INTERNATIONAL SOCIETY FOR MICROPILES

May 31- June 2, 2023
Vail, Colorado

15TH International Workshop On Micropiles

DESIGN AND IN-CONSTRUCTION GEOLOGIC CHARACTERIZATION OF MICROPILES

TO SUPPORT A HISTORIC TRANSMISSION LINE UPGRADE IN THE STEEP TALUS AND BASALT SLOPES OF THE COLUMBIA RIVER GORGE

presented by Brian J. Olson, C.E.G. | Crux Subsurface

CRUX
A QUANTA SERVICES COMPANY

Bonneville-Hood River 115kV Transmission Line

Bonneville Power Administration (BPA) – Transmission Line Micropile Foundations

- Phase 1: Verification Testing + 3 Foundations
- Phase 2: Remaining 24 Structure Foundations

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Historic Background

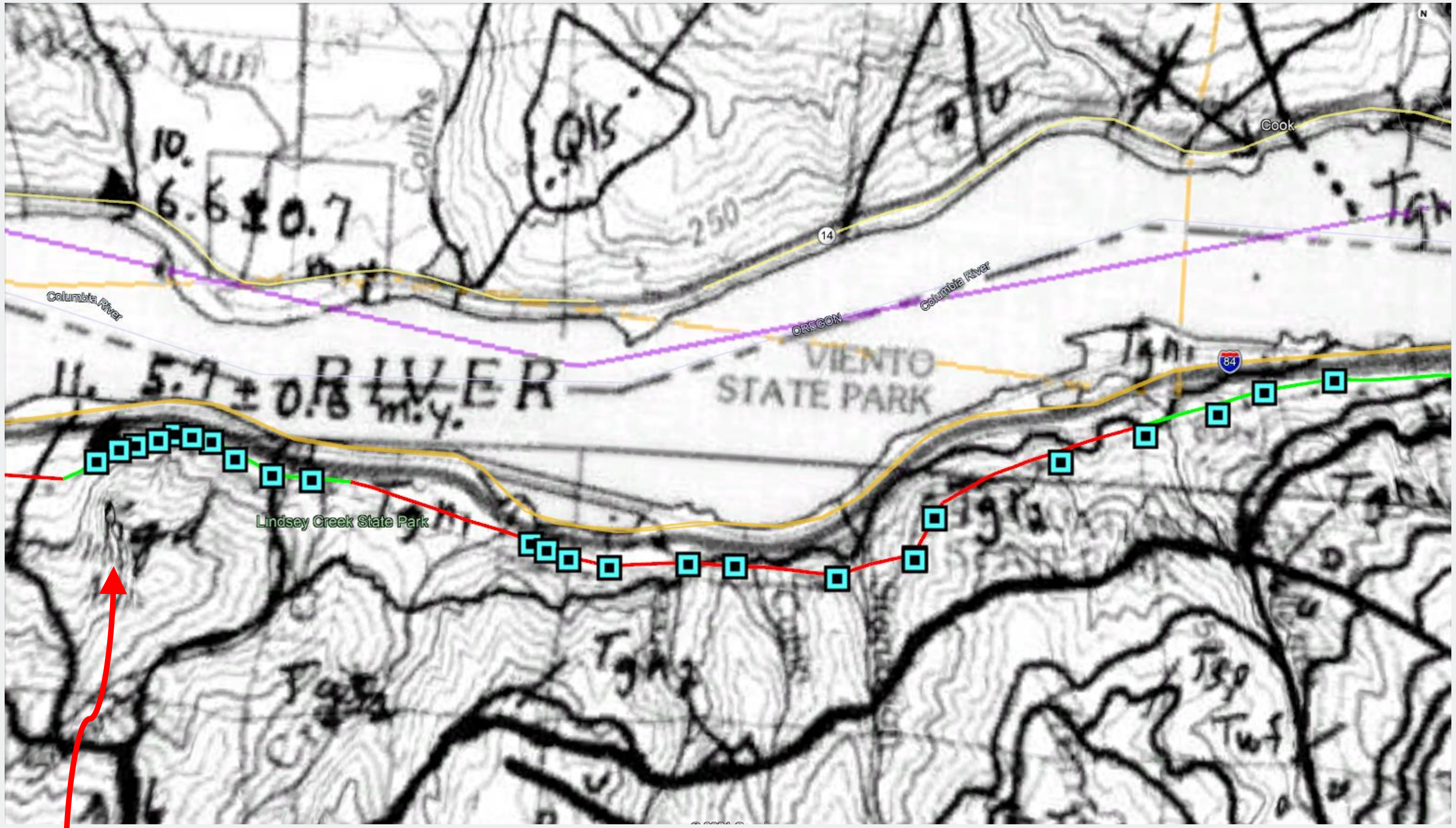
- Originally constructed between 1939-1941
- Transmitted much needed electricity from the Bonneville Dam to Eastern Oregon
- The westernmost 22-mile segment (Bonneville to Hood River) proved to be most difficult
- State-of-the-art Modular H-Frames

Historic Background

- Hand-excavated foundations supported the state-of-the-art modular H-Frame design
- Energized in 1941, it remained in service for over 75 years
- 68 structure sites along the segment
  - Drilled shafts designed for accessible sites
  - Micropiles at 26 locations with challenging access

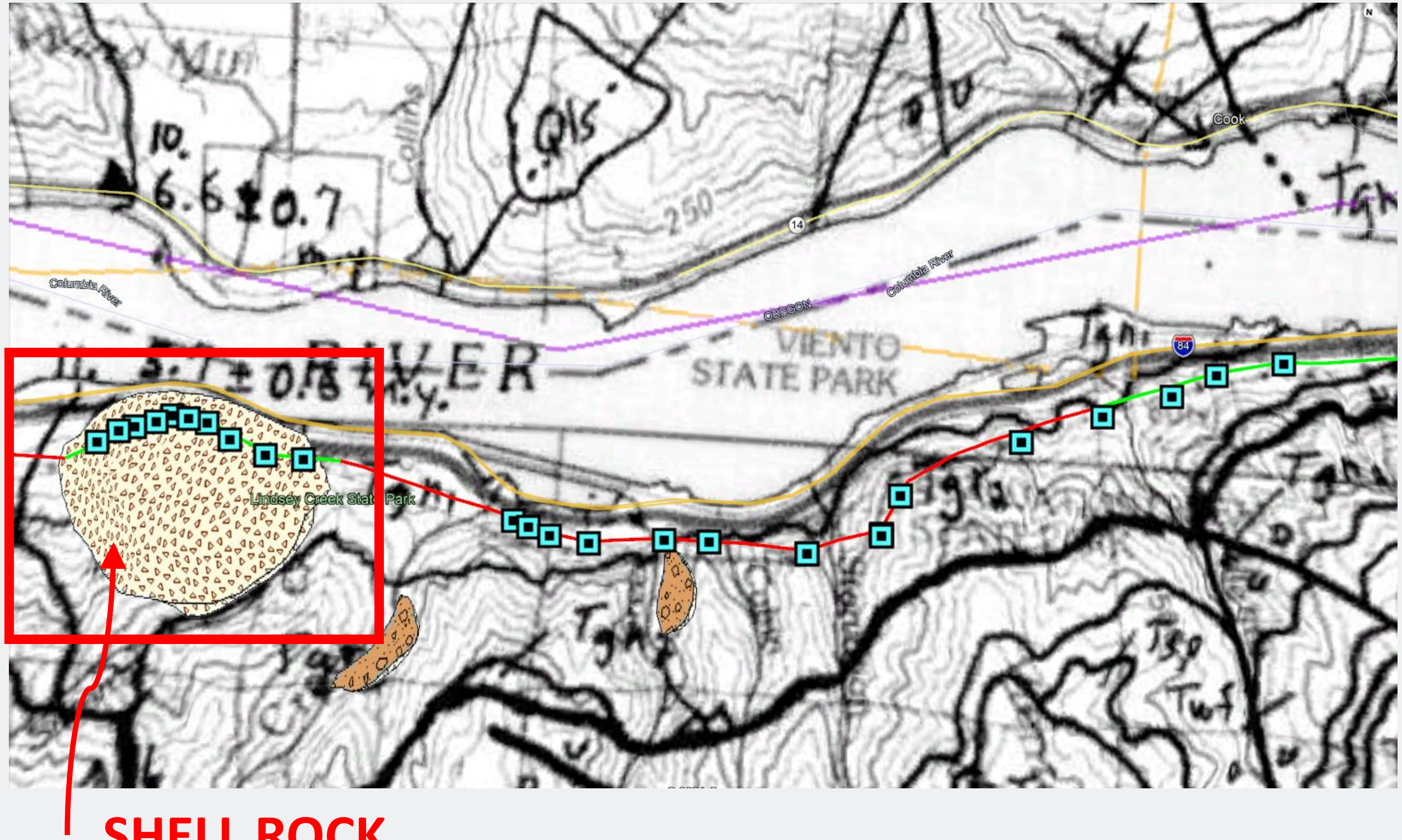
Geologic Mapping - Bedrock

- Geologic Maps published by DOGAMI (Department of Geology and Mineral Industries)
- Kgd (Granodiorite) underlies Shell Rock
- Grand Ronde Basalt units to the east



Geologic Mapping - Surficial Deposits

- Limited mapping of surficial deposits
- Existing landslide and talus mapping not well defined



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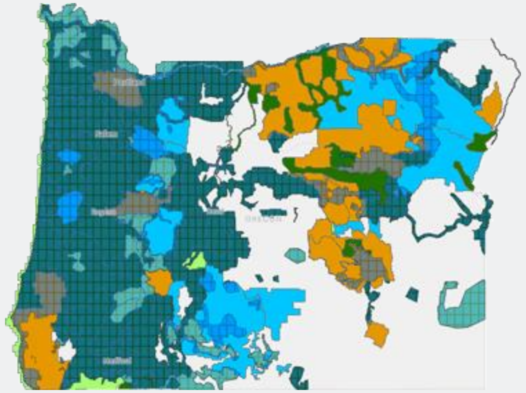
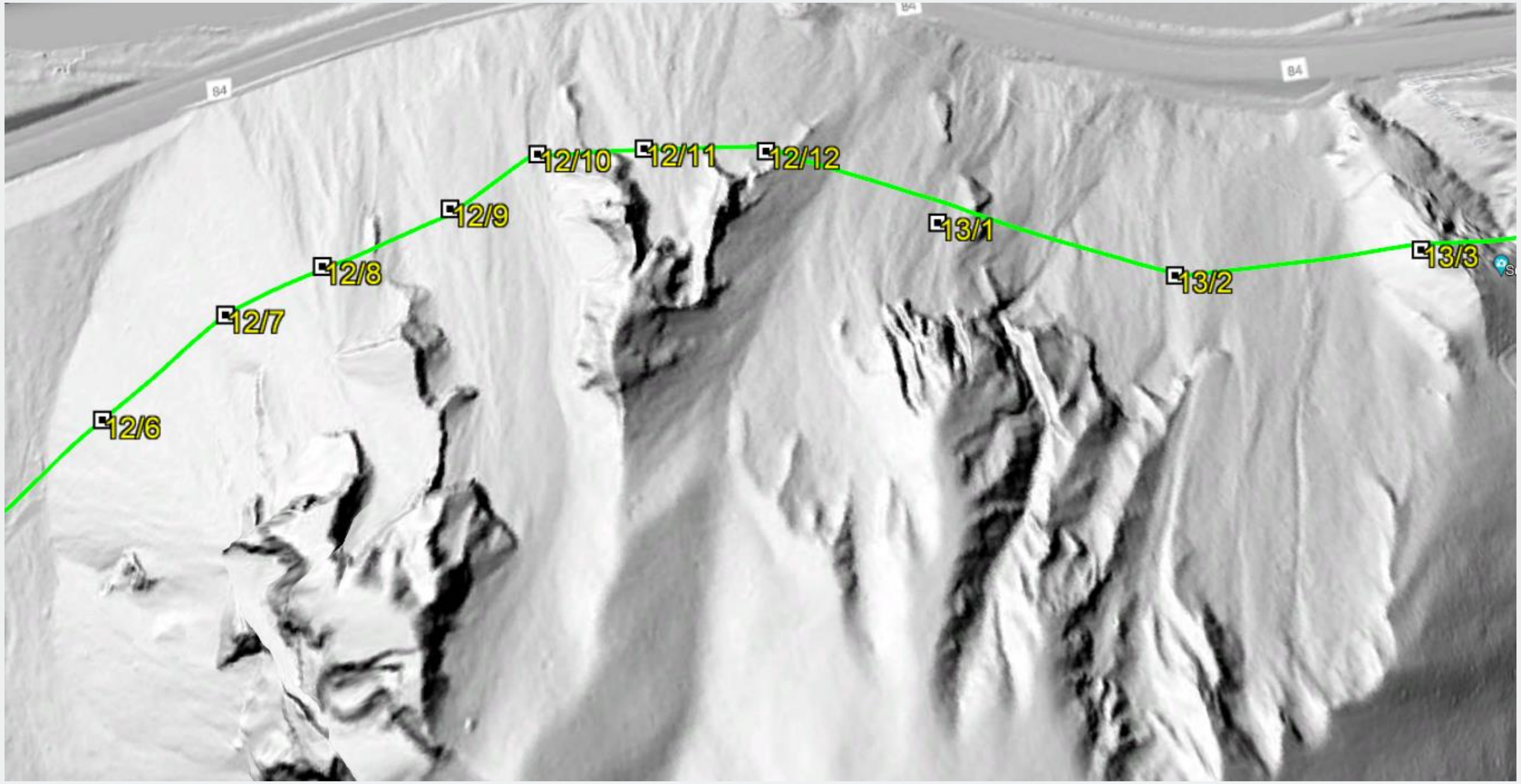
LiDAR and GIS

- Hillshade models derived from LiDAR
- Data maintained by DOGAMI





SHELL ROCK with LiDAR-Derived Hillshade

Bedrock Sites

- Grande Ronde Basalt of the Columbia River Basalt group
- Granitic rock would be encountered at depth in a lesser percentage of the foundations
- Micropile bond stress values for these bedrock types were well established
- Design parameters were relatively well defined
- Variations were limited to the depth and weathering profile of the bedrock
- Depth expected to vary considerably, sometimes across an individual tower footprint

Talus Sites

- Talus are an outward sloping and accumulated heap or mass of rock fragments of any size or shape (usually coarse and angular)
- Derived from, and laying at the base of, a cliff or very steep, rocky slope
- Here, consisted of angular gravel to boulder-sized basalt and granitic clasts shed from the elevated cliff areas south of the structure sites
- Although the interlocking angular deposits provide a high degree of global slope stability, the materials at the surface can be loosened when loaded by equipment or even heavy foot traffic.

Talus Sites - Challenges

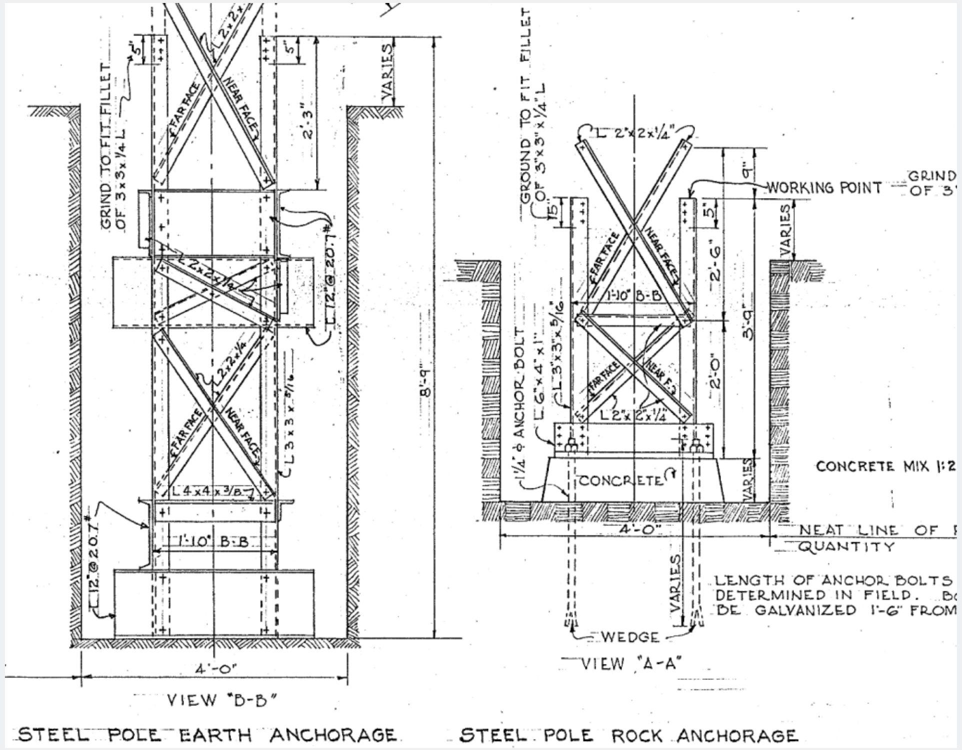
- Bond stress values are not well established
- Clast size ranges from gravel to boulder
- Unit often masks underlying debris- or mud-flow deposits
- Voids within the larger clasts pose a challenge during drilling and grouting
- A verification test program to characterize this material was developed

Soil Sites

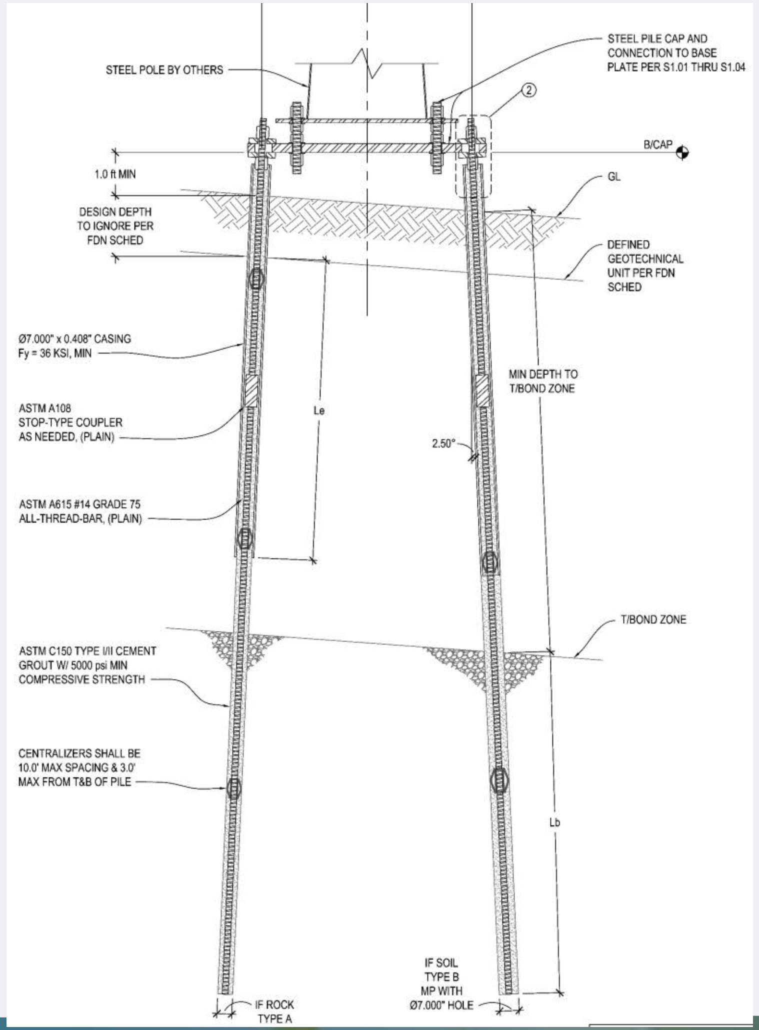
- Surficial talus deposits can hide buried finer grained soils and debris- or mud-flow deposits
- Contradicting bedrock outcrops or geologic mapping, deep soils would necessitate longer, specialized micropile bonds
  - Piles would need to be deepened to establish bonds in underlying bedrock
  - Or pressurized Type B or Type D bonds would be required
- Pre-construction desktop studies suggested soil deposits would be the least common category among the three

Before and After

1940



2018



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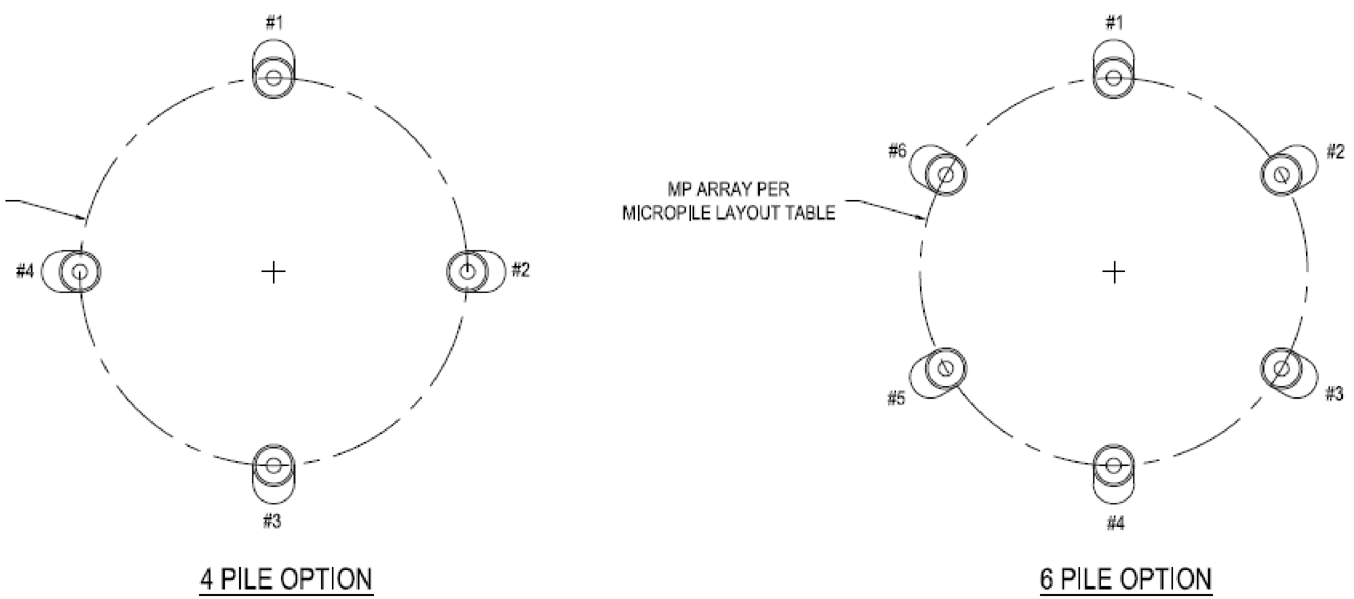
Foundation Design

- BPA Design Standards
  - Slope
  - Erosion/Scour
- Talus Characterization
  - Lateral Performance
  - Bond Stress
- Construction Tolerance
- Access Limits

Foundation Design

- Micropile Foundations
  - Portability
  - Steel pile caps
  - All helicopter equipment transport



Maximum Foundation Design Loads			
	4-Pile	6-Pile	8-Pile
Moment, (k-ft)	907.1	1723.4	2142.1
Axial, (k)	15.3	83.8	12.8
Shear, (k)	**13.8**	**29.5**	14.2

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Foundation Design

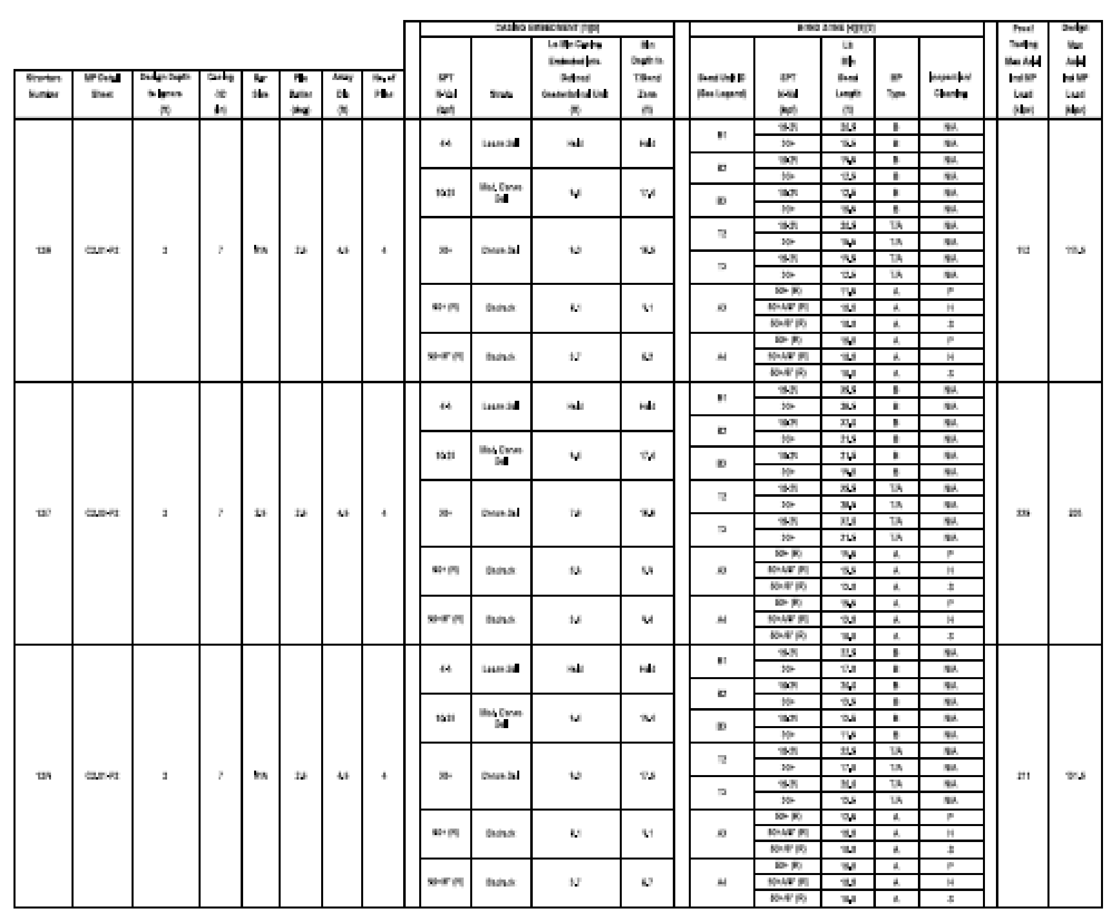
- Pile Arrays of 4, 6, and 8 Piles
  - Casing: 7” x 0.408”
  - Bar: #18 Gr 75, 2.25” 150ksi
  - Batter: 2.5 deg
  - Stick-up: 12” min at uphill side
  - Pinned vs Fixed
  - Corrosion Protection - Galvanized

Foundation Design

- Steel Pile Cap Design
  - FEA modeling for strength and performance
  - A572 Gr 50, Galvanized
  - Pile Cap Thickness:
    - Single Plate: 2.5”-4.5”
    - Double Plate: 5”-5.5”
  - Cap diameters ranged from 52-82”
  - Designed to serve as a reaction frame for load testing where possible

Foundation Design

- Foundation Schedule
  - Specific to each site
  - Allows flexibility in the field
  - Options based on varying soil/rock types, slopes, batter, pile materials
  - Each site characterized during drilling of first pile: cased zone and bond zone
  - QA/QC Requirements



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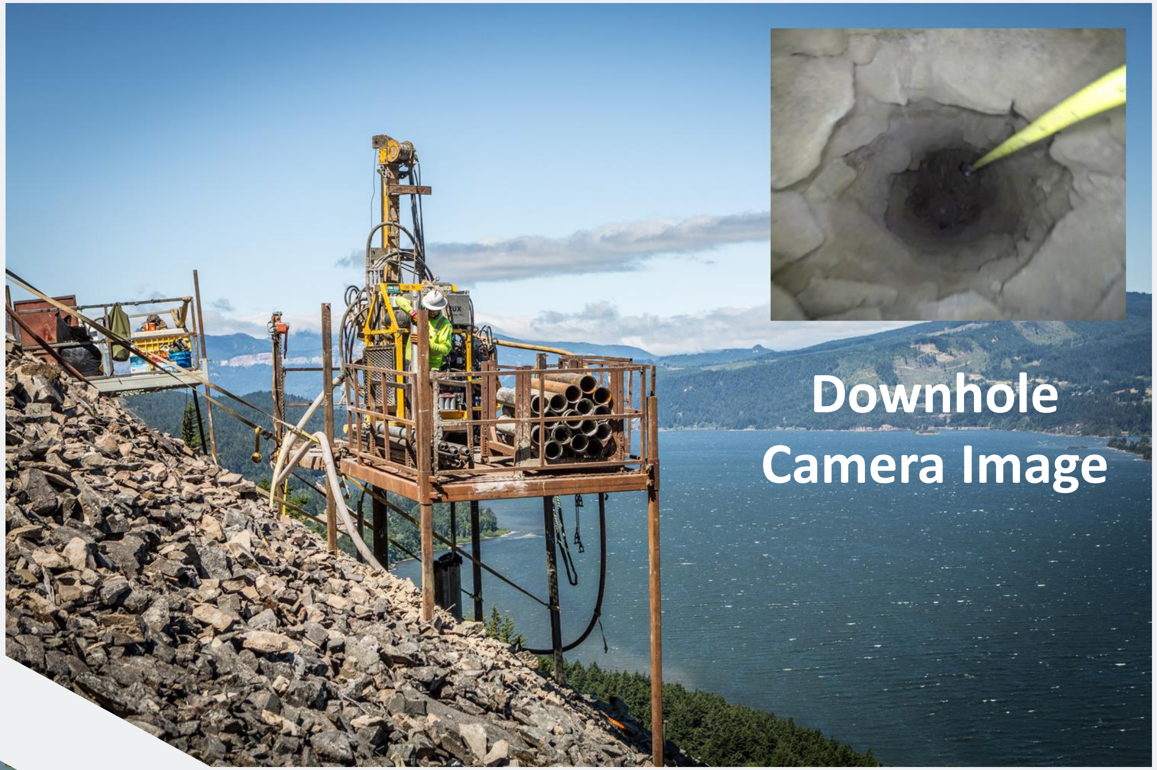
Load Testing – Verification Testing (Phase 1)

- Pre-production verification test program as a first order of work under the construction contract.
- Two sacrificial micropiles were installed in locations established by the owner.
- To define the bond zone strength for talus materials.
- confirming the adequacy of the installation methods.
- SPT sampling, geologic logging, and downhole camera video were utilized to document the geotechnical conditions in each of these sacrificial piles

Geologic Characterization and Monitoring



- Geologists representing the Foundation Engineer of Record (EOR) were onsite to work with the drillers, confirm the subsurface conditions, and assign cased zone and bond zone IDs.
- Standard Penetrometer Test (SPT) sampling was performed in general accordance with ASTM D1586.
- Classification in general accordance with ASTM D2488.
- Downhole camera system specially adapted for micropile diameters.

Production QC – Proof Testing (Phase 2)

- Conducted on a percentage of total production piles installed
  - Verifies consistency of the construction procedure
  - Confirms application of soil/rock strengths
- When a high degree of geologic uncertainty exists and geotechnical bond units may vary due to:
  - Variations inherent in the geologic unit
  - Distance between the sacrificial test locations
- Proof testing was performed on all foundations where talus or soil bonds were installed

Keys to Success

- Steel Cap Design
- Handling unforeseen variability in the Talus materials
  - Pre-construction verification testing
  - Differentiating between Talus and finer grained alluvial/colluvial sites
- Proof testing of production piles at all Talus and Alluvial sites

Project Completion

Energized in the Fall of 2020

Questions?

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