TIEKEL RIVER

HYDROPOWER RECONNAISSANCE STUDY

Prepared for:

Copper Valley Electric Association

Revised Final Report
October 2016

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EXECUTIVE SUMMARY

STUDY OBJECTIVE

The primary objective of the Tiekel River Hydropower Reconnaissance Study (Study) was to determine if potentially feasible hydropower projects could be developed on the Tiekel River, with a particular focus on the Tiekel River reach between the Richardson Highway and its confluence with the Copper River. Characterization of potential projects used the following guidelines for configuring and sizing candidate dams, reservoirs and powerplant combinations:

- Scenario 1A: displacing diesel and cogen production, using budgeted 2012 amounts for establishing targets to be used for this initial analysis.
- Scenario 1B: Scenario 1A plus 5 megawatts (MW) continuous.
- Scenario 2: displacing about 50% of the budgeted diesel and cogen production occurring in any monthly pattern, but constrained not to exceed the monthly pattern for Scenario 1A.
- Scenario 3A: Similar to 1B, but the continuous load is increased to 10 MW.
- Scenario 3B: Maximum development.
- Scenario 4: Originally contemplated as a project sized to export energy to statewide markets. Hydrological analyses indicated insufficient energy in the Tiekel River watershed to support this concept. Scenario 4 was not considered further.

All scenarios assume that the Allison Creek Hydroelectric Project is constructed and operating. Based on the understanding of the existing loads and hydro and fossil generation resources, the following energy targets were established for formulating physical projects that could meet the objectives stated by the scenarios:

	Initial Energy Targets for each Scenario			
Period	**1A (GWh)**	**1B (GWh)**	**2 (GWh)**	**3A (GWh)**
Jan	5.81	9.53	< Scenario 1A	13.25
Feb	5.54	8.90	< Scenario 1A	12.26
Mar	4.52	8.24	< Scenario 1A	11.96
Apr	4.90	8.50	< Scenario 1A	12.10
May	0	3.43	0	7.15
Jun	0	1.09	0	4.69
Jul	0	1.20	0	4.92
Aug	0	1.49	0	5.21
Sep	0	1.96	0	5.56
Oct	0	2.88	0	6.60
Nov	3.61	7.22	< Scenario 1A	10.81
Dec	5.09	8.81	< Scenario 1A	12.53
Total	**29.5**	**63.2**	**15.0**	**107.0**

BASELINE RESOURCE CONDITIONS

Hydrological Conditions. The estimated average Tiekel River discharge near its confluence with the Copper River is 1,170 cubic feet per second (cfs), which is relevant for the purposes of estimating average annual energy production. The flow is not measured directly, and the estimated flow is based on adjustment of U.S. Geological Survey (USGS) gaged records from nearby watersheds. About 87% of the flow occurs during the period from May through September.

For the purposes of configuring structural features in this preliminary evaluation, the estimated 100-year flood is on the order of 25,000 to 30,000 cfs, and the estimated probable maximum flood is on the order of 90,000 cfs.

Geological Conditions. The Tiekel River study area is highly glaciated. Glacial scour has removed a large majority of the soil in the Tiekel River valley below an elevation of about 3,000 to 3,500 feet leaving exposed bedrock at the ground surface. Where present, soil in the Tiekel River valley consists of isolated deposits of recent alluvium, talus and colluvium.

The rock mass consists of fresh, strong, dark gray argillite and slate. Rock is expected to be generally suitable for each of the dam scenarios proposed in this Study. Given the tightness of the rock mass discontinuities, the proposed reservoirs are anticipated to have a relatively high degree of water tightness; however, detailed geotechnical investigations (including subsurface explorations) will be required to confirm the limited observations of surface conditions.

Regional geologic data and site observations suggest that the rock mass structure has a prevalent discontinuity set with a strong east-west strike. The dip angle of these discontinuities appears to vary with location. The orientation, as well as the strength, of these discontinuities will have an impact on the design of the dam, tunnel, and other project facilities constructed on rock. Geologic mapping of the project area will be required to further refine the design of a selected hydroelectric project.

The Study area is located in a region that is known to be seismically active. No known faults or seismic sources were identified within the footprint of any of the postulated dam structures or reservoirs; however, there are little available data or studies of the Tiekel River valley with respect to seismicity and faulting. It is recommended that future studies include detailed seismic and lineament studies of the selected project site.

Potential Construction Materials. Talus and colluvial deposits in the glaciated tributary valleys located southwest and northwest of the dam site could be mined. Hard rock sources are relatively abundant, because rock is present at or near the ground surface. Rock excavations for project facilities, including the dam, powerhouse, construction staging, housing, and drill and blast portions of the tunnels, could potentially be used for aggregate. Additional rock could be quarried in close proximity of the candidate dam locations. Evaluations of strength, durability, and alkali reactivity should be conducted during future site investigations to confirm the suitability of selected borrow and quarry sources.

ENVIRONMENTAL CONSTRAINTS

Project-related issues involving aquatic and terrestrial resources fall into three main categories: direct impacts – fill, excavation, and inundation; impacts to habitat from changes in hydrology; and impacts from increased human access and disturbance. Wetland maintenance near Tiekel River mouth, including potential changes to Tiekel Lake, may be one of the most important habitat issues. There are no immediately apparent constraints to project development with respect to environmental and community impacts.

Impacts on fish, plants, wildlife, and their habitats are not likely to constrain development of the project. This is due in part to the fact that there are no records of species listed by federal or state governments as threatened or endangered, or habitats listed as critical in the project study area. Further, the most valuable wildlife habitats in the project study area – likely the delta wetland and riparian habitats at the confluence with the Copper River followed by habitats in the floodplain of the Tiekel River near the Richardson Highway – would mostly be outside potential areas of direct habitat impact.

The Tiekel River supports minimal fish resources and it is unlikely that unacceptable impact to aquatic resources would interfere with development of a hydroelectric project on the lower Tiekel River. Aquatic habitat issues are centered on protection of existing anadromous fish habitat in the lower Tiekel River, downstream from the upper limit of anadromous fish use. Use by fish species normally considered to be of commercial, sport, and subsistence value is limited to a short segment at the mouth where the Tiekel River meets the Copper River. However, aquatic habitats in the vicinity of the Tiekel River mouth do contribute to the productivity of the very important Copper River system. Chinook, coho, and sockeye salmon will likely be identified as key evaluation species – with both spawning and rearing habitat for these species considered sensitive to alterations in flow, temperature, substrate, and hydrologic stability. There is a need for more information regarding fish use of the short reach of the Tiekel River between the canyon mouth and the Copper River confluence. Abundance, seasonal distribution, habitat use, and habitat value for key species and life stages will be needed to assess project impacts and design appropriate mitigation measures.

The most common large mammals in the project area are likely Dall sheep, moose, mountain goats, wolves, and black and brown bears. Common furbearers and small mammals include lynx, wolverine, beaver, marten, porcupine, fox, coyotes, marmots, river otters, ground squirrels, pikas, voles, and shrews. Of the marine mammals occurring in Wrangell-St. Elias National Park (NP), only the harbor seal may come up the Copper River as far as the Tiekel River confluence. The Alaska Department of Fish and Game (ADF&G) publishes management reports for species whose populations are hunted or managed. These provide some regional information on a number of species of economic and subsistence interest occurring in the project area, which lies within Game Management Unit (GMU) 13 and subunit 13D.

The Copper River Delta is a critical area for migrating birds of all types, but especially waterbirds and shorebirds. Major migratory routes follow the river valleys of interior Alaska en route to the Copper River Delta and the coast, which accounts for the diversity of bird species recorded in the Copper River watershed. It is likely that the Tiekel River watershed, especially wetland habitats, likely sees its share of migratory birds. In general, birds that potentially nest and rear young in the area would be most affected by the project. Those that are also listed as special concern species by the ADF&G and/or have federal protection would include raptors, trumpeter swans, loons, harlequin ducks, and migratory song birds – such as the olive-sided flycatcher and blackpoll warbler.

A total of 15 previously documented cultural resources sites are located within the project study area, although several additional resources have been reported from the area that lack precise location information. The absence of known sites in the Study area may be result from lack of examination rather than lack of existence.

Measures that may be required to address cultural resources for the proposed hydroelectric project in the Tiekel River may include: archaeological surveys and/or excavation, collection of oral histories from indigenous communities in the region, archival research concerning the development of the region in the historic period, or other cultural resource research activities. Consultations with the State Historic Preservation Office (SHPO), Native communities and tribal governments, Ahtna, Inc., all landowners whose property will be used or impacted by the proposed construction, other interested parties, and the public at large, will be an integral part of addressing cultural resources, as the project moves forward beyond the literature review.

CANDIDATE PROJECT CONFIGURATIONS

Based on desktop map review and field visits, MWH has identified three general dam locations with reservoir topography capable of providing storage. Candidate dam locations are termed Dam Alternatives 1, 2 and 3. Exhibit 03 (Appendix A) presents a map and profile showing the locations of the candidate dams, along with locations of associated candidate powerhouses. These features were used to create candidate dam and powerhouse combinations intended to address the various production objectives of the scenarios.

Using the hydrological data set and the monthly energy targets, MWH used reservoir and hydropower operational simulation to determine how various dam and powerhouse alternatives could be configured to meet the target production scenarios.

A total of 12 candidate dam and powerhouse combinations were identified that could meet the production objectives of Scenarios 1 through 3. The combinations of dams, reservoirs, waterways and powerhouses that meet the target production at minimum cost appear to be the following:

- Scenario 1A: Small dam and storage reservoir at Dam Alternative 3, with an 8-mi tunnel to a 20-MW powerhouse to be located near the Tiekel River confluence with the Copper River.
- Scenario 1B: Moderate height dam and storage reservoir at Dam Alternative 2, with a 1-mi aboveground penstock to a 30-MW powerhouse to be located about 1 mile downstream of the dam site.

- Scenario 2: Diversion (or 'intake') dam upstream of Dam Alternative 3, with an 8-mi tunnel to a 10-MW powerhouse to be located near the Tiekel River confluence with the Copper River.
- Scenario 3A: Moderate height dam and storage reservoir at Dam Alternative 2, with a 1-mi aboveground penstock to a 50-MW powerhouse to be located about 1 mile downstream of the dam site.
- Scenario 3B: High dam and storage reservoir at Dam Alternative 1, with a 1-mi tunnel to a 100-MW powerhouse located near the Tiekel River confluence with the Copper River.

OTHER HYDROPOWER DEVELOPMENT POSSIBILITIES

MWH addressed the following two additional possibilities with an objective of maximizing use of Tiekel River resources for hydropower production:

1. <u>Potential Development for Pumped Storage Hydropower.</u> A major constraint for hydropower in Alaska is the fact that peak load requirements occur in winter and abundance of runoff occurs in summer. Finding a way to capture and store summer runoff is key to the economic development of the hydropower resource in Alaska. MWH considered the possible development of off-stream storage reservoirs, combined with the installation of reversible pump-turbines operated to fill an off-stream storage reservoir during summer months while generating using stored water in the winter. The topography appears to offer some potential for developing storage reservoirs in three drainage features adjacent to the Tiekel River. MWH prepared dam layouts and quantity estimates for candidate off-stream storage possibilities, but found that the dams and equipment required to provide meaningful storage and generation capability would be extremely costly.

2. <u>Other Hydropower Development in the Tiekel Drainage.</u> MWH examined the Tiekel River drainage network, and found that the development of storage projects at elevations above the Richardson Highway (outside the focus area addressed in this Study) is probably impractical due to existing infrastructure and lack of sites that would appear to be appropriate for storage reservoir development based on topographic conditions. Although one tributary appears to have run-of-river development potential, there is not presently a need for additional seasonal generation.

COSTS

MWH prepared rough order of magnitude cost estimates for the five candidate hydropower projects. These estimates are intended to give an indication of the anticipated project cost, but at the current time, with the very limited development and design information, it must be recognized that the actual cost could be substantially different from those indicated below. A reliable cost estimate of any of these candidates would require a significant further effort consisting of surveying and mapping, geological investigations, environmental studies and feasibility-level design and construction planning work. The cost estimates described below are characterized as AACE International Class 5 estimates (very high-level budgetary estimates). This type of estimate is generally based on a design of between 0 to 2 percent complete, and because of very limited information, the actual cost can be expected to lie within a range of -20% to +50% of the stated estimate, not including those exclusion items listed below.

The estimated costs provided below are intended to be MWH's best professional opinion of the expected cost of the construction and equipment procurement contracts for the physical features, including the transmission line and interconnection to the existing 138-kV transmission line, plus additional allowances for: engineering, reasonable licensing and permitting activities, procurement, project management, and construction monitoring and project start up – all expressed in 2012Q4 price levels. A conventional design, bid, build contracting approach with conventional International Federation of Consulting Engineers (FIDIC) contract conditions is assumed. The estimates do not include escalation of costs beyond 2012Q4, financing costs or interest during construction, reserves or contingencies that may be deemed necessary to allow for unusual risks, land, risk costs associated with alternative contracting approaches, costs associated with a disproportionately large licensing effort, or costs associated with expediting or accelerating project completion – all of which are impossible to estimate at the present time.

The following table presents the rough order of magnitude costs, cost per kW of generating capacity, and the levelized cost per kWh of usable generation for the five possible developments described above. Note that usable annual generation represents modeled production from selected project configuration, and is less than or equal to the initial energy targets used to start the project sizing process.

Scenario	Total Project Cost (2012 $M)	Installed Capacity (MW)	Average Power (MW)	Cost per kW ($/kW)	Usable Annual Generation (GWh/yr)	Potential Annual Average Generation (GWh/yr)	Levelized Project Cost per Usable kWh ($/kWh)
1A	$ 354.6	20	3.4	$ 17,729	29.5	113.0	$ 0.76
1B	$ 449.9	30	7.2	$ 14,995	63.2	150.0	$ 0.45
2	$ 229.5	10	1.6	$ 22,951	14.1	71.0	$ 1.03
3A	$ 530.5	50	12.1	$ 10,610	106.0	204.0	$ 0.32
3B	$1,564.3	100	43.8	$ 15,643	384.0	384.0	$ 0.26

Note: Levelized cost calculated based on 6% discount rate and 50 year period.

ECONOMIC EVALUATION

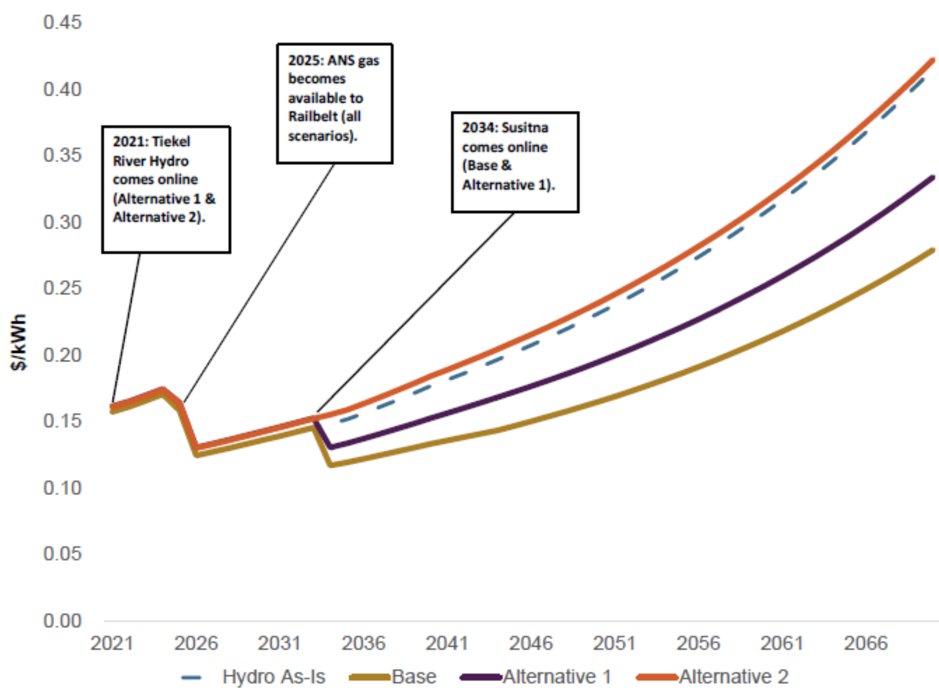
Tiekel Scenario 3B, with the lowest unit cost per usable kilowatt-hour, was tested against other supply options using the cost of electricity supply as the comparative indicator. The evaluation considered the combined predicted demand from the existing Railbelt and the CVEA service areas under the following four scenarios (with reference to):

- Susitna is built, but Tiekel is not (Base Case).
- Both Susitna and Tiekel are built (Alternative 1).
- As-is scenario where natural gas is the preponderant generation fuel for the Railbelt.
- Tiekel is built, but Susitna is not (Alternative 2).

Given the disproportionate energy output of Tiekel relative to projected CVEA demand, this analysis included the cost of an intertie between Glennallen and Sutton as part of the cost of Tiekel.

As illustrated in the below figure, this analysis concluded that the weighted cost of energy (as measured in estimated 2021 dollars per kilowatt-hour) would be lowest in a scenario in which Susitna comes online in 2034 and Tiekel is not built, and highest in a scenario in which Tiekel is built but Susitna is not.

Weighted Cost of Energy (2021$/kWh)



Source: Northern Economics analysis.

This analysis also concluded that the scenario that would yield the second lowest cost of energy would include the construction of both Susitna and Tiekel, while the second highest cost of energy would result from a scenario in which neither Susitna nor Tiekel is built.

These results suggest that investments in Tiekel would not minimize the overall regional electricity supply cost and could be difficult to justify from an economic perspective.

CONCLUSIONS AND RECOMMENDATIONS

Reconnaissance-level evaluations of the Tiekel River watershed indicate that it has potential for hydropower development that could:

- Decrease CVEA dependence on fossil fuels;

- increase inventory of renewable energy sources;
- provide power to new regional customers (residential and/or industrial); and
- increase reliability for the northern half of CVEA's current service territory in the event of a transmission outage.

Five candidate project concepts on the mainstem of the Tiekel River were developed to represent the available range of storage projects (i.e., year-round power). These five storage projects appear to have technical merit, warranting further investigation, as well as no readily-apparent environmental constraints that would preclude development. The project development driver appears to be economic.

If CVEA determines that a storage project is in their best interest, the recommended next steps for resource evaluation would include:

- Refine load projections as a function of time and customer expansion projections to guide selection of an appropriate project size.
- Refine financing assumptions (interest rates, bond terms, etc.) to shape debt service for hydropower construction in order to reduce early year $/kWh.
- Refine grant funding assumptions (current calculations assume zero grant funding).
- Conduct more detailed economic analysis to compare hydropower generation costs with 50-yr regional thermal generation price forecasts.
- Install stream gage(s) in the Tiekel River at appropriate location(s) for the selected project to confirm design criteria.
- Acquire high-resolution maps and imagery of the project area.
- Refine and optimize selected project concept.
- Develop and implement geotechnical investigation plans, including seismic and avalanche hazard evaluations.
- Prepare a Class 4 engineering construction cost estimate.
- Continue stakeholder outreach.
- Initiate licensing, if desired.
- Develop and implement environmental study plans, particularly those with potential for design impacts (i.e. dam release requirements, fish passage requirements).
- Conduct more detailed land ownership research.
- Develop project schedule.

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List of Acronyms and Abbreviations

ac-ft	acre-feet
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ALP	Alternative Licensing Process
APEA	Applicant-prepared Environmental Assessment
BLM	Bureau of Land Management
Catalog	*Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes*
CFR	Code of Federal Regulations
CFRD	concrete faced rockfill dam
cfs	cubic feet per second
cfs/sq.mi.	cubic feet per second per square mile
CVEA	Copper Valley Electric Association
cy	cubic yards
DLA	Draft License Application
EA	Environmental Assessment
EIS	Environmental Impact Statement
El	Elevation
EPS	Electric Power Systems, Inc.
FERC	Federal Energy Regulatory Commission
FIDIC	International Federation of Consulting Engineers
FLA	Final License Application
FSL	Full Supply Level
GIS	Geographic Information System
GMU	Game Management Unit
GWh	gigawatt-hour(s)
H	horizontal
IDF	inflow design floods
ILP	Integrated Licensing Process
km^2	square kilometer(s)
kV	kilovolt(s)
kW	kilowatt(s)
kWh	kilowatt-hour(s)
ma	million years ago
MW	megawatt
MWh	megawatt-hour(s)
MWH	MWH Americas, Inc.
NEI	Northern Economics, Inc.
NEPA	National Environmental Policy Act
NGO	non-governmental organization
NGVD	National Geodetic Vertical Datum

NHPA	National Historic Preservation Act
NOI	Notice of Intent
NP	National Park
NPS	National Park Service
NWI	National Wetlands Inventory
OPCC	Opinion of Probable Construction Cost
PAD	Pre-Application Document
PM&E	Protection, Mitigation, and Enhancement
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RCC	roller compacted concrete
RIS	reservoir triggered seismicity
ROM	rough order of magnitude
SDMI	Statewide Digital Mapping Initiative
SHPO	State Historic Preservation Office
SPOT	*Satellite Pour l'Observation de la Terre*
SRMA	Special Recreation Management Area
Study	Tiekel River Hydropower Reconnaissance Study
TAPS	Trans-Alaska Pipeline System
TLP	Traditional Licensing Process
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
V	vertical

1 Introduction

Copper Valley Electric Association (CVEA) is committed to reducing dependence on fossil fuels while providing member-owners with the most safe, reliable, cost-effective, and sustainable energy solutions available. CVEA obtained grant funding from the State of Alaska to conduct a reconnaissance study of the Tiekel River watershed. The Tiekel River basin is centrally located within CVEA's extensive service area and has been studied in the past as a potential hydropower resource.

The Tiekel River basin has been considered as a potential hydropower generation source for many years by various communities and agencies, yet no detailed studies had been conducted to date. The increasing costs of fossil fuels made it timely to conduct this study to determine whether the resource is well-matched to current load-requirement scenarios and whether further feasibility studies are warranted.

CVEA contracted MWH Americas, Inc. (MWH) to investigate and quantify hydropower generation and load-matching scenarios – ranging from displacement of some or all of CVEA's existing fossil-generation to large-scale development with potential export to local industry, regional, or statewide markets. This report documents the results of the Tiekel River Hydropower Reconnaissance Study (Study).

1.1 Project Location

The Tiekel River watershed is strategically located within CVEA's current service area, approximately halfway between Glennallen and Valdez, Alaska (Figure 1-1 and Exhibit 01, Appendix A), with existing CVEA transmission lines paralleling the Richardson Highway. Figure 1-2 depicts the lower Tiekel River (between the Richardson Highway and the Copper River confluence), along with general land status information from the Alaska Department of Natural Resources (ADNR), anadromous fish range information from the Alaska Department of Fish and Game (ADF&G), and some historical features. The topography of the area is characterized by mountainous terrain with deep ravine river channels.

Figure 1-1 Tiekel River Vicinity Map

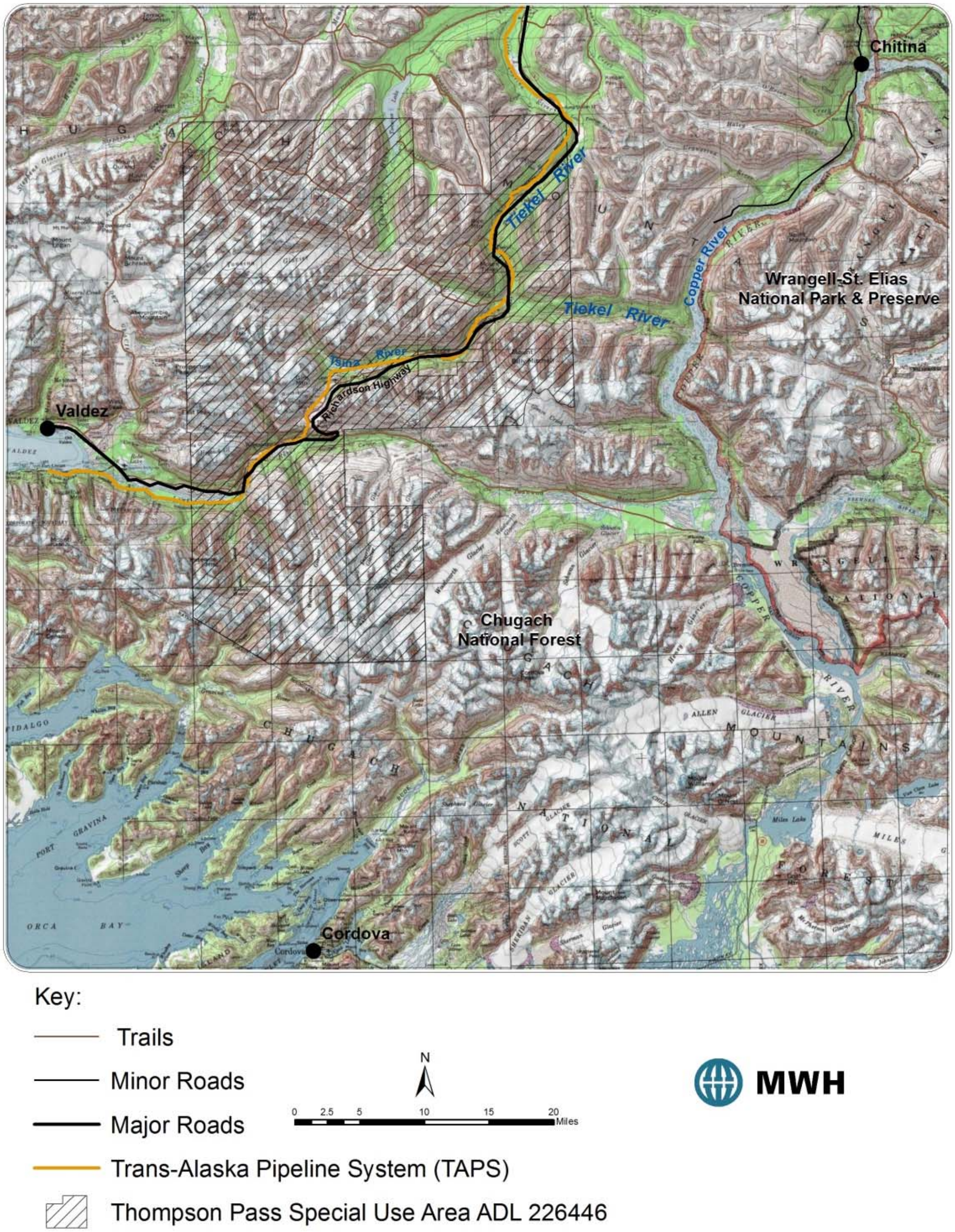
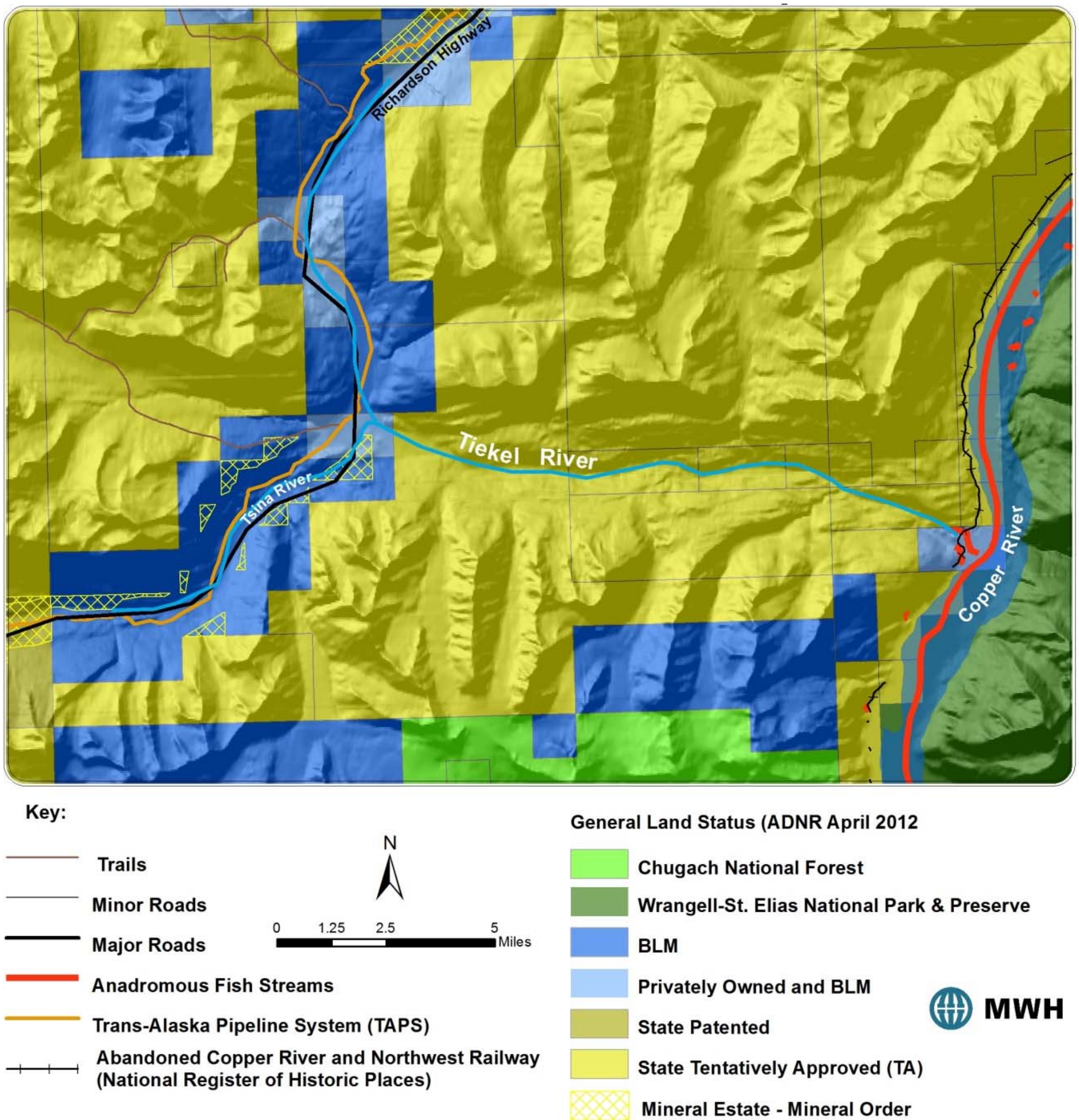


Figure 1-2 Tiekel River Area Use Overview



1.2 Scope of Work

MWH was tasked to obtain sufficient information to develop conceptual layouts of hydropower projects and their corresponding cost effective energy (cost per kilowatt-hour [$/kWh]) for each of the following four scenarios:

- Scenario 1 – Displace all existing CVEA fossil-fuel generation. CVEA's annual fossil fuel generation is approximately 14,400 megawatt-hours (MWh), or 16 percent of the system's total demand. The majority of this generation is during the winter months. This suggests that, for this scenario, a storage reservoir would be required to provide sufficient hydro generation to work in coordination with the Solomon Gulch, and potentially Allison Creek, Projects to totally displace the need for diesel generation within the system.

- Scenario 2 – Displace a meaningful increment of existing CVEA fossil-fuel generation. Studies may indicate that it may be technically and economically infeasible to develop the Tiekel site to totally displace all of CVEA's fossil-fuel generation. In this scenario, the Project would be scaled back.
- Scenario 3 – Displace all existing CVEA fossil-fuel generation and serve new industrial or regional customers. Regional demand expansion plans have been developed that provide an estimate of the need for additional generating capacity. Without expansion of CVEA's hydro generating capacity, it is likely that the demand will be met with fossil fuel generation. Pending the results of Scenarios 1 and 2, the Tiekel Hydro Project could potentially be expanded to meet future growth in energy consumption.
- Scenario 4 – Assess potential for export to statewide markets. CVEA may choose to develop the Project to its greatest potential to be able to sell excess generation to other state-wide markets. It is likely that the topographic, geologic, and hydrologic constraints will limit the size of the Project for this scenario.

Two additional Scenario variations were added during the course of the study to represent the full range of generation options resulting from the reconnaissance-level resource analyses, and are described later in this report.

The scope of work includes the tasks described below. The work under each task is discussed in subsequent sections of this report.

1.2.1 Data Gap Analysis and Fatal Flaw Screening

Reconnaissance efforts focused first on data gap analyses in each engineering and environmental specialty area, screening for "fatal-flaws", and developing initial recommendations for studies that would likely be required for engineering development and Federal Energy Regulatory Commission (FERC) licensing needs. Literature searches were conducted by technical specialists as part of this task.

1.2.2 Site Visits

An initial site visit was performed by hydropower planning specialists at the start of the Study to validate and refine map-identified project concepts for subsequent analysis. A follow-up site visit was conducted by specialty engineers and environmental scientists later in the project once critical factors had been identified.

1.2.3 Conceptual Engineering

Conceptual engineering efforts consisted of: identification of candidate project components (dams and powerhouses), identification of production targets to address the desired scenarios, hydrological studies, power and energy operational studies, screening and identification of physical scenario concepts meeting energy targets, geosciences review, transmission line planning, preliminary land ownership research, preparation of conceptual layouts with preliminary feature refinements, cost estimation, and economic review.

In addition, MWH sought to identify possible candidate hydropower developments outside the primary study focus area, searching for storage, run-of-river and pump-back opportunities within the Tiekel basin.

The first step was to identify potential physical dams and powerhouse development possibilities. Dam Alternative 1, 2, and 3 were identified as potential dams to create reservoirs with storage. Associated powerhouse locations were also identified. The locations of these candidate features are shown on Exhibit 03.

Power modeling results indicated that the Tiekel River watershed has insufficient energy potential to support Scenario 4 (statewide export) as defined in Section 1.2 above. Therefore, the study team and CVEA restructured the load scenario targets to achieve a full range of candidate projects to be evaluated given the available energy. MWH developed concepts for the following revised Scenarios using the Dam Alternatives and associated powerhouses described above:

- Scenario 1A (local – replace all fossil-fuel generation), involving Dam Alternative 3 to create a small storage reservoir with an 8-mi tunnel to a 20-MW powerhouse to be located near the Tiekel River confluence with the Copper River.
- Scenario 1B (local – replace all fossil-fuel generation + 5MW continuous new load), involving Dam Alternative 2 to create a moderately sized reservoir with a 1-mi above ground penstock to a 30-MW powerhouse to be located about 1 mile downstream of the dam location.
- Scenario 2 (local – replace some fossil-fuel generation), involving a diversion (or 'intake') dam upstream of Dam Alternative 3 with an 8-mi tunnel to a 10-MW powerhouse to be located near the Tiekel River confluence with the Copper River.
- Scenario 3A (regional – replace all fossil-fuel generation + 10MW continuous new load), involving Dam Alternative 2 and a moderate sized storage reservoir with a 1-mi above ground penstock to a 50-MW powerhouse to be located about 1 mile downstream of the dam location.
- Scenario 3B (regional – replace all fossil-fuel generation + maximum available energy), involving a Dam alternative 1 and a large storage reservoir with a 1-mi tunnel to a 100-MW powerhouse located near the Tiekel River confluence with the Copper River.

Conceptual layouts for projects sized to meet the five viable Scenario targets (1A, 1B, 2, 3A and 3B) are provided in Exhibits 4 through 13 (Appendix A). The logic behind the development of the project configurations to address the scenario targets and the engineering features of the candidate projects are described in detail in Section 5.

1.2.4 FERC Licensing and Strategy

This Study includes information regarding FERC licensing alternatives and provides a recommendation regarding an approach to the licensing process for a Tiekel River hydropower project, should it move forward.

1.2.5 Recommendations

This Study includes recommendations on feasibility, future engineering, and environmental study topics and timing.

1.3 Organization of the Report

The report is organized to address the topics covered in the scope of work, as follows:

Section 1	Introduction
Section 2	Previous Studies
Section 3	Data Gap Analysis and Fatal Flaw Screening
Section 4	Site Visits
Section 5	Conceptual Engineering
Section 6	FERC Licensing and Strategy
Section 7	Recommendations
Section 8	References

Appendix A	Exhibits
Appendix B	Opinion of Probable Construction Cost
Appendix C	Stakeholder Contact
Appendix D	Transmission Line and Land Status Report
Appendix E	Cultural Resource Report (confidential – not for public distribution)
Appendix F	Socioeconomic Impacts, Benefit-Cost Analyses

1.4 Contributors

MWH partnered with several firms to conduct this Study. Each of the following companies contributed to this report in their respective area(s) of expertise:

- Electric Power Systems, Inc. (EPS) – Transmission Lines and Land Status
- Northern Ecological Services – Aquatic and Terrestrial Resources
- Stephen R. Braund & Associates – Cultural Resources
- Northern Economics, Inc. (NEI) – Economic Analysis

2 Previous Studies

A review of available reference materials indicates that both storage and run-of-river projects have been considered in the Tiekel River watershed. Most developments considered were on the main stem Tiekel River. However, project developments on the Tsina River tributary have also been considered. The Tsina River schemes are generally no longer feasible due to conflicts with infrastructure that was built alongside subsequent to the studies. Where specific information was available, proposed dam heights mostly ranged from 100 feet to 200 feet with installed capacities ranging from 2 MW to 22 MW. Table 2-1 lists various hydropower and energy planning reports for the region. The references section of this report lists additional reports pertinent to particular specialty areas.

Table 2-1 Previous Studies

Year	Report Title (Author)	Category(ies)
1915	*A Water Power Reconnaissance in South Central Alaska, Water-Supply Paper 372* (USGS)	Hydropower Engineering
1978	*Alaska's Hydroelectric Resources Inventory* (Division of Energy and Power)	Hydropower Engineering
1979	*Reconnaissance Study of Hydropower Sites Near Cordova, Alaska (CH2M Hill)*	Regional Expansion
1980	Alaska Regional Energy Resources Planning Project, Hydroelectric Development (Division of Energy and Power)	Hydropower Engineering
1981	Interim Feasibility Report and Final Environmental Impact Statement – Electrical Power for Valdez and the Copper River Basin (U.S. Army Corps of Engineers)	Engineering, Environmental
1981	Reconnaissance Study of Energy Requirements and Alternatives for Cordova (Alaska Power Authority)	Regional Expansion
1982	Cordova Power Supply – Interim Feasibility Assessment (Alaska Power Authority)	Regional Expansion
1986	*Cordova Power Plan* (Alaska Power Authority)	Regional Expansion

CVEA has conducted additional scouting in the Tiekel River watershed in recent years. Photos, videos, and available documentation from those efforts were made available for this Study as well.

3 Data Gap Analysis and Fatal Flaw Screening

Initial Study efforts focused on data gap analyses in various engineering and environmental specialty areas, screening for "fatal-flaws" and identifying studies that would likely be required for engineering development and FERC licensing of a Tiekel River basin hydropower development. Literature reviews and other appropriate research methods were used.

3.1 Geosciences

Public domain geoscience information was collected during this Study to help characterize the site and identify potential site conditions that would preclude development. Geosciences data gap analysis and future study needs are documented in Section 5 (Conceptual Engineering).

3.2 Hydrology

Existing hydrological flow information was collected during this study to provide an indication of potential Tiekel River energy profile matches with CVEA load scenarios. Hydrology data gap analysis and future study needs are documented in Section 5 (Conceptual Engineering).

3.3 Mapping and Imagery

MWH utilized public domain topographic information for reconnaissance-level conceptual design[1]. Higher resolution products would be needed for more detailed engineering design and environmental study work. MWH researched the availability of topographic mapping and imagery products from private vendors and government entities.

The multi-agency Alaska Statewide Digital Mapping Initiative (SDMI) does not currently have imagery or planned acquisitions in the project study area. SDMI does intend to have statewide coverage eventually, but the timeline might not meet project development needs. If a project were to move forward, there might be potential for working with the agencies to increase the region's acquisition priority.

Geoeye, a private satellite imagery vendor, has partial Ikonos-2 coverage of the Study area available. The missing areas include the most likely dam locations.

Satellite Pour l'Observation de la Terre (SPOT) satellite imagery was acquired with government agency licensure in 2012 and was expected to be available in the first quarter of 2013. However,

[1]Digital topography developed from USGS 15-minute series topographic mapping was acquired from http://agdc.usgs.gov/data/usgs/geodata/dem/63K/demlist_V.html and was used to create the topographic base maps for the exhibits attached to this report.

SPOT satellite imagery does not provide stereo coverage, and cannot be used to generate high quality elevation models.

Quantum Spatial, Inc., a private local vendor, was expected to have digital mapping camera orthophoto coverage for part of the area available sometime in 2013 that could be used to create topographic mapping at an accuracy standard consistent with 10-ft interval contouring. They also have 1978 color infrared imagery of the whole area that could be used to create topographic mapping at an accuracy standard consistent with 20-ft interval contouring.

In summary, it appears that new mapping and imagery acquisitions will be required to obtain current high-resolution data for the entire area of interest.

3.4 Constructability / Site Access

Access to many Tiekel River basin sites of interest is currently limited by lack of infrastructure and challenging terrain, both overland and by water. Site access for design, environmental studies, and construction are likely to require some helicopter use. Jet boats are known to be utilized for Tiekel River mouth access from Chitina, but may not be practical for field work or construction – depending on the nature of the required site activity.

Constructability and site access options were evaluated by map studies and during site visits to provide a basis for construction pricing and planning. Although the topography is rugged, there appear to be feasible access road alignment alternatives. Additional information about site access is provided in Section 5 (Conceptual Engineering).

3.5 Transmission Routing and Preliminary Land Ownership Review

MWH was tasked to consider transmitting power from proposed hydropower plants to existing CVEA transmission lines, but not integration into the CVEA system. CVEA's existing transmission lines run roughly parallel to the Richardson Highway, transecting the midsection of the Tiekel River basin. Hydropower schemes with power plants near the mouth of the Tiekel River would require on the order of 15 miles of new overland transmission lines, up the Tiekel River drainage itself as the most direct route.

Early identification of transmission line routing is important to support the FERC licensing process as well, since the primary transmission line would be under FERC jurisdiction as part of the licensed project work. Land ownership issues (site control) are especially important considerations for transmission line routing.

Electric Power Systems, Inc. (EPS) conducted transmission line routing and land status research for the Study, as documented in Section 5 (Conceptual Engineering) of this report, as well as Appendix D. No fatal flaws have been identified to date.

3.6 Aquatic Resources

3.6.1 Overview of Project Implications

Compared to other major tributaries of the Copper River, the Tiekel River supports minimal fish resources. The topography of its watershed prevents upstream passage of anadromous and resident fish from downstream and, thus, use by fish species normally considered to be of commercial, sport, and subsistence value is limited to a short segment at the mouth where the Tiekel River meets the Copper River. It is unlikely that unacceptable impact to aquatic resources would interfere with development of a hydroelectric project on the lower Tiekel River.

Nevertheless, aquatic habitats in the vicinity of the Tiekel River mouth likely contribute to the productivity of the highly productive Copper River system and will need to be adequately considered. A reasonable study program to identify fish resources and aid in the planning of mitigation measures will be required for licensing, and some regulation of flow releases will probably be needed to ensure adequate instream flow in valuable habitat areas.

3.6.2 Known Resources

The portion of the upper Tiekel River that parallels the Richardson Highway upstream from the confluence with the Tsina River is characterized by relatively clear water and a moderate gradient that is favorable to fish use. The stream contains resident Dolly Varden and sculpins. Two research projects sponsored by the Alaska Cooperative Fisheries Research Unit at the University of Alaska-Fairbanks (Martin, 1988; Gregory, 1988) have described the habitats and population characteristics of Dolly Varden in considerable detail. Fish within the stream are slow growing and small, whereas Dolly Varden within some of the Tiekel drainage beaver ponds are somewhat larger (Gregory, 1988). This upstream reach provides some sport fishing opportunity for travelers on the Richardson Highway; however, fishing pressure is light because of the small size of the fish and the difficult access to the most productive beaver ponds (Martin, 1988).

After joining the turbid glacial Tsina River, the Tiekel River heads eastward through a steep canyon. It is generally agreed that the high velocity conditions in the canyon are a block to fish passage, preventing fish from moving upstream much beyond the downstream end of the canyon. Consequently, the upper Tiekel River is isolated from the fish resources inhabiting other portions of the Copper River drainage, including anadromous salmon. This 13-mile canyon reach is generally unsuitable as fish habitat.

Downstream from the canyon, the Tiekel River flattens out and traverses an alluvial fan for about 2 miles before joining the Copper River. Several studies have indicated that the lower 1.5 to 2.0 miles of the Tiekel River are utilized by anadromous species – including juvenile chinook and coho salmon (Gilleland et al., 1992) and, possibly, adult sockeye salmon spawners (Wade et al., 2008). The Gilleland study found that the alluvial fans of steep tributaries entering the Copper River were valuable habitat for Copper River juvenile salmon, especially chinook and coho. The Wade study used radio tracking to determine the distribution of sockeye salmon within the Copper River and found that small numbers ended up at the mouth of the Tiekel River. The small lake at the south side of the Tiekel River delta, called Tiekel Lake in some reports, also supports sockeye salmon. This lake has a separate outlet to the Copper River, but may have a high water connection to the Tiekel River.

The exact upstream extent of salmon spawning in the Tiekel River is not known. The turbid water prevents visual observation and detailed studies have not been conducted to follow individual fish. Observations by the MWH team in September 2012 did not identify any obvious fish passage barriers such as high waterfalls, but it is virtually certain that velocities become too high at some point within the narrow canyon, probably between 2 and 4 miles from the mouth. The ADF&G anadromous stream atlas (Figure 3-1) indicates that only the lower 1.0 to 1.5 miles of the Tiekel River is currently classified as anadromous waters.

3.6.3 Key Species and Sensitivities

Resident Dolly Varden within the upper Tiekel River would probably not be considered a key species. Candidate projects would not directly affect the upper river, although the projected impoundment would likely be accessible to some of these fish and would introduce a large open water component to the drainage.

The short segment of the Tiekel River between the mouth of the canyon and the Copper River confluence is clearly the most valuable area to fish. The area is known to provide rearing habitat for juvenile chinook and coho salmon and at least some spawning habitat for sockeye salmon and likely other species as well. The area has not been well studied and its overall importance is unknown. However, the Gilleland et al. (1992) study emphasized the importance of the Copper River tributary alluvial fans as rearing habitat. Chinook, coho, and sockeye salmon will likely be identified as key evaluation species – with both spawning and rearing habitat for these species considered sensitive to alterations in flow, temperature, substrate, and hydrologic stability.

Wetlands within and adjacent to the alluvial fan of the Tiekel River, including the Tiekel Lake complex, may also be important fish habitat. The existing flow regime in the Tiekel River probably plays a part in maintaining the hydrologic characteristics of these areas. While the importance of these wetlands as fish habitat is currently unknown, sensitivity should be assumed.

3.6.4 Aquatic Habitat Issues and Mitigation Implications

Table 3-1 compares the aquatic habitat issues and mitigation implications for five development scenarios. The most significant aquatic habitat issues are centered on protection of existing anadromous fish habitat in the lower Tiekel River, downstream from the upper limit of anadromous fish use. The area of concern will likely encompass 2 to 4 miles of stream, depending on fish distribution. Maintaining a flow regime conducive to spawning and rearing will be one area of emphasis.

In the case of Scenario 3B – (the maximum development case) – there will be two areas of instream flow emphasis: 1) the reach between the dam and the powerhouse discharge, that will be potentially totally dewatered; and 2) the reach downstream of the powerhouse, where the flows will likely be altered from the natural seasonal regime of summer and fall highs and much lower winter flow. Below the powerhouse, stabilization of daily and seasonal flow (especially increased winter flow) has the potential to improve fish habitat by eliminating damaging extremes. Flow supplementation within the ½-mile reach between the dam and powerhouse may be required if studies show that the reach has significant fish habitat. Instream flows for both reaches will need to be negotiated with the permitting agencies. If studies show that anadromous fish habitat extends above the location of the Scenario 3B Dam (Dam Location 1), then compensatory mitigation may be required to replace the lost resource. Habitat enhancement within the delta area might be appropriate as a mitigation measure.

Figure 3-1 Anadromous Waters Atlas – Valdez A-3

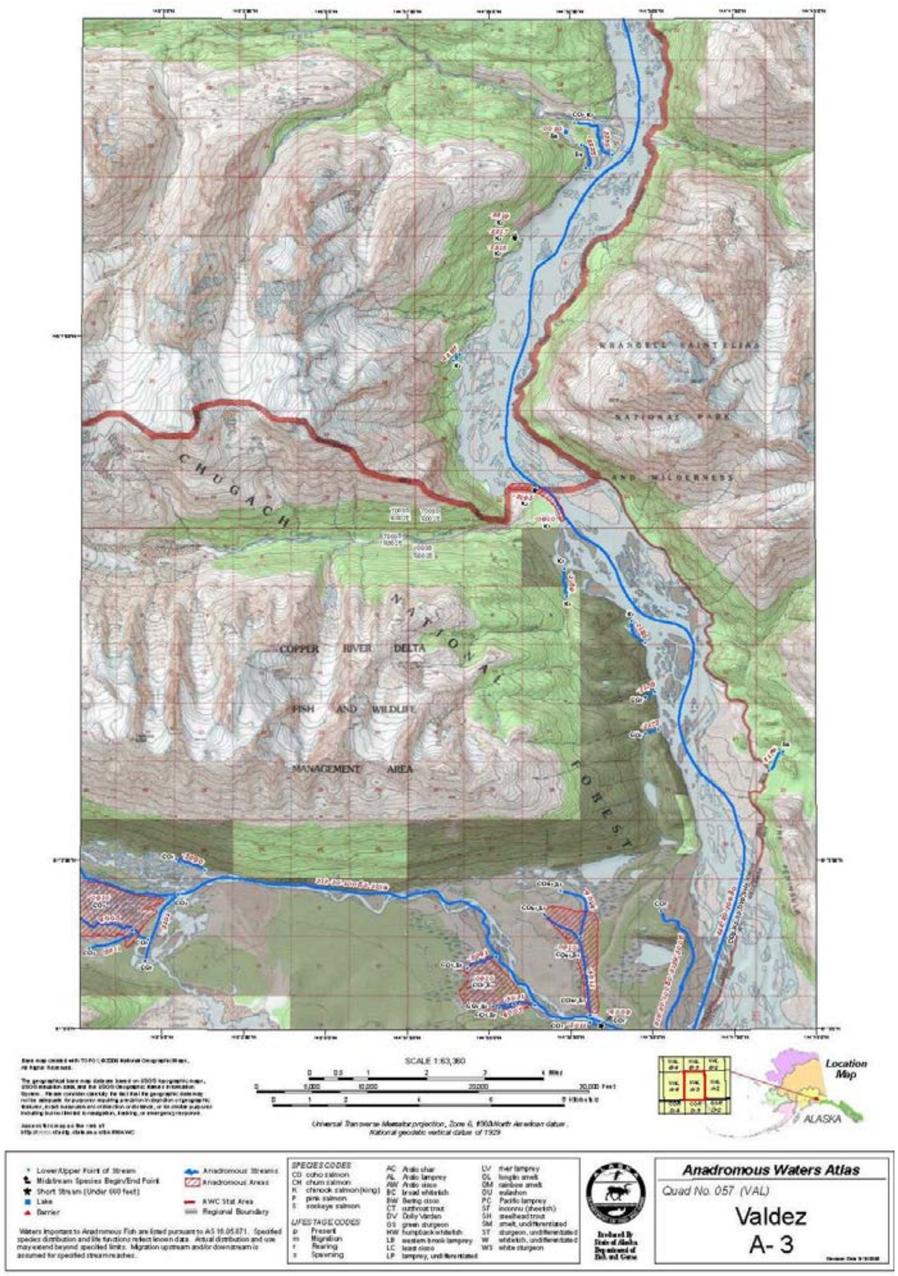


Table 3-1 Aquatic Habitat Issues, Study Needs and Mitigation Requirements for Tiekel River Hydroelectric Power Scenarios

Item	Scenarios 1A and 2	Scenarios 1B and 3A	Scenario 3B
Principal Features	Dam 9.8 miles upstream from mouth; long power tunnel; powerhouse located at same location as Scenario 3B, 5,400 feet upstream from confluence. Scenario 1A impoundment 2.5 miles long. Scenario 2 impoundment very small, 2,000 feet long.	Dam 4.5 miles upstream from mouth; powerhouse 4,500 feet downstream from dam.	Dam 8,000 feet upstream from confluence; powerhouse 5,400 feet upstream from confluence; 11-mile long impoundment.
Direct Habitat Alteration Issues	Scenario 1A will convert about 2.5 miles of high gradient, gorge-type habitat into a narrow impoundment. Scenario 2 impoundment will alter about 2,000 feet of gorge habitat. Dam and tunnel construction areas, as well as the powerhouse and tailrace footprint, will impact riparian and riverine habitat in the delta area. Spoils from long tunnel will require disposal sites.	About 7.4 miles and 8.3 miles of high gradient, gorge-type habitat converted into a long narrow impoundment by Scenarios 1B and 3A, respectively. Fish habitat likely improved for resident Dolly Varden within impoundment area. Some disturbance to gorge habitat due to dam and tunnel construction, but no direct impact to sensitive delta area.	About 11 miles of high gradient, gorge -type habitat converted into a long narrow impoundment. Fish habitat likely improved for resident Dolly Varden. Dam likely will cut off some existing anadromous fish habitat, the extent of which will not be known until studies are completed. Dam and tunnel construction areas, spoil disposal, as well as the powerhouse and tailrace footprint will impact riparian and riverine habitat in the delta area.
Instream Flow Issues	Flow between dam and powerhouse will be reduced by diversion for power generation. Accretion from tributaries downstream of the dam will moderate flow impact on the sensitive delta area. Mean annual flow downstream from powerhouse unchanged, but seasonal flow altered from natural regime. Flood flow extremes will be reduced somewhat.	Flows between dam and powerhouse reduced or eliminated; mean annual flow downstream from powerhouse unchanged, but seasonal flow altered from natural regime. Most effects will be limited to canyon area, but seasonal flow regime in delta area will be altered. The extent of alteration will depend in part on the amount of accretion downstream from the dam. Flood flows needed for flushing will be damped by reservoir storage, but effect will likely be less than Scenario 3B.	Flows between dam and powerhouse reduced or eliminated; mean annual flow downstream from powerhouse unchanged, but seasonal flow altered from natural regime. Flood flows needed for flushing will be damped by reservoir storage.

Table 3-1 (Cont.) Aquatic Habitat Issues, Study Needs and Mitigation Requirements for Tiekel River Hydroelectric Power Scenarios

Item	Scenarios 1A and 2	Scenarios 1B and 3A	Scenario 3B
Issues Related to Interaction of Hydrology and Habitat	May be issues related to wetland maintenance near Tiekel River mouth, including potential changes to Tiekel Lake. Damping of flood flows may affect maintenance of gravel spawning habitat in lower river.	May be issues related to wetland maintenance near Tiekel River mouth, including potential changes to Tiekel Lake. Damping of flood flows may affect maintenance of gravel spawning habitat in lower river.	May be issues related to wetland maintenance near Tiekel River mouth, including potential changes to Tiekel Lake. Damping of flood flows may affect maintenance of gravel spawning habitat in lower river.
Water Temperature and Quality Issues	Changes to seasonal water temperature regime may affect timing of salmon spawning, incubation of salmon eggs, and growth rates of juvenile salmon in the delta area. Actual temperature effects may be small because of mixing with accretion flow. Improved water clarity downstream from the dam (due to settling in the reservoir) will likely be a beneficial impact.	Changes to seasonal water temperature regime may affect timing of salmon spawning, incubation of salmon eggs, and growth rates of juvenile salmon in the delta area. Actual temperature effects will likely be less than with Scenario 3B, because of mixing with accretion flow. Improved water clarity downstream from the dam (due to settling in the reservoir) will likely be a beneficial impact.	Changes to seasonal water temperature regime may affect timing of salmon spawning, incubation of salmon eggs, and growth rates of juvenile salmon. Improved water clarity downstream from the dam (due to settling in the reservoir) will likely be a beneficial impact.
Study Needs	Firm documentation of the upstream extent of anadromous fish use in the lower river, along with seasonal use patterns and habitat preferences, will likely require radio tagging of salmon. Year-round monitoring of downstream discharge and water temperature. Instream flow analysis tailored to needs of project. A temperature model that looks at operational temperature regimes will also be needed. Contribution from tributaries downstream of the dam will need to be firmly established.	Firm documentation of the upstream extent of anadromous fish use in the lower river, along with seasonal use patterns and habitat preferences, will likely require radio tagging of salmon. Year-round monitoring of downstream discharge and water temperature. Instream flow analysis tailored to needs of project. A temperature model that looks at operational temperature regimes will also be needed. Contribution from tributaries downstream of the dam will need to be firmly established.	Firm documentation of the upstream extent of anadromous fish use in the lower river, along with seasonal use patterns and habitat preferences, will likely require radio tagging of salmon. Year-round monitoring of downstream discharge and water temperature. Instream flow analysis tailored to needs of project. A temperature model that looks at operational temperature regimes will also be needed.

Table 3-1 (Cont.) Aquatic Habitat Issues, Study Needs and Mitigation Requirements for Tiekel River Hydroelectric Power Scenarios

Item	Scenarios 1A and 2	Scenarios 1B and 3A	Scenario 3B
Design and/or Operational Mitigation Requirements	Instream flow needs will depend on results of studies, but some release may be required from the dam to supply water to the dewatered reach. However, accretion flow will minimize this need compared to Scenario 3B. Powerhouse flows may have upper and lower limits according to an approved seasonal flow regime, including limitations on project shutdown. Possible requirement for occasional flushing flows. Again, accretion flows will minimize this need compared to Scenario 3B. Possible need for compensatory habitat enhancement in delta area. Possible need for control of public access.	Instream flow needs will depend on results of studies, but some release may be required from the dam to supply water to the dewatered reach. However, accretion flow will minimize this need compared to Scenario 3B. Powerhouse flows may have upper and lower limits according to an approved seasonal flow regime, including limitations on project shutdown. Possible requirement for occasional flushing flows. Again, accretion flows will minimize this need compared to Scenario 3B. Compensatory habitat enhancement in delta area probably not needed with this scenario. Possible need for control of public access. Access issues greatly diminished with Scenario 1B and 3A compared to the other scenarios because no need to access sensitive delta area.	Instream flow needs will depend on results of studies, but some release may be required from the dam to supply water to the dewatered reach. Powerhouse flows may have upper and lower limits according to an approved seasonal flow regime, including limitations on project shutdown. Possible requirement for occasional flushing flows. Possible need for compensatory habitat enhancement in delta area. Possible need for control of public access.

The physical characteristics of aquatic habitats associated with wetlands, side channels, and distributaries on the Tiekel River alluvial fan, as well as the Tiekel Lake complex, likely exist because of the hydrological regime of the lower river. Maintenance of these characteristics will be another issue related to the flow regime and will need to be considered in instream flow planning.

Scenarios 1A and 2, with a dam far upstream and a powerhouse downstream on the delta, will have most of the same flow issues – except that they would be expected to be less restrictive because of the contribution of water from portions of the watershed downstream from the dam. Flow supplementation above the powerhouse, if required, would likely entail less non-generation water use.

Scenarios 1A, 2, and 3B all involve substantial disturbance to the lower Tiekel River floodplain because of the locations of the tunnel portal, powerhouse, tailrace, and powerhouse access road (including a possible bridge required over the river). This disturbance will need to be evaluated and potentially compensated through mitigation measures. Scenarios 1B and 3A do not involve physical disturbance to the lower Tiekel River and, thus, some issues would be alleviated. Negotiation of instream flows downstream from the powerhouse would still be required, with Scenarios 1B and 3A but might be less rigid because of the presence of accretion flow in the river downstream from the powerhouse.

Scenarios 1A, 2, and 3B would all involve access to the river mouth for construction of the powerhouse. Access to undisturbed areas often becomes one of the more contentious issues associated with Alaska projects. The proximity to Cordova and the past history of access via a Copper River Highway will contribute to access controversy. Scenarios 1B and 3A would have less potential for creating access connections to the Copper River.

3.6.5 Data Gaps and Licensing Study Needs

The most glaring data gap is the need for more information regarding fish use of the short reach of the Tiekel River between the canyon mouth and the Copper River confluence. Abundance, seasonal distribution, habitat use, and habitat value for key species and life stages will be needed to assess project impacts and design appropriate mitigation measures. Because of the turbid water, fish studies will need to employ methods such as active capture and radio tracking to document distribution and habitat use. Minimum study needs for licensing, impact analysis, and mitigation planning related to aquatic resources would include the following:

- Hydrological Studies
  - Flow monitoring in Tiekel River at the mouth and near the beginning of the canyon reach.
  - Flow monitoring in selected Tiekel River tributaries.
  - Modeling of stream flow gains and losses from beginning of canyon to the mouth.
  - Surface water connectivity and near-surface groundwater conditions at selected locations on the Tiekel delta to determine relationship between river flow and the maintenance of wetland, river channel, and lake habitats.

- Anadromous Fish Studies
  - Abundance, distribution, and upstream limits of adult salmon.
  - Abundance, distribution, and upstream limits of juvenile salmon.
  - Spawning and rearing habitat suitability criteria.
  - Identification of special use areas.
- Resident Fish Studies
- Instream Flow Modeling Studies within Anadromous Fish Use Area
  - Mainstream habitats.
  - Off-channel habitats.
- Water Temperature Studies
  - Temperature monitoring at flow stations and other selected sites.
  - Temperature modeling for various operational scenarios.

3.6.6 Proposed Next Steps

Once a decision is made to proceed with the project, at least into the early stages of development, a licensing/permitting strategy should be developed along with an initial schedule for interacting with stakeholders. Most proposed Alaska hydroelectric developments have chosen to engage with stakeholders early in the process rather than later. Additionally, it may be advantageous to conduct one season of preliminary field environmental studies prior to the start of a time-driven licensing process. An early study start may be especially relevant for a project on the Tiekel River, because of the logistical difficulties that will be encountered while working on the Tiekel delta and the potential learning curve required to develop effective aquatic resource study methods on a fast, turbid river system. Plans for preliminary studies, while potentially not subject to formal licensing review, will still need to be reviewed and approved by the agencies. Consequently, it will be advantageous to begin study planning as early in the process as possible.

CVEA met with ADF&G to introduce the project and initiate stakeholder communications. Meeting notes are provided in Appendix C.

3.7 Terrestrial Resources

The terrestrial resources of the project study area are discussed in this section.

3.7.1 Overview of Project Implications

The following discussion of terrestrial resources includes the plants, wildlife, and habitats that may occur in the project study area. The area considered extends from the floodplain of the Tiekel River adjacent to the Richardson Highway downstream through the Tiekel River canyon to the delta at the river's confluence with the Copper River. It includes a range of habitats with a variety of plant and animal life. There is little information available on terrestrial resources specific to the project study area. However, information for nearby regions, such as Wrangell-St. Elias NP, and Game Management Unit (GMU) 13 and Subunit 13D, provide a basis for discussing likely project effects on terrestrial resources.

The construction and operation of a candidate project would directly impact some habitats by placing fill, excavating, inundating, and changing the hydrologic regime, which would displace or affect the plants and wildlife there. The impact of construction and operation of a candidate project on plants, wildlife, and their habitats is not likely to adversely affect development of the project because of several factors:

- There are no records of species listed by federal or state governments as threatened or endangered or habitats listed as critical in the project study area (Table 3-2) (USFWS, 2012 and ADF&G, 2006 and 2012).
- Although there are habitats within the project area that support or likely support species of interest or special concern (Table 3-3), some study and consideration of their occurrence and minimization or mitigation of potential impacts should satisfy concerns.
- The most valuable wildlife habitats in the project study area – likely the delta wetland and riparian habitats at the confluence with the Copper River, followed by habitats in the floodplain of the Tiekel River near the Richardson Highway – would mostly be outside potential areas of direct habitat impacts.
- The Tiekel River canyon is rugged and relatively inaccessible and is currently not used by either humans or wildlife to the same extent as some neighboring areas.

Table 3-2 State and Federal Endangered, Threatened, and Special Concern Species (USFWS, 2012 and ADF&G, 2006)

Common Name	Scientific Name
State	
Endangered	
Short-tailed albatross	*Phoebastria albatrus*
Eskimo curlew	*Numenius borealis*
Blue whale	*Balaenoptera musculus*
Humpback whale	*Megaptera novaengliae*
North Pacific Right whale	*Eubalaena japonica*
Special Concern Species – See Table 3-3	
Federal	
Endangered	
Aleutian shield fern	*Polystichum aleuticum*
Bowhead whale	*Balaena mysticetus*
Cook Inlet beluga whale	*Delphinapterus leucus*
Eskimo curlew	*Numenius borealis*
Fin whale	*Balaenoptera physalus*
Humpback whale	*Megaptera novaengliae*
Leatherback sea turtle	*Dermochelys coriacea*
North Pacific right whale	*Eubalaena japonica*
Sei whale	*Balaenoptera borealis*
Short-tailed albatross	*Phoebastria albatrus*

Common Name	Scientific Name
Federal (Cont.)	
Endangered	
Sperm whale	*Physeter macrocephalus*
Steller sea lion (west of 144°)	*Eumetopias jubatus*
Threatened	
Green sea turtle	*Chelonia mydas*
Loggerhead sea turtle	*Caretta caretta*
Northern sea otter (SW AK population)	*Enhydra lutris kenyoni*
Olive Ridley sea turtle	*Lepidochelys olivacea*
Polar bear	*Ursus maritimus*
Spectacled eider	*Somateria fisheri*
Steller sea lion (east of 144°)	*Eumetopias jubatus*
Steller's eider	*Polysticta stelleri*
Wood bison	*Bison bison athabascae*
Under Consideration	
Bearded seal: Candidate	*Erignathus barbatus*
Black-footed albatross	*Phoebastria nigripes*
Kittlitz's murrelet: Candidate	*Brachyramphus brevirostris*
Pacific herring (SE AK): Candidate	*Clupea pallasii*
Pacific walrus: Candidate	*Odobenus rosmarus divergens*
Ringed seal: Candidate	*Phoca hispida*
Yellow-billed loon: Candidate	*Gavia adamsii*

Table 3-3 State Designated Species of Special Concern that May Occur in the Project Area (ADF&G, 2006)

State Designated Species Special Concern	
Mayflies, stoneflies, and caddisflies	Ephemeroptera, Plecoptera, Trichoptera
Freshwater fish (see aquatics discussion): Pacific lamprey and eulachon	
Western toad	*Bufo boreas*
Wood frog	*Rana sylvatica*
Horned grebe	*Podiceps auritus*
Red-necked grebe	*Podiceps grisegena*
Red-throated loon	*Gavia stellata*
Pacific loon	*Gavia pacifica*
Common loon	*Gavia immer*
Harlequin duck	*Histrionicus histrionicus*
Long-tailed duck (oldsquaw)	*Clangula hyemalis*
Black scoter	*Melanitta nigra*
Surf scoter	*Melanitta perspicillata*
White-winged scoter	*Melanitta fusca*
Arctic tern	*Sterna paradisaea*
Bald eagle	*Haliaeetus leucocephalus*
Northern harrier	*Circus cyaneus*
Sharp-shinned hawk	*Accipiter striatus*
Northern goshawk	*Accipiter gentilis*
Red-tailed hawk	*Buteo jamaicensis*

State Designated Species Special Concern	
Rough-legged hawk	*Buteo lagopus*
Golden eagle	*Aquila chrysaetos*
Merlin	*Falco columbarius*
Peregrine	*Falco peregrinus*
Gyrfalcon	*Falco rusticolus*
Lesser yellowlegs	*Tringa flavipes*
Solitary sandpiper	*Tringa solitaria*
Great horned owl	*Bubo virginianus*
Snowy owl	*Nyctea scandiaca*
Northern hawk owl	*Surnia ulula*
Great grey owl	*Strix nebulosa*
Short-eared owl	*Asio flammeus*
Boreal owl	*Aegolius funereus*
Rufous hummingbird	*Selasphorus rufus*
Belted kingfisher	*Ceryle alcyon*
Hairy woodpecker	*Picoides villosus*
Three-toed woodpecker	*Picoides tridactylus*
Black-backed woodpecker	*Picoides arcticus*
Northern flicker	*Colaptes auratus*
Olive-sided flycatcher	*Contopus borealis*
Violet-green swallow	*Tachycineta thalassina*
Bank swallow	*Riparia riparia*
Cliff swallow	*Hirundo pyrrhonota*
Barn swallow	*Hirunda rustica*
Boreal chickadee	*Parus hudsonicus*
Red-breasted nuthatch	*Sitta canadensis*
Brown creeper	*Certhia americana*
Golden-crowned kinglet	*Regulus satrapa*
Hermit thrush	*Catharus guttatus*
Varied thrush	*Ixoreus naevius*
Blackpoll warbler	*Dendroica striata*
Townsend's warbler	*Dendroica townsendi*
Wilson’s warbler	*Wilsonia pusilla*
Rusty blackbird	*Euphagus carolinus*
Dark-eyed junco	*Junco hyemalis*
Smith's longspur	*Calcarius pictus*
Pine siskin	*Carduelis pinus*
Pine grosbeak	*Pinicola enucleator*
White-winged crossbill	*Loxia leucoptera*
Little Brown Bat	*Myotis lucifugus*

3.7.2 Resource Issues

3.7.2.1 Known Vegetation and Habitat Resources

The Tiekel River watershed lies in an ecoregion of Alaska described by ADF&G as “Temperate Coastal – Hypermaritime Forests – Chugach-St. Elias Mountains” (ADF&G, 2006) and by the U.S. Geological Survey (USGS) as the “Pacific Coastal Mountains Ecoregion of Alaska” (Gallant, et al., 1995). The ecoregion is characterized by steep, glaciated mountains whose plant communities/habitats are dominated by dwarf and low scrub/shrub, except in valleys where there may be mixed forests of hemlock and Sitka spruce (Gallant, et al. 1995; ADF&G, 2006). The project area, which extends from the higher elevation valley of the upper Tiekel River through a canyon surrounded by glaciated peaks and to the Copper River valley, includes lowland, wetland, upland, sub-alpine, and alpine habitats.

Both vegetation types/cover classes/communities and wetlands have been mapped within the project study area. The Tiekel River watershed was mapped as part of a cooperative effort between the Bureau of Land Management (BLM) and Ducks Unlimited, Inc. to map uplands and wetlands within Alaska (BLM, 2002). Wetlands also have been mapped by the U.S. Fish and Wildlife Service (USFWS) for their National Wetlands Inventory (NWI), and data for the Tiekel River canyon and vicinity is available in digital format (USFWS, 2012).

Table 3-4 lists the vegetation cover classes and their corresponding area mapped within the Tiekel River watershed. According to the BLM mapping analysis, the predominant vegetation cover classes identified in the project study area appear to be: rock/gravel and low dwarf shrub at higher elevations; low shrub/low shrub – willow/alder, closed mixed needleleaf/deciduous, and open deciduous at lower elevations; and aquatic bed in the Tiekel River delta area. Figure 3-2 shows the vegetation cover classes mapped in the Tiekel River watershed (BLM, 2002). Table 3-5 lists 83 plants identified during field verification for the mapping project (BLM, 2002). More detailed information specific to the project area is available for query in the database and can be used for evaluating project effects (BLM, 2002).

Table 3-4 Vegetation Cover Classes Mapped in the Teikel River Watershed (BLM, 2002)

Class Name	Mapped Acres	Mapped Percent
Closed Needleleaf	28,910	1.19%
Open Needleleaf	597,953	24.58%
Woodland Needleleaf	201,278	8.27%
Woodland Ndl.- Lichen	1048	0.04%
Closed Deciduous	103,413	4.25%
Open Deciduous	29584	1.22%
Closed Mixed Ndl./Decid.	59,287	2.44%
Open Mixed Ndl./Decid.	102,566	4.22%
Tall Shrub	100,653	4.14%
Low Shrub	369,539	15.19%
Low Shrub - Lichen	7,897	0.32%
Dwarf Shrub	168,866	6.94%
Low Shrub - Willow/Alder	11,088	0.46%
Wet Graminoid	1788	0.07%
Aquatic Bed	1310	0.05%
Emergent	31	< 0.05%
Clear Water	18,456	0.76%
Turbid Water	82,576	3.39%
Snow/Ice	162,469	6.68%
Sparse Vegetation	72,515	2.98%
Rock/Gravel	249,963	10.27%
Agriculture	1399	0.06%
Tenain Shadow	60,475	2.49%
Total	2,433,064	100%

Figure 3-2 Vegetation Classification Map Including Tiekel River Watershed (BLM, 2002)

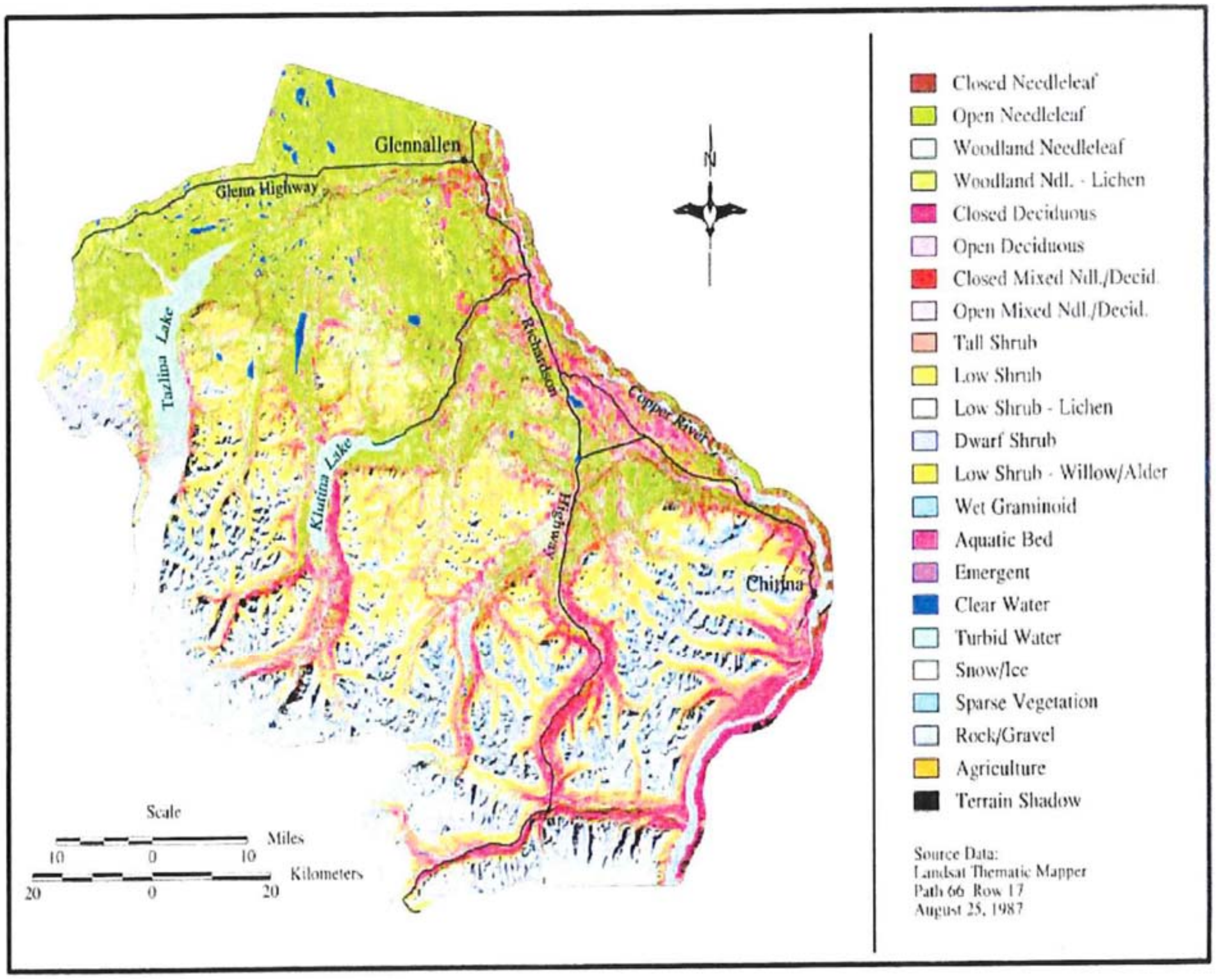


Table 3-5 Plant Species Identified in the Tiekel River Watershed (BLM, 2002 - Appendix C)

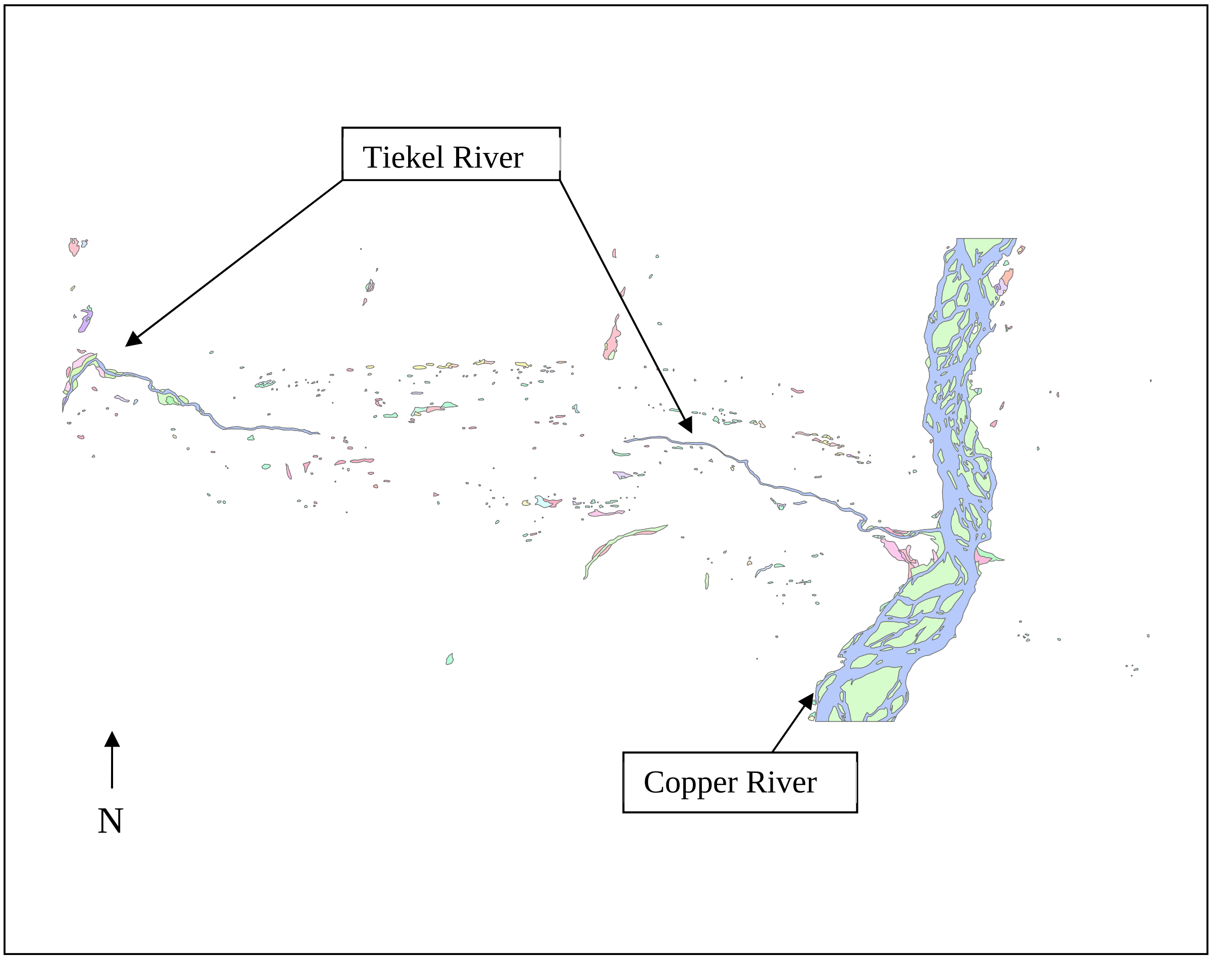
Common Name	Species
Birch, resin	*Betula glandulosa*
Willow	*Salix spp*
Spruce, white	*Picea glauca*
Crowberry, black	*Empetrum nigrum*
Sedge, water	*Carex aquatilis*
Labrador tea	*Ledum palustre*
Willow tree	*Salix tree*
Aspen, quaking	*Populus tremuloides*
Lichen	*Lichen*
Alder, thin-leaf	*Alnus tenuifolia*

Common Name	Species
Spruce, black	*Picea mariana*
Mountain-avens	*Dryas spp*
Alder, tree	*Alnus spp tree*
Sedge spp	*Carex spp*
Bell-heather, arctic	*Cassiope tetragona*
Blueberry, bog	*Vaccinium uliginosum*
Red bearberry	*Arctostaphylos rubra*
Poplar, balsam	*Populus balsamifera*
Willow, dwarf	*Salix dw*
Kinnekinnick	*Arctostaphylos uva-ursi*
Alder, green	*Alnus crispa*
Horsetails spp	*Equisetum spp*
Sweetgale	*Myrica gale*
Soapberry	*Shepherdia canadensis*
Bunchberry, canada	*Cornus canadensis*
Saxifrage spp	*Saxifraga spp*
Water lily	*Nuphar polysepalum*
Toadflax, northern	*Geocaulon lividum*
Birch, paper	*Betula papyrifera*
Reedgrass, blue-joint	*Calamagrostis canadensis*
Lupine	*Lupinus spp.*
Cotton-grass	*Eriophorum spp*
Buckbean	*Menyanthes trifoliata*
Cinquefoil, shrubby	*Potentilla fruticosa*
Rose, prickly	*Rosa acicularis*
Leatherleaf	*Chamaedaphne calyculata*
Black cottonwood	*Populus trichocarpa*
Woodfern, mountain	*Dryopteris dilatata*
Coltsfoot, arctic sweet	*Petasites frigidus*
Cranberry, highbush	*Viburnum edule*
Vetch	*Astragalus spp*
Crane's-bill, meadow	*Geranium pratense*
Pondweed	*Potamogeton spp*
Cow-parsnip	*Heracleum lanatum*
Fireweed spp.	*Epilobium spp*
Forget-me-not, alpine	*Myosotis alpestris*
Currant spp.	*Ribes spp.*
Willow, diamond- leaf	*Salix planifolia*
Mustard, tall	*Sisymbrium altissimum*
Spiraea, beauvered	*Spiraea beauverdiana*
Cranberry, lowbush	*Vaccinium vitis-idaea*
Yarrow, common	*Achillea millefolium*

Common Name	Species
Rosemary, bog	*Andromeda polifolia*
Sagebrush, alasi	*Artemisia alaskana*
Arnica	*Arnica spp.*
Bearberry	*Arctostaphylos spp.*
Vetch, hairy arctic milk	*Astragalus umbellatus*
Indian-paintbrush, spp	*Castilleja caudata*
Bellflower, common	*Campanula lasiocarpa*
Indian-paintbrush	*Castilleja*
Chickweed, mouse-ear	*Cerastium arvense*
Sweetvetch, alpine	*Hedysarum alpinum*
Sweetvetch, species	*Hedysarum spp.*
Twinflower	*Linnaea borealis*
Arctic lupine	*Lupinus arcticus*
Clubmoss, trailing	*Lycopodium complanatum*
Clubmoss	*Lycopodium spp.*
Bluebells, tall	*Mertensia paniculata*
Lousewort, capitate	*Pedicularis capitata*
Lousewort, labrador	*Pedicularis labradorica*
Bistort, meadow	*Polygonum bistorta*
Cinquefoil, varileaf	*Potentilla diversifolia*
Fern, bracken	*Pteridium aquilinum*
Raspberry, arctic	*Rubus arcticus*
Cloudberry	*Rubus chamaemorus*
Willow, arctic	*Salix arctica*
Willow, skeleton-leaf	*Salix phlebophylla*
Unknown	*Senecio spp*
Campion, moss	*Silene acaulis*
Mountain-ash, greene's	*Sorbus scopulina*
Burreed, northern	*Sparganium hyperboreum*
Valerian, Sitka	*Valeriana sitchensis*
Death camas, mountain	*Zigadenus elegans*

Wetlands in the project study area, based on NWI data, are shown on Figure 3-3 (USFWS, 2012). The predominant wetland types that may be affected by the project area are: open water wetlands, such as the lakes of the Tiekel River delta and the ponds perched on the terraces above the river canyon; palustrine wetlands, such as the marshes of the delta and the shrubby bogs perched along the canyon terraces; and riverine wetlands in the canyon and delta.

Figure 3-3 NWI Mapping of the Project Study Area (USFWS, 2012)



3.7.2.2 Known Wildlife Resources

The most complete information on regional wildlife is available from the National Park Service (NPS) for the Wrangell-St. Elias NP and from the ADF& G for GMU 13 and subunit 13D. Table 3-6 lists the 48 mammal species recorded for Wrangell-St. Elias NP that possibly also occur in the project area (NPS, 2008). The most common large mammals in the project area are likely Dall sheep, moose, mountain goats, wolves, and black and brown bears. Common furbearers and small mammals include: lynx, wolverine, beaver, marten, porcupine, fox, coyotes, marmots, river otters, ground squirrels, pikas, voles and shrews. Of the marine mammals occurring in Wrangell-St. Elias NP, only the harbor seal may come up the Copper River as far as the Tiekel River confluence.

Table 3-6 Mammal Species of Wrangell-St. Elias National Park that Potentially Occur in the Project Area (NPS, 2008)

Common Name	Scientific Name
Masked Shrew	*Sorex cinereus*
Dusky Shrew	*Sorex monticolus*
Pygmy Shrew	*Sorex hoyi*
Water Shrew	*Sorex palustri*
Tundra Shrew	*Sorex tundrensis*
Tiny Shrew	*Sorex yukonicus*
Little Brown Bat	*Myotis lucifugus*
Collared Pika	*Ochotona collaris*
Snowshoe Hare	*Lepus americanus*
Northern Flying Squirrel	*Glaucomys sabrinus*
Hoary Marmot	*Marmota caligata*
Arctic Ground Squirrel	*Spermophilus parryii*
Red Squirrel	*Tamiasciurus hudsonicus*
American Beaver	*Castor canadensis*
Deer Mouse	*Peromyscus maniculatus*
Bushy-tailed Woodrat	*Neotoma cinerea*
Northern Red-backed Vole	*Clethrionomys rutilus*
Long-tailed Vole	*Microtus longicaudus*
Singing Vole	*Microtus miurus*
Tundra Vole	*Microtus oeconomus*
Meadow Vole	*Microtus pennsylvanicus*
Taiga Vole (probable)	*Microtus xanthognathus*
Common Muskrat	*Ondatra zibethicus*
Brown Lemming	*Lemmus trimucronatus*
Northern Bog Lemming	*Synaptomys borealis*
Meadow Jumping Mouse	*Zapus hudsonicus*
Common Porcupine	*Erithizon dorsatum*
Coyote	*Canis latrans*
Gray Wolf	*Canis lupus*
Red Fox	*Vulpes vulpes*
Black Bear	*Ursus americanus*
Brown (Grizzly) Bear	*Ursus arctos*
Harbor Seal	*Phoca vitulina*
American Marten	*Martes americana*
Ermine	*Mustela erminea*
Least Weasel (probable)	*Mustela nivalis*
American Mink	*Mustela vison*
Wolverine	*Gulo gulo*
Northern River Otter	*Lontra canadensis*
Sea Otter	*Enhydra lutris*
Canada Lynx	*Lynx canadensis*
Puma (possible)	*Puma concolor*
Moose	*Alces alces*
Caribou	*Rangifer tarandus*
American Bison	*Bison bison*
Mountain Goat	*Oreamnos americanus*
Dall's Sheep	*Ovis dalli*

ADF&G publishes management reports for species whose populations are hunted or managed. These provide some regional information on a number of species of economic and subsistence interest occurring in the project area, which lies within GMU 13 and subunit 13D.

Black Bear. Generally, data from field observations and harvest statistics indicate that black bear are abundant in large portions of GMU 13D, which has more black bears than other subunits (Robbins, 2011). Bears tend to live where there is favorable forested habitat; although, they also may use shrub habitats in spring and fall. Observations indicate, however, there is less forest habitat in the Tiekel River canyon than other parts of GMU 13D. The ADF&G has not made a black bear population estimate for GMU 13 nor have they documented trends (Robbins, 2011). Lack of access to areas of GMU 13D is considered responsible for a low harvest of black bears in the area (Robbins, 2011).

Brown Bear. The latest data reported by ADF&G (May 2006 to May 2008) indicate a minimum density of 13.4 independent brown bears/1000 square kilometers (km^2) (25.4 all brown bears/1,000 km^2) in GMU 13 (Toby and Schwanke, 2009). Much of the focus of brown bear population studies in GMU 13 has been in the western portion near the proposed Susitna/Watana Hydroelectric Project and may not be entirely representative of conditions in the Tiekel River canyon. The intent of management in GMU 13 is to control bear numbers to increase moose populations. Likely recruitment of bears from Wrangell-St. Elias NP has maintained the brown bear population in GMU 13 – despite high harvest numbers (Toby and Schwanke, 2009).

Dall Sheep. The Tiekel River Controlled Use Area is a walk-in only hunting area extending north from the Tiekel River. The ADF&G has collected data on Dall sheep in this area for many years. They report a population low of 148 sheep in 1976 that increased to a high of 312 in 1992 and has decreased but apparently stabilized at 171 sheep – as last reported in 2008 (Schwanke et al., 2008).

Furbearers. Information on furbearer populations in GMU 13 is sparse and based on harvest statistics. Only beaver, lynx, river otter, and wolverine pelts are sealed, but trapper interviews also supplied information on these and other species, such as fox, coyote, muskrat, mink, marten, weasel, and wolf (Schwanke, 2010). ADF&G also monitors yearly trends in lynx abundance using standardized aerial transects for winter track surveys (Schwanke, 2010). The furbearer population is considered healthy and any fluctuations are within normal ranges (Schwanke, 2010). Aquatic, riparian, and forest habitats in the project study area are likely the most heavily used by furbearers, with the exception of those that may also use alpine tundra, such as fox, coyotes, wolves, and wolverine.

Moose. Although moose numbers have been increasing in GMU 13 in general, GMU 13D had the lowest moose density compared to the rest of the unit (2009 data – Tobey and Schwanke, 2010). Snow depth is a limiting factor for moose. Moose habitat is likely limited in the project area with the best forage and shelter being along the floodplain near the Richardson Highway and near the confluence of the Tiekel and Copper rivers.

Mountain Goats. All recent estimates of mountain goat populations in GMU 13D are based on incidental counts collected during Dall sheep surveys. Mountain goat populations in the western Chugach Mountains are likely limited by deep snow and heavy ice conditions during winter

(Coltrane, 2010). The general vicinity of the project study contains many areas that would be considered good mountain goat habitat: rocky steep slopes for escape; open grassy slopes for feeding; and dense shrubs and rock outcrops for cover (Coltrane, 2010).

Wolves. GMU 13 has been actively managed to control wolf numbers with the goal of increasing the populations of moose and caribou. Wolf control measures brought estimated wolf numbers in GMU 13 down from 520 in fall 2000 to objective levels of 135 to 165 (3.3 to 4.1 wolves/1000 km^2) by 2006 (Schwanke, 2009). The project study area is likely not an area of high wolf numbers because of limited high quality habitat for prey species.

Birds. Wrangell-St. Elias NP maintains a list of over 200 bird species sighted within park boundaries (NPS, 2012). Of those bird species recorded in all habitat types in the NP, perhaps 160 bird species may also occur in the project study area (Table 3-7).

Table 3-7 Birds Species Potentially Occurring in the Project Area (derived from NPS, 2008)

Common Name	Scientific Name
Red-throated loon	*Gavia stellata*
Pacific loon	*Gavia pacifica*
Common loon	*Gavia immer*
Horned grebe	*Podiceps auritus*
Red-necked grebe	*Podiceps grisegena*
Tundra swan	*Cygnus columbianus*
Trumpeter swan	*Cygnus buccinator*
Greater white-fronted goose	*Anser albifrons*
Snow goose	*Chen caerulescens*
Canada goose	*Branta canadensis*
Green-winged teal	*Anas crecca*
Blue-winged teal	*Anas discors*
Mallard	*Anas platyrynchos*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American widgeon	*Anas americana*
Eurasian widgeon	*Anas penelope*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Greater scaup	*Aythya marila*
Lesser scaup	*Aythya affinis*
Common eider	*Somateria mollissima*
Harlequin duck	*Histrionicus histrionicus*
Long-tailed duck (oldsquaw)	*Clangula hyemalis*
Black scoter	*Melanitta nigra*
Surf scoter	*Melanitta perspicillata*
White-winged scoter	*Melanitta fusca*
Common goldeneye	*Bucephala clangula*
Barrow's goldeneye	*Bucephala islandica*
Bufflehead	*Bucephala albeola*

Common Name	Scientific Name
Common merganser	*Mergus merganser*
Red-breasted merganser	*Mergus serrator*
Bald eagle	*Haliaeetus leucocephalus*
Northern harrier	*Circus cyaneus*
Sharp-shinned hawk	*Accipiter striatus*
Northern goshawk	*Accipiter gentilis*
Swainson's hawk	*Buteo swainsoni*
Red-tailed hawk	*Buteo jamaicensis*
Rough-legged hawk	*Buteo lagopus*
Golden eagle	*Aquila chrysaetos*
American kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Peregrine	*Falco peregrinus*
Gyrfalcon	*Falco rusticolus*
Spruce grouse	*Dendragopus canadensis*
Willow ptarmigan	*Lagopus lagopus*
Rock ptarmigan	*Lagopus mutus*
White-tailed ptarmigan	*Logopus leucurus*
Ruffed grouse	*Bonasa umbellus*
Sharp-tailed grouse	*Tympanuchus phasianellus*
Sandhill crane	*Grus canadensis*
American coot	*Fulica americana*
American golden plover	*Pluvialis dominica*
Black-bellied plover	*Pluvialis squatarola*
Semi-palmated plover	*Charadrius semipalmatus*
Killdeer	*Charadrius vociferus*
Greater yellowlegs	*Tringa melanolueca*
Lesser yellowlegs	*Tringa flavipes*
Solitary sandpiper	*Tringa solitaria*
Upland sandpiper	*Bartramia longicauda*
Wandering tattler	*Heteroscelus incanus*
Whimbrel	*Numenius phaeopus*
Hudsonian godwit	*Limosa haemastica*
Ruddy turnstone	*Arenaria interpres*
Western sandpiper	*Calidris mauri*
Least sandpiper	*Calidris minutilla*
Baird's sandpiper	*Calidris bairdii*
Pectoral sandpiper	*Calidris melanotos*
Semiplamated sandpiper	*Calidris pusilla*
Long-billed dowitcher	*Limnodromus scolopaceus*
Common snipe	*Gallinago gallinago*
Surfbird	*Aphriza vergata*
Red-necked phalarope	*Phalaropus lobatus*
Long-tailed jaeger	*Stercorarius longicaudus*
Parasitic jaeger	*Stercorarius parasiticus*
Bonaparte's gull	*Larus philadelphia*
Ring-billed gull	*Larus delawarensis*
Mew gull	*Larus canus*
Herring gull	*Larus argentatus*
Glaucous gull	*Larus glaucescens*
Glaucous-winged gull	*Larus glaucescens*

Common Name	Scientific Name
Arctic tern	*Sterna paradisaea*
Great horned owl	*Bubo virginianus*
Snowy owl	*Nyctea scandiaca*
Northern hawk owl	*Surnia ulula*
Great grey owl	*Strix nebulosa*
Short-eared owl	*Asio flammeus*
Boreal owl	*Aegolius funereus*
Rufous hummingbird	*Selasphorus rufus*
Belted kingfisher	*Ceryle alcyon*
Hairy woodpecker	*Picoides villosus*
Three-toed woodpecker	*Picoides tridactylus*
Black-backed woodpecker	*Picoides arcticus*
Northern flicker	*Colaptes auratus*
Downy woodpecker	*Picoides pubescens*
Olive-sided flycatcher	*Contopus borealis*
Western wood-pewee	*Contopus sordidulus*
Alder flycatcher	*Empidonax alnorum*
Say’s phoebe	*Sayornis saya*
Hammond's flycatcher	*Empidonax hammondii*
Horned lark	*Eremophila alpestris*
Tree swallow	*Tachycineta bicolor*
Violet-green swallow	*Tachycineta thalassina*
Bank swallow	*Riparia riparia*
Cliff swallow	*Hirundo pyrrhonota*
Barn swallow	*Hirunda rustica*
Gray jay	*Perisoreus canadensis*
Black-billed magpie	*Pica pica*
Common raven	*Covrus corax*
Steller's jay	*Cyanocitta stelleri*
Black-capped chickadee	*Parus atricapillus*
Boreal chickadee	*Parus hudsonicus*
Siberian tit	*Parus cinctus*
Red-breasted nuthatch	*Sitta canadensis*
Brown creeper	*Certhia americana*
American dipper	*Cinclus mexicanus*
Golden-crowned kinglet	*Regulus satrapa*
Ruby-crowned kinglet	*Rugulus calendula*
Gray-cheeked thrush	*Catharus minimus*
Swainson’s thrush	*Catharus ustulatus*
Hermit thrush	*Catharus guttatus*
American robin	*Turdus migratorius*
Townsend's solitaire	*Myadestes townsendi*
Varied thrush	*Ixoreus naevius*
Mountain bluebird	*Sialia currucoides*
Northern wheatear	*Oenanthe oenanthe*
Arctic warbler	*Phylloscopus borealis*
American pipit	*Anthus rubescens*
Bohemian waxwing	*Bombycilla garrulus*
Northern shrike	*Lanius excubitor*
European starling	*Sturnus vulgaris*
Orange-crowned warbler	*Vermivora celata*

Common Name	Scientific Name
Yellow warbler	*Dendroica petechia*
Yellow-rumped warbler	*Dendroica coronata*
Blackpoll warbler	*Dendroica striata*
Townsend's warbler	*Dendroica townsendi*
Northern waterthrush	*Seiurus noveboracensis*
Wilson’s warbler	*Wilsonia pusilla*
Rusty blackbird	*Euphagus carolinus*
Red-winged blackbird	*Agelaius phoeniceus*
American tree sparrow	*Spizella arborea*
Chipping sparrow	*Spizella passerina*
Savannah sparrow	*Passerculus sandwichensis*
Fox sparrow	*Passerella iliaca*
Song sparrow	*Melospiza melodia*
Lincoln’s sparrow	*Melospiza lincolnii*
Golden-crowned sparrow	*Zonotrichia atricapilla*
White-crowned sparrow	*Zonotrichia leucophrys*
Dark-eyed junco	*Junco hyemalis*
Lapland longspur	*Calcarius lapponicus*
Smith's longspur	*Calcarius pictus*
Snow bunting	*Plectrophenax hyperboreus*
Pine grosbeak	*Pinicola enucleator*
Rosy finch	*Leucosticte arctoa*
Common redpoll	*Carduelis flammea*
Hoary redpoll	*Carduelis hornemanni*
Pine siskin	*Carduelis pinus*
White-winged crossbill	*Loxia leucoptera*

The Copper River Delta is a critical area for migrating birds of all types, but especially waterbirds and shorebirds (NPS, 2012; USFS, 2000 and 2012; Ecotrust, 2005). Major migratory routes follow the river valleys of interior Alaska en route to the Copper River Delta and the coast, which accounts for the diversity of bird species recorded in the Copper River watershed. The Tiekel River watershed, especially wetland habitats, likely sees its share of migratory birds.

Wetlands in the Tiekel River delta, as well as wetlands perched along the canyon sides and in the floodplain near the Richardson Highway, are probably the most sensitive habitats for birds in the project study area. Harlequin ducks breed along steep gradient streams and may be present on the Tiekel River and its tributaries in the canyon. Forested habitats that may be impacted by inundation and facility construction could provide breeding and foraging habitat for a number of raptors and song birds.

In general, birds that potentially nest and rear young in the area would be most affected by the project. Those that are also listed as special concern species by ADF&G and/or have federal protection would include raptors (e.g. in appropriate habitats bald eagles and northern goshawks), trumpeter swans, loons, harlequin ducks, and migratory song birds (olive-sided flycatcher and blackpoll warbler). A pair of trumpeter swans was sighted on a Tiekel River delta lake during the reconnaissance visit of September 21, 2012. No obvious raptor nesting sites were observed during the September reconnaissance.

Amphibians. One amphibian, the wood frog (*Rana sylvatica*), likely occurs in the project area and the range of another, the western toad (*Bufo boreas*), extends as far north as the Tiekel River (AKHNP, 2012).

3.7.2.3 Project-Related Issues

Project-related issues involving terrestrial resources fall into three main categories: direct impacts – fill, excavation, and inundation; impacts to habitat from changes in hydrology; and impacts from increased human access and disturbance. Wetland maintenance near Tiekel River mouth including potential changes to Tiekel Lake may be one of the most important habitat issues. Additionally, the damping of flood flows may affect maintenance of riparian habitats, specifically early successional vegetation.

Scenarios 1A and 2:

- Shortest access roads – less cut and fill and human access reaches a shorter distance down the Tiekel River canyon and ends farther from the Copper River than other scenarios.
- Smallest impoundments – less area of riparian and upland habitats inundated than other scenarios.
- Furthest upstream dams – leave a longer length of riparian habitat below the dams unchanged except for hydrologic impacts.
- Impoundment of scenario 1A – possible effect on wildlife movements across the Tiekel River.
- Powerhouses and tailraces – would impact riparian habitats near area of valuable habitats near delta.
- Long transmission lines – could pose a bird collision hazard.

Scenarios 1B and 3A:

- Longer access roads than Scenarios 1A and 2 – more cut and fill and human access would extend closer to the delta, almost as far as Scenario 3B; may affect movements of wildlife up and down the canyon and across the Tiekel River gorge; however, the road alignment would provide the opportunity to bury the transmission line and mitigate the bird collision hazard.
- Larger impoundments than Scenarios 1A and 2 – much of the canyon riparian habitat inundated and may affect movements of wildlife up and down the canyon and across the Tiekel River gorge, but less than Scenario 3B. Powerhouses and tailraces – farther upstream from the delta than the other scenarios and would affect less valuable habitat. No direct impact to the delta area.
- Hydrologic changes – may affect wetlands and riparian vegetation succession in the delta.
- Long transmission lines – could pose a bird collision hazard (see comment above about access road alignment).

Scenario 3B:

- Longest access road – most cut and fill and human access would reach nearly to delta; may affect movements of wildlife up and down the canyon and across the Tiekel River gorge; however, the road alignment would provide the opportunity to bury the transmission line and mitigate the bird collision hazard.
- Largest impoundment – more area inundated and the entire high gradient canyon habitat lost (potential harlequin duck habitat); may inundate some of the wetlands perched on terraces (but may be compensated by replacement with more open water habitat of reservoir); and may affect movements of wildlife up and down the canyon and across the Tiekel River gorge.
- Powerhouse and tailrace – would impact riparian habitats near area of valuable habitats near delta.
- Hydrologic changes – may affect wetlands and riparian vegetation succession in the delta.
- Long transmission line – could pose a bird collision hazard (see comment above about access road alignment).

3.7.2.4 Study Needs

Studies will likely be requested for plants, wildlife, and habitats of special interest and concern or of economic importance. The state relies on its 'Wildlife Action Plan' (ADF&G, 2006) for conservation guidelines for habitats and species of concern and identifies species currently considered of "special concern." Such species that could possibly be found in the project area are listed in Table 3-3. Studies will not need to encompass all species on the list, but should include some species considered of "special concern." Studies related to habitat will also be required, including:

- Seasonal surveys for mountain goats, Dall sheep, bear denning, and moose use (especially moose wintering habitat) to understand presence and travel both up and down and across the Tiekel River canyon.
- Surveys for raptor nests (especially bald eagles), trumpeter swan nests, harlequin duck nests, and loon nests.
- Breeding bird surveys in areas of direct impacts.
- Investigation of bird migration pathways in the area to evaluate potential for bird collisions with the transmission line.
- Analysis of existing vegetation type/habitat classification and wetland mapping information available from the BLM (BLM, 2002) and USFWS (USFWS NWI mapping). Existing data may be sufficient for resource descriptions and impacts analysis.
- Areas directly impacted by fill and impoundment will require a wetlands determination.
- Some evaluation of invasive plants in areas of direct impacts – areas where there is a potential for invasives to be introduced.

- Study of hydrologic connections between the river, wetlands, and lakes in the Tiekel River delta area.

3.8 Cultural Resources

MWH subcontracted Stephen R. Braund & Associates (SRB&A) to identify cultural resources in the project study area through a review of available literature regarding archaeological and cultural data and an examination of the Alaska Heritage Resources Survey (AHRS) database.

SRB&A's detailed report contains confidential information not suitable for public distribution. It is provided in Appendix E for CVEA's reference; however, it should be redacted for wider distribution. A summary is provided in the following paragraphs.

The project study area used for this report includes all lands within Township 007 South, Ranges 001 to 003 East of the Copper River Meridian (C007S001E, C007S002E, and C007S003E). This project study area is larger than the proposed footprints of the dam and reservoir configurations, but because the precise locations of these and other facilities and infrastructure associated with the proposed hydroelectric project are not yet known, a broad project study area is justified to provide a comprehensive overview of cultural resources in the vicinity of the candidate projects.

SRB&A's research results indicate that a total of 15 previously documented cultural resources sites are located within the project study area, although several additional resources have been reported from the area that lack precise location information. A majority of past research efforts in the area have focused on the Richardson Highway/Trans-Alaska Pipeline System (TAPS) corridors at the western side of the project area and along the banks of the Copper River on the eastern side of the project area. Historic resources are well represented in these areas, a majority of which relate to the Copper River and Northwestern Railroad which operated between Cordova and Chitina in the early 20th century. Periodic compliance-driven surveys along TAPS and the Richardson Highway have revealed additional historic materials relating to the construction of the Valdez Trail and the Washington-Alaska Military Cable and Telegraph System (WAMCATS). In contrast, little archaeological investigation has taken place within the lower Tiekel River valley itself, and while the project area contains only one or two possible archaeological sites, other sites are known to exist outside of the project boundaries, and the absence of known sites in the project study area may be a result from a lack of examination rather than a lack of existence.

The present review of available literature and cultural resource information has demonstrated that, overall, the project study area has received only cursory examination in past investigations. Areas near the major transportation corridors (Richardson Highway and Copper River) have been more intensively examined, resulting in the 15 documented sites clustering along these corridors.

As the project moves forward beyond the literature review, CVEA will likely be required to address and manage cultural resources in the project study area under a number of legal mandates, potentially including the: National Historic Preservation Act of (NHPA), National Environmental Policy Act (NEPA), Alaska State Historic Preservation Act, Native American Graves Protection and Repatriation Act, American Indian Religious Freedom Act, and several Executive Orders pertaining to historic preservation and the recognition of indigenous sacred sites. For development of a license application it will be necessary to include archaeological surveys, collection of oral histories from indigenous communities in the region, and archival research concerning the development of the region in the historic period, or other cultural resource research activities.

Consulting with the State Historic Preservation Officer (SHPO), Native communities and tribal governments, Ahtna, Inc., all landowners whose property will be used or impacted by the proposed construction, other interested parties, and the public at large will be an integral part of addressing cultural resources as the project moves forward beyond the literature review. This consultation should begin as soon as the project enters into the feasibility stage to allow interested parties to be included in the process of determining how cultural resources might be affected by the proposed configurations and how they will be addressed during the life of the project. This early consultation will help prevent unnecessary delays in planning and development as the project moves forward.

3.9 Recreation and Other Resources

Typical recreational use of the Project area includes, but is not limited to: hiking, fishing, berry-picking, heli-skiing, and recreational boating.

ADNR manages the Thompson Pass Special Use Area (Figure 1-1) that overlaps a portion of the Tiekel River watershed. The management plan for the Thompson Pass Special Use Area is limited to requirements for guided back country skiing activities.

Tiekel River is located within ADF&G GMU 13D and forms the southern boundary of the Tonsina Controlled Use Area within GMU 13D. The Tonsina Controlled Use Area is closed to the use of motorized vehicles or pack animals for hunting and the transportation of hunters, gear, or harvested game from July 26 to September 30. This restriction on motorized vehicles limits the number of hunters that utilize the area; however, ADF&G reports indicate that game animals such as grizzly bear, moose, caribou, mountain goat, and sheep are all harvested within GMU 13D. It is likely that a reservoir created by a candidate project will increase access for hunters to GMU 13D.

Within the Tiekel Special Recreation Management Area (SRMA), as characterized by the BLM, several trails begin at entrance points on the Richardson Highway and provide access to recreation opportunities off of the road system (BLM, 2006). The BLM maintains three trailheads within the area. The BLM reports that the southern portion of the Tiekel SRMA, which is located north of the study area, "is renowned for winter skiing activities because of the heavy snows that accumulate during winter months." (BLM, 2006). There are permitted helicopter-supported skiing and snowboarding enterprises operating on BLM and State lands within the area (BLM, 2006). A reservoir created by a candidate project would open up new areas for hiking, camping, and watersports.

ADF&G reports that the Tiekel River contains small Dolly Varden in the stretch of the river that parallels the Richardson Highway, between Mileposts 43 and 50. There is no indication that fishing is a substantial activity occurring in the lower reach of the river. The lower portion of the Tiekel River is characterized as containing habitat suitable for rearing of coho and Chinook salmon by *the Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* (Catalog) – (Johnson & Blanche, 2012). However the Catalog does not indicate that the Tiekel supports any spawning runs of salmon. There is no historic indication that salmon fishing has occurred on the Tiekel, and there is little information regarding any other fishing interests in the lower portion of the river.

The Tiekel River has historically been divided into two sections for purposes of describing boating opportunities, the upper portion and the lower (or canyon run) portion. The upper portion is approximately 19 river-miles long, running from put-ins along the Richardson Highway from approximately Milepost 61.5, or more likely Milepost 60 (above Milepost 60, the river is quite small), to the take-out at the last highway bridge crossing the river at Richardson Milepost 46.9. This is a section marked by Class II waters suitable primarily for kayaks and white-water rafts. Of the two portions of the river, this upper section is more accessible and more easily run and receives the bulk of any boat-use (Embick, 2004).

The canyon run section is approximately 16 river miles long and is considered Class V to VI with several difficult portages. The put-in is at Milepost 45.6, where the Richardson Highway crosses Stuart Creek, and the take-out is at the confluence of the Tiekel with the Copper River. The technical challenges to successfully running the river include high flows during most of the year; steep, deep canyon walls; several portages requiring technical climbing; and reports of 30 to 35 foot waterfalls. Jet boats have run tourism trips up the Tiekel from the Copper River, but stop before encountering any waterfalls (Embick, 2004).

No Federal Power Act withdrawals or Wild and Scenic designation activities have been located in the Project area to date.

3.10 Environmental and Community Benefit Analysis

There are no immediately apparent constraints to project development with respect to environmental and community benefits. MWH has not undertaken to identify or quantify specific environmental and community benefits at this early stage. Once a preferred project emerges, it will become more clear what service area and stakeholders would be appropriate to include in such an analysis.

4 Site Visits

4.1 Initial Site Visit

Three members of the MWH project study team – two hydropower planning engineers and a hydrologist – performed an initial site visit in conjunction with the project kickoff meeting. The field work was conducted by helicopter on July 30, 2012. A map used for flight planning is included as Exhibit 03 (Appendix A). The team landed near the river at a confluence with a major sidestream between Dam Alternative locations 1 and 2. This location is the powerhouse location for scenarios 1B and 3A. This initial site visit allowed refinement of map-based project concepts and early identification of critical factors to consider during the remainder of the study. Figures 4-1 through 4-8 present photographs taken during the initial site visit.

Figure 4-1 Dam Alternative 1 (Photo 7-30-12)

Figure 4-2 Dam Alternative 2 (Photo 7-30-12)

Figure 4-3 Dam Alternative 3 (Photo 7-30-12)

Figure 4-4 Scenario 1B, 3A Powerhouse – Landing Site (Photo 7-30-12)

Figure 4-5 Scenario 1B, 3A Powerhouse – Rock Outcrop (Photo 7-30-12)

Figure 4-6 Scenario 1B, 3A Powerhouse – Rock Detail (Photo 7-30-12)

Figure 4-7 Scenario 1B, 3A Powerhouse – View Upstream (Photo 7-30-12)

Figure 4-8 Scenario 1B, 3A Powerhouse – View Downstream (Photo 7-30-12)

4.2 Critical Factor Site Visit

Following initial concept development and resource analyses, specialty engineers and environmental specialists attempted to visit the site for a more detailed reconnaissance. A geosciences specialist, a site access specialist, and an aquatic resource specialist were able to visit the area by helicopter on September 21, 2012. They made several landings, as described in Section 5.7 of this report. Due to extremely high water, they were unable to land near the river near dam or powerhouse locations. The terrestrial resource specialist and hydropower dam designer were weathered into Valdez and unable to visit the site. Key observations included:

- No obvious anadromous fish velocity barriers such as major falls were observed.
- Tiekel River delta area has the characteristics of valuable fish and wildlife habitat, as well as terrestrial, recreational and cultural resource value. There is also private property in the delta area.
- New road construction with helicopter/jetboat support for some of the powerhouse locations appeared to be the most feasible option.
- Potential for avalanche and seismic hazards was noted.

Figures 4-9 through 4-12 present photographs taken during the critical factor site visit.

Figure 4-9 Dam Alternative 1 (Photo 9-21-12)

Figure 4-10 Dam Alternative 2 (Photo 9-21-12)

Figure 4-11 Dam Alternative 3 (Photo 9-21-12)

Figure 4-12 Site Access / Transmission Design Conditions (Photo 9-21-12)

5 Conceptual Engineering

This section of the report presents information on the conceptual engineering performed to arrive at the preliminary and conceptual definition of five Tiekel River development scenarios. Included in this chapter are MWH's opinion of the probable cost (given on a very preliminary basis due to the early stage state of project design information) and an economic feasibility review to characterize the potential for any of the identified scenarios to be economically feasible.

The sequence of conceptual engineering was as follows:

1. Identification of candidate dam and powerhouse locations
2. Identification of production targets to address the desired scenarios,
3. Hydrological studies,
4. Power and energy operational studies,
5. Screening and identification of physical scenario concepts meeting energy targets,
6. Preparation of conceptual layouts with preliminary feature refinement,
7. Geosciences review,
8. Transmission line and preliminary land ownership research
9. Cost estimation and
10. Economic review.

5.1 Identification of Candidate Dam and Powerhouse Locations

The first step in the conceptual engineering was to develop a map of the study area and identify logical locations for siting storage or run-of river dams and associated powerhouses.

A run of river intake or diversion dam was sited where it was judged that access was judged to be reasonably convenient from the Richardson Highway. From the intake dam, a long tunnel could be constructed to a point near the confluence of the Tiekel and the Copper, thus developing the whole study reach as a run of river project.

Dam Alternative 1 was identified on the Tiekel, near its confluence with the Copper River. A high dam at this point, with a powerhouse would be the largest storage facility that could be developed within the study reach.

The run of river with the long tunnel and the high dam near Copper River represent the two bookends in terms of development of the study area for hydropower.

Additional dam alternatives, termed Dam Alternatives 2 and 3, were also identified as potential dams to create reservoirs with storage. It was anticipated that Dam Alternatives 2 and 3 would be constrained to smaller storage volumes, but might offer economically attractive options or alternatives with lower environmental impact in comparison with a Dam Alternative 1 involving a high dam.

The locations of storage dams were identified by inspection of a map of the river prepared from publically available digital elevation data (described previously). Locations where the slope of the river bed changed from mild to a steeper section were considered as dam location candidates, while also considering the shape of the valley. Candidate powerhouses were located at the ends of steeper reaches. The locations of the candidate features identified for the study are shown on Exhibit 03 (Appendix A).

5.2 Target Hydro Project Power and Energy Production

This section provides numerical values for electricity loads that were used to appropriately size the candidate Tiekel River scenarios. Numerous assumptions and approximations have been incorporated in the development of the targets, but these are appropriate in the current early phase of studies. The electricity targets provide a basis for the determination of maximum usable generation that could be provided by any of the scenarios developed for consideration. For all of the Tiekel River scenarios, both usable (constrained by the calculated target) and potential generation values were determined.

5.2.1 Solomon Gulch Generation

The reference values for Solomon Gulch generation were initially taken from the 2012 production budgets provided by CVEA, which includes maintenance downtime for Solomon Gulch affecting the monthly distribution of average generation in comparison with the historical average production. A plot of average and median actual monthly Solomon Gulch generation for 1993 through 2011 and the 2012 production budget is shown on Figure 5-1.

Because the 2012 production budget is substantially different from the average and median in several months, the average Solomon Gulch generation values in MWh was used for estimating the target generation for the candidate projects. Average generation used in establishing targets were as follows:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2,383	2,200	2,548	2,116	4,314	6,170	6,769	6,600	5,570	5,040	2,718	2,550	48,978

The use of average historical values rather than the 2012 production budget is considered an appropriate representation of anticipated longer-term conditions for evaluating the candidate hydropower project development scenarios.

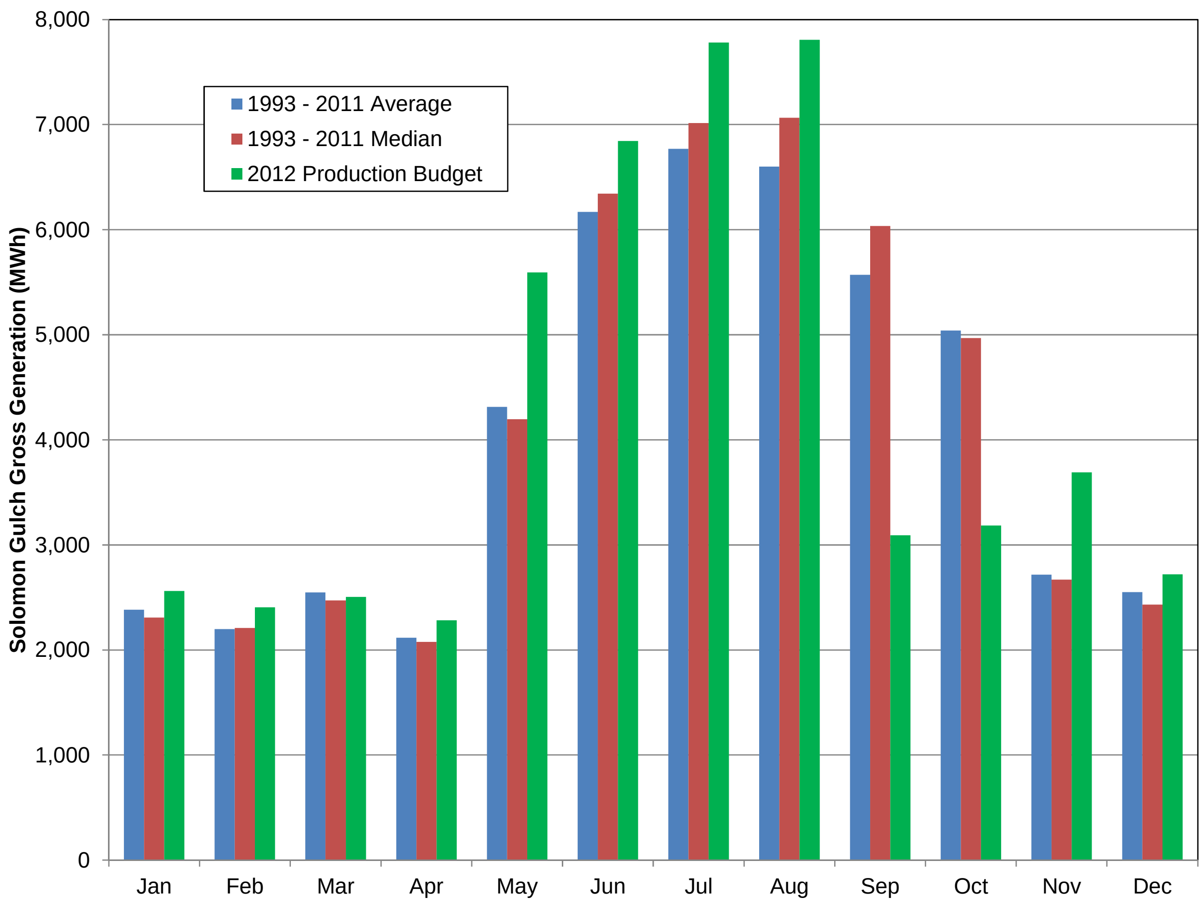
5.2.2 Loads and Resources Assumptions

The following key assumptions are incorporated in the development of the generation targets for each scenario:

- The total CVEA electricity load under existing conditions is shown below in MWh, as taken from the 2012 production budget provided by CVEA. This formed the base load for the scenarios, with modifications as noted in the following sections. Loads are typically projected to increase at some rate in future years.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
8,296	7,744	7,069	7,116	6,227	7,786	7,781	8,171	7,530	6,900	7,326	8,036	89,982

Figure 5-1 Solomon Gulch Monthly Historic Generation



- As the basis for the calculations with the Allison Creek and Tiekel River projects, the existing average distribution of load among the resources will be the following:

Pre-Allison Resources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MWh Total	Total
Solomon Gulch Gross Gen	2,383	2,200	2,548	2,116	4,314	6,170	6,769	6,600	5,570	5,040	2,718	2,550	48,978	54%
Diesel Gross Generation	2,608	2,044	721	1,700	413	1,616	1,012	1,271	1,360	760	1,308	2,181	16,994	19%
Cogen Gross Generation	3,305	3,500	3,800	3,300	1,500	0	0	300	600	1,100	3,300	3,305	24,010	27%
Total Gross Generation	8,296	7,744	7,069	7,116	6,227	7,786	7,781	8,171	7,530	6,900	7,326	8,036	89,982	100%

- Allison Creek is assumed to be constructed before the Tiekel River Project and would be available as a run-of-river project. To ensure that the Solomon Gulch reservoir fills, Allison Creek generation will generally be used before Solomon Gulch, when Solomon

Gulch is not spilling. The monthly potential generation from Allison Creek, as taken from the attachments to the RFP[2], will be as follows in MWh:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	0	0	100	2,200	4,300	4,800	4,300	3,600	2,700	1,000	400	23,500

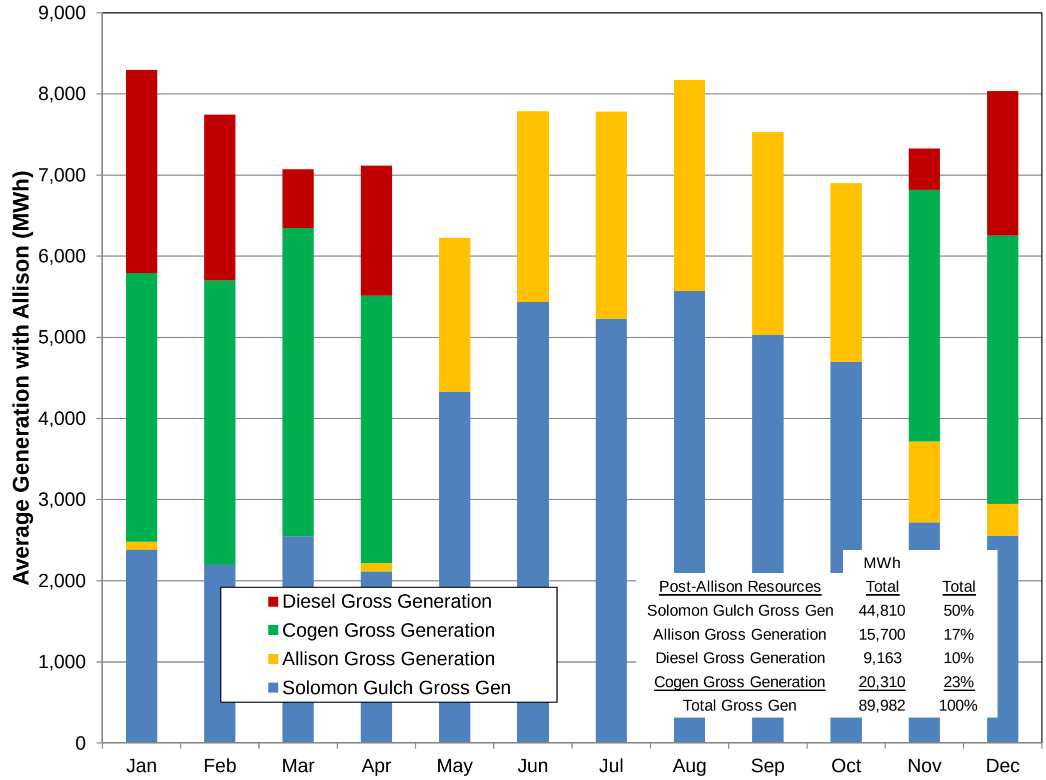
- Replacement of fossil fuel-fired generation in CVEA's system will include both diesel generation and the cogeneration plant.
- Once the Allison Creek project is on-line, but before the Tiekel River Project is on-line, the average loads and resources are calculated as follows:

Post-Allison Resources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MWh Total	Total
Solomon Gulch Gross Gen	2,383	2,200	2,548	2,116	4,327	5,436	5,231	5,571	5,030	4,700	2,718	2,550	44,810	50%
Allison Gross Generation	100	0	0	100	1,900	2,350	2,550	2,600	2,500	2,200	1,000	400	15,700	17%
Diesel Gross Generation	2,508	2,044	721	1,600	0	0	0	0	0	0	508	1,781	9,163	10%
Cogen Gross Generation	3,305	3,500	3,800	3,300	0	0	0	0	0	0	3,100	3,305	20,310	23%
Total Gross Generation	8,296	7,744	7,069	7,116	6,227	7,786	7,781	8,171	7,530	6,900	7,326	8,036	89,982	100%

During the months of May through July, when hydroelectric generation is sufficient to supply the entire load, the distribution of generation between Solomon Gulch and Allison does not affect the results of this analysis. Figure 5-2 graphically depicts the estimated monthly average resource utilization from the above table.

[2] RFP is the Request for Proposal issued during CVEA's procurement for the services described in this Tiekel River Hydropower Reconnaissance Study Report.

Figure 5-2 Average Monthly Generation with Allison Creek



- The basic fossil fuel-fired generation to be displaced by the Tiekel River Project would be as follows, with modifications for each scenario noted in the following sections:

Generation to be Displaced	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Diesel Gross Generation	2,508	2,044	721	1,600	0	0	0	0	0	0	508	1,781	9,163
Cogen Gross Generation	3,305	3,500	3,800	3,300	0	0	0	0	0	0	3,100	3,305	20,310
Total Fossil Fuel Gen.	5,813	5,544	4,521	4,900	0	0	0	0	0	0	3,608	5,086	29,473

5.2.3 Scenarios 1A and 1B

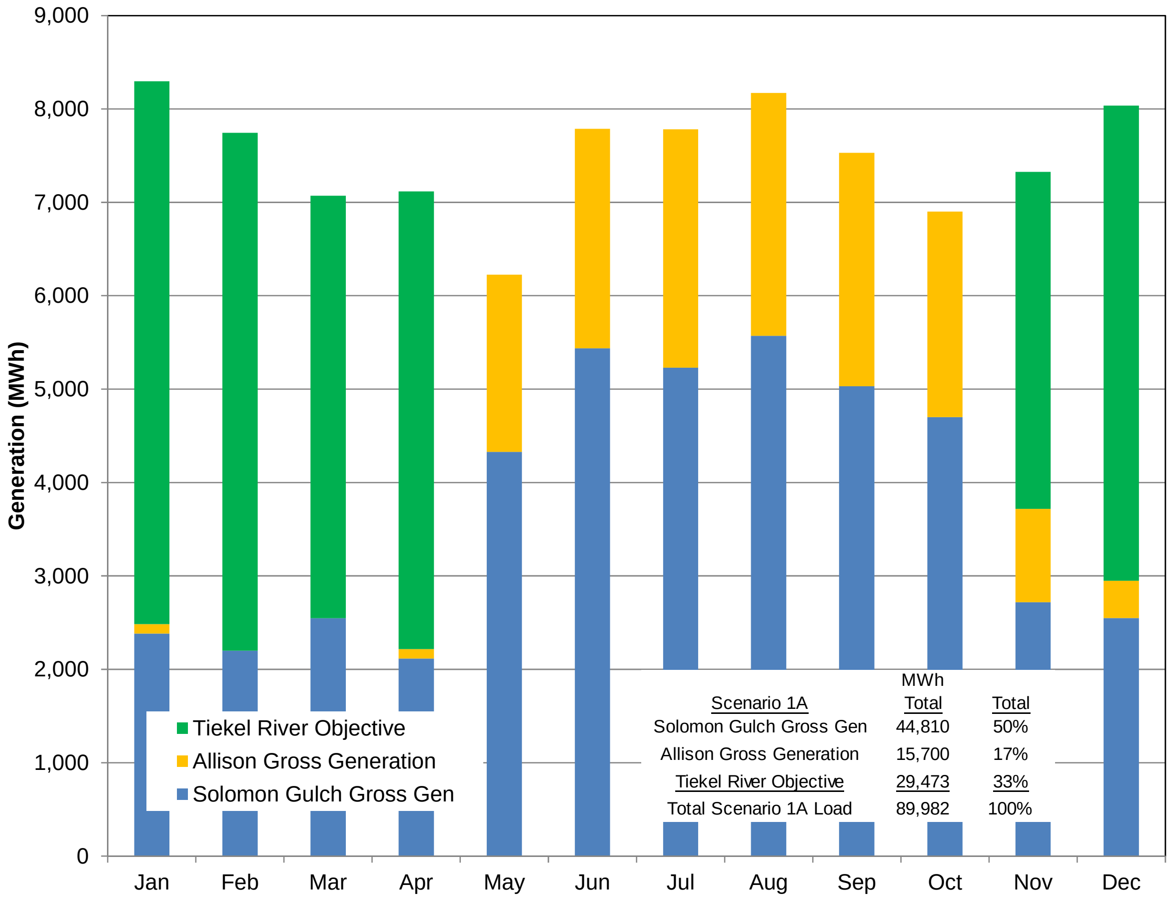
5.2.3.1 Scenario 1A

The objective of Scenario 1A is to provide cost effective energy to displace all existing fossil fuel-fired generation on CVEA's system. The fossil fuel generation to be displaced by Tiekel River generation has the following monthly distribution:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
5,813	5,544	4,521	4,900	0	0	0	0	0	0	3,608	5,086	29,473

Complete displacement of this energy pattern cannot be accomplished with a run-of-river project. Therefore, appropriately sized storage reservoirs for Alternatives 1, 2, and 3 were investigated to develop a preferred project layout for this scenario. The monthly generation distribution for Scenario 1A is plotted on Figure 5-3.

Figure 5-3 Average Monthly Scenario 1A Generation



5.2.3.2 Scenario 1B

The electricity load for Scenario 1B is defined as that from Scenario 1A, plus sufficient capacity to serve regional customers or new customers. Regional and new customers could include also Cordova (5 to 6 MW peak), Alyeska Valdez Marine Terminal (10 MW), or tankers (6 MW for periods of time). For the purposes of this Study, the new load will be estimated to be 5 MW of continuous new power requirement. That would total 43,800 MWh per year, or an increase of almost 50% in excess of the existing load. The new monthly load is summarized as follows:

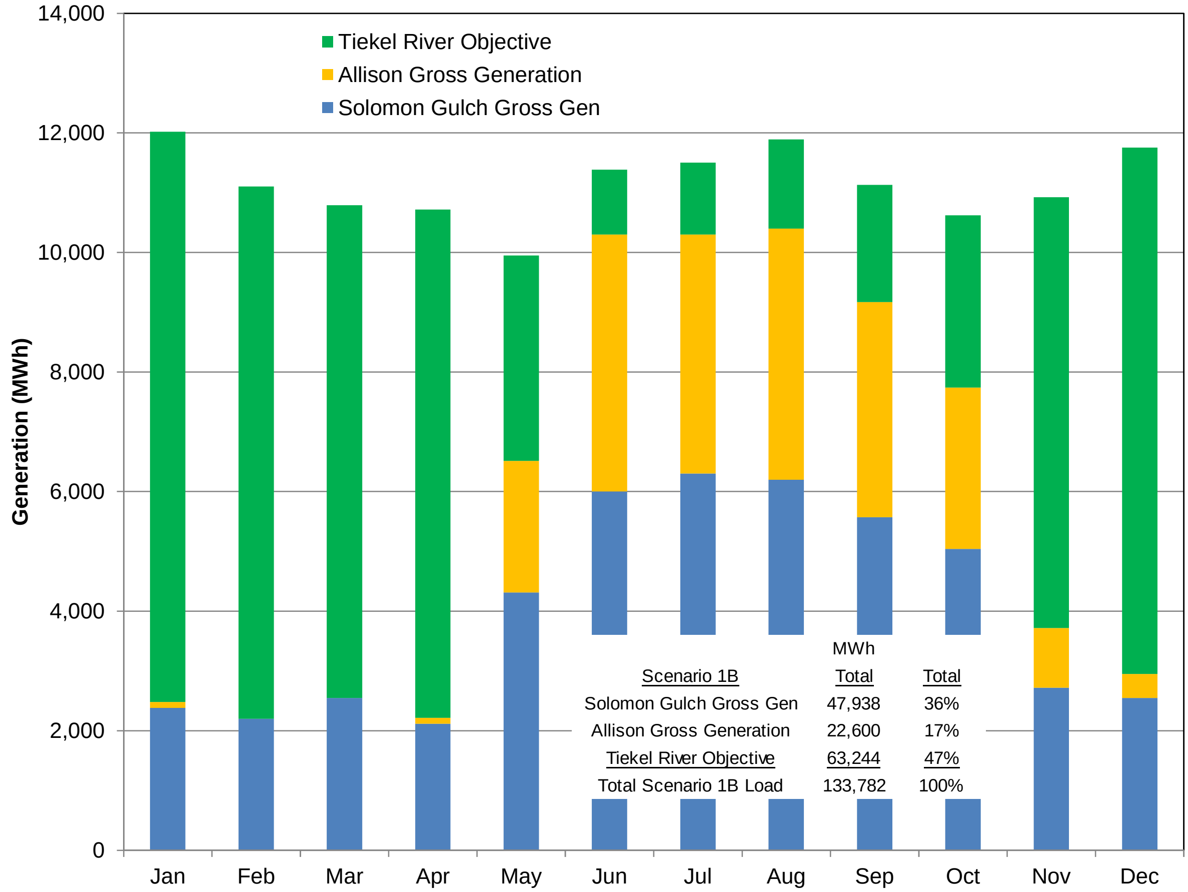
Scenario 1B	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MWh Total
Existing CVEA Requirements	8,296	7,744	7,069	7,116	6,227	7,786	7,781	8,171	7,530	6,900	7,326	8,036	89,982
Regional or New Load	3,720	3,360	3,720	3,600	3,720	3,600	3,720	3,720	3,600	3,720	3,600	3,720	43,800
Total Scenario 1B Load	12,016	11,104	10,789	10,716	9,947	11,386	11,501	11,891	11,130	10,620	10,926	11,756	133,782

Some of the additional load could be picked-up by existing resources, plus Allison Creek, so the distribution of generation including Tiekel River would be as follows:

Scenario 1B	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MWh Total	Total
Solomon Gulch Gross Gen	2,383	2,200	2,548	2,116	4,314	6,000	6,300	6,200	5,570	5,040	2,718	2,550	47,938	36%
Allison Gross Generation	100	0	0	100	2,200	4,300	4,000	4,200	3,600	2,700	1,000	400	22,600	17%
Tiekel River Objective	9,533	8,904	8,241	8,500	3,433	1,086	1,201	1,491	1,960	2,880	7,208	8,806	63,244	47%
Total Scenario 1B Load	12,016	11,104	10,789	10,716	9,947	11,386	11,501	11,891	11,130	10,620	10,926	11,756	133,782	100%

The monthly generation distribution for Scenario 1B is plotted on Figure 5-4.

Figure 5-4 Average Monthly Scenario 1B Generation



Because of the large amount of November through April generation that is needed for Scenario 1B, a substantial storage reservoir would be required. Dam Alternatives 1 and 2 might have sufficient topography for such a reservoir. It is unlikely that Dam Alternative 3 would allow for sufficient storage to provide the needed winter generation. These possibilities were investigated in formulating an appropriate configuration for Scenario 1B.

5.2.4 Scenario 2

The objective of Scenario 2 is to provide a meaningful increment of cost effective energy to displace existing fossil fuel-fired generation. This objective is assumed to be met if the fossil fuel displacement is about half of the objective for Scenario 1A. This would amount to an annual total of about 15,000 MWh of fossil fuel energy displacement, which could occur in any pattern as long as the monthly totals did not exceed the monthly generation objectives for Scenario 1A. The 15,000 MWh would be similar to the usable generation that is expected to be provided by Allison Creek, but the monthly distribution of usable generation would necessarily be different. The run-of-river forms of Dam Alternatives 1, 2, and 3 were checked to determine the amount of usable energy they can supply.

5.2.5 Scenarios 3A and 3B

5.2.5.1 Scenarios 3A

The objective for Scenario 3A is similar to that for Scenario 1B, except that the new load will be increased to 10 MW of continuous new power requirement that would total 87,600 MWh per year, or an increase of almost double the existing load. The new monthly load is summarized as follows:

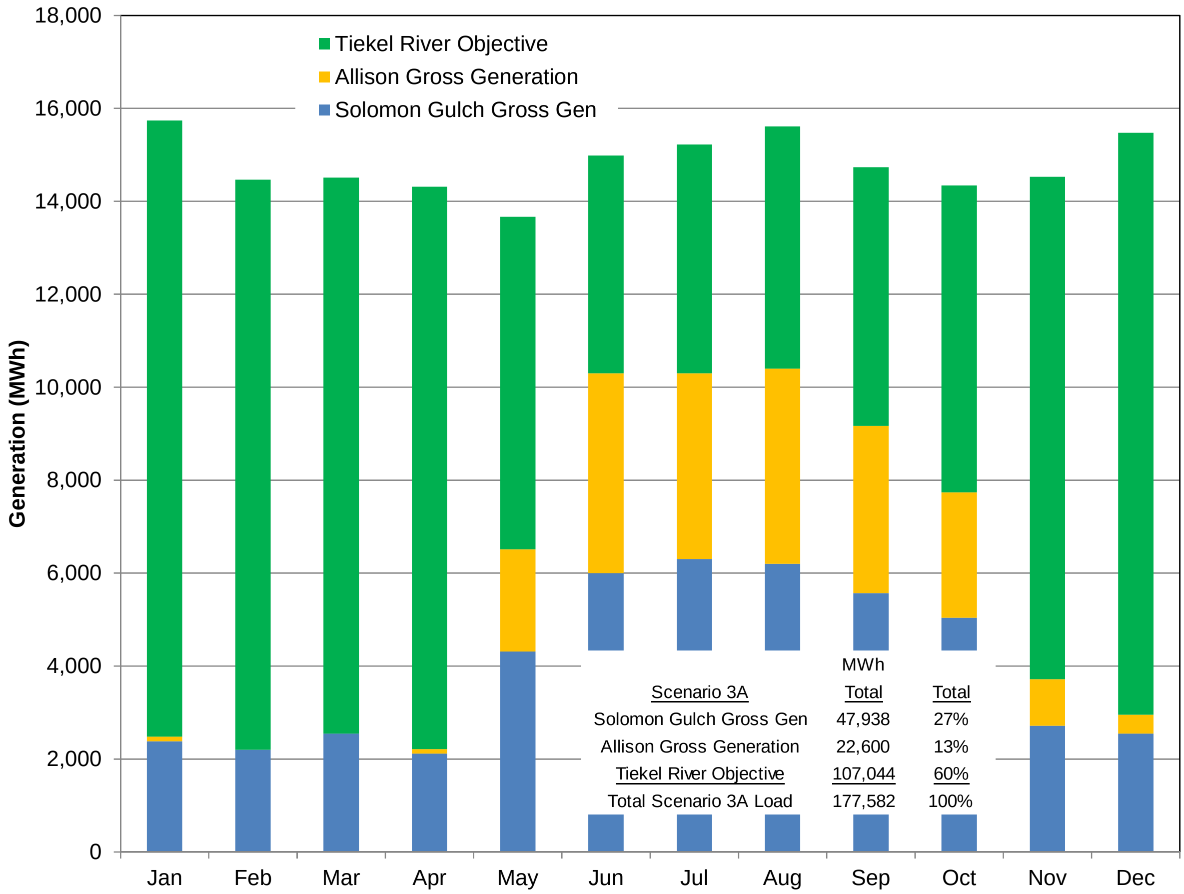
Scenario 3A	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MWh Total
Existing CVEA Requirements	8,296	7,744	7,069	7,116	6,227	7,786	7,781	8,171	7,530	6,900	7,326	8,036	89,982
Regional or New Load	7,440	6,720	7,440	7,200	7,440	7,200	7,440	7,440	7,200	7,440	7,200	7,440	87,600
Total Scenario 3A Load	15,736	14,464	14,509	14,316	13,667	14,986	15,221	15,611	14,730	14,340	14,526	15,476	177,582

Some of the additional load could be picked-up by existing resources plus Allison Creek, but the Tiekel River objective would be to generate 107 GWh per year. The distribution of generation including Tiekel River would be as follows:

Scenario 3A	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MWh Total	Total
Solomon Gulch Gross Gen	2,383	2,200	2,548	2,116	4,314	6,000	6,300	6,200	5,570	5,040	2,718	2,550	47,938	27%
Allison Gross Generation	100	0	0	100	2,200	4,300	4,000	4,200	3,600	2,700	1,000	400	22,600	13%
Tiekel River Objective	13,253	12,264	11,961	12,100	7,153	4,686	4,921	5,211	5,560	6,600	10,808	12,526	107,044	60%
Total Scenario 3A Load	15,736	14,464	14,509	14,316	13,667	14,986	15,221	15,611	14,730	14,340	14,526	15,476	177,582	100%

The monthly generation distribution for Scenario 3A is plotted on Figure 5-5.

Figure 5-5 Average Monthly Scenario 3A Generation



5.2.5.2 Scenario 3B

Scenario 3B is directed at providing an assessment of major regional generation benefits from the Tiekel River. The generation objective will not be exactly defined, but a minimum of roughly several hundred GWh annually is assumed to be necessary to provide major regional generation benefits. It will be assumed that the objective is to use the reservoir storage to provide maximum cool season (November through April) energy with a high reliability. It was assumed that all potential generation would be usable.

5.2.6 Scenario 4

Scenario 4 is directed at providing an assessment of potential statewide generation benefits from the Tiekel River. The generation objective will not be exactly defined, but a minimum of roughly 1,000 GWh annually is assumed to be necessary to provide significant statewide generation benefits. It was assumed that the additional electricity load would be effectively unlimited. For Scenario 4, the maximum generation potential from the Tiekel River would be developed. Dam Alternative 1 configured for the maximum dam height but constrained to avoid impact to existing infrastructure was used to attempt to achieve the Scenario 4 generation objective. This scenario would include the assumption that a new transmission line would be built to serve other load centers.

5.2.7 Summary

The annual Tiekel River generation objectives for the four scenarios (rounded to the nearest 100 MWh) are summarized below. It is expected that these scenarios will provide a sufficient range of alternatives to display a wide range of Tiekel River Project generation capabilities.

Scenario	Initial Annual Energy Production Target (MWh)
Scenario 1A	29,500
Scenario 1B	63,200
Scenario 2	15,000
Scenario 3A	107,000
Scenario 3B	>300,000
Scenario 4	>1,000,000

5.3 Hydrological Studies

This section summarizes the Tiekel River hydrology used for the reconnaissance studies. Included are summaries of available existing flow data in the vicinity of Tiekel River. The recorded flow data and other references are used to develop the long-term reservoir inflows for the power studies, and the flood hydrology for sizing of the spillways. The long-term reservoir inflows and the flood hydrology were developed for three alternative dam locations, as shown on Exhibit 03 (Appendix A).

5.3.1 Available Hydrological Data

Because no continuous recorded flow data is available at any location on the Tiekel River, a search for other recorded flow data in the region was conducted. Table 5-1 lists the available USGS data in the vicinity of Tiekel River.

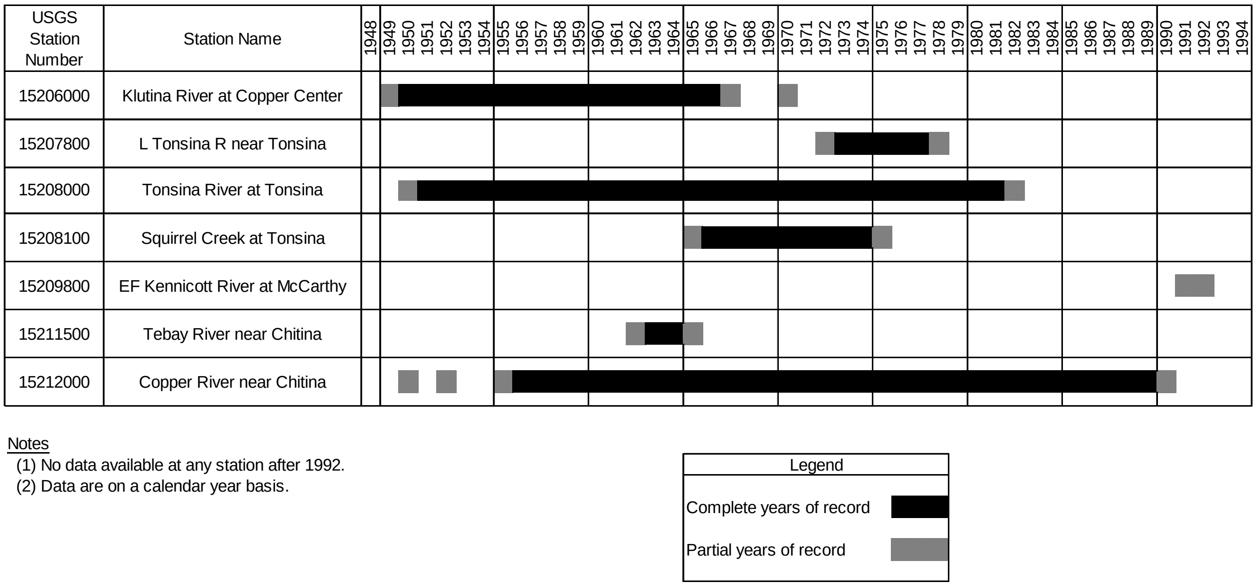
Table 5-1 also includes average flows in units that facilitate comparisons (cfs/square mile and inches of runoff over the watershed). The average flow values illustrate how runoff per unit area is progressively reduced when moving from stations near Valdez (Solomon Gulch and Allison Creek) to the rain shadowed inland stations (Klutina River and Squirrel Creek). Figure 5-6 presents the chronological availability of selected USGS stations with daily flow data. The longest records in the vicinity of Tiekel River are for the Tonsina River and Klutina River, that have comparable drainage areas, and for the Copper River that has a much larger drainage area.

Table 5-1 Available Flow Data Summary

USGS Gage Number	Gage Name	Drainage Area (sq.mi.)	Average Flow (1) (cfs/sq.mi.)	Average Runoff (inches)	Latitude	Longitude	Gage Datum (feet)	Available Period of Daily Flow Record (and additional data where no daily flow data is available)
None	Tiekel River at Alt.1 Dam Site	446	-----	-----	61°13'53"	144°54'10"	420	None
15212600	Tiekel River near Tiekel	115	-----	-----	61°16'56"	145°16'23"	1,190 approx.	No daily flow data, 4 years peak flow, 15 water quality samples
15213300	Tsina River above Stuart Creek	-----	-----	-----	61°15'25"	145°16'51"	1,170 approx.	No daily flow data or peak flow data, 8 water quality samples
15213400	Stuart Creek near Tiekel	37	-----	-----	61°15'32"	145°16'54"	1,220 approx.	No daily flow data, 10 years peak flow, 11 water quality samples
15206000	Klutina River. at Copper Center	938	1.78	24.2	61°57'10"	145°18'20"	1,011	18 years: 1949 - 1967
15207800	L Tonsina River near Tonsina	22.7	1.42	19.3	61°28'49"	145°09'05"	1,850	6 years: 1972 - 1978
15208000	Tonsina River at Tonsina	422	2.00	27.1	61°39'41"	145°11'02"	1,500	31 years: 1950 - 1982
15208100	Squirrel Creek at Tonsina	70.5	0.44	6.0	61°40'05"	145°10'26"	1,520	10 years: 1965 - 1975
15209800	EF Kennicott River at McCarthy	-----	-----	-----	61°26'04"	142°55'49"	1,345	1 year: 1991 - 1992 (partial years)
15211500	Tebay River near Chitina	55.4	2.74	37.2	61°13'55"	144°11'50"	1,796	3 years: 1962 - 1965
15212000	Copper River near Chitina	20,600	1.85	25.1	61°27'56"	144°27'21"	400	36 years: 1950 - 1990
15225945	Allison Creek	7.5	8.02	109	61°04'54"	146°21'06"	60	2 years: 1983 - 1985
15226000	Solomon Gulch near Valdez	19.7	8.20	111	61°05'02"	146°18'13"	1	25 years: 1986 - 2011
15226500	Lowe River near Valdez	201	5.78	78.4	61°05'49"	145°51'32"	450	3 years: 1971 - 1974

Note (1): Because the period of record varies widely among the stations, the cfs/sq.mi. values are general indicators and are not exactly comparable.

Figure 5-6 USGS Gage Flow Data Chronology



5.3.2 Long-Term Reservoir Inflows

Long-term daily reservoir inflows for each of the alternatives was used in the power studies to develop the generation estimates. The Tonsina River is adjacent to the Tiekel River and has a similar drainage area to the Tiekel River. Because the Tonsina River also has a continuous daily flow record of over 30 years, it was selected to be used as the base flow data to be adjusted to Tiekel River. Tebay River data is also critical, because it is in a geographically similar position in relation to the mountains, and because annual precipitation maps indicate similar values for Tebay and Tiekel River watersheds.

An initial comparison was made among the three rivers in the vicinity of the Tiekel River with long-term USGS records on the basis of runoff per unit area, as shown on Figure 5-7. Similarities in runoff during the low flow cold season are evident. Higher spring runoff for the Tonsina River can also be observed. Figure 5-8 shows the runoff relationships among the Klutina, Tonsina, and Tebay rivers. The Tebay exhibits somewhat higher runoff compared to the Tonsina, as might be expected from its geographic position.

Figure 5-7 Long-Term USGS Gage Daily Data

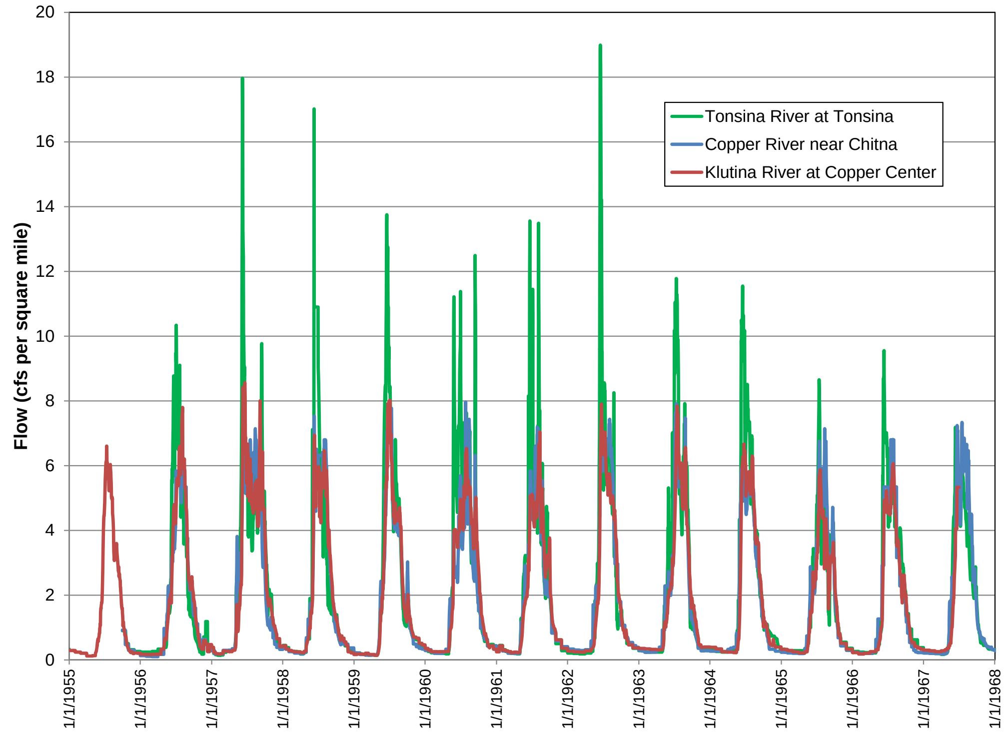
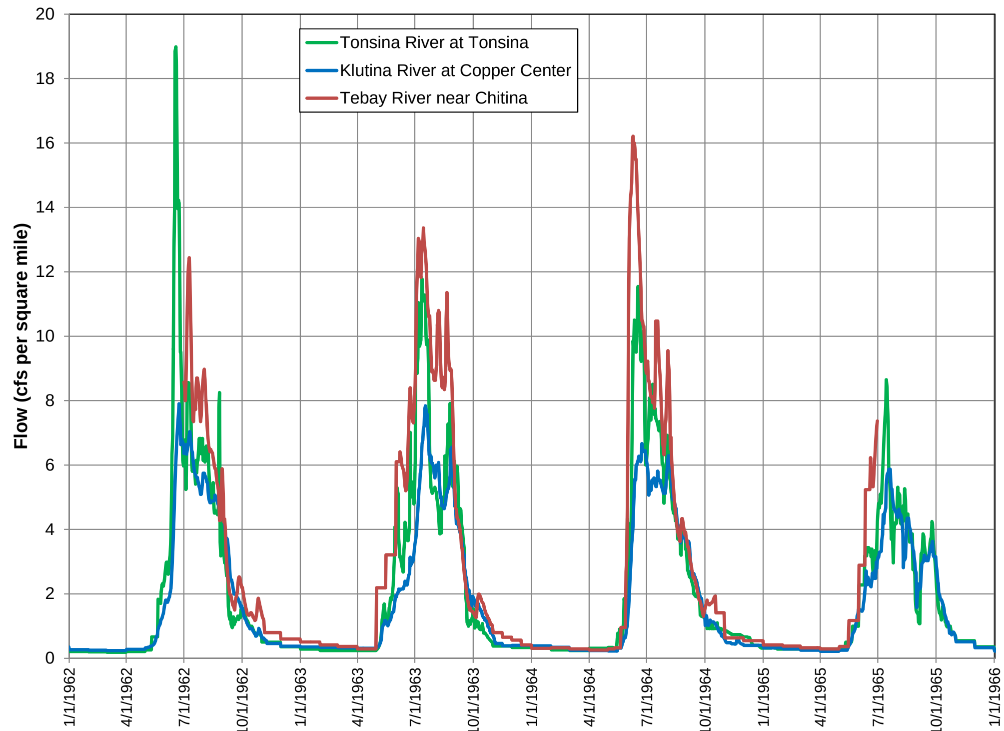


Figure 5-8 Tebay, Tonsina, and Klutina USGS Gage Daily Data



Factors considered in developing the adjustment factor from Tonsina River to the Tiekel River dam locations include:

- Drainage area;
- Available USGS flow records;
- Three different average annual rainfall maps;
- The pattern of decreasing runoff with increasing distance from Valdez that is related to topography and positioning of the watersheds in relation to the mountains;
- Observations made by the hydrologist during the initial site visit.

Based on concurrent USGS flow records, Tonsina River flows are about 16% greater than Klutina River flows on a runoff per unit area basis, and Tebay River flows are about 37% greater than Tonsina River flows. Two of the available average annual precipitation isohyetal maps (Lamke, 1979; Jones and Fahl, 1994) are in general agreement that Tiekel River and Tebay River have similar average annual precipitation, and both are about 25% greater than the average annual precipitation for the Tonsina River.

A third source for average annual precipitation that is very detailed and geographic information system (GIS)-based (Daly et al., 2009, as referenced in Percia et al., 2012) indicates that Tebay River has 107% greater precipitation than Tonsina River, and that the Tiekel River would have 16% greater average annual precipitation than Tebay River. Also, the GIS mapping shows the average Tonsina rainfall is 26 inches, but the recorded runoff is over 27 inches, which of course would be impossible. It was concluded that the Tonsina average precipitation from GIS mapping was low, and could not be used directly.

The final determination of flow for the Tiekel River was that it would be 30% greater than for the Tonsina River on a runoff per unit area basis. Final results show 2.0 cfs/sq. mi. for the Tonsina River, 2.6 cfs/sq. mi. for the Tiekel River, and 2.7 cfs/sq. mi. for Tebay River. The estimates for Tiekel River are more likely to be slightly low (conservative) than high, because there are indications that precipitation in the Tiekel River basin is about the same or greater than for the Tebay River basin.

A summary of flow data sets at the dam locations for Alternatives 1, 2, and 3 are shown in Tables 5-2, 5-3, and 5-4, respectively. Assuming that the runoff per unit area is the same at all of the dam locations is reasonable considering all locations are reasonably close to one another. The flows indicated in the tables are expected to be sufficient to fill the potential Tiekel River storage reservoirs in virtually every year, or perhaps every year in the 30 years of record.

Table 5-2 Flow (cfs) at Dam Alternative 1

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1951	130	120	120	124	657	2,264	4,038	2,487	3,896	872	467	206	1,287
1952	137	124	117	117	362	2,690	3,428	2,551	1,073	1,312	555	412	1,081
1953	234	165	96	120	1,156	6,437	4,597	2,931	1,511	490	275	220	1,524
1954	179	151	128	113	1,410	3,627	3,175	3,531	1,587	514	398	192	1,257
1956	137	137	151	192	575	3,252	4,219	2,529	927	347	217	389	1,097
1957	135	84	143	179	1,353	5,148	2,690	2,858	3,266	1,452	660	273	1,523
1958	240	159	144	120	687	5,779	3,564	1,929	843	503	276	158	1,203
1959	111	100	100	88	779	5,538	3,465	2,768	848	766	371	247	1,270
1960	164	124	121	111	1,917	3,901	3,648	2,894	2,299	667	289	261	1,373
1961	241	166	125	109	1,091	3,249	3,414	3,280	1,616	676	289	165	1,209
1962	122	114	109	121	593	4,975	3,868	3,053	992	578	289	206	1,257
1963	165	137	136	136	850	2,437	5,107	3,172	1,893	495	220	192	1,255
1964	179	151	137	179	493	4,680	4,057	2,638	1,192	564	438	281	1,254
1965	176	165	165	165	353	1,716	3,149	2,263	1,750	701	316	206	933
1966	151	137	132	124	417	3,758	3,163	2,277	1,705	683	357	220	1,097
1967	165	131	110	104	709	3,152	2,975	2,190	1,415	493	249	187	994
1968	179	188	214	176	1,221	3,818	3,924	2,338	1,091	376	230	200	1,169
1969	175	145	120	141	519	2,571	3,043	1,397	719	392	222	162	805
1970	133	119	115	150	605	2,143	2,829	2,474	1,073	438	247	159	880
1971	131	112	99	119	432	2,470	3,675	2,836	1,027	562	324	230	1,009
1972	190	149	130	131	1,137	2,822	3,896	2,917	1,620	806	429	216	1,212
1973	144	119	105	113	338	2,110	2,158	2,103	663	364	171	106	712
1974	76	59	50	53	724	2,000	2,822	2,624	1,959	601	213	117	948
1975	104	103	101	108	501	2,675	4,798	2,448	2,040	770	184	157	1,174
1976	112	101	96	108	709	3,352	3,089	2,631	1,037	601	465	355	1,060
1977	296	299	261	237	953	5,002	5,618	3,641	1,673	694	275	224	1,606
1978	197	172	147	150	515	2,190	2,605	2,520	1,152	393	181	150	869
1979	137	128	126	231	860	2,800	3,435	2,686	1,270	818	334	250	1,097
1980	237	215	183	199	1,005	4,200	4,546	2,749	1,167	601	256	128	1,298
1981	232	147	143	159	1,955	3,903	3,884	4,053	1,463	1,015	474	260	1,485
Average (cfs)	167	141	131	139	829	3,489	3,629	2,692	1,492	651	322	218	1,165
Maximum (cfs)	296	299	261	237	1,955	6,437	5,618	4,053	3,896	1,452	660	412	1,606
Minimum (cfs)	76	59	50	53	338	1,716	2,158	1,397	663	347	171	106	712
Avg.(cfs/sq.mi.)	0.37	0.32	0.29	0.31	1.86	7.82	8.14	6.04	3.35	1.46	0.72	0.49	2.61
Total (acre-feet)	10,264	7,815	8,046	8,281	50,988	207,594	223,159	165,544	88,794	40,057	19,179	13,384	843,106
Min. (acre-feet)	4,646	3,258	3,092	3,172	20,799	102,112	132,718	85,916	39,463	21,348	10,162	6,530	515,594

Table 5-3 Flow (cfs) at Dam Alternative 2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1951	124	115	115	118	628	2,163	3,857	2,375	3,722	833	446	197	1,229
1952	131	118	112	112	346	2,570	3,274	2,437	1,025	1,254	530	394	1,032
1953	223	157	92	115	1,104	6,148	4,391	2,799	1,444	468	262	210	1,456
1954	171	144	122	108	1,346	3,465	3,033	3,373	1,516	491	380	184	1,201
1956	131	131	144	184	549	3,106	4,030	2,416	885	332	207	371	1,047
1957	128	81	137	171	1,293	4,917	2,570	2,730	3,119	1,387	630	261	1,455
1958	229	151	138	114	656	5,520	3,404	1,843	805	480	264	151	1,149
1959	106	96	96	84	744	5,290	3,310	2,644	810	732	354	236	1,213
1960	157	118	116	106	1,831	3,726	3,484	2,764	2,196	637	276	249	1,312
1961	230	158	119	104	1,042	3,104	3,261	3,133	1,543	645	276	157	1,155
1962	117	109	104	115	566	4,752	3,694	2,916	947	552	276	197	1,201
1963	157	131	130	130	812	2,328	4,878	3,030	1,808	473	210	184	1,199
1964	171	144	131	171	470	4,470	3,875	2,520	1,138	539	418	268	1,198
1965	168	157	157	157	338	1,639	3,008	2,161	1,672	670	302	197	891
1966	144	131	126	118	399	3,589	3,021	2,175	1,629	652	341	210	1,048
1967	157	125	105	100	677	3,010	2,841	2,092	1,352	471	238	179	950
1968	171	180	204	168	1,167	3,647	3,748	2,234	1,042	359	220	191	1,117
1969	167	138	115	134	496	2,455	2,907	1,335	686	375	212	155	769
1970	127	113	110	143	578	2,047	2,702	2,363	1,025	419	236	152	840
1971	125	107	95	114	412	2,360	3,510	2,709	981	536	310	220	964
1972	181	143	124	125	1,086	2,696	3,722	2,786	1,547	770	410	207	1,157
1973	137	113	100	108	323	2,016	2,062	2,009	633	348	163	101	680
1974	72	56	48	51	692	1,911	2,696	2,507	1,871	574	203	112	905
1975	99	98	96	103	479	2,555	4,583	2,339	1,949	736	175	150	1,121
1976	107	96	92	103	677	3,202	2,950	2,513	990	574	444	339	1,013
1977	283	286	250	226	910	4,778	5,366	3,478	1,598	663	263	214	1,534
1978	188	164	141	143	491	2,092	2,488	2,407	1,100	375	173	143	830
1979	131	123	120	221	821	2,675	3,281	2,566	1,213	781	319	238	1,047
1980	226	206	175	190	960	4,012	4,342	2,626	1,115	574	244	122	1,239
1981	221	141	137	152	1,867	3,728	3,710	3,871	1,398	970	453	249	1,418
Average (cfs)	159	134	125	133	792	3,332	3,467	2,572	1,425	622	308	208	1,112
Maximum (cfs)	283	286	250	226	1,867	6,148	5,366	3,871	3,722	1,387	630	394	1,534
Minimum (cfs)	72	56	48	51	323	1,639	2,062	1,335	633	332	163	101	680
Avg.(cfs/sq.mi.)	0.37	0.32	0.29	0.31	1.86	7.82	8.14	6.04	3.35	1.46	0.72	0.49	2.61
Total (acre-feet)	9,803	7,465	7,685	7,910	48,702	198,285	213,152	158,120	84,812	38,261	18,319	12,784	805,298
Min. (acre-feet)	4,438	3,112	2,953	3,030	19,866	97,533	126,766	82,063	37,693	20,391	9,706	6,237	492,473

Table 5-4 Flow (cfs) at Dam Alternative 3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1951	107	98	99	101	539	1,858	3,314	2,041	3,198	716	383	169	1,056
1952	113	101	96	96	297	2,208	2,813	2,094	881	1,077	456	338	887
1953	192	135	79	99	949	5,282	3,773	2,405	1,240	402	225	180	1,251
1954	147	124	105	92	1,157	2,977	2,606	2,898	1,302	422	327	158	1,032
1956	113	113	124	158	472	2,669	3,463	2,076	761	285	178	319	900
1957	110	69	117	147	1,111	4,225	2,208	2,345	2,680	1,192	542	224	1,250
1958	197	130	118	98	564	4,742	2,925	1,583	692	412	227	129	987
1959	91	82	82	72	639	4,545	2,844	2,272	696	629	304	203	1,042
1960	135	102	100	91	1,573	3,201	2,993	2,374	1,886	548	237	214	1,127
1961	198	136	102	90	896	2,667	2,802	2,691	1,326	554	237	135	992
1962	100	94	89	99	486	4,083	3,174	2,505	814	474	237	169	1,032
1963	135	113	112	112	697	2,000	4,191	2,603	1,554	406	180	158	1,030
1964	147	124	113	147	404	3,840	3,329	2,165	978	463	359	230	1,029
1965	145	135	135	135	290	1,408	2,584	1,857	1,436	575	259	169	765
1966	124	113	108	101	343	3,084	2,595	1,868	1,399	560	293	180	900
1967	135	107	90	86	582	2,586	2,441	1,797	1,161	405	204	153	816
1968	147	154	175	145	1,002	3,133	3,220	1,919	895	309	189	164	959
1969	144	119	98	115	426	2,110	2,497	1,147	590	322	182	133	660
1970	109	97	94	123	497	1,759	2,321	2,031	880	360	203	131	722
1971	108	92	82	98	354	2,027	3,016	2,327	843	461	266	189	828
1972	156	122	107	107	933	2,316	3,198	2,394	1,329	661	352	177	994
1973	118	97	86	93	278	1,732	1,771	1,726	544	299	140	87	584
1974	62	48	41	44	594	1,642	2,316	2,154	1,608	493	174	96	778
1975	85	85	83	89	412	2,195	3,937	2,009	1,674	632	151	129	963
1976	92	83	79	88	582	2,751	2,535	2,159	851	493	381	291	870
1977	243	246	215	194	782	4,105	4,610	2,988	1,373	569	226	184	1,318
1978	162	141	121	123	422	1,797	2,138	2,068	945	323	149	123	713
1979	113	105	104	190	705	2,298	2,819	2,204	1,042	671	274	205	900
1980	194	177	150	163	825	3,447	3,731	2,256	958	493	210	105	1,065
1981	190	121	117	131	1,604	3,203	3,187	3,326	1,201	833	389	214	1,218
Average (cfs)	137	115	107	114	680	2,863	2,978	2,209	1,225	535	264	179	956
Maximum (cfs)	243	246	215	194	1,604	5,282	4,610	3,326	3,198	1,192	542	338	1,318
Minimum (cfs)	62	48	41	44	278	1,408	1,771	1,147	544	285	140	87	584
Avg.(cfs/sq.mi.)	0.37	0.32	0.29	0.31	1.86	7.82	8.14	6.04	3.35	1.46	0.72	0.49	2.61
Total (acre-feet)	8,423	6,413	6,603	6,796	41,842	170,358	183,131	135,850	72,867	32,872	15,738	10,983	691,876
Min. (acre-feet)	3,813	2,674	2,537	2,603	17,068	83,796	108,912	70,505	32,384	17,519	8,339	5,359	423,111

5.3.3 Flood Hydrology

The objective of the flood hydrology analysis is to develop inflow design floods (IDF) for use in the preliminary design of spillways at each of the three potential dam locations. The IDF can range anywhere from the 100-year flood for a small, low-hazard diversion dam, to the PMF for a high value or high-hazard dam. For the potential dam locations, the IDF inflow volume is expected to be large in comparison to the reservoir flood control storage, which means the spillway must be sized such that the peak flood outflow is equal to the peak flood inflow. Therefore, only the peak flood inflow values at the dam locations must be known to size the spillways.

At the current early stage of studies, developing the PMF by approximate means is appropriate. If one of the hydroelectric alternatives advances to a more detailed phase of studies, the PMF should be determined in accordance with FERC PMF guidelines (FERC, 2001).

Based on the high value of a high dam built to provide a large storage reservoir and the potential for downstream damages, the Probable Maximum Flood (PMF) was selected as the inflow design flood for the dam alternatives that include large storage reservoirs. For the diversion dam alternatives that have no active storage, the 100-year flood is selected for spillway design.

Table 5-5 presents a summary of the recorded flood data available in and near the Tiekel River watershed. Although this peak flow data provides valuable information, caution must be used in making precise direct comparisons among the stations because of the short length of record and differing periods of record. Peak flows are not only a function of rainfall intensities and snowmelt, they are also a function of physical watershed characteristics (area, slopes, soils, lakes, etc.). As is the case with average annual rainfall, the watersheds closer to the saltwater moisture source generally have higher unit runoff rates (cfs/sq. mi.). The first two stations listed in the table are within the Tiekel River watershed. Stuart Creek is steep both in channel slope and average catchment slope, which is conducive to producing high peak flows. As a conservative measure, the 100-year floods for the alternative dam locations will be based on the Stuart Creek peak flow records as adjusted to the dam locations.

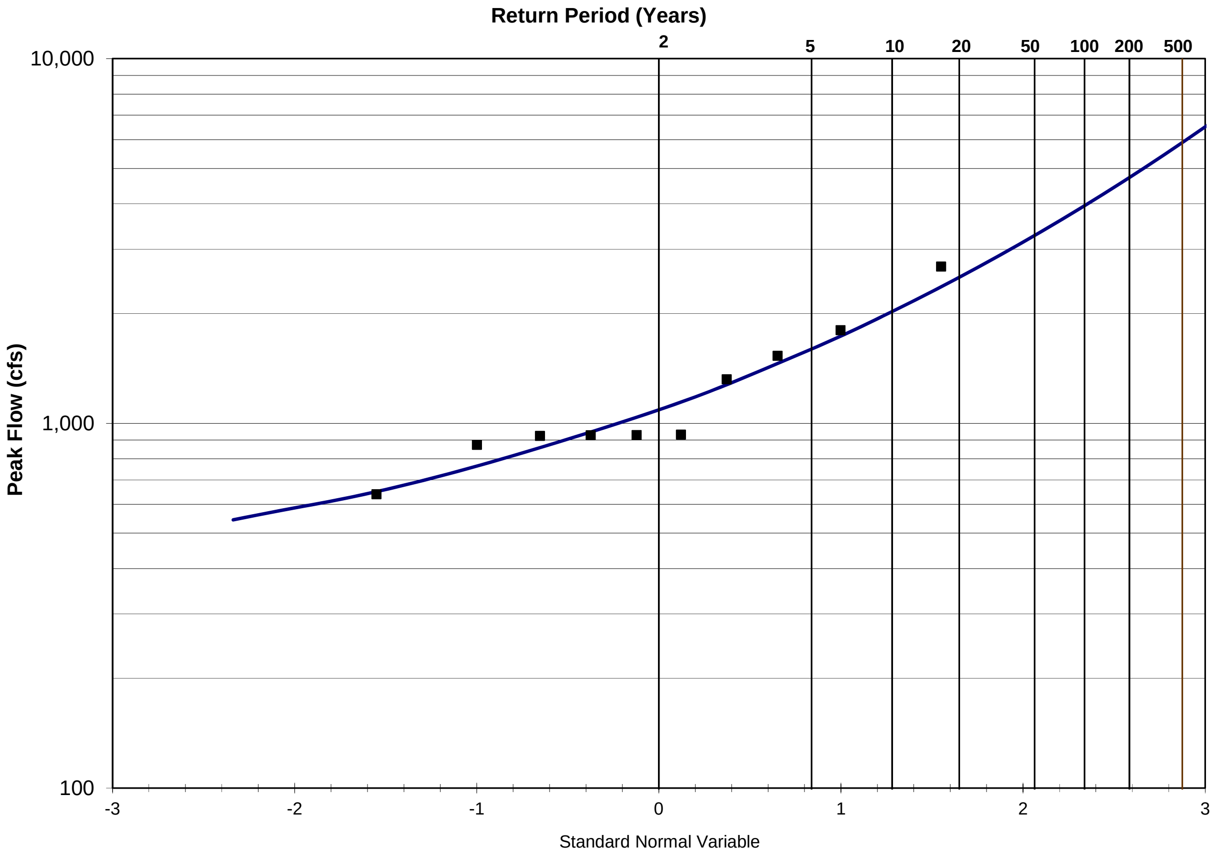
Table 5-5 Recorded Flood Data Summary

USGS Gage Number	Gage Name	Drainage Area (sq.mi.)	Avg. Annual Flood (1) (cfs/sq.mi.)	Max. Annual Flood (1) (cfs/sq.mi.)	Gage Datum (feet)	Available Period of Peak Flow Data
15212600	Tiekel River near Tiekel	115	23	42	1,190 approx.	4 years: 1978 - 1981
15213400	Stuart Creek near Tiekel	37.4	34	72	1,220 approx.	10 years: 1972 - 1981
15206000	Klutina River. at Copper Center	938	8	10	1,011	18 years: 1949 - 1967
15207800	L Tonsina River near Tonsina	22.7	8	25	1,850	6 years: 1972 - 1978
15208000	Tonsina River at Tonsina	422	11	33	1,500	32+ years: 1950 - 1982, 1995, 2006
15208100	Squirrel Creek at Tonsina	70.5	6	17	1,520	10 years: 1965 - 1975
15211500	Tebay River near Chitina	55.4	15	17	1,796	3 years: 1962 - 1965
15212000	Copper River near Chitina	20,600	9	18	400	36 years: 1950 - 1990
15226000	Solomon Gulch near Valdez	19.7	73	138	1	25 years: 1986 - 2011

Note (1): Because the period of record varies widely among the stations,
the cfs/sq.mi. values are general indicators and are not exactly comparable.

The PMF peak flows for the Tiekel River dam locations utilized site-specific information and estimates of the relationship between the PMF and the more easily estimated 100-year flood. At USGS Gage 15213400, Stuart Creek near Tiekel, there are 10 years of annual peak flow data. The 100-year flood was estimated using the log-Pearson type III (LP3) distribution fitted to the peak flow data. Using procedures provided in Bulletin 17B (Interagency Committee on Water Data 1982), the 100-year flood estimate for Stuart Creek was 3,950 cfs. The flood frequency plot for the gaging station is shown on Figure 5-9. The PMF peak flow for the Tiekel River sites was estimated based on an approximate relationship to the 100-year flood and experience values from developing PMFs by more detailed methods.

Figure 5-9 Flood Frequency for Stuart Creek at USGS Gage 15213400



For the 48 contiguous United States area, maps of the ratio of the Probable Maximum Precipitation (PMP) for 10 square miles to the 100-year frequency rainfall (both for 24-hour durations) have been developed. These PMP/100-year rainfall ratios range between 2 and 6 (CSCD, 1985). The 24-hour PMP and 100-year frequency rainfall for the Tiekel River watershed was obtained from Weather Bureau Technical Paper No. 47 (Miller 1963). For the Tiekel River watershed, the calculated ratio was 3.0. From hydrologic principles, it could be expected that the ratio of the PMF to the 100-year flood would be of similar magnitude, which has been confirmed in detailed PMF studies performed by MWH for other projects where snowmelt makes a significant contribution to extreme floods. For the Tiekel River basin, the PMF is estimated to be three times the 100-year flood.

The 100-year flood of 3,950 cfs was estimated for Stuart Creek at the USGS gaging station. The 100-year flood estimates were then adjusted to the three dam locations with a drainage area adjustment factor based on the ratio of the drainages areas (A) raised to a power, as follows:

$$\text{Drainage area adjustment factor} = \left(\frac{A_1}{A_2}\right)^n$$

Based on flood-of-record for USGS gages in southcentral Alaska, and a regression equation for estimating peak flows (Lamke, 1979), the exponent n was estimated to be 0.82. Using this drainage area adjustment factor and a PMF/100-year flood ratio of 3.0 yields the spillway design floods presented in Table 5-6. The Tiekel River spillway design floods are the peak of the inflow flood. Diversion dam alternatives would use the 100-year flood as the spillway design flood, while the storage reservoir alternatives would use the PMF. The estimated spillway design flood flows are appropriate for preliminary design. If studies of hydroelectric projects at any of the potential dam locations progress to more detailed phases, more detailed PMF studies should also be performed.

Table 5-6 Spillway Design Floods

Location or Dam Site	Drainage Area (sq.mi.)	100-Year Flood Peak (cfs)	PMF Peak (cfs)
Stuart Creek USGS Gage	37.4	3,950	11,900
Alternative 1	446	30,200	90,600
Alternative 2	426	29,000	87,000
Alternative 3	366	25,600	76,800

5.4 Reservoir Operation and Power Studies

The general objective of project operation study was to generate to the electricity loads that are calculated for the various scenarios with high reliability. Additional generation in excess of the specific electricity loads could occur during high inflow months from flow that would otherwise be spilled.

An integrated modeling approach in which hydroelectric generation was driven by the specific required loads, as opposed to letting the generation occur in any pattern with any reliability, was used for reservoir operation and power studies of the potential hydroelectric projects on the Tiekel River. The integrated approach allowed for the determination of both the potential hydroelectric generation (assumes all generation is usable) and the usable hydroelectric generation based on the specific future electrical load under consideration and the output of other system generating resources.

As is typical for Alaskan utilities, generating reliable winter energy is the most valuable, because loads are simultaneously the highest when flows for hydroelectric generation are the lowest. This argues in favor of developing a hydroelectric project with sufficient storage to meet the winter demand. Run-of-river alternatives were also investigated to determine if they could be effectively integrated into the CVEA system to work in coordination with Solomon Gulch to reduce the winter use of fossil fuel generation, as run-of-river projects are generally lower in cost and do not require construction of a major dam. Run-of-river projects may have high potential generation, but low usable generation. To effectively differentiate potential and usable generation, the reservoir operation and power study simulation model operates the storage reservoirs, as necessary, to meet the load. Both the potential and usable generation are output for each alternative model run. Fossil fuel generation would simply be equal to the load that was unserved by other resources.

A reservoir operation model developed by MWH was used to simulate project operations and to provide the needed information on projected generation, reservoir levels, flows throughout the system, and other parameters. The model is a water balance type of reservoir operation model that accounts for flow through reservoir, tunnels, and powerhouse system on an hourly basis, and uses inflow hydrology covering a continuous period of 30 years as described previously.

The general procedure for sizing the storage reservoirs was to iteratively adjust the dam height and the associated reservoir size until the required generation for the scenario was completely met in at least 98% of the months for most alternatives. The maximum normal pool level for any reservoir was assumed to be at El 1,050 feet[3] so that, even with flood storage above the maximum normal pool, the reservoir would not inundate the Richardson Highway and TAPS. The remainder of this section provides simulation results based on the reservoir operation and power study model.

Table 5-7 is a summary of power study runs that were directed at meeting the generation objectives of Scenarios 1, 2 and 3, including two additional variations for Scenarios 1 and 3 that appear to warrant consideration. The 'run numbers', A1R1 for example, mean Dam Alternative 1, Run 1. Each 'run' was directed at meeting the target energy requirement of a particular scenario.

The 14 model runs were intended to provide a variety of configurations which could then be evaluated for cost-effectiveness and potentially selected as the 'scenario' configuration.

Scenario 1A: Run numbers A1R3, A2R1, A3R2

Scenario 1B: Run numbers A1R5, A2R3, A3R4

Scenario 2: Run numbers A1R2, A1R4, A2R2, A3R1, A3R3

Scenario 3A: Run numbers A1R6, A2R4

Scenario 3B: Run numbers A1R1

Of the 14 candidates, A1R2 and A3R4 didn't meet target production.

Power study modeling concluded that the Tiekel River watershed has insufficient generation potential to support a statewide export scenario. The maximum hydroelectric potential of the

[3] All elevations are intended to be with respect to National Geodetic Vertical Datum (NGVD).

Tiekel River is developed in Scenario 3B (Run No. A1R1). Therefore, Scenario 4 was not considered further and no concepts were developed for that scenario.

All runs assumed zero environmental releases to the bypass reach. If minimum environmental releases were required, the run-of-river alternatives would probably not meet the minimum generation requirements.

As an illustration of the maximum generation potential of the Tiekel River, Figure 5-10 presents the average monthly generation for Run A1R1 that is directed at Scenario 3B, which provides generation of a magnitude to be a regional resource. Reservoir storage is sufficient to provide substantial winter generation, but peak generation potential still occurs during the high flow months.

Table 5-7 Reservoir Operation and Power Study Run Results Summary

Run No.	Alt.	Directed at Scenario	Powerhouse Capacities Output (MW)	Powerhouse Capacities Flow (cfs)	No. of Units	Type of Units	Type (1) of Opera-tion	Normal Power Pool Max (ft)	Normal Power Pool Min (ft)	Normal Power Pool Range (ft)	Tailwater Elevation (ft)	Max. Static Head (ft)	Active Storage (ac-ft)	Average Reservoir Inflow (ac-ft)	Ratio of Active Storage to Inflow	Environ. Release Req.	Energy Shortage Months	Annual Potential Generation (2) Min. (GWh)	Annual Potential Generation (2) Avg. (GWh)	Annual Potential Generation (2) Min. Gen. Cap. Fac.	Annual Potential Generation (2) Avg. Gen. Cap. Fac.	Annual Usable Generation (2) Energy (GWh)	Annual Usable Generation (2) Capacity Factor	Average Spill (cfs)	Comments
A1R1	1	3B	100	2,220	2	Francis	Storage	1,050	850	200	425	625	391,000	843,000	0.46	None	0	293	384	33%	44%	384	44%	127	Maximizes the generation potential of the Tiekel River
A1R2	1	2	10	1,110	2	Kaplan	ROR	550	550	0	425	125	0	843,000	0.00	None	Many	30	39	34%	45%	5.0	6%	605	Unacceptable. Generation is far short of minimum requirements.
A1R3	1	1A	20	800	2	Francis	Storage	775	625	150	425	350	71,000	843,000	0.08	None	1	84	101	48%	58%	29.5	17%	693	Provides required generation in 99.5% of months.
A1R4	1	2	10	520	2	Francis	Storage	700	575	125	425	275	34,000	843,000	0.04	None	2	50	58	57%	67%	14.7	17%	819	Provides required generation in 99% of months.
A1R5	1	1B	30	1,000	2	Francis	Storage	850	650	200	425	425	142,000	843,000	0.17	None	2	129	149	49%	57%	63.2	24%	562	Provides required generation in 99% of months.
A1R6	1	3A	50	1,500	2	Francis	Storage	890	690	200	425	465	184,000	843,000	0.22	None	2	175	212	40%	48%	107	24%	393	Provides required generation in 99% of months.
A2R1	2	1A	20	720	2	Francis	Storage	915	775	140	525	390	67,000	805,000	0.08	None	1	86	103	49%	59%	29.5	17%	684	Provides required generation in 99.5% of months.
A2R2	2	2	10	440	2	Francis	Storage	850	775	75	525	325	26,000	805,000	0.03	None	1	53	61	61%	70%	14.7	17%	809	Provides required generation in 99.5% of months.
A2R3	2	1B	30	940	2	Francis	Storage	980	775	205	525	455	127,000	805,000	0.16	None	2	131	150	50%	57%	63.2	24%	557	Provides required generation in 99% of months.
A2R4	2	3A	50	1,400	2	Francis	Storage	1,020	785	235	525	495	174,000	805,000	0.22	None	5	165	204	38%	47%	106	24%	347	Provides required generation in 98.6% of months.
A3R1	3	2	10	280	2	Francis	ROR	975	975	0	425	550	0	692,000	0.00	None	9	58	71	67%	81%	14.1	16%	744	95% reliability. Dam at the location of the storage alternative.
A3R2	3	1A	20	460	2	Francis	Storage	1,075	1,000	75	425	650	22,000	692,000	0.03	None	3	99	113	56%	65%	29.5	17%	659	Provides required generation in 98.5% of months.
A3R3	3	2	10	250	2	Francis	Storage	1,025	1,000	25	425	600	5,300	692,000	0.01	None	2	60	73	69%	84%	14.7	17%	760	Provides required generation in 99% of months.
A3R4	3	1B	30	680	2	Francis	Storage	1,075	1,000	75	425	650	22,000	692,000	0.03	None	Many	121	145	46%	55%	49.4	19%	570	Unacceptable. Generation is far short of minimum requirements.

Notes: (1) Storage - Includes active storage to provide substantial winter output. ROR - Run-of-river operation.
(2) Includes a 3% deduction for outages of all types.

Figure 5-10 Power Study Run A1R1 Potential Generation

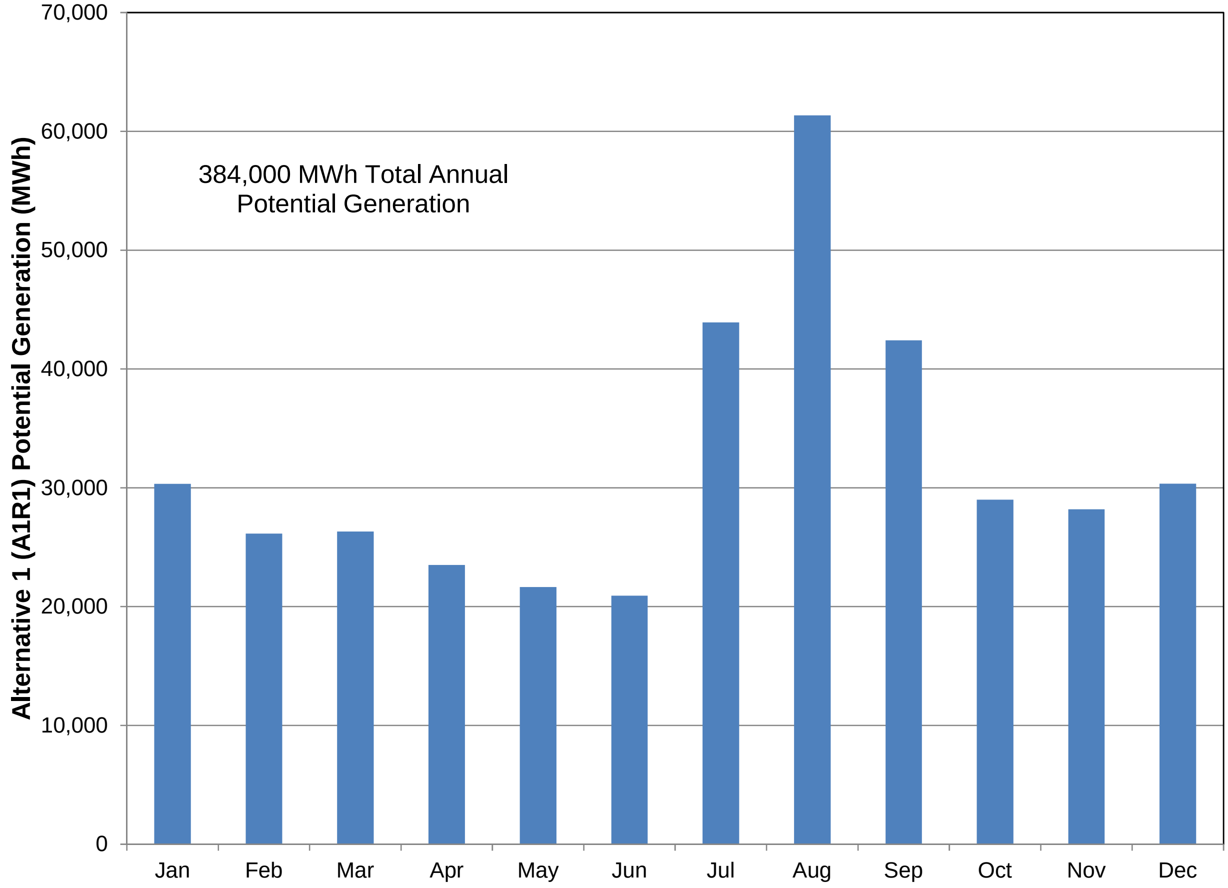
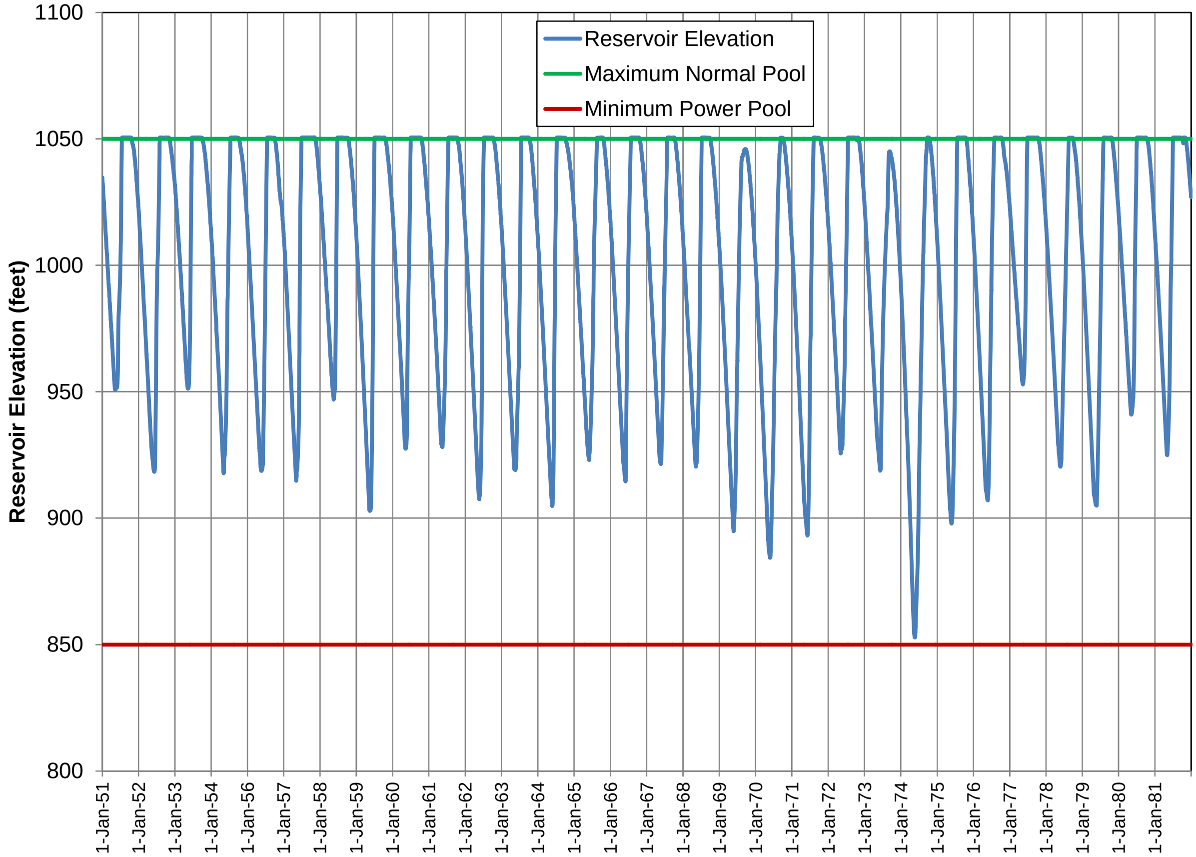


Figure 5-11 shows the daily reservoir levels for power study Run A1R1 for the 30-year period of simulation. The indication is that Tiekel River flows are sufficient to fill or almost fill the largest Tiekel River reservoir in every year.

Figure 5-11 Daily Reservoir Elevations for Power Study Run A1R1



5.5 Screening and Identification of Physical Scenario Concepts Meeting Energy Targets

Based on a rough order of magnitude cost evaluation, generally using a levelized cost per kWh of target or usable energy, the following are elevated as the best candidates to represent the hydropower development aligned with the identified Scenarios:

Scenario 1A: Run number A3R2

Scenario 1B: Run number A2R3

Scenario 2: Run number A3R1

Scenario 3A: Run number A2R4

Scenario 3B: Run number A1R1

5.6 Conceptual Layouts and Refinements

For the five scenario configurations listed in the previous section, preliminary layouts were developed based on the constraints, opportunities, and risks identified during the review of previous reports and site visits, along with the review of available river flows determined during the hydrology study. No subsurface exploration, at-site mapping, detailed at-site reconnaissance, nor at-site environmental characterization has been carried out. If any concept is considered feasible for continued evaluation, it would be necessary to further define the concept and cost estimate for a definite determination of economic feasibility and budgeting.

Aquatic resource research indicated that fish passage provisions are not likely to be required at these sites; therefore, none have been included in design layouts. If subsequent studies determine that fish passage features are required, the cost could be significantly impacted.

The general layout concepts established for this Study are presented in Exhibits 04 to 14 (Appendix A). The layouts are summarized in the following section.

5.6.1 Project Alternatives

5.6.1.1 Dam Type

The level of information currently available on the geological conditions of the Tiekel River reach being considered in this Study, would not preclude the suitability of any type of dam. Dams that could be constructed, include earth core rockfill, asphaltic core rockfill, roller compacted concrete (RCC), and concrete faced rockfill dam (CFRD).

Initial indications suggest that there may be a limit of suitable, locally-available, low-permeability material to construct the core of an earth core rockfill dam. An asphaltic core dam would eliminate the need to locally source the impermeable core material; an asphalt wall would be constructed within the dam supported by rockfill shoulders. Rock to form the dam shoulders would be quarried from the river valley. The placement of asphaltic cores is a specialist operation and there are only a limited number of contractors worldwide with the required expertise.

CFRD structures use a concrete slab constructed on the sloping upstream face of the dam to create the impermeable zone. The rock to form the dam and for use as aggregate in the concrete would be quarried from the river valley; cement and flyash would need to be imported to the site.

The RCC dam would also use locally-quarried rock for the aggregate, but as the entire structure would be concrete, more flyash and cement would need to be imported. The volume of material required for a RCC dam is about one-fourth that required for an equivalent height CFRD structure.

CFRD or RCC dams are the most common type of dam under construction around the world and would both be suitable. RCC is a popular construction material due to its speed of placement. A RCC dam could, theoretically, be completed faster that a CFRD structure – which would provide economic benefits in terms of earlier generation. A RCC dam also allows the spillway to be constructed integrally with the structure, which simplifies construction and reduces the impact of the structure on the surrounding environment.

The preferred dam will be assessed in greater detail during a subsequent phase if further project development studies proceed. Based on the prevailing conditions, it is judged that an RCC type dam would be an appropriate selection for comparison purposes, and was used for the layout and cost estimation for all scenarios.

5.6.1.2 Tiekel River Mainstem

Scenario 1A – Dam Alternative 3, Run 2 (A3R2)

This 20 MW installed capacity project would comprise a powerhouse containing two 10 MW Francis turbines located approximately 1.1 miles upstream of the Tiekel River's confluence with the Copper River.

The reservoir would be about 8.7 miles upstream of the powerhouse with a Full Supply Level (FSL) of Elevation (El) 1,075. The reservoir would have a surface area of about 398 acres at FSL, with a stored volume of approximately 26,709 ac-ft.

The RCC dam would have a crest elevation of El 1,090 and would be approximately 165 ft tall. Approximately 225,000 cubic yards of RCC would be required to construct the dam. Floods will be conveyed past the dam through a gated spillway located in the dam; three radial gates would discharge down a chute on the downstream face of the dam that would end at a flip bucket.

The required generation flow of 460 cfs would be abstracted from the reservoir at a screened intake structure located on the right (south) side of the valley at El 980. Flow would pass through a 7.7-ft diameter, concrete-lined low pressure tunnel approximately 40,500 ft in length before dropping 450 ft in a 6.7-ft diameter, concrete-lined shaft. The tunnel would then continue for 3,580 ft to the powerhouse; the first 2,580 ft would be a 6.7-ft diameter, concrete-lined tunnel. The remaining 970 ft would transition to a 5.0-ft diameter, steel-lined penstock which would bifurcate to 3.6-ft diameter, steel-lined conduits, about 30 ft upstream of the powerhouse. The powerhouse would be located on the right (south) side of the river with a tailwater level at El 425. The reservoir would be operated with a reservoir minimum operating level of El 1,000. Exhibits 04 and 05 (Appendix A) illustrate the concept for this scenario.

Scenario 1B – Dam Alternative 2, Run 3 (A2R3)

A 305-ft high RCC dam would be constructed at the Dam Alternative 2 location, approximately 4.5 miles upstream of the Tiekel River's confluence with the Copper River. The dam would have a crest elevation of El 995. Construction of the dam would require about 905,000 cubic yards of RCC. A gated spillway would be integral with the dam of similar configuration to the Scenario 1A layout.

The reservoir created behind the dam would have an FSL of El 980 with a surface area of about 1,115 acres and a stored volume of about 133,237 ac-ft. The reservoir minimum operating level would be El 775.

The powerhouse would be located on the right (south) side of the river about 7,000 ft downstream of the dam. The powerhouse would contain two 15 MW Francis turbines discharging to a tailwater at El 525.

The required generation flow of 940 cfs would be abstracted from the reservoir at a screened intake structure located on the right (south) side of the valley at El 740 immediately upstream of the dam. Flow would pass along a 7.2-ft diameter, aboveground steel penstock. The penstock would follow the El 750 contour along the right side of the valley in an easterly alignment. Approximately 300 ft downstream of the dam, the penstock alignment will take a south-easterly direction deviating away from the side of the river. The penstock would continue to follow the El 750 ground contour, resulting in it resorting to an easterly alignment for the final 2,500 ft. The last 200 ft will be an inclined penstock ending at the powerhouse. Concrete saddles, or thrust blocks, would support the penstock at regular intervals.

The configuration of this scenario is shown on Exhibits 06 and 07 (Appendix A).

<u>Scenario 2 – Dam Alternative 3, Run 1 (A3R1)</u>

The 65-ft tall RCC dam would be located at the Dam Alternative 3 location that would be 8.7 miles upstream of the powerhouse. The gated spillway would be of similar configuration to the other scenarios.

The reservoir would have a FSL of El 975 with a surface area of about 96 acres and a volume of about 1,604 ac-ft. The project would operate in a run-of-river mode.

A tunnel system will pass 280 cfs to the powerhouse. The tunnel will be located on the south side of the valley following a roughly easterly alignment. A screened intake structure located on the right (south) side of the valley at El 960 will abstract flow from the reservoir into a 40,500-ft long, 6.0-ft diameter, concrete-lined low pressure tunnel. The tunnel then transitions to a 5.2-ft diameter, concrete-lined 450-ft deep shaft before continuing for a further 3,100 ft to the powerhouse. The first 1,300 ft would be a 5.2-ft diameter, concrete-lined tunnel, then transitioning to a 1,770-ft long 3.9-ft diameter, steel-lined tunnel. The tunnel would then bifurcate to two 2.8-ft diameter, steel-lined conduits, about 30 ft upstream of the powerhouse.

The powerhouse would be located on the right (south) side of the river and would contain two 5 MW Francis turbines. The tailwater at the powerhouse would be about El 425. Exhibits 08 and 09 (Appendix A) detail this conceptual layout.

Scenario 3A – Dam Alternative 2, Run 4 (A2R4)

This 50 MW installed capacity project would comprise a powerhouse containing two 25 MW Francis turbines located approximately 4.5 miles upstream of the Tiekel River's confluence with the Copper River.

The reservoir would be about 7,000 ft upstream of the powerhouse, with a FSL of El 1,020. The reservoir would have a surface area of about 1,370 acres at FSL, with a stored volume of approximately 86,170 ac-ft. The operating range of the reservoir would be 245 ft.

The RCC dam would have a crest elevation of El 1,035 and would be approximately 355 ft tall. Approximately 1,286,000 cubic yards of RCC would be required to construct the dam. Floods will be conveyed past the dam through a gated spillway located in the dam; three radial gates would discharge down a chute on the downstream face of the dam that would end at a flip bucket.

The required generation flow of 1,400 cfs would be abstracted from the reservoir at a screened intake structure located on the right (south) side of the valley at El 750 immediately upstream of the dam. Flow would pass along an 8.8-ft diameter, aboveground steel penstock. The penstock would follow the El 750 contour along the right side of the valley in an easterly alignment. Approximately 300 ft downstream of the dam, the penstock alignment will take a south-easterly direction deviating away from the side of the river. The penstock would continue to follow the El 750 ground contour, resulting in it resorting to an easterly alignment for the final 2,500 ft. The last 200 ft will be an inclined penstock ending at the powerhouse. Concrete saddles or thrust blocks would support the penstock at regular intervals.

The powerhouse would be located on the right (south) side of the river, with a tailwater level at El 525.

Scenario 3B – Dam Alternative 1, Run 1 (A1R1)

A 550-ft high RCC dam would be constructed across the Tiekel River at the Dam Alternative 1 location, with a concrete volume of about 5.2 million cubic yards. The gated spillway would be located centrally in the dam, discharging along a chute terminating in a flip bucket.

The reservoir FSL would be El 1,050 and would be approximately 11 miles long when full, with a stored volume of about 553,000 ac-ft (391,000 ac-ft active storage). The operating range of the reservoir would be 200 ft.

A screened intake structure located on the right (south) side of the valley at El 805 would extract water from the reservoir into a 16.8-ft diameter, concrete-lined low pressure tunnel. The low pressure tunnel would be approximately 750-ft long before transitioning to a 14.7-ft diameter, concrete-lined 350-ft deep shaft. The tunnel would then continue for 1,800 ft to the powerhouse. The first 900 ft would be a 14.7-ft diameter, concrete-lined tunnel before transitioning to a 870-ft long, 11.1-ft diameter, steel-lined tunnel – which would bifurcate to 7.8-ft diameter steel lined conduits, about 30 ft upstream of the powerhouse.

The 100 MW project would require a flow of 2,220 cfs to pass through two Francis turbines located in the powerhouse on the right side of the valley, about 1,800 ft downstream of the dam. The tailwater would be El 425 at the powerhouse. The layout of this scenario is shown on Exhibits 12 and 13.

Table 5-8 presents a summary of key features for the five candidate projects, as well as comparison information for the Susitna-Watana Hydroelectric Project. The volume of concrete required to construct large dams is a significant cost driver, as can be seen in Section 5.9 and Appendix B.

5.6.2 Project Refinements and Additional Site Prospecting

Following consultation with CVEA on initial ROM cost estimates, MWH undertook an effort to refine layouts and positioning of structures with an objective or reducing costs. Efforts focused on:

- dam locations;
- conveyance alignment;
- prospecting for other sites in the Tiekel basin; and
- pumped storage.

5.6.2.1 Dam Location

The initial position of the dam axis at Dam Alternative 2 was reviewed to assess the potential merits of moving the dam downstream. Relocating the dam would shorten the distance to the powerhouse, which would reduce the length of the penstock. The shape of the valley suggests that moving the dam axis downstream by up to 2,000 ft would be feasible. To achieve the same reservoir FSL, the height of the dam would increase as the dam axis is moved downstream, resulting in an increase in dam volume.

Five dam axis locations were assessed and five crest elevations considered for each axis location. The original axis location (STA 0+00) required the smallest concrete volume for each crest elevation. The results of the assessment for three of the axis locations are shown on Figure 5-12.

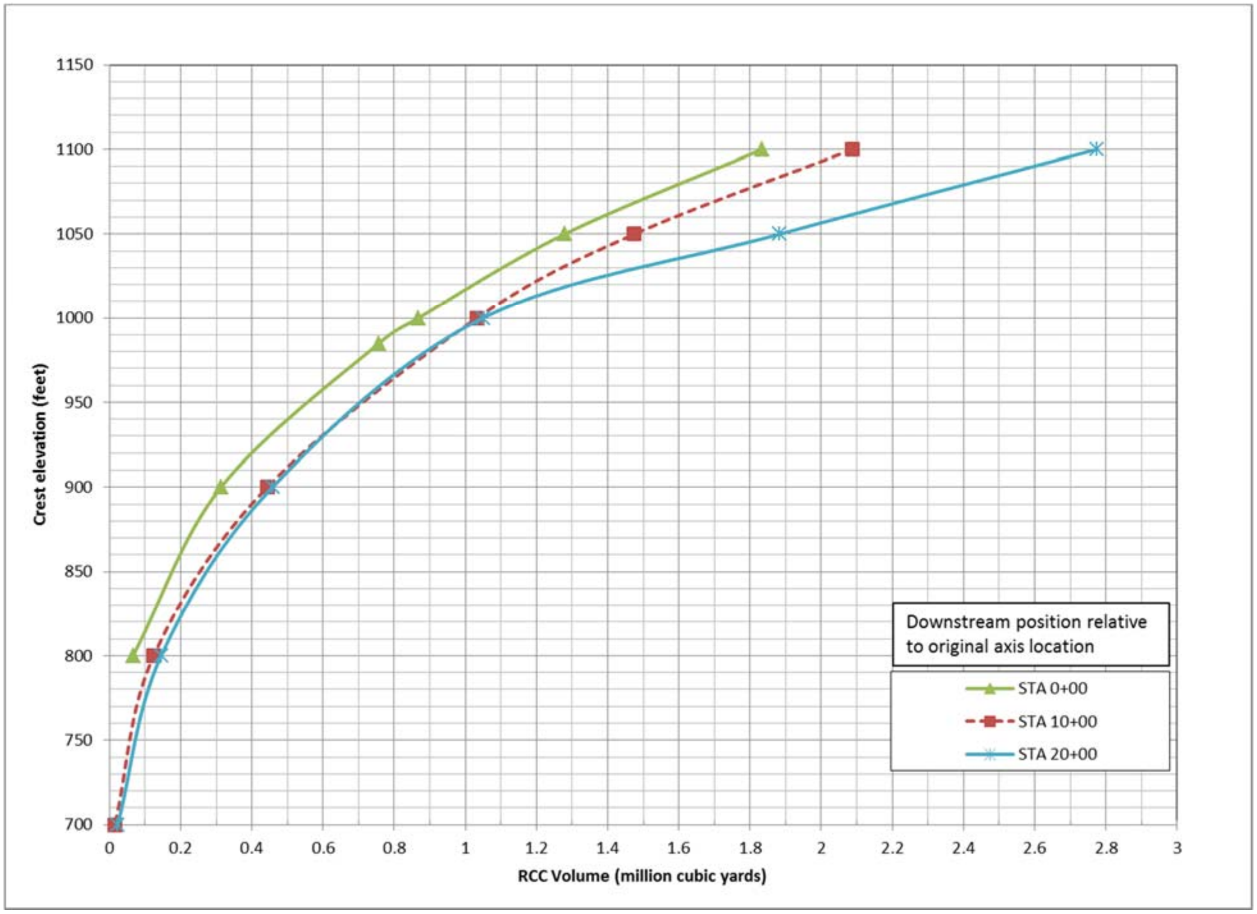
The valley sides have a uniform slope for the majority of the dam axes; however, above El 1,000, the valley sides flatten at the STA 20+00 location and this results in a greater increase in dam volume per foot increase in dam height. This is illustrated in Figure 5-12 by the flattening of the curve above El 1,000.

For Scenario 1B the estimated comparative cost increase of a dam at STA 20+00 relative to the original axis location would be approximately $38.2 million. For Scenario 3A the comparative cost increase would be approximately $54 million.

Table 5-8 Candidate Projects - Key Feature Summary

	Scenario 1A	**Scenario 1B**	**Scenario 2**	**Scenario 3A**	**Scenario 3B**	**Scenario 4**	**Susitna-Watana (for context)**
Dam Location	Alternative 3	Alternative 2	Alternative 3	Alternative 2	Alternative 1	N/A	N/A
Powerhouse Location	Below Dam Alternative 1	Between Dam Alternatives 1 and 2	Below Dam Alternative 1	Between Dam Alternatives 1 and 2	Below Dam Alternative 1	N/A	N/A
Power Study Model Run Basis	A3R2	A2R3	A3R1	A2R4	A1R1	N/A	N/A
Installed Capacity (MW)	20	30	10	50	100	N/A	600
Annual Usable Energy (GWh/yr)	29.5	63.2	14.1	106.0	384.0	N/A	2,600
Average Gen (MW)	3.4	7.2	1.6	12.1	43.8	N/A	300
Dam Height (ft)	165	305	65	355	550	N/A	710
Concrete Volume (Mcy)	0.23	0.91	0.03	1.29	5.19	N/A	5.4
Active Storage (ac-ft)	22,000	127,000	0	174,000	391,000	N/A	3,400,000

Figure 5-12 Dam Alternative 2 Concrete Volume Location Relationship



To determine the preferred location for the dam, outline cost estimates were produced for the two scenarios with the dam axis located at either the original position or 1,500 ft downstream. The STA 15+00 dam location was selected as the downstream location alternative since at the STA 20+00 location, additional seepage control measures would likely be required on the right abutment – adding further cost to the estimate.

The result of the cost comparison exercise is provided in Table 5-9. The costs are for comparative purposes only; the estimates for the selected scenarios described in Section 5.9 were prepared subsequent to this exercise.

Table 5-9 Comparative Cost Estimate Based on Dam Location

Dam Location	Scenario 1B	Scenario 3A
STA 0+00	$ 483,950,000	$ 593,976,000
STA 15+00	$ 514,200,000	$ 632,462,000

The analysis showed that a dam located at the original axis alignment would result in the lowest cost project for both scenarios. This shows that the dam has a greater influence on the project cost than the length of the waterways.

5.6.2.2 Conveyance alignment

Following the October 2012 progress meeting with CVEA, the water conveyance arrangements for Scenarios 1B and 3A were reviewed and consideration given to a surface penstock from the dam, running along the left side of the valley. For the purposes of the assessment, a steel penstock was used for comparative purposes.

The analysis compared a surface penstock configuration against a part tunnel, part surface penstock arrangement. The location of the dam was positioned at the STA 0+00 location, which was determined previously to be the lowest cost location. An intake located at the upstream face of the dam would discharge into the surface penstock, which would approximately follow the right side of the river valley supported on concrete saddles. The penstock would then diverge from the river side to follow a contour along a ledge about 4,000 ft downstream of the dam. The penstock would continue for a further 2,800 ft across the ledge. The surface penstock would then be inclined, following the ground surface profile to connect to the powerhouse.

The results of the comparative costing exercise are summarized in Table 5-10. The costs are for comparative purposes only; the estimates for the selected scenarios described in Section 5.9 were prepared subsequent to this exercise.

Table 5-10 Comparative Cost Estimate Based on Conveyance Alignment

Conveyance	Scenario 1B	Scenario 3A
Surface Penstock	$ 465,750,000	$ 584,560,000
Tunnel & Surface Penstock	$ 483,950,000	$ 593,980,000

The results show that a surface penstock is more cost effective than a tunnel alternative. Further inspection of the valley would be required to verify the alignment and feasibility of constructing a surface penstock at this location.

5.6.2.3 Prospecting for Other Tiekel Basin Hydropower Opportunities

At the request of CVEA, MWH performed a map study with an objective of identifying additional opportunities beyond those being studied in the reach between the Richardson Highway and the confluence of the Tiekel River with the Copper River, for hydropower development in the Tiekel River drainage area (Exhibit 02, Appendix A).

A conventional storage reservoir would require the availability of a suitable dam location – generally a steep sided valley with favorable geological conditions, topographic conditions to contribute to formation of a reasonable storage reservoir, and a reasonably sized upstream drainage area. Map inspections did not reveal any obvious candidates in the drainage area, particularly considering existing infrastructure in the area (Richardson Highway, TAPS, etc.). One tributary drainage appears to have potential for a run of river project; however, there is not presently a need for additional seasonal power generation.

5.6.2.4 Pumped Storage

The average monthly energy generation profile of Scenario 1 set out in Section 5.2.3 shows that the project would not be required for about 6 months of the year, which coincides with the highest flows in the river. To capture the high flows, a pumped storage alternative was investigated where water would be pumped from the Tiekel River to an off-line upper storage reservoir and used for energy generation when required to displace the fossil fuel generation. The pumping would require significant energy, but as this would occur during periods of surplus energy, the impact of the pumping demands would have less impact on the system.

Inspection of the topographic maps identified three potential sites for the upper reservoir. The locations of the upper reservoir sites are shown on Exhibit 15 (Appendix A). To minimize the energy requirements during the pumping phase, the length of the penstock needs to be kept as short as possible. The locations of the upper reservoirs were nearest the Dam Alternative 2 location, so the Dam Alternative 2 location was selected as the site for the lower reservoir. Pump turbines would be located in a powerhouse just upstream of the lower dam location, and the water conveyance system connecting the powerhouse to the upper reservoir would be used for the pumping and generation phases. A small reservoir would be formed on the Tiekel River, impounded by a low dam. A penstock would extend from the low dam along the side of the valley to a second powerhouse positioned at the same location as Scenario 3A. The downstream powerhouse would be used during the summer months to offset some of the energy requirements of the pumping operation. During the winter months, the second powerhouse would also be used for generation, the water released from the upper reservoir would pass through both powerhouses.

The active storage volumes for the three potential upper reservoir sites ranged from 17,000 ac-ft to 30,500 ac-ft, which would require dams with concrete volumes ranging from 814,000 cy to 1,534,000 cy. The volumes of these dams alone would be greater than that required for the conventional Scenario 1A project. Combined with additional hydro-mechanical, electrical, penstocks, and the concrete volume for the lower dam, a pumped storage project was not considered to be feasible.

5.6.3 Site Access

5.6.3.1 Options Considered

Potential access options that were considered included: construction of a new access road from the Richardson Highway; construction of an access road from either Chitina or Cordova via the old railroad grade along the Copper River; access by boat from either Chitina or Cordova via the Copper River; and access by helicopter or airplane. During the site reconnaissance work, it became clear that access from the Richardson Highway was the most feasible option.

Access via the old railroad grade from either Chitina or Cordova would present many challenges. The railroad grade would essentially require complete reconstruction in many locations. Either route would require multiple river crossings, as well as extensive erosion protection and drainage control work. Maintenance of these features could be expected to be costly. While the approximate 30-mile distance to Chitina is more reasonable than the 100+ mile distance to Cordova, it would still be considerably more costly to permit, design, and construct a road of this length to any potential dam site on the Tiekel River than it would be to construct a road from the Richardson Highway (a maximum of length of about 15 miles). These access options were not considered further.

Access by boat or barge is limited to the lower section of the Tiekel River. Shallow draft boats can navigate approximately the lower 4 miles of the river; otherwise, the steep, fast river conditions further upstream are not conducive to on-water access. As such, on-water access to a powerhouse located near the mouth of the Tiekel is included herein as an option for those configurations where it would be useful. On-water traffic could originate from Chitina (30 miles) or Cordova (120 miles).

Access by air is feasible by helicopter. It was apparent during the September 21, 2012, site reconnaissance, that several favorable locations for helipads are present within the project area. While it may be possible to construct air strips within the highway corridor at the head of the Tiekel River, or on the alluvial fan at the mouth of the Tiekel River, the utility of these features would be limited. The highway already located at the head of the river eliminates the need for an airstrip in that area, and an airstrip at the mouth of the river provides no significant usefulness for construction. Helicopters would still be required to shuttle materials and equipment to the construction sites.

Access via the Richardson Highway provides several advantages over the other access options considered, including:

- The Richardson Highway provides year-round, state-maintained access to the head of the Tiekel River from the Valdez port.
- Several possible aggregate borrow areas and construction staging areas are located along the Richardson Highway in the vicinity of the Tiekel River.
- Power transmission infrastructure is already located within the highway corridor.
- The site reconnaissance visit revealed to the design team that while the terrain is steep and rocky in the Tiekel River canyon, construction of up to approximately 15 miles of new gravel road is not expected to be overly challenging or cost prohibitive, although it will require extensive drilling and blasting work.
- Rock excavation from road construction that can be processed for RCC dam aggregate would offset the cost of road construction.
- The considerably shorter lengths of road construction from the Richardson Highway provide a cost advantage over the minimum distance required to construct a road from Chitina (30 miles).

- Permitting the access road within the Tiekel River canyon would be included with the permitting of the other features (dam, transmission lines, etc.) at an incremental cost and effort.

5.6.3.2 Conceptual Road Design

Construction and operational access to the dam for each scenario would be via gravel road from the Richardson Highway. During the September 21, 2012, site reconnaissance, particular attention was paid to assessing reasonable road alignments. Side drainages, topography, geologic features, and access from the Richardson Highway were all examined during this reconnaissance.

In general, the topography and the drainage conditions of the north side of the canyon appear to be more favorable for constructing access. Thus, for all scenarios, the gravel access road would be constructed along the north side of the Tiekel River to the dam location. For Scenarios 1B and 3A, additional access would be provided across the dam to the south side of the Tiekel River to provide access to the powerhouse. For other scenarios where the powerhouse is located near the mouth of the Tiekel River, access to the powerhouse would be by boat and helicopter. Under those scenarios, a jetty would be constructed in the river at the powerhouse location and a construction staging area/helipad would also be constructed in the vicinity of the powerhouse.

Potential landing zones for helicopters and areas for construction staging were noted during the site reconnaissance in reasonable proximity each dam site. Development of these areas would require additional excavation and in some cases require a short spur road to provide access.

The expected width of the width of the road would be limited to about 20 ft, with periodic turnouts to provide passing room for large equipment, when needed. The road would have gravel surfacing, a maximum grade of 10%, and a 2% cant to a drainage ditch on the uphill side with periodic relief culverts.

At small creek and gully crossings, culverts would be placed to convey flow beneath the road. Bottomless, arch-type culverts with concrete footings would be used at larger gully crossings. Conditions were very wet during the September 21, 2012, site reconnaissance, providing an opportunity to observe the side drainages under high flow conditions. Depending on the scenario, there are one to three large tributary crossings where conventional culverts would not be sufficient. A qualitative observation of the volume and velocity of flow in these tributaries indicates that large structural plate culverts or modular truss bridges would be required to cross these tributaries.

Conventional drill and blast techniques are expected to be utilized for rock excavation. Typical permanent cut and fill slopes in common material are expected to be around 1.5-2.0V:1H. Rock fill slopes are expected to be 1.25H:1V. Typical cut slopes in competent rock would be 0.25-0.5H:1V. Where the natural slopes are flatter than 1.5H:1V, cut-to-fill construction techniques would be utilized for construction of the road. For portions of the road located in areas where the existing side slope is steeper than 1.25V:1H, the road would be constructed as an excavation only, requiring removal of excavated material. In these areas, some to a considerable amount of blasted cut material can be expected to fall down the steep hill slope below the cut, some to the river.

Both overburden and rock excavation would be utilized in road embankments. Excess rock excavation from the access road that is not used in access road embankments would be processed and utilized as aggregate for dam construction, gravel road surfacing, and riprap. Unsuitable materials would be disposed of as part of borrow area and/or quarry reclamation as appropriate.

5.7 Geosciences Review

5.7.1 Introduction

For this Study, previous documentation was used to make a general assessment of geotechnical risks. Observations during the critical factor site visit – along with the review of previous reports – served as the basis for recommending future site investigations, should any of the candidate projects move forward.

MWH identified three potential hydroelectric dam sites along the Tiekel River between the Richardson Highway and the Copper River. MWH conducted a literature review and a brief geologic reconnaissance of the region of these three potential sites. Initial plans were to visit each of the sites during this reconnaissance; however, poor weather, high river levels, and rugged conditions at the time of the reconnaissance restricted access. In lieu of gaining access to the dam sites, regional geologic conditions were evaluated by observing conditions at three accessible points within the Tiekel River valley. The purpose of the site visit and evaluation was to review the following:

- Regional site conditions:
  - Geologic setting.
  - Potential geologic hazards.
  - Review regional seismicity and faulting.
- Overall site characteristics, including:
  - The general feasibility of conceptual projects.
  - Site topography.
  - General rock and soil conditions.
  - Other site factors.
- Potential borrow and quarry areas for use in project construction.
- Potential instability of slopes within the project areas.

This section describes the findings and conclusions of MWH's limited site visit.

5.7.2 Regional Conditions

5.7.2.1 Location

MWH reviewed three potential hydropower sites on an approximate 15.5-mile stretch of the Tiekel River between its confluence with the Tsina River and where it meets the Copper River (Exhibit 03, Appendix A). This portion of the Tiekel River is located within the Townships, Ranges, and Sections (Copper River Meridian) listed in Table 5-11.

Table 5-11 Tiekel River Study Area Extent

Township	Range	Sections
7 South	1 East	15, 16, 22, 23, 24
7 South	2 East	19, 20, 21, 22, 23, 24
7 South	3 East	19, 27, 28, 29, 30, 33, 34

Sources: USGS, 1994a; USGS, 1994b; USGS, 1994c; USGS, 1995.

5.7.2.2 Physiology

The Tiekel River is located within the Chugach Mountain physiographic province of Alaska (Howell et al., 1983). This physiographic province includes the mountains of the Chugach, Kenai, and St. Elias ranges. The St. Elias Mountains comprise the highest and most dramatic mountains of the province, with some peaks exceeding 18,000 ft. The foothills to the south of these ranges have peak elevations from about 3,000 to 6,500 ft. The mountains are punctuated by steep glaciated valleys, forming some of the most rugged terrain in the country. The valleys have formed along the alignment of regionally predominant discontinuities in the underlying bedrock (Wahrhaftig, 1965). Portions of the province, especially along the coastal margins of the mountain ranges, are covered by large ice fields. It is noted by Plafker et al. (1993) that, with the exception of the Cooper River and Alsek River, each of the major drainages within the coastal mountains are blocked by glaciers. Further south, the province is composed of coastal lowlands that are covered by glaciers and alluvium that are up to 25 miles wide. The flat to rolling slopes within of this region starkly contrast the mountainous terrain to the north.

5.7.2.3 Geology

<u>Regional Geologic Setting</u>

The southern margin of Alaska is comprised of a number of accreted terranes that have tectonically collided into the North American continent. These accreted terranes can be divided in to two groups, or composite terranes, which are delineated by their location with respect to the Boarder Ranges Fault System. To the north, the Wrangellia composite terrane is comprised of the Peninsular, Wrangellia, and Alexander terranes. To the south, the Chugach, Ghost Rocks, Prince William, St. Elias, and Yakutat terranes constitute the Southern Margin Composite terrane. The study area lies within the Chugach terrane portion of the Southern Margin Composite terrane (Plafker et al., 1994; Burns et al., 1991).

The Chugach terrane was thrust against and partially subducted below the Wrangellia terrane along the Border Ranges Fault System during the Early Jurassic (252 million years ago [ma]) through the Late Cretaceous (66 ma). The Prince William terrane was then accreted to the southern portion of the Chugach terrane prior to about 50 ma along the Contact Fault system. Since the time of accretion of the Chugach and Prince William terranes, the zone of active accretion has shifted southward approximately 150 miles south of the project area. Currently, the zone of accretion is located along the Aleutian Megathrust fault where the Pacific plate subducts below the continental margin. Published literature indicates that both the Border Range Fault and Contract Fault systems are no longer active (Plafker et al., 1993 and 1994). The Chugach terrane is bound by the Fairweather Fault and Queen Charlotte Fault to the west. Portions of both of these western faults are known to be active in recent time.

The Chugach terrane is comprised of Mesozoic (250 ma to 65 ma) rocks that can be subdivided into three subterranes or formations. These formations consist of a late Triassic (235 ma) to Jurassic (145 ma) greenschist in the far northern portion of the terrane, a late Triassic (235 ma) to Early Cretaceous (100 ma) mélange deposit including the McHugh Complex (also known as the Uyak Formation on Kodiak Island) to the east, and the late Cretaceous (100 to 66 ma) flysch deposit that locally includes the Valdez Formation to the west where the study area is located (Plafker et al., 1994; Coulter and Coulter, 1962; Winkler et al., 1981). Each of the three subterranes are bound by faults. The greenschist and mélange formation are separated by the Second Lake Fault Zone within the Chugach Mountains. The mélange formation and the flysch deposits of the Valdez Formation are separated by the Tazlina Fault. A study completed in 2012 excluded these faults from a database of Quaternary (2.6 ma to present) faults and folds, implying that they are no longer active (Koehler et al., 2012).

The Valdez Formation is a thick sequence of thinly bedded, slate and argillite that is rhythmically interbedded with pebble conglomerates and graywackes. The Valdez formation is comprised of low grade metamorphic rocks of the prehnite-pumpellyte to greenschist facies. The rocks are tightly and isoclinally folded. Much of the formation has a slaty or phyllitic cleavage that closely mirrors the orientation of the original bedding. This cleavage is also roughly parallel with the trend of the Chugach Mountain Range. These meta-sedimentary rocks are intruded by igneous rocks in the forms of plutons, dikes and sills throughout the formation (Burns et al., 1991). The formation lacks distinguishing strata and is commonly described as monotonous. As a result, the actual thickness of the Valdez Formation monotony and non-descript nature has made determining actual thickness difficult, although it is reported to be as much 6 to 12 miles thick below the central Chugach Mountains (Plafker et al., 1994).

Tectonics and Seismology

Much of the topography and structure surrounding the Tiekel River study area can be attributed to the tectonic history of the region. There are numerous major faults that were formed during the time when the Chugach terrane was being accreted. For the most part, these faults roughly mimic the arched shape of southern Alaska coastline, but are generally east-west in the vicinity of the project area. Faults associated with this period of geologic time include the Boarder Ranges Fault Zone, the Contact Fault Zone, the Tazlina Fault, the Second Lake Fault Zone, and others. The most recent literature on active folds and faults in Alaska imply that these faults are no longer active.

The most predominant tectonic structure of the southern margin of Alaska is the Aleutian Megathrust fault located 140 miles to the south of the Study area. This approximately 2,200-mile long, arch-shaped structure is formed by the Pacific Plate subducting below the overriding North American Plate. The two plates are estimated to be moving between 2 and 2.6 inches per year with respect to each other. This fault was the source of three of the world's largest earthquakes – including the 1964 Alaska Earthquake (moment magnitude 9.2).

In addition to the Aleutian Megathrust, there are a number of faults believed to be active near the Study area. These active faults and fault zones include a series of southwest-northeast trending faults to the south, thrust faults to the southeast, and localized crustal faults to the northeast and northwest. Faults located within approximately 100 miles of the Study that are believed to be active are listed in Table 5-12.

Table 5-12 Selected Mapped Faults near the Tiekel River Study Area

Fault/ Fault Zone	Range of Most Recent Activity (in Years; Plafker et al., 1993)	Approximate Distance from Study Area (Miles)
Rude River Fault	<2,600,000[2]	30
Cordova Fault	<2,600,000[2]	35
Eyak Fault	<2,600,000[2]	40
Heney Fault	<2,600,000[2]	50
Ragged Mountain Fault	<12,000	50
Chugach-St. Elias Fault	<2,600,000[2]	50
Redwood Fault	Suspicious[1]	55
Long Glacier Fault	<12,000[1]	55
Etches Fault	<2,600,000[2]	65
Chilkat Fault	Suspicious[1]	70
Kayak Island Fault Zone	<2,600,000[2]	80
Kosakuts Fault	<2,600,000[2]	85
Hicks Creek Fault	Suspicious[1]	85
Hope Creek Fault	<2,600,000[2]	90
Caribou Fault Zone	<2,600,000[2]	90
Castle Mountain Fault East	<2,600,000[2]	95

Notes
[1] Source is Plafker et al., 1993
[2] Source is Koehler et al., 2012

There are a number of pronounced lineaments within the region. One such lineament includes a 140-mile long feature that extends from the Klutina River, along the Tiekel River valley within the study area, and extending to approximately Granite Creek in the Bering Glacier Quadrant (USGS, 1984). No discussions of this lineament were found during the literature review conducted as part of this Study. This lack of discussion could suggest that previous geologic mapping events concluded that it was not fault related. Additional study is recommended to determine the geomorphic background of this lineament and other significant lineaments in the region.

Available databases where queried to identify significant recorded earthquakes within 100 kilometers (62 miles) of the Study area. It is noted that the recorded events are heavily skewed toward the City of Anchorage. It is believed that this skewed data set is a function of available data recorders, and is not fully representative of the actual earthquakes in the region. Regional metropolitan areas typically have both more earthquake data recorders and more complete historical records. Accordingly, it is likely that the skewed data set represents an absence of data from the eastern portion of the Study area rather than lower seismic activity.

Both the USGS/National Earthquake Information Center (NEIC) database (records from 1973 to present) and the Stover Coffman Catalog of Principal Earthquakes (records from 1569 to 1989) were queried on December 6, 2012, for earthquakes with magnitudes of greater than 4. The search resulted in a total of 60 recorded events. While there are records of older events with very strong ground shaking (VII on the Modified Mercalii Scale), only one recorded event (in 1954) exceeded a magnitude of 6. This event was located approximately 100 kilometers from the Study area. The records also indicate a total of six seismic events exceeding a magnitude of 5 occurring between 1964 and 2008. The magnitude 5 events were located between 62 and 100 kilometers of the site. The query results of earthquake database records are presented in Table 5-13.

Table 5-13 List of Recorded Earthquakes within 100 km of Potential Dam Sites

Event No.	Year	Month	Day	Depth (km)	Magnitude	Modified Mercalli Intensity	Distance To: Dam Site 1 (km)	Distance To: Dam Site 2 (km)	Distance To: Dam Site 3 (km)	Notes
1	1896	5	-	-	-	VII	64	61	54	1, 3
2	1898	8	25	-	-	-	64	61	54	1, 3
3	1903	3	-	-	-	V	64	61	54	1, 3
4	1903	6	3	-	-	-	64	61	54	1, 3
5	1908	2	14	-	-	VII	77	73	66	1, 3
6	1916	2	15	-	-	-	30	28	29	1, 3
7	1954	3	3	56	6.2	V	>100	>100	93	1, 4
8	1964	5	8	18	5.5	-	90	95	>100	1, 4
9	1970	8	18	30	5.9	IV	64	64	62	1, 5
10	1973	9	6	29	5.5	III	>100	>100	94	1, 5
11	1973	9	6	29	5.5	III	>100	>100	94	2, 5
12	1974	7	13	55	4.7	IV	29	27	28	2, 6
13	1975	9	8	33	4.3	-	78	74	66	2, 5
14	1977	6	12	35	4.2	-	80	75	68	2, 5
15	1977	12	29	57	4.3	III	91	87	80	2, 6
16	1978	2	16	33	4.1	-	9	8	14	2, 5
17	1978	8	8	53	4.3	IV	>100	>100	96	2, 6
18	1982	10	14	15	4.1	-	84	86	88	2, 5
19	1982	11	10	40	4.8	-	90	86	79	2, 6
20	1983	9	16	33	4.1	-	78	73	65	2, 5
21	1983	10	18	50	4.2	III	95	91	83	2, 6

Event No.	Year	Month	Day	Depth (km)	Magnitude	Modified Mercalli Intensity	Distance To: Dam Site 1 (km)	Dam Site 2 (km)	Dam Site 3 (km)	Notes
22	1986	1	16	27	4	IV	92	87	79	2, 5
23	1986	3	8	9	4	-	92	88	80	2, 5
24	1986	9	15	52	4.5	IV	67	70	77	2, 6
25	1986	10	22	38	4	III	>100	>100	92	2, 5
26	1988	5	9	27	4.9	IV	62	57	49	2, 5
27	1989	6	2	31	4.1	IV	>100	96	88	2, 5
28	1989	9	15	0	4.5	IV	94	96	97	2, 5
29	1990	2	15	30	4.5	IV	61	56	48	2, 5
30	1990	5	21	41	4.6	III	14	12	15	2, 5
31	1995	6	2	38	4	III	90	86	78	2, 5
32	1995	7	27	28	4.9	IV	96	92	84	2, 5
33	1996	4	29	26	4	-	>100	97	89	2, 5
34	1996	10	18	39	4.6	-	89	84	77	2, 5
35	1997	4	21	30	4.3	-	92	87	79	2, 5
36	1997	5	13	37	4.3	-	41	40	42	2, 5
37	1998	4	29	33	4.5	-	71	72	77	2, 6
38	1998	9	2	46	4.6	IV	>100	>100	97	2, 5
39	1998	10	8	14	4	-	>100	>100	92	2, 5
40	1999	11	26	23	4	IV	83	78	71	2, 5
41	1999	12	10	36	4.3	III	88	83	75	2, 5
42	2000	2	15	5	4.2	III	80	76	68	2, 5
43	2000	5	2	55	4.8	-	96	91	83	2, 5
44	2000	6	9	7	4.2	III	71	68	62	2, 5
45	2001	6	19	12	4.6	IV	79	75	67	2, 5
46	2002	3	3	4	4	II	88	84	76	2, 5
47	2004	7	16	37	4.2	III	84	79	72	2, 5
48	2004	8	25	39	5.3	IV	90	85	78	2, 7
49	2004	10	6	30	4.1	III	96	92	84	2, 5
50	2005	4	6	16	4.8	IV	90	85	77	2, 7
51	2005	4	6	17	4.5	III	90	85	77	2, 6
52	2006	6	20	14	4.4	II	94	89	82	2, 6
53	2006	9	13	25	4	III	72	68	60	2, 5
54	2007	5	10	29	4.4	IV	>100	>100	94	2, 6
55	2007	6	12	25	4.1	III	>100	>100	93	2, 5
56	2007	9	19	30	4.5	III	66	61	53	2, 6
57	2008	9	23	33	4.1	-	90	85	77	2, 6
58	2008	10	8	7	5.2	III	86	90	97	2, 7
59	2009	2	15	37	4.5	III	87	82	75	2, 7
60	2010	4	10	43	4.5	III	>100	>100	93	2, 7

Notes:

1 Principal Earthquakes with magnitudes of 5.5 or intensities of VI (Alaska) (Stover and Coffman, 1993)
2 USGS/NEIC Database (USGS, 2012, accessed December 6)
3 Historical Earthquakes, intensities where available estimated from records.
4 Magnitude Scale Unknown
5 Local Magnitude
6 Average Body Wave Magnitude
7 Moment Magnitude

5.7.2.4 Geologic Hazards

Local Seismic Hazards

Fault Rupture

Fault rupture, or a discrete offset along a fault or shear, can result in loss of water tightness of the reservoir or even failure of the dam structure when not properly accounted for in the design. Mitigation measures for displacement within dams have become somewhat common in recent years, and have been included on several U.S. dams, including Auburn Dam, Eastside Reservoir, Lauro Dam, Ridgeway Dam, and Seven Oaks Dam (Allen and Clough, 2000).

MWH's review of available geologic data did not identify any mapped active or inactive faults within the Tiekel River valley between the Richardson Highway and the Copper River. In addition, MWH did not observe any signs of recent faulting during the limited geologic reconnaissance. MWH's review of the study area did identify an approximately 140-mile linear feature that includes the Tiekel River valley; however, the geologic significance of this feature is not clear at this time. MWH recommends that the lineament be reviewed by a qualified seismologist during future phases of study. If required, design modifications to the dam and reservoir can be made to accommodate offset along this feature.

Reservoir Triggered Seismicity

Reservoir triggered seismicity (RIS) can occur in reservoirs located over existing faults. While the occurrences of such events are rare and not fully understood at the current time, it is suggested that RIS can be triggered as a result from either the increased total stress under the direct load of the water column, or as a result of decreased effective stress from the increased pore water pressure along the fault surface (Simpson et al., 1988). Available literature indicates that RIS events are most common in very large and deep reservoirs (Packer et al., 1979).

There is an absence of mapped active and inactive faults within the Study area. Further, most of the hydroelectric scenarios under consideration include moderate to small dams with relatively small reservoirs. These factors suggest a relatively low risk of RIS. It is recommended that the risk of RIS be revisited as part of a detailed seismic evaluation of the area and once the project scope is defined in more detail.

Volcanism

The southern margin of Alaska comprises the northern extent of the Pacific Ring of Fire, which designates the outer rim of the Pacific Plate. Both volcanism and earthquakes are common in these areas. When located in close proximity to a volcano, potential risk could potentially include earthquakes, tephra and ash outfall, landslides, lava flows, lahars, and outburst flooding due to glacial melt.

The closest active volcanos to the site are Mt. Spurr (235 miles), Mt. Redoubt (260 miles), Mt. Iliamna (280 miles), and Mt. Augustine (310 miles). Given the relatively large distance between these mountains and the study area, hazards associated with volcanism are considered negligible.

Arctic and Periglacial Region Related Hazards

Permafrost can present unique hazards with respect to dams and reservoirs. Several common hazards associated with arctic and periglacial regions are discussed in the flowing paragraphs.

Permafrost

Reservoir inundation can lead to the melting of permafrost over time. The resulting loss of ice can leave voids or planes of weakness in the soil and rock subsurface, providing preferential seepage pathways. These pathways can potentially compromise the water tightness of the reservoir.

The study area is mapped as being “generally underlain by isolated masses of permafrost” (Ferrians, 1965). When identified, permafrost in the dam abutments and critical parts of the reservoir can be designed for and mitigated through methods such as remedial grouting. It is recommended that the detailed design of any proposed dam include ground thermistor instrumentation to determine the presence and extent of permafrost so that it may be properly mitigated.

Solifluction

Reservoir water can also lead to solifluction, a process by which soil loses strength and becomes unstable as it melts. The results of this type of slope failure can lead to discharges of large volumes of sediment into the reservoir, which can significantly reduce storage. In other more extreme cases, solifluction can lead to rapid flow-type slope failures that could potentially cause overtopping of the dam.

Given the lack of soil deposits in the evaluated reservoir areas, hazards resulting from solifluction are considered negligible.

Ice Jacking and Frost Heave

Ice jacking and frost heave occur when ice forms within the discontinuities of rock. Over time, this process widens the aperture of the discontinuities, resulting in greatly reduced shear strength. This reduced shear strength can greatly decreases the lateral resistance of the dam foundation if not identified and properly mitigated (Michaud and Dyke, 1999).

The project is located in an area that is considered susceptible to ice jacking and frost heave. It is recommended that detailed geotechnical investigations include evaluations of these phenomenon.

Glacial Outburst Floods

Glacial outburst floods occur when a reservoir that is impounded by a glacier fails catastrophically. These types of floods are relatively common in southern and southeast Alaska. Noted examples include floods of lakes impounded by the Knik, Brady, Hubbard, Tulsequah, and Salmon glaciers.

A study commissioned by the USGS in 1971 concluded that there was a risk of glacial lake outbursts resulting from glaciers located in the upper reaches of the Tsina River (Post and Mayo, 1971). Currently, there are no glacially-impounded lakes in this area. In addition, no glacially-impounded lakes of significant size have been identified in the drainages leading into the project area. Accordingly, the risk of impact to the proposed reservoirs and dams from glacial outburst flooding is considered negligible.

Disrupted Bedrock

Fell et al. (2005) note three modes of bedrock disturbance that are applicable to the study area. First, glaciers can move relatively large blocks of weak rock. These blocks are sometimes large enough to be mistaken for intact bedrock. Second, the recession of glaciers can result in sub-horizontal stress relief joints in the base of glaciated valleys. These joints can be compressible under large loads, or can form preferential seepage paths. Thirdly, glacier recession can also result in stress relief joints can also occur in valley side slopes. Fell et al. (2005) note instances where large rock slides have occurred in these situations. Similar to glacially transported rock, landslides of significant size can transport large blocks of rock that could be mistaken for intact bedrock. Once a hydroelectric project has been selected for more advance stages of design, it is recommended that subsurface explorations be conducted to identify any disrupted bedrock within the dam foundation area.

Avalanche

The Study area is well known for deep snow packs. The recording station at nearby Thompson Pass has an annual average snowfall of 551.5 inches, which is the second highest rate in the U.S. This snowpack, combined with the steep, rugged terrain in the region, results in a very high risk of avalanches. Avalanches can have a significant financial impact on civil structures. For example, CEVA's existing transmission line has suffered four damaging avalanches at Thompson Pass between 2000 and 2011 (Dryden & LaRue, 2011).

MWH recommends that a detailed avalanche risk assessment of the Study area during the next stage of project design. The avalanche study can then be used to minimize avalanche exposure of aboveground facilities, including control structures, penstocks, powerhouses, transmission lines, and housing.

Reservoir Stability

Constructing a reservoir will alter the pore water pressure and in-situ stresses of the soil and rock along the reservoir rim. In some cases, this change in stress can trigger instability of the reservoir rim. This instability could potentially compromise the stability of the reservoir, or cause overtopping of the dam. Several instances of slope stability issues have been noted upon the inundation of reservoirs, including instances at Grand Coulee Dam, Mica Dam, Revelstoke Dam and Three Gorges dam (Eckel, 1958; Hoek, 2008; Wang et al., 2010).

MWH conducted a cursory review of the Study area with respect to slope instability as part of our geological site reconnaissance. Available aerial imagery was also reviewed for areas of large-scale slope instability. No areas of large-scale slope instability were readily identified during the review of the Study area. MWH recommends that geologic mapping and evaluation of reservoir rim stability be conducted to confirm these findings during future study phases.

5.7.3 Potential Dam Sites

5.7.3.1 Tiekel River Valley Geologic Conditions

The Tiekel River valley and the adjoining tributary valleys within the Study area are highly glaciated. Glacial scour has removed a large majority of the soil in the Tiekel River valley below an elevation of about 3,000 to 3,500 ft, leaving exposed bedrock at the ground surface. Where present, soil in the Tiekel River valley consists of isolated deposits of recent alluvium, talus, and colluvium. The adjoining tributary valleys do not exhibit the scour observed in the Tiekel River valley. Glacial soil deposits are exposed at the ground surface in these adjoining valleys and are not covered by glacial ice.

Observations of the regional rock mass and published geologic maps suggest that the rock type is somewhat consistent within the study area. Where observed in outcrops, the rock mass consists of fresh, strong (R4), dark gray, argillite and slate. Discontinuities in the argillite are generally moderately to widely spaced and tight. Discontinuities within the slate are somewhat variable, ranging from very closely spaced to moderately spaced and tight. Discontinuities are typically planar, rough, and clean; however, calcite infilling and slickensided discontinuities were observed on occasion. Based on these rock mass conditions, intact rock is expected to be generally suitable for each of the dam scenarios proposed in this Study. Given the tightness of the rock mass discontinuities, the proposed reservoirs are anticipated to have a relatively high degree of water tightness; however, detailed geotechnical investigations including subsurface explorations will be required to confirm the limited observations of surface conditions.

5.7.3.2 Dam Alternative 1 (Scenario 3B)

Dam Alternative 1 (Site 1) is located at approximate river mile 1.5. A total of five dam heights were considered as part of this preliminary evaluation. The scenarios considered included dam heights from 80 to 580 ft high, which ranged in generation capacity from 10 to 100 MW. Initial evaluations for each of the scenarios included a concrete gravity type, roller compacted concrete (RCC) dam structure. Each dam includes a gated spillway located on the crest of the dam. Powerhouses for each option included an aboveground facility located approximately 2,600 ft downstream of the dam on the south side of the river. Intake facilities were situated in the reservoir upstream of the right abutment. In each instance, the water would be conveyed from the intake to the powerhouse though either a tunnel or an above ground penstock.

Surface Conditions

The left abutment of Site 1 is covered by deciduous trees, brush, and bare ground. Occasional spruce trees are present near the base on the northern side of the river. Much of the left abutment is covered by talus that is estimated to be up to approximately 20 ft thick. The left abutment slopes downward to the southwest at approximately 1.4 horizontal to 1 vertical (1.4H:1V). The right abutment slope is covered by brush, deciduous trees, and spruce, but lacks significant surficial talus exposures. The right abutment is somewhat steeper, dipping to the northeast at nearly 1.2H:1V. The base of the valley is relatively narrow and lacks significant soil deposits. Rock outcrops are visible at several locations within the foundation area, suggesting that bedrock is present near the ground surface.

Subsurface Conditions

Based on existing geologic maps and aerial observations, the foundation rock at the Dam Site 1 consists of meta-sedimentary rock of the Valdez Formation. The rock at is location is expected to be consistent with the meta-sedimentary argillite and slate observed at nearby locations. Aerial imagery indicates two dominant structural features at Site 1. The first is an east-west trending structure that is prevalent throughout the valley. Geologic maps suggest that this feature is related to the foliation of the underlying rock. Winkler et al. (1981) indicates that the foliation dips to the north at an angle of about 70 degrees to the north. The second regional feature is visible in areal imagery and has a strike of approximately 120 degrees from north. This feature is roughly parallel to the orientation of the river at Site 1. This feature has not been identified by geologic maps and the dip of this feature is not currently known.

Potential Borrow and Quarry Sources

Gravel borrow is somewhat limited in the immediate vicinity of Dam Site 1. Talus and colluvial deposits could be mined from the slopes upstream of the right abutment for an estimated 750,000 cubic yards of material. Other nearby alluvial, colluvial, and talus deposits are relatively small and would not provide a significant amount of borrow material. Larger borrow material sources are located in the glaciated tributary valleys located southwest and northwest of the dam site. Several million yards of borrow material could be obtained from each of these valleys; however, haul distances from these sources are estimated to be on the order of 3 to 10 miles.

Hard rock sources are relatively abundant, because rock is present at or near the ground surface in the areas surrounding Site 1. Rock excavations for project facilities including the dam, powerhouse, construction staging, housing, and drill and blast portions of the tunnels could potentially be used for aggregate. Additional rock could be quarried from the slopes located upstream of the dam, resulting in a minimal haul distance.

Preliminary Dam Alternative 1 Conclusions

The geologic conditions are expected to be suitable for the hydroelectric alternatives considered at Dam Site 1, including the dam, powerhouse, penstock tunnel, and ancillary facilities. However, the following key geotechnical issues should be addressed during future study phases:

- The depth to intact rock on the left abutment. A large talus slope is present on the left abutment of Site 1. It has been assumed that the depth of this talus is approximately 20 ft deep on average. This material will need to be removed from the dam footprint in order to found the dam on intact bedrock. Excessive talus depths would result higher than anticipated construction costs.
- The strength of the rock foundation. Envisioned scenarios for Site 1 include structures of up to 580 ft high. If constructed today, this would constitute the 10th tallest dam in the U.S. Very large dams impose high stresses on the rock foundation and abutments. Extensive investigations and evaluations are required to evaluate the underlying rock mass and to provide a safe foundation design.
- The permeability of the rock mass under large reservoir heads. East-west oriented discontinuities in the rock mass could potentially provide preferential seepage paths. High seepage pressures would add to the potential for developing preferential seepage pathways. Future site evaluations should carefully evaluate the need and design of a curtain grouting program and drainage gallery.
- The stability of the reservoir slopes under operating conditions. The proposed deep reservoir would significantly increase the pore water pressures of the soil and rock that comprises the reservoir rim. Future studies should include an evaluation of the impact of the reservoir on the slope stability within the reservoir area.
- The rock mass discontinuities with respect to tunnel excavation. The east-west oriented discontinuities in the rock mass are generally sub-parallel to the alignment of the tunnel. Dip angle of these joints will be a critical factor in the design of the tunnel. If moderate to steeply dipping joints are identified, more extensive ground support efforts may be required. Future investigations of Site 1 should include an assessment of rock mass discontinuities along the tunnel alignment.
- Suitability of aggregate materials. The meta-sedimentary rocks identified in the region can contain high percentages of silicates that are susceptible to alkali-silica reaction, a process that is detrimental to concrete if not properly mitigated. In some instances, meta-sedimentary rocks can also be relatively soft and lack the durability needed for aggregate. Future study phases should include evaluations of aggregate suitability.

5.7.3.3 Dam Alternative 2 (Scenarios 1B and 3A)

Dam Alternative 2 (Site 2) is located at approximate River Mile 4.5. Dam configurations for this site range in height from 165 ft to 300 ft. Each of the initially considered dam layouts include an RCC gravity dam with a gate-controlled spillway over the crest. The configurations at Dam Site 2 range in generation capacity from 10 to 30 MW. Each scenario would include powerhouse located approximately 7,000 ft downstream of the dam on the south side of the river. Water would be conveyed to the powerhouse from an intake upstream of the right abutment either through a tunnel or an aboveground penstock.

Surface Conditions

Dam Site 2 is located in an irregularly-shaped valley. The left abutment of Site 2 is covered with talus and is sparsely vegetated with deciduous trees. The left abutment slopes downward to the south uniformly at about 1.6H:1V. There right abutment is densely vegetated with low brush, deciduous trees, and occasional spruce trees. The right abutment is steps downward to the north in a series of benches and cliffs with an average slope of 2.5H: 1V. One of the intermediate benches in the right creates a shallow valley, forming a hanging lake near the upper portion of the right abutment.

Rock outcrops are present at many locations on both the left and right abutment. Talus deposits are present at river level on the left abutment, which extend upstream for approximately 400 ft and downstream for nearly 3,000 ft. Talus depths along this slope are expected to be on the order of 15 to 20 ft thick. Rock is exposed within the cliffs of the right abutment. It is anticipated that only minor surficial soil deposits are present on the intermediate benches.

Subsurface Conditions

The rock at Dam Site 2 is mapped as part of the meta-sedimentary rock of the Valdez Formation. The rock at is location is expected to be consistent with the meta-sedimentary argillite and slate observed at nearby locations. The relatively small talus block size exposed in the right abutment slope suggests that slate, or a relatively thinly bedded rock type, underlies the site.

Similar to Dam Site 1, aerial imagery of Dam Site 2 reveals the presence of two predominant structural features. The most predominant structural feature appears to have an average strike of about 100 degrees where exposed at the surface. This orientation is consistent with the published values for rock foliation in the region. Surface expressions also indicate a second, less common structural feature is present near Dam Site 2 – with a strike that ranges from about 125 degrees to 140 degrees. The dip of these structures is not known. The presence of benches along the right abutment could suggest the presence of a third sub-horizontal structural feature at the site. This type of feature would be consistent with stress relief jointing following the recession of glaciers. It is noted that no sub-horizontal features are indicated on the readily available geologic maps of the site.

Potential Borrow and Quarry Sources

There are limited barrow sources within the immediate proximity of Dam Site 2. A talus and colluvial deposit, with an estimated volume of approximately 400,000 cubic yards of material, is located along the left abutment. Additional talus, colluvial, and alluvial deposits near Dam Site 2 are expected to be negligible. Larger deposits of borrow materials are located within about 2 to 3 miles away in the tributary valleys north and south of the site. Each of these borrow sources is estimated to contain several million cubic yards of glacial deposited material.

Intact rock is anticipated to be at or near the ground surface. Accordingly, a rock quarry could be developed immediately upstream of the dam. A quarry at this location would provide an abundant source of rock with a minimal haul distance. Further, the quarry would then be inundated following the reservoir filling, negating the need for reclamation following construction. As with Dam Site 1, rock excavations associated with project facilities also could be used for aggregate.

Preliminary Dam Alternative 2 Conclusions

The geologic conditions are expected to be suitable for the hydroelectric alternatives considered for Dam Site 2, including the dam, tunnel, powerhouse and ancillary facilities. However, the following key geotechnical issues should need to be addressed during more detailed study phases:

- The depth to intact rock on the left abutment. Rock on the left abutment is obscured by a large talus deposit that will need to be removed in order to found the dam on intact rock. It has been assumed that the depth of this talus is approximately 20 ft deep on average; however, subsurface explorations will be required to determine the actual depth of talus.
- The strength of the rock foundation. The near vertical cliffs situated on the right abutment suggest that the rock at this location is strong. However, the small block size of the talus on the left abutment could suggest either thinly bedded or closely fractured rock. If present, the design and construction of a dam would need to account for either of these conditions.
- The rock mass permeability. The discontinuities oriented perpendicular to the dam could provide preferential seepage pathways resulting in high seepage rates. Future site evaluations should carefully evaluate these discontinuities, as well as the need and design of a curtain grouting program and drainage gallery.
- The stability of the reservoir slopes under operating conditions. The impounding reservoir will alter the pore water pressure of the slopes, which could lead to slope instability. Geologic mapping should be conducted to identify any slopes that are susceptible to failures with the potential to impact the integrity of the dam or reservoir.
- The rock mass discontinuities with respect to the dam foundation. Discontinuities oriented perpendicular or sub-horizontal to the dam can act as planes of weakness resulting in key block failures if not identified and properly mitigated.
- The rock mass discontinuities with respect to tunnels. A considerable amount of the envisioned penstock tunnel is oriented roughly parallel to the strike of predominant discontinuity set for the region. If future investigations identify these discontinuity sets to be steeply or moderately dipping, ground support efforts may be required. Future investigations should evaluate the orientations of rock mass discontinuities along the tunnel alignment.
- Suitability of aggregate materials. The meta-sedimentary rocks identified in the region can contain high percentages of silicates that are susceptible to alkali-silica reaction, a process that is detrimental to concrete if not properly mitigated. In some instances, meta-sedimentary rocks can also be relatively soft and lack the durability needed for aggregate. Future study phases should include evaluations of aggregate suitability.

5.7.3.4 Dam Alternative 3 (Scenarios 1A and 2)

Dam Alternative 3 (Dam Site 3) is located at approximate River Mile 9.8. Dam configurations considered at Dam Site 3 included RCC gravity dams ranging from 75 to 160 ft high. The resulting generation capacities ranged from 10 to 30 MW. For each of the layouts considered, the powerhouse would be located on the southern bank of the river – with the powerhouse located 8.7 miles downstream of the dam. In each scenario, the water would be carried from an intake upstream of the right abutment to the powerhouse though either a tunnel or an aboveground penstock.

Surface Conditions

Dam Site 3 is located in a rugged box canyon with rock outcrops present on either side of the river. The left abutment of Dam Site 3 is covered by sparse vegetation consisting primarily of brush and deciduous trees. Rock is exposed over approximately 70 percent of the left abutment. The rock slope of the left abutment dips steeply downward to the south at approximately 1H:1V. The ground surface of the right abutment is covered primarily by low lying shrubs, brush, deciduous trees, and occasional spruce trees. The right abutment of Dam Site 3 is comprised of steep cliffs punctuated with flat benches, similar to those found at Dam Site 2. The right abutment has an average slope of about 2.4H:1V. A small lake is present in a shallow valley formed on one of the intermediate benches of the right abutment.

Subsurface Conditions

The rock underlying Dam Site 3 is mapped as meta-sedimentary rock of the Valdez Formation. This is consistent with the aerial observations made during MWH's geologic reconnaissance of the site. The rock at Dam Site 3 is massive and forms large cliffs on either side of the Tiekel River. What little slope debris was present at this location was comprised of moderate to large blocks.

Existing data regarding structures near Dam Site 3 is lacking. Regional mapping data indicates that rock foliation in the mountains to the north of the site is generally east-northeast striking with a north dip ranging from 45 to 70 degrees (Winker et al., 1981). This is consistent with the predominant surface expressions observed in aerial imagery. Foliation data is not available for rock outcrops located to the south of Dam Site 3; however, surface expressions suggest that the dominant structure is slightly more east-west trending. The dip of these structures is not known. Similar to Dam Sites 1 and 2, a secondary lineament is visible in aerial imagery that strikes at an angle ranging from about 120 to 130 degrees. The dip of this lineament is not known. The presence of benches suggests a third set of sub-horizontal discontinuities may be present at the site. Discontinuities with this orientation are consistent with potential rock bedding or post-glacial stress relief joints.

Potential Borrow and Quarry Sources

Sand and gravel materials are not present in significant quantities in the immediate area of Dam Site 3. Small gravel deposits comprised of talus and colluvium are present on the slopes to the north of the dam site. Combined, these gravel deposits could potentially provide around 350,000 cubic yards of fill material. Additional talus and colluvial deposits located immediately south of the dam site could provide an additional 250,000 cubic yards of sand and gravel. There are multiple large deposits of glacial and alluvial soils to the north, south, and west of Dam Site 3. Glaciated valleys are located within approximately 2 miles to the north and south of the site. Each of these sources could provide several milling cubic yards of sand and gravel. Alluvial deposits are located along the Tiekel River about 3 miles upstream of Dam Site 3. This alluvium could potentially yield between 1.5 and 2 million cubic yards of sand and silt.

Bedrock is exposed at the ground surface in the area surrounding Dam Site 3. Accordingly, it is expected that a quarry site could be developed immediately adjacent to the proposed dam site. In addition, rock excavations would be required for many of the project facilities. It is anticipated that rock produced from these excavations could be used as aggregate for construction purposes.

Preliminary Dam Site 3 Conclusions

The geologic conditions are expected to provide suitable for the postulated hydroelectric alternatives at Dam Site 1, including the dam, powerhouse and ancillary facilities. However, the following key geotechnical issues should need to be addressed during more detailed study phases:

- The rock mass discontinuities with respect to the dam foundation. Discontinuities oriented perpendicular or sub-horizontal to the dam can act as planes of weakness resulting in key block failures if not identified and properly mitigated.
- The rock mass permeability. Discontinuities oriented perpendicular to the dam axis are expected to be present at Dam Site 3. These discontinuities could provide preferential seepage pathways resulting in high seepage rates. Future site evaluations should carefully evaluate the need and design of a curtain grouting program and drainage gallery.
- The stability of the reservoir slopes under operating conditions. The impounding reservoir will alter the pore water pressure of the slopes, which could lead to slope instability. Geologic mapping should be conducted to identify any slopes that are susceptible to failures that would impact the integrity of the dam or reservoir.
- The rock mass discontinuities with respect to tunnels. A considerable amount of the envisioned penstock tunnel is oriented roughly parallel to the strike of predominant discontinuity set for the region. Additional ground support measures are typically required for tunnels that are driven with the orientation of steeply or moderately dipping discontinuities. Future investigations should evaluate the predominant orientations of rock mass discontinuities along the tunnel alignment.
- Suitability of aggregate materials. The meta-sedimentary rocks identified in the region can contain high percentages of silicates that are susceptible to alkali-silica reaction, a process that is detrimental to concrete if not properly mitigated. In some instances, meta-sedimentary rocks can also be relatively soft and lack the durability needed for aggregate. Future study phases should include evaluations of aggregate suitability.

5.7.4 Geotechnical Summary

In summary, each of the three dam sites evaluated are considered generally feasible from a geotechnical standpoint, and no fatal flaws have been identified. Each of the sites share similar geologic setting and conditions, and thus share many key geotechnical considerations regarding site development. Given the consistent geologic setting of the Study area, the key geotechnical considerations such as rock mass strength, seepage, and slope stability within the reservoir are expected to be similar from location to location; however, these considerations will be highly influenced by the height of the dam and depth of the reservoir.

5.7.5 Geotechnical Recommendations

The data and recommendations presented in this section are based on a cursory review of multiple project sites. The design of hydroelectric projects generally requires multiple geotechnical investigations of increasing level of detail. Upon the selection of a project site, MWH recommends conducting a site-specific preliminary design investigation of the selected project. The data collected from the preliminary design investigation would be used to support both project design activities and a preliminary application document. Preliminary design investigations would likely include:

- Subsurface evaluations of rock mass conditions for the proposed dam, powerhouse, tunnel and quarry areas.
- A review of active tectonic sources in the region and a study of seismic ground motions.
- Hydrologic studies to assess the water tightness of the surrounding rock mass and the need for curtain or consolidation grouting programs.
- Geologic mapping of the dam, reservoir, powerhouse, and transmission areas to identify areas susceptible to landslides and other geologic hazards.
- Evaluation and testing of proposed borrow and quarry areas including tests to determine aggregate suitability.
- Conducting an avalanche risk assessment of the area to assist in the layout of project facilities.
- Preliminary geotechnical evaluations of appurtenant structures.

5.8 Transmission Line Routing and Preliminary Site Control

Electric Power Systems, Inc. (EPS) was contracted by MWH to perform rough order of magnitude cost estimates for supporting infrastructure for the Tiekel River Hydroelectric project. Specific work consisted of cost development of the electrical infrastructure connecting the hydro plant to the existing CVEA 138 kV transmission network.

In addition to the substation and line costs, EPS estimated an “allowance” cost for future system improvements likely to be required by the addition of the hydro plant. These improvements cannot be defined at this time, because the loads to support this project are not sufficiently known. When the loads are defined for the cases, the additional stability and power flow work can commence. Based on EPS' work with other projects in stability limited systems, EPS is reasonably confident that the allowances provided are representative of what will be required, should the project proceed to that stage. MWH did not include this system improvement estimate in the cost estimates presented here.

In addition to the electrical infrastructure work, MWH requested that EPS analyze land use issues along the transmission corridor and at the substation location in the vicinity of the existing line.

EPS' complete report is provided in Appendix D of this report. It should be noted that the scenario numbers referenced in the EPS report do not reflect current scenario naming.

5.9 Cost Opinion (AACE International Class 5)

The construction costs for the major work packages were estimated using MWH's in-house cost database. Particular attention was given to those areas having the greatest likelihood of cost significance and impact. The cost opinion is presented as an AACE International Class 5 product which characterizes the opinion as a very preliminary indication of the expected project cost.

The cost estimate is intended to be an indication of fair market value, based on the current level of design, and is not necessarily a predictor of lowest bid. The following sections outline the specific estimating methodology employed by the estimating team during the development of the cost opinion. In addition, significant cost estimate assumptions/exclusions and qualifications are also detailed to define and document the pricing basis.

Some estimate assumptions will be refined during discussions with CVEA in future phases; specifically the concept of construction cost vs. project cost, owner's costs, financing terms, treatment of escalation and interest, treatment of risk and contingencies, and the project development mode.

5.9.1 Estimate Classification

MWH classifies all cost estimating opinions (the opinion of probable construction cost, or OPCC) in accordance with the criteria established by the AACE International cost estimating classification system described in Recommended Practice 18R-97. The AACE International Cost Estimate Classification System maps the various stages of project cost estimating together with a generic maturity and quality matrix, which can be applied across a wide variety of industries and capital infrastructure.

The following table summarizes the typical estimating methodology employed relative to AACE International cost estimate classification:

AACE Intl. Class	Software	Methodology
5	Spreadsheet	Parametric/Stochastic
4	Spreadsheet	Semi-detailed Unit Price
3	IPE/TL/ similar	Detailed Crew Analysis
2	IPE/TL/ similar	Detailed Crew Analysis w/ Budget Quotes
1*	IPE/TL/or similar	Detailed Crew Analysis w/ Firm Quotes

IPE is International Project Estimating; TL is Timberline estimating software (both commercial estimating products)

* Class 1 OPCCs are reserved for actual contractor proposals that factor in final subcontractor quotes and firm vendor materials pricing.

The following table provides some basic guidance regarding expected estimating accuracy and contingency level recommendation relative to estimate class and input design definition:

AACE Intl. Class	Design	Accuracy Range	Typical Contingency
5	<5%	-35% to +50%	20% to 40%
4	<15%	-25% to +35%	10% to 30%
3	10%-40%	-15% to +20%	5% to 20%
2	50%-99%	-10% to +15%	0% to 10%
1*	100%	+/-5%	0% to 5%

* Class 1 OPCCs are reserved for actual contractor proposals that rely on finalized bidding documents and access to all pre-tender addendums.

Directs costs, representing the project's fixed physical scope, are estimated for major equipment using a parametric approach. Quantities were developed by scaling the furnished drawings. Class 5 and 4 cost opinions typically apply all-in unit prices against the line item quantities.

Indirect costs representing the contractor's time-related, variable field management expenses or general conditions costs are factored to Class 4 and 5 cost opinions in a top-down approach as a function of running direct costs. Estimate add-ons representing the contractor's allowances for home office overhead expenses, sales taxes, insurance costs, risk provision, and fee are added to the cost estimate as a function of running direct costs. Allowances are added to the OPCC to anticipate expenses for anticipated but undefined scope items.

Contingency is added to the cost estimate to account for unknown risks or unforeseen market conditions. It should be noted that unprecedented market volatility has been a significant factor in contractor pricing over the last several years. Current market conditions have shown an aggressive approach to pricing, with contractors assuming more risk to win project work. Consequently, while the market price may be significantly under the reported "fair valuation" of the OPCC, owners need to be aware of the increased potential for claims and other compensation demands that contractors may employ to offset aggressive bidding strategies.

5.9.2 Assumptions and Qualifications

The following generic assumptions are incorporated into the cost estimate:

- Competitive bid conditions will prevail at tender (e.g. +3 bidders).
- Standard industry commercial terms will attach to all procurements.
- Stable market conditions will prevail without significant geo-political events or economic disruptions.
- An optimized contracting strategy will be employed to efficiently sequence and coordinate the work scope.
- No trade discounts were considered.
- Bulk material quantities are based on manual quantity take-offs.

The following specific assumptions are incorporated into the OPCC:

- Pricing basis is Q4 2012.
- Labor and equipment rates are Alaska rates.

Based on the assumptions summarized above and listed in Appendix B, the estimated project costs for each scenario are presented in Table 5-14. Additional detail is given in Appendix B.

The cost opinions stated above are very preliminary AACEI Class 5 estimates, but intended to be MWH's best professional opinion, given what is known at the present time, of the expected cost of the construction and equipment procurement contracts for the physical features, including the transmission line and interconnection to the existing 138-kV transmission line, plus additional allowances for engineering, reasonable licensing and permitting activities, procurement, project management, construction monitoring and project start up, all expressed in 2012Q4 price levels. A conventional design, bid, build contracting approach with conventional FIDIC contract conditions is assumed. The estimates do not include escalation of costs beyond 2012Q4, financing costs or interest during construction, reserves or contingencies that may be deemed necessary to allow for unusual risks, land, risk costs associated with alternative contracting approaches, costs associated with a disproportionately large licensing effort, or costs associated with expediting or accelerating project completion, all of which are impossible to estimate at the present time.

5.9.3 Timeline

A generalized project timeline is provided in Figure 5-13. More specific schedules can be developed for particular candidate projects. It is expected that the timeline would vary depending on the size and potential environmental impact of a selected candidate project.

Table 5-14 Summary of Cost Opinion

Item		Cost Estimate (2012 $M)				
		Scenario 1A	Scenario 1B	Scenario 2	Scenario 3A	Scenario 3B
A	Roads	$ 9.0	$ 14.4	$ 9.0	$ 14.4	$ 17.3
B	Construction Facilities	$ 9.2	$ 9.2	$ 9.2	$ 9.2	$ 9.2
C	Dam	$ 45.0	$ 142.1	$ 8.5	$ 164.3	$ 637.4
D	Power Intake and Tunnel	$ 68.5	$ 3.5	$ 50.6	$ 3.5	$ 18.4
E	Penstock	$ 0.5	$ 6.1	$ 0.6	$ 8.6	$ 2.0
F	Powerhouse	$ 5.4	$ 7.4	$ 2.9	$ 12.0	$ 21.6
G	Equipment	$ 22.6	$ 33.6	$ 13.1	$ 49.0	$ 100.4
H	Transmission	$ 27.5	$ 24.8	$ 27.5	$ 24.8	$ 27.5
I	Indirect Costs	$ 43.5	$ 55.2	$ 28.4	$ 64.1	$ 193.4
	Unlisted Items and Unknown Scope	$ 41.2	$ 50.9	$ 24.7	$ 60.5	$ 192.4
	Markups	$ -	$ -	$ -	$ -	$ -
Total Construction Cost		**$ 272.5**	**$ 347.2**	**$ 174.4**	**$ 410.4**	**$ 1,219.4**
	Engineering Studies and Design - Feas/Licensing	$ 5.5	$ 6.9	$ 3.5	$ 8.2	$ 24.4
	Engineering Studies and Design - Final Design	$ 28.6	$ 36.5	$ 18.3	$ 43.1	$ 128.0
	FERC Licensing and Environmental Studies	$ 6.0	$ 6.0	$ 6.0	$ 6.0	$ 8.0
	Owner's Admin / Land Rights / Insurance	$ 17.4	$ 21.8	$ 11.5	$ 25.6	$ 74.2
	Construction Management / Permitting	$ 24.7	$ 31.4	$ 15.8	$ 37.1	$ 110.4
Total Owner and Third Party Services ALLOWANCES		**$ 82.1**	**$ 102.7**	**$ 55.1**	**$ 120.1**	**$ 344.9**
Total Program Cost		**$ 354.6**	**$ 449.9**	**$ 229.5**	**$ 530.5**	**$ 1,564.3**
	-20%	$ 283.7	$ 359.9	$ 183.6	$ 424.4	$ 1,251.5
	50%	$ 531.9	$ 674.8	$ 344.3	$ 795.8	$ 2,346.5

5.10 Economic Viability Assessment

5.10.1 Levelized Cost of Project Energy

A review was conducted to determine if a candidate project appeared to have economic viability, and thus be considered for more detailed study. 50-yr levelized project costs were calculated for the Scenarios (Table 5-15). These costs do not consider operation and maintenance costs.

Levelized project costs per kWh, using as a basis the amount of energy considered as the 'target' for that scenario, ranged from 0.26 $/kWh to over 1.00$/kWh. It should be noted that four of the candidate projects actually have the capability to generate additional energy beyond the target energy, and if a market could be found for such additional energy, the calculated cost per kWh could be lower. Scenario 3B does not have additional available energy and assumes that a market could be found for all of the energy. If the power was not all sold, the cost per kWh could be higher.

It should further be noted that the calculated cost per kWh is based solely on the project cost estimated at 2012Q4 price levels, without financing costs, and without certain other costs that may be associated with the capital cost of the project. Inclusion of such financing costs into the base project cost would tend to increase the $/kWh value.

On the other hand, the levelized costs stated above, are based on a 6% time value of money (the discount rate), which may be on the high side. Using a lower discount rate would tend to reduce the calculated levelized project cost.

Figure 5-14 provides an illustration of how hydropower costs compare to escalating diesel alternatives. Depending on diesel forecasts selected, hydropower projects with high initial capital investments can compare favorably with the cost of diesel generation.

A value of 0.30 $/kWh is used as a 2012Q4 price level variable cost for diesel generation. A reasonable range of escalation for diesel fuel is from zero to 4%. The growth of a 30 cent per kWh value at 2 and 4% is illustrated in Figure 5-14. The corresponding levelized values, calculated using a 6% discount rate, are 0.41 and 0.59 $/kWh.

Figure 5-13 Project Timeline

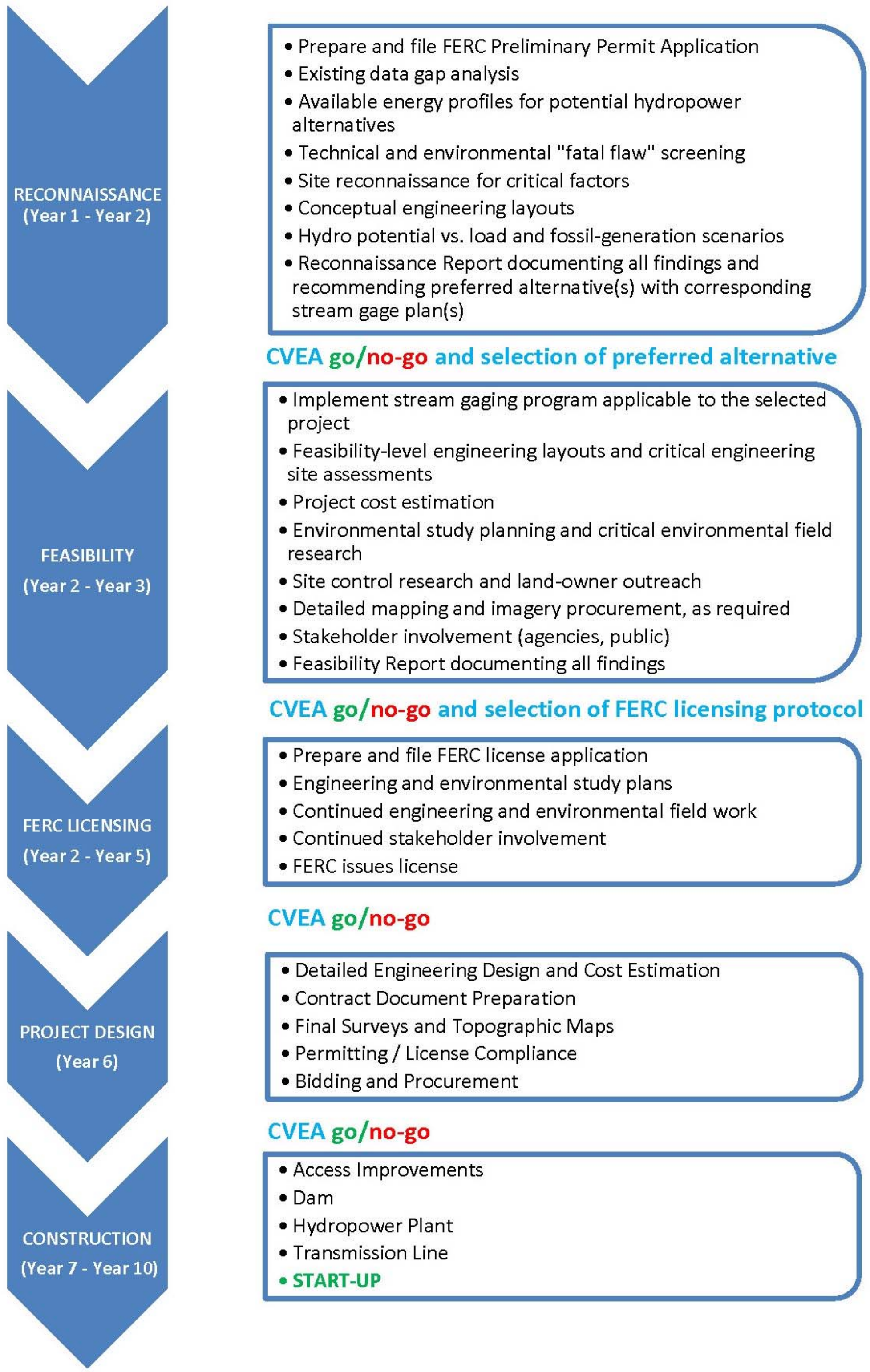


Table 5-15 50-year Levelized Cost of Project Usable Energy

	Scenario 1A	Scenario 1B	Scenario 2	Scenario 3A	Scenario 3B	Scenario 4
Scenario Target	Local	Local	Local	Regional	Regional	Statewide
Scenario Load Case	Replace all fossil-fuel gen	Replace all fossil-fuel gen + 5MW additional continuous load	Replace some fossil-fuel gen	Replace all fossil-fuel gen + 10MW additional continuous load	Replace all fossil-fuel gen + maximum available	Insufficient available energy
Installed Capacity (MW)	20	30	10	50	100	N/A
Annual Usable Energy (GWh/yr)	29.5	63.2	14.1	106.0	384.0	N/A
Average Power (MW)	3.4	7.2	1.6	12.1	43.8	N/A
Construction Cost (2012 $M - Class 5)	$272.50	$347.20	$174.40	$410.40	$1,219.40	N/A
Total Program or Project Cost (2012 $M – Class 5)[1]	$354.60	$449.90	$229.50	$530.50	$1,564.30	N/A
50-yr Levelized Cost of Usable Energy ($/kWh)[2,3,4]	$0.76	$0.45	$1.03	$0.32	$0.26	N/A

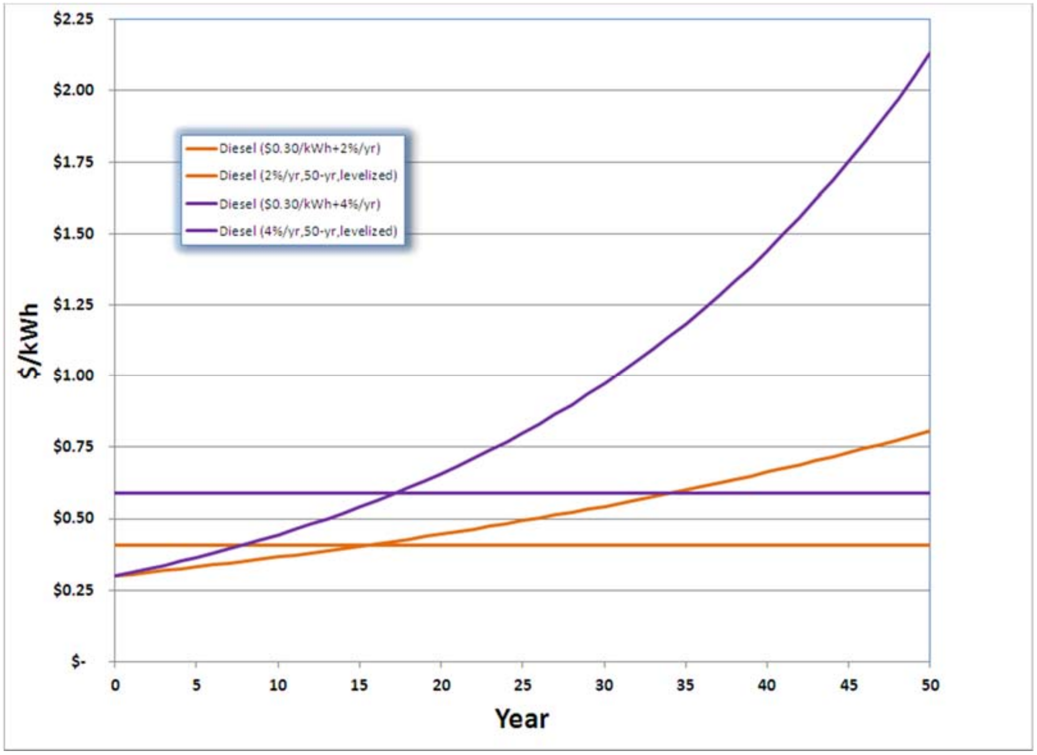
[1] Does not include escalation, financing costs, financing reserves and costs associated with alternative contracting approaches or allowances for low probability risk events.

[2] Assumes 50-yr life and 6% discount rate.

[3] Does not include operation and maintenance costs.

[4] Calculated based on sale of all annual usable energy.

Figure 5-14 Diesel Fuel Cost Escalation and Equivalent Levelized Values



Levelized project costs for Scenarios 1B, 3A and 3B compare somewhat favorably with the calculated levelized variable diesel generation cost.

5.10.2 Comparative Weighted Cost of Energy for Candidate Regional Supply Options

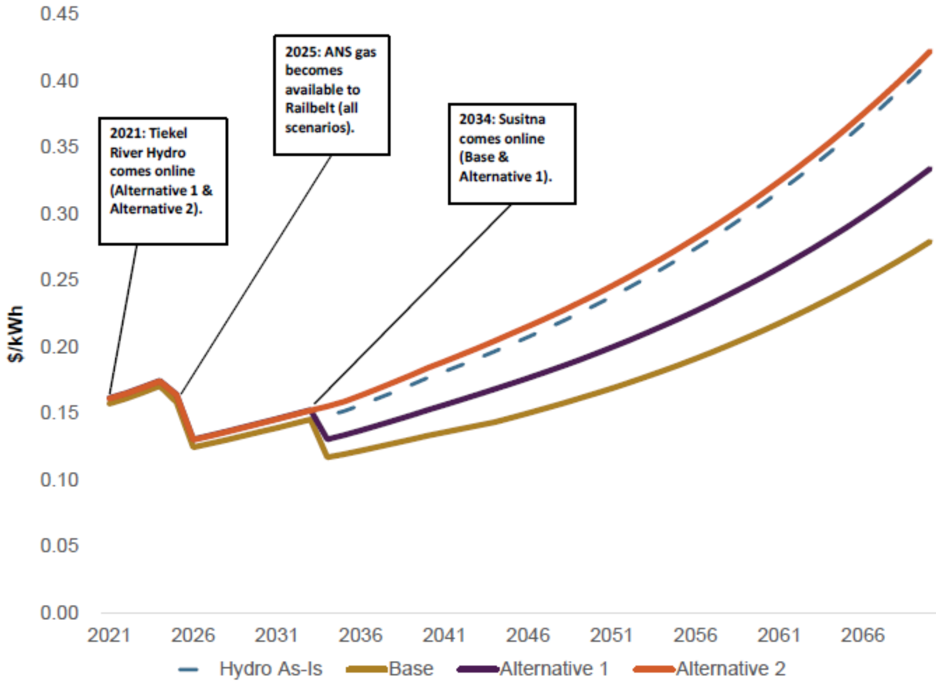
MWH subcontracted Northern Economics, Inc. (NEI) to assess socioeconomic impacts and analyze the benefits and costs of various Tiekel River hydropower development scenarios. NEI's detailed report is provided in Appendix F. A summary is provided in the following paragraphs.

Analyses were conducted that assessed the relative economic feasibility of various infrastructure scenarios over a 50-year horizon. These scenarios variably included two potential hydroelectric projects: the Tiekel River Hydroelectric project (Tiekel) and the Susitna-Watana Hydroelectric project (Susitna). Given the disproportionate energy output of Tiekel relative to projected CVEA demand, this analysis included the cost of an intertie between Glennallen and Sutton as part of the cost of Tiekel.

Among the key outputs of this analysis for four future scenarios was the estimated weighted cost of energy that combined predicted demand from the existing Railbelt and the CVEA service area. This analysis concluded that the weighted cost of energy (as measured in estimated 2021 dollars per kilowatt-hour) would be lowest in a scenario in which Susitna comes online in 2034 and Tiekel is not built, and highest in a scenario in which Tiekel is built but Susitna is not.

This analysis also concluded that the scenario that would yield the second lowest cost of energy would include the construction of both Susitna and Tiekel, while the second highest cost of energy would result from a scenario in which neither Susitna nor Tiekel is built.

Figure 5-15 Weighted Cost of Energy (2021$/kWh)



Source: Northern Economics analysis.

This analysis also assessed the economic feasibility of constructing an intertie from Glennallen to Tok that would provide for the transmission of power from Tiekel to Tok and nearby communities. However, the capital cost of the transmission line yielded an estimated cost of transmission well over $1 per kWh, rendering this piece of infrastructure economically infeasible.

6 FERC Licensing and Strategy

6.1 Introduction

As a general rule, developers of new hydropower projects that fall in FERC jurisdiction obtain preliminary permits (although it is not an absolute requirement in order to start or complete a licensing process). A preliminary permit accords the permittee priority in applying for a license for a project. Only the permittee can file a license application with FERC during the three-year term of the preliminary permit. If later studies show the Project is not favorable, the permit can be surrendered without much effort. The timing of the permit application is important as the permit term is only three years duration, providing a short timeline to perform environmental studies and complete the necessary FERC licensing requirements involved in preparing a license application. However, a successive permit can be obtained and another three years can be obtained, if no other party applies for a permit for the site upon its expiration. There is some risk that the initial permit holder might lose the priority afforded by the initial permit.

Much of the information needed to prepare a permit application is within this report. Once the preliminary permit application is filed, FERC will perform a brief review for adequacy, and then prepare a public notice of the Permit Application and provide 60 days for interested parties to intervene. It typically takes about 3-5 months after submittal of an application for FERC to actually issue the permit. The Permit term will typically begin the beginning of the month in which the permit is issued. Once the permit is in hand, CVEA would need to prepare short progress reports on a 6 month basis as required by FERC.

The FERC licensing process for hydropower projects is described in the Code of Federal Regulations, Section 18, Parts 1 to 399, Conservation of Power and Water Resources. A step-by-step guide to the process, entitled the Handbook for Hydroelectric Project Licensing and 5 MW Exemptions from Licensing, is available on the FERC website (http://www.ferc.gov/industries/hydropower/gen-info/handbooks/licensing_handbook.pdf). Below is a brief summary of the process.

A potential applicant must file for a FERC license using one of the three available licensing processes: traditional, alternative, or integrated. All of the licensing processes are based on consultation procedures designed to develop a record on which FERC bases its licensing decision and fulfills its responsibilities under the Federal Power Act, NEPA, Fish and Wildlife Coordination Act, and other statutes. The Integrated Licensing Process (ILP) is the default process and requires no special approval. FERC approval early in the process is required to use the Traditional Licensing Process (TLP) or the Alternative Licensing Process (ALP).

Obtaining FERC approval to use the TLP or ALP requires some form of agreement from at least a few key resource agencies, non-governmental organizations (NGOs), and/or representatives of Alaska Native corporations and/or tribal entities to allow FERC some basis to grant permission. Use of the TLP is generally restricted to Projects that have little potential for controversy over natural resources, such as for projects adding generation at an existing dam or other off-channel hydro development schemes. The TLP can be the fastest licensing process to develop a license application, and is often defined as being a more paper-driven process, with deadlines mostly defined by the applicant; however, it also is the process that provides the greatest chance for having to conduct additional studies after filing a license application. The TLP is probably not a realistic choice for licensing a Tiekel River Project as FERC would likely be hard pressed to allow it due to the involvement of a dam on a river with no other existing development and it would be a new project that needs a wide range of studies that require agency and Alaska Native concurrence.

The ALP offers the applicant more choices on timelines than the ILP, and is a more collaborative process than the TLP. This is useful as agencies, Alaska Native interest groups, and NGOs will be participants in the process and it is often best to try and fully understand their concerns or issues early on, rather than after a license application is filed with FERC. The ALP has been used extensively in Alaska and resource agencies seem to prefer the approach; however, the potential downside is that the ability to meet a planned schedule for development is more open-ended compared to the ILP.

The ILP is a highly structured process that is front-loaded with a series of intensive, process-driven meetings and report filings that involve an often intense pace of work, review, consideration, and collaboration. The ILP has the benefit of providing clear and predictable milestones and schedules that can often help to keep the regulatory approval process on a defined schedule.

With either the ILP or ALP, FERC and other agencies can work together to deliberately explore and implement arrangements for cooperation in the preparation of the environmental document. Such cooperation can lessen disputes between FERC and the agencies, so that FERC's environmental document provides the administrative record necessary for all agency decisions.

Because the ILP provides a structured formal sequence for all licensing steps, all participants are enabled to play key roles from the very beginning of the process. The ALP is a bit more informal, but has similar steps to the ILP in allowing opportunities for public participation; the only real difference is that the timeframes for each step can vary and will not necessarily be known in advance to the public and other potential interested parties. However, the ALP is likely a better choice than the ILP for a Tiekel River project because it appears to be the favored choice among resource agencies in Alaska, provides the framework to get all necessary input early on in the process, and can be structured to meet deadlines without being so highly structured that agencies, NGOs, and Alaska Native interest groups feel overwhelmed.

The purpose of the ALP is to provide an efficient and timely licensing process that ensures appropriate resource protections through coordination of FERC’s processes with those of federal and state agencies that have authority to condition hydropower licenses.

FERC required licensing actions to be undertaken by the applicant include:

- Early Licensing Activities, including the Request to Use ALP
- Development of Pre-Application Document (PAD), Schedule, and Notice of Intent (NOI)
- Scoping and Study Plan Approval
- Execute Engineering and Environmental Studies
- Development of Preliminary Draft NEPA Document

- Preparation of Draft License Application (DLA)
- Filing of Final License Application (FLA) and NEPA documentation
- Post-FLA Activities and Section 401 Water Quality Certification

Following submittal of the FLA, FERC will process the application and prepare an environmental review document, such as an Environmental Assessment (EA) or Environmental Impact Statement (EIS).

6.2 Early Licensing Activities

Early licensing activities will “set the stage” for the subsequent licensing effort. Identification of licensing stakeholders and development of a contact list of key individuals from these agencies for future communications and document distribution is an important task. These stakeholders may include, in addition to FERC: Federal agencies, State Agencies, local government representation, regional and local native corporations and tribal entities, and environmental and natural resources NGOs.

One of the early tasks for the potential applicant under the ALP is the formation of a stakeholder work group and the development of communications procedures. To form the stakeholder work group, the applicant must make a reasonable effort to identify and engage all potentially interested resource agencies, tribes, and citizen’s groups. This stakeholder work group must come to consensus on both the use of the ALP and the communication process to be utilized by all participants during the pre-filing period. Once the stakeholder work group is formed, then the applicant can submit to FERC a written request to utilize the ALP. Every six months, the applicant is required to file a summary report with FERC of the progress made in the licensing process.

Another key early licensing activity is to collect and assemble existing information, including reference documents. As part of preparing the PAD, the applicant will undertake due diligence information activities where agencies and others are engaged to help identify relevant information sources to establish as much information as possible about baseline resource conditions in the Project area. The idea is that, after all the existing information has been identified, studies can be scoped to determine how to fill in the gaps around the relevant information to be able to adequately characterize environmental resource conditions.

6.3 Development of PAD, Schedule, and NOI

The ALP requires the development and submittal of a PAD by the applicant. Based on information collected during early licensing, the PAD will include: proposed facilities, location, and operating method; existing environmental information; a process plan and schedule; interest statements; and draft study plans (negotiated with stakeholders). The applicant consults the stakeholder work group in the development of the PAD, particularly in determining the importance of resources in the region of the project. Once the Final PAD is completed, it is submitted to resource agencies and stakeholders simultaneously with the FERC NOI to File a License Application.

6.4 Scoping and Study Plan Development

Post-PAD filing activities will include: the development of a scoping document for the NEPA environmental review; a site visit and scoping meeting; review of PAD comments and study requests from agencies and other stakeholders; development of a formal study plan; and participation in a study plan meeting to finalize study plans for FERC approval.

Within 60 days of the notification of the NOI and filing of the PAD, FERC will issue a notice of commencement of proceeding in the Federal Register. This will commence the Study Plan Approval and Scoping Process.

6.5 Execute Engineering and Environmental Studies

It is likely that the following biological and social resource topics will have issues that need addressing during licensing of the Tiekel River Project:

- Water use and quality
- Cultural Resources (archeological, cultural, and historic)
- Aquatic Resources
- Wildlife Resources
- Subsistence
- Land Use
- Aesthetics
- Recreation
- Cumulative Impacts on Affected Resources

Studies required to address these issues may include:

- Hydrologic information development and evaporation make-up water investigations.
- Engineering analyses, designs, and drawing preparation.
- Water quality assessment (temperature, dissolved oxygen, etc.).
- Wildlife and botanical surveys, including rare, threatened, and endangered species (as required under the Endangered Species Act).
- Wildlife habitat mapping.
- Archaeological and historical resource surveys as required under the NHPA.
- Recreation inventory and opportunity identification.
- Recreational use surveys and assessments.
- Land management study.
- Visual resource inventory and impact assessment.
- Fisheries and aquatic resources.

- Geology and soils investigations.
- Surface water quality and temperature.

6.6 Development of Preliminary Draft NEPA Document and Licensing Proposal

The applicant will prepare what is known as an Applicant-prepared EA along with its draft license application (DLA). The Applicant-prepared EA (APEA) will be submitted in place of Exhibit E in the FLA and will be utilized by FERC to develop its required NEPA documentation (whether that be an EA or EIS, as required by NEPA). This document must describe proposed project facilities, project lands, and project waters. The DLA will also describe the proposed project operation and maintenance plan, which includes proposed protection, mitigation, and enhancement (PM&E) measures. The DLA will include the draft APEA and maps depicting resource conditions. Reviewers, including FERC staff, have 90 days to submit comments, including recommendations on whether FERC should prepare an EA or an EIS.

6.7 Development of Draft and Final License Application

As part of the draft and final license application, the engineering and environmental exhibits need to be developed. These include:

- Initial Statement
- Exhibit A (Description of the Project)
- Exhibit B (Project Operation and Resource Utilization)
- Exhibit C (Construction Schedule)
- Exhibit D (Costs and Financing)
- Exhibit E (Preliminary Draft APEA and supporting reports)
- Exhibit F (General Design Drawings and Supporting Design Report)
- Exhibit G (Map of the Project)

Exhibit A is a description of the proposed project. The description will contain information on:

- The physical composition, dimensions, and general configuration of dams, spillways, penstocks, powerhouses, tailraces, or other structures.
- The normal maximum water surface area and normal maximum water surface elevation (mean sea level), and gross storage capacity of impoundments.
- The number, type, and rated capacity of any turbines or generators.
- The number, length, voltage, and interconnections of primary transmission lines.
- The description of mechanical, electrical, and transmission equipment appurtenant to the project.
- A listing of all lands of the United States (if any).

Exhibit B is a statement of project operation and resource utilization. The information will be provided for the operation of the reservoirs, dams, gates, emergency spillways, primary transmission lines, and powerhouse. Information to be documented in Exhibit B includes:

- Automated and manual operational characteristics.
- An estimate of the annual plant factor.
- A statement of how the project will be operated during adverse, mean, and high water years.
- An estimate of the dependable capacity and average annual energy production in kilowatt-hours.
- The minimum, mean, and maximum recorded flows, in cfs, of the facility (with a specification of any adjustment made for evaporation, leakage minimum flow releases [including duration of releases] or other reductions in available flow).
- Monthly flow duration curves indicating the period of record and the gauging stations used in deriving the curves; and a specification of the critical streamflow used to determine the dependable capacity.
- An area-capacity curve showing the gross storage capacity and usable storage capacity of the impoundments, with a rule curve showing the proposed operation of the impoundment and how the usable storage capacity is to be utilized.
- The estimated minimum and maximum hydraulic capacity of the power plant in terms of flow and efficiency (cfs at one-half, full, and best gate), and the corresponding generator output in kilowatts.
- A tailwater rating curve with a curve showing power plant capability versus head and specifying maximum, normal, and minimum heads.
- A statement of system and regional power needs and the manner in which the power generated at the project is to be utilized, including the amount of power to be used on-site, if any, supported by the following data: (i) Load curves and tabular data, if appropriate; (ii) Details of conservation and rate design programs and their historic and projected impacts on system loads; and (iii) The amount of power to be sold and the identity of proposed purchaser(s).
- A statement regarding plans for future development of the project, or of another existing or proposed water power project, on the affected stream or other body of water, indicating the approximate location and estimated installed capacity of the proposed developments.

Exhibit C is the proposed construction schedule for the project. The construction schedule must contain: (1) The commencement and completion dates of construction, modification, or repair of major project works; and (2) The commencement date of first commercial operation of each major facility and generating unit.

Exhibit D is a statement of project costs and financing. The exhibit will contain:

- A statement of estimated costs of construction, including: (i) The cost of any land or water rights necessary to the development; (ii) The total cost of all major project works; (iii) Indirect construction costs such as costs of construction equipment, camps, and commissaries; (iv) Interest during construction; and (v) Overhead, construction, legal expenses, and contingencies.
- A statement of the estimated average annual cost of the total project, specifying any projected changes in the costs (life-cycle costs) over the estimated financing or licensing period if the applicant takes such changes into account, including: (i) Cost of capital (equity and debt); (ii) local, state, and federal taxes; (iii) Depreciation or amortization, (iv) Operation and maintenance expenses, including interim replacements, insurance, administrative and general expenses, and contingencies; and (v) The estimated capital cost and estimated annual operation and maintenance expense of each proposed environmental measure.
- A statement of the estimated annual value of project power based on a showing of the contract price for sale of power or the estimated average annual cost of obtaining an equivalent amount of power (capacity and energy) from the lowest cost alternative source of power, specifying any projected changes in the costs (life-cycle costs) of power from that source over the estimated financing or licensing period if the applicant takes such changes into account.
- A statement describing other electric energy alternatives, such as gas, oil, coal, and nuclear-fueled power plants and other conventional and River hydroelectric plants.
- A statement and evaluation of the consequences of denial of the license application and a brief perspective of what future use would be made of the proposed site if the proposed project were not constructed.
- A statement specifying the sources and extent of financing and annual revenues available to the applicant to meet the costs identified.
- An estimate of the cost to develop the license application.
- The on-peak and off-peak values of project power, and the basis for estimating the values.

Exhibit E is the environmental report. If the ALP is utilized, the APEA generated for the DLA will be submitted. The APEA will need to include or have a supplement to include all aspects of the Exhibit E, including:

- Description of topography, climate, major land uses, and economic activities.
- Geographic and temporal scope of cumulative effects.
- Identification of applicable laws (Clean Water Act, Endangered Species Act, National Historic Properties Act, etc.).
- Description of project facilities.

- Proposed action including cost estimates for construction, operation, and maintenance of proposed facilities or environmental measures (and possible alternatives that were considered).
- Affected environment and environmental effects on resources, including:
  - Geology and soils
  - Water use and quality
  - Fish and aquatic resources
  - Wildlife and botanical resources
  - Wetlands, riparian, and littoral habitats
  - Rare, threatened, and endangered species
  - Recreation resources
  - Aesthetics
  - Cultural resources
  - Socioeconomics
  - Tribal and/or native corporation resources
  - PM&E measures
  - Economic analysis including annualized, current, cost-based information
  - Consistency with comprehensive plans
  - Functional design drawings of environmental (PM&E) measures.

Exhibit F consists of general design drawings of the principal project works described in Exhibit A and supporting information used as the basis of design. The Exhibit F drawings must show all major project structures in sufficient detail to provide a full understanding of the project, including: (i) Plans (overhead view); (ii) Elevations (front view); (iii) Profiles (side view); and (iv) Sections.

Exhibit G is a map of the project that conforms to the specifications of 18 Code of Federal Regulations (CFR) 4.39. Exhibit G serves as a map of the project showing its location and principal features, project boundary, impoundments, and federal and non-federal land ownership.

6.8 Post-FLA Filing Activities

Within 14 days of the FLA filing date, FERC will issue a public notice of the tendering in the Federal Register, which will include a preliminary schedule for processing of the application. It is assumed, for the purposes of this document, that FERC will find the application complete. FERC will then issue its Notice of Ready for Environmental Analysis (REA), which solicits any further comments, interventions, and preliminary terms and conditions from the resource agencies. If FERC does not find the application complete, additional interim steps would become necessary.

7 Conclusions and Recommendations

Reconnaissance-level evaluations of the Tiekel River watershed indicate that it has technical potential for hydropower development that could:

- decrease CVEA dependence on fossil fuels;
- increase inventory of renewable energy sources;
- provide power to new regional customers (residential and/or industrial); and
- increase reliability for the northern half of CVEA's current service territory in the event of a transmission outage.

Five candidate project concepts on the mainstem of the Tiekel River were developed to represent the available range of storage projects (i.e. year-round power). These five storage projects appear to have technical merit, warranting further investigation, as well as no readily-apparent environmental constraints that would preclude development. The project development driver appears to be economic. Although a promising candidate for a run-of-river project (i.e. summer-only power) was identified, there is not presently a need for additional seasonal generation.

If CVEA determines that a storage project is in their best interest, the recommended next steps for resource evaluation would be:

- Refine load projections as a function of time and customer expansion projections to guide selection of an appropriate project size.
- Refine financing assumptions (interest rates, bond terms, etc.) to shape debt service for hydropower construction in order to reduce early year $/kWh.
- Refine grant funding assumptions (current calculations assume zero grant funding).
- Conduct more detailed economic analysis to compare hydropower generation costs with 50-yr regional thermal generation price forecasts.
- Install stream gage(s) in the Tiekel River at appropriate location(s) for the selected project to confirm design criteria.
- Acquire high-resolution maps and imagery of the project area.
- Refine and optimize selected project concept.
- Develop and implement geotechnical investigation plans, including seismic and avalanche hazard evaluations.
- Prepare a Class 4 engineering construction cost estimate.
- Continue stakeholder outreach.
- Initiate licensing, if desired.

- Develop and implement environmental study plans, particularly those with potential for design impacts (i.e. dam release requirements, fish passage requirements).
- Conduct more detailed land ownership research.
- Develop project schedule.

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