MHE DPC

McGOEY, HAUSER and EDSALL
CONSULTING ENGINEERS D.P.C.

Main Office
33 Airport Center Drive
Suite 202
New Windsor, New York 12553

(845) 567-3100
fax: (845) 567-3232
e-mail: mheny@mhepc.com

MARK J. EDSALL, P.E., P.P. (NY, NJ & PA)
MICHAEL W. WEEKS, P.E. (NY, NJ & PA)
MICHAEL J. LAMOREAUX, P.E. (NY, NJ, PA, VT & VA)
MATTHEW J. SICKLER, P.E. (NY & PA)
PATRICK J. HINES

Principal Emeritus:
RICHARD D. McGOEY, P.E. (NY & PA)
WILLIAM J. HAUSER, P.E. (NY, NJ & PA)

TOWN OF NEWBURGH
PLANNING BOARD
TECHNICAL REVIEW COMMENTS

PROJECT:	**NYCDEP RONDOUT WEST BRANCH BYPASS TUNNEL BELL PROPERTY AMENDED SITE PLAN**
PROJECT NO.:	**11-15**
PROJECT LOCATION:	**SECTION 8, BLOCK 1, LOT 15.2 & 22.2**
REVIEW DATE:	**13 MARCH 2015**
MEETING DATE:	**19 MARCH 2015**
PROJECT REPRESENTATIVE:	**NYCDEP**

1. A revised SWPPP addressing storm water quantity and quality controls on the expanded site must be submitted.

2. Consideration as to where overflow from the storm water management facilities discharge if emergency outlets discharge.

3. A SWPPP must address a greater than 5 acres disturbance proposed.

4. SWPPP must address any chemicals utilized in the water treatment plan area or chemical additives for any of the dewatering/storm water management facilities proposed.

5. Design of the storm water pumping system must be submitted to the MS4 for review. If this is deferred as a contractor item, a submittal from DEP from the contractor should be forwarded to the regulated MS4.

6. Plans depict notes which state that grading for water treatment ponds is schematic in nature and appears to defer to future contractor design of the facilities. Future submissions modifying approved site plans must be supplied to the planning board for review.

7. Show connection between the large sediment 4 bay for receives flow from catch basin 2 to catch basins. No connection between the sediment 4 bay and the treatment pond is apparent.

Respectfully submitted,

McGoey, Hauser & Edsall
Consulting Engineers, D.P.C.

____
Patrick J. Hines
Principal

Environmental Protection

Emily Lloyd
Commissioner

Sean McAndrew, P.E.
Program Director

Water for the Future Program

Bureau of Engineering Design & Construction

mcandrews@dep.nyc.gov

16 Little Hollow Road
P.O. Box 260
Grahamsville, NY 12740

T: (845) 334-7195
F: (845) 985-2282

March 5, 2015

Mr. John P. Ewasutyn, Chairman
Town of Newburgh Planning Board
308 Gardner Town Road
Newburgh, New York 12550

MAR - 5 2015

Re: New York City Department of Environmental Protection
Delaware Aqueduct Rondout-West Branch Tunnel Repair Program
West Connection Support Site (Bell Property) Final Design &
Shaft 5B Landscaping Modifications
Town Project Number 2011-15

Dear Mr. Ewasutyn:

The New York City Department of Environmental Protection (DEP) respectfully requests approval of modifications to the site plan for Project 2011-15 originally granted in 2012[1] in order to incorporate changes encountered during the construction of the Delaware Aqueduct Rondout-West Branch Tunnel (RWBT) Repair Program West Connection Site, also known as Shaft 5B. As described in the attached project description, figures, design drawings, and slope stability documentation, the modifications include a major change, namely the proposed acquisition and development of the West Connection Support Site (i.e., the Bell Property, Tax Lot 8-1-22.2) which will roughly double the area of DEP's ongoing construction in the Town of Newburgh. The modifications also include minor field changes to the landscaping plans to the existing Shaft 5B site.

DEP has proposed the expansion into the Bell property for the purposes of placement of material from bypass tunnel excavation, process water treatment, and construction storage and laydown area. Beyond efficiency benefits for DEP, the use of the Bell property for these purposes would reduce the traffic associated with transporting excavated material from the bypass tunnel on Route 9W as the material would be handled solely on the internal, larger, combined site.

The intention of this submission is to submit the final design drawings to the Planning Board, and to continue the dialogue with the ultimate aim of obtaining approval for the modified site plan. Please note that several additional items will be delivered to your office under separate cover in the coming weeks and months, including an addendum to the original environmental impact statement to cover the West Connection Support Site; an updated stormwater pollution prevention plan (SWPPP); and an escrow payment of $5,000.00 for project 2011-15.

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[1] July 5, 2012 Planning Board Resolution; October 22, 2012 Letter of Agreement Executed by Town Supervisor and Planning Board Chair; and October 24, 2012 Planning Board Chair Endorsed Site Plans.

Per your communications with Mr. Chris Villari, we will be prepared to attend the Planning Board meeting on Thursday, March 19, 2015.

Should you have any questions or require additional information in the meantime, please do not hesitate to contact me or my staff, and we thank you once again for your attention to this critical water supply project.

Sincerely,

Sean McAndrew

cc.
Town of Newburgh Planning Board (care of the Chairman) – 7 full packages with 11x17 drawings
Michael Donnelly, Town of Newburgh Planning Board Attorney – full package with 11x17 drawings
Patrick Hines, Town of Newburgh Planning Board Engineer – full package with full size drawings
Gerald Canfield, Town of Newburgh Code Compliance Officer – full package with full size drawings
Ken Wersted, Town of Newburgh Traffic Consultant – full package with 11x17 drawings
Gil Piaquadio, Town of Newburgh Supervisor – full package with 11x17 drawings
Mark Taylor, Town of Newburgh Attorney, – full package with 11x17 drawings
James Osborne, Town of Newburgh Engineer – full package with full size drawings
Dan Michaud, DEP BWS (w/o attachments)
Ted Dowey, DEP BEDC (w/o attachments)
Phil Simmons, DEP BEDC (w/o attachments)
C. Villari, DEP BEDC (w/o attachments)

Project Description

New York City Department of Environmental Protection
Delaware Aqueduct Rondout-West Branch Tunnel Repair Program
West Connection Site/Shaft 5B
Town Project Number 2011-15[1]

West Connection Support Site (Bell Property) Final Design
Shaft 5B Landscaping Modifications
March 4, 2015

Introduction

The New York City Department of Environmental Protection (DEP) respectfully requests approval of modifications to the site plan for Project 2011-15 originally granted in 2012[2] in order to incorporate changes encountered during the construction of the Delaware Aqueduct Rondout-West Branch Tunnel (RWBT) Repair Program West Connection Site, also known as Shaft 5B. As described below, the modifications include a major change, namely the proposed acquisition and development of the West Connection Support Site (i.e., the Bell Property) which will roughly double the area of DEP's ongoing construction in the Town of Newburgh. The modifications also include minor field changes to the landscaping plans to the existing Shaft 5B site.

The following provides descriptions of specific modifications related to the acquisition and use of the West Connection Support Site and the Shaft 5B landscaping changes. Additional information regarding the larger Water For the Future (WFF) project and supporting information for the support site (e.g., zoning, land use) are included, as well.

Description of Modifications

Subsequent to the start of ongoing construction, DEP has taken advantage of an opportunity to improve the Shaft 5B project through the acquisition of an adjacent 30.8 acres, more than doubling the site area. Hence, the clear need to document design changes and obtain Town Planning Board approval. DEP has also encountered minor field changes during construction that require a change in landscaping design at the original site. Both sets of changes are presented in one modification package as the two sites will be merged as part of the same project.

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[1] The site plan approval process was initiated under project number 2011-15, and several post-approval site plan updates were submitted under project number 2013-5. The initial project number, 2011-15, will be used going forward.

[2] July 5, 2012 Planning Board Resolution; October 22, 2012 Letter of Agreement Executed by Town Supervisor and Planning Board Chair; and October 24, 2012 Planning Board Chair Endorsed Site Plans.

Please note the attached figures which are intended to help the reviewer visualize the modifications. Figures 1 through 9 include annotated excerpts from site plans. Figures 10 through 18 include renderings of the combined site with during- and post-construction views.

Major Modification: West Connection Support Site Acquisition (i.e., Bell Property) (see figures 1-6)

Purpose

To better support the construction of the RWBT bypass, DEP will expand the existing Shaft 5B site by adding the 30.8-acre Bell property (i.e., the West Connection Support Site or support site) to the site plan. The additional space would be used for the following purposes (see figure 4).

- Permanent placement of excavated material, on the order of 375,000 cubic yards, from the construction of the bypass tunnel, thereby raising and generally leveling the elevation of the Support Site;
- Location of temporary settling ponds and treatment facilities to properly treat process water and groundwater infiltration from the tunnel excavation during construction; and
- Supplemental, temporary storage and laydown to facilitate the bypass tunnel construction, primarily for tunnel lining segments.

In addition to cost savings and efficiency gains, the use of the Bell property for these purposes would provide major benefits to the project, as follows, most importantly, reduced truck traffic.

- Streamline incoming construction material storage and handling;
- Provide for more effective process and infiltration water treatment; and
- Reduce truck traffic by transporting excavated material within the greater site (i.e., from Shaft 5B to the Support Site) and precluding these trucks from traffic on Route 9W.

Final Disposition *(see figures 5, 6, 11, 12, and 18)*

After construction of the bypass tunnel and completion of the connection to the aqueduct, the Support Site would be returned to a state similar to its existing meadow/forest condition, albeit with a modified topography due to the placement of excavated material from the tunnel. DEP's intention in working with the Town of Newburgh was to create a scheme that would mirror and complement the landscaping plan for the existing 5B site.

Of note, the design calls for a 60-foot buffer of existing trees and vegetation to be maintained along the perimeter of the site throughout construction. This buffer would serve to largely screen the Support Site from view during construction and contribute to successional reforestation in the final condition.

Location *(see figure 1)*

The 30.8-acre West Connection Support Site property (Tax Lot 8-1-22.2) is located immediately north of and adjacent to Tax Lot 8-1-19.1, the lot comprising the majority of the existing Shaft 5B site. To the east, the Support Site property is bordered by Tax Lots 8-1-21.12 and 8-21.22. A narrow portion of the lot also extends to Route 9W. To the north, the site is bounded by a Central Hudson Gas and Electric (CHGE) utility right of way (8-1-31.12). And to the west, the site is adjacent to five lots, including 8-1-85.2, 8-1-85.3, 8-1-85.4, 8-1-4.22, and 8-1-5.1.[3]

Zoning and Land Use *(see figure 2)*

The Support Site property is zoned "AR, Agricultural" with a "Professional Office Overlay (O)" covering a small portion along the eastern boundary of the site.[4] Note that it is DEP's understanding per consultation with the Town Planning Board that with the addition of the Support Site property, the full, combined site would be considered a public utility, as the Shaft 5B site is currently categorized with regard to zoning and use variances.

Minor Modifications: West Connection Site (i.e., Existing Shaft 5B Site) (see figures 7-9)

Field Changes

Due to field conditions encountered during construction and design changes, several minor modifications to the existing Shaft 5B site landscaping design need to be reflected in the NYCPDC approval. These changes include the following.

- The planting on the east facing constructed tiered slope has been revised due several field conditions.
    - Species substitution – The constructed slope dictates the limit of topsoil placement over the structural fill to deter soil erosion. Plants were substituted that can thrive in this shallow topsoil depth.
    - Relocation of plantings along benches – Access for maintenance of the plants and electrical poles occurs exclusively on the slope "benches" or level tiers. Therefore, plantings in these areas have been relocated.

[3] Town of Newburgh Tax Year 2013, Tax Map 334600, Orange County Tax Map Department, New York
[4] Town of Newburgh, Orange County, New York, Official Zoning Map, Orange County Planning Department, October 22, 2012.

- Deer fencing – To support the growth and establishment of saplings, deer fencing is proposed around planted areas.
  - Safety barrier – Field conditions dictated the placement of a wider safety barrier along the roadway encircling the shaft and adjacent laydown areas, occupying some of the area originally intended for plantings along the ridgeline. The landscaping plan has been adjusted in this area, but maintains the original intent of visual diversity and screening.
  - Slope stabilization – Drainage conditions predicated the placement of rip rap "panels" on portions of the east facing slope where sloughing occurred. The rip rap has effectively stabilized those areas of slope, although, some of the "panels" are located in areas originally intended for plantings.

    As part of the overall redesign of the landscape plan, the plantings precluded by the rip rap panels have been relocated, and the panels themselves have been incorporated into the design. Over time, the edges of the panels will soften, and in conjunction with the overall planting scheme, the original intention of establishing visual diversity on the slope will be met.

- 9W site frontage
  - Plantings in the NYSDOT right-of-way – Trees that were proposed within the road's right-of-way have been relocated.
  - Turn-around island additions – Plantings have been added to the turn-around island at the entrance to the site. These will aid in screening the east facing slope from 9W during construction, while the slope is developing into its full meadow condition. When shaft and tunnel construction are complete, the turn-around will be removed and these plantings will be replaced with a bioretention basin. The final condition plantings proposed for this area have not changed.

- New planting areas
  - Native plant material has been proposed in other areas of the site that allow for deep topsoil depth and do not require regular access by construction / DEP personnel. This will encourage future growth and reforestation of the site. These areas include:
    - Hilltop above the access road rock face which was adjusted, in part, due to the installation of the road cut slope stabilization (i.e.,

soil nails, rock bolts, and shotcrete) addressed in previous Planning Board meetings and communications.

- Lowland area to the south of the on-site stream.

Water for the Future Background[5]

DEP has developed the Water for the Future (WFF) Program: Delaware Aqueduct RWBT Repair project to address known leaks in the RWBT section of the Delaware Aqueduct that currently conveys more than 50 percent of the daily drinking water for New York City and is the primary source of water for residents and businesses of the Towns of Newburgh and Marlborough. This critical component of water supply infrastructure conveys an annual average of 600 million gallons per day from the upstate Cannonsville, Pepacton, Neversink, and Rondout reservoirs to a population of approximately 9 million people.

There are two areas of significant leakage in the RWBT, the Wawarsing and Roseton crossings. Together, they leak approximately 35 million gallons of water per day. The Wawarsing crossing can be repaired from within the tunnel; however, the Roseton crossing poses additional challenges. Therefore, DEP will construct a bypass tunnel around the leaking areas in Roseton, which would consist of a new tunnel segment 600 feet below the Hudson River to bypass the leaking section, and two shafts at each end - one in the Town of Newburgh, Orange County, New York (West Connection Site, Shaft 5B), and one in the Town of Wappinger, Dutchess County, New York (East Connection Site, Shaft 6B). This work began in March 2013 and is scheduled to be completed in 2021. Once the shafts and bypass tunnel are constructed, the aqueduct would be shut down and unwatered. At that time the leaks in Wawarsing would be repaired, and the bypass tunnel would be connected to the existing tunnel. This work would begin in the 2020/2021 time frame and take between 6 and 15 months.

Design is underway for other projects intended to augment the City's water supply during the shutdown of the RWBT, for instance, Queens groundwater wells rehabilitation project and the Catskill Aqueduct Repair and Rehabilitation project.

Approval Status

The project has worked with the Planning Board on the initial Site Plan Approval and various updates to the site plan drawings, as follows:

- Site Plan Approval Granted in 2012
    - July 5, 2012 Planning Board Resolution
    - October 22, 2012 Letter of Agreement Executed by Town Supervisor and Planning Board Chair

[5] Water for the Future Program: Delaware Aqueduct Rondout-West Branch Tunnel Repair Final Environmental Impact Statement, CEQR No. 10DEP042U, Prepared by New York City Department of Environmental Protection, May 2012.

- October 24, 2012 Planning Board Chair Endorsed Site Plans

- Existing Modifications
  - February 20, 2013 (regrading and stormwater management)
  - October 17, 2013 (grading, PRV vault relocation concept, entrance road, stormwater management, retaining wall concept)
  - April 15, 2014 (rock delivery to Milton Waterfront Park, LED lighting, security fence)
  - October 2, 2014 (Saturday work hours)
  - October 2, 2014 (alternate stream crossing)
  - October 16, 2014 (PRV vault location final)
  - December 15, 2014 (retaining wall final)

- Proposed Modification
  - March 5, 2015 (West Connection Support Site, landscaping)

Construction Status

As of January 2015, site preparation is largely complete, although additional landscaping will be installed in the forthcoming spring and fall planting seasons. Shaft excavation has progressed to roughly 450 feet deep. The procurement process for the tunneling work has been initiated, and a contractor should be on board mid to late 2015.

Project Number and Escrow

The initial project number, 2011-15, will be reinstated and used for this West Connection Support Site and landscaping modification request as well as any others in the future. Note that many of the modifications listed above used the project number 2013-5.

In addition, the escrow account to support the review of the modification request will be opened under the initial project number, 2011-15, at a level of $5,000.00.

Supporting Documentation and Drawings

The following supporting drawings and documentation are included in this submission.

- Attached figures
- West Connection Site - Site Plan Application Modification, 58 sheets, February 2015.
- West Connection Support Site: Slope Stability Analyses, January 28, 2015.

Forthcoming submissions will include:

- Stormwater Pollution Prevention Plan (SWPPP)
- Environmental Review documentation – An addendum to the original environmental impact statement[6] covering the project is under development and will be submitted to the Planning Board in the coming weeks. The review will include cumulative transportation, air, noise, greenhouse gas, and historic resources assessments for use of both the current site and the proposed Support Site.

6 Water for the Future Program: Delaware Aqueduct Rondout-West Branch Tunnel Repair Final Environmental Impact Statement, CEQR No. 10DEP042U, Prepared by New York City Department of Environmental Protection, May 2012.

Major Modification:
Addition of West Connection Support Site

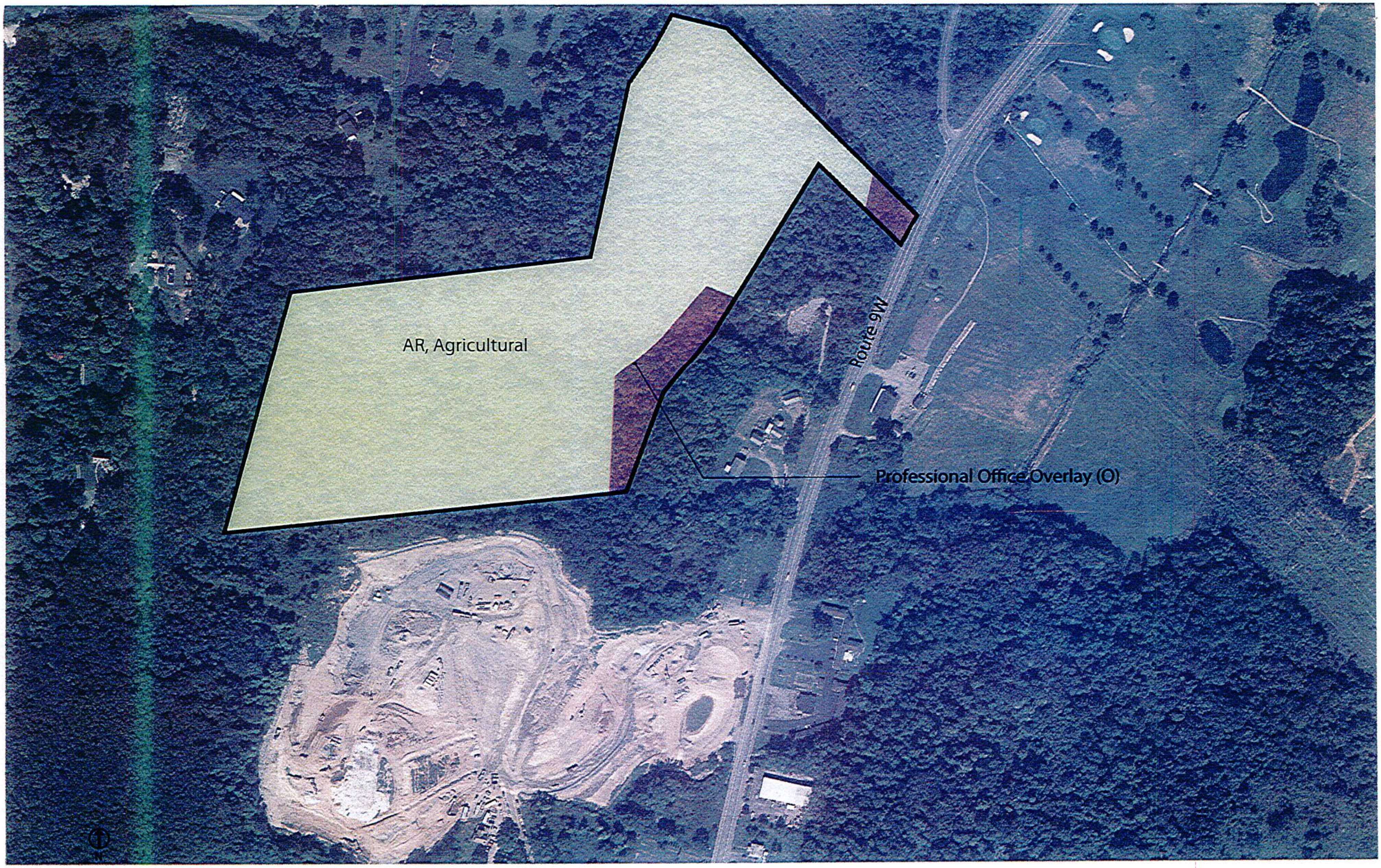
Major Purposes for aquisition of West Connection Support Site
- Placement of excavated material, on the order of 375,000 cubic yards, from the construction of the Bypass Tunnel.
- Location of settling ponds and treatment facilities to properly treat water.
- Supplemental storage and laydown to facilitate the bypass tunnel construction, primarily for tunnel lining segments.

Major Benefits for Site Use
- Streamline incoming construction material storage and handling.
- Provide for more effective water treatment.
- Reduce truck traffic by transporting excavated material within the site (i.e., from Shaft 5B to the adjacent Bell property) and removing these trucks from traffic on Route 9W.

Minor Modifications:
Landscaping Field Changes

- Due to field conditions encountered during construction and minor design changes, several minor modifications to the existing Shaft 5B site landscaping design are reflected in this modification request.

WEST CONNECTION SUPPORT SITE / BELL PROPERTY OVERVIEW
Figure 1



NYC Environmental Protection Stantec

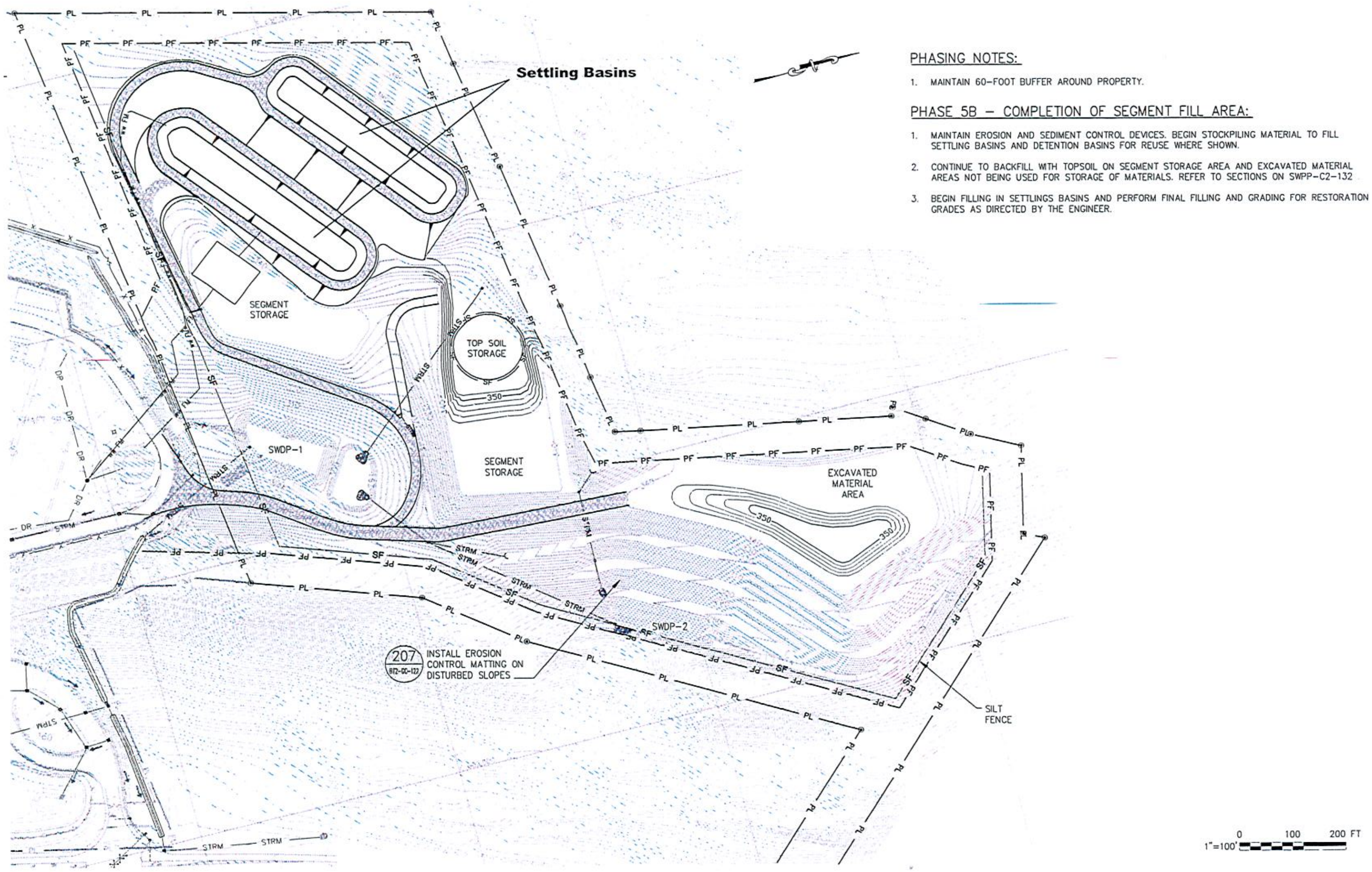
ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

WEST CONNECTION SUPPORT SITE / BELL PROPERTY
ZONING CLASSIFICATION
Figure 2

NYC Environmental Protection · Stantec

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

SHAFT 5B SITE
CONSTRUCTION PLAN - AERIAL VIEW
Figure 3



PHASING NOTES:

1. MAINTAIN 60-FOOT BUFFER AROUND PROPERTY.

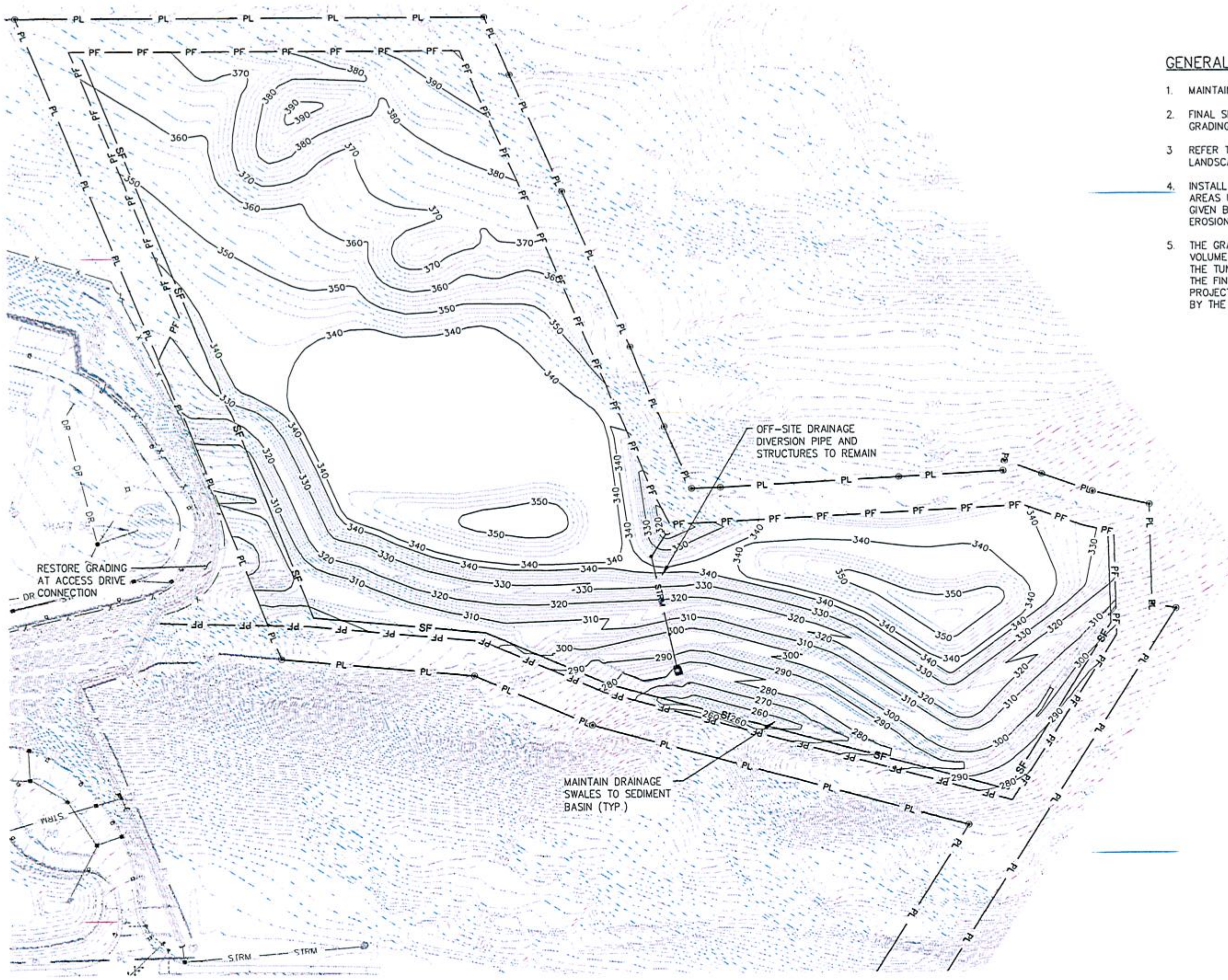
PHASE 5B – COMPLETION OF SEGMENT FILL AREA:

1. MAINTAIN EROSION AND SEDIMENT CONTROL DEVICES. BEGIN STOCKPILING MATERIAL TO FILL SETTLING BASINS AND DETENTION BASINS FOR REUSE WHERE SHOWN.
2. CONTINUE TO BACKFILL WITH TOPSOIL ON SEGMENT STORAGE AREA AND EXCAVATED MATERIAL AREAS NOT BEING USED FOR STORAGE OF MATERIALS. REFER TO SECTIONS ON SWPP-C2-132
3. BEGIN FILLING IN SETTLINGS BASINS AND PERFORM FINAL FILLING AND GRADING FOR RESTORATION GRADES AS DIRECTED BY THE ENGINEER.

NYC Environmental Protection | Stantec

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

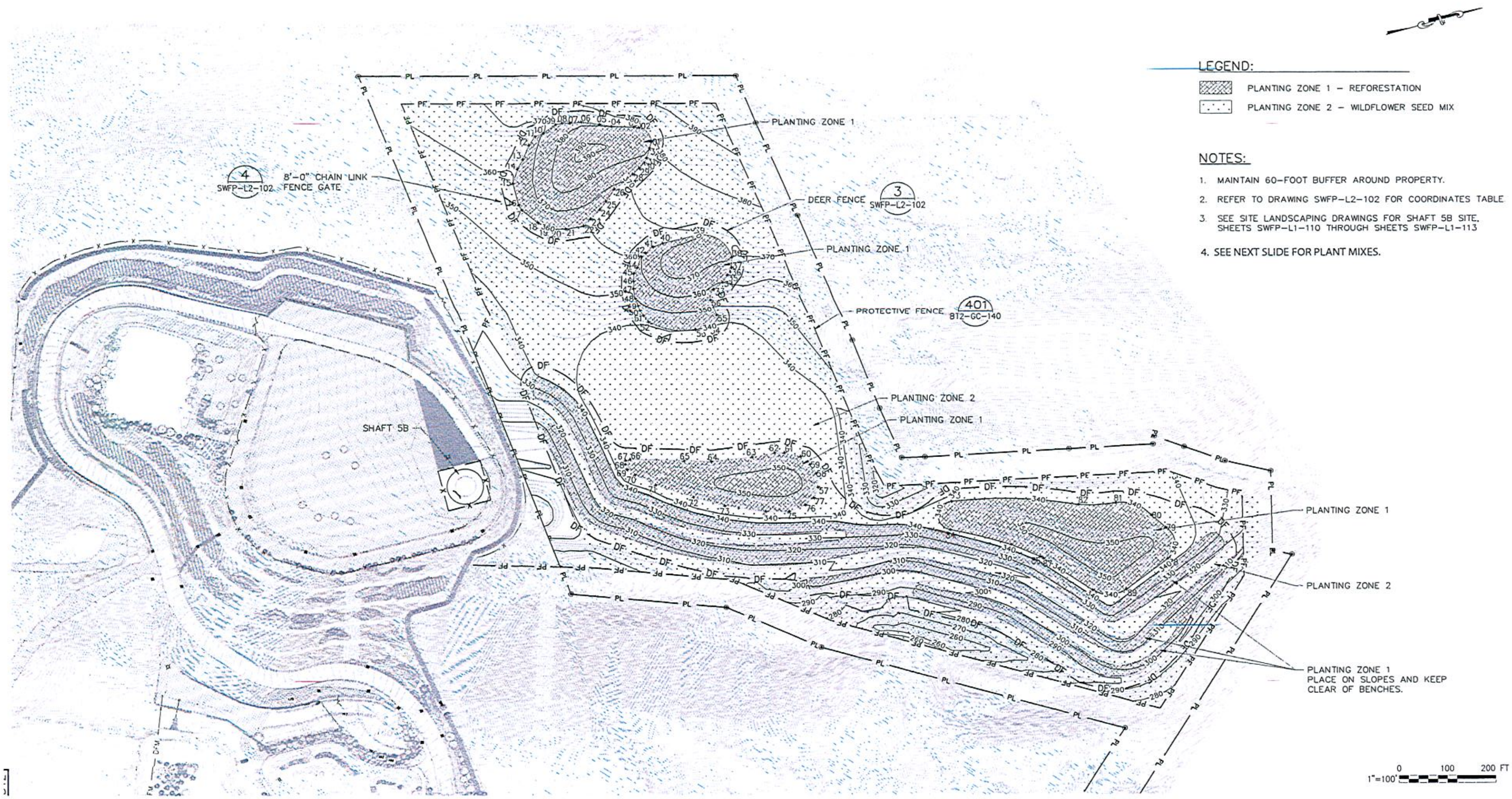
WEST CONNECTION SUPPORT SITE / BELL PROPERTY
PHASE 5B SITE PLAN - EXCAVATED MATERIAL AREA CONSTRUCTION
Figure 4



GENERAL NOTES:

1. MAINTAIN 60-FOOT BUFFER AROUND PROPERTY.
2. FINAL SITE GRADING OF SETTLING BASINS SHALL MATCH EXISTING GRADING
3. REFER TO DRAWINGS SWFP-L2-101 FOR SITE RESTORATION AND LANDSCAPING.
4. INSTALL AND MAINTAIN SILT FENCE DOWN GRADIENT OF ALL DISTURBED AREAS UNTIL SITE RESTORATION IS ESTABLISHED AND APPROVAL IS GIVEN BY THE ENGINEER. REFER TO SECTION 31 25 13 – DUST, SOIL EROSION AND SEDIMENT CONTROL OF THE SPECIFICATIONS.
5. THE GRADES SHOWN ON THIS PLAN ARE BASED ON AN ESTIMATED VOLUME OF FILL GENERATED BY THE TUNNELING OPERATION. SHOULD THE TUNNELING PROJECT GENERATE LESS FILL THAN ESTIMATED, THEN THE FINAL GRADES SHALL BE MODIFIED DURING THE COURSE OF THE PROJECT. MODIFICATIONS TO THE FINAL GRADES SHALL BE APPROVED BY THE ENGINEER

WEST CONNECTION SUPPORT SITE / BELL PROPERTY
SITE GRADING PLAN - SITE RESTORATION
Figure 5



NOTES:

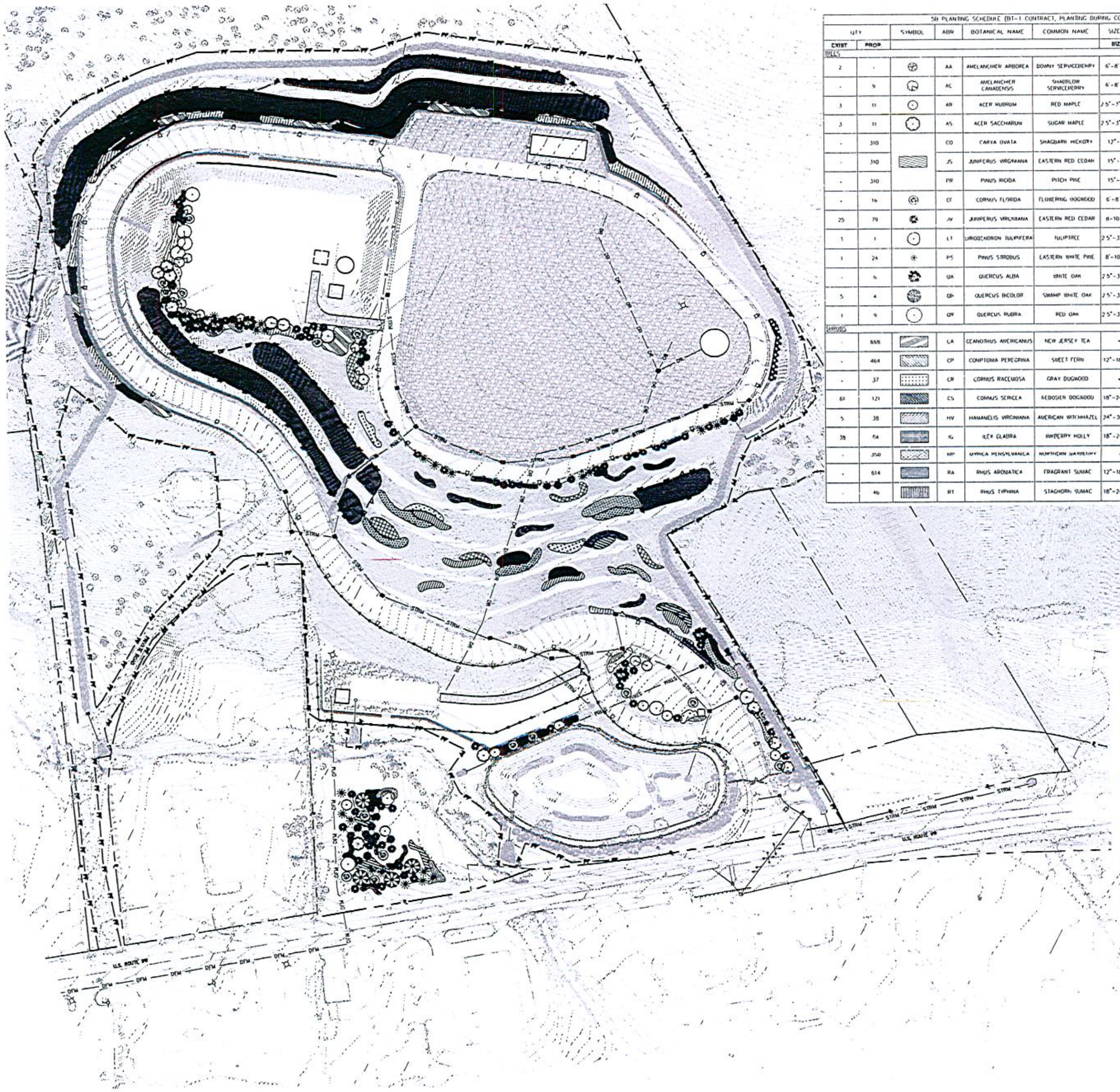
1. MAINTAIN 60-FOOT BUFFER AROUND PROPERTY.
2. REFER TO DRAWING SWFP-L2-102 FOR COORDINATES TABLE.
3. SEE SITE LANDSCAPING DRAWINGS FOR SHAFT 5B SITE, SHEETS SWFP-L1-110 THROUGH SHEETS SWFP-L1-113
4. SEE NEXT SLIDE FOR PLANT MIXES.

Figure 6

PLANTING SCHEDULE (BT-1 CONTRACT, PLANTING DURING CONSTRUCTION)							
QTY	SYMBOL	ABR.	BOTANICAL NAME	COMMON NAME	SIZE AT PLANTING HT	SIZE AT PLANTING CAL	REMARKS
TREES/CONIFERS							
2		AA	AMELANCHIER ARBOREA	DOWNY SERVICEBERRY	7-8'		B&B AT PLANTING. SPACING AS SHOWN ON PLANS
7		AC	AMELANCHIER CANADENSIS	SHADBLOW SERVICEBERRY	7-8'		B&B AT PLANTING. SPACING AS SHOWN ON PLANS
13		AR	ACER RUBRUM	RED MAPLE		2.5-3"	B&B AT PLANTING. SPACING AS SHOWN ON PLANS
16		AS	ACER SACCHARUM	SUGAR MAPLE		2.5-3"	B&B AT PLANTING. SPACING AS SHOWN ON PLANS
13		CF	CORNUS FLORIDA	FLOWERING DOGWOOD	7-8'		B&B AT PLANTING. SPACING AS SHOWN ON PLANS
65		JV	JUNIPERUS VIRGINIANA	EASTERN RED CEDAR	8-10'		B&B AT PLANTING. SPACING AS SHOWN ON PLANS
3		LT	LIRIODENDRON TULIPIFERA	TULIPTREE		2.5-3"	B&B AT PLANTING. SPACING AS SHOWN ON PLANS
13		QB	QUERCUS BICOLOR	SWAMP WHITE OAK		2.5-3"	B&B AT PLANTING. SPACING AS SHOWN ON PLANS
6		QR	QUERCUS RUBRA	RED OAK		2.5-3"	B&B AT PLANTING. SPACING AS SHOWN ON PLANS
10		PS	PINUS STROBUS	EASTERN WHITE PINE	8-10'		B&B AT PLANTING. SPACING AS SHOWN ON PLANS
SHRUBS/GRASSES							
462		CP	COMPTONIA PEREGRINA	SWEET FERN	12-18"		#2 CONTAINER. TO BE SPACED AT 2 - 2.5' O.C
61		CS	CORNUS SERICEA	REDOSIER DOGWOOD	18-24"		#5 CONTAINER. TO BE SPACED AT 2.5- 3' O.C
137		HV	HAMAMELIS VIRGINIANA	AMERICAN WITCHHAZEL	24-30"		#5 CONTAINER AT PLANTING. TO BE SPACED AT 5-5.5' O.C.
38		IG	ILEX GLABRA	INKBERRY HOLY	18-24"		#3 CONTAINER. TO BE SPACED AT 2.5 - 3' O.C
57		PV	PANICUM VIRGATUM	SWITCHGRASS	18-24"		#3 CONTAINER. TO BE SPACED AT 3 - 3.5' O.C
160		RA	RHUS AROMATICA	FRAGRANT SUMAC	12-18"		#2 CONTAINER. TO BE SPACED AT 3 - 4' O.C
107		RT	RHUS TYPHINA	STAGHORN SUMAC	12-18"		#2 CONTAINER. TO BE SPACED AT 4.5 - 5' O.C
17		VP	VIBURNUM PRUNIFOLIUM	BLACKHAW VIBURNUM	2-3'		B&B AT PLANTING. TO BE SPACED AT 5 - 6' O.C.
151		LS	LONICERA SEMPERVIRENS	TRUMPET HONEYSUCKLE	12-18"		#2 CONTAINER (STAKED). TO BE SPACED AT 2-2.5' O.C.
PLUGS							
348		IV	IRIS VERSICOLOR	BLUE FLAG IRIS			2" PLUG TO BE SPACED AT 18" O.C
971		LC	LOBELIA CARDINALIS	CARDINAL FLOWER			2" PLUG TO BE SPACED AT 12-15" O.C

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

SHAFT 5B SITE
PREVIOUSLY APPROVED BT-1 SITE PLAN
Figure 7



5B PLANTING SCHEDULE (BT-1 CONTRACT, PLANTING DURING CONSTRUCTION)

QTY EXIST	QTY PROP.	SYMBOL	ABR	BOTANICAL NAME	COMMON NAME	SIZE AT PLANTING SIZE	SIZE AT PLANTING FORM	REMARKS
TREES								
2	-		AA	AMELANCHIER ARBOREA	DOWNY SERVICEBERRY	6'-8' HT	-	B&B AT PLANTING 3 STEM SPACING AS SHOWN ON PLANS
-	9		AC	AMELANCHIER CANADENSIS	SHADBLOW SERVICEBERRY	6'-8' HT	-	B&B AT PLANTING 3 STEM SPACING AS SHOWN ON PLANS
3	11		AR	ACER RUBRUM	RED MAPLE	2.5"-3" CAL.	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
3	11		AS	ACER SACCHARUM	SUGAR MAPLE	2.5"-3" CAL.	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
-	310		CO	CARYA OVATA	SHAGBARK HICKORY	12"-18"	-	SAPLING SPACED AT 9' O.C.
-	310		JS	JUNIPERUS VIRGINIANA	EASTERN RED CEDAR	15"-24"	-	
-	310		PR	PINUS RIGIDA	PITCH PINE	15"-24"	-	
-	16		CF	CORNUS FLORIDA	FLOWERING DOGWOOD	6'-8' HT	-	B&B AT PLANTING SPACING AS SHOWN ON PLANS
25	79		JV	JUNIPERUS VIRGINIANA	EASTERN RED CEDAR	8-10 HT	-	B&B AT PLANTING SPACING AS SHOWN ON PLANS
1	1		LT	LIRIODENDRON TULIPIFERA	TULIPTREE	2.5"-3" CAL.	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
1	24		PS	PINUS STROBUS	EASTERN WHITE PINE	8'-10' HT	-	B&B AT PLANTING SPACING AS SHOWN ON PLANS
-	6		QA	QUERCUS ALBA	WHITE OAK	2.5"-3" CAL.	-	B&B AT PLANTING SPACING AS SHOWN ON PLANS
5	4		QB	QUERCUS BICOLOR	SWAMP WHITE OAK	2.5"-3" CAL.	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
1	9		QR	QUERCUS RUBRA	RED OAK	2.5"-3" CAL.	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
SHRUBS								
-	668		CA	CEANOTHUS AMERICANUS	NEW JERSEY TEA	-	#2 CONT	SPACED AT 3' O.C.
-	464		CP	COMPTONIA PEREGRINA	SWEET FERN	12"-18" HT	#2 CONT	SPACED AT 2.5' O.C.
-	37		CR	CORNUS RACEMOSA	GRAY DOGWOOD	-	#2 CONT	SPACED AT 8' O.C.
61	121		CS	CORNUS SERICEA	REDOSIER DOGWOOD	18"-24" HT	#5 CONT.	SPACED AT 3' O.C.
5	38		HV	HAMAMELIS VIRGINIANA	AMERICAN WITCHHAZEL	24"-30" HT	#2 CONT	SPACED AT 8' O.C.
38	64		IG	ILEX GLABRA	INKBERRY HOLLY	18"-24" HT	#3 CONT	SPACED AT 5' O.C.
-	350		MP	MYRICA PENSYLVANICA	NORTHERN BAYBERRY	-	#2 CONT	SPACED AT 3' O.C.
-	614		RA	RHUS AROMATICA	FRAGRANT SUMAC	12"-18" HT	#2 CONT	SPACED AT 4' O.C.
-	46		RT	RHUS TYPHINA	STAGHORN SUMAC	18"-24" HT	#2 CONT	SPACED AT 8' O.C.

5B PLANTING SCHEDULE (BT-1 CONTRACT, PLANTING DURING CONSTRUCTION)

QTY EXIST.	QTY PROP.	SYMBOL	ABR	BOTANICAL NAME	COMMON NAME	SIZE AT PLANTING SIZE	SIZE AT PLANTING FORM	REMARKS
SHRUBS CONT'D								
-	1,189		VA	VACCINIUM ANGUSTIFOLIUM	LOWBUSH BLUEBERRY	-	#2 CONT	SPACED AT 2.5' O.C.
17	37		VP	VIBURNUM PRUNIFOLIUM	BLACKHAW VIBURNUM	2-3' HT	#2 CONT	SPACED AT 5' O.C.
GRASSES AND VINES								
178	-		LS	LONICERA SEMPERVIRENS	TRUMPET HONEYSUCKLE	12"-18" LONG	#2 CONT.	STAKED. SPACED AT 2.5' O.C.
57	83		PV	PANICUM VIRGATUM	SWITCHGRASS	18"-24" HT	#2 CONT	SPACED AT 3' O.C.
PLUGS								
246	-		IV	IRIS VERSICOLOR	BLUE FLAG IRIS	-	-	2" PLUG SPACED AT 18" O.C.
971	-		LC	LOBELIA CARDINALIS	CARDINAL FLOWER	-	-	2" PLUG. SPACED AT 15" O.C.

INDIVIDUAL WILDFLOWER SEED SPECIES

QTY EXIST	QTY PROP	SYMBOL	ABR	BOTANICAL NAME	COMMON NAME	RATE
-	APROX 3,000 SF		MF	MONARDA FISTULOSA	WILD BERGAMOT	0.5 LB PER 1,000 SF OR AS SPECIFIED BY MANUFACTURER
-	APROX 4,000 SF		SJ	SOLIDAGO JUNCEA	EARLY GOLDENROD	0.5 LB PER 1,000 SF OR AS SPECIFIED BY MANUFACTURER
-	APROX 1,200 SF		SNA	SYMPHYOTRICHUM NOVAE-ANGLIAE	NEW ENGLAND ASTER	0.5 LB PER 1,000 SF OR AS SPECIFIED BY MANUFACTURER

NOTE

1 UNLESS OTHERWISE INDICATED, ALL DISTURBED AREAS OF SITE ARE TO BE STABILIZED AND SEEDED WITH WILDFLOWER SEED MIX. SEE MIX BELOW, THIS SHEET

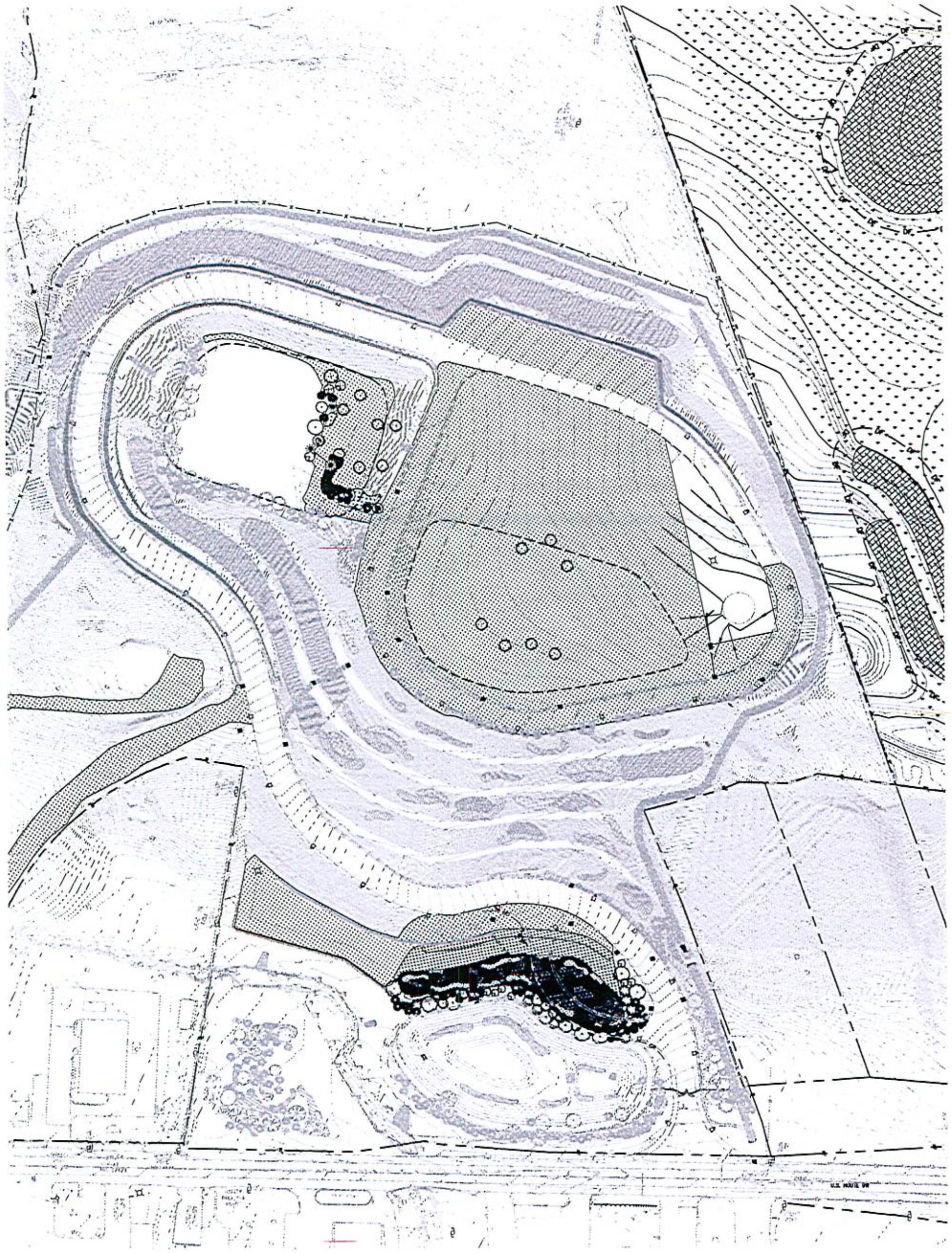
WILDFLOWER SEED MIX

	DESCRIPTION	RATE (LBS PER ACRE)
1	LITTLE BLUESTEM, 'CAMPER'	6
2	BIG BLUESTEM, 'NIAGARA'	3
3	SWITCHGRASS, 'BLACKWELL'	2
4	INDIANGRASS, 'HOLT'	3
5	PURPLE LOVEGRASS	6
6	SIDEOATS GRAMA, 'BUTTE'	1
7	CANADA WILDRYE	1
8	ANNUAL RYEGRASS	10
9	EASTERN COLUMBINE	0.0625
10	PURPLE CONEFLOWER	0.1250
11	BUTTERFLY MILKWEED	0.0625
12	PARTRIDGE PEA	0.2500
13	OXEYE SUNFLOWER	0.1250
14	ROUNDHEAD LESPEDEZA, ALBANY PINE BUSH	0.0625
15	BLACKEYED SUSAN	0.1880
16	CANADA GOLDENROD	0.0625
17	SMOOTH BLUE ASTER	0.0625

Minor Modifications: Landscaping Field Changes and Slope Stabilization

- Tiered slope: Species substitution, planting relocated from benches, deer fencing, slope stabilization.
- 9W site frontage: planting in right-of-way relocated, plantings added to turn-around.
- Additional planting areas
- Road cut slope stabilization

Figure 8



QTY	SYMBOL	ABR	BOTANICAL NAME	COMMON NAME	SIZE AT PLANTING: SIZE	SIZE AT PLANTING: FORM	REMARKS
5B PLANTING SCHEDULE (BT-2 CONTRACT, PLANTING DURING CONSTRUCTION)							
TREES							
10		AC	AMELANCHIER CANADENSIS	SHADBLOW SERVICEBERRY	6'-8' HT	-	B&B AT PLANTING 3 STEM SPACING AS SHOWN ON PLANS
5		AR	ACER RUBRUM	RED MAPLE	2.5"-3" CAL	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
1		AS	ACER SACCHARUM	SUGAR MAPLE	2.5"-3" CAL	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
17		CO	CARYA OVATA	SHAGBARK HICKORY	2.5"-3" CAL	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
2		CF	CORNUS FLORIDA	FLOWERING DOGWOOD	6'-8' HT	-	B&B AT PLANTING SPACING AS SHOWN ON PLANS
13		JV	JUNIPERUS VIRGINIANA	EASTERN RED CEDAR	8'-10' HT	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
3		LT	LIRIODENDRON TULIPIFERA	TULIPTREE	2.5"-3" CAL	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
3		PS	PINUS STROBUS	EASTERN WHITE PINE	8'-10' HT	-	B&B AT PLANTING SPACING AS SHOWN ON PLANS
4		QA	QUERCUS ALBA	WHITE OAK	2.5"-3" CAL	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
1		QR	QUERCUS RUBRA	RED OAK	2.5"-3" CAL	-	B&B AT PLANTING SINGLE LEADER SPACING AS SHOWN ON PLANS
GRASSES							
180		AG	ANDROPOGON GERARDI	BIG BLUESTEM	12"-18" HT	#2 CONT	SPACED AT 4' O.C
338		PV	PANICUM VIRGATUM	SWITCHGRASS	18"-24" HT	#3 CONT	SPACED AT 3' O.C
PLUGS							
1,110		AB	ANDROPOGON GERARDI	BIG BLUESTEM	-	-	2" PLUG SPACED AT 18" O.C
454		AV	ANDROPOGON VIRGINICUS	BROOMSEDGE	-	-	2" PLUG SPACED AT 18" O.C
1,965		EP	~~EUTROCHIUM PURPUREUM~~	PURPLE JOE-PYE WEED	-	-	2" PLUG SPACED AT 18" O.C
1,259		PA	PANICUM VIRGATUM	SWITCHGRASS	-	-	2" PLUG SPACED AT 18" O.C
375		SN	SYMPHIOTRICHUM NOVAE-ANGLIAE	NEW ENGLAND ASTER	-	-	2" PLUG SPACED AT 18" O.C

NOTE:

1. UNLESS OTHERWISE INDICATED, ALL DISTURBED AREAS OF SITE ARE TO BE STABILIZED AND SEEDED WITH WILDFLOWER SEED MIX, SEE MIX BELOW, THIS SHEET.

PLANTING ZONE 1

QTY	SYMBOL	ABR	BOTANICAL NAME	COMMON NAME	RATE
APPROX 290,400 SF		-	ANDROPOGON GERARDII	BIG BLUESTEM 'NIAGRA'	0.25 LBS/AC
			ASCLEPIAS SYRIACA	COMMON MILKWEED	1 LB/AC
			ASCLEPIAS TUBEROSA	BUTTERFLYWEED	1 LB/AC
			AQUILEGIA CANADENSIS	WILD COLUMBINE	1 OZ/AC
			BOUTELOUA CURTIPENDULA	SIDEOATS GRAMA 'BUTTE'	1 LB/AC
			CHAMAECRISTA FASCICULATA	PARTRIDGE PEA	4 OZ/AC
			ELYMUS CANADENSIS	CANADA WILDRYE	1 LB/AC
			ERAGROSTIS SPECTABILIS	PURPLE LOVEGRASS	6 LBS/AC
			HELIOPSIS HELIANTHOIDES	OXEYE SUNFLOWER	2 OZ/AC
			LESPEDEZA CAPITATA	ROUNDHEAD LESPEDENZA, ALBANY PINE BUSH	1 OZ/AC
			LOLIUM PERENNE SSP MULTIFLORUM	ANNUAL RYEGRASS	10 LBS/AC
			PANICUM VIRGATUM	RED SWITCHGRASS 'BLACKWELL'	2 LBS/AC
			RUDBECKIA HIRTA	BLACK-EYED SUSAN	3 OZ/AC
			SCHIZACHYRIUM SCOPARIUM	LITTLE BLUESTEM 'CAMPER'	6 LBS/AC
			SOLIDAGO CANADENSIS	CANADA GOLDENROD	1 OZ/AC
			SORGHASTRUM NUTANS	INDIANGRASS 'HOLT'	3 LBS/AC
			SYMPHIOTRICHUM PILOSIUM	HEATH ASTER	1 OZ/AC

PLANTING ZONE 2

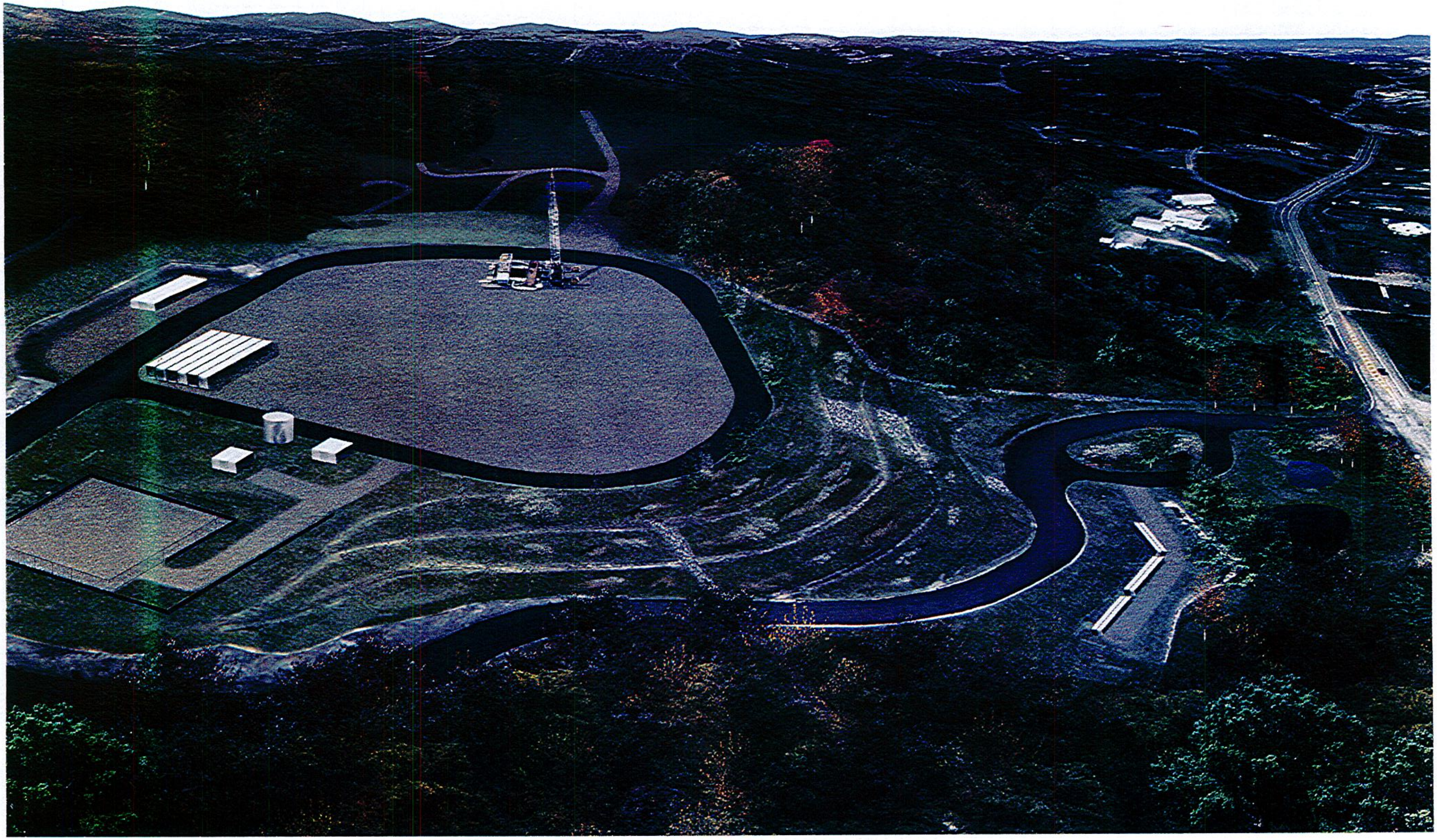
QTY.	SYMBOL	ABR	BOTANICAL NAME	COMMON NAME	RATE
APPROX 10,200 SF		-	ANDROPOGON GERARDII	BIG BLUESTEM	20 LBS/AC
			ASCLEPIAS SYRIACA	COMMON MILKWEED	1 LB/AC
			ASCLEPIAS TUBEROSA	BUTTERFLYWEED	1 LB/AC
			LOLIUM PERENNE SSP MULTIFLORUM	ANNUAL RYEGRASS	10 LBS/AC

QTY	SYMBOL	ABR	BOTANICAL NAME	COMMON NAME	SIZE AT PLANTING: SIZE	SIZE AT PLANTING: FORM	REMARKS
5B PLANTING SCHEDULE (BT-2 CONTRACT, PLANTING DURING CONSTRUCTION)							
SHRUBS							
10		CM	CORNUS AMOMUM	SILKY DOGWOOD	18"-24" HT	#5 CONT	SPACED AT 2.5' O.C
13		CR	CORNUS RACEMOSA	GRAY DOGWOOD	-	#2 CONT	SPACED AT 8' O.C
12		HV	HAMAMELIS VIRGINIANA	AMERICAN WITCHHAZEL	24"-30" HT.	#2 CONT	SPACED AT 8' O.C
8		IW	ILEX VERTICILLATA	WINTERBERRY	18"-24" HT	#3 CONT	SPACED AT 3' O.C
40		RA	RHUS AROMATICA	FRAGRANT SUMAC	12"-18" HT	#2 CONT.	SPACED AT 4' O.C

Stantec

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

SHAFT 5B SITE
BT-2 POST CONSTRUCTION
Figure 9



NYC Environmental Protection | Stantec

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

AERIAL PERSPECTIVE
R1 - DURING CONSTRUCTION
Figure 10

NYC Environmental Protection | Stantec

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

AERIAL PERSPECTIVE
R1 - POST CONSTRUCTION (0-5 YEAR MATURITY)
Figure 11

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

AERIAL PERSPECTIVE
R1 - POST CONSTRUCTION (10-15 YEAR MATURITY)
Figure 12

Route 9W Entrance To Shaft 5B Site (West Connection Support Site In Background)

Figure 13

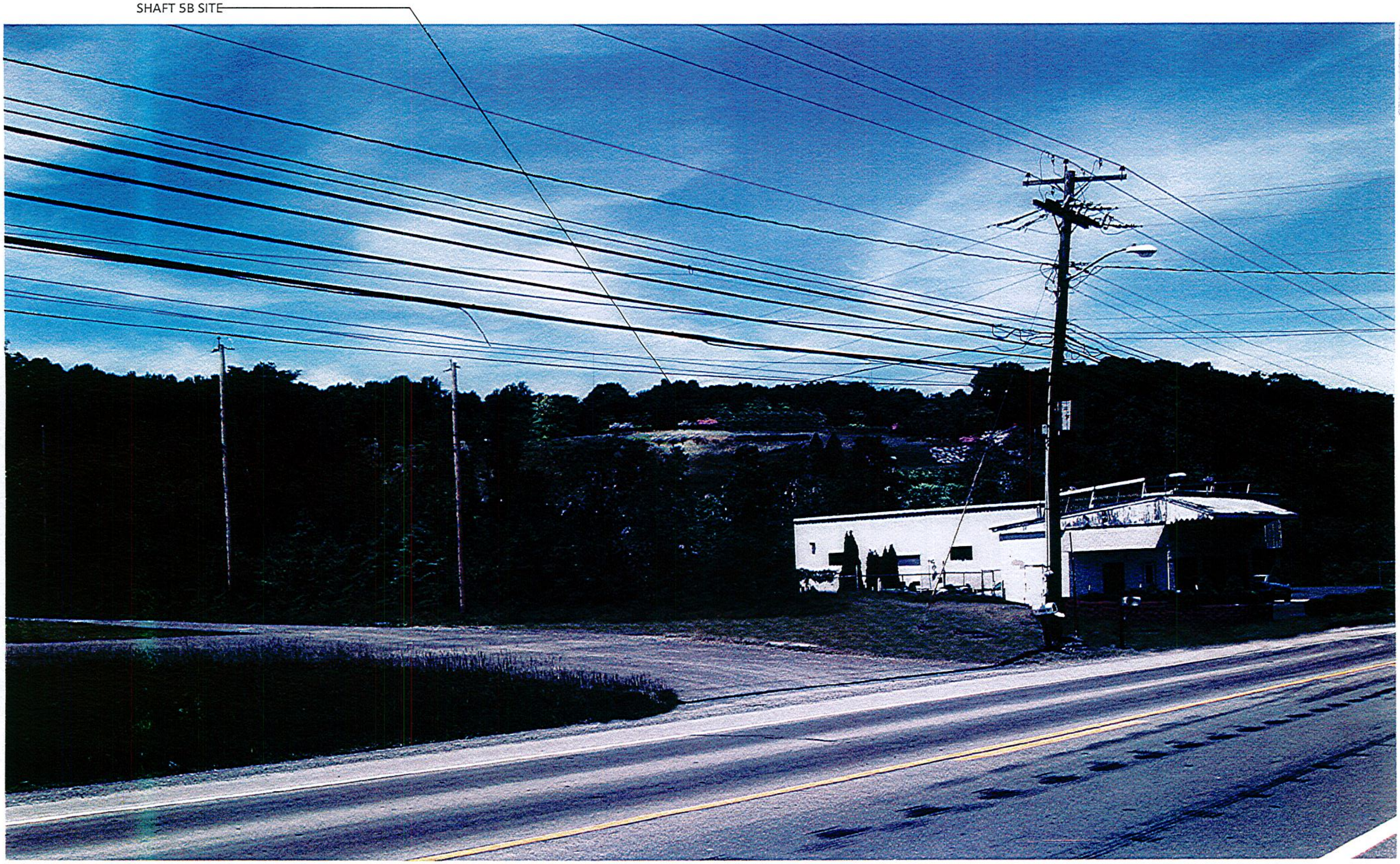
Route 9W Entrance To Shaft 5B Site (West Connection Support Site In Background)

9W STREET VIEW PERSPECTIVE
R2 - POST CONSTRUCTION
Figure 14

NYC Environmental Protection | Stantec

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

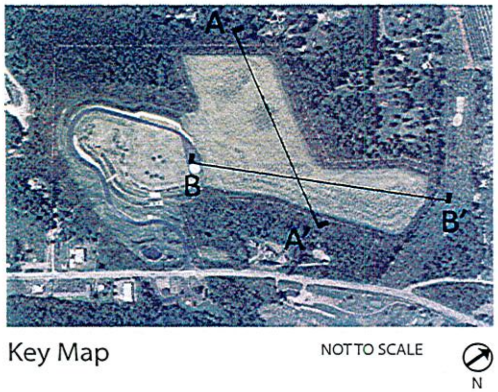
9W STREET VIEW PERSPECTIVE
R3 - DURING CONSTRUCTION
Figure 15



NYC Environmental Protection | Stantec

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

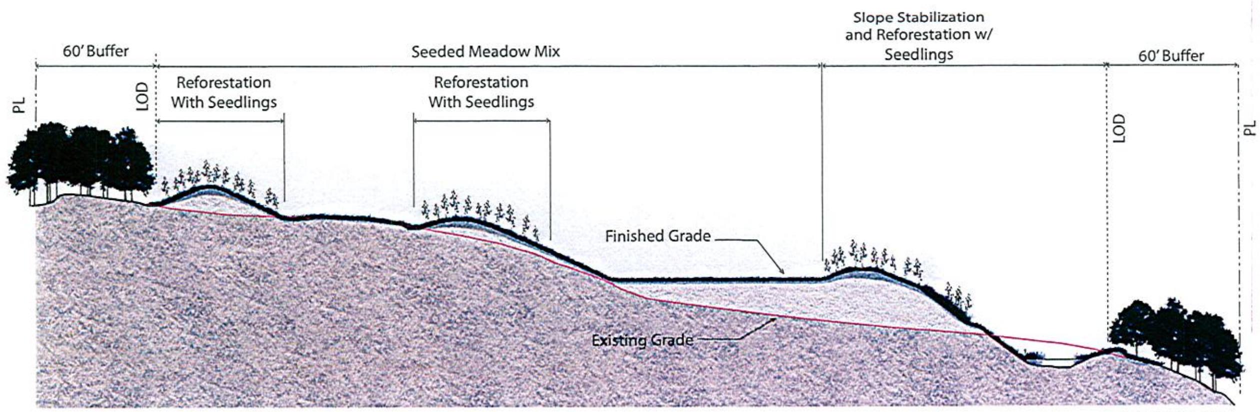
9W STREET VIEW PERSPECTIVE
R3 - POST CONSTRUCTION
Figure 16



Key Map

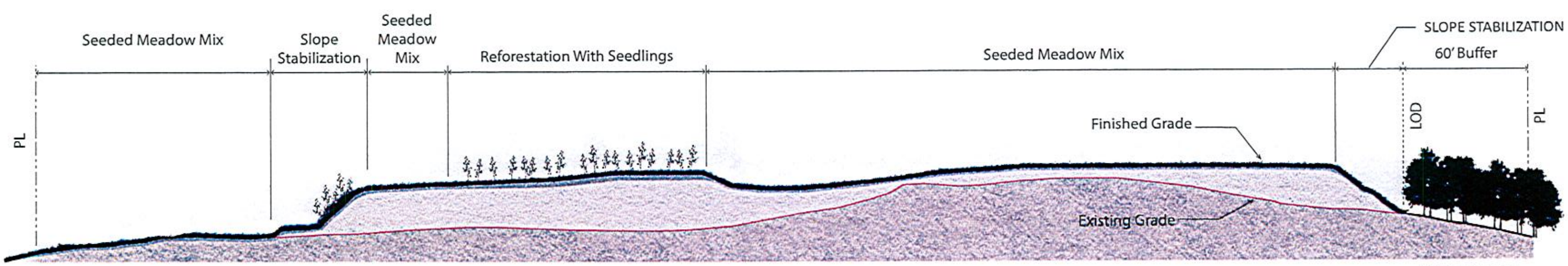
NOT TO SCALE

N



Section A - A'

NOT TO SCALE



Section B - B'

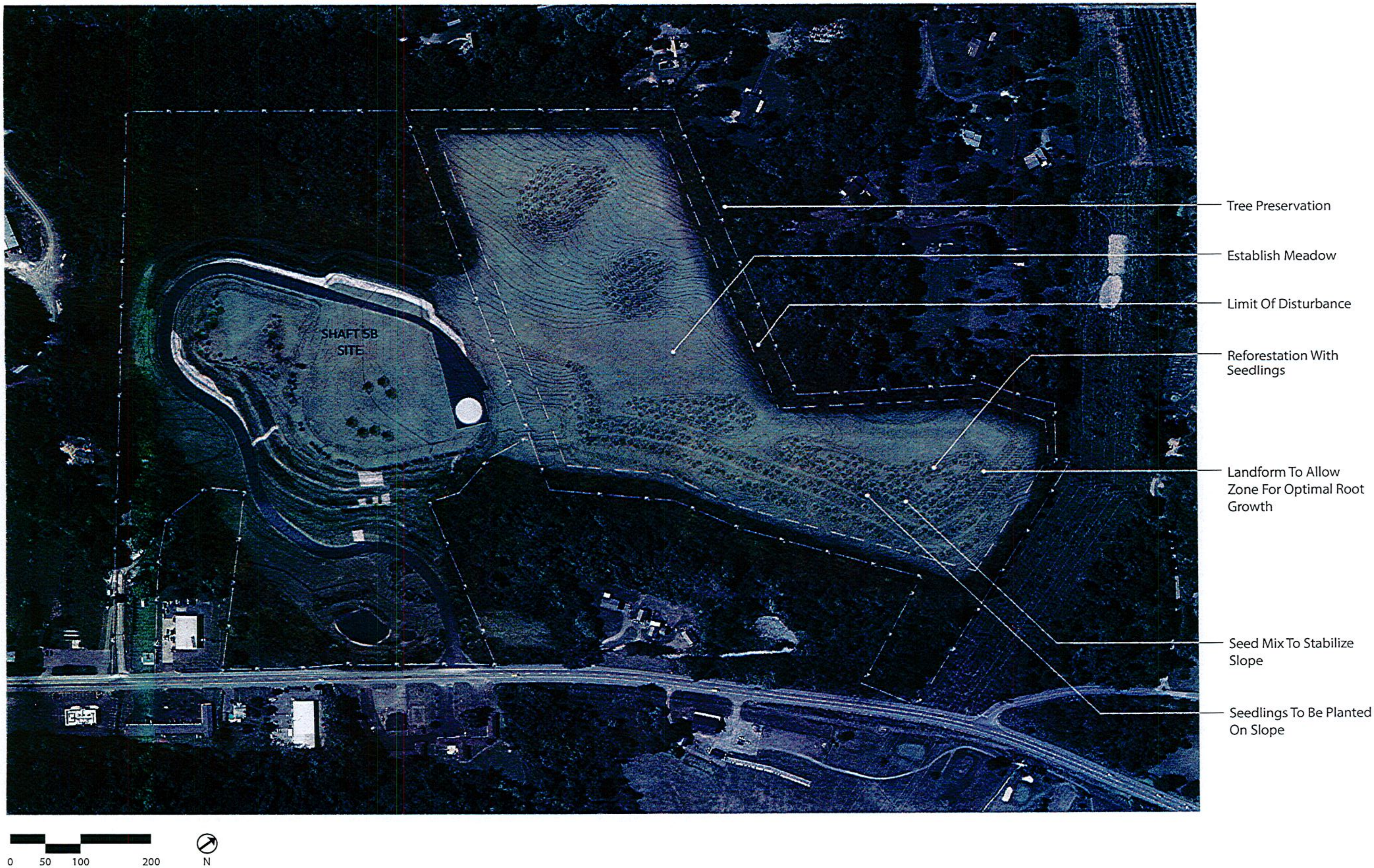
NOT TO SCALE

NYC Environmental Protection | Stantec

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

WEST CONNECTION SUPPORT SITE / BELL PROPERTY
GRAPHIC SITE SECTIONS - AS NOTED

Figure 17



NYC Environmental Protection | Stantec

ROUNDOUT - WEST BRANCH TUNNEL - WEST CONNECTION
FEBRUARY 2015

PLAN RENDERING - POST CONSTRUCTION
1″ = 50′

Figure 18

NYC Water for the Future
Environmental Protection

Rondout-West Branch Bypass Tunnel
Construction and Wawarsing Repairs Project

West Connection Support Site: Slope Stability Analyses

January 28, 2015

Prepared by:

JA·UNDERGROUND·P.C.
dba Jacobs Associates

JA Underground: Professional Corporation
dba Jacobs Associates
183 Madison Avenue, Suite 505
New York, NY 10016

Distribution

To:	Phil Simmons New York City Department of Environmental Protection
	Ted Dowey New York City Department of Environmental Protection
From:	Dan Van Roosendaal, PE JA Underground: P.C. dba Jacobs Associates
Prepared By:	Kush Chohan, PE JA Underground: P.C. dba Jacobs Associates
	Daniel Ebin JA Underground: P.C. dba Jacobs Associates
Reviewed By:	Dan Van Roosendaal, PE JA Underground: P.C. dba Jacobs Associates

Revision Log

Revision No.	Date	Revision Description
0	May 2, 2014	Draft for DEP Review
1	January 28, 2015	Draft Revised Per BT-2 Revision

Table of Contents

List of Tables

List of Figures

List of Appendices

1 Introduction

1.1 West Connection Support Site

The West Connection Support Site, also known as the Bell Property in other documents, is a 30.8 acre site in the Town of Newburgh, NY, as shown in Figure 1. The site is situated directly to the north of the West Connection Site and Shaft 5B of the Rondout-West Branch Bypass Tunnel Project (Bypass Tunnel). Primary construction activities for the Bypass Tunnel will occur on the West Connection Site. However, additional space is needed to support construction activities not suited to the West Connection Site. It is currently proposed that the West Connection Support Site be used for water handling and treatment, additional storage and construction staging needs, and permanent placement of the excavated material from the Bypass Tunnel. The work on the West Connection Support Site will be staged to coincide with work being performed on the Bypass Tunnel and the West Connection site. (See the Shaft 5B Stormwater Pollution Prevention Plan, Addendum for Bell Property [Stantec, 2015] for details.)

1.2 Purpose

The purpose of this memorandum and analysis is to evaluate the slope stability of the Excavated Material Area (EMA) and other grading features at the West Connection Support Site for the Bypass Tunnel. The slope stability analysis is performed to verify that the idealized configuration has an adequate factor of safety against failure under the design loading conditions.

2 Slope Design Criteria

Slopes on the West Connection Support Site will consist of both cut and fill slopes. All slopes are detailed with a 2H:1V slope faces and benches typically every 20 feet vertically, resulting in an overall slope angle of 22.4° (see Figure 2). The Specifications define three different types of material to be used for fill and backfill on the project: Common Fill, Select Fill, and Topsoil. As described in this section, these three types of material will be used on the West Connection Support Site to develop storage and water treatment areas and the EMA. Before any material is placed, the area must be prepared per the Specifications to remove any unsuitable material.

Relative compaction requirements discussed below refer to the percent of the maximum dry density as determined by ASTM D1557 (latest methods). The optimum moisture content is also determined by the same specification as the maximum dry density.

2.1 Fill and Backfill Material

2.1.1 Common Fill

Per the Specifications, Common Fill can consist of soil or rock materials generated from construction activities with a maximum particle size of 6 inches. Individual particles, up to 12 inches, are allowed provided they are not nested and are completely encapsulated by material smaller than 6 inches. The material will be compacted to not less than 90 percent of the maximum dry density in 16-inch lifts. Common Fill will need to meet the gradation requirements as defined in the Specifications.

2.1.2 Select Fill

The outer shell of fill and backfill areas will have a 12-inch layer (vertically) of Select Fill covering the Common Fill. Material excavated from construction activities on site may be reused as Select Fill provided it meets the gradation requirements as defined in the Specifications. The material can be processed through mechanical means to meet these criteria. Other materials that have a tendency to flow under pressure when wet are unacceptable as Select Fill and have been excluded from use on this site by the Specifications. The material will be compacted to not less than 95 percent of the maximum dry density in 16-inch lifts.

2.1.3 Topsoil

This material will provide a final and top layer over the Select fill and will be suitable to regrow vegetation to limit erosion. This layer will be 12 inches (vertically) thick and placed and compacted in place to limit erosion and provide suitable conditions to seed and plant vegetation. An erosion control mat is proposed for all slopes exceeding 3H:1V to minimize surface erosion. Topsoil will be obtained at the site and stockpiled after the site has been cleared of vegetation and debris. If necessary, imported Topsoil may also be used provided that it meets the Topsoil requirements defined in the Specifications.

2.2 Drainage Control

The design of stormwater management and the temporary and permanent erosion and sediment control measures contribute to the slope stability. The stormwater management and drainage system and the final cover perform several functions: serve as a rainfall infiltration barrier; support acceptable aesthetics (vegetation); and provide erosion control and slope stability.

Slope stability is based on the interplay between two types of forces: driving forces and resisting forces. Driving forces promote downslope movement of material, whereas resisting forces deter movement. The slope becomes unstable when the driving forces overcome the resisting forces. The presence of water in slopes contributes to instability. Water can erode the base of slopes, removing support, which increases driving forces. Water can also increase driving forces by adding to the total mass that is subjected to the force of gravity. The weight (load) on the slope increases when water fills previously empty pore spaces and fractures. Water infiltration increases the pore pressures behind the slope, thus increasing the driving forces and decreasing the resisting forces. The following measures will be used to control drainage and infiltration into fill and backfill; Figure 2 presents a detail of the additional drainage measures for stability:

1. Grading for drainage will occur as the fill material is compacted into place. Before the final cover is placed on the fill material, the grading shall deliver efficient surface drainage to onsite stormwater drainage facilities by way of graded swales and culverts. Ponding of surface water should not be allowed on fill material. The proposed grading plan shown in Figure 1 and Figure 2 presents a series of swales and collection points to remove surficial water. Swales are located every 20 vertical feet along the slope. The swales are 15 feet wide and allow a flow depth of 1 foot. The swales are designed and will be installed to convey surface water from upper parts of the slope to culverts at the end of the swale that outlets on the east side of the site to a stormwater detention pond. The measures will be able to remove surficial water off of the slope to prevent infiltration.

2. A geomembrane liner will be installed along the entire length of the swales to prevent water infiltration. The liner will be covered with topsoil in the swales to allow installation of erosion control measures (e.g., vegetation), which will prevent the forming of gullies. Stormwater collected by the swales will be prevented from infiltrating the Common Fill. The geomembrane liner will be sloped along with the swale to allow collected water to drain to the discharge points and culverts.

3. Weep drains will be installed to drain any water that may have permeated the slope. The drains will outlet into the swales, allowing captured water to be removed from the fill areas. Weep drains will be installed at the point where the slope meets the swales at a spacing of 50 feet. The 2-inch-diameter weep drains will be installed 20 feet into the slope at a 5% upslope. Fifteen feet of the weep drain will be slotted polyvinyl chloride (PVC) wrapped in geotextile. Geotextile is used to prevent clogging of the slotted PVC by fines. The last 5 feet of the drain will be solid PVC pipe before it exits into the swale.

The stormwater management and drainage system will allow water to be efficiently removed off of the fill areas and be conveyed to stormwater collection points on the site. The additional measures will allow additional water that may not be fully captured to be removed from the fill areas. The drainage measures as designed will increase the slope stability.

2.3 Method and Application

The stability factor of safety of the typical cross section was analyzed using limit equilibrium theory along with the methods of slices. The procedure consisted of analyzing numerous surfaces to find the critical surface that resulted in the minimum factor of safety for the slope.

Static and pseudostatic slope stability analyses were performed using Spencer's method (Spencer, 1973), as implemented in the computer program SLIDE, version 6.026 (Rocscience, 2014). Spencer's method, which satisfies both vertical and horizontal force equilibrium and moment equilibrium, is considered more rigorous that other methods, such as the simplified Janbu method (Janbu, 1973) and the simplified Bishop method (Bishop, 1955).

In general, selection of a slope stability method depends on the accuracy of the analytical derivation of the method as well as the numerical implementation in a slope stability program. SLIDE offers nine separate methods to analyze slope stability. The Ordinary or Fellenius (Fellenius, 1936) and simplified Bishop methods satisfy only force equilibrium in one direction and moment equilibrium. The simplified Janbu, Corps of Engineers (#1 and #2) (USACE, 2003), and Lowe-Karafiath methods (Lowe and Karafith, 1960) satisfy only force equilibrium in two directions. Janbu's corrected method as implemented in SLIDE uses a modification factor to correct the factor of safety to indirectly account for moment equilibrium. Spencer's General Limit Equilibrium (GLE) method, and the Morgenstern-Price method (Morgenstern and Price, 1965) satisfy force equilibrium in two directions and moment equilibrium. The implementation of the GLE method in SLIDE is essentially the same as the Morgenstern-Price method. Based on the number of equilibrium equations satisfied, the Spencer and GLE/Morgenstern-Price methods are the most rigorous methods available. GLE/Morgenstern-Price methods are generally not available in many slope stability programs because of the complexity of numerical implementation; therefore, the applications of these methods in general practice are significantly fewer than those of Spencer's method. For this reason, the Spencer's method is the preferred method in standard practice for analyzing general circular slip surfaces. Therefore, Spencer's method was chosen as the standard method for performing slope stability analyses for potential circular critical surfaces.

Rotational type failure mode (i.e., circular slip surfaces) was considered to assess the slope stability factor of safety (FS) at the selected cross sections. The SLIDE program generated several potential circular slip surfaces, calculated the FS for each of these surfaces, and identified the most critical slip surface (i.e., the slip surface with the lowest FS). Wedge type (noncircular) slip surfaces were not considered applicable for slip surfaces for the excavated material and soil embankment as they generally only apply when known weak layers or interfaces are present. Regardless, an analysis was performed assuming wedge-type slip surfaces. The results indicated that the factors of safety calculated using the wedge-type slip surfaces were greater than those calculated using the circular slip surfaces.

Information used for the analyses includes:

- Geometry of the slope
- Subsurface soil stratigraphy (JA, 2014a)
- Water table, assumed to be at the surface and as controlled by the weep drains
- Properties of subsurface materials (JA, 2014a)
- External loading from material storage and seismic loads (JA, 2014b)

2.3.1 Target Factor of Safety

An FS of 1.5 is required for the long-term, static condition. This is consistent with FS values used in general engineering practice for the long-term condition (USACE, 2003). An FS of 1.1 is required for the seismic condition. This is consistent with FS values used in general engineering practice for the long-term condition (NYSDOT, 2014).

3 Slope Stability Analyses

3.1 Material Properties

Detailed information related to the selection of subsurface material properties is presented in Appendix A. Table 1 summarizes the properties (i.e., unit weights, undrained and drained shear strengths) of each material used in the stability analyses. Two cases were run for each analyzed cross section for each type of analysis: static and pseudostatic. One case assumed that there was a 300 psf surcharge applied to the top of the slope to represent storage of construction materials. The other case had no surcharge load applied. All cases assumed that the groundwater was at the surface or as controlled by the drainage in the slope face.

3.1.1 Bedrock

Bedrock at the West Connection Support Site is assumed to be the Normanskill Formation (JA, 2014a). Material properties for this material were obtained from RocLab (Rocscience, 2011) results from Technical Memorandum No. 3: Initial Support Addendum A (JA, 2014c). Appendix A presents the material properties selected for this analysis.

3.1.2 Overburden

The overburden ranges from 8.3 feet to 34.8 feet, with an average of 20.9 feet, on the western portion of the site; and 0.8 feet to 16.1 feet, with an average of 6.5 feet, on the eastern portion (from boring logs [JA, 2014a]). Laboratory testing for soil classification was conducted. Based on the laboratory testing and boring logs, the overburden material onsite is assumed to be very dense/stiff gravel, sand, silt, and clay. This material is similar to the material encountered at the West Connection Site. An undisturbed sample for strength testing was not obtained through the subsurface investigation because of the very dense nature of the subsurface. The material properties for this material were selected based on correlations with similar material as presented by Duncan et al. (1989), as shown in Appendix A.

3.1.3 Excavated Rock

Rock excavated from the Bypass Tunnel will consist of shale and limestone. The specifications call for the same level of processing and compaction of the two materials in the fill area, though there will likely be a variation in particle shape. The stability analyses assumed that the entire fill area in the West Connection Support Site was comprised of shale, which has lower strength properties than the limestone. The material properties for this compacted, freely draining, non-cohesive crushed rock were selected from the *Mining Reference Handbook* (SME, 2011).

3.1.4 Excavated Soil

The material for the soil embankment was assumed to be consistent with the overburden material encountered at the West Connection Support Site. The overburden material will be excavated, reworked, conditioned, and compacted into the proposed embankment. Appendix A presents the material properties selected for this analysis. A 300 psf surcharge was applied to the top of the slope since the embankment will be used for storage of tunnel support materials (e.g., steel pipe, concrete tunnel segments, etc.).

It should be noted that in these analyses the excess pore water pressures in the materials were assumed to have dissipated as a result of the high permeability of the overburden soil, and the excavated material and drained shear strengths control the design.

3.2 Selection of Critical Cross Sections

As shown on the proposed grading plan in Figure 1, three cross sections were selected for the stability analysis. The descriptions of the cross sections are provided below.

3.2.1 Section 1

Section 1 is located along the southern slope of the EMA and includes a section of the soil embankment that may be used to store precast concrete tunnel segments. Two different conditions were analyzed at the location of Section 1. The first of these contains the soil embankment, stormwater detention ponds, and the existing ground. This condition exists during the construction of the Bypass Tunnel. This section is identified as "Section 1 – Construction" and presented in Figure 3. The height of the soil embankment from the toe to the crest is 27 feet and set at a 2H:1V slope. The embankment slope has a 15-foot-wide bench every 20 feet of vertical rise. This section was analyzed because of the height of the soil embankment, the thickness of underlying overburden, and the length of exposed slope and existing ground that is sloping away from the embankment.

The second condition is taken after the excavated rock has been placed against the soil embankment slope and stormwater detention ponds. The section is identified as "Section 1 – Final" and presented in Figure 4. This section was chosen because the height of the soil embankment is greatest in combination with the EMA. The EMA slope from the toe to the crest is 38 feet high and is set at a 2H:1V slope. The slope has a 15-foot-wide bench every 20 feet of vertical rise.

3.2.2 Section 2

Section 2 is located on the southeast slope of the proposed EMA. The height of the slope from the toe to the crest is 85 feet and set at a 2H:1V slope. The slope has a 15-foot-wide bench every 20 feet of vertical rise. Figure 5 presents the section modeled in SLIDE. This cross section was chosen because the EMA slope is at its greatest height and the slope of the existing ground sloping is away from the EMA.

3.2.3 Section 3

Section 3 is located on the northeast slope of the proposed EMA. The height of the slope from the toe to the crest is 72 feet and set at a 2H:1V slope. The slope has a 15-foot-wide bench every 20 feet of vertical rise. Figure 6 presents the section modeled in SLIDE. This cross section was chosen because of the combination of the EMA slope height, the slope of the existing ground, and the depth of overburden material underlying the EMA in this area.

4 Results and Conclusions

4.1 Results

Slope stability analyses were performed for the cross sections shown in Figure 1. The results of the analyses are reported as the factor of safety against failure along the likely critical surface. Table 2 provides a summary of the factors of safety that were obtained from the analyses. Slide output files for Sections 1 through 3 are available in Appendix B.

The following can be concluded from the analyses:

- Based on the analysis of Section 1 – Construction, the computed static factor of safety (FS) is 2.24, which is greater than the minimum value of 1.5 recommended by the U.S. Army Corps of Engineers (USACE, 2003). The addition of a surcharge load at the top of the slope had no effect on the stability of the slope. The likely critical surface was observed to occur through the excavated soil and the overburden foundation material. The computed seismic FS is 1.88, which is greater than the recommended minimum value of 1.1.

- Based on the analysis of Section 1 – Final, the computed static FS is 2.02, which is greater than the minimum value of 1.5 recommended by the USACE. The addition of a surcharge load at the top of the slope had no effect on the stability of the slope. The likely critical surface was observed to occur through the excavated rock and the overburden foundation material. The computed seismic FS is 1.69, which is greater than the recommended minimum value of 1.1.

- Based on the analysis of Section 2, the computed static FS is 1.64, which is greater than the minimum value of 1.5 recommended by the USACE. The likely critical surface was observed to occur through the excavated rock fill and not through the foundational material. The program did find a very shallow potential critical surface (less than a 6-inch depth of critical surface), which was at an FS of 1.63. This critical surface was filtered out because of the very shallow failure the surface. The addition of a surcharge load at the top of the slope had no effect on the stability of the slope. The presence of a thick overburden material below the EMA had little effect on the stability of the slope. The computed seismic FS is 1.45, which is greater than the recommended minimum value of 1.1.

- Based on the analysis of Section 3, the computed static FS is 1.51, which is greater than the minimum value of 1.5 recommended by the USACE. The likely critical surface was observed to occur through the excavated rock fill and not through the foundational material. The program did find a very shallow potential critical surface (less than a 6-inch depth of critical surface), which was at an FS of 1.42. This critical surface was filtered out because of the very shallow critical surface. The addition of a surcharge load at the top of the slope had no effect on the stability of the slope. The presence of a thick overburden material below the EMA had little effect on the stability of the slope. The computed seismic FS is 1.26, which is greater than the recommended minimum value of 1.1.

4.2 Conclusions

The three sections were analyzed to determine the factor of safety for the assumed loading conditions. The analyses showed that with the assumed loadings, groundwater at the surface or as controlled by the slope drainage, and either static or pseudostatic conditions, the slopes have the recommended factor of safety per USACE (2013) and NYSDOT (2014). The analyses did show certain sections where the factor of safety was below the recommended level. However, these failures were generally 6 inches or less in depth and only in the EMA. Additionally, the Select Fill and Topsoil were not considered in these analyses. Therefore, these results were filtered out.

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Tables

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Table 1. Summary of Material Properties for Slope Stability Analyses

Material	γ_d	γ_{sat}	Drained Shear Strength		Reference
	pcf	pcf	φ' (deg)	c' (psf)	
Excavated Soil	130	145	35	200	Duncan et al., 1989
Excavated Rock	135	135	40	0	SME Mining Reference Handbook
Overburden	130	145	35	200	Duncan et al., 1989
Bedrock	175	175	44	41,904	JA RocLab Results

Table 2. Summary of Slope Stability Analysis Results

Section	Results			
	Static		Seismic	
	No Surcharge	Surcharge	No Surcharge	Surcharge
Section 1 - Final	2.02	2.01	1.69	1.69
Section 1 - Construction	2.24	2.24	1.88	1.88
Section 2	1.64	1.64	1.44	1.45
Section 3	1.51	-	1.26	-

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Figures

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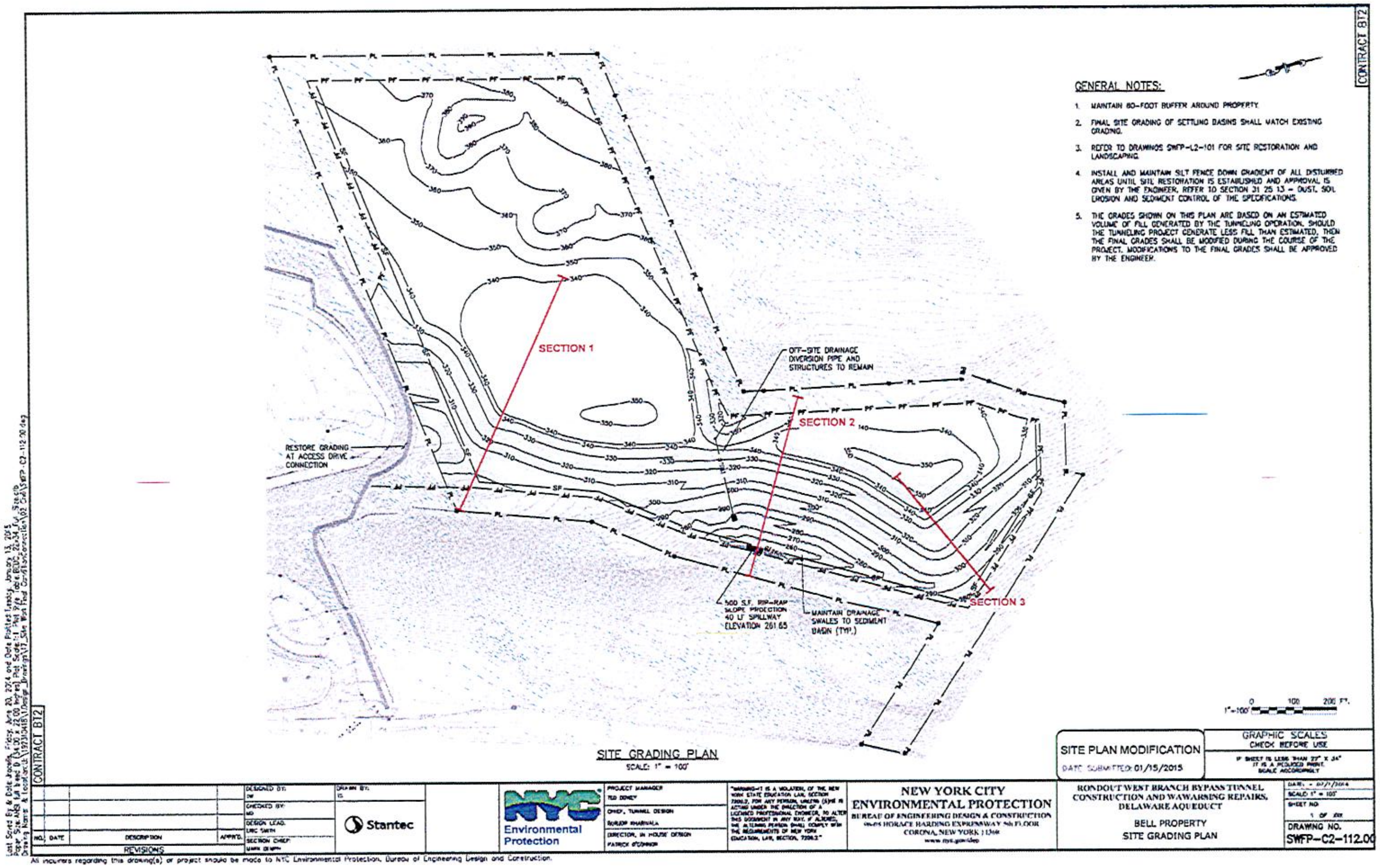

Figure 1. West Connection Support Site with Section Lines

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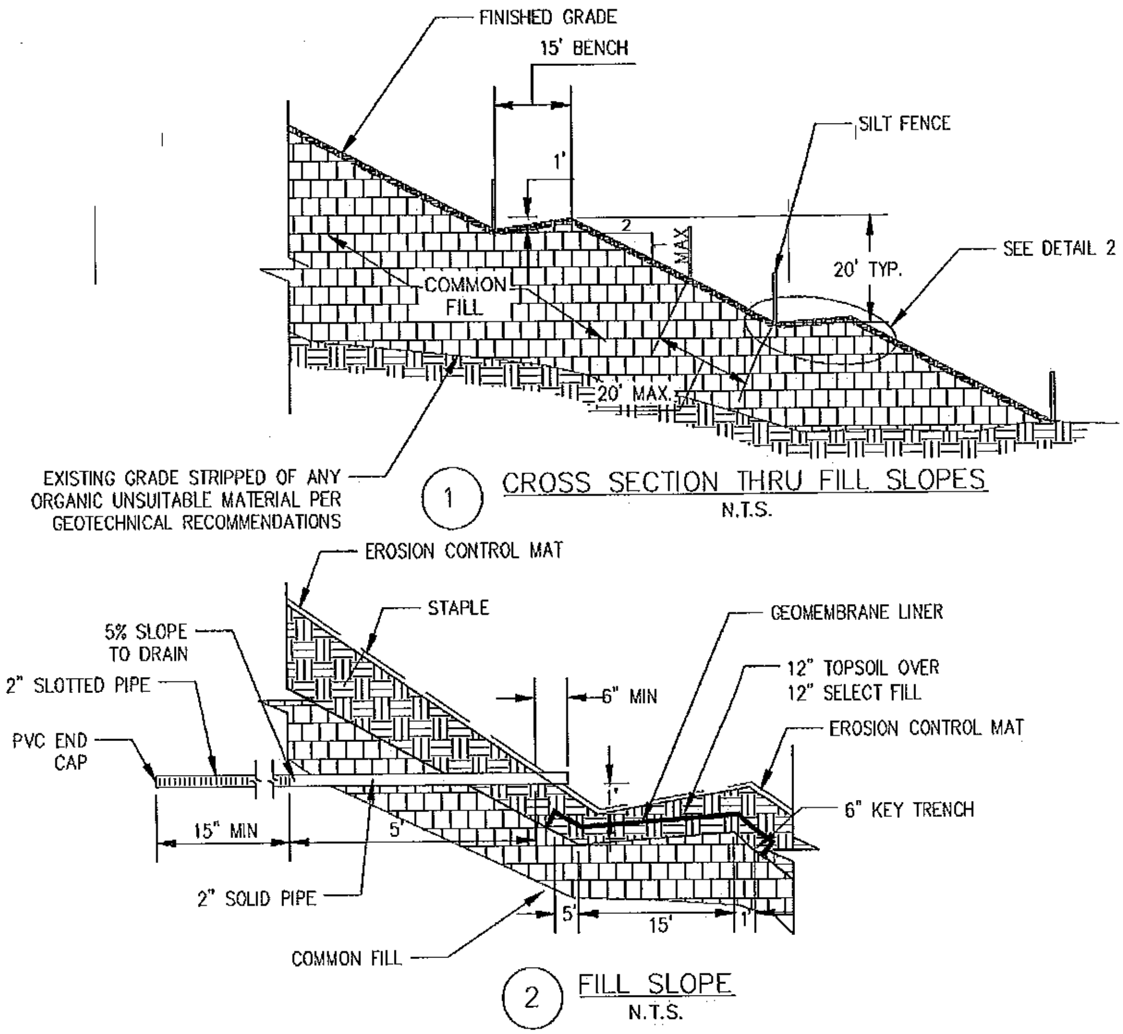

Figure 2. Cross Section and Drainage Details for Fill Slopes

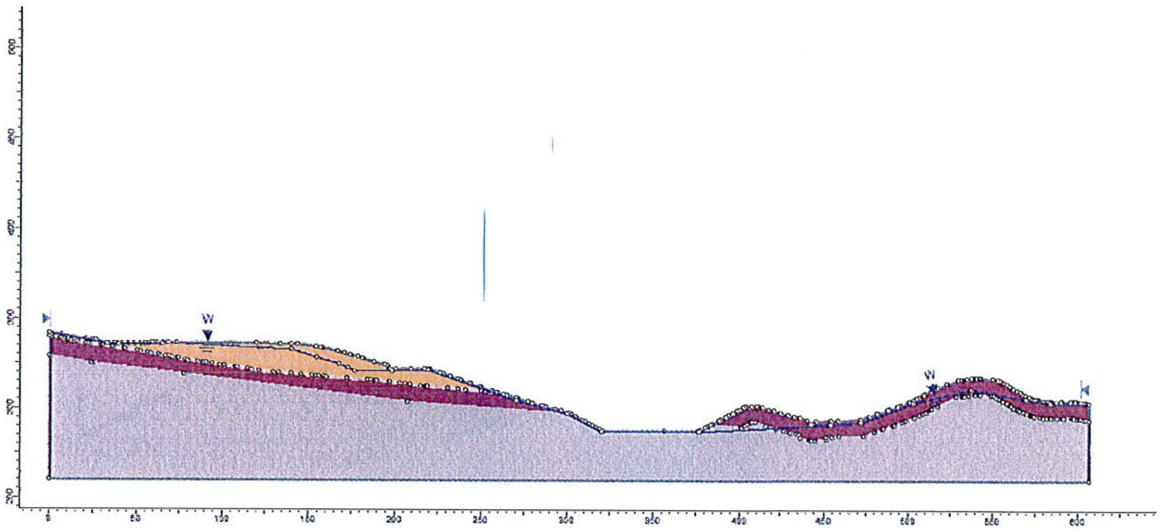

Figure 3. Section 1 – Construction

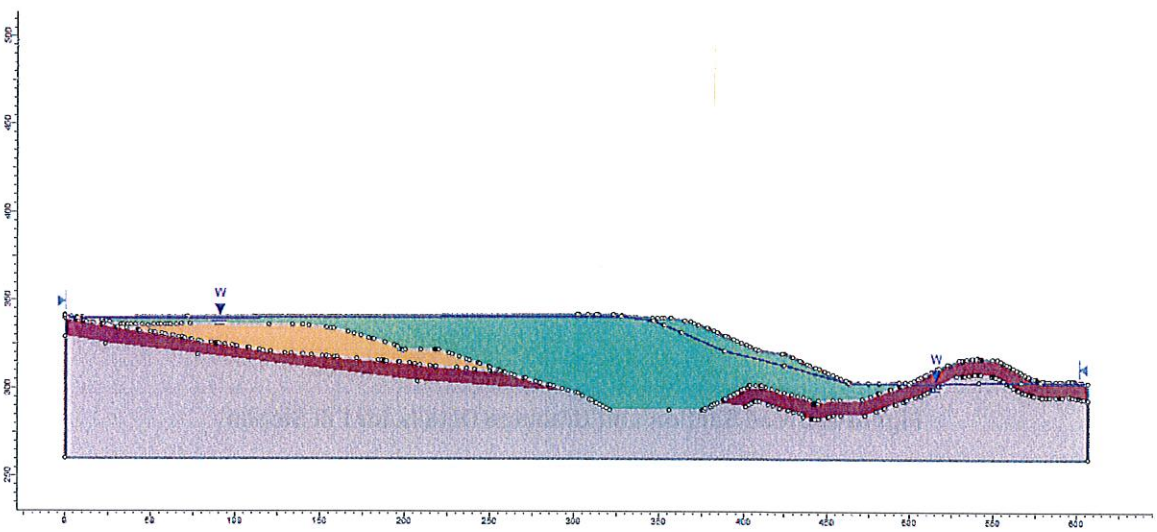

Figure 4. Section 1 – Final

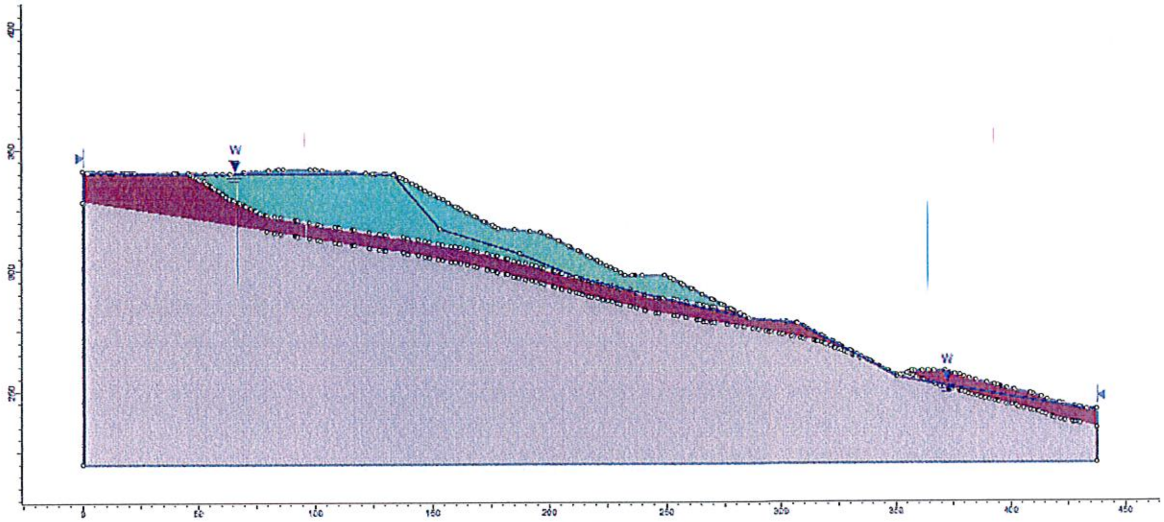

Figure 5. Section 2

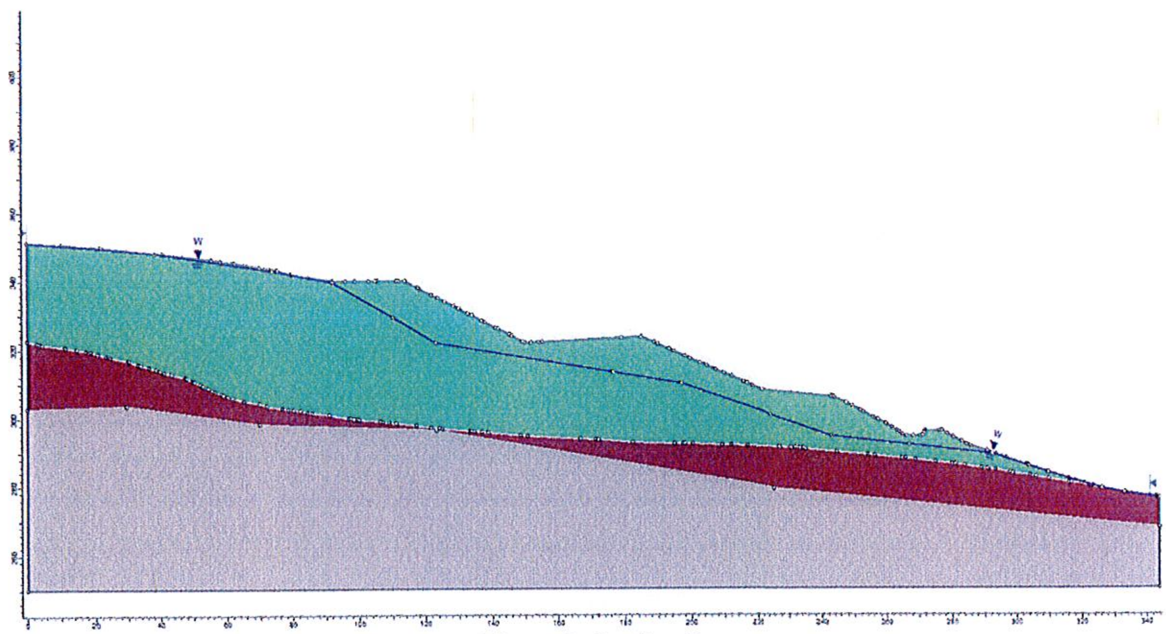

Figure 6. Section 3

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Appendix A – Selection of Material Properties

3.4 Various Unit-Weight Relationships

In Sections 3.2 and 3.3, we derived the fundamental relationships for the moist unit weight, dry unit weight, and saturated unit weight of soil. Several other forms of relationships that can be obtained for γ, γ_d, and γ_{sat} are given in Table 3.1. Some typical values of void ratio, moisture content in a saturated condition, and dry unit weight for soils in a natural state are given in Table 3.2.

Table 3.1 Various Forms of Relationships for γ, γ_d, and γ_{sat}

Moist unit weight (γ)		Dry unit weight (γ_d)		Saturated unit weight (γ_{sat})	
Given	**Relationship**	**Given**	**Relationship**	**Given**	**Relationship**
w, G_s, e	$\dfrac{(1+w)G_s\gamma_w}{1+e}$	γ, w	$\dfrac{\gamma}{1+w}$	G_s, e	$\dfrac{(G_s+e)\gamma_w}{1+e}$
S, G_s, e	$\dfrac{(G_s+Se)\gamma_w}{1+e}$	G_s, e	$\dfrac{G_s\gamma_w}{1+e}$	G_s, n	$[(1-n)G_s+n]\gamma_w$
w, G_s, S	$\dfrac{(1+w)G_s\gamma_w}{1+\dfrac{wG_s}{S}}$	G_s, n	$G_s\gamma_w(1-n)$	G_s, w_{sat}	$\left(\dfrac{1+w_{sat}}{1+w_{sat}G_s}\right)G_s\gamma_w$
w, G_s, n	$G_s\gamma_w(1-n)(1+w)$	G_s, w, S	$\dfrac{G_s\gamma_w}{1+\left(\dfrac{wG_s}{S}\right)}$	e, w_{sat}	$\left(\dfrac{e}{w_{sat}}\right)\left(\dfrac{1+w_{sat}}{1+e}\right)\gamma_w$
S, G_s, n	$G_s\gamma_w(1-n)+nS\gamma_w$	e, w, S	$\dfrac{eS\gamma_w}{(1+e)w}$	n, w_{sat}	$n\left(\dfrac{1+w_{sat}}{w_{sat}}\right)\gamma_w$
		γ_{sat}, e	$\gamma_{sat}-\dfrac{e\gamma_w}{1+e}$	γ_d, e	$\gamma_d+\left(\dfrac{e}{1+e}\right)\gamma_w$
		γ_{sat}, n	$\gamma_{sat}-n\gamma_w$	γ_d, n	$\gamma_d+n\gamma_w$
		γ_{sat}, G_s	$\dfrac{(\gamma_{sat}-\gamma_w)G_s}{(G_s-1)}$	γ_d, S	$\left(1-\dfrac{1}{G_s}\right)\gamma_d+\gamma_w$
				γ_d, w_{sat}	$\gamma_d(1+w_{sat})$

Table 3.2 Void Ratio, Moisture Content, and Dry Unit Weight for Some Typical Soils in a Natural State

Type of soil	Void ratio, e	Natural moisture content in a saturated state (%)	Dry unit weight, γ_d lb/ft³	Dry unit weight, γ_d kN/m³
Loose uniform sand	0.8	30	92	14.5
Dense uniform sand	0.45	16	115	18
Loose angular-grained silty sand	0.65	25	102	16
Dense angular-grained silty sand	0.4	15	121	19
Stiff clay	0.6	21	108	17
Soft clay	0.9–1.4	30–50	73–93	11.5–14.5
Loess	0.9	25	86	13.5
Soft organic clay	2.5–3.2	90–120	38–51	6–8
Glacial till	0.3	10	134	21

Table 1. Strength Parameters for Soils of Various Types and Degrees of Compaction

Unified Classification	RC Stand. AHTO	γ_m Kips/ft^3	ϕ_o deg	$\Delta\phi$ deg	C Kips/ft^2
GW, GP SW, SP	105	0.150	42	9	0
	100	0.145	39	7	0
	95	0.140	36	5	0
	90	0.135	33	3	0
SM	100	0.135	36	8	0
	95	0.130	34	6	0
	90	0.125	32	4	0
	85	0.120	30	2	0
SM-SC	100	0.135	33	0	0.5
	95	0.130	33	0	0.4
	90	0.125	33	0	0.3
	85	0.120	33	0	0.2
CL	100	0.135	30	0	0.4
	95	0.130	30	0	0.3
	90	0.125	30	0	0.2
	85	0.120	30	0	0.1

Values in this table are conservative in the sense that they are typical of the lower values of strength and the higher values of unit weight for each type of soil (after Duncan, et al., 1980).

TABLE 2, PART B. CLASSIFICATION AND STRENGTH PARAMETERS FOR SOILS TESTED UNDER DRAINED CONDITIONS

Soil	Group	Soil Description	References	Grain Size, mm D60	Grain Size, mm D30	Grain Size, mm D10	LL	PP	Compaction Type	Compaction Max Dry Unit Wt. (PCF)	Compaction Opt. w/c	Compaction Dry U. Wt. (PCF)	Compaction w/c	Init. Void Ratio
GW	GW-1	Conglomerate Rockfill (Netzahu Dam)	Marsal et al. (38)	47.	7.5	0.9						118.9		0.39
GW	GW-2	Granitic Gneiss Rockfill (Mica Dam)	Casagrande (10)/Marsal (39)	79.	24.	4.						123.7		0.32
GW	GW-3	Quartzite Rockfill (Fumas Dam Shell)	Casagrande (10)	10.	-	-								
GW	GW-4	Quartzite Rockfill (Fumas Dam Transit.)	Casagrande (10)	25.										
GW	GW-5	Fumas Dam Transition	Casagrande (10)	10.										
GW	GW-6	Pinzandapan Gravel	Marsal et al. (38)	21.	2.7	0.25						132.1		0.34
GW	GW-7	Diorite Rockfill (El Infiernillo Dam)	Marsal et al. (38)	93.	42.	17.						105.7		0.56
GP	GP-2	Sandy Gravel (Mica Dam Shell)	Casagrande (10)	22.	1.2	0.23								
GP	GP-3	Basalt Rockfill	Casagrande (10)/Marsal (39)	19.	3.6	1.						133.8		0.3
GP	GP-6	Silty Sandy Gravel (Oroville Dam)	Hall & Gordon (25)	18.	4.8	0.4	21	3				148.0		0.21
GP	GP-7	Amphibolite Gravel (Oroville Dam Shell)	Marachi (37)	13.2	4.6	0.36						152.0		0.2
GP	GP-11	Crushed Basaltic Rock (Round Butte Dam)	Shannon & Wilson (41)	15.	12.	6.				91.6		99.0	3.2	
GP	GP-13	Sandy Gravel (Rowallan Dam)	Boughton (5)	10.	3.	0.6						135.0		0.233
GC	GC-1	Clayey Gravel (New Hogan Dam Core)	Bird (3)	12.	0.6	-	51	30		113.0	10.8	107.0	10.8	
SW	SW-1	Argillite Rockfill (Pyramid Dam Shell)	Marachi (37)	4.1	1.8	0.6						111.6		0.46
SW	SW-2	Crushed Olivine Basalt	Marachi (37)	4.1	1.8	0.6						125.4		0.43
SW	SW-3	Silty Sand, Some Gravel (Round Butte Dam)	Shannon & Wilson (41)	1.7	0.09	0.009	NP	NP	16,450	120.0	13.2	108.7	13.5	
SW	SW-5	Venato Sandstone (0.5 in. max. size)	Becker, Chan & Seed (2)	0.17	0.07	0.025	NP	NP		118.3		117.5		0.47
SP	SP-3	Glacial Outwash Sand	Hirschfeld & Poulos (26)	0.03	0.4	0.14						112.3		0.5
SP	SP-4A	Sacramento River Sand	Lee (34)	0.22	0.17	0.15						89.5		0.87
SP	SP-4B	Sacramento River Sand	Lee (34)	0.22	0.17	0.15						94.0		0.78
SP	SP-4C	Sacramento River Sand	Lee (34)	0.22	0.17	0.15						97.8		0.71
SP	SP-4D	Sacramento River Sand	Lee (34)	0.22	0.17	0.15						103.9		0.61
SP	SP-5A	Ham River Sand	Bishop (4)	0.25	0.17	0.15								0.82
SP	SP-5B	Ham River Sand	Bishop (4)	0.25	0.17	0.15								0.64
SP	SP-7A	Poorly Graded Sand (Port Allen Lock)	Sherman & Trahan (44)	0.2	0.17	0.12	NP	NP		100.0	13.0	95.5		0.73
SP	SP-7B	Poorly Graded Sand (Port Allen Lock)	Sherman & Trahan (44)	0.2	0.17	0.12	NP	NP		100.0	13.0	100.0		0.65
SP	SP-7C	Poorly Graded Sand (Port Allen Lock)	Sherman & Trahan (44)	0.2	0.17	0.12	NP	NP		100.0	13.0	105.1		0.57
SP	SP-12	Coarse to Fine Sand (Round Butte Dam)	Shannon & Wilson (41)		minus No. 4 sieve		NP	NP				74.8		1.22
SP	SP-13	Pumiceous Sand (Round Butte Dam)	Shannon & Wilson (41)	0.85	0.41	0.24				87.4		84.2	18.0	
SP	SP-14	Pumiceous Sand (Round Butte Dam)	Shannon & Wilson (43)	1.0	0.5	0.24				80.7		76.9	25.0	
SP	SP-16A	Fine Silica Sand (Loose)	Duncan & Chang (22)	0.27	0.2	0.165								0.65
SP	SP-16B	Fine Silica Sand (Dense)	Duncan & Chang (22)	0.27	0.2	0.165								0.54
SP	SP-17A	Monterey No. 0 Sand (Cylind. specimen)	Lade (33)	0.43	0.37	0.29	NP	NP						0.78
SP	SP-17B	Monterey No. 0 Sand (Cubical specimen)	Lade (33)	0.43	0.37	0.29	NP	NP						0.78
SP	SP-17C	Monterey No. 0 Sand (Cylind. specimen)	Lade (33)	0.43	0.37	0.29	NP	NP						0.57
SP	SP-17D	Monterey No. 0 Sand (Cubical specimen)	Lade (33)	0.43	0.37	0.29	NP	NP						0.57
SP	SP-18	Basaltic Sand (Round Butte Dam)	Shannon & Wilson (42)	3.	9.	0.13				120.1	9.5	120.0	9.5	
SM	SM-4	Silty Sand (Chatfield Dam)	COE, Omaha District (19)	0.62	0.16	0.026	20	0	Std AASHO	123.0	9.5	116.7	9.4	
SM	SM-5	Silty Gravelly Sand (Chatfield Dam)	COE, Omaha District (19)	1.15	0.28	0.05	NP	NP	Std AASHO	132.0	8.1	124.5	7.53	
SM	SM-6	Silty Sand w/Pebbles (Round Butte Dam)	Shannon & Wilson (41)	0.31	0.1	0.04	NP	NP	16,450	110.6	17.5	108.1	17.5	
SM	SM-9	Silty Sand w/Pumice (Round Butte Dam)	Shannon & Wilson (41)	0.15	0.054	0.013	NP	NP	16,450	91.7	19.5	88.4	19.0	
SM	SM-13	Silty Sand (Round Butte Dam)	Shannon & Wilson (43)	0.27	0.027	0.0022				105.6	16.4	104.5	15.	
SM	SM-16	Silty Sand & Gravel (Round Butte Dam)	Shannon & Wilson (42)	0.45	0.052	0.012				109.3	12.9	109.	12.	
SM-SC	SM-SC-1A	Silty Clayey Sand (Mica Dam Core)	Casagrande (10)/Insley & Hillis (27)	0.34	0.03	0.002	21	4	Std AASHO	136.0	9.8	131.1	7.7	
SM-SC	SM-SC-1B	Silty Clayey Sand (Mica Dam Core)	Casagrande (10)/Insley & Hillis (27)	0.34	0.03	0.002	21	4	Std AASHO	138.0	9.8	134.0	9.7	
SM-SC	SM-SC-1C	Silty Clayey Sand (Mica Dam Core)	Casagrande (10)/Insley & Hillis (27)	0.34	0.03	0.0002	21	4	Std AASHO	136.0	9.8	128.2	11.9	
ML	ML-1	Cannonsville Silt (Undisturbed)	Hirschfeld & Poulos (26)	0.033	0.018	0.005						108.0		0.57
ML	ML-4	Sandy Silt w/Pumice (Round Butte Dam)	Shannon & Wilson (41)	0.078	0.032	0.0064	NP	NP	16,450	97.0	19.0	92.8	17.7	
ML	ML-5	Sandy Silt w/Pumice (Round Butte Dam)	Shannon & Wilson (41)	0.1	0.025	0.0052	NP	NP	16,450	102.5	16.5	99.2	17.0	
CL	CL-29C	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (8)	0.037	0.008	-	34	19	Harvard	116.2	15.2	111.2	13.1	
CL	CL-29D	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (8)	0.037	0.008	-	34	19	Harvard	116.2	15.2	116.2	13.3	
CL	CL-30E	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (8)	0.037	0.008	-	34	19	Harvard	112.8	16.7	115.1	15.2	
CL	CL-30F	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (8)	0.037	0.008	-	34	19	Harvard	112.8	16.7	110.0	17.4	
CL	CL-34E	Silty Clay (Canyon Dam)	Casagrande & Hirschfeld (7)	0.037	0.008	-	34	19	Harvard	105.6	19.8	106.3	19.0	

Table 4. Relationship Among Relative Density, Penetration Resistance, Dry Unit Weight and Angle of Internal Friction of Cohesionless Soils

Descriptive Relataive Density	Relative Density **	Standard Penetration Resistance N *	Static Cone Resistance q_c	Angle of Internal Friction ϕ	Dry Unit Weight
	%	blows/ft	tsf or kgf/cm^2	degrees	KN/m^3
Very Loose	< 15	< 4	< 50	< 30	< 14
Loose	15 - 35	4 - 10	50 - 100	30 - 32	14 - 16
Medium Dense	35 - 65	10 - 30	100 - 150	32 - 35	16 - 18
Dense	65 - 85	30 - 50	150 - 200	35 - 38	18 - 20 114 - 127
Very Dense	85 - 100	> 50	> 200	> 38	> 20 > 127

* At an effective vertical overburden pressure of 100 kPa

** Freshly deposited, normally consolidated sand

After Mitchell and Katti (1981).

Table 1. Design Rock Mass Parameters from RocLab

				RocLab Input							RocLab Output					
Rock Mass Type	Reaches	Description of Rock Mass Type	Terzaghi Class	Unconfined Compressive Strength, UCS (ksi)	Modulus (Intact), E_i, (ksi)	Material Constant (Intact), m_i	Geologic Strength Index, GSI	Disturbance Factor, D	Unit Weight, γ (pcf)	Poisson's Ratio, v_m	Cohesion, c (psi)	Friction Angle, ϕ (°)	Tensile Strength, σ_t (psi)	Uniaxial Compressive Strength, σ_c (psi)	Global Strength, σ_{cm} (psi)	Deformation Modulus, E_{rm} (ksi)
N1	R1, R3	Slate-shale; slightly weathered; blocky/foliated	T2	9.8	11,300	7	65	0	175	0.28	291	44	-100	1,391	2,096	7,140
N2	R2	Slate-shale; fault zone; blocky/disturbed/seamy & disintegrated	T5, T6	9.8	11,300	7	35	0	170	0.3	119	36	-10	236	1,018	1,280
W1	R4a, R7	Dolomite/limestone; blocky to massive; slightly weathered to unweathered	T2	30.9	13,000	9	75	0	175	0.25	1,177	54	-521	7,686	9,700	10,600
W5	R4b	Dolomite/limestone; blocky; slightly weathered; wide to very wide joint spacing	T2, T3	13.3	10,000	9	60	0	175	0.25	270	49	-72	1,423	2,774	5,200
W3	R5	"Faulted and weathered zone" – dolomite/limestone; highly to completely and slightly to moderately weathered; blocky/disturbed/seamy & disintegrated; very close to moderate joint spacing	T5, T6	0.75	1,600	9	35 (20–45)	0	145	0.25	37	22	-1	18	88	181
W2	R5, R6	"Weathered zone" – dolomite/limestone; slightly weathered to unweathered; blocky and very blocky; moderate to wide joint spacing	T4	5.7	7,300	9	50	0	170	0.25	124	40	-15	343	945	2,240
W4	R6	Dolomite/limestone; unweathered; massive to blocky; moderate to wide joint spacing	T3, T4	4	3,000	9	60	0	165	0.27	131	41	-22	428	834	1,560
M1	R8	Slate-shale; slightly weathered; blocky/foliated	T2	7.3	8,400	7	65	0	171	0.22	221	43	-75	1,036	1,562	5,310

Table 11. Average Effective Stress Shear Strengths for Compacted Soils

Unified Classification	Soil Type	Proctor Compaction[1]: Maximum Dry Unit Weight, pcf	Proctor Compaction[1]: Maximum Dry Unit Weight, kN/m³	Proctor Compaction[1]: Optimum Water Content %	Void Ratio e_o	Cohesion[2] C' kgf/cm²	Friction Angle ø' deg
GW	well graded clean gravels, gravel-sand mixtures	> 119	> 19.4	< 13.3	*	*	> 30
GP	poorly graded clean gravels, gravel-sand mixtures	> 110	> 18.0	< 12.4	*	*	> 37
GM	silty gravels, poorly graded gravel-sand-silt	> 114	> 18.6	< 14.5	*	*	> 34
GC	clayey gravels, gravel-sand-clay mixtures	> 115	> 18.8	< 14.7	*	*	> 31
SW	well graded clean sand, gravelly sand	119 ± 2	19.4 ± 0.3	13.3 ± 2.5	0.37 ± *	*	30 ± 1
SP	poorly graded clean sand, sand-gravel mixtures	110 ± 1	18.0 ± 0.2	12.4 ± 1.0	0.50 ± 0.03	*	37 ± 1
SM	silty sands, sand-silt mixtures	114 ± 1	18.6 ± 0.2	14.5 ± 0.4	0.48 ± 0.02	0.21 ± 0.07	34 ± 1
SC-SM	sand-silt-clay with slightly plastic fines	119 ± 1	19.4 ± 0.2	12.8 ± 0.5	0.41 ± 0.02	0.15 ± 0.06	33 ± 3
SC	clayey sands, poorly graded sand-clay mixtures	115 ± 1	18.8 ± 0.2	14.7 ± 0.4	0.48 ± 0.01	0.12 ± 0.06	31 ± 3
ML	inorganic silts and clayey silts	103 ± 2	16.8 ± 0.3	19.2 ± 0.7	0.63 ± 0.02	0.09 ± *	32 ± 2
CL-ML	mixtures of inorganic silts and clays	109 ± 1	17.8 ± 0.2	16.8 ± 0.7	0.54 ± 0.03	0.23 ± *	32 ± 2
CL	inorganic clays of low to medium plasticity	108 ± 1	17.6 ± 0.2	17.3 ± 3.0	0.56 ± 0.01	0.14 ± 0.02	28 ± 2
OL	organic silts and silty clays of low plasticity	*	*	*	*	*	*
MH	inorganic clayey silts, elastic silts	82 ± 4	13.4 ± 0.7	36.3 ± 3.2	1.15 ± 0.12	0.21 ± 0.09	25 ± 3
CH	inorganic clays of high plasticity	94 ± 2	15.3 ± 0.3	25.5 ± 1.2	0.80 ± 0.04	0.12 ± 0.06	19 ± 5
OH	organic clays and silty clays	*	*	*	*	*	*

* denotes insufficient data, > is greater than, < is less than
Maximum liquid limit for the MH soil : 81%
Maximum liquid limit for the CH soil : 88%

[1] USBR standard compaction. Energy per unit volume equivalent to AASHTO standard compaction.

[2] From specimens compacted to maximum dry unit weight and optimum water content. Specimens saturated before shear.

Table 1. Strength Parameters for Soils of Various Types and Degrees of Compaction

Unified Classi-fication	RC Stand. AHTO	γ_m Kips/ft^3	ϕ_o deg	$\Delta\phi$ deg	c Kips/ft^2
GW, GP SW, SP	105	0.150	42	9	0
	100	0.145	39	7	0
	95	0.140	36	5	0
	90	0.135	33	3	0
SM	100	0.135	36	8	0
	95	0.130	34	6	0
	90	0.125	32	4	0
	85	0.120	30	2	0
SM-SC	100	0.135	33	0	0.5
	95	0.130	33	0	0.4
	90	0.125	33	0	0.3
	85	0.120	33	0	0.2
CL	100	0.135	30	0	0.4
	95	0.130	30	0	0.3
	90	0.125	30	0	0.2
	85	0.120	30	0	0.1

Values in this table are conservative in the sense that they are typical of the lower values of strength and the higher values of unit weight for each type of soil (after Duncan, et al., 1980).

TABLE 2. PART B. CLASSIFICATION AND STRENGTH PARAMETERS FOR SOILS TESTED UNDER DRAINED CONDITIONS (CONTINUED)

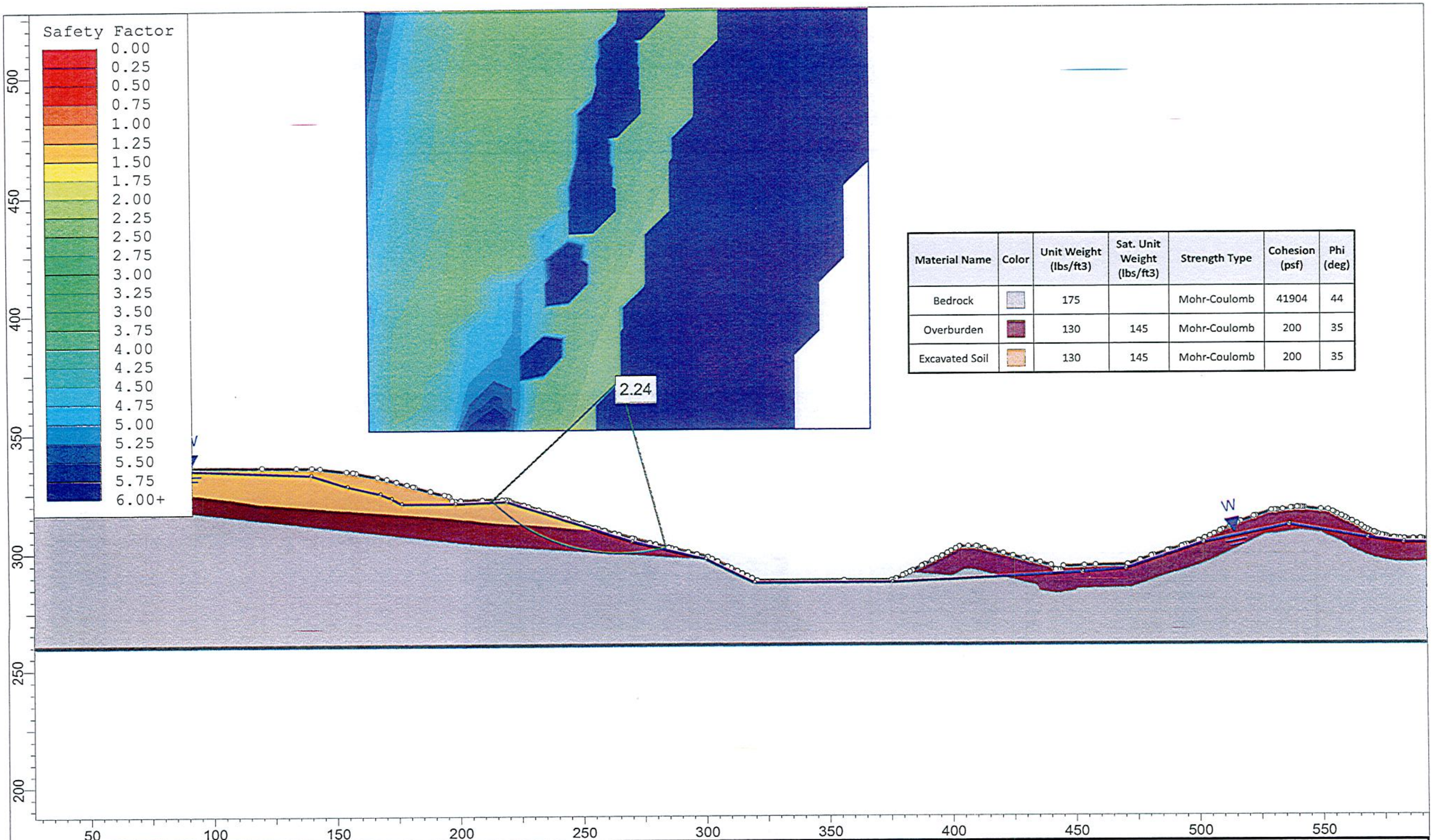
Soil	Group	Soil Description	Init. Void Ratio	Relative Density	Degree Saturation	Rating	Particle Shape	Stress Range (TSF)	Number of Tests	C (TSF)	Friction Angle
GW	GW-1	Conglomerate Rockfill (Netzahu Dam)	0.39	70		••	Sub-angular	1.9 - 25.5	3	0.	50 (10)
GW	GW-2	Granitic Gneiss Rockfill (Mica Dam)	0.32	95		••	Sub-angular	5.1 - 25.6	3	0.	44 (9)
GW	GW-3	Quartzite Rockfill (Fumas Dam Shell)				•••	Sub-rounded	4.1 - 36.9	4	0.	49 (6)
GW	GW-4	Quartzite Rockfill (Fumas Dam Transit.)				•••	Sub-rounded	4.1 - 36.9	4	0.	53 (7)
GW	GW-5	Fumas Dam Transition				•••	Sub-rounded	4.1 - 36.9	4	0.	50 (7)
GW	GW-6	Pinzandapan Gravel	0.34	65		••	Sub-rounded	0.4 - 26.5	6	0.	51 (9)
GW	GW-7	Diorite Rockfill (El Infiernillo Dam)	0.56	50		••	Angular	0.4 - 17.0	7	0.	48 (9)
GP	GP-2	Sandy Gravel (Mica Dam Shell)		50		••	Sub-angular	7.2 - 32.5	3	0.	41 (3)
GP	GP-3	Basalt Rockfill	0.30	95		•••	Angular	5.1 - 25.6	3	0.	52 (10)
GP	GP-6	Silty Sandy Gravel (Oroville Dam)	0.21	100		•••	Rounded	9.0 - 46.8	4	0.	53 (8)
GP	GP-7	Amphibolite Gravel (Oroville Dam Shell)	0.20	100		••	Rounded	2.2 - 28.6	4	0.	51 (6)
GP	GP-11	Crushed Basaltic Rock (Round Butte Dam)		90.0		••	Angular	2.0 - 14.1	3	0.	51 (14)
GP	GP-13	Sandy Gravel (Rowallan Dam)	0.233	100		••	Rounded	1.8 - 10.8	4	0.	58 (10)
GC	GC-1	Clayey Gravel (New Hogan Dam Core)			51	••		1.1 - 4.3	3	0.28	19
SW	SW-1	Argillite Rockfill (Pyramid Dam Shell)	0.46	100		•	Angular	2.2 - 46.8	4	0.	53 (9)
SW	SW-2	Crushed Olivine Basalt	0.43	100		•	Angular	2.2 - 46.8	4	0.	55 (10)
SW	SW-3	Silty Sand, Some Gravel (Round Butte Dam)				•	Sub-rounded	2.0 - 14.0	3	0.	38 (3)
SW	SW-5	Venato Sandstone (0.5 in. max. size)	0.47	93		•	Angular	2.2 - 28.6	4	0.	43 (4)
SP	SP-3	Glacial Outwash Sand	0.50	80		•••	Sub-rounded	1.0 - 41.1	6	0.	44 (4)
SP	SP-4A	Sacramento River Sand	0.87	38		•	Rounded	1.0 - 41.1	8	0.	35 (2)
SP	SP-4B	Sacramento River Sand	0.78	60		•	Rounded	1.0 - 13.0	4	0.	37 (2)
SP	SP-4C	Sacramento River Sand	0.71	78		•	Rounded	1.0 - 41.1	8	0.	41 (5)
SP	SP-4D	Sacramento River Sand	0.61	100		•	Rounded	3.0 - 41.1	6	0.	45 (7)
SP	SP-5A	Ham River Sand	0.82	Loose		••	Rounded	7.2 - 287.9	4	0.	31 (2)
SP	SP-5B	Ham River Sand	0.64	Dense		••	Rounded	7.2 - 71.3	3	0.	47 (9)
SP	SP-7A	Poorly Graded Sand (Port Allen Lock)	0.73	49		••	Rounded	0.9 - 3.9	3	0.	39 (0)
SP	SP-7B	Poorly Graded Sand (Port Allen Lock)	0.65	73		••	Rounded	0.9 - 3.9	3	0.	40 (1)
SP	SP-7C	Poorly Graded Sand (Port Allen Lock)	0.57	98		••	Rounded	0.9 - 3.9	3	0.	44 (3)
SP	SP-12	Coarse to Fine Sand (Round Butte Dam)	1.22	70		••	Angular	2.0 - 14.0	3	0.	39 (6)
SP	SP-13	Pumiceous Sand (Round Butte Dam)		77		•	Angular	2.0 - 14.1	3	0.	48 (10)
SP	SP-14	Pumiceous Sand (Round Butte Dam)		71		•	Angular	2.0 - 14.1	3	0.	49 (12)
SP	SP-16A	Fine Silica Sand (Loose)	0.65	38		•••	Rounded	1.0 - 5.1	3	0.	30 (0)
SP	SP-16B	Fine Silica Sand (Dense)	0.54	100		•••	Rounded	1.0 - 5.1	3	0.	37 (0)
SP	SP-17A	Monterey No. 0 Sand (Cylind. Specimen)	0.78	27		•••	Rounded	0.3 - 1.2	3	0.	35 (0)
SP	SP-17B	Monterey No. 0 Sand (Cubical Specimen)	0.78	27		••	Rounded	0.3 - 1.2	3	0.	39 (0)
SP	SP-17C	Monterey No. 0 Sand (Cylind. Specimen)	0.57	98		•••	Rounded	0.3 - 1.2	3	0.	45 (3)
SP	SP-17D	Monterey No. 0 Sand (Cubical Specimen)	0.57	98		••	Rounded	0.3 - 1.2	3	0.	47 (5)
SP	SP-18	Basaltic Sand (Round Butte Dam)				••	Angular	2.0 - 14.0	3	0.	39 (13)
SM	SM-4	Silty Sand (Chatfield Dam)				••	Sub-rounded	6.0 - 10.0	3	0.	37 (0)
SM	SM-5	Silty Gravelly Sand (Chatfield Dam)				•	Sub-rounded	6.0 - 10.0	3	0.	41 (0)
SM	SM-6	Silty Sand w/Pebbles (Round Butte Dam)				•••	Angular	2.0 - 14.0	3	0.	46 (8)
SM	SM-9	Silty Sand w/Pumice (Round Butte Dam)				••	Angular	2.0 - 13.7	3	0.	43 (8)
SM	SM-13	Silty Sand (Round Butte Dam)				•	Sub-angular	2.0 - 14.1	3	0.	36 (5)
SM	SM-16	Silty Sand & Gravel (Round Butte Dam)				••	Sub-angular	2.0 - 14.0	3	0.	36 (11)
SM-SC	SM-SC-1A	Silty Clayey Sand (Mica Dam Core)				••		3.6 - 32.4	6	0.31	33
SM-SC	SM-SC-1B	Silty Clayey Sand (Mica Dam Core)				•••		3.6 - 18.0	4	0.85	34
SM-SC	SM-SC-1C	Silty Clayey Sand (Mica Dam Core)				•••		3.6 - 32.4	6	0.40	34
ML	ML-1	Cannonsville Silt (Undisturbed)	0.57			•		1.5 - 7.4	4	0.	45 (6)
ML	ML-4	Sandy Silty w/Pumice (Round Butte Dam)				•		2.0 - 13.9	2	0.	42 (7)
ML	ML-5	Sandy Silty w/Pumice (Round Butte Dam)				••		2.0 - 13.9	3	0.	36 (1)
CL	CL-29C	Silty Clay (Canyon Dam)			69	••		1.0 - 8.2	4	0.17	30
CL	CL-29D	Silty Clay (Canyon Dam)			79	••		1.0 - 8.2	4	0.59	29
CL	CL-30E	Silty Clay (Canyon Dam)			88	••		1.0 - 8.2	4	0.51	33
CL	CL-30F	Silty Clay (Canyon Dam)			88	••		1.0 - 4.0	4	0.39	30
CL	CL-34E	Silty Clay (Canyon Dam)			87	•		0.5 - 8.0	5	0.26	31

TABLE 2, PART B. CLASSIFICATION AND STRENGTH PARAMETERS FOR SOILS TESTED UNDER DRAINED CONDITIONS (CONTINUED)

Soil	Group	Soil Description	Init. Void Ratio	Relative Density	Degree Satura-tion	Rating	Particle Shape	Stress Range (TSF)	Number of Tests	C (TSF)	Friction Angle
GW	GW-1	Conglomerate Rockfill (Netzahu Dam)	0.39	70		**	Sub-angular	1.9 - 25.5	3	0.	50 (10)
GW	GW-2	Granitic Gneiss Rockfill (Mica Dam)	0.32	95		**	Sub-angular	5.1 - 25.6	3	0.	44 (9)
GW	GW-3	Quartzile Rockfill (Fumas Dam Shell)				***	Sub-rounded	4.1 - 36.9	4	0.	49 (6)
GW	GW-4	Quartzile Rockfill (Fumas Dam Transit.)				***	Sub-rounded	4.1 - 36.9	4	0.	53 (7)
GW	GW-5	Fumas Dam Transition				***	Sub-rounded	4.1 - 36.9	4	0.	50 (7)
GW	GW-6	Pinzandapan Gravel	0.34	65		**	Sub-rounded	0.4 - 26.5	6	0.	51 (9)
GW	GW-7	Diorite Rockfill (El Infiernillo Dam)	0.56	50		**	Angular	0.4 - 17.0	7	0.	46 (9)
GP	GP-2	Sandy Gravel (Mica Dam Shell)		50		**	Sub-angular	7.2 - 32.5	3	0.	41 (3)
GP	GP-3	Basalt Rockfill	0.30	95		***	Angular	5.1 - 25.6	3	0.	52 (10)
GP	GP-6	Silty Sandy Gravel (Oroville Dam)	0.21	100		***	Rounded	9.0 - 46.8	4	0.	53 (8)
GP	GP-7	Amphibolite Gravel (Oroville Dam Shell)	0.20	100		**	Rounded	2.2 - 28.6	4	0.	51 (6)
GP	GP-11	Crushed Basaltic Rock (Round Butte Dam)		99.0		**	Angular	2.0 - 14.1	3	0.	51 (14)
GP	GP-13	Sandy Gravel (Rowallan Dam)	0.233	100		**	Rounded	1.8 - 10.8	4	0.	58 (10)
GC	GC-1	Clayey Gravel (New Hogan Dam Core)			51	**		1.1 - 4.3	3	0.28	19
SW	SW-1	Argillite Rockfill (Pyramid Dam Shell)	0.48	100		*	Angular	2.2 - 46.8	4	0.	53 (9)
SW	SW-2	Crushed Olivine Basalt	0.43	100		*	Angular	2.2 - 46.6	4	0.	55 (10)
SW	SW-3	Silty Sand, Some Gravel (Round Butte Dam)				*	Sub-rounded	2.0 - 14.0	3	0.	38 (3)
SW	SW-5	Venato Sandstone (0.5 in. max. size)	0.47	93		*	Angular	2.2 - 28.6	4	0.	43 (4)
SP	SP-3	Glacial Cutwash Sand	0.50	80		***	Sub-rounded	1.0 - 41.1	6	0.	44 (4)
SP	SP-4A	Sacramento River Sand	0.87	38		*	Rounded	1.0 - 41.1	8	0.	35 (2)
SP	SP-4B	Sacramento River Sand	0.78	60		*	Rounded	1.0 - 13.0	4	0.	37 (2)
SP	SP-4C	Sacramento River Sand	0.71	78		*	Rounded	1.0 - 41.1	8	0.	41 (5)
SP	SP-4D	Sacramento River Sand	0.61	100		*	Rounded	3.0 - 41.1	6	0.	45 (7)
SP	SP-5A	Ham River Sand	0.82	Loose		**	Rounded	7.2 - 287.9	4	0.	31 (2)
SP	SP-5B	Ham River Sand	0.64	Dense		**	Rounded	7.2 - 71.3	3	0.	47 (9)
SP	SP-7A	Poorly Graded Sand (Port Allen Lock)	0.73	49		**	Rounded	0.9 - 3.9	3	0.	39 (0)
SP	SP-7B	Poorly Graded Sand (Port Allen Lock)	0.65	73		**	Rounded	0.9 - 3.9	3	0.	40 (1)
SP	SP-7C	Poorly Graded Sand (Port Allen Lock)	0.57	98		**	Rounded	0.9 - 3.9	3	0.	44 (3)
SP	SP-12	Coarse to Fine Sand (Round Butte Dam)	1.22	70		**	Angular	2.0 - 14.0	3	0.	39 (6)
SP	SP-13	Pumiceous Sand (Round Butte Dam)		77		*	Angular	2.0 - 14.1	3	0.	48 (10)
SP	SP-14	Pumiceous Sand (Round Butte Dam)		71		*	Angular	2.0 - 14.1	3	0.	49 (12)
SP	SP-16A	Fine Silica Sand (Loose)	0.55	38		***	Rounded	1.0 - 5.1	3	0.	30 (0)
SP	SP-16B	Fine Silica Sand (Dense)	0.54	100		***	Rounded	1.0 - 5.1	3	0.	37 (0)
SP	SP-17A	Monterey No. 0 Sand (Cylind. Specimen)	0.78	27		***	Rounded	0.3 - 1.2	3	0.	35 (0)
SP	SP-17B	Monterey No. 0 Sand (Cubical Specimen)	0.78	27		**	Rounded	0.3 - 1.2	3	0.	39 (0)
SP	SP-17C	Monterey No. 0 Sand (Cylind. Specimen)	0.57	98		***	Rounded	0.3 - 1.2	3	0.	45 (3)
SP	SP-17D	Monterey No. 0 Sand (Cubical Specimen)	0.57	98		**	Rounded	0.3 - 1.2	3	0.	47 (5)
SP	SP-18	Basaltic Sand (Round Butte Dam)				**	Angular	2.0 - 14.0	3	0.	39 (13)
SM	SM-4	Silty Sand (Chatfield Dam)				**	Sub-rounded	6.0 - 10.0	3	0.	37 (0)
SM	SM-5	Silty Gravelly Sand (Chatfield Dam)				*	Sub-rounded	6.0 - 10.0	3	0.	41 (0)
SM	SM-6	Silty Sand w/Pebbles (Round Butte Dam)				***	Angular	2.0 - 14.0	3	0.	46 (8)
SM	SM-9	Silty Sand w/Pumice (Round Butte Dam)				**	Angular	2.0 - 13.7	3	0.	43 (8)
SM	SM-13	Silty Sand (Round Butte Dam)				*	Sub-angular	2.0 - 14.1	3	0.	36 (5)
SM	SM-18	Silty Sand & Gravel (Round Butte Dam)				**	Sub-angular	2.0 - 14.0	3	0.	38 (11)
SM-SC	SM-SC-1A	Silty Clayey Sand (Mica Dam Core)				**		3.6 - 32.4	6	0.31	33
SM-SC	SM-SC-1B	Silty Clayey Sand (Mica Dam Core)				***		3.6 - 18.0	4	0.85	34
SM-SC	SM-SC-1C	Silty Clayey Sand (Mica Dam Core)				***		3.6 - 32.4	6	0.40	34
ML	ML-1	Cannonsville Silt (Undisturbed)	0.57			*		1.5 - 7.4	4	0.	45 (6)
ML	ML-4	Sandy Silty w/Pumice (Round Butte Dam)				*		2.0 - 13.9	2	0.	42 (7)
ML	ML-5	Sandy Silty w/Pumice (Round Butte Dam)				**		2.0 - 13.9	3	0.	36 (1)
CL	CL-29C	Silty Clay (Canyon Dam)			89	**		1.0 - 8.2	4	0.17	30
CL	CL-29D	Silty Clay (Canyon Dam)			79	**		1.0 - 8.2	4	0.59	29
CL	CL-30E	Silty Clay (Canyon Dam)			88	**		1.0 - 8.2	4	0.51	33
CL	CL-30F	Silty Clay (Canyon Dam)			88	**		1.0 - 4.0	4	0.39	30
CL	CL-34E	Silty Clay (Canyon Dam)			87	*		0.5 - 8.0	5	0.26	31

Appendix B – Slide Output

Appendix B1. Section 1 – Construction



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Bedrock		175		Mohr-Coulomb	41904	44
Overburden		130	145	Mohr-Coulomb	200	35
Excavated Soil		130	145	Mohr-Coulomb	200	35

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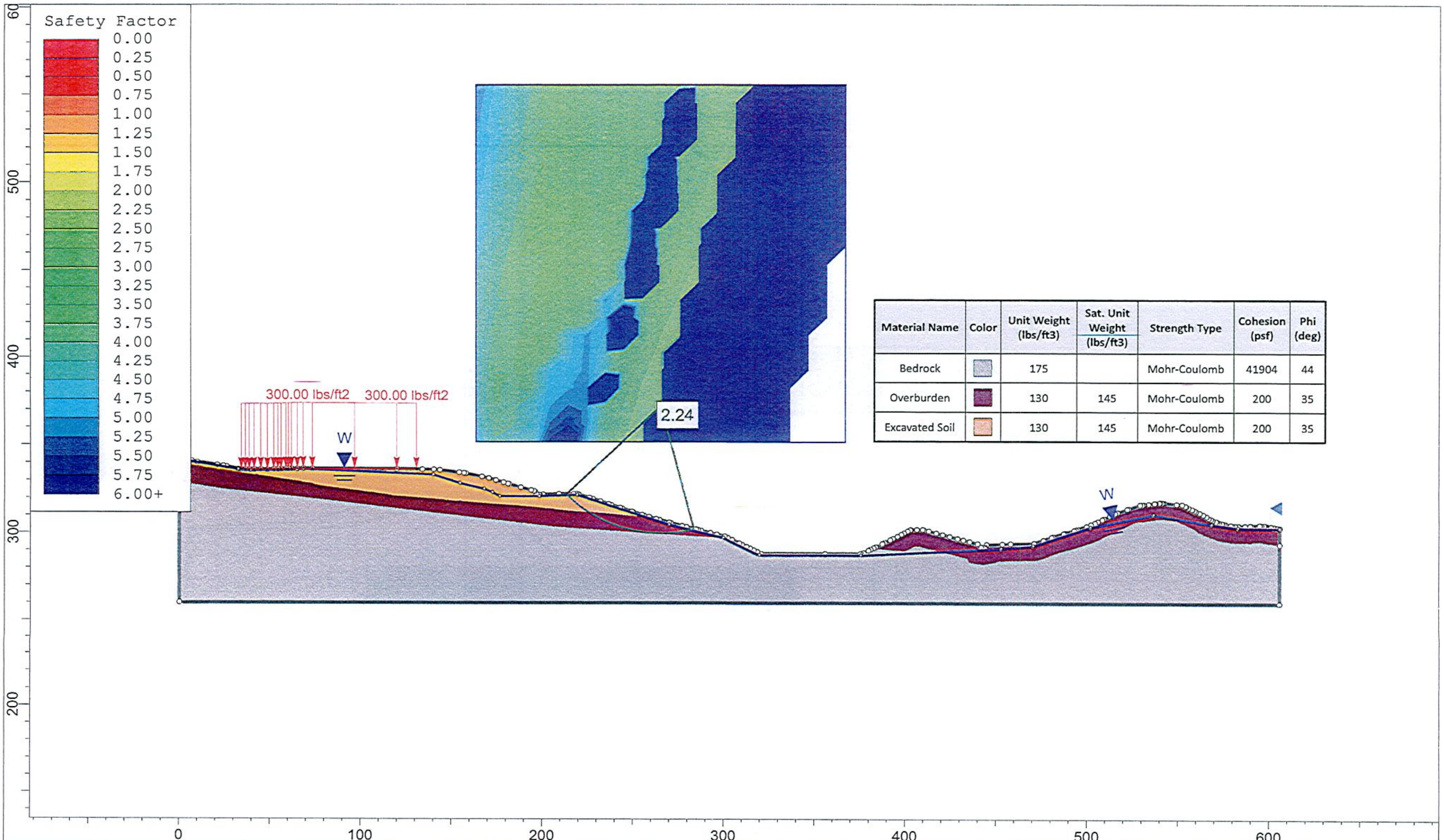
SLIDEINTERPRET 6.031

Project	West Connection Support Area - Slope Stability
Analysis Description	Section 1 - Construction
Drawn By	DE/KSC
Scale	1:658
Company	JA Underground: P.C. dba Jacobs Associates
Date	
File Name	Section 1.slim



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Bedrock		175		Mohr-Coulomb	41904	44
Overburden		130	145	Mohr-Coulomb	200	35
Excavated Soil		130	145	Mohr-Coulomb	200	35

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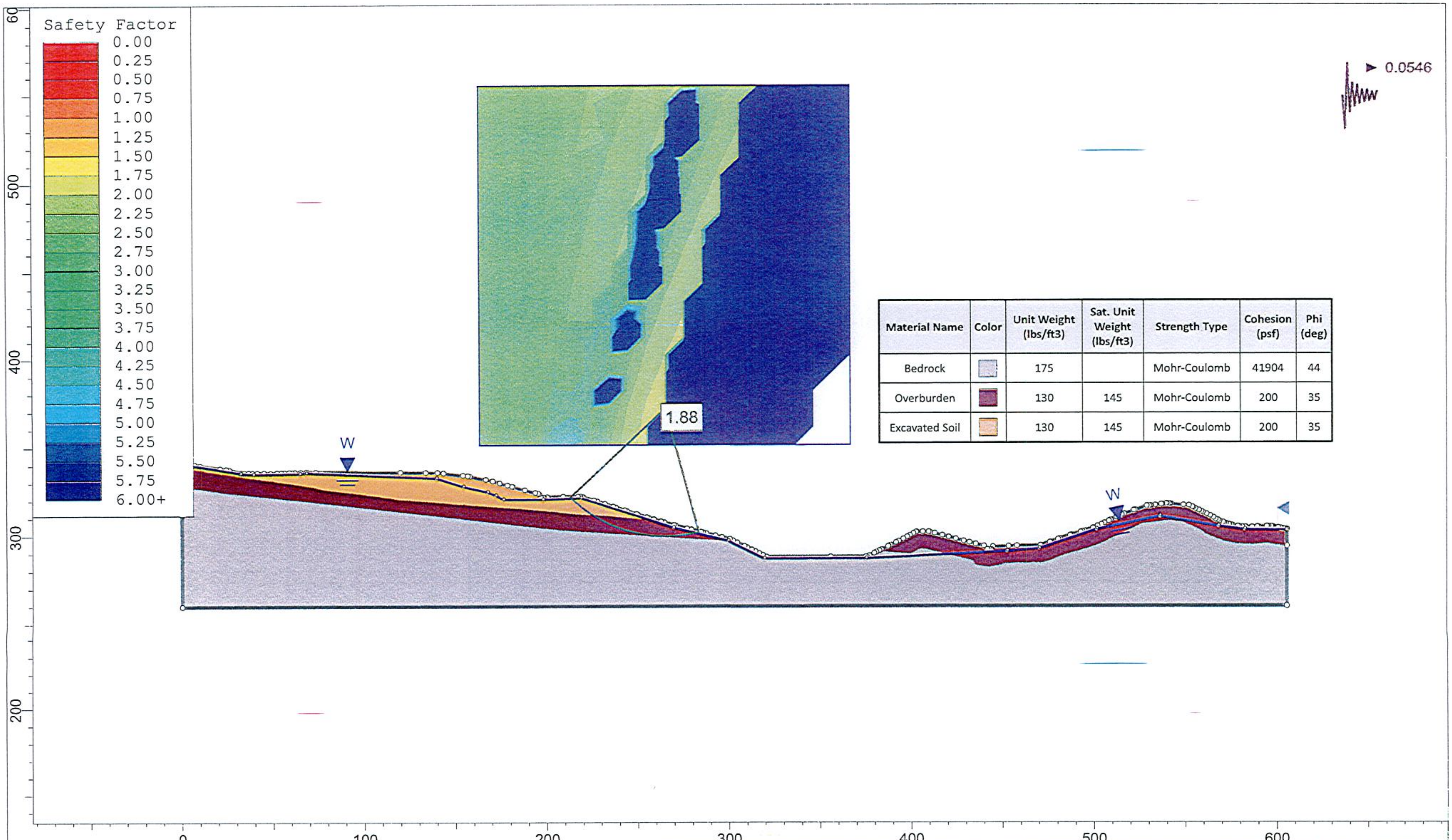
SLIDEINTERPRET 6.031

Project	West Connection Support Area - Slope Stability
Analysis Description	Section 1 - Construction - Surcharge
Drawn By	DE/KSC
Scale	1:903
Company	JA Underground: P.C. dba Jacobs Associates
Date	
File Name	Section 1 - Surcharge.slim



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Bedrock		175		Mohr-Coulomb	41904	44
Overburden		130	145	Mohr-Coulomb	200	35
Excavated Soil		130	145	Mohr-Coulomb	200	35

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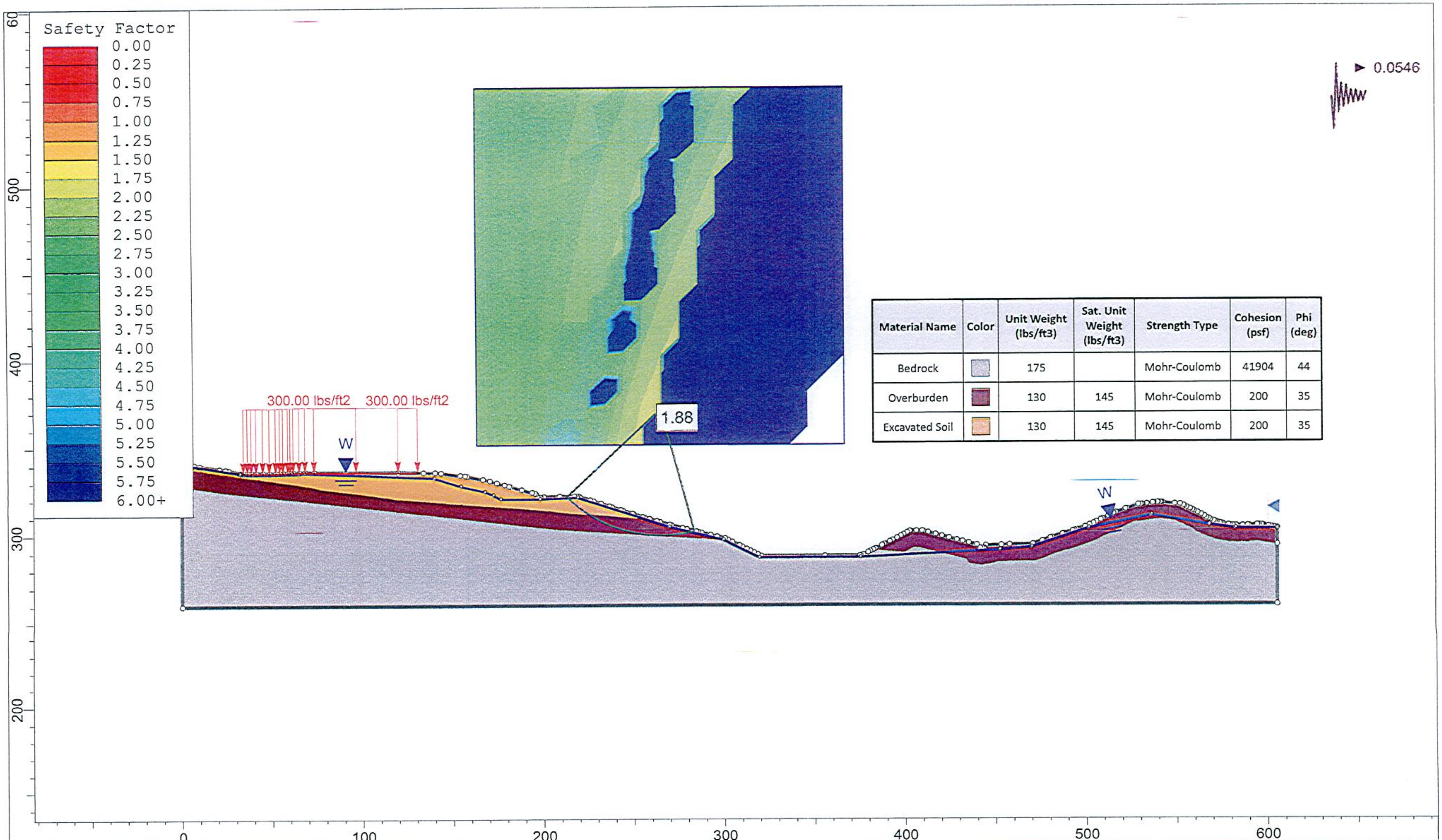
Project	West Connection Support Area - Slope Stability		
Analysis Description	Section 1 - Construction - Seismic		
Drawn By DE/KSC	*Scale* 1:903	*Company*	JA Underground: P.C. dba Jacobs Associates
Date		*File Name*	Section 1 - Seismic.slim

SLIDEINTERPRET 6.031

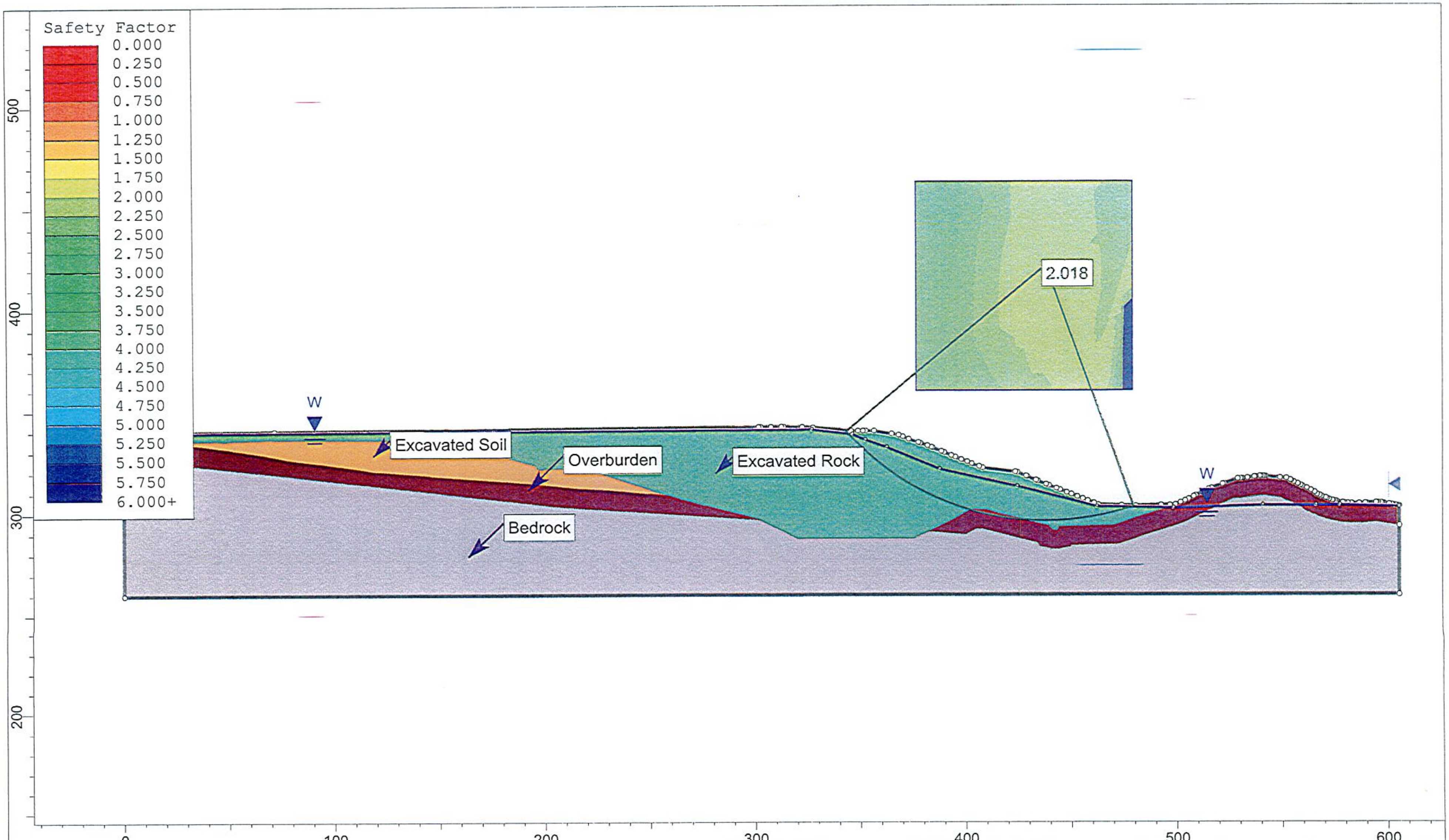


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Bedrock		175		Mohr-Coulomb	41904	44
Overburden		130	145	Mohr-Coulomb	200	35
Excavated Soil		130	145	Mohr-Coulomb	200	35

Project	West Connection Support Area - Slope Stability
Analysis Description	Section 1 - Construction - Surcharge - Seismic
Drawn By	DE/KSC
Scale	1:903
Company	JA Underground: P.C. dba Jacobs Associates
Date	
File Name	Section 1 - Surcharge - Seismic.slim

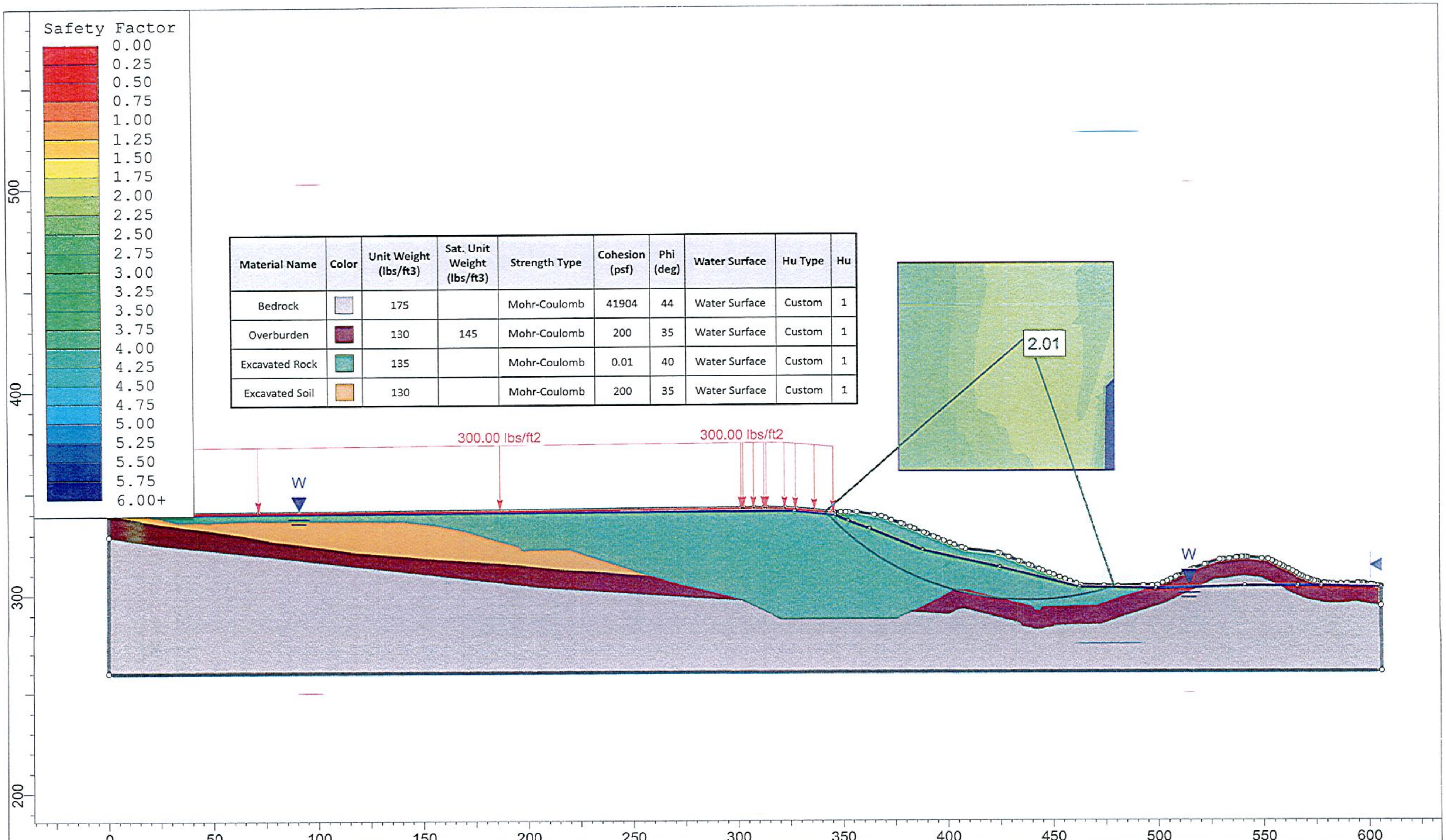
SLIDEINTERPRET 6.031

Appendix B2. Section 1 – Final



Project	West Connection Support Area - Slope Stability
Analysis Description	Section 1 - Final
Drawn By	DE/KSC
Scale	1:780
Company	JA Underground: P.C. dba Jacobs Associates
Date	
File Name	Section 1.slim

SLIDEINTERPRET 6.031



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Bedrock		175		Mohr-Coulomb	41904	44	Water Surface	Custom	1
Overburden		130	145	Mohr-Coulomb	200	35	Water Surface	Custom	1
Excavated Rock		135		Mohr-Coulomb	0.01	40	Water Surface	Custom	1
Excavated Soil		130		Mohr-Coulomb	200	35	Water Surface	Custom	1

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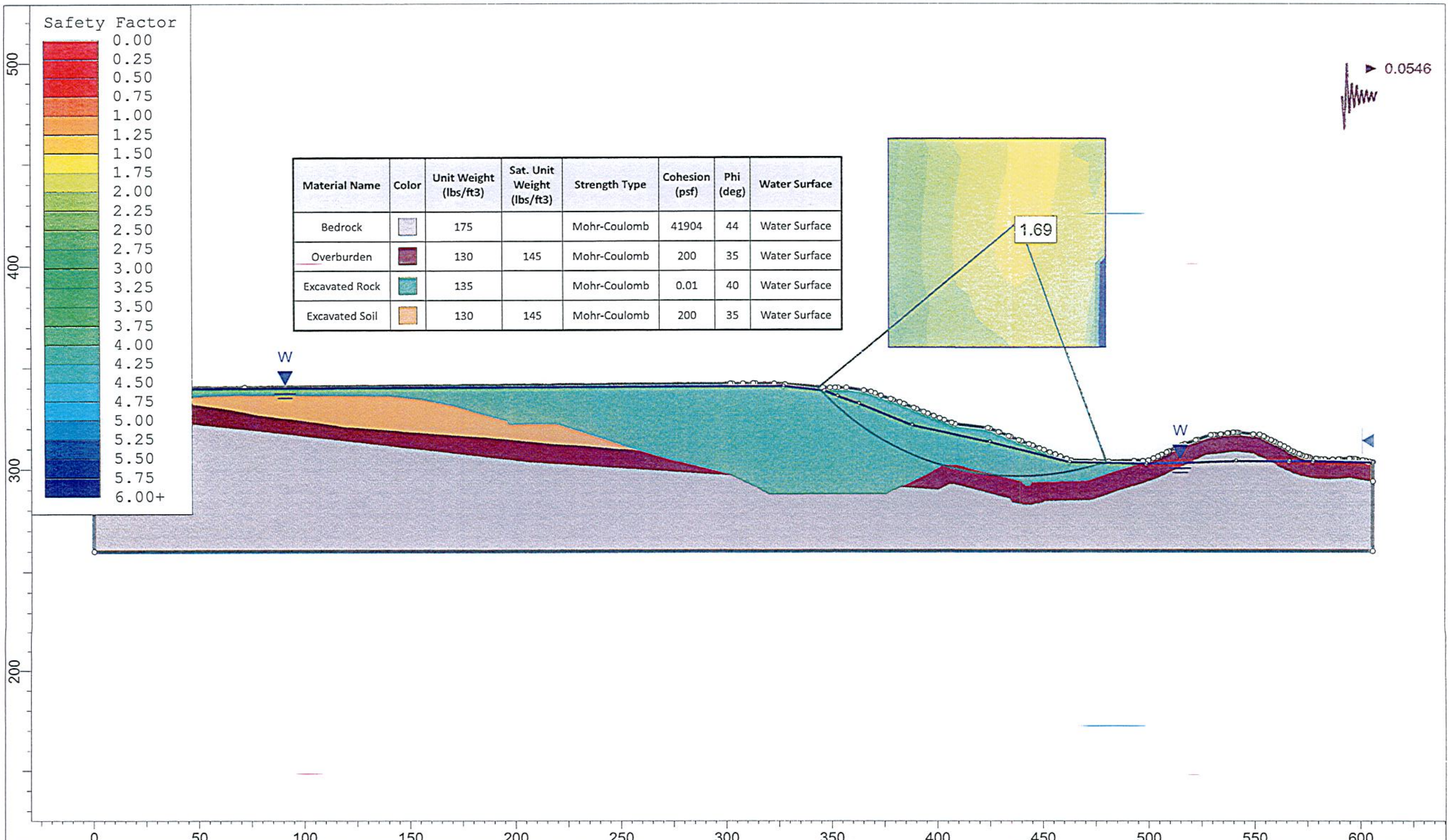
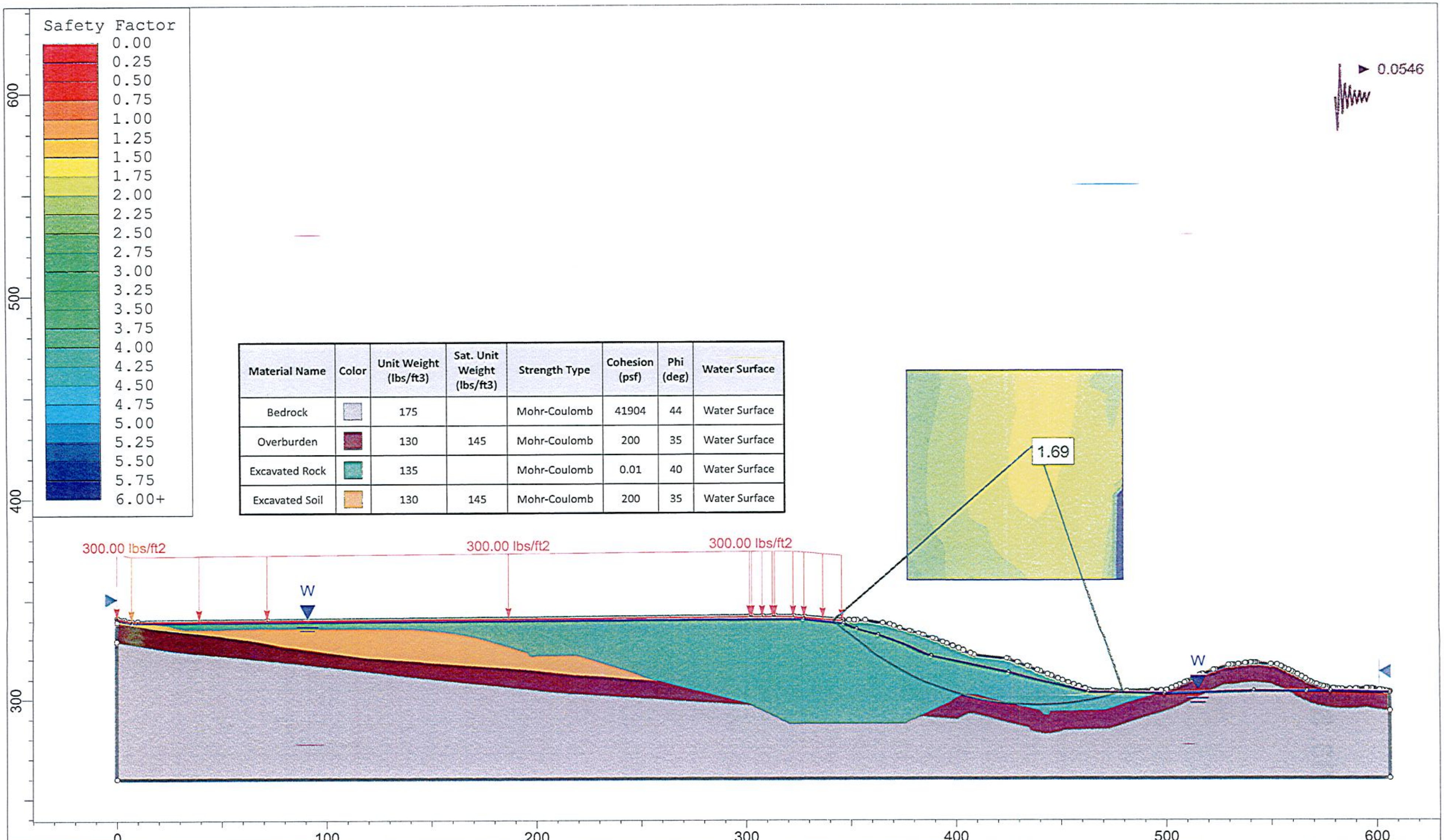
Project	West Connection Support Slope Stability		
Analysis Description	Section 1 - Final with Surcharge		
Drawn By	DE/KSC	*Scale* 1:780	*Company* JA Underground: P.C. dba Jacobs Associates
Date			*File Name* Section 1 - Surcharge.slim



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Bedrock		175		Mohr-Coulomb	41904	44	Water Surface
Overburden		130	145	Mohr-Coulomb	200	35	Water Surface
Excavated Rock		135		Mohr-Coulomb	0.01	40	Water Surface
Excavated Soil		130	145	Mohr-Coulomb	200	35	Water Surface

Project	West Connection Support Area - Slope Stability		
Analysis Description	Section 1 - Final - Seismic		
Drawn By: DE/KSC	Scale: 1:780	Company	JA Underground: P.C. dba Jacobs Associates
Date		File Name	Section 1 - Seismic.slim

SLIDEINTERPRET 6.031



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Bedrock		175		Mohr-Coulomb	41904	44	Water Surface
Overburden		130	145	Mohr-Coulomb	200	35	Water Surface
Excavated Rock		135		Mohr-Coulomb	0.01	40	Water Surface
Excavated Soil		130	145	Mohr-Coulomb	200	35	Water Surface

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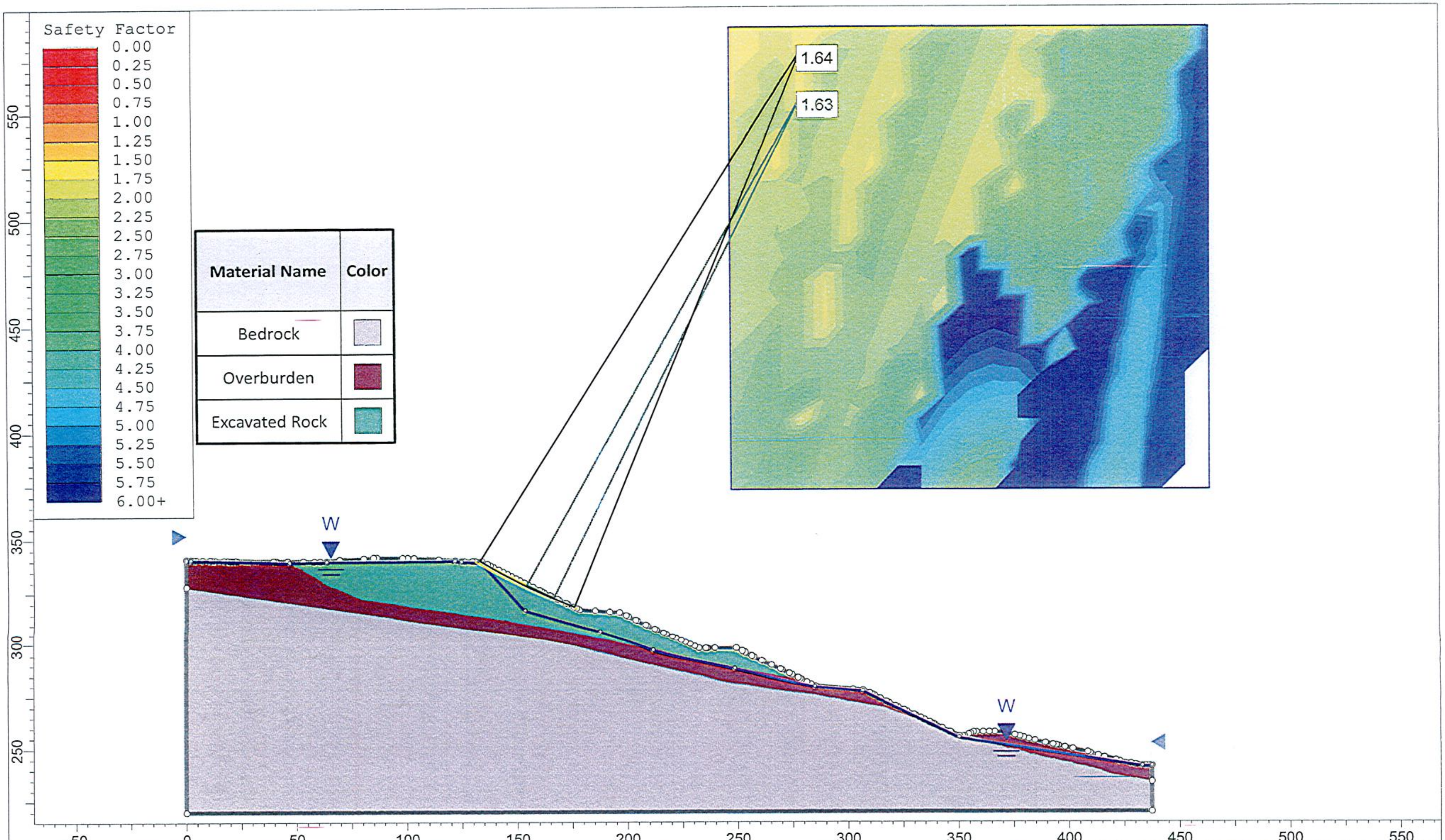
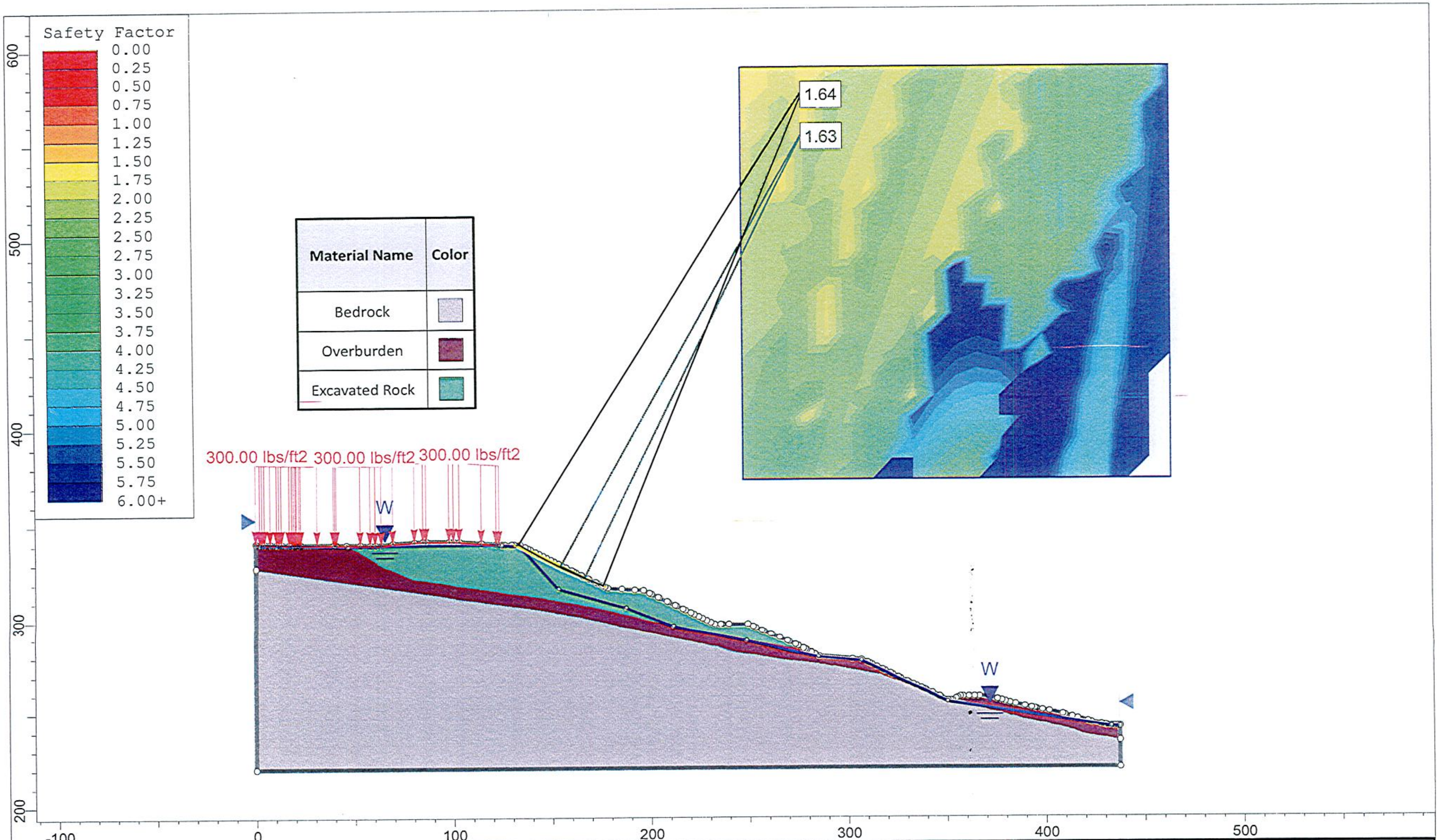
Project	West Connection Support Slope Stability
Analysis Description	Section 1 - Final with Surcharge
Drawn By	DE/KSC
Scale	1:780
Company	JA Underground: P.C. dba Jacobs Associates
Date	
File Name	Section 1 - Surcharge - Seismic.slim

Appendix B3. Section 2

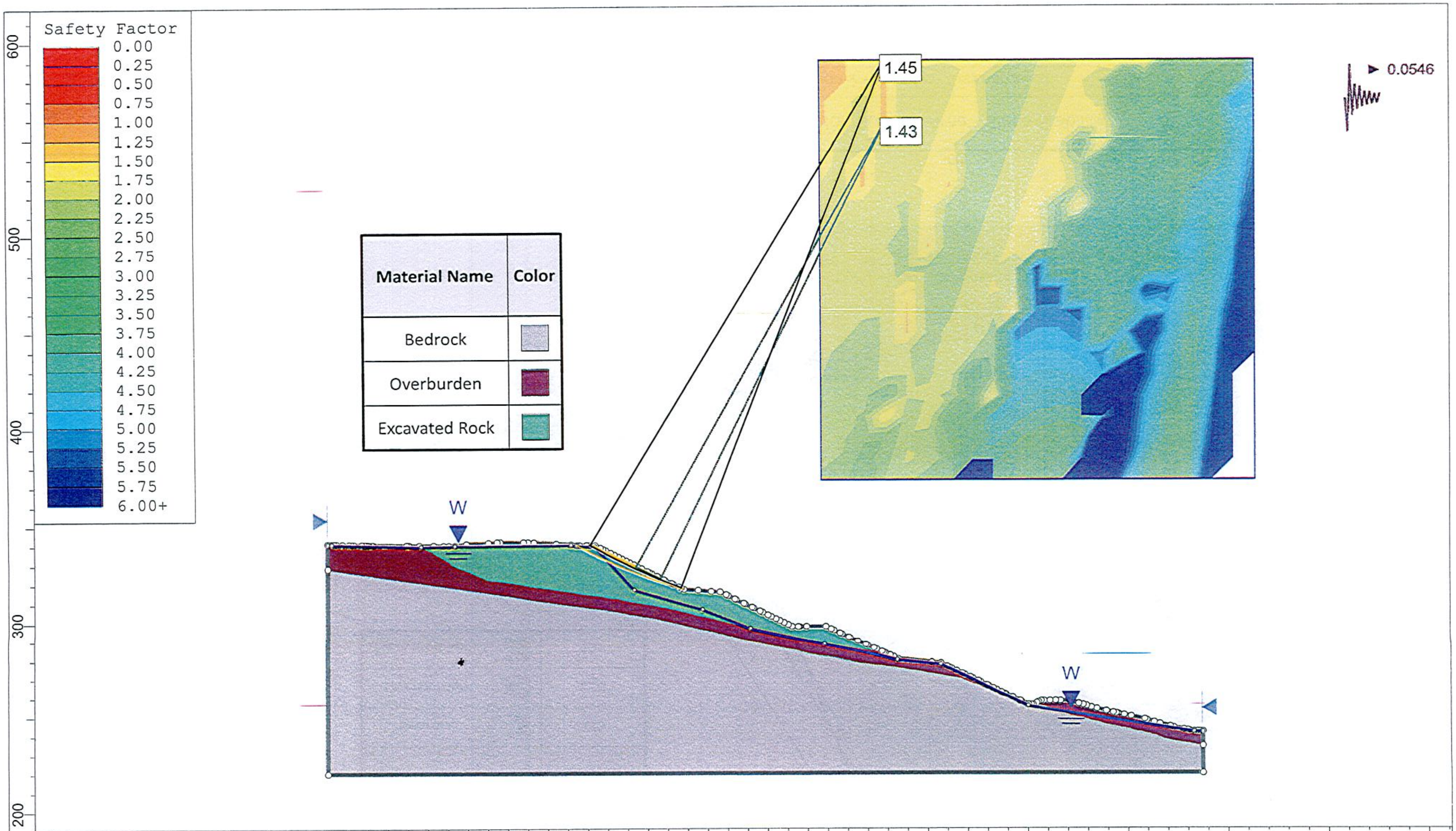


rocscience	Project: West Connection Support Area - Slope Stability		
	Analysis Description: Section 2		
	Drawn By: DE/KSC	Scale: 1:742	Company: JA Underground: P.C. dba Jacobs Associates
SLIDEINTERPRET 6.031	Date:		File Name: Section 2 - Drainage Measures.slim



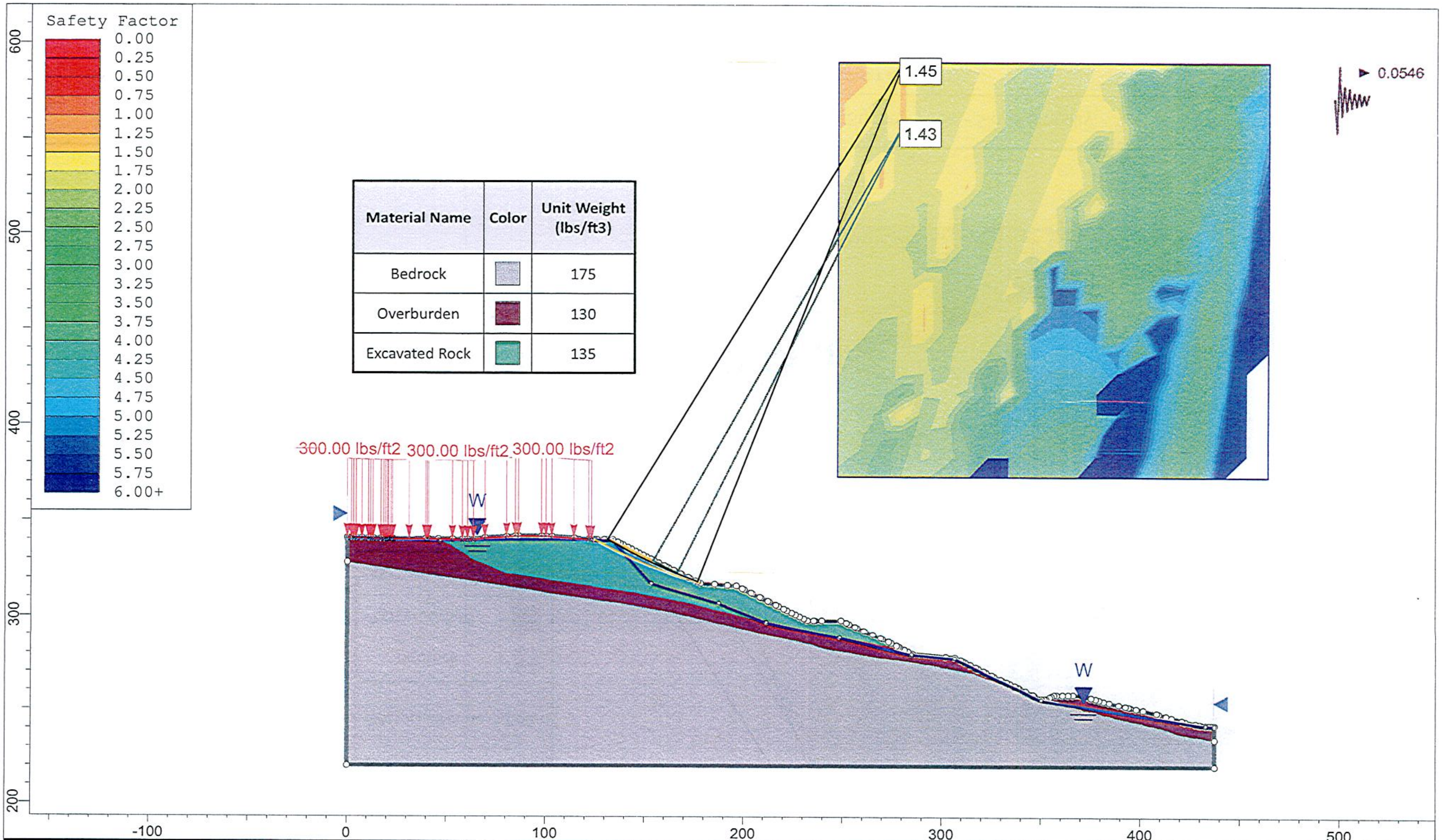
Project	West Connection Support Area - Slope Stability		
Analysis Description	Section 2 - Surcharge		
Drawn By DE/KSC	*Scale* 1:824	*Company*	JA Underground: P.C. dba Jacobs Associates
Date		*File Name*	Section 2 - Drainage Measures - Surcharge.slim

SLIDEINTERPRET 6.031



Project	West Connection Support Area - Slope Stability
Analysis Description	Section 2 - Seismic
Drawn By	DE/KSC
Scale	1:824
Company	JA Underground: P.C. dba Jacobs Associates
Date	
File Name	Section 2 - Drainage Measures - Seismic.slim

SLIDEINTERPRET 6.031

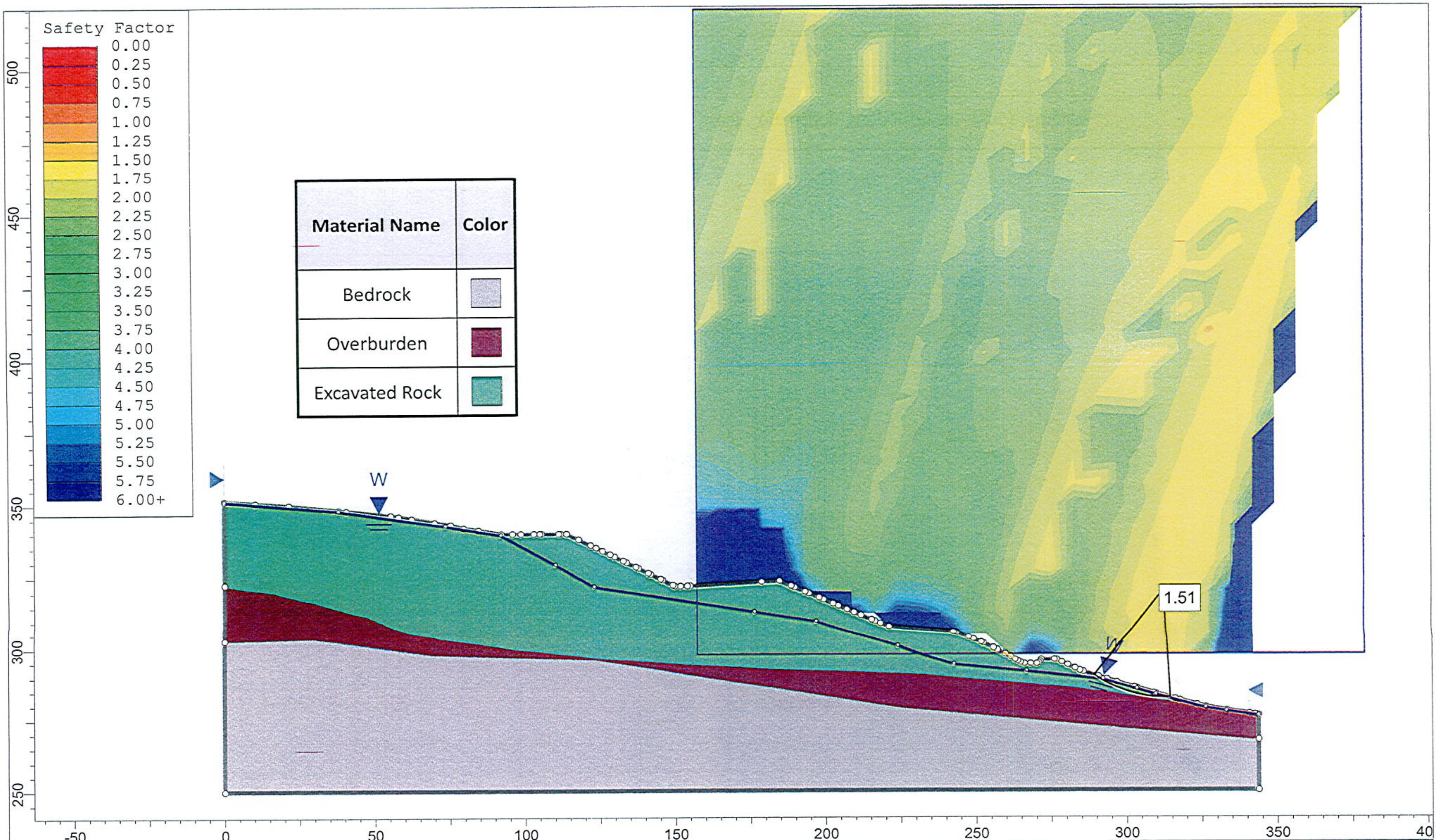


Material Name	Color	Unit Weight (lbs/ft3)
Bedrock		175
Overburden		130
Excavated Rock		135

Project	West Connection Support Area - Slope Stability
Analysis Description	Section 2 - Seismic - Surcharge
Drawn By	DE/KSC
Scale	1:824
Company	JA Underground: P.C. dba Jacobs Associates
Date	
File Name	Section 2 - Drainage Measures - Seismic Surcharge.slim

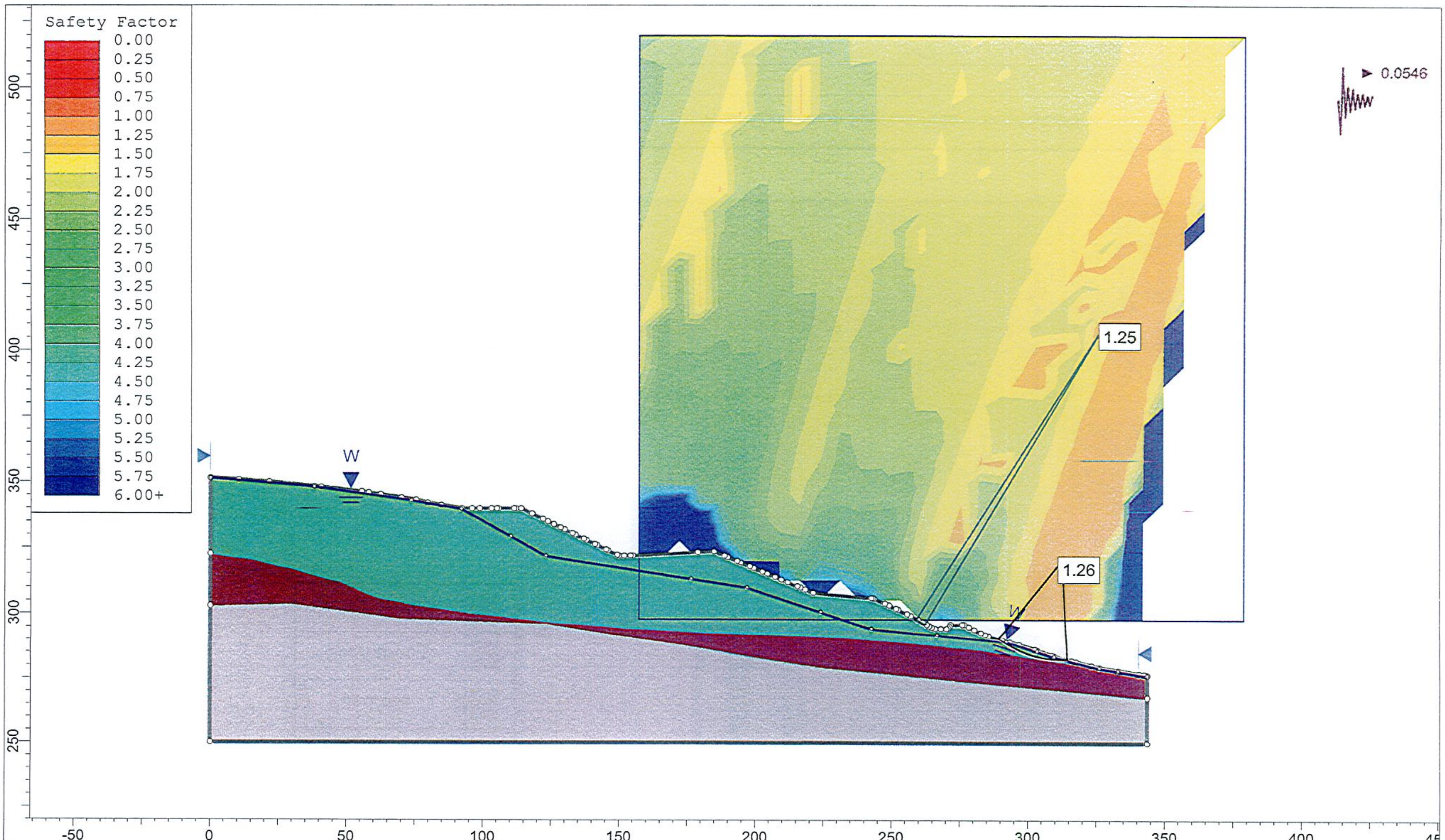
SLIDEINTERPRET 6.031

Appendix B4. Section 3



Project	West Connection Support Area - Slope Stability		
Analysis Description	Section 3		
Drawn By: DE/KSC	Scale: 1:541	Company	JA Underground: P.C. dba Jacobs Associates
Date		File Name	Section 3 - Drainage Measures.slim

SLIDEINTERPRET 6.031



Project	West Connection Support Area - Slope Stability		
Analysis Description	Section 3 - Seismic		
Drawn By	DE/KSC	Scale	1:601
Company	JA Underground: P.C. dba Jacobs Associates		
Date		File Name	Section 3 - Drainage Measures - Seismic.slim

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