of Construction Phase II), the configuration will be different from that shown on the figures, which are based on pre-mine topographic maps prepared by the USGS topography in the early 1950s. The intent is that the actual topography after excavating waste rock and contaminated soils in this basin be resurveyed, and necessary geotechnical and other investigations be performed at that time. The design for the West Pond, including the spillway will then need to be finalized. The design presented for the West Pond spillway in this document represents the conditions assumed for the 100% Basis of Design Report.

Table 6. Spillway Channel Summary

Channel Reach	Channel Lining	Manning's n	Channel Depth (ft)	Slope (%)	Pond Outflow Design Flow			Pond Inflow Design Flow		
					Flow Depth (ft)	Velocity (ft/s)	Froude No.	Flow Depth (ft)	Velocity (ft/s)	Froude No.
West Pond Control Structure[1]	Concrete	0.013	5.0	2.0	1.6	18.6	2.9	2.1	21.9	3.0
West Pond Outlet[1]	Grouted Riprap	0.035	5.0	2.0	2.7	9.2	1.2	3.6	10.7	1.2
West Pond Spillway Chute[1]	Grouted Riprap	0.035	5.0	36.7	1.2	25.5	4.5	1.7	30.2	4.6
West Pond Spillway Outlet[1]	Riprap	0.040	5.0	2.0	2.9	8.4	1.0	3.9	9.7	1.1
South Pond Control Structure[2]	Concrete	0.013	5.0	0.5	2.4	14.94.4	0.6	4.9	6.4	0.6
South Pond Outlet[2]	Grouted Riprap	0.035	5.0	0.5	2.6	4.2	0.5	5.0	6.2	0.6
South Pond Outlet[2]	Natural Cut Bedrock	0.040	5.0	0.5	2.5	4.3	0.6	4.8	6.5	0.6
South Pond Spillway Chute[2]	Natural Cut Bedrock	0.040	5.0	22.6	0.9		2.9	2.0	22.7	3.2
South Pond Spillway Outlet[2]	Riprap	0.040	5.0	9.5	1.5	12.7	2.4	2.6	20.3	2.8

Notes: [1] West Pond calculations were performed using a spreadsheet model and the Manning's equation

[2] South Pond calculations performed using a spreadsheet model and the Manning's equation and consequently verified using the HEC-RAS hydraulics model

5.0 REFERENCES

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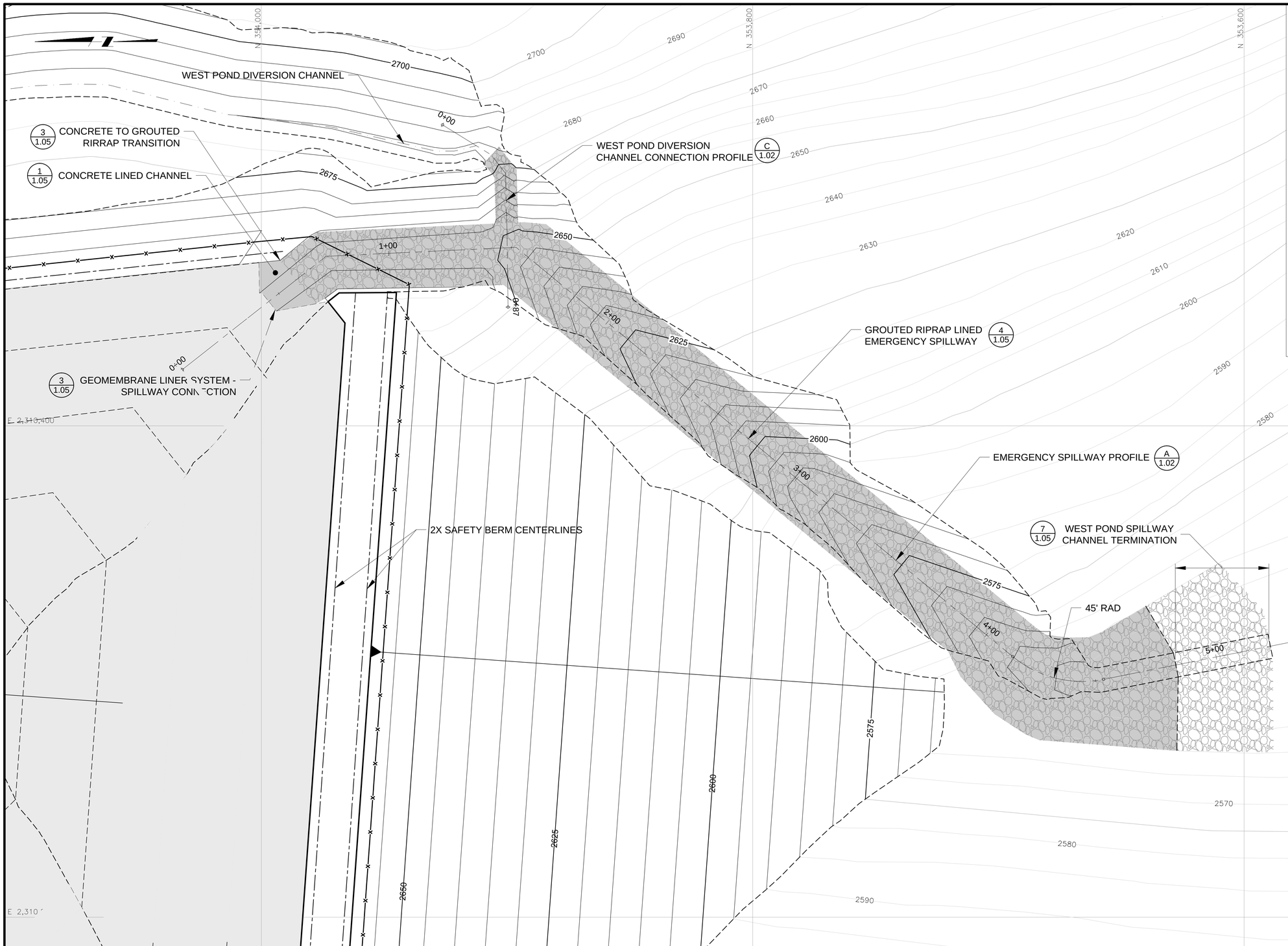
FIGURES



LEGEND:

- CONCRETE LINED
- GROUTED RIPRAP
- LOOSE RIPRAP
- CHAIN LINK FENCE

NOTES:

1. POND INTERIOR CONTOURS SHOWN ARE APPROXIMATE. FINISHED SURFACE WILL BE DETERMINED IN THE FIELD ACCORDING TO RIPPABILITY OF SOILS. SLOPES SHALL BE NO STEEPER THAN 2.5H:1V.
2. THE FOOTPRINT OF THE WEST POND EMBANKMENT SHALL BE OVER–EXCAVATED ACCORDING TO THE REQUIREMENTS OF THE SPECIFICATIONS PRIOR TO PLACEMENT OF COMPACTED FILL.
3. AN AS–BUILT SURVEY OF THE WEST POND AREA, AND AN INVESTIGATION TO FURTHER CHARACTERIZE GEOTECHNICAL CONDITIONS WITHIN THE WESTERN DRAINAGE WILL BE NECESSARY AFTER COMPLETION OF PHASE 2 WASTE ROCK REMOVAL WITHIN THE WESTERN DRAINAGE. THE DESIGN OF THE WEST POND MAY REQUIRE UPDATING BASED UPON THE AS–BUILT CONDITIONS PRIOR TO CONSTRUCTION OF THE WEST POND EMBANKMENT AND SPILLWAY.
4. FINAL 100% DESIGN OF THE WEST POND SPILLWAY IS PENDING UNTIL FURTHER INFORMATION OF THE ACTUAL TOPOGRAPHY AFTER COMPLETION OF PHASE 2 WASTE ROCK REMOVAL IS AVAILABLE. NO UPDATES TO THE WEST POND SPILLWAY HAVE BEEN PERFORMED SINCE 90% DESIGN

0 20' 40'
CONTOUR INTERVAL = 5'

DESIGNED BY	C BERNEDO	06–15
DRAWN BY	K REED	06–15
CHECKED BY	S MCMANUS	06–15
APPROVED BY	C STRACHAN	06–15
PROJECT MANAGER	V DRAIN	06–15
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

NEWMONT

PROJECT LOCATION: WELLPINIT, WASHINGTON

PROJECT: MIDNITE MINE

TITLE: WEST POND EMERGENCY SPILLWAY GRADING PLAN

MWH

FIGURE 1 — REVISION 3

FILE NAME: FIGURE 1 — DATE: JUNE 2015

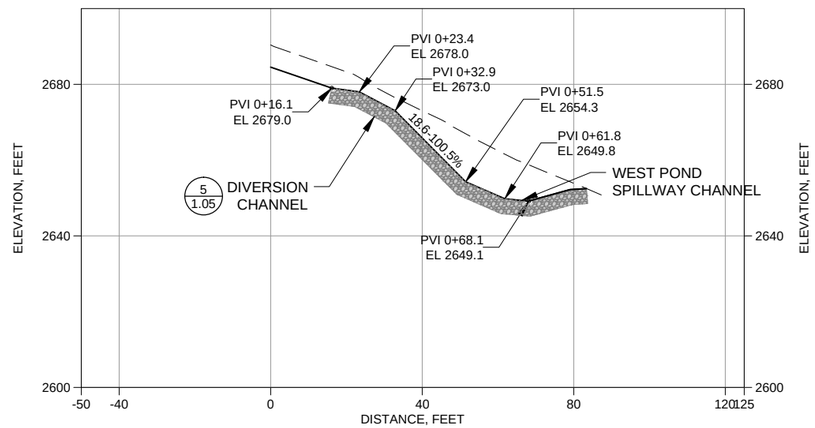
P:W:\\AMERVPWNT03.MWHGLOBAL.COM:AM_PROJECTS03\DOCUMENTS\FTC2_NEWMONT\MIDNIGHT MINE\RD-RA\013-SHEET SET\FIGURES\2015-06-03 SW POND SPILLWAYS\FIGURE 1.dwg

LEGEND:

- ESTIMATED GROUND SURFACE AFTER COMPLETION OF PHASE 2 WASTE REMOVAL
- FINISHED GRADE
- LOOSE RIPRAP
- GROUTED RIPRAP
- REINFORCED CONCRETE

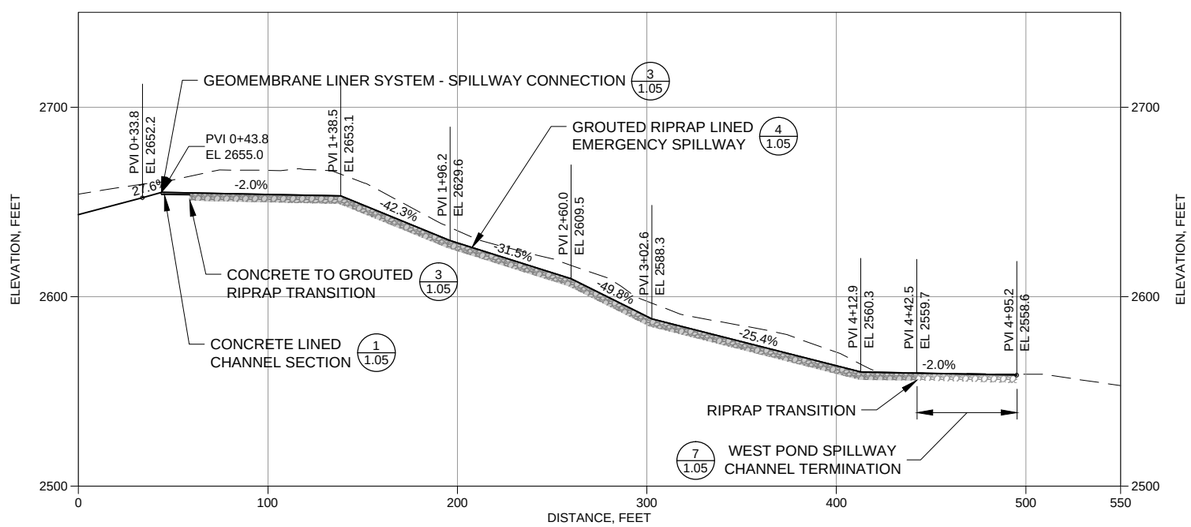
NOTES:

1. AN AS-BUILT SURVEY OF THE WEST POND AREA, AND AN INVESTIGATION TO FURTHER CHARACTERIZE GEOTECHNICAL CONDITIONS WITHIN THE WESTERN DRAINAGE WILL BE NECESSARY AFTER COMPLETION OF PHASE 2 WASTE ROCK REMOVAL WITHIN THE WESTERN DRAINAGE. THE DESIGN OF THE WEST POND MAY REQUIRE UPDATING BASED UPON THE AS-BUILT CONDITIONS PRIOR TO CONSTRUCTION OF THE WEST POND EMBANKMENT AND SPILLWAY.



C 1.01 WEST POND DIVERSION CHANNEL CONNECTION PROFILE

0 20' 40'



A 1.01 WEST POND EMERGENCY SPILLWAY PROFILE

0 40' 80'

DESIGNED BY	C BERNEDO	06-15
DRAWN BY	K REED	06-15
CHECKED BY	S MCMANUS	06-15
APPROVED BY	C STRACHAN	06-15
PROJECT MANAGER	V DRAIN	06-15
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

NEWMONT

PROJECT LOCATION: WELLPINIT, WASHINGTON

PROJECT: MIDNITE MINE

TITLE: WEST POND EMERGENCY SPILLWAY PROFILE

MWH

FIGURE 2

REVISION 3

FILE NAME: FIGURE 1

DATE: JUNE 2015

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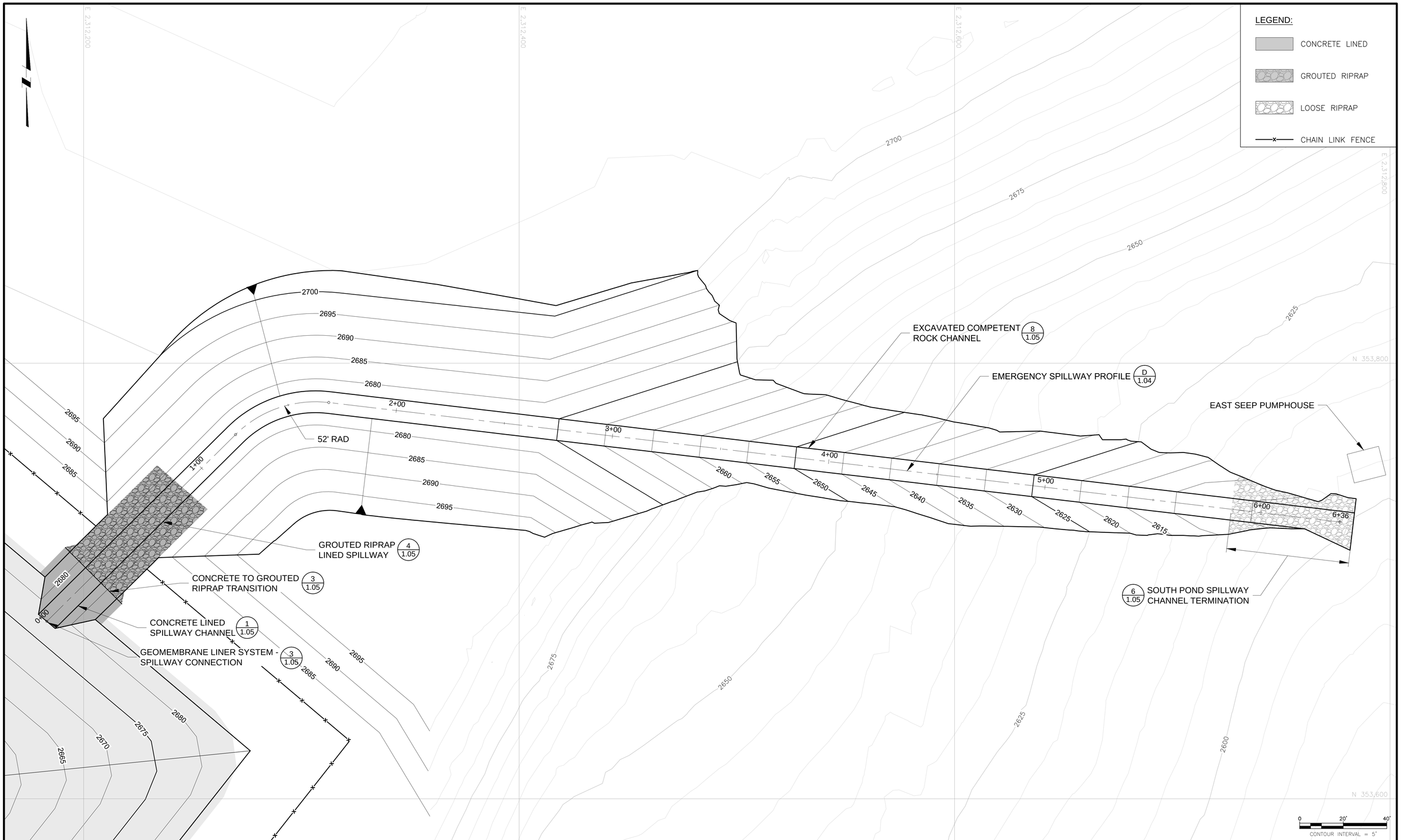


DESIGNED BY	C BERNEDO	06–15
DRAWN BY	K REED	06–15
CHECKED BY	S MCMANUS	06–15
APPROVED BY	C STRACHAN	06–15
PROJECT MANAGER	V DRAIN	06–15
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

NEWMONT

PROJECT LOCATION: WELLPINIT, WASHINGTON

PROJECT: MIDNITE MINE

TITLE: SOUTH POND EMERGENCY SPILLWAY GRADING PLAN

MWH

FIGURE 3

REVISION 3

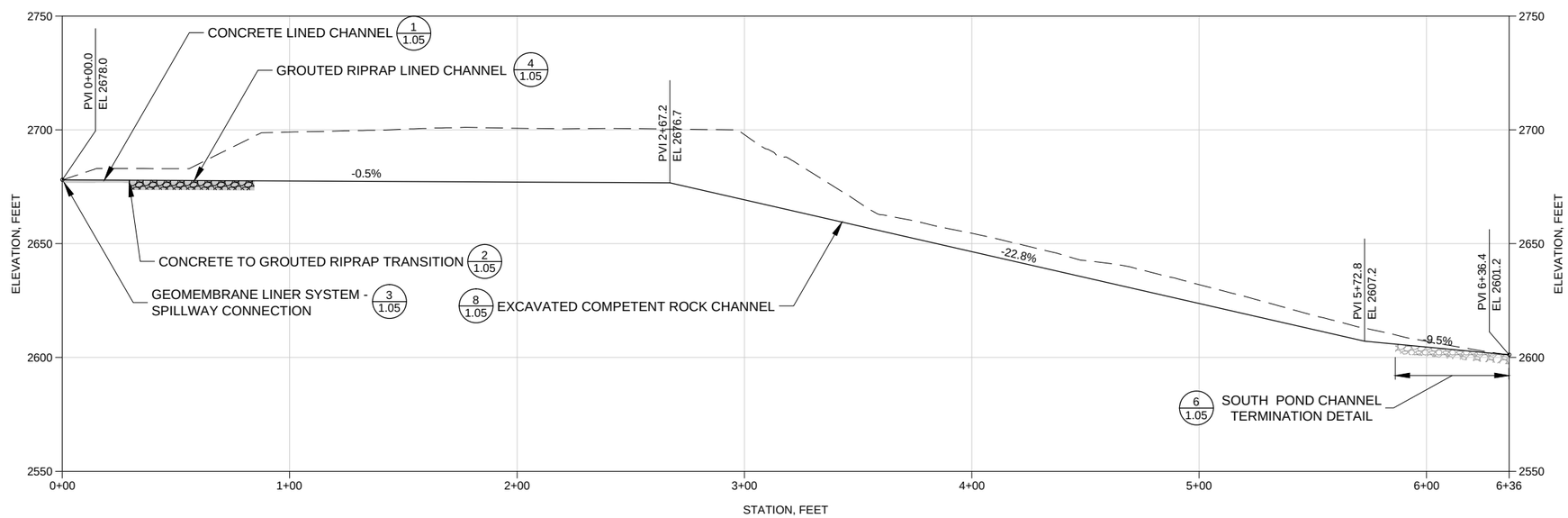
FILE NAME: FIGURE 3

DATE: JUNE 2015

PW:\\AMERVPWNT03.MWHGLOBAL.COM:AM_PROJECTS03\DOCUMENTS\FTC2_NEWMONT\MIDNIGHT MINE\RD-RA\013-SHEET SET\FIGURES\2015-06-03 SW POND SPILLWAYS\FIGURE 3.dwg

LEGEND:

- ESTIMATED GROUND SURFACE AFTER COMPLETION OF PHASE 1 WASTE REMOVAL
- FINISHED GRADE
- LOOSE RIPRAP
- GROUTED RIPRAP
- REINFORCED CONCRETE



D/1.03 SOUTH POND EMERGANCY SPILLWAY PROFILE

0 30' 60'

DESIGNED BY	C BERNEDO	06-15
DRAWN BY	K REED	06-15
CHECKED BY	S MCMANUS	06-15
APPROVED BY	C STRACHAN	06-15
PROJECT MANAGER	V DRAIN	06-15
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

NEWMONT

PROJECT LOCATION: WELLPINIT, WASHINGTON

PROJECT: MIDNITE MINE

TITLE: SOUTH POND EMERGENCY SPILLWAY PROFILE

MWH

FIGURE 4 | REVISION 3

FILE NAME: FIGURE 3 | DATE: JUNE 2015

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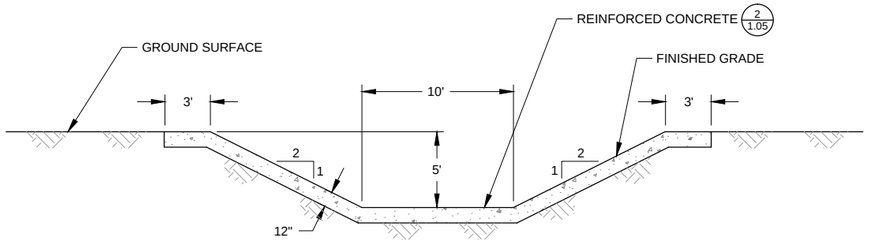
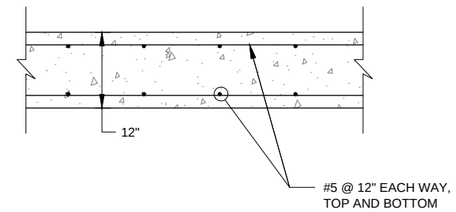
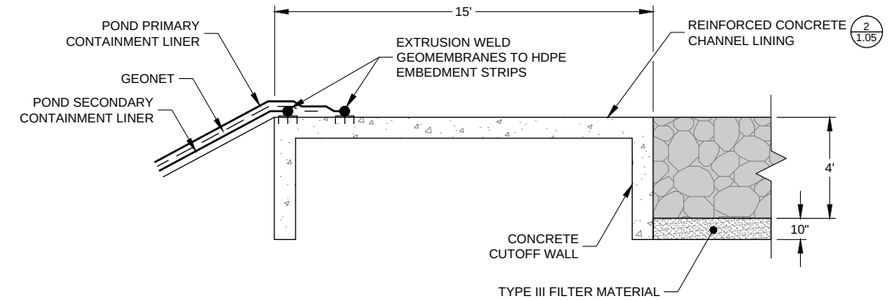


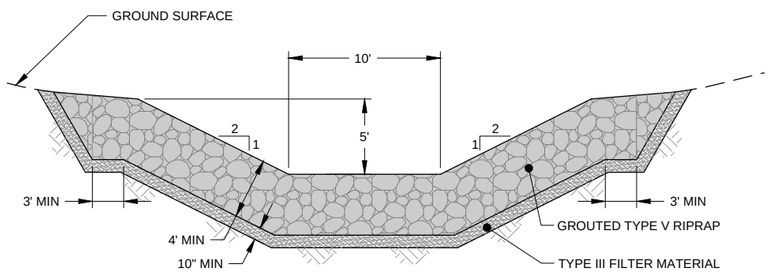
1/1.05 CONCRETE LINED CHANNEL TYPICAL SECTION
NOT TO SCALE



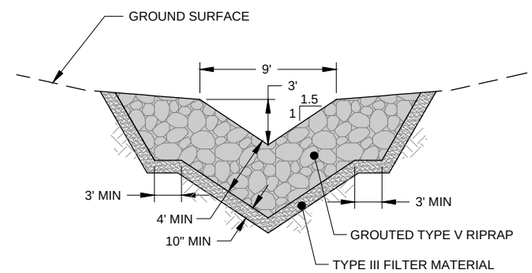
2/1.05 CONCRETE REBAR DETAIL
NOT TO SCALE



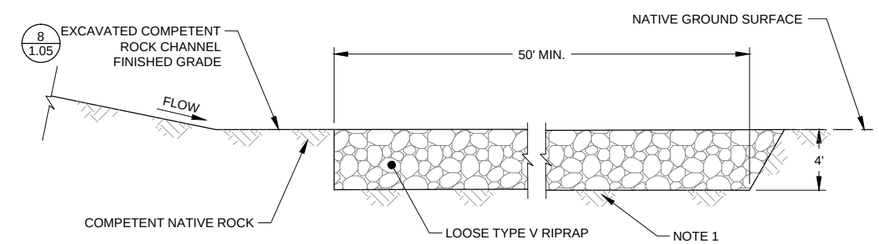
3/1.05 TYPICAL TRANSITION - CONCRETE TO GROUTED RIPRAP
NOT TO SCALE



4/1.05 GROUTED RIPRAP LINED CHANNEL TYPICAL SECTION
NOT TO SCALE



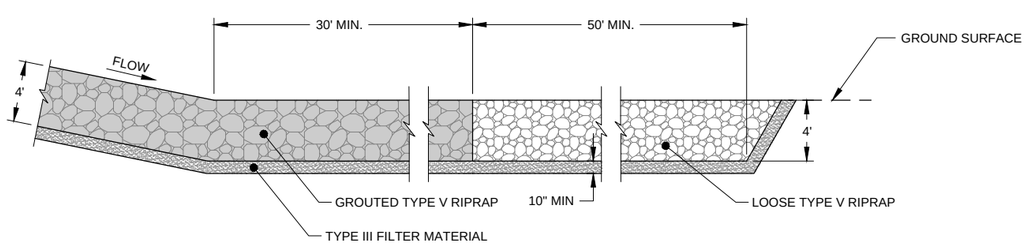
5/1.05 WEST POND DIVERSION CHANNEL CONNECTION TYPICAL SECTION
NOT TO SCALE



NOTE:

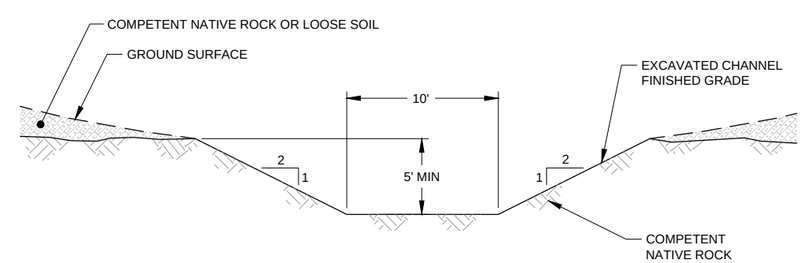
1. PLACE LAYER OF TYPE III FILTER MATERIAL (10" MIN THICKNESS) BELOW RIPRAP IN AREAS WHERE COMPETENT NATIVE ROCK IS NOT PRESENT.

6/1.05 SOUTH POND SPILLWAY CHANNEL TERMINATION DETAIL
NOT TO SCALE



7/1.05 WEST POND SPILLWAY CHANNEL TERMINATION DETAIL
NOT TO SCALE

TABLE 1 - TYPE III FILTER MATERIAL GRADATION	
	SIZE (INCHES)
D_{85}	3
D_{50}	2
D_{15}	0.5
THICKNESS	10



8/1.05 EXCAVATED COMPETENT ROCK CHANNEL TYPICAL SECTION
NOT TO SCALE

DESIGNED BY	C BERNEDO	06-15
DRAWN BY	K REED	06-15
CHECKED BY	S MCMANUS	06-15
APPROVED BY	C STRACHAN	06-15
PROJECT MANAGER	V DRAIN	06-15
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

NEWMONT

PROJECT LOCATION: WELLPINIT, WASHINGTON
PROJECT: MIDNITE MINE
TITLE: TYPICAL DETAILS AND SECTIONS (4 OF 4)

MWH

FIGURE 5
REVISION 3
FILE NAME FIGURE 5
DATE JUNE 2015

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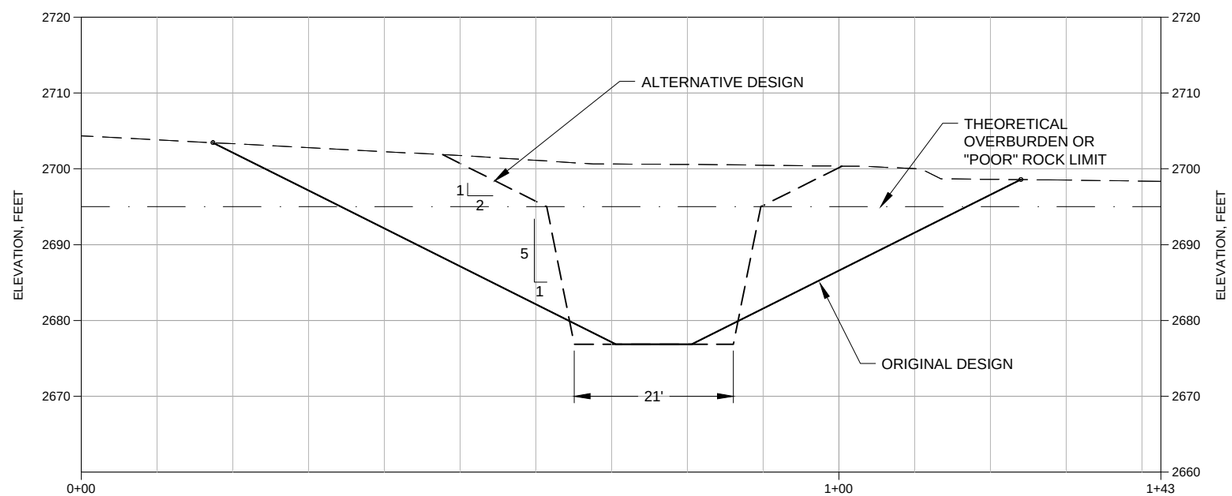
NOTES:

1. OVERBURDEN OR "POOR" ROCK LIMITS SHOWN ARE FOR ILLUSTRATION PURPOSES ONLY. OVERBURDEN DEPTHS AND ROCK QUALITY WILL BE DETERMINED IN THE FIELD BASED ON SOIL AND ROCK RIPPABILITY.

2. IF THE CHANNEL IS EXCAVATED INTO "GOOD" ROCK THEN SIDE SLOPES CAN BE CUT AT 1:5 OR STEEPER. OTHERWISE THE CHANNEL SIDE SLOPES SHALL NOT BE STEEPER THAN 2:1.



B
1.03

SOUTH POND ALTERNATIVE CHANNEL SECTION

0 10' 20'

DESIGNED BY	C BERNEDO	06–15
DRAWN BY	K REED	06–15
CHECKED BY	S MCMANUS	06–15
APPROVED BY	C STRACHAN	06–15
PROJECT MANAGER	V DRAIN	06–15
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

NEWMONT

PROJECT LOCATION: WELLPINIT, WASHINGTON

PROJECT: MIDNITE MINE

TITLE: SOUTH POND ALTERNATIVE CHANNEL CROSS SECTION DESIGN

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FIGURE 6

REVISION 3

FILE NAME: FIGURE 6

DATE: JUNE 2015

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Attachment E-11

Water Management Ponds Freeboard Calculations

ATTACHMENT E-11

MIDNITE MINE REMEDIAL ACTION
MIDNITE WATER MANAGEMENT PONDS
FREEBOARD CALCULATIONS

Revisioning						
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**	**Reviewed**
1	*13-May-15*	*100% Design*	*Zach Elliott*	*Chris Gifford-Miears*	*15-May-15*	*Carmen Bernedo*

Location and Format
Electronic copies of these calculations are located in the project files system at: *\\USDEN1S01\Projects\NRII\Clients_I-P\Newmont\1011322 Midnite Mine\Technical\Calculations\Hydrology\Spillway\Wave Action and Freeboard* *The following calculations were performed using the following guidelines:* • *Dam Safety Guidelines Part IV: Dam Design and Construction (WSDOE, 1993)*

1.0 INTRODUCTION

The purpose of these calculations is to present the analysis and results for estimating the minimum freeboard requirements for the design of the water management ponds and spillways at the Midnite Mine Site (Site). Available Washington State Department of Ecology (WSDOE) guidelines were consulted to determine the freeboard requirements for the ponds. A summary of the Site water management pond parameters is given in Table 1. A plan view of the West and South Ponds is shown on Figure 1.

Table 1. Water Management Pond Parameters

PARAMETER	WEST POND	SOUTH POND
Dam Crest Elevation (ft)	2,660	2,683
Reservoir Volume (ac-ft)	99.85	247.78
Pond Depth (ft)	50	59
Fetch Length (ft)	710	784

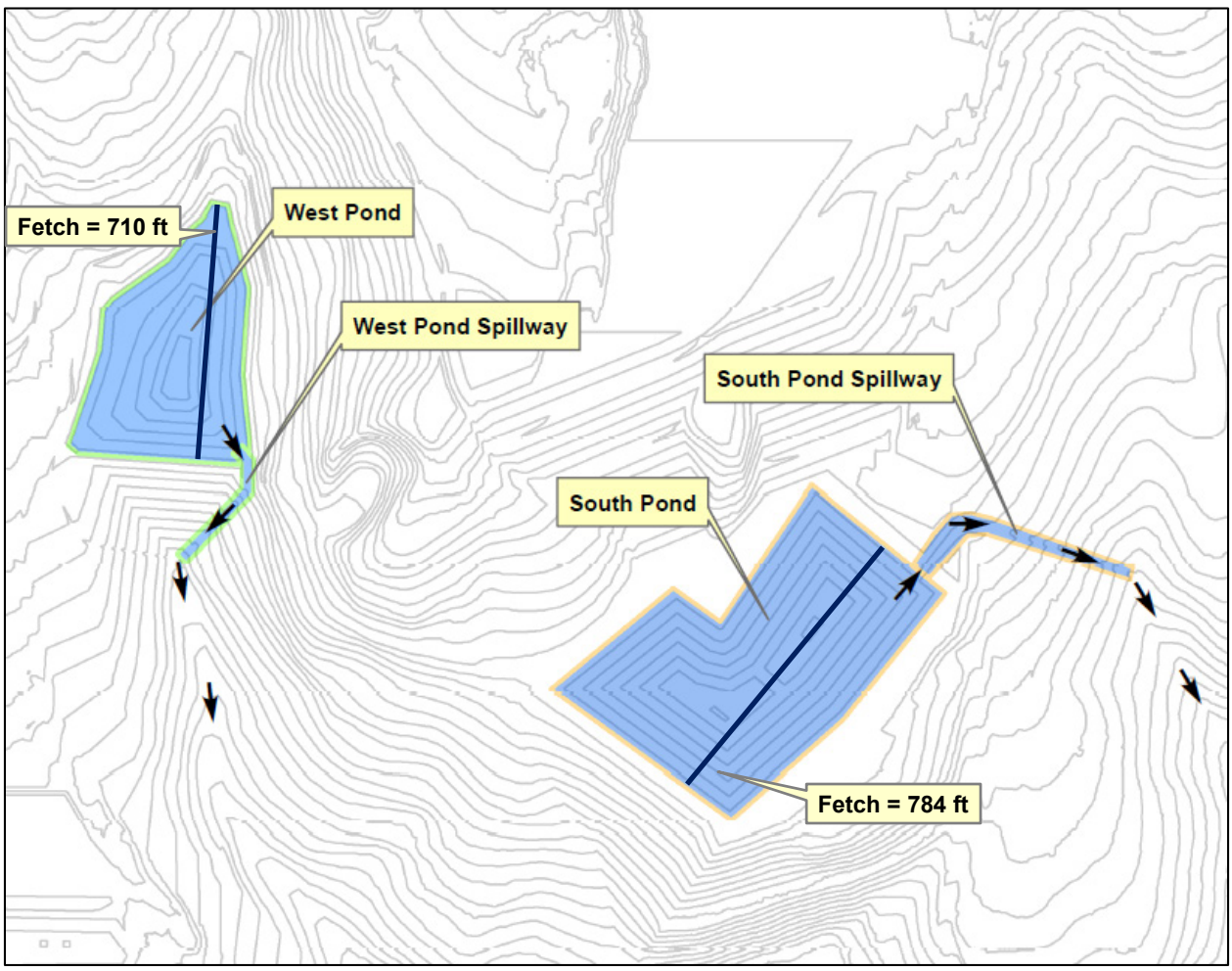

Figure 1. Plan of West and South Ponds

2.0 ANALYSIS

2.1 DESIGN CRITERIA

The *Dam Safety Guidelines Part IV: Dam Design and Construction* (WSDOE, 1993) provides specific guidelines for estimating freeboard for dams.
The minimum required freeboard needed to contain wave action from wind generated waves is computed as (WSDOE, 1993):

$$F_w = S_w + R_w$$

Where:

F_w = freeboard needed to contain wind/wave action (ft)
S_w = wind setup (ft)
R_w = wave runup (ft)

Figure 1 shows the relationship between reservoir freeboard, significant wave height, wind setup, and wave runup as it applies to dams for use in freeboard analyses for wind generated waves (WSDOE, 1993).

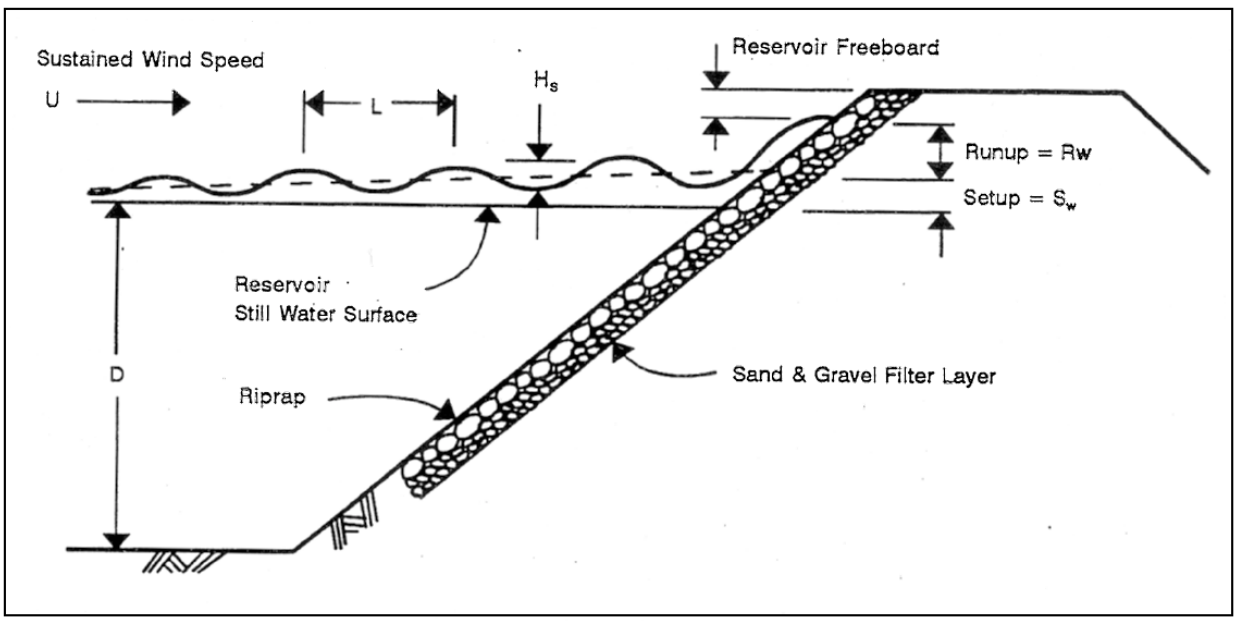

Figure 1. Depiction of Reservoir Freeboard and Wind/Wave Effects (WSDOE, 1993)

Table 2 from *Dam Safety Guidelines Part IV: Dam Design and Construction* (WSDOE, 1993) gives design minimums for selecting reservoir freeboard for dams. The values given in Table 2 are to be considered as minimums and are not intended to supersede larger values estimated from wind and wave action and engineering judgment (WSDOE, 1993). “Normal Freeboard” is defined as the vertical distance between the normal storage elevation (normal high pool level) and the dam crest elevation. “Minimum Freeboard” is the vertical distance between the maximum reservoir water surface elevation attained during passage of the inflow design flood and the dam crest elevation. A “Large Dam” is defined as a dam with a barrier hydraulic height of 50 ft or greater (WSDOE, 1993). The maximum depths at the upstream toe of the West Pond

and South Pond are both greater than 50 ft. The minimum required freeboard for large dams is given as 1.00 ft as shown in Table 2.

Table 1. Design Minimums in Selecting Reservoir Freeboard (WSDOE, 1993)

RESERVOIR FREEBOARD (FEET)	SMALL DAM	INTERMEDIATE DAM	LARGE DAM
NORMAL FREEBOARD	2.00	3.50	5.00
MINIMUM FREEBOARD	0.50	0.75	1.00

To determine if the minimum required freeboard needed to contain wave action from wind generated waves is greater than the minimum required freeboard given in Table 1, the wind setup and wave runup were estimated using the procedures described in *Dam Safety Guidelines Part IV: Dam Design and Construction* (WSDOE, 1993).

2.2 WIND SETUP

In general, wind setup is usually small relative to the magnitude of the significant wave height, except for large reservoirs. The wind setup is estimated from the following the equation provided in the *Dam Safety Guidelines Part IV: Dam Design and Construction*:

$$S_w = \frac{U^2 F}{1400D}$$

Where:

S_w = wind setup (ft)
F = effective fetch (mi)
U = design wind speed (mph) at 25 feet above the reservoir surface
D = average reservoir depth (ft)

The effective fetch, F, for each pond was estimated as the longest length of water from the opposite shore to the embankment crest, perpendicular to the embankment crest. The effective fetches were estimated to be approximately 0.13 mi and 0.15 mi for the West Pond and South Pond, respectively.

The design wind speed, U, was determined to be 30 mph from generalized design wind speeds for "Eastern Washington" given in *Dam Safety Guidelines Part IV: Dam Design and Construction* and shown in Table 3 below.

Table 3. Suggested Design Wind Speeds for Areas of Limited Data

FREEBOARD CONDITION	WASHINGTON LOCATION		
	COASTAL AREAS	WESTERN WASHINGTON	EASTERN WASHINGTON
NORMAL FREEBOARD	70 MPH	60 MPH	50 MPH
MINIMUM FREEBOARD	50 MPH	30 MPH	30 MPH

The average reservoir depth, D, was taken as the maximum reservoir depth at the location of the spillway crest (upstream toe of the embankment) for each of the water management ponds. The average reservoir depths were estimated to be 50 ft and 59 ft for the West Pond and South Pond, respectively.

2.3 WAVE RUNUP

The wave runup is estimated as a function of the wave height, the steepness of the wave, and the slope and roughness of the dam face. Wave runup is estimated from the following the equation provided in the *Dam Safety Guidelines Part IV: Dam Design and Construction*:

$$R_w = C_r(H_s)$$

Where:
R_w = wave runup (ft)
C_r = coefficient of wave runup
H_s = significant wave height (ft)

The significant wave height, H_s, was estimated based on the effective fetch and the design wind speed as shown in Table 4, which is presented in *Dam Safety Guidelines Part IV: Dam Design and Construction* and based on U.S. Army Corps of Engineers reports. Figure 2 was generated based on the values in Table 4 in order to estimate the significant wave heights for the West Pond and South Pond effective fetches for a design wind speed of 30 mph (50 mph shown for comparison only).

Table 4. Estimation of Wind Generated Waves

SIGNIFICANT WAVE HEIGHT (FEET)							
SUSTAINED WIND SPEED	**EFFECTIVE FETCH (MILES)**						
	0.05	0.10	0.25	0.50	1	2	5
20 MPH	0.20	0.30	0.45	0.60	0.85	1.20	1.75
30 MPH	0.35	0.45	0.65	0.90	1.30	1.75	2.70
40 MPH	0.45	0.60	0.90	1.25	1.75	2.45	3.70
50 MPH	0.55	0.75	1.15	1.60	2.20	3.00	4.70
60 MPH	0.65	0.90	1.40	1.90	2.70	3.60	5.70
70 MPH	0.75	1.15	1.60	2.25	3.20	4.30	6.70
80 MPH	0.90	1.20	1.85	2.60	3.70	5.00	7.80
90 MPH	1.00	1.35	2.10	3.00	4.20	4.70	8.90
100 MPH	1.15	1.50	2.40	3.40	4.70	6.40	10.00

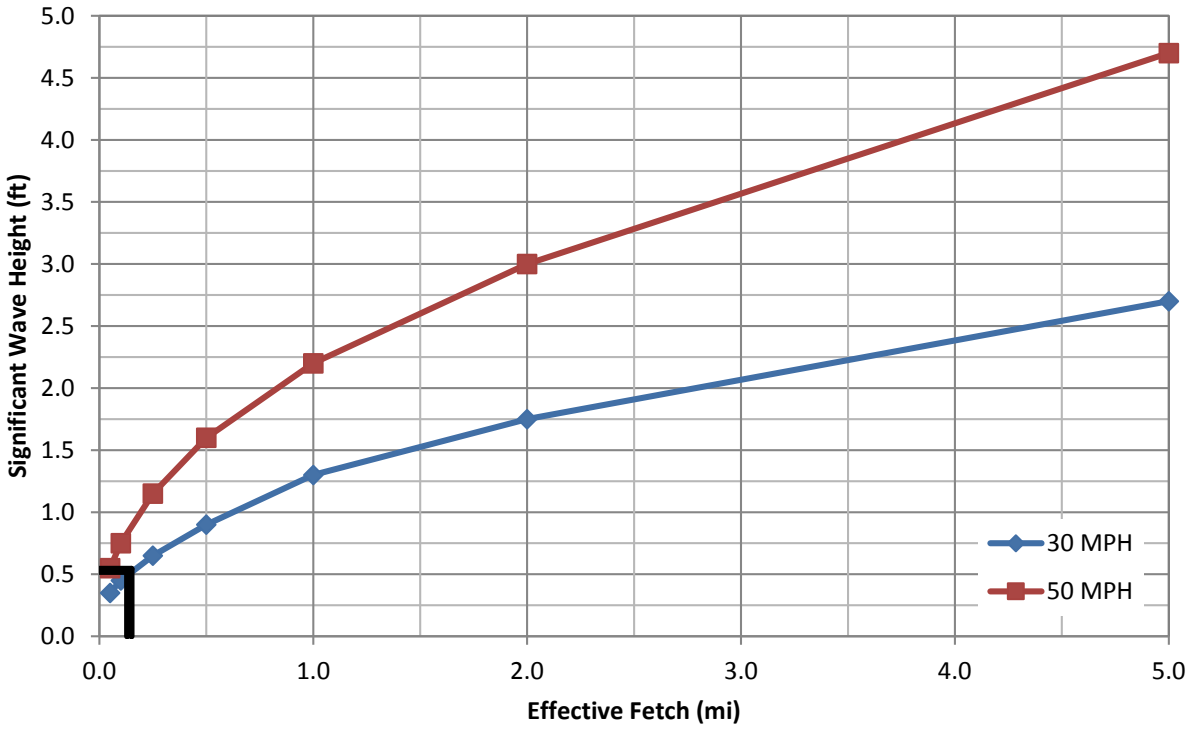

Figure 2. Significant Wave Height vs. Effective Fetch (30 mph and 50 mph design wind speeds)

Using Figure 2, the significant wave heights for a design wind speed of 30 mph were estimated to be approximately 0.519 ft and 0.543 ft, respectively.

Dam Safety Guidelines Part IV: Dam Design and Construction contains estimates of the coefficient of wave runup, C_r, obtained from information contained in U.S. Army Corps of Engineers reports and shown in Table 5.

Table 5. Values of the Coefficient of Wave Runup

COEFFICIENT OF WAVE RUNUP (C_r)							
DAM FACE	**SLOPE OF UPSTREAM FACE OF DAM (H:V)**						
	Vertical	1.5:1	2:1	3:1	4:1	6:1	10:1
Concrete Facing	1.7	2.5	2.2	1.8	1.3	0.8	0.5
Grass Lined	-	2.3	2.0	1.6	1.2	0.8	0.5
Riprap	-	1.4	1.3	1.2	1.0	0.7	0.4

The water management pond embankments were assumed to be made of compacted earthfill and waste rock materials with upstream face slopes of 3H:1V. Based on the descriptions and values given in Table 5, the coefficient of wave runup for the West Pond and South Pond was estimated to be approximately 1.5 (less than “grass lined” and greater than “riprap”).

3.0 RESULTS

The wind setup value was estimated to be approximately 0.002 ft for the West Pond and South Pond and the wave runup values were estimated to be approximately 0.778 ft and 0.814 ft,

respectively. Therefore, by summing the wind setup and wave runup heights for the West Pond and South Pond, the freeboard heights needed to contain wind and wave action were estimated to be approximately 0.780 ft and 0.815 ft, respectively. Table 6 gives a summary of the estimated freeboard components described above.

Table 6. Summary of Freeboard Required to Contain Wind/Wave Action

WATER MANAGEMENT POND	WIND SETUP (FT)	WAVE RUNUP (FT)	REQUIRED FREEBOARD (FT)
WEST POND	0.002	0.78	0.78
SOUTH POND	0.002	0.81	0.82

4.0 SUMMARY AND CONCLUSIONS

The freeboard needed to contain wind and wave action was estimated using methods presented in *Dam Safety Guidelines Part IV: Dam Design and Construction* for the Site water management ponds and was estimated to be slightly less than 1 ft as shown in Table 6. It is recommended that a minimum design freeboard between the maximum reservoir water surface elevation during routing of the inflow design flood (IDF) and the dam crest elevation for the Site water management ponds should be at least 1 foot based on the guidelines and results presented in this summary.

The West Pond is planned to be constructed during Construction Phase III after significant clean-up of waste rock and contaminated soils. The West Pond configuration is based on pre-mine topography, which is likely to change and require updated analyses prior to final West Pond configuration and spillway construction. Therefore, all West Pond calculations presented in this report are considered preliminary and should be reviewed and updated as needed once the post-mine-waste excavations are completed and as-built topography of the terrain in the West Pond area is available.

5.0 REFERENCES

Washington State Department of Ecology (WSDOE), 1993. *Dam Safety Guidelines Part IV: Dam Design and Construction*. 92-55D, July.