From: Larson, Tim (DEC)
To: McAuliffe, John
Cc: Glaza, Edward; robert.edwards@dec.ny.gov; donald.hesler@dec.ny.gov; tara.blum@dec.ny.gov; rebecca.quail@dec.ny.gov; Bob Nunes; Israel, Brian; margaret.sheen@dec.ny.gov; John Davis; Sergott, Mark; "maureen.schuck@health.ny.gov"; "Heath, Joseph"; "Joyal, Thane"; "Shenandoah, Jeanne"; "Waterman, Curtis"; "Alma Lowry (alma.lowry@gmail.com)"; "Charsleissa E King (DEC) (charsleissa.king@dec.ny.gov)"; "Spera, Mike"; "McDonald, Michelle"
Subject: Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design, MPC RA-B1 Design Revision [Approval Letter]
Date: Friday, November 06, 2015 3:23:00 PM
Attachments: 110615 OL RAB1 Design Revision Approval Ltr.pdf
110615 MPC RA-B1 Design Revision Final.pdf

John,

Attached is a copy of my approval letter for the above-referenced document. Please see that copies of the final version of this document (also attached), including my approval letter, are send to the distribution list selected for this site as well as the document repositories selected for this site.

Thank you,

Tim

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Environmental Remediation, Remedial Bureau D
625 Broadway, 12th Floor, Albany, NY 12233-7013
P: (518) 402-9676 I F: (518) 402-9773
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November 6, 2015

Mr. John P. McAuliffe, P.E.
Program Director, Syracuse
Honeywell
301 Plainfield Road, Suite 330
Syracuse, NY 13212

Re: Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design, Modified Protective Cap RA-B1 Design Revision, Dated November 2015

Dear Mr. McAuliffe:

We have received and reviewed the above-referenced document, a copy of which was attached to Edward Glaza's November 6, 2015 email to my attention, and the revised version of the document appropriately addresses our previous comments. Therefore, the Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design, Modified Protective Cap RA-B1 Design Revision, dated November 2015, is hereby approved. Please see that copies of the approved document, including this approval letter, are sent to the distribution list selected for this site as well as the document repositories selected for this site.

Sincerely,

Timothy J. Larson, P.E.
Project Manager

ec: B. Israel, Esq, - Arnold & Porter
J. Davis - NYSDOL, Albany
M. Schuck - NYSDOH, Albany
M. McDonald – Honeywell
R. Nunes - USEPA, NYC
M. Sergott - NYSDOH, Albany
E. Glaza - Parsons

ONONDAGA LAKE CAPPING, DREDGING, HABITAT AND PROFUNDAL ZONE (SMU 8) FINAL DESIGN

MODIFIED PROTECTIVE CAP RA-B-1 DESIGN REVISION

Prepared for:

Honeywell

301 Plainfield Road, Suite 330
Syracuse, NY 13212

Prepared by:

PARSONS

301 Plainfield Road, Suite 350
Syracuse, NY 13212

ANCHOR QEA

290 Elwood Davis Road, Suite 318
Liverpool, NY 13088

NOVEMBER 2015

SUMMARY OF DESIGN REVISION

This cap design revision pertains to a portion of Remediation Area B (RA-B) where geotechnical investigations completed subsequent to the Final Design identified soft (low strength) sediment on relatively steep slopes. These sediments are softer than was identified during the Pre-design Investigation (PDI), and therefore a design revision is required in this area. For a capping project of the scale of Onondaga Lake Remediation, it is not unusual to expect to incur field conditions in minor areas throughout the implementation that may require adjustments to the cap system to achieve the remedial goals for the project. As discussed below, the various modified protective caps (MPC) in these areas will be protective for more than 1,000 years, consistent with the evaluation timeframe used in the final design.

The Modified Protective Cap (MPC) designs shown in Figure 1 were determined to be stable based on substantial geotechnical data collected following the movement and detailed geotechnical analysis, as presented in Attachment 1. The thickness and composition of the various layers comprising the MPCs are shown below as well as on Figure 1. Chemical isolation modeling was completed to determine the granular activated carbon (GAC) application rates that will be protective for more than 1,000 years, consistent with the evaluation timeframe used in the final design, as documented in Attachment 2. The updated GAC application rate based on this modeling are also listed below.

RA-B-1A (Multi-layer Cap) - GAC application rate of 1.29 lbs/sf

- 12-inch minimum sand habitat/erosion protection layer
- 7.5-inch minimum sand/GAC chemical isolation layer
- 3-inch minimum sand/siderite mixing layer

RA-B-1B (Multi-layer Cap) - GAC application rate of 1.30 lbs/sf

- 6-inch minimum sand habitat/erosion protection layer
- 3-inch minimum sand/GAC chemical isolation layer
- 3-inch minimum sand/siderite mixing layer

RA-B-1C (**4 to 10 feet**) (**Multi-layer Cap**) - **GAC application rate of 0.61 lbs/sf**

- 12-inch minimum fine gravel habitat/erosion protection layer
- 9-inch minimum sand/GAC chemical isolation layer
- 3-inch minimum of sand/siderite mixing layer

RA-B-1C (10 to 20 feet): (Mono-layer Cap) - GAC application rate of 0.49 lbs/sf

- 8-inch average sand/GAC/siderite

RA-B-1C (20 to 30 feet) (Mono-layer Cap) - GAC application rate of 0.49 lbs/sf

- 2-inch average sand/GAC/siderite

RA-B-1D (less than 4 feet) (Multi-layer Cap) - GAC application rate of 0.60 lbs/sf

- 12-inch minimum coarse gravel habitat/erosion protection layer
- 9-inch minimum sand/GAC chemical isolation layer
- 3-inch minimum sand/siderite chemical isolation layer
- 3-inch minimum sand/siderite mixing layer

RA-B-1D (4 to 10 feet) (Multi-layer Cap) - GAC application rate of 0.64 lbs/sf

- 12-inch minimum fine gravel habitat/erosion protection layer
- 4.5-inch minimum sand/GAC chemical isolation layer
- 3-inch minimum sand/siderite mixing layer

RA-B-1D (10 to 30 feet) (Multi-layer Cap, Conservatively Modeled as Mono-layer Cap) - GAC application rate of 0.49 lbs/sf

- 4.5-inch average sand
- 7.5-inch average sand/GAC/siderite

RA-B-1D (10 to 30 feet) (Mono-layer Cap) - **GAC application rate of 0.49 lbs/sf**

- 7.5-inch average sand/GAC/siderite

RA-B-1E (less than 4 feet) (Multi-layer Cap) - GAC application rate of 0.60 lbs/sf

- 12-inch minimum coarse gravel habitat/erosion protection layer
- 9-inch minimum sand/GAC chemical isolation layer
- 3-inch minimum sand/siderite chemical isolation layer
- 3-inch minimum sand/siderite mixing layer

RA-B-1E (4 to 10 feet) (Multi-layer Cap) - GAC application rate of 0.60 lbs/sf

- 12-inch minimum fine gravel habitat/erosion protection layer
- 9-inch minimum sand/GAC chemical isolation layer
- 3-inch minimum sand/siderite chemical isolation layer

- 3-inch minimum sand/siderite mixing layer

RA-B-1E (10 to 30 feet) (Multi-layer Cap) - **GAC application rate of 0.63 lbs/sf**

- 12-inch minimum sand habitat/erosion protection layer
- 6-inch minimum sand/GAC chemical isolation layer
- 3-inch minimum sand/siderite mixing layer

RA-B-1F (Mono-layer Cap) - **GAC application rate of 0.49 lbs/sf**

- 10-inch average sand/GAC/siderite

Siderite will be incorporated into all of the RA-B-1 MPCs to neutralize high pH and thus promote biodegradation of organic contaminants. Cap modeling of multi-layer caps in this area incorporates biodegradation. Biodegradation of organic contaminants is also expected to occur in the mono-layer caps. However, the GAC application rate in the mono-layer caps was conservatively developed through modeling assuming there was no biological decay. The siderite ore application rate based on lbs/sf will be consistent with the Final Design in all of the RA-B-1 MPCs. The siderite percent by weight within the sand/siderite mixture will be increased to account for the thinner sand/siderite layers (when less than 6 inches) as compared to the Final Design. The revised design as it pertains to the pH neutralization provides a level of protection that is equivalent to that of the original design even though the cap thickness over which the siderite is distributed will be decreased in some areas, as detailed in the Modified Protective Cap RA-D-1 Design Revision (Parsons and AnchorQEA 2015).

A comprehensive Construction Quality Assurance Plan (CQAP) (Parsons and AnchorQEA, 2012) has been developed and implemented to ensure that the cap is constructed consistent with the Final Design, including thickness and amendment application rate requirements. The construction verification methods will be revisited as necessary to ensure the MPCs are constructed consistent with this design modification.

Post-construction monitoring and maintenance of the capped areas throughout the lake, inclusive of the MPC areas addressed in the design revision, will be performed to verify that the overall integrity of the cap is maintained so that it remains physically stable (i.e., does not erode) and chemically protective over time. Long-term monitoring of the caps will include physical monitoring to verify stability and sampling of the caps to verify their chemical integrity, as summarized below. It will also include macrobenthic community sampling and documentation of vegetation recovery, as appropriate. Details of the monitoring methods, frequencies, and procedures and response actions will be developed based on joint discussions with NYSDEC and will be presented in the Onondaga Lake Monitoring and Maintenance Scoping document (OLMMS).

Physical monitoring of the capped areas, including the MPC areas included in this design revision, will involve verifying that the various layers of cap material placed are stable and intact using a combination of methods including bathymetric surveys, sediment probing and coring, and/or other geophysical methods. The cap integrity will be monitored routinely and following wind/wave, tributary inflow, ice scour or seismic events that exceed a threshold design magnitude, consistent with USEPA (2005) recommendations. The frequency of routine monitoring will be greater initially after construction (e.g., multiple monitoring events within the first 5 to 10 years), and reduced over time once the monitoring is able to establish a consistent pattern of cap performance.

Chemical monitoring will involve measuring chemical concentrations within the caps to verify that contaminants are not moving through or accumulating within the cap at rates and concentrations that exceed specified remedy success metrics. Samples will also be collected within the MPC areas as the different cap configurations in these areas will likely result in different monitoring approaches, depths, and compliance points. The frequency of routine monitoring may be reduced over time once the monitoring is able to establish a consistent pattern of cap performance. Details of the chemical monitoring methods, frequencies, locations, sampling intervals, procedures, and response actions will be developed based on joint discussions with NYSDEC and will be presented in the OLMMS for NYSDEC review and approval.

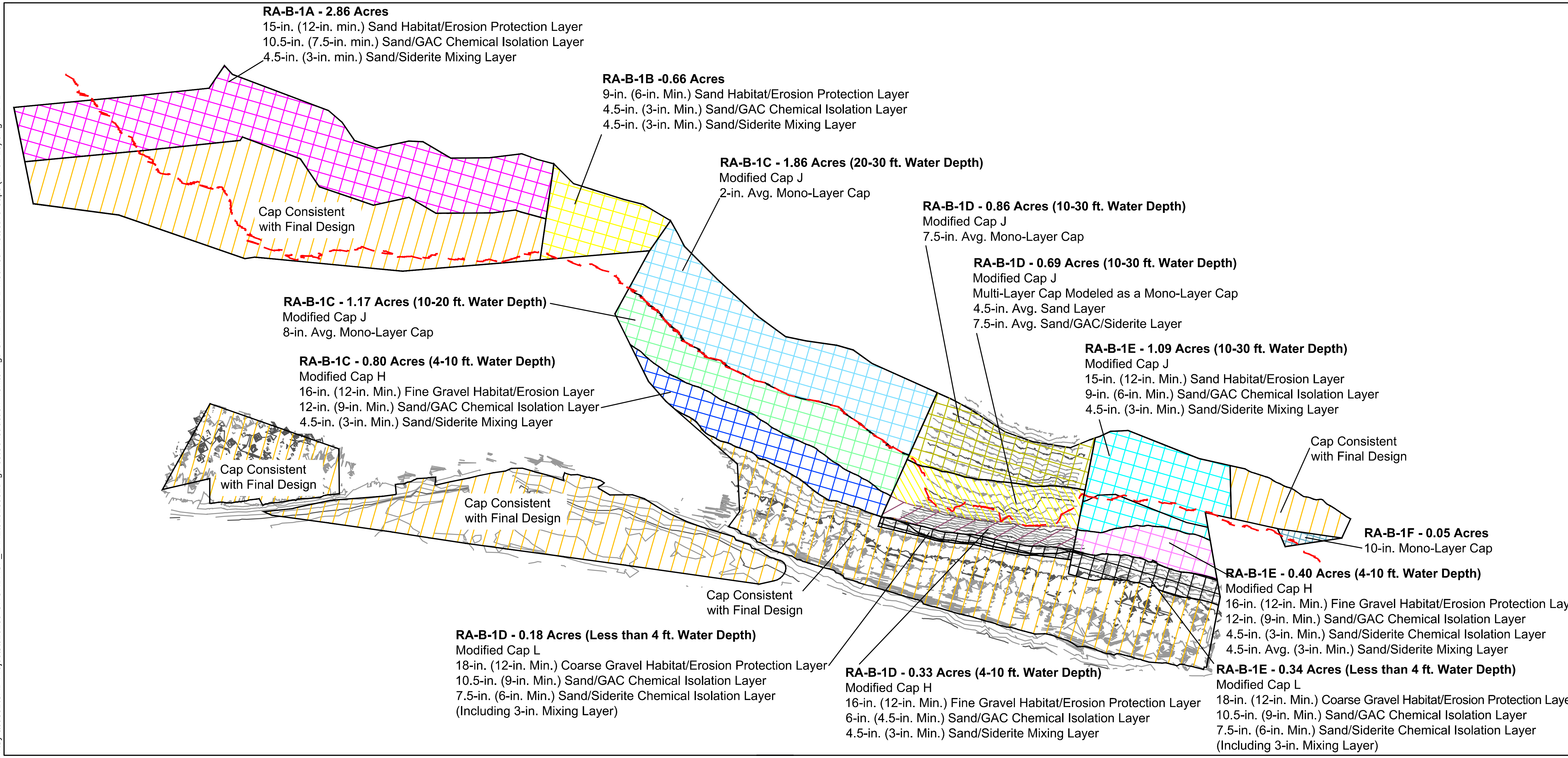
In the unlikely event that the monitoring plan discussed above identifies areas where the cap may not be performing consistent with expectations, follow-up assessments and/or response actions will be implemented. Follow-up assessments/actions may include additional investigation to further evaluate potential deficiencies, continued monitoring and assessment of overall remedy effectiveness over time, and/or placement of additional cap materials. Cap maintenance and response actions will be detailed in the OLMMS.

REFERENCES

Parsons and AnchorQEA. 2012. "*Construction Quality Assurance Plan Onondaga Lake Capping, Dredging and* Habitat"

Parsons and AnchorQEA. 2015. "*Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design Modified Protective Cap RA-D-1 Design Revision*"

United States Environmental Protection Agency. 2005. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites.* EPA-540-R-05-012. OSWER 9355.0-85. Office of Solid Waste and Emergency Response. December 2005.



H:\Syracuse1\CAD Projects\010139-ONONDAGA_LAKE\01013902\Figures\Construction Monitoring\FCF RA-B\RA-B Modified Protective Caps (11-02-15).dwg RA-B

Nov 02, 2015 5:03pm cyard

SOURCE: Exg-Lake, RAB Sevenson Pre-Final
HORIZONTAL DATUM: New York State Plane, Central Zone, North American Datum 1983 (NAD83), U.S. Feet
VERTICAL DATUM: North American Vertical Datum 1988 (NAVD88)

LEGEND:
Shoreline (elev. 362.5')
20-foot Post Dredge Depth Contour (elev. 342.5')

0 200
Scale in Feet

ANCHOR QEA

Figure 1
Modified Protective Caps
Remediation Area B
Onondaga Lake

ATTACHMENT 1

MODIFIED PROTECTIVE CAP RA-B-1
GEOTECHNICAL ANALYSIS

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

REVISION 2
SLOPE STABILITY ANALYSIS
FOR CAP PLACEMENT IN MODIFIED PROTECTIVE CAP AREA RA-B-1

This report evaluates the geotechnical aspects of a modified protective cap (MPC) in Remediation Area B (RA-B) for various sequential cap lift placement configurations. The results of slope stability analyses showed that a MPC design in this area would consist of various cap thicknesses in various sub-areas, as shown in Figure 15. The slope stability analyses presented herein accounts for the increase in strength of soft sediments in a normally consolidated state with time due to consolidation under the cap loading. Therefore, one or two week waiting periods between placements of the lifts were evaluated in this analysis. These prescribed waiting periods will be required during construction. The strength and stability of the underlying sediment will continue to increase with time following construction. Longer wait time between cap placements would not improve the undrained shear strength of deeper sediments (which the controlling slip surfaces pass through) and thus, would not increase the calculated factor of safety. The MPC design in RA-B (RA-B-1) will be protective consistent with the intent of the Remedial Design, which will be documented in a separate submittal to the New York State Department of Environmental Conservation (NYSDEC).

INTRODUCTION

For a capping project of the scale of Onondaga Lake Remediation, it is not unusual to expect previously unforeseen field conditions in small areas that may warrant adjustments to the cap system to achieve the remedial goals for the project. Evaluation of recently collected sediment strength data in RA-B indicates that the sediments in portions of RA-B are significantly softer than anticipated based on pre-design investigations [Geosyntec, 2015b]. Therefore, modification of the cap designs detailed in the *Onondaga Lake Capping, Dredging, Habitat, and Profundal Zone Final Design* (Final Design) submittal in March 2012 is appropriate in small portions of RA-B.

This slope stability calculation package was prepared in support of the cap stability evaluation and development of MPCs in RA-B. The location of RA-B in Onondaga Lake is shown in Figure 1. The areas where MPCs are being developed in RA-B are referred to as modified cap areas RA-B-1A through RA-B-1F.

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Sediment capping operations have been underway in Onondaga Lake since August 2012. The primary functions of the cap materials are to provide chemical and physical isolation for contaminated sediments and to reconstruct the habitat layer on the lake bottom. A portion of contaminated materials in RA-B have been dredged prior to capping to provide adequate post-construction water depth to achieve habitat objectives; these areas are referred to as "dredge and cap areas". A portion of contaminated materials in RA-B is to be capped with no dredging; these areas are referred to as "cap-only areas."

This report evaluates the interim geotechnical slope stability condition of the cap after each cap lift is placed under a variety of cap placement configurations in the cap-only and dredge and cap areas. Practical cap lift thicknesses, based on input from the capping operations team, which are considered in this evaluation include:

- an average 2-in. lift of sand;
- an average 4.5-in., 6-in., or 7.5-in. lift of sand (i.e., minimum of 3-in., 4.5-in., or 6-in. lifts, respectively) including a typical 1.5 in. of over-placement;
- an average 10-in. lift of fine gravel (i.e., minimum of 6-in. lift) including a typical 4 in. of over-placement; and
- an average 12-in. lift of coarse gravel (i.e., minimum of 6-in. lift) including a typical 6 in. of over-placement.

In this analysis, Cap Type J includes a minimum of 6 inches of siderite mixed with medium sand, 9 inches of granular activated carbon (GAC) mixed with medium sand, and 12 inches of medium sand.

Cap Type H includes a minimum of 6 inches of siderite mixed with medium sand, 9 inches of GAC mixed with medium sand, and 18 inches of fine gravel.

Cap Type L includes a minimum of 6 inches of siderite mixed with medium sand, 9 inches of GAC mixed with medium sand, 12 inches of coarse gravel, and 12 inches of fine gravel.

SLOPE STABILITY ANALYSES

The slope stability analyses were performed using Janbu's simplified method [Janbu, 1973] for block failure slip surfaces and Spencer's method [Spencer, 1973] for the circular slip surfaces, as implemented in the computer program SLIDE, version 6.026 [Rocscience, 2013]. Spencer's method, which satisfies vertical and horizontal force equilibrium and moment equilibrium, is considered to be more rigorous than other methods, such as Janbu's simplified method [Janbu, 1973] and the simplified Bishop's method [Bishop, 1955]. However, Spencer's method often encounters numerical convergence difficulties when considering block slip surfaces. Therefore, Spencer's method was used for the circular slip surfaces, while Janbu's method was used for block slip surfaces.

The rotational and block modes of slope stability analyses are consistent with the methods presented in the RA-C-1 Report [Geosyntec, 2015a].

Target Factor of Safety

Consistent with the RA-C-1 Report [Geosyntec, 2015a], a target FS of 1.5 was selected for the analyses presented herein. The target FS (1.5) for the slope stability analysis of the cap is consistent with the target FS selected for previous slope stability analyses, including the FS used for stability analysis of the In-lake Waste Deposit (ILWD) area included as Appendix H to the Final Design. The FS of 1.5 for the ILWD stability analysis was specified in the Statement of Work included as part of the Remedial Design/Action Consent Decree for the lake. Given the potential implications of additional cap movement, as demonstrated by the prior areas of cap movement, a FS of 1.5 is appropriate for this analysis consistent with prior stability analysis associated with the remediation design.

Subsurface Stratigraphy

Because the sediments in RA-B are soft, undisturbed samples could not be collected in the field and tested in the laboratory for measuring the shear strength and consolidation properties. Therefore, the information regarding the subsurface stratigraphy was obtained from in situ field testing techniques, including the Cone Penetrometer Test (CPT) and Full-Flow Penetrometer Test (FFP). It should be noted that the FFP is generally more accurate than the CPT for assessing the low shear strength of soft sediments. Therefore, only the results of FFP tests are presented in this report.

The locations of in situ tests within RA-B are presented in Figure 2. These in situ tests provided information to characterize the in situ shear strength and consolidation properties of the soft sediments within different regions of RA-B. In 2013, twelve FFPs (PRO-FFP-B1, B2, B3, B3A, B4, B4A, B5, B6, B6A, B7, B7A, and B8) and three CPTs (PRO-CPTu-B2, B3, and B4) were advanced. In May 2015, fifteen FFPs (FFP-15-B1 to B15), four CPTs (FFP-15-B1-CPT, B4-CPT, B7-CPT, and B12-CPT), and three vibracores (FFP-15-B4-VC, B7-VC, and B11-VC) were conducted in the cap-only area of RA-B. The FFP results and selected shear strength profiles for slope stability analyses are shown in Figures 3 to 8.

In selection of the shear strength profiles and subsurface stratigraphy, the effect of creep behavior, as stated in Geosyntec (2015b), was considered. The effect of creep behavior on slope stability was addressed within the target FS of 1.5 and the selection of lower bound values for undrained shear strength of the sediments. The target FS and lower shear strength values are expected to result in relatively low stress level (induced by capping load) along the predicted failure surfaces and reduce the likelihood of the creep behavior and reduction in the undrained shear strength with time.

For Cross Section A, the shear strength profile and subsurface model were developed using the collected FFP data, as presented in Figure 3. The presence of a weak layer was captured in the FFP data collected near the cross section.

For Cross Section B, the shear strength profile and subsurface model were developed using the collected FFP data, as presented in Figure 4. CPT-15-B7 and PRO-FFP-B2 captured the weak sediment layer at the depth of 12 to 20 ft below the lake-bottom. Other FFPs near this cross section reached refusal in shallower depths, so the shear strength for the deeper sediments could not be evaluated. Therefore, a weak layer with an undrained shear strength of 50 psf between depths of 12 and 20 ft below the lake-bottom was considered.

For Cross Section C, the shear strength profile and subsurface model were developed using the collected FFP data, as presented in Figure 5. FFP-15-B8, FFP-15-B6, and FFP-15-B15 exhibited the weak layer as modeled in the slope stability analyses.

For Cross Section D, the shear strength profile and subsurface model were developed using the collected FFP data, as presented in Figure 6. PRO-FFP-B6, PRO-FFP-B6A, and FFP-15-B5 exhibited a weak sediment layer extended to about 10 to 12 ft below the lake-bottom. A weak layer with an undrained shear strength of 20 psf was modeled in the slope stability analysis, as shown in Figure 6, to account for the extent of this weak sediment.

For Cross Sections E and F, the shear strength profiles and subsurface models were developed using the collected FFP data, as presented in Figures 7 and 8.

The development of geotechnical parameters used for the lakebed sediments is described in a separate Geosyntec report submitted to NYSDEC [Geosyntec 2015b].

GEOTECHNICAL STABILITY EVALUATION

Shear Strength Gain

The shear strength gain caused by an increase in vertical effective stress (in this case, as a result of cap placement) is proportional to the degree of consolidation. The shear strength gain considered in the analyses for RA-B-1 was consistent with the method described in the report titled "Development of Geotechnical Design Parameters for Lakebed Sediments in Onondaga Lake Capping Areas" [Geosyntec, 2015b].

In general, the strength gain of sediments deeper than 6 ft below the lake bottom was neglected due to the long drainage path and negligible degree of consolidation for the practical few-week wait periods. The normally consolidated and over-consolidated state of the lakebed sediments were considered in slope stability analyses and developed based on the method described in Geosyntec [2015b]. The normally and over-consolidated sediments are noted in Figures 3 to 8.

Geotechnical Parameters

The material properties used for the geotechnical slope stability analyses in this report are presented in Table 1 and Figures 3 to 8. In summary, the subsurface materials in the modified protective cap area RA-B-1 consist of three strata: Soft Sediments, Marl, and Silt and Clay. Soft Sediments extend to depths of about 10 to 20 ft. Marl lies between depths of 20 and 60 ft. Silt and Clay is below depths of 60 ft.

Geotechnical parameters of lakebed sediments are described in Geosyntec report [2015b].

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

ANALYZED CROSS SECTIONS

Six cross sections in RA-B-1 were selected as critical cross sections for slope stability analyses in various areas of RA-B-1 (Figure 2). These cross sections were developed to represent the stability conditions in each modified protective cap area RA-B-1A to RA-B-1F. Figures 3 to 8 show the bathymetry, subsurface conditions, and selected strength profiles for these cross sections.

RESULTS OF SLOPE STABILITY ANALYSES

Figures 9 to 14 show the shapes of failure surfaces and minimum calculated FS at the current condition (i.e., prior to cap placement) and after each stage of cap placement.

For cross section A, predicted failure surfaces are shown in Figure 9 and the minimum calculated FS for placement of Cap Type J are listed in the table below.

Lift	Existing	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5	Lift 6 with 110 ft Setback		
Average Cap Thickness (in.)	-	4.5	4.5	6.0	7.5/6*	7.5	7.5		
Wait Before Placement (week)	-	-	1	1	1	1	1	2	1
Feathering or Setback (ft)	-	-	20	20	20	20	20	20	110
Calculated Minimum FS	3.17	1.61	1.84	1.67	1.51	1.50	1.38	1.39	1.51
Recommended for Placement	-	X	X	X	X	X	-	-	X

* The first value is the lift thickness in the 110-ft setback area and the second value is the lift thickness in the upslope area of the setback in Figure 9.

Therefore, six lifts of cap (two average 4.5 in. + two average 6.0 in. + two average 7.5 in. lifts) with a one-week wait between lifts and five lifts of cap (two average 4.5 in. + one average 6.0 in. + two average 7.5 in. lifts) within the 110-ft setback presented in the table above and Figure 9 are recommended. The 20-ft feathering is required to maintain a FS of 1.5 after Lift 5. With the exception of the 110-ft setback area for the final lift, this design is consistent with the original full-thickness cap design in this area. It should be noted that the required setback of 110 ft for Lift 6 is due to the presence of a deep weak layer of soft sediments with an undrained shear strength of 40 psf, as shown in Figure 3. This set back is required to obtain a minimum calculated FS of 1.5. A smaller setback results in a FS below the target FS of 1.5.

The area of setback (as shown in Figure 9) was reevaluated for placement of five cap lifts including a minimum of 3 in. (average 4.5 in.) of siderite, 7.5 in. (average 10.5 in.) of GAC, and 12 in. (average 15 in.) of medium sand habitat layer. Additional analyses were also performed to check the FS for Lift 3 in the setback area and if the thickness can be increased from 6 in. to 7.5 in. The calculated FS dropped to 1.42 when a 7.5 in. lift is placed for Lift 3. Therefore, this alternative is not feasible.

In general, the calculated failure surfaces are within the upper zone of the soft sediments (i.e., depths of 2 to 4 feet) or deeper weak layer of soft sediments with an undrained shear strength of 40 psf (i.e., depths of 8 to 14 ft).

In the slope stability analysis presented in this report, various feathering and setback configurations were considered to place the maximum cap thickness with a calculated FS above the target FS of 1.5. For example, in Cross Section A, cap placement has been extended further outside and downslope of the cap-only area (into SMU-8) to achieve the original design thickness within the boundary of the cap-only area. The site investigation program conducted in SMU-8 [Geosyntec, 2015c] has shown that sediments are extremely soft in SMU-8 which would impact the cap stability. Therefore, the extension of cap was limited to about 80 ft into SMU-8.

For cross section B, predicted failure surfaces are shown in Figure 10 and the minimum calculated FS for placement of Cap Type J are listed in the table below.

Lift	Existing	Lift 1	Lift 2	Lift 3	Lift 4
Average Cap Thickness (in.)	-	4.5	4.5	4.5	4.5
Wait Before Placement (week)	-	-	2	2	2
Feathering or Setback (ft)	-	-	20	50	20
Calculated Minimum FS	1.95	1.50	1.52	1.61	1.50
Recommended for Placement	-	X	X	X	X

Therefore, four lifts of cap with an average of 4.5 in. per lift with a two-week wait between each lift and the setbacks presented in the table above and Figure 10 are recommended. It should be noted that the requirement for the reduced thickness and setback for Lift 3 and Lift 4 is due to the presence of soft sediments with undrained shear strengths of 10 to 30 psf in the top 6 ft and the presence of a weak deep layer of sediment with an undrained shear strength of 50 psf on relatively steeper areas along Cross Section B, as shown in Figure 4. Since the failure surface for Lift 4 is relatively deep, additional wait times more than 2 weeks have a negligible improvement on the calculated factor of safety.

Written by:	**C. Carlson/M. Erten**	Date:	**11/6/2015**	Reviewed by:	**A. Ebrahimi/ J. Beech**	Date:	**11/6/2015**
Client:	**Honeywell**	Project:	**Cap Placement in Modified Protective Cap Area RA-B-1**	Project No.:	**GD5837**	Task No.:	**03**

In general, the calculated failure surfaces are within the upper zone of the soft sediments (i.e., depths of 2 to 4 feet) or deeper weak layer of soft sediments (i.e., depths of 8 to 14 ft). Also, further extension of the cap downslope of cap-only area beyond 70 ft was not considered due to the presence of very soft sediments in SMU-8.

For cross section C, predicted failure surfaces are shown in Figure 11 and the minimum calculated FS for placement of Cap Type J are listed in the table below.

Lift	Existing	Lift 1		Lift 2		Lift 3	Lift 4
Average Cap Thickness (in.)	-	4.5	2	2	2	2	2
Wait Before Placement (week)	-	-	-	2	2	2	2
Feathering or Setback (ft)	-	-	-	50	170	20	20
Calculated Minimum FS	1.68	1.35	1.52	1.41	1.52	1.50	1.50
Recommended for Placement	-	-	X	-	X	X	X

Therefore, four lifts of cap with an average of 2.0 in. per lift with a two-week wait between each lift and the setbacks presented in the table above and Figure 11 are recommended for Cap Type J. It should be noted that the required setback of 120 ft for Lift 2 and 50-ft extension into SMU-8 (total setback of 170 feet) is due to the presence of a deep weak layer (8-10 ft deep) of soft sediments with an undrained shear strength of 25 psf as shown in Figure 5. Also, further extension of cap downslope of the cap-only area was not considered since the predicted failure surfaces do not extend beyond the downslope boundary of recommended cap placement (i.e., additional extension would not improve the calculated FS). The 120-ft setback is extended to the area along the cross section where over-consolidated sediments (Figure 5) is present. Therefore, implementation of a toe berm was not considered practical in this area.

For Cap Type H, four lifts of cap (one average 4.5 in. sand/siderite + two average 6 in. of GAC + one average 16 in. of fine gravel lifts) with a two-week wait after Lifts 1 and 2 (Figure 11) are recommended. The calculated FS for the placement of Lift 4 in Cap Type H with 16 inches of fine gravel is 1.52 (see Figure 11). Placement of additional fine gravel in this section results in calculated FS that are less than the target FS of 1.5. This recommendation results in a minimum of 3 inches of sand/siderite layer, 9 in. of GAC layer, and 12 in. of fine gravel layer.

The calculated failure surfaces in Cross Section C, in general, extend 8-10 ft below the mudline (Figure 11), where the strength gain with additional wait time is considered negligible for the slope stability analyses. Therefore, extending the wait time between lift placements to 2 weeks would have minimal benefit in this area.

For cross section D, predicted failure surfaces are shown in Figure 12 and the minimum calculated FS for placement of Cap Type J are listed in the table below.

Lift	Existing	Lift 1	Lift 2		Lift 3		Lift 4
Average Cap Thickness (in.)	-	4.5	4.5	3	3	4.5	4.5
Wait Before Placement (week)	-	-	2	2	1	1	1
Feathering or Setback (ft)	-	-	20	20	20	100	20
Calculated Minimum FS	1.83	1.61	1.46	1.50	1.28	1.50	1.46
Recommended for Placement	-	X	-	X	-	X	-

Therefore, three lifts of cap (one average 4.5 in. + one average 3.0 in. + one average 4.5 in. lifts) with a two-week wait between the placement of Lifts 1 and 2 and a one-week wait between each subsequent lift and the setbacks presented in the table above and Figure 12 are recommended. It should be noted that the required setback of 100 ft for Lift 3 is due to the presence of a deep weak layer of soft sediments with an undrained shear strength of 20 psf, as shown in Figure 6. Also, further extension of cap downslope of the cap-only area was not considered due to the presence of the deep weak layer of soft sediments. The setback of 100 ft is extended to the area along the cross section where over-consolidated sediments (Figure 6) are present. Therefore, implementation of a toe berm was not considered practical in this area.

For Cap Type H, three lifts of cap (one average 4.5 in. sand/siderite + one average 6 in. of GAC + one average 16 in. of fine gravel lifts) with a two-week wait between the placement of Lifts 1 and 2 and a one-week wait between each subsequent lift (Figure 12) are recommended. Placement of additional fine gravel in Cap Type H results in calculated FS less than the target FS of 1.5.

For Cap Type L, four lifts of cap (one average 7.5 in. sand/siderite + one 10.5 in. of GAC + one average 18 in. of coarse gravel + one average 16 in. of fine gravel lifts) with a setback of 20 ft presented in Figure 12 are recommended. A setback of 10 ft for Lift 4 in Cap Type L resulted in a FS of 1.45, which is less than the target FS of 1.5.

The calculated failure surfaces in Cross Section D, in general, extend 8-10 ft below the mudline (Figure 12), where the strength gain is considered negligible for the slope stability analyses. Therefore, extending the wait time between lift placements to 2 weeks would have minimal benefit in this area.

For cross section E, predicted failure surfaces are shown in Figure 13 and the minimum calculated FS for placement of Cap Type J are listed in the table below.

Lift	Existing	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5	Lift 6
Average Cap Thickness (in.)	-	4.5	4.5	4.5	7.5	7.5	7.5
Wait Before Placement (week)	-	-	1	1	1	1	1
Feathering or Setback (ft)	-	-	20	20	20	20	20
Calculated Minimum FS	2.78	2.22	2.00	1.68	1.60	1.50	1.41
Recommended for Placement	-	X	X	X	X	X	-

Therefore, five lifts of cap (three average 4.5 in. + two average 7.5 in. lifts) with a one-week wait between each lift and the setbacks presented in the table above and Figure 13 are recommended. The shallow sediments in this area are over-consolidated; therefore, an increase in wait time does not translate to an increase in the undrained shear strengths and thus, calculated FS. It should be noted that the failure surface for Lift 6 is due to the presence of a deep weak layer of soft sediments with an undrained shear strength of 40 psf, as shown in Figure 7. Longer wait time between cap placements would not improve the undrained shear strength of deeper sediments and therefore calculated factor of safety.

For Cap Type H, five lifts of cap (two average 4.5 in. sand/siderite + two average 6 in. of GAC + one average 16 in. of fine gravel lifts) with a one-week wait between the lift placements (Figure 13) are recommended. Placement of additional fine gravel (i.e., 18 in Cap Type H) in this section results in calculated FS less than the target FS of 1.5.

For Cap Type L, four lifts of cap (one average 7.5 in. sand/siderite + one average 10.5 in. of GAC + one average 18 in. of coarse gravel + one average 16 in. of fine gravel lifts) with a setback of 50 ft presented in Figure 13 are recommended. A setback of 40 ft for Lift 4 in Cap Type L resulted in a calculated FS less than the target FS of 1.5.

In general, the calculated failure surfaces are within the upper zone of the soft sediments (i.e., depths of 2 to 4 feet) or deeper soft sediments (i.e., depths of 8 to 14 ft). Also, further extension of cap downslope of the cap-only area (beyond the 80 ft. recommended) was not considered due to the presence of very soft sediments in SMU-8.

For cross section F, predicted failure surfaces are shown in Figure 14 and the minimum calculated FS for placement of Cap Type J are listed in the table below.

Lift	Existing	Lift 1	Lift 2	Lift 3			Lift 4	Lift 5	Lift 6
Average Cap Thickness (in.)	-	4.5	5.5	6	6	6	6	7.5	7.5
Wait Before Placement (week)	-	-	1	1	2	1	1	1	1
Feathering or Setback (ft)	-	-	10	10	10	10	10	20	20
Cap Placement	-	Above El. 340 ft				Below El. 340 ft			
Calculated Minimum FS	2.08	2.09	1.52	1.24	1.24	1.57	1.57	1.57	1.57
Recommended for Placement	-	X	X	-	-	X	X	X	X

Therefore, one average 4.5-in.+ one average 5.5 in. cap lifts with a one-week wait between lifts are recommended in the area with bathymetry elevation above 340 ft. Placement of two average 4.5-in.+ one average 3.0 in. cap lifts with one-week wait between lifts results in a calculated FS of 1.4, which is less than the target FS of 1.5.

Six lifts of cap (two average 4.5-in. + two average 6-in. + two average 7.5-in. cap lifts) with a one-week wait between each lift and the setbacks presented in the table above and Figure 14 are recommended in the area with bathymetry elevation below 340 ft. The recommendations below bathymetry 340 ft are consistent with the original full-thickness cap design in this area. It should be noted that the reduced cap thickness for elevations above 340 ft is due to the presence of shallow soft sediments with undrained shear strength of 20 to 40 psf on a relatively steep slope in this area, as shown in Figure 8.

In general, the calculated failure surfaces are within the upper zone of the soft sediments (i.e., depths of 2 to 4 feet) or deeper soft sediments (i.e., depths of 8 to 14 ft). Longer wait times between cap placements would not improve the undrained shear strength of the deeper sediments and thus, the calculated FS.

The cap placement procedure in RA-B-1 includes a verification of successful placement of each lift by the operations team through methods such as coring prior to proceeding with the subsequent lift. However, the monitoring and verification of successful lift placement will not provide information regarding whether additional lift placements would be stable, it only verifies that it was stable for what was already placed. Therefore, real time monitoring would not allow additional cap material to be placed.

Other engineering methods to improve stability and allow additional cap material placement, such as toe berms and keyways, were considered. However, the critical slip surfaces are large and deep along the relatively continuous steep slope areas in RA-B that could not potentially be targeted for methods such as toe berms and keyways. Therefore, implementation of these methods would not be practical for this area.

It should be noted that the potential for creep behavior (as stated in Geosyntec 2015b) would be offset by the strength gain due to consolidation with time, resulting in an increase in the calculated FS over time. Additional long-term analysis of slope stability for a representative cross section (Cross Section E) was conducted. The calculated FS for the long-term condition (after consolidation of sediments under the cap loading is completed) in Cross Section E is 1.92 (compared to the calculated FS of 1.5, immediately after the cap placement). Also, the long-term presence and performance of the cap throughout the lake, including the MPC areas, will be verified as part of the long-term cap monitoring program.

CONCLUSIONS

The results of the slope stability analyses for the placement of multiple lifts of cap with a one or two-week wait between lifts show that in general:

- the calculated FS at current condition in various areas of RA-B-1 varies between 1.68 and 3.17; and

- in several areas in RA-B, a reduction in cap thickness in Cap Types J, H, and L from that detailed in the Final Design is required to result in a calculated FS that can be considered sufficient.

Figure 15 shows the recommendation for cap placement in the modified protective cap area RA-B-1.

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Table 1. Summary of Material Properties for the Slope Stability Analysis in Modified Protective Cap area RA-B-1

Material	Total Unit Weight (pcf)	Undrained Shear Strength, s_u (psf)
Soft Sediments	85	Selected as shown in Figures 3 through 8
Marl	100	220, for depth < 30 ft 440, for depth ≥ 30 ft
Silt and Clay	110	$\frac{s_u}{\sigma_v'} = 0.3$

Written by:	**C. Carlson/M. Erten**	Date:	**11/6/2015**	Reviewed by:	**A. Ebrahimi/ J. Beech**	Date:	**11/6/2015**
Client:	**Honeywell**	Project:	**Cap Placement in Modified Protective Cap Area RA-B-1**	Project No.:**GD5837**		Task No.:	**03**

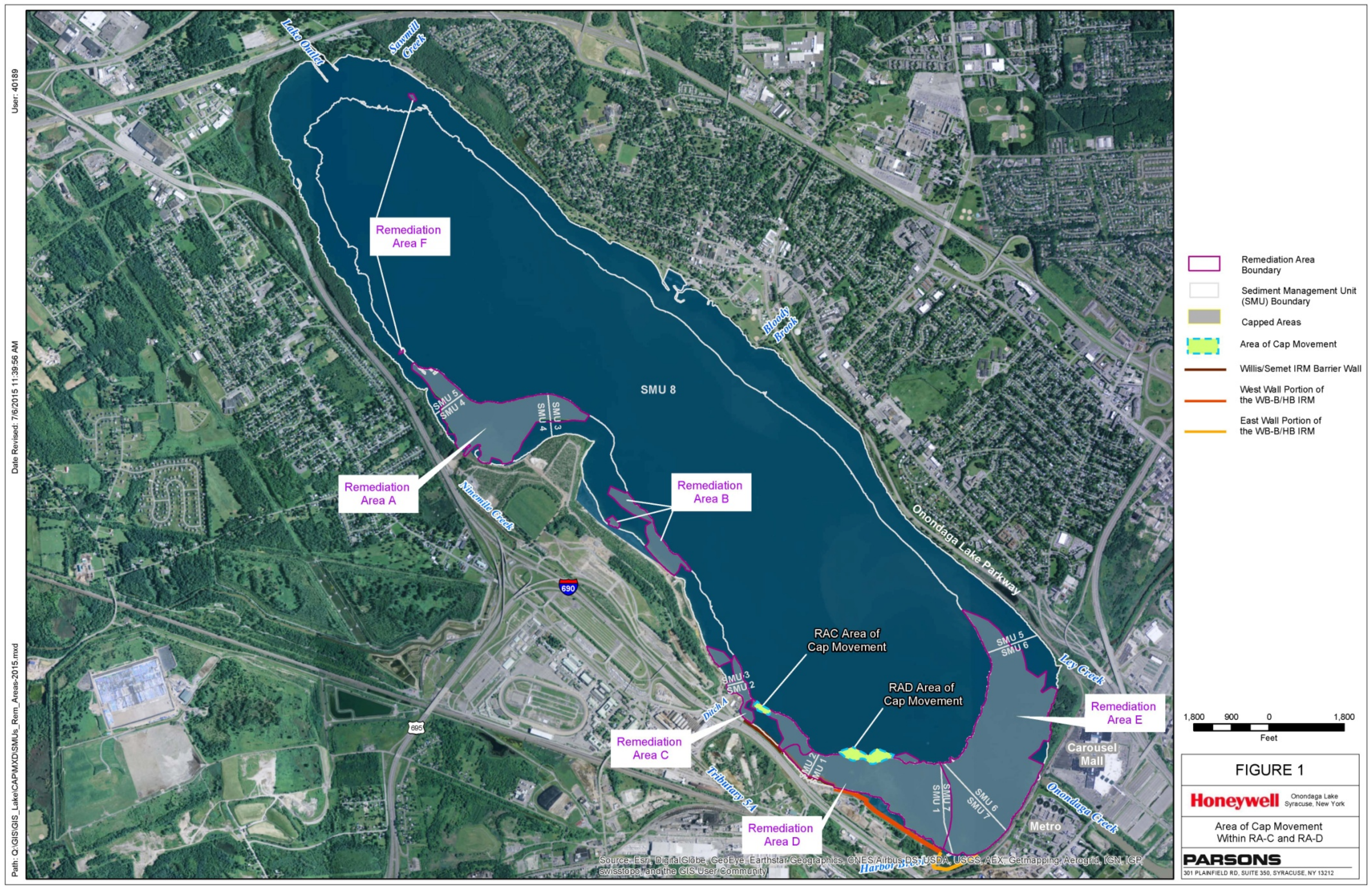

Figure 1. Remediation Area B (RA-B) among other Remediation Areas in the Onondaga Lake Capping Project

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
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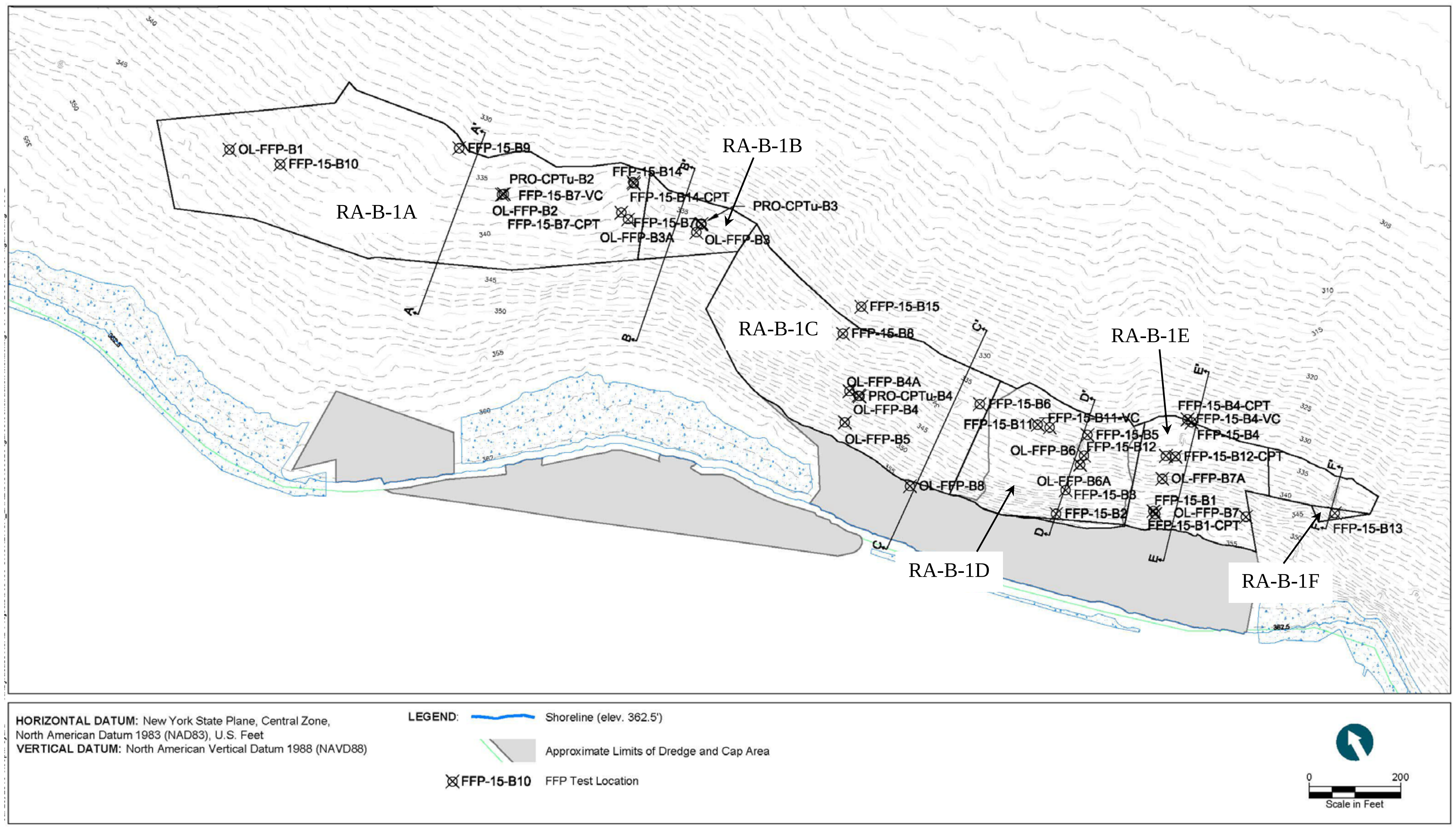

Figure 2. Map of modified protective cap area RA-B-1. This map also shows locations of in situ FFP and CPT tests and the six analyzed cross sections.

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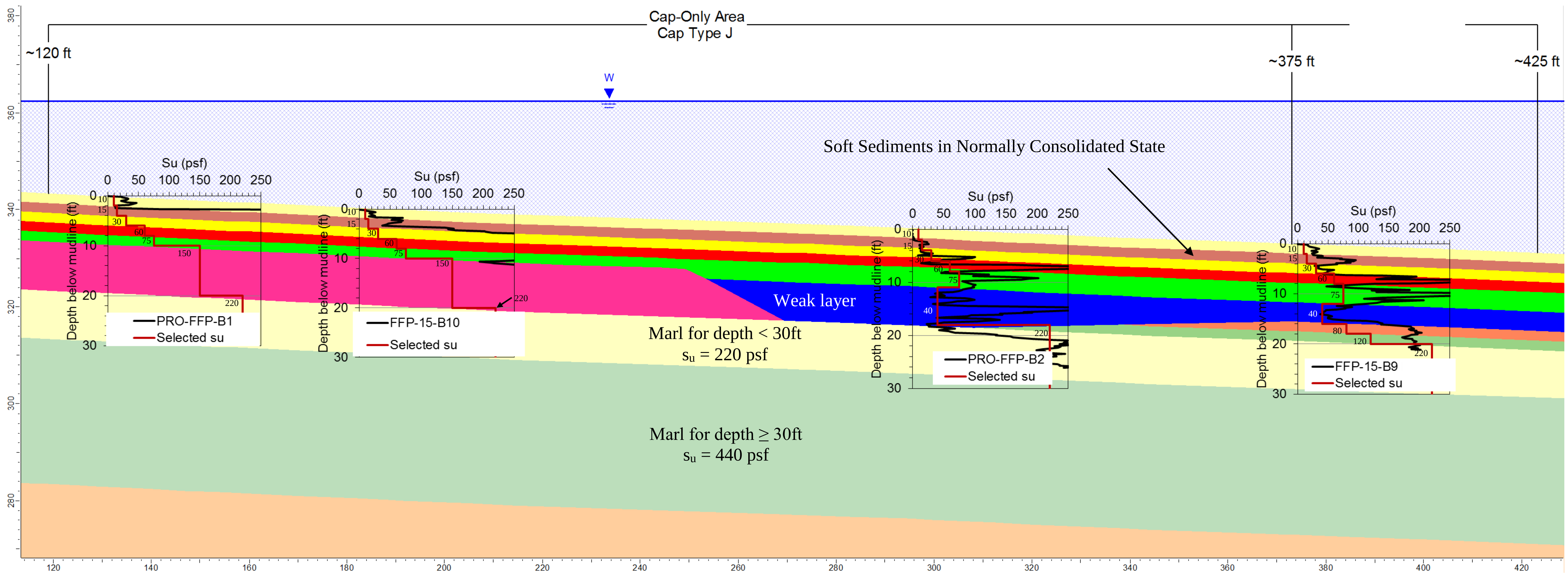

Figure 3. Subsurface stratigraphy and shear strength (s_u) profiles from the FFPs collected near Cross Section A. The values on the profiles show the selected shear strengths in psf.

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Client:	**Honeywell**	Project:	**Cap Placement in Modified Protective Cap Area RA-B-1**	Project No.:	**GD5837**	Task No.:	**03**

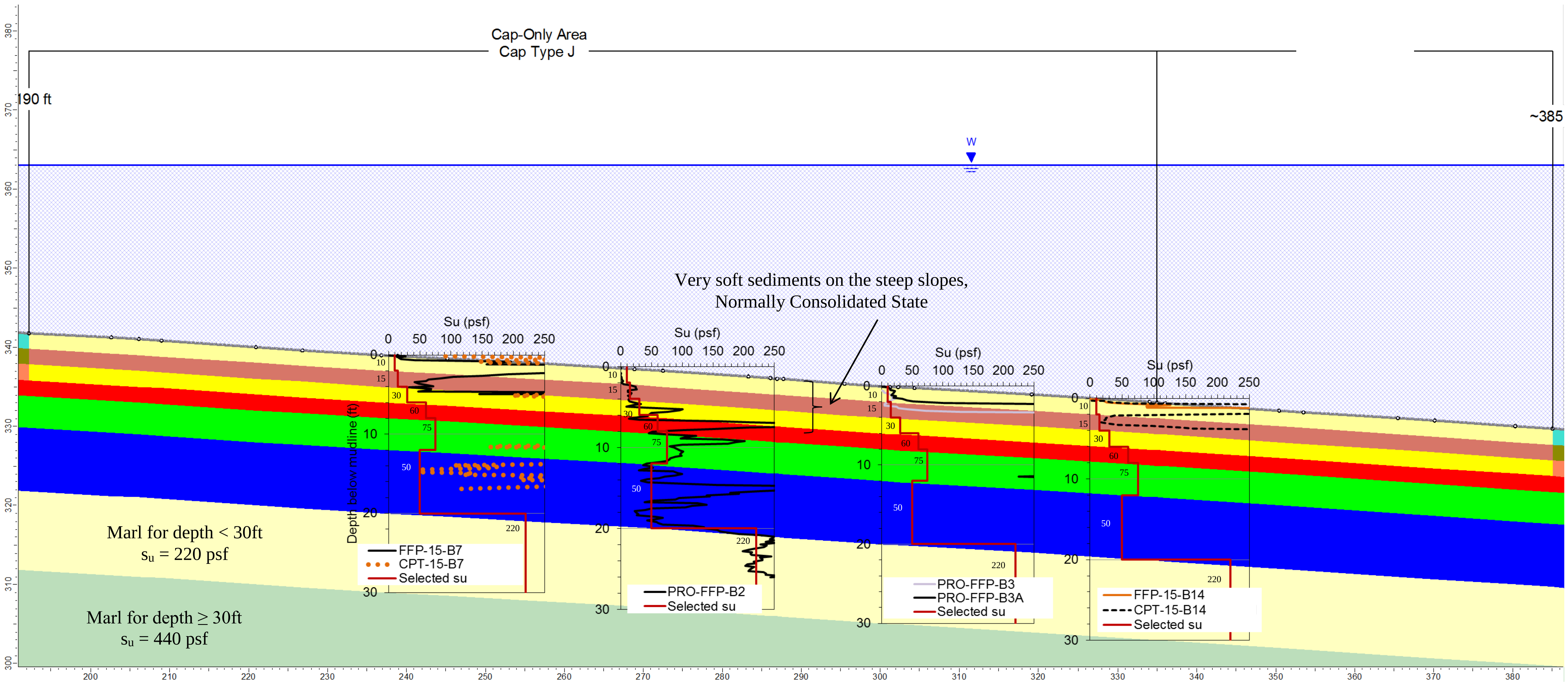

Figure 4. Subsurface stratigraphy and shear strength (s_u) profiles from the FFPs collected near Cross Section B

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Client:	**Honeywell**	Project:	**Cap Placement in Modified Protective Cap Area RA-B-1**	Project No.:	**GD5837**	Task No.:	**03**

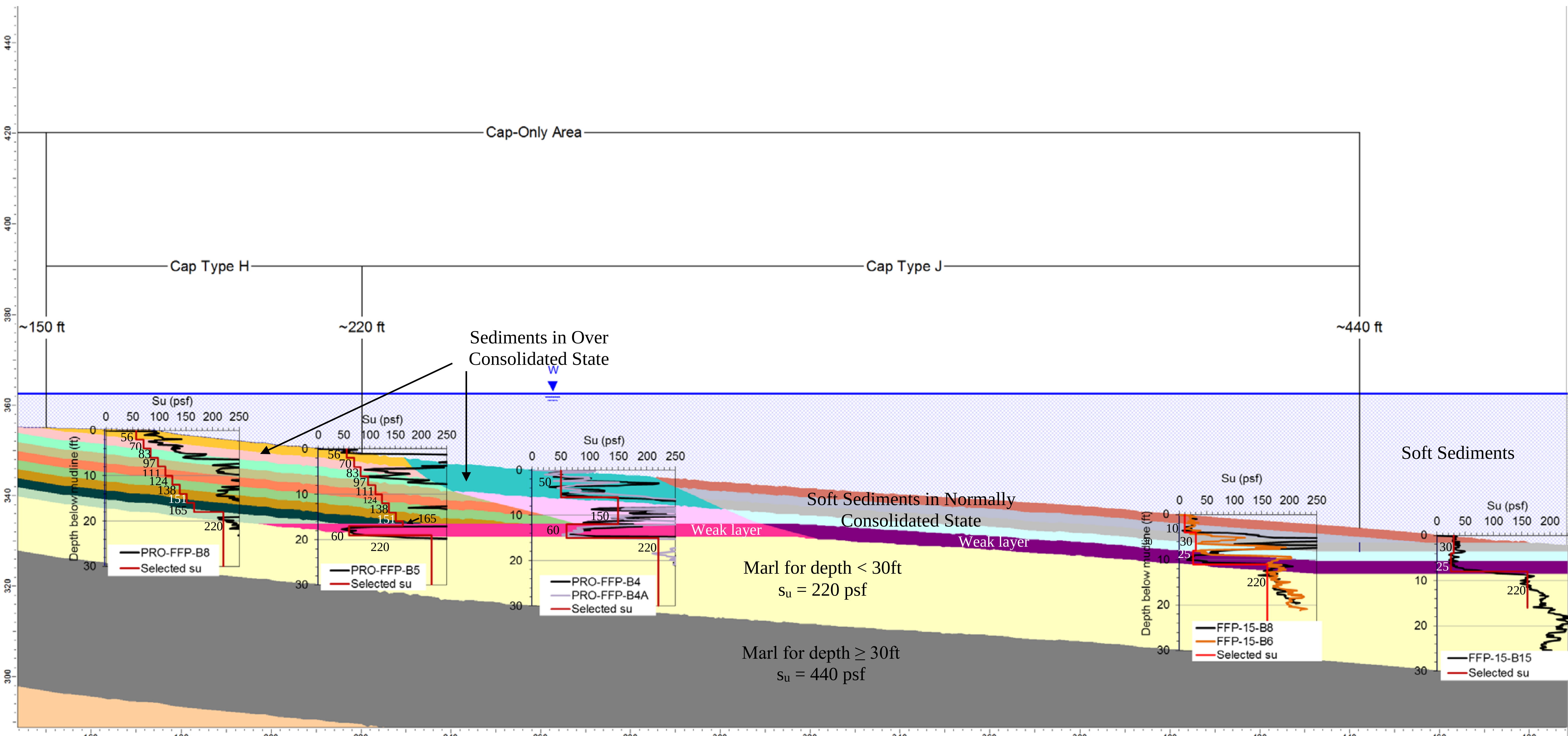

Figure 5. Subsurface stratigraphy and shear strength (s_u) profiles from the FFPs collected near Cross Section C

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:GD5837		Task No.:	03

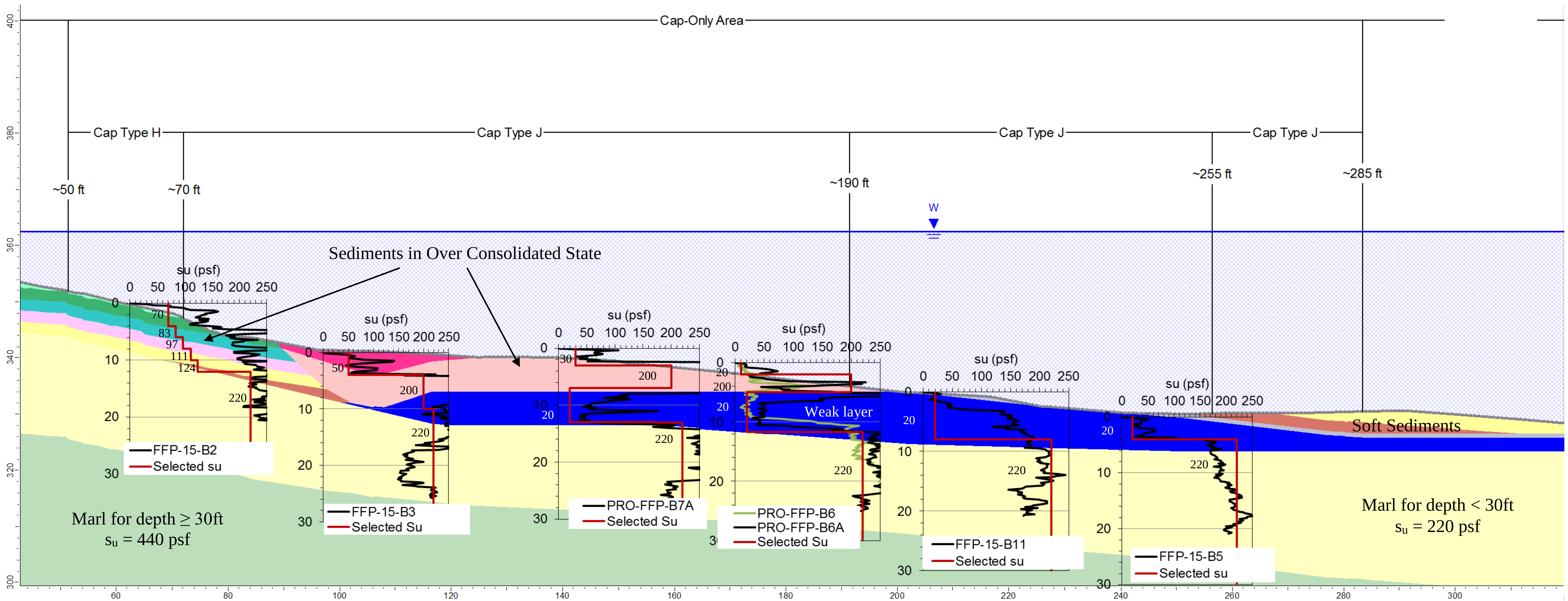

Figure 6. Subsurface stratigraphy and shear strength (s_u) profiles from the FFPs collected near Cross Section D

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

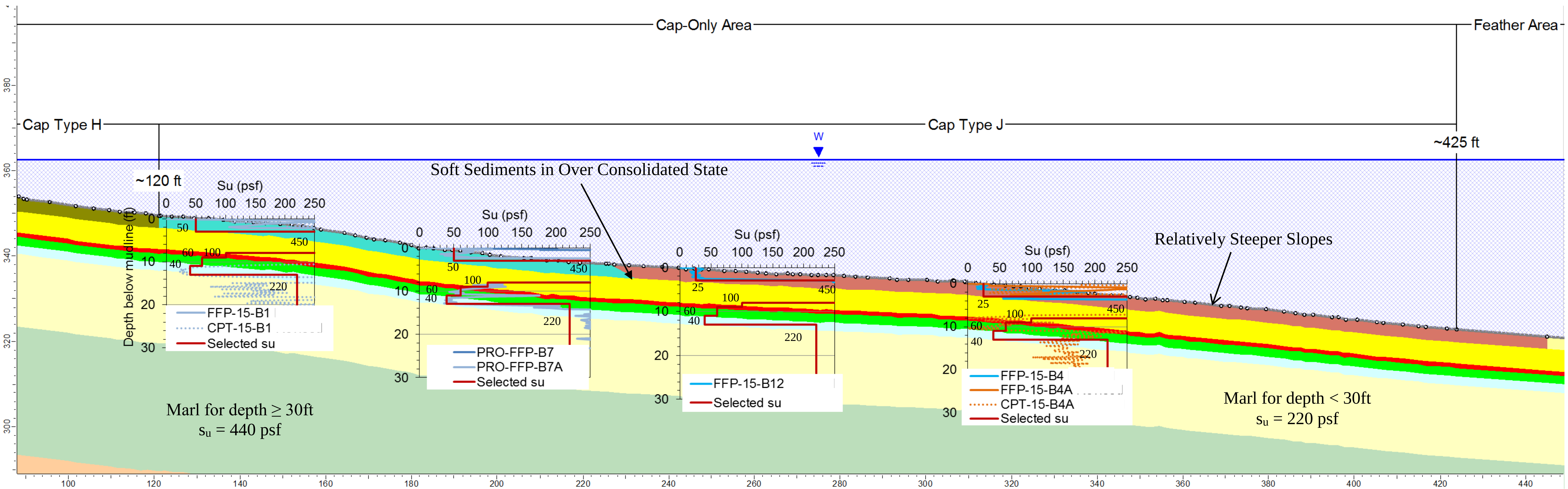

Figure 7. Subsurface stratigraphy and shear strength (s_u) profiles from the FFPs collected near Cross Section E

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

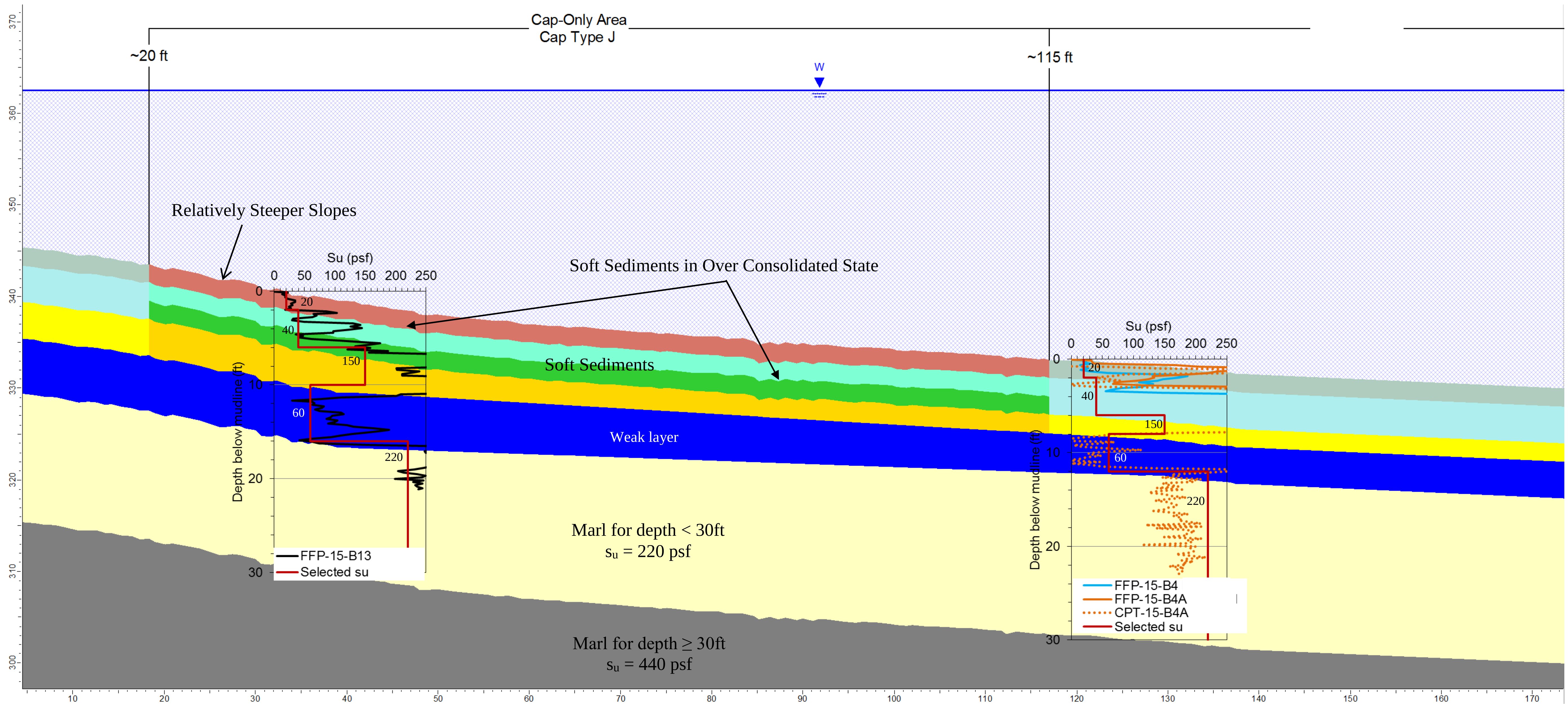

Figure 8. Subsurface stratigraphy and shear strength (s_u) profiles from the FFPs collected near Cross Section F

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Written by: C. Carlson/M. Erten Date: 11/6/2015 Reviewed by: A. Ebrahimi/ J. Beech Date: 11/6/2015

Client: Honeywell Project: Cap Placement in Modified Protective Cap Area RA-B-1 Project No.:GD5837 Task No.: 03

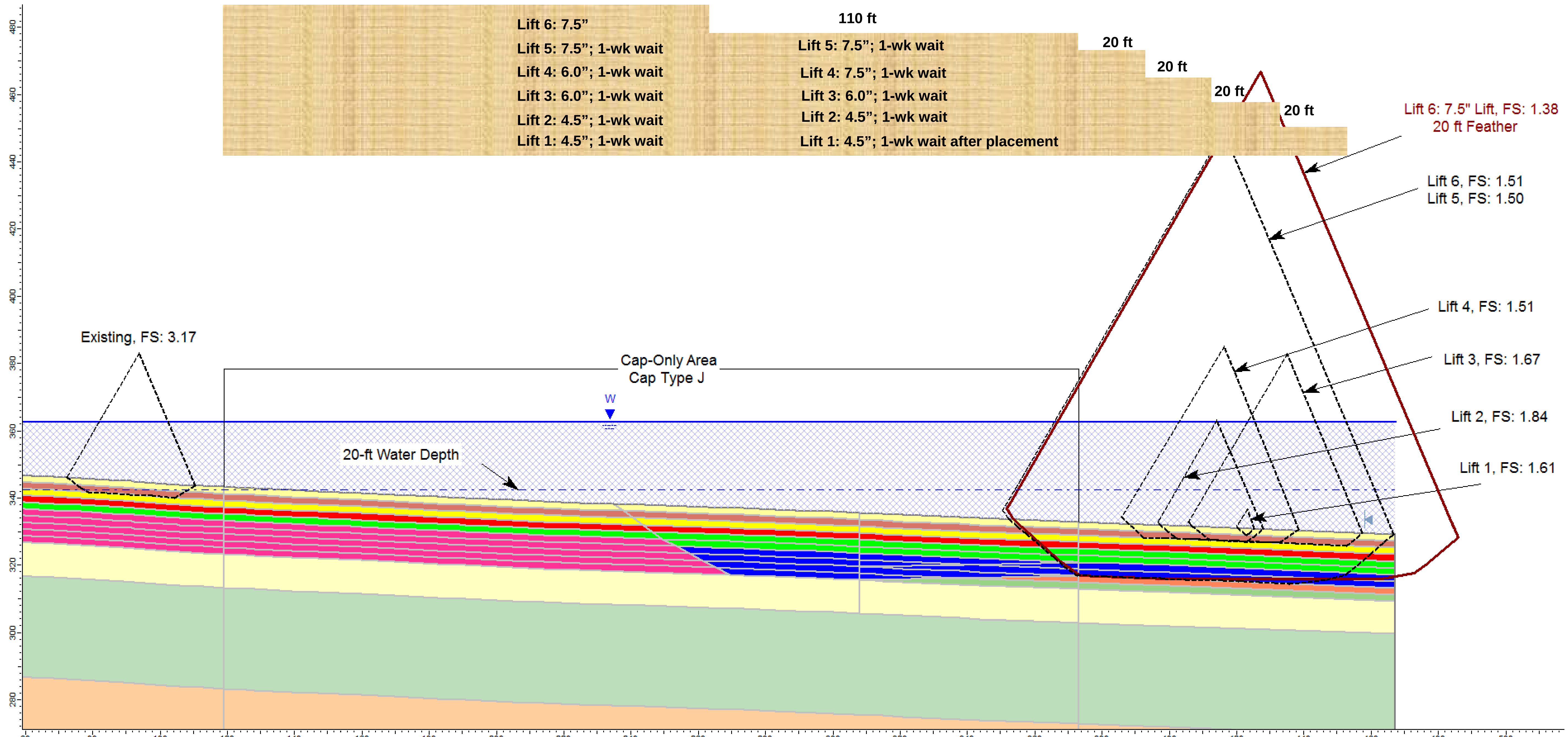

Figure 9. Calculated factors of safety and critical slip surfaces in Cross Section A for various cap placement conditions

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

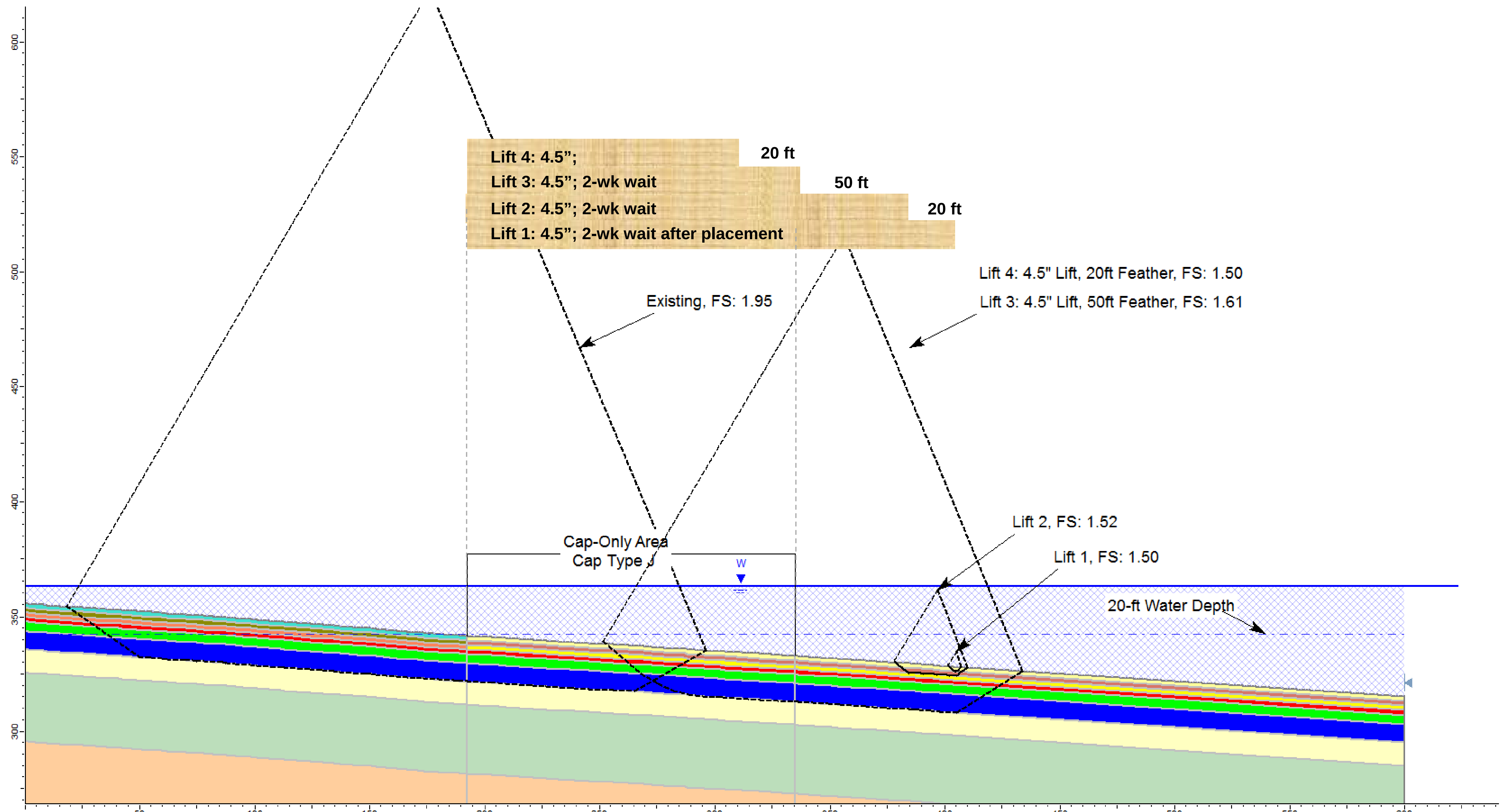

Figure 10. Calculated factors of safety and critical slip surfaces in Cross Section B for various cap placement conditions

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

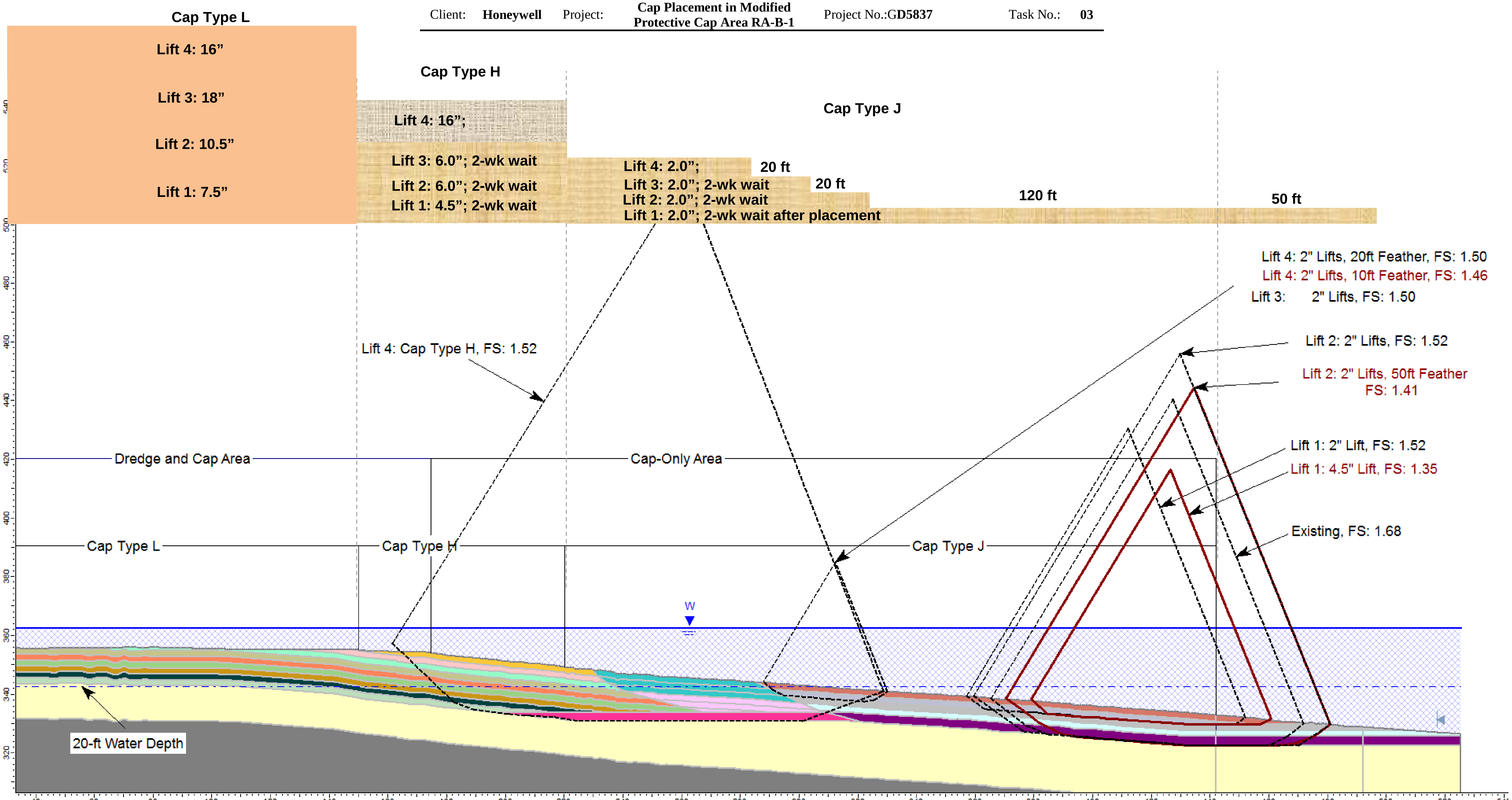

Figure 11. Calculated factors of safety and critical slip surfaces in Cross Section C for various cap placement conditions

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

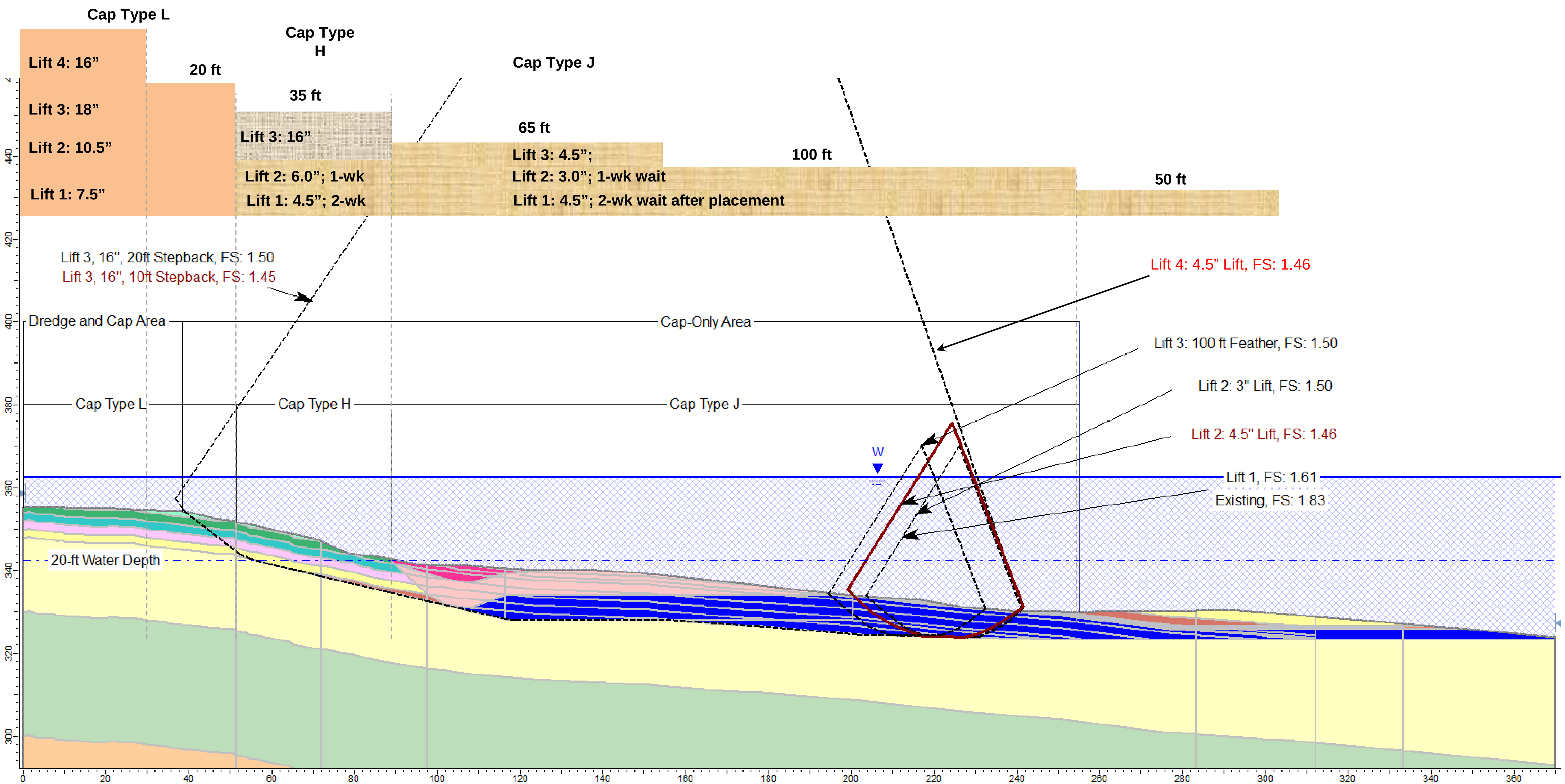

Figure 12. Calculated factors of safety and critical slip surfaces in Cross Section D for various cap placement conditions

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

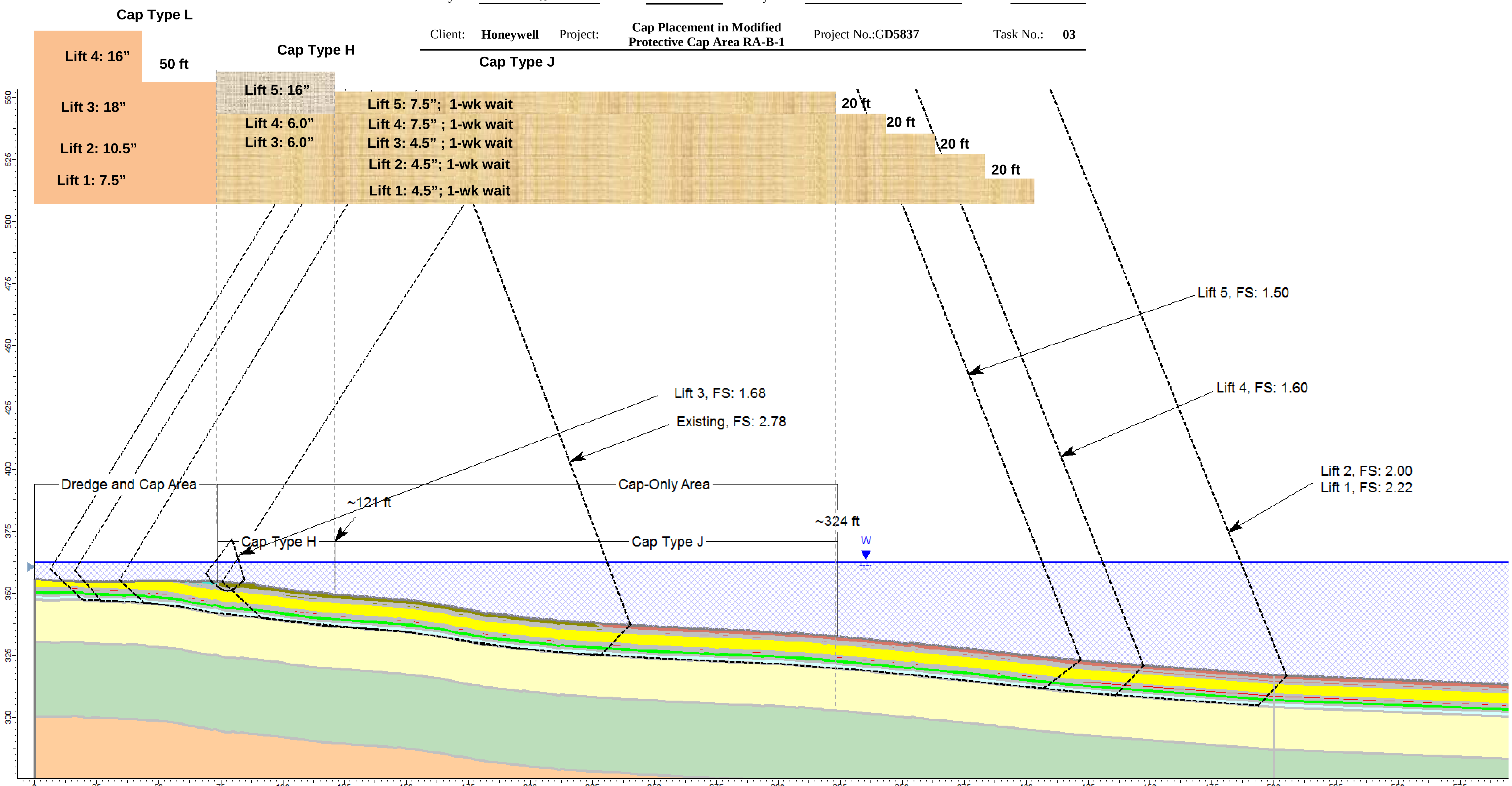

Figure 13. Calculated factors of safety and critical slip surfaces in Cross Section E for various cap placement conditions

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

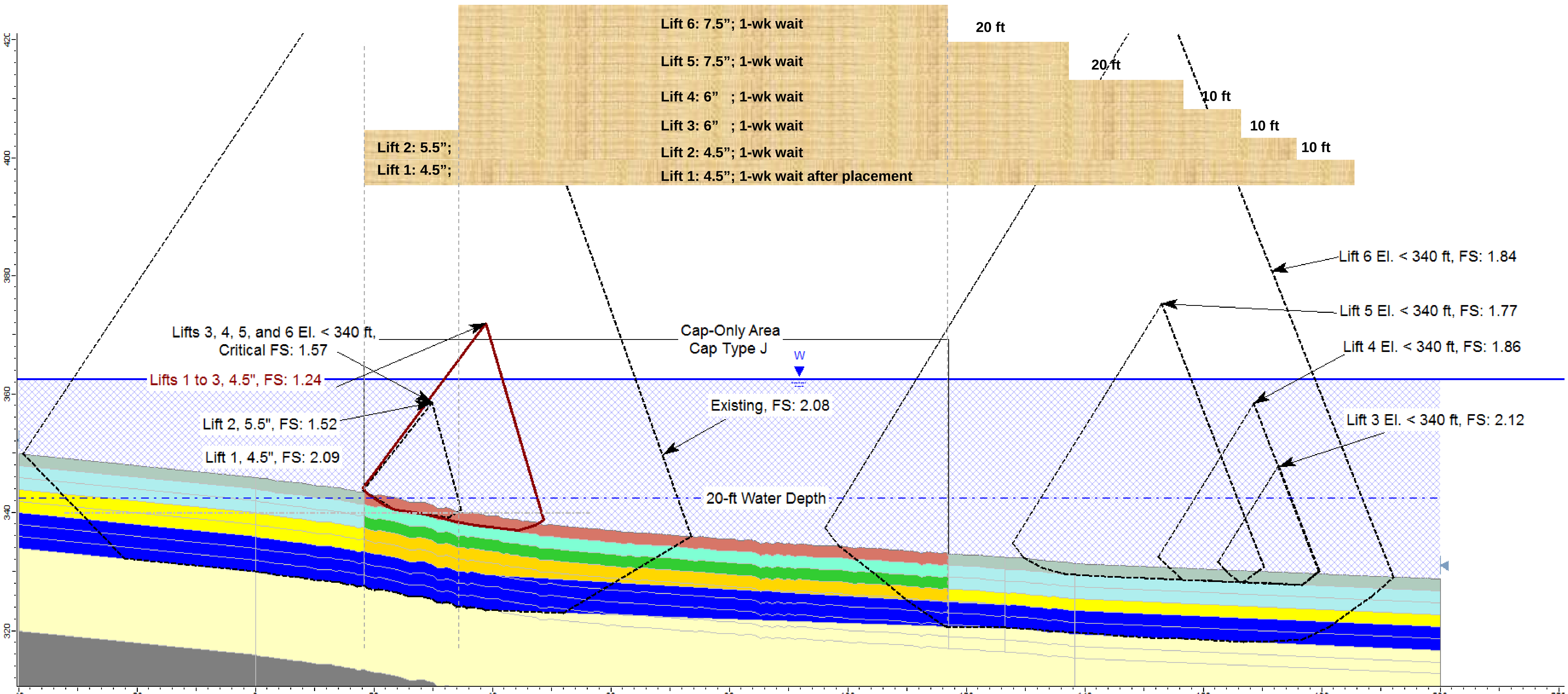

Figure 14. Calculated factors of safety and critical slip surfaces in Cross Section F for various cap placement conditions

Written by:	C. Carlson/M. Erten	Date:	11/6/2015	Reviewed by:	A. Ebrahimi/ J. Beech	Date:	11/6/2015
Client:	Honeywell	Project:	Cap Placement in Modified Protective Cap Area RA-B-1	Project No.:	GD5837	Task No.:	03

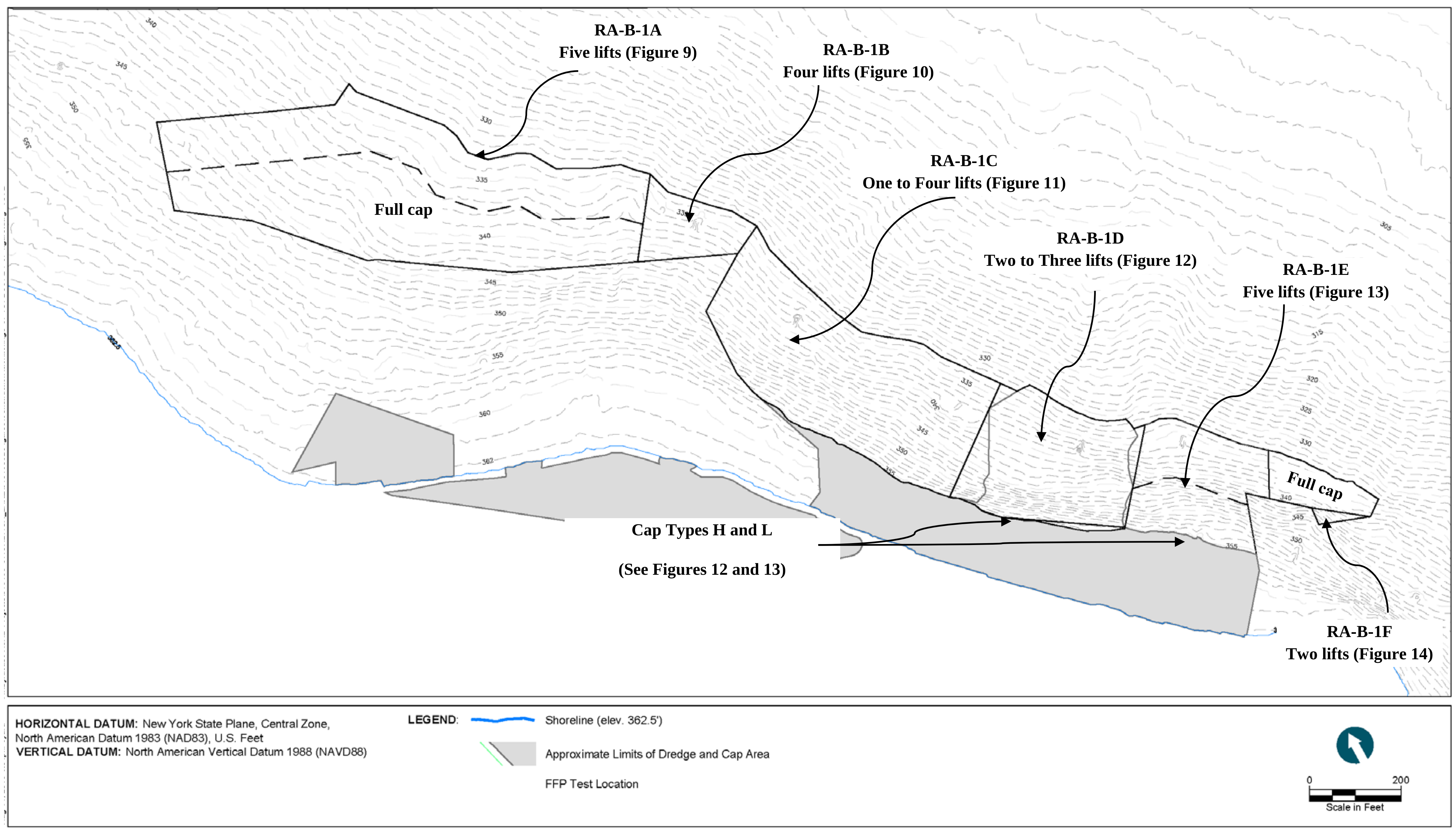

Figure 15. Recommended cap placement in modified protective cap area RA-B-1

ATTACHMENT 2

MODIFIED PROTECTIVE CAP RA-B-1
CHEMICAL ISOLATION MODELING

ANCHOR QEA

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Liverpool, New York 13088
Phone 315.453.9009
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www.anchorqea.com

MEMORANDUM

To:	Ed Glaza, Parsons	**Date:**	November 5, 2015
From:	Deirdre Reidy and Kevin Russell, Anchor QEA, LLC	**Project:**	E50139-09.02
Cc:	Paul LaRosa and Ram Mohan, Anchor QEA, LLC		
Re:	Cap Modeling in Modified Protective Cap Area RA-B-1		

1 INTRODUCTION

This memorandum documents the numerical modeling conducted for the Modified Protective Caps (MPCs) in Remediation Area (RA) RA-B-1. The numerical modeling was conducted to verify the protectiveness of the MPCs and to develop granular activated carbon (GAC) application rates that would be required for these modified caps to be protective for more than 1,000 years, consistent with the evaluation timeframe used in the final design.

For a capping project of the scale of Onondaga Lake Remediation, it is not unusual to expect previously unforeseen field conditions in small areas that may warrant adjustments to the cap system to achieve the remedial goals for the project. Subsequent to the cap movements that were observed to have occurred in RA-C and RA-D, additional in situ data collection and geotechnical analyses were conducted in those two RAs, as well as in other portions of the lake. These recent geotechnical stability evaluations have indicated that the cap thicknesses developed as part of the final design (Parsons and Anchor QEA 2012a) need to be reduced in the small areas of cap movement, as well as in other small portions of Onondaga Lake RAs where the sediments are much softer than previously identified.

This memorandum consists of the following sections:

- Section 2 describes the general modeling approach used to evaluate the various modified cap configurations, as well as the modeling details specific to RA-B-1.
- Section 3 presents the GAC application rate required in each portion of RA-B-1 to meet the target criteria for more than 1,000 years.
- Section 4 presents model sensitivity analyses.

- Section 5 presents a list of references.
- Attachment 1 includes the model files associated with the RA-B-1 MPCs.

2 MODELING APPROACH

2.1 General Approach

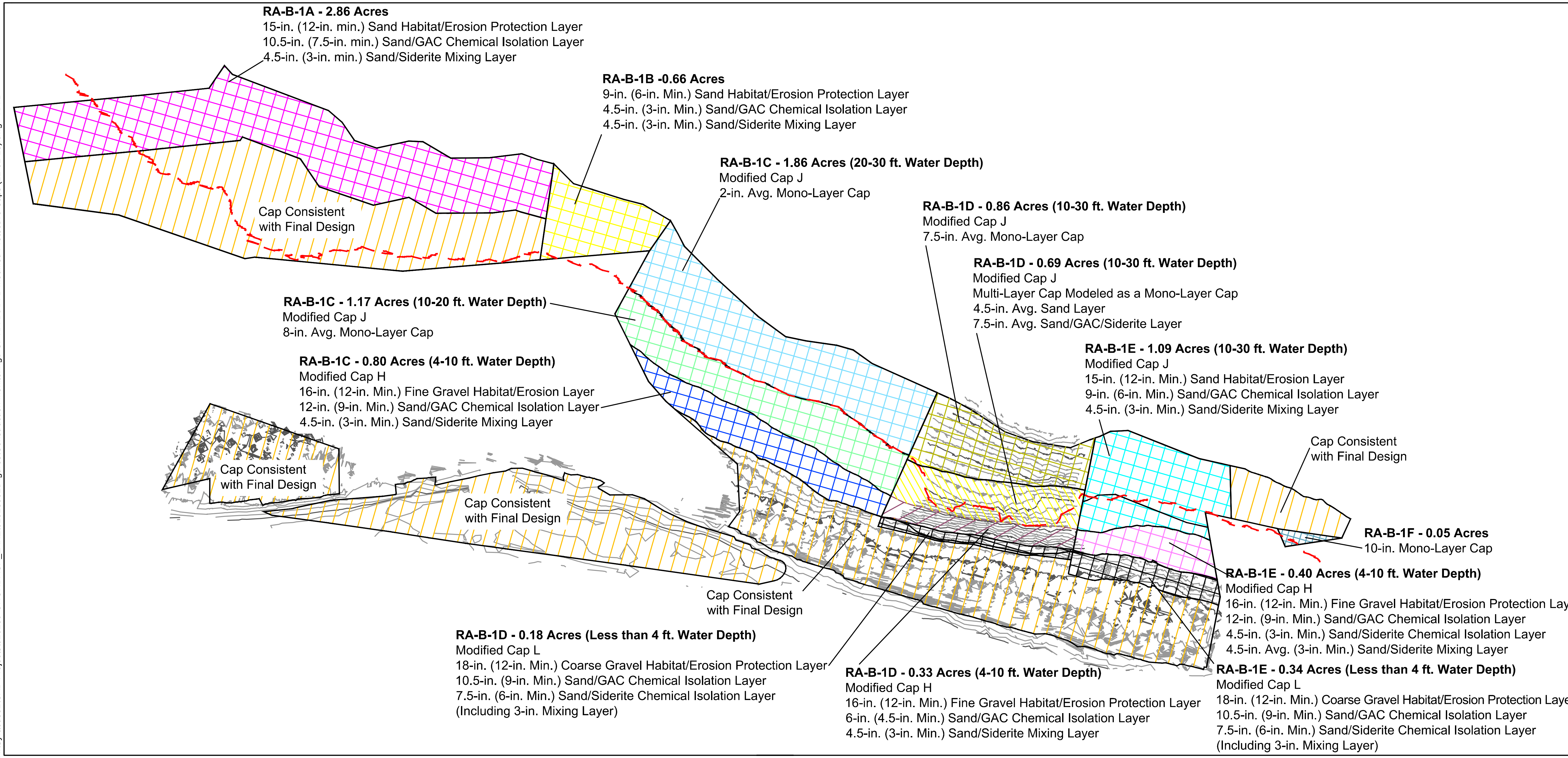
The modeling approaches employed for the proposed MPC configurations identified from the geotechnical analyses can be simplified into three basic categories:

1. Multi-layer caps (simulated with the transient numerical model)
2. Mono-layer caps (simulated with the transient numerical model)
3. Modeling deposition effects for mercury (simulated with the Sediment Management Unit 8 [SMU 8] monitored natural recovery [MNR] model)

Detailed descriptions of the modeling approach for each of these categories were provided in the first memorandum in this series (Anchor QEA 2015) and are not repeated here. Considerations specific to area RA-B-1 are described in the following subsection. These considerations include the site-specific cap configuration, chemical source term (i.e., initial sediment porewater concentrations), bioturbation depth, and biological decay rate.

2.2 Modeling Approach for RA-B-1 Modified Protective Caps

MPCs were evaluated within six different subareas of RA-B-1, as depicted in Figure 1. Subareas RA-B-1A and RA-B-1B are located within the final design Model Area B2, and subareas RA-B-1C through RA-B-1F are located within the final design Model Area B1/C1. Results of slope stability analyses showed these areas can accommodate a range of MPC configurations, which can be categorized into two general MPC types—multi-layer MPCs and mono-layer MPCs.



H:\Syracuse1\CAD Projects\010139-ONONDAGA_LAKE\01013902\Figures\Construction Monitoring\FCF RA-B\RA-B Modified Protective Caps (11-02-15).dwg RA-B

Nov 02, 2015 5:03pm cyard

SOURCE: Exg-Lake, RAB Sevenson Pre-Final
HORIZONTAL DATUM: New York State Plane, Central Zone, North American Datum 1983 (NAD83), U.S. Feet
VERTICAL DATUM: North American Vertical Datum 1988 (NAVD88)

LEGEND:
Shoreline (elev. 362.5')
20-foot Post Dredge Depth Contour (elev. 342.5')

ANCHOR QEA

Figure 1
Modified Protective Caps
Remediation Area B
Onondaga Lake

Subareas defined as multi-layer MPCs will have sufficient thicknesses based on geotechnical analysis such that there will be separate habitat and chemical isolation layers. These multi-layer MPCs were simulated in the model consistent with the final design cap configuration (except using the reduced thicknesses, as discussed in Section 2.1 of Anchor QEA [2015]). Multi-layer MPCs having a sand/siderite layer placed separately from the GAC-amended chemical isolation layer were evaluated incorporating biological degradation (which is expected to occur over the long term following porewater pH neutralization by siderite), consistent with the final design, as discussed in Section 2.1 of Anchor QEA (2015).

Consistent with the approach described in Anchor QEA (2015), subareas identified as mono-layer caps were simulated in a manner consistent with the Modified Erosion Resistant Cap (MERC) that was designed and constructed in the area of the Metro deepwater outfall (Parsons and Anchor QEA 2014). In general, mono-layer caps will be constructed with one or more lifts of a single cap material (sand that includes both GAC and siderite).[1,2] All mono-layer caps were represented in the model using a total 6-inch thickness for the purposes of defining a GAC application rate. This is appropriate even for mono-layer caps that are less than 6 inches thick because the GAC will be distributed over time by bioturbation (the littoral zone bioturbation depth used in the final design was 6 inches) as detailed in Section 2.2 of Anchor QEA (2015). The model construct assumes that the initial concentration in the cap is zero (i.e., initial cap concentration is not a user input for the model). The upward movement of contaminant mass due to mixing of the underlying sediments with the cap would have an impact on cap concentrations in the near term, but compared to the mass that enters the cap over the timeframe of the model simulation (i.e., 1,000 years), this impact is negligible over the long term. Because siderite will not be placed in a separate layer beneath the sand/GAC material in mono-layer caps, biodegradation was

[1] There is one exception (described in detail in a subsequent section). The portion of RA-B-1D (10 to 30 feet) that consists of a 12-inch cap was evaluated as a 6-inch mono-layer, but will be constructed in multiple lifts that have two sand/GAC/siderite lifts and a final sand lift.

[2] Studies have shown that toxicity and bioaccumulation in benthic organisms decrease with the addition of GAC to sediments due to reductions in contaminant concentrations in porewater (Janssen and Beckingham 2013). If GAC with adsorbed contaminants is ingested by benthic organisms, it would likely pass through their digestive system with minimal, if any, impact. Organic chemicals strongly bind to GAC and, therefore, would not be assimilated into the organism.

conservatively excluded from the modeling for these cases. Although portions of the 6- to 9-meter zone may be considered net depositional, that process was conservatively not incorporated into the modeling for chemicals other than mercury in certain cases (see below). Compliance with design standards (i.e., porewater-equivalent probable effects concentrations [PECs] and sediment screening concentrations [SSCs]) for mono-layer MPCs was assessed at the midpoint of the bioturbation depth, as detailed in Section 2.2 of Anchor QEA (2015).

2.2.1 Transient Numerical Modeling to Develop GAC Application Rate

Based on the results of the slope stability analysis, MPC configurations for the six subareas of RA-B-1 (Figure 1) evaluated in the modeling are summarized below (multiple configurations within a subarea are differentiated by water depths, shown in parenthesis). As shown in Figure 1, MPCs are also denoted for RA-B-1D (less than 4 feet), RA-B-1E (less than 4 feet), and RA-B-1E (4 to 10 feet). However, the only modification in these areas from the final design is that the habitat layer was reduced to 12 inches. This is consistent with the cap configuration assumed for these areas in the final design; therefore, these areas are not listed below and the GAC application rate in these areas will be consistent with the final design.

- **RA-B-1A:** This subarea will include a multi-layer cap consisting of:
  - 12 inches minimum of sand (habitat restoration layer)
  - 7.5 inches minimum of sand/GAC (chemical isolation layer)
  - 3 inches minimum of sand/siderite (which were excluded from modeling due to assumed mixing with underlying sediments, consistent with the final design; mixing layer)
- **RA-B-1B**: This subarea will include a multi-layer cap consisting of:
  - 6 inches minimum of sand (habitat restoration layer)
  - 3 inches minimum sand/GAC (chemical isolation layer)
  - 3 inches minimum of sand/siderite (which were excluded from modeling due to assumed mixing with underlying sediments, consistent with the final design; mixing layer)

- **RA-B-1C:** Three separate MPCs were simulated in this subarea:
  1. RA-B-1C (4 to 10 feet): A multi-layer cap consisting of:
     - 12 inches minimum of fine gravel (habitat restoration layer)
     - 9 inches minimum of sand/GAC (chemical isolation layer)
     - 3 inches minimum of sand/siderite (which were excluded from modeling due to assumed mixing with underlying sediments; mixing layer)
  2. RA-B-1C (10 to 20 feet): This subarea will include a mono-layer cap consisting of an average of 8 inches of cap material[3]
  3. RA-B-1C (20 to 30 feet): This subarea will include a mono-layer cap consisting of an average of 2 inches of cap material[3]
- **RA-B-1D:** Two separate MPCs were simulated in this subarea:
  1. RA-B-1D (4 to 10 feet): A multi-layer MPC consisting of:
     - 12 inches minimum of fine gravel (habitat restoration layer)
     - 4.5 inches minimum of sand/GAC (chemical isolation layer)
     - 3 inches minimum of sand/siderite (which were excluded from modeling due to assumed mixing with underlying sediments; chemical isolation layer)
  2. RA-B-1D (10 to 30 feet)[4]: A portion of this area will include a mono-layer cap consisting of an average of 7.5 inches of cap material and a separate portion consists of a 12-inch average cap that includes 4.5-inch average sand and a 7.5-inch average sand/GAC/siderite layer. Each was modeled as a 6-inch mono-layer cap.[3]
- **RA-B-1E (10 to 30 feet):** This subarea will include a multi-layer cap consisting of:
  - 12 inches minimum of sand (habitat restoration layer)
  - 6 inches minimum of sand/GAC (chemical isolation layer)
  - 3 inches minimum of sand/siderite (which were excluded from the model due to assumed mixing with underlying sediment; mixing layer)

[3] Simulated as a 6-inch mono-layer cap.
[4] Subareas RA-B-1D (10 to 30 feet) and RA-B-1F were simulated in the numerical transient model using the same cap configuration, model parameters, and input chemical concentrations as RA-B-1C (20 to 30 feet); therefore, no independent numerical modeling was done for those areas, and results from RA-B-1C (-20 to 30 feet) are applied to those areas for the purposes of assessing the required GAC application rate.

- **RA-B-1F:** This subarea will include a mono-layer cap consisting of an average of 10 inches of cap material.[5]

Chemical isolation cap modeling using the numerical transient model was conducted to develop the GAC application rate required for each of the MPCs in area RA-B-1 described above. No additional sediment or porewater chemistry samples have been collected in RA-B-1 since the final design. Therefore, initial porewater concentrations in these model areas were set to the 95th percentile porewater concentrations used during the final design for Model Area B2 for MPCs in RA-B-1A and RA-B-1B and to those for Model Area B1/C1 for MPCs in RA-B-1C through RA-B-1F.

The MPC thicknesses in RA-B-1 are significantly less than the full-thickness cap that was used as the basis for the final design porewater flux estimates. Therefore, consolidation settlement and porewater flux estimates from the final design are considered conservative for this MPC evaluation.

All 25 of the organic chemicals evaluated during final design (i.e., VOCs, PAHs, and PCBs) were evaluated with the transient numerical model using deterministic simulations to identify the GAC application rate that would be needed to maintain concentrations below the applicable PECs or SSCs for more than 1,000 years. Mercury was also evaluated with the transient numerical model to evaluate whether concentrations are predicted to be below the applicable PEC for more than 1,000 years in cases where the total MPC thickness was at least 6 inches (as detailed in Section 2.3 of Anchor QEA [2015]). Evaluation of mercury for mono-layer MPCs having less than 6 inches total thickness was conducted with the MNR model, as described in the next subsection.

Probabilistic modeling was not conducted for these MPCs. During the final design, although probabilistic modeling was performed for 13 separate modeling areas, the GAC dose was increased in one model area only—WBB1-8, which is not an area of concern for these evaluations. In this area, the GAC application rate increased by less than 10%. These results

[5] Simulated as a 6-inch mono-layer cap.

indicate that the deterministic modeling drives the GAC application rate in nearly all cases and probabilistic modeling is not needed for the MPC evaluations.

2.2.2 MNR Modeling to Evaluate Mercury in RA-B-1C

For mercury, the MPC protectiveness evaluations conservatively assumed adsorption is not enhanced by the presence of GAC, consistent with the final design. Thus, in this modeling approach, the thickness of the cap provides protectiveness for mercury by providing a layer over which adsorption to sand and dispersion attenuate porewater concentrations. However, deposition of new material atop the cap also provides an important attenuating mechanism for mercury. Therefore, in the 6- to 9-meter zone where the proposed cap thickness is less than the bioturbation depth of 6 inches, mercury was evaluated with the MNR model. In general, as cap thickness is reduced (i.e., cases in which MPCs are less than 6 inches thick), the effects of this deposition become more significant and are therefore important to consider in the effectiveness evaluation, as discussed in Section 2.3 of Anchor QEA (2015). Consideration of deposition is appropriate in model area RA-B-1C because it is located in water depths greater than 6 meters, which may be considered net depositional as documented in Section 10 of Appendix D in the Final Design. Because deposition rates have not been measured within the 6- to 9-meter zone, the modeling with the MNR model for areas within the 6- to 9-meter zone was conducted for a range of deposition rates observed in SMU 8. Therefore, mercury was evaluated with the MNR model (Parsons and Anchor QEA 2012b) to verify the protectiveness of the mono-layer cap in RA-B-1C (20 to 30 feet) as described in Section 2.3 of Anchor QEA (2015). In this subarea, concentrations within the "mixed layer" were compared to the mercury PEC of 2.2 mg/kg. The specific inputs for this area are as follows:

- The model "mixed layer" thickness was set to 6 inches.
- The initial concentration of the model "mixed layer" was set to 1.78 mg/kg, which was calculated based on mixing of 2 inches of clean sand with 4 inches of sediment having a concentration of 4.6 mg/kg (see below) and accounting for the differences in dry bulk density of the two materials. This configuration was used to represent the long-term mixing over the final design littoral zone bioturbation depth of 6 inches.
- The concentration of the model "buried layer" was set to the maximum mercury concentration measured in surface sediment samples (0 to 6 inches) collected during

the pre-design investigation within this sub-area (4.6 mg/kg from location OL-VC-30036). These data are specific to the MPC subarea and are direct measurements of the required model input (i.e., the MNR model uses sediment concentration as its input, as compared to the transient cap model, which uses porewater concentration).

- The partitioning coefficient (Kd) for the “mixed layer” and “buried layer” was set to the final design sediment Kd ($10^{2.45}$ L/kg). This is appropriate given that initially the “mixed layer” is a combination of sediment and sand, and over time additional sediment that settles will be incorporated into the mixing layer.
- The model “mixed layer” porosity was set to 0.6, which was calculated based on mixing of 2 inches of sand (porosity of 0.4) with 4 inches of sediment having a porosity of 0.77 (see below) and accounting for the differences in dry bulk density of the two materials.
- The model “buried layer” porosity was set to 0.77, which is the porosity of sediments used in the final design cap modeling in model area B1/C1.
- Sediment deposition rates in the 6- to 9-meter zone have not been measured. Deposition rates reported in Appendix M of the final design indicate the lower end of the range observed in SMU 8 is 0.08 g/cm^2/year and the midpoint of the range observed in SMU 8 is 0.25 g/cm^2/year. Sediment traps deployed at South Deep station in 2012 resulted in deposition rates ranging from 0.1 g/cm^2/year to 0.62 g/cm^2/year (average of 0.26 g/cm^2/year, which is similar to the deposition rate of 0.25 g/cm^2/year used in the MNR modeling for SMU 8 during the final design). Therefore, caps within in the 6- to 9-meter zone were simulated using the midpoint of the range observed in SMU 8 (0.25 g/cm^2/year) and the low end of the range observed in SMU 8 (0.08 g/cm^2/year).
- The model simulation period for mercury was 500 years (long enough to reach steady-state concentrations).

3 RESULTS

The GAC application rates for the RA-B-1 MPCs were developed based on the transient numerical modeling described in the preceding sections. For the mono-layer MPCs, where compliance is assessed within the sand/GAC layer, compliance was assessed against the

PEC-equivalent porewater concentrations and SSCs for each of the chemicals evaluated at the midpoint of the 6-inch layer. For RA-B-1C (20 to 30 feet) mono-layer cap, where less than 6 inches is placed, mercury was evaluated with the MNR model and compliance with the PEC of 2.2 mg/kg was assessed over the average concentration within the 6-inch bioturbation zone. For multi-layer caps, where a designated habitat layer (sand or fine gravel) exists, compliance with the PECs and SSCs was assessed against the maximum concentration within the habitat layer. Model results indicate all 26 chemicals meet the target criteria for the length of the simulation (in this case, more than 1,000 years) with the specified GAC application rate. Results for GAC application rates based on the numerical modeling are tabulated in Table 1. MNR model simulations for mercury in RA-B-1C (20 to 30 feet) indicate that mercury meets the PEC of 2.2 mg/kg for the range of deposition rates evaluated. A steady-state mercury concentration of 1.62 mg/kg was predicted when simulating a deposition rate of 0.25 g/cm^2/year, and 2.17 mg/kg was predicted when simulating the lower bound deposition rate of 0.08 g/cm^2/year.

Table 1
Transient Numerical Model Results

Model Area	Final Design GAC Application Rate (lb/sf)	Final Design Driving Chemical	MPC Modeling Results		
			MPC Type	GAC Application Rate (lb/sf)[1]	Driving Chemical
RA-B-1A	1.22	Phenol	Multi-layer	1.29	Phenol
RA-B-1B	1.22	Phenol	Multi-layer	1.30	Phenol
RA-B-1C (4 to 10 feet)	0.6	Phenol	Multi-layer	0.61	Phenol
RA-B-1C (10 to 20 feet)	0.6	Phenol	Mono-layer	0.49	Xylene
RA-B-1C (20 to 30 feet)	0.6	Phenol	Mono-layer	0.49	Xylene
RA-B-1D (4 to 10 feet)	0.6	Phenol	Multi-layer	0.64	Phenol
RA-B-1D (10 to 30 feet)	0.6	Phenol	Mono-layer	0.49	Xylene
RA-B-1E (10 to 30 feet)	0.6	Phenol	Multi-layer	0.63	Phenol
RA-B-1F	0.6	Phenol	Mono-layer	0.49	Xylene

Note:
1 Although the MPC thicknesses are less than the final design cap thickness, the GAC application rate, in the case of the mono-layer caps, decreased. These decreases in GAC application rate are due to the change in location of the compliance point relative to the boundary condition (i.e., cap/water interface, where concentrations are zero). Phenol was the controlling chemical during final design cap modeling; because phenol is evaluated for compliance using a porewater concentration, the controlling compliance point during the final design was the bottom of the habitat restoration layer, or 1 foot below the cap/water interface. With the modeling of these mono-layer MPCs, the compliance point is positioned closer to the cap/water interface, where model-predicted porewater concentrations are lower, particularly for phenol, which is very mobile, due to exchange with surface water. This change in compliance point resulted in decreased phenol concentrations such that the driving chemical changed to xylene, which did not drive during the final design—hence the need for a lower GAC application rate than that defined in the final design.

4 SENSITIVITY ANALYSIS

This section describes sensitivity analyses that were conducted to evaluate select model input parameters.

4.1 Depth of Mixing

The model approach for RA-B-1C (20 to 30 feet water depth) assumes the GAC placed within a 2-inch sand/GAC layer will be mixed to a depth of 6 inches, which is the depth of mixing due to bioturbation in the littoral zone. Although bioturbation occurs to a depth of 6 inches, a sensitivity analysis was conducted to evaluate the impacts on model results if the GAC mixed to a depth that is 25% less than the bioturbation depth. To evaluate this scenario, the modeling for the RA-B-1C mono-layer MPC was repeated at a GAC application rate of 0.49 lb/sf and a thickness of 4.5 inches (with all other model settings unchanged, including assessing compliance at the midpoint of the bioturbation depth, or 3 inches). Results indicated that all chemicals meet the SSCs and porewater equivalent PECs for more than 1,000 years, except xylene, which was predicted to exceed the porewater-equivalent PEC after 650 years. However, compliance is expected for longer than this prediction because biodegradation of contaminants and natural deposition of clean sediments over time were conservatively excluded from the modeling simulation. Using the low end of the deposition rate discussed in Section 2.3 results in a predicted deposition of 4.5 feet of new sediment over the 1,000-year modeling period.

4.2 Mercury Diffusion Coefficient in MNR Model for RA-B-1C

The molecular diffusion coefficient for mercury in the MNR model used to evaluate natural recovery in SMU 8 sediments during the final design was set to 202 cm^2/year based on literature. The molecular diffusion coefficient for mercury in the cap modeling conducted during final design was 61.8 cm^2/year, which was also based on literature (but a different source). The mercury molecular diffusion coefficient of 61.8 cm^2/year was used to maintain consistency with the final design cap modeling. Therefore, a sensitivity analysis was conducted to evaluate the impact on results from using the molecular diffusion coefficient of 202 cm^2/year in the MNR model used to simulate mercury in RA-D-1B. Simulations using this value were conducted for the low-end deposition rate of 0.08 g/cm^2/year and the midpoint of the range observed in SMU 8 (0.25 g/cm^2/year). The use of the higher diffusion coefficient of 202 cm^2/year in the MNR model indicates that mercury concentrations are predicted to exceed the PEC of 2.2 mg/kg after 19 years, reaching a steady-state concentration of 2.27 mg/kg, when simulating the average deposition rate of 0.25 g/cm^2/year in conjunction with the higher molecular diffusion coefficient. Mercury is predicted to exceed the PEC of 2.2 mg/kg after 8 years in those areas where the maximum mercury concentrations are present, reaching a steady-state concentration of 2.69 mg/kg which only slightly exceeds the PEC criteria of 2.2 mg/kg, when simulating the low-end deposition rate of 0.08 g/cm^2/year in conjunction with the higher molecular diffusion coefficient. This prediction likely overestimates the steady-state mercury concentration because it uses the low-end deposition rate and the high end of the diffusion coefficient in combination with the maximum mercury concentration.

5 REFERENCES

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Parsons and Anchor QEA, 2012a. *Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design. Appendix B – Cap Modeling.* Prepared for Honeywell. March 2012.

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ATTACHMENT 1
ONONDAGA LAKE CAP MODELING FILES
FOR MPC RA-B-1

ATTACHMENT 1: MODEL FILES

This attachment details the files and directory structure associated with the numerical modeling conducted for the Modified Protective Cap (MPC) Area RA-B-1. The cap modeling files are organized into two main folders:

1. Numerical Model
2. MNR Model

The following sections describe the files and subfolders contained in each folder.

Numerical Model

The numerical cap modeling files are contained in two subfolders:

1. Inputs
2. Outputs

The contents of each of these subfolders are described in this section. Please reference Attachment 4 to Appendix B of the final design (Parsons and Anchor QEA 2012[1]) for the numerical model code files and their descriptions. In addition, the structure and formatting of the input and output files for this numerical cap modeling is identical to that from the final design; differences in input values from the final design associated with using the model to represent MPCs are mainly what is described in the subsections that follow.

Numerical Model Inputs

The input files used for simulations with the numerical model are located in the *Numerical_Model\Inputs* folder. Separate input files are used for each of the unique model areas evaluated as part of the RA-B-1 MPC modeling effort:

- RA-B-1A.xls (RA-B-1A multi-layer MPC)
- RA-B-1B.xls (RA-B-1B multi-layer MPC)
- RA-B-1C-1.xls (RA-B-1C [4 to 10 feet] multi-layer MPC)

[1] Parsons and Anchor QEA (Anchor QEA, LLC), 2012. *Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design.* Prepared for Honeywell. March 2012.

- RA-B-1C-2.xls (RA-B-1C [10 to 20 feet], RA-B-1C [20 to 30 feet], RA-B-1D [10 to 30 feet], and RA-B-1F [10 to 20 feet] mono-layer MPCs)[2]
- RA-B-1C-2-45in.xls (RA-B-1C-2.xls mono-layer MPC modeled as 4.5-inch cap for sensitivity analysis)
- RA-B-1D-1.xls (RA-B-1D [4 to 10 feet] multi-layer MPC)
- RA-B-1E.xls (RA-B-1E [10 to 30 feet] multi-layer MPC)

These input files are identical in format and layout to those described and included in Attachment 4 to Appendix B of the final design. Each input file contains one tab per chemical modeled, as well as an *Input_Matrix* tab, which specifies the inputs for the various model parameters. Changes made to input values used in the final design for this MPC modeling effort (e.g., cap configuration, decay parameters) are described in the following subsections.

RA-B-1A.xls

The input file titled *RA-B-1A.xls* was set up for modeling the RA-B-1A multi-layer MPC. Changes to this file, as compared to the Model Area B2 final design modeling, are highlighted in orange on the *Input_Matrix* tab, as well as the chemical-specific tabs, where applicable. The following changes were made to the cap configuration for all chemicals except mercury (mercury was simulated as an 8-inch combined foundation layer and chemical isolation layer, consistent with the final design):

1. The chemical isolation layer thickness was set to a thickness of 19.05 cm.
2. The foundation/siderite layer thickness was set to a nominal thickness of 1 cm.

RA-B-1B.xls

The input file titled *RA-B-1B.xls* was set up for modeling the RA-B-1B multi-layer MPC. Changes to this file, as compared to the Model Area B2 final design modeling, are

[2] The modeling performed for RA-B-1C (10 to 20 feet) is also applicable to RA-B-1C (20 to 30 feet), RA-B-1D (10 to 30 feet), and RA-B-1F because the same model input parameters and model construct are appropriate for all three areas, as discussed in the main memorandum. Therefore, no separate model files were needed for RA-B-1C (20 to 30 feet), RA-B-1D (10 to 30 feet), and RA-B-1F.

highlighted in orange on the *Input_Matrix* tab, as well as the chemical-specific tabs, where applicable. The following changes were made to the cap configuration for all chemicals:

1. The habitat restoration layer thickness was set to a thickness of 15.24 cm.
2. The bioturbation zone thickness was set to a thickness of 14.24 cm (although this area is characterized with a 15.24-cm bioturbation depth, the simulated bioturbation zone requires a thickness less than that of the habitat restoration layer for model function, so it was accordingly reduced by a nominal amount [i.e., 1 cm]).
3. The chemical isolation layer thickness was set to a thickness of 7.62 cm.
4. The foundation/siderite layer thickness was set to a nominal thickness of 1 cm.

RA-B-1C-1.xls

The input file titled *RA-B-1C-1.xls* was set up for modeling the RA-B-1C (4 to 10 feet) multi-layer MPC. Changes to this file, as compared to the Model Area B1/C1 final design modeling, are highlighted in orange on the *Input_Matrix* tab, as well as the chemical-specific tabs, where applicable. The following changes were made to the cap configuration for all chemicals except mercury (mercury was simulated as an 8-inch combined foundation layer and chemical isolation layer, consistent with the final design):

1. The foundation/siderite layer thickness was set to a nominal thickness of 1 cm.

RA-B-1C-2.xls

The input file titled *RA-B-1C-2.xls* was set up for modeling RA-B-1C (10 to 20 feet), RA-B-1C (20 to 30 feet), RA-B-1D (20 to 30 feet), and RA-B-1F (10 to 20 feet) mono-layer MPCs. Changes to this file, as compared to the Model Area B1/C1 final design modeling, are highlighted in orange on the *Input_Matrix* tab, as well as the chemical-specific tabs, where applicable. The following changes were made:

1. Decay rates for VOCs were set to 1E-12 to effectively eliminate the effects of degradation kinetics in the model simulations (1E-12 is used because a non-zero number is necessary for model function).
2. FOC in the bioturbation zone was set to a nominally low value of 0.022% (the value used in the final design for cap sand) so that sorption would be negligible.

3. The following inputs for cap configuration were specified to represent the total simulated thickness of 6 inches for the purposes of identifying GAC amendment application rates for mono-layer MPC evaluation, for all chemicals. For the portions of this area that can handle a 2-inch-thick cap (for RA-B-1C [20 to 30 feet]), mercury was simulated with the MNR model as described in the last section of this attachment:
   a. The habitat restoration layer thickness was set to a nominal thickness of 1 cm.
   b. The bioturbation zone thickness was set to a nominal thickness of 0.5 cm.
   c. The chemical isolation layer thickness was set to a thickness of 15.24 cm.
   d. The foundation/siderite layer thickness was set to a nominal thickness of 1 cm.

RA-B-1C-2-45in.xls

The input file for modeling the RA-B-1C mono-layer MPC modeled as a 4.5-inch cap is titled *RA-B-1C-2-45in.xls*. Changes to this file, as compared to the Model Area B1/C1 final design modeling, are highlighted in orange on the *Input_Matrix* tab, as well as the chemical-specific tabs, where applicable. Changes to this file compared to the Model Area B1/C1 final design modeling are the same as those described above for *RA-C-1C-2.xls*, except the cap thickness. The following inputs for cap configuration were specified to represent the total simulated thickness of 4.5 inches for the purpose of evaluating sensitivity to GAC mixing to a depth that is 25% less than the depth of mixing due to bioturbation:

1. The habitat restoration layer thickness was set to a nominal thickness of 1 cm.
2. The bioturbation zone thickness was set to a nominal thickness of 0.5 cm.
3. The chemical isolation layer thickness was set to a thickness of 11.43 cm.
4. The foundation/siderite layer thickness was set to a nominal thickness of 1 cm.

RA-B-1D-1.xls

The input file titled *RA-B-1D-1.xls* was set up for modeling the RA-B-1D (4 to 10 feet) multi-layer MPC. Changes to this file, as compared to the Model Area B1/C1 final design modeling, are highlighted in orange on the *Input_Matrix* tab, as well as the chemical-specific tabs, where applicable. The following changes were made to the cap configuration for all chemicals:

1. The chemical isolation layer thickness was set to a thickness of 11.43 cm.
2. The foundation/siderite layer thickness was set to a nominal thickness of 1 cm.

RA-B-1E.xls

The input file titled *RA-B-1E.xls* was set up for modeling the RA-B-1E (10 to 30 feet) multi-layer MPC. Changes to this file, as compared to the Model Area B1/C1 final design modeling, are highlighted in orange on the *Input_Matrix* tab, as well as the chemical-specific tabs, where applicable. The following changes were made to the cap configuration:

1. The chemical isolation layer thickness was set to a thickness of 15.24 cm.
2. The foundation/siderite layer thickness was set to a nominal thickness of 1 cm.

Numerical Model Outputs

The numerical model output files are located in the *Numerical_Model\Outputs\Det_Output* folder. Within this folder, outputs for each model area are contained in separate folders. The outputs are saved in comma-delimited format (*.csv). Output file names used the same naming convention from the final design, which helps to understand the model scenario:

"Output_"<Model Area>"_"<Chemical Name Abbreviation>"_"<GAC application rate>"-"<Initial Concentration Type>

For file-naming purposes, the GAC application rate component of the file name does not include a decimal point. It should be understood that the decimal place is located between the first and second digits. For example, *Output_RA-B-1A_EB_129-C95_UT2.csv* is the file containing outputs from the model simulation of ethylbenzene using the 95th percentile porewater concentrations in Model Area RA-B-1A (multi-layer MPC) with a 1.29 lb/sf GAC application rate.

MNR Model

The MNR model was used to simulate mercury for the mono-layer MPCs having less than 6 inches total thickness. RA-B-1C (20 to 30 feet) is the single area having less than 6 inches of placed cap material. The model is based on the SMU 8 MNR model used in the final design, with slight modifications to allow for the simulation of organic chemicals. These changes are described in Attachment 1 to Anchor QEA (2015)[3]. Model input settings specific to the RA-B-1C (20 to 30 feet) 2-inch mono-layer MPC are as follows:

- The "mixed layer" was configured to initially represent mixing of the 2 inches of placed cap material (i.e., sand) with 4 inches of underlying sediments by setting the initial concentration to an average concentration based on differences in mercury concentration and dry bulk density of the two materials.
- The "buried layer" in the MNR model was set to the sediment concentrations that will be present beneath the placed cap material, based on available sediment sampling data.

Everything else associated with this model file works similar to the SMU 8 MNR model from the final design (e.g., the "Run Model" button executes the code to run the model and outputs are generated for each simulated chemical; see "Instructions" worksheet for more detail).

[3] Anchor QEA, 2015. *Cap Modeling in Modified Protective Cap Area RA-D-1 and Adjacent Amended Thin-layer Cap in SMU 8.* Prepared for Parsons. October 2015.