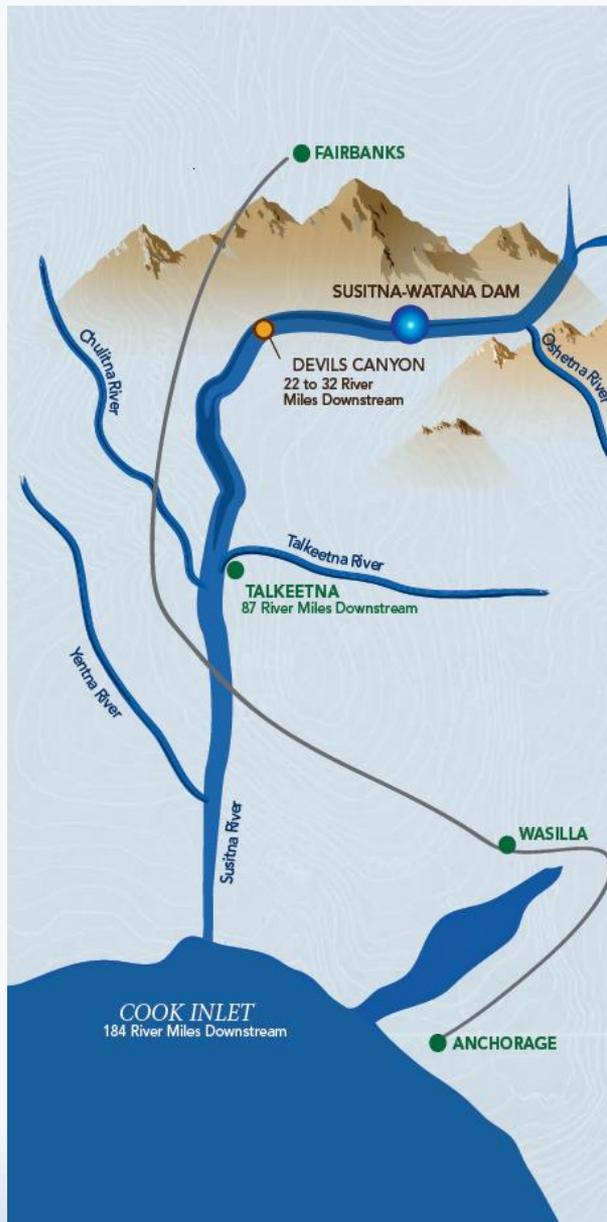


# Initial Study Report Meeting

## *Study 4.5 Geology and Soils Characterization*

*March 30, 2016*

Prepared by MWH



# Study 4.5 Status

## ISR documents (ISR Part D Overview):

- Initial Study Report: Parts A, B and C (June 3, 2014)
- 2014-2015 Study Implementation Report (SIR) (November 4, 2015)

## Status:

- Completed drilling, laboratory analysis, geotechnical instrumentation monitoring, dam site geologic mapping a fault rupture evaluation, seismic network monitoring of earthquake activity, and crustal seismic source evaluation.
- Geologic characterizations and investigations are continuing.

## Study 4.5 Objectives

- **Identify the existing soil and geology** at the proposed construction site, reservoir area, and access road and transmission line corridors
- Determine the **potential effects of Project construction, operation, and maintenance** activities on the geology and soil resources (including mineral resources) in the Project area including identification and potential applicability of protection, mitigation, and enhancement (PM&E) measures
- Identify known **mineral resources** and **mineral potential** of the Project area
- Acquire soils and geologic information for the Project area for use in the preparation of a **supporting design report** that demonstrates that the proposed structures are safe and adequate to fulfill their stated functions

## *Study 4.5 Components*

- 1. Review of Project Documentation** (ISR Part A, Section 4.1.1; pg 3)
- 2. Regional Geologic Analysis and Mineral Resources Assessment** (ISR Part A, Section 4.1.2; pg 3)
- 3. Geologic and Geotechnical Investigation and Testing Program Development** (ISR Part A, Section 4.1.3; pg 4)
- 4. Field Geologic and Geotechnical Investigations** (ISR Part A, Section 4.1.4; pg 4)
- 5. Reservoir-Triggered Seismicity** (ISR Part A, Section 4.1.5; pg 5)
- 6. Reservoir Slope Stability Study** (ISR Part A, Section 4.1.6; pg 5)
- 7. Long-Term Earthquake Monitoring System** (ISR Part A, Section 4.1.7; pg 6)
- 8. Geologic and Engineering Analysis** (ISR Part A, Section 4.1.8; pg 6)

## Study 4.5 Variances

- Due to land access restrictions in the study area in 2013, the planned field exploration and testing program, specifically geologic mapping, geophysical surveys, drilling and testing, and excavation of an exploratory audit at the dam site, were deferred until 2014 when land access was granted.
- The Chulitna Corridor was eliminated from the study area (ISR Part D Overview, Section 1.3) and the Denali East Corridor Option was added to the study area as an additional, alternative north-south corridor alignment for transmission line and road access from the dam site to the Denali Highway (ISR Part C, Section 7.1.2).

# ***Study 4.5 Summary of Results (ISR Part A Section 5 and SIR Section 5)***

- **Review of Project Documentation**

- Existing geologic, geotechnical, and seismic documentation from 1970s and 1980s was brought into geo-referenced, geotechnical databases; review of earlier rock cores
- Earlier data was a factor in development of geologic model and site characterization

- **Geologic and Geotechnical Field Investigation and Testing**

- A multi-phased geotechnical exploration and testing program work plan was prepared for the feasibility and licensing studies.
- Dam site and proposed rock quarry (A & M) subsurface investigations included 15 borings and a total of 4708 feet of drilling, primarily in bedrock, over three field seasons.
- Rock core was recovered and logged, in situ testing (packer testing and downhole imagery) performed, geo-instrumentation installed (vibrating wire piezometers and temperature acquisition cables), and laboratory testing performed.

## ***Study 4.5 Summary of Results (ISR Part A Section 5 and SIR Section 5)***

- **Dam Site Geology**

- The dam will be founded on fresh to slightly weathered, hard, strong dioritic rock. The rock mass is locally fractured, sheared and altered; blocky to very blocky
- Fracture, shear, and alteration zones generally trend in a northwest-southeast direction and to a lesser extent in a north –south direction. Fracture and shear zones are less than 2 feet wide but in a few locations, the width can be up to 10 feet or more
- “Geologic features”, shear and/or fracture zones greater than 5 feet in width, which were described and shown in 1980s documents were not as wide (over-represented) as was previously interpreted
- There is no evidence of a previously postulated east-west trending fault beneath the river
- The potential for surface fault rupture is considered extremely low (e.g., lack of continuity and small scale)

# Study 4.5 Summary of Results (ISR Part A Section 5 and SIR Section 5)

- **Dam Site Geology (continued)**
  - Groundwater
    - Right (north) abutment - generally moderate to deep
    - Left (south) abutment - groundwater levels are complicated by the presence of frozen ground; but are generally at about 170 feet depth
  - Permafrost
    - Right abutment - at moderate depths in the lower right abutment
    - Left abutment - present at considerable depth
    - Ice-filled discontinuities in bedrock will affect rock mass properties and will likely impact foundation treatment
  - Abutment Stability
    - Slopes at the dam site are stable
    - Minor shallow debris flows are evident, particularly on the moderately dipping north facing slopes where thawing of frozen ground has occurred
    - Toppling failures occur u/s and d/s of the dam site; oversteepened slopes

## ***Study 4.5 Summary of Results (ISR Part A Section 5 and SIR Section 5)***

- **Reservoir (Regional) Area Geology Studies**
  - Geology and Soil
    - Variable thicknesses of glacial till, lacustrine deposits, colluvium, outwash and alluvium overlying igneous and metamorphic bedrock.
    - Till and lacustrine deposits dominate in the upland plateau areas while bedrock is exposed along the lower river channel.
  - Perennially frozen ground (permafrost), is evidenced by periglacial features, patterned ground, exposures of frozen ground in debris flows, and thawing ice-rich deposits.
  - Mass movement - most active landslides and debris flows are associated with the thawing of frozen ground.
  - Mineral resources - eleven mining claims and three gold placer or lode prospects have been identified within the proposed reservoir impoundment area. No active mining was observed at these claims or prospects.
  - Impacts to Geology and Soils

# *Study 4.5 Summary of Results (ISR Part A Section 5 and SIR Section 5)*

- **Reservoir (Regional) Area Geology Studies**
  - Impacts to Geology and Soils
    - Regional geology studies
      - Submergence of potential aggregate (sand and gravel) sources in the river channel, mining claims and gold placer prospects by the impoundment of the reservoir.
      - Frozen ground beneath and adjacent to the reservoir, is anticipated to thaw as a result of reservoir impoundment.
      - Groundwater levels adjacent to the reservoir will rise to higher levels as a function of reservoir impoundment.
    - Reservoir slope stability study
      - Shallow mass movement, instability of slopes, could occur along the reservoir rim due to thawing permafrost and changes in the groundwater levels

# *Study 4.5 Summary of Results (ISR Part A Section 5 and SIR Section 5)*

- **Seismic Hazards Studies**

- Crustal seismic source evaluation indicate:
  - Evidence suggests that the Talkeetna block is relatively stable
  - A lack of evidence of major crustal Quaternary faults near the dam site.
  - Detailed evaluations have not identified any evidence of potential Quaternary faulting within at least 25 mi (40 km) of the Watana dam site.
  - Watana dam site area is subject to NW-SE oriented sub-horizontal compressive stress associated with the on-going subduction of the Pacific Plate.
  - Relative to the fault rupture evaluation at the dam site, the previously identified “geologic features”, appear to be relatively minor structures and are least favorable to reactivation in the contemporary stress regime.

- **Seismic Monitoring**

- A total of 2,523 earthquakes have been recorded by the project network over a 26 month period from late 2012 through 2014
- The largest intraslab and crustal events were a M4.6 and a M3.8, respectively

## ***Study 4.5 Summary of Results (ISR Part A Section 5 and SIR Section 5)***

- **Reservoir Triggered Seismicity**
  - See results of ISR Study 16.6
- **Geologic and Engineering Analyses**
  - Design criteria
    - Engineering properties of the rock mass
    - Slope design criteria, soil and rock
    - Seismic design criteria
  - Abutment stability, preliminary
  - Foundation evaluation – depth of excavations, treatment, etc.
  - Concrete aggregate assessment, preliminary mix designs

## *Study 4.5 Summary of Results*

### *Technical Memoranda / Reports*

- Interim Mineral Resource Assessment Report, March 2014
- Exploration and Testing Program Work Plan 2014-15, December 2013
- Preliminary Reservoir Slope Stability Technical Memorandum, September 2013
- Geotechnical Data Report, February 2015
- Dam Site Geology Technical Memorandum, October 2015
- Regional Geologic Analysis Technical Memorandum, April 2013
- Crustal Seismic Source Evaluation, May 2015
- Seismic Network 2014 Annual Seismicity Report Susitna-Watana, March 2015
- Seismic Monitoring Project: January –June 2015 Quarterly Report, September 2015
- Engineering Feasibility Report, December 2014

## *AEA's Proposed Modifications to Study 4.5 (ISR Part D, Section 7)*

- No modifications to the Study Plan methods are needed to complete the study and meet Study Plan objectives.
- The Chulitna Corridor was eliminated from the study area (ISR Part D Overview, Section 1.3) in 2014 and the Denali East Corridor Option was added to the study area as an additional, alternative north-south corridor alignment for transmission line and road access from the dam site to the Denali Highway (ISR Part C, Section 7.1.2).

## *Steps to Complete Study 4.5 (ISR Part D, Section 8)*

- Mineral resource assessment - an assessment of the mineral resources within the Project area was initiated and an interim report prepared (Golder 2014, Attachment 1). The catalog of claims and prospects will be updated.
- Geotechnical Exploration – field investigations and testing will be conducted in the future to characterize the geology and soil resources, determine construction impacts, and mitigate the impacts in the dam site area, reservoir area, construction material sources, and access road and transmission line corridors.

## *Licensing Participants Proposed Modifications to Study 4.5?*

- Agencies
- CIRWG members and Ahtna
- Public