11. TRANSMISSION AND INTERCONNECTION FACILITIES

Three transmission line corridors have been investigated in this report, but no route (or routes) has been recommended. One of the five possible configurations has been used for the sole purpose of cost estimating.

This section provides a description of the proposed transmission and interconnection facilities and the factors that were considered in selecting the preliminary designs for the major features. The main project dam and powerhouse features and site infrastructure are described in Section 10; site access roads important to transmission line construction and maintenance are described in Section 8.

11.1. Electric System Studies

11.1.1. General

The transmission studies performed were to identify possible transmission interconnections from the Susitna-Watana Project site to the electrical transmission system of the Railbelt (which itself is expected to be improved before the projected completion of the project). The studies were also used to assess system improvements to the Railbelt electrical system that may be required – in excess of other required improvements – specifically to accept generation from the Project. In particular there was a focus on examining any further system improvements necessary to accommodate 200 megawatts (MW) units at Susitna-Watana Project, rather than 150 MW units. A more extensive discussion on the choice of unit size is included in Section 7.

11.1.2. Transmission Study Assumptions

The Railbelt electrical system – to which the project will connect approximately midway between Anchorage and Fairbanks – currently consists of a single transmission line between Anchorage and Healy (with two lines between Healy and Fairbanks), as well as a single line between the Kenai Peninsula and Anchorage. These single lines are a constraint and limit the transfer between both areas to approximately 60–80 MW of non-firm power between any of the areas. The Railbelt Utilities and the State of Alaska are in the process of developing a transmission plan to promote energy transfer and improve the reliability of the electrical transmission system. The plan identifies needed upgrades to the transmission system, whether the Susitna-Watana Project is implemented or not. The projected improvements would eliminate the single contingency lines between the Railbelt areas and allow total hydro coordination among all resources in the Railbelt. The studies for the Susitna-Watana Project interconnection assume the improvements required in the Railbelt for energy and reliability have been completed by

2025, and are therefore in service and available for use in the transfer of Susitna-Watana Project energy throughout the Railbelt.

The exact electrical and mechanical characteristics of the Susitna-Watana Project generators were not known at the time the initial system planning studies (described in this section) were performed. Representative unit parameters used in the studies were assumed from similar sized units at other projects. The system planning studies will be updated at the time of detailed design.

11.1.3. Study Criteria

The planning criteria for the Railbelt system includes desired operating parameters for both steady-state conditions as well as transient conditions. The planning criteria are divided into four main areas; reliability, power flow, stability, and voltage, and are discussed in detail below.

11.1.3.1. Reliability

The ultimate goal of any planning criteria is to provide the desired level of reliability at a cost the system can afford. For islanded systems this level of reliability is often less than large interconnected systems due to the evaluation of reliability against the costs required to obtain the same level of reliability standards in the Lower 48. For the Susitna-Watana Project, the interconnecting transmission system was planned to withstand the loss of any single contingency item without experiencing a loss of firm load on the Railbelt system for transmission system contingencies and to result in no more than the first stage of under frequency load shedding for Susitna-Watana generation contingencies.

The planning criteria used to evaluate the impact of the Susitna-Watana Project are outlined below.

11.1.3.2. Power Flow

The power flow criterion includes limits on voltage levels as well as branch flow levels for the Railbelt during steady state conditions. The power flow criterion is listed below and was used for normal (all equipment in service) and N-1 (single outage) contingency analysis:

- underground works (tunneling);
- Flows on transmission lines below their megavolt-Ampere (MVA) rating (winter or summer); and,
- Flows on transformers below their maximum MVA rating.

The Railbelt system experiences large temperature swings between the winter and summer seasons. These changes in temperature require the power flow analysis to use the appropriate conductor rating for the specific temperature (load) season.

It is assumed that short term thermal overloads are acceptable if planned remedial action schemes (generation dispatch changes, non-firm energy contract reductions) are designed to minimize and or eliminate the overload.

11.1.3.3. Stability

The transient stability criteria include limits on the system frequency, voltage levels, system response, and unit response. The transient criteria listed below will be used for N-1 contingency analysis.

- Sustained voltages on the transmission system buses must not be below 0.8 per unit (pu);
- Frequency must stay between 57 hertz (Hz) and 62 Hz (trip limits);
- System response must not exhibit large or increasing amplitude oscillations in frequency or voltage;
- Units must not exhibit out of step or loss of synchronism response; and,
- Single contingency events cannot cause uncontrolled load shedding.

It is not acceptable to operate the system in a configuration that would result in unstable system response for single contingencies. Therefore, infrastructure improvements or operational constraints must be completed/implemented to eliminate the possibility of an unstable condition occurring.

11.1.3.4. Voltage

The criterion to be applied includes limits on the maximum and minimum voltages allowed on the Railbelt system as well as operation limits of the generators and the Static Var Compensators (SVCs). The criteria are listed below:

- Voltages at 230 kilovolt (kV), 138kV undersea cables must be below 1.02 pu;
- Voltages at 230 kV, 138 kV, and 115 kV substations serving load must be below 1.05 pu;
- Voltages at 230 kV, 138 kV, and 115 kV substations NOT serving load must be below 1.10 pu;
- Voltages at 230 kV, 138 kV, and 115 kV substations must be above 0.95 pu;

- High Voltage limits must be met with online generators operating at unity power factor; and,
- Voltage limits must be met with SVC's operating with a minimum five MVA report of margin.

As with the stability criteria, it is not acceptable to operate the system in a configuration that would result in the system violating the voltage criteria. Therefore, infrastructure improvements or operational constraints must be completed/implemented to eliminate the possibility of an unstable condition occurring.

11.1.4. System Study Methodology

The studies for the interconnection of the Susitna-Watana Project were completed using the Utility supplied loads and generation schedule expected to be in place in the year 2024. As noted above the Railbelt transmission system is expected to undergo substantial changes from its existing configuration to the 2025 system configuration. These changes are required to alleviate the restrictions on Bradley Lake and Cooper Lake energy and increase reliability and transfer capacity between the load/generation areas of Kenai Peninsula, Anchorage/Mat-Su, and Fairbanks, as identified by the current State of Alaska and Utility transmission plan. This "pre-Watana" improved transmission system is expected to be in service by 2025, and was the starting point for the Susitna-Watana studies.

The Susitna-Watana studies can be divided into two distinct categories:

- Transmission system analysis required for the Susitna-Watana interconnection with the Railbelt electrical system; and,
- Unit sizing studies designed to evaluate the system impacts resulting from two different unit sizes for the Susitna-Watana Project.

11.1.4.1. Transmission System Analysis

The transmission system studies evaluated the transmission infrastructure requirements for interconnection of the Susitna-Watana Project and the Railbelt system based on the planning criteria listed above. The studies consisted of utilizing single contingencies (N-1) for both transient (stability) analysis and steady state (power flow) analysis.

11.1.4.1.1 Stability Analysis

Stability analysis consists of applying faults to the transmission lines both in the project area and at key points in the Railbelt transmission system. The faults were applied and subsequently cleared by opening the faulted line section. The stability of the transmission system was then evaluated by plotting various generator rotor angles relative to each other and the system frequency.

The stability analysis was used to determine the sensitivity of the system response to clearing times of the Susitna-Watana interconnection, and to determine the required transmission infrastructure to ensure stable Railbelt system operation following the addition of Susitna-Watana. Analysis was completed to determine the impact of utilizing Power System Stabilizers for the Susitna-Watana units, and to determine the feasibility of utilizing SVC to reduce the required transmission infrastructure.

11.1.4.1.2 Reactive Support Analysis

Reactive analysis was completed to determine if the feasibility of line energization utilizing support from Susitna-Watana units as well as the ability of the Railbelt system to maintain voltages during low Susitna-Watana output conditions.

11.1.4.1.3 Power Flow Analysis

Power flow analysis was completed for the different load season cases to determine if single contingencies during high Susitna-Watana output would result in thermal overloads of transmission lines or transformers.

11.1.4.2. Unit Size Analysis

As input to the final choice of unit size, the unit sizing studies focused on the requirement for transmission system improvements for a nominal 150 MW generator and for a nominal 200 MW generating unit. These potential improvements relate to any necessity for stored energy devices at various places in the Railbelt to accommodate Susitna-Watana unit sizes and characteristics. The thrust of the unit sizing studies were centered on simulating the loss of a Susitna-Watana unit on the Railbelt transmission system under various total loading conditions and to determine if there were any differences between the unit sizes for various transmission line faults. The proposed generator sizes are considerably larger than units that will exist in the Railbelt in the 2025 time frame. These proposed larger units would put strain on the Railbelt system if tripped when operating under full load, requiring mitigating measures to be implemented. These studies were intended to evaluate the costs of the mitigating measures of the large unit sizes.

In general, when electrical systems suffer load or generating conditions that result in a severe mis-match between load and generation, the response is to shed load to stabilize the system. The under frequency load shed (UFLS) scheme in the Railbelt is designed with multiple stages of decreasing frequency set points. The first stage of UFLS activates at 59.0 Hz, with the second, third, and final stages activating at 58.7 Hz, 58.5 Hz, and 58.2 Hz, respectively. When the system frequency drops below these set points, the load shed relays will activate (after a short timer delay) and shed load. The first stage of UFLS results in approximately 10 percent of the load in the Railbelt being shed or turned off to help stabilize the system. If all stages of UFLS were activated, approximately 75 percent of the Railbelt Consumers would be without power.

The studies of Susitna-Watana attempted to determine the mitigating measures that would be required to limit the loss of load in the Railbelt system to its first stage of UFLS following the loss of a Susitna-Watana generating unit – similar to the conditions that exist prior to construction of Susitna-Watana.

11.1.5. Results

The system studies indicate that the Susitna-Watana Project can be integrated into the planned upgraded Railbelt transmission infrastructure with few transmission improvements required specifically to accepting Susitna-Watana energy (i.e., outside the immediate project area). In general, the difference in unit sizes has no appreciable impact on transmission line faults, but both units require additional energy storage within the Railbelt to prevent load shedding in excess of the "first stage" situation (currently existing) if a unit is lost at maximum output.

11.1.5.1. Transmission Infrastructure

As discussed later, there are a number of possible configurations of transmission interconnection with the Alaska Intertie. At a minimum, however, for evacuation of energy from the project to the interconnection(s) with the Alaska Intertie, the Project will need to include the following:

- New Susitna-Watana 230 kV substation
- Gold Creek substation operated at 230 kV
  - New Gold Creek -/+ 150 MVA report SVC
  - 4 cycle Susitna-Watana – Gold Creek clearing times
- Three 230 kV transmission lines, double bundled Rail conductor, from the Project to the Intertie
- Power System Stabilizers on all Susitna-Watana units
- Healy – Gold Creek – Douglas lines operated at 230 kV
- Teeland – Douglas 138 kV line converted to 115 kV operation

During summer loading seasons, where the transmission line ratings are reduced due to higher ambient air temperatures, single contingencies can result in thermal overloads of transmission lines during transfers south of Douglas greater than 500 MW. Reducing Susitna-Watana transfers to the south to a total of 310 MW will eliminate the overload conditions.

11.1.5.2. Energy Storage

The sizes of the proposed project units considered early in the feasibility study (nominal 150 MW or 200 MW (at average water level) – which represent a peak of 200 MW or 275 MW respectively at maximum normal operating level) are substantially larger capacity than any generator in the Railbelt system. Although later proposals – discussed in Section 7 – are for turbine units of 206 MW rated at normal maximum operating level, they are still the largest units of the system. The analysis indicates that a trip of one of these projected unit sizes (operating at full output) will need to be compensated (to control subsequent load shedding to that experienced prior to Susitna-Watana) by the addition of an Energy Storage System (ESS) at specific locations within the Railbelt. The ESS can be comprised of batteries, fly wheels or other storage technologies. Such systems – whether batteries or fly wheels – are modular and can be scaled to high power levels, whether centralized or distributed. The energy storage will be required to feed power into the system and thus maintain the system frequency while other units on the system – that are providing spinning reserve – are brought on line. Based on simulations, the ESS will be required to go to full output in as little as one second. Therefore, for a recommended ESS of 100 MW, the ramp rate required would be 100 MW per second. The ESS would stay at this high level until other units at Susitna-Watana or elsewhere in the Railbelt could ramp up to replace the energy of the ESS.

The maximum requirement for the ESS was determined by a worst case study that assumed one Susitna-Watana unit was operated at full load, while the remaining Susitna-Watana units are at minimum load or off-line. This operating condition would likely never occur in the plant's operation, but does outline the boundary case for the amount of required ESS for the Susitna-Watana units. In actual practice the units would likely be more evenly loaded, reducing the unit's loading to a much lower level than in the study.

Hydro units are often operated "part gate" allowing very fast response to low frequency conditions, with typical ramp rates of 10 MW per second. The fast response of the Susitna-Watana units would replace the power provided by the ESS very quickly, but requires reserving part of the unit rating as "spinning reserve."

11.1.5.2.1 4 x 150 MW Units

For the worst possible case to limit load shedding to first stage conditions existing today and with Susitna-Watana comprised of approximately 150 MW units requires the following:

- Summer minimum load 120 MW ESS
- Summer peak load 100 MW ESS
- Winter peak load 80 MW ESS

A total of 100 MW of ESS is recommended to mitigate the UFLS action to a stage 1 event. The mitigation will limit the UFLS to a Stage 1 event for winter and summer peak load conditions.

Summer valley conditions may reach stage 2 UFLS with the 100 MW ESS recommendation, however a dispatch scenario that would provide a potential for a 200 MW unit trip is most likely not practical. To stress the system (for the model), a dispatch of one unit at 200 MW with the remaining two units dispatched to 50 MW (300 MW total plant output) was used. In actual practice, it is unlikely the units would have such a large disparity between loading amounts – as good practice is to run units at approximately equivalent output. A 20 MW battery energy storage system (BESS) is required during the typical summer loading period.

The amount of energy storage required for the 100 MW ESS depends upon the speed of the spinning reserves and the time it will take to displace the power provided by the ESS. Assuming there is enough capacity on the Susitna-Watana units to displace the ESS, and the units will respond seven seconds after an event with a ramp rate of 10 MW per second (requiring 10 seconds to increase output 100 MW), the total energy requirement of the ESS will be approximately 0.0079 MWh. This is a very small energy requirement, due to the Susitna-Watana plant requiring a maximum of 17 seconds to displace the ESS.

11.1.5.2.2 3 x 200 MW Units

For the worst possible case to limit load shedding to first stage conditions and with Susitna-Watana comprised of 200 MW units requires the following:

- Summer minimum load 180 MW ESS
- Summer peak load 150 MW ESS
- Winter peak load 120 MW ESS

This is a nominal increase in compensation requirements over the smaller 150 MW units. The ESS will require further review and study, however the technology and maturity of the technology provide a high degree of confidence in the proposed solution.

The amount of energy storage required for the 180 MW ESS depends upon the speed of the spinning reserves and the time it will take to displace the power provided by the ESS. Assuming there is enough capacity on the Susitna-Watana units to displace the ESS, and the units will respond seven seconds after an event with a ramp rate of 10 MW per second (requiring 16 seconds to increase output 90 MW each), the total energy requirement of the ESS will be approximately 0.0153 MWh.

11.1.5.2.3 Railbelt Transmission Plan ESS

The recently completed draft Railbelt Transmission Plan recommended a 25 MW ESS to mitigate issues on the Railbelt without the Susitna-Watana Project online. These studies assumed the 25 MW ESS is built and can be utilized for the Susitna-Watana Project, limiting the size of additional energy storage due to the Susitna-Watana Project to 75 MW if Susitna-Watana incorporates 150 MW units.

11.1.5.3. Energy Storage Locations

The location of the ESS does not impact the ability of the chosen storage to provide support to the system for the loss of a large Susitna-Watana unit trip. Other benefits to the system that are beyond the scope of this study could be realized by splitting the total ESS system into different areas of the Railbelt, and may drive the location of and optimization of the ESS. Locating a portion of the ESS on the Kenai Peninsula would allow total hydro-hydro coordination between the hydro resources of the Kenai Peninsula and the Susitna-Watana Project. The ESS would eliminate generation restrictions on the Kenai Peninsula by providing an energy resource to stabilize the Kenai Peninsula system following loss of one of the Kenai Peninsula – Anchorage transmission lines. Stabilization would be provided by the ESS until Kenai Peninsula generation could be dispatched on the system. Studies indicate a minimum of 20 MW ESS would be required on the Kenai Peninsula to provide stabilizing support.

Locating a portion of the ESS (approximately 30 MW) in the GVEA area near the North Pole Station would allow the system to support large motor cycling for existing and future mine or industrial loads without additional Fairbanks area generation or transmission improvements.

Siting the remainder (approximately 25 MW) of the ESS adjacent to the 25 MW ESS in the Anchorage area would increase the transfer capability of the Kenai Peninsula – Anchorage system and eliminates import restrictions into the Anchorage area. Elimination of import restrictions would allow full Kenai Peninsula hydro-hydro and thermal generation coordination with the Susitna-Watana Project.

11.1.6. Future Studies

The studies of the units rated at average head indicate that the smaller 150 MW project units require less extra infrastructure (SVCs, BESS, or Flywheels) than the larger (200 MW) units to maintain stability throughout the Railbelt system; however, the incremental increase in cost of the required infrastructure relative to the total cost of the project is relatively small between the two unit sizes and the differences between the two proposed unit sizes do not present any large cost increases or system implementation issues. Discussion of all the costs associated with unit sizing are contained in Section 7 of this report. The revised proposal – for 206 MW turbine rated at normal maximum operating level – approximates to the units studied in this evaluation (150 MW at average head).

Future studies will further refine the impacts of unit size and plant configurations. The preliminary studies reported herein used a wide range of possible energy transfers for the Northern and Southern utilities to evaluate the electrical transmission system. Future studies will concentrate on the actual proposed energy split between the Northern and Southern systems based on the maximum expected capacity of each respective system and the transmission requirements of the final energy flow. The studies will confirm any additional infrastructure that is required for transmission line faults and or unit trips to provide acceptable reliability and service characteristics.

Future studies will also identify the proposed sizing and location of the energy storage devices on the Railbelt as well as refine the system studies once more information is known regarding the actual Susitna-Watana generating unit characteristics. Future studies will also provide a more detailed analysis of the system response to an expanded list of transmission contingencies, including breaker-failure and N-1-1 contingency analysis.

The future studies will also need to analyze the response of the Railbelt system units, such as Bradley Lake, to the proposed Susitna-Watana Project in addition to the response of the project to the interconnected system.

11.2. Corridor Selection

11.2.1. General

Preliminary studies indicate that to transmit a peak generation of approximately 600 MW from the Project, three 230 kV transmission lines will be required to connect to the Railbelt interconnected system. The Project will provide power to the Fairbanks area to the north and to the Anchorage/Mat-Su/Kenai Peninsula areas south of the project. At the time of assessing transmission alternatives for the project, it was assumed that a maximum of 200 MW of capacity will be supplied north and 500 MW will be shipped south, although not simultaneously.

The corridor selection studies have been described in detail in the *Watana Hydro Transmission Corridor Report* prepared by EPS and included as Appendix B9.

Three corridors have been identified in which the new transmission lines could be constructed to connect the project with the existing Railbelt transmission system. The corridors generally follow the same corridors selected for study for the access road, so that significant portions of the transmission facilities can be constructed using the project access. The transmission corridors are shown in Figure 1.1–1.

It may be beneficial to the reliability of the Railbelt system that power is evacuated from Susitna-Watana through two corridors (rather than in a single corridor), and if such an option is finally selected, one of the lines will have to be constructed by helicopter, which would increase the cost of that line (or lines).

In particular areas, the selected transmission route diverges from suggested road alignments, either to take advantage of a straighter route (where road construction would be difficult or impossible) or to avoid high altitude. Such deviations may require some helicopter construction.

Three circuits could be constructed in one corridor or – if a split evacuation is selected – in combination with a second corridor. The selected alternatives for consideration, therefore, included three routes with all circuits in the same corridor, and two alternatives with the circuit split between corridors.

The examination of corridors has required consistent criteria as discussed below.

11.2.2. Evaluation Criteria

The criteria below describe the differences between routes and the level of suitability to meet the purpose and needs. They are not being used to eliminate routes at this stage, but have been used in development of the routes, in parallel with the access road route derivation. The following describes the evaluation criteria:

- **Adjacent to an Access Road –** This is significant to the construction cost of the line.
- **Avoid Land Use Conflicts –** Used to exclude areas that could provoke major conflicts in land use (i.e., airports, dedicated recreation areas, and densely populated areas).
- **Avoid Major Terrain Obstacles** – Used to exclude areas that could cause significant construction and/or major difficulty in construction or maintenance (i.e., large rivers, mountains, high value wetlands, ponds, and lakes – landslide prone areas).
- **Avoid Particular Land Ownership** – If the transmission were to utilize a corridor in Bureau of Land Management land, the whole project could be subject to additional permitting and regulation**.**

- **Minimize Climatological Conditions** – Alaskan climatological conditions are significantly influenced by elevation and the higher elevations produce more severe conditions, such as snow accretion, avalanche, icing, and wind. As a result, routes are selected that primarily avoid higher elevations. Maximum corridor elevations are approximately:

Chulitna	El. 3400 ft.
Gold Creek	El. 2400 ft.
Denali	El. 3800 ft.

As a comparison, the Anchorage/Fairbanks Intertie in this region reaches an elevation of about 3,000 ft. and has exhibited a good performance record.

- **Minimize Route Distance** – Used to minimize route distance and decrease the total cost of the project.
- **Minimize Environmental Impacts –** This aspect of selection is complex with many attributes. For the current level of this study, the avoidance of wetlands that can be determined from aerial photographs was the only criterion used. The width of the proposed corridors is expected to be sufficient to adjust the detailed transmission line route in response to field studies that will be undertaken. The adjustments will be made within the corridor so that the final route of the line will minimize environmental impact. It is anticipated that some agency stipulations will require that at least portions of the construction will be required to be completed in the winter when ground conditions reduce construction impacts.

Intangible criteria such as visual impacts, public safety, existing facilities, construction impacts, and land use primarily deal with impacts to the public. These criteria will be addressed during later stages of the design. The routing alternatives costing factors are noted in Section 12.

11.2.3. Route Alternatives

Based on the three corridors, and a project configuration in which two corridors are used, Table 11.2-1 shows the Route Miles (length of the corridor) and Circuit Miles (total miles of circuits within the corridor) for the various possible routes.

Plans and profiles of each route are shown in Drawings 06-17T001 through 008, 06-18T001 through 011, and 06-18T001 through 012 for the Gold Creek, Denali, and Chulitna corridors, respectively.

Table 11.2-1. Summary of Transmission Alternatives

	Corridor	Description	Route Miles	Circuit Miles
1	Chulitna	3 Circuits Susitna-Watana to Chulitna Substation	37	111
2	Gold Creek	3 Circuits Susitna-Watana to Gold Creek Substation	35	105
3	Denali	3 Circuits Susitna-Watana to Cantwell Substation	62	186
4	Chulitna and Denali	2 Circuits Susitna-Watana to Chulitna Substation; 1 Circuit Susitna-Watana to Cantwell Substation	99	136
5	Gold Creek and Denali	2 Circuits Susitna-Watana to Gold Creek Substation; 1 Circuit Susitna-Watana to Cantwell Substation	97	132

For the Denali route, the interconnection would be close to Cantwell and therefore some 19 miles of the transmission line would be alongside of the Denali Highway.

Although no recommendation is made in this report, and no decision has been taken by AEA on the appropriate transmission route(s), the estimate of project cost detailed in Section 13 has assumed Alternative 5, using two circuits in a southern corridor to Gold Creek and one circuit to Cantwell.

11.3. Towers, Foundations and Conductors

Power flow studies have identified the need to use twin bundled 954 thousands of circular mil (kcmil) conductors on all transmission lines to achieve satisfactory electrical performance. A single optical ground wire and a single overhead ground wire are also assumed to be attached to each structure.

Typical transmission line tangent structures used in Alaska that would be suitable to support three twin bundles of 954 kcmil conductor and two ground wires are the steel H-frame structure, the steel X tower, or the steel single-pole structure.

Structures may be guyed or self-supporting. Foundations will vary with soil conditions and access and may include direct embedment, driven pile, grouted pile, rock anchor, or micro-piles.

11.4. Interconnections

A substation location has been identified for interconnection with the Alaska Intertie for each selected corridor as follows:

- For the Chulitna corridor, approximately eight miles northeast from the Parks Highway;
- For the Gold Creek corridor, approximately five miles northwest of the Gold Creek railroad bridge; and,

- For the Denali corridor, to the north side of the Denali highway approximately one mile east of the junction with the Parks Highway.

A drawing of a typical intertie connection is shown in Figure 11.4-1, and a typical layout of the substation interconnection is indicated in Figure 11.4-2.

11.4.1. Substation Costs

The substation costs will vary dependent upon the line configuration and number of lines selected for the project's interconnection with the Railbelt system. Comparative costs of the options associated with the transmission line configurations identified are presented in Table 11.4-1.

Table 11.4-1. Substation Cost

Location	Description	Watana Lines	Low Costs	High Costs
Chulitna	Alternative 1 – 8 mi NE of Watana Access Road	3 lines + 4 Interties	$35M	$42M
Chulitna	Alternative 1 – 8 mi NE of Watana Access Road	2 lines + 4 Interties	$40M	$48M
Gold Creek	Alternative 2 – 5 mi NW of Gold Creek Bridge	3 lines + 4 Interties	$35M	$42M
Gold Creek	Alternative 2 – 5 mi NW of Gold Creek Bridge	2 lines + 4 Interties	$40M	$48M
Denali	Alternative 3 – Denali Highway location	3 lines + 4 Interties	$42M	$50M
Denali	Alternative 3 – Denali Highway location (No SVC)	1 lines + 4 Interties	$8.7M	$11.5M

11.4.2. BESS Costs

The two unit sizes for the Susitna-Watana Project require differing amounts of stored energy in the Railbelt system. This stored energy will likely be split between battery energy storage systems BESS and rotating inertia systems (Flywheel) systems. In general, for high capacity short-term energy requirements, Flywheel technology may offer some savings over BESS installations. Siting and sizing studies in the next phase of the project will determine the cost of recommended mix between the two technologies. For the purposes of this phase of the project, all storage systems are considered to be BESS technologies.

The costs of the required storage systems are between US$ 75M and US$ 115M. These costs have not been included in the project estimate described in Section 13.

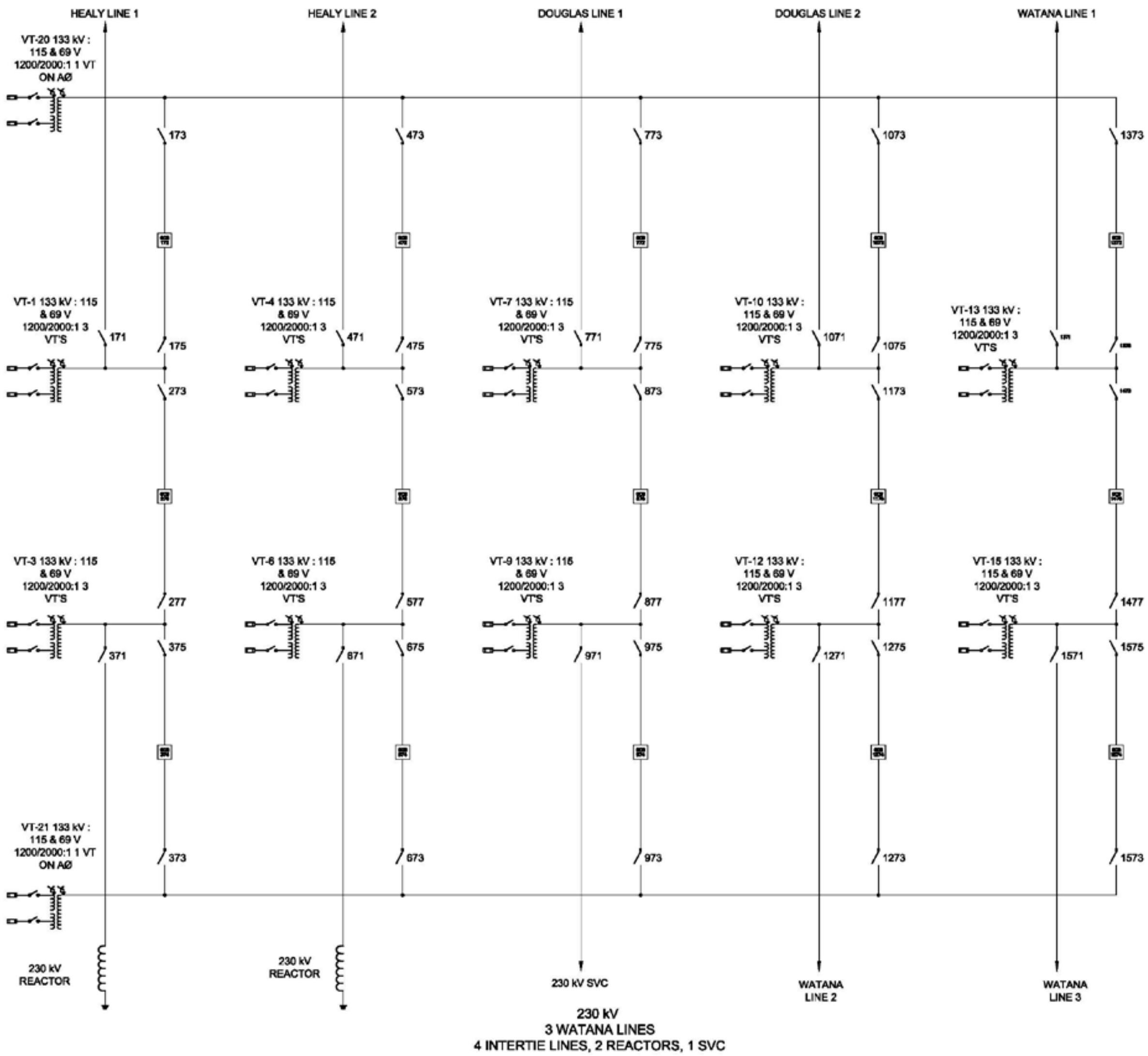

Figure 11.4-1. Typical Intertie Connection

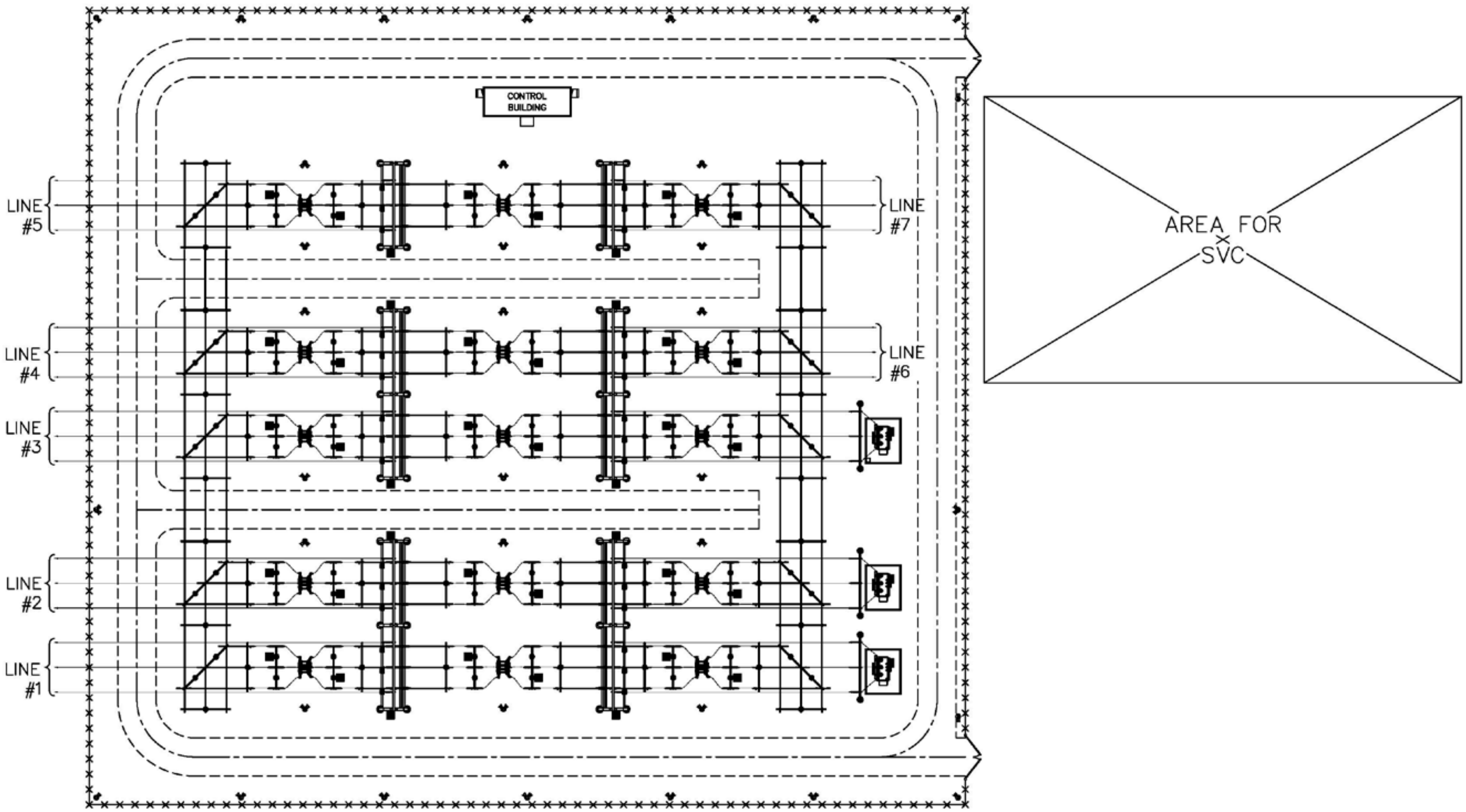

Figure 11.4-2. Typical Layout of the Substation Interconnection

11.5. Comparative Costs

Comparative costs have been prepared for the conceptual arrangements, both for routes alongside an all-weather road (which can be used to access the transmission corridor for construction) and assuming a road is not constructed and construction access is via all terrain equipment and helicopters. Table 11.5-1 compares the costs of these two scenarios for the five alternatives described above. At this stage, without a final decision on which transmission arrangements are to be used, the maximum cost, shown for Alternative 3, has been used in the overall project cost estimate presented in Section 13.

Table 11.5-1. Estimated Comparative Transmission Line Costs

Alternative	Description	Road Nearby		No Road	
		Low ($1,000)	High ($1,000)	Low ($1,000)	High ($1,000)
1	3 Circuits Chulitna Corridor 37 + miles	$147,174	$171,703	$178,518	$208,271
2	3 Circuits Gold Creek Corridor 35 ± miles	$163,856	$190,114	$170,021	$198,357
3	3 Circuits Denali Corridor 62+ miles	$246,484	$287,565	$298,946	$348,771
4	2 Circuits Chulitna Corridor 37+ miles and 1 circuit Denali Corridor 62+ miles	$196,692	$229,474	$238,569	$278,330
5	2 Circuits Gold Creek Corridor 35± miles and 1 circuit Denali Corridor 62± miles	$208,240	$242,220	$232,150	$270,842

There will also be some upgrades required to the Alaska Intertie transmission facilities, which are the subject of a separate study being undertaken for AEA.