Railbelt Large Hydro Evaluation

Preliminary Decision Document

November 23, 2010

Prepared By
Alaska Energy Authority

November 23, 2010

Executive Director's Statement:

The Alaska Energy Authority (AEA) has been appropriated $10 million in State funds to start planning and designing a large hydroelectric project. Our first goal has been to identify the project to pursue that would give the State the best chance of success to be built and meet the State's goal to produce 50% of Alaska's electrical energy from renewable resources by 2025. It has been generally understood that a multi-billion dollar hydroelectric project will require State participation and financial assistance.

In the Preliminary Decision Document AEA has focused its efforts on the Susitna River and Chakachamna hydroelectric projects. This document provides a risk analysis comparison of the two projects by summarizing the known information and risks of the two projects and identifies the Susitna Hydroelectric project as the recommended primary project for the State to pursue. The Chakachamna project is recommended to be studied as an alternative to Susitna. Alternative projects need to be evaluated as part of the FERC licensing process, unless or until it is determined that there is reason to reject it as an alternative. As an alternative project, AEA recommends allocating the minimum necessary State funds to study the Chakachamna project thereby using the maximum amount available to further advance the Susitna project.

AEA will hold public workshops in February to educate and receive input from the public on the Preliminary Decision Document and the recommended approach to meet the Alaska's 50% renewable energy goal by 2025. After December, please refer to our webpage, www.akenergyauthority.org for workshop schedule. In the meantime, I encourage interested parties to submit written comments to AEA by the any of the following methods:

Email: largehydro@aidea.org

Fax: 907-771-3044 Attn: Large Hydro Project

Address: Large Hydro Project
Alaska Energy Authority
813 West Northern Lights Blvd
Anchorage, AK 99503

AEA looks forward to your comments on the Preliminary Decision Document.

Sincerely,

ALASKA ENERGY AUTHORITY

Michael C. Harper
Acting Executive Director

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Terms and Acronyms

AEA	Alaska Energy Authority
ALP	Alternative License Process
APA	Alaska Power Authority
cfs	cubic feet per second
Chakachamna Project	Chakachamna Hydroelectric Project
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
GWhrs	Gigawatt hours
HB	House Bill
ILP	Integrated License Process
IRP	Integrated Resource Plan
KWhrs	Kilowatt hours
MW	Megawatt
NOI	Notice of Intent
NP	National Park
PAD	Preliminary Application Document
Railbelt	The region of Alaska served by the railroad, stretching from Seward to Fairbanks
RIRP	Regional Integrated Resource Plan
SNW	Seattle Northwest Securities
Susitna Project	Susitna Hydroelectric Project, Low Watana Non-expandable Alternative
TBM	tunnel boring machine
TLP	Traditional License Process

Executive Summary

There are two proposed major hydroelectric projects in the Alaska Railbelt Region: the Susitna Hydroelectric Project, Low Watana Non-expandable Alternative (Susitna Project) and the Chakachamna Hydroelectric Project (Chakachamna Project). The purpose of this document is to identify which of these is most likely to successfully meet the long term energy needs of the railbelt at reasonable cost. This preliminary evaluation also considers the possibility to permit a project in its presently proposed configuration and to be able to do so in a reasonable time frame.

The 2010 AEA Regional Integrated Resource Plan (RIRP) is a 50-year long range plan that identifies combinations of generations and transmission capital improvement projects in the railbelt region (Black and Veatch 2010). The RIRP documented the need for a large amount of new annual generation for the railbelt within the next 10 to 15 years. The type of generation constructed will be influenced by declining Cook Inlet natural gas production, legislative environment, financing, and ability to permit or license and construct a project in a timely manner.

The 2010 Alaska legislature passed House Bill (HB) 306 which declares a State energy policy. This bill directs the State to receive 50 percent of its electrical generation from renewable and alternative energy sources by 2025. The only way to achieve this goal is for a new large hydroelectric project to be built in the railbelt region. The project sites, one on the Susitna River at Watana and one at Lake Chakachamna, are shown on Figure 1-1. The energy generated by one of these two projects would provide roughly one fourth (Chakachamna) to roughly one half (Susitna) of the current electrical energy demand.

Alaska Energy Authority received funding from the Alaska Legislature in 2010 for the preliminary planning, design, permitting and field work for the Susitna and Chakachamna Projects, as well as Glacier Fork Hydroelectric Project and other hydroelectric projects along the Railbelt. Most of the funds were allocated to the Susitna and Chakachamna Projects. There are a variety of alternatives on the Susitna River as documented in the HDR Report (2009). The Susitna Project chosen for this comparison is the Low Watana Non-expandable alternative. It was chosen because it offers a combination of greater winter storage capacity while still maintaining a low overall cost and low cost of power generated.

Permitting and licensing of a large hydroelectric project is regulated by the Federal Energy Regulatory Commission (FERC) and is a lengthy, complex and costly process. For this reason, the two projects must be evaluated at an early stage to determine if either has a fault that would prevent it from being licensed and constructed. As substantial research has already been done on each project, this document summarizes existing information on the projects, and uses this information for evaluation and comparison. Additional detailed information is available in the referenced documents. By using existing information to choose a primary project, resources can be concentrated on its development, with the goal of satisfying future railbelt energy demand and compliance with the legislative intent that the State receives 50 percent of its electric generation from renewable and alternative energy sources by 2025.

The ultimate goal of developing a project is to provide a cost-effective and long-term energy source to the railbelt region. Therefore, the cost, potential environmental impact, engineering issues and energy production potential of both projects were evaluated. This evaluation highlights key elements of each project that affect the cost of resulting energy, timeliness of energy contribution, and long term environmental and the projects' socioeconomic operational effects.

The results of this comparison show that the Susitna Project should be the Alaska's primary hydroelectric project; the Chakachamna Project should be considered as an alternative. Although the design, permitting and construction of the Susitna Project would cost approximately 50 percent more than it would for the Chakachamna Project the Susitna Project would produce more than twice the annual amount of energy as the Chakachamna Project. In addition, risk of cost overruns with the Chakachamna Project would be much greater than with the Susitna Project because of the extensive underground work required and its location in steep terrain.

The environmental impact of the Chakachamna Project would also be greater because it would require a cross-basin water transfer in a river system with salmon migration. Significant salmon runs travel to and through Lake Chakachamna. To allow enough environmental flow to protect fisheries, energy from the Project would have to be substantially reduced.

Additional conclusions that can be drawn from the comparison of the two projects include:

- As indicated above, in terms of energy production, the Susitna Project would produce more than two times the amount of the Chakachamna Project. The Susitna Project would have the added advantage of sufficient storage for significant energy production in the winter.

- The licensing, permitting and construction process for the Chakachamna Project would take roughly 3.5 years longer than for the Susitna Project because of the complex environmental studies required for the cross basin transfer and the time for the tunnel construction.

- The State would need to contribute substantial equity and be the licensee for either project. The ability to finance the projects is equal in either case.

- There are relatively less long term operational uncertainties for the Susitna Project.

- Both projects have some seismic risk; however the dams and powerhouses could be designed to withstand major seismic events as long as a fault does not pass through the structure. The Chakachamna Project has a relatively greater risk of damage to the power tunnel or fish passageway during a seismic event or volcanic eruption.

- The Susitna Project would be a larger construction project and have greater impacts on electrical rates than the Chakachamna Project along the railbelt and Statewide, in the form of lower rates in the long term.

- The Susitna Project would allow the State to achieve the State Energy policy goal of 50 percent renewable by 2025. The Chakachamna Project would not accomplish this goal by itself.

Overall, the Susitna Project would have a relatively lower cost of energy, fewer likely environmental effects, could start sooner, a reduced licensing/permitting schedule, less construction and long term operational risk, and greater positive impacts on the Alaskan economy than the Chakachamna Project.

A year of field studies at Lake Chakachamna would not be sufficient to determine an definitive environmental flow, would not predict project energy outcomes, or substantially change the economic factors that make the Susitna Project more desirable. Thus, Chakachamna Project field work should not proceed in 2011. Instead it may be prudent to perform some additional studies to confirm conceptual size optimization and cost.

Much of the information in this document came from reports prepared by HDR (HDR 2010), R&M Consultants/Hatch Associates Consultants (R&M Consultants/Hatch Associates Consultants 2010), and Seattle-Northwest Securities Corporation (SNW 2010). In addition, R&M Consultants/Hatch Associates provided Operational Uncertainty evaluation in Chapter 9. The referenced documents should be read for the full assumptions. Referenced documents and other important documents regarding these projects are available on the Alaska Energy Authority's Railbelt Large Hydro webpage.

Chapter 1

Project Descriptions

Each of the potential projects is described in the following section.

1.1 Susitna River Hydroelectric Project (Low Watana Non-expandable Alternative)

A two dam scheme was developed for the Susitna River Hydroelectric Project initially by the Corps of Engineers in the late 1970's for which a feasibility study was completed by Acres American Inc. for the Alaska Power Authority (APA) in 1982 (Acres 1982) and a license application was filed with FERC. An amended license was prepared in 1985 (Harza Ebasco 1985) and the project was cancelled in early 1986. Extensive site work including surveying, deep rock drilling as well as soil drilling and sampling was conducted at the Watana site. In addition environmental studies including fish and wildlife studies were conducted throughout the basin and included instream flow studies in the side channel sloughs downstream of Portage Creek.

In the two dam scheme developed in the Acres feasibility study (Acres 1982) the upper dam was at Watana (Figure 1-1) and was to be an 885 foot high earthfill embankment with a 1040 MW underground powerhouse. It was to be constructed first. The amended license (Harza Ebasco 1985) proposed to develop the project in three stages instead of two with an expandable 700 foot high embankment at Watana as the first phase with an installed capacity of less than 500 MW.

A number of hydroelectric generation alternatives were studied recently on the Susitna River (HDR 2009), of which the Low Watana Non-Expandable Alternative is the selected Susitna Project discussed in this document. The Low Watana Alternative, a 700 foot high dam with a 600 MW powerhouse was chosen because the best combination of winter storage, less environmental impact and low overall cost in addition to meeting the 50 percent renewable goal by 2025. The expandable version of a dam at this location was not chosen because it is more expensive initially relative to power output and the ultimate raised dam would have more environmental impacts related to terrestrial habitat as well as other technical challenges. The location of the Susitna Project as chosen for this review is the same location as the Watana dam in the two dam scheme as proposed in the 1980's (Acres 1982, Harza Ebasco 1985).

The Susitna Project would be located approximately half-way between Anchorage and Fairbanks. It would create a dam on the Susitna River at river mile 184 above the mouth of the Susitna River. The dam would be located within a steep sided river valley approximately 15 miles upstream of Devil's Canyon. The 700 foot high dam would have a 557 foot difference between tail water and maximum pond elevation, with a maximum pond level of 2014 feet. The reservoir would be 39 miles long and a maximum of 2 miles wide. Installed capacity would be 600 MW with the average annual generation determined to be 2600 GWhrs (HDR 2009). A final decision has not been made on the type of dam or the type of powerhouse (underground or surface) that would be used. The location of the Project is shown in Figure 1-1.

1.2 Chakachamna Hydroelectric Project

The Chakachamna Project was studied in detail in the 1980's as reported in the Bechtel report (Bechtel 1983). The project developed in that report consisted of an intake under the lake, and a 12 mile tunnel to an underground powerhouse on the McArthur River. At that location, the best alternative had a small regulating dam on the Chakachatna River and was estimated to produce 1,300 GWhrs of electricity annually although the report indicated that the maximum power could be generated by eliminating environmental flows and producing 1664 GWhrs of electricity annually with an installed capacity of 400MW. This latter alternative was identified to have adverse impacts on the fishery resources which use the Chakachatna River. Chapter 4 of this document; Preliminary Energy Estimate, further addresses the energy potential of the Chakachamna Project in light of environmental flows in the Chakachatna River.

The 1983 report (Bechtel 1983) also included an extensive environmental study which included environmental hydrology, aquatic biology, terrestrial vegetation and wildlife as well as human resources.

The Chakachamna Hydroelectric Project (Chakachamna Project) currently has a Preliminary Application before FERC (FERC No. 12660). In its Pre-Application Document (PAD) filed with FERC, the applicant, TDX Power described the Project to have 300 MW installed capacity and generate 1300 GWhrs hours of annual energy (TDX Power 2009).

The Chakachamna Project is located approximately 85 miles west of Anchorage at the south base of Mt. Spurr. Chakachamna Lake drains into the Chakachatna River, which flows downstream through a complicated system, ultimately flowing into Cook Inlet. That flow is partially joined to the McArthur River flow by way of the Noaukta Slough. The Chakachamna Project is essentially the same as the original scheme in the Bechtel study and involves diverting water from Chakachamna Lake through an 11 mile tunnel to an underground power plant near the McArthur River. The power plant would discharge its tailrace flow to the McArthur River and the flow would not rejoin the Chakachatna River until a point much further downstream, reducing flow in a portion of the Chakachatna River, and the Noaukta Slough and Middle River as well. The location of the Project is shown in Figure 1-1. The Project and vicinity are shown in Figure 1-2. The current scheme does not have a dam on the Chakachatna River as it exits the lake.

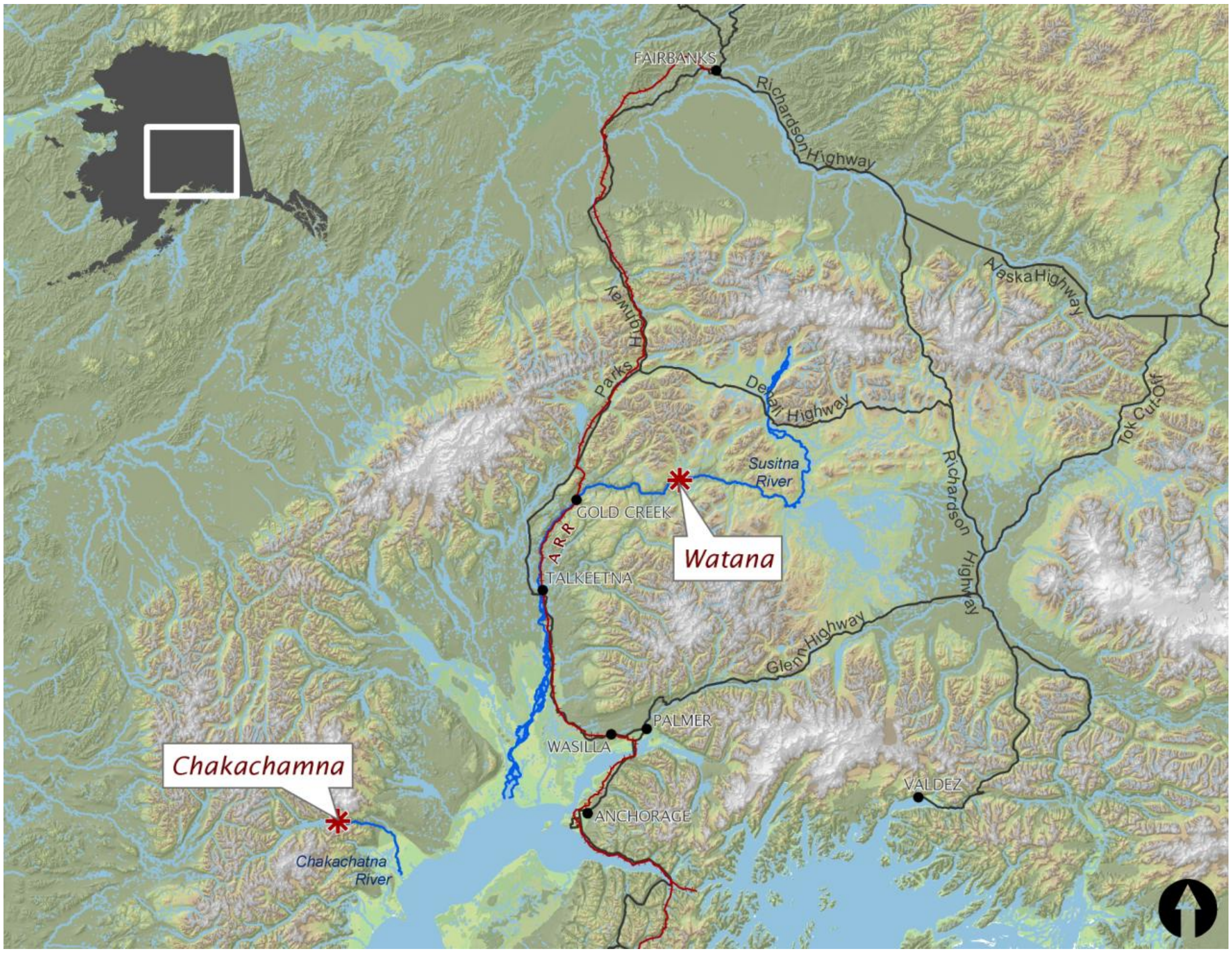

Figure 1-1 **Locations of the Susitna Project (Low Watana Alternative) and the Chakachamna Project**

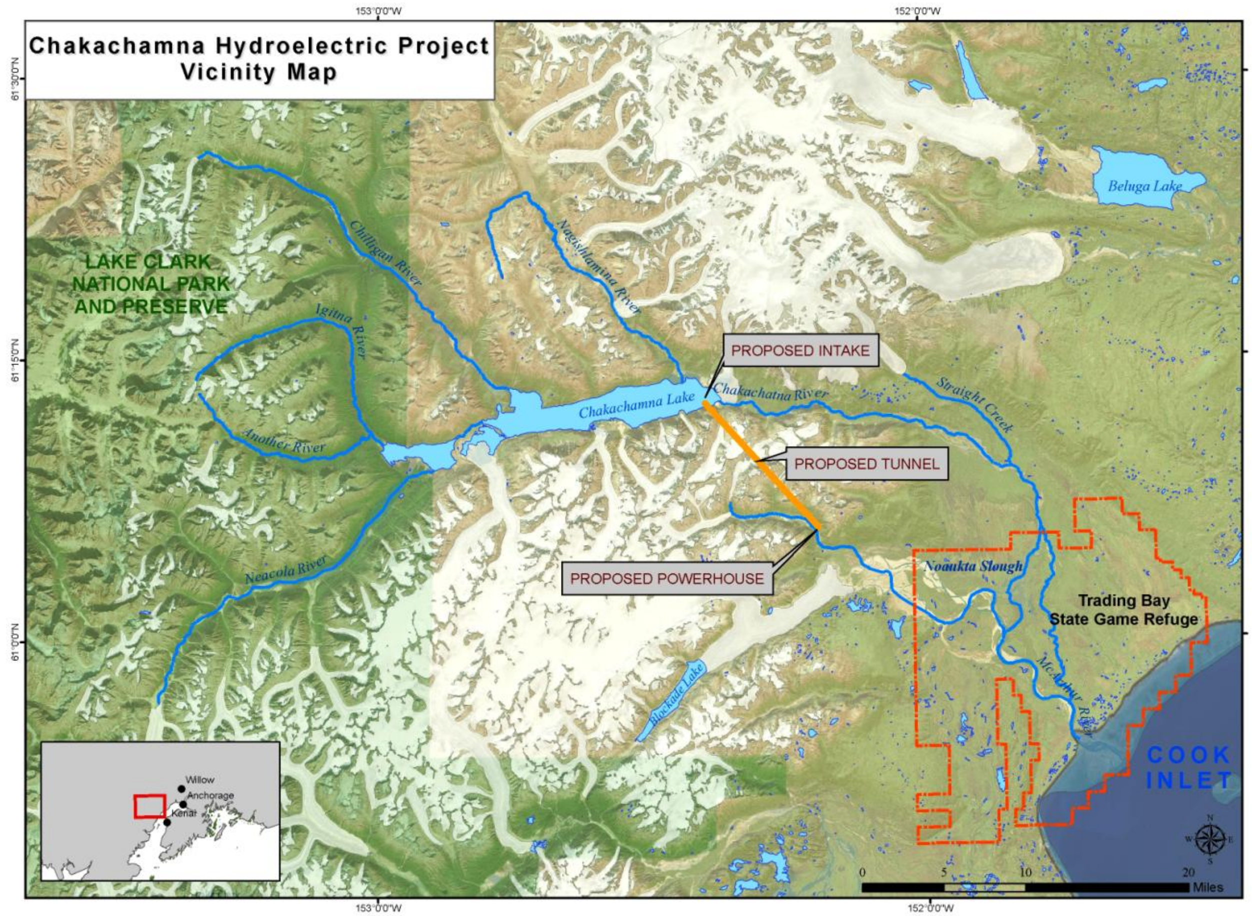

Figure 1-2 Vicinity of the Chakachamna Project

Chapter 2

Engineering Issues

Engineering issues associated with each potential project are discussed in the following section.

2.1 Access

2.1.1 Susitna Project

The Susitna Project could be accessed both from the Denali Highway by a new road and from Gold Creek (existing railroad bridge over the Susitna River) by a new rail line. Access via two modes of transportation provides the Project with advantages; the most significant of which is that the road could be built quickly, allowing early on site construction work. The rail link would allow materials from outside the State to be transported directly to the site by rail without having to off load to trucks.

2.1.2 Chakachamna Project

The Chakachamna site requires access from tidewater to the lake, the tunnel adits, and the McArthur River powerhouse location. Construction of a large dock to handle heavy equipment at Tyonek would be necessary. Access routes needed for construction and operation would be challenging. The construction access road could not cross the Trading Bay Game Refuge, and would therefore require crossing the braided Chakachatna River delta and wetland, as well as traversing high on steep mountain slopes to access the area near the lake

2.1.3 Access Comparison

Both projects would require roads and/or railroad to be constructed to handle very large and heavy equipment. Constructing access into both projects is likely to require two years. The advantages of access to the Susitna Project are that a major bridge is not required and that the routes cross less steep terrain compared to the Chakachamna Project. The bridge (or two) over the Chakachatna River will be large, expensive structure(s) with capacity to handle the heavy equipment. It is questionable whether a road built to handle heavy equipment could be constructed to the fish passageway location. If a road could not be constructed to handle a tunnel boring machine, drill and blast construction of the fish passageway would be required.

2.2 Transmission

2.2.1 Susitna Project

The Susitna Project would connect to the north-south intertie near Gold Creek. The cost of that transmission from the Susitna power plant to the intertie is included in the Susitna Project cost estimate. A conceptual study of the transmission needs in the railbelt if the Susitna Project was constructed was completed by EPS (EPS 2009). Upgrades to the existing intertie and substations would be required to transmit energy to Anchorage and Fairbanks.

2.2.2 Chakachamna Project

The Chakachamna Project transmission costs were estimated in today's dollars based on the original 1980's scheme. The cost of the transmission from the power plant to the Beluga Power plant was included in the cost estimate. It is believed a triple circuit would be required for the segment of the powerplant to Beluga, as well as additional changes in the railbelt transmission system. If the Chakachamna Project was constructed, transmission upgrades from Beluga plant to the intertie and an upgrade of the intertie upgraded would likely be necessary.

2.2.3 Transmission Comparison

Transmission line construction beyond the two projects will be needed. Because the Susitna Project will be located centrally between Anchorage and Fairbanks, it will require less total length of new line construction, but because of the larger power output will require more actual circuits. Chakachamna Project will likely require some new line construction from Beluga to Anchorage and changes if energy is to be transmitted north to Fairbanks. Overall there is not a significant difference between the two projects due to transmission needs.

2.3 Geologic Hazards

2.3.1 Susitna Project

The design earthquake for the Susitna Project would likely be a based on consideration of a Denali fault event somewhere in the range of magnitude 8.0, a local crustal earthquake and a subduction zone earthquake with a magnitude of roughly 8.5. The original Project design considered all of these earthquakes in the design. Excellent recent data exist on the Magnitude 7.9, 2002 Denali fault earthquake. A review of the earthquake design requirements for a Susitna Project was made by R&M Consultants (R&M 2009).

Subsurface conditions at the Susitna Project site are well known due to considerable rock drilling in the 1980's at the site. At the time, it was considered feasible to construct both diversion tunnels, power tunnels and an underground powerhouse.

There have been recent earthfill dams designed for large earthquakes, the most significant being the Seven Oaks Dam in Orange County, California, which is designed for a magnitude 8 earthquake from a distance of 1.2 miles away.

2.3.2 Chakachamna Project

The design earthquake for the Chakachamna Project would likely be from the Castle Mountain fault, which is approximately 6 miles from the power plant location. Proximity to the fault would likely mean that smaller connecting faults would be encountered during tunneling, which could cause delays and increased cost during construction. Subsurface geologic conditions along the tunnel alignment are not known. The frequency of any significant faulting and associated zones of fractured rock are not known, and could affect tunnel construction.

The Chakachamna Project also has other geologic hazards due to its proximity to Mount Spurr and Barrier Glacier. The most recent eruption at Mount Spurr was in 1992. If the volcano were to erupt again, ash fall and mud flows have the potential to block or partially block the powertunnel intake, fish passageway, or natural outflow of the lake. Facilities would need to be located or designed to minimize risk from an eruption. Also, at Lake Chakachamna, Barrier Glacier, which partially dams the lake, is a geologic risk. The glacier does not appear to be currently moving, is covered with debris, and has an ice core. A partial release of the lake occurred in 1971 when the outlet was eroded. The lake level dropped 10 to 15 feet. Facilities would need to be designed to accommodate a change in the glacier, which could cause the lake level to go up or down and substantially affect Project energy production and fish passage.

2.3.3 Geologic Hazards Comparison

Overall geologic hazards are somewhat greater at the Chakachamna site due to the close proximity of the castle Mountain fault and Mount Spurr.

2.4 Estimates of Probable Project Development Costs

A comparison of cost estimates for development of both project are provided in the following Section.

2.4.1 Susitna Project

2.4.1.1 Cost Estimate History

In 1982 to 1983, a detailed cost estimate to develop the complete Watana/Devil Canyon project was prepared. This estimate was revised in1985 to 1986, and again in March 2009. The latest estimate, prepared in November, 2009, is for a Low Watana Non-Expandable alternative. The estimate for this project in 2008 dollars is $4.5 billion as detailed in Table 2-1 below.

Table 2-1 Susitna, Low Watana Project Cost Summary

FERC Line #	Line Item Name	Low Watana (2008 Dollars Millions)
71A	Engineering, Environment, and Regulatory (7%)	$ 236
330	Land and Land Rights	$ 121
331	Power Plant Structure Improvements	$ 115
332.1-.4	Reservoir, Dams and Tunnels	$ 1,538
332.5-.9	Waterways	$ 590

Table 2-1 Susitna, Low Watana Project Cost Summary

FERC Line #	Line Item Name	Low Watana (2008 Dollars Millions)
333	Waterwheels, Turbines and Generators	$ 297
334	Accessory Electrical Equipment	$ 41
335	Misc Power Plant Equipment	$ 21
336	Roads, Rails and Air Facilities	$ 232
350-390	Transmission Features	$ 224
399	Other Tangible Property	$ 16
63	Main Construction Camp	$ 180
71B	Construction Management, 4%	$ 135
Total Subtotal		**$ 3,746**
Total Contingency		**$ 749**
Total (Millions of Dollars, rounded)		**$ 4,500**

2.4.2 Chakachamna Project

2.4.2.1 Cost Estimate History

In 1982, a detailed cost estimate was prepared for developing the Chakachamna Project. In 2008 and 2009, re-evaluations of this original estimate were made to take into account potential new alternative arrangements. In 2010, the detailed 1982 was updated with unit prices modified to be consistent with the estimated costs for the Susitna Project. The estimate for the Chakachamna Project in 2008 dollars is $2.9 billion, as detailed in Table 2-2 below.

Table 2-2 Chakachamna Project Cost Summary Table

FERC Line #	Line Item Name	Chakachamna (2008 Dollars Millions)
71A	Engineering, Environment, and Regulatory (7%)	$ 151
330	Land and Land Rights	$ 75
331	Power Plant Structure Improvements	$ 105
332.1-.4	Reservoir, Dams and Tunnels	$ 1,147
332.5-.9	Waterways	$ 123
333	Waterwheels, Turbines and Generators	$ 181
334	Accessory Electrical Equipment	$ 20

Table 2-2 Chakachamna Project Cost Summary Table

FERC Line #	Line Item Name	Chakachamna (2008 Dollars Millions)
335	Misc Power Plant Equipment	$ 15
336	Roads, Rails and Air Facilities	$ 172
350-390	Transmission Features	$ 232
399	Other Tangible Property	$ 0
63	Main Construction Camp	$ 90
71B	Construction Management, 4%	$ 86
Total Subtotal		**$ 2,400**
Total Contingency		**$ 480**
Total (Millions of Dollars, rounded)		**$ 2,880**

2.4.3 Cost Comparison

Although capital cost is greater for the Susitna Project, the evaluation in Chapter 9 will show that the cost to repay the financing of the project relative to energy production will be lower for the Susitna Project. Since the financing cost is a major portion of the energy cost, and since operation and maintenance and utility cost will be roughly equal regardless of the power source, overall, the Susitna Project cost per unit of energy will be relatively lower.

Detailed Susitna costs can be found at Susitna Hydroelectric Project Alternatives Design Report 2009 located on the AEA Railbelt Large Hydro webpage.

Detailed Chakachamna costs can be found at Susitna and Chakachamna – Preliminary Decision Document 2010 located on the AEA Railbelt Large Hydro webpage.

Chapter 3

Environmental Issues

Development of a hydroelectric project would face a variety of issues over the design lifetime. The design lifetime for a modern hydroelectric facility is anticipated to be greater than 100 years. The following discussion is not all inclusive but highlights the likely major areas of concern regarding both projects. Botanical and cultural resource issues are not discussed in this document since they have not been fully explored and tend to have less overall impact on whether a project is licensed and constructed.

3.1 Fisheries

3.1.1 Susitna Project

Fish resources have the highest potential to be impacted by the project. Most of the potential impacts would occur in the reservoir and the middle Susitna River downstream of the reservoir. There would be impacts due to changes in water quality, thermal regime, suspended sediment load, reservoir draw-down fluctuations, impoundment zone inundation, flow regime, and fish habitat. Not all impacts to fish populations would be negative. For example, an increase in winter water temperatures could lead to the enhancement of overwintering habitat and thus greater fish survival; however, the cooler spring water temperatures could slow fish growth.

The majority of the salmon production occurs in tributaries outside the area of anticipated effects. Devil Canyon acts as an effective passage barrier to upstream migration of salmon. Radio telemetry studies of Susitna drainage conducted by ADF&G (Yanusz et. al., 2007) observed no sockeye salmon moving above Portage Creek near the entrance to Devils Canyon. A few (less than 100) adult Chinook salmon have been observed above the Devil Canyon dam site (FERC Amend Nov 1985). Electrofishing surveys conducted by ADF&G in 2003 (Johnson, 2010) documented Chinook salmon rearing in Kosina Creek and the Oshetna River, both located above the Watana Dam site.

In the Watana impoundment zone, approximately 40 river miles of the Susitna River would be inundated and transformed into reservoir habitat. An additional 15 miles of four named tributary streams (including Kosina Creek) and numerous smaller unnamed tributaries and eight small lakes would be inundated. There are nine species of fish occurring in the proposed impoundment zones: Arctic grayling would lose approximately nine miles of spawning habitat and would not likely populate the impoundment zone (ENTRIX 1985). River habitat would be transformed into lake/reservoir habitat that may be occupied by a different array of fish species. Lake drawn down may limit spawning of species dependent upon these areas for reproduction. Table 3-1 shows the possible fisheries impact of the Susitna Project.

3.1.2 Chakachamna Project

Chakachamna Project has fish issues of concern to resource agencies. Since this document is a summary, only the three that most affect project economics and licensing ability will be discussed.

3.1.2.1 Lake Level Fluctuations

Chakachamna Lake and the surrounding tributaries support abundant salmon and freshwater fisheries resources. Five significant tributaries and numerous minor drainages empty from the surrounding mountains into Kenibuna and Chakachamna Lakes. Of these, the Chilligan and Igitna Rivers provide significant sockeye salmon spawning habitat. The lake tributary streams also provide habitat for Dolly Varden.

Studies in 1982 showed significant numbers of adult sockeye salmon milling along the north shore of Chakachamna Lake and spawning was suspected but not confirmed. Chakachamna Lake also provides habitat for resident lake trout, Dolly Varden, and round whitefish. Life histories of lake trout, Dolly Varden, and whitefish have not been investigated in Chakachamna Lake.

Under the proposed operational structure (base case), the lake level would fluctuate approximately 60 feet from the normal maximum pool elevation of 1,142 feet to the normal minimum pool elevation of 1,082 feet. If sockeye salmon spawn along lake shoals, it is likely that their spawning timing would coincide with the maximum pool elevation. The resulting eggs might subsequently be exposed and killed when the lake level drops to the minimum pool elevations in March or April. Similarly, lake trout spawning areas may be affected by the winter lake drop in lake level.

An additional impact relating to lake level drop is the potential for down-cutting of the channel between Kenibuna and Chakachamna Lakes and the fluvial fans of lake tributaries such as the Chilligan River. If down cutting occurs and as a result effects the level of Kenibuna lake (within Lake Clark National Park) then project can not be licensed by FERC. Down cutting may also effect fish passage into the tributaries particularly during periods of low lake level.

3.1.2.2 Reduced Flows into the Chakachatna River

The proposed operation of the Chakachamna Hydroelectric Project involves diverting a portion of the natural flow out of Lake Chakachamna to the powerhouse located in the McArthur River valley. In the base case, the average flow in the Chakachatna River will be reduced by approximately 50 to 80 percent from June through November.

The Chakachatna River provides a migration corridor, spawning habitat, and rearing habitat for salmon. The lower Chakachatna River splits into three branches: Middle River, which flows southeast to Cook Inlet, the Chakachatna River, which flows south and joins the McArthur River near its mouth, and a third braided section called Noaukta Slough which joins the middle part of the McArthur River. Hydrologic ties to the Chakachatna and McArthur rivers appear important in supporting the lower elevation wetlands north of Noaukta Slough and in the Trading Bay State

Game Refuge. Reduced river flow may cause floodplains, wetlands, and riparian habitats to dry. Drying of these wetland would effect fish populations in the Trading Bay State Game Refuge.

3.1.2.3 False Attraction

Transfer of water from Chakachamna Lake to the upper McArthur River may cause false attraction of adult salmon to the powerhouse tailrace during their spawning migration. The tailrace is proposed to be located approximately 15 miles up the McArthur River from the Noaukta Slough (Chakachatna River) confluence. The mixture of Chakachamna Lake water from the tailrace may confuse salmon migration and could prevent or delay the movement of salmon to spawning areas in Chakachamna Lake and its tributaries.

Critical months for salmon passage into and out of the lake occur between May and September, when a majority of the lake's discharge will be diverted to the upper McArthur River. Adult salmon return to their natal spawning areas by using olfactory cues (chemical "smells"). For Lake Chakachamna sockeye salmon, these cues are imprinted at the smolt stage when juvenile salmon migrate from spawning and rearing areas in the lake out the Chakachatna River to salt water. Because the majority of the Lake Chakachamna water is being discharged from the powerhouse into the McArthur River a substantial number of the adult salmon may be falsely attracted to the powerhouse in the McArthur River.

3.1 Wildlife Impacts

3.1.1 Susitna Project

There are currently no known listed endangered species in the project area. The most significant effect on wildlife would be on the species that live in the spruce forested valley walls. Impacts on each species would be different based on species abundance and use of the habitat; however, major threats common to most species have been identified. Downstream of the Watana reservoir there may be an increase in preferred moose browse, thus increasing the moose population (Harza Ebasco 1985b). The Susitna Project development would impact mink and otter in the middle river by increasing the winter turbidities which would reduce the value of the mainstem as feeding habitat. Open water in the winter would have a positive effect on mink and otter (Harza Ebasco 1985b). Other impacts to animals downstream of the reservoir would be negligible (Harza Ebasco 1985b).

A summary of the potential environmental impacts of the Susitna Project is provided in Table 3.1 below.

Table 3-1 Potential Environmental Impacts of the Low Watana Hydroelectric Project on the Susitna River

Impacts	Issues
Reservoir - Impacts	
River Habitat & Fisheries Impacts	Approximately 40 river miles of the main stem of the Susitna River and 15 miles of tributary streams will be converted from riverine to reservoir environment. Arctic grayling are the most abundant fish species in the impound zone and will have the greatest

	impacts with the loss of approximately nine miles of spawning habitat. A significant portion of lower Kosina Creek used by rearing Chinook salmon will be lost to inundation.
Fish passage	Fish passage may be blocked for a small number of Chinook salmon that travel above the site.
Drawdown impacts	The annual drawdown and refilling of the reservoir will affect an estimated 10 miles of river that will alternate between river and reservoir habitat.
Terrestrial Impacts	An estimated 20,000 acres of habitat will be flooded. Reservoir may alter traditional migration routes.
Downstream Impacts	
Flow change impacts to fish	Lower summer flows may reduce access to side channel fish habitats and reduce the amount of rearing habitat for salmonids. Increased winter time flows may provide more rearing habitat benefiting overwinter survival. Dampening of flows may alter streambed movement and affect side channel habitats.
Temperature impacts to fish	Lower than natural water temperatures in spring/early summer may cause a delay in the onset of favorable summer rearing conditions for salmonids. Warmer than normal fall water temperatures may extend the summer rearing period later into fall. Overwinter survival for salmonids may be benefited by warmer water temperatures and a delay in ice formation. Higher main stem discharges in winter may maintain higher rates of warm groundwater upwelling in side sloughs affecting incubation of salmon eggs.

3.1.2 Chakachamna Project

Wildlife impacts from the Chakachamna Project have not been studied in detail. Reduction of salmon traveling to Lake Chakachamna tributaries would reduce the food source for bears and eagle in Lake Clark National Park. Drying of Trading Bay State Game Refuge would potentially alter wildlife habitat effecting birds and mammals in the refuge.

Increased flow down the McArthur River may cause some increased flooding and wetlands south of Trading Bay State Game Refugee. The net effect of the changes in food source and habitat over a large area (Lake Clark NP, Trading Bay, and McArthur River) has not been studied.

3.2 Environmental Flow

3.2.1 Susitna Project

Environmental flow requirements are met by water being used for energy production passing through the generating units and then being released into the natural stream channel. The effect of environmental flows is to change the timing of the energy production but not necessarily the average annual amount of generation.

A preferred environmental flow regime in the 1980's was developed to have high late summer flows for maintenance of rearing habitat for Chinook salmon juveniles. However, peak summer flows would be reduced and winter flows (within limits) would be increased to generate more power. A comparison of the 1980 selected environmental flow and of the existing Susitna River flows are shown in Figure 3-1 below.

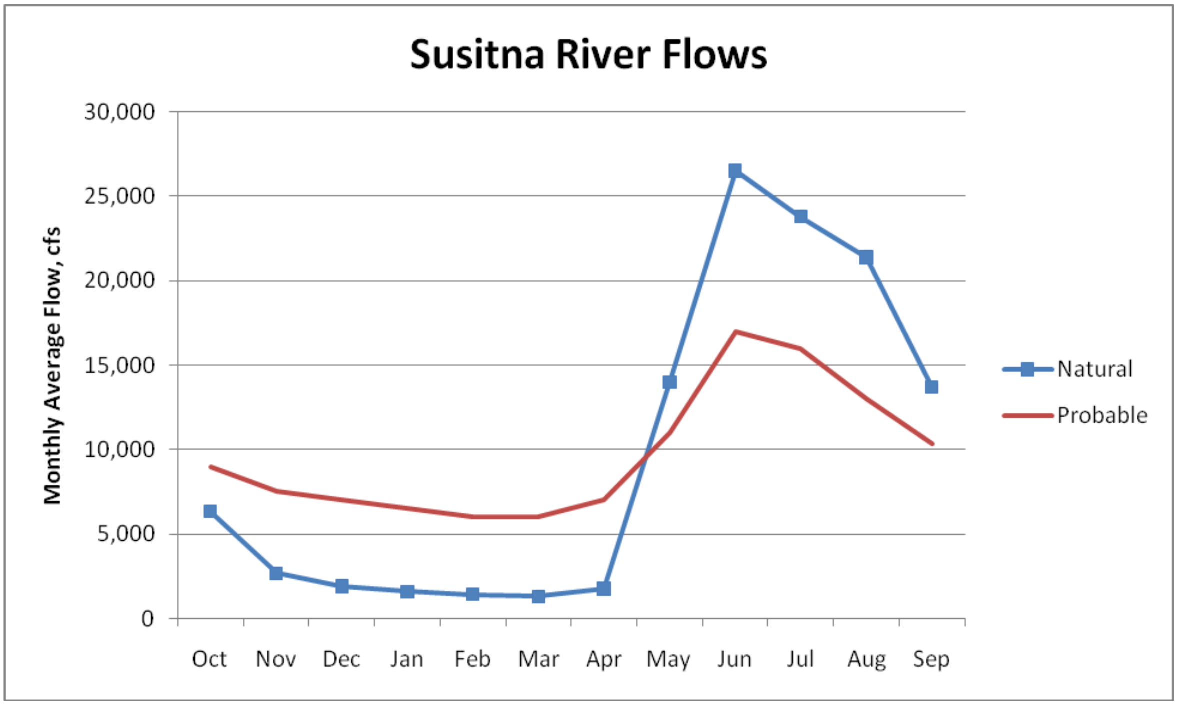

Figure 3-1. Susitna River monthly mean flow at Gold Creek.

3.2.2 Chakachamna Project

The preliminary environmental flow recommendations suggested for the Chakachatna River in the PAD are based on the Montana Method (Tennant 1972) as presented in the Bechtel report on the project in 1983. The Bechtel report assumed environmental flows during the months of April to September of 1094 cfs or lake inflow, whichever was less. During the months of October through March, the minimum environmental flow was assumed to be 365 cfs or lake inflow, whichever was less. These amounts of discharge are rated as “fair to degrading” flows in the Montana Method. This method was developed for and has primarily been used on rivers in the lower 48 states, which show little similarity to the glacially driven and highly seasonal flows of the Chakachatna River. Winter time flows using this method drop below historic average monthly flows, potentially resulting in freeze-out of spawning beds located outside the main river or in side channel areas. Summertime flows provided may not be sufficient to attract adult spawners confused by the discharges into the McArthur drainage or to provide for upstream passage through the canyon area located below Chakachamna Lake. Additionally, this environmental flow method does not take into consideration the groundwater hydrology feeding wetlands of the Trading Bay Game Refuge.

While it is outside of the scope of this document to complete the environmental flow analysis needed to adequately address all of the environmental issues in the Chakachamna watershed, Table 3-2 below provides an estimate of environmental flows that may be more likely to be viewed favorably by permitting agencies. It should be noted, however, that these flows have not been reviewed or endorsed by any permitting agencies. Determination of environmental flows for the project will ultimately be the result of a detailed analysis of instream flow data by conducted by a multiagency review team over a multi year time period.

Table 3-2 Estimate of Probable Environmental Flows

Month	Historic Natural Flow (cfs)	Base Case Flow (cfs)	Minimum Probable Flow (cfs)	Notes
October	2468	402	1,250	50% of mean monthly flow: provides water to Noaukta Slough to attract adult coho spawners and protect historic side channel spawning habitats.
November	1206	365	600	50% of mean monthly flow: provides water to Noaukta Slough to attract adult coho spawners and protect historic side channel spawning habitats.
December	813	363	600	75% of mean monthly flow: protects incubation in Chakachatna/Noaukta Slough spawning beds.
January	613	365	500	100% of mean monthly flow: protects incubation in Chakachatna/Noaukta Slough spawning beds.
February	505	357	500	100% of mean monthly flow: protects incubation in Chakachatna/Noaukta Slough spawning beds.
March	445	358	500	100% of mean monthly flow to protect incubation in Chakachatna/Noaukta Slough spawning beds.
April	441	582	500	100% of mean monthly flow: protects incubation in Chakachatna/Noaukta Slough spawning beds.
May	1042	1,094	750	75% of mean monthly flow: protects juvenile rearing in Chakachatna/Noaukta Slough areas and provides for outmigration of smolts from lake.
June	5,875	1,094	2,000	33% of mean monthly flow: provides water for outmigration of smolts from lake and feeds groundwater to Trading Bay Refuge wetlands.
July	11,944	1,421	4,000	33% of mean monthly flow: provides water to attract spawning adults to Chakachatna/Noaukta as opposed to McArthur, provides adequate flow for adult passage through canyon below lake outlet, and feeds groundwater to Trading Bay Refuge wetlands.
August	11,996	5,599	4,000	33% of mean monthly flow: provides water to attract spawning adults to Chakachatna/Noaukta as opposed to McArthur, provides adequate flow for adult passage through canyon below lake outlet, and feeds groundwater to Trading Bay Refuge wetlands.
September	6,042	2,164	2,000	33% of mean monthly flow: provides water to attract spawning adults to Chakachatna/Noaukta as opposed to McArthur, provides adequate flow for adult passage through canyon below lake outlet, and feeds groundwater to Trading Bay Refuge wetlands.

3.2.3 Environmental Flow Analysis

To evaluate the effect of increased minimum environmental flow requirements in the Chakachatna River and/or the effect of lake level fluctuations, two alternatives to the base case were also evaluated. Environmental issues surrounding project operations generally revolve around three main issues: 1) habitat affected by flows in the bypass reach; 2) upstream and downstream fish passage; and 3) habitat affected by lake level fluctuations. The alternatives to the Base case evaluated were:

- **Alternative #1 – Base case with probable environmental flow.** Alternative 1 is the same as the base case except that:
  - Environmental flow requirements are revised as described in Table 3-2 above.
  - The lake level fluctuations are not restricted.
- **Alternative #2 – Base case with probable environmental flow & minimization of lake fluctuation**. Alternative 2 is the same as the base case except that:
  - Environmental flow requirements are revised as described in Table 3-2 above.
  - The maximum lake level fluctuation would be 15 feet below the weir outlet.

A comparison of potential environmental impacts resulting from each alternative are presented in Table 3-3.

Table 3-3 Comparison of Potential Environmental Impacts Resulting from Chakachamna Lake Hydro Alternatives

Issue	Base Case	Alternative 1	Alternative 2
Lake Level Fluctuation			
Impacts to shoal spawning areas for sockeye salmon and lake trout	Significant impacts to incubating eggs due to draw down	Significant impacts	Least significant case but impacts may still occur
Access to inlet streams (Chilligan and Igitna) for sockeye spawners	Not likely to be impacted	Could be impacted due to drawn down	Not likely to be impacted
Adult salmon passage into lake	Minor to moderate, passage via natural outlet 87% of time	Significant, dependent upon using fish tunnel 91% of the time	Minor to moderate passage via natural outlet 87% of time
Smolt outmigration from lake	Unknown, smolts 100% dependent on fish passage tunnel	Unknown, smolts 100% dependent on fish passage tunnel	Unknown, smolts 100% dependent on fish passage tunnel
Chakachatna / McArthur Issues			
False attraction of Chakachamna sockey spawners to the McArthur powerhouse	Likely to occur	Least likely case but may still occur	Least likely case but may still occur
Noauktna Slough and Chakachatna side channel spawning and rearing habitats	Moderate impacts possible from winter freeze-out	Lower impacts than Base Case	Lower impacts than Base Case
Trading Bay Wildlife Refuge			
Groundwater fed wetland habitats	Moderate impacts	Lower impacts than Base Case	Lower impacts than Base Case

Under the Base Case and Alternative 1 the lake level would fluctuate approximately 60 feet from the normal maximum pool elevation of 1,142 feet to the normal minimum pool elevation of 1,082 feet. Spawning of adult salmon and Lake Trout may be effected and down cutting to tributaries may occur.

Lake level affects adult salmon passage into the lake in Alternative 1, where the natural outlet is not available to spawning adults 91 percent of the time. In this alternative, fish will be dependant upon using the two mile long fish passage tunnel. There is uncertainty whether fish will be willing to use the tunnel. In all cases the fish passage tunnel will be required for smolt outmigration.

In Alternative 2, the lake level is minimized to 15 feet below the outlet. While this amount of drawdown may exceed natural lake level fluctuation, it is the scenario offering the least impact to lake habitats.

For Chakachamna, limiting lake fluctuation (Alternative 2) to minimize the affect on upstream spawning will decrease the amount of runoff that can be captured, thereby decreasing the average annual generation. Figure 3-2 shows the post-project lake elevation by month for the base case and the two alternatives.

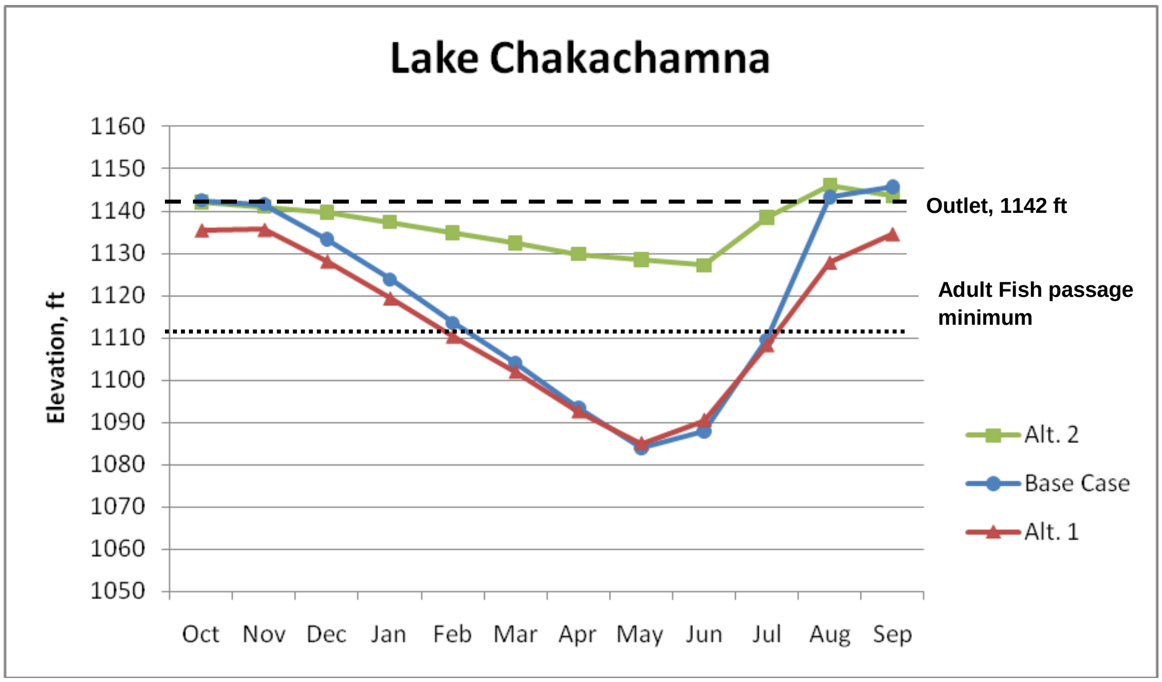

Figure 3-2 Chakachamna Lake Elevation by Month

Flows in the Chakachatna River during Project operation will be comprised of environmental flow releases and spill as shown in Figure 3-3. Since the powerhouse discharges return to the McArthur River, the net flows in the Chakachatna River are reduced in all cases.

Detailed Chakachamna environmental discussion can be found at Susitna and Chakachamna – Preliminary Decision Document, Environmental-Energy-Cost November 12, 2010 located on the AEA Railbelt Large Hydro webpage.

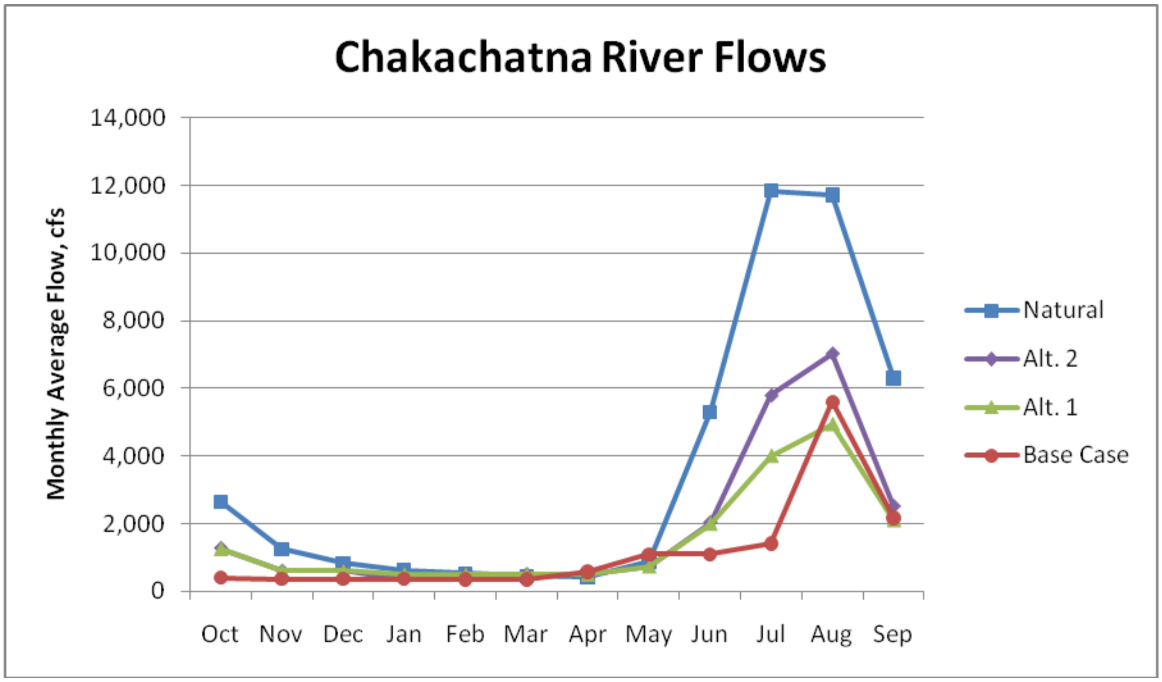

Figure 3-3 Chakachatna River Flows (Downstream of Lake) by Month

Chapter 4

Preliminary Energy Estimate

4.1 Evaluation of Average Annual Energy and Firm Winter Capacity

The amount of energy that can be produced from hydroelectric projects is a function of the amount of available water and, in the case of storage projects, how the available water can be regulated (systematically released). In addition to the average annual energy, the firm capacity attainable during winter months is of particular importance. For hydroelectric projects, the firm capacity is almost always lower than the installed generation capacity for a project. For the purposes of this study work, firm capacity is defined as:

"The amount of power the project can generate on a continuous basis from November 1 through April 30 with 98 percent reliability."

It should be noted that this is only one manner of regulation. The water can be regulated in a variety of different means in order to achieve other objectives, such as peaking, spinning reserve, or backup capacity. Major assumptions used to develop the estimates average annual energy and winter plant capacity are presented below.

4.1.1 Susitna Model Assumptions and Data Sources

This potential project consists of the construction of a large storage reservoir on the Susitna River at the Watana site with a 700-foot-high dam and a four-unit powerhouse with a total installed capacity of 600 MW. This "Low Watana non-expandable" alternative is described in detail in *Susitna Hydroelectric Project, Conceptual Alternative Design Report (*HDR Alaska 2009b).

4.1.2 Chakachamna Model Assumptions and Data Sources

This potential project consists of the inter basin transfer of water from a lake tap near the outlet of Chakachamna Lake through an approximately 10.8-mile-long tunnel to an underground powerhouse that would discharge to the McArthur River. The powerhouse would have a total generating capacity of 300 MW. The Base case (as proposed) and two alternatives were evaluated. Alternatives, described in Section 3.1.3, show how alternative operational constraints on the project would affect project energy. These alternatives are as follows:

- **Base Case** for analysis was the project as described in the PAD (TDX Power 2009). This project used environmental flow recommendations for the Chakachatna River based on the Montana Method (Tennant 1972).

- **Alternative #1 – Base Case with Probable Environmental Flow.** Alternative 1 is the same as the Base Case except that higher environmental flows are required.

- **Alternative #2 – Base Case with Probable Environmental Flow & Minimization of Lake Fluctuation**. Alternative 2 is the same as the Base Case except that higher environmental flows are required and lake level drop would be limited.

4.2 Results

Firm capacities and average annual energy estimates are presented in Table 4-1.

Table 4-1 Firm Capacity and Average Annual Energy Estimates

Alternative	98% Winter Capacity (MW)	Average Annual Energy Production (GWhrs)
Susitna	245	2,600
Chakachamna, Base Case	170	1,300
Chakachamna, Alternative 1	140	1,100
Chakachamna , Alternative 2	30	860

The energy distribution by month for each of the above alternatives is shown in Figure 4-1 below.

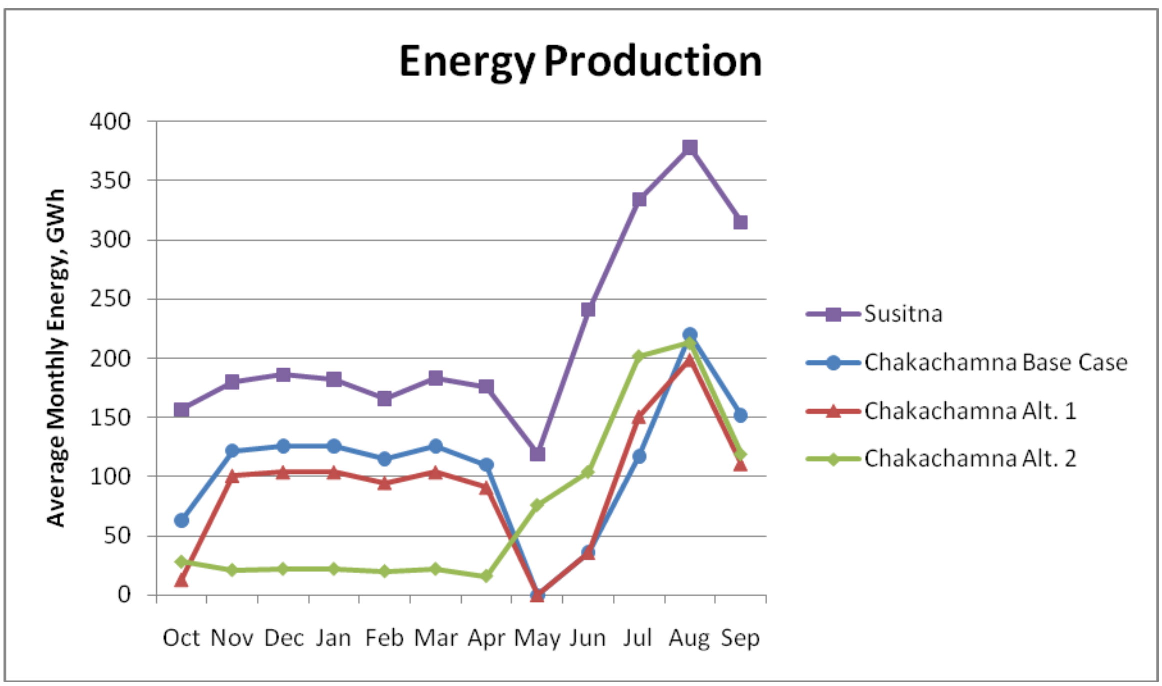

Figure 4-1 Energy Distribution by Month

As can be seen by these results, the firm winter capacity and average annual energy production estimates can vary significantly based upon the assumed environmental constraints placed upon the project. For the Chakachamna Project, increased environmental flow requirements (Alternatives 1 and 2) reduce the amount of water that is available for generation, thereby lowering the annual energy. Reduced use of reservoir storage greatly limits the amount of energy that can be produced during the winter months (Alternative 2).

Detailed Chakachamna environmental discussion can be found at Susitna and Chakachamna – Preliminary Decision Document, Environmental-Energy-Cost November 12, 2010 located on the AEA Railbelt Large Hydro webpage.

For the Susitna Project, environmental flow requirements are met by water passing through the generating units and then being released into the natural stream channel. The effect of changed environmental flows is to change the timing of the energy production but not necessarily the average annual amount of generation.

Chapter 5 Permitting

5.1 Overview – Regulatory Processes

While pursuant to the Federal Power Act (FPA), the Federal Energy Regulatory Commission (FERC) has exclusive authority to issue licenses for most non-federal hydropower projects, there are several federal and state agencies that are authorized under several federal statutes to submit mandatory and recommended terms and conditions to be included in a FERC-issued license.

- **FERC's licensing process options** – Applicants may propose to use one of three options: the Integrated (ILP), Alternative (ALP), or Traditional (TLP). The default is the ILP, unless FERC approves use of either the ALP or TLP.
- **Pre-filing consultation** – extensive pre-filing meetings and exchange of information required.
- **Federal Energy Regulatory Commission – Application for License** required; Draft submitted for review & comments; Final filed.
- **Federal and State resource agencies consultation & terms & conditions** – File mandatory & recommended terms and conditions; most become License Articles and require compliance.
- **Numerous other State & Federal approvals & permits are required** – Applicants are required to provide evidence of consultation with agencies in an Application for License, and provide copies of permits and/or approvals.

Please also see R&M Consultants/Hatch Associates Consultants report (2010) for a detailed presentation of the various agencies and their authorities who would shape the content of any issued license.

5.2 Regulatory Issues – Chakachamna Project

TDX received its first Preliminary Permit on November 14, 2006. The purpose of a Preliminary Permit is to reserve priority to conduct studies for a period of three years, and if the effort results in filing an Application for License. A successive (second) permit was issued on February 25, 2010. This permit expires on January 31, 2013. FERC noted in issuing the permit that "a successive permit can warrant a greater standard of Commission oversight." "If the permittee fails to make significant progress toward developing a license application, the permit may be subject to cancellation."

On July 17, 2009, TDX filed its Notice of Intent to File an Application for License (NOI), Request to Use a Traditional Licensing Process (TLP), and Pre-Application Document (PAD). By letter dated July 27, 2009, FERC requested that they consider which licensing process it wishes to use and to refile its request noting that there would not be a need to refile the PAD. TDX met with FERC on August 5, 2009 to discuss the proceeding. On September 21, 2009, TDX requested to rescind its PAD. TDX stated that "this Project may be best served by an Integrated Licensing Process (ILP). TDX stated its intent to implement a field season in 2010 and to hold a study plan review and workshop in February 2010. TDX has a website for the Project and there is no evidence that work is proceeding as noted in their September 21, 2009, correspondence to the FERC. Nor has any further information been filed with the Commission. Under TDX's current development schedule, a third FERC Permit would be necessary.

5.2.1 Licensing Schedule

Once the pre-filing process restarts the schedule could be:

- Prepare and File Final Application for License – 4.5 years
- FERC Processing and License Issuance – 2.5 years

5.3 Regulatory Issues – Susitna / Low Watana Project

At present, there is no FERC Preliminary Permit in effect. While a FERC Permit is not required, it would be prudent for an entity representing the State to secure priority to study the Project. As discussed above, the Alaska Power Authority (APA), now known as AEA prepared and filed an application for license in February 1983. That application was withdrawn and APA revised the Project schedule to realize benefits identified with a three, as opposed to two-year construction schedule in 1985. In 1986, APA abandoned pursuit of a FERC license for numerous reasons, including financial feasibility.

In 2008, AEA began an update of the project, including preparation of the Railbelt IRP to evaluate the ability of the Susitna Project, and other resources, to meet long term demand in the Railbelt Region.

5.3.1 Licensing Schedule

Table 5-1 shows a Licensing, Engineering and Construction Schedule Comparison for the two projects. For the Susitna Project, based on information available at this time, the FERC schedule could be:

- Prepare and File Final Application for License – 3.5 years
- FERC Processing and License Issuance – 2 years

5.4 Total Project Development Timeline

Table 5-1 provides a Development Schedule Comparison for the two projects. Based on information available at this time, the comparative total schedule from start of the FERC process, in the case of the Chakachamna a restart of their pre-filing process, could be:

Table 5-1 Development Schedule Comparison

Major Task	Chakachamna	Susitna Low Watana
FERC Pre-filing Process	4.5 years	3.5 years
FERC Processing – DC	2.5 years	2.0 years
FERC Processing - Portland	2.0 years	1.0 years
Construction through Start up	5.5 years	4.5 years
TOTALS	**14.5 YEARS**	**11 YEARS**

Detailed Susitna and Chakachamna Licensing and permitting information is found at Susitna-Low Watana & Chakachamna Projects, Large Hydro Evaluation of Two Projects, Preliminary Decision Document, Environmental & Regulatory Issues November 14, 2010 located on the AEA Railbelt Large Hydro webpage.

Chapter 6

Development Schedule

The following tables (Table 6-1 and Table 6-2) show the major tasks associated with hydro project development, and the estimated preliminary schedule for completion for the Chakachamna Project compared to the estimated preliminary schedule for completion for the Susitna Project. Special considerations and assumptions for each are listed below.

Table 6-1 Considerations / Assumptions

Chakachamna Project	Susitna Project
▪ TBM est. 14-16 months to order and deliver to site ▪ 4.5 year pre-filing process assumes studies underway in 2011 (one year behind schedule in TDX PAD, 2009) ▪ 2.5 years for FERC Processing and License Issuance, and 5.5 year construction schedule based on PAD (Appendix 2-1) ▪ FERC-PRO processing and some procurement must be accomplished before field work can begin ▪ Longer construction schedule due to significant underground work, with higher risk profile and greater uncertainty ▪ Project "access" to require 2 yrs to construct ▪ Chakachamna has higher risk that the schedule to Project Startup will extend beyond 14.5 years.	▪ Significant, extensive and valid environmental studies performed in 1980's to be updated and used to develop FERC documents ▪ Significant geotechnical investigations performed previously ▪ FERC-PRO processing and some procurement must be accomplished before field work can begin ▪ More surface features and work carries more schedule certainty, less risk ▪ Project "access" to require 2 yrs to construct ▪ Engineering schedule based on "Low Watana Non-Expandable Development" (HDR, 2009) ▪ Susitna has lower risk that the schedule to Project Startup will extend beyond 11 years.

Table 6-2 Licensing, Engineering, and Construction Schedule Comparison

	Regulatory / Environmental Major Tasks			Engineering / Construction Major Tasks		
		Chakachamna	**Susitna**		**Chakachamna**	**Susitna**
Pre-License Issuance	Preliminary Permit Scoping Draft Application Final Application	4.5 yrs	3.5 yrs	Feasibility Engineering Design Specifications, Drawings & Bid Documents		
	FERC Processing (DHAC) License Order Issued	2.5 yrs	2 yrs			
Post-License Issuance	License & Permits Compliance			FERC Processing (Portland Regional Office) Procurement	2 yrs	1 yr
				Construction Testing & Commissioning Project Startup	5.5 yrs	4.5 yrs
Reg/Env Estimated Schedule		**7 yrs**	**5.5 yrs**	**Eng/Const Estimated Schedule**	**7.5 yrs**	**5.5 yrs**
				ESTIMATED TOTAL TO STARTUP	**14-15 years**	**11 years**

Chapter 7

Financial

Based on project risk for investors, the two projects, Susitna and Chakachamna, are similar. Project financing for either project, where the costs of the project is paid for solely by the sale of power produced from the project, is assumed to be unavailable. Without State participation these project are unlikely to proceed. State participation of whatever form it takes place will enable these projects to occur and lower the cost of the energy to ratepayers.

Large projects have financing that is structured on some amount of government participation. Government participation is normally required because of the following risks generally associated with large hydroelectric projects make project financing unattainable:

- **Timeline**: Project may take 10-20 years prior to first power sales. Private investors do not like to spend substantial funds for an extended time when the payoff is a long time or may not occur.
- **Licensing and Permitting Risk**: Significant funds can be spent only for the project to have long delays in licensing and in operation constraints placed on project.
- **Construction Risk**: Estimating the cost of a project many years out has risk of the prices changing for materials and labor. In addition, the demand for a product can change.

The "Bradley Model" has been discussed as a way that a new large hydroelectric facility can be financed for construction with State assistance. Licensed and constructed in the 1980's and early 1990's it is Alaska's largest hydroelectric project. Bradley Lake Hydroelectric Project (Bradley Project) is located southeast of Homer, Alaska and is a 125-foot high concrete faced rock filled gravity dam. The project has 126MW of installed capacity and produces approximately 9 percent of the railbelt's annual energy. The state paid for licensing and much of the cost of the project. Approximately 50 percent of the project's licensing and construction cost was paid by the State. The railbelt utilities purchase all the power for the projects and pay all the costs of the project (bond financing, Operations and maintenance). Once the debt service is retired then the utilities will continue to pay the State the same amount as the debt service.

Detailed information on State participation and Bradley financing is available at Hydroelectric Project Risk Analysis & the Bradley Lake Funding Model Summary Report, November 15, 2010 located on AEA's website at the Railbelt Large Hydro webpage.

Chapter 8

Cost of Power

The cost of power from the Susitna and Chakachamna Projects is addressed in this chapter. A simple calculation of the cost of power, which assumes 50 percent State equity in either project, a financing rate of 6 percent, and annual energy from sections above results in the generation costs shown in Table 8-1 below.

Table 8-1 Cost of Power Comparison

Project	Finance Amount (50%)	Rate	Term (years)	Annual Energy (GWhrs)	Cost per kWhr
Susitna	2,250,000,000	6%	30	2600	$0.063
Chakachamna Alt 1	1,440,000,000	6%	30	1100	$0.09
Chakachamna Alt 2	1,440,000,000	6%	30	860	$0.12

This simple table gives an idea of how the two projects compare in the cost of power. Interest during construction is excluded from this comparison.

The estimated construction cost of Chakachamna Alternative 1 would need to decrease by 30 percent to have a comparable cost of power with the Susitna Project. Or, assuming no changes in the cost the energy of the Chakachamna Project, annual energy would need to be 1600 GWhrs. This could only be achieved by having zero environmental flow.

An alternative way of analyzing cost comparisons is to estimate State contributions needed if generation costs are held at $0.06 kWhr. From this perspective, the State required contribution would be $2.35 B for the Susitna Project (2,600 GWhrs) and $1.96 B for the Chakachamna Project (1100 GWhrs) or $2.17 B (860 GWhrs). Assuming state participation would be based on providing $.06 cost per kWh, the Susitna project would cost 20% more than Chakachamna project Alternative 1; however, it will provide approximately 136% more energy and compared to Alternative 2, an 8% greater cost with 200% more energy.

Chapter 9

Operational Uncertainty

Table 9-1 presents a summary of the comparative operational uncertainties associated with developing the Chakachamna and Susitna Projects.

Table 9-1 Operational Uncertainties Issue Comparison

Issue and likelihood of occurrence within next 100 years	Chakachamna Project	Susitna Project
	Issue Notes/Requirements	**Issue Notes/Requirements**
Earthquake Risk		
Immediate damage due to fault movement Studies show 700-year return period for significant earthquakes (magnitude 6 to 7), last such earthquake approximately 650 years ago.	Castle Mountain fault, approximately 11 miles from the lake, magnitude 7+, displacements of up to 6 ft, only 4500 ft from powerhouse site. Infrastructure near the fault include; powerhouse and bridge over Chakachatna River. Power tunnel intersects numerous smaller faults. Seismic event may cause localized collapse in the fault zone if not lined. Lack of information about whether movement could occur on any of these smaller faults.	Castle Mountain Fault located 65 miles from powerhouse, intake, lake, magnitude 7+, Denali Fault located 45 miles , magnitude 8.0, Inter-plate subduction zone located 40 miles, magnitude 9.2 Dam could experience high seismic loads (known seismic zone, EQ design case should consider loading)
Secondary effects	Landslide and avalanche potential into lake and onto access road.	Potential landslides and avalanches along access roads.
Hydrological Risk		
Generation	USGS record at site 11 years of data, correlation with 4 streams. Understanding of the hydrology There is potential during events such as floods or glacial activity for down cutting of the glacial moraine at the end of the lake which could reduce head and storage in the project Smaller basin will cause greater deviations from average hydrological flow and energy generation. Drought (Not sure if needed, see above) Tunnel roughness may increase with time due to wear which will reduce generation.	USGS record at site 54 years of data on Susitna River. Understanding of the hydrology vis a vis climate change effects.
Climate Change		
Glacier recession	Increase in flows as the glaciers melt (>100 yrs), followed by reduced and more "flashy" flows at the project.	Increase flow for a period with glacier recession (>100 yrs) followed by decreased flow.
Volcanism		

Table 9-1 Operational Uncertainties Issue Comparison

Issue and likelihood of occurrence within next 100 years	Chakachamna Project	Susitna Project
	Issue Notes/Requirements	**Issue Notes/Requirements**
Effects on Project Facilities and Features	Mt Spurr is located immediately adjacent to the project, Redoubt volcano is approx. 50 miles to the west. Explosive eruption at Mt. Redoubt 2009 Previous eruption on Mt. Spurr was a side blowout. Debris flows similar to those that occurred in 1953 and 1992 eruptions of Crater Peak could dam Chakachatna River. The debris dams might erode progressively or may burst abruptly. Lava flows could dam the Chakachatna River and raise Chakachamna Lake. Large floods would be produced by surging and melting of glacial ice during an eruption. Glacier movement (melting at base) is probable. Ice flow on Barrier Glacier may surge, dam the lake, raise water level and erode through, typically below the glacier in material. Access road may become blocked or destroyed by mud or erosion (high flows in river from melting glacier or glacial dam breakout). Effects on river bridges from debris flow Ash effects on transmission Poison gas cloud could affect the powerhouse (unlikely with distance & powerhouse location) Communications may be disrupted by volcano.	Mt Wrangell is located to the more than a hundred miles to the East and is closer to Watana. Mt Wrangell is in a non-eruptive active state at present but with history of 9 reported possible eruptions since 1760, most recently 1930; steaming at present. Ash could reach the Watana project and transmission lines depending on wind conditions. Pyroclastic flows are unlikely to affect Watana due to distance and intervening terrain.
Tunnelling and Foundation Conditions		
Dam	Small structure on rock foundation. Material of the natural dam, believed to be moraine, could contain significant quantities of ice, lahar material, or volcanic ash that could affect the permanence of the natural dam.	Geotechnical exploration indicates favorable foundation conditions on bedrock. Foundation (permafrost). Melting permafrost in the rock could lead to increased permeability of foundation that may require additional grouting associated with project site.

Table 9-1 Operational Uncertainties Issue Comparison

Issue and likelihood of occurrence within next 100 years	Chakachamna Project	Susitna Project
	Issue Notes/Requirements	**Issue Notes/Requirements**
		River diversion tunnels. Large spillway.
Power tunnel(s)	Extensive underground construction will be expensive to shut down for inspection and repair if necessary. Very hard rock along tunnel alignment – more than 35,000 psi, which is extremely hard and could present difficulty for a tunnel boring machine resulting in slow progress.	Competent rock conditions for dam and tunnel construction, studies date to 1982. Very short power tunnel(s) – 1.0 mile max, and shallow and surface power tunnel, therefore less risk of delay in construction. Limited number of geotechnical fault zones to pass through, due to location and short length of tunnels, provided “Fingerbuster” and “Fin” zones are avoided.
Glacier Activity		
Dam and Intake	Unpredictability regarding the interaction of glaciers with the volcanic activity, including possible melting at the base of the ice that would cause glacial pulses or surges. An advance of Barrier Glacier at the Chakachamna Lake outlet, initiated by heat from below the ice, could dam the outlet and raise the lake level. When the ice nose decayed, a large volume of water would be released that could erode the lake outlet and lower the lake below its present level. There is potential during events such as floods, glacial activity for down cutting of the glacial moraine at the end of the lake which could reduce head and storage in the project. Lowering the lake would reduce the submergence of the power inlet below what is acceptable. Breakout in 1971 one of Alaska’s largest recorded floods.	N/A
Powerhouse	Blockade Glacier has been identified as a source of outburst floods on McArthur River	N/A
Surging Glaciers	Four glaciers in the Chakachamna study area have been identified as surging glaciers. They include Pothole Glacier and Harpoon Glacier in the Nagishlamina River Valley and Capps Glacier on the eastern slope of Mt Spurr.	N/A

Table 9-1 Operational Uncertainties Issue Comparison

Issue and likelihood of occurrence within next 100 years	**Chakachamna Project**	**Susitna Project**
	Issue Notes/Requirements	**Issue Notes/Requirements**
Outburst Glaciers	Glacier damming of the Nagishlamina Valley by a surging glacier may result in outburst conditions at the outlet from Chakachamna Lake. A sudden influx of water into Chakachamna Lake could produce significant changes including lowering of the lake outlet.	N/A
Other		
Intake	Lake tap would need fish screens Volcano eruption may affect power tunnel intake.	N/A
Access Road	Landslide, avalanche danger part of the route.	Avalanche danger over a portion of the route.
Transmission Line	42 miles of new transmission line to Beluga Sub Station. Submarine cable across Cook Inlet subject to marine environment risks such as currents, scour, dragging anchors.	58 miles of new transmission line.
Operation & Maintenance		
Operations & Maintenance	Long tunnel intersecting numerous faults susceptible to rock-falls over time and maintenance requirements Rock entrained in tunnel flow could damage turbines Long tunnel has higher risk of collapse, blockage Long tunnel will require planned outages for inspection and maintenance over life of project, higher risk of interruption.	Multiple short tunnels allows for more regular inspection and maintenance without prolonged outages and impact to operations
Load Stability		
Powerhouse location with respect to load centers	Off the end of the railbelt load center, not easy to stabilize (brown-out/black-out).	Location between Anchorage and Fairbanks means project is closer to center of load, easier to stabilize grid using reactive potential.
Hydrological Risk - Water Shortage		
Drought	Small catchment mainly fed by meltwater from glaciers, which make this site more susceptible to water shortages and less dependable as a source of energy.	Catchment is less susceptible to drought.

Chapter 10

Summary and Conclusions

This document compared two large hydroelectric projects to determine which would better meet the needs of the railbelt population and the State of Alaska now and into the future. The following table shows a comparison summary of the two projects.

Table 10-1 Comparison Summary

Criteria	Susitna (Low Watana) Project	Chakachamna Project
Engineering (Cost)	$4.5B	$2.9
Environmental	Same basin, modified flows, little to no salmon present.	Cross basin drainage, substantial concern regarding fisheries and Trading Bay State Game Refuge.
Energy	2,600 GWhrs annual average. About 50% of existing railbelt annual electrical energy. Meets and exceeds State energy policy without other projects.	Most likely to be less than 1,100 GWhrs annual average. About 20% of existing railbelt annual electrical energy. Does not provide substantial winter power.
Start-up Date	Approximately 11 years	Approximately 15 years
Licensing/Permitting	Substantial site knowledge likely to reduce licensing/permitting delays.	Significant unknowns on environment, geology, and hydrology likely to slow process
Finance	Requires State financial support	Requires State financial support
Cost of Energy	Simple calculation using cost & energy numbers above, 50% State equity, and 6% interest yields $0.06 /khr	Simple calculation using cost & energy numbers above, 50% State equity, and 6% interest yields $0.09-0.12 /khr
Operational Uncertainty	Less long term operational risk from seismic. Central location helps to stabilize grid.	Greater long term operational risk from seismic events, volcano eruption, & glacial changes. Energy more variable on an annual basis. Harder to stabilize.
Notes	River system has potential to expand generation by going upstream, downstream, or raise dam height. Transmission lines could connect to other areas of the State.	

The Susitna Project would produce more energy and at a lower cost per MW. Historically the flow has varied little year to year so that the amount of energy can be better estimated. Most of the Project is anticipated to be above ground so that geotechnical unknowns that influence construction cost risk are minimized. Produced energy during summer would be greater than desired so that flows would remain high for salmon downriver. However, the reservoir area would give the Project the ability to still generate substantial power during the winter critical months.

The Chakachamna Project would not be able to divert flow as was used for estimating energy in the early 1980's. The reduced flow would have substantial effects on the Trading Bay State Game Refuge down river and would cause false attraction to return adult salmon so that they are not able to find their way to the lake. In addition, the smolt salmon in the lake need substantial outlet flow to enable them to find the exit to the lake. Drawing down the lake during the winter would cause mortality of shallow spawners and may prevent salmon from ascending up the rivers at the head of the lake during early summer. If the Project is operated to provide significant environmental flows and restrict the lake drawdown then the cost of energy increases significantly and would produce minimal energy during the critical winter months. Because of the complex two drainage system hydrology and rich fisheries determining the environmental flow and conditions will require many years and millions of dollars. The substantial number of multi-year studies would delay the licensing and start-up date.

The Susitna Project is thought to be a licensable project without a fatal flaw. Geotechnical information indicates bedrock is suitable for construction. Environmental information indicates that impacts would be minimal. The Chakachamna Project has many fisheries concerns that will restrict the Project operation, increase the cost, and decrease the energy output of the Project. Some of the issues may not be able to be mitigated.

The Susitna Project provides a lower cost per unit of energy, the least environmental impact, a greater total amount of energy, and the anticipated startup date is sooner.

Based on the projects economics and impacts Susitna Project (Low Watana non-expandable alternative) should be the primary Project to pursue with Chakachamna Project as the alternative.

Chapter 11

Recommendations

We recommend that field studies and engineering evaluations be conducted on the Susitna Project preparing for a Final Decision Document scheduled to be released on November 15, 2011. In addition, we also recommend that a FERC license application be initiated on January 1, 2012 for the selected Project. In order for the process to move forward it is recommended that a Preliminary Permit be filed with FERC for the selected Project by December 31, 2011.

Specific studies to be completed in 2011 include:

- A complete review of the 1985 Susitna environmental study plan and the conduct of critical studies from that plan. Changes to the river system and the environment need to be documented.
- Field work to verify Susitna environmental conditions.
- A detailed cost estimate of the Chakachamna Project including changes to the Project introduced by environment constraints such as downstream flow releases (size optimization).
- A final determination of the type dam to be used at the Susitna site and the access plan and a revised cost estimate of the overall scheme.
- Detailed engineering studies on transmission needs, design drawings, and geotechnical review.

It is anticipated based on the schedule discussion in preceding Section 6.0 that the data gathered in the 2011 field season can be used for both the primary and alternative project. The FERC Preliminary Permit for the Susitna Project should be filed by December 2011.

Chapter 12

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