Washington State
Department of Transportation

Memorandum

8/29/2011

FHWA Approval

By: [signature]

Date: 9/16/2011

TO: Greg Lippincott
MS 47329

THRU: Rick Keniston RKK
MS 15

FROM: Frank Green FTG 8/29/11
360-816-8855

HQ Concurrence

By: [signature]
Assistant State Design Engineer

Date: 9/8/2011

SUBJECT: Proprietary Item Request and Justification, XL #3604
I-5 (OR MP 307.00 - WA MP 0.34)
Columbia River Crossing – Drilled Shaft and Driven Pile Test Program

The Region requests approval to utilize the following proprietary items in the subject project:

- Loadtest Inc. to perform Osterberg Cell testing on drilled shaft foundations using specific synchronized equipment.
- Pile Dynamics, Inc./GRL Engineers, Inc for thermal integrity testing
- Synthetic slurry

Project Description: The test shaft program is a research program that will construct four drilled shafts and two test pile arrays to test/validate foundation design parameters and allow for improved strength reduction factors.

Proprietary Item(s): O-Cell test and O-cell test-specific synchronized equipment
Manufacture: LoadTest Inc.
Product: Osterberg Cell (O-Cell) test

Manufacture: Geokon
Product: Sister bar strain gages
Model Number: 4911

Manufacture: Geokon
Product: Linear Vibrating Wire Displacement Transducers
Model Number: 4450

Manufacture: Geokon
Product: Vibrating wire pressure transducer
Model Number: 4500H(H)

Justification: Loadtest Inc. is the patent and trademark holder for O-Cell technology. It has been determined by the ODOT and WSDOT geotechnical departments that O-Cell technology is the suitable technology to test the drilled shafts for the Columbia River Crossing Project. The geotechnical departments are aware that this technology is proprietary. Attached is a technical document which details the rationale for using an O-Cell test and a meeting summary which documents ODOT and WSDOT geotechnical department concurrence with the O-Cell test method.

The O-Cell test is the only tool available to provide unique information about drilled shafts within the project area. This unique information increases the project's capacity to refine foundation design and reduce foundation costs. The O-cell test is designed specifically to use the identified Geokon products.

Benefit: The use of this product is in the public interest because no other equally suitable alternative exists (see attachments).

The information gathered will enable the use of fewer and/or shallower foundations results in improved reliability and reduced cost of foundations for the Marine Drive interchange bridges, Hayden Island interchange bridges, SR-14 interchange bridges, bridges crossing the North Portland Harbor, bridges crossing the Columbia River.

Proprietary Item(s): Thermal integrity testing.
Manufacture: Pile Dynamics, Inc./GRL Engineers, Inc (PDI/GRL)
Product: Thermal integrity tests

Justification: Thermal integrity testing is new technology and PDI/GRL is the sole source for this type of testing. WSDOT headquarters construction and geotechnical departments recommend using thermal integrity testing as part of the drilled shaft test project.

The O-cell test involves embedding steel plates within the concrete core of the drilled shaft. This increases the potential for anomalies in the concrete within the shaft over a typical production shaft. To use O-cell test results to develop geotechnical assumptions for future foundation design work, the integrity of the concrete must be confirmed. There are two methods for confirming the integrity of the concrete: CSL tubes and thermal integrity testing. CSL tubes will be used for this project however, due to the presence of the O-cell/embedded plates in the concrete, CSL testing sufficiency is less certain than in a production shaft. Thermal integrity testing is being proposed to ensure that data is collected to demonstrate the shaft integrity.

Benefit: The use of this product is in the public interest because no other equally suitable alternative exists to provide necessary durability under O-cell testing conditions. Thermal integrity testing ensures getting the most benefit from conducting the O-cell test by ensuring capacity to confirm concrete integrity.

Proprietary Item: Synthetic slurry
Manufacture: CETCO
Product: ShorePac GCV

Manufacture: KB International, LLC
Product: SlurryPro CDP

Justification: The characteristics of mineral slurry could affect results for this test project. The use of synthetic slurry will provide more accurate data. Other providers have been on the pre-approved list in the past but have chosen to not continue to pursue pre-approval due to changing regulatory requirements and local market conditions.

Benefit: The use of this product is in the public interest because no other equally suitable alternative exists for delivering the level of accuracy necessary in this project.

If you have any questions or comments, please contact Carley Francis at 360-816-8869.

Attachments: Draft CRC Load Test Memo
Drilled Shaft Test Program Meeting Minutes
Load Testing Email to Chris Workman from Carley Francis, dated 6/27/2011

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

3990 Collins Way, Suite 100
Lake Oswego, Oregon 97035
Phone: 503·210·4750
Fax: 503·210·4890

MEMORANDUM

TO:	Rob Turton
COMPANY:	Columbia River Crossing (CRC)
FROM:	Risheng (Park) Piao, Gary Peterson
DATE:	January 24, 2011
PROJECT:	Task AH 8.9 Geotechnical Engineering Studies for I-5 CRC Project
RE:	**DRAFT Conceptual Drilled Shaft and Driven Pile Load Testing Program**

We have developed, and describe herein, conceptual drilled shaft and driven pile load test programs for the CRC project. The purpose of these test programs is to evaluate constructability of these foundation types and to provide direct measures of soil/foundation resistances for the Main Span through Marine Drive area. The test shaft and pile installations will allow evaluation of constructability, provide in-situ performance data to finalize design of the foundation systems, and allow environmental impacts of foundation installation to be evaluated. We believe that the geotechnical design parameters derived from test drilled shafts and driven piles will provide field measured resistances, including side friction and end bearing resistances, for the different soil and soft bedrock units at the site that will permit use of higher resistance factors in design, with related project cost savings. We propose a test program consisting of constructing and testing four drilled shafts and two driven pile arrays. Descriptions of the individual load tests are presented in this memorandum.

Background Information

We evaluated the proposed drilled test shaft load numbers, types, sizes, and locations based upon the site subsurface conditions and our current understanding of the proposed structure locations and design loads. The current site plans and preliminary geologic profiles for the project are attached to this memorandum as Figures 1 through 6. In general, the project site is underlain by fill and loose to very dense alluvial sand overlying dense to very dense gravel and the Troutdale Formation. Based on our discussions with the CRC team and review of the current design plans, we understand that the anticipated axial design load for the 10-foot diameter drilled shafts supporting the proposed Columbia River Bridge is approximately 14,000 kips per shaft. The typical design loads for the proposed Hayden Island structures could be in the range of 200 kips to 400 kips for small diameter driven piles, or in the range of 400 kips to 800 kips per large diameter driven pile or drilled shaft. More detail on the anticipated foundation types is presented below.

Anticipated Foundation Types for the CRC Project

Based upon the current limited structural information and the preliminary foundation design studies, the following deep foundation types may be used to support bridge structures included in the CRC project:

- Columbia River Bridges – Foundations will consist of groups of 230- to 250-foot long 10-foot diameter drilled shafts embedded into the Troutdale Formation to support each bridge pier.
- Hayden Island Bridge Structures – The foundation types for the Hayden Island bridge structures are critically dependent on the calculated liquefaction depths and associated pore water pressure and soil strength impacts under the design seismic conditions. Shannon & Wilson has not completed the seismic hazard evaluation. At the current time, we have assumed that the liquefaction depth is limited to between 75 and 80 feet below the ground surface, based upon the requirements of the ODOT and WSDOT GDMs. This assumption generally is consistent with the explored depth of the dense to very dense alluvial sand layer at Hayden Island. Therefore, we propose installing test elements consisting of driven steel pipe piles and drilled shafts founded in the dense to very dense alluvial sand (approximately 150 feet below the existing ground surface).
- North Portland Harbor Bridges – The foundations will consist of 120- to 150-foot long 8- or 10-foot diameter drilled shafts embedded into the very dense gravel or Troutdale Formation to support each bridge pier.
- Marine Drive Interchange Structures – Based upon limited geotechnical data developed by others, it is our opinion that it will be effective and economical to support the bridge structures with driven steel pipe piles. However, due to the anticipated seismic hazards, and the public and environmental impacts on the foundation construction in the Marine Drive area, we also expect that some bridge piers will be supported by relatively large diameter drilled shafts. The anticipated driven pile lengths vary between 120 and 140 feet. The anticipated drilled shaft lengths vary between 150 and 170 feet.

Conceptual Drilled Shaft Testing Program

Plans for four drilled shaft load tests are being prepared based upon the above described foundation types. These load tests consist of:

1. 6-foot Diameter Drilled Shaft Load Test in WA Approach Area (Pier RC-8, Boring CRC-RC-026) – The intent of a load test at this site is to evaluate the drilled shaft nominal side resistance in the gravel and the Troutdale Formation and the nominal tip resistance in the Troutdale Formation. The testing drilled shaft length is approximately 130 to 150 feet.
2. 10-foot Diameter Drilled Shaft Load Test on Hayden Island (Boring CRC-HI-006 or CRC-HI-010) – The intent of this load test is to evaluate deep drilled shaft constructability and the tip resistance in the Troutdale Formation, as well as the nominal side resistance in the Troutdale Formation and the alluvial sand. The test shaft is approximately 240 to 260 feet long.
3. 6-foot Diameter Drilled Shaft Load Test on Hayden Island (Boring CRC-HI-006 or CRC-HI-010) – The intent of this load test is to evaluate nominal side resistance and nominal tip

resistance in the dense to very dense alluvial sand. The test shaft will be founded in the dense to very dense alluvial sand approximately 150 feet below the existing ground surface.

4. 6-foot Diameter Drilled Shaft Load Test on Marine Drive (Proposed Boring CRC-MD-012) – The intent of this load test is to evaluate nominal side resistance and nominal tip resistance in the dense to very dense alluvial gravel. The test shaft will be founded in the dense to very dense gravel approximately 150 feet below the existing ground surface.

We considered three different drilled shaft load testing methods, including Standard Test Methods for Deep Foundations Under Static Axial Compressive Load (ASTM D1143) static load tests, Statnamic load tests (ASTM D7383), and Osterberg Cell load tests. Based upon our comparison of these three load test methods, it is our opinion that the ASTM D1143 method will be expensive for large diameter drilled shafts due to the need for reaction piles or shafts and large reaction beams. The Statnamic load test appears unacceptable primarily because it has a limited maximum test load (possibly under 6,000 or 7,000 kips) which is low compared to the anticipated foundation loads for the overwater structures on project. Also, the Statnamic loading test does not provide separate skin friction and end bearing resistance estimates; it only provides the total axial test load versus the shaft vertical movement.

Based on the above, we recommend employing the Osterberg Cell load test method for drilled shafts because it would: 1) be less expensive, 2) provide a test capacity that matches anticipated design loads, and 3) provide both side resistance from skin friction and end resistance from bearing estimates.

Conceptual Driven Pile Testing Program

We have developed a conceptual driven pile testing program for the CRC project based upon the background information and the anticipated foundation types previously described in this memo. For the driven pile load test program, we primarily considered a conventional static pile load test method, ASTM D1143 Standard Test Methods for Deep Foundations Under Static Axial Compressive Load, and ASTM D3689, the Pile Driving Analyzer (PDA) test method. Based upon the current AASHTO requirements, a pile resistance factor as high as 0.8 can be used in the pile design if one conventional load test is completed per project site and PDA tests are completed on at least 2% of the production piles. Therefore, we plan to use both the conventional load test method and PDA testing.

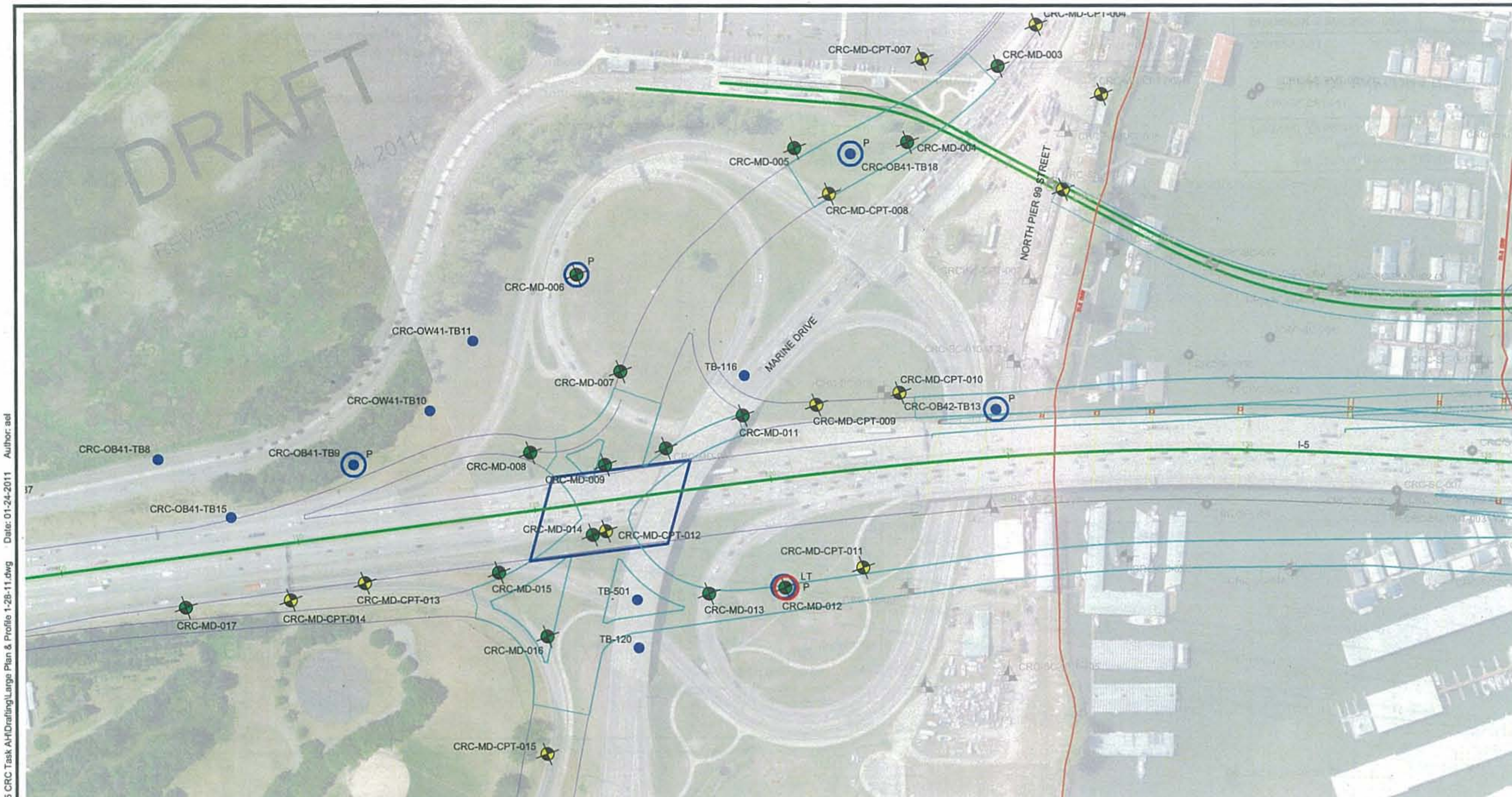
Two conventional load tests and ten PDA tests are planned based upon the explored subsurface conditions and the anticipated foundation types.

1. Conventional Compressive and Tensile Load Test and PDA Tests on Hayden Island (Boring CRC-HI-006 or CRC-HI-010) – We plan to install one test pile and four reaction piles into the dense to very dense alluvial sand (approximately 150 deep). The PDA tests will be performed during installation of all test and reaction piles.

2. Conventional Compressive and Tensile Load Tests and PDA Tests in the northeast quadrant of the Marine Drive interchange (Proposed Boring CRC-MD-012) – We plan to install one test pile and four reaction piles into the dense to very dense gravel (approximately 130 to 150 feet deep). The PDA tests will be performed during installation of all test and reaction piles.

Enc.:

- Figure 1 – Plan of Explorations (Marine Drive)
- Figure 2 – Plan of Explorations (Hayden Island)
- Figure 3 – Plan of Explorations (Main Span)
- Figure 4 – Generalized Subsurface Profile (Marine Drive)
- Figure 5 – Generalized Subsurface Profile (Hayden Island)
- Figure 6 – Generalized Subsurface Profile (Main Span)



EXPLANATION

- Mud Rotary Boring
- Roto-Sonic Boring
- Combined Mud Rotary & Roto-Sonic Boring
- Casing Advancer Boring
- Boring by Others
- CPT
- P — Indicates Piezometer Installed in Boring
- LT — Indicated Boring is at Proposed Load Test Location
- Proposed Mud Rotary Boring
- S — Proposed Roto-Sonic Boring
- Proposed CPT
- Proposed CPT with Seismic Testing

Designation Abbreviations:
CRC = Columbia River Crossing
SC = Slough Crossing
MD = Marine Drive
CPT = Cone Penetration Test

Additional Testing Notes:
1 = Pressuremeter Test
2 = OYO Suspension Log
3 = Seismic Testing

N

0 200 400
Scale in Feet

I-5 Columbia River Crossing
Marine Drive
Portland, Oregon / Vancouver, Washington

PLAN OF EXPLORATIONS

January 2011 24-1-03595-050

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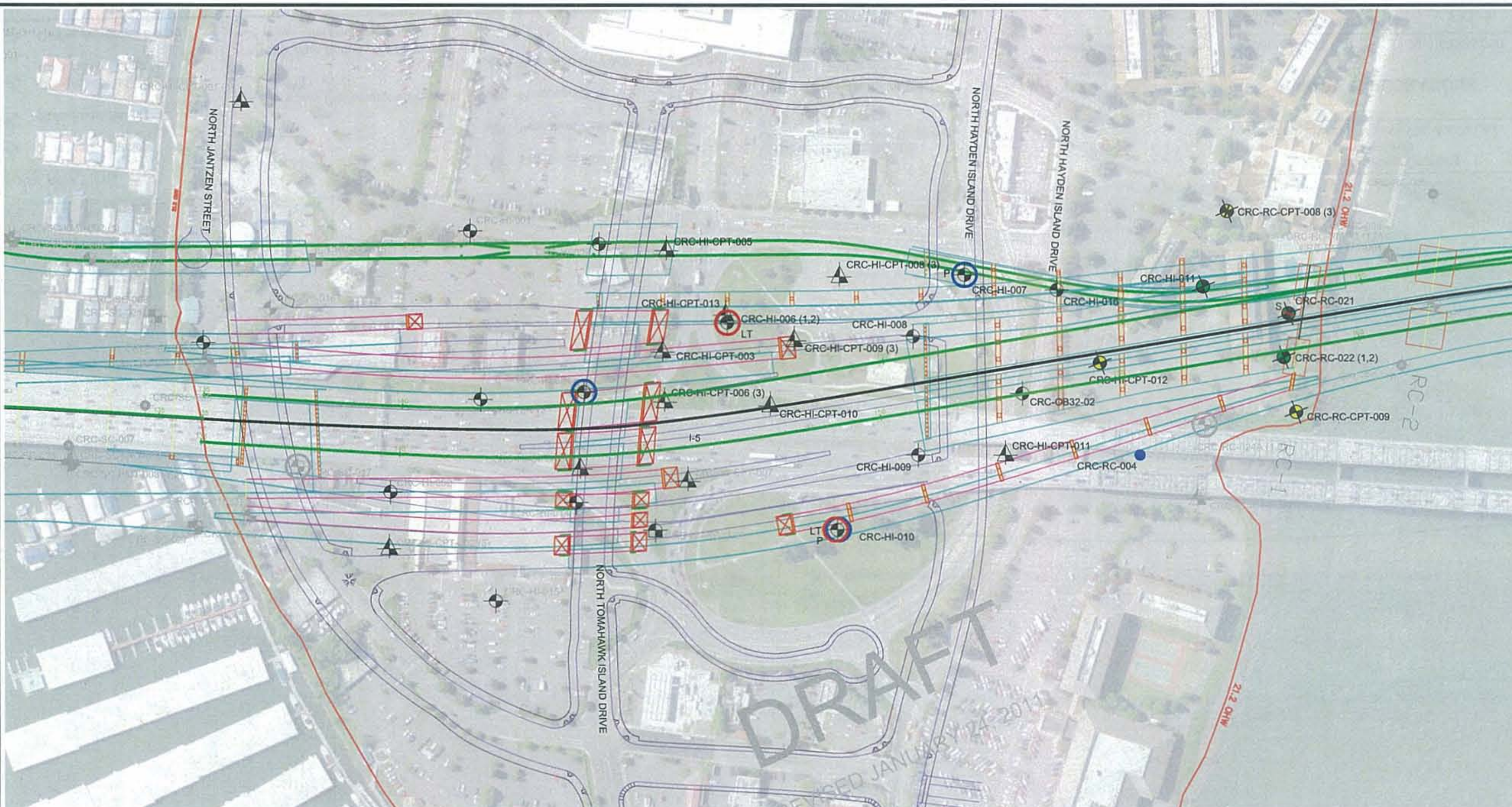
Geotechnical and Environmental Consultants

FIG. 1

File: I:\WIP\Projects\24-1 Portland\3500\3595 CRC Task AH\Drafting\Large Plan & Profile 1-28-11.dwg Date: 01-24-2011 Author: ael



EXPLANATION

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- Proposed CPT with Seismic Testing

Designation Abbreviations:
CRC = Columbia River Crossing
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HI = Hayden Island
RC = River Crossing
CPT = Cone Penetration Test

Additional Testing Notes:
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N

0 200 400

Scale in Feet

I-5 Columbia River Crossing
Hayden Island
Portland, Oregon / Vancouver, Washington

PLAN OF EXPLORATIONS

January 2011 24-1-03595-050

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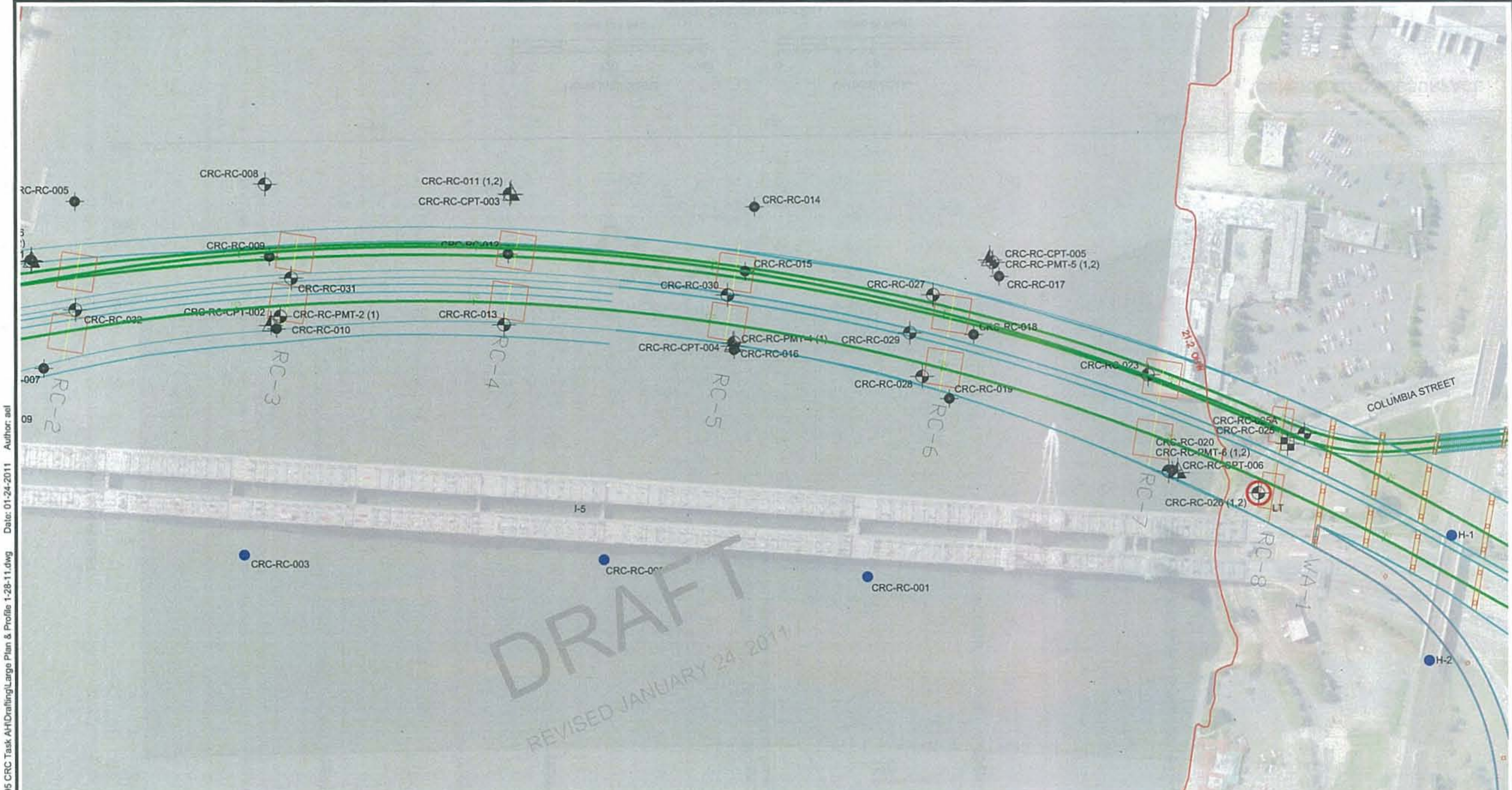
FIG. 2

File: I:\WIP\Projects\24-1 Portland\3500\3595 CRC Task AH\Drafting\Large Plan & Profile 1-28-11.dwg Date: 01-24-2011 Author: ael



EXPLANATION

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Designation Abbreviations:
CRC = Columbia River Crossing
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Additional Testing Notes:
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N

0 200 400
Scale in Feet

I-5 Columbia River Crossing
Main Span
Portland, Oregon / Vancouver, Washington

PLAN OF EXPLORATIONS

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FIG. 3

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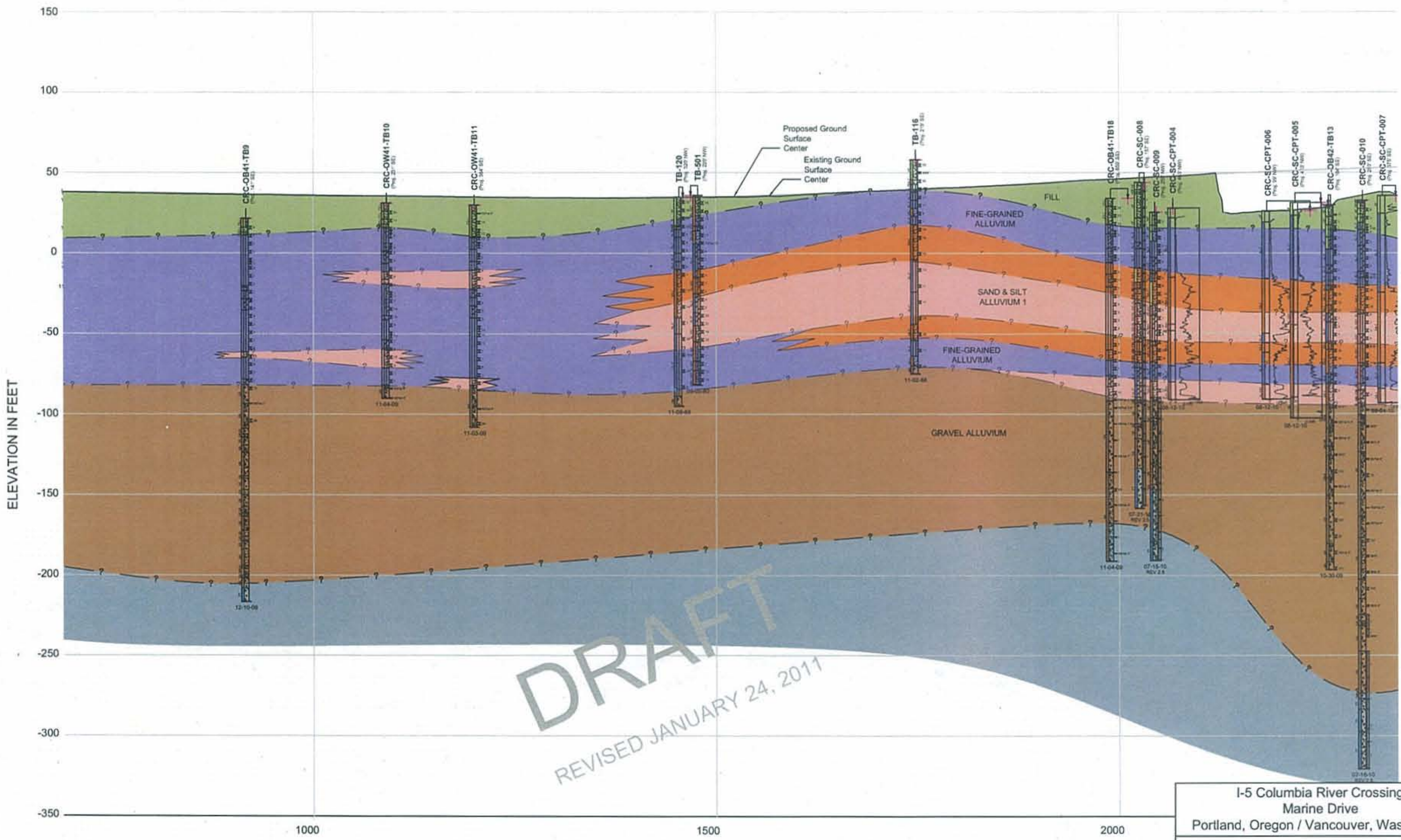

Horizontal Scale

0 120 240

Scale in Feet

Vertical Scale

0 60 120

Scale in Feet

Vertical Exaggeration = 2x

I-5 Columbia River Crossing
Marine Drive
Portland, Oregon / Vancouver, Washington

GENERALIZED SUBSURFACE PROFILE

January 2011 | 24-1-03595-050

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FIG. 4

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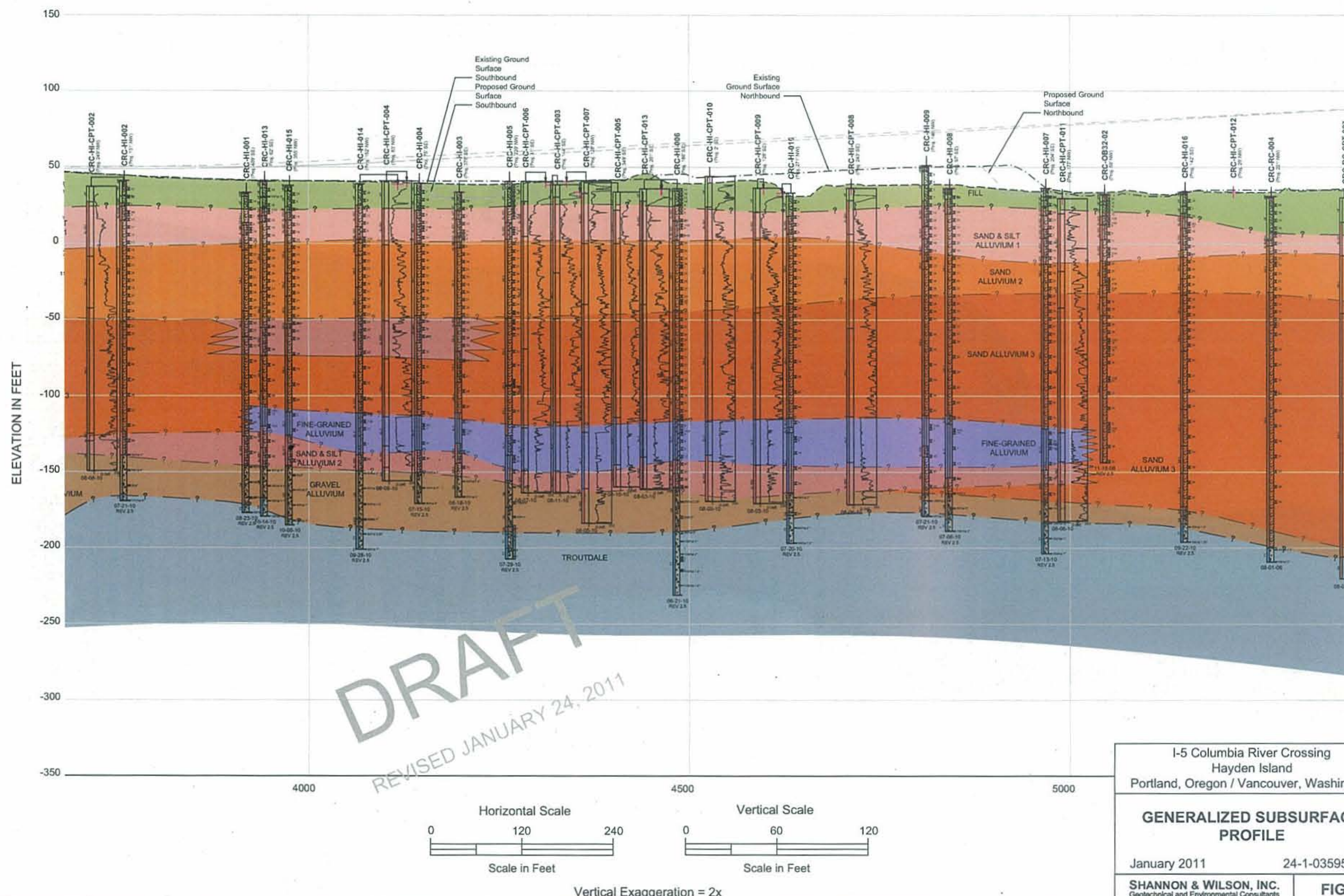

I-5 Columbia River Crossing
Hayden Island
Portland, Oregon / Vancouver, Washington

GENERALIZED SUBSURFACE PROFILE

January 2011 24-1-03595-050

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FIG. 5

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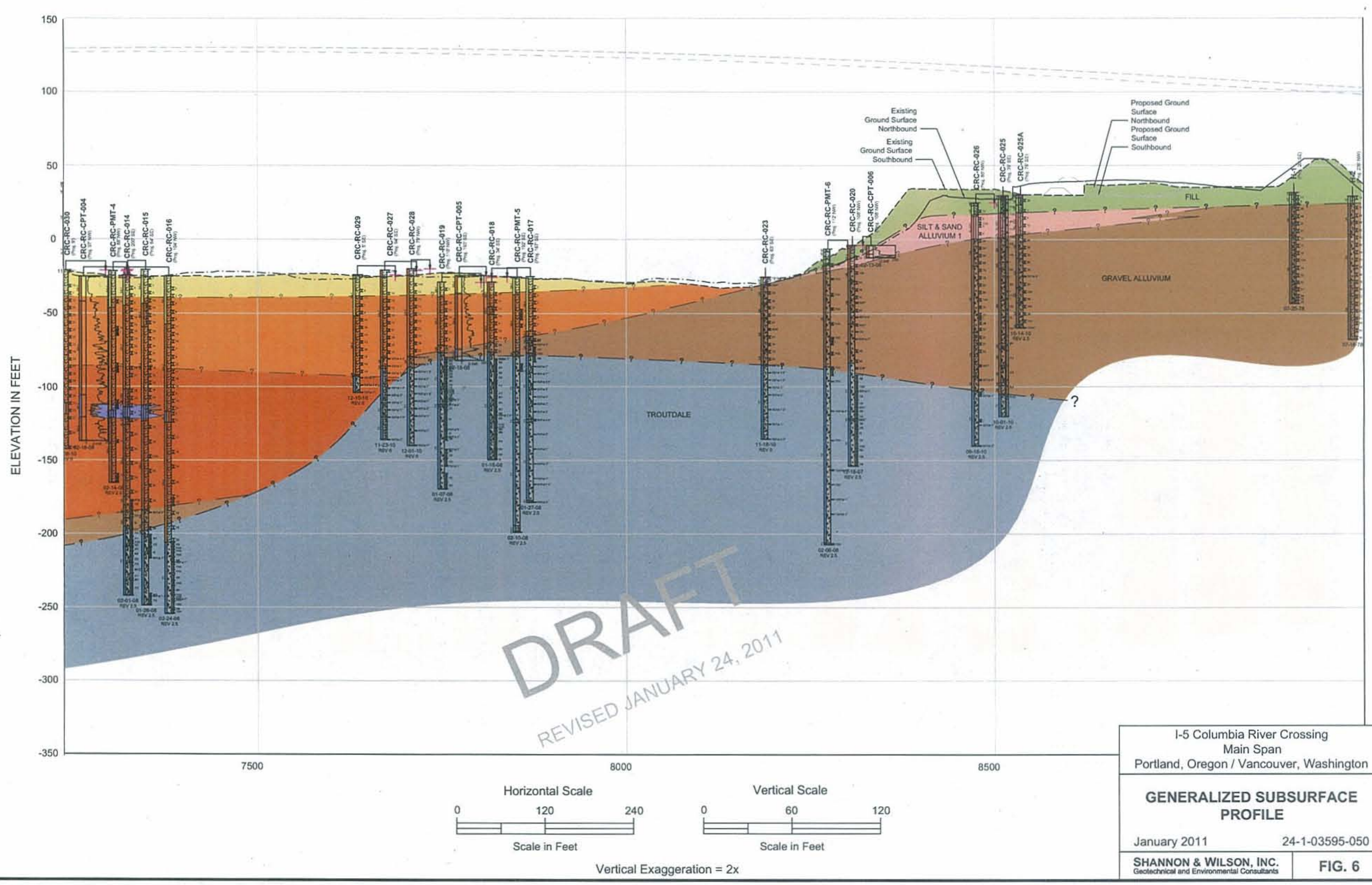

I-5 Columbia River Crossing
Main Span
Portland, Oregon / Vancouver, Washington

GENERALIZED SUBSURFACE PROFILE

January 2011 | 24-1-03595-050

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FIG. 6

File: I:\WIP\Projects\24-1 Portland\3500\3595 CRC Task AH\Drafting\Large Plan & Profile 1-28-11.dwg Date: 01-24-2011 Author: ael

Columbia River CROSSING

Meeting Minutes

MEETING: Drilled Shaft Test Program Meeting

MEETING DATE: Thursday, January 27, 2011

ATTENDEES: Frank Green; CRC, Jan Six; ODOT, Tova Peltz; ODOT, Bill Hegge; WSDOT, John McAvoy; FHWA, Park Piao; Shannon & Wilson, Gary Peterson; Shannon & Wilson, Matt Deml; CRC

ATTENDEES BY PHONE: Chris Heathman; WSDOT, Steve Saxton; FTA, John Buchheit; FTA

The meeting began at 2:30 a.m. and concluded at approximately 4:00 p.m.

Drilled Shaft Test Program

- Park reviewed the Draft Conceptual Drilled Shaft and Driving Pile Load Testing Program memo dated January 24, 2011.The program will consist of various drilled shafts at three separate locations as indicated below. Additional details and site plans are currently under development.
  - Washington
    - (1) Six foot diameter drilled shaft
  - Hayden Island
    - (1) Six foot diameter drilled shaft
    - (1) Ten foot diameter drilled shaft
    - (1) driven test pile with reaction piles
  - Maine Drive
    - (1) Six foot diameter drilled shaft
    - (1) driven test pile with reaction piles
- Smaller diameter (6-foot) shafts are being used so that the shafts can be failed during testing
- The 10-foot diameter shaft will be constructed using permanent casing with an O-cell at the shaft tip.
- Further details of piles/shafts construction will be determined by future design work. These details included exact test locations, the use of permanent or temporary casing (for the 6' diameter shafts), design depths, design capacities, and test instrumentation/detailing. No special procedures such as tip grouting or permeation grouting are anticipated.
- Jan Six and Bill Hegge agreed that O-cells are the preferable test method.
- Bill Hegge inquired about performing a lateral load test on the driven piles since the reaction piles and load frame will already be in place. Park Piao will evaluate cost and benefit.
- Park Piao asked ODOT and WSDOT geotechnical departments if the anticipated level of testing meets AASHTO requirements. Jan Six noted that the level of testing is appropriate. Bill Hegge said he would review the framework with others at WSDOT geotech before responding.
- 30% design (draft test program details) is anticipated in approximately three weeks.

360/737-2726 503/256-2726 WWW.COLUMBIARIVERCROSSING.ORG 700 WASHINGTON STREET, SUITE 300, VANCOUVER, WA 98660

From: Francis, Carley
To: Workman, Chris
Cc: Green, Frank; Peterson, Laura
Subject: RE: Load Testing
Date: Monday, June 27, 2011 5:32:46 PM

Hi Chris,

No, even if cost was not an issue, the ASTM D1143 method would not be appropriate.

Given the size of the drilled shafts being tested, the ASTM D1143 test would expensive, impractical, and not provide the same results as an O-cell. The physical size reaction assembly (piles, frame, etc.) would have much greater impacts at the ground surface, in addition to cost. Furthermore, the O-cell tests is the only method that can be used to adequately assess the geotechnical characteristics of the Troutdale formation. Without adequate assessment of the Troutdale geotechnical characteristics, the test project would not facilitate revising design assumptions for foundations which will allow the project to realize cost savings.

I hope this answers your question.

Carley

From: Workman, Chris [mailto:WorkmaC@wsdot.wa.gov]
Sent: Wednesday, June 22, 2011 7:10 AM
To: Francis, Carley
Subject: Load Testing

Hi Carley,

I have a question about the following in bold:

DRAFT Conceptual Drilled Shaft and Driven Pile Load Testing Program. Page 3 of 4

We considered three different drilled shaft load testing methods, including Standard Test Methods for Deep Foundations Under Static Axial Compressive Load (ASTM D1143) static load tests, Statnamic load tests (ASTM D7383), and Osterberg Cell load tests. Based upon our comparison of these three load test methods, it is our opinion that the ***ASTM D1143 method will be expensive for large diameter drilled shafts due to the need for reaction piles or shafts and large reaction beams****. The Statnamic load test appears unacceptable primarily because it has a limited maximum test load (possibly under 6,000 or 7,000 kips) which is low compared to the anticipated foundation loads for the overwater structures on project. Also, the Statnamic loading test does not provide separate skin friction and end bearing resistance estimates; it only provides the total axial test load versus the shaft vertical movement.*

Based on the above, we recommend employing the Osterberg Cell load test method for drilled shafts because it would: 1) be less expensive, 2) provide a test capacity that matches anticipated design loads, and 3) provide both side resistance from skin friction and end resistance from bearing estimates.

If cost was not an issue, would the ASTM D1143 method be acceptable?

Chris Workman, P.E.
Assistant Design Services Engineer
WSDOT SW Region
360.905.2191