EXECUTIVE SUMMARY

E.1. Introduction

The Alaska Energy Authority (AEA) is conducting engineering and environmental studies for the Susitna-Watana Project in preparation for a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC). This Engineering Feasibility Report (EFR) was prepared to support the licensing process. The report will provide the basis for required License Application exhibits – most notably the Supporting Design Report, Exhibit F – which must be filed concurrently with the FERC License Application.

The EFR incorporates the results of studies conducted between February 2011 and December 2014. During the summer of 2014, AEA conducted geotechnical studies at the dam site to verify various assumptions presented in this report. As a starting point for the EFR, the November 23, 2010 AEA Railbelt Large Hydro Evaluation Preliminary Decision Document was used. That document concluded that the Susitna-Watana Project was favored over other potential large hydro projects to serve future Railbelt power needs. Also used in the preparation of the EFR were reports and designs prepared as part of the 1980s FERC License Application (and subsequent revision) for the larger Susitna Hydro project proposed at that time. Ongoing environmental studies may influence the engineering design and proposed project operations, such as the choice of access and transmission routes, operational criteria and downstream flow regime. Accordingly, this EFR is a snapshot in time.

The study results described in this EFR reflect a progression from the proposal presented in the Pre-Application Document (PAD), which was submitted to FERC in December 2011. Engineering feasibility updates based on additional geotechnical investigations and environmental studies can be expected to result in further design refinements and modifications to the proposed project features, as well as to the operational criteria proposed in the FERC License Application.

The Railbelt utilities have been engaged with AEA during the past three years in the development process for the EFR. This engagement has focused on the operational modeling of the Project, sizing of the generating units, and system integration work, all of which are key to the benefits this long-term resource will bring to the Railbelt region.

E.2. Previous Studies

The Project site has been studied for decades, principally in the early 1980s by the State of Alaska, through the Alaska Power Authority (APA), although both the United States Bureau of Reclamation (USBR) and the United States Army Corps of Engineers (USACE) had also previously studied the site. APA conducted extensive engineering, environmental and economic studies and, in 1983, filed a License Application to FERC. The License Application was revised in 1985 to propose a three-phase development including the initial development of a 700-foot high dam at Watana. In March 1986 the License Application was withdrawn.

E.3. Project Description

The Project will be a major development on the Susitna River 184 river miles upstream from the mouth of the Susitna River, approximately 125 miles north and east of Anchorage and about 140 miles south of Fairbanks. The general location of the proposed project is shown on Figure E.3-1.

The Project is being developed to provide long-term dependable power supply to the Railbelt. It will be capable of generating about 50 percent of the Railbelt's electricity, or approximately 2,800 Gigawatt hours (GWh) per annum (depending on the agreed operating rules).

The Watana Dam will be a curved gravity dam constructed using Roller Compacted Concrete (RCC) methodology, together with a straight gravity (thrust) section on each abutment. It will have a nominal crest elevation (El.) 2065 ft. North American Vertical Datum of 1988 (NAVD88) corresponding to a maximum height of approximately 705 ft. above the prepared rock foundation (assumed to be at El. 1360 ft.) and a crest length of approximately 2,810 ft. The maximum height of the structure will depend on the results of the further site investigations (which will indicate the extent of rock excavation required below the river bed). The current site plan is shown in Figure E.3-2.

The Watana Reservoir normal maximum operating water level (NMOL) is proposed as El. 2050 ft. At NMOL, the reservoir will be approximately 42 miles long (along the reservoir centerline) and average 1.25 miles wide. The maximum reservoir width is three miles at Watana Creek. The reservoir will have a total storage capacity of approximately 5.2 million acre-ft., of which approximately 3.4 million acre-ft. will be active storage.

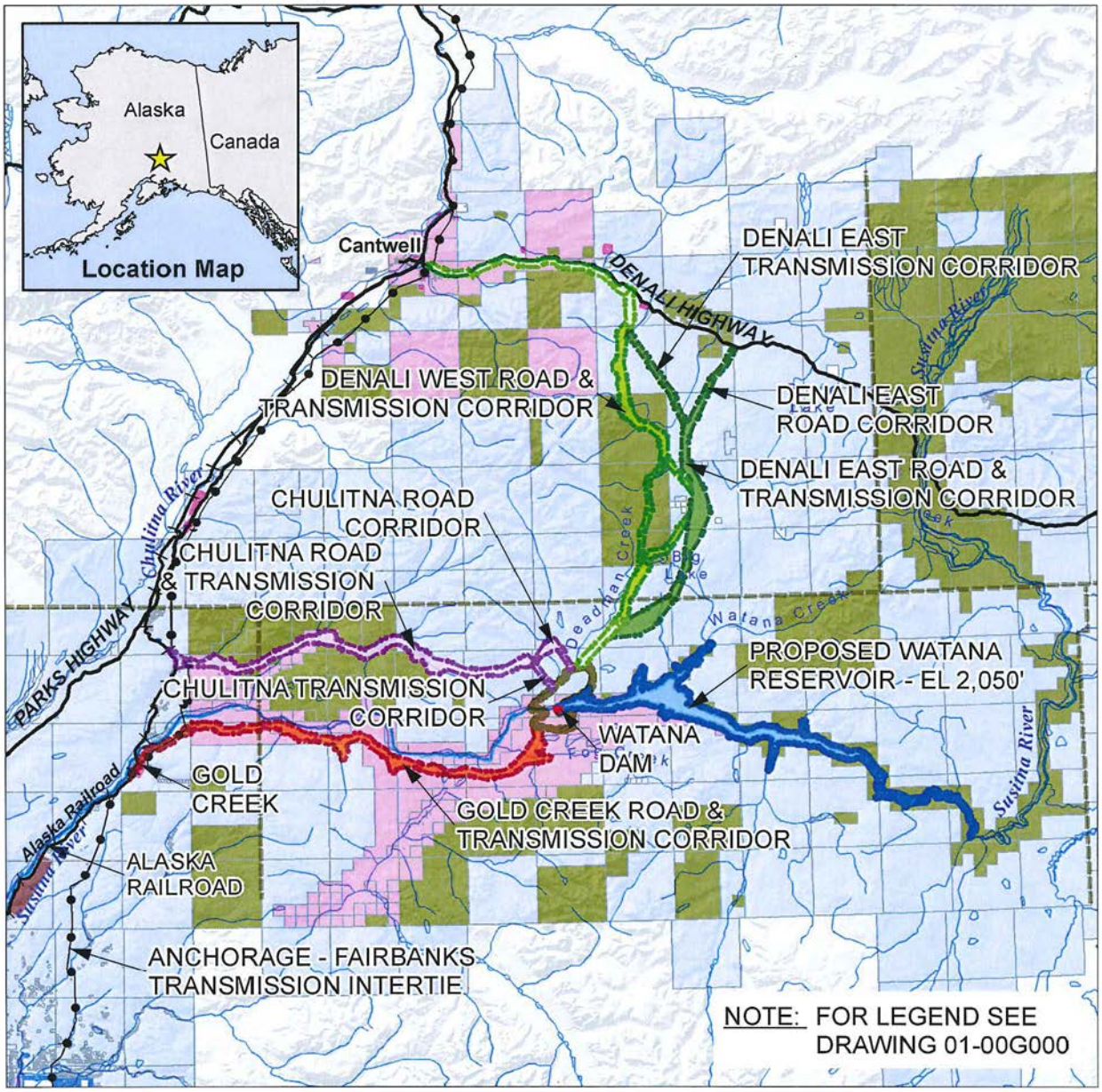

Figure E.3-1. Proposed Project – General Location

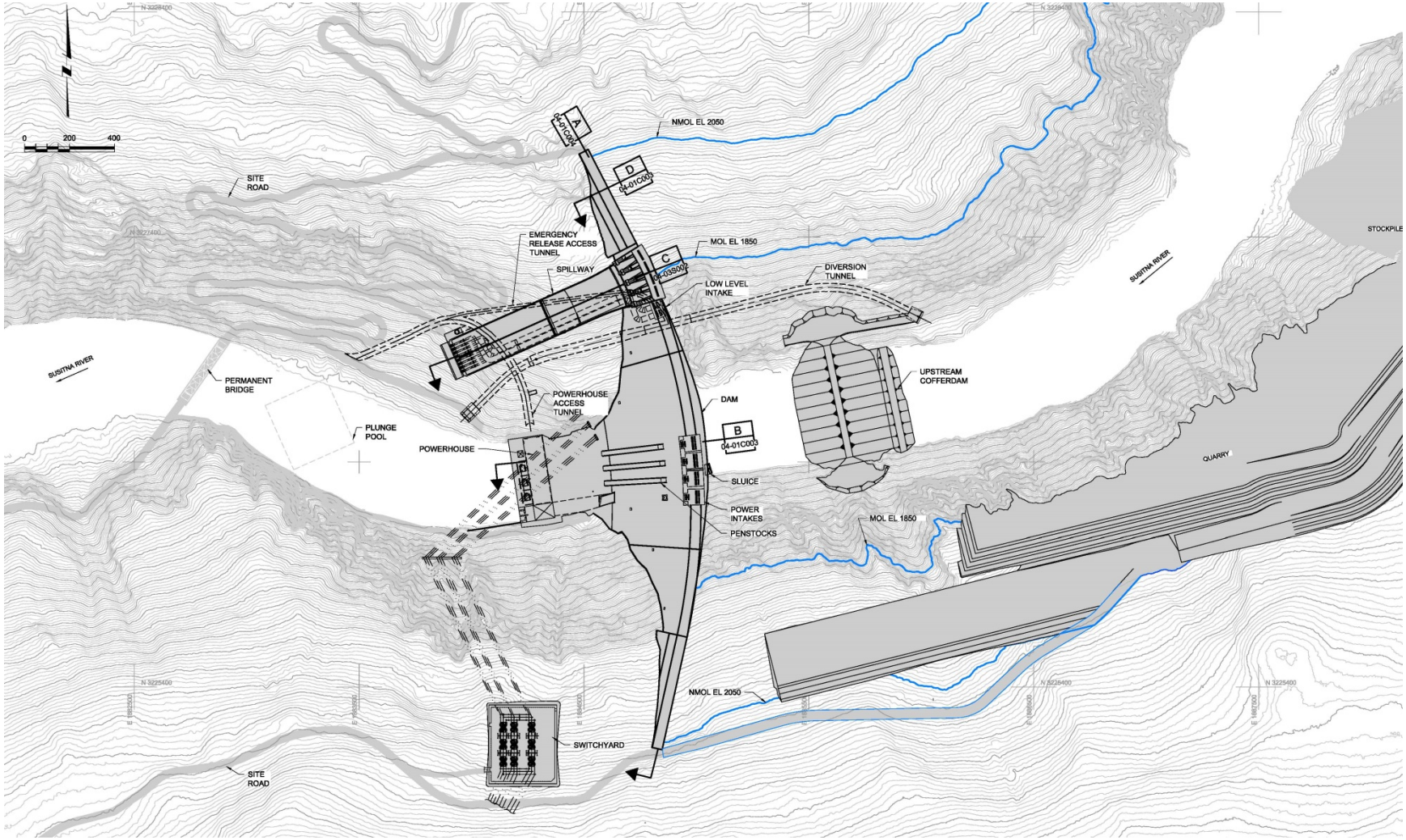

Figure E.3-2. Dam Site Plan

Emergency release facilities installed within the plugged diversion tunnel will be capable of operation, if necessary for reservoir drawdown, when the water level is at the minimum operating level (MOL) of El. 1850 ft. (or lower).

The low-level outlet facilities will provide a discharge of up to 32,000 cubic ft. per second (cfs). Together with the maximum powerhouse flow, the outlet facilities will be capable of passing the 50-year flood without opening the spillway gates. During the 50-year flood event the reservoir will be temporarily surcharged. The low level outlet facilities will be located so that they may be used even when the reservoir elevation is at its minimum operating level.

The bulk of the rock excavated to provide aggregate for concrete and road base will be obtained from a quarry located on the left abutment upstream of the Watana Dam. The lowest level of the quarry will be below the projected minimum operating level of the reservoir to minimize visual impact. A spoil area upstream of the Watana Dam has also been identified, and configured so that it will also be permanently submerged within the reservoir.

The powerhouse will be located immediately downstream of the Watana Dam, and will house three generating units, each with a rated turbine capacity of approximately 153 MW at a reservoir elevation of El. 1950 ft., but a maximum turbine capacity of 206 MW at the normal maximum operating level (i.e., full pool), for a total rated plant installed turbine capacity of 459 MW (and maximum turbine capacity of 618 MW at normal maximum operating level). The powerhouse will be designed and constructed with an extra unused unit bay to facilitate the potential installation of a fourth unit in the future.

The Project will incorporate a spillway with a gated ogee crest at El. 2010 ft. Four hydraulically operated radial gates will allow controlled release of floods above the 50-year flood. The spillway will be able to safely pass the routed Probable Maximum Flood (PMF). To further enhance project safety, the 10,000-year flood can be passed with one spillway gate inoperable.

Permanent housing will be constructed at the site, sufficient for operating and security staff. Permanent works will include community facilities for operation and maintenance (O&M) staff members and guests. Other permanent works will include maintenance buildings for use during local operation of the power facilities.

E.4. Site Access

A site access road will be constructed to facilitate project construction and for long-term operational access. Three possible alternatives for access roads were identified based on a corridor route study by the Alaska Department of Transportation and Public Facilities

(DOT&PF) which incorporated 1980s study results. The corridor routes have been refined during these feasibility studies. The three potential corridor routes are:

- East from a railway offloading area at Gold Creek, along the south side of the Susitna to the project site, unconnected to the State highway system.
- East from a railway offloading area at Chulitna, along the north side of the Susitna to the project site, unconnected to the State highway system.
- South from the Denali Highway to the project site. There are two variations of this route, which allows direct connection of the project site to the State highway system without necessitating use of the Alaska Railroad Corporation (ARRC) rail facilities. If the Denali Corridor is selected, the sections of the Denali Highway that will be used by construction traffic will be upgraded in order to facilitate safe construction of the Project.

During the execution of the feasibility studies, AEA has proposed to FERC to eliminate the Chulitna corridor from further consideration. All three competing routes have been examined in the EFR and no access corridor recommendation has been made in the report. The final proposal for access will be based upon the results of environmental studies, together with stakeholder input. FERC and the USACE will ultimately approve the selection of the access corridor during the Environmental Impact Statement (EIS) process.

A permanent road bridge is planned downstream of the Watana Dam irrespective of the selected access route.

To conservatively estimate construction costs of the access, the Gold Creek access route was used because it has the most bridge crossings and will likely exhibit a higher construction cost compared to the other access corridors.

At the chosen location for connection to the existing ARRC rail facilities, a railhead and storage facility occupying up to 40 acres will be constructed alongside the existing railroad. For the Gold Creek corridor this would be at Gold Creek, for the Chulitna corridor, at Chulitna, and for the Denali corridor this would be at Cantwell. New sidings would be constructed so that off-loading and transfer of goods and materials could take place both during construction and operation without interrupting the daily operations of the ARRC.

In addition to the access road, an airstrip will be constructed at the project site to facilitate construction access and operational access.

E.5. Transmission and Interconnection

Power will be transmitted from the Project to the existing power grid through the Watana switchyard. Transmission arrangements will consist of three 230-kilovolt (kV) lines, in either single- or double-circuit configuration. The same corridors under consideration for the access road are also under consideration to connect the project primary transmission lines to the Alaska Intertie. Essentially the transmission line corridor would be co-located with the access road corridors, but because transmission lines can be routed over steep terrain more easily, there may be occasional alignment separation within the corridors between the access road and transmission line. One or two transmission corridors may be chosen in order to allow lines to be separated, to provide redundancy in case of line failure.

In parallel with the choice of the Gold Creek access route for construction cost estimating, a configuration incorporating two circuits within the Gold Creek transmission corridor and one circuit within the Denali corridor was used to estimate construction costs for transmission. No recommendation of the preferred transmission configuration or routing has been made in the EFR, and the final choice of transmission corridor (or corridors) will depend on the environmental assessment and stakeholder input.

Each chosen route will include an interconnection at the point of tie in to the Alaska Intertie (Chulitna, Gold Creek and/or Cantwell).

The right-of-way for the transmission lines within the corridors will consist of a linear strip of land; the width will depend on the number of lines. The transmission rights-of-way will be 200, 300, or 400 ft. wide, depending on whether one, two, or three lines run in parallel.

The Railbelt Utilities and the State of Alaska are evaluating transmission additions to provide for firm energy transfers and improved reliability of the Railbelt electrical system. These “pre-Watana” Railbelt system improvements are independent of the Susitna-Watana Project and would eliminate the single contingency conditions between the Railbelt load areas. The construction costs associated with the upgrading of the Alaska Intertie have not been included in the project cost, as most of the upgrades are needed irrespective of the Susitna-Watana Project. The results of the system studies performed as part of the planning of the Railbelt transmission improvements have been available for the benefit of the Susitna-Watana feasibility studies.

E.6. Temporary Infrastructure

Construction of the Project will require various facilities to support activities throughout the entire construction period. The most significant item among the temporary site facilities will be a construction camp. The construction camp will be a largely self-sufficient community

normally housing approximately 800 persons, but with a peak capacity of up to 1,200 people. After construction, AEA plans to remove most of the infrastructure of the camp facility, leaving only those buildings and facilities that are to be used to support the smaller permanent residential and O&M facilities.

Other site facilities include contractor work areas, site power, services, and communications. Site power and fiber optic cabling for construction will be brought either on the transmission line, or along the side of the access road. Items such as power and communications will be required for construction operations, independent of camp operations.

E.7. Project Operation

Project operating flexibility is important to Railbelt utilities that will utilize the project's capacity and energy output. To maximize the benefit of the Watana generation for the entire Alaska Railbelt interconnected system and provide operational flexibility, project operation simulations included load-following when and if needed and maximizing energy during the critical winter months of November through April each year. Minimum downstream flow requirements during the summer months may dictate the amount of available reservoir storage for provision of winter energy production. Energy simulations were conducted using the minimum instream flow releases proposed in the APA 1980s FERC License Application. No operational scenario has been recommended in the EFR.

Production cost modeling has encompassed the whole Railbelt system and has highlighted the benefits that will accrue to the whole system if a centralized dispatch method of operation is selected.

To facilitate efficient dispatch, the reservoir would be drafted annually by an average of about 140 ft. to 150 ft., and subject to a rare maximum drawdown of 200 ft. during dry years, as shown in Figure E.7-1. Minimum instream flow releases would be made through the powerhouse – or through low level outlet works during the rare occasions when the power plant is offline. Flow discharges through the powerhouse under the operating plan would range from the minimum required instream flow release (yet to be determined) to a high of about 14,000 cfs (based on all generating units operating) during times of maximum power generation. Daily power generation during a peak winter month (January) would average about 8,250 MWh and powerhouse discharges would average approximately 8,360 cfs during that time.

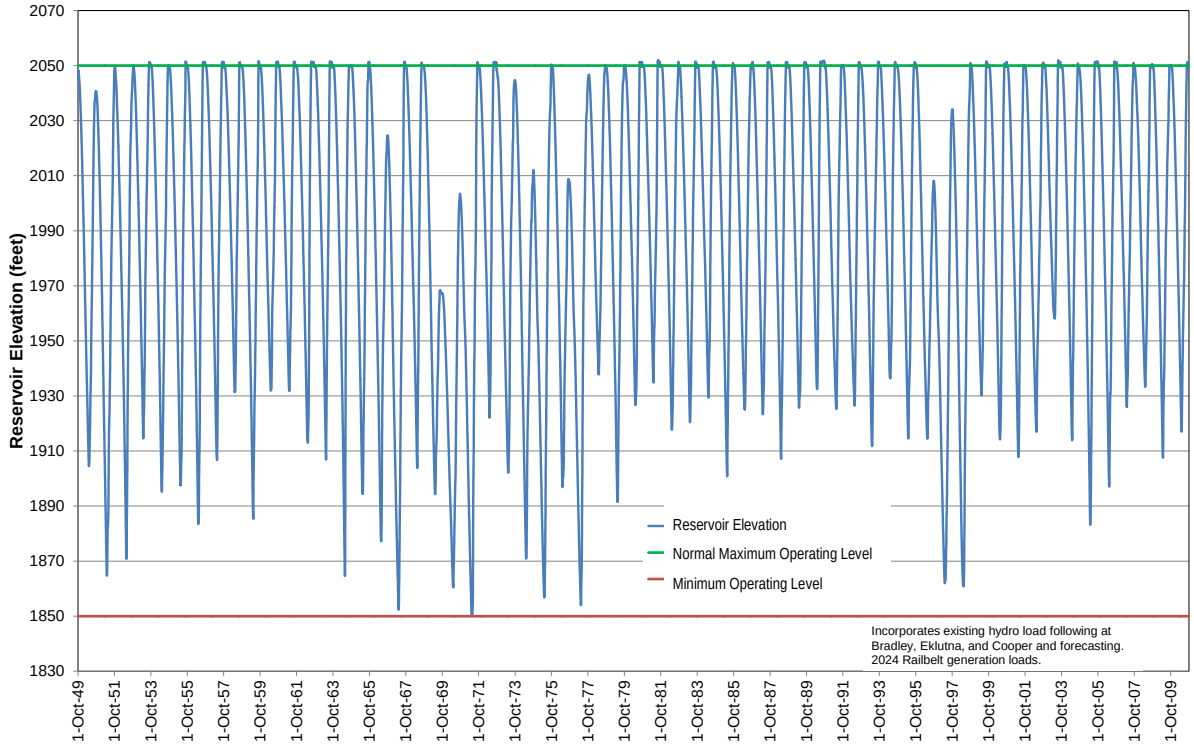

Figure E.7-1. Daily Reservoir Elevations (feet)

For efficient operation of the whole Railbelt system, powerhouse discharges are expected to vary over a 24-hour period during the peak winter months, typically ranging from a low of about 7,000 cfs to a high of 9,050 cfs. The daily flow variation may be constrained by environmental protection, mitigation and enhancement measures. However, flow variations immediately downstream of the powerhouse will be partially attenuated by the time the flow reaches Gold Creek, Talkeetna, and the other downstream locations.

Average annual energy generation is estimated to be 2,800 Gigawatt hours (GWh) with approximately half that energy provided in the November to April period. Figure E.7-2 displays hourly generation during an average water year under PROMOD assumed operational scheme.

A proposed operating plan will be prepared and submitted in the FERC License Application.

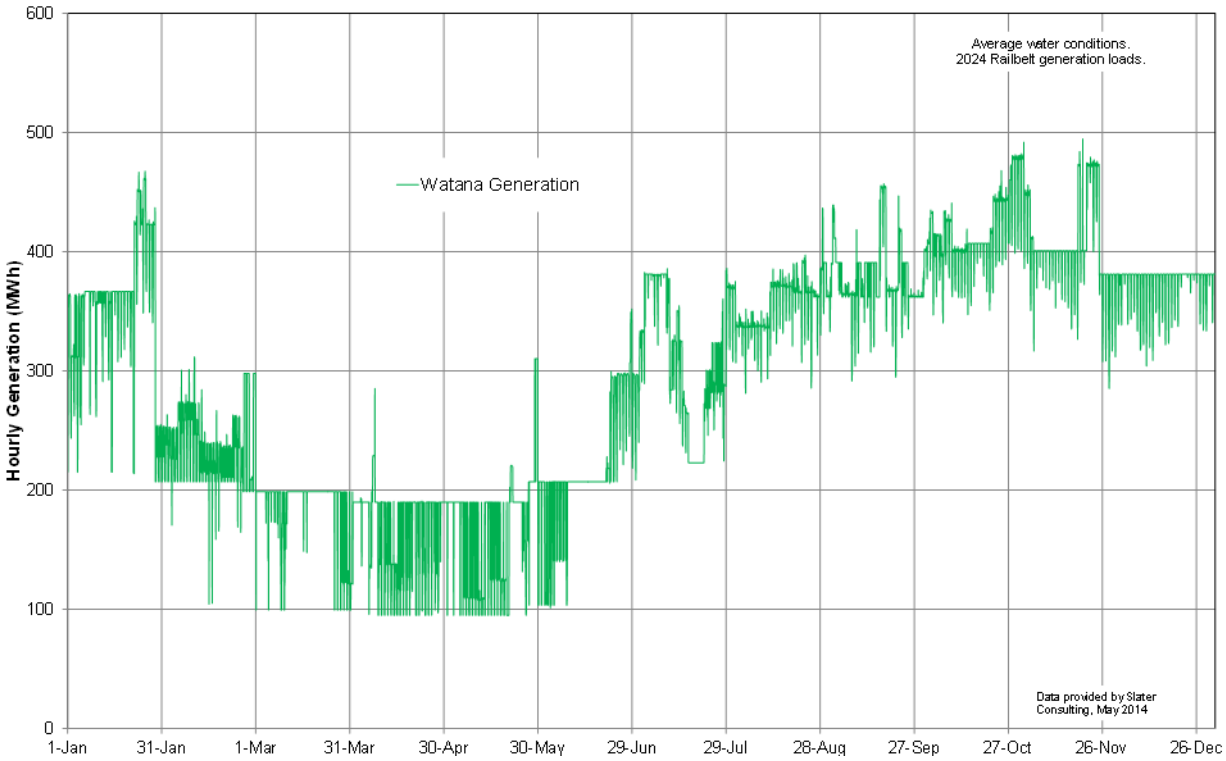

Figure E.7-2. Watana Hourly Generation as Developed by PROMOD for Average Water Conditions

E.8. Design and Construction Schedule

A schedule for the design and construction of the project has been derived, based on the times for completion of site investigations (including exploratory adit excavation) and the required time for design, preparation of contract documents, the bidding process, and construction. No construction on site (including the construction of the access road) will be permitted until the FERC license has been issued, Clean Water Act Section 404 and 401 permits have been granted, and FERC has performed any required reviews of the design and drawings.

The schedule and cost estimate are based on the assumption that the project would be implemented using eight separate supply or construction contracts, and four service contracts. The contracts are assumed to be traditional design-bid-build contracts and separate design contracts are assumed as appropriate. Because no project construction can begin until the FERC License is issued (and associated design review and permitting are completed), it will be difficult to shorten the schedule by using different contracting strategies.

The schedule spans 12 years from the time that final design phase site investigations (SI) are initiated to commercial operation of the first turbine-generator unit. Several assumptions have been made regarding the times required for the various activities.

The following are approximate time periods for major components of project construction, including concurrent activities:

- Total Project development from SI initiation — 12 years
- Site Investigation and design engineering — 3 years
- Access road construction — 2 years
- Dam and power facilities construction — 7.5 years
- Reservoir filling — 1 to 2 years
- Site restoration — throughout construction

Design work would be initiated during the licensing process to maintain the project schedule. Construction activities critical to the schedule (such as access roads and construction support facilities) will be ready to commence shortly after issuance of the FERC license and the other required regulatory approvals.

E.9. Project Cost

The project cost estimate is classified as Class 4 according to recommended practice of the Association for the Advancement of Cost Engineering (AACE). However, some facilities have been defined in greater detail, and their construction cost estimates approach Class 3. The current construction cost estimate was developed employing a "joint venture" type of methodology, using an independent estimator as a "cross-check".

The anticipated project cost is estimated to be approximately US$ 5.655 billion (July 2014 dollars), including licensing, design, and construction, but excluding escalation and interest during construction. AEA has included these costs in its financing plans developed independently from the EFR.

Probabilistic analysis has been performed on the quantities and unit costs used in the current estimate to develop a range of probable total costs shown in Figure E.9-1. Contingencies were applied in accordance with AACE guidelines.

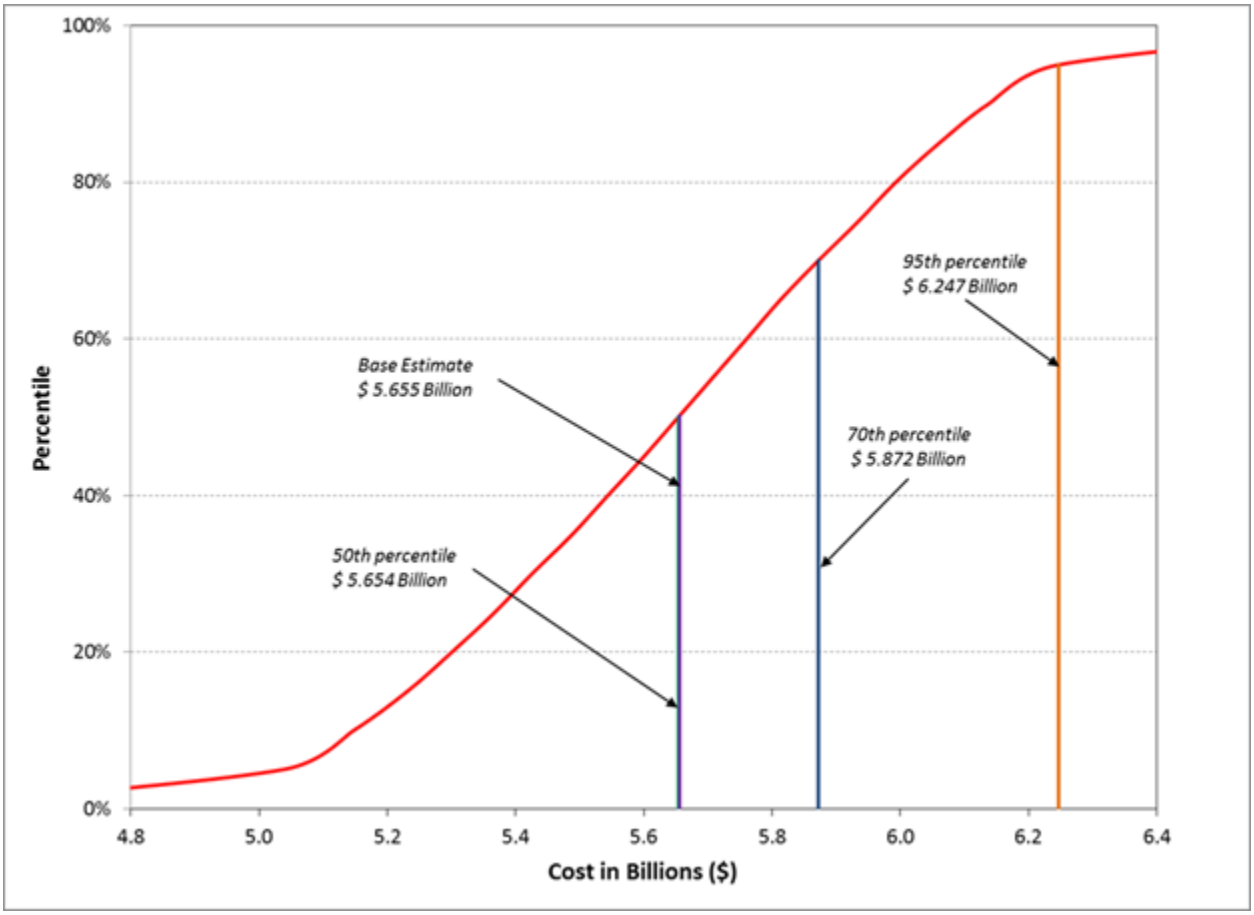

Figure E.9-1. Project Cost Range (S-Curve)

E.10. Key Design Considerations

E.10.1. Seismic Hazard Evaluation

One of the 58 environmental study plans required by FERC is a Site Specific Seismic Hazard Analysis (SSSHA, Study Plan 16.6). Work on the SSSHA began in 2011 and is complete except for the final crustal lineament studies, which are expected to be finished in 2015. The work to date has been used to determine ground motions applicable to the feasibility studies.

A microseismic network has been set up for the project (first installed in September 2012) including seven seismographic stations linked to the seismic network operated by Alaska Earthquake Center (AEC). The seismic analyses completed to date indicate that the governing seismic event – from which the seismic criteria for the project will be derived – will be a subduction intraslab zone event, not a crustal event. The results from the microseismic network

have helped to achieve excellent definition of the subducting plate, which has contributed to the definition of potential sources of interface and intraslab events.

In determining the ground motions for the seismic design of the project features (for the Maximum Credible Earthquake [MCE]), the analysis followed guidance furnished by FERC in "Engineering Guidelines for the Evaluation of Hydropower Projects, Draft Chapter 13 – Evaluation of Earthquake Ground Motions". For the initial (preliminary) analyses of the dam structure – when different geometries were being compared – uniform hazard spectra from the initial results of the site specific seismic hazard analysis were used. Later in the preliminary dam analysis, time histories were developed using spectral matching techniques for four deterministically calculated response spectra: intraslab M8.0; intraslab M7.5; interface M9.2; and crustal M7.0. The largest of the peak ground accelerations from these four selected scenario events was determined to be the intraslab M8.0 at 0.81g. For the final finite element analysis for the feasibility studies (including mass in the foundation) the response spectra and time histories were refined to suit required model input.

The key structures must safely withstand a MCE, but the whole project must continue to operate satisfactorily under the Operating Basis Earthquake (OBE). Although published guidelines (including Alaska Dam Safety guidelines) for determining the OBE call for an earthquake with a 50 percent probability of occurring in the life of the project, such an event would translate to a peak ground acceleration of 0.16 g, which is deemed too low, and not sufficiently conservative for such a large dam. It was therefore decided to adopt a conservative approach and instead use the 500 yr. event for the OBE – reflecting a peak ground acceleration of 0.27g.

The criteria adopted will be revisited when the crustal lineament studies are complete, but they are not expected to change because the subduction events produce such large ground motions relative to crustal events.

Equally important to the deterministic analysis of the seismic hazard is the verification that there are no features within the foundation of the project dam that could suffer coseismic movement. In particular, in the past, the existence of a "Watana lineament" along the Susitna River channel has been postulated – but previous angled intersecting drill holes had not identified the existence of such a feature, and it was discounted during the 1980s investigations. Angled holes drilled during 2014 have again confirmed that such a feature does not exist. Structural mapping of the site area and crustal lineament inspection (both performed in 2014), together with the reinterpretation of the postulated geologic features, demonstrate that any local lineaments will not exhibit coseismic behavior.

E.10.2. Probable Maximum Precipitation and Probable Maximum Flood Studies

The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the drainage basin under study, generated by the Probable Maximum Precipitation (PMP). PMP is defined as theoretically the greatest amount of precipitation for a given duration that is physically possible for a given size storm area at a particular geographic location at a certain time of year.

FERC also required, as one of the 58 study plans, a PMP/PMF study (Study 16. 5). The Inflow Design Flood (IDF) used in the sizing and design of spillways can range from a 100-year flood to the Probable Maximum Flood (PMF). Because of its size, downstream hazard potential, and economic importance to the Railbelt, the selected IDF for Watana Dam was determined to be the PMF.

PMPs are often derived using publications such as Hydrometeorological Report (HMR) 57 (for the Pacific Northwest). The existing standard U.S. Weather Bureau (now National Weather Service) PMP guidance document for Alaska is however only applicable to drainage areas up to 400 square miles and for storm durations up to only 24 hours. Because the Susitna River basin above the dam site is, at 5,180 square miles, an order of magnitude larger, a site specific PMP was developed. The site-specific all-season (maximum) PMP was found to occur in July or August and was derived on an hourly basis for a 216 hour (nine day) time sequence for each of the 29 sub-basins tributary to the Watana Dam site.

Associated concurrent meteorological data (temperature, wind speed, dew point) were also derived for the 216 hour PMP period plus 24 hours prior to and 72 hours subsequent to the PMP for a total of 312 hours. Because snowpack and snowmelt are significant hydrologic conditions in the Susitna River watershed that affect the estimated PMF, seasonal PMP and meteorological data were derived for the period from April through October based on different factors applied to the all-season data.

The critical PMF case used for spillway sizing was found to be formed by a spring PMP combined with the 100-year snowpack and with conservative low infiltration loss rates. For the critical PMF case including a conservative assumption that the reservoir is already at full pool, the maximum reservoir level was modeled to be El. 2064.5 ft. with a peak inflow of 310,000 cfs, a peak outflow of 282,000 cfs, and a 13-day total inflow volume to the reservoir of 3,980,000 acre-ft. The flood routing is shown on Figure E.10-1.

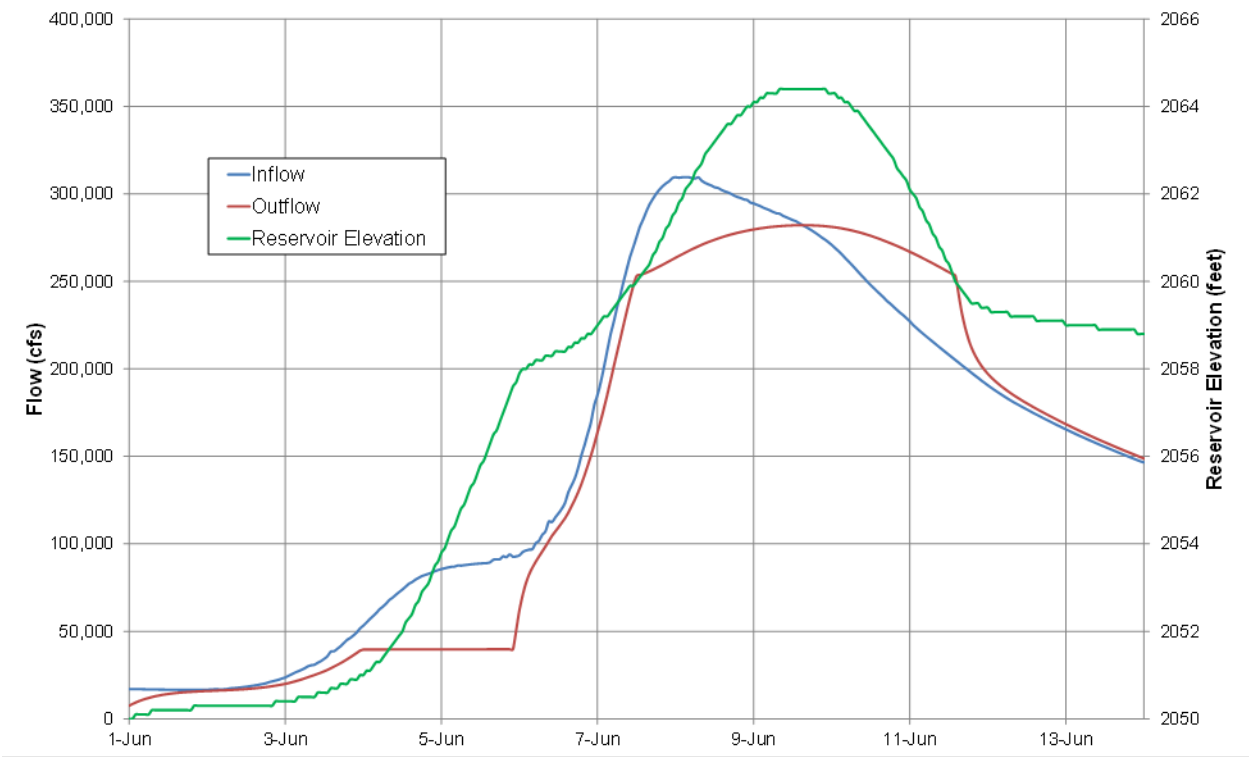

Figure E.10-1. PMF Inflow, Outflow, and Reservoir Elevation

E.10.3. Type of Dam

The 1980s proposed project configuration at Watana was based on an Earth Core Rockfill Dam (ECRD), but in the years since, dam construction technologies and experience have developed such that a Concrete Faced Rockfill Dam (CFRD) and a Roller Compacted Concrete (RCC) Dam are viable alternatives for a safe dam of a height considered for Watana. All three dam types have performed satisfactorily during large seismic events, most notably the Sechuan, China, M8 event in 2008 which epicenter was 10 miles from a CFRD, and 22 miles from a large RCC dam.

Project configurations were developed based on each of the three types of dams and included either a surface power plant or underground power facilities as appropriate for the project layout. Two variants of the CFRD configuration were created, one with an underground powerhouse and one with a surface facility. Comparative costs were derived – with no common items being included. The lowest cost alternative was determined to be that based on an RCC dam with a surface powerhouse. To ensure that non-cost items were also considered in the choice of the type of dam at Watana, a further analysis was performed, based on the Water Resources Assessment Methodology (WRAM). The analysis considered: seismic resistance; ease of raising; risk of price increase; visual intrusion; possibilities for construction schedule acceleration; cold weather construction; potential for optimization; accommodation of

environmental mandates; and long term cold weather performance. The results of the WRAM analysis confirmed and supported the choice of a project configuration based on a RCC dam. In addition, an RCC dam could be constructed quicker than a CFRD or ECRD.

E.10.4. Turbine-Generator Unit Size and Rating

The individual power plant generating unit size and total plant installed capacity were investigated from two perspectives. Unit size and plant capacity were first considered with respect to reservoir operation and power studies, and then to optimize production costs with respect to the whole Railbelt integrated electrical system.

The installed capacity, unit size and normal maximum operating level of the reservoir have all been reviewed during the course of the current feasibility studies, taking into account the maximum annual generation that can be achieved, the possible operating scenario, minimizing reservoir spills, and requirements for redundancy to account for unit maintenance and downtime. Reservoir operation and hydroelectric power studies modeling of the plant operation using 61 years of hydrological flow records, on an hourly basis, was performed for two different installations. The first installation considered was three turbine units rated at 153 MW at reservoir level of El. 1950 ft. This unit is equivalent to 206 MW at NMOL of El. 2050 ft. The second installation considered was three 206 MW units (turbine capacity) rated at an elevation of El. 1950 ft. The larger units would not increase the annual generation substantially, and the difference in production of the smaller units can be minimized by forecasting of basin runoff and implementing a consequent adjustment of the operation. Larger units would, however, allow for a little more flexibility for mitigating unit outage and for operation as spinning reserve. Following these studies, and in the absence of any stated system requirement for greater redundancy, it was determined that an installed total turbine capacity of 459 MW at reservoir level of El. 1950 ft. (618 MW NMOL and 315 MW MOL) is most appropriate and would provide an annual energy generation similar to larger units.

The system studies performed during this feasibility study indicate that the required system energy storage (that is being considered under the separate studies of system improvements) would need to be larger if Susitna-Watana were to be constructed. A small amount of extra energy storage would be necessary to restrict load shedding – in the event of a Watana unit trip – to the current regime of allowable load shedding. However, the incremental cost of the energy storage specifically required for the various Watana unit sizes considered is relatively small.

Production cost modeling was performed for the year of 2024 and beyond to assess the project operation within the whole Railbelt system using an average water year. Production cost modeling showed that the turbines are adequate for meeting the required generation with high

reliability, although additional thermal generation would be required during the very rare times when the Watana reservoir was abnormally low due to a dry water cycle.

E.10.5. Hydraulic Analysis

Hydraulic analysis was focused on two key aspects of the project layout; the spillway and the emergency outlet works. The PMF peak inflow of 310,000 cfs (and corresponding peak outflow of 282,000 cfs), was used to size the spillway taking advantage of the 32,000 cfs low level outlet capacity, the curved dam, and the abutment topography. A four bay spillway was selected; with a bay width of 42 ft. and an ogee crest elevation of El. 2010 ft. Computational Fluid Dynamics (CFD) software was used to model the spillway, to verify hydraulic performance, wall heights, location of aeration, and the angle of the flip bucket to determine the plunge pool location and geometry. A central wall was introduced into the spillway so that one side can be operated up to 60,000 cfs while any required maintenance is underway in the other chute.

The emergency outlet was also subject to extensive hydraulic analysis. The diversion tunnel will be converted to an emergency outlet and allow for a maximum flow of 30,000 cfs at MOL.

E.10.6. Dam Structural Analysis

The analysis of the dam centered on dam stability - using FERC criteria - and stress analysis under the MCE event. After the choice of an RCC dam had been made, an iterative series of analyses was performed incorporating a progressive adjustment of the dam geometry, using the foundation rock characterization derived from the 1980s site investigations and interpretation (and re-interpretations). Industry standard software was used, including ADSAS (a computer version of Trial Load Analysis), CADAM (2D stability software), and ANSYS (finite element software). Dam alternatives with three centers, simple circular curves and a single curve with straight abutments were analyzed progressively using ANSYS and without modeling mass in the foundation. Post-earthquake stability was checked each time. As the geometry was progressively modified, the concrete tensile stresses at the crown cantilever predicted by the software reduced. The most favorable geometry was determined to be a dam curved in plan with a radius of 2,600 ft., and two straight abutment sections, acting as gravity dams and thrust blocks.

Academic studies have compared analyses of existing dams without – and secondly including – the mass of the foundation rock, and have concluded that the inclusion of the mass of the foundation rock into the finite element model represents a more realistic representation of the structural behavior of the structure, compared to a numerical model that ignores the foundation mass. Therefore, the selected dam configuration for Susitna-Watana was reanalyzed including foundation mass, and for that final analysis the downstream face geometry was adjusted slightly.

The analysis was carried out using time histories for four different seismic events representing two intraslab events, an interface event and a crustal event. The results showed that the configuration and geometry proposed in the EFR is appropriate, and the expected overstressing during the MCE is acceptably restricted to one or two cycles. Under these conditions, minimal damage can be expected, although there could be some displacement between RCC "blocks" formed by the induced joints. Vertical drains at the induced joints will be sized accordingly during detailed design so that they will continue to function properly after the MCE. Post-earthquake stability was checked and is satisfactory, so the geometry chosen is considered acceptable for a feasibility level design. The structure was also modeled for an OBE greater than that suggested under Alaska dam safety guidelines, and was found to perform adequately.

Although the foundation characterization remains under study, sensitivity analyses were performed (using conservative assumptions) to assess the structural behavior if foundation conditions are determined to be less favorable than assumed from the previous investigations for the 1980s feasibility studies. Under these assumed (sensitivity) ranges of foundation conditions, the structure still performed satisfactorily as modeled. The reinterpretation of the foundation performed during the 2014 field season – and after completion of the finite element modeling and sensitivity studies - indicates that previous interpretation of width and continuity of the various geological features has been very conservative, and confirms that the sensitivity modeling has also been conservative.

Once dam structural foundation mapping is available, proposed exploratory adits have been excavated, and various geological features have been drilled and the cores tested, the proposed foundation excavation and characterization will be able to be better defined – and the design assumptions and feasibility analyses will be verified, or adjustments in geometry will be included during detailed design.

E.11. Board of Consultants Review

As endorsed by FERC, AEA convened an (independent) Board of Consultants for the purposes of review of the feasibility studies as they relate to dam safety. The key elements and decisions recorded in this report – relating to the type of dam, the PMP and PMF studies, the Site Specific Seismic Hazard Analysis, the Finite Element studies of the dam structure, and the projected site investigations required to verify the designs adopted – have been subject to review by the Board of Consultants through the feasibility study period and their observations have been incorporated in the EFR.

E.12. Conclusions

The project as presented in the EFR – incorporating a RCC dam with a crest El. 2065 ft.; a downstream powerhouse with an installed turbine capacity of 459 MW (at reservoir El. 1950 ft.); a four bay gated ogee spillway; and a low level outlet – is technically feasible, safe, and sufficient to withstand the Maximum Credible Earthquake and safely pass the Probable Maximum Flood.

Feasibility plans and layouts incorporate technically viable alternatives for both site access and transmission – including transmission/Alaska Intertie interconnection. In each case a preferred route has not been suggested.

The base project cost – excluding escalation, interest during construction, etc. is estimated to be approximately US$ 5.655 billion in Q2 2014 dollars. After probability analysis of estimating variabilities, it was determined that this estimate represents approximately the 50th percentile cost – i.e., there is a 50 percent probability that the cost will not be greater than US$ 5.655 billion.

Considering only the construction tasks – which cannot commence until a FERC license is approved, and subsequent approvals and permits are issued – the total time from commencement of construction (access road) to provision of power from the first unit is approximately eight years.

Projected improvements to the Alaska Intertie are sufficient to allow power from Susitna-Watana to be transmitted both north to Fairbanks and south to Anchorage. The sole extra modification to the system that might be required to accommodate Susitna-Watana power is a small increase in the projected energy storage on the system.

The results of production modeling simulations with – and without – the project show that the inclusion of the project in the integrated Railbelt system will result in a significant reduction in the use of gas and oil by the utilities, and a large decline in the use of what is now (thermal) peaking plant over time. Because it has the lowest operating cost and the highest reliability among generation options, the implementation of substantial hydro capacity at Susitna-Watana will inevitably reduce the need for gas fired generation in future years. Maximum benefits will accrue if the integrated Railbelt system is centrally dispatched.

E.13. Further Engineering Work Necessary

Although there has been extensive engineering performed for the preparation of the feasibility design, additional dam site subsurface investigations are necessary to better define the foundation character, design criteria and other parameters required for verification of the

assumptions made during this study, and to improve the accuracy of the construction cost estimate. The geotechnical information used in the project feasibility design was largely derived from the site investigation program performed in the 1980s (which was oriented towards the footprint of an ECRD, with the focus on a core) and the drilling conducted in 2012. Geological mapping and drilling during the 2014 season has assisted in the definition. When information is available from further foundation drilling specific to the chosen dam type, together with the excavation of adits, rock testing and enhanced geological mapping, the assumptions made in the formulation of the feasibility design should be re-examined, and the layout, design, features and the project cost estimate verified or adjusted if necessary.