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SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Site-Specific Seismic Hazard Study
Study Plan Section 16.6

Initial Study Report
Part C: Executive Summary and Section 7

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

MWH / Fugro

June 2014

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EXECUTIVE SUMMARY

Site-Specific Seismic Hazard Study 16.6	
Purpose	The objectives of this study are to identify potential seismic hazards and conduct deterministic and probabilistic seismic hazard evaluation in order to estimate earthquake ground motion parameters at the Project site and develop seismic design criteria for the Project
Status	Field data collection and desk-top studies have begun; however, certain elements of the field investigation evaluation of crustal seismic sources have not been completed. Field activities included aerial reconnaissance and geologic mapping. Preliminary Probabilistic Seismic Hazard Analysis (PSHA) and Reservoir Triggered Seismic Analysis (RTS) studies have been completed. In the 2014 field season, the crustal seismic source evaluation, with a focus in the dam site area, which will included aerial surveys, on the ground geologic mapping will be undertaken. If needed, trenching and age dating would be undertaken in 2015. At the completion of the crustal seismic source assessment, a Probabilistic Seismic Hazard Analysis will be completed and an estimate of ground motion parameters for the project will be selected. Additionally, the seismic monitoring data collection efforts will be continued.
Study Components	The key study methods include review of scientific literature, Interferometric Synthetic Aperture Radar (INSAR) and Light Detection and Ranging (LiDAR) datasets, and lineament mapping and analysis in order to identify potential seismic hazards, field reconnaissance and mapping of potential fault features, monitor and review of earthquake event data for the Project area, obtain shear wave velocity measurements of bedrock, development of a PSHA including ground motions for design.
2013 Variances	Land access restrictions in 2013 limited ground studies on Cook Inlet Regional Working Group (CIRWG) lands. This restriction largely impacted on the ground field activities, (e.g., geologic mapping, shallow pits and sampling). Also new LiDAR imagery being obtained for other studies near the dam site area was not obtained because of weather. New field techniques were implemented to measure shear wave velocities.
Steps to Complete the Study	In 2014 and 2015 AEA will complete all remaining data collection for this study. This includes conducting field reconnaissance and mapping of lineaments and features on lands that were inaccessible in 2013 and completing the crustal seismic source evaluation that may require trenching (2015) and age dating of suspect fault development leading to development of a refined seismic source model. Activities to be undertaken in both 2014 and continuing into 2013 including continuation of the field evaluation of crustal seismic sources, potential trenching of lineaments or suspect faults, preparation of a site-specific seismic hazard assessment (PSHA) including an update to the preliminary RTS study, and continue data collection of

	earthquake events in the Project area.
Highlighted Results and Achievements	A long-term earthquake monitoring network has been established and data on events is being collected and is being used to define the geometry of the crust and subducting North American Plate and to refine the velocity model. Over the past year, 1507 earthquakes were recorded within a region roughly 50 miles east-west by 30 miles north-south, all below magnitude 4.0. Preliminary seismic hazard and reservoir triggered seismicity assessments have been completed and will be updated following completion of the crustal seismic source assessment and utilization of earthquake event data. Initial results indicate that most RTS events will have relatively small magnitudes. The crustal seismic source characterization study is on-going.

7. COMPLETING THE STUDY

7.1. Proposed Methodologies and Modifications

To complete the study, AEA will continue to implement the methods in the Study Plan, except as described in Sections 7.1.1 and 7.1.2. These activities include the following:

- Update the understanding of geologic conditions and seismo-tectonic setting for the dam site area;
- Identify and characterize the seismic sources, including detailed geologic studies and lineament analyses;
- Identify whether a fault may be encountered beneath or adjacent to the dam and assess the activity of the feature and, if active, the likelihood for potential fault displacement or ground offset;
- Perform a deterministic and probabilistic seismic hazard assessment in order to define earthquake ground motions for structural analyses. Ground motion estimates from the PSHA and DSHA are to be developed for a number of critical seismic sources using weighted ground motion prediction equations (GMPE's) appropriate for each source in the analyses. Results from the PSHA analyses will consist of hazard curves for a range of spectral response frequencies, uniform hazard spectra (UHS) for a range of return periods, and deaggregation of seismic source contributions for design-specific return periods and spectral frequencies. The purpose of the deaggregation is to provide parameters for the development of Conditional Mean Spectra (CMS). CMS will be generated using the methodology of Baker (2011). As recommended in FERC guidelines, the CMS will be extended so that the envelope of the CMS for a given return period equals the UHS. The PSHA will then be used to guide the selection of a deterministic event. Ultimately, the ground motion will be estimated through a risk-based approach, and AEA will work with FERC and BOC to establish the ground motion and criteria for the dam analysis.;
- Assess risks to Project structures and operation associated with seismic loading conditions; and
- Propose appropriate seismic design criteria.

7.1.1. Decision Points from Study Plan

There were no decision points in the FERC-approved Study Plan to be evaluated for this study following completion of 2013 work.

7.1.2. Modifications to Study Plan

No modifications to the Study Plan are needed to complete the study and meet Study Plan objectives.

7.2. Schedule

In general, the schedule for completing the FERC-approved Study Plan is dependent upon several factors, including Project funding levels authorized by the Alaska State Legislature, availability of required data inputs from one individual study to another, unexpected weather delays, the short duration of the summer field season in Alaska, and other events outside the reasonable control of AEA. For these reasons, the Study Plan implementation schedule is subject to change, although at this time AEA expects to complete the FERC-approved Study Plan through the filing of the Updated Study Report by February 1, 2016, in accordance with the ILP schedule issued by FERC on January 28, 2014.

With regard to this specific study, AEA expects to complete data collection in both the 2014 and 2015 study seasons, which will be reported in the USR. The current schedule for the Site-specific Seismic Hazard Study is as follows:

Seismic study field efforts in 2014 will focus on conducting field reconnaissance and mapping of lineaments and features on lands that were inaccessible in 2013 and completing the crustal seismic source evaluation that may require trenching (2015) and age dating of suspect faults. Plans for 2014 also include:

- Continued review and analysis of geospatial data within the Project area, review and interpretation of the planned expansion of the LiDAR coverage (e.g., Stephan Lake area and upper Watana Creek),
- Continued field geologic reconnaissance, mapping, and sampling in selected areas, including the dam site that were inaccessible in 2013 for crustal seismic source evaluation,
- Continued development of a refined seismic source model, and
- Review of earthquake event data including preparation of an annual Seismic Monitoring Summary Report

The field investigations and studies planned for 2015 include:

- Perform limited field mapping near the proposed dam site during the winter season of geologic features that may be fault related as part of the fault rupture study,
- Shear wave velocity measurements at the dam site,
- Development of a refined seismic source model,
- Preparation of site-specific seismic hazard assessment, including final DSHA and PSHA analysis; conduct ground motion analyses and assessments to estimate the expected ground motions at the Project facilities in accordance with FERC guidelines,
- Review of earthquake event data including preparation of an Annual Seismic Monitoring Summary Report,
- Within the site-specific seismic hazard assessment include an updated RTS evaluation based on crustal seismic source characterization and

- Development of final seismic design criteria.

7.3. Conclusion

Continued implementation of the Site-specific Seismic Hazard Study is planned for 2014 and 2015 with no modification of the FERC-approved Study Plan. This study will use information from the Geology and Soils Characterization Study (Study 4.5). AEA expects the approved Study Plan objectives for this study to be fully achieved, and the results of this study will be reported in the USR.

With the land (ground) access restrictions in 2013, as described in Subsection 4.1.5, the crustal seismic source evaluation is incomplete. Consequently, the crustal seismic source evaluation will continue with mapping at the dam site and field reconnaissance and mapping in June 2014. With this delay in the field work, completion of the crustal seismic source evaluation, potential need for trenching of lineaments or fault features, preparation of a PSHA, and selection of seismic design criteria will continue into 2015.

From the preliminary deterministic and probabilistic seismic hazard desktop evaluation, the site-specific seismic source model and initial ground motion estimates have been updated and compared to results from the 1980s seismic studies. The updated seismic source model identified subduction interface and intraslab seismic sources associated with the Alaska Subduction Zone (ASZ) as well as crustal faults and seismicity sources in the Project area. Lineament mapping and analysis using recently acquired INSAR and LiDAR imagery data has been used to identify potential features that may be associated with Quaternary faulting as potential crustal seismic sources. Field reconnaissance and mapping of these identified features is underway; however, with the restriction for land access in 2013, the field reconnaissance, mapping and drilling planned in the dam site and adjacent area as well as the acquisition of additional LiDAR imagery will now be completed (excluding any trenching if required) during the 2014 field season, thus causing a delay in the original completion schedule to the study plan. In 2014, the field reconnaissance and mapping will continue to gather evidence on the presence or absence of potential shallow crustal seismic sources by analyzing the anticipated additional LiDAR coverage and completing the field mapping, drilling (see 4.5 Geology and Soils), and sampling. Based on these findings, possibly trenching and age dating of samples may need to be undertaken in 2015.

Earthquake event data collection by the Project long-term earthquake monitoring network will continue. This data will be useful in refining the seismic source model and for developing ground motion estimates.

With the benefit of the crustal seismic source characterization, seismological analysis and refinement of the ASZ model, coupled with further evaluation of worldwide subduction zone data, the deterministic and probabilistic seismic hazard assessment (PSHA) report will be prepared to document the findings of this study. This will include the identification of the seismic sources of significance to this Project, updated estimates of ground motions, and development of seismic design criteria. It is anticipated that the updated PSHA will be completed early in 2016 and included in the USR..

7.4. Literature Cited

Baker, J.W. 2011. Conditional mean spectrum: tool for ground motion selection, Journal of Structural Engineering, 137(3), 322-331.